Jemena Gas Networks (NSW) Ltd

2020-25 Access Arrangement Proposal

Attachment 8.2

Demand Forecast Report

Gas Demand and Customer Forecasts

Jemena Gas Networks | NSW Gas Access Arrangement 2021-2025

May 2019

Final Draft

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Glossary

AA	Gas Access Arrangement Review
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
BASIX	Building Sustainability Index
BOM	Bureau of Meteorology
CBJV	Cooper Basin Joint Venture
CD	Chargeable Demand
COAG	Council of Australian Governments
CORE	Core Energy & Resources Pty. Limited
DD	Degree Days
EDD	Effective Degree Days
EEO	Energy Efficiency Opportunities
EGP	Eastern Gas Pipeline
E-to-G	Electricity-to-Gas
GBJV	Gippsland Basin Joint Venture
GEMS	Greenhouse and Energy Minimum Standards
HDD	Heating Degree Days
HRVI	Individually Metered HR Connection
HRVB	Boundary Metered HR Connection
IPART	Independent Pricing and Regulatory Tribunal
JCC	Japanese Cleared Crude
LGA	Local Government Area
LRET	Large-scale Renewable Energy Target
LRMC	Long Run Marginal Cost
MD	Medium Density (Dwelling)
MD/HR	Medium Density/ High-Rise
MDQ	Maximum Daily Quantity
MEPS	Minimum Energy Performance Standards
MSP	Moomba to Sydney Pipeline
NABERS	National Australian Built Environment Rating System
NSW	New South Wales
RET	Renewable Energy Target
SRES	Small Scale Renewable Energy Scheme
STTM	Short Term Trading Market
UHI	Urban Heat Island

Section 1 | Summary

Section 1 | 1. Executive Summary

1.1. Scope of this Report

This report has been prepared by Core Energy & Resources Pty Ltd (“**CORE**”) for the purpose of providing Jemena Gas Networks (“**Jemena or JGN**”) with an independent forecast of gas customers and demand for the company’s natural gas distribution network in New South Wales (“**NSW**”), for the five financial years from 1 July 2020 to 30 June 2025 (“**Review Period**”).

CORE has noted that these projections (both this Report and related forecasting models[1]) will form part of Jemena’s Gas Access Arrangement Review (“**AA**”) submission to the Australian Energy Regulator (“**AER**”).

CORE acknowledges that the derivation of mid to longer range forecasts generally, and this customer and demand forecast specifically, involve a significant degree of uncertainty. Accordingly, CORE has taken all reasonable steps to ensure this Report, and the approach to deriving the forecasts referred to within the Report, comply with Division 2 of the National Gas Rules (“**NGR**”) "Access arrangement information relevant to price and revenue regulation", and in particular, parts 74 and 75 as referenced below.

"74. Forecasts and estimates

(1) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.

(2) 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.

75. Inferred or derivative information

Information in the nature of an extrapolation or inference must be supported by the primary information on which the extrapolation or inference is based." [2]

1 The forecasting models are Confidential and an application will be sought for disclosure to be suppressed in accordance with NGR part 43 (2) (b).
2 NGR dated April 2014 and accessed from AEMC website.

1.2. Core Energy Group- Demand Forecast Experience

The following table outlines the experience held by members of CORE for both energy demand forecasting and independent expert witness roles:

Focus Area	Experience
Independent Expert/Witness	▪ A variety of independent expert roles covering: > Gas contract disputes > Gas price reviews – east and western Australia > Gas demand – electricity, industrial, distribution, transmission > Drilling activity (LNG) > Gas processing plants > Gas transmission pipelines > Gas storage > International LNG
Demand forecasting, modelling and scenario analysis	▪ Development of models and analytical tools, forecasts and demand scenarios along the gas sector value chain: > Exploration and production; > Transmission; > Distribution; > Electricity generation; > Retailing; and > Liquefaction (LNG) ▪ Demand forecasting for a diverse range of clients including energy producers, gas infrastructure companies, retailers and the market operator (AEMO- in support of the GSOO publication).
Gas Distribution	Access Arrangements > WA – ATCO > NSW – Jemena > VIC – AGN > SA – Envestra (now AGN) > ACT – ActewAGL (now Evoenergy) General > Demand forecasting, modeling and scenario analysis covering all Australian networks > Acquisition of Wagga Gas Network from NSW Government
Gas Transmission	▪ Development of gas demand scenarios for major transmission systems: > South West Queensland > Roma Brisbane > Moomba Sydney > EGP > Moomba Adelaide > SEAGas > Tasmania > QCLNG transmission line
Gas Exploration and Production	▪ Development of contracted and potential demand and supply scenarios: > Cooper Basin: SA and SWQ JV; unconventional gas (shale, coal seam, tight gas) > Gippsland Basin: Gippsland Basin JV > Otway Basin: Minerva, Thylacine-Geographe, Casino > Surat/Bowen Basins: all major Queensland coal seam gas fields > WA Basins: NWS Domgas, John Brookes, Gorgon, Wheatstone, Pluto > LNG – NWS JV, Gorgon, Pluto, Ichthys, Wheatstone, GLNG, APLNG, QCLNG, Darwin LNG

1.3. Structure of Report

This report comprises two Sections:

Section 1 – Summary

A summary of the approach to forecasting JGN demand and customer numbers including:

- Methodology
- Tariff V Forecast – connections/customer numbers and demand
  - Residential
  - Small Business
- Tariff D Forecast – Maximum Demand and ACQ Forecast
- Conclusion

Section 2 – Supporting Information and Analysis

Information and analysis undertaken by CORE to derive the forecasts set out in the Summary. This includes:

- Weather Normalisation
- Retail Gas & Electricity Price Forecast
- Price Elasticity of Demand
- Regression Analysis and Results
- Review of Appliance and Dwelling Efficiency; Associated Policy
- Review of Previous AA Forecast

Please note that all years referred to are financial years unless otherwise stated.

1.4. Overview of JGN

The JGN extends over 25,000 km and provides gas to around 1.4 million customers across Sydney, Newcastle, Wollongong and over 20 regional centres. The gas distributed by the network has historically been produced mainly from the Cooper Basin and Gippsland Basin (Bass Strait) Joint Ventures. [3]

1.4.1. Tariff Classification

For the purpose of this Report, reference will be made to two Customer segments - Tariff V and Tariff D[4] as defined in Table 1.1 below.

3 Source: Jemena website.

4 These types are consistent with the Volume Tariff and Demand Tariff customer groups used in tariff assignment as referenced in the 2018 JGN Schedule of Reference Tariffs and Charges.

Table 1.1. Customer Segments used for Tariff Classification.

Customer segment	Description
Tariff V (<10TJ)	Jemena's Volume Tariff customer group consists of residential and business customers who are reasonably expected to consume less than 10 TJ of natural gas per year. For the purpose of this Report the Volume Tariff customer group has been further segmented as follows: ▪ Residential (residential customers who are billed quarterly); and ▪ Small Business (business customers who are billed quarterly and monthly) As the business customers billed quarterly (Small Business) have significantly different gas usage (and also drivers of demand) than residential customers, CORE has recorded forecasts for these types of customer separately under 'Small Business'. New Residential customers are further segmented as follows: ▪ E-to-G – electricity only dwellings which connect to gas ▪ New Homes – typically new, free-standing houses but can include semi-detached or duplex/townhouse dwellings (1-2 dwellings) ▪ Medium Density/High Rise – houses connected as part of a higher density apartment (3 or more dwellings). These can be individually metered or metered at the boundary (whereby billing occurs according to strata title rather than individually metered usage). Jemena has advised CORE that individual hot water meters for new high rise dwellings will be phased out and this report will detail how the forecast has incorporated this change. Throughout this Report, the Volume Tariff customer group will be referred to as Tariff V customers and the customer segments defined above will also be frequently referred to.
Tariff D (>10TJ)	Jemena's Demand Tariff customer group consists of large industrials that are reasonably expected to consume more than 10 TJ of gas per year. Throughout this Report, the Demand Tariff customer group will be referred to as Tariff D customers and MDQ will be referred to for certain historical data and analysis- this refers to the highest day within a particular year. ACQ refers to the total volume consumed within one year.

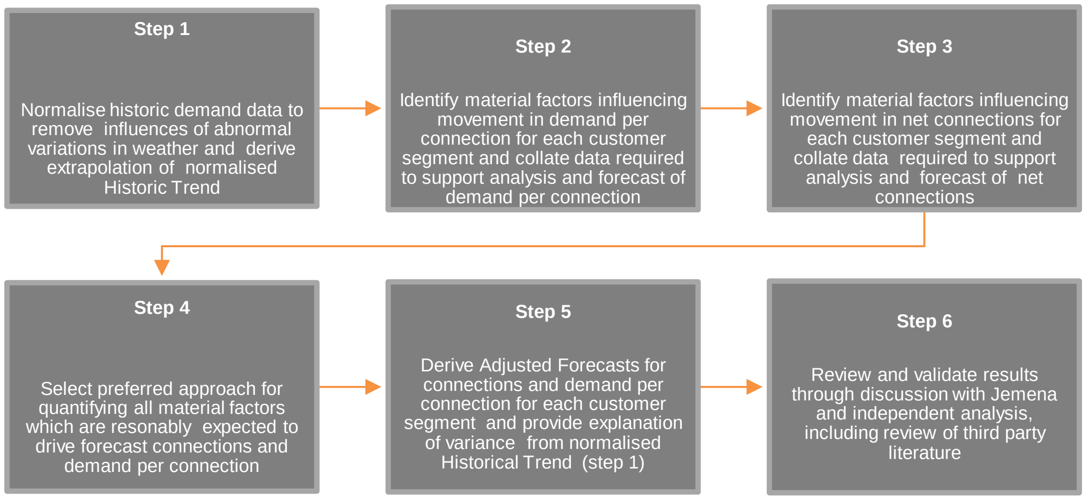
Source: CORE based on advice from Jemena and JGN Schedule of Reference Tariffs and Charges.

1.5. Methodology Overview

An overview of the methodology adopted by CORE to derive forecasts of JGN demand and customer numbers is provided below for both Tariff V and Tariff D customers. Further detail is presented in Section 2.

1.5.1. Tariff V

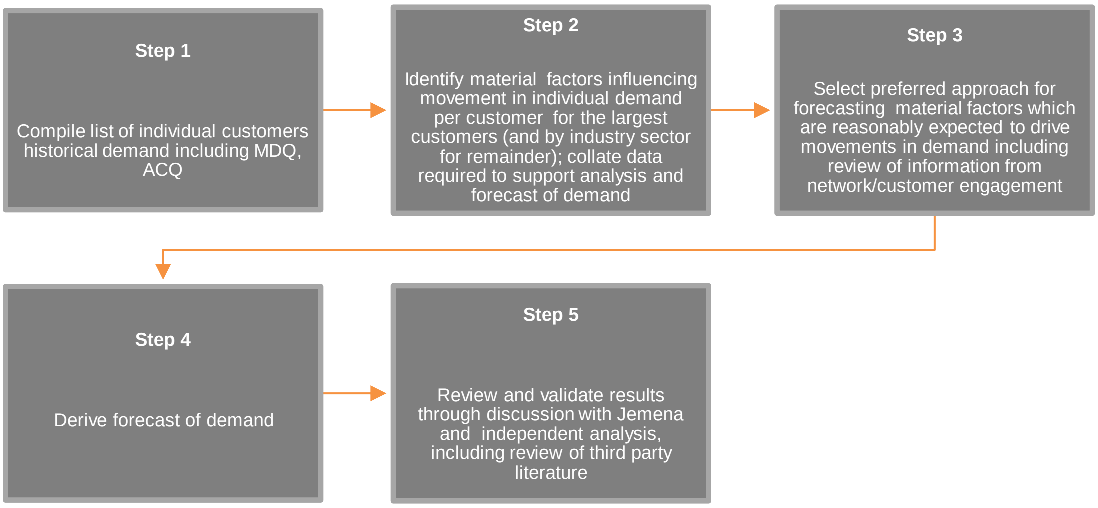
Figure 1.1. CORE Methodology – Tariff V.



Source: CORE.

1.5.2. Tariff D

Figure 1.2. CORE Methodology - Tariff D.



Source: CORE.

CORE is of the opinion that the rigorous application of this methodology, as presented within this Report, derives forecasts which satisfy the requirements of the NGR - as the forecasts are derived on a reasonable basis, to provide the best forecast or estimate possible under the circumstances, utilising appropriate primary information, where available, to support the extrapolations/ forecasts.

1.6. Overview of Tariff V History & Forecast

Table 1.2 and Figure 1.3 provide a summary of actual connections, demand per connection and total demand for Tariff V, together with a summary of average annual growth.

Table 1.2. Historical Connections, Demand per Connection and Demand – Tariff V.

Tariff V	2018 Actual	AAGR 09-18 A	2025 Forecast	AAGR 21-25 F
Closing Connections				
Residential	1,353,889	3.08%	1,503,736	1.45%
Small Business	36,022	1.70%	39,630	1.34%
Total Tariff V Connections	**1,389,911**	**3.04%**	**1,543,366**	**1.45%**
Demand per Connection				
Residential	18.8	-1.16%	18.3	-0.55%
Small Business	383.9	-0.52%	335.3	-0.96%
Total Demand				
Residential	25,507,290	1.89%	27,550,788	0.38%
Small Business	13,828,468	1.17%	13,289,424	0.38%
Total Tariff V Demand	**39,335,757**	**1.62%**	**40,840,211**	**0.72%**

Source: CORE with historical data from Jemena.

Figure 1.3. Total Tariff V Demand

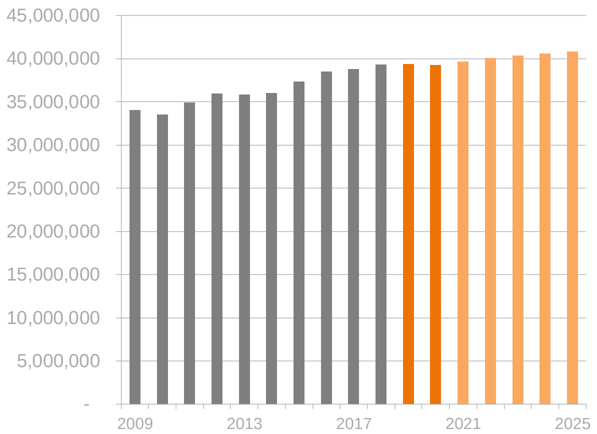
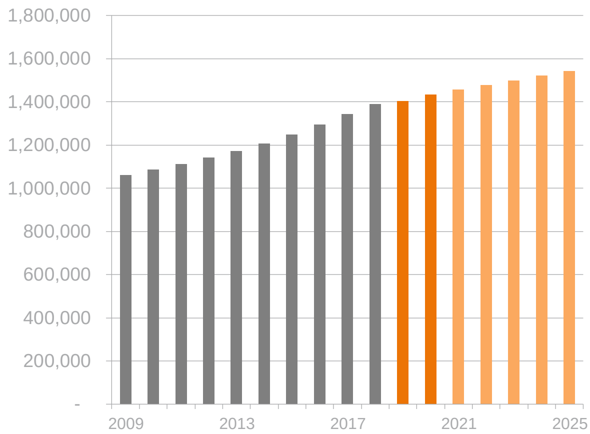


Figure 1.4. Total Tariff V Connections



Source: CORE with historical data from Jemena.

1.7. Overview of Historical Tariff D Demand

The following table and figures provide a summary of historical and forecast ACQ and MDQ demand for Tariff D, together with a summary of average annual growth rates.

Table 1.3. Tariff D Demand Projection | Summary

Tariff D Demand (GJ)	2018 Actual	AAGR 09-18 A	2025 Forecast	AAGR 21-25 F
ACQ	49,588,365	-2.84%	42,086,222	-2.12%
MDQ	254,885	-2.57%	212,498	-2.18%

Source: CORE based on historical data from Jemena.

Figure 1.5. Total Tariff D MDQ

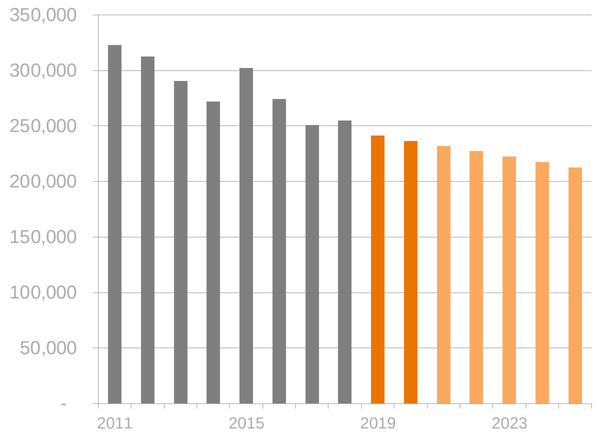
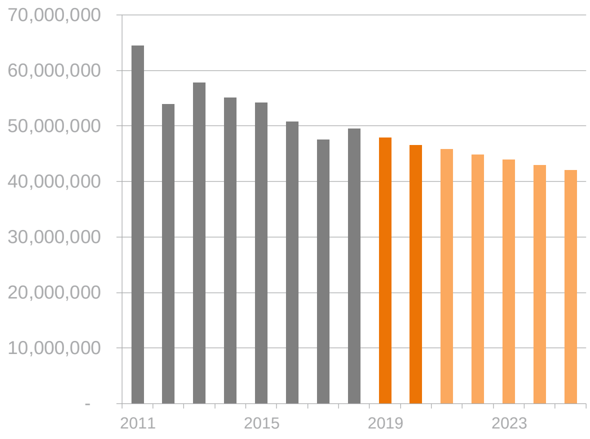


Figure 1.6. Total Tariff D ACQ



Source: CORE with historical data from Jemena.

1.8. Overview of Connections and Demand Forecast

The following paragraphs provide a summary of the forecasts derived by CORE for both the Tariff V and Tariff D customer types.

1.8.1. Tariff V

Gas demand for Tariff V customers is forecast to increase by 0.72% p.a. from 2021 to 2025. This forecast is influenced by two principal forces - an increase in connections of 1.45% p.a., offset by a reduction in demand per connection of -0.71% p.a. The contribution from each customer group is shown in the following table:

Table 1.4. Tariff V Connections, Demand per Connection and Demand | Summary

Tariff V	2021	2022	2023	2024	2025	AAGR 2009-2018	AAGR 2021-2025
Tariff V Connections							
Residential	1,419,534	1,440,478	1,460,831	1,481,644	1,503,736	3.08%	1.45%
Small Business	37,569	38,090	38,608	39,121	39,630	1.75%	1.34%
Total	**1,457,103**	**1,478,568**	**1,499,439**	**1,520,765**	**1,543,366**	**2.98%**	**1.45%**
Tariff V Demand Per Connection							
Residential	18.7	18.7	18.6	18.4	18.3	-1.04%	-0.55%
Small Business	348.5	345.9	342.8	338.9	335.3	-0.57%	-0.96%
Total	**27.2**	**27.1**	**26.9**	**26.7**	**26.5**	**-1.29%**	**-0.71%**
Tariff V Demand							
Residential	26,585,541	26,886,480	27,112,545	27,332,636	27,550,788	1.89%	0.90%
Small Business	13,091,660	13,175,723	13,234,527	13,256,373	13,289,424	1.11%	0.38%
Total	**39,677,202**	**40,062,203**	**40,347,072**	**40,589,008**	**40,840,211**	**1.65%**	**0.72%**

Source: CORE Demand Forecast

The major factor contributing to the reduction in Tariff V demand is a reduction in demand per connection for residential customers, which is influenced by:

- continued growth in share of connections for medium and high-density connections which exhibit lower gas usage per dwelling;
- continued trends in gas appliance and dwelling efficiency, contributing to reductions in demand per connection;
- customer demand response to gas and electricity price movements whereby electricity prices are projected to move more favourably than gas during the forecast period;
- reduced space heating usage attributable to competition with alternative energy sources, including R-C air-conditioning

1.8.2. Tariff D

Capacity demand (as measured by MDQ) for Tariff D customers is forecast to fall by an annual average of -2.18% p.a. from 2021 to 2025 as shown in the table below. This fall is attributable to a continued reduction in gas-intensive industrial capacity and an increase in operational energy efficiencies at the individual plant level.

Table 1.5. Tariff D Demand Projection | Summary

Tariff D	2021	2022	2023	2024	2025	AAGR 2009-2018	AAGR 2021-2025
MDQ	232,101	227,472	222,298	217,452	212,498	-3.07%	-2.18%
ACQ	45,845,197	44,898,001	43,955,208	43,018,111	42,086,222	-1.92%	-2.12%

Source: CORE, utilising historical data from Jemena.

The decline in MDQ is projected to continue its decline albeit at a slower rate than the historical period:

- known and projected business closures/ capacity reductions are not as significant relative to the large closure events contained within the historical period;

- continuing trend in energy efficiency, including peak demand as a response to increased energy costs and profit pressures more broadly.

1.9. Validation

An important part of the work program undertaken by CORE in relation to the derivation of JGN forecasts is a validation process. This involves CORE identifying independent third-party analysis which addresses one or more factors considered by CORE in deriving a final forecast. This validation process has been applied in a range of areas including, but not limited to:

- estimates of NSW residential dwelling growth;
- projections of NSW retail gas and electricity prices;
- trends in energy efficiency at the appliance and building level; and
- trends in manufacturing activity.

In addition, CORE has reviewed all recent demand forecasts which have formed part of final AA decisions for other networks in Eastern Australia, to determine whether trend forecasts are consistent with other networks. The following charts show that the residential forecast (the majority of volume and connections) is forecast to move in the same direction as all other eastern networks albeit with a more conservative forecast decline in demand per connection. The following sections will detail why the forecast decline in demand per connection for JGN appears less aggressive than due to the growth in high-rise boundary connections (also promoted by network policy) which contain multiple dwellings behind one connection, pushing the average demand per connection up.

Figure 1.7. Forecast Benchmarking | Residential Demand per Connection

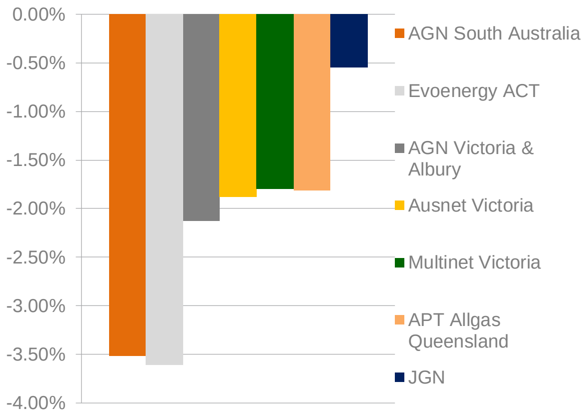
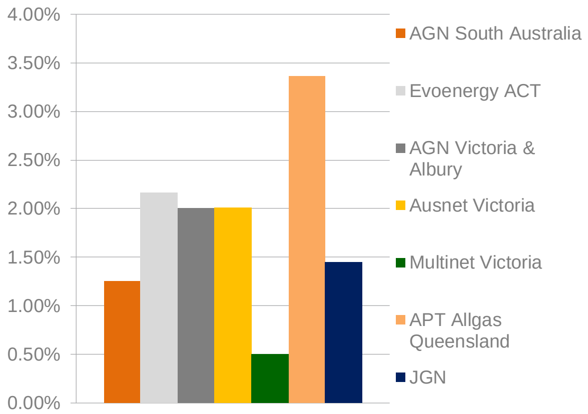


Figure 1.8. Forecast Benchmarking | Residential Connections



Section 1 | 2. Methodology

The methodology adopted by CORE to derive a gas demand forecast for JGN, involves four primary elements. Each element is expanded upon in the relevant section of this report.

1. An approach to normalising historical demand to remove the impact of abnormal weather and prices
2. An approach to deriving a forecast of Residential demand
3. An approach to deriving a forecast of Small Business commercial demand
4. An approach to deriving a forecast of Tariff D industrial demand

The methodology adopted by CORE considers all recent AA demand forecast proposals, draft decisions and final decisions, which allowed the development of a best-practice approach whilst also remaining compliant with the NGR.

The methodology favours a highly transparent approach, including a demand forecast model that examines all factors that could potentially impact normalised demand. This approach is fundamentally consistent with the methodology presented by AEMO in its latest National Gas Forecasting Report ("**NGFR**").[5]

This report sets out the underlying facts and assumptions that were necessary when analysing gas demand. The requested data set as provided by JGN covers the 2009 to 2018 period, enabling CORE to review a full decade of historical trends for the volume tariff class and demand tariff class.

