Appendix A: Modelling the phase-out of gas appliances

In preparing this report, IEEFA has modelled the impacts of a scenario in which all gas appliances in Victoria are transitioned to electric alternatives at end of life, starting from 2025.

Methodology

A baseline projection of appliance stock for Victoria was produced from the Residential Baseline Study[1] by:

- Taking the average number of appliances per household by type, and;
- Scaling this based on the projected growth in households.

An estimated trajectory of appliance sales was also derived by:

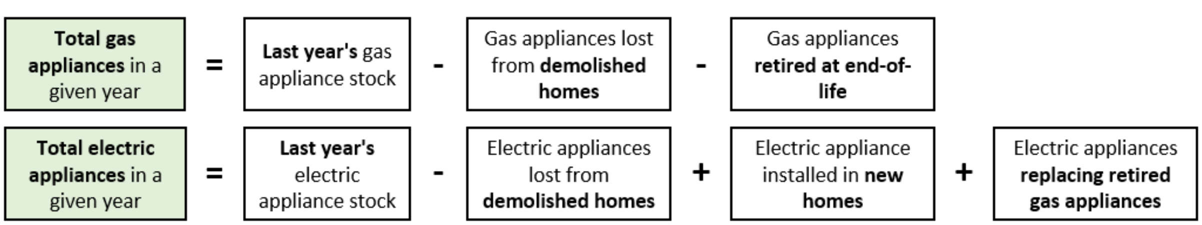
- Digitising and extrapolating appliance sales data used in the underlying Residential Baseline Study methodology and technical appendix,[2] and;
- Calibrating this to the appliance stock projection for Victoria.

As an example of this calibration, we assumed that for an appliance with an average lifetime of 20 years, the number of sales in the 20-year period leading to 2021 should broadly equal the total appliance stock in 2021.

After the specified start year of the intervention (2025 by default), the appliance sales projection assumes all gas appliance sales cease, and are replaced with equivalent electric appliances from Table 1. The overall appliance stock projection switches from the baseline to an alternative projection, which estimates the change in appliances in existing and new homes (Figure 1).

Although the Residential Buildings Baseline Study includes LPG and Mains Gas appliances, we have excluded any impacts on LPG appliance sales, and excluded LPG appliances from final gas demand results. This is necessary to focus on the implications for gas distribution networks.

Figure 1: Calculations underlying alternative appliance stock projection



[1] EnergyConsult. 2021 Residential Baseline Study for Australia and New Zealand for 2000-2040. 2022.
[2] EnergyConsult. RBS2.0 Methodology Report. September 2020; and EnergyConsult. Residential Energy Baseline Study: Technical Appendix. August 2015.

Appliances in demolished homes

Gas and electric appliances lost from demolished homes are estimated by:

- Taking the housing stock projection from the Residential Baseline Study;
- Assuming it incorporates a demolition rate of 0.3% pa, which is consistent with ABS data from 2017-21;[3]
- Using this to project how many homes are demolished and built per year, and;
- Determining the appliances lost for each demolition based on the average number of appliances per household from the Residential Baseline Study.

Following the Victorian government's policy to stop connecting new homes to the gas network from 2024, the model assumes that all new homes after 2024 receive electric appliances.

In reality, there may be a small number of new gas appliances in 2024 installed in new homes where permits had already been issued, and in demolition/rebuilds where the property has an existing gas connection. However, the impact on the overall trajectory of estimating these cases was considered non-material.

It is therefore assumed that gas appliances that would have been installed in new homes are replaced by a direct electric alternative (Table 1).

Table 1: Gas appliances covered by this modelling, and their assumed electric replacements

Gas appliance	Assumed electric replacement
Gas cooktop	Induction cooktop
Gas oven	Electric oven
Gas upright cooker	Electric upright cooker
Gas ducted heater	3x non-ducted reverse-cycle air conditioners
Gas non-ducted heater	1x non-ducted reverse-cycle air conditioner
Gas instant water heater	Heat pump water heater
Gas storage water heater	Heat pump water heater
Gas-boosted solar water heater	Electric-boosted solar water heater

Appliance retirement schedule

To determine the number of gas appliances up for retirement each year, a "retirement function" was applied to the assumed sales trajectories to determine how many appliances of a particular type are up for replacement in a given year. This function is a distribution where 50% of appliances are assumed to retire by the time their average lifetime is reached, based on the lifetimes in Table 2.

[3] ABS. Building Approvals, Australia. Table 87. Number of dwellings approved for demolition, original, states and territories. August 2023.

This approach was chosen as it simulates the real lifecycle of appliances, which may last for less than or more than their expected lifetime based on differences in usage patterns, maintenance and manufacturing quality. It introduces a level of conservatism in the modelling, and avoids assuming that an entire cohort of appliances is retired in a single year.

Retirement functions were constructed based on relevant examples found in literature.[4] The final function for each appliance is shown in Figure 2.

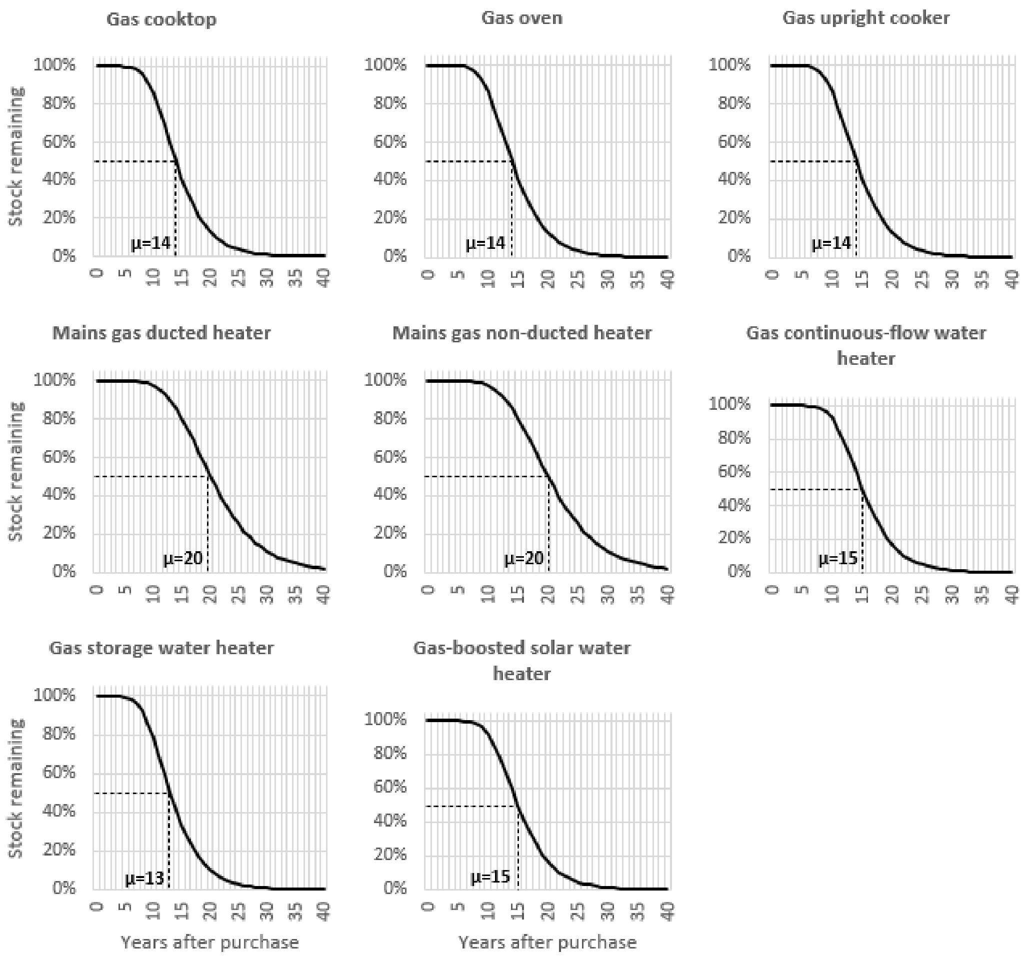
Table 2: Assumed average lifetime of gas appliances covered by the modelling

