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ATCO MWSW GDS
Accelerated Depreciation Modelling Review

A report for the Economic Regulation Authority, Western Australia | 26 March 2024

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1 Introduction

ATCO Gas Australia Pty Ltd (ATCO) operates the Mid-West and South-West Gas Distribution Systems (MWSW GDS). The MWSW GDS is a regulated distribution network and requires an approved access arrangement. On 1 September 2023, ATCO submitted its access arrangement proposal for 1 January 2025 to 31 December 2029 (the sixth access arrangement period {AA6}). The Economic Regulation Authority (ERA) is to consider ATCO's proposal and will publish a draft decision.

The ERA uses a building block framework to determine the efficient revenues that ATCO is allowed to earn over the regulatory period. A key component of the allowed revenues is the return of capital allowance, also referred to as regulatory depreciation. Rule 89(1)(b) requires that the depreciation schedule used to set the regulatory depreciation allowance should be designed:

> *… so that each asset or group of assets is depreciated over the economic life of that asset or group of assets …*

ATCO's AA6 proposal has included $80 million ($real 2023) for accelerated depreciation (AD) due to the uncertainty of the future of gas and the use of the gas distribution network. This represents 23% of the increase in proposed AA6 revenue.

In support of this proposal ATCO has submitted to the ERA modelling undertaken by ACIL Allen. Within this modelling, ACIL Allen forecasts demand for ATCO's gas distribution services over a 50-year period for four different scenarios. ACIL Allen applied expenditure forecasts supplied by ATCO that were relevant for each scenario and projected regulated revenue given the demand forecasts for each of the four scenarios. ACIL Allen then combined the projections of demand with the projections of revenue requirements to derive the regulated distribution prices that would be implied and, from this, backed out the necessary AD required to deliver constant real prices.

ATCO has submitted a report by ACIL Allen on the development of scenarios and the calculation of AD,[1] as well as a report by Incenta Economic Consulting which included a review of the ACIL Allen report[2].

1.1 Our engagement

We have been engaged by the ERA to review the approach and implementation of the AD models prepared by ATCO's consultants for ATCO's AA6 proposal, in order to assist the ERA in its decision relating to AD allowances. Specifically, we have been engaged to:

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

2 Incenta Economic Consulting 2023, *Regulatory depreciation for AA6*, ATCO Gas Australia, https://www.erawa.com.au/cproot/23615/2/11.001---Regulatory-depreciation-for-AA6.pdf (**Incenta report**).

- Review the reasonableness of ACIL Allen's modelling approach to uncertainty of future long-term demand.
- Review the reasonableness of ACIL Allen's model, advising of any errors or issues in the model.
- Conduct sensitivity analysis to determine which assumptions are the most material.
  - Review and report on the identified material assumptions from above for reasonableness.
- Comment on the reasonableness of proposed AD amounts for AA6.
- Advise on possible alternative methods of determining an amount of AD for AA6.

1.2 The report

This report is structured as follows:

- Section 2 provides an overview of the ACIL Allen model, including an overview of the key drivers of the results.
- Section 3 provides an overview of the scenarios in the modelling and the gas demand forecasts produced, including further analysis of the key drivers of the variation in the gas demand forecasts produced and potential factors that may influence AD.
- Section 4 discusses and assesses the inputs and assumptions used in the modelling and includes the results of sensitivity analysis undertaken.
- Section 5 discusses and reviews key elements of the methodology.
- Section 6 presents the conclusions and recommendations from this analysis.

2 Overview of the ACIL Allen model

The following section provides a brief overview of the modelling undertaken by ACIL Allen and subsequently details and discusses the key drivers of the results within the modelling.

2.1 The ACIL Allen model

The ACIL Allen model is an Excel-based model that consists of:

- a model of appliance choice by customers, given the relative cost of electricity and gas appliances and the forecast relative prices of delivered electricity and gas,
- a building block post-tax revenue model, and
- a model able to calculate the AD allowances required to maintain a constant annual average tariff.

The purpose of the model is to assess the impact of each scenario on the gas distribution system including the need for accelerated depreciation. The model does this by forecasting demand for ATCO's gas distribution services over the long term. Demand forecasts were produced out to 2100. However, the period of interest for the purposes of deriving a proposed AD amount is the five-year AA6 period and the 45 subsequent years (i.e. a 50-year modelling period).

ATCO engaged ACIL Allen to develop four scenarios for which demand forecasts were produced. The four scenarios were developed via stakeholder working groups, however further detail regarding the process or stakeholders was not provided. The four scenarios developed include:

- Hydrogen Future: "*Under the Hydrogen Future scenario, rapid learning rates relating to green hydrogen and renewable gas production enable these gases to displace natural gas domestically and internationally. The resulting green hydrogen industry mirrors the current natural gas and LNG industries with a broader high-volume export focus enabling the economic servicing of a smaller domestic market*" [3].
- Electricity Dominates: "*Under the Electricity Dominates scenario, renewable electricity generation and storage experience a rapid reduction in cost through fast technological learning. As such, the relative cost of electricity against natural gas and renewable gases falls to such an extent that a broad-based electrification of industry and households occurs*" [4].
- Energy Hybrid: "*Under the Energy Hybrid scenario, technical learning rates for renewable gases and electrification develop similarly, resulting in some customers electing to electrify and some remaining on the gas network. From an economic and environmental point of view, electricity and zero emissions gases become viable alternatives for natural gas. This results in a mixed response from residential/commercial and industrial consumers, with an even split electing to follow electrification or to stick with a gas-based energy supply chain*" [5].
- Natural Gas Retained: "*Under the Natural Gas Retained scenario, global and local factors result in natural gas being retained in the ATCO network, broadly in line with medium-term expectations as of the previous Access Arrangement process. Zero-emissions gases such as green hydrogen or renewable methane experience slow technological learning rates, which results in them generally*

3 ACIL Allen 2023, *Future of gas*, p.10.

4 ACIL Allen 2023, *Future of gas*, p.12.

5 ACIL Allen 2023, *Future of gas*, p.14.

> *remaining uneconomic at scale … natural gas continues to be embraced as a 'transition fuel' used in large volumes … rapid technological learning relating to carbon capture and storage CCS/CCUS and improved access to adequate and affordable carbon offset options"* [6].

The appropriateness of the scenarios developed by ACIL Allen and the demand forecasts resulting from the modelling are discussed further in Section 3.

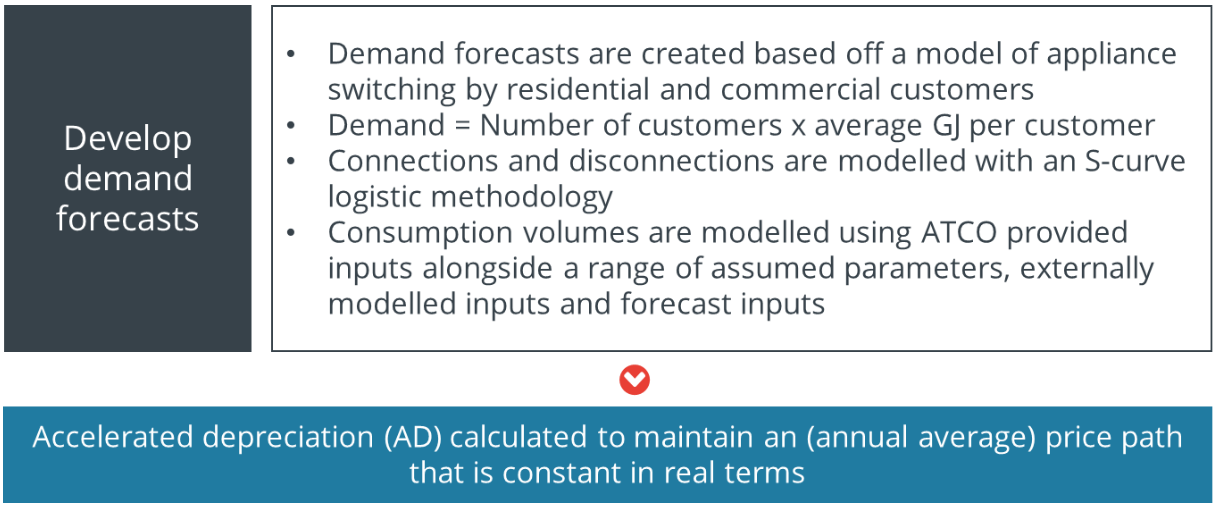
At a high-level, what the ACIL Allen model is doing is deriving demand forecasts for a given scenario by separately estimating customer numbers (split into new connections[7] and disconnections) and average consumption per connection on an annual basis and calculating total demand from these figures. Forecasts for both customer numbers and average consumption are split between residential customers (one tariff class), commercial customers (two tariff classes), and industrial customers (two tariff classes).

Once the demand forecasts for each of the four scenarios are developed, ACIL Allen utilises a building block, post-tax revenue modelling approach to determine the amount of AD. Specifically, ACIL Allen calculates the constant real annual average tariff that provides the same present value of regulated revenue as the annual average tariff between 2025 and 2074 with no AD. This in turn enables calculation of how depreciation must be adjusted on a yearly basis to maintain the constant real annual average tariff. That is, how much AD is required in AA6 and how does the depreciation profile need to be adjusted between 2030 and 2074 thereafter to maintain the new constant real annual average tariff.

Section 2.2 below provides greater detail regarding the modelling approach and different modelling components outlined above and identifies the inputs and calculations that drive the models results.

Figure 1 below provides a high-level synopsis of the modelling approach discussed above.

Figure 1: Overview of the model



Source: Frontier Economics analysis

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6 ACIL Allen 2023, *Future of gas*, p.15.

7 New connections include both completely new customers and reconnections.

2.2 Key drivers of results

2.2.1 Customer numbers (residential and commercial customers)

ATCO distributes gas to residential, commercial and industrial customers across its natural gas distribution network. According to the historical customer number data included in the ACIL Allen model, over 98% of ATCO customers are residential customers on the B3 tariff, approximately 0.025% are industrial customers on the A1 or A2 tariff and the remainder are commercial customers on either the B1 or B2 tariff. Residential and commercial customer numbers are modelled using an S-curve model of switching. Industrial customers are treated separately (discussed in Section 5.2).

The number of connections, disconnections and the existing number of gas network users in each local government area (LGA) determines the number of gas customers in a given LGA in the subsequent year. Within each scenario (model), there are a number of inputs and assumptions that contribute to determining customer numbers in a given year in a given LGA. These include assumptions made with respect to connection and disconnection growth rates abstracted from economic considerations, S-curve parameter calibration and assumptions made with respect to when and how consumers decide whether to electrification (these inputs are discussed further in Section 4). Figure 2 provides an overview of the key determinants and the mechanics driving the customer number results.

Figure 2: Overview of residential and commercial customer connection and disconnection modelling

The switching decision determines the number of gas customers in each LGA

New connections	Disconnections
New connection = S-curve probability x 'new connection absent appliance economics'	Disconnection = (S-curve probability x customers at decision point) + assumed disconnection growth (0.5%)

• New connection absent appliance economics = assumed new connection growth (2%) x number of customers in the previous year
• S-curve probability of switching
  • Relative utility is based on NPV of electricity v gas and S-curve calibration (constant and NPV coefficient)
  • Relative utility is transformed into probability of switching
	• Assumed disconnection growth (0.5%) x number of customers in the previous year
	• S-curve probability of disconnecting
	  • Relative utility is based on NPV of electricity v gas x (S-curve constant + NPV coefficient)
	  • Relative utility is transformed into probability of disconnecting
	• Assumed 1/15 of customers from previous year are at decision point

Source: Frontier Economics analysis

The driver of the variation in customer connections and disconnections across the four scenarios are the inputs used for retail electricity and gas prices. These inputs impact the annual operating cost of appliances, which in turn impacts the relative net present value (NPV) of switching from a gas appliance to a comparable electrical appliance[8]. That is, the variation in total customer

8 The appropriateness of the appliances compared within the modelling is discussed in Section 5.4.

numbers across the scenarios is driven by these retail prices given all other inputs are identical across scenarios, including appliance capital and maintenance costs, annual energy consumption, appliance efficiency, S-curve parameters and so on[9]. Consequently, the retail gas and electricity prices utilised in the modelling are critical inputs that drive the results of the modelling to a large extent.

The inputs and assumptions made with respect to retail gas and electricity prices used within the modelling are discussed in greater detail in Sections 3.1 and 4.1.

2.2.2 Average annual volume (GJ) consumed per connection

To obtain total demand forecasts for each year and for each customer class, average volumes consumed per connection by customer class are calculated for each year (at the LGA level for residential and commercial customers). These figures are then multiplied by the total number of natural gas customers in that year for a given customer class (and LGA where applicable) to estimate total gas demand.

An ATCO provided forecast for volume per connection in 2025 (measured in GJ/connection) is used as the base year and is subsequently trended out year-on-year based on[10]:

- Percentage change in the forecast retail electricity price from the previous year multiplied by an assumed price elasticity of demand (applies for all customer classes).
- Percentage change in the forecast retail gas price from the previous year multiplied by an assumed price elasticity of demand (applies for all customer classes).
- Percentage change in forecast heating degree days (HDD) with a reference temperature of 18 degrees multiplied by an assumed elasticity (applies for all customer classes).
- Percentage change in the forecast gross state product (GSP) of Western Australia multiplied by an assumed elasticity (applies for commercial and industrial customers categories only).

Notably, the ATCO provided demand figures for 2025 that are utilised in the ACIL Allen model do not align with the gas demand forecasts produced by Core Energy and submitted as part of ACTO's AA6 pricing submission[11]. Clarification was sought from ATCO, and ATCO advised that:

> *"The consumption data used in the ACIL Allen modelling was prepared in February 2023 before the CORE forecast was available. However, the data modelled by ACIL Allen for the 2025 – 2029 period should not necessarily match the CORE forecast even if it were available. The data for the 2025 – 2029 period is based on ACIL Allen's modelling of the 4 scenarios including its own proprietary techniques for modelling changes in gas consumption due to factors such as weather, relative electricity and gas prices and gross state product where relevant.*

[9] The only exception to this statement is that under the Electricity Dominates scenario, the 'decision point' that determines the number of customers that may disconnect from the gas network in a given LGA in a given year progressively decreases and is not held constant at 15 years as it is in the Hydrogen Future, Gas Retained and Energy Hybrid scenarios.

[10] Industrial customer average annual volumes under the electricity dominance scenario does not use this method – historical industrial average annual consumption is forecast out based on the declining trend in residential average annual consumption in this scenario (and only this scenario). This is discussed further in Section 5.2.

[11] Core Energy & Resources 2023, *ATCO Gas Australia MWGDS AA6: Gas Demand Forecast,* https://www.erawa.com.au/cproot/23608/2/07.001---Core-Energy---Gas-Demand-Forecast.pdf

The average consumption data to 2025 is based on ATCO's 2023 business plan data prepared in mid-2022. The data was based on forecast customer numbers and average consumption and did not take account of other factors taken account of by CORE, such as use of macro and micro economic data and demographic data, customer survey responses, new dwelling and appliance efficiency and the outlook and expected impact of Government policy on gas to electricity appliance substitution.