CORE considers this process to be compliant with s 74(2) of the NGR. Forecasts are constructed on a reasonable basis whilst representing the best forecasts possible in the circumstances.

Tariff V (residential and small business) demand is derived by multiplying the forecast number of connections by the forecast demand per connection, for each customer segment. Tariff D (industrial) demand was completed on an individual customer basis with customers sorted according to size, ANZSIC division and demand pattern (e.g. macroeconomic influence and/or weather-induced demand).

Further detail of approach is set out below for residential, small business and industrial tariff classes.

[5] NGFR now delivered as part of the GSOO publication. Refer to Gas Demand Forecasting Methodology Information Paper, March 2019

2.1. Weather Normalised Demand

Gas demand is materially influenced by weather, particularly in the residential sector. Accordingly, the weather impact on historical residential and commercial demand was normalised to provide an appropriate basis for demand forecasting. CORE adopted a weather normalisation methodology based on AEMO's forecasting guidelines[6], which favours the application of Effective Degree Days ("**EDD**"). In comparing the methods of Heating Degree Days ("**HDD**") and EDD, EDD accounts for additional climatic factors such as:

- Sunshine hours;
- Wind chill; and
- Seasonality.

The coefficient of determination calculated by CORE also showed that EDD has a stronger relationship with gas demand than HDD. In addition, the Akaike Information Criterion ("**AIC**") supports the use of EDD instead of HDD as an index of weather fluctuations. For these reasons, CORE used EDD as a superior approach to weather normalisation.

2.1.1. EDD Index

The weather index selected for weather normalisation was based on AEMO's EDD_{312} methodology which has been approved by the AER in a number of previous gas access arrangements ("**AA**"). AEMO has endorsed the EDD_{312} as a more rigorous approach than EDD_{129} or HDD indices. The calculation method and resulting parameters are outlined below:

EDD Calculation:

1. Develop an EDD Index Model that calculates the EDD Index coefficients – this model is included as a supporting document to this report.
2. Derive EDD Index coefficients by regressing daily gas demand on climate data, ranging from 2009 to 2018. The start date of the regression was based on the availability of reliable daily gas demand data which spanned 10 years- deemed appropriate by CORE. Historical climate data for the Sydney Airport weather station was obtained from the Bureau of Meteorology (temperature, wind speed, sunshine hours).[7] It should be noted that in instances where data was unavailable, CORE has interpolated to estimate a data point. The average daily temperature and wind speed data was estimated using the average of 8x3-hourly data between 3.00a.m. and 12.00a.m. Dummy variables for certain days of the week (Friday, Saturday and Sunday) were also included in the regression to capture the additional gas demand that occurs on Sundays and the reduced demand that occurs on Fridays and Saturdays.[8]
3. Calculate EDD by using the weather normalised demand model and derived EDD index coefficients. The weather normalisation model is included as a supporting document to this report.

[6] AEMO, *2012 Weather Standards for Gas Forecasting.*

[7] Weather Station 066037. CORE notes that the JGN includes customers located some distance from Sydney. However, the majority of customers are located in the Greater Sydney area hence the weather observations for Sydney Metro are appropriate, as has been approved by the AER previously. CORE notes that the AER has accepted this approach in Vic and SA for networks that also have significant latitude ranges and customers located at different altitudes.

[8] Main difference in activity includes business opening hours and the number of hours residents spend at home cooking and using space heaters.

Below are the model structure and coefficients of CORE's EDD_{312} Index:

Daily demand per connection = $b_0 + b_1$*EDD + b_2*Friday + b_3*Saturday +b_4*Sunday.

EDD =	Degree Day ("**DD312**")	temperature effect
	+ **0.0106** * DD312*average wind speed	wind chill factor
	- 0.05 * sunshine hours	warming effect of sunshine
	+ max(**3.98***2* Cos $\left(\frac{2\pi(\text{day}-190)}{365}\right)$)	seasonality factor

Where DD_{312} is the degree day as calculated by the following table:

DD_{312} =	$T_2 - T_1$ if $T_1 < T_2$	Daily temperature above threshold temperature
	0 if $T_1 > T_2$	Daily temperature below threshold temperature

- T_1 is the average of 8 three-hourly temperature readings (in degrees Celsius) from 3.00am to 12.00am from the Bureau of Meteorology's Sydney Airport Weather Station- deemed by CORE to be an appropriate weather station for the JGN.
- T_2 is equal to 20.96 degrees Celsius and represents the estimated threshold temperature for gas heating within the JGN.
- Average wind speed is the average of the 8 three-hourly wind observations (measured in knots) from 3.00am to 12.00am measured at the Sydney Airport Weather Station.
- Sunshine hours are the number of hours of sunshine above a standard intensity as measured at the Weather Bureau's Sydney Airport Weather Station.[9]
- The seasonality factor models variability in consumer response to different weather. It indicates that residential and commercial consumers more readily turn on, adjust heaters higher or leave heaters on longer in winter than in the shoulder seasons given the same weather or change in weather conditions. For example, central heaters are often programmed once cold weather sets in resulting in more regular use and consumers are potentially in the habit of using heating appliances once the middle of winter is reached. This change in consumer behaviour is captured in the Cosine term in the EDD formula, which implies that for the same weather conditions heating demand is higher in winter than in the shoulder seasons or in summer.[10]

[9] CORE has set this coefficient to 0.05 as this provided a higher R squared result than a coefficient of 0 which was the coefficient achieved using the Excel Solver add-in. Given the higher predictive power and greater consistency with historical precedent (e.g. prior AA), the decision was made to use 0.05 rather than defer to the 0 coefficient which was likely being achieved due to an upper limit of iterations imposed by Solver. The same process was applied to other variables but this did not lead to a superior statistical result.

[10] As described in; AEMO, *Victorian EDD Weather Standards – EDD312 (2012)*

2.1.2. Weather Normalised Demand Model

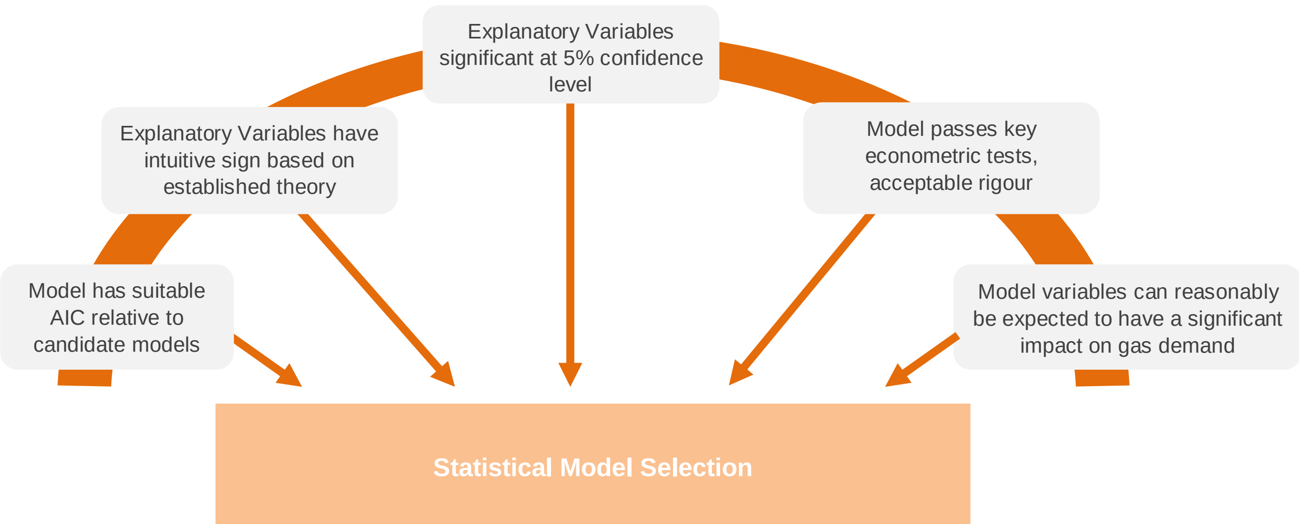
The EDD_{312} Weather Index was then used for regression analysis on JGN residential and small business demand data.

1. Residential and small business data was regressed separately on historical EDD data, on a monthly basis
2. The optimum statistical relationship between customer gas demand and weather fluctuations was obtained
3. The regressions were performed with the two main data sets:
   - Monthly sum of EDDs (calculated from the daily EDD series obtained from the first stage)
   - Monthly sum of gas demand (JGN demand data)

A variety of model specifications and model terms were tested for their predictive power and statistical rigour, including:

- Lagged values of the gas demand data
- Logarithmic and differencing transformations of the weather/demand data
- Variables that capture the impact from events specific to one part of the data series (dummy variables)

Please see Appendix A1 for a full summary of the regression model output and statistical test results. The statistical models selected for the forecast of residential and commercial demand satisfied the following criteria:



CORE considers this process to be compliant with s 74(2) of the NGR. Forecasts are constructed on a reasonable basis whilst representing the best forecasts possible in the circumstances.

2.2. Weather Normalisation | Tariff D

In addition to the residential and commercial tariff groups detailed in the previous section, CORE adopted the same methodology to weather normalise particular sectors within the industrial tariff group. After segregating these customer groups into their respective ANZSIC code sectors, it was clear that certain sectors exhibit strong weather-induced patterns whereas others do not. For instance, the following charts compare the monthly sum of demand for manufacturing customers and industrial customers within the Health Care & Social Assistance sector. For manufacturers there are fluctuations around December and January which are typically driven by maintenance periods and reduced operations during the festive season. In comparison, the Health & Social Assistance sector comprises large medical facilities and residential premises which exhibit a strong winter peak. For this sector, weather-induced heating load is a key determinant.

Figure 2.1. Seasonal Demand Pattern | Manufacturing Sector Average Monthly ACQ

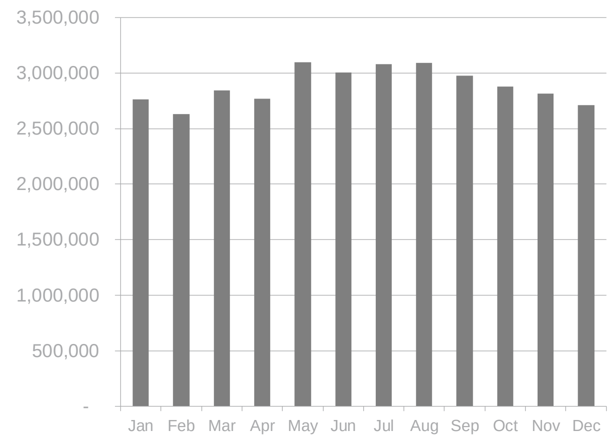
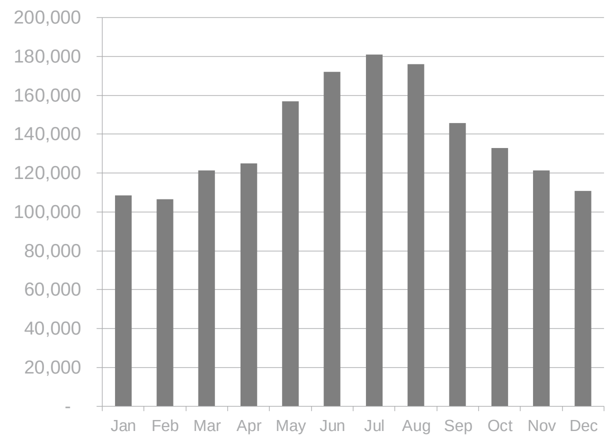


Figure 2.2. Seasonal Demand Pattern | Health Care & Social Assistance Sector Average Monthly ACQ



CORE then weather normalised the following industrial customer groups:

- Transport, Postal and Warehousing
- Financial and Insurance Services
- Health Care & Social Assistance
- Information Media and Telecommunications
- Public Administration and Safety

The remaining sectors were forecast using GVA[11], GSP[12] and other regression analysis (refer Appendix A4 for additional details):

[11] Gross Value Add refers to the economic output of an economic sector
[12] Gross State Product refers to the economic output of a State/Territory

- Agriculture, Forestry & Fishing
- Arts and Recreation Services
- Education and Training
- Mining
- Manufacturing
- Electricity, Gas, Water and Waste Services
- Professional, Scientific and Technical Services
- Construction
- Wholesale Trade
- Retail Trade
- Accomodation and Food Services

Statistical model types, regression post-estimation and overall methodology was consistent with the previous description for Tariff V above. Please refer to Appendix A1 and A4 for a full description of weather normalisation regression analysis and results.

CORE notes that the approach is consistent with AEMO’s GSOO 2018 methodology whereby GVA is used to project annual volume and large customers are individually analysed, separate to the trends applied to the pool of smaller industrials. CORE notes also that the same econometric model (natural logarithmic transformation) was used by AEMO to derive the relationship between ACQ and sector output.[13]

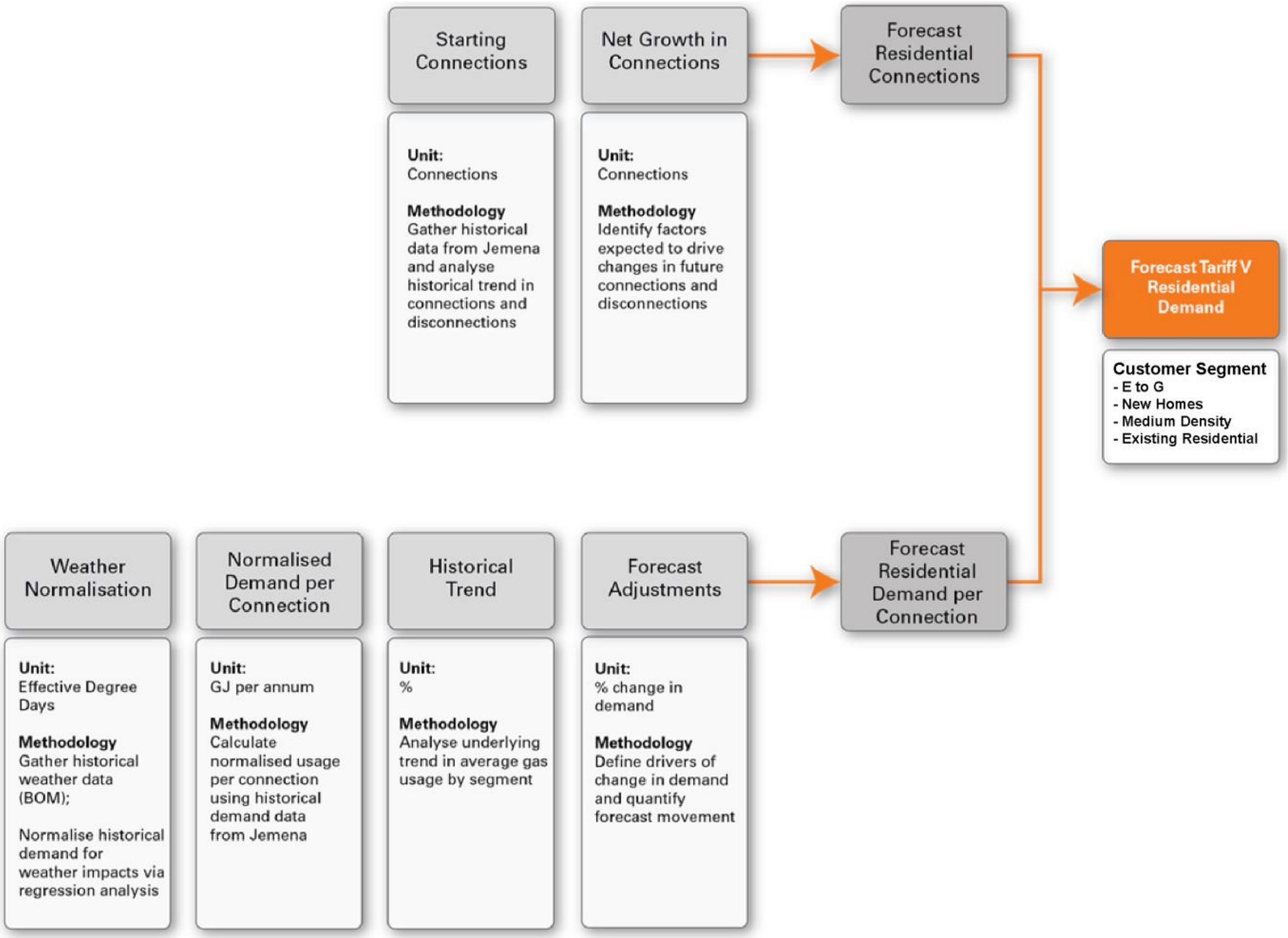
2.3. Tariff V Demand Methodology

2.3.1. Residential | Tariff V

Figure 2.2 provides a diagrammatic representation of the approach used by CORE to derive a forecast of Tariff V Residential demand, including a forecast of connections and demand per connection.

[13] Gas Demand Forecasting Methodology Information Paper, March 2019

Figure 2.3. Tariff V Residential Demand Forecast Methodology



Source: CORE.

2.3.1.2. Connections

This section details the approach undertaken to derive residential connections. Due to the different types of dwellings, CORE reconciles bottom-up and top-down approaches based on the connection type (e.g. single home, medium-density, high-rise). Separate analysis is also undertaken for the pool of existing connections versus a forecast of new connections. The integration of third-party forecasts is inherent to this approach and provides a natural source of validation.

- The bottom-up approach analyses historical trends and major factors which influence gas connections; and
- The top-down approach surveys the relevant forecasts completed by qualified third parties. The specific focus here is on dwelling completions within the distribution network.

Generally, each dwelling type exhibits its own growth cycle. By including a bottom-up approach, the total connections forecast will likely be more accurate. This is consistent with other views within the industry such as AEMO who noted that underlying causes of growth cannot be ascertained when distribution businesses report aggregated customer numbers - the full picture of growth only becomes apparent when each dwelling type is separated.[14] CORE agrees

[14] AEMO, *Forecasting Methodology Information Paper*, December 2014.

with AEMO's views in regard to the distinct growth factors for different dwelling types. The method specific to each dwelling type is outlined as follows:

Existing Connections

- Residential connection numbers for 2009 to 2018 were compiled by CORE based on data provided by JGN- including disconnections, net and gross/new connections.
- The closing 2018 connections are defined as existing connections in the forecast. This forms a basis to derive a forecast for the period 2021 to 2025. The forecast of existing connections for a given year is derived by removing the predicted disconnections in the previous year from the opening number of connections in the previous year. Forecast disconnections are based on the historical average of disconnections as a percentage of the year-opening number of connections.
- There are meters on the JGN network for which there is no associated demand. This situation may occur if a property is vacant or if supply has been cut off as a result of non-payment. A significant removal program has been disclosed to CORE in addition to a network policy that will remove future zero-consuming meters ("ZCMs") once a certain period of non-consumption is observed. An adjustment has been made to the forecast to capture this impact.

New Connections

CORE has derived an estimate of new dwelling connections in the 2021 to 2025 period via a four-step process:

1. Estimate new dwellings in NSW
   - CORE has undertaken an extensive literature search and statistical analysis as a basis for projected dwelling completions. Additionally, CORE has incorporated an independent third-party dwelling forecast published by This historical and forecast series indicates that the recent substantial new dwellings growth in NSW has been underpinned by MDHR growth and this is expected to reduce back to ~2014/15 levels by 2020.
   - The key results of this forecast are that total new dwellings growth is expected to slow and single homes are expected to regain some of the share of total dwelling completions which was lost during the recent high levels of MDHR activity.
2. Estimate the number of dwellings within JGN area that will be connected to the gas network
   - CORE has undertaken analysis of the historical JGN network penetration rate. The 5-year average and 10-year average are the same and this rate is reflected throughout the projection period.
3. Determine the apportionment of network connected dwellings in the JGN area that are single, medium density and high-rise dwellings
   - CORE has undertaken analysis of the historical average increase of each connection type and then applied HIA dwelling type projections to arrive at a new dwelling forecast by connection type. As noted above, MD/HR is the fastest growing source of new dwellings, but single homes are forecast to regain some of the share lost in the last 2-3 years.
4. Jemena has disclosed to CORE that corporate policy phased in over the next years will mean that the majority of new high-rise dwellings will be connected via a single boundary meter and that individual hot water meters will not be offered. To account for this, CORE has forecast total new HR dwellings first, and then made an apportionment between individual and boundary metered dwellings. Given that ~88 dwellings will generally sit behind one boundary meter, this is acting to reduce the total residential connections number whereas the total number of connected dwellings is a more stable series.

2.3.1.3. Demand per Connection

CORE has undertaken a qualitative assessment of the alternative methodologies which can reasonably be used to derive a forecast of Demand per Connection for the Residential segment of the JGN. CORE has determined that an approach which analyses the Historical Trend and adjusts for the impact of each material factor which is reasonably expected to influence Demand per Connection (with appropriate rigour and data quality), to be the best available approach under the AA circumstances. Further, CORE is of the opinion that such analysis must be set out in a transparent fashion using a model which clearly sets out assumptions/ inputs, calculations and results, in a manner which facilitates efficient scenario and sensitivity analysis.

Therefore, the steps taken to arrive at forecast demand per connection are as follows:

1. Develop models for calculation of EDD, normalised demand and forecast of Demand per Connection (these have been provided to Jemena).
2. Normalise total demand per annum for the effects of weather using the methodology discussed in Section 1| 3.
3. Divide total historical demand by number of connections to determine average demand per connection. This includes an assessment of the relative demand per connection exhibited by different connection types (new versus existing; new home versus E2G, medium-density and high-rise)
4. Determine the Historical Trends in demand per connection, by connection type
5. Derive Adjusted Forecast of demand per connection having regard to the Historical Trend and the influence of factors which are not present in the Historical Trend.

Section 1| 3 presents a detailed description of this process.

2.3.1.4. Forecast Demand

The product of forecast residential connections and forecast demand per residential connection is total forecast demand for the Tariff V residential segment. CORE notes that its approach is consistent with the Tariff V forecasting methodology relied upon by the market operator AEMO. AEMO also use dwelling completion forecasts to project new connections and has also reverted to a historical average connections trend for non-residential connections (just as CORE did after reviewing the historical volatility in the gross new connections series and relationship with historical GSP). AEMO's trend in demand per connection is primarily driven by a weather normalised trend (same EDD_{312} methodology as CORE) and price responses. However, CORE notes that an ex-post adjustment was then made to account for energy/appliance trends and climate change. CORE has reviewed available data sets and believes historical trends captured in the weather normalised demand per connection series, capture the anticipated and continuing impact of these drivers in the AA period (noting that AEMO has to account for appliance and climate changes to 2040, a far longer time horizon and sufficient time for larger scale technology switch-out).[15]

CORE also considers there to be downside risk to Tariff V gas demand due to the potential introduction of new renewable energy schemes. At the time of writing there is considerable political uncertainty, the resolution of which could lead to different energy policies and emissions targets (and policy mechanisms to achieve those targets). This uncertainty prohibits robust quantitative adjustments to the demand forecast but CORE believes there is more significant downside risk to demand per connection than upside risk.