Gas appliance	Average lifetime
Gas cooktop	14 years
Gas oven	14 years
Gas upright cooker	14 years
Gas ducted heater	20 years
Gas non-ducted heater	20 years
Gas instant water heater	15 years
Gas storage water heater	13 years
Gas-boosted solar water heater	15 years

Source: EnergyConsult (2015), EnergyConsult (2011), Syneca Consulting (2008).

[4] See Equipment Energy Efficiency Program. Consultation Regulation Impact Statement – Air Conditioners and Chillers. February 2016. Page 62; and EnergyConsult. Product Profile: Gas Space & Decorative (Fuel Effect) Heaters. April 2012. Page 38.

Figure 2: Retirement functions for all gas appliances – stock remaining as a function of years after purchase



Total energy demand

An annual gas consumption per appliance in Victoria was taken directly from the Residential Baseline Study from 2020-25.

Beyond 2025, the average consumption per appliance was assumed to vary over time based on an average autonomous energy efficiency improvement rate that was extracted from the 2020-25 data.

These autonomous energy efficiency rates ranged from 0-2.5% improvement a year depending on appliance. In a small number of cases, the Residential Baseline Study showed an increase in gas consumption per appliance. In these cases, a 0% improvement rate was assumed.

The final appliance stock projections and annual energy consumption per appliance were combined to produce a final projection of mains gas demand across all appliances.

Total number of residential connections

The relationship between residential gas consumption and the number of connected customers is not necessarily linear, as households are likely to disconnect their appliances gradually, only disconnecting from the network after removing their last gas appliance.

To model a trajectory of residential connections it was necessary to model different numbers of customer "cohorts" based on the appliance configuration in each home (Table 3).

Table 3: Customer cohorts included in the residential connections modelling

Customer cohort	Appliance configuration
E	All-electric home
C	Gas cooktop only
HW	Gas hot water only
SH	Gas space heater only
C+HW	Gas cooktop and hot water
C+SH	Cas cooktop and space heater
HW+SH	Gas hot water and space heater
C+HW+SH	Gas cooktop, hot water and space heater

The initial breakdown of customer cohorts was derived from assumptions in the Consumer Choice models published by AusNet, AGN and Multinet, which were also used in the modelling described in Appendix B. These were simplified assumptions that only considered three cohorts: C, C+HW and C+HW+SH.

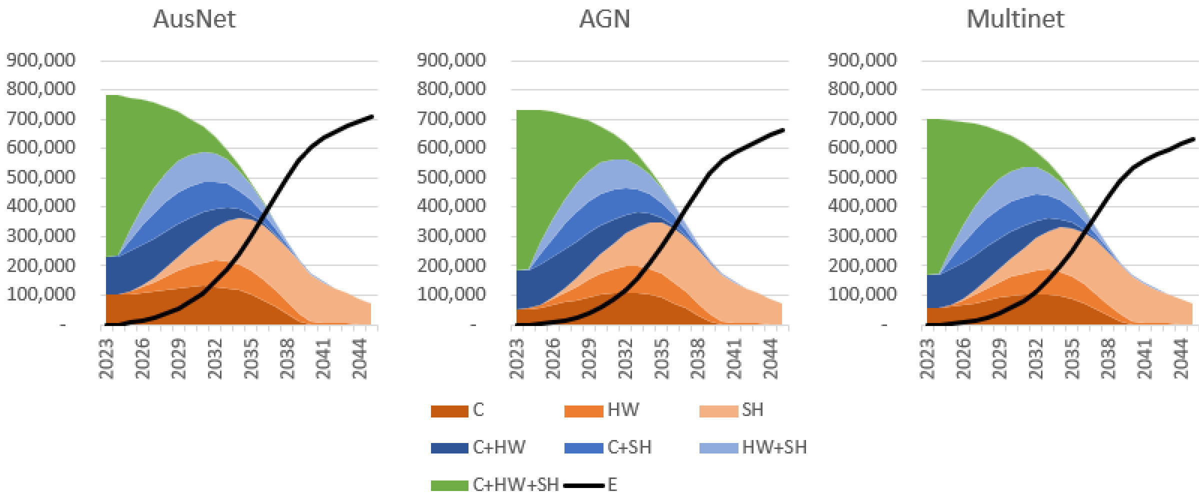
When cooking, hot water or space-heating gas appliances were retired according to the modelling above, each appliance retirement was attributed proportionally to a particular customer cohort. Based on the appliance that was lost, customers in this cohort were moved to a new cohort with fewer appliances.

For example, if 100 gas hot water systems were retired in a given year, and customers were equally spread across the cohorts C, C+HW and C+HW+SH, 50 customers in the C+HW group would move to the C cohort, and 50 customers from the C+HW+SH group would move to the C+SH cohort.

For the cohorts that only have one gas appliance – C, HW or SH – customers are assumed to fully electrify and disconnect from the gas network once their appliance retires.

The transition of customer cohorts for each network is shown in Figure 3. By 2045, the remaining customers on the gas network are mostly in the SH cohort, as space heaters are assumed to have longer lifetimes than other gas appliances (Table 2).

Figure 3: Changes in customer appliance configurations by network



Note: Households that are already all-electric prior to 2023 are not counted.

Total emissions

The implications of the gas appliance phase-out on emissions was considered by assuming a Scope 1 + 3 emissions factor for fossil gas of 55.53 kg CO_2-e/GJ for Victoria.[5] The Scope 3 component of this figure considers combustion emissions from exploration, production/processing, transmission and distribution, and fugitive emissions from all the above processes except distribution.[6]

If this analysis were extended to other jurisdictions, a higher emissions factor would need to be assumed, as Victoria's Scope 3 emissions factors are the lowest reported factors in Australia.[7]

Another layer of analysis was added to estimate the additional Scope 2 emissions from added electric appliances.

The final appliance stock trajectory was compared against the initial baseline trajectory to determine the avoided stock of gas appliances given the intervention.

This was converted into avoided fossil gas consumption via the method described under "Total energy demand".