It is understandable the demand data does not initially align across the Core Energy and ACIL Allen modelling given the misalignment in modelling timeframes and that ACIL Allen was constrained to using the best available data at the time. However, it is concerning that in spite of the noted differences in methodological approaches of each of these forecasts, the Core Energy demand forecasts produced do not fall within the range of the 4 demand forecasts produced by ACIL Allen for each of the scenarios. Table 1 provides an example of this misalignment, showing the differences in the residential gas demand data and forecasts used and produced in the ACIL Allen model compared to the residential gas demand forecast produced by Core Energy.

Given the magnitude of the differences between the gas demand forecasts, there is substantial uncertainty regarding the robustness of the demand 'baseline' used in the ACIL Allen model. This also raises the question as to whether more consideration needs to be given to the use of a baseline number as a methodological approach as well as greater consideration for estimating what this baseline demand figure is if the approach is maintained.

As noted above, it is likely that at least part of the misalignment between the demand forecasts stems from different methodological decisions by different consultants. However, the question remains as to why the approaches are so different. For example, Core Energy utilise an Effective Degree Day approach to weather normalisation, whereas the ACIL Allen model utilises a heating degree day (HDD) approach for weather normalisation. No explanation is provided for the inconsistency in methodologies used. Section 4 discusses the implications of this misalignment in greater detail.

Table 1: ACIL Allen and Core Energy & Resources demand forecast misalignment example, residential volumes (GJ/annum)

Source	2025	2026	2027	2028	2029
ACIL Allen model, Electricity Dominates	10,053,048	10,029,142	9,981,286	9,934,123	9,934,522
ACIL Allen model, Gas Retained	10,053,048	10,045,892	10,018,617	9,998,323	10,031,798
ACIL Allen model, Energy Hybrid	10,053,048	10,045,892	10,018,606	9,998,290	10,031,743
ACIL Allen model, Hydrogen Future	10,053,048	10,051,142	10,029,547	10,015,506	10,055,661
Core Energy & Resources	9,575,007	9,389,004	9,219,968	9,070,417	8,936,747

Source: ACIL Allen model; Core Energy & Resources 2023, ATCO Gas Australia MWGDS AA6: Gas Demand Forecast.

Note: 2025 gas volumes in the ACIL Allen model are an input. 2026-2029 gas volumes are forecast outputs of the model.

The HDDs and elasticities for all of the aforementioned variables are identical and held constant across all four of the scenarios modelled. GSP forecasts are the same for all scenarios other than the Hydrogen Future scenario. Therefore, the only input that varies across the other scenarios is the retail electricity and retail gas prices inputs used (that do vary by scenario). The variation in the results for average GJ consumed per customer across the scenarios for residential customers is therefore driven entirely by the retail electricity and gas price inputs used (and commercial customers in all scenarios except Hydrogen Future).

The inputs and assumptions made with respect to retail gas and electricity prices used within the modelling are discussed in greater detail in Section 4.1.

2.2.3 Constant annual average tariff approach and estimating AD

As detailed in Section 2.1, ACIL Allen utilised an augmented building block regulatory modelling approach similar to the post-tax revenue model published and utilised by the ERA to model constant annual average tariffs under each of the four scenarios and, in turn, calculate the necessary AD to maintain the constant annual average tariff constraint. Specifically, the approach taken by ACIL Allen was to:

1. Replicate the revenue and depreciation schedule associated with underlying demand and expenditure (data provided by ATCO) under the four separate scenarios.
    a. The current regulatory asset base (RAB), remaining asset lives, new asset expenditure (and asset lives) and operating expenditure associated with the four respective scenarios was also provided by ATCO.
2. Calculate the annual average tariff for the respective depreciation schedules out to 2074.

3. Calculate the constant annual average tariff in real terms that provides the same present value of revenue as the average annual tariff between 2025 and 2074.
4. Shift regulatory depreciation to accommodate the constant annual average tariff constraint.

There are several critical inputs within this regulatory modelling that influence the results for both the constant annual average tariff calculation and the AD calculations. These critical inputs include in particular the capital and operating expenditure profiles/assumptions. The inputs and assumptions associated with this component of the modelling are discussed further in Section 4.3.

Additionally, the fundamental underlying assumption within this modelling – that a constant annual average tariff (in real terms) is preferable– is the key driver of the AD results presented. The ACIL Allen report determines a constant annual average tariff because "[t]his approach does not advantage or disadvantage any group of customers across time while allowing the revised depreciation schedule to reflect the economic value of the gas distribution assets"[12]. The Incenta Report argues that a constant annual average tariff is preferable on the grounds of preventing stranded asset risk, promoting economic efficiency and lowering future tariffs. The reasonableness of this assumption is addressed in Section 6.

12 ACIL Allen 2023, *Future of gas*, p. viii.

3 Model review – Scenarios

The following section details and discusses the reasonableness and implication of the scenarios modelled by ACIL Allen, focusing on the gas demand forecasts for the scenarios.

As we understand the operation of ACIL Allen's modelling, all differences in the estimated requirement for AD between the four scenarios can ultimately be traced back to differences in gas demand forecasts in the four scenarios. That is, if gas demand forecasts in the four scenarios were the same, the requirement for AD between the four scenarios would also be the same. This is not to say that gas demand forecasts are the only inputs that change; as we discuss, forecast of capital expenditure and operating expenditure also change. However, we understand that these differing forecasts of expenditure between the scenarios are driven by differences in gas demand forecasts.

This being the case, the assessment of the reasonableness of the scenarios modelled by ACIL Allen is ultimately a question about the reasonableness of the gas demand forecasts produced by ACIL Allen. That is the focus of this section.

3.1 Retail gas and electricity prices drive differences in gas demand forecasts

As we discuss in Section 2.2.1, our understanding is that the variation in total customer numbers across the scenarios, and therefore also the variation in gas demand forecasts, is driven by retail gas and electricity prices. Other key inputs into the gas demand forecasting process are identical across scenarios, including appliance capital and maintenance costs, annual energy consumption, appliance efficiency, S-curve parameters and so on.[13] Consequently, the retail gas and electricity prices utilised in the modelling are critical inputs. These prices drive the rate of connections and disconnections (through the S-curve mechanism), the annual average volumes consumed by customers on the network (through price elasticity impacts) and, ultimately, the key model output – AD allowances.

There is not a great deal of information provided about the gas and electricity retail price forecasts used by ACIL Allen to forecast gas demand. Nevertheless, we have some questions about the reasonableness of these inputs.

Retail electricity price forecasts

It is clear from ACIL Allen's report that residential and commercial retail electricity prices are assumed to be the same in three scenarios – Hydrogen Future, Energy Hybrid and Natural Gas Retained – and differ only in the Electricity Dominates scenario. These retail electricity prices are shown in Figure 3.

It is not clear to us that these retail electricity prices forecasts are internally consistent with the gas price forecasts. Specifically, we note that ACIL Allen is forecasting carbon-inclusive retail gas prices, with the projected carbon price, and the impact of that projected carbon price on retail

13 The two exceptions to this are that there is a different GSP forecast in the Hydrogen Future scenario, which is a driver of differences in commercial and industrial gas demand forecasts in the Hydrogen Future scenario, and that under the Electricity Dominates scenario, the 'decision point' that determines the number of customers that may disconnect from the gas network in a given LGA in a given year, progressively decreases and is not held constant at 15 years (which it is in the Hydrogen Future, Gas Retained and Energy Hybrid scenarios).

gas prices, set out in the ACIL Allen report.[14] Indeed, the carbon price seems to be the key driver, and perhaps the only driver, of differences in retail gas price forecasts. However, it does not appear that the retail electricity prices are carbon-inclusive prices, since the retail electricity price is identical in the Hydrogen Future, Energy Hybrid and Natural Gas Retained scenarios despite very material differences in assumed carbon prices in those scenarios. If it is the case that the retail gas prices used in ACIL Allen's modelling are carbon-inclusive and the retail electricity prices used in ACIL Allen's modelling are carbon-exclusive, it is not clear to us what the justification for this would be. Our expectation would be that the modelling would be based on carbon-inclusive retail prices for both gas and electricity, or carbon-exclusive retail prices for both gas and electricity.

Given that retail prices are the key driver of gas demand forecasts, we would expect that if retail electricity prices forecasts were higher (to be carbon-inclusive) this could have a material impact on resulting gas demand forecasts.

We also question whether the retail electricity price forecasts used by ACIL Allen can be considered to reasonably capture the likely range of outcomes for future retail electricity prices. Keeping these prices constant in three of four scenarios, does seem to unnecessarily limit the range of potential outcomes that are considered in ACIL Allen's modelling. Additionally, it appears that within the ACIL Allen modelling, their model outputs for previous and current residential retail electricity prices do not align with the current level of regulated tariffs in Western Australia. For example, the input for residential electricity tariffs in 2023 is $0.354/kWh however the current tariff as of 1 July 2023 is only $0.308/kWh.[15] Without more detail on the composition of these retail electricity price forecasts it is difficult for us to say more about their reasonableness.

ATCO/ACIL Allen subsequently clarified that the tariffs do not align because of the following reasons:

- At the time of modelling, the 2023 retail price of electricity was not known to ACIL Allen.
- The ACIL Allen number incorporates the daily supply charge and hence lies above the regulated usage charge
- The ACIL Allen number is in real terms as of June 2022.

In our view, regardless of whether the regulated 2023 retail price was known when ACIL Allen undertook its modelling, the fact remains that the price in ACIL Allen's modelling is quite different to the regulated 2023 retail price. Indeed, it is also quite different from the regulated 2022 retail price, which presumably was known when ACIL Allen undertook its modelling.

We also note that, in our view, the fixed component of the retail electricity price should not be included in ACIL Allen's modelling. The daily supply charge (fixed component) of an electricity bill will be incurred by a residential or commercial customer regardless of if they use, or switch to, electric cooking, water heating or space heating appliances. The economics of appliance-switching (at the end of the existing asset's life) should be based on incremental costs, and the daily electricity supply charge is not an incremental cost because all customers already incur this daily supply charge.

Clarification was also sought from ATCO regarding the treatment of a carbon price within the retail electricity price forecasts. The following response was provided by ACIL Allen:

[14] ACIL Allen 2023, *Future of gas*, p. 23.

[15] Current rates are available on the Western Australia Government website here.

"The price series are modelled projections, not extrapolations. The starting point of the projections is not inconsistent with historical and current tariffs.

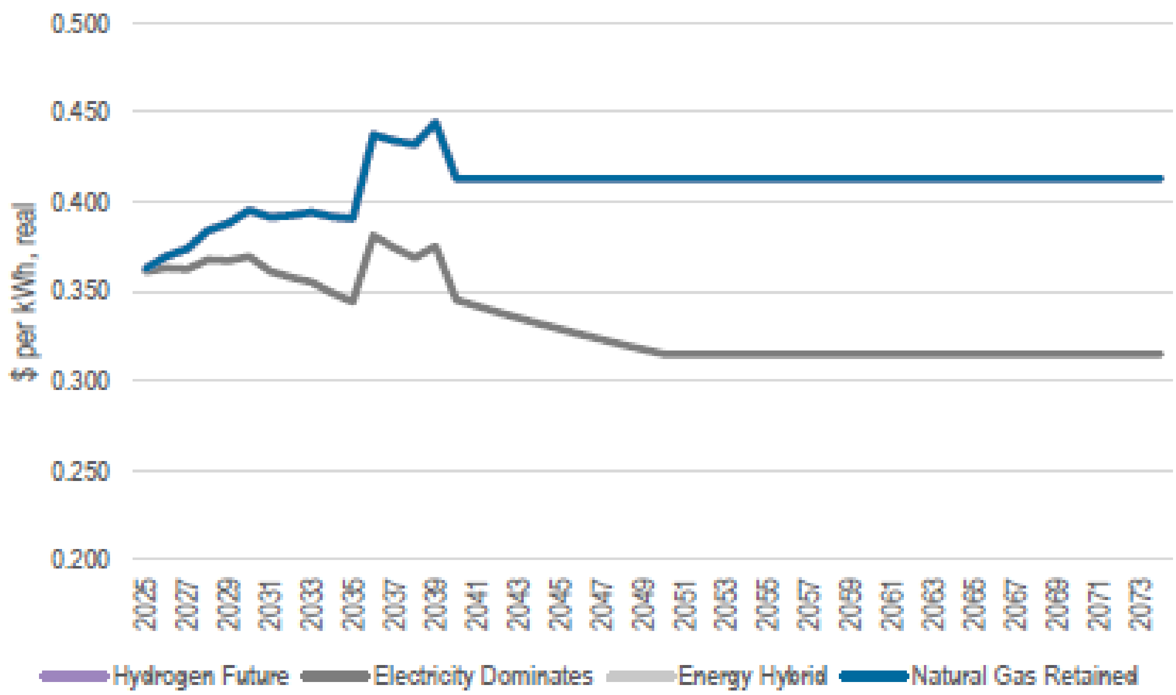
The four cases are scenarios reflecting potential futures. The scenarios were designed in concert with ATCO stakeholders. They represent a broad range of futures, but none of the scenarios is presented as a central or base case. The price series for each scenario has been adjusted (where considered necessary) to reflect the relative competitiveness of gas and electricity in each scenario.

The scenarios are designed to demonstrate the potential effects on gas demand and asset utilisation under the different scenarios. As reflected in the models, the relative cost of gas and electricity is the most crucial factor in driving consumer behaviour. The choice of electricity and gas price inputs and how they vary is consistent with the scenario design."

Based on this response, it is still unclear whether the carbon price is included within the retail electricity tariffs modelled.

Finally, we note that ACIL Allen's modelling does not account for the effect that rooftop solar PV can have on the effective price that customers with solar PV pay for electricity. The implications for the treatment of solar PV within this modelling is discussed in Section 5.4.