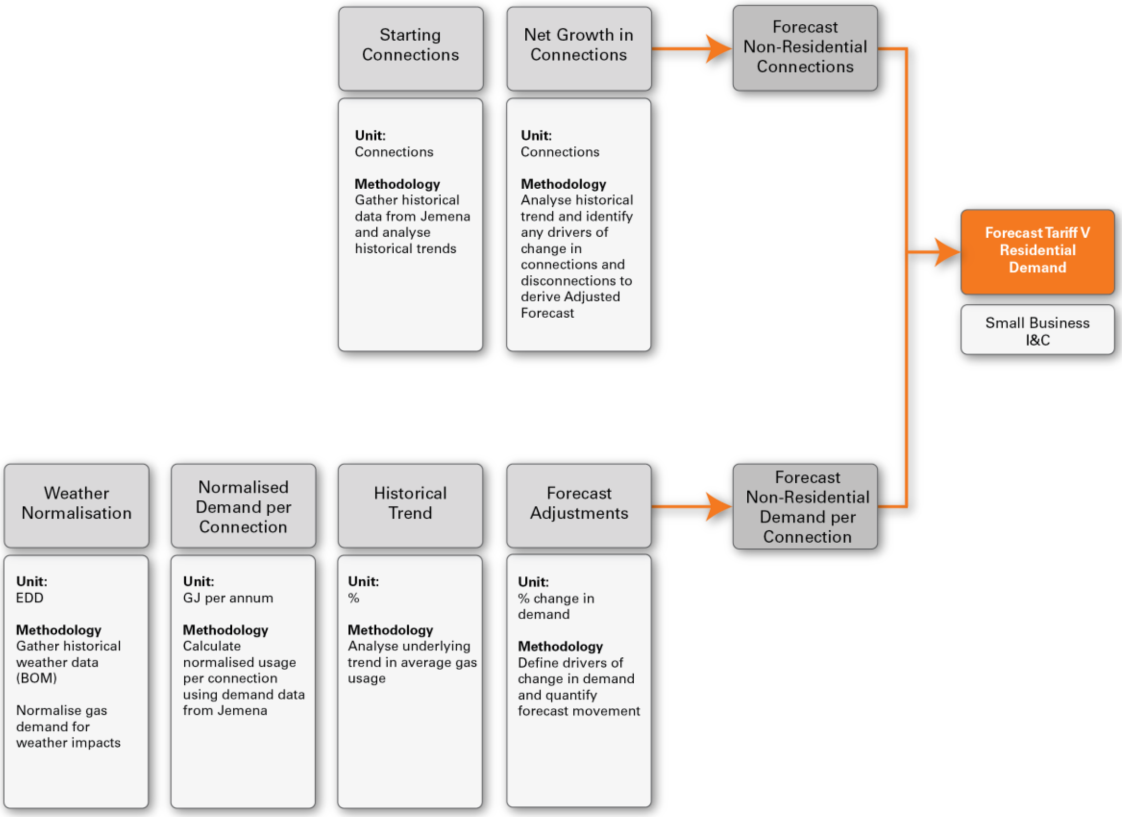
[15] Gas Demand Forecasting Methodology Information Paper, March 2019

2.3.2. Tariff V Small Business Demand

This section provides a summary of the methodology used to derive a forecast for Small Business elements of Tariff V.

Figure 2.3 provides an outline of the Methodology and explanations of key elements of the approach are provided below.

Figure 2.4. Tariff V Non-residential Methodology.



2.3.2.2. Connections

The following steps were taken to derive a forecast for total commercial connections.

1. Collate connections data from the 2009 to 2018 period based on inputs provided by JGN.
2. Initially, statistical analysis was undertaken to assess the relationship between historical GSP, other potential macroeconomic factors, and growth in commercial connections.
3. Upon review of volatility in the historical data and uncertainty as to the commercial response to projected wholesale gas price increases, the connections forecast then reverted to a historical annual average gross new/ disconnections series.
4. Apply the connections forecast growth rates to closing commercial connection numbers in 2018 to derive a forecast of total commercial connections between 2021 and 2025.
5. These steps were carried out before total connections were then disaggregated into existing connections and new connections. Existing connections are derived by taking the number of connections in 2018 and adjusting for the forecast in annual disconnections to 2025. The disconnections forecast is calculated using the average historical proportion of disconnections as a percentage of opening connections for a given year. The new connections forecast is derived by adding the disconnections forecast to the total net connections forecast.

The specific assumptions used for these projections are outlined in Section 1| 3 and Section 2.

2.3.2.3. Demand per Connection

CORE has undertaken a qualitative assessment of the alternative methodologies which can reasonably be used to derive a forecast of Demand per Connection for the Non-residential segment of the JGN. CORE has determined that the preferred approach would be to analyse specific factors of relevance to specific customers or customer groups/ clusters. However, the lack of transparency of information relating to specific customers makes such an approach impractical. CORE is of the opinion that the next best alternative under the AA circumstances is an approach which analyses the Historical Trend and adjusts for the impact of material factors which are reasonably expected to influence Demand per Connection across industry sectors (with appropriate rigour and data quality). Further, CORE is of the opinion that such analysis must be set out in a transparent fashion using a model which clearly sets our assumptions/ inputs, calculations and results, in a manner which facilitates efficient scenario and sensitivity analysis and general scrutiny by Jemena and the AER.

Therefore, the following steps have been taken to derive a forecast of demand per connection:

1. Develop model logic to accommodate Non-residential demand per connection forecasting;
2. Normalise historical actual demand for the effects of weather using the methodology discussed above;
3. Divide historical annual demand by actual annual connections to determine average demand per connection;
4. Determine the Historical Trend in demand per connection across new connections and existing connections;
5. Analyse all factors such as GSP and macroeconomic structural trends which are reasonably expected to influence future connections; define net impact of each factor; and
6. Derive Adjusted Forecasts of demand per connection by adjusting for any factors which are not present in the Historical Trend.

The specific assumptions and analysis used to derive these projections are outlined in Section 1| 3.

2.3.2.4. Forecast Total Demand

The product of forecast connections and forecast demand per connection is Total Forecast Demand for the Tariff V Small Business segment.

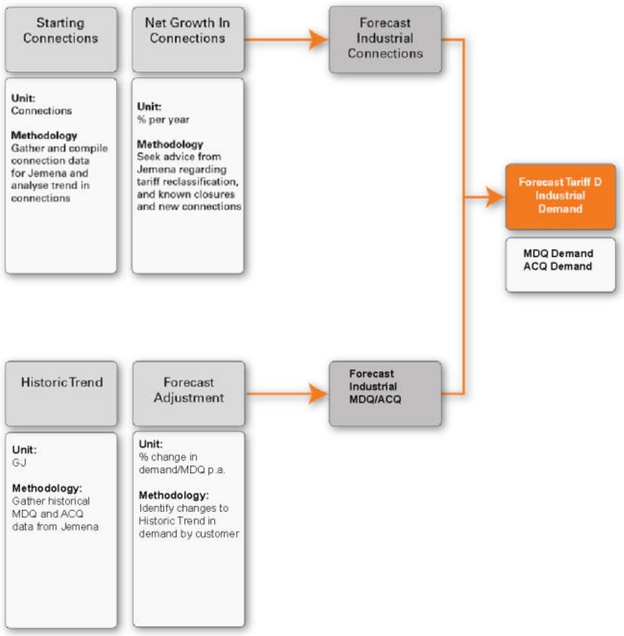
2.4. Tariff D Demand Methodology

This section provides a summary of the methodology used to derive at a forecast for Tariff D demand.

It is important to note that in 2011 Jemena moved from an MDQ-based charge to a CD-based system; CORE's forecast of Tariff D demand considered the total annual quantity of demand (ACQ), the maximum daily demand (MDQ- both the highest day and the 9th highest day) and the total number of connections.

The following figure provides an outline of the Methodology and explanations of key elements of the approach are provided below.

Figure 2.5. Tariff D Industrial Methodology



Source: CORE.

2.4.2. Annual Quantity

The methodology adopted to arrive at forecast annual quantity at the customer level was as follows:

- Review list of Tariff D customers and allocate to industry sectors;
- Identify individual customers and industry sectors which have potential to experience material change in demand (via public domain evidence and any movements disclosed to JGN via regular ongoing correspondence and individual customer engagements with larger customers);
- Adjust for any known closures, new connections, tariff reallocation and expected material load changes; and
- Adjust demand for remaining customers via analysis of the output of industry segments.

2.4.2.1. Connections

As the methodology used does not rely upon use of any form of average demand per customer, the connection or customer number statistic for Tariff D is deemed, by CORE, to be somewhat immaterial. However, a minor adjustment is made to account for the historical net connections trend and the associated loss of load. CORE has therefore assumed that connection numbers follow historical trend throughout the period, while allowing for:

- known closures;
- known new connections including a large group of overconsuming Tariff V customers who have been identified by JGN for reallocation; and
- customers reasonably expected to switch between Tariff D and Tariff V over the review period.

2.4.2.2. MDQ

To derive the Adjusted Forecast CORE has considered the following:

- Information provided by Jemena regarding known Tariff D customer business closures and tariff reclassifications.[16]
- CORE forecast of additional underlying movements in demand relative to forecast ACQ movements.
- Historical relationship between the highest day and the 9th highest day (in order to derive a forecast of the 9th highest MDQ which informs JGN's calculation of CD).

2.4.3. Model Outputs

CORE has provided Jemena with the Excel-based models and all underlying data that has been used to project Tariff D gas demand and connections.

2.5. Limitations of Forecast Methodology

While CORE believes that the adopted methodology (outlined throughout Section 1 | 2 above) gives rise to the best forecasts possible in the circumstances, there are some limitations which have the potential to bias the demand forecasts. These include:

- **Non-linearities in demand** – CORE's trend analysis of a number of key demand drivers rely on the assumption that the relationship with demand is linear in nature. For example, the own price elasticity effect on demand assumes a linear relationship between gas prices and gas usage, when in reality there may be some price thresholds where a larger demand response is observed (e.g. more severe declines in demand as gas prices move beyond a certain level). The analysis required to address these non-linearities is deemed to be overly complex and have not been undertaken. Nevertheless, CORE is of the opinion that the projections resulting from its current methodology to be the best estimate possible under reasonable circumstances.
- **Degrees of Freedom** – CORE's historical trend analyses of annual data generally use 10-12 years of data points, meaning that the resulting regression equations contain around 10 degrees of freedom when using linear trends. As this is fewer than the widely accepted range of 15-20 degrees of freedom the coefficients may not fully converge with their true population values and some forecasting error may be present.

[16] Several closures and expansions were readily discernible from information disclosed in the public domain or disclosed to JGN via the standard interactions it has with its industrial customer base.

Nevertheless, CORE is of the opinion that a ten year period of historical data is adequate (given the generally fast rate of change in energy markets and associated technology observed over time) and that the projections resulting from its current methodology are the best estimates possible under reasonable circumstances.

In the case of CORE’s EDD and Weather Normalisation models, thousands of daily data points are used in generating a daily EDD series, contributing to a monthly normalised demand. The degrees of freedom in these models are deemed to be adequate.

Section 1 | 3. Weather Normalisation Process

3.1. Introduction

CORE's analysis of historical demand was based on normalised data to remove fluctuations caused by weather factors. This section summarises the results of the weather normalisation process. CORE's proprietary Excel-based models were used to calculate EDD index coefficients to weather normalise demand. For greater detail, the EDD index model and weather normalised demand model should be read in conjunction with this report. These models have been submitted to JGN and form a confidential attachment to JGN's Access Arrangement Information.

3.2. EDD Index

Historical demand data was normalised to remove the impact of weather on demand and demand per connection for each of the residential and small business customer groups respectively. The EDD Index presented in the following figure and table was used to normalise both the residential and small business groups as daily demand data was only available as a combined series (as is typical for Australian gas distribution networks). The long-term trend of EDD is compared to the fluctuations in weather in the following figure. Actual EDD in 2016 and 2017 is lower than the EDD trend, which implies that weather in this year was warmer than normal. The warmer weather induces lower demand per connection, as less gas is required for heating. The opposite is shown from 2011 to 2013, when EDD was higher than the trend. Colder weather between 2011 and 2013 required more heating- hence actual demand per connection was higher.

Figure 3.1. EDD Index

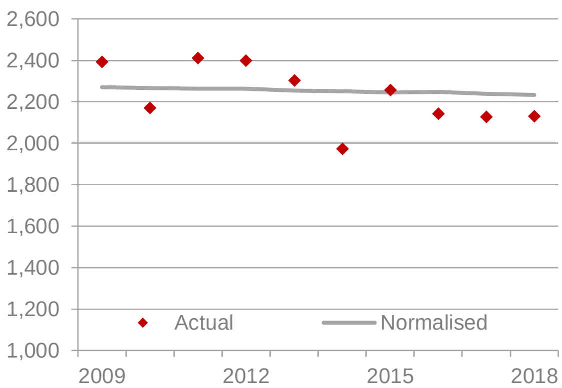


Table 3.1. EDD Index

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Normalised EDD	2,270	2,266	2,262	2,264	2,254	2,249	2,245	2,247	2,237	2,233
Actual EDD	2,393	2,170	2,412	2,399	2,302	1,972	2,256	2,143	2,128	2,131
Difference	123	(96)	150	136	48	(277)	11	(104)	(109)	(102)

3.3. JGN Weather Normalised Demand Results | Tariff V

For the residential customer group, historical normalised demand per connection exhibits a steady 0.87% declining trend, whereas total volume has increased at a rate of 1.98%, driven by strong growth in connections. Normalised small business demand has experienced steady growth of 1.28% on average despite a steady -0.41% decline in volume per connections. Connections growth has more than offset this volume per connection decline. Please note that Appendix A1 provides an overview of statistical techniques and analysis used to derive the normalised values shown below.

Figure 3.2. Residential Demand per Connection | GJ

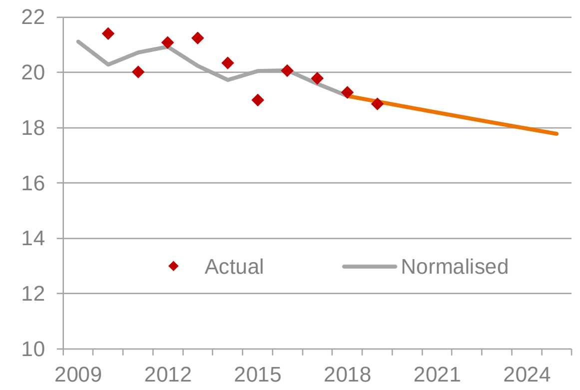


Figure 3.3. Residential Demand | GJ

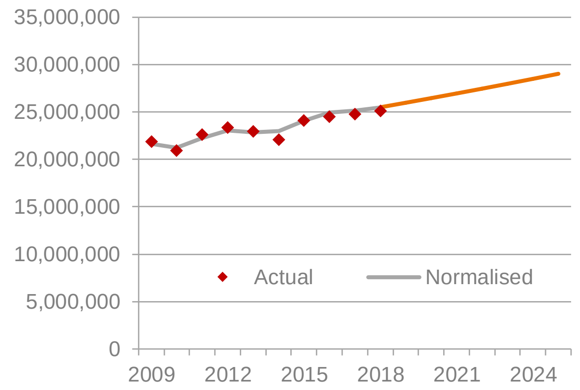


Figure 3.4. Small Business Demand per Connection | GJ

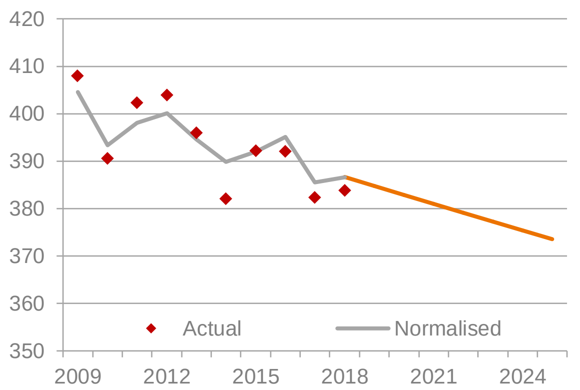
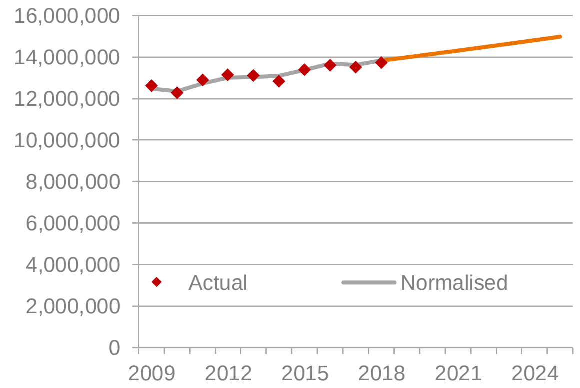


Figure 3.5. Small Business Demand | GJ



The charts above show the trajectory of demand and demand per connection once weather- induced demand is removed. CORE notes that 2016 was a slightly unusual demand pattern for the small business group as demand per connection increased despite a fall in demand. After consultation with Jemena and review of historical data, CORE is confident that this was likely due to a group of large consuming customers that are/were in the process of being reallocated to the industrial tariff. In the subsequent years (2017, 2018) demand per connection returned to a level closer to historical trend.

Table 3.2. Normalised Residential Demand per Connection/Demand | GJ

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Normalised Demand	21,637,879	21,236,964	22,243,130	23,036,663	22,879,226	22,972,773	24,096,245	24,921,171	25,178,236	25,507,261
Actual Demand	21,946,959	20,970,182	22,643,235	23,408,624	23,006,111	22,134,027	24,108,808	24,567,597	24,797,288	25,144,448
Difference	309,080	(266,782)	400,106	371,961	126,885	(838,746)	12,563	(353,574)	(380,948)	(362,813)
Normalised D/C	21.12	20.28	20.72	20.93	20.25	19.74	20.06	20.09	19.59	19.16
Actual D/C	21.42	20.03	21.09	21.27	20.36	19.01	20.07	19.80	19.29	18.88
Difference	.3	(.3)	.4	.3	.1	(.7)	.0	(.3)	(.3)	(.3)

Table 3.3. Normalised Small Business Demand per Connection/Demand | GJ

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Normalised Demand	12,486,926	12,350,442	12,737,012	13,021,802	13,049,655	13,095,855	13,363,759	13,695,924	13,612,732	13,828,452
Actual Demand	12,591,046	12,261,749	12,869,140	13,144,538	13,091,783	12,829,299	13,370,470	13,589,634	13,499,580	13,725,744
Difference	104,120	(88,693)	132,128	122,736	42,128	(266,556)	6,711	(106,290)	(113,151)	(102,709)
Normalised D/C	405	393	398	400	395	390	392	395	385	387
Actual D/C	408	391	402	404	396	382	392	392	382	384
Difference	3.4	(2.8)	4.1	3.8	1.3	(7.9)	.2	(3.1)	(3.2)	(2.9)

3.4. Tariff D - Weather Normalisation of Select Sectors

As discussed in the methodology section, industrial customer sectors that exhibited weather-induced demand patterns were weather normalised using the same EDD_{312} Index. Regression analysis was performed using historical demand data from 63 customers that existed in the network for the entire historical period (thus removing bias from customers joining or leaving partway through). Results are presented thereafter and show an annual average decrease of 0.57% in ACQ between 2009 and 2018. The moderate decline rate suggests that these sectors are experiencing similar efficiency and appliance trends to non-residential Volume Tariff customers.

- Transport, Postal and Warehousing (6 customers)
- Information Media and Telecommunications (1 customer)
- Financial and Insurance Services (only new or disconnected customers but demand pattern deemed to be weather-induced).
- Health Care and Social Assistance (40 customers)
- Public Administration and Safety (16 customers)

Figure 3.6. Tariff D Weather Group- Demand per Connection | GJ

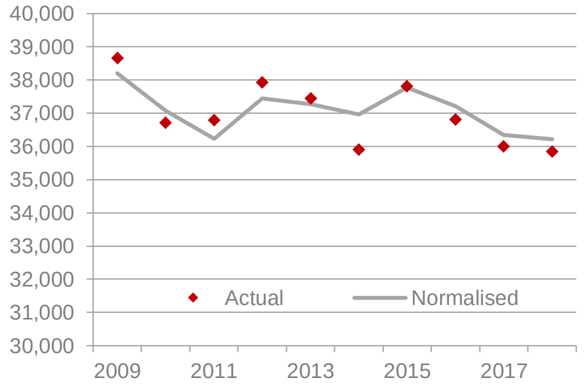


Table 3.4. Normalised Industrial Weather Group Demand per Connection/Demand | GJ

Year	2011	2012	2013	2014	2015	2016	2017	2018
Normalised Demand	2,406,693	2,336,477	2,282,861	2,358,775	2,348,664	2,328,169	2,379,711	2,343,873
Actual Demand	2,435,454	2,312,295	2,318,178	2,389,024	2,359,576	2,262,272	2,382,499	2,319,405
Difference	28,761	(24,182)	35,317	30,249	10,911	(65,897)	2,789	(24,467)

Section 1 | 4. Residential Demand Forecast

4.1. Introduction

This section of the report details the Residential demand forecast in the JGN.

Total demand is derived using a bottom-up approach: the product of individual forecasts of connections and demand per connection. CORE takes into consideration historical trends as well as expectations of future drivers of demand not present in the historic data.

The demand data and forecasts presented in this section have undergone the weather normalisation process.

4.2. Residential Demand Forecast Summary

In the JGN, total Residential demand is forecast to increase from 26,585,541 GJ in 2021 to 27,550,788 GJ in 2025, equivalent to an average annual increase of 0.90% over the Review Period. The forecast shows a continuance of a trend increase in residential gas demand evident in the historic gas demand data. The major factors driving the trend in projected gas demand include:

- Continued connections growth albeit at a moderately reduced rate- a correction in NSW dwelling completions is expected after historic growth prevailed from 2013.
- An increasing preference for medium density and high-density dwelling types, such as multi-unit apartments. These dwellings typically exhibit lower energy demand due to smaller floor space and lower number of average residents per dwelling.
- Improvements in the energy efficiency of buildings and appliances
- An increasing preference for electric appliances and other energy sources instead of gas appliances- particularly in MD/HR dwellings where there is a higher incidence of gas used only for water heating. Frequently, gas space heating and cooking is not supported by large apartment building designs.

The following table presents historical data and forecasts for Residential demand:

Table 4.1. Residential Demand Forecast | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		25,903,068	25,392,177	25,182,704	24,976,823	24,741,749	24,513,660	24,280,222
New Dwelling | Home		116,187	456,381	795,918	1,087,159	1,353,040	1,610,452	1,870,867
New Dwelling | E2G		20,216	80,041	144,262	206,064	265,210	322,029	376,443
New Dwelling | HRVB		18,619	78,164	150,225	220,191	283,977	346,782	411,060
New Dwelling | MD		11,200	44,560	79,040	109,146	136,401	163,143	190,206
New Dwelling | HRVI		39,532	147,943	233,393	287,097	332,167	376,570	421,989
Total Demand	**25,507,290**	**26,108,822**	**26,199,266**	**26,585,541**	**26,886,480**	**27,112,545**	**27,332,636**	**27,550,788**

The annual forecasts presented are the product of forecast connections and forecast demand per connection. These elements are addressed below.

4.3. Residential Connections Forecast

JGN Residential connections are forecast to increase from 1,419,534 in 2021 to 1,503,736 in 2025 during the Review Period, at a rate of 1.45% p.a. The growth rate of Residential connections in the Review Period is slower than the historical period, due to a lower level of forecast new dwellings in the NSW economy and a commercial policy favouring VB connections whereby multiple high-density dwellings exist under a single connection.

- According to HIA historical data, NSW dwelling completions were relatively flat between 2009 and 2013 before more than doubling by 2017 before another 7.4% increase in 2018. This was due mainly to substantial growth in medium and high-density dwellings in the Greater Sydney area.
- Dwelling completions growth has now plateaued and HIA forecasts expect a return to levels experienced around 2015 and 2016. Preliminary indications from ABS dwelling commencement and completion data suggests this correction has commenced.
- Medium and high-density dwellings were the primary contributor to the increased completion activity, and it is this dwelling category that is also the main source of the forecast correction. Accordingly, single homes are likely to regain some of their completion share although CORE notes that there is an overall continued preference for medium and high density living in a large city such as Sydney where proximate, unoccupied land is scarce and there is a general preference to develop up rather than out.

Key components and trends that support this forecast are summarised as follows:

- NSW Population Growth that is forecast to fall from 1.58% in 2017 to 1.40% by 2025. CORE has relied on the NSW Treasury for this forecast and notes that the Greater Sydney population growth rates are higher, typically around the ~2.00% rate and likely to fall to ~1.85%
- NSW Dwelling Completions (per HIA forecast)
  - Plateauing around 2022/23 after coming off 30% from an expected peak in 2018.
  - After losing around 15% of completion shares between 2009 and 2019, detached houses are expected to increase their share from 42.9% to 43.3% by 2025.
  - CORE has also reviewed public domain commentary and believes the source of recent completions growth and expected correction is consistent with market consensus. ABS data for dwelling approvals and dwelling commencements are a key lead indicator for dwelling completions and these both suggest that a plateau and subsequent downturn in dwelling completions (particularly for higher density dwellings) has likely commenced.
- JGN Network Penetration
  - The network is expected to capture around 73% of completed dwellings during the AA period- consistent with the 66-82% range over the entire 2009-2018 period. CORE notes 73% is both the 5yr and 10yr average penetration rate.
- This reflects the trend that gas is losing market share in the residential space-heating market, but overall connection numbers are being supported by larger apartment buildings that use centralised hot water systems and hence capture 100% of all dwellings within the development (but without an associated space or cooking load). A recovery in the proportionate share of detached estates will help the penetration rate remain around 73%. Larger heating requirements means these dwelling types will often favour gas over reverse-cycle systems due to superior running costs. Appliance

costs for gas heating are typically higher than electricity but this factor represents a smaller percentage of overall build cost when a dwelling size is large.

