frontier economics

Cost of switching from gas to electric appliances in the home

A report for the Gas Appliance Manufacturer's Association of Australia | 24 June 2022

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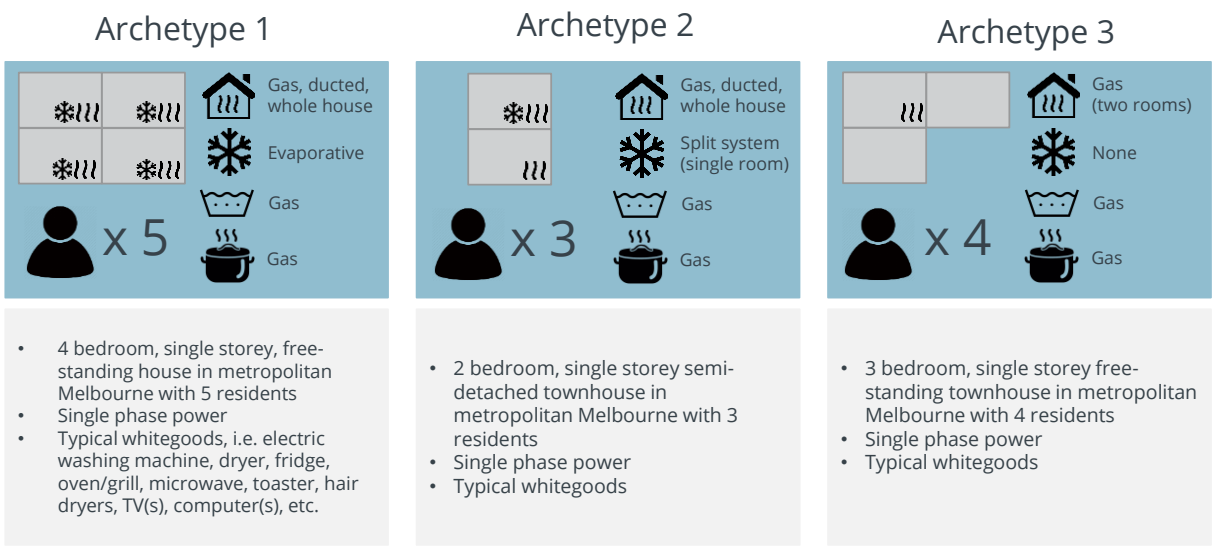
There is an information gap in electrification studies on the full cost to consumers of switching from gas to electric appliances. In the Australian context, previous studies on the cost of electrification to consumers

- only consider the cost to new builds, not considering the cost of retrofitting electrical appliances in a previously dual fuel (gas and electric) home and different electrical requirements of different appliances, and/or
- only consider the appliance and (limited) installation cost components of replacing gas appliances with electrical appliances, ignoring the cost of removing and rectifying existing installations and any requisite power supply upgrades.

These costs not considered in previous studies are significant. This report estimates a more complete picture of upfront costs that Victorian consumers would face if switching from dual fuel to electricity-only arrangements, compared to remaining on gas. We categorise these costs as follows:

- The cost of removing existing appliances, including any rectification work that might be required.
- The cost of purchasing new appliances, with a 30% uplift applied to estimate 'hydrogen compatible' gas appliance costs.
- The cost of installing new appliances, including labour and materials.
- The cost of electricity supply upgrades, if this is required as a result of the new electrical appliances.

This study uses cost estimates provided by electric and gas appliance installers to calculate a range of upfront costs for three household archetypes in Victoria as follows:



- 4 bedroom, single storey, free-standing house in metropolitan Melbourne with 5 residents
- Single phase power
- Typical whitegoods, i.e. electric washing machine, dryer, fridge, oven/grill, microwave, toaster, hair dryers, TV(s), computer(s), etc.

- 2 bedroom, single storey semi-detached townhouse in metropolitan Melbourne with 3 residents
- Single phase power
- Typical whitegoods

- 3 bedroom, single storey free-standing townhouse in metropolitan Melbourne with 4 residents
- Single phase power
- Typical whitegoods

We asked installers to estimate high, typical and low costs for the categories and archetypes above for an all-gas appliance option and for three different all-electric options, including the following.

