Gas consumption forecasts for JGN

Final report for JGN | 9 January 2025

1 Introduction

On 29 June 2024, Jemena Gas Networks (NSW) Ltd (JGN) submitted its Access Arrangement (AA) proposal for the period of 1 July 2025 to 30 June 2030 which included gas demand forecasts for its network based on forecasts prepared by Core Energy & Resources (CORE).

On 29 November 2024, the Australian Energy Regulator (AER) published its draft decision on JGN's 2025−30 Access Arrangement proposal. This included the draft decision on demand forecasting. The AER engaged ACIL Allen (ACIL) to advise on JGN's demand forecast and to develop alternative demand forecasts.

ACIL identified three points of difference to CORE's forecasts:

1. Existing residential demand per connection
2. Commercial (i.e. small business) demand per connection
3. Number of residential disconnections

JGN has engaged Frontier Economics to review the AER's draft decision on JGN's Volume Market demand forecasts. We have focused on the three points of differences that ACIL identified and have:

- Reviewed and compared ACIL's forecasts and methodologies against CORE's.
- Provided alternative demand per connection forecasts to test CORE's forecasts.
- Reviewed and commented on ACIL's approach to forecasting residential disconnections.

In producing the report, we have relied upon the following documents:

- Jemena Gas Networks (NSW) Ltd (2024), 2025-30 Access Arrangement Proposal, Attachment 8.1, Overview of JGN's Demand Forecast
- Core Energy & Resources (2024), Jemena Gas Networks (NSW) Gas Access Arrangement July 2025 to 30 June 2030, Gas Demand and Connections Forecast
- AER (2024), Draft Decision, Jemena Gas Networks (NSW) access arrangement 2025 to 2030, (1 July 2025 to 30 June 2030), Attachment 12 – Demand
- ACIL Allen (2024), Review of Jemena Gas Network's demand forecasts, Review of JGN demand forecasts for the Australian Energy Regulator (AER) (**ACIL Allen report**)
- ACIL Allen (2024), Response to JGN questions, 18 December 2024

In producing the report, we have also relied upon the following Excel files:

- Core Energy & Resources (2024), *JGN - Core Energy - Att 8.4M - NSW Demand Forecast Model - 20240417 - Confidential (1),* (**CORE AA initial proposal model**)

- ACIL Allen (2024), *ACIL Allen JGN forecast adjustment*, (**ACIL model**)
- Core Energy & Resources (2025), *Jemena Gas Networks – 2025-2030 Access Arrangements; Demand & Connections Forecast* (JGN – CORE Energy – RP – Att 6.3M – NSW Demand Forecast Model – 20250107 – Confidential), (**CORE revised proposal model**)

The report structure is set out as follows:

- Section 2 sets out our review and comparison of CORE's and ACIL's forecasts of existing residential demand per connection along with our alternative forecast.
- Section 3 sets out our review and comparison of CORE's and ACIL's forecasts of commercial demand per connection along with our alternative forecast.
- Section 4 sets out our analysis of ACIL's approach to forecasting residential disconnections.

2 Residential demand per connection

In this section, we review and compare the following forecasts for residential demand per connection for existing customers:

- CORE's AA initial proposal forecasts
- ACIL's forecast which the AER adopted for the draft decision
- CORE's forecast for the revised proposal utilising new data for the 2024 financial year
- ACIL's method applied to the new data for the 2024 financial year
- Our alternative forecast utilising the new data.

Each forecast uses the same methodology for calculating historical residential demand per connection. Historical demand per connection is defined as the total weather corrected residential usage divided by the average number of residential connections in a given financial year. CORE has weather corrected the total residential usage. This historical time series forms the basis for each forecast.

A weighted average of the proportion of existing and new customers is applied to the forecast existing residential demand per connection and assumed new residential demand per connection to calculate a forecast weighted demand per connection. This forecast weighted demand per connection is then applied to total average number of residential connections.

Our analysis only focuses on the existing residential demand per connection as this was a point of difference that ACIL identified in its report to CORE's forecasts which the AER adopted in its draft decision.

This section first sets out the methodology for each forecast and then compares the forecasts against each other.

2.1 CORE AA initial proposal forecast

CORE's AA initial proposal forecast for existing residential demand per connection can be summarised as an annual rate of decline applied to the demand per connection starting from the 2023 historical demand per connection. The annual rate of decline is as follows:

- Base rate decline of -0.82% (Average Annual Movement of 2010-2019 and 2023)
- 2025: unchanged (-0.82%)
- 2026: 10% increase to the base rate decline (-0.90%)
- 2027: 30% increase to the base rate decline (-1.07%)
- 2028: 100% increase to the base rate decline (-1.64%)
- 2029: 130% increase to the base rate decline (-1.88%)
- 2030: 170% increase to the base rate decline (-2.21%)

2.2 ACIL's forecast and method for draft decision

ACIL tested two separate regression models using CORE's weather normalised historical data for the existing residential demand per connection. The first model covered the period from 2009 to 2019 and the second model covered the full period from 2009 to 2023 with the Covid-19 impacted years[1] accounted for by a separate dummy variable. These models are shown in the following equations and yield the regression results in Table 1.

Model 1 2010 – 2019:

$$demand_t = \alpha + \beta_1 Time_t + \varepsilon_t$$

where:

- $demand_t$ is the residential demand per connection in year t
- $Time_t$ is the time trend variable where 2009 is defined to be 1

Model 2 2009 – 2023:

$$demand_t = \alpha + \beta_1 Time_t + \beta_1 COVID_t + \varepsilon_t$$

where:

- $demand_t$ is the residential demand per connection in year t
- $Time_t$ is the time trend variable where 2009 is defined to be 1
- $COVID_t$ is the dummy variable accounting for the Covid-19 impact

Table 1: **ACIL residential demand per connection regression models results**

Variable Variables	Model 1 2010 – 2019		Model 2 2009 – 2023	
	Coefficient	p-values	Coefficient	p-values
Intercept	21.0642***	0.0000	21.0920***	0.0000
Trend	-0.1563***	0.0006	-0.1573***	0.0000
Covid-19			0.6259**	0.0192
Number of observations	10		15	
Adjusted R-squared	0.8053		0.7985	
F-statistics	19.6089		28.7310	

Source: ACIL Allen model

*Note: *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level ***denotes statistical significance at the 1% level*

[1] Covid-19 impacted years are the 2020, 2021 and 2022 financial years.

ACIL noted that both regressions produced similar results and adopted Model 1's time trend. ACIL forecast by applying the trend factor to the latest observation of data, the 2024 residential demand per connection.[2]

There are two approaches to determining the starting value for the forecast of demand per connection:

1. The starting value for the forecast can be determined by the most recent historical data point.
2. The starting value for the forecast can be determined by the fitted value of a historical trend or an econometric model for the relevant year.

The forecast ACIL provided adopted the former approach. This assumes that the most historical data point is a better starting point and reflects the future forecasts compared to the fitted value of the historical trend. ACIL's Model 1 yields a coefficient of -0.156. This means that each year demand for existing residential demand per connection decreases by 0.156 GJ per connection.

ACIL also applied a post-model adjustment to account for an assumed gas price elasticity of -0.25 and an assumed electricity cross-price elasticity of demand of 0.1. ACIL applied these elasticities to its forecast of gas and electricity prices and the elasticities seem to have been applied multiplicatively for each year following this equation:[3]

$$demand_t = (demand_{t-1} - 0.156) \times (1 + \Delta GPE_t) \times (1 + \Delta CPE_t)$$

where:

- $demand_t$ is the residential demand per connection in year t
- ΔGPE_t is the percentage change in the forecast gas price multiplied by the gas price elasticity.
- ΔCPE_t is the percentage change in the forecast electricity price multiplied by the cross-price elasticity.

2.3 CORE's revised proposal forecast

CORE's revised proposal forecast utilises new data for the 2024 financial year which also slightly changed the historical data due to the weather normalisation process.

CORE's revised forecast for existing residential demand per connection can be summarised as an annual rate of decline applied to the demand per connection starting from the 2024 historical demand per connection. The base rate of decline is the same as per the AA proposal forecast but instead of applying a percentage adjustment factor, CORE applied a GJ per connection factor based on CORE's analysis crossed-checked to AEMO. The annual rate of decline is as follows:

- Base rate decline of -0.82% (Average Annual Movement of 2010-2019 and 2023)
- 2025: unchanged (-0.82%)
- 2026: base rate of decline plus an electrification factor adjustment of -0.015 GJ
- 2027: base rate of decline plus an electrification factor adjustment of -0.02 GJ
- 2028: base rate of decline plus an electrification factor adjustment of -0.03 GJ
- 2029: base rate of decline plus an electrification factor adjustment of -0.03 GJ

[2] This was a forecast as of April 2024 for the whole 2024 financial year for the AA proposal submission.

[3] We could not replicate ACIL's figures exactly, but this methodology produced results within a 0.032% difference for any forecast year.

- 2030: base rate of decline plus an electrification factor adjustment of -0.03 GJ

2.4 ACIL's method applied to the new data

Applying ACIL's method as described in section 2.2 to the new historical dataset and including the 2024 financial year data yields the following regression results in Table 2.

To forecast forward, we applied the trend factor to the latest observation of data. We then applied the gas price and cross-price elasticities as a post-model adjustment to the model.

Table 2: ACIL's method applied to new data residential demand per connection regression models results

Variable Variables	Model 1 2010 – 2019		Model 2 2009 – 2024	
	Coefficient	p-values	Coefficient	p-values
Intercept	20.9636***	0.0000	21.1615***	0.0000
Trend	-0.1376***	0.0019	-0.1712***	0.0000
Covid-19			0.7646***	0.0046
Number of observations	10		16	
Adjusted R-squared	0.6948		0.8622	
F-statistics	18.2136		40.6820	

Source: Frontier Economics

*Note: *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level ***denotes statistical significance at the 1% level*

2.5 Our alternative forecast

We have developed an alternative forecast and model that improves on ACIL's method. The key difference is that given ACIL has assumed elasticities in its forecast, the regression models should also include the impact of the elasticities in its historical data as independent variables.

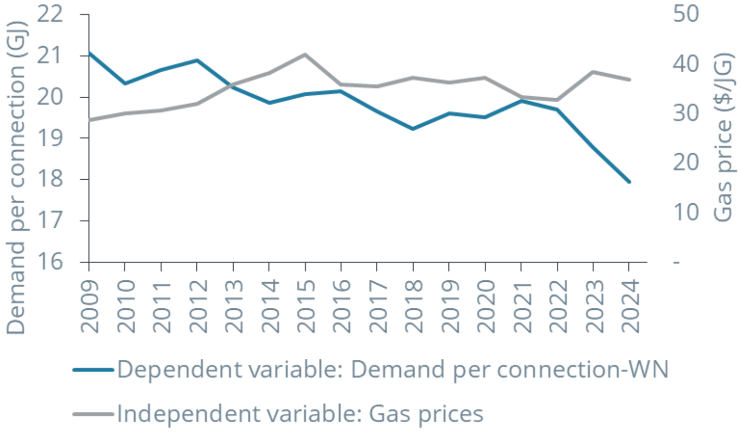
This required creating a time series of historical gas and electricity prices. To do this, we used ACIL's 2024 gas and electricity prices[4] and applied gas and electricity price indexes – Sydney (June)[5] from 2009 to 2024 to calculate the change in nominal prices and applied CPI – Sydney (June)[6] from 2009 to 2024 to calculate the prices in real $2024. Figure 1 and Figure 2 depict these time series against residential demand per connection.

4 We have assumed ACIL's prices to be in real 2024 dollars.

5 ABS (2024), Consumer Price Index, Australia, TABLES 1 and 2. CPI: All Groups, Index Numbers and Percentage Changes, Index Numbers; All groups CPI; Sydney

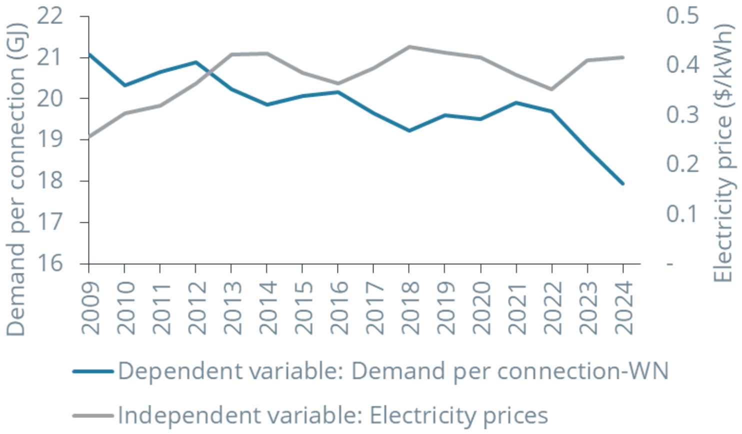
6 ABS (2024), Consumer Price Index, Australia, TABLE 9. CPI: Group, Sub-group and Expenditure Class, Index Numbers by Capital City, Index Numbers; Gas and other household fuels; Sydney

Figure 1: Residential demand per connection and historical gas prices



Source: Frontier Economics

Figure 2: Residential demand per connection and historical electricity prices



Source: Frontier Economics

Using these two new price time series along with the weather normalised residential demand per connection, a time trend variable and Covid-19 dummy variable, we explored multiple regression models:

- Including or excluding the Covid-19 impacted years (including dummy for impacted years)
- Including both elasticities or just the gas price elasticity
- Letting the model calculate the elasticities or forcing the elasticities to be as assumed by ACIL

Our preferred model has the following characteristics:

- We have included the Covid-19 impacted years to provide more data points (2009 to 2024) as we found that including or excluding the Covid-19 impacted years produced similar results.
- We have included both elasticities to be more consistent with ACIL's assumptions.
- We have used the assumed elasticities as letting the model calculate elasticities resulted in unintuitive results for the coefficients (e.g. positive coefficient for gas prices) and to be more consistent with ACIL's assumptions.