Figure 4.1. NSW Dwelling Completions

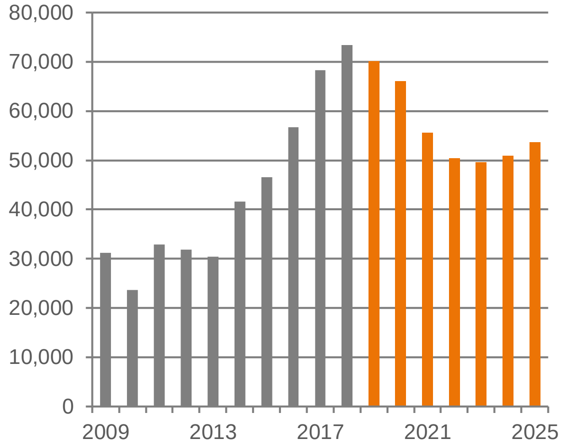


Figure 4.2. Greater Sydney Population Growth | %

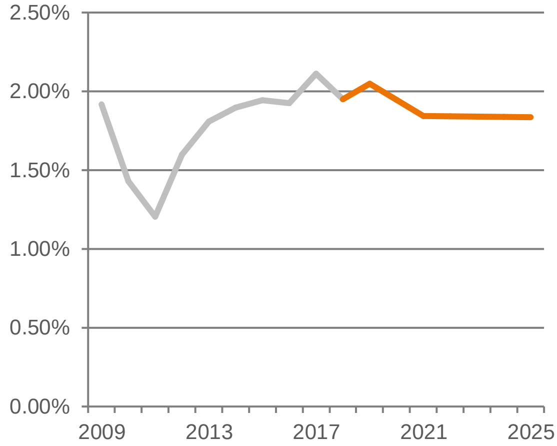
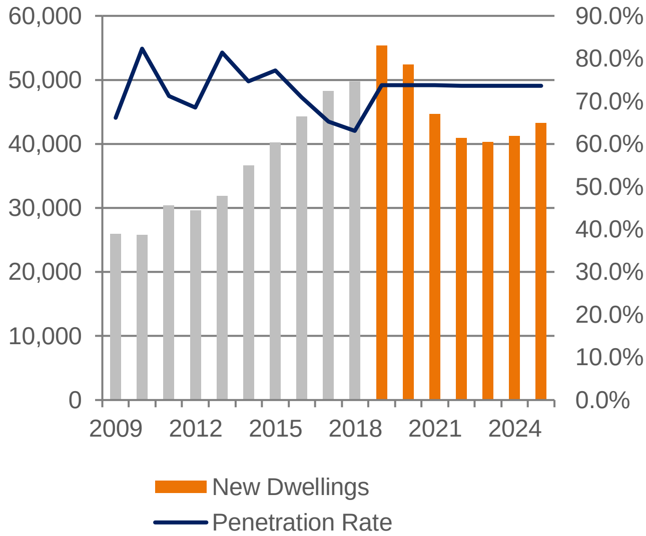


Figure 4.3. New Residential Connections (LHS, No.) versus Penetration Rate of New Dwellings (RHS, %)



The following table presents historical data and forecasts for Residential connections:

Table 4.2. Residential Connection Forecast | No.

	2018	2019	2020	2021	2022	2023	2024	2025
Opening Connections		1,353,889	1,366,847	1,396,854	1,419,534	1,440,478	1,460,831	1,481,644
Disconnections		3,134	2,814	2,457	2,058	2,112	2,164	2,218
		26,861	5,027	5,153	5,253	5,348	5,440	5,535
Existing 2018 Connections		1,323,894	1,316,053	1,308,443	1,301,132	1,293,672	1,286,068	1,278,315
New Dwelling Connections | Residential Home		24,201	22,464	18,935	17,742	17,360	17,805	18,945
New Dwelling Connections | Residential E2G		4,000	4,000	4,000	4,000	4,000	4,000	4,000
New Dwelling Connections | Residential HRVB		142	167	166	145	144	148	155
New Dwelling Connections | Residential MD		3,432	3,293	2,838	2,551	2,530	2,584	2,682
New Dwelling Connections | Residential HRVI		11,178	7,924	4,352	3,818	3,779	3,881	4,063
Total Connections	**1,353,889**	**1,366,847**	**1,396,854**	**1,419,534**	**1,440,478**	**1,460,831**	**1,481,644**	**1,503,736**
Net Connections	**47,184**	**12,958**	**30,007**	**22,681**	**20,944**	**20,353**	**20,813**	**22,092**

4.4. Residential Demand per Connection Forecast

The demand per connection forecast for JGN was derived using the methodology outlined in Section 1. The weighted average demand per connection in the network is expected to decline from 18.7 GJ in 2021 to 18.3 GJ in 2025, at a decline rate of -0.55%.

The following tables and figures outline the forecast of Residential demand per connection. Please note that the new demand per connection is a weighted average of all customers joining from July 2018 and the increase is due to the ramp-up of new customers. Historical data shows that customers typically reach their mature demand volumes during their 2nd full year on the network.

In 2019, the new customer group comprises only brand-new customers ramping up. By 2025, there are several cohorts of mature customers (customers who joined between 2019 and 2023) and 2 years of new-join customers. A breakdown of new mature demand by new customer cohort is provided below along with the weighted average demand per connection. Please be aware that first year customers are forecast to consume 29.3% of their mature demand and second year customers are forecast to consume 90.3% (as per historical average).

Table 4.3. New Customer Demand Forecast by Year, by Cohort | GJ/conn

	2019	2020	2021	2022	2023	2024	2025
New Home | Mature Volume	16.37	16.05	15.91	15.76	15.60	15.45	15.29
New E2G | Mature Volume	17.23	16.73	16.42	16.12	15.80	15.49	15.19
New HRVB | Mature Volume	445.61	440.16	439.73	439.20	438.15	437.20	436.15
New MD | Mature Volume	11.13	10.96	10.92	10.88	10.82	10.76	10.71
New HRVI | Mature Volume	12.06	11.91	11.90	11.89	11.86	11.83	11.81
Weighted Average Demand per Connection	**4.79**	**9.99**	**12.63**	**13.70**	**14.18**	**14.41**	**14.51**

The stock of existing customers is projected to experience a mild increase in 2019 due to the significant ZCM removal program which will remove connections from that customer group without any corresponding loss in volume. There is also a positive own and cross-price elasticity impact expected. The growth of HRVB connections also increases the weighted average of connections as this connection type exhibits consumption of multiple dwellings behind one connection (estimated average 88 dwellings per connection).

Table 4.4. Residential Demand per Connection Forecast | GJ/conn

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		19.57	19.29	19.25	19.20	19.13	19.06	18.99
New Connections | Weighted Average		4.79	9.99	12.63	13.70	14.18	14.41	14.51
Weighted Average Demand per Connection	**18.8**	**19.1**	**18.8**	**18.7**	**18.7**	**18.6**	**18.4**	**18.3**

The forecast and analysis of demand per connection was derived by identifying the following drivers:

- Drivers with historical impact that will perpetuate throughout the Review Period; and
- Drivers with historical impact that will deviate in the Review Period.
- Impact of the removal of zero consuming meters

The significant factors driving the expected reduction in Residential demand per connection are continued gains in energy efficiency, appliance substitution, movements in gas prices and electricity prices. Additionally, the proportion of less gas-intensive dwelling types is increasing across the network and this is also contributing to a lower weighted average demand per connection forecast. These factors are described in further detail below.

4.4.2. Demand per Connection | Drivers with Continued Impact

Historical Annual Average Growth

For Residential demand per connection, the historical average annual growth removes the impact of gas and electricity prices, and weather by adjusting historical demand per connection by the estimated impact of each of these factors. The process of weather normalisation has been discussed in detail in Section 2. This normalised demand per connection was then adjusted for historical price movements by netting off the product of historical price changes and assumed historical price elasticity. However, the impacts of appliance trend, energy efficiency trend, and government policy are still captured by the normalised historical rate. Accordingly, CORE research determined the likely impact of these drivers over the Review Period. There is also considerable overlap with the efficiency, policy and appliance trend analysis that is discussed in the context of small business demand. Ultimately it was determined that the combined impact of each of these factors is best predicted by what was observed during the historical period 2009-2018, captured by the normalised historical average annual growth rate, which is perpetuated in the forecast period with no expected adjustment.

Realistically, building and appliance efficiency data is not comprehensive enough to enable robust, reliable statistical relationships. Instead CORE has assessed the drivers of these factors such as policy, building commencements (as a proportion of existing housing stock) and technology. There is no evidence to suggest that these factors are losing momentum or accelerating so CORE deems it appropriate to incorporate the recent historical impact which has been captured by the weather normalised trend in volume per connection.

Macroeconomic Variables and Residential Demand per Connection

Similar to the small business sector, a comprehensive analysis concluded that the relationship between economic variables and Residential demand is unreliable and not statistically significant. Such factors (such as household income and population growth) can be key drivers of connections but volume per connection does not typically demonstrate a robust statistical relationship. To derive an optimal forecast with maximum precision, the decision was made to exclude any additional economic variables.

4.4.3. Demand per Connection | Drivers with Changing Impact

Own-Price Elasticity

Movements in gas price significantly affect the demand per connection in a given year as well as in subsequent years. Consistent with previous AA submissions, economic literature and statistical tests, CORE forecasting captures the elasticity impact across four lagged periods (measured in years).

The gas price movements that instigate this elasticity impact are derived using CORE's proprietary model. CORE has undertaken gas price forecasting within an AA context for AGN's South Australian distribution network, the previous submission for JGN's New South Wales distribution network and Envestra's (now AGN) Victorian distribution network. CORE has also developed gas price forecasts for each eastern Australian jurisdiction as part of its Gas Networks Sector Study, commissioned by the Energy Networks Association in August 2014. CORE has also been engaged by AEMO to develop gas price forecasts for the NGFR 2015 and provide updated forecasts for the NGFR 2016 and 2018 GSOO (which now incorporates the NGFR).

The approach undertaken by CORE to forecast retail gas prices consists of analysing each individual component of the retail gas price. A full listing and analysis of these components can be found in Appendix A2. The forecast is driven by the following:

- An expected increase in wholesale gas costs in the Review Period, as forecast by AEMO in the 2018 GSOO and consistent with the AER's LNG netback series.
- An expected decrease in distribution costs in the Review Period as per JGN Forecast Tariffs.

The elasticity value used by CORE is a product of extensive third-party analysis via international literature review as well as a review of previous AA price elasticity factors that have been accepted by the ERA (WA) and AER. Accordingly, a long-run elasticity factor of -0.30 has been used for Residential demand.

The following table provides the forecast of own-price impacts on demand per connection. The increasing wholesale prices are more than offset by the anticipated reduction in distribution charge.

Table 4.5. Own Price Elasticity Impact on Residential Demand per Connection| %

Own-Price Elasticity Impact on Demand (%)	2019	2020	2021	2022	2023	2024	2025
Change in Gas Bill	1.32%	-0.99%	-1.72%	-0.35%	0.69%	-0.32%	-0.16%
Own-Price Elasticity Impact (-0.30)	-0.38%	-0.22%	0.11%	0.16%	0.04%	0.06%	0.04%

Further detail on the gas price forecast and price elasticity impact can be found in Sections A2 and A3.

Cross-Price Elasticity

Cross-price elasticity measures the change in demand per gas connection that occurs when the price of electricity, a substitute energy source to gas, changes. There are two components to this effect:

- The propensity of consumers to switch between gas and electricity appliances when faced with a given price movement
- The size of the relative price movements between gas and electricity.

CORE forecasting captures the response of consumers as they face relative price changes between gas and electricity. For example, the model would capture the degree of substitution that occurs between gas heating and heating by RC air-conditioning when there is a shift in relative prices between gas and electricity.

CORE has derived electricity retail price movements in the Review Period from AEMC projected pricing in addition to general public domain review. Further detail on the electricity price forecast and price elasticity impact can be found in Sections A2 and A3.

The following table summarises the cross-price elasticity impact on demand per connection.

Table 4.6. Cross-Price Elasticity Impact on Residential Demand per Connection | %

Cross-Price Elasticity Impact on Demand (%)	2019	2020	2021	2022	2023	2024	2025
Change in Electricity Bill	-6.95%	-7.26%	0.75%	0.00%	0.00%	0.00%	0.00%
Cross-Price Elasticity Impact (0.10)	-0.69%	-0.73%	0.07%	0.00%	0.00%	0.00%	0.00%

4.4.4. Other Forecast Inputs

Certain adjustments were made to the forecast connections or demand per connection on the basis of new business initiatives or macroeconomic factors.

4.4.4.1. High-Rise Connection Type

JGN is undertaking a program to phase out the offering of individually metered high-rise hot water connections ("HRVI") which are large apartment buildings that typically only use gas for centralised hot water. From 2021, new HR gas connections will generally only be offered a boundary connection which is a single meter that covers the entire premises. Please note this phasing out will eliminate individual hot water meters only whereas individual gas meters will still be available. With advice from JGN, the following assumptions have been built into the forecast, aided in part by the 2017 and 2018 relative connection rates and actual number of dwellings per connection seen to date.

The key features are that HRVI connections will not usually be offered from 2021 such that a predicted 77% of new HR dwellings that connect to the network will do so via an HRVB connection. Furthermore, it is estimated that the average HRVB connection will have ~88 dwellings existing behind a single meter by 2025. This is an assumption formed via JGN's analysis of HRVB applications.

HRVB and HRVI Impact	2017	2018	2019	2020	2021	2022	2023	2024	2025
% of HR Dwellings allocated to HRVB	24.2%	40.8%	52.87%	64.9%	77.0%	77.0%	77.0%	77.0%	77.0%
HRVB Dwellings per Connection			88	88	88	88	88	88	88

4.4.4.2. Disconnections

The long-term historical average disconnection rate for the Residential segment has been reviewed by CORE and determined to be an appropriate guide for future disconnections. However, CORE has favoured the stable rate exhibited between 2009 and 2015 of around 0.13-0.15% before a sharp increase in 2016/17. Accordingly, the forecast disconnection rate steps down from the current 0.24% rate down to 0.14%. The sudden increase seen in the last 2 years could have been associated with the substantial increase in new dwellings whereby a housing 'churn' effect was occurring as households demolish and rebuild. CORE notes that the disconnections increase amounts to less than 1000 households and hence could have been caused by a handful of outlier events.

Table 4.7. Residential Disconnections

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Residential Disconnections (Trend)	1,531	1,084	1,558	1,769	2,737	3,039	3,025	3,134	2,814	2,457	2,058	2,112	2,164	2,218
% of Opening Connections	0.14%	0.10%	0.14%	0.15%	0.23%	0.24%	0.23%	0.23%	0.20%	0.17%	0.14%	0.14%	0.14%	0.14%
Residential Disconnections (ZCM)								26,861	5,027	5,153	5,253	5,348	5,440	5,535
% of Opening Connections								1.98%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%

Source: CORE.

Section 1 | 5. Small Business Demand Forecast

5.1. Introduction

This section of the report details the small business demand forecasts for JGN.

As per the residential sector, this forecast was derived using a bottom-up approach, as the product of individual forecasts of connections and demand per connection. CORE takes into consideration historical trends as well as expectations of future drivers of demand not present in the historic data.

The demand data and forecasts presented in this section have undergone the weather normalisation process.

5.1.1. Small Business Demand Forecast Summary

Over the Review Period, small business demand in the JGN is forecast to grow at a rate of 0.38% from 13,091,660 GJ in 2021 to 13,289,424 GJ in 2025. The overall increase is primarily driven by connections growth which more than offsets the relatively moderate decline in demand per connection.

The following tables summarise the different connection types within the forecast.

Table 5.1. Small Business Demand Forecast | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		13,233,170	12,787,753	12,597,869	12,435,803	12,246,826	12,021,853	11,805,916
New Small Business		56,344	251,935	493,791	739,920	987,701	1,234,519	1,483,508
Total Demand	**13,828,468**	**13,289,514**	**13,039,688**	**13,091,660**	**13,175,723**	**13,234,527**	**13,256,373**	**13,289,424**

5.1.2. Small Business Connections Forecast

Over the Review Period, total Small Business connections in the JGN are forecast to grow at a rate of 1.34% from 37,569 in 2021 to 39,360 in 2025.

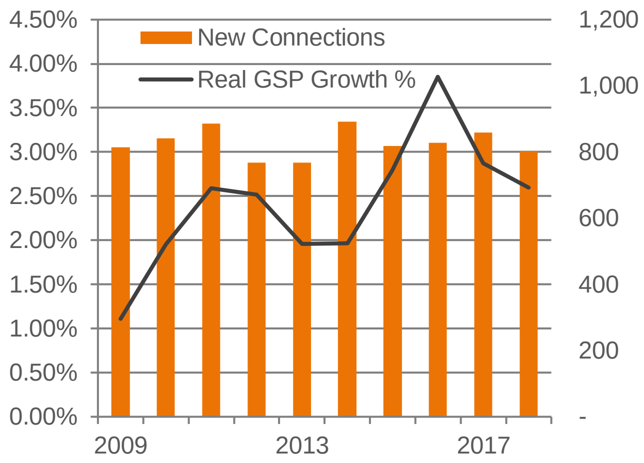
The JGN Small Business total connections are forecast based on the historical average new connections and disconnections. Following a review of historical trends and volatility, and the relationship with GSP, CORE decided to apply a historical average gross new connection rate. The growth rate of Small Business connections in the Review Period is moderately below the average of the entire historical period. This is reflected by a forecast GSP growth that sits slightly below the last 5 years and slightly above the 2009-2013 period. Before reverting to a historical average approach, CORE relied on NSW Treasury's GSP projection to statistically test the relationship between Real GSP and JGN commercial connections.

Key components and trends contained within this forecast are summarised as follows:

- Historical trend
  - Connections growth was relatively stable until 2016. The higher GSP period of 2016-2018 saw an increase in connections growth before the lowest growth seen over the ten years occurred in 2018.

- Reversion to Historical Average Gross New Approach
  - There are additional trends within the connections forecast that CORE was unable to verify due to a lack of data or statistical insignificance. Such trends include penetration rate and GSP composition (by sector, region etc.)
  - CORE has decided to apply historical average gross new connections in the forecast. The final few years of the historical series had a volatile GSP growth and that did not induce a reliable pattern in connections growth. Accordingly, no direct GSP relationship can be reasonably relied upon but CORE notes that the forecast connections growth rates and projected GSP move in the same direction relative to their historical counterparts.

Figure 5.1. Historical GSP Growth (%) and New Small Business Connections (No.)



The following tables summarise Small Business total and net connections forecasts.

Table 5.2. Small Business | Connections Forecast | No.

	2018	2019	2020	2021	2022	2023	2024	2025
Opening Connections		36,022	36,534	37,043	37,569	38,090	38,608	39,121
Disconnections		315	319	302	306	310	314	318
Disconnections | Zero Consuming Connections								
Existing 2018 Connections		35,707	35,387	35,086	34,780	34,470	34,156	33,837
New Commercial Connections		828	828	828	828	828	828	828
Cumulative New Commercial Connections		828	1,655	2,483	3,310	4,138	4,966	5,793
Total Connections	**36,022**	**36,534**	**37,043**	**37,569**	**38,090**	**38,608**	**39,121**	**39,630**
Net Connections	**470**	**512**	**508**	**526**	**522**	**518**	**513**	**509**

5.1.3. Small Business Demand per Connection Forecast

Over the Review Period, total Small Business demand per connection was derived using the methodology outlined in Section 3. The following tables provide a summary of Small Business demand per connection.

- Small Business annual demand per connection is forecast to decrease from 348.5 GJ to 335.3 GJ over the Review Period, equivalent to an average annual decline rate of -0.96%.

The following tables summarise Small Business weighted average demand per connection forecast which includes a ramp-up phase for all new connections as was described in the previous section for the residential sector. For small business customers it is estimated that first-year customers consume 23.7% of their mature demand levels and second-year customers consume 81.6% (based on historical averages).

Table 5.3. Small Business Annual Demand per Connection Forecast | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		370.6	361.4	359.1	357.6	355.3	352.0	348.9
New Commercial		68.1	152.2	198.9	223.5	238.7	248.6	256.1
Weighted Average Demand per Connection	**383.9**	**363.8**	**352.0**	**348.5**	**345.9**	**342.8**	**338.9**	**335.3**

The forecast and analysis of demand per connection was derived by identifying these sources of influence:

- Drivers with historical impact that will perpetuate throughout the Review Period; and
- Drivers with historical impact that will deviate in the Review Period.

The significant factors driving the expected reduction in Small Business demand per connection are the impact of own-price and cross-price elasticities, due to expected decreases in gas prices and electricity prices. These factors are described in further detail below.

5.1.4. Demand per Connection | Drivers with Continued Impact

Historical Annual Average Growth

For Small Business demand per connection, the historical average annual growth removes the impact of gas and electricity prices, and weather by adjusting historical demand per connection by the estimated impact of each of these factors. The process of weather normalisation has been discussed in detail in Section 2. This normalised demand per connection was then adjusted for historical price movements by netting off the product of historical price changes and assumed historical price elasticity. However, the impacts of appliance trend, energy efficiency trend, and government policy are still captured by the normalised historical rate. Accordingly, CORE research determined the likely impact of these drivers over the Review Period. There is also considerable overlap with the efficiency, policy and appliance trend analysis that is discussed in the context of Residential demand. Ultimately it was determined that the combined impact of each of these factors is best predicted by what was observed during the historical period 2009-2018, captured by the normalised historical average annual growth rate, which is perpetuated in the forecast period with no expected adjustment.

Realistically, building and appliance efficiency evidence is not comprehensive enough to enable robust statistical relationships. Instead CORE has assessed the drivers of these factors such as policy, dwelling commencements (as a proportion of existing non-residential dwelling stock) and technology. There is no evidence to suggest that these factors are losing momentum or accelerating so CORE deems it appropriate to rely on their recent historical impact which has been captured by the weather normalised trend in volume per connection.

Macroeconomic Variables and Small Business Demand per Connection

Similarly, to the Residential Sector, statistical analysis concluded that the relationship between candidate economic variables and Small Business demand is unreliable and not statistically significant. Such factors (such as state output) are key drivers of connections but volume per connection does not demonstrate a robust statistical relationship. To derive an optimal forecast with maximum precision, the decision was made to exclude any economic variables. For more detail please refer to Appendix A6.

5.1.5. Demand per Connection | Drivers with Changing Impact

Own-Price Elasticity

Movements in gas price significantly affect the demand per connection in a given year as well as in subsequent years. Consistent with previous AA submissions, economic literature and statistical tests, CORE forecasting captures the elasticity impact across four lagged periods (measured in years).

The gas price movements that instigate this elasticity impact are derived using CORE's proprietary model. CORE has undertaken gas price forecasting within an AA context for AGN's South Australian distribution network, the previous access arrangement submission for JGN's New South Wales distribution network and Envestra's (now AGN) Victorian distribution network. CORE has also developed gas price forecasts for each eastern Australian jurisdiction as part of its Gas Networks Sector Study, commissioned by the Energy Networks Association in August 2014. CORE has also been engaged by AEMO to develop gas price forecasts for the NGFR 2015 and provide updated forecasts for the NGFR 2016.

The approach undertaken by CORE to forecast retail commercial gas prices consists of analysing each individual component of the retail gas price. A full listing and analysis of these components can be found in Appendix A2. The forecast is driven by the following:

- An expected increase in wholesale gas costs in the Review Period, as forecast by AEMO in the 2018 GSOO and consistent with the AER's LNG netback series.
- An expected decrease in distribution costs in the Review Period as per JGN Forecast Tariffs.

The elasticity value used by CORE is a product of extensive third-party analysis via international literature review as well as a review of previous AA price elasticity factors that have been accepted by the AER and ERA (WA). Accordingly, a long-run elasticity factor of -0.35 has been used for Small Business demand.

The following table provides the forecast of own-price impacts on demand per connection.

Table 5.4. Own-Price Elasticity Impact on Small Business Demand per connection | %

Own-Price Elasticity Impact on Demand (%)	2019	2020	2021	2022	2023	2024	2025
Change in Gas Prices | Real 2018	-2.0%	-1.6%	-2.5%	-0.8%	0.9%	-0.8%	-0.6%
Price Elasticity Impact (-0.35)	-1.0%	-0.3%	0.4%	0.6%	0.4%	0.1%	0.1%

Further detail on the gas price forecast and price elasticity impact can be found in Sections A2 and A3.

Cross-Price Elasticity

Cross-price elasticity measures the change in demand per gas connection that occurs when the price of electricity, a substitute energy source to gas, changes. There are two components to this effect:

- The propensity of consumers to switch between gas and electricity appliances when faced with a given price movement
- The size of the relative price movements between gas and electricity.