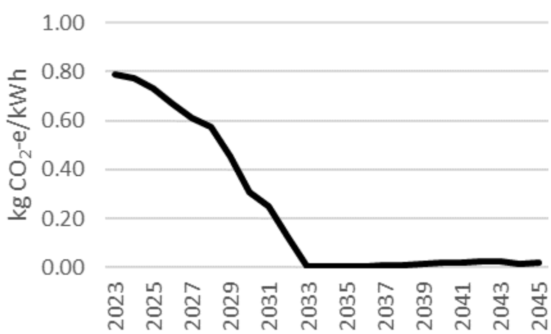
This fossil gas consumption was converted into an additional electricity consumption forecast based on energy efficiency ratios described in the Appendix C methodology.

[5] DCCEEW. Australian National Greenhouse Accounts Factors. August 2023. Pages 16-17.
[6] Ibid. Page 48.
[7] Ibid. Page 17.

A forecast for electricity emissions intensity was developed based on AEMO's 2022 ISP *Step Change* forecast for Victoria.[8] Emissions intensities for existing generators were taken from the 2022 Inputs and Assumptions Workbook.[9] These were then mapped to the generation technology categories in AEMO's *Step Change* generation forecast by using the average value for that generation technology.

These average emissions intensities were combined with AEMO's *Step Change* generation forecast to develop an overall emissions trajectory forecast for Victoria (Figure 4).

Figure 4: Forecast emissions intensity of electricity in Victoria, Step Change (2022 ISP)



Forecast electricity demand was mapped against this trajectory to determine a final trajectory for Scope 2 emissions from added electricity consumption.

Key results

Figure 5 shows the final trajectory for residential mains gas demand in Victoria, if sales of gas appliances were to end from 2025. Table 4 shows the percentage reduction in residential gas demand from 2025 levels by key milestone years.

[8] AEMO. 2022 Integrated System Plan (ISP). Generation Outlook. June 2022.
[9] AEMO. 2022 Integrated System Plan (ISP). Inputs, assumptions and scenarios workbook. June 2022.

Figure 5: Modelled residential mains gas projection for Victoria

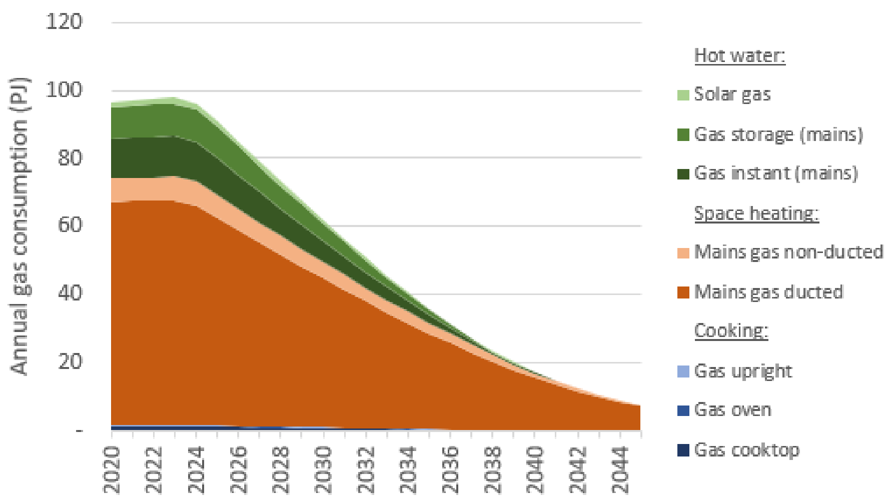
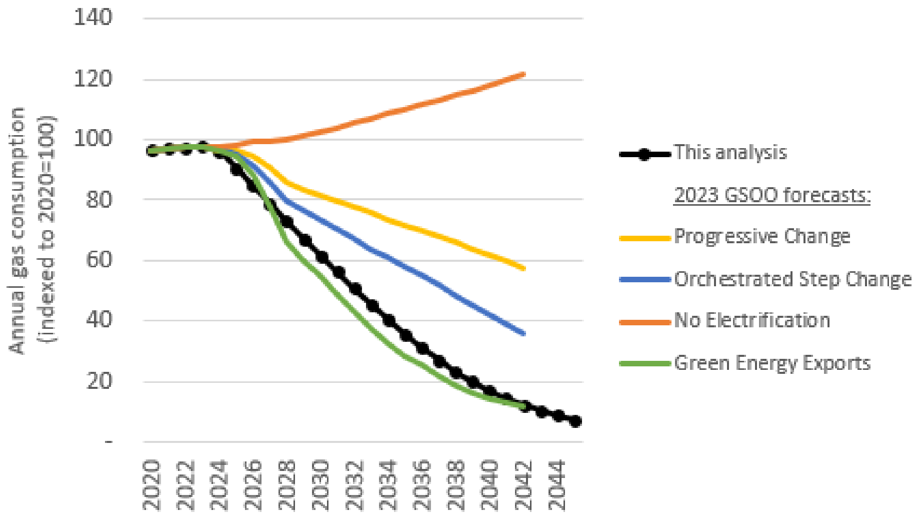


Table 4: Reduction in residential gas consumption from modelled trajectory

Year	Reduction in residential gas (% change from 2025)
2030	-32%
2035	-61%
2040	-81%
2045	-92%

Figure 6 compares this trajectory against AEMO's recent GSOO forecasts for Victoria (noting these projections combine commercial and residential demand; they are indexed to 2020 here for comparison.

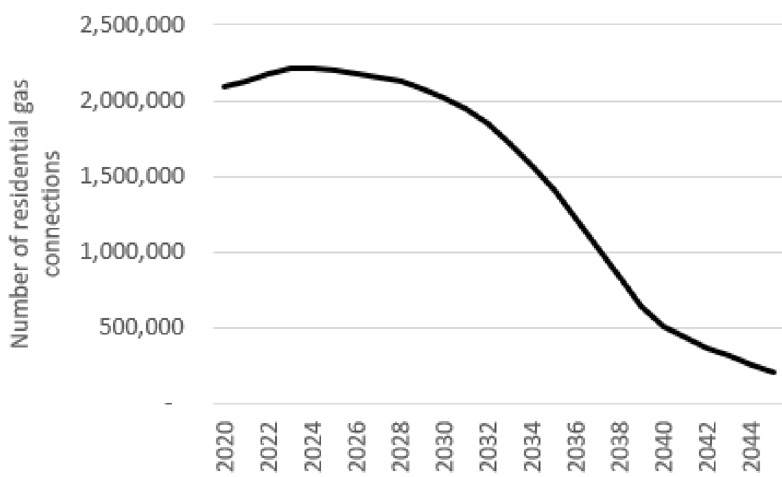
Figure 6: Model outcomes compared with 2023 GSOO forecasts



Source: AEMO. Note: GSOO forecasts include residential and commercial consumption for Victoria.

Total residential gas connections are shown in Figure 7.

Figure 7: Modelled trajectory of residential gas connections in Victoria



Appendix B: Modelling distribution network revenue and price impacts

Modelling context

To understand the impacts of the modelled residential electrification trajectory for Victoria on gas distribution network prices and revenues, IEEFA has used an adapted version of a suite of models published by the three Victorian distribution networks under their 2023-28 Access Arrangements.