Figure 3: ACIL Allen retail electricity price forecasts for residential and commercial customers



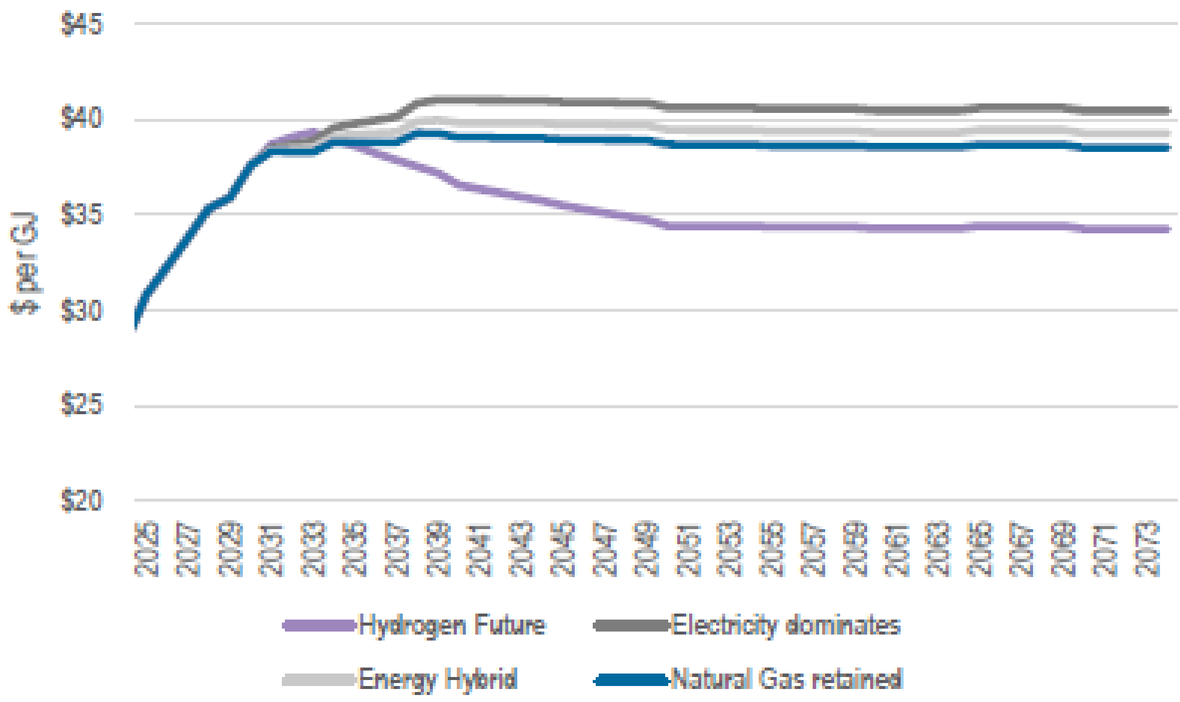
Source: ACIL Allen 2023, Future of gas, Figure 4.5

Note: The blue line, representing Natural Gas Retained, is lying on top of the lines for the Hydrogen Future scenario and Energy Hybrid scenario. That is, the retail electricity price inputs for these three scenarios are identical.

Retail gas price forecasts

ACIL Allen's report notes that the main driver of differences in gas retail prices are differences in wholesale gas prices. Our understanding is that the main driver of differences in wholesale gas prices, in turn, is differences in the assumed carbon price. The retail gas prices used by ACIL Allen are shown in Figure 4.

Figure 4: ACIL Allen retail gas price forecasts for residential customers



Source: ACIL Allen 2023, Future of gas, Figure 4.7.

As with retail electricity price forecasts, we question whether the retail gas price forecasts used by ACIL Allen can be considered to reasonably capture the likely range of outcomes for future retail gas prices. At the very least, we would expect that keeping wholesale gas price forecasts essentially the same in three of four scenarios would unnecessarily limit the range of potential outcomes that are considered in ACIL Allen's modelling.

A broader issue with the retail gas prices assumed in forecasting gas demand is that the retail gas prices do not appear to reflect changes in the distribution component of tariffs between the scenarios. In our view this is an important issue. The key contribution of the ACIL Allen report is to understand how ATCO's gas distribution tariffs vary across the four scenarios given their associated (modelled) gas demand forecasts. However, in modelling gas demand forecasts across these four scenarios, ACIL Allen do not appear to account for the impact of different distribution tariffs that would be associated with these differing demand forecasts/scenarios across the four scenarios (i.e. there is no iteration between the distribution tariffs produced from the modelling and the distribution tariffs utilised as inputs).

Finally, it is not clear to what extent, the inputs and assumptions that underpin the retail gas price inputs produced align with Australian Energy Market Operator's (AEMO) WA Gas Statement of Opportunities[16]. AEMO's most recent WA GSOO (2023)[17] was released subsequent to this modelling however it identifies wholesale gas demand being greater than supply in Western Australia over the next few years. These potential shortfalls are more severe than those published in the 2022 WA GSOO[18] which was current at the time of modelling. Impacts such as these should be reflected in any further modelling undertaken by ACIL Allen with respect to forecasting wholesale gas price impacts.

3.2 Other factors that might impact gas demand forecasts do not vary between scenarios

In addition to the questions we raised in the previous section about whether the assumed differences in gas and electricity retail prices reasonably reflect the range of potential outcomes for retail gas and electricity retail prices, we also question whether the scenarios reasonably capture potential outcomes for other drivers of gas demand.

As discussed, other drivers of gas demand in ACIL Allen's model include:

- Rates of new connection ('Non-Appliance Cost Related Growth' in the model).
- Rates of disconnection ('Non-Appliance Cost Related Disconnection' in the model).
- The cost of gas appliances and electricity appliances.
- The efficiency of gas appliances and electricity appliances.
- The specification of the S-curve that relates net present value outcomes to switching rates.
- The socio-economic designation ('income class') of different Local Government Areas (LGAs) across the ATCO gas distribution network service area.
- Forecasts for population and household growth.

All of these inputs are kept constant across the scenarios in ACIL Allen's modelling. But, in our view, these inputs could reasonably be expected to vary across scenarios and over time and, in doing so, could affect forecast gas demand and the need for AD. Additionally, other underlying drivers of demand such as government policy with respect to housing and planning, and consideration of factors such as consumers tastes and preferences, are not directly addressed in the modelling and are therefore implicitly assumed to be the same across the scenarios.

16 Australian Energy Market Operator 2023, *Western Australia Gas Statement of Opportunities*, https://aemo.com.au/en/energy-systems/gas/gas-forecasting-and-planning/wa-gas-statement-of-opportunities-wa-gsoo

17 Australian Energy Market Operator 2023, *Western Australia Gas Statement of Opportunities: Market outlook to 2033*, https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/wa_gsoo/2023/2023-wa-gas-statement-of-opportunities-wa-gsoo.pdf?la=en

18 Australian Energy Market Operator 2022, *Western Australia Gas Statement of Opportunities: Market outlook to 2032*, https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/wa_gsoo/2022/2022-wa-gas-statement-of-opportunities.pdf

3.3 Other factors that might impact estimated AD do not vary between scenarios

As discussed, in assessing the scenarios we have focused on the factors that drive gas demand forecasts. We have raised questions about whether assumed retail prices that drive gas demand forecasts will reasonably capture the range of potential gas demand outcomes over the modelling period. We have also raised questions about other potential drivers of gas demand that do not vary between scenarios.

As well as these questions about gas demand forecasts in the scenarios, we also question whether the scenarios reasonably capture the range of potential states-of-the-world and the associated outcomes for other drivers of average distribution tariffs. Since the ACIL Allen approach to estimating the requirement for AD is based on setting constant real distribution tariffs, drivers of distribution tariffs other than gas demand forecasts could also be expected to affect the estimated requirement for AD. These other drivers of distribution tariffs include forecasts of WACC and estimates of unit costs for capital expenditure and operating expenditure.

3.4 Scenario weighting

ACIL Allen conclude that each scenario represents a plausible future, but the relative probability of each scenario occurring is unknown. For this reason, ACIL Allen propounds that deriving an accelerated depreciation allowance based on a weighted average of results or based on an identified central case is not feasible. Instead, ACIL Allen recommend AD that is halfway between the Electricity Dominates scenario and the Gas Retained scenario, on the basis that these scenarios represent the bounds of those three scenarios that cluster closely together (i.e. excluding the Hydrogen Future scenario).

This challenge of identifying the relative probability of scenarios, and even identifying a central scenario, is common when trying to define future states of the world. For instance, it is consistent with the approach that AEMO adopts when defining scenarios for the Integrated System Plan (ISP): AEMO does not define a central scenario or define scenario probabilities.

Given this, we consider ACIL Allen's approach of recommending an amount for AD that is based on outcomes for those scenarios that are most closely clustered, is a reasonable approach. We note, however, that this approach to recommending an amount for AD would potentially give a different result if outcomes for the four scenarios changed (for instance as a result of any of the recommendations made in this report).

4 Model review – Inputs and assumptions

The following sections provide an overview and comment on the inputs and assumptions used within the ACIL Allen model. The following sections also include a 'traffic light' assessment for each of the inputs and assumptions used. The traffic light system is structured as follows:

- Red lights represent inputs or assumptions that we consider are not fit-for-purpose.
- Amber lights represent inputs or assumptions that we consider could be improved, but doing so would increase modelling complexity and may not be justified by the materiality of the assumption to the results. Sensitivity testing would be required to determine the materiality of the assumption to form a view of whether or not these inputs or assumptions are fit-for-purpose.
- Green lights represent inputs or assumptions that we consider are fit-for-purpose.
- Dashes represent inputs or assumptions for which there is not sufficient transparency for us to form a view on whether the input or assumption is fit-for-purpose.

4.1 Retail gas and electricity price inputs

As noted in Section 2.2, the retail gas and electricity price inputs are the key drivers of the results for residential and commercial customer connections and disconnections, estimating average consumption per connection and generating variation in the results across the scenarios.

Retail gas price inputs

For the purposes of this modelling, ACIL Allen employed a bottom-up approach to estimating retail gas prices in Western Australia. Specifically, retail gas prices are broken down into five components:

- Wholesale
- Transmission
- Distribution
- Environmental
- Retail (margins)

A number of elements relating to the retail gas price inputs used in this modelling are problematic. First, the only component of the retail gas price that varies across the four scenarios is the wholesale component, and that variation seems to be driven solely by differences in assumed carbon prices for 3 of the 4 scenarios. Because only the wholesale component varies, and the amount of variation in the wholesale component is relatively small in 3 out of 4 scenarios, it is not clear that the resulting retail gas prices sufficiently capture the potential for future variability in retail gas prices.

Network components of gas prices change over time with network usage, amongst other factors. By definition, the scenarios modelled by ACIL Allen involve differing levels of gas network usage. It is therefore odd that the retail price inputs used by ACIL Allen in the model – which are critical to determining the economics of gas appliances – have network components that do not vary across scenario. As noted previously, in our view this is an important issue: the key contribution of the ACIL Allen report is to understand how ATCO's gas distribution tariffs vary between the four scenarios, but in modelling gas demand in these four scenarios ACIL Allen do not appear to account for the impact of different distribution tariffs between the four scenarios.

Second, there is little transparency provided to assess the reasonableness of the wholesale cost component estimates used for each of the scenarios. ACIL Allen utilises an in-house proprietary model to estimate these costs, however no information relating to the underlying assumptions (e.g. relative mix of natural and renewable gases) is provided. It is therefore also difficult to assess how the inputs and outputs of the ACIL Allen retail price model aligns with the inputs and outputs of other relevant information on Western Australia's gas demand, such as the Australian Energy Market Operator's (AEMO) *WA Gas Statement of Opportunities.*[19] AEMO's most recent WA GSOO, for example, identifies wholesale gas demand being greater than supply in Western Australia over the next few years. These potential shortfalls are more severe than those published in the 2022 WA GSOO,[20] which was current at the time of modelling. Impacts such as these should be reflected in any further modelling undertaken by ACIL Allen with respect to forecasting wholesale gas prices.

Further detail with respect to how ACIL Allen derived their estimate of retail gas price inputs, including with respect to each component of the respective retail prices, was sought from ATCO. This included requesting any additional available information with respect to underlying assumptions or retail price model inputs, as well as clarification regarding whether the 'indexing' approach used in the *Future of Gas*[21] modelling undertaken for some Victorian gas distribution network service providers (Australian Gas Networks, Multinet and Ausnet) in 2022 has been replicated for this retail price modelling. The following response was provided by ACIL Allen:

> *"The retail electricity and gas prices were developed using ACIL Allen proprietary models."*

Finally, the inputs, assumptions and reasoning underpinning the price elasticity of demand inputs for residential and commercial customers are not clear. These variables are used to estimate how the average consumption of a residential or commercial consumer varies over time and are therefore important in determining how consumption behaviour varies. These elasticities are held constant across the scenarios, which is not an unreasonable assumption on simplicity grounds. ACIL Allen confirmed that all elasticities used in the modelling were estimated empirically, however no further information was provided regarding the methodology, inputs and assumptions used to derive these estimates.

To summarise, the apparent use of a limited range of wholesale gas price forecasts, and the use of one set of homogenous gas network tariffs, is a problematic assumption, particularly in light of the importance of these to estimating gas demand forecasts. Given the level of retail gas price is one of the only inputs that varies across scenarios,[22] and is a key determinant of both

19 Australian Energy Market Operator 2023, *Western Australia Gas Statement of Opportunities*.

20 Australian Energy Market Operator 2022, *Western Australia Gas Statement of Opportunities: Market outlook to 2032*.

21 ACIL Allen 2022, *Future of gas model: model description, Report to Australian Gas Networks, Multinet and Ausnet*, pp.13-15, https://www.aer.gov.au/system/files/AGN%20%28Victoria%20%26%20Albury%29%20-%20Attachment%206.3%20-%20ACIL%20Allen%20Future%20of%20Gas%20model%20description%20-%20July%202022.pdf

22 The only other variables that vary across scenarios are retail electricity prices, GSP (in the hydrogen Future scenario) and the 'decision point' (in the Electricity Dominates scenario).

customer numbers and average consumption, issues with these assumptions have important implications for customer numbers, average gas consumption, total gas demand and, ultimately, the level of the constant annual average tariff and AD allowance required to maintain that tariff.

Retail electricity price inputs

With respect to retail electricity price inputs, ACIL Allen used a proprietary model with a bottom-up building block approach to estimate total retail electricity prices in Western Australia for each year of the modelling period. Specifically, retail electricity prices are broken down into six components:

- Wholesale,
- Transmission
- Distribution
- Environmental components (LRET and SRES)
- Retail
- Losses

Total retail electricity price forecasts are identical across three of the four scenarios, with Electricity Dominates the only scenario with a different retail electricity price path. As ACIL Allen reports, under the Energy Hybrid, Gas Retained and Hydrogen Future scenarios, electricity prices rise consistently from 2025 onwards before peaking at $0.44 per kWh in 2039 with prices stabilising at $0.413 per kWh after 2040. Under the Electricity Dominates scenario, electricity prices peak at $0.381 per kWh in 2036, drop to $0.315 per kWh by 2050, and then remain at this level out to 2074.

Notably, it appears that within the ACIL Allen modelling their model outputs for previous and current residential retail electricity prices do not align with the current level of regulated tariffs in Western Australia. For example, the input for residential electricity tariffs in 2023 is $0.354/kWh however the current tariff as of 1 July 2023 is only $0.308/kWh. [23] This misalignment requires clarification and is significant. As will be detailed in Section 4.5, the results of the model (i.e. AD amounts) is relatively sensitive to the inputs used for residential retail electricity prices. Additionally, there is a considerable lack of transparency regarding the assumptions made within the retail price modelling undertaken by ACIL Allen. The retail electricity price used in the modelling is reported only as a total retail price – the components of the retail electricity price are not reported. This prevents observation of how the different components of the retail electricity price are modelled to change over time, as well as what component(s) of the retail price is driving the difference between the Electricity Dominates scenario and the other three scenarios.