CORE forecasting captures the response of consumers as they face relative price changes between gas and electricity. For example, the model would capture the degree of substitution that occurs between gas heating and heating by RC air-conditioning when there is a shift in relative prices between gas and electricity.

CORE has derived electricity retail price movements in the Review Period from AEMO's NEFR publication, together with the relevant component of the AEMC's projection (such as wholesale price movements):

Further detail on the electricity price forecast and price elasticity impact can be found in Sections A3 and A4.

The following table summarises the cross-price elasticity impact on demand per connection.

Table 5.5. Cross-Price Elasticity Impact on Small Business Demand per connection | %

Cross-Price Elasticity Impact on Demand (%)	2019	2020	2021	2022	2023	2024	2025
Change in Electricity Prices | Real 2018	7.5%	7.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%
Price Elasticity Impact (0.10)	0.75%	0.75%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%

5.1.6. Other Forecast Features

Certain adjustments were made to the forecast connections or demand per connection on the basis of new business initiatives or macroeconomic factors:

5.1.6.1. Over-Consuming Customers

JGN is undertaking a program to reallocate 66 customers that it has observed to be over-consuming according to the upper bound volume for Tariff V (10TJ p.a.). These customers are several orders of magnitude higher than the average Small Business customer and account for 6.4% of Small Business volume. It is assumed (via consultation with JGN) that they will be reallocated to Tariff D over the 2018-2020 period. Accordingly, CORE has removed 6.4% of the existing Small Business customer volume over this period and adjusted the Tariff D forecast accordingly (refer Section 1 | 6).

Section 1 | 6. Tariff D Demand Forecast

6.1. Forecast Overview

This section of the report details the demand forecast for industrial customers.

- The JGN includes larger industrial customers that are reasonably anticipated to consume more than 10TJ per annum. In the Greater Sydney region this typically includes manufacturing operations, construction, and chemicals processing. These customers generally require gas for process heat.
- Smaller industrial customers are more likely to consume gas for large-scale space heating and water heating including shopping centres, hotels, hospitals and other large public buildings.
- For the industrial customer group, CORE has forecast annual demand volumes (ACQ) and capacity (measured by GJ of MDQ).

For the JGN, growth rates or trends are derived on a sector or whole-network basis. Each customer is then forecast individually but exposed to the relevant group's trend or growth rate.

The forecast comprises forecasts of four customer groupings:

Forecast Type	Description	Forecast
Reviewed customers	MDQ and ACQ is forecast according to known load changes obtained via public domain review and JGN's ongoing correspondence with its industrial customer base (which also includes individual customer engagement although this process resulted in minimal reliable forecast inputs)	41 large, joining or disconnecting customers (predominantly mining and manufacturing customers)
GVA customers	Customers that belong to a particular segment (per ANZSIC classification) that has a demonstrated statistical relationship between gas demand and output (measured by ABS' Gross Value Add "GVA")	Customers from the following sectors: ▪ Wholesale Trade ▪ Accommodation and Food Services ▪ Education and Training ▪ Arts and Recreation Services
Weather Normalised Trend	Several sectors that exhibited a clear weather-induced demand pattern	Customers from the following sectors: ▪ Transport, Postal and Warehousing ▪ Financial and Insurance Services ▪ Rental, Hiring and Real Estate Services ▪ Professional, Scientific and Technical Services ▪ Administrative and Support Services ▪ Public Administration and Safety ▪ Health Care and Social Assistance
Average Trend Customers	Customers who did not fall into the above groupings have ACQ forecast according to observed historical trend[17]	Customers from the following sectors: ▪ Agriculture, Forestry & Fishing ▪ Mining ▪ Manufacturing ▪ Electricity, Gas, Water and Waste Services ▪ Construction ▪ Retail Trade ▪ Information media and Telecommunications ▪ Other Services

[17]Historical trend is derived from customers that existed in the customer group for the entire historical period (2009-2018). This is to capture true underlying growth and remove the impact on load that occurs when customers join or leave the customer group.

At the end of 2018, JGN had a total of 386 industrial customers which includes new or recently joined customers. 302 of these customers existed in the network for the entire 2009-2018 period.

The annual demand and MDQ forecast for industrial customers are based upon analysis of the following:

- Existing MDQ, by customer, at the end of 2018.
- Known and forecast load changes, disconnections and new connections
- To forecast the 9th highest MDQ (a requisite component of the CD calculation), CORE has applied the historical average relationship between 9th and absolute highest days for each customer for each year. Where outlier values existed and/or the historical series featured a new connection event/ ramp-up, CORE has then applied the historical weighted average customer-wide relationship.

Overall CORE expects MDQ to decrease by an annual average of -2.18% between 2021 and 2025. This decrease is associated with a total ACQ which is expected to fall on average -2.12% during the same period. This is primarily driven by the 0.84% average annual decline in the trend group which includes major sectors manufacturing and construction.

Please note there is an increase in MDQ and ACQ forecast for 2018-2020 which is associated with the reallocation of 66 Tariff V customers as well as an adjustment for new and disconnecting customers which are known to JGN and have been disclosed to CORE.

For detailed analysis on the statistically derived growth rates for industrial customer groups please refer to Appendix A4.

6.2. Tariff D Demand Forecast Summary

Table 6.1. Tariff D MDQ | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
MDQ	254,885	241,541	236,695	232,101	227,472	222,298	217,452	212,498
MDQ (9th Highest)	204,503	194,408	189,983	186,826	183,053	179,069	175,229	171,355

Table 6.2. Tariff D Annual Demand Forecast | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
ACQ	49,588,365	47,896,975	46,563,806	45,845,197	44,898,001	43,955,208	43,018,111	42,086,222

Table 6.3. Tariff D Closing Connections Forecast | No.

	2018	2019	2020	2021	2022	2023	2024	2025
Closing Connections	386	400	414	428	420	412	404	396

Figure 6.1. Industrial MDQ | GJ

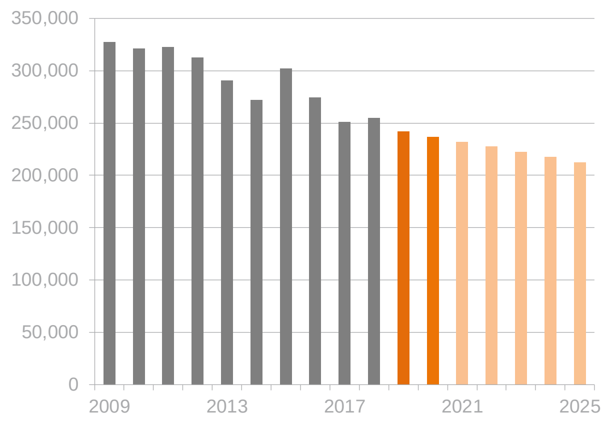


Figure 6.2. Industrial Annual Demand | GJ

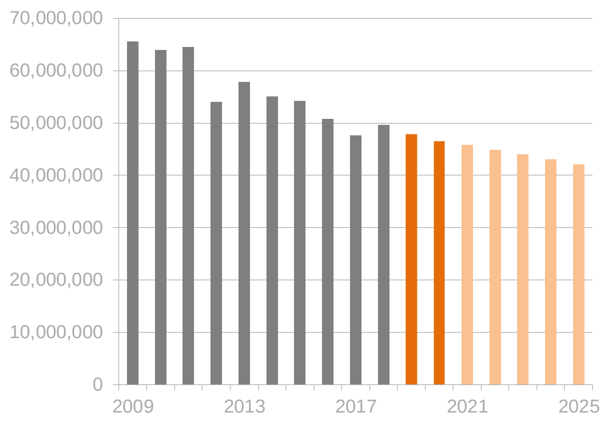


Figure 6.3. Industrial MDQ (9th Highest Day) | GJ.

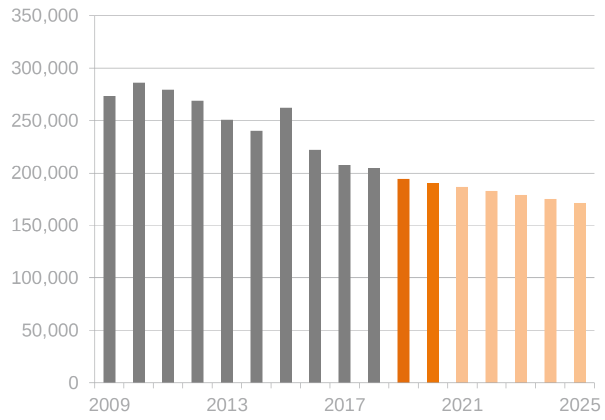
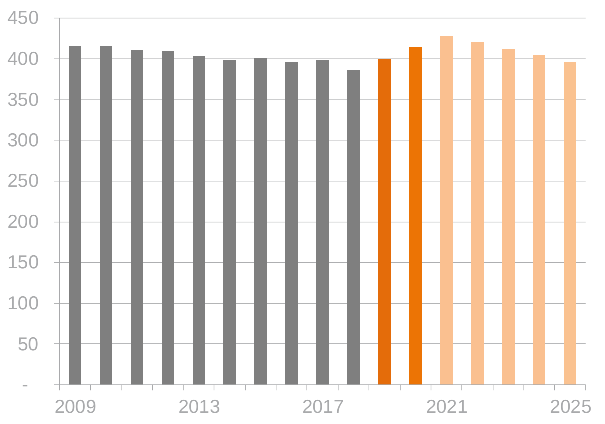


Figure 6.4. Industrial Customer Numbers | No.



The forecast of connections is primarily driven by the reallocation of over-consuming Tariff V customers (66 in total between 2018 and 2020). There is also an underlying historical trend built into the forecast which captures the annual average decrease of -1.90%. This represents the ten-year average disconnection number of 15 net of a shorter term (2016-18) average of 7 gross new connections on average each year. A shorter term gross new connection rate was applied to honour the step change that has occurred in the series whereby the 2016-2018 average of 7 is substantially below the 2009-2015 average of 13. This can be explained in part by the significant wholesale gas price increases that coincided with this time period.

Economic & Manufacturing Sector Outlook

CORE has considered general economic trends and specific analysis of major industry segments of significance to CD customers. As noted below, the vast majority of industrial customers are grouped within the Manufacturing sector, a sector which is experiencing a sustained period of change in NSW and Australia more broadly.

CORE concedes there is significant downside risk in industrial connections relative to the forecast values. This conclusion is based on economic conditions and competition faced by a lot of industrial sectors generally in Australia (including New South Wales), particularly in key sectors such as manufacturing. The State economy enjoys a diverse range of industrial activity, but CORE notes a concentration of JGN customers in the manufacturing and construction sector. Given that dwelling completions are expected to fall, and international competition is an ever-present threat to manufacturing, there is significant downward pressure on industrial customer numbers.

The following major themes are weighing on the Manufacturing sector.

Table 6.4. General Economic Themes - Manufacturing Sector.

Economic Theme	Description
Manufacturing Sector Faces Structural Challenge	A range of Government and other independent reviews highlight the challenges facing the Australian manufacturing industry. Key factors include: ▪ unfavourable exchange rates although markets indicate AUD in the 0.70-0.75 range going forward ▪ high relative labour, and other input costs- which now includes energy ▪ lower productivity than competitors ▪ smaller scale ▪ unfavourable proximity to markets
Material Increases in Energy Costs are Impacting Energy-intensive Businesses	Electricity, gas and other energy cost increases (combined with other input costs) have been widely reported to be having a material impact on the profitability of energy-intensive sectors. The impact is expected to be widespread and will be reflected in: ▪ the use of cost-effective substitutes ▪ investment in efficiency initiatives ▪ rationalisation of businesses and closures
Global Competition Forces Remain Strong	Many sectors are suffering from competition against lower cost importers.

Source: CORE Energy Group.

6.2.1.2. Additional Note | Review of MDQ and ACQ Relationship

The level of MDQ required by a company is determined by the maximum demand during a given year. The relationship between ACQ and MDQ is referred to as load factor and can be expressed as follows:

LF = Average Daily Demand/MDQ

where:

- LF = load factor; and
- average daily gas demand is calculated as the total year's demand divided by the number of days in a year
  - ACQ/ 365

The load factor quantifies the extent to which the average daily demand is below the maximum daily demand with 100% indicating a perfectly flat load and 50% indicating a maximum day that is twice the volume of the year average. The table below also expresses load factor in terms of the ratio between MDQ and average daily quantity, given that both expressions are commonly used in the industry. For example, a LF of 80% has a load factor ratio of 1.25.

The MDQ is higher than the average daily demand due to variability of activity throughout a year.

As noted in the following table, the JGN Tariff D sector had a load factor of 53.3% (1.88) in 2018. After sustained falls in the last few years (believed to be primarily driven by large closure events and maintenance for large customers), this load factor is expected to be stable throughout the AA period: it is reasonable to expect Tariff D customers to respond to a weak manufacturing environment and increasing gas prices by reducing ACQ. Similarly, given that the distribution component of a customer's total gas cost is a function of MDQ, and wholesale gas contracts are typically charging more for flexible contract structures, CORE expects equivalent reductions in MDQ relative to any ACQ decrease.

Table 6.5. Tariff D Load Factors.

Load Factor	2018	2019	2020	2021	2022	2023	2024	2025
LF	53.3%	54.3%	53.9%	54.1%	54.1%	54.2%	54.2%	54.3%
LF Ratio	1.88	1.84	1.86	1.85	1.85	1.85	1.85	1.84

Source: CORE.

Section 1 | 7. Conclusion

CORE considers that the forecasts presented below represent the best estimate of gas demand and customer numbers for the JGN distribution network during the Review Period. CORE has taken all reasonable steps to ensure this report complies with ss 74 and 75 of the *NGR*. The methodology is consistent throughout the various sections. The statistical rigour and validation processes ensure precision and reliability.

7.1. Tariff D

CORE forecasts that Tariff D MDQ will decrease by -2.18% per annum throughout the forthcoming AA Period and ACQ will decrease by an average of -2.12% per annum. The results shown below have been influenced by:

- Known demand and changes due to public domain review and known new customers
- Sector output and statistically significant relationships between demand and GVA
- Statistically significant relationships between demand and EDD for industrial customers that use gas for space or water heating
- An adjustment for Tariff V reallocation and historical trend in customer churn.

CORE believes there is greater downside risk to the industrial forecast due to the following:

- Continued efficiency trends which are expected to continue during the Review Period
- The momentum towards reduction of gas demand or partial fuel switching
- The ongoing economic challenge faced by industrials in the network arising from competitive pressures in the Asia Pacific region and elsewhere. This challenge is seemingly increasing as energy input costs rise.

Table 7.1. Forecast of MDQ | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
MDQ	254,885	241,541	236,695	232,101	227,472	222,298	217,452	212,498

Table 7.2. Forecast of Annual Demand | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
ACQ	49,588,365	47,896,975	46,563,806	45,845,197	44,898,001	43,955,208	43,018,111	42,086,222

Table 7.3. Forecast Average Annual Growth in Tariff D Demand | %

Average Growth	2019 - 2025	2021 - 2025
MDQ	-2.11%	-2.18%
ACQ	-2.13%	-2.12%

Figure 7.1. Industrial MDQ | GJ

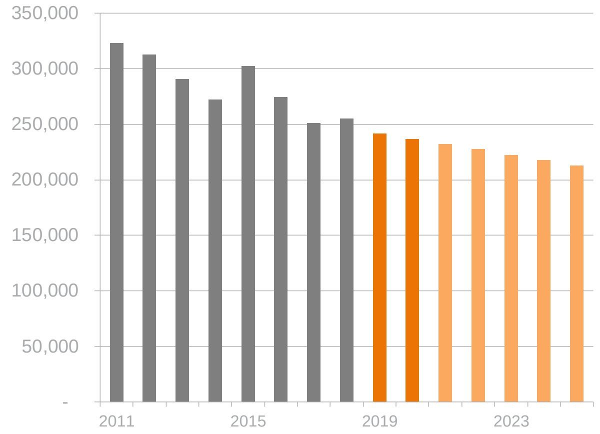


Figure 7.2. Industrial Annual Demand | GJ

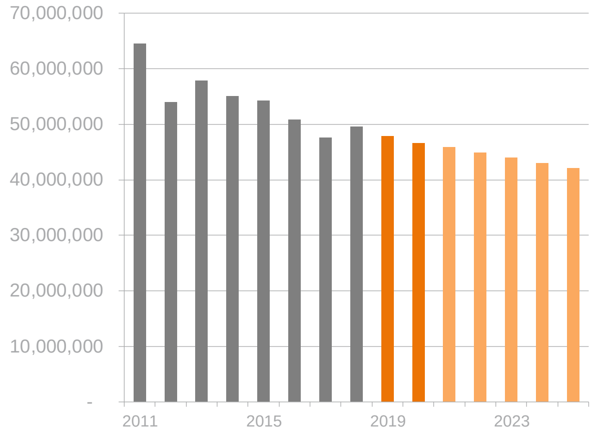
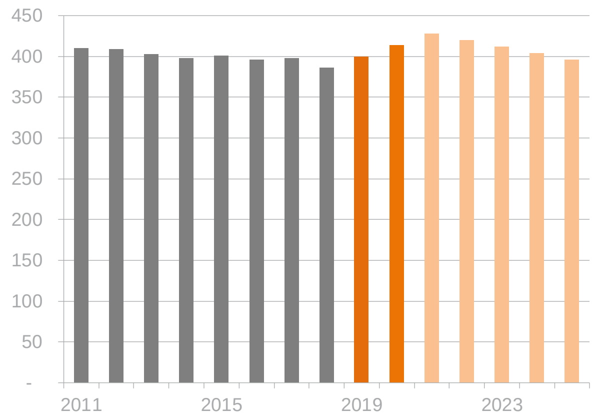


Figure 7.3. Industrial Connections | GJ



7.2. Tariff V | Small Business

7.2.1. Small Business Demand

The forecasts for Small Business demand incorporate a continued significant decrease in existing demand per connection and a continuation of historical connections growth. The front few years of the forecast are also impacted by a Tariff V reallocation of large consuming customers which removes around 6.4% of total volume for an associated loss of only 66 customers.

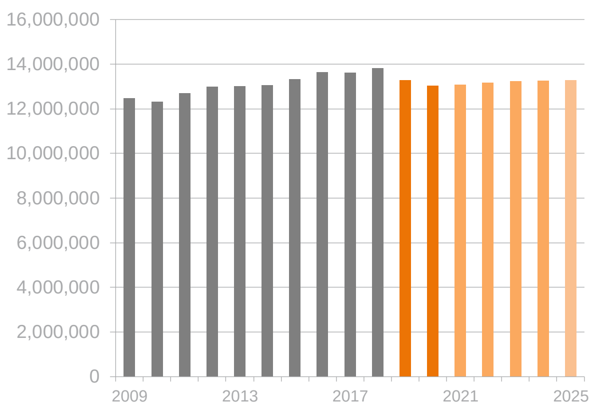
Table 7.4. Small Business Demand Forecast | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		13,233,170	12,787,753	12,597,869	12,435,803	12,246,826	12,021,853	11,805,916
New Commercial		56,344	251,935	493,791	739,920	987,701	1,234,519	1,483,508
Total Demand	**13,828,468**	**13,289,514**	**13,039,688**	**13,091,660**	**13,175,723**	**13,234,527**	**13,256,373**	**13,289,424**

Table 7.5. Small Business Demand | Average Annual Growth | %

	Small Business	
Average Growth	**2021 - 2025**	**2019 - 2025**
Existing 2018	-1.61%	-1.88%
New Commercial	32.12%	95.27%
Total Demand	**0.38%**	**0.00%**

Figure 7.4. Small Business Demand | GJ p.a.



7.2.2. Small Business Connections

CORE's analysis has determined that Real GSP conditions for the forecast period will closely match the historical period and that the reasonably stable growth rate in connections will continue.

Table 7.6. Small Business Connections Forecast | No.

	2018	2019	2020	2021	2022	2023	2024	2025
Opening Connections	35,552	36,022	36,534	37,043	37,569	38,090	38,608	39,121
Disconnections	326	315	319	302	306	310	314	318
Disconnections | Zero Consuming Connections								
Existing 2018 Connections	36,022	35,707	35,387	35,086	34,780	34,470	34,156	33,837
New Commercial Connections	803	828	828	828	828	828	828	828
Cumulative New Commercial Connections		828	1,655	2,483	3,310	4,138	4,966	5,793
Total Connections	**36,022**	**36,534**	**37,043**	**37,569**	**38,090**	**38,608**	**39,121**	**39,630**
Net Connections	**470**	**512**	**508**	**526**	**522**	**518**	**513**	**509**

Small Business Connections | Average Annual Growth | %

	Small Business	
Average Growth	2021 - 2025	2019 - 2025
Opening Connections	1.37%	1.39%
Disconnections	1.37%	0.20%
Existing 2018 Connections	-0.90%	-0.89%
New Commercial Connections	0.00%	0.00%
Cumulative New Commercial Connections	23.75%	40.83%
Total Connections	**1.34%**	**1.36%**
Net Connections	**-0.81%**	**-0.09%**

Figure 7.5. Small Business Connections | No.

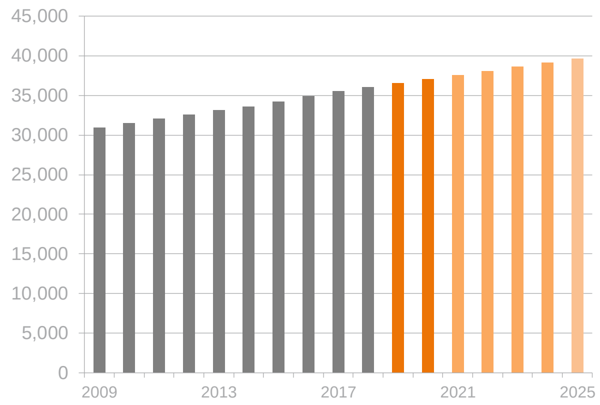


Figure 7.6. Small Business Existing Connections | No.

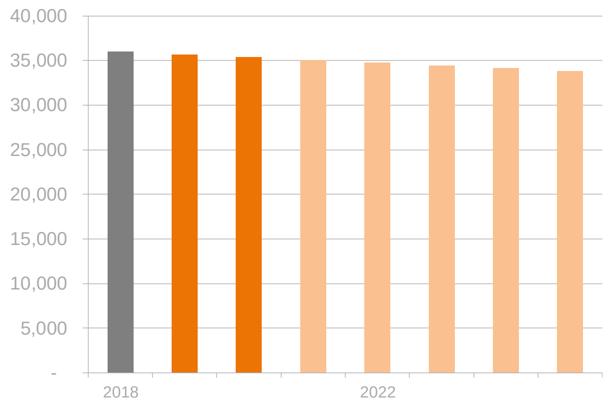


Figure 7.7. Small Business Net Connections | No.

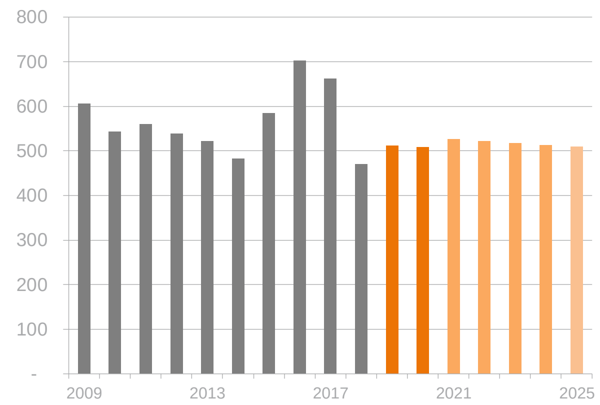
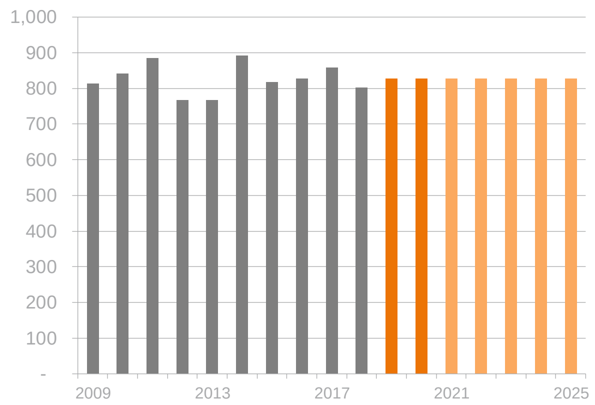


Figure 7.8. Small Business New Connections | No.