For each network, two linked models were published:

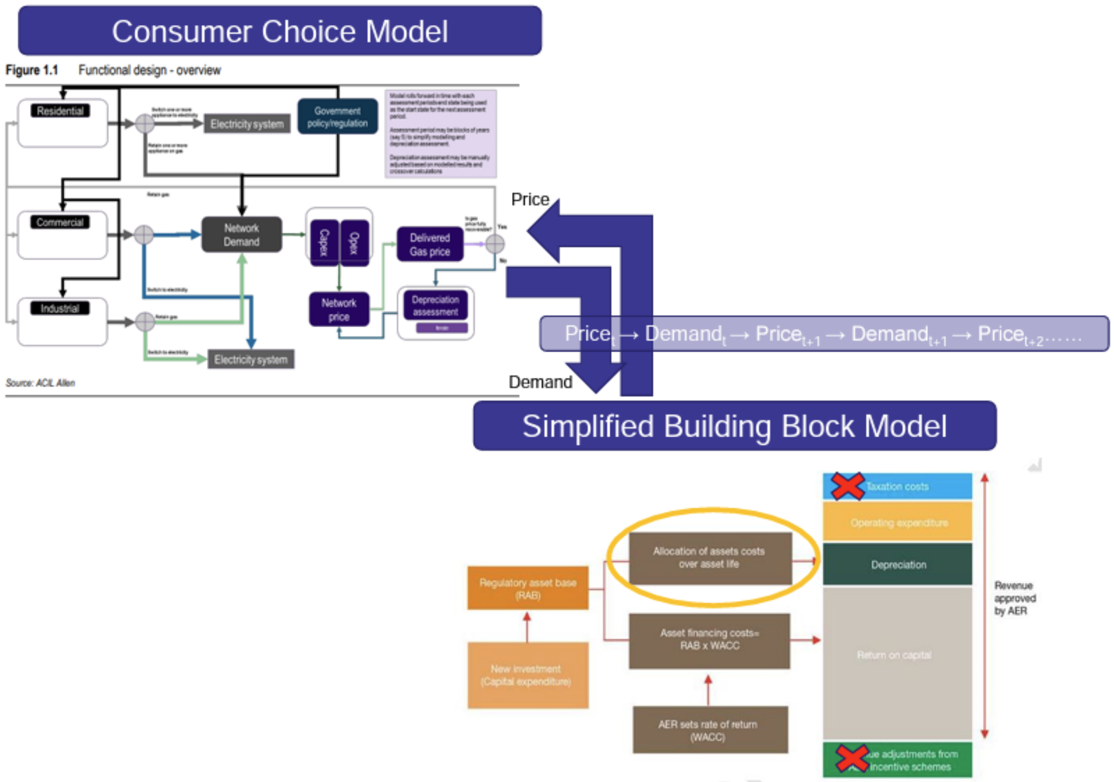
- A Consumer Choice model designed by consultancy Acil Allen, which aims to forecast customer gas consumption, disconnections and connections to the gas network given price inputs and other scenario assumptions, and;
- A Simplified Building Block model designed by the networks themselves, that forecasts gas distribution prices given network volumes and customer forecasts, and other key revenue inputs. This shares similarities with the AER's Post-Tax Revenue Model (PTRM), except that:
    - It works entirely in real terms;
    - It includes greater flexibility to test different accelerated depreciation proposals, and;
    - It is a longer-term forecast.

Documentation for the Acil Allen Consumer Choice model is publicly available on the AER consultation pages for the Victorian networks' 2023-28 Access Arrangements.[10]

Figure 8 shows the default interaction of the two models.

[10] The same report is accessible via Multinet, AGN or AusNet's consultation documentation. (Acil Allen, June 2022)

Figure 8: Default interactions between the Consumer Choice and Simplified Building Block models



Source: AGIG

The original context for these models was to test the networks' proposals for accelerated depreciation under a set of varying scenarios. These scenarios were developed under the Future of Gas initiative that was convened by the three Victorian gas distribution networks during their 2023-28 Access Arrangement proposals.[11]

[11] For more details see KPMG. Future of Gas: What are the plausible scenarios for Victoria's 2030-2050 energy system and what role does gas play in each? October 2021.

IEEFA methodology

The Consumer Choice and Simplified Building Block models were chosen to model impacts of electrification forecasts on gas distribution networks and prices. Using these models was advantageous for the following reasons:

- Unlike the Post-Tax Revenue Models, they are designed to produce long-term forecasts, and;
- They are credible for the purpose of forecasting distribution network revenue, as they were designed by the distribution networks themselves to support their proposals for up to $461 million in accelerated depreciation.

However, several modifications were needed to adapt these models for the context used in this report.

A customised interface for inputs/outputs was developed

This interface included controls to:

- Override the Consumer Choice model's residential gas volume and connection decision making, and replace this with exogenous trajectories;
- Align the accelerated depreciation setting in the models to the AER's final accelerated depreciation setting;
- Disable the model's in-built thresholds that were used to determine whether the network shuts down:
    - For example, two of the models included an assumption that the network would fully shut down if the distribution price rose at least 70% above current levels.
- Cap the maximum allowable real price increase per year.
    - This was used to generate a comparison price and revenue path, to look at the impacts of price caps on future revenue;
- Calibrate the 2023-28 outcomes to parameters that are assumed to be "locked in" by the AER's final decision, including price caps, and;
- Limit the amount of new capital and operating expenditure assumed by the model.

An exogenous gas volume trajectory was introduced

The Forecasts worksheet in the Consumer Choice model was updated to draw on an exogenous trajectory for gas volumes, rather than relying on the in-built decision making.

In the same worksheet, the residential connections forecast was overridden to draw on an exogenous connections trajectory.

The main trajectories in this modelling exercise were drawn from the modelled phase-out of gas appliances described in Appendix A.

Accelerated depreciation settings were aligned to the final AER decisions

The last public version of the Consumer Choice and Building Blocks models was uploaded alongside networks' initial proposals. However, the final proposed level of accelerated depreciation was altered in the AER's draft and final decisions (to $53 million for Multinet,[12] $175 million for AGN[13] and $105 million for AusNet[14]).

The main mechanism for controlling accelerated depreciation in the Simplified Building Blocks model is via a "tilt factor" that alters depreciation as a function over time. The Goal Seek function in Microsoft Excel was used to solve for the "tilt factor" that aligned the model's accelerated depreciation amount over the 2023-28 Access Arrangement period to the amount approved in the AER's final decision.

Other settings were calibrated to the final AER decisions

Several key inputs in the Simplified Building Blocks models were updated, following revisions to the network's final plans and the AER's final decision. This impacted:

- Opening RAB
- Capital expenditure (capex) and depreciation forecasts
- Operational expenditure (opex) forecasts
- Proposed tariffs for the coming access arrangement period
- Forecast volumes/customers by tariff for the next access arrangement period
- Pre-tax real weighted average cost of capital (WACC)

An additional line item was added to the calculation of building block revenue to hold revenue adjustments over the 2023-28 Access Arrangement period. These were not included in the networks' original models as they are not relevant to the accelerated depreciation analysis. However, they were added here to verify the calibration of the model, and they do impact network prices over the coming access arrangement period.