In summary, our model has made two improvements compared to the ACIL model:

- Using a log-log regression model to allow the gas price and cross-price elasticity to be included in the model
- Adjusting the dependent variable to account for the implied gas and cross-price elasticities

This adjustment to the regression equation to force the elasticities to be as assumed by ACIL is depicted in the following equations and produces the results shown in Table 3. The adjustment is possible as both the gas price elasticity of -0.25 and the cross-price elasticity of 0.1 is defined as per ACIL's assumptions and the historical time series of gas prices and electricity prices are known.

Starting regression model with assumed elasticities:

$$\ln(demand_t) = \alpha + \beta_1\, time_t + \beta_2 COVID_t - 0.25\ln(gas\ price_t) + 0.1\ln(electricity\ price_t) + \varepsilon_t$$

Defining $adjusted\ demand_t$ to force elasticities:

$$adjusted\ demand_t = \ln(demand_t) + 0.25\ln(gas\ price_t) - 0.1\ln(electricity\ price_t)$$

Final regression model:

$$adjusted\ demand_t = \alpha + \beta_1\, time_t + \beta_2 COVID_t + \varepsilon_t$$

where:

- $demand_t$ is the residential demand per connection in year t
- $Time_t$ is the time trend variable where 2009 is defined to be 1
- $COVID_t$ is the dummy variable accounting for the Covid-19 impact
- $gas\ price_t$ is the time series of gas prices in year t
- $electricity\ price_t$ is the time series of electricity prices in year t

Table 3: Preferred residential demand per connection regression model results

Variable Variables	Preferred model 2009 – 2024	
	Coefficient	p-values
Intercept	4.0301	0.3914
Time trend	-0.0073***	0.0001
Covid-19	0.0253	0.1160
Number of observations	16	
Adjusted R-squared	0.6938	
F-statistics	14.7264	

Source: Frontier Economics

*Note: *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level ***denotes statistical significance at the 1% level*

The interpretation of these coefficients is as follows:

- Residential demand per connection decreases by 0.73% per year, equivalent to around 0.13 GJ per year in the forecast period.
- A Covid-19 impact year increases residential demand per connection by around 2.53%, equivalent to around 0.46 GJ per year in the forecast period.

To forecast we have applied the trends by using the most recent historical data point as the starting point of the forecast following ACIL's method. The impact of ACIL's forecast prices is implicit in the model as shown in the following equation:

$$demand_t = e^{\ln demand_{t-1} - 0.0073 \times (\Delta time_t) + 0.0253 \times (\Delta COVID_t) + \Delta GPE_t + \Delta CPE_t}$$

where:

- $demand_t$ is the residential demand per connection in year t
- $\Delta time_t$ is the change in the time variable comparing year t to year t-1
- $\Delta COVID_t$ is the change in the Covid-19 impact dummy variable comparing year t to year t-1
- ΔGPE_t is the change in the natural log of forecast gas prices multiplied by the gas price elasticity comparing year t to year t-1
- ΔCPE_t is the change in the natural log of forecast electricity prices multiplied by the cross-price elasticity comparing year t to year t-1

2.6 Forecast comparisons

2.6.1 Existing residential demand per connection

Table 4 compares the forecasts from 2023 to 2030. We present the annualised rate of change from 2023 to 2030 and 2025 to 2030 noting that the CORE's AA initial proposal forecast and ACIL's forecast adopted in the draft decision use different 2023 and 2024 figures.[7] Figure 3 below compares the forecasts against the historical time series.

[7] The values for 2023 are slightly different due to updated weather normalisation and the values for 2024 are significantly different because a forecast has been replaced by actual data.

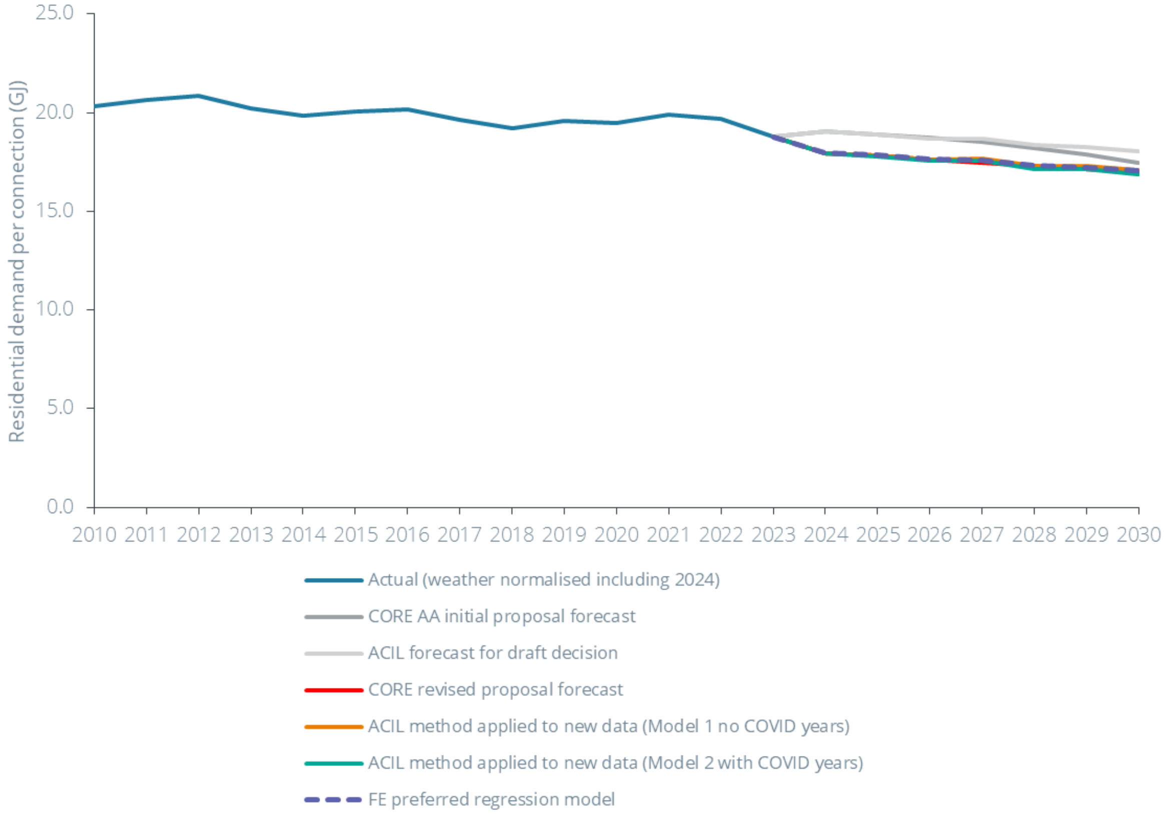
Table 4: Existing residential demand per connection forecasts comparison

Forecast	2023	2024	2025	2026	2027	2028	2029	2030	Annualised rate of change (2023-2030)	Annualised rate of change (2025-2030)
CORE AA initial proposal forecast	18.76	19.05	18.89	18.72	18.52	18.21	17.86	17.46	-1.02%	-1.56%
ACIL forecast for draft decision	18.76	19.05	18.91	18.70	18.67	18.38	18.24	18.03	-0.56%	-0.94%
CORE revised proposal forecast*	18.78	17.95	17.80	17.64	17.48	17.30	17.13	16.96	-1.45%	-0.96%
ACIL method applied to new data (Model 1 no COVID years)	18.78	17.95	17.82	17.63	17.65	17.28	17.28	17.07	-1.36%	-0.86%
ACIL method applied to new data (Model 2 with COVID years)	18.78	17.95	17.79	17.56	17.55	17.14	17.11	16.87	-1.52%	-1.06%
FE preferred regression model	18.78	17.95	17.83	17.63	17.61	17.35	17.24	17.06	-1.36%	-0.88%

Source: Frontier Economics analysis

**These figures relate to the closing demand per connection for existing residential demand per connection and not demand per connection for total residential demand, which is a weighted average of existing and new residential connections.*

Figure 3: Existing residential demand per connection forecasts comparison



Source: Frontier Economics analysis

2.6.2 Total residential demand

When extrapolating to forecast total residential demand for our preferred regression model and ACIL's method applied to the new data, we assumed CORE's revised proposal forecast figures for residential connections, the proportion split between existing and new residential connections and the residential demand per new connection which had changed from CORE's proposal forecast.

In other words, CORE's revised proposal forecast figures for residential connections, the proportion split between existing and new residential connections and the residential demand per new connection were taken as given, and the only difference between CORE's revised proposal forecast, our estimation of ACIL's method applied to the new data and our preferred econometric model forecast, is the different residential demand per connection forecasts for existing customers. CORE's proposal forecast and ACIL's forecast adopted in the draft decision have not been changed in the table below.

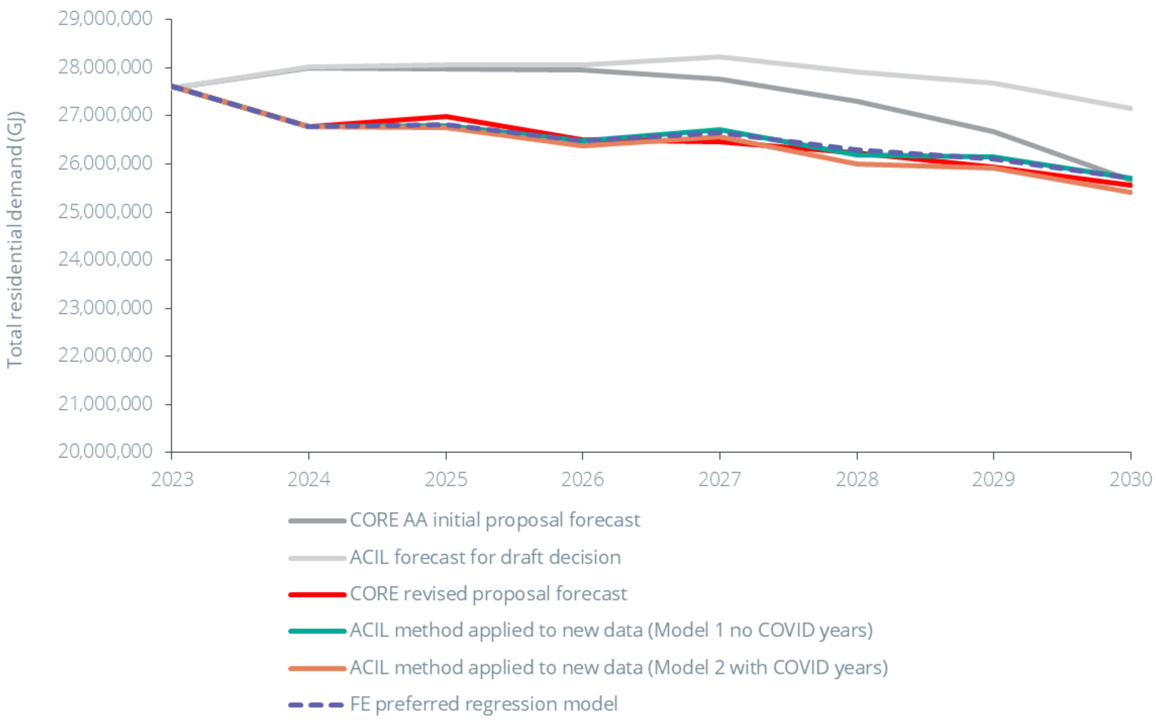
Table 5 compares the forecasts and presents the annualised rate of change from 2023 to 2030 and 2025 to 2030. Figure 4 compares the total residential demand forecasts from 2023 to 2030.

Table 5: Total residential demand forecasts comparison

Forecast	2023	2024	2025	2026	2027	2028	2029	2030	Annualised rate of change (2023-2030)	Annualised rate of change (2025-2030)
CORE AA initial proposal forecast	27,582,541	27,986,775	27,972,222	27,950,597	27,757,484	27,308,683	26,661,912	25,665,813	-1.02%	-1.71%
ACIL forecast for draft decision	27,582,541	28,013,273	28,064,642	28,069,141	28,219,736	27,905,879	27,674,512	27,153,167	-0.22%	-0.66%
CORE revised proposal forecast	27,613,123	26,777,580	26,993,854	26,504,264	26,462,334	26,232,747	25,937,406	25,552,391	-1.10%	-1.09%
ACIL method applied to new data (Model 1 no COVID years)	27,613,123	26,777,580	26,803,165	26,482,248	26,713,326	26,191,356	26,152,515	25,705,631	-1.02%	-0.83%
ACIL method applied to new data (Model 2 with COVID years)	27,613,123	26,777,580	26,752,802	26,383,195	26,564,289	25,996,943	25,910,246	25,420,235	-1.18%	-1.02%
FE preferred regression model	27,613,123	26,777,580	26,814,996	26,489,946	26,659,744	26,295,917	26,095,405	25,696,145	-1.02%	-0.85%

Source: Frontier Economics analysis

Figure 4: Total residential demand forecasts comparison



Source: Frontier Economics analysis

2.7 Conclusions

Our preferred econometric model provides forecasts that are very similar to CORE's revised forecasts and our estimation of what ACIL's existing models would deliver when applied to the new data which suggests that CORE's revised forecasts are not unreasonable.