Given the lack of transparency regarding the retail electricity price modelling assumptions, approach and outputs, it is challenging to comment on the appropriateness of the decision to impose identical total retail electricity price inputs for the Energy Hybrid, Gas Retained and Hydrogen Future scenarios. The retail electricity price inputs alongside the retail gas price inputs are two of the most critical inputs in the modelling. This lack of transparency undermines the integrity of the modelling approach.

Further to this, as noted in Section 3.1 it does not appear that the retail electricity prices are carbon-inclusive prices, since the retail electricity price is identical in the three aforementioned

[23] Current rates are available on the Western Australia Government website here.

scenarios despite very material differences in assumed carbon prices in those scenarios. Our expectation would be that the modelling would be based on carbon-inclusive retail prices for both gas and electricity, or carbon-exclusive retail prices for both gas and electricity.

We also question whether the retail electricity price forecasts used by ACIL Allen can be considered to reasonably capture the likely range of outcomes for future retail electricity prices. Keeping these prices constant in three of four scenarios, does seem to unnecessarily limit the range of potential outcomes that are considered in ACIL Allen's modelling. Without more detail on the composition of these retail electricity price forecasts it is difficult for us to say more about their reasonableness.

As detailed in Section 3.1, clarification was sought from ATCO and ACIL Allen regarding the inclusion/exclusion of the carbon price within the retail electricity inputs and the apparent misalignment between retail electricity price model outputs and the historical and current regulated tariff. The following response was provided by ACIL Allen:

> *"The price series are modelled projections, not extrapolations. The starting point of the projections is not inconsistent with historical and current tariffs.*
>
> *The four cases are scenarios reflecting potential futures. The scenarios were designed in concert with ATCO stakeholders. They represent a broad range of futures, but none of the scenarios is presented as a central or base case. The price series for each scenario has been adjusted (where considered necessary) to reflect the relative competitiveness of gas and electricity in each scenario.*
>
> *The scenarios are designed to demonstrate the potential effects on gas demand and asset utilisation under the different scenarios. As reflected in the models, the relative cost of gas and electricity is the most crucial factor in driving consumer behaviour. The choice of electricity and gas price inputs and how they vary is consistent with the scenario design."*

Finally, it is unclear whether four separate retail price models have been developed for each of the scenarios or if the approach taken in the *Future of Gas*[24] modelling undertaken for the Victorian gas distribution network service providers (Australian Gas Networks, Multinet and Ausnet) in 2022 has been replicated for ATCO. If the latter is the case, the index-based methodology applied in this modelling, wherein the retail price estimates constructed for a 'base case' like scenario are adjusted according to index values reflecting scenario characteristics, is not ideal. There is little information or evidence provided in the *Future of Gas* modelling report to justify the use of these indices and such an approach in the context of the ACIL Allen model developed for ATCO would be problematic given the importance of the retail electricity price inputs.

As noted above, clarification was sought as to whether the 'indexing' approach used in the Victorian *Future of Gas* modelling was replicated for this retail price modelling. The following response was provided by ACIL Allen:

24 ACIL Allen 2022, *Future of gas model: Report to Australian Gas Networks, Multinet and Ausnet*, pp.13-15.

"The retail electricity and gas prices were developed using ACIL Allen proprietary models."

Table 2 below summarises the key points above and includes a 'traffic light' assessment of different elements of the retail gas and electricity price inputs used.

Table 2: Traffic light assessment – Retail gas and electricity price inputs

Input	Source	Comment	Rating
Prices (retail gas)	External ACIL Allen modelling (wholesale, transmission, retail margin) ATCO (distribution) Some calculations (fixed retail)	The only component of the retail price that varies across scenarios is the wholesale component (driven largely by carbon price assumptions). Transmission, distribution and retail components of the price are unchanged across scenario. This is a problematic assumption in the context of this study, particularly for distribution tariffs.	🔴
		Wholesale gas price forecasts are essentially the same in three of four scenarios. This unnecessarily limits the range of potential outcomes. It is also unclear if these price forecasts reflect AEMO forecasts of supply deficits in coming years.	🔴
		It is assumed industrial consumers face the same movement in retail price levels as commercial customers. This is discussed in Section 5.2.	🟡
Prices (retail electricity)	External ACIL Allen modelling	Retail electricity prices appear to be carbon-exclusive, as opposed to the approach taken for retail gas prices. Our expectation would be that the inputs include carbon-inclusive or carbon-exclusive retail prices for both gas and electricity.	🔴
		Prices are not broken down into the building block components and it is unclear which component(s) of the retail electricity price are varying over time and across scenarios.	🟡
		Retail electricity prices are identical across all scenarios other than 'Electricity Dominates'. Further, inputs for current retail residential electricity prices do not align with the current level of the regulated tariff in Western Australia.	🔴
		The modelling approach is unclear. If the same retail price modelling methodology as the Victorian DNSP *Future of Gas* modelling is used, there is a concern that the approach is overly simplistic and lacks transparency for such an important input.	🟡
Retail prices (both electricity and gas)	Assumption	ACIL Allen forecasts carbon-inclusive retail gas prices and carbon-exclusive retail electricity prices.	🔴

Source: Frontier Economics analysis

4.2 Appliance related inputs

Appliance costs and efficiencies

Appliance cost inputs are a critical input in any model of technology uptake or technology switching. The economics of switching away from natural gas appliances and use of the natural gas networks to electrical appliances is almost exclusively a function of the relative costs of electrical appliances and gas appliances while accounting for switching costs. Importantly, the costs that residential and commercial customers must consider include more than just the capital costs of appliances, but also the relative operating, maintenance, installation and removal costs; financing and time/opportunity costs; and network connection, disconnection and upgrade costs.

The ACIL Allen report states that the inputs for appliance capital costs and appliance consumption inputs are sourced from the Grattan Institute report *Flame out: The future of natural gas*[25]. However, the appliance capital costs, including gas disconnection and electricity connection upgrade costs, do not align with the figures reported in the Grattan Institute report. The same is true for annual average electricity and gas consumption inputs used in the modelling. In some cases, the difference is material.

In response to the identified discrepancies, ATCO/ACIL Allen subsequently clarified that:

> *"[One of the identified discrepancies identified by Frontier Economics is] between ACIL Allen and Grattan for the cost of the ducted RCAC and Ducted gas furnace heaters. This is mostly due to the omission of the cost of ducting which was $5,000 for both types of heating. As only the relative costs matter for the NPV calculation, this makes little or no difference to the relative NPV of the switching decision.*
>
> *Some of the other discrepancies are due to amendments which were made after discussions with DNSPs [Distribution Network Service Providers] for whom we have previously developed similar models.*
>
> *The other major difference between Grattan and ACIL Allen numbers is in the gas disconnection and electricity connection upgrade. Discussions with several DNSPs led to the conclusion that the Grattan estimates were not accurate, and ACIL Allen therefore have low confidence in the Grattan estimates for the disconnection and connection upgrade costs. The numbers presented reflect the discussions with DNSPs."*

A cursory comparison with comparable reports such as *Cost of switching from gas to electric appliances in the home*[26] shows that at a high-level, the appliance cost assumptions with respect to capital costs made by ACIL Allen can be considered reasonable. There are further questions however regarding the appropriateness of the electricity and gas appliances compared. This is discussed further in Section 5.4.

25 Grattan Institute 2020, *Flame out: The future of natural gas*, https://grattan.edu.au/wp-content/uploads/2020/11/Flame-out-Grattan-report.pdf

26 Frontier Economics 2022, Cost of switching from gas to electric appliances in the home, https://gamaa.asn.au/wp-content/uploads/2022/07/Frontier-Economics-Report-GAMAA.pdf

With respect to maintenance costs, there is only one notable inconsistency between the costs used in the model and those reported in the Alternative Technology Association *Are we still Cooking with Gas?*[27] report (the source of ACIL's inputs). This difference relates to the annual maintenance costs for a ducted gas furnace. ATCO/ACIL Allen subsequently clarified that:

> *"ACIL Allen set the ducted gas furnace annual maintenance costs to be the as the RCAC split system. This is most likely an error due to an inability to locate the relevant number for the ducted gas system. This leads to a difference of around $40 per year in favour of the gas system and the overall impact on the modelling is not considered significant".*

Additionally, it should be noted that this report was published in 2014, meaning estimates of maintenance costs for both gas and electrical appliances may not reflect current maintenance costs associated with each appliance. Additionally, it is clear that ACIL Allen has inflated the ATA report figures to approximately $FY21, but it is unclear from the provided material how this was done.

The ACIL Allen model also includes the functionality to include inputs regarding changes in both appliance efficiency and appliance cost over time. However, it is assumed across all scenarios that there is no change in appliance cost or efficiency over the modelling period. Sensitivity analysis undertaken (see Section 4.5 below) shows that moderate changes in retail prices materially impact the AD allowances that the model calculates; equivalent moderate changes in assumed energy efficiency would be expected to have an equivalent impact on AD allowances. Given the potential for future appliances efficiency improvements, and the sensitivity of results to assumptions about appliance efficiency, consideration should be given to varying assumptions about appliance sensitivity over time, and potentially between scenarios.

Average annual consumption

The model assumes that average annual consumption of electricity and gas for each type of appliance is the same for residential and commercial customers. As noted above, appliance consumption inputs were sourced from the Grattan Institute report *Flame out: The future of natural gas*[28]. However, model inputs do not align with the figures reported in the Grattan Institute report.

The Grattan Institute report publishes annual average consumption according to the appliances within a household. Households with '2 appliances' refer to tariffs and costs for cooking and water heating only. Households with '3 appliances' refer to tariffs and costs for cooking, water heating and space heating[29].

Table 3 shows the annual average consumption figures from Grattan Institute report, as compared to the annual average consumption figures used in the ACIL Allen model. These

27 Alternative Technology Association 2014, *Are we still Cooking with Gas?*, https://www.ata.org.au/wp-content/projects/CAP_Gas_Research_Final_Report_251114_v2.0.pdf

28 Grattan Institute 2020, *Flame out: The future of natural gas*.

29 Grattan Institute 2020, *Flame out: The future of natural gas*, p.60.

inconsistencies are significant given appliance efficiency and capital and maintenance cost changes are assumed to be zero over the modelling period, meaning average annual consumption by appliance type interacting with the (varying) retail electricity and gas prices causes appliance operating costs to vary over time and across scenario. This in turn drives both the customer connection and disconnection results and the average consumption per connection results.

Given the lack of alignment between the modelling inputs and the published figures from the Grattan Institute report, it is unclear if the average annual consumption inputs are Western Australia specific. Finally, it is also unclear where the ACIL Allen assumptions regarding household consumption where ducted heating is utilised are derived from, given that the Grattan Institute report only published the data below.

Table 3: Grattan Institute and ACIL Allen model average annual appliance consumption alignment

Household Type	Source	Annual average consumption (GJ or kWh depending on appliance)
Gas appliances		
2 appliance household – cooking and water heating only	Grattan Institute	13.20 GJ
	ACIL model	21.80 GJ
3 appliance household – cooking, water heating and space heating (assuming room heating)	Grattan Institute	24.70 GJ
	ACIL model	41.17 GJ
3 appliance household – cooking, water heating and space heating (assuming ducted heating)	Grattan Institute	N/A
	ACIL model	90.39 GJ
Electrical appliances		
2 appliance household – cooking and water heating only	Grattan Institute	893.00 kWh
	ACIL model	1,228.30 kWh
3 appliance household – cooking, water heating and space heating (assuming room heating)	Grattan Institute	1,876.00 kWh
	ACIL model	2,398.30 kWh
3 appliance household – cooking, water heating and space heating (assuming ducted heating)	Grattan Institute	N/A
	ACIL model	5,964.01 kWh

Source: Frontier Economic analysis

Assumptions across scenarios

Finally, a key assumption made with respect to appliance related costs relates to the decision to have identical appliance capital and maintenance costs, identical average annual consumption and identical appliance cost and efficiency changes across all four scenarios. It is not clear that this enables the model to capture the reasonable range of future outcomes for gas demand.

Table 4 below summarises the key points above and includes a 'traffic light' assessment of different elements of the appliance-related inputs used.

Table 4: Appliance cost and efficiency and annual consumption inputs traffic light assessment

Input	Source	Comment	Rating
Appliance capital costs	Grattan Institute (2020), *Flame Out: The future of Natural Gas*	Appliance capital costs are said to be taken from the Grattan Institute report. However, the cost of almost all appliances used does not reflect the estimates cited in the Grattan Institute report.	●
Appliance maintenance costs	ATA (2014), *Are we still cooking with gas?*	There is only one notable inconsistency in the maintenance costs between those used in the model and those cited in ACIL Allen's report. However, the source report was published in 2014, meaning estimates of maintenance costs for both gas and electrical appliances may not reflect current maintenance costs.	●
Appliance operating costs	Assumptions and calculations	Given appliance efficiency improvements over time are assumed to be 0% for all appliances and scenarios, operating costs are mainly driven by retail prices and average annual consumption assumptions.	●
% change in costs and appliance efficiency	Assumption	In all scenarios, change in appliance capital and maintenance costs as well as appliance efficiency is assumed to be 0. This likely doesn't reflect what would happen across these scenarios.	●
Average annual consumption (kWh and GJ)	Grattan Institute (2020), *Flame Out: The future of Natural Gas*	Model inputs do not align with the figures reported in the Grattan Institute report. It is unclear where the ACIL Allen figures have been sourced from. Average consumption inputs appear significantly higher for both gas and electrical appliances than those reported in the Grattan Institute report.	●

Source: Frontier Economics analysis

4.3 Regulatory modelling inputs

Once the total demand forecasts for each customer class are determined, they are fed into the regulatory calculation component of ACIL Allen's model. ACIL Allen utilises a building block, post-tax revenue regulatory modelling approach to obtain AD allowance outputs from each of the four scenarios as well as other outputs such as average tariffs by customer class and the RAB.

The key inputs and assumptions for the regulatory component of the modelling include the:

- Current asset base.
- Remaining asset lives.
- Assumed inflation, cost of equity, cost of debt and WACC.
- Proposed new assets expenditure and asset lives.
- Operating expenditures.

The regulatory inputs, in particular the capital expenditure and operating expenditure profiles (including unaccounted for gas (UAFG)) for each of the scenarios, are significant inputs in the context of determining AD allowances. These inputs, alongside the demand forecasts, drive variation in the AD allowances required to maintain constant annual average tariffs and also drive variation in average tariffs across scenarios.