7.2.3. Demand per Connection

The forecast results for Small Business demand per connection are driven by a combination of factors. CORE's bottom-up approach has accounted for price effects (own and cross-price), weather effects, appliance trends and efficiency trends to arrive at the following growth rates. A recent historical increase in the demand per connection of new customers is expected to reverse as the over-consuming customers are reallocated to Tariff D and new customers are more readily placed into Tariff D if they exhibit larger demand.

The forecast of tariff Small Business demand per connection is presented in the following tables and charts.

Table 7.7. Small Business Demand per Connection Forecast | GJ/conn

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		370.6	361.4	359.1	357.6	355.3	352.0	348.9
New Commercial		68.1	152.2	198.9	223.5	238.7	248.6	256.1
Weighted Average Demand per Connection	**383.9**	**363.8**	**352.0**	**348.5**	**345.9**	**342.8**	**338.9**	**335.3**

Table 7.8. Small Business | Average Annual Growth of Demand per Connection | %

	Small Business	
Average Growth	**2021 - 2025**	**2019 - 2025**
Existing 2018	-0.71%	-1.00%
New Commercial	6.58%	30.09%
Weighted Average Demand per Connection	**-0.96%**	**-1.34%**

Figure 7.9. Small Business Total Demand per Connection | GJ/conn

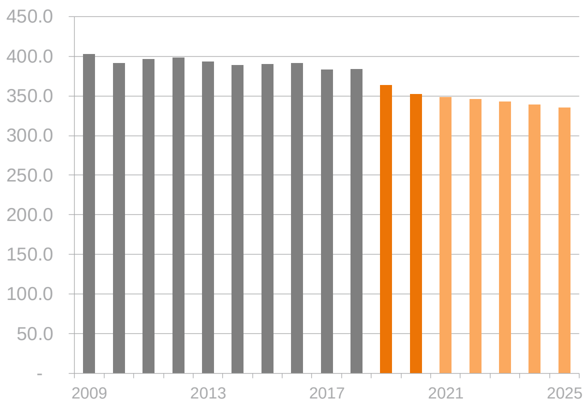
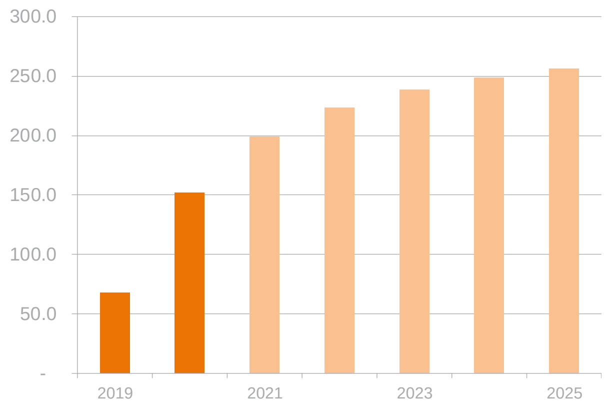


Figure 7.10. Small Business New Demand per Connection | GJ/conn



7.3. Tariff V | Residential

7.3.1. Residential Demand

The forecast increase in Residential demand is due to a steady increase in connections offset by a continued decline in volume per connection- which in turn is driven by appliance and efficiency trends. New dwelling completions are expected to be strong in the first few years of the forecast before reverting to more stable 2015/16 years and MD/HR construction growth shrinks and new homes regain some market share.

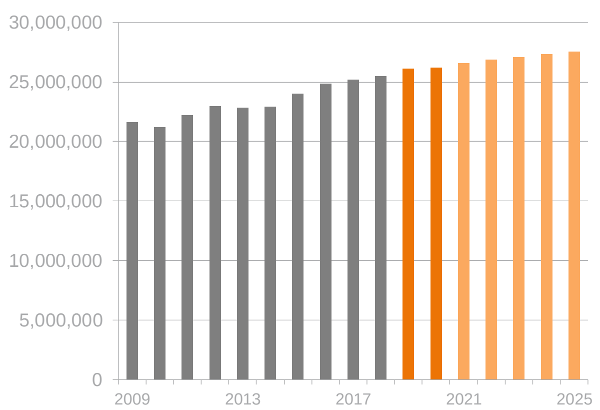
Table 7.9. Residential Demand Forecast | GJ

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		25,903,068	25,392,177	25,182,704	24,976,823	24,741,749	24,513,660	24,280,222
New Dwelling | Home		116,187	456,381	795,918	1,087,159	1,353,040	1,610,452	1,870,867
New Dwelling | E2G		20,216	80,041	144,262	206,064	265,210	322,029	376,443
New Dwelling | HRVB		18,619	78,164	150,225	220,191	283,977	346,782	411,060
New Dwelling | MD		11,200	44,560	79,040	109,146	136,401	163,143	190,206
New Dwelling | HRVI		39,532	147,943	233,393	287,097	332,167	376,570	421,989
Total Demand	**25,507,290**	**26,108,822**	**26,199,266**	**26,585,541**	**26,886,480**	**27,112,545**	**27,332,636**	**27,550,788**

Table 7.10. Residential Demand | Average Annual Growth | %

Average Growth	2021 - 2025	2019 - 2025
Existing 2018	-0.91%	-1.072%
New Dwelling | Home	24.06%	77.24%
New Dwelling | E2G	27.47%	81.01%
New Dwelling | HRVB	29.05%	88.03%
New Dwelling | MD	24.81%	79.08%
New Dwelling | HRVI	16.03%	66.02%
Total Demand	**0.90%**	**0.90%**

Figure 7.11. Residential Demand | GJ



7.3.2. Residential Connections

The connections growth of 1.45% over the forthcoming AA period is a function of expected new dwellings in the Greater Sydney region and the recent average 73% average penetration rate of the JGN. The primary feature of the new connections by connection type is the impact of JGN's decision to only offer HRVB post 2020 to all new HR customers with centralised hot water.

Table 7.11. Residential Connections Forecast | No.

	2018	2019	2020	2021	2022	2023	2024	2025
Opening Connections		1,353,889	1,366,847	1,396,854	1,419,534	1,440,478	1,460,831	1,481,644
Disconnections		3,134	2,814	2,457	2,058	2,112	2,164	2,218
Disconnections | Zero Consuming Connections		26,861	5,027	5,153	5,253	5,348	5,440	5,535
Existing 2018 Connections		1,323,894	1,316,053	1,308,443	1,301,132	1,293,672	1,286,068	1,278,315
New Dwelling Connections | Residential Home		24,201	22,464	18,935	17,742	17,360	17,805	18,945
New Dwelling Connections | Residential E2G		4,000	4,000	4,000	4,000	4,000	4,000	4,000
New Dwelling Connections | Residential HRVB		142	167	166	145	144	148	155
New Dwelling Connections | Residential MD		3,432	3,293	2,838	2,551	2,530	2,584	2,682
New Dwelling Connections | Residential HRVI		11,178	7,924	4,352	3,818	3,779	3,881	4,063
Total Connections	**1,353,889**	**1,366,847**	**1,396,854**	**1,419,534**	**1,440,478**	**1,460,831**	**1,481,644**	**1,503,736**
Net Connections	**47,184**	**12,958**	**30,007**	**22,681**	**20,944**	**20,353**	**20,813**	**22,092**

Table 7.12. Residential Connections | Average Annual Growth | %

Average Growth	2021 - 2025	2019 - 2025
Opening Connections	1.48%	1.51%
Disconnections	-2.16%	-5.26%
Existing 2018 Connections	-0.58%	-0.58%
New Dwelling Connections | Residential Home	0.13%	-3.73%
New Dwelling Connections | Residential E2G	0.00%	0.00%
New Dwelling Connections | Residential HRVB	-1.48%	1.73%
New Dwelling Connections | Residential MD	-1.25%	-3.81%
New Dwelling Connections | Residential HRVI	-1.48%	-13.35%
Forecast Connections	**1.45%**	**1.60%**
Net Connections	**-0.52%**	**17.51%**

Figure 7.12. Residential Total Connections | No.

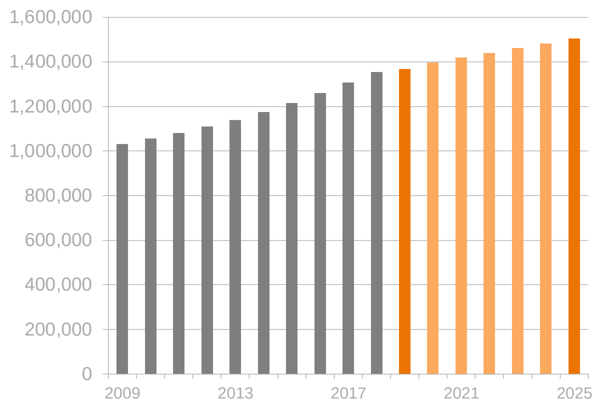


Figure 7.13. Residential Existing Connections | No.

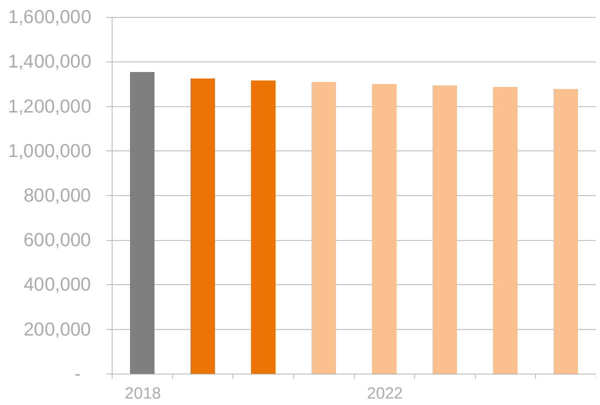


Figure 7.14. Residential New Connections | No.

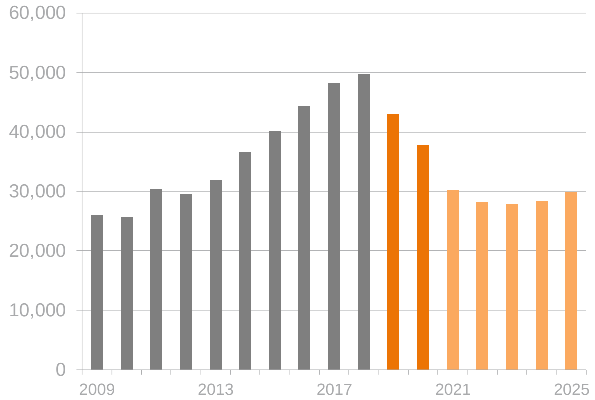


Figure 7.15. Residential Net Connections | No.[18]

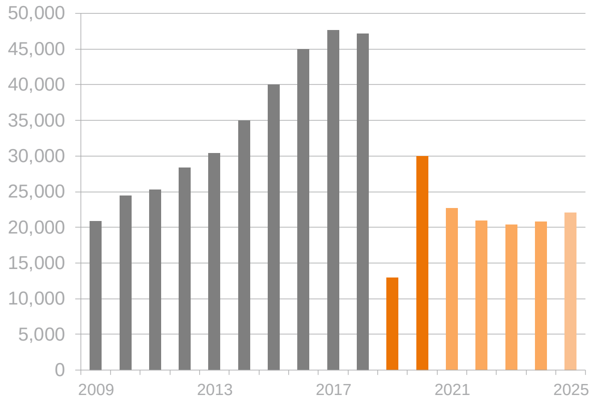


Figure 7.16. New Residential Home Connections | No.

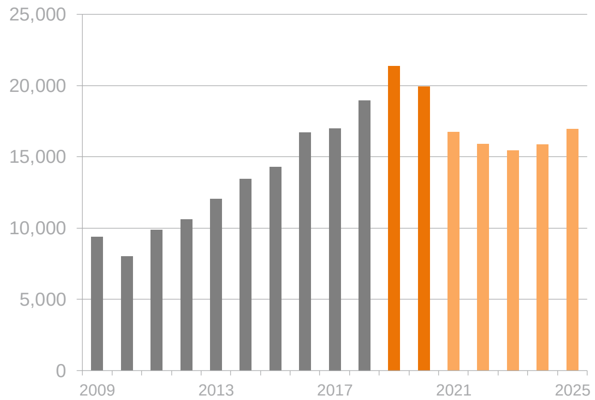
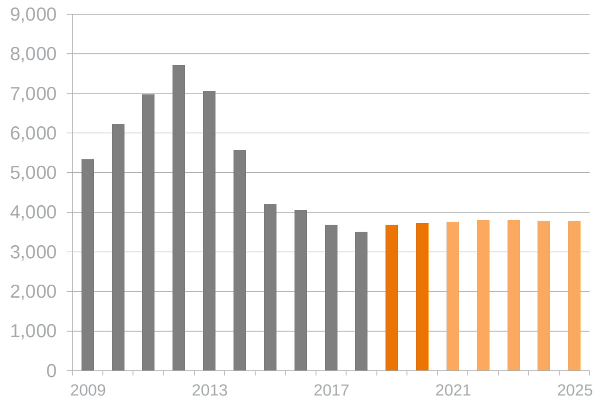


Figure 7.17. New Residential E2G Connections | No.



[18] Please note the short term trend seen in this chart is significantly impacted by the zero consuming MIRN program.

Figure 7.18. New Residential HRVB Connections | No.

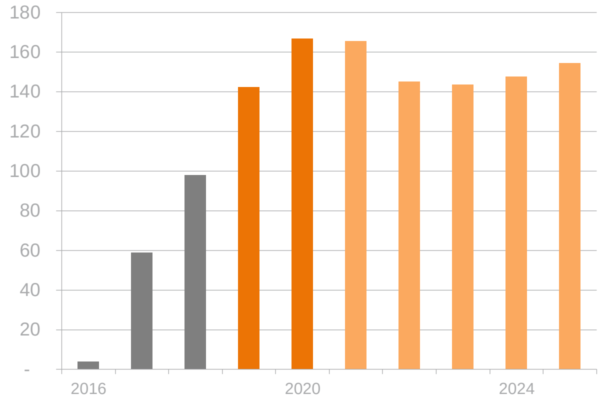


Figure 7.19. New Residential MD Connections | No.

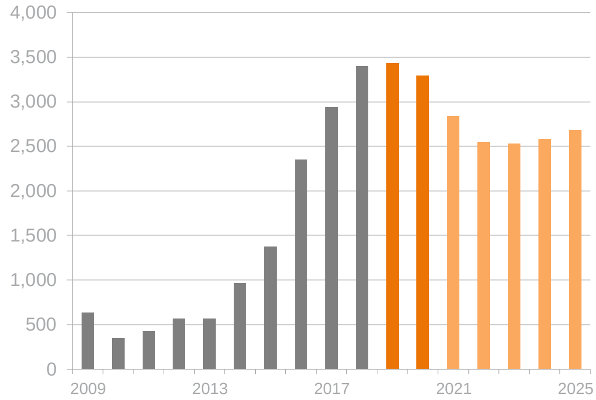
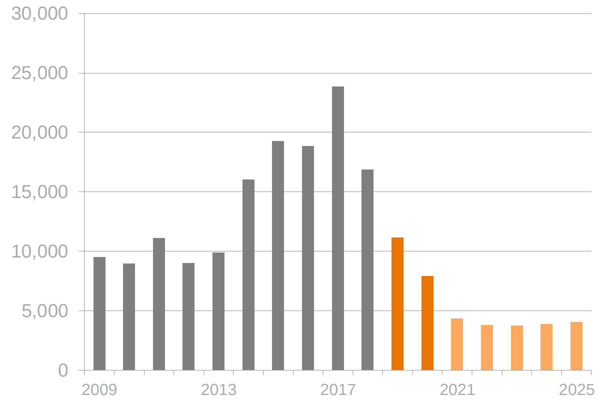


Figure 7.20. New Residential HRVI Connections | No.



7.3.3. Demand per Connection

The -0.55% decline is consistent with the continuation of efficiency and appliance trends experienced by this customer group in addition to the price impacts from the gas and electricity retail market. The true underlying decline per dwelling exceeds this rate as the projected decline includes:

- the impact of the ZCM removal program (removes connections with no associated loss in volume), and
- the growth of HRVB connections which structure a projected average of 88 individual dwellings behind one network connection.

Table 7.13. Residential Demand per Connection Forecast | GJ/conn

	2018	2019	2020	2021	2022	2023	2024	2025
Existing 2018		19.57	19.29	19.25	19.20	19.13	19.06	18.99
New Dwelling Connections | Residential Home		4.8	9.8	12.1	13.0	13.4	13.6	13.6
New Dwelling Connections | Residential E2G		5.1	10.0	12.0	12.9	13.3	13.4	13.4
New Dwelling Connections | Residential HRVB		130.7	252.8	316.4	355.1	371.8	380.5	385.6
New Dwelling Connections | Residential MD		3.3	6.6	8.3	9.0	9.3	9.5	9.6
New Dwelling Connections | Residential HRVI		3.5	7.7	10.0	10.5	10.7	10.8	10.8
Weighted Average Demand per Connection	**18.8**	**19.1**	**18.8**	**18.7**	**18.7**	**18.6**	**18.4**	**18.3**

Table 7.14. Residential | Average Annual Growth of Demand per Connection | %

Average Growth	2021 - 2025	2018 - 2025
Existing 2018	-0.33%	-0.49%
New Dwelling Connections | Residential Home	2.95%	23.26%
New Dwelling Connections | Residential E2G	2.87%	21.60%
New Dwelling Connections | Residential HRVB	5.15%	23.21%
New Dwelling Connections | Residential MD	3.74%	23.78%
New Dwelling Connections | Residential HRVI	2.14%	26.01%
Weighted Average Demand per Connection	**-0.55%**	**-0.69%**

Please note that each year smaller, new customers increase their share of the total customer group. This decreases the weighted average beyond the respective decline rates of each group. The weighted average is a function of existing growth rate, new growth rate and the increased share of lower, new customers (as existing customers disconnect and new, lower customers join).

Figure 7.21. Residential Demand per Connection | GJ/conn

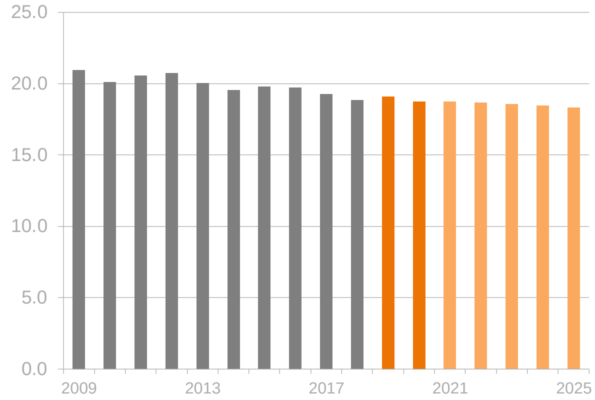


Figure 7.22. Existing Demand per Connection | GJ/conn

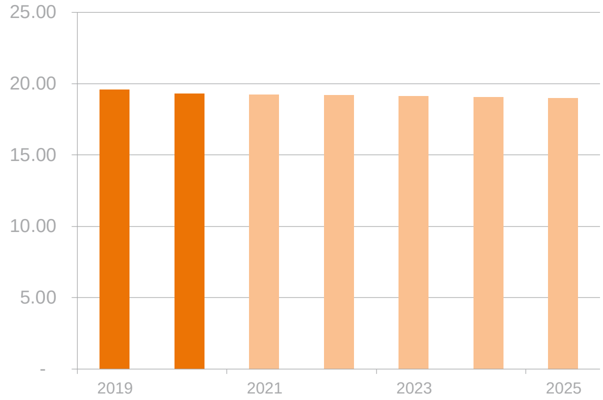
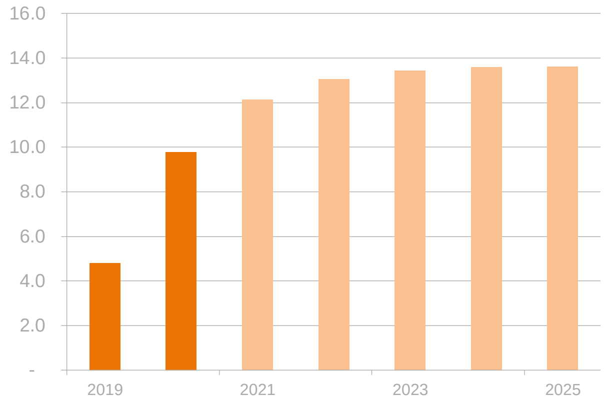


Figure 7.23. New Residential Demand per Connection | GJ/conn



Terms of Reference

Scope and Context

CORE has been engaged to deliver a gas demand forecast for JGN AA 2021-2025 pursuant to the terms contained herein. The forecast addresses the level of demand arising from the residential, commercial and industrial sectors as well as forecasting customer numbers for these sectors. The methodology reviews the leading approaches to forecasting demonstrated by previous AAs and other experts in the field. The opinions formed are based entirely on quality statistical analysis, economic theory and industry experience. The analysis forecasts the customer numbers and total demand for each connection type, within each sector and under each tariff class. The approach is quantitative whenever appropriate although qualitative analysis will also be required to justify the methodology and results of the forecast. The context of the forecast and report is that of an independent expert. Accordingly, the methodology and output are a best-practice approach that complies with the *NGR*.

Relevant Considerations

Consideration and analysis occurs for the aspects listed below. The relevant time frame for the forecast includes the period leading up to the Review Period as well as all years contained within the period.

- Annual gas demand for new and existing users within the JGN distribution network.
- Quantity and capacity-based demand for industrial users within the network.
- The historical trends in gas demand and customer numbers. The relevance of these trends should also be examined.
- The various drivers and variables that create movements in average gas usage.
- The suitability and reliability of each statistical method used for the forecast.
- Thorough analysis for all market segments but particularly those where JGN identifies or predicts significant changes.
- Appliance trends and policies driving appliance efficiency changes.
- Macroeconomic analysis such as population growth, real output and income in the areas covered by the network.

Output

CORE provides the following deliverables:

- Weather Normalised Demand and Demand Forecast
  - Preliminary and Final
- AER Report
  - Draft and Final

Upon completion of the AER Report, all results, forecasts and assumptions are clearly set out. All methodology is revealed and explained. The findings are adequately justified and compliance with the *NGR* is shown.

Key References

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A1. Weather Normalisation Results

The following section shows the regression results and key statistical tests performed during the weather normalisation stage:

- Regression analysis was performed using monthly sum of EDD_{312} units.
- Separate regressions were performed for each sector:
  - Residential
  - Small Business
  - Weather-induced industrial customers
- Statistical models and parameters that were tested included:
  - Lagged demand per connection (up to and including 12 lags)
  - Transformations such as logarithmic and differencing
  - Year dummy variables to test for outlier years (no year between 2008 and 2018 consistently fell below 5% threshold across different models)
  - Time-trend dummy variable which captures constant processes/ changes over time

Residential

The regression results and statistical tests performed for these models are summarised in the following tables:

Table A1.1 Regression Output

	Residential Gas Demand
EDD Coefficient (GJ of Demand per Connection per EDD Unit)	0.0026 (p value = 0.00)
First Lag of Demand per Connection	0.1526 (p value = 0.00)
Time Trend Coefficient	-0.0011 (p value = 0.08)
Constant	23.3096 (p value = 0.07)
No. of observations	119 (119 months)

CORE's preference is to complete a series of conventional tests for heteroskedasticity, autocorrelation and omitted variable bias. Post-estimation testing and analysis was completed where possible and CORE elected to use the coefficients from the Prais-Winsten (generalized least-squares) estimator as a safeguard against autocorrelation. As an additional safeguard against heteroskedasticity, the regression was run using robust standard errors.

Table A1.2 Post-estimation & Other Results

Test	Residential Statistics and Conclusion	
Breusch-Pagan & White Test	Unavailable due to Prais-Winsten method- robust standard errors used as a precaution (White-Huber standard errors)	
Durbin Watson	d-stat = 1.32 (transformed to 1.71)	Not overly distant from 2. Sufficiently close to 2 using Prais-Winsten regression.
Durbin Watson	Unavailable as post-estimation but note that Prais-Winsten method was ultimately used due to a Breusch-Godfrey result with OLS that suggested the potential for autocorrelation	
Prais-Winsten iterations	13	
Rho	0.4330	
AIC	AIC = -189.9	good predictive power relative to other model specifications
R Squared	R^2 = 0.937	acceptable predictive power

Small Business

The regression results and statistical tests performed for these models are summarised in the following tables:

Table A1.3 Regression Output

	Small Business Demand
EDD Coefficient (GJ of Demand per Connection per EDD Unit)	0.0284 (p value = 0.00)
First Lag of Demand per Connection	0.1343 (p value = 0.00)
Constant	23.0954 (p value = 0.00)
No. of observations	119 (119 months)

As with the residential regression analysis, CORE elected to use the coefficients from the Prais-Winsten (generalized least-squares) estimator as a safeguard against autocorrelation. As an additional safeguard against heteroskedasticity, the regression was run using robust standard errors.