3 Commercial demand per connection

Similar to residential demand per connection in Section 2, in this section, we review and compare the following forecasts for commercial demand per connection:

- CORE's AA initial proposal forecasts
- ACIL's forecast which the AER adopted for the draft decision
- CORE's forecast for the revised proposal utilising new data for the 2024 financial year
- ACIL's method applied to the new data
- Our alternative forecast utilising the new data.

Each forecast uses the same methodology for calculating historical commercial demand per connection. Historical demand per connection is defined as the total weather corrected commercial usage divided by the average number of commercial connections in a given financial year. CORE have weather corrected the total commercial usage. This historical time series forms the basis for each forecast.

Unlike the residential demand per connection, the commercial demand per connection does not differentiate between demand per existing connection and demand per new connection.

This section first sets out the methodology of each forecast and then compares the forecasts against each other.

3.1 CORE's AA initial proposal forecast

CORE's AA initial proposal forecast for commercial demand per connection can be summarised as an annual rate of decline applied to the demand per connection starting from 2023 historical demand per connection. The annual rate of decline is as follows:

- Base rate decline of -0.75%
- 2024: 10% increase to the base rate decline (-0.83%)
- 2025: 50% increase to the base rate decline (-1.13%)
- 2026: 100% increase to the base rate decline (-1.50%)
- 2027: 200%increase to the base rate decline (-2.25%)
- 2028: 300% increase to the base rate decline (-3.00%)
- 2029: 400% increase to the base rate decline (-3.75%)
- 2030: 600% increase to the base rate decline (-5.25%)

3.2 ACIL's forecast and method for draft decision

ACIL's forecast and method for the draft decision were unclear in the model provided. ACIL analysed a regression utilising data for all years post-2014 but did not adopt the trend factor in its forecasts. Instead ACIL adopted a trend factor of -5 GJ per annum. ACIL noted the following:[8]

- *Small business demand per connection is driven by a linear trend and an elasticity impact from gas and electricity prices.*
- *The regression coefficient covering all years from 2014 onwards was -1.398.*
- *We used -5 instead which provides a slightly greater negative impetus and is more consistent with residential which shows a stronger negative trend.*
- *Using the actual estimated historical trend for small business would result in a slightly higher demand per connection forecast.*

ACIL also applied a post-model adjustment to account for an assumed gas price elasticity of -0.3 and a cross-price elasticity of demand of 0.1. ACIL applied these elasticities to its forecast of gas and electricity prices and the elasticities seem to have been applied multiplicatively for each year following this equation:[9]

$$demand_t = (demand_{t-1} - 5) \times (1 + \Delta GPE_t) \times (1 + \Delta CPE_t)$$

where:

- $demand_t$ is the commercial demand per connection in year t
- ΔGPE_t is the percentage change in the forecast gas price multiplied by the gas price elasticity.
- ΔCPE_t is the percentage change in the forecast electricity price multiplied by the cross-price elasticity.

3.3 CORE's revised proposal forecast

CORE's revised proposal forecast utilises new data for the 2024 financial year which also slightly changed the historical data due to the weather normalisation process.

CORE's revised forecast for commercial demand per connection can be summarised as an annual rate of decline applied to the demand per connection starting from the 2024 historical demand per connection. The annual rates of decline are as follows:

- 2025: -1.15% rate decline
- 2026: -1.15% rate decline
- 2027: -1.50% rate decline
- 2028: -1.75% rate decline
- 2029: -2.00% rate decline
- 2030: -2.50% rate decline

8 ACIL Allen (2024), Response to JGN questions, 18 December 2024, p. 1.

9 We could not replicate ACIL's figures exactly, but this methodology produced results within a 0.102% difference for any forecast year.

3.4 ACIL's method applied to the new data

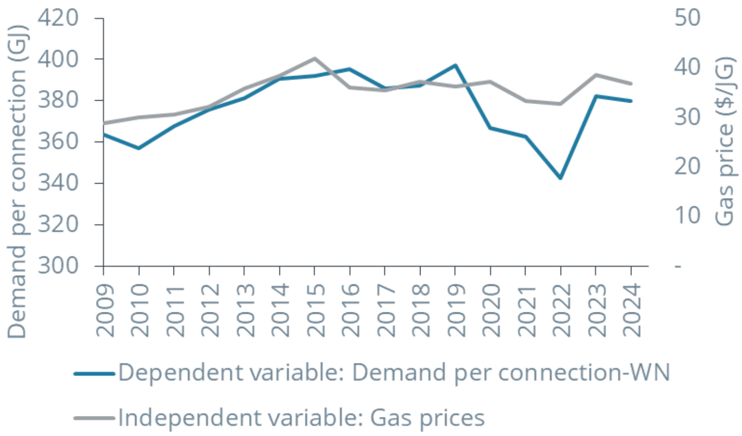
Applying ACIL's method to the new data simply involved the time trend of -5 applied to the latest observation of data, 2024 commercial demand per connection. We then applied the gas price and cross-price elasticities as a post-model adjustment to the model as described in section 3.2.

3.5 Our alternative forecast

Similar to the residential demand per connection forecast, we have developed an alternative forecast and model. We have made the same adjustments to include the impact of the elasticities in the historical data as independent variables as part of the regression.

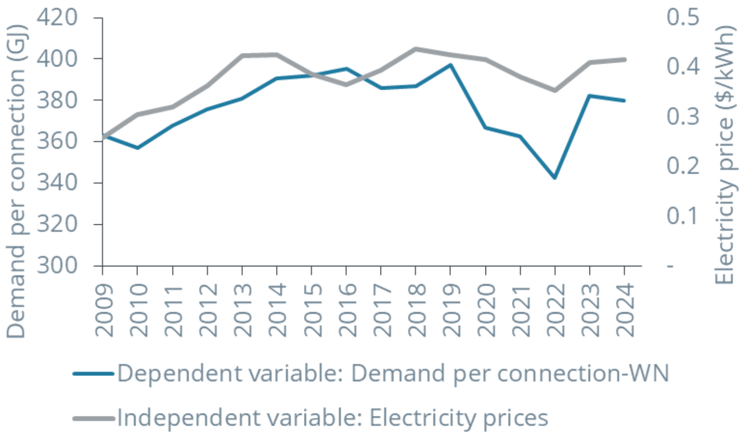
The same time series of historical gas and electricity prices as outlined in section 2.5 was utilised. Figure 5 and Figure 6 depict these time series against commercial demand per connection.

Figure 5: Commercial demand per connection and historical gas prices



Source: Frontier Economics

Figure 6: Commercial demand per connection and historical electricity prices



Source: Frontier Economics

Using these two new price time series along with the weather normalised commercial demand per connection, time trend variable and Covid-19 dummy variable, we explored multiple regression models including:

- Including a longer or shorter time period similar to ACIL utilising data for all years post-2014
- Including or excluding the Covid-19 impacted years (including dummy for impacted years)
- Including both elasticities or just the gas price elasticity
- Letting the model calculate the elasticities or forcing the elasticities to be as assumed by ACIL

Our preferred model has the following characteristics:

- We have assumed a structural break in demand from 2015, similar to ACIL, and therefore only included data from 2015 to 2024.
- We have included the Covid-19 impacted years to provide more data points as we found that including or excluding the Covid-19 impacted years produced similar results.
- We have included both elasticities to be more consistent with ACIL's assumptions.
- We have used the assumed elasticities as letting the model calculate elasticities resulted in unintuitive results for the coefficients (e.g. positive coefficient for gas prices) and to be more consistent with ACIL's assumptions.

The model has the same characteristics as the residential demand per connection model, and the same two improvements compared to the ACIL model:

- Using a log-log regression model to allow the gas price and cross-price elasticity to be included in the model
- Adjusting the dependent variable to account for the implied gas and cross-price elasticities

This adjustment to the regression equation to force the elasticities to be as assumed by ACIL is depicted in the following equations and produces the results shown in Table 3. The adjustment is possible as both the gas price elasticity of -0.3 and the cross-price elasticity of 0.1 is defined as per ACIL's assumptions and the historical time series of gas prices and electricity prices are known.

Starting regression model with assumed elasticities:

$$\ln(demand_t) = \alpha + \beta_1\, time_t + \beta_2 COVID_t - 0.3\ln(gas\ price_t) + 0.1\ln(electricity\ price_t) + \varepsilon_t$$

Defining $adjusted\ demand_t$ to force elasticities:

$$adjusted\ demand_t = \ln(demand_t) + 0.3\ln(gas\ price_t) - 0.1\ln(electricity\ price_t)$$

Final regression model:

$$adjusted\ demand_t = \alpha + \beta_1\, time_t + \beta_2 COVID_t + \varepsilon_t$$

where:

- $demand_t$ is the commercial demand per connection in year t
- $Time_t$ is the time trend variable where 2009 is defined to be 1 (i.e. 2015 is defined to be 7)
- $COVID_t$ is the dummy variable accounting for the Covid-19 impact
- $gas\ price_t$ is the time series of gas prices in year t
- $electricity\ price_t$ is the time series of electricity prices in year t

Table 6: Preferred commercial demand per connection regression model results

Variable Variables	Preferred model 2015 – 2024	
	Coefficient	p-values
Intercept	7.2083	0.3914
Time trend	-0.0064*	0.0001
Covid-19	-0.0901***	0.1160
Number of observations	10	
Adjusted R-squared	0.8263	
F-statistics	16.6468	

Source: Frontier Economics

*Note: *denotes statistical significance at the 10% level, **denotes statistical significance at the 5% level ***denotes statistical significance at the 1% level*

The interpretation of these coefficients is as follows:

- Commercial demand per connection decreases by 0.64% per year, equivalent to around 2.3 GJ per year in the forecast period.
- A Covid-19 impact year decreases commercial demand per connection by around 9.01%, equivalent to around 32 GJ per year in the forecast period.

To forecast demand per connection we have applied the trends by using the most recent historical data point as the starting point of the forecast following ACIL's method which was accepted by the AER. The impact of ACIL's forecast prices is implicit in the model as shown in the following equation:

$$demand_t = e^{\ln demand_{t-1} - 0.0064 \times (\Delta time_t) - 0.0901 \times (\Delta COVID_t) + \Delta GPE_t + \Delta CPE_t}$$

where:

- $demand_t$ is the commercial demand per connection in year t
- $\Delta time_t$ is the change in the time variable comparing year t to year t-1
- $\Delta COVID_t$ is the change in the Covid-19 impact dummy variable comparing year t to year t-1
- ΔGPE_t is the change in the natural log of forecast gas prices multiplied by the gas price elasticity comparing year t to year t-1
- ΔCPE_t is the change in the natural log of forecast electricity prices multiplied by the cross-price elasticity comparing year t to year t-1

3.6 Forecast comparisons

3.6.1 Commercial demand per connection

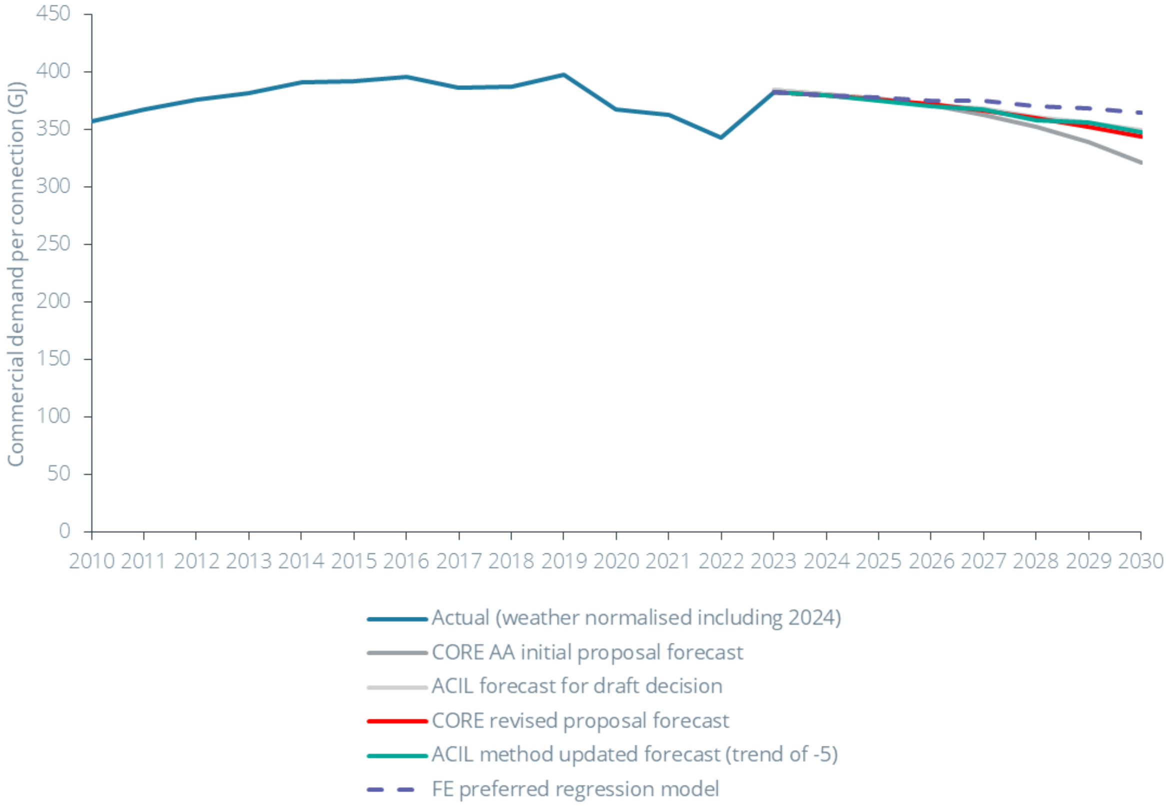
Table 7 compares the forecasts from 2023 to 2030. We present the annualised rate of change from 2023 to 2030 and 2025 to 2030 noting that the CORE's AA initial proposal forecast and ACIL's forecast adopted in the draft decision use different 2023 and 2024 figures. Figure 7 below compares the forecasts against the historical time series.