All of the above inputs were drawn from the final Post-Tax Revenue Models (PTRMs) published by the AER for the 2023-28 Access Arrangement period.[15]

[12] AER. Final decision: Multinet Gas Networks Gas distribution access arrangement 2023 to 2028. Attachment 4 – Regulatory depreciation. Page 4.
[13] AER. Final decision: Australian Gas Networks (Victoria & Albury) Gas distribution access arrangement 2023 to 2028. Attachment 4 – Regulatory depreciation. Page 4.
[14] AER. Final decision: AusNet Gas Services Gas distribution access arrangement 2023 to 2028. Attachment 4 – Regulatory depreciation. Page 4.
[15] AER. Final Decision – PTRM for Multinet, AGN and AusNet. June 2023.

The calibration was verified across the 2023-28 access arrangement period

As a calibration check, the models were tested to ensure that they replicated full cost recovery over the 2023-28 access arrangement period, if the volume forecast aligned to the AER's final decision.

The accuracy of the models can be tested by confirming how accurately they forecast the required and actual revenue from the AER's final decision forecasts. An average annual error for these parameters across all networks was minimised to less than 2.2% (Table 5).

Table 5: Average annual error between modelled results and approved AER Final Decision results

Parameter	Multinet	AGN	AusNet
Building blocks (required) revenue	1.03%	1.36%	2.20%
Actual revenue	0.02%	0.01%	1.51%

New capital expenditure was limited

The original Simplified Building Block model featured several scenarios for capital expenditure. Capital expenditure assumptions materially impact the final results, as a high capex spend will increase the networks' RAB, hence requiring more depreciation to be recovered in the long term.

We have assumed that as there is no growth in residential connections under the scenario modelled in this report, there would be no further capital expenditure associated with extending the network.

Other capex requirements are uncertain. For example, several networks have engaged in mains replacement works to upgrade their pipelines.[16] Other upgrades or capital works could be needed in future if, for example, safety hazards were identified on the network.

Networks also have non-pipeline assets, for example buildings, which may need works or replacement over time.[17]

To avoid the risk of overestimating each networks' required costs due to overestimating their necessary future capex, we assumed that no future capex would occur after 2025. This includes capex forecast after 2025 under the networks' Access Arrangements. This introduces an inherent conservativeness to the analysis.

[16] Australian Gas Networks. Gas mains renewal program.
[17] As reported in AER. Final Decision – PTRM for Multinet, AGN and AusNet.

New operating expenditure was limited

Similarly, the model featured several scenarios to adjust operating expenditure. These were removed for this exercise. The final operating expenditure is expressed as a function of the growth in network connections.

We have assumed the same relationship exists with operating expenditure and a decline in network connections. This results in operating expenditure declining in parallel with, but at a slower rate than, the number of connections.

This is a conservative assumption given the complex relationship between operating expenditure and network connections. If households leave the network one street at a time, sections of the network serving those streets could be decommissioned, avoiding future operating expenditure. However, if households disconnect in a random spatial pattern, it may not immediately translate to a reduction in network length and therefore operating expenditure.

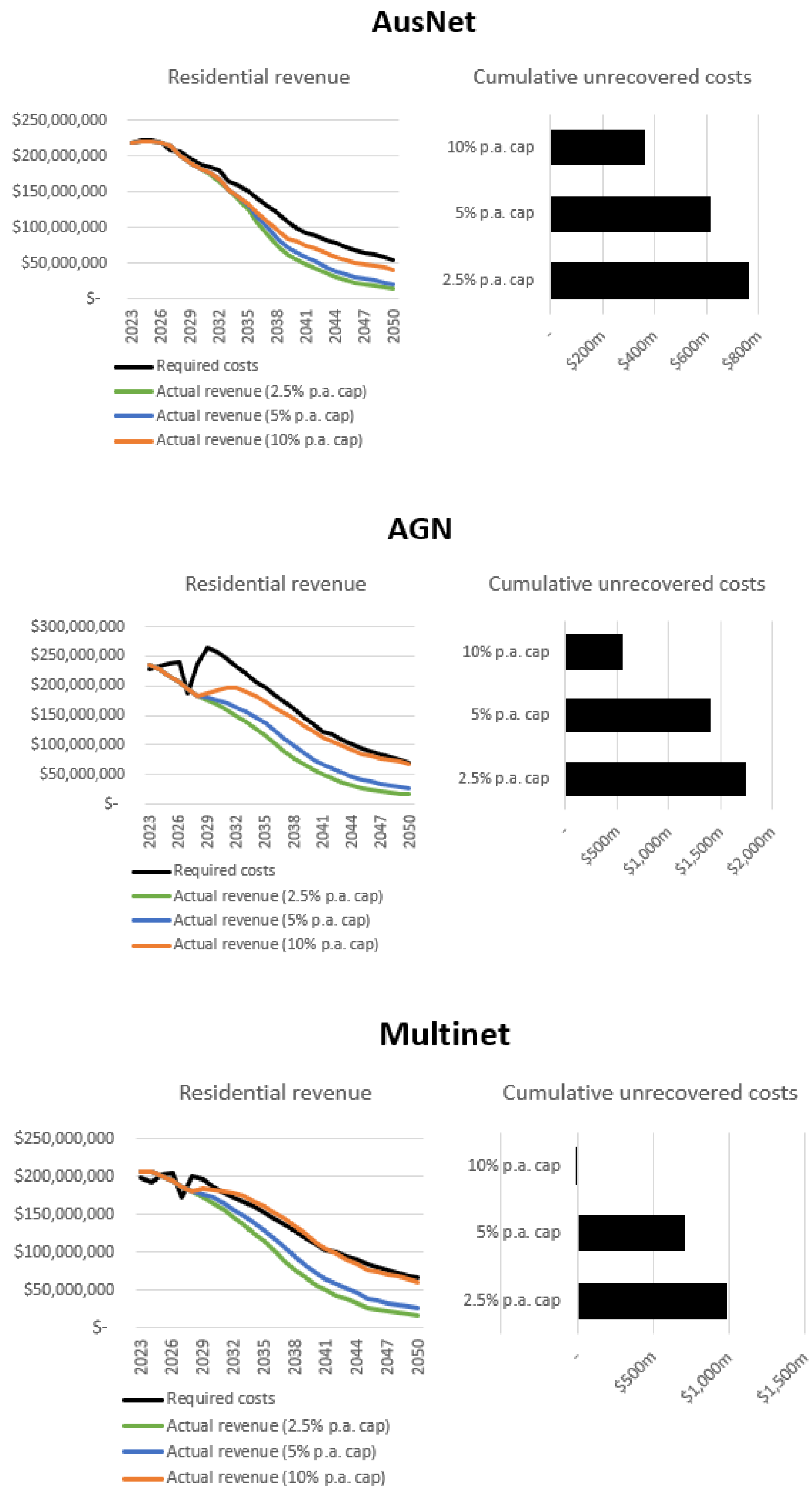
Key results

Each distribution network was modelled separately, and key results are shown for each below. These results reflect the modelling assumptions discussed above, including a gas volume and connections trajectory that assumes end-of-life retirement of gas appliances.