Table A1.4 Post-estimation & Other Results

Test	Residential Tariff Statistic and Conclusion	
Breusch-Pagan & White Test	Unavailable due to Prais-Winsten method- robust standard errors used as a precaution (White-Huber standard errors)	
Durbin Watson	d-stat = 1.62 (1.93 transformed)	Sufficiently close to 2 using Prais-Winsten regression
Breusch-Godfrey	Unavailable as post-estimation but note that Prais-Winsten method was ultimately used due to a Breusch-Godfrey result with OLS that suggested the potential for autocorrelation	
Prais-Winsten iterations	7	
Rho	0.189	
AIC	AIC = 408.8	good predictive power relative to other model specifications
R Squared	R^2 = 0.943	acceptable predictive power

Tariff D

For the industrial tariff please refer to the separate Industrial regression analysis provided in Appendix A4 which combines the GSP and GVA based regressions that applied to different sections of those customer groups.

Conclusion

Overall the statistical models for residential, commercial and industrial demand per connection are sufficiently robust- particularly after the shift away from simple OLS. CORE has not relied upon any coefficient that does not meet 5% critical significance.[19] Importantly, the coefficients of the regressors and constant provide an intuitive commercial interpretation in terms of magnitude and sign. The fitted regression and normalisation results also honour historical trends net of monthly or yearly EDD fluctuations.

[19] The 10%, 5% and 1% significance levels are widely considered to be appropriate benchmarks. Test results below or equal to 1% require caution and further investigation. CORE believes no test result presented here invalidates the weather normalisation process undertaken.

A2. Retail Gas and Electricity Price Forecast

Summary of Retail Gas Price Forecast

The retail gas price is assumed by CORE to consist of the cost components outlined in Table A2.1. The price forecast was developed by analysing each of these components- a process in which CORE has significant experience. Gas price forecasting has been completed by CORE for several previous AA reports and in countless other engagements. The bottom-up approach to price forecasting is a comprehensive way to capture all factors that influence final gas prices.

Table A2.1 Components of Retail Gas Price

Cost Component	Units	Description
Variable Cost		
Wholesale	AUD/GJ	The market price of gas realised by the supplier to produce and deliver gas into the transmission pipeline. This is the price for flat load gas production. ▪ Wholesale prices were forecast by analysing the reference and high case from the 2018 AEMO GSOO and the LNG future netback series published by the AER. Additionally, CORE's experience advising large Eastern Australia gas consumers through their procurement processes provides a natural source of validation within the bounds of confidentiality.
MDQ	AUD/GJ	The cost of production (via storage or other production flexibility) to deliver maximum daily supply capacity to meet peak customer demand during the winter heating season.
Transmission	AUD/GJ	Cost of transporting gas along the MSP and EGP transmission pipelines from the supply source to the distribution network. This includes base load and an additional load factor for maximum daily quantity MDQ capacity allowance.
Distribution	AUD/GJ	Cost of transporting gas though the distribution network to the customer- JGN has provided provisional estimated tariffs.
Retail Margin	AUD/GJ	Retailer costs and profit margin- calculated from historical values and then remain largely consistent throughout the forecast period on the assumption that retail markets have reached a relatively mature level of competition and the current level of discounting is a sound representation for future discounting.
Market Charges	AUD/GJ	Cost to cover AEMO market participant fees.
Fixed Cost		
Fixed Retail Supply Charge	AUD p.a.	Annual fixed charge per customer per annum to cover certain fixed costs.

Table A2.2 NSW Residential Retail Gas Price Forecast | AUD Real 2018

Cost Component	Unit	2018	2019	2020	2021	2022	2023	2024	2025
Wholesale	AUD/GJ	8.76	8.81	8.97	9.25	9.25	9.66	9.67	9.71
MDQ	AUD/GJ	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Transmission	AUD/GJ	1.18	1.18	1.18	1.18	1.19	1.19	1.20	1.22
Distribution	AUD/GJ	12.06	11.70	11.07	10.01	9.78	9.54	9.31	9.09
Retail Cost & Margin	AUD/GJ	8.73	8.82	8.91	9.00	9.09	9.18	9.27	9.36
Market Charges	AUD/GJ	0.21	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Total Variable Cost	**AUD/GJ**	**30.27**	**30.89**	**30.50**	**29.82**	**29.68**	**29.95**	**29.83**	**29.77**
Fixed Supply Charge | Incl. GST	**AUD**	**194.73**	**192.54**	**192.46**	**192.46**	**192.46**	**192.46**	**192.46**	**192.46**
Retail Bill | Real 2018	**AUD**	**830**	**841**	**833**	**819**	**816**	**821**	**819**	**818**
Absolute Change in Retail Bill	**AUD**	**27**	**11**	**(8)**	**(14)**	**(3)**	**6**	**(3)**	**(1)**

Percentage Change in Retail Bill	%	**3.38%**	**1.32%**	**-0.99%**	**-1.72%**	**-0.35%**	**0.69%**	**-0.32%**	**-0.16%**

Source: JGN, CORE

Table A2.3 NSW Commercial Retail Gas Price Forecast | AUD Real 2018

Cost Component	Unit	2018	2019	2020	2021	2022	2023	2024	2025
Wholesale	AUD/GJ	8.76	8.81	8.97	9.25	9.25	9.66	9.67	9.71
MDQ	AUD/GJ	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Transmission	AUD/GJ	1.09	1.09	1.09	1.09	1.09	1.10	1.10	1.11
Distribution	AUD/GJ	10.29	9.76	9.23	8.36	8.16	7.96	7.77	7.59
Retail Cost & Margin	AUD/GJ	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Market Charges	AUD/GJ	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total Variable Cost | Excl. GST	**AUD/GJ**	**23.42**	**22.95**	**22.58**	**21.98**	**21.79**	**22.01**	**21.83**	**21.70**
Fixed Supply Charge | Incl. GST	**AUD**	**198.01**	**195.79**	**195.71**	**195.71**	**195.71**	**195.71**	**195.71**	**195.71**
Retail Bill | Real 2018	**AUD**	**4,508**	**4,419**	**4,350**	**4,240**	**4,205**	**4,245**	**4,212**	**4,188**
Absolute Change in Retail Bill	**AUD**	**322**	**(89)**	**(69)**	**(110)**	**(35)**	**40**	**(33)**	**(24)**
Percentage Change in Retail Bill	%	**7.69%**	**-1.97%**	**-1.55%**	**-2.53%**	**-0.82%**	**0.95%**	**-0.78%**	**-0.57%**

Source: JGN, CORE

Summary of Retail Electricity Price Forecast

Table A2.4 NSW Residential Historical Retail Electricity Price | AUD Real 2018

	2010	2011	2012	2013	2014	2015	2016	2017
Retail Bill | Real 2018	953	1,139	1,242	1,329	1,338	1,003	927	1,198
Percentage Change | %		19.60%	8.97%	7.01%	0.68%	-25.01%	-7.60%	29.30%

Source: AEMC; AEMO NEFR

Table A2.5 NSW Commercial Historical Retail Electricity Prices | AUD Real 2018

	2010	2011	2012	2013	2014	2015	2016	2017
Retail Bill | Real 2018	4,500	5,500	6,500	7,500	7,200	6,800	6,400	6,000
Percentage Change | %		22.22%	18.18%	15.38%	-4.00%	-5.56%	-5.88%	-6.25%

Source: AEMC; AEMO NEFR

Forecast

The forecast electricity bill for Residential and Small Business consumers is derived from the AEMC 2018 electricity price trends publication and AEMO NEFR price forecasting. The following factors are key drivers for both price forecasts:

- Recent large closures such as Hazelwood are to be followed by significant renewables growth and the return to service of Swanbank E power station. Overall the competitive market costs (wholesale and retail margin component) are forecast to fall.

- Regulated network costs are likely to remain at the levels set to 2019 although prices for this next regulatory period have not yet been determined.

The table below summarises the forecasts for residential & commercial electricity bills adjusted to real 2018 values and their respective year on year percentage changes.

Table A2.6 NSW Forecast Retail Electricity Price | AUD Real 2018

	2018	2019	2020	2021	2022	2023	2024	2025
Residential Retail Bill | Real 2018	1,395	1,298	1,204	1,213	1,213	1,213	1,213	1,213
Percentage Change | %	16.41%	-6.95%	-7.26%	0.75%	0.00%	0.00%	0.00%	0.00%
Commercial Retail Bill | Real 2018	6,450	6,934	7,454	7,417	7,379	7,343	7,306	7,269
Percentage Change | %	7.50%	7.50%	7.50%	-0.50%	-0.50%	-0.50%	-0.50%	-0.50%

A3. Price Elasticity of Demand Analysis

Introduction

CORE notes that it is nationally and internationally recognised that a material movement in the price of a good such as gas, is likely to cause some degree of movement in the level of demand for that good or service- 'own-price elasticity of demand'. Further, CORE notes that it is well recognised that a material movement in the price of a good or service (electricity) is likely to cause some degree of movement in the level of demand for a close substitute good or service (gas) – 'cross-price elasticity of demand'. These relationships have been accepted by the AER in prior AA final and draft decisions (and the ERA in equivalent Access Arrangement processes in Western Australia). For the reasons above, CORE has derived a forecast of both own-price and cross-price elasticity of demand for gas in the JGN over the AA Review period.

Approach

CORE has undertaken an assessment of the alternative approaches available to derive an estimate of the price elasticity of gas demand within the JGN, including research of approaches adopted nationally and internationally. CORE is of the opinion that the preferred approach would involve an observation of actual demand response to actual price movements over a statistically relevant period. There is not an acceptable dataset that corresponds to the circumstances of the Review Period meaning it is not possible to apply such an approach. Nonetheless CORE did conduct econometric analysis using historical JGN data, but the datasets contained significant variability and no statistically rigorous results were achieved. CORE is of the opinion that the best estimate, under the circumstances, will be derived by applying a rigorously determined elasticity factor against a detailed assessment of future gas and electricity prices in NSW during the Review Period. CORE has undertaken an extensive review of historical AA's and empirical studies relating to price elasticity of demand generally, and in relation to gas and electricity more specifically.

The two price elasticity factors CORE has quantified are:

- Own-price elasticity (the change in gas demand resulting from a change in the price of gas); and
- Cross-price elasticity (the change in gas demand resulting from a change in the price of a substitute energy source - electricity).

CORE's analysis has considered:

- The results of third-party analysis via an international literature review regarding price elasticity factors; and
- The range of price elasticity factors previously accepted by the AER and ERA in prior AA's.

CORE is of the opinion that the listing of own price and cross-price elasticity factors, which are summarised in Table A3.1 and Table A3.2 provide a reasonable basis for deriving an estimate of the price elasticity of demand for gas in the JGN.

Table A3.1 Price Elasticity of Gas Demand – Literature Review.

Date	Study	Country	Author / Source	Own Price Elasticity of Gas Demand	Cross-Price Elasticity of Gas Demand
1987	Residential gas demand	US	Herbert	-0.30 (Short run)	0.10 (short run)
1999	Gas demand forecast and transmission and distribution tariffs	Australia	Harman et al	-0.54 (Short run) -0.65 (Long run)	N/A
2004	The ex-post impact of an energy tax on household energy demand	Netherlands	Berkhout et al	-0.19 (Short run) -0.44 (Long run)	N/A
2005	Regional differences in the price-elasticity of demand for energy	US	Bernstein, Griffin	-0.12 (Short run) -0.36 (Long run)	0.11 (electricity price of previous year)
2010	Residential demand of gas and electricity in the US	US	Alberini et al	-0.552 (Short run) -0.693 (Long run)	0.15 (Long run)
2011	Residential gas demand	US	Payne, Loomis, Wilson	-0.264 (Long run)	0.123 (Long run)

Source: Third party expert reports and analysis

Table A3.2 Price Elasticity of Gas Demand – Prior AER Submissions.

Period	Network	Source	Own Price Elasticity of Demand	Cross-Price Elasticity of Demand
2013-17	Multinet (VIC)	NIEIR	-0.28 (all customer segments)	N/A
2011-16	Envestra (SA)	NIEIR	-0.30 (residential, long-run) -0.35 (industrial, long-run)	N/A
2013-17	Ausnet (VIC)	CIE	-0.17 (residential, long-run) -0.77 (commercial, long-run)	N/A
2013-17	Envestra (VIC, Albury)	CORE	-0.30 (residential, long-run) -0.35 (non-residential, long-run)	N/A
2015-2020	Jemena (NSW)	CORE	-0.30 (residential, long-run) -0.35 (non-residential, long-run)	0.1
2016-2021	ActewAGL (ACT, Palerang, Queanbeyan)	CORE	-0.30 (residential, long-run) -0.35 (non-residential, long-run)	0.1
2016-2021	AGN (SA)	CORE	-0.30 (residential, long-run) -0.35 (non-residential, long-run)	0.1

Source: Access arrangement demand forecast submissions.

Own Price Elasticity

CORE has adopted a long-term price elasticity factor which is consistent with Envestra's 2011-16 regulatory submission for South Australia, as prepared by NIEIR and accepted by the AER. This elasticity falls within the AER's accepted range as outlined in its Final Decision:

"*NIEIR's assumed long run price elasticity appears to be consistent with those produced by other studies. However, the AER acknowledges the limitations of this comparative analysis due to geographical factors and time differences. For this reason, it has performed a regression analysis to estimate price elasticity based on historical average residential demand data, the real retail gas price index, and ABS real household disposable income per capita data to compare against NIEIR's estimate. The regression analysis produced an indicative estimate for long run price elasticity of -0.41, with a 95 per cent confidence interval for the estimate range from -0.23 to -0.58.*"

As NIEIR's estimate is broadly in line with the range of the estimates obtained in other studies and the AER's own indicative estimate, the AER considers that the assumed long run Residential price elasticity of -0.30 is reasonable and CORE believes this represents the best estimate possible in the circumstances.[20] Given the price elasticity factors used for Envestra's SA network, reference values of -0.30 (Residential) and -0.35 (Small Business) as long-run elasticity factors were used for the final demand forecast model as shown in the following table.

Table A3.3 Own Price Elasticity.

Market Type	Reference
Residential	-0.30
Small Business	-0.35

Source: AER Final Decision, Envestra Limited Access Arrangement Proposal, SA Gas Network 2011 –16.

The interpretation of these elasticity factors is that for every percentage increase in retail gas price, gas demand will decrease by 0.30 percent (0.35 percent for Small Business customers). These long-run elasticity factors are a summation of the individual price elasticity factors, which are applied as shown in the table below. Demand impacts are highest in the year of the price change for Residential demand and the year after the price change for Small Business demand.

These price elasticity factors originate from Envestra's (now AGN) gas demand forecasts for the 2013-2017 Victorian AA submission, and further perpetuated in the development of gas demand forecasts for Jemena's 2015-2020 New South Wales AA submission, more recently ActewAGL's (now Evoenergy) 2016-2021 ACT, Palerang and Queanbeyan and AGN's 2016-2021 South Australian AA submissions.

In the context of energy markets, this has been observed for the impact of electricity prices and AEMO states the following regarding the asymmetric response;

'*Consumer response to changes in electricity prices is asymmetric. While consumers may reduce demand in response to price rises, they do not necessarily revert to previous levels of demand when prices later fall, due to permanent changes in behaviour, or momentum. To reflect this, AEMO applied a Maximum Price Model which assumes that rather than responding to the carbon price repeal, customers will continue to respond to the highest prices they have experienced in recent years'.*[21]

Table A3.4 Price Elasticity Factors.

Elasticity	Residential	Small Business
Δp(t)	-0.13	-0.06
Δp(t-1)	-0.08	-0.16
Δp(t-2)	-0.05	-0.09
Δp(t-3)	-0.03	-0.03
Δp(t-4)	-0.01	-0.01
Total	**-0.30**	**-0.35**

These short-run elasticity factors are applied to the annual real increase in gas prices to arrive at the own-price elasticity impact in each year, for each customer segment, as summarised below.

[20] AER, *Final Decision*: *Envestra Limited Access Arrangement Proposal for the SA Gas Network 1 July 2011 – 30 June 2016*, June 2011, p103.

[21] AEMO, *Forecasting Methodology Information Paper, National Electricity Forecasting Report 2014,* July 2014. p. 12

Table A3.5 Own Price Elasticity Impact on Demand

Own Price Elasticity Impact on Demand (%)	2019	2020	2021	2022	2023	2024	2025
Residential							
Change in Gas Prices	1.32%	-0.99%	-1.72%	-0.35%	0.69%	-0.32%	-0.16%
Price Elasticity Impact (-0.30)	-0.38%	-0.22%	0.11%	0.16%	0.04%	0.06%	0.04%
Small Business							
Change in Gas Prices	-1.97%	-1.55%	-2.53%	-0.82%	0.95%	-0.78%	-0.57%
Price Elasticity Impact (-0.35)	-1.00%	-0.26%	0.36%	0.58%	0.36%	0.06%	0.13%

Cross-Price Elasticity

CORE acknowledges that cross-price elasticity has not been addressed widely in prior AA reviews. However, in the recent AGN SA AA and ActewAGL (now Evoenergy) ACT Palerang and Queanbeyan AA, the cross-price elasticity of 0.10 has not been disputed.

Based on CORE's analysis, an assumed long run elasticity of 0.10 for both Residential and Small Business customers is deemed reasonable, and the impact is shown in the table below. The interpretation of the elasticity factor is that for every percentage increase in retail gas price in a given year, demand for electricity will increase by 0.10 percent in that year. Alternatively, for every percentage increase in electricity price, gas demand will increase by 0.10 per cent. These price elasticity factors are applied to the forecast annual real increase in electricity prices to arrive at the cross-price response for each customer segment as summarised below.

Table A3.6 Cross-Price Elasticity Impact on Demand

Cross-Price Elasticity Impact on Demand (%)	2019	2020	2021	2022	2023	2024	2025
Residential							
Change in Electricity Prices	-6.95%	-7.26%	0.75%	0.00%	0.00%	0.00%	0.00%
Price Elasticity Impact (0.10)	-0.69%	-0.73%	0.07%	0.00%	0.00%	0.00%	0.00%
Small Business							
Change in Electricity Prices	7.50%	7.50%	-0.50%	-0.50%	-0.50%	-0.50%	-0.50%
Price Elasticity Impact (0.10)	0.75%	0.75%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%

A4. Tariff D GVA Regression Results

As part of the demand forecast for JGN Tariff D, regression analysis was performed on historical demand volumes and sector output measured by ‘Gross Value Add’ (“**GVA**”) as published by the Australian Bureau of Statistics. Additional tests using New South Wales historical GSP was also tested. As discussed in the methodology section, the balance of the Tariff D group comprises sectors exhibiting weather-induced demand patterns. Historical demand for these groups was amalgamated and weather normalised.

All three species of regression analysis are detailed here in turn.

Annual Demand versus GVA

This part of the forecast incorporated any change to industrial gas demand that occurs due to a projected change in sector output. Industrial customers were classified by ANZSIC 2006 divisional structure. Historical demand for each industry segment was regressed against historical GVA using several different models. The four models are listed below followed by the regression output table:

1. $Demand = \beta_0 + \beta_1 \, GVA$
2. $log \, Demand = \beta_0 + \beta_1 \, log \, GVA$
3. $log \, Demand = \beta_0 + \beta_1 \, log \, GVA_{t-1}$
4. $log \, Demand = \beta_0 + \beta_1 \, log \, GVA_t + \beta_2 \, log \, GVA_{t-1}$

Overall, 4 sectors showed statistically significant relationships between annual gas demand and sector GVA:

- Wholesale Trade
- Accommodation and Food Services
- Education and Training
- Arts and Recreation Services

The following table shows which model was ultimately selected for the forecast and what significance level was observed.

Table A4.1 Economic Outlook | Historical GVA and Gas Demand Regression Results

Industry Sectors	Model Selected	B_1 coefficient
Other Services	$log\_ACQ = B_0 + B_1(log\_GVA)$	1.1272**
Accommodation and Food Services	$log\_ACQ = B_0 + B_1(log\_GVA)$	0.9825 **
Education and Training	$log\_ACQ = B_0 + B_1(log\_GVA)$	1.1860**
Arts and Recreation Services	$log\_ACQ = B_0 + B_1(log\_GVA)$	2.1589**

** Significant at the 5% level
* Significant at the 10% level

CORE excluded GVA regression analysis where the following trends were observed:

- Results did not have appropriate levels of statistical significance.
- Negative coefficients (implying an inverse relationship between GVA growth and gas demand) were observed and hence could not be interpreted logically from a commercial standpoint.
- ANZSIC sector consisted of a small number of customers rather than a significantly large group.
- Sectors with a pronounced weather-induced demand pattern were assigned to a weather normalised trend given these customers rely on gas for space and water heating.

To complete the forecast for customers in the four sectors above, the historical growth rate of GVA was regressed on NSW Real GSP. The resulting statistically significant coefficient was then applied to the NSW Treasury's Real GSP forecast to arrive at a forecast of sector GVA. The b1 regression coefficients from the previous table could then be applied to this forecast GVA.

GSP and Average Trend Analysis

A handful of sectors did not exhibit statistical relationships with GVA and do not have obvious weather-induced demand patterns. These customers were grouped, and historical demand was regressed against State Output (GSP) on the hypothesis that their demand is based on production levels which could be driven by economic activity generally. Across several statistical models this relationship was not statistically proven, however. It is likely that gas demand for these customers is driven by other factors and possibly specific to individual customers or influenced by a handful of large customers. CORE has honoured the historical average decline of -0.84% for the ACQ forecast of this residual group:

- Agriculture, Forestry & Fishing
- Mining
- Manufacturing
- Electricity, Gas, Water and Waste Services
- Construction
- Retail Trade
- Information Media and Telecommunications
- Other Services

One ANZSIC sector (Agriculture, Forestry & Fishing) demonstrated a reliable statistical relationship with GSP and hence ACQ has been forecast using the historical average percentage change in demand given a percentage change in GSP.

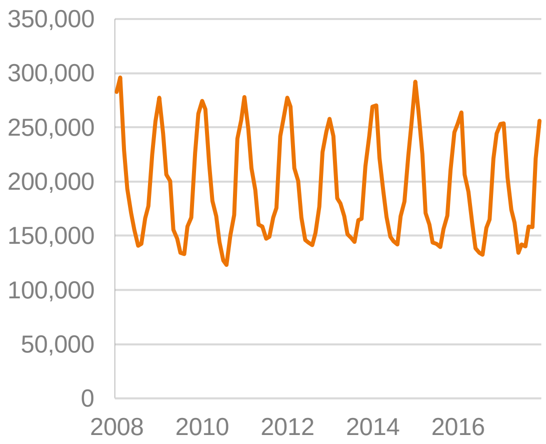
Tariff D Weather Normalisation Group

The following sectors exhibited clear weather-induced demand patterns and hence CORE has captured appliance efficiency and fuel switching trends in the space and water heating markets. Realistically, this is the approach taken for the Small Business customer group with which this group of industrial customers has significant overlap, albeit on a moderately different scale of demand.

Weather Normalisation Sectors:

- Financial and Insurance Services
- Rental, Hiring and Real Estate Services
- Professional, Scientific and Technical Services
- Administrative and Support Services
- Public Administration and Safety
- Transport, Postal and Warehousing
- Health Care and Social Assistance

Historical Weather-Induced Demand Patterns (Actual Monthly, GJ)



Normalised versus Actual ACQ per Customer | GJ[22]

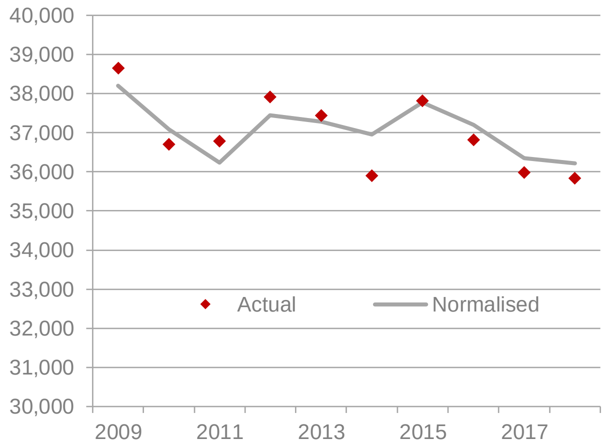


Table A4.2 Regression Output

	Tariff D Weather Group Demand
EDD Coefficient (GJ of Demand per EDD Unit)	233.6782 (p value = 0.00)

[22] Please note that only customers that existed within the network during the 2009-2018 period were included so as to avoid bias from customers joining or leaving during the sample period.