Table 7: Commercial demand per connection forecasts comparison

Forecast	2023	2024	2025	2026	2027	2028	2029	2030	Annualised rate of change (2023-2030)	Annualised rate of change (2025-2030)
CORE AA initial proposal forecast	384.16	380.99	376.70	371.05	362.71	351.82	338.63	320.85	-2.54%	-3.16%
ACIL forecast for draft decision	384.16	380.99	376.30	371.17	368.52	360.99	356.53	349.84	-1.33%	-1.45%
CORE revised proposal forecast	382.32	379.98	376.18	371.85	366.27	359.86	352.67	343.85	-1.50%	-1.78%
ACIL method updated forecast (trend of -5)	382.32	379.98	375.20	370.22	367.21	357.83	355.60	347.99	-1.34%	-1.49%
FE preferred regression model	382.32	379.98	377.79	375.25	375.07	370.20	368.51	364.13	-0.69%	-0.73%

Source: Frontier Economics analysis

Figure 7: Commercial demand per connection forecasts comparison



Source: Frontier Economics analysis

3.6.2 Total commercial demand

When extrapolating to forecast total commercial demand for our preferred regression model and ACIL's method applied to the new data, we assumed CORE's revised proposal forecast figures for commercial connections which had changed from CORE's proposal forecast.

In other words, CORE's revised proposal forecast figures for commercial connections were taken as given and the only difference between CORE's revised proposal forecast, our estimation of ACIL's method applied to the new data and our preferred econometric model forecast is the different commercial demand per connection forecasts for existing customers.

CORE's proposal forecast and ACIL's forecast adopted in the draft decision have not been changed in the table below.

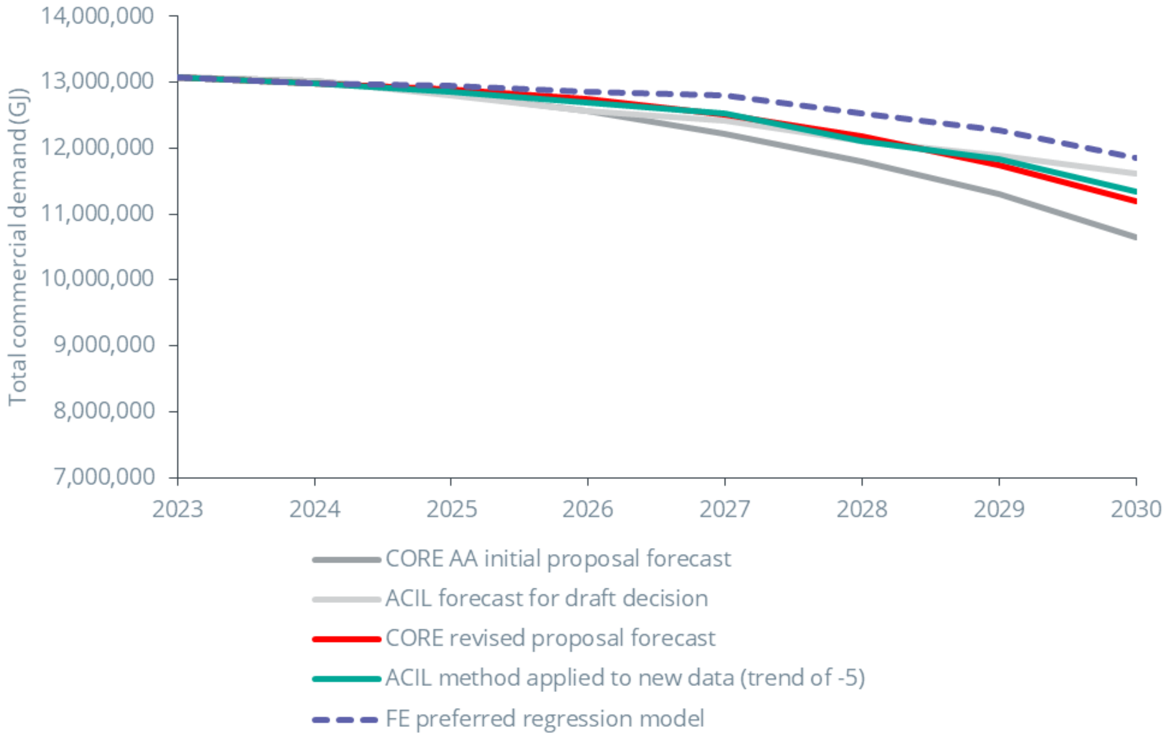
Table 8 compares the forecasts and presents the annualised rate of change from 2023 to 2030 and 2025 to 2030. Figure 8 compares the total residential demand forecasts from 2023 to 2030.

Table 8: Total commercial demand forecasts comparison (GJ)

Forecast	2023	2024	2025	2026	2027	2028	2029	2030	Annualised rate of change (2023-2030)	Annualised rate of change (2025-2030)
CORE AA initial proposal forecast	13,080,056	13,023,144	12,815,494	12,560,188	12,217,736	11,794,816	11,295,550	10,646,065	-2.90%	-3.64%
ACIL forecast for draft decision	13,080,056	13,023,144	12,801,707	12,563,989	12,413,510	12,102,001	11,892,641	11,607,792	-1.69%	-1.94%
CORE revised proposal forecast	13,085,665	12,980,390	12,893,351	12,742,457	12,505,099	12,176,588	11,739,460	11,200,869	-2.20%	-2.78%
ACIL method applied to new data (trend of -5)	13,085,665	12,980,390	12,859,703	12,686,607	12,537,167	12,107,626	11,837,089	11,335,675	-2.03%	-2.49%
FE preferred regression model	13,085,665	12,980,390	12,948,568	12,858,870	12,805,380	12,526,423	12,266,719	11,861,380	-1.39%	-1.74%

Source: Frontier Economics analysis

Figure 8: Total commercial demand forecasts comparison



Source: Frontier Economics analysis

3.7 Conclusions

Both CORE's and ACIL's forecasts have suggested that historical trends are not a good guide to the future in forecasting commercial demand per connection.

Our forecast, based on an econometric approach, implicitly assumes that historical trends are a good guide to the future. Because of this different in approach, our forecast is materially different to the forecasts developed by CORE and ACIL: our forecast, which is based on historical trends, provides a higher forecast compared to CORE and ACIL.

We make two key observations regarding our approach:

1. While the econometric model accounts for historical trends, due to time constraints and data constraints, we have ended up with a relatively simply model with a time trend of price elasticities. No doubt there are other drivers of commercial demand per connection that are not included in this econometric model. For example, variables such as the level of small business confidence or measures of the relative cost of purchasing gas and electricity appliances could be predictors of future gas demand. If we could include other variables in the econometric model, it could provide a different forecast.

2. There may be other factors that influence the future demand of commercial customers that exhibit different characteristics from historical trends, such as the level of electrification of gas appliances or energy efficiency. These are usually treated as post-model adjustments, and these adjustments can be an important step in using econometric models to forecast demand. However due to time constraints we have not applied any post-model adjustments to the econometric approach.

4 Residential disconnections and S-curve approach

One of the key components of ACIL Allen's alternative demand forecasts is ACIL's revised residential customer disconnection forecasts. As detailed in ACIL's *Review of Jemena Gas Network's demand forecasts*[10] report, an appliance switching model based on an S-curve logistic function is used to determine the probability of switching from gas appliances to electrical appliances. This methodological decision and feature of the model is of central importance. The shape of the S-curve function (that is, how the S-curve is parametrised) is one of the most important factors that determines the number of customers disconnecting from the gas distribution network in ACIL's revised demand forecasts.

This section discusses in-turn:

- Information gaps relating to ACIL Allen's residential disconnection forecast.
- Frontier Economics analysis of the S-curve modelling approach.
- Conclusions regarding the ACIL Allen revised disconnection forecasts.

4.1 Information gaps relating to ACIL Allen's residential disconnection forecast

To be able to undertake an adequate and meaningful review of an economic model, it is critical to be able to access and interrogate the key inputs, outputs and the model itself. Without access to this key information, it is generally challenging to conduct a meaningful review of a model and engage in constructive criticism or questioning of key inputs or methodological decisions.

We note that the information provided to us to review the revised demand forecast produced by ACIL– as it relates to its estimation of residential disconnections – consists of:

- The *Review of Jemena Gas Network's demand forecasts* report.
- The *ACIL Allen JGN forecast adjustment* Excel workbook.
- The *Responses to JGN questions* note (dated 18 December 2024).

We have not been provided access to the appliance switching model utilised to produce the residential disconnection forecasts. Nor have we been provided information key assumptions regarding how the S-curve that ACIL use has been parameterised. As a consequence of this – as well as a distinct lack of transparency in the drafting of the report – we are unable to observe how key inputs were utilised, and are unable to verify how ACIL's forecasts are produced.

Fronter Economics recently reviewed other ACIL distribution gas network demand forecasts. Frontier Economics was engaged by the Western Australia Economic Regulation Authority (ERA) as part of the ATCO Gas Australia Pty Ltd (ATCO) sixth access arrangement period (AA6) Mid-West and South-West Gas Distribution Systems [MWSW GDS] (1 January 2025 to 31 December 2029) review determination.

Specifically, Frontier Economics was engaged to review ACIL's modelling of demand forecasts for the ATCO MWSW GDS, which were utilised by ATCO to propose an allowance for accelerated depreciation. In its work for ATCO, ACIL utilised an appliance switching model centred on a

[10] ACIL Allen, *Review of Jemena Gas Network's demand forecasts*, November 2024.

logistic S-curve that determined the probability of switching from gas appliances to electrical appliances. That model was described in very similar terms to the model used by ACIL to forecast disconnections from JGN's network.

Over the course of our engagement with the ERA, Frontier Economics was provided access to:

- ATCO AA6 **Proposed** Access Arrangement stage:
  - Each of the four appliance switching/demand forecast models (one for each scenario developed)[11].
  - The ACIL Allen *Future of gas*: *Scenario development and modelling for the ATCO gas distribution system* report, which detailed how the modelling was undertaken[12].
- ATCO AA6 **Revised** Access Arrangement stage:
  - An updated, consolidated appliance switching/demand forecast model[13].
  - An updated ACIL Allen *Future of gas* report[14].
  - An ATCO-branded *Accelerated Depreciation – Modelling, Guideline, Assumptions & Sensitivities* report[15].
- ATCO AA6 **Final Decision** Access Arrangement stage:
  - Another updated model due to further errors identified in the updated model[16].

Each of the items listed above are publicly available[17].

As part of our engagement with the ERA, Frontier Economics produced two reports for the ERA and became extensively reviewed the appliance switching/demand forecasting components of the models produced by ACIL Allen and ATCO (and Incenta Economic Consulting).

These public reports and models provided far greater detail on the assumptions, calculations and outputs of ACIL's models. Crucially, these public reports and models provide clear detail on the parameterisation of the S-curve, which is at the heart of the forecasts produced by ACIL, but which ACIL has declined to provide to support its forecasts of disconnections for JGN's network. It is unclear why ACIL have been prepared to release this information when developing forecasts for ATCO, but has declined to release equivalent information when developing forecasts for JGN's network.

11 Individual models for each scenario are available here:

Electricity Dominates - https://www.erawa.com.au/cproot/23708/4/03.005-ATCO-Demand-Model-v14-ED-V12.XLSM
Energy Hybrid - https://www.erawa.com.au/cproot/23709/4/03.006-ATCO-Demand-Model-v14-EH-V6.XLSM
Hydrogen Future - https://www.erawa.com.au/cproot/23710/4/03.007-ATCO-Demand-Model-v14-HF-V6.XLSM
Natural Gas Retained - https://www.erawa.com.au/cproot/23711/4/03.008-ATCO-Demand-Model-v14-GR-V6.XLSM

12 ACIL Allen, *Future of gas: Scenario development and modelling for the ATCO gas distribution system*, June 2023, https://www.erawa.com.au/cproot/23603/2/03.002---Future-of-Gas-Report.pdf

13 https://www.erawa.com.au/cproot/24105/4/10.101A-Accelerated-Depreciation-Model.xlsm

14 ACIL Allen, *Future of gas: Scenario development and modelling for the ATCO gas distribution system*, June 2024, https://www.erawa.com.au/cproot/24106/2/10.102-Future-of-Gas-Report-ACIL-Allen.pdf

15 ATCO, Accelerated Depreciation – Modelling Guideline, Assumptions And Sensitivities AA6 Draft Decision, June 2024, https://www.erawa.com.au/cproot/24108/2/10.104A-Accelerated-Depreciation-Modelling-Handbook.pdf

16 https://www.erawa.com.au/cproot/24416/4/Final-Decision-Second-Update-Accelerated-Depreciation-Model-24OCT2024-PUBLIC.XLSM

17 Economic Regulation Authority, *Access Arrangement for Period commencing 2025*, https://www.erawa.com.au/gas/gas-access/mid-west-and-south-west-gas-distribution-systems/access-arrangements/access-arrangement-for-period-commencing-2025

Based on our review of the public information provided by ACIL in its forecasting work for ATCO, we have identified two key information gaps that have hindered JGN's and Frontier Economics' ability to undertake an adequate and meaningful review of ACIL's revised demand forecasts for JGN's network.