Residential revenue and costs

Figure 9 shows required residential costs across the networks, compared with the actual costs that can be recovered from residential customers under the scenario modelled here, subject to a cap on real price increases of 2.5%, 5% or 10% a year. Cumulative unrecovered costs for each price cap from 2023-2050 are shown on the right.

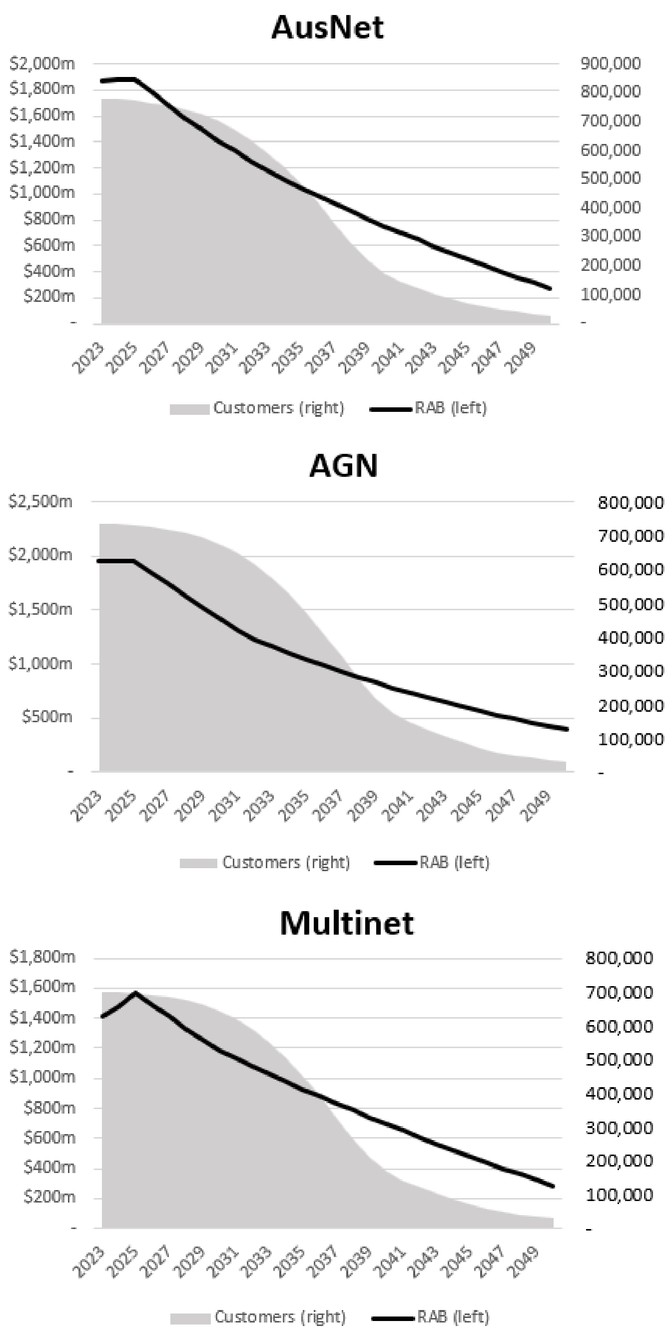
Figure 9: Required residential costs vs actual revenue and cumulative unrecovered costs for each network



Regulated asset base

Figure 10 shows the modelled underlying regulated asset base for each network over time, compared to the input customer connections trajectory. It shows the main driver of price rises and unrecovered costs, which is that the RAB declines at a slower rate than the customer base.

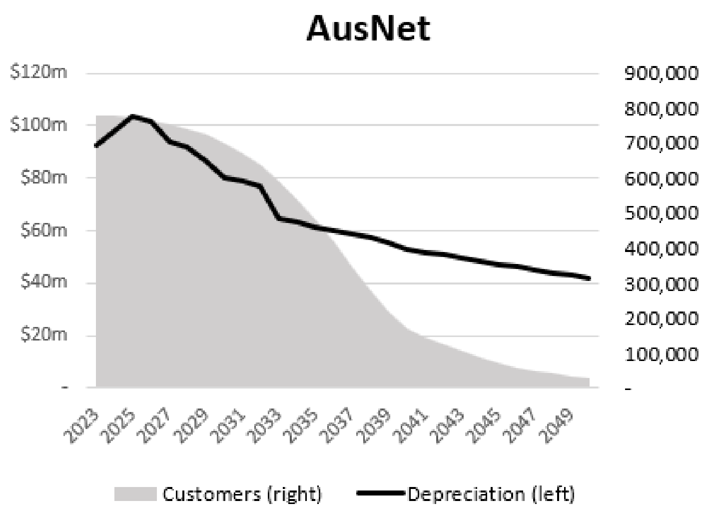
Figure 10: Regulated asset base compared with customer numbers for each network

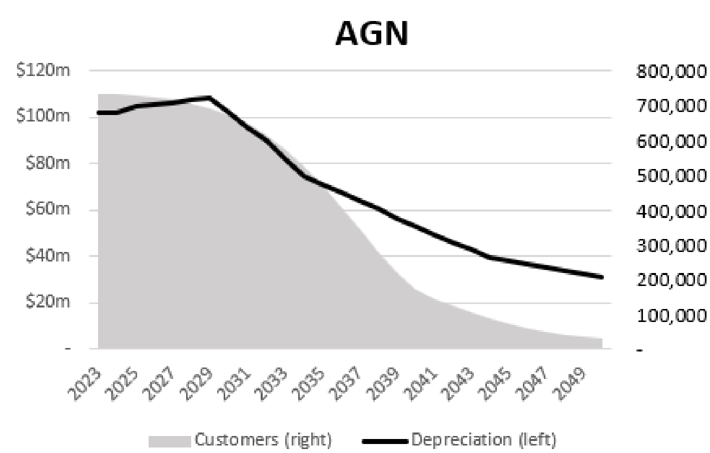


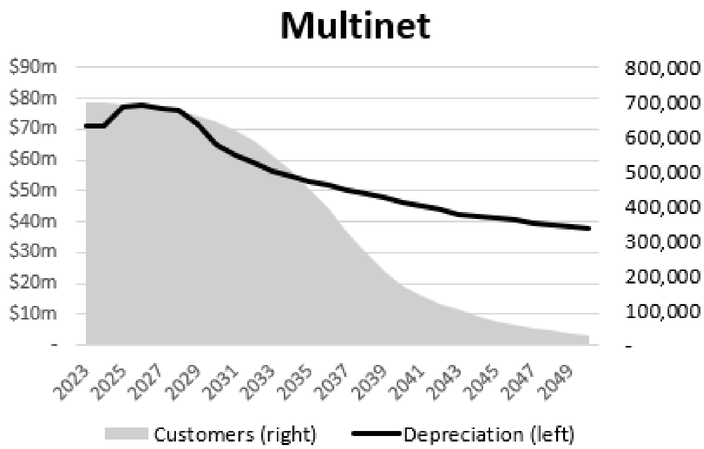
Regulatory depreciation

Figure 11 shows the modelled annual depreciation for each network, compared with the input customer connections trajectory. Several step changes are visible as assets reach their end of life, and accelerated depreciation assumptions influence short-term depreciation being higher. A long tail exists reflecting very long-lived assets that are far from their end of life. Depreciation and number of customers are not related here, as no further capex has been assumed.