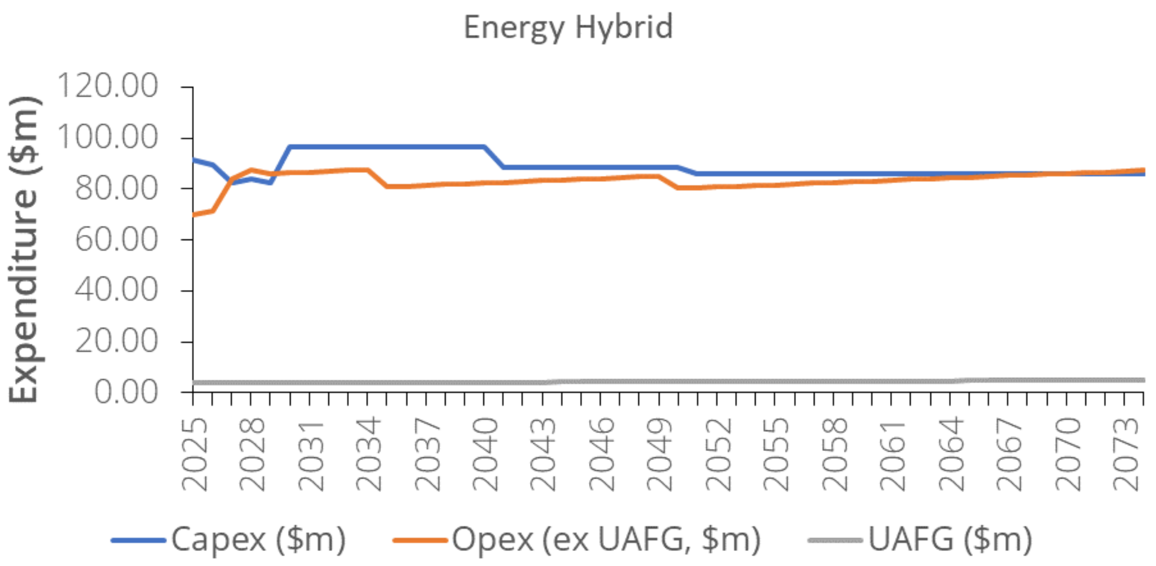
The scenario specific inputs used are summarised below.

Energy Hybrid

Energy hybrid capital expenditure is based on Sustech Engineering estimates of the capital expenditure requirements for a 10% hydrogen blend over the period 2030 to 2050. Incremental operating expenditure is also based on Sustech Engineering estimates. Sustech have calculated the incremental operating expenditure of operating a 10% blend versus business-as-usual operation (see Gas Retained section below). An incremental amount of $12 million per annum is required from 2027 to 2034 and $5 million per annum thereafter.

Figure 5 shows the total capital expenditure, total operating expenditure and total UAFG expenditure for the Energy Hybrid scenario across the modelling period.

Figure 5: Expenditure profile – Energy Hybrid scenario



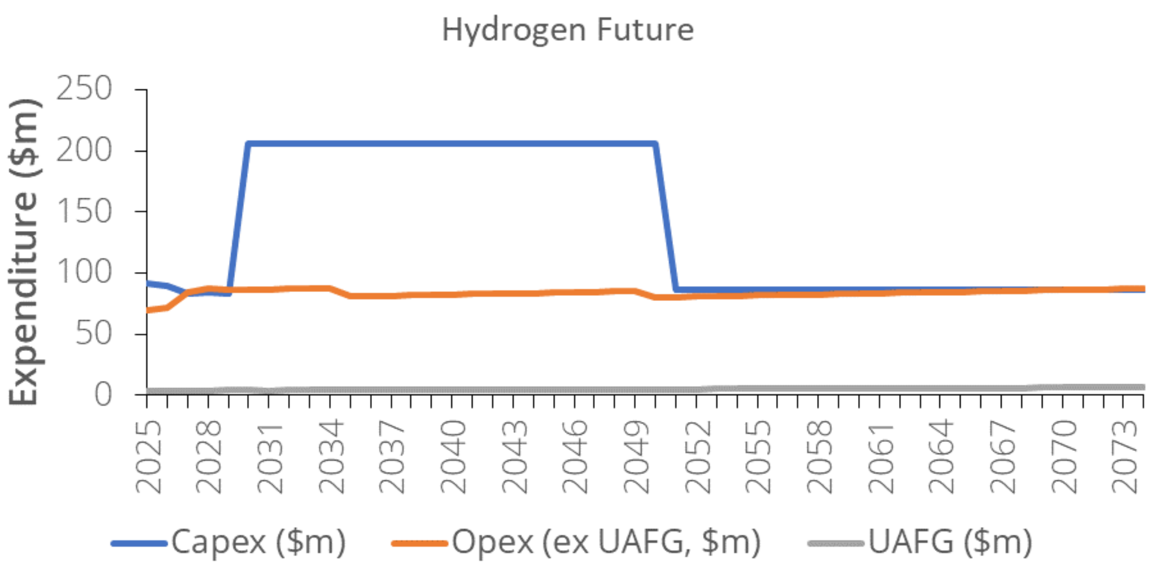
Source: Frontier Economics analysis

Hydrogen Future

Hydrogen Future capital expenditure is based on Sustech Engineering estimates of the capital expenditure requirements for a 10% hydrogen blend over the period 2030 to 2050. Incremental operating expenditure is also based on Sustech Engineering estimates. Operating expenditure has been retained at business-as-usual levels plus incremental operating expenditure for the hydrogen blend. Further, it is assumed there is no additional incremental operating expenditure associated with the 100% blend on the basis that new pipes and fittings will likely reduce the incidence and cost of maintenance.

Figure 6 shows the total capital expenditure, total operating expenditure and total UAFG expenditure for the Hydrogen Future scenario across the modelling period.

Figure 6: Expenditure profile – Hydrogen Future scenario



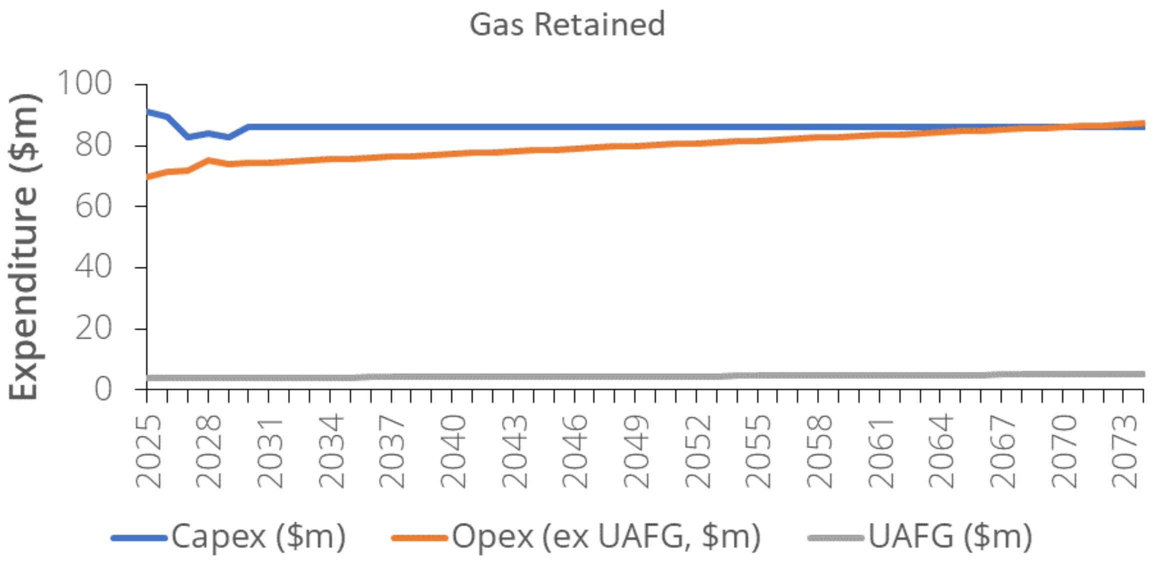
Source: Frontier Economics analysis

Gas Retained

The Gas Retained scenario utilises 'business-as-usual' expenditure profiles. These business-as-usual profiles are based on Version 2.1 (Base Case) of the AA6 tariff model (set up in February 2023). Network operating expenditure is increased proportionate to the customer base in this scenario and UAFG increases automatically with volume. ESG costs were excluded.

Figure 7 shows the total capital expenditure, total operating expenditure and total UAFG expenditure for the Gas Retained scenario across the modelling period.

Figure 7: Expenditure profile – Gas Retained scenario



Source: Frontier Economics analysis

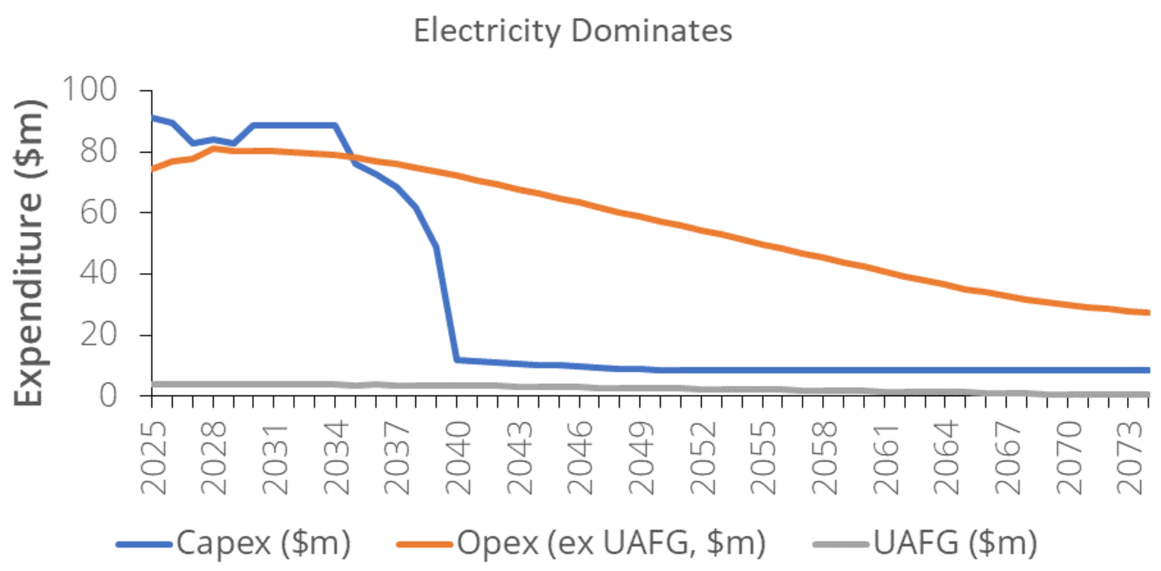
Electricity Dominates

Under the Electricity Dominates scenario, network usage and customer numbers fall significantly over the modelling period. In the later years of the modelling, forecast expenditure profiles reflect the minimum costs required to keep the network still operating safely. ATCO 2009 costs escalated to 2023 real dollars are used to represent the minimum costs for both capital and operating expenditure to reflect estimates of the minimum expenditure needed to keep the network running safely.

Capital expenditure is reduced at a linear rate from 2035 to 2050 to the minimum amount of $8.4 million. Capital expenditure on medium and low pressure mains, meters and service pipes has been reduced during the period 2035 to 2040 to zero assuming reducing network expansion. Operating expenditure is reduced at the rate of $34,000 per 1,000 customers exiting the customer base. Operating expenditure reflects estimates of minimum safe operating expenditure from 2070. Asset lives have been capped at 2074 to reflect the end of the economic life of the network.

Figure 8 shows the total capital expenditure, total operating expenditure and total UAFG expenditure for the Electricity Dominates scenario across the modelling period.

Figure 8: Expenditure profile – Electricity Dominates scenario



Source: Frontier Economics analysis

The importance of these figures and the sensitivity of the AD results as a consequence of these inputs is demonstrated in Table 5 (as well as in Section 4.5). Table 5 demonstrates the differences in the AD allowances produced from the model when operating expenditure and UAFG are trended out (with 2025 as a base year) in line with movements in total gas demand on the ATCO network. As Table 5 highlights, the AD allowance results are sensitive to relatively small changes in expenditure profiles. Further sensitivity analysis with respect to capital and operating expenditure profiles is reported in Section 4.5).

Table 5: AA6 AD Allowances under different operating expenditure profiles, all scenarios

Scenario	AA6 AD Allowance – no opex or UAFG adjustments ($m)	AA6 AD Allowance – opex and UAFG tied to demand ($m)
Gas Retained	$78.36	$55.66
Energy Hybrid	$103.82	$85.55
Electricity Dominates	$160.62	$114.93
Hydrogen Future	$340.37	$342.37

Source: Frontier Economics analysis

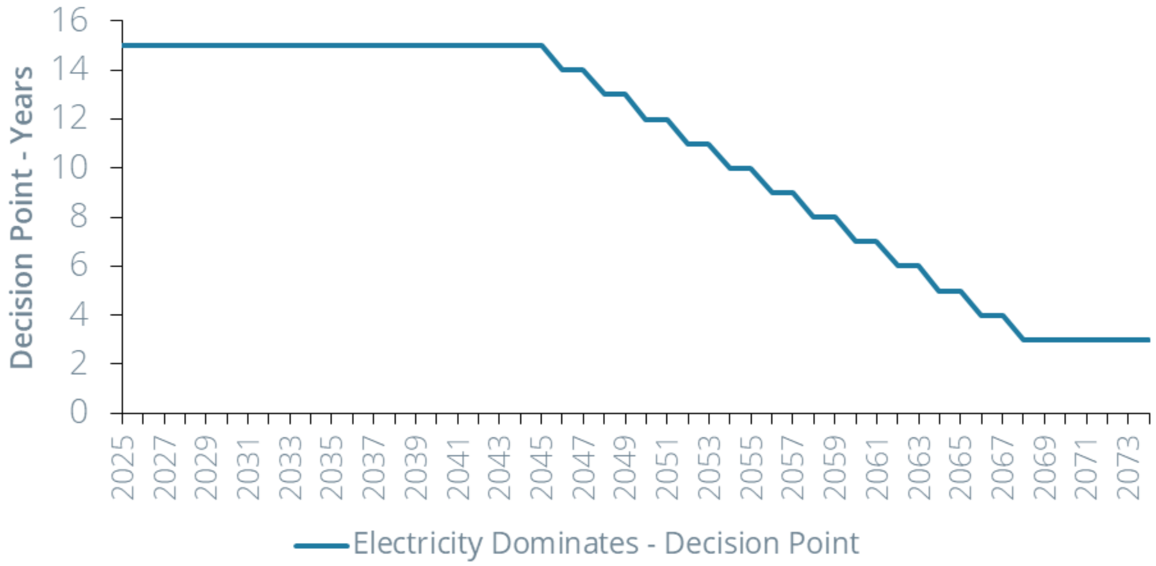
4.4 Other inputs and assumptions

Prior to assessing the remaining inputs and assumptions, the model's treatment of asset lives is one set of key inputs and assumptions that requires addressing. Specifically, the assumptions made with respect to the 'decision point' under the Electricity Dominates scenario is problematic. For context, asset life inputs are not used in the model. A 'decision point' is used instead to represent 'average appliance life'. The 'decision point' is assumed to be 15 years. That is, it is assumed that 1/15th of households decide whether or not to disconnect from the gas network each year. The decision point is the same across 3 of the 4 scenarios (Hydrogen Future, Energy Hybrid and Gas Retained).