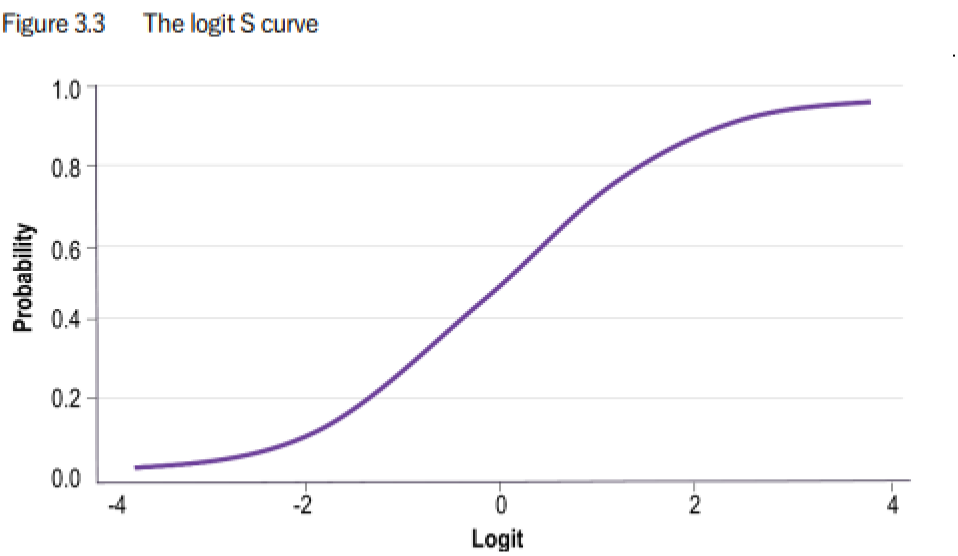
1. S-curve parameterisation

Based on our previous experience, our understanding of what the S-curve does in ACIL's model is to convert the net present value (NPV) of switching from gas to electricity into a measure of relative utility in each year (for disconnecting from the network). This relative utility is then transformed into a probability of disconnecting from the network using a logistic function. This probability then determines the number of those customers that *are able to* disconnect in a given year that actually *do* disconnect.

Fundamentally, S-curves are intended to represent the diffusion of a given technology or innovation. However, S-curve modelling requires several critical assumptions and 'judgement calls'. One of the most important 'judgement calls' in the ACIL Allen model is the S-curve parametrisation. That is, the 'end-points' of the S-curves (which can also be thought of as the NPV at which 100% of users choose *to* disconnect from the network and 100% of users choose *not to* disconnect from the network).

We have not been provided the parameters utilised to specify the S-curve for the purposes of ACIL's revised demand forecasts. The only information provided by ACIL is the generic S-curve in Figure 9 below, as well as brief descriptions in the report and note. Figure 9 is the same generic example ACIL included in its reports regarding the ATCO MWSW GDS network models, although in these reports they also provided a representation of the specific S-curves used[18]. We further discuss this generic S-curve in Section 4.2.2 below.

Figure 9: ACIL Allen indicative logistic S-curve



Source: ACIL Allen, Review of Jemena Gas Network's demand forecasts, November 2024, p.21.

Further discussion of the application of S-curves in the context of disconnection forecasting is detailed in Section 4.2 below.

18 See: ACIL Allen, *Future of gas*, June 2023 and ACIL Allen, *Future of gas*, June 2024.

2. The calculation of NPVs, and the application of key inputs

Further to the lack of information regarding customer types/distributions and their application, there is also a lack of information regarding how the NPVs reported by appliance type were estimated, and how the other costs provided (e.g. electricity connection upgrade) have been applied, in arriving at the published disconnection forecast.

It appears that our replication of the approach utilised in the estimation of NPVs in the ATCO WA MWSW GDS models, utilising the inputs provided in the *Review of Jemena Gas Network's demand forecasts* report, is not able to exactly reproduce the relative NPVs hard coded into the *Appliance switching NPV* tab of the *ACIL Allen JGN forecast adjustment* Excel workbook. That said, it is hard to verify if our attempted replication is correct given no model to accompany the *Review of Jemena Gas Network's demand forecasts* report was provided.

Additionally, it is not clear how other costs have been applied, and whether the application of these other costs aligns with their application in the WA MWSW GDS ATCO models. As the *Review of Jemena Gas Network's demand forecasts* report details, the key inputs into the NPV calculation for switching decisions are:

- Relative capital costs of the appliances
- Relative running costs
- Gas disconnection charges
- Electricity upgrade connection costs
- Rebates for electric appliances

No information is included in the *Review of Jemena Gas Network's demand forecasts* report or the *ACIL Allen JGN forecast adjustment* Excel workbook regarding what the level of the gas disconnection and electricity upgrade connections costs are, or how these are applied. For instance, is an electricity upgrade cost assumed for all customer types (even a customer with only gas cooking for instance), and is the same electricity upgrade cost assumed for all customer types?

These omissions mean we have been unable to reproduce ACIL Allen's disconnection forecasts.

Distribution of customer types

We had also initially identified that a lack of information was made available regarding the distribution of customer types across the network and whether the NPV(s) fed into the S-curve calculations were 'aggregated' into an 'average' or 'weighted average' NPV for a 'representative customer'.

In the models developed for ATCOs MWSW GDS in WA, residential connections and disconnections were weighted based on a distribution of customer types, defined over the type of appliances they owned. The customer types were:

- Gas cooktop only (all other appliances electric)
- Gas cooktop and gas water heating only (all other appliances electric)
- Gas cooktop, gas water heating and gas room heating (all other appliances electric)
- Gas cooktop, gas water heating and gas space heating (all other appliances electric)

ACIL Allen has since clarified via its 18 December 2024 note responding to questions that there are "Four sets of NPVs based on 4 customer types:

1. Households with gas cooktops only

2. Households with gas cooktops and gas hot water
3. Households with gas cooktops, gas hot water and gas room heating
4. Households with gas cooktops, gas hot water, and gas space heating

These are then combined into a single weighted average NPV which is input into the logistic model to calculate the share of households that are disconnecting".

The weights applied by ACIL Allen are as follows:

- Cooktops: 16.4%
- Cooktops + hot water: 37.5%
- Cooktops + hot water + room heating: 22.0%
- Cooktops + hot water + space heating: 24.1%

No reference or source was provided for these customer type shares.

4.2 S-Curve analysis

As noted above, S-curves require important judgement calls to be made as part of their parametrisation, the most important of which is the specification of their 'end-points' (which can also be thought of as the NPV at which 100% of users choose *to* disconnect from the network and 100% of customers choose *not to* disconnect from the network).

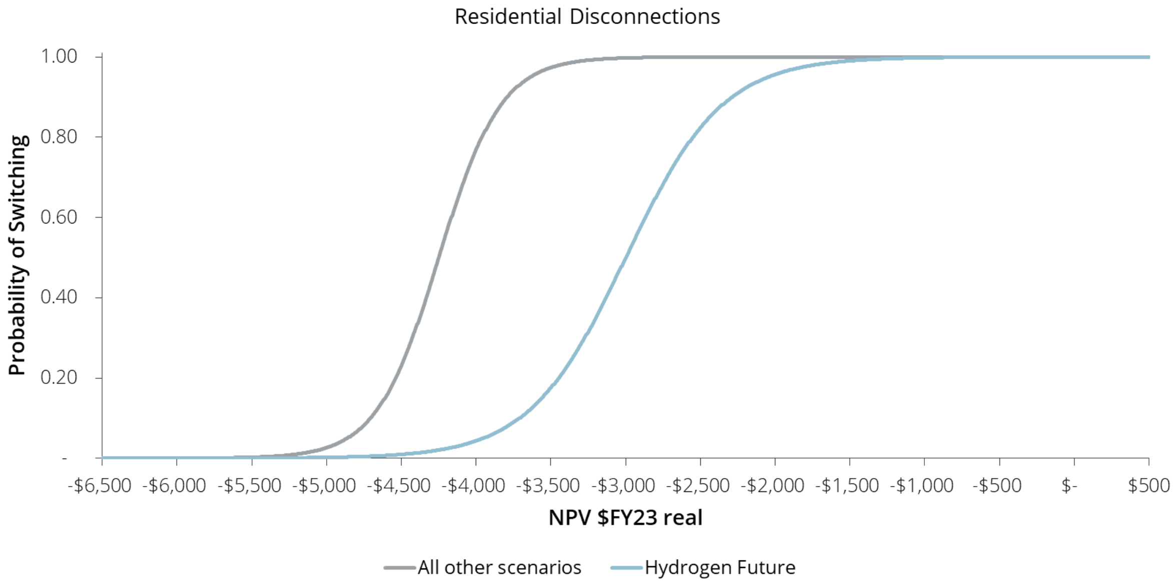
We have been provided little information as to how the S-curve has been parametrised for the purposes of ACIL's revised demand forecasts. ACIL did provide in its *Review of Jemena Gas Network's demand forecasts* report a generic example of an S-curve (see Figure 9 above), the same example they included in its reports regarding the ATCO MWSW GDS network models[19].

Consequently, we have had to rely on our previous experience with the S-curves developed for the ATCO MWSW GDS disconnection and demand forecasts to interrogate the revised residential gas disconnection forecast developed for the JGN network.

Figure 10 shows the S-curves that calculated the probability of residential customers disconnecting from the gas network across the four scenarios in the updated and final ATCO MWSW GDS WA models developed and utilised by ACIL Allen. Focusing on the '*All other scenarios*' S-curve, the S-curve logistic function suggests that 50% of customers would disconnect despite being over $4,000 in NPV terms *worse off* by disconnecting from the gas distribution network. This S-curve also implies a probability of disconnecting of about 100% for customers that would be around $3,000 in NPV terms *worse off* by disconnecting.

[19] See: ACIL Allen, *Future of gas*, June 2023 and ACIL Allen, *Future of gas*, June 2024.

Figure 10: S-curve for residential gas disconnection – ACIL updated and final MWSW GDS models



Source: Frontier Economics analysis of ACIL Allen updated and finalised models

As we have previously concluded[20], we have significant concerns with the parameterisation of this S-curve. The way that this S-curve for residential gas disconnections has been parameterised suggests that there is a very high probability that customers would disconnect from the gas network even if doing so would make those customers quite significantly worse off in financial terms (up to several thousand dollars in present value terms).

It is unlikely based off the responses provided in ACIL Allen's *Responses to JGN questions* note that ACIL Allen has parametrised the S-curve exactly the same way that they ultimately did in the updated and finalised version of the ATCO MWSW GDS models. However our previous conclusions above are likely still pertinent given ACIL Allen did state that "*The logistic model is calibrated such that if the relative NPV of switching is close to zero, the probability of switching will be close to 100% and nearly all customers facing the disconnection decision will do so*" and that "*while the NPV remains considerably negative in 2030, the logistic formula calculates a probability of disconnecting of 24% which means that 24% of customers facing the switching decision in 2030 will do so*". Further, our attempted replication utilising the updated and finalised S-curve in the ATCO MWSW GDS models does obtain estimated disconnections close to those forecasted by ACIL Allen (see Section 4.2.3).

Another concerning element of ACIL's previous application of S-curves in its appliance switching modelling relates to the significant revision of the S-curve end-point parameters, with seemingly no justification for such a change.

Table 9 below outlines the large change in end-point parameters ACIL Allen applied when moving from the model developed for ATCO's initial proposal for accelerated depreciation of the MSW GDS, relative to the end-point parameters utilised in the revised and final models. Because the S curve is intended to capture the rate of adoption (in this case, the rate of disconnection of existing customers) it is not clear why the parameterisation of the S-curve needed to change as a

[20] Frontier Economics, *ATCO MWSW GDS Model Review – Accelerated Depreciation, Stage 2*, September 2024, https://www.erawa.com.au/cproot/24415/2/Final-Decision-Frontier-Economics-Review-of-Accelerated-Depreciation-Stage-2.PDF

result of other changes to inputs in the model made by ACIL in response to our review of its initial model[21].

Table 9: ACIL Allen S-curve end-point parametrisation – initial, updated and final models for ATCO MWSW GDS disconnection and demand forecasts ($NPV)

	Initial models ($NPV of additional cost of using gas)		Updated/final model ($NPV of additional cost of using gas)	
Scenarios	Against Gas - 100% choosing electricity	For Gas - 100% choosing gas	Against Gas - 100% choosing electricity	For Gas - 100% choosing gas
Residential Disconnections				
Natural Gas Retained	$6000	-$2000	-$2000	-$6,500
Energy Hybrid	$6000	-$2000	-$2000	-$6,500
Hydrogen Future	$6000	-$2000	$500	-$6,500
Electricity Dominates	$6000	-$2000	-$2000	-$6,500

Source: Frontier Economics analysis of ACIL Allen initial, updated and final models for the ATCO MWSW GDS

Little explanation has been provided by ACIL to support the specific way that the S-curve has been parameterised when forecasting disconnections from JGN's network, and no evidence in support. In response to questions, ACIL has stated that the model is calibrated "*so that the NPV in 2024 matches the observed base rate of disconnections*". We take this to mean that the S-curve is parameterised so that using current estimates of NPV results in a forecast of disconnections that equates to the observed rate of disconnections. Even if this calibration can be reliably performed, this provides only a single point on the S-curve. How the S-curve varies as the NPV varies cannot be calibrated in this way, meaning that all other points on the S-curve are simply a matter of judgement. Ultimately, in our view this means that the disconnection forecasts are also a matter of judgement. ACIL provides no evidence to suggest that this exercise of judgement is reasonable. In our view, the conclusion that there is a very high probability that customers would disconnect from the gas network even if doing so would make those customers quite significantly worse off in financial terms suggests, at the very least, that this judgement is questionable.