First Lag of Demand	-0.0957 (p value = 0.00)
Constant	134,243 (p value = 0.00)
No. of observations	119 (119 months)

As per Tariff V regression analysis, CORE elected to use robust standard errors, as an additional safeguard against heteroskedasticity.

Table A4.3 Post-estimation & other results

Test	Tariff D Weather Group Statistics and Conclusion	
White Test	Robust standard errors used as a precaution (White-Huber standard errors)	
Durbin Watson	d-stat = 1.58	Sufficiently close to 2
AIC	AIC = 2150.483	good predictive power relative to other model specifications tested
R Squared	R^2 = 0.9634	acceptable predictive power

A5. Appliance, Efficiency and Energy Mix Trends

The following paragraphs contain analysis for the various factors that continue to drive demand per connection. These factors include:

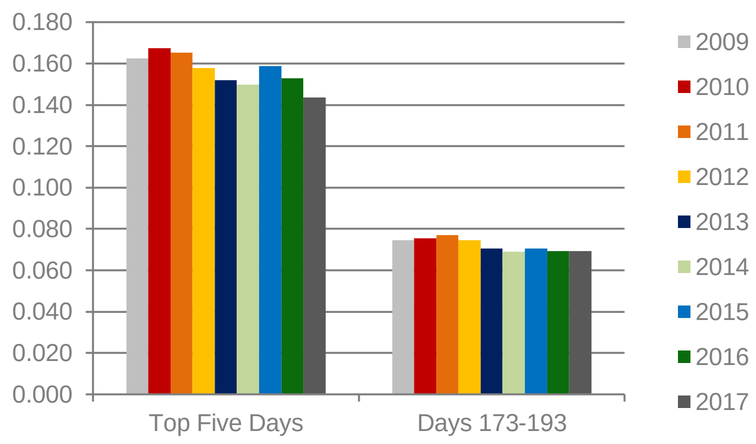
- appliance efficiency
- dwelling efficiency and dwelling type
- competition from other energy sources and fuel switching

These factors give rise to some of the observed trends and projections within CORE's forecast. Typically, data for these factors is not comprehensive enough for rigorous statistical analysis with network demand data; however, the combined effect of these drivers is captured by the historical annual average growth rates identified by CORE. The qualitative and quantitative evidence for these factors is presented below and justifies why it is likely for the combined effect of these factors to maintain the trends experienced since 2009.

Forecast Context

As discussed in the main body of this report, the Tariff V group is exhibiting a persistent long-term decline in demand per connection. CORE has analysed the daily Tariff V data (combined Residential and Small Business) to assess whether this downward trend is also holding for peak and median days. The following chart contains some key results;

Average Tariff V Demand per Connection (by Calendar Year) | GJ/ connection/ day



- The peak demand per connection is trending downward- represented by the average demand per connection across the 5 highest days each year. CORE assumes that weather does not have an impact between years as the 5 highest days should generally represent a year's most significant EDD events and hence maximum appliance usage.
- The median band of demand per connection is also trending downward as would be expected given that weather normalised average demand per connection is also declining.
- The use of 5 and 20 days at the peak and median is to reduce the impact of any outliers.
- Please note calendar years have been used for this analysis to extend the observation period to CY2008 and also increase available data points.

- CORE notes that several large over-consuming Small Business customers are impacting 2016/2017. These customers represent over 6% of Small Business volume between only 66 customers. Removing these customers from future peak/median calculations will only increase the downward trend.
- The charts above underpin the conclusion that appliances and dwellings are becoming more efficient with their energy demand and gas demand is falling even when appliance usage is at its highest. This suggests that gas may be losing share in the heating market (i.e. gas connections remain but there may be higher incidence of customers using gas for cooking or water heating only rather than space heating which requires a larger amount of energy). The following sections evaluate evidence and reasons for efficiency gains and gas' market share across major usage types.

New South Wales Energy Use Trends

The most significant uses of gas for Australian households are space heating, water heating and cooking. Data released by the ABS shows that gas space heating appliances are losing market share as growth in electricity and solar energy occurs.[23]

The table below illustrates an increase in the number of New South Wales households that now use electricity for their main heating purposes and solar for hot water heating. Unlike other Australian jurisdictions in this timeframe, gas showed an increase in space heating market share also. However, this coincided with around 10% of households switching from wood and other heating sources which suggested the growth of gas heating was driven by network expansion and access to distribution networks whereas growth in electricity was fed by fuel switching and new builds (virtually all dwellings are built with an electricity connection). The fuel switching activity is likely due to the increase in RC air-conditioning penetration. Consumers are likely to favour the convenience of a single appliance that has two functions, cooling and heating.

The market share for solar water heating has increased from 5.0% to 8.5% between 2008 and 2014 which also represents competition for gas although market share increased over this period particularly as solar rebate programs were removed and/or associated financial incentives reduced.

Table A5.1 New South Wales Energy Use | % of Households

Energy Use	2008	2011	2014
Electricity main source for heating	43.1	44.0	44.3
Gas main source for heating	21.2	22.4	24.8
Gas energy for hot water (includes gas boosting)	23.9	26.4	29.1
Solar used for hot water system	5.0	6.8	8.5

Source ABS, 2008, 2011, 2014

[23] ABS, *4602.0.55.001 - Environmental Issues: Energy Use and Conservation*, Mar 2014.

Table A5.2 Sydney Energy Use | % of Households

Energy Use	2008	2011	2014
Electricity main source for heating	48.0	47.1	48.8
Gas main source for heating	18.7	22.1	23.1
Gas energy for hot water (includes gas boosting)	31.0	32.4	35.1
Solar used for hot water system	3.9	4.0	6.0

Source ABS, 2008, 2011, 2014

A widely sourced study entitled Are We Still Cooking with Gas? conducted by Renew (formerly the Alternative Technology Association) and supported by the ECA (formerly the Consumer Advocacy Panel) found that houses already connected to the gas network could steadily withdraw from using gas for space heating in favour of using reverse cycle air conditioners, on economic grounds. An updated publication from Renew advocates all-electric appliances for new households and fuel switching away from gas in several other situations.[24]

As shown by the statistics above, the role of gas in the water heating market is growing steadily. This is consistent with the growth in medium and high-density dwellings where centralised hot water systems ensure that 100% of associated dwellings in that development are captured (or face having no hot water). Typically, many new high-rise developments are not configuring gas connections to each dwelling meaning no cooking or space heating load is possible. Overall, energy usage trends show that electricity and solar appliances represent a fuel switching risk although gas has maintained and at times increased its market share suggesting that appliance and dwelling efficiency is having a greater impact on demand per connection.

Key Policy

There are a range of Federal and State Government initiatives in place that are expected to have an impact on future gas demand. These include, but are not limited to:

- BASIX Building Program and its interface with NatHERS energy star rating building standards;
- various labelling/ standards, rebate and incentive schemes favouring renewable energy and energy efficiency.

Although it is possible to determine whether a specific policy is expected to increase, decrease or have no effect on gas demand in a qualitative sense, quantifying the effect poses a significant challenge due to the lack of adequate and consistent data. As a result, the following section focuses on a qualitative assessment of the impact of energy policy initiatives.

Dwelling Efficiency | BASIX and NatHERS

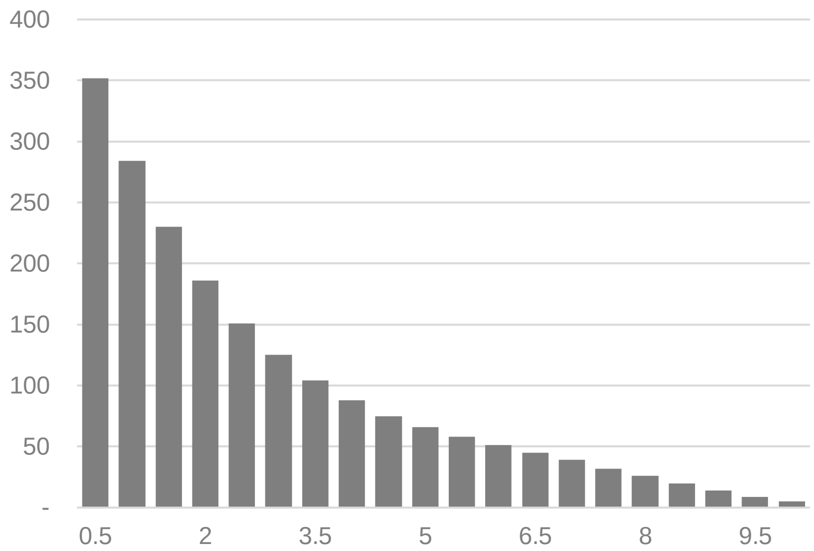
BASIX is implemented under the Environmental Planning and Assessment Act and applies to all residential dwelling types as part of the development application process in NSW. The BASIX assessment evaluates development plans against sustainability targets including energy and water consumption. Any new homes or alterations greater than AUD 50,000 in value are subject to the program.

[24] Household fuel choice in the NEM, June 2018, Renew.

The new (July 2017) BASIX targets impose a 5.5-6.0-star NatHERS equivalent rating in its thermal comfort targets, depending on dwelling location.

Based on NatHERS Star Band analysis, a standard Sydney home is expected to use 22.7% less energy for temperature control when moving from a Star Rating of 5 to 6 (see figure below). This implies a significant reduction in the gas demand of new or altered homes during the forecast period.

Energy Use (Vertical Axis, MJ/M2) by Star Rating (Horizontal Axis)



Source: NatHERS; Starbands.

The impact of BASIX and NatHERS standards occurs with each new dwelling and alteration. Given that the standards are continually being revised (as recently as 2017), CORE expects continued impacts of improvements in household energy efficiency on residential gas demand per connection.

BASIX Key developments:

- July 2007
  - Threshold of build/alteration value set to AUD 50,000- BASIX applies above this minimum.
- March 2009
  - Thermal comfort section aligned to NatHERS software
- March 2010
  - IPART review yields revised targets
- July 2011
  - Fee introduced for BASIX certification (New homes only)
- November 2011
  - Fees extended to alterations
- July 2017

- Energy targets increased

Other Labelling, Standards and Efficiency Policies

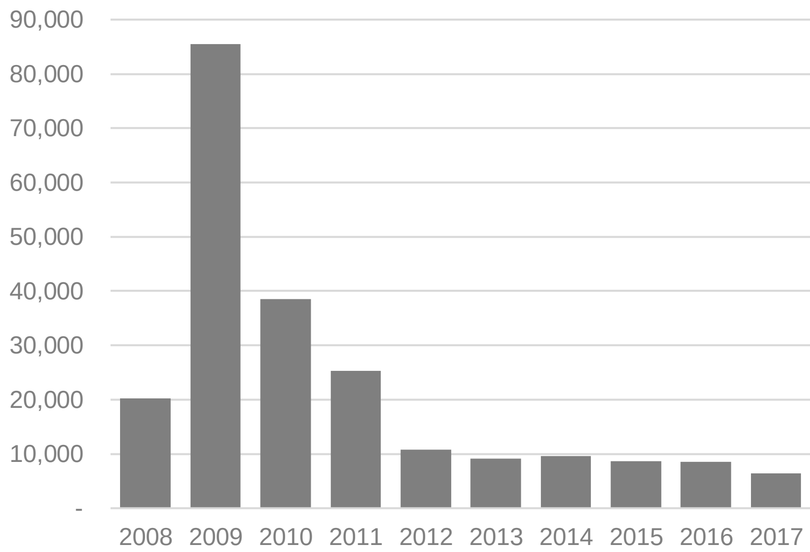
The following policies also contribute to energy efficiency and/or fuel switching.

Policy	Description	Impact on Gas Demand
Energy Rating Label	▪ Every new household appliance displays energy rating and typical consumption allowing the consumer to easily observe the efficiency of an appliance before purchasing	▪ Underpins the continued appliance efficiency increases ▪ Increased visibility has also incentivised appliance manufacturers to develop more efficient appliances
Smarter Choice Program	▪ Information provided to consumers about energy usage and efficiency across different appliance choices	▪ Similar impact to the energy rating label program above
Small-scale Renewable Energy Scheme	▪ Financial incentives via certificates for renewable energy appliance installations such as solar	▪ Fuel switching risk fell once rebates were removed or lessened- refer section below.

Solar Hot Water and Heat Pumps

During the first part of the historical period, a significant rebate program was in place to give a financial incentive to NSW households for the purchase and usage of solar hot water and heat pump appliances. As shown in the following chart, the solar hot water installations peaked around the introduction of this rebate and then lost momentum. This reflects the ABS data which shows gas increasing market share in the hot water market. CORE believes that in the absence of any new direct program, solar hot water is unlikely to significantly erode gas' market share. CORE review has not identified any such policy announcement and notes broader indirect policies (such as the SRES) have not had a significant impact. There is a downside risk however as energy policy is not settled at a federal level and future national energy policies could promote solar and heat pump appliances.

Solar Water Heater Installations | No.



Shift to Electricity & Alternate Energy

CORE has reviewed several other factors that present a downside risk to residential and commercial connections (and potentially volume per connection. Emerging and renewable technologies are heavily weighted towards electricity which could act to erode gas' share of the energy mix.

Solar PV and battery storage/ microgrid configurations have the potential to drive households towards electric appliances to magnify the savings made in such technology. CORE expects the impact of such technology to be significant but gradual. The greatest risk to gas occurs during appliance switch-out at the end of economic life. Given heating appliances can operate well beyond 10 years, the switch-out influence is unlikely to present a significant risk before the end of the forthcoming AA period. However, there is still a moderate risk that substitution of gas appliances will begin to occur prior to 2025.

Alternative	Trend	Impact on Gas Demand
Microgrids	▪ Pilot Projects beginning to occur in Northern Regions (re Enova Energy) ▪ Microgrids are autonomous grids which can operate off-grid or connected to existing grids and which can combine different assets and loads. ▪ These networks connect, and coordinate power sources and loads distributed over a small area.	▪ Potential long-term impact, within assessment period it is unlikely as microgrids currently are focused on communities outside of JGN.
PV and Battery	▪ Australian Energy Council analysis suggests Rooftop PV generation increased by 29.2% in 2017 (total of 2,225 GWh) ▪ Competitive reduction in pricing for PV makes it a viable alternative for new buildings.	▪ Decrease in gas demand but delayed by slow appliance switch-out rates of household appliances
High Density Living	▪ 65+ population increasing, potentially moving to newer, clustered living as requirements change. ▪ High density living is trending to smaller floor area, and higher energy efficiency standards.	▪ Reduction in demand related to space heating primarily.

A6. Additional Commercial and Residential Regression Results

The following section provides a summary of additional regression analysis that was completed for the forecast. In the interests of transparency, excluded functional forms and regressors are listed below:

Forecast Component	Variable	Description	Result
Residential Demand per Connection	NSW Household Income	2009-2018 annual data; various structural models including lagged variables and time period dummies.	P value >0.05 and/or non-intuitive negative coefficient whereby economic theory does not support decreased gas demand when income increases.
	NSW State Final Demand	2009-2018 annual data; various structural models including lagged variables and time period dummies.	P value >0.05 and/or non-intuitive negative coefficient whereby economic theory does not support decreased gas demand when state demand increases.
Small Business Demand per Connection	NSW GSP	2009-2018 annual data; various structural models including lagged variables and time period dummies.	P value >0.05 and/or non-intuitive negative coefficient whereby economic theory does not support decreased commercial sector energy demand when state output increases.
	NSW State Final Demand	2009-2018 annual data; various structural models including lagged variables and time period dummies.	P value >0.05 and/or non-intuitive negative coefficient whereby economic theory does not support decreased commercial sector energy demand when state demand increases.

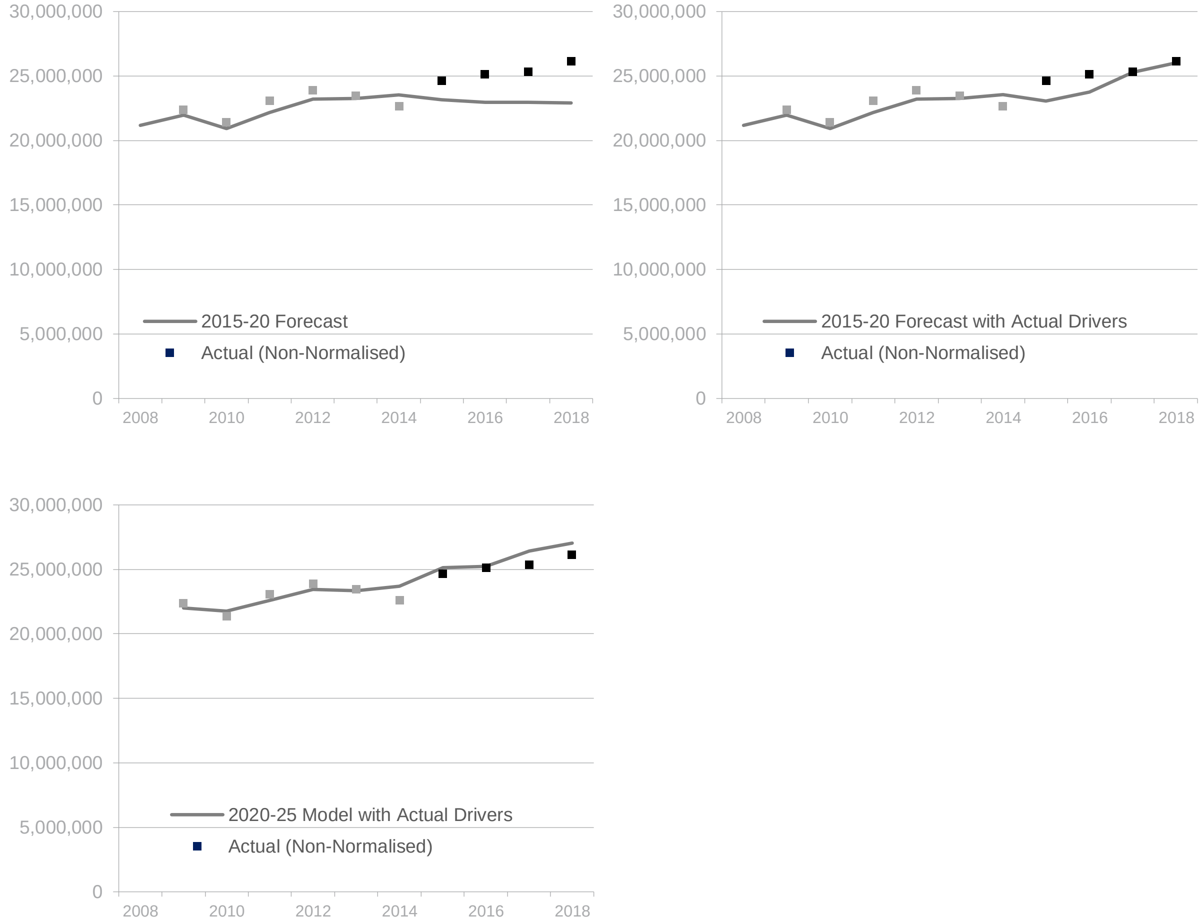
A7. Additional Validation & Review of Previous AA

As part of the AA 2020-2025 demand forecast, CORE has completed a back-cast modelling exercise to review the previous 2015-2020 residential forecast against updated actual observations and assess whether the current methodology is providing a bias-free estimate of future demand.

The process and methodology occurred as follows:

- Compare the original 2015-2020 forecast against the actual observation for 2015-2018
- Populate the 2015-2020 forecast with known actual drivers (e.g. price and dwelling completions) and compare the back-cast values with the 2015-2018 historical observations
- Lastly, use the 2020-2025 Model with known actual drivers and back-cast the 2015-2018 period- to assess structural bias

Summary Results of Back-cast Modelling | Residential Demand, GJ



Key observations and enhancements to methodology in the current forecast:

- Connections and demand per connection exceeded the forecast during the 2015-2018 period
- This has resulted in a combined demand forecast which exceeded the 2015-2020 forecast.
- The major reasons for the difference are as follows:

- The 2015-2020 model overestimated appliance and dwelling efficiency gains
- The 2015-2020 revised model used a fitted approach and ultimately overestimated the impact of future retail gas prices
- The 2015-2020 revised model featured a third-party dwelling completions forecast that underestimated the ultimate growth of the NSW property boom. CORE acknowledges the considerable uncertainty of housing growth projections at the time of the forecast
- Final retail prices did not increase as significantly as what was predicted. Furthermore, the fitted statistical approach that was applied at the final, revised stage has overestimated the impact of retail gas prices. CORE completed a similar statistical process for the current forecast but found the data series to be too volatile to apply a fitted approach with requisite statistical significance. CORE's revised approach has applied the most relevant/accepted econometric theory of price impacts rather than an econometric result based on available data.

- For the underlying historical trend, CORE notes that its revised econometric program (helped in part by 2015-2018 data points) is resulting in a forecast underlying growth trend closer to what was observed during 2015-2018. The original 2015-2020 model featured a moderately more aggressive efficiency trend which overestimated the actual fall in demand. The overall methodology used in the current draft model is broadly similar but more recent enhancements include an expanded econometric program that includes more post-estimation and corrections for issues such as autocorrelation.
- There has been substantial growth in high-density connections as part of a State housing boom, the magnitude of which was underestimated in the third-party (BIS Shrapnel) forecast series. Water heating will typically assume a larger role in the consumption per dwelling of these connection types. This gas usage also has a slower efficiency trend given that dwelling efficiency does not have an impact (only driven by appliance efficiency). As this gas usage and dwelling type combination becomes more prominent in the network, CORE expects the efficiency trend to slow somewhat.
- The latest ABS and HIA data show that the sharp increase in dwelling activity has plateaued and began to trend back towards long term averages. CORE is confident that its lower new connections forecast reflects key lead indicators such as dwelling approvals and commencements as published by the ABS and reflected by the HIA forecast.
- Model structure: In addition to the inputs described above, the revised model structure is improving the forecast accuracy. CORE now includes a 2yr ramp-up of new customer demand (in-line with observed historical trend) and a more granular structure which forecasts new connections and demand per connection for each connection type.

Importantly, CORE's current methodology and approach for the AA 2020-2025 forecast features the following enhancements:

- Increased data granularity & structure
  - The forecast now features a significantly more granular data set across individual connection types. The previously combined category of "Medium and high-density" is now divided into medium density, individual high-rise and boundary high-rise.
  - This has increased accuracy across connections growth and demand per connection given the individual trends contained within each of these connection types.
  - Furthermore, CORE has analysed how new/joining customers typically ramp-up gradually over 2 years after joining the network. This revised step in the forecast will help capture this ramp-up impact in the new customer group and more precisely forecast the consumption path from part-year joining customer, to new first year customer, and finally to a mature customer.

  - The underlying growth trends of the new customers have also been more accurately forecast according to the trend of their own connection type. Crucially, HRVI connections have exhibited a significantly less aggressive decline in demand per connection and this is now honoured in the 2020-2025 forecast.
  - The HRVI connections growth experienced from 2015-2018 has amplified the importance of this enhancement in the 2020-2025 forecast.
- Increased time series incorporating a substantial, recent macroeconomic event
  - The 2015-2018 period featured record NSW housing growth and changes to dwelling type composition. CORE's connections forecast is now able to incorporate the demand influence of this event and the third-party dwellings forecast will have accounted for the impact and benefits from a relatively lower level of housing growth uncertainty compared to the 2015-2020 forecast.
  - CORE acknowledges that it is now equally crucial to forecast the correction in dwelling completions (as it was to reflect the increase for the 2015-2020 forecast). However, there is a broad consensus that completions activity has reached the end of the growth phase and has begun trending back towards long term averages. Key lead indicators discussed in the previous section support this.
  - There is broad consensus between the HIA forecast CORE is now relying on, the ABS lead indicators mentioned above and other broader public domain review (including but not limited to housing loan activity and loan conditions, third party statements and forecasts across the financial and construction sectors, and NSW DPE projections).
- Price elasticity that honours established econometric theory
  - CORE's forecast explored a fitted price impact but ultimately omitted this input in favour of AA precedent methodology.[25] There was significant volatility and "noise" in the available data, and this resulted in statistical significance that fell below critical levels. As shown in the summary charts above, the revised methodology performs better in the 2015-2018 back-cast.

[25] Methodology now consistent with that approved in the most recent AA demand forecasts submitted for AGN (VIC), Envestra (SA), ActewAGL (ACT, now Evoenergy).