Figure 11: Annual depreciation compared with number of customers for each network







Appendix C: Modelling the household economics of electrification

To understand the economic costs and benefits of electrification at a household level, IEEFA has constructed a household economic model, based on a representative Victorian home.

Methodology

Energy prices

Electricity and gas retail prices were collected from energy fact sheets on retailers' websites in July and August 2023, based on their most competitive market offer available to the public.

Offers were collected from AGL, Origin Energy and EnergyAustralia, representing the three major retailers for both gas and electricity.

Further offers were collected from lowest-cost retailers for each distribution network identified via the Victorian government's EnergyCompare website. These were GloBird, CovaU and Sumo for gas, and OVO Energy, GloBird, 1st Energy and Energy Locals for electricity.

Flat rate plans were collected for electricity, as most Victorians use these rather than time-of-use tariffs.[18]

Gas tariff structures are complex, containing multiple blocks that decrease in price with higher volumes of gas delivered. Rates can also vary seasonally, with the exact tariff design varying significantly across networks and retailers.

[18] ACCC. Inquiry into the National Electricity Market. Page 63. May 2022.

Gas tariffs were therefore simplified into a single fixed charge (cents/day) and average volumetric charge (c/MJ), based on the average volumetric cost that would apply to a household consuming 69.22 GJ/year fossil gas under any given tariff structure. This figure is based on the total residential gas consumption in Victoria reported in the Residential Baseline Study for 2021,[19] divided by total private occupied dwellings in Victoria in 2021.[20]

Gas and electricity prices were grouped into three settings, where High was the average of the major retailers, Low was the average of low-cost retailers, and Medium was the average of High and Low. Medium prices were used throughout this report unless otherwise noted.

Prices were also recorded separately for each distribution network (gas and electricity), with a weighted average used in the model.

Fixed price trajectories were used, due to inherent uncertainties in forecasting long-term gas and electricity price changes.

Alternatively, a modelled price trajectory was available in the model based on modelling described in Appendix B. Switching to this trajectory allowed for analysis of the impacts of changes in gas tariffs on the household economics of electrification.

Appliance configuration

The modelling is based on one representative household, and assumes the configuration of appliances in Table 6

Table 6.

Table 6: Configuration of appliances assumed for the representative household

	Before appliance replacement	After replacement with electric appliances	After replacement with new gas appliances
Space heating	Gas ducted heating system	1x 7-8 kW reverse-cycle air conditioner 2x 3-4 kW reverse-cycle air conditioners	Gas ducted heating system (5+ star furnace)
Hot water	Gas storage water heater	Heat pump water heater	Gas continuous flow water heater
Cooking	Gas cooktop	Electric induction cooktop	Gas cooktop

This is broadly based on an average family home, where a ducted heating system is replaceable with one large-capacity reverse cycle air conditioner in the main living space, and two smaller units in

[19] EnergyConsult. 2021 Residential Baseline Study for Australia and New Zealand for 2000 – 2040. November 2022.
[20] ABS. 3.6 Dwellings – Report on the quality of 2021 Census data. June 2022. Tables 3.6.1 and 3.6.2.

bedrooms or an office. It is comparable to assumptions used in similar studies by Renew[21] and Grattan Institute.[22]

Gas ducted heating systems were chosen as the target for space heating replacement as these consume the most residential gas by far of any appliance group in Victoria.[23]

In theory, a gas ducted heating system could be replaced with a ducted reverse-cycle system. However, due to higher appliance costs and in some cases the need to upgrade electricity connections to support a ducted system, it is often more cost effective to install multiple individual in-room units even for large homes.[24] This avoids losses from the ducting, and allows greater control over heating or cooling individual spaces.

The optimal appliance configuration will of course vary by home. Households with three bedrooms in use may wish to add an additional 3-4 kW system. Many Victorian homes have a single gas heater in the main living space rather than a ducted system. This could be replaced directly with a reverse-cycle air conditioner, and homes may optionally consider adding more units to rooms that previously were not heated.

Heat pump systems were chosen as the replacement appliance for hot water, as they are significantly more efficient than conventional electric resistive systems. Another viable option for some households may be solar hot water, which can be boosted with electricity. However, there are trade-offs to consider such as sacrificing roof space that could host solar panels.

Induction cooktops were chosen as the replacement appliance for gas cooktops, as they are generally considered superior to ceramic electric cooktops and provide many of the benefits that users associate with gas cooktops, such as immediate temperature control.[25]

The replacement appliance configuration assumes the same amount of useful energy is delivered as under the dual fuel home. That is, the difference in energy consumption is based only on relative appliance efficiencies, with no reduction in the underlying end-use service demand.

Appliance costs

Most appliance costs were based on average retail prices found from major Australian retailer websites such as Bunnings or Appliances Online.

Appliance samples were restricted to reasonably equivalent groups of appliances where possible. For example, cooktops greater than 60cm or more than four burners were excluded.

[21] ATA (Renew). Household fuel choice in the National Energy Market. Page 15. July 2018.
[22] Grattan Institute. Getting off gas: Why, how, and who should pay? Page 21. June 2023.
[23] EnergyConsult. 2021 Residential Baseline Study for Australia and New Zealand for 2000 – 2040. November 2022.
[24] GHD. All-Electric New Homes Cost Assessment – Department of Environment, Land, Water and Planning. Page 6. April 2022.
[25] EnergyAustralia. Is an induction cooktop right for you?

Installation costs were also assumed for each appliance, based on online quotes or from similar modelling studies including by GHD.[26]

Appliance and installation costs for relevant appliances are listed in Table 7.

Table 7: Assumed appliance and installation costs

Appliance	Purchase cost (2023)	Installation cost
Reverse-cycle air conditioner (3-4kW)	$1,054	$720
Reverse-cycle air conditioner (7-8kW)	$1,775	$720
Heat pump hot water system (160-250L)	$2,582	$1,000
Electric induction cooktop (<60cm)	$589	$900
Gas ducted heating system (20-30kW; 5+ stars)	$3,273	$2,790
Gas continuous flow hot water system (20-26L/min; 6+ stars)	$1,398	$555
Gas cooktop (> 60cm)	$475	$500

Note: Costs for gas appliances are used in determining the marginal end-of-life replacement cost difference of electric appliances.

For some appliances, the literature was reviewed to assess whether future cost reductions are likely, and an appropriate learning rate curve was applied.