Given no information has been forthcoming regarding the parametrisation of the S-curve utilised by ACIL to develop the revised disconnection forecasts for JGN, we have had to rely on the information that is available to us to attempt to review ACIL's disconnection forecasts – i.e. the generic S-curve and the S-curves developed and utilised in the ATCO MWSW GDS models. The following sections detail our attempts to replicate and then review the disconnection forecasts developed by ACIL Allen and published in the *Review of Jemena Gas Network's demand forecasts* report.

[21] Our review of ACIL Allen's initial models can be found here: https://www.erawa.com.au/cproot/23996/2/GDS---ATCO---AA6---Frontier-Economics-Accelerated-depreciation-report.PDF

4.2.1 Approach to attempted replication of ACIL Allen NPVs and disconnection forecasts

As noted in Section 4.1, a lack of available information regarding how the NPVs reported by appliance type were estimated, and how the other costs provided (e.g. electricity connection upgrade) have been applied, in arriving at the published disconnection forecast. Consequently, based on our previous experience reviewing ACIL's appliance switching S-curve model, we have attempted to replicate the NPVs, and the disconnection forecasts published in the *ACIL Allen JGN forecast adjustment* Excel workbook, utilising ACIL's approach in the ATCO MWSW GDS models.

In line with ACIL Allen's MWSW GDS models we have specified four customer types:

- Gas cooktop only (all other appliances electric)
- Gas cooktop and gas water heating only (all other appliances electric)
- Gas cooktop, gas water heating and gas room heating (all other appliances electric)
- Gas cooktop, gas water heating and gas space heating (all other appliances electric)

For each customer and for each year we have estimated the total NPV, utilising the inputs reported in the *ACIL Allen JGN forecast adjustment* Excel workbook, as comprising:

- The difference in the capital, operating and bill cost for each appliance type (gas minus electricity), replicating the approach in the '*Appliance costs*' tab in the ACIL ATCO models.
  - (We have not been able to precisely recreate these NPVs utilising the inputs provided by ACIL Allen given no information was provided about how the inputs were provided were ultimately turned into the NPVs reported in the *ACIL Allen JGN forecast adjustment* Excel workbook).
- Gas disconnection charge
- Electricity connection upgrade
- Gas service charge

It is important to note that no input has been provided or referenced in ACIL's revised demand forecast report regarding a gas service charge, however we have included this charge to align with its approach in the ATCO MWSW GDS models[22]. Additionally, it is also important to note that, in line with the ATCO MWSW GDS models, the gas disconnection and electrical connection upgrade costs have been applied to all customer types (including those that only currently use a cooking appliance, for example). We question whether this is a good assumption to make, however we have included it to align with the approach in the ATCO MWSW GDS models.

A weighted average of the NPVs for each customer type is then calculated for each year utilising ACIL Allen's specified weightings, after these were provided in the 18 December *Responses to JGN questions* note.

Replicating the approach and calculations in the ATCO MWSW GDS models, a relative utility for each year is then calculated utilising the NPV and the constant and NPV coefficient associated

[22] This charge was input as $116.99 in each year in the ACIL Allen ATCO MWSW GDS models.

with the S-curve parameters specified by ACIL Allen. The relative utilities are then transformed into a 'S-curve probability' using the following equation:

$$\frac{1 - \exp\,(relative\ utility)}{(1 + \exp(relative\ utility))}$$

This probability is then multiplied by the number of customers facing decision points to calculate the estimated number of 'economics driven' disconnections. Given a number of the inputs and the model were not provided for review, we have estimated the number of decision points as the total number of opening customers reported in the *ACIL Allen JGN forecast adjustment* Excel workbook divided by 15 (the assumed appliance life). We also apply the non-economics related disconnection rate to the total number of opening customers reported in the *ACIL Allen JGN forecast adjustment* Excel workbook in line with the approach adopted by ACIL.

Table 10 below details the NPVs we have calculated for each customer type. These NPVs include the relative capital costs of the appliances, relative running costs, gas disconnection charges, electricity upgrade connection costs, rebates for electric appliances and the gas service charge. This is why the figures are larger in magnitude than those reported by ACIL and again highlights the lack of transparency in the inputs and information provided for the purposes of this review.

Table 11 details the differences in the NPVs calculated for each appliance type, with the gas disconnection charges and electricity upgrade connection costs removed.

Table 10: Frontier Economic estimated NPVs of switching from gas to electrical appliances

Customer type	2024	2025	2026	2027	2028	2029	2030
Cooking	-$4,010.27	-$4,007.83	-$3,917.80	-$3,945.11	-$3,887.01	-$3,879.22	-$3,895.61
Cooking + Hot water	-$5,950.71	-$5,922.39	-$4,989.59	-$5,300.33	-$4,661.09	-$4,588.93	-$4,705.75
Cooking + Hot water + Room heating	-$5,920.19	-$5,879.96	-$4,559.33	-$5,000.48	-$4,093.84	-$3,992.05	-$4,155.12
Cooking + Hot water + Ducted heating	-$8,263.85	-$8,214.86	-$6,608.97	-$7,146.12	-$6,042.70	-$5,919.14	-$6,116.07

Source: Frontier Economics analysis

Table 11: Comparison of Frontier Economics and ACIL NPVs by appliance, with gas disconnection and electrical connection upgrade costs removed

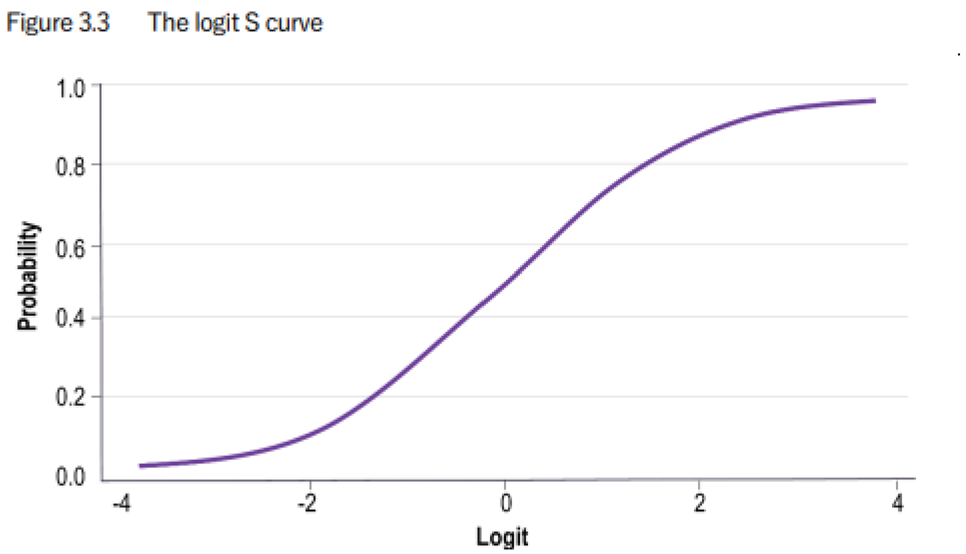
Customer type	2024	2025	2026	2027	2028	2029	2030
Frontier Economics Estimate - Cooking	-$959.59	-$957.15	-$867.12	-$894.43	-$836.32	-$828.53	-$844.92
ACIL - Cooking	-$895.16	-$866.73	-$841.92	-$728.66	-$733.64	-$651.22	-$620.28
Frontier Economics Estimate – Hot water	-$1,940.44	-$1,914.56	-$1,071.79	-$1,355.22	-$774.09	-$709.71	-$810.14
ACIL– Hot water	-$1,819.30	-$1,788.91	-$1,794.12	-$970.63	-$1,280.32	-$701.64	-$649.52
Frontier Economics Estimate - Room heating	$30.52	$42.43	$430.26	$299.84	$567.25	$596.88	$550.64
ACIL– Room heating	$106.35	$127.91	$133.02	$519.41	$384.27	$657.83	$689.04
Frontier Economics Estimate - Ducted heating	-$2,313.14	-$2,292.47	-$1,619.39	-$1,845.80	-$1,381.61	-$1,330.21	-$1,410.32
ACIL - Ducted heating	-$2,608.18	-$2,502.82	-$2,426.71	-$1,689.55	-$1,858.26	-$1,318.14	-$1,199.41

Source: ACIL Allen JGN forecast adjustment Excel workbook; Frontier Economics calculations

4.2.2 Disconnection forecast utilising a replicated 'generic' S-curve

As previously noted, ACIL Allen did not provide the end-points utilised to parametrise its S-curve. They do however provide a generic example of an S-curve detailed in Figure 11 below. This is the same example they included in its reports regarding the ATCO MWSW GDS network models[23].

Figure 11: ACIL Allen indicative logistic S-curve



Source: ACIL Allen, Review of Jemena Gas Network's demand forecasts, November 2024, p.21.

Given the lack of information regarding the S-curve provided by ACIL, we have begun by developing a generic S-curve to test.

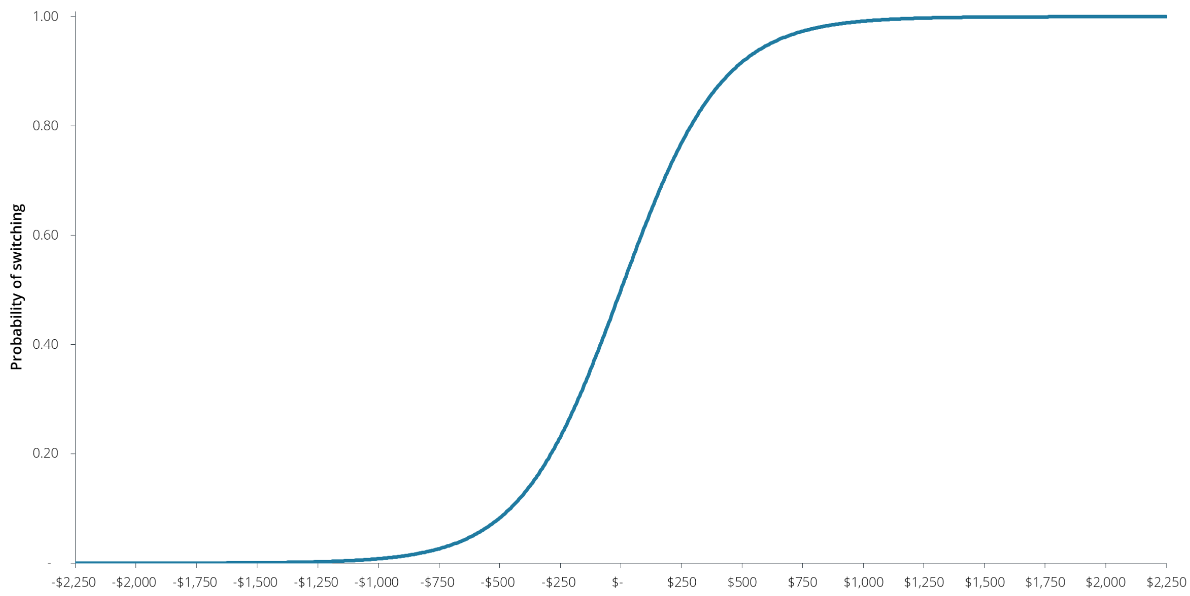
Figure 12 below visualises the S-curve we have developed to produce a disconnection forecast with a generic S-curve. We have parametrised the S-curve utilising NPV end-points of $2,250 and -$2,250, corresponding to an implied NPV coefficient of approximately -0.0048[24] and centred on zero. We specified these end-points so that the range between them would align with the total range across the end-points utilised in the ATCO MWSW GDS S-curve inputs in the updated and finalised models.

This S-curve implies that a customer that is indifferent between switching to electrical appliances or remaining a gas distribution network customer on an NPV basis, has a 50% chance of switching to electrical appliances and disconnecting from the network.

[23] See: ACIL Allen, *Future of gas*, June 2023 and ACIL Allen, *Future of gas*, June 2024.