- **Option 1:** Heat pump split systems capable of heating and cooling the whole house (either multiple single splits or one multi-split unit)
- **Option 2:** A heat pump split system capable of heating and cooling a living area and master bedroom (either multiple single splits or one multi-split unit)
- **Option 3:** Ducted heat pump capable of heating and cooling the whole house.

We used the installers' responses to estimate indicative upfront costs for fuel-switching in Victoria based on the existing housing stock and appliance mix. The findings of this analysis suggest that the additional upfront cost to Victorian consumers of replacing their existing gas appliances with electric appliances, compared to replacing them with new gas appliances capable of burning hydrogen gas, varies significantly based on the level of amenity required. If all Victorian homes were to only attempt to heat and cool two major rooms of their home (Option 2), upfront costs of electrification of households could be as low as $4 billion. If, however, whole of home heating and cooling is required (Options 1 and 3), the cost is likely to increase to a figure in the region of $14 to $31 billion.

1 Introduction

1.1 Background

Many households in Victoria rely on natural gas to meet their energy needs, primarily by using gas space heating, gas water heating and gas cooking appliances.

Household use of natural gas contributes around 7% of Victoria's carbon dioxide equivalent emissions. The Victorian Government has expressed a desire for a pathway towards net zero emissions for this gas use. The Victorian Government is currently developing a Gas Substitution Roadmap to help "navigate the path to net zero emissions".[1] The consultation paper for the Gas Substitution Roadmap notes that "electrification, hydrogen and biogas will all likely play a role in the decarbonisation of gas".[2]

These options decarbonise natural gas use in different ways:

- Electrification involves replacing natural gas appliances with electric appliances. For instance, gas space heaters can be replaced with electric heat pump space heaters, gas water heaters can be replaced with electric heat pump water heaters, and gas stoves can be replaced with electric induction or resistance stoves. As long as the electricity that is used by households is renewable electricity, this means that households' gas use is decarbonised. Victoria's electricity supply currently relies mainly on carbon-emitting coal-fired generation and some gas-fired generation, but electricity supply is expected to shift towards renewables and storage as part of the path to net zero greenhouse gas emissions by 2050.
- The supply of hydrogen involves replacing the natural gas that is supplied to households through the gas distribution network with hydrogen gas supplied through the same distribution network. This would require some changes to the gas distribution network and would require households to have gas appliances – space heaters, water heaters and cookers – that can operate on hydrogen. As long as the hydrogen that is supplied to consumers is renewable hydrogen – for instance, hydrogen produced from electrolysers that are powered by renewable electricity – this means that households' gas use is decarbonised.
- The supply of biogas involves replacing natural gas that is supplied to households through the gas distribution network with biogas supplied through the same distribution network. Biogas is created through the anaerobic digestion of organic material. It is a renewable energy source. Biogas can be upgraded to biomethane, which is chemically identical to methane (which is the primary component of natural gas). Biomethane can be blended with natural gas and can be supplied through the existing distribution network without requiring any changes to the network, and can be used in existing natural gas appliances without any modification.

To date there have been a number of studies that have compared the total costs to society of these different pathways to decarbonising natural gas use. However, these studies have tended to focus on the upstream costs – the costs associated with electricity generation and supply, hydrogen production and supply, and/or biomethane production and supply – and have not dealt

[1] Victoria State Government, Gas Substitution Roadmap, Consultation Paper, 2021, page 4.

[2] Victoria State Government, Gas Substitution Roadmap, Consultation Paper, 2021, page 6.

in detail with the upfront costs to households. These upfront costs to households could include the costs of different appliances, the costs of additional wiring within the house, the costs of upgrading power supply to the house and the cost of decommissioning existing appliances and gas supply.