The decision point under the Electricity Dominates scenario begins at 15 years, however it decreases from 2046 onward, reaching 3 years by 2068 and remaining at 3 years out to 2074 (see Figure 9). No justification was provided for this assumption. After seeking clarification from ATCO, ACIL Allen advised that:

> *"The reducing decision point reflects the diminishing period available to remaining end users to make a decision as the network approaches the end of its economic life, assumed to be 2074. The effect is to increase the number of customers reaching a decision point as the network approaches closure.*
>
> *The decision point is how frequently customers must decide whether or not to retain a gas connection. It is related to average appliance life of 15 years."*

Figure 9: Electricity Dominates – 'decision point' over modelling period



Source: Frontier Economics analysis of ACIL Allen 03.005 – ATCO Demand Model v14 ED V12

In spite of the additional information provided by ACIL Allen, the treatment of the 'decision point' under this scenario remains problematic. Our understanding is that this component of the model is supposed to produce forecast customer numbers given a set of scenario specific inputs, with network disconnections and usage an observable outcome of the modelling. Forcing in a decreasing decision point over the modelling period creates a somewhat arbitrary 'self-fulfilling' outcome in the model. Given the decision point is intended to represent 'average asset lives', it is odd that it is being used to increase the rate at which customers leave the network. This prevents observing how the economics of switching impacts network usage over the course of the modelling period given the decision point is now artificially being forced to a level that results in network usage dropping to nearly zero.

This approach renders the rest of the customer connection and disconnection modelling for this scenario somewhat irrelevant. If the intention of manually changing the decision point was to model a scenario where the network is no longer in use by 2074, this should have been clearly stated instead of altering inputs to generate a given outcome.

ATCO/ACIL Allen then also subsequently advised that:

> *"The choice to decrease the decision point in the Electricity Dominates scenario after 2046 was to capture the fact that the decision point must be decreasing as the number of customers starts to decrease and few connections arrive to take their place. While ACIL Allen agrees that there is some arbitrariness to the way the decision point steps down, it must decrease over time if the customer base is shrinking. Moreover, the step down in the decision point may also be interpreted as an indirect increase in non-economic factors playing a role in the decision making of households, with households reconsidering their appliance choices more frequently than once every 15 years after 2045."*

It is unclear what non-economic factors are being referred to, why non-economic factors would cause customers to reconsider their appliance choices more frequently after 2045, of what link there is between these non-economic factors and the rate of decrease in the decision point.

Fundamentally it seems to us that the decrease in the decision point is intended to capture the impact on customers of higher gas network prices if the number of customers on the gas network declines. It seems to us that a better approach for dealing with this would be to iterate the model, so that as demand declines and gas network prices increase, this increase is reflected in the retail prices paid by customers.

If there was iteration with respect to the retail gas price inputs used within the model, this 'stepping down' in the decision point shouldn't be necessary as the increasing cost of remaining on the network would be reflected in the network tariffs and retail costs.

Table 6 provides a description of the remaining inputs and assumptions used in the model. Table 6 also includes comments on the reasonableness and impact of these assumptions and inputs as well as a traffic light assessment adhering to the same structure as outlined at the beginning of Section 4.

Table 6: Other inputs and assumptions, traffic light assessment

Input	Source	Comment	Rating
Discount rates/cumulative discount factors	Assumption & Calculation	Real discount rates are stratified by income group – discount rates of 5% (high income), 10% (medium income) and 15% (low income) for residential customers. All commercial customers have 3% discount rate. Cumulative discount factors (CDFs) over a 15-year period are then calculated using these real discount rates and used to calculate NPV of switching for each year for each income class. The real discount rates and CDFs are the same across all scenarios.	● (yellow)

Input	Source	Comment	Rating
Price elasticity of demand	Assumption Modelling	All elasticities used in the modelling were estimated empirically. No further information was provided by ACIL Allen after clarification was sought regarding the methodology, inputs and assumptions that underpinned the empirical derivation of these elasticities. In practice, elasticities are often not constant as you move along a demand curve. Additionally, price elasticities would almost certainly change over time and would likely be different over time across scenarios. Holding price elasticity of demand estimates constant over time and across scenarios is a limitation. However it is not an unreasonable assumption to impose for the purposes of managing modelling complexity.	
Income class	Assumption	All LGAs are designated medium income LGAs. There is little evidence to support this assumption. There is no link between census data reported and LGA income groupings. This assumption would potentially materially change customer connection and disconnection outcomes.	
Non-Appliance Cost Related Growth	Assumption	Potential new connections are assumed to be 2% of customers in an LGA across all scenarios on an annual basis. The number of new gas connections in a year in a given LGA is then calculated by multiplying this number with the S-curve probability of adoption. It is unclear what the basis for this assumption is.	
Weather (HDDs)	Unknown	The source for this data is unclear. Heating Degree Days (HDDs) are trended out using the historic trend (from 1980). This results in increased temperatures over the modelling period and lower HDDs. 18 degrees is used as the reference temperature. Utilising HDD, as opposed to EDD, means that ACIL Allen's chosen methodology is not consistent with the EDD approach used by Core Energy & Resources to produce their own gas demand forecasts as part of separate component of the AA6 pricing submission.	

Input	Source	Comment	Rating
Census (average household occupants)	2016 Census	It is unclear why 2021 census data was not used. Average household occupants data is used to back out the number of households in each LGA using the population data.	
Population	ABS or WA Tomorrow	It is unclear if the population data comes from WA Tomorrow or the ABS.	
Share of retail fixed charge	Assumption	It is assumed that the share is 40% residential and 40% is commercial. This implies that 20% is attributed to industrial customers. This is not reflected in the modelling and is a problematic assumption given industrial customers are assumed to face the same changes in price as commercial customers and a significant proportion of industrial customers deal directly with network service providers.	
'Historical' demand	ATCO	The only input from this dataset used is volumes reported for 2025 for each customer class. This number is used as a base year, with volumes per connection trended out based on GSP, weather and price (and their respective elasticities) from this anchor year. The volumes for 2025 are ATCO provided forecasts that are identical across scenarios. They do not align with Core Energy & Resources forecasts of demand in 2025 as published as part of the AA6 pricing submission due to the Core Energy & Resources forecasts being published after the demand forecast were compiled for the ACIL Allen modelling.	

Source: Frontier Economics analysis

4.5 Sensitivity Analysis

Sensitivity analysis has been undertaken as part of this modelling review to understand the inputs and assumptions that have material impacts on the key outputs of ACIL Allen's model. This analysis is not intended to derive an alternative or 'refined' estimate of what, if any, AD allowance is appropriate. Rather, the purpose of this sensitivity analysis is to identify the key inputs and assumptions that drive the results in the model and, with consideration to the input and assumption assessment above and methodological decisions and issues in Section 5 below, discuss the implications of the sensitivity analysis results.

Sensitivities were tested for the following inputs and assumptions:

- Retail electricity prices (for residential and commercial customers respectively);

- Retail gas prices (for residential and commercial customers respectively);
- Capital expenditure;
- Operating expenditure;
- Appliance capital costs[30] (for electricity and gas appliances respectively);
- Discount rates (for medium income LGAs only given all LGAs in the model are designated medium income by assumption);
- S-curve 'end-point' assumptions (for both the residential and commercial S-curves).

For all of the variables above, other than the discount rates, sensitivities of plus and minus 15% of the original input or assumption value were tested. For discount rates, values of 5% and 15% were tested (the original medium income discount rate used in the models was 10%). Only one variable at a time was altered, with all other inputs held at their original values. Sensitivity analysis was limited to the Electricity Dominates and Gas Retained scenarios only. Table 7, Table 8 and Table 9 provide the results of the sensitivity analysis. Table 7 provides the results for retail price sensitivities, Table 8 provides the results for regulatory assumptions sensitivities and Table 9 provides the results for sensitivities on appliances capital costs, discount rates and S-curve parameters.

30 This includes adjusting the inputs for gas disconnection charges and electricity connection upgrade costs.

Table 7: Sensitivity analysis results – retail prices

Scenario	Electricity Dominates		Gas Retained	
Input/Assumption	Constant annual average tariff ($/GJ, $2021)	AA6 AD Allowance ($mill, $2021)	Constant annual average tariff ($/GJ $2021)	AA6 AD Allowance ($mill, $2021)
Original Results	**$9.12**	**$160.62**	**$8.37**	**$78.36**
Retail electricity prices, residential (+15%)	$7.94 (-13%)	$18.96 (-88%)	$8.15 (-3%)	$46.10 (-41%)
Retail electricity prices, residential (-15%)	$10.57 (16%)	$370.10 (130%)	$8.87 (6%)	$151.07 (93%)
Retail electricity prices, commercial (+15%)	$8.84 (-3%)	$119.51 (-26%)	$8.27 (-1%)	$62.24 (-20%)
Retail electricity prices, commercial (-15%)	$9.39 (3%)	$192.37 (20%)	$8.46 (1%)	$89.45 (14%)
Retail gas prices, residential (+15%)	$11.64 (28%)	$516.60 (222%)	$9.34 (12%)	$217.66 (178%)
Retail gas prices, residential (-15%)	$7.18 (-21%)	-$135.18 (-184%)	$8.07 (-4%)	$35.16 (-55%)
Retail gas prices, commercial (+15%)	$9.54 (5%)	$211.69 (32%)	$8.49 (1%)	$93.02 (19%)
Retail gas prices, commercial (-15%)	$8.59 (-6%)	$81.61 (-49%)	$8.25 (-1%)	$60.80 (-22%)

Source: Frontier Economics analysis

Table 8: Sensitivity analysis results – regulatory assumptions

Scenario	Electricity Dominates		Gas Retained	
Input/Assumption	**Constant annual average tariff ($/GJ, $2021)**	**AA6 AD Allowance ($mill, $2021)**	**Constant annual average tariff ($2021)**	**AA6 AD Allowance ($2021)**
Original Results	**$9.12**	**$160.62**	**$8.37**	**$78.36**
Capital expenditure (+15%)	$9.51 (4%)	$201.04 (25%)	$8.78 (5%)	$122.48 (56%)
Capital expenditure (-15%)	$8.74 (-4%)	$120.21 (-25%)	$7.96 (-5%)	$34.23 (-56%)
Operating expenditure (+15%)	$9.58 (5%)	$167.39 (4%)	$8.78 (5%)	$81.56 (4%)
Operating expenditure (-15%)	$8.67 -(5%)	$153.85 (-4%)	$7.97 (-5%)	$75.16 (-4%)

Source: Frontier Economics analysis

Table 9: Sensitivity analysis results – other key inputs

Scenario	Electricity Dominates		Gas Retained	
Input/Assumption	**Constant annual average tariff ($/GJ, $2021)**	**AA6 AD Allowance ($mill, $2021)**	**Constant annual average tariff ($2021)**	**AA6 AD Allowance ($2021)**
Original Results	**$9.12**	**$160.62**	**$8.37**	**$78.36**
Appliance capital cost, gas (+15%)	$10.58 (16%)	$372.08 (132%)	$8.79 (5%)	$137.96 (76%)
Appliance capital cost, gas (-15%)	$7.88 (-14%)	-$26.12 (-116%)	$8.15 (-3%)	$46.56 (-41%)
Appliance capital cost, electricity (+15%)	$7.07 (-22%)	-$150.10 (-193%)	$8.03 (-4%)	$28.90 (-63%)
Appliance capital cost, electricity (-15%)	$12.27 (34%)	$585.51 (265%)	$9.61 (15%)	$251.99 (222%)
Discount rate, medium income household (5%)	$13.14 (44%)	$655.80 (308%)	$10.18 (22%)	$320.29 (309%)
Discount rate, medium income household (15%)	$7.00 (-23%)	-$163.88 (-202%)	$8.07 (-4%)	$34.96 (-55%)
'Against gas', residential and commercial connect and disconnect (+15%)	$7.93 (-13%)	-$17.75 (-111%)	$8.13 (-3%)	$43.50 (-44%)
'Against gas', residential and commercial connect and disconnect (-15%)	$10.70 (17%)	$388.88 (142%)	$8.76 (5%)	$133.94 (71%)
'For gas', residential and commercial connect and disconnect (+15%)	$9.66 (6%)	$237.12 (48%)	$8.54 (2%)	$102.62 (31%)
'For gas', residential and commercial connect and disconnect (-15%)	$8.59 (-6%)	$82.13 (-49%)	$8.22 (-2%)	$56.76 (-28%)

Source: Frontier Economics analysis

As the results in Table 7, Table 8 and Table 9 demonstrate, the impact on the constant annual average tariff and AD allowance under the Electricity Dominates scenarios is particularly sensitive to residential retail gas prices, residential retail electricity prices (to a lesser extent), capital appliance costs and discount rates. There are also high magnitude impacts when adjusting the end points of the S-curves under this scenario. The magnitude of some of these impacts is so great that in some instances the AD allowance is more than doubled and in other instances the estimated AD allowance becomes negative with only a 15% increase or decrease to the input value (see retail residential gas price sensitivity analysis results above).

The magnitude of the changes in the constant annual average tariff and AD allowances under the Gas Retained scenario in response to the same sensitivities is lower than under the Electricity Dominates scenario however the same variables – retail residential prices, capital appliance costs and discount rates – still generate the greatest variation in results from the sensitivity value tested.

What these results highlight is how sensitive the model results are to some critical inputs. In particular, in light of the discussion around the retail electricity and gas prices inputs, the results of the sensitivity analysis indicate that further refinement of these inputs is likely necessary and that further information regarding the underlying assumptions and actual derivation of these inputs should be provided. Similar implications apply for the capital appliance cost inputs, income class designation for LGAs and the capital and operating expenditure profiles.

5 Model review – Methodology

The following section discusses some of the key methodological decisions made within the ACIL Allen model and their implications for the models' outputs.

5.1 Retail gas price representation

As noted in Sections 2.2, 3.1 and 4.1, retail electricity and gas prices are critical in determining results for both customer connections and disconnections and average volumes consumed. As discussed in these sections, there were several problematic assumptions and components of ACIL Allen's retail gas and retail electricity modelling.

Another fundamental issue here is that one set of homogeneous distribution and transmission (and retail) prices are being used to produce demand forecasts. These demand forecasts ultimately produce new distribution tariffs for each of the scenarios. There is no iteration or convergence within the model that links retail price inputs and the demand forecasts in the model, with the distribution tariffs produced by the model. The network and retail inputs used to calculate the demand forecasts do not reflect how network and retail prices would change over time under that given scenario and it is not reasonable to assume that only wholesale prices (driven by the carbon price) vary over the modelling period and adequately capture the retail price variation across the scenarios over time.

For example, as more and more people electrify under the Electricity Dominates scenario (due to lower retail electricity prices and higher wholesale gas prices), gas network tariffs and retail prices will increase, hence resulting in quicker and quicker network exits, higher and higher prices and so on. This is commonly known in the energy sector as a 'death spiral'. However, due to the approach taken by ACIL Allen wherein network and retail prices do not reflect changing levels of network usage, this 'death spiral' is not represented in the model.