[24] With a relative utility input of 10.82

Figure 12: Generic S-curve for Frontier Economics analysis

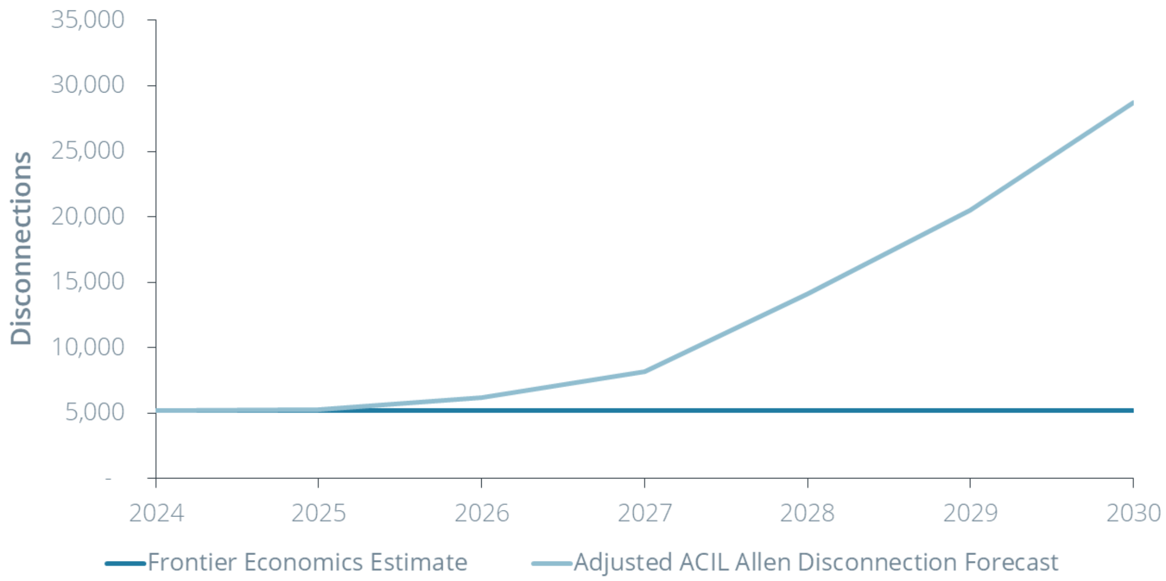


Source: Frontier Economics

As Figure 13 shows, utilising this 'generic' S-curve centred on zero results in forecast disconnections, generated by the S-curve, of zero. That is, the only disconnections relate to those driven by the assumed 0.35% non-appliance cost related rate of disconnection.

This highlights how sensitive the results are of ACIL's S-curve based appliance switching modelling is to the parametrisation of the S-curve and demonstrates how this type of approach requires the specification of S-curve parameters that are unintuitive in nature.

Figure 13: Frontier Economics disconnection forecast – generic S-curve scenario



Source: Frontier Economics

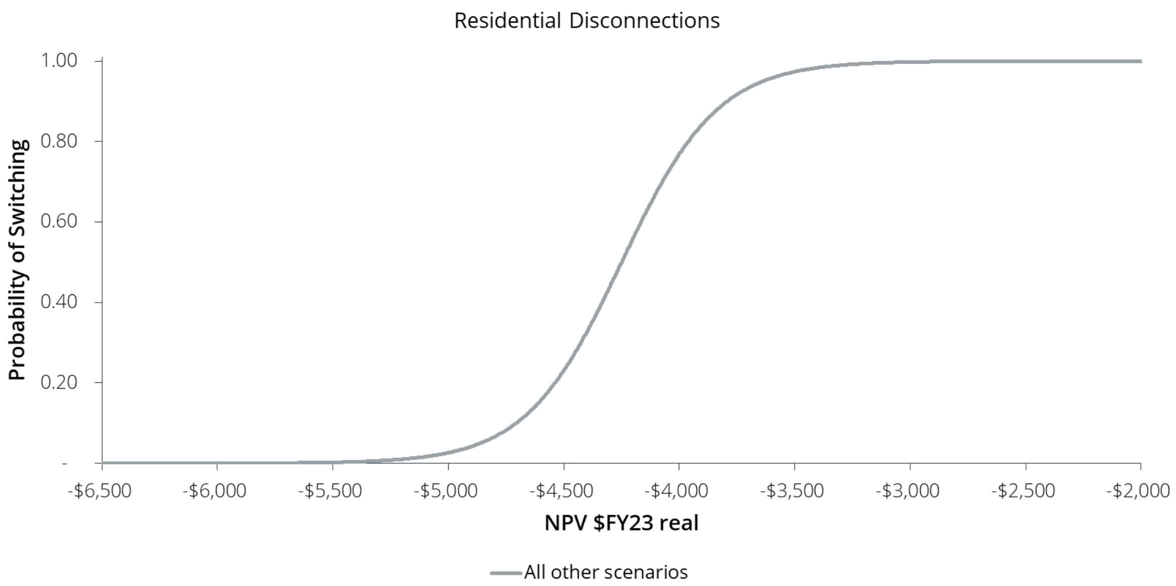
4.2.3 Disconnection forecast replicating S-curve from updated and finalised ATCO MWSW GDS models

Figure 14 details the S-curve ACIL developed for all of the scenarios other than '*Hydrogen Future*' as part of its updated and finalised disconnection forecast modelling for ATCOs MWSW GDS. The end-points of this S-curve are -$6,500 and -$2,000.

As noted at the top of Section 4.2, we have significant concerns with the parameterisation of this S-curve. This S-curve logistic function suggests that 50% of customers would disconnect despite being over $4,000 in NPV terms *worse off* by disconnecting from the gas distribution network. This S-curve also implies a probability of disconnecting of about 100% for customers that would be around $3,000 in NPV terms *worse off* by disconnecting. The bottom-line is that the way that this S-curve has been parameterised suggests that there is a very high probability that customers would disconnect from the gas network even if doing so would make those customers quite significantly worse off in financial terms.

Regardless, we have utilised these S-curve parameters to attempt to replicate ACIL's disconnection forecast (utilising the NPVs we have attempted to replicate) given these are the S-curve parameters that were utilised in the final iteration of the ATCO MWMSW GDS models.

Figure 14: S-curve for residential gas disconnection – ACIL Allen updated and final MWSW GDS models

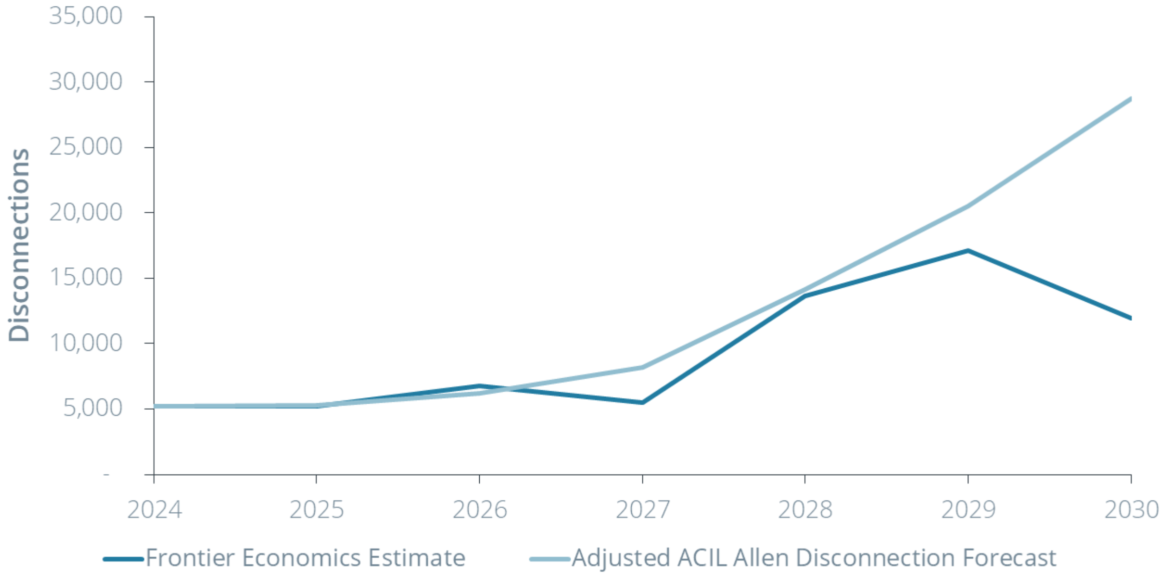


Source: Frontier Economics analysis of ACIL Allen updated and finalised models

As Figure 15 shows, utilising this S-curve produces a disconnection forecast that closely mirrors the disconnection forecast published by ACIL, although with a divergence in the final year. In line with the estimated NPVs utilised, the disconnection forecast replication we have produced is not as smooth as those produced by ACIL – further highlighting the lack of information that was made available for this demand forecast review.

What Figure 15 also shows is that it is possible that ACIL have parametrised an S-curve that is similar to the S-curve utilised to produce the updated and final disconnection forecasts in the ACTO MWSW GDS models. If this is the case, our reservations regarding the problematic parametrisation of the S-curve in the ATCO context would also be relevant for the revised disconnection forecast – and revised demand forecast by extension – produced by the ACIL modelling (in addition to our previously noted concerns regarding the sensitivity of the results to S-curve parametrisation more broadly).

Figure 15: Frontier Economics disconnection forecast – replicating S-curve from updated and finalised ATCO MWSW GDS models



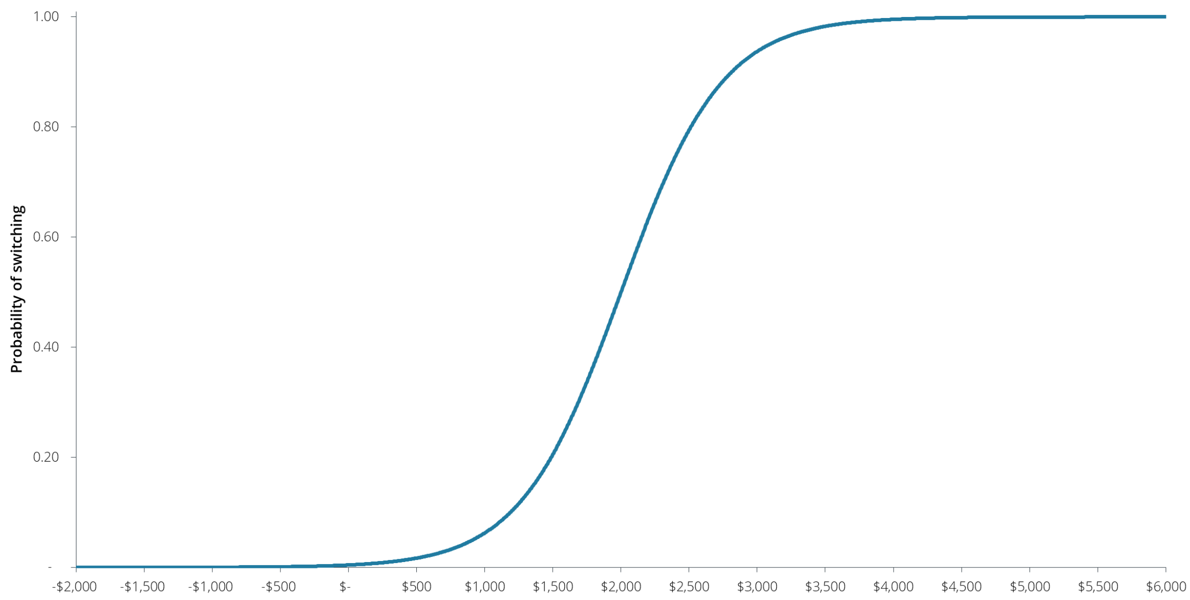
Source: Frontier Economics

4.2.4 Disconnection forecast replicating S-curve from initial ATCO MWSW GDS models

To highlight how sensitive the S-curve disconnection forecasts produced by ACIL are to the parametrisation of the S-curve, we have also developed disconnection forecasts utilising the NPVs we have estimated applying the S-curve parameters ACIL utilised in its initial model produced for the ATCO MWSW GDS disconnection and demand forecasts.

That is, the S-curve detailed in Figure 16 has end-points of $6,000 and -$2,000. These are the end-points which were updated – without any clear reason – in the updated and finalised ACIL demand forecasts for the ATCO MWSW GDS to be -$2000 and -$6,500 (see the beginning of Section 4.2 and Table 9).

Figure 16: S-curve for residential gas disconnection – ACIL Allen initial MWSW GDS models

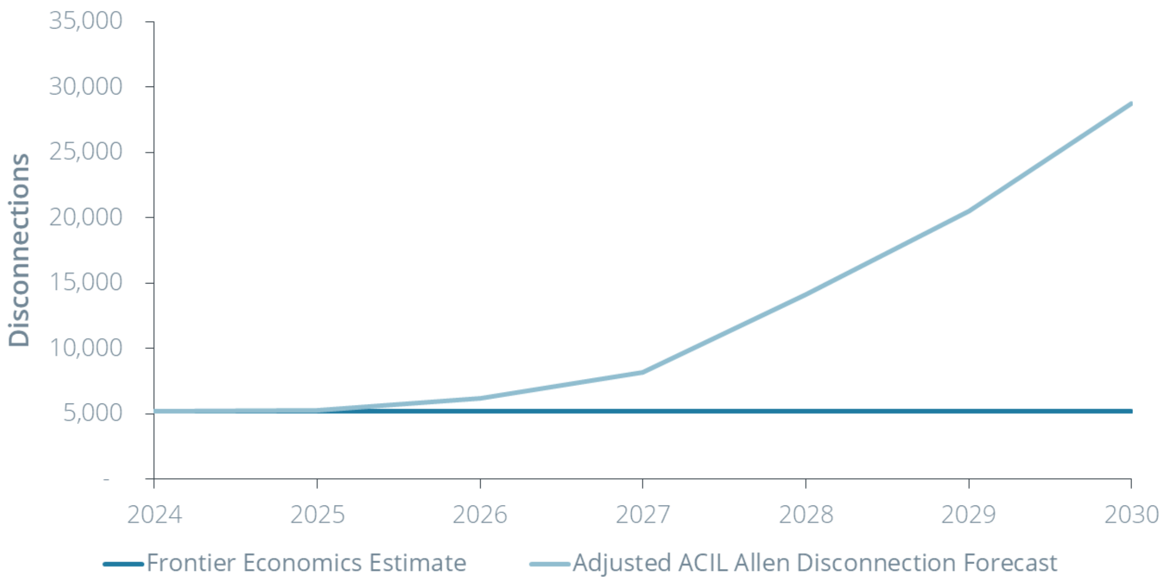


Source: Frontier Economics analysis of ACIL Allen initial model

As Figure 17 shows, this tweak to the end-point parameters (mimicking S-curve parameters previously used by ACIL) completely changes the disconnection forecast produced using the same NPVs as the analysis undertaken in the previous Section (Section 4.2.3). This update of the end-point parameters results in forecast disconnections related to the 'economics' of switching of zero. That is, the only disconnections relate to those driven by the assumed 0.35% non-appliance cost related rate of disconnection.