This only led to material impacts for heat pump hot water systems, where a 4.5% real cost decrease is assumed to occur from 2023-25.[27]

Appliance rebates

The household economic model can be run with or without the impacts of government rebates. Two rebate schemes were considered:

1. The Small-scale Renewable Energy Scheme (SRES), which provides rebates via Small-scale Technology Certificates (STCs) for installing heat pump hot water systems. Hot water electrification was assumed to be eligible for 18 STCs.[28]
2. The Victorian Energy Upgrades (VEU) program, which provides rebates via Victorian Energy Efficiency Certificates (VEECs) for a range of different household energy upgrades. In July 2023, the VEU program was updated to include more rebates for electrification activities. We have assumed:
    a. Replacing a gas ducted heating system with a 7-8kW reverse-cycle air conditioner is eligible for 30 VEECs.[29]

[26] GHD. All-Electric New Homes Cost Assessment – Department of Environment, Land, Water and Planning. April 2022.
[27] National Renewable Energy Laboratory. Electrification futures study: End-Use Electric Technology Cost and Performance Projections through 2050. Page 44. 2017.
[28] Based on the Clean Energy Regulator's Solar water heater STC calculator, for a Stiebel Eltron WWK222H system installed in 2025.
[29] Essential Services Commission. VEEC Calculator. Based on Panasonic CS/CU-RZ71XKR 7.1kW system under Activity 6(vii) Replacing gas ducted heater only.

b. Installing an additional two 3-4kW reverse-cycle air conditioners is eligible for four VEECs.[30]
c. Replacing a gas storage hot water system with a heat pump hot water system is eligible for an average 6.7 VEECs.[31]

The value of STCs and VEECs was assumed to be $39.90/certificate and $74/certificate respectively.[32]

Appliance efficiencies

The relative efficiency of gas and electric appliances was used to determine the difference in energy consumption for a household before and after electrification.

For reverse-cycle air conditioners and heat-pump hot water systems, the coefficient of performance was recorded for the same sample data used to determine average appliance costs, and an average value was taken.

For gas ducted heating systems, an efficiency was calculated based on average values from Beyond Zero Emissions for existing systems (0.7),[33] and a maximum efficiency of five-star condensing heater for new systems (0.95)[34] combined with an assumed efficiency of the ducting (0.63, where most losses occur).[35]

For other appliances, efficiencies were taken from Renew.[36]

Final appliance efficiencies or coefficients of performance are shown in **Table 8Table 8**.

Table 8: Assumed appliance efficiencies and coefficients of performance

Appliance	Efficiency	Coefficient of performance
Reverse-cycle air conditioner (3-4kW)	-	4.1
Reverse-cycle air conditioner (7-8kW)	-	3.64
Heat pump hot water system (160-250L)	-	4.17
Electric induction cooktop (< 60cm)	0.8	-
Gas ducted heating system (average existing system)	0.44	-
Gas ducted heating system (20-30kW; 5+ stars)	0.59	-
Gas storage hot water system (average existing system)	0.7	-
Gas continuous flow hot water system	0.86	-

[30] Ibid. Based on Panasonic CS/CU-HZ35YKR 3.5 kW systems under Activity 6(xi) No decommissioning.
[31] Ibid. Average of a sample of heat pump hot water systems under Activity 3C – Water heating – Heat pump replacing gas.
[32] Green Energy Markets. Spot Market Prices. Accessed September 2023.
[33] Beyond Zero Emissions. Zero Carbon Australia Buildings Plan. Appendix 9: Supporting information on Sankey diagram for residential HVAC. 2013.
[34] EnergyConsult. Product Profile: Gas Ducted Heaters. Page 5. January 2011.
[35] Beyond Zero Emissions. Zero Carbon Australia Buildings Plan. Appendix 9: Supporting information on Sankey diagram for residential HVAC. 2013.
[36] ATA (Renew). Household fuel choice in the National Energy Market. July 2018.

(20-26L/min; 6+ stars)		
Gas cooktop (> 60cm)	0.4	-

Annual energy consumption

The annual energy consumption for existing gas ducted heating systems and gas storage hot water systems was estimated from Victorian data in the Residential Baseline Study to be 55.9GJ and 12.1GJ respectively. Gas cooktop appliance stocks aren't provided by the study, so the annual energy consumption for gas cooktops was assumed to be 1.2GJ based on Renew.[37]

Treatment of fixed charges

A $220 one-off abolishment fee is assumed to apply in scenarios where households are fully electrifying. This is the reference tariff set by the AER for this service in Victoria.[38]

The annual fixed charge for a retail gas bill is assumed to be avoided in scenarios where households are fully electrifying.

Investment parameters

A discount rate of 5.9% is assumed based on average variable home loan rates as at March 2023.[39]

Amortised savings were calculated and expressed over a 10-year period.

In most cases, appliance investments were assumed to occur in 2025. However, this year can be changed for specific scenarios.

Modelling

The household economic model works by considering different combinations of cost building blocks, based on the scenario being explored.

Building blocks include avoided gas consumption (and associated savings), added electricity consumption (and associated costs), any avoided fixed charges, any added fixed charges, capital costs of new appliances and applicable rebates.

An interface was developed to construct scenarios based on combinations of the following settings:

- Whether the replacement is end of life or premature, which controls whether costs are presented as the difference between gas and electric appliances, or only the cost of electric appliances.

[37] Ibid. Page 50.
[38] AER. AER decision supports Victorian gas consumers in energy transition. June 2023.
[39] Canstar. What are the average interest rates on home loans? Accessed March 2023.

- Whether to assume future cost reductions in electric appliances (which mainly impacts heat pump hot water systems).
- Whether to include savings from avoiding gas fixed charges.
- Whether to include gas connection abolishment fees.
- Whether to include rebates.
- Which end-uses to electrify (space heating, water heating and/or cooking).
- The cost of electricity (Low – High).
- The cost of gas (Low – High).
- The capital cost of appliances (Low – High).

Results are reported as annual bill savings, total upfront costs, payback periods, and net monthly savings if annualised over 10 years.

Key results

Key results for several scenarios featured in this report are listed in Table 9.

In these scenarios, we have assumed that the connection abolishment fee and avoided gas fixed charge applies if all three appliances are electrified. Bill savings were found to be higher for premature replacement scenarios, as these cases are compared against existing gas appliances, which are typically less efficient and more expensive to run than new gas appliances.

Table 9: Key household economic results for various modelled scenarios

Replacement timing	Rebates included	End-uses			Annual bill savings	Total upfront cost	Payback period	Net monthly savings
		Space heating	*Water heating*	*Cooking*				
End of life	✓	✓	-	-	$710.47	-$2,537.45	0	$87.28
	✓	✓	✓		$852.84	-$2,238.07	0	$95.83
	✓	✓	✓	✓	$1,205.83	-$1,525.33	0	$117.36
	-	✓	-	-	$710.47	-$21.45	0	$59.44
	-	✓	✓	-	$852.84	$1,489.47	2	$54.59
	-	✓	✓	✓	$1,205.83	$2,202.20	2	$76.13
Premature	✓	✓	-	-	$1,133.89	$3,526.03	4	$55.49
	✓	✓	✓	-	$1,345.99	$5,778.86	6	$48.24
	✓	✓	✓	✓	$1,698.97	$7,466.14	6	$58.99
	-	✓	-	-	$1,133.89	$6,042.03	7	$27.65
	-	✓	✓	-	$1,345.99	$9,506.40	10	$7.01
	-	✓	✓	✓	$1,698.97	$11,193.67	9	$17.76

Note: Negative upfront costs are savings. Rebates refer to VEECs and STCs where eligible. Net monthly savings calculated based on annualised costs over a 10-year period at an interest rate of 5.9%.

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