Similarly, there have been a number of studies that have compared changes in energy costs that households would face under these different pathways to decarbonising natural gas use. But these studies have also tended to focus just on bills, either without considering, or considering in a limited capacity, the upfront costs to households. In the Australian context these studies either:

- Only consider the cost to new builds, not considering the cost of retrofitting electrical appliances in a previously dual fuel (gas and electric) home and different electrical requirements of different appliances. For example, a Grattan Institute report on the future of gas only considers new builds, noting that costs for existing dual-fuel homes "include the cost of replacing functioning gas appliances, additional plumbing and rewiring costs (including, in some cases, the need to upgrade the house's electrical connection), and the cost of safely disconnecting from the gas network."[3]
- Only consider the appliance and (limited) installation cost components of replacing gas appliances with electrical appliances, ignoring the cost of removing and rectifying existing installations and any requisite power supply upgrades. For example, an Alternative Technology Association report on household fuel choice from 2018[4] makes no allowance for removal and rectification or power supply upgrades.

However, these costs not accounted for can be significant. The Western Australian government has recently committed $10.5 million to transition 379 customers from reticulated gas to electricity or bottled gas.[5] This cost includes financial assistance to customers for removal of existing appliances and installation of new appliances, including electrical works required for an all-electric solution. This implies a transition cost of at least $27,704 per customer[6], which is considerably more than just the appliance costs, as indicated by the provided appliance cost caps.[7]

There is an information gap in electrification studies about the 'complete' cost to consumers of switching from gas to electric appliances. We consider that this is likely the case because:

- Obtaining estimates of appliance costs is relatively easy with prices widely available online.
- There is limited information on installation costs. Quotes and estimates are available online, although with little information on what specific work would be undertaken.
- Removal and rectification costs and power supply upgrades are considerably more variable and depend on specific consumer circumstances, as such they are therefore not generally available online.

3 See https://grattan.edu.au/wp-content/uploads/2020/11/Flame-out-Grattan-report.pdf

4 See https://renew.org.au/wp-content/uploads/2018/08/Household_fuel_choice_in_the_NEM_Revised_June_2018.pdf

5 See https://www.mediastatements.wa.gov.au/Pages/McGowan/2022/04/Esperance-energy-transition-plan-secured-with-10-5-million-dollars.aspx, accessed 29 April 2022

6 This includes a mix of residential and business customers – the media statement above references 258 private residential and 41 private business customers

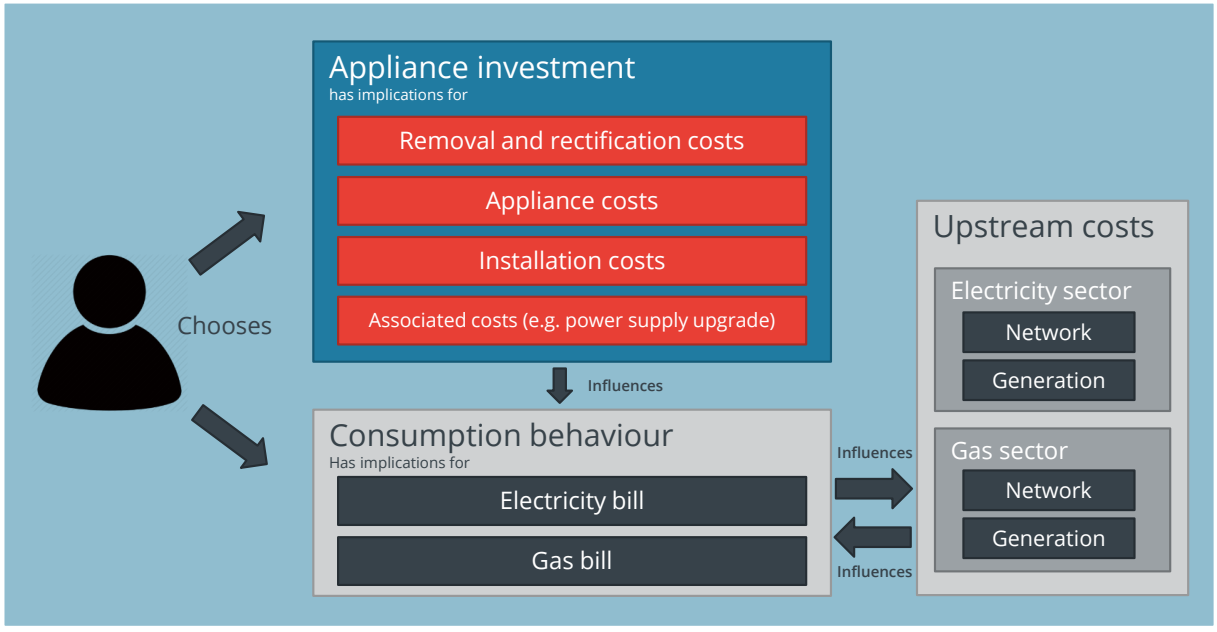
7 See https://www.horizonpower.com.au/energypackage, in particular the "Appliance supply cost caps" tab. Accessed 29 April 2022