This highlights how sensitive the results of ACIL's S-curve based appliance switching modelling is to the parametrisation of the S-curve and again demonstrates the malleability of the outputs of this modelling to inputs that have not been provided or justified by ACIL and that potentially are unintuitive in nature.

Figure 17: Frontier Economics disconnection forecast – replicating S-curve from initial ATCO MWSW GDS models



Source: Frontier Economics

4.2.5 Disconnection forecast replicating S-curve from updated and finalised ATCO MWSW GDS models, utilising information regarding the distribution of customer types across the network

Despite our stated concerns regarding the potential parametrisation of the S-curve, we note that no source or reference was provided for the distribution of customer types across the network utilised to produce a weighted average NPV. In lieu of a cited source or the calculations underpinning these inputs, we have attempted to replicate these proportions utilising publicly available information.

Utilising the *2021 Residential Baseline Study for Australia and New Zealand*[25], we have been able to back out an estimated distribution of customer types across the network. Table 12 below details the inputs, assumptions and sources we utilised to estimate the distribution of customer types reported in Table 13. Our designation of customer types, and the assumption that all residential customers on the gas distribution network have a gas cooking appliance aligns with the approach utilised by ACIL in the ATCO MWSW GDS modelling.

Table 13 also includes the distributions utilised by ACIL Allen to enable easy comparison.

25 Australian Government, *2021 Residential Baseline Study for Australia and New Zealand for 2000 to 2040*, November 2022, https://www.energyrating.gov.au/industry-information/publications/report-2021-residential-baseline-study-australia-and-new-zealand-2000-2040

Table 12: Inputs, assumptions and sources for estimated customer type distribution

Customer types	Input	Source
Total customers 2024	1,480,276	The *ACIL Allen JGN forecast adjustment* Excel workbook.
Gas cooking appliances	1,480,276	Assumption – all customers on the network have a gas cooking appliance
Gas water heating appliances	1,291,135	Residential Baseline Study Total Stock by End Use, Hot water gas storage and gas instant
Gas room heating appliances	477,642	Residential Baseline Study Total Stock by End Use, Space conditioning gas non-ducted
Gas ducted heating	81,764	Residential Baseline Study Total Stock by End Use, Space conditioning gas ducted

Source: Frontier Economics analysis

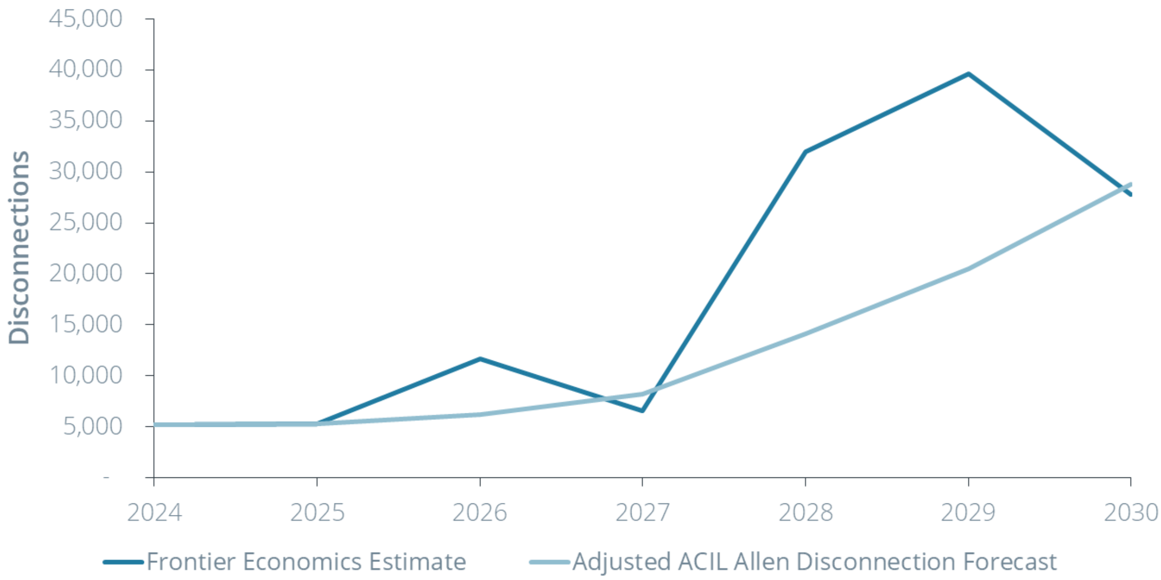
Table 13: Estimated customer type distribution

Customer type	ACIL Allen input	Frontier Economics estimate
Gas cooktop only (all other appliances electric)	16.40%	12.78%
Gas cooktop and gas water heating only (all other appliances electric)	37.50%	49.43%
Gas cooktop, gas water heating and gas room heating (all other appliances electric)	22.00%	32.27%
Gas cooktop, gas water heating and gas space heating (all other appliances electric)	24.10%	5.52%

Source: Frontier Economics analysis

As Figure 18 shows, applying the Frontier Economics estimated customer distribution in Table 13 to generate a weighted average NPV and then applying the S-curve parameters from the updated and finalised ATCO MWSW GDS modelling results in the number of disconnections increasing relative to the ACIL Allen weighted average approach. That is, when we utilise publicly available information to represent the customers on the network, applying the approach previously developed by ACIL Allen (in lieu of being provided the full suite of inputs and the models ACIL Allen developed for these revised demand forecasts) the estimate for the number of disconnections on the network is higher in generally higher or close to the forecasts produced by ACIL Allen.

Figure 18: Frontier Economics disconnection forecast – replicating S-curve from updated and finalised ATCO MWSW GDS models – application of weighted average customer type



Source: Frontier Economics

4.2.6 Omission of solar photovoltaic (PV)

It is not clear if or how small-scale rooftop solar photovoltaic (PV) installations are accounted for in the ACIL Allen model. Solar PV, as well as other consumer energy resources (CER) such as batteries and electric vehicles, have dramatically altered patterns of energy consumption and the economics of fuel-switching and will likely increasingly do so as their penetration increases.

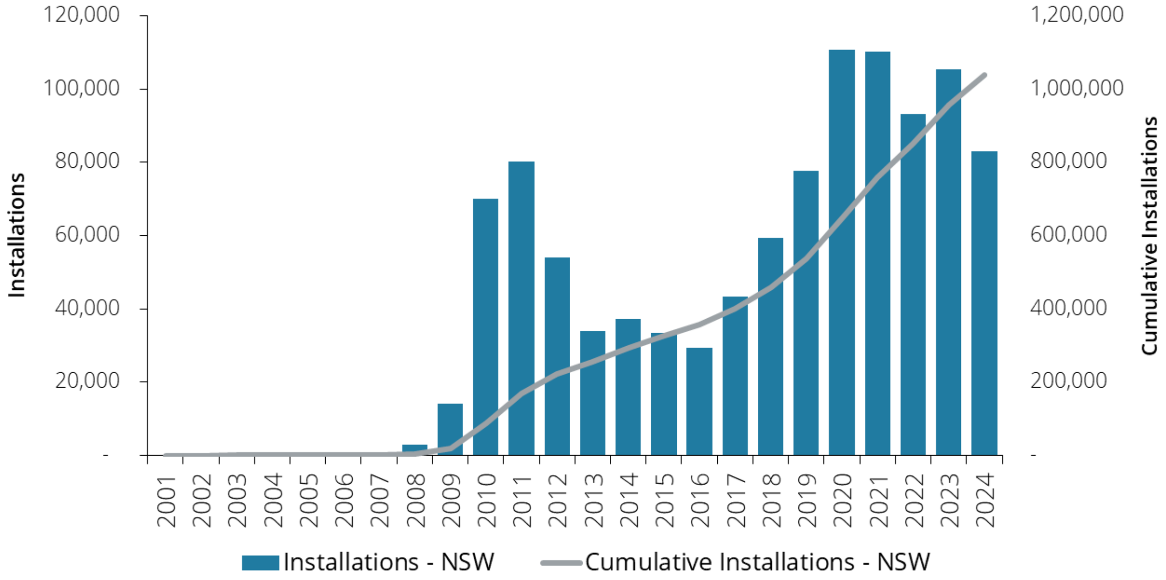
In New South Wales, there is already a high proportion of buildings (particular residential buildings) with small-scale solar PV. Cumulative installations for small-scale solar (<100kW) in New South Wales exceed 1 million[26] (see Figure 19). This means that a high proportion of residential dwellings in New South Wales already have solar PV. Further, it is projected that the penetration of rooftop solar PV at the residential level in New South Wales will continue to grow, and that as existing systems are replaced or upgraded, the size of these installations (as well as new installations) are likely to be increasingly larger in size (kW)[27].

[26] Clean Energy Regulator, *Postcode data for small-scale installations*, December 2024, https://cer.gov.au/markets/reports-and-data/small-scale-installation-postcode-data#Historical-data

Note: this figure may overstate total installations as replacement installations are treated as new installations. Further, this figure is not restricted to residential dwellings only, and includes some commercial and non-residential installations.

[27] See for example: Commonwealth Scientific and Industrial Research Organisation, *Small-scale solar PV and battery projections 2022*, December 2022, https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/supporting-materials-for-2023/csiro-2022-solar-pv-and-battery-projections-report.pdf; Jacobs, Clean Energy Regulator Stage 1: Small-scale Technology Certificate Projections, August 2024, https://cer.gov.au/document/stc-modelling-report-jacobs-august-2024

Figure 19: Small-scale solar PV installations, New South Wales



Source: Frontier Economics analysis of Clean Energy Regulator, Small-scale installation postcode data, December 2024

Solar PV and other CER fundamentally alter energy consumption patterns, the operating costs of electrical appliances and the decisions that households may make with respect to if, when and how they electrify gas appliances. Households with existing solar PV systems and households that install new or larger PV systems would receive higher benefits, relative to non-PV households, from electrification if they can make use of electricity from their solar panels to operate electrified appliances. To the extent that residential and commercial customers are exporting excess solar electricity and are able to make use of some of that exported solar electricity to power electrified appliances, the NPV of switching for these connections is likely higher.

However, it is difficult to comment on the magnitude to which solar PV and CER would impact on the NPVs and the level of disconnections. This is largely due to uncertainty about the extent to which demand from electrified appliances can be met by solar generation that is currently being exported to the grid. This will vary from customer to customer, depending on the size of their solar systems, their existing patterns of electricity consumption, their patterns of consumption for newly electrified appliances, and the extent to which they have other CER, particularly batteries.

As noted, it is not clear based on the information provided by ACIL Allen whether existing and future solar PV uptake is captured in their appliance switching model. ACIL Allen's response to the ERA's subsequent Draft decision and our previous report which highlighted the same issue in ACIL Allen's MWSW GDS models detailed that rooftop solar PV was not incorporated in the NPV analysis[28]. If solar PV penetration has not been included in the model again – or has been 'included' in such a way that its impact does not accurately reflect the impacts that it has on customers switching and energy consumption decisions – the model developed by ACIL Allen is likely inaccurately representing the economics of switching and hence the rate of customer disconnections.

[28] ACTO, *ATCO Gas 2025-29 Revised Plan: ATCO Mid-West and South-West Gas Distribution System*, June 2024, p. 221, https://www.erawa.com.au/cproot/24095/2/ATCO-Gas-2025-29-Revised-Plan-Redacted.pdf

It is difficult to comment on the impact of omitting/including rooftop solar PV in this model due to the extent of the uncertainty surrounding the modelling undertaken by ACIL Allen. Nonetheless, there is clearly the prospect that integrating consideration of solar PV and other CER into the ACIL Allen model would generate materially different results with respect to disconnections over the next 5 years.

4.3 Conclusion

While ACIL have provided information on some of the key inputs used to forecast disconnections, information on the single most important driver of disconnection forecasts – the way that the S-curve is parameterised – has not been provided. This means that we are unable to verify ACIL's forecasts.

The results provided by ACIL – and information provided by ACIL in support of its previous forecasts of disconnections for ATCO – suggest that the S-curve is parameterised in such a way that the probability of disconnection is very high even when customers would be significantly financially worse off by disconnecting. ACIL provide no real evidence to support this assumption or to explain why this would be the case.

ACIL does state that the calibrate the S-curve such that its estimate of current NPVs provides a forecast that aligns with baseline disconnections. Even if this calibration can be relied upon, at best it provides one point on the S-curve, which does not help when forecasting rates of disconnections once the NPV changes (as it does in ACIL's forecast).

In short, our view is that ACIL's approach to forecasting disconnections is based on little more than judgement, without supporting evidence to suggest that the judgement is sound.

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