To summarise, this is a critical methodological decision. The retail price inputs drive results for both customer connections and disconnections and average volumes consumed and hence are the primary determinant of the gas demand forecasts (which in turn determine tariffs and AD). This amplifies the problematic nature of the inputs used within a methodology that relies on prices to drive variation across the scenarios. The treatment of retail prices within this methodology highlights a fundamental flaw in the modelling that undermines the robustness of the results presented for both demand and AD.

5.2 Treatment of industrial customers

The treatment of industrial customers, both with respect to the number of industrial customers and the volumes of gas consumed by the total industrial customer base, involved key methodological decisions. As Table 10 highlights, industrial customers account for substantial proportions of total gas demand across all scenarios throughout the entire modelling period.

Table 10: Industrial customers (A1 and A2) share of total gas demand, 2025 – 2074

Scenario	Minimum share	Maximum share
Gas Retained	45.62%	53.11%
Energy Hybrid	46.66%	53.11%
Hydrogen Future	41.32%	53.11%
Electricity Dominates	44.41%	53.11%

Source: Frontier Economics analysis

However, within the model there is no detailed consideration given to the decisions faced by industrial customers. For example, both A1 and A2 industrial tariff classes under the Energy Hybrid, Gas Retained and Hydrogen Future scenarios have the current number of industrial customers respectively held constant over the entire modelling period. That is, despite changes in retail prices, changes in the gas mix and the numerous other external factors that would impact the number of industrial customers ATCO has, for both A1 and A2 tariff classes the number of customers is held constant from 2025 – 2074 in these three scenarios.

Further to this, both A1 and A2 industrial tariff classes under the Energy Hybrid, Gas Retained and Hydrogen Future scenarios have their volumes trended out using the same method. Specifically, the forecast demand for 2025 is trended out based on changes in heating degree days, commercial gas prices, commercial electricity prices, gross state product and the associated, industrial customer specific elasticities for each of these variables. There is no detailed consideration given to prices that would potentially be faced by industrial customers in these three scenarios, with price impacts driven by changes in commercial retail prices.

With respect to industrial customers under the Electricity Dominates scenario, the following approach is taken:

- The total volume consumed by customers on the A1 tariff and the number of industrial customers on the ATCO network on the A1 tariff are both trended out to 2074 in line with the trend in the GJ consumed per connection and trend in customer numbers respectively for residential customers.
- The total volume consumed by customers on the A2 tariff and the number of industrial customers on the ATCO network on the A2 tariff are both trended out to 2074 in line with the trend in the GJ consumed per connection and trend in customer numbers respectively for commercial customers.

These are significant methodological decisions (and assumptions) given the substantial proportion of demand that industrial customers account for on the ATCO network. Alternative approaches that integrate a more nuanced treatment of industrial customers, such as by identifying industrial customers in 'easy-to-electrify' and 'hard-to-electrify' sectors and accounting for emissions constraints or commitments where applicable (for example, if any customers are captured by the *Safeguard Mechanism*) and then utilising an alternative customer number and consumption forecasting method for specific classes of industrial customer could be a more nuanced and robust way to estimate demand for such a significant customer class (with respect to total demand forecasts).

5.3 Appropriateness of S-curve methodology

An S-curve logistic function is used to determine the probability of switching from gas appliances to electrical appliances within the ACIL Allen model. This methodological decision and feature of the model is of central importance. The shape of the S-curve function – in particular, it's steepness – is one of the most important factors in determining the number of customers connecting and disconnecting to the gas distribution network over time and across scenarios. The switching decision is modelled as an absolute decision – if a customer switches from gas appliances to electricity appliances, the household fully electrifies, gas network disconnection occurs immediately, and gas consumption immediately ceases. Separate S-curve logistic functions are estimated for residential and commercial customers and separate calculations are made regarding customer connection decisions and customer disconnection decisions.

S-curves have been widely employed across both academic and other literature in the context of studying technology diffusion[31]. S-curves are a product of the diffusion of innovations theory and literature (first developed by Rogers in 1962)[32] which explicitly considers the factors that determine the rate of market adoption for a given technology, including canonical attributes, contextual factors and other factors such as network effects and standards[33]. Diffusion of innovations theory propounds that a technology spreads over time based on perception of its being new, and that the rate of adoption differs among five distinct categories of consumers (innovators, early adopters, early majority, late majority, and laggards). The cumulative uptake of a given technology over time results in an S shaped curve that is typical of a technology adoption curve[34].

The function utilised in the ACIL Allen model is characterised by a slow build-up phase, a ramp-up phase and a maturing phase where total uptake begins to plateau. This function aligns with the traditional shape of the S-curve as discussed above. Figure 10 shows the logistic function S-curve utilised by ACIL Allen.

Essentially, what the ACIL Allen model does is convert the NPV of switching from gas to electricity into a relative measure of utility in each year (for connecting to the gas network or disconnecting from the network) and transforms that into a probability of connecting or disconnecting. This probability then determines the number of those customers that are able to disconnect or connect in any year that actually do disconnect or connect. A critical part of these calculations, and S-curve modelling in general, is the S-curve parametrisation. S-curve modelling requires several critical assumptions and 'judgement calls', discussed further below.

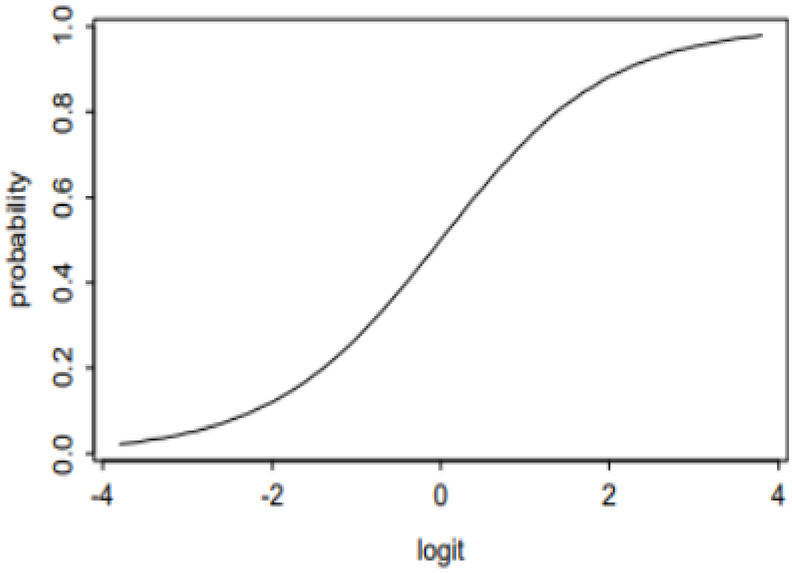
31 See for example: Schilling, MA & Esmundo, M, 2009, 'Technology S-curves in renewable energy alternatives: Analysis and implications for industry and government', *Energy Policy*, vol. 37, no. 5, pp. 1767–1781, doi:10.1016/j.enpol.2009.01.004; Adner, R & Kapoor, R, 2016, 'Innovation ecosystems and the pace of substitution: Re-examining technology S-curves', *Strategic Management Journal*, vol. 37, no. 4, pp. 625–648, doi:10.1002/smj.2363

32 Rogers, EM, 1962, Diffusion of innovations., Free Press of Glencoe, New York.

33 Adner, R & Kapoor, R, 2016, 'Innovation ecosystems and the pace of substitution: Re-examining technology S-curves', *Strategic Management Journal*, vol. 37, no. 4, pp. 625–648, doi:10.1002/smj.2363

34 Rogers, EM, 2003, Diffusion of innovations, Fifth edn., Free Press of Glencoe, New York.

Figure 10: ACIL Allen S-curve logistic function



Source: ACIL Allen report

In our view, adopting an S-curve approach is a reasonable method for modelling gas network connections and disconnections. After all, fundamentally, S-curves are intended to represent the diffusion of a given technology or innovation.

However, in order to provide a reasonable forecast, S-curves should capture all of the factors that will materially impact the rate of uptake for a given technology. The approach developed and used by ACIL Allen uses a single measure – NPV – to parametrise the S-curve and to model connections and disconnections. Implicitly, the NPV measure captures a number of price factors (e.g. capital costs, operating costs and so on). However, the NPV approach used by ACIL Allen does not capture 'non-price' factors that may materially impact the rate of disconnection and connection to the gas network on the ATCO network. 'Non-price' factors that could be material include consumer preferences and tastes and potential technical or physical constraints that may hinder electrification in some areas or buildings for example. These factors are, of course, challenging to model. We consider that focusing the S-curve analysis on NPV is a reasonable approach, but the potential importance of other factors in customers decisions highlights the importance of testing the outcomes of the modelling against observable data where possible. We discuss this further in the section that follows.

Parameter calibration – key assumptions

To calibrate an S-curve requires specification of several assumptions that are typically not directly observable, and therefore requires professional judgement. Our understanding is that the S-curve function designed by ACIL Allen is calibrated by:

- Selecting the NPV corresponding to 100% of users connecting to gas and the NPV corresponding to 100% of users connecting to electricity;
- Solving for the relative utility where there is less than one disconnection (for disconnection S-curve parametrisation) and where there is less than one connection (connection S-curve parametrisation);

- Dividing the relative utility value by the range between the bottom and upper bound of the NPV to calculate the NPV coefficient; and
- Calculating the intercept term by subtracting the relative utility calculated by the product of the NPV where households don't switch and the implied NPV coefficient.

A relative utility of connecting or disconnecting for each year is then calculated by adding the product of the NPV coefficient and the actual NPV of switching in a given LGA in a given year to the intercept term. This relative utility for a given year is then transformed using the logistic function to return an output between 0 and 1 representing the S-curve probability of connecting or disconnecting (in that given LGA in that given year).

We are not aware of any literature that relates specifically to household and commercial natural gas switching decisions from a technology diffusion perspective. In ACIL Allen's model, the parametrisation of the S-curve is underpinned by assumptions regarding NPVs corresponding to 100% of users connecting to gas and 100% of users connecting to electricity. These assumptions are key drivers of the forecasts of customer connections and disconnections. It is not clear what reasoning or what calibration process ACIL Allen used to arrive at the assumptions regarding NPVs corresponding to 100% of users connecting to gas and 100% of users connecting to electricity.

Analysis of adoption rates using S-curves does require assumptions about the shape of S-curves. Particularly during the early stages of adoption of a new technology, there is generally only limited data available against which to test these assumptions. However, there are some approaches that are available for ACIL Allen to test the assumptions used to parameterise the S-curve:

- A simple approach would be to test the forecasts of connection and disconnection produced by ACIL Allen against observed rates of connection and disconnection in recent years. If the forecasts diverge markedly from recently observed data, this should presumably be explicable by expected changes in key drivers of rates of connection and disconnection.
- A more systematic approach would be to use the approach adopted by ACIL Allen to back-cast rates of connection and disconnection over recent years. The key drivers of ACIL Allen's forecasts of connections and disconnections – the inputs to the NPV – could all be back-cast for recent years to develop a back-cast of rates of connection and disconnection over these years. These forecasts could then be tested against the available data on connection and disconnection rates.

Going forward, the forecasts from ACIL Allen's model can be tested against data on connection and disconnection rates that will become available, in order to provide an additional sense-check of the assumptions made by ACIL Allen in relation to the parameterisation of the S-curves.

In our view, efforts to test the reasonableness of the assumptions used to parameterise the S-curve are particularly important since these assumptions are key drivers of ACIL Allen's forecasts. As Section 4.5 details, the AD allowances calculated within the modelling do vary materially in response to relatively moderate adjustments in the inputs used for the calibration of the S-curve.

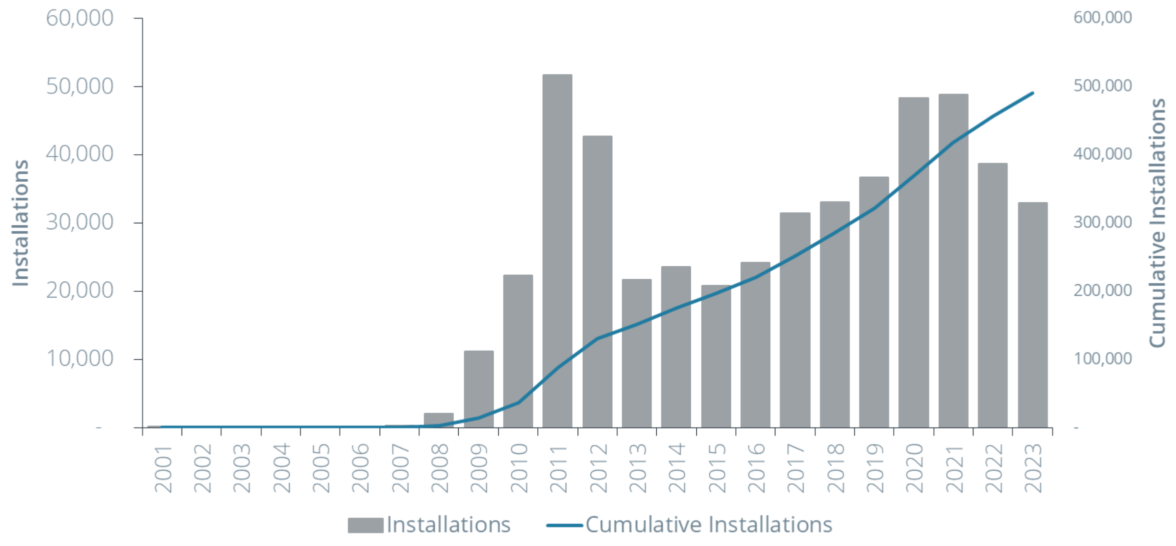
5.4 Other methodological considerations

Omission of solar photovoltaic (PV)

We note that residential, commercial and industrial solar photovoltaic (PV) installation is not accounted for in this modelling. Solar PV, as well as other consumer energy resources (CER) such as batteries and electric vehicles, will increasingly alter patterns of energy consumption and most importantly, the economics of fuel-switching.

In Western Australia, there is already a high proportion of buildings with small-scale solar PV. As Figure 11 shows, cumulative installations for small-scale solar in Western Australia are nearly at 500,000[35] as of 2023[36]. This means that a high proportion of residential dwellings in Western Australia already have solar PV. Further, it is projected that the penetration of rooftop solar PV at the residential level in Western Australia will continue to grow. The CSIRO's most recent modelling (2022) estimates that the share of households in Western Australia that will have rooftop solar PV in 2050 is likely to fall in the range of 39% to 50%[37]. This report also notes that as existing systems are replaced or upgraded, the size of these installations as well as new installations entirely are increasingly larger and larger on average in size (kW).