1.2 This study

Frontier Economics has been engaged by the Gas Appliance Manufacturers Association of Australia (GAMAA) to estimate the upfront costs that Victorian consumers will face under different pathways to decarbonising natural gas use. In particular, we are interested in comparing the upfront costs that households currently using gas will face if they electrify their energy use compared with the upfront costs these households will face if they continue to use gas appliances.

We note that the upfront cost to households is not the only cost or benefit to households that is associated with decarbonisation. This is illustrated in **Figure 1**, showing that energy bills and indirect costs related to upstream supply sectors are also important cost/benefit categories to consider in the decarbonisation equation as a whole. The scope of this report is the appliance investment choice faced by the consumers in this figure, although we do put this in perspective of energy bills in our results in Section 3.2.

Figure 1: Context for this study



Source: Frontier Economics

Specifically, upfront costs that we consider in this study are:

- The cost of removing existing appliances, including any rectification work that might be required. This includes activities such as covering up existing ducts, plastering, and painting.
- The cost of purchasing new appliances. For gas appliances we assumed that newly installed appliances will be hydrogen compatible appliances. We have increased the cost of natural gas appliances by 30% to reflect the potential for additional costs associated with being hydrogen compatible.
- The cost of installing new appliances, including labour and materials.
- The cost of electricity supply upgrade, if this is required as a result of the new electrical appliances. Electricity supply upgrades are required when electrical demand thresholds are met, for example, as a result of installing new heat pump appliances. In Melbourne, a 63A

single phase supply is common[8], meaning potential loads above around 14.5 kW will require a three-phase power upgrade. Older homes are likely to have smaller power supplies (e.g. 32A or 40A) and may also require additional re-wiring for safety and compliance reasons.

This study seeks to estimate these upfront costs for a number of representative household types in Victoria. Once we have estimated upfront costs for these representative household types, we then seek to estimate the total of these upfront costs to all households in Victoria. In our view, the total of these upfront costs should be accounted for in any assessment of the relative costs and benefits of different pathways to decarbonising natural gas use.

This study does not consider costs other than these upfront costs that households will face. That is, this study does not consider the costs associated with electricity generation and supply, hydrogen production and supply, and/or biomethane production and supply. Other existing reports address these upstream costs of production and supply of alternative fuels.[9]

This study also does not consider changes in electricity bills under the different pathways to decarbonising natural gas use.

1.3 Related work

The UK-based Energy and Utilities Alliance published a report in 2021 that looks at the upfront cost of decarbonising heating in homes in the UK, including costs beyond simple appliance and install costs.[10] Due to differences in climate and appliances, the results of the UK study are not directly applicable to Australia. However, the results are noteworthy because they consider upfront costs of different heating options in detail, taking into account installation costs for different housing archetypes. A key finding from the Energy and Utilities Alliance report is that upfront costs of hydrogen-compatible boilers are currently significantly less than heat-pump equivalents.

The installation costs used by the Energy and Utilities Alliance are sourced from a report written by consultant Delta-ee for the UK Department of Business, Energy and Industrial Strategy from 2018.[11] This report provides a detailed breakdown of installation costs for different heating systems, including high, low and central estimates for installations. Delta-ee collected cost data via interviews and data requests with installers. This is a similar approach to that taken in this report.

8 See https://www.kennerelectrics.com.au/residential/supply-upgrades

9 See, for example, Frontier Economics' report for Energy Networks Australia: https://www.energynetworks.com.au/resources/reports/2020-reports-and-publications/the-benefits-of-gas-infrastructure-to-decarbonise-australia-frontier-economics/

10 Available https://eua.org.uk/uploads/61941B07BA17D.pdf

11 Available https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/913508/cost-of-installing-heating-measures-in-domestic-properties.pdf

2 