Figure 11: Small-scale solar PV installations, Western Australia



Source: Frontier Economics analysis of Clean Energy Regulator data

Solar PV and other CER fundamentally alter energy consumption patterns, the operating costs of appliances and the decisions that households may make with respect to if, when and how they disconnect from the gas network. It is likely that 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. To the extent that residential and commercial customers are exporting excess solar electricity and are able to make use of some of that

35 Clean Energy Regulator, *Postcode data for small-scale installations*, https://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations#Historical-data

36 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.

37 Commonwealth Scientific and Industrial Research Organisation, *Small-scale solar PV and battery projections 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

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 the NPVs. 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.

It is also uncertain whether solar PV uptake is already implicitly included in the S-curve calibration or if adjustments (or entirely separate S-curves) would be required when integrating solar PV into the model. The subsequent impact on the rate of connection and disconnection on the gas network, and the eventual gas demand forecasts, is difficult to comment on due to the level of uncertainty.

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 AD allowances. Integrating solar PV and other CER into the model would involve adding significant complexity to the model. However, in our view, given the important role that CER plays in household energy costs it is important that CER is appropriately accounted for in the modelling.

Choice of appliances for comparison

ACIL Allen's model relies on a comparison of a specific set of gas appliances with a specific set of electrical appliances, namely:

- A gas cooktop, an instantaneous gas water heater and either a gas wall furnace or a ducted gas furnace.
- An electric induction cooktop, a heat pump electric water heater and either a RCAC split system or ducted RCAC.

However, there are alternative appliances that some customers may adopt. Particularly for electrical appliances, the options considered by ACIL Allen are relatively expensive up front, but have lower ongoing operating costs. Cheaper alternatives – such as resistance cooktops and resistance storage water heaters – are likely to be preferred by customers that are capital constrained and/or have a higher discount rate. Indeed, the Residential Baseline Study for Australia suggests that electric storage water heaters will continue to be far more common than heat pump water heaters in Western Australia out to 2040.[38] Although this study is based on a methodology from 2020 and technology uptake trends and the economics of different appliances has likely changed since then, the point remains that for both residential and commercial customers a different choice of electrical appliance could materially change their NPV of switching.

Similarly, some gas customers may prefer a gas storage water heater to an instantaneous water heater. However, the Residential Baseline Study for Australia suggests that instantaneous water heaters are more common and will grow in popularity in Western Australia out to 2040, while gas storage water heaters are less common and will decline in popularity in Western Australia.[39] In any case, since the up front costs and operating costs of these alternative gas water heaters

38 Australian Government, *2021 Residential Baseline Study for Australia and New Zealand for 2000 to 2040*, available here.

39 Australian Government, *2021 Residential Baseline Study for Australia and New Zealand for 2000 to 2040*, available here.

do not vary as much as is the case for alternative electrical appliances, this decision is less likely to impact the results of the analysis.

Finally, some customers that currently rely on gas heating will already have some form of RCAC installed, which could be used as an alternative to gas heating.[40] While this would presumably be less preferred for customers that continue to use gas heating despite having RCAC installed, it would materially reduce the capital cost of electrification relative to having to install new RCAC.

Our view is that the assumed appliance choices should reflect the likely choices of customers in Western Australia. Given that the effect of appliance costs on estimated AD amounts is material, our view is that alternative appliances choices should be considered in the modelling where this is likely to result in materially different appliance costs assumptions. This includes in respect of assumptions about electric cooktops (resistance vs induction), about electric water heating (resistance vs heat pump) and about the prevalence of RCAC for customers with gas heating.

Constant real tariffs by customer class

In their report Incenta Economic Consulting propose a different approach to ACIL Allen to determining constant real prices. Incenta Economic Consulting recommend that the target should be to set constant real prices for each customer class (residential, commercial, etc), rather than to target constant average prices for all customers (which is what ACIL Allen does).[41] These two approaches produce different results when the mix of customers change over time, as they do in three of four scenarios.

Our view is that Incenta Economic Consulting's approach is preferable to ACIL Allen's approach. To the extent that there is merit in maintaining constant real tariffs our view is that the relevant measure of this is the tariffs that customers are actually paying, rather than the average tariff across a diverse mix of customer groups.

40 The Residential Baseline Study for Australia suggests that there are close to 1.5 million residential RCACs in Western Australia in 2023. Australian Government, *2021 Residential Baseline Study for Australia and New Zealand for 2000 to 2040*, available here.

41 Incenta Economic Consulting 2023, *Regulatory depreciation for AA6*.

6 Conclusions and recommendations

6.1 Has the case for AD to promote cost recovery been established?

Incenta Economic Consulting identify an outcome for regulatory depreciation that has "been accepted as desirable or applied in Australian regulatory matters" which is that "there should be a high degree of confidence that costs will be recovered over the economic life of the assets such that financial capital maintenance is achieved".[42]

However, we note that the modelling undertaken by ACIL Allen does not directly address whether ATCO will be able to recover its capital investment in the absence of AD, or whether ATCO's expectation of recovering its capital investment will be increased by the proposed AD.

ACIL Allen do not report whether ATCO will be able to recover its costs under any of the four scenarios, with or without AD. Incenta Economic Consulting suggest that it is unlikely that ATCO will be able to recover its costs in the Electricity Dominates scenario (presumably as a result of the significant increase in tariffs that would be required from around 2055 in this scenario). Incenta Economic Consulting do not express an opinion on the likelihood of cost recovery under the other scenarios.

The reason that ACIL Allen's modelling does not identify whether there is a risk to cost recovery under any of the four scenarios is that ACIL Allen's modelling never forecasts customer switching, or customer demand, or cost recovery, for scenarios in which customers face the distribution network tariffs that they model – with or without AD. It may be that if out-turn distribution tariffs from ACIL Allen's model were used to determine retail gas prices in ACIL Allen's model, the resulting forecasts of demand would be consistent with cost recovery. While ACIL Allen have built a model that is capable of determining the impact of distribution tariffs on customer demand and cost recovery, ACIL Allen do not use the model for that purpose, but only model customer switching and customer demand using a set of assumptions about distribution tariffs that do not vary between scenarios and do not reflect the outcomes of ACIL Allen's modelling of distribution tariffs under the four scenarios.

Recommendation 1: In order to determine whether there is a high degree of confidence that costs will be recovered, for all four modelling scenarios, analysis should be undertaken to establish:

- **the extent to which ATCO would be unable to recover its costs in the absence of AD, and**
- **if ATCO is unable to recover its costs in the absence of AD, the extent to which ATCO's cost recovery is improved as a result of the proposal AD.**

[42] Incenta Economic Consulting 2023, *Regulatory depreciation for AA6*, p.6.

6.2 Has the case for AD to promote efficient utilisation been established?

Incenta Economic Consulting identify an outcome for regulatory deprecation that has "been accepted as desirable or applied in Australian regulatory matters" which is that "the recovery of costs should be spread over time in a manner than encourages the efficient use of assets".[43]

However, we note that the modelling undertaken by ACIL Allen does not directly address whether utilisation of ATCO's assets would be inefficient in the absence of AD, or whether utilisation of assets would be made more efficient by the proposed AD. The reason that ACIL Allen's modelling does not identify whether asset utilisation would be improved is the same reason that ACIL Allen's modelling does not identify whether there is a risk to cost recovery under any of the four scenarios: ACIL Allen's modelling never forecasts customer switching, or customer demand, or cost recovery, for scenarios in which customers face the distribution network tariffs that they model – with or without AD. While ACIL Allen have built a model that is capable of determining the impact of distribution tariffs on customer demand and cost recovery, ACIL Allen do not use the model for that purpose, but only model customer switching and customer demand using a set of assumptions about distribution tariffs that do not vary between scenarios and do not reflect the outcomes of ACIL Allen's modelling of distribution tariffs under the four scenarios.

Recommendation 2: For all four modelling scenarios, analysis should be undertaken to establish:

- **the extent to which inefficient utilisation of ATCO's assets would occur in the absence of AD, and**
- **if inefficient utilisation of ATCO's assets would occur in the absence of AD, the extent to which efficiency of utilisation is improved as a result of the proposal AD.**

In our view this would require forecasting demand using the network prices modelled by ACIL Allen as inputs into the retail prices faced by customers.

6.3 Has the case for AD to ensure constant real tariffs been established?

Incenta Economic Consulting notes its agreement with ACIL Allen's conclusion that deriving depreciation in a manner that delivers a price path that is constant in real terms is preferable. Incenta Economic Consulting's stated reasons are that this would (depending on the scenario) increase confidence that costs will be recovered and increase efficient utilisation of the asset.[44] As discussed in the previous sections, our view is that the existing modelling does not establish the case that there are issues with cost recovery or efficient utilisation of assets in the absence of AD or that the proposed AD will improve outcomes in respect of cost recovery or efficient utilisation of assets.

[43] Incenta Economic Consulting 2023, *Regulatory depreciation for AA6,* p.6.

[44] Incenta Economic Consulting 2023, *Regulatory depreciation for AA6,* p.23.

Like Incenta Economic Consulting, ACIL Allen also suggest that AD is justified "where future tariffs rise to such an extent that consumers are unwilling to pay them"[45], presumably because if customers are unwilling to pay the tariffs this may prevent cost recovery or result in inefficient asset utilisation. ACIL Allen also offer another argument for constant real tariffs, being that "[t]his approach does not advantage or disadvantage any group of customers across time".[46]

In our view, it is not necessarily the case that constant real tariffs can be said not to advantage or disadvantage any group of customers across time. For instance, if costs are changing over time (such as operating costs or the cost of capital) it might be thought to advantage a group of customers across time to keep tariffs constant in real terms and shield customers from those increases in costs.

Putting this question to one side, we are also not clear that the approach to calculating AD that is proposed by ACIL Allen and Incenta Economic Consulting will necessarily deliver prices that are more stable over time. Certainly, if we confine our consideration to a single scenario, then the approach to AD would be expected to deliver prices that are more stable over time than having no AD. However, the reason for having alternative scenarios is that we do not know what the future will hold. There are plausible outcomes in which AD in AA6 turns out to be unnecessary, with the result that prices in AA6 are higher than necessary and prices in subsequent periods are lower. This outcome has to be considered in light of the potential price volatility in the absence of AD. Here, we can see that two of the three scenarios considered relevant by ACIL Allen and Incenta Economic Consulting – the Energy Hybrid and Natural Gas Retained scenarios – result in tariffs that are expected to be very stable over time even in the absence of AD.

6.4 Has the case for taking action on AD now been established?

A common justification for taking action on AD is to avoid the risk of asset stranding. Incenta Economic Consulting state that:[47]

> *In our view, when interpreting the advice from the scenarios for AA6 depreciation, the priority should be to minimise the risk of asset stranding, which is a particular issue under the Electricity Dominance scenario. We say this because reducing stranded asset risk relies upon early action because (that is, if action to address stranded asset is excessively delayed, then the scope to recover cost may already have passed) and because providing a reasonable opportunity to recover efficient cost has been a central element in how utilities have been regulated in Australia. In contrast to our views in relation to the Hydrogen Future scenario, there is much less scope to defer action if substantial stranded asset risk is to be avoided under the Electricity Dominance scenario.*

Incenta Economic Consulting present some analysis of the consequences of waiting for better information on the future of the gas network and delaying any action on AD until AA7. Incenta Economic Consulting report the following residential distribution tariffs under the Electricity Distribution scenario:

- For AA6, in the absence of action on AD, the average tariff would be $18.87/GJ.
- For AA6, with action on AD to levelise tariffs in real terms from AA6, the average tariff would be $21.68/GJ.

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45 ACIL Allen 2023, *Future of gas*, p. iv.

46 ACIL Allen 2023, *Future of gas*, p. viii.

47 Incenta Economic Consulting 2023, *Regulatory depreciation for AA6*, pp.3-4.

- For AA7, with action on AD to levelise tariffs in real terms from AA7, the average tariff would be $22.85/GJ.

Based on this, Incenta Economic Consulting point out that "if the decision to levelise was deferred until AA7, then the ultimate price would be approximately 5.4 per cent higher than if the levelisation occurred from AA6 ($22.85 per GJ compared to $21.68 per GJ)".[48]

This analysis is correct so far as it goes, but it does not really inform the trade-off that is made by taking action in AA6 rather than delaying action until AA7. The key justification for delaying action until AA7 would presumably be that the intervening time would provide more information on the future of ATCO's gas network. For instance, the intervening time might make it clearer which of the three relevant scenarios best matches actual outcomes over the intervening years and best matches future expectations at the time of AA7: Electricity Dominates, Energy Hybrid or Natural Gas Retained or another potential future. If it turns out at the time of AA7 that Energy Hybrid or Natural Gas Retained are more likely, and Electricity Dominates is less likely, then it may be the case that the action on AD in AA6 was unnecessary, because tariffs may not need to increase much beyond $18.87/GJ in any case.

In our view, deciding whether to take action on AD now, rather than delay action, requires weighing:

- The certain price increase that would occur in AA6 if action is taken in AA6, which is 15% (based on Incenta Economics Consulting's figures of $18.87/GJ without AD and $21.68 with AD)
- The potential higher price increase that might be necessary in AA7 if action is delayed in AA7, which might be 5.4% but could also be much higher or lower, depending on what the intervening time suggests about future scenarios.

Balancing these considerations requires consideration of the effect of deferring action on AD in all scenarios, not just the Electricity Dominates and Hydrogen Future scenarios presented by Incenta Economic Consulting.

Recommendation 3: Analysis should be undertaken to determine the effect of deferring action on AD in all scenarios. This analysis should not only compare outcomes from deferring action under a single scenario – such as the Electricity Dominates scenario. Rather, the analysis should recognise that there is risk to taking action on AD on the expectation of the Electricity Dominates scenario occurring, if in future it turns out that another scenario occurs.

6.5 Are there other modelling issues that need to be address?

Our review of ACIL Allen's modelling and assumptions has also highlighted a number of other more specific issues with input assumptions and the way that they are used. These are discussed in Section 4 and Section 5.

48 Incenta Economic Consulting 2023, *Regulatory depreciation for* AA6, p.27.

Recommendation 4: Our comments on inputs and assumptions should be considered, with changes to inputs and assumptions or justification of existing inputs and assumptions as appropriate. As a priority the following issues should be considered:

- **Varying the inputs assumptions for distribution, transmission and retail components of retail gas prices across all scenarios.**
- **Varying wholesale gas price forecasts across all four scenarios.**
- **Varying the inputs and assumptions for retail electricity prices across all scenarios.**
- **Ensuring consistency in the inclusion of carbon costs between gas and electricity retail tariffs.**
- **Varying income assumptions for LGAs based on census data.**
- **Incorporating iteration between network tariff assumptions and demand forecasts in order to account for the relationship between forecast demand and out-turn network tariffs.**
- **Incorporating behind the meter PV in the analysis of NPV.**
- **Considering other representative appliance types in the analysis of NPV.**
- **Considering the extent to which customers with gas heating already have RCAC installed.**
- **Considering how existing data on rates of electrification can be used to inform and test assumptions relating to the specification of the S-curve, and the modelling approach generally, provides reasonable results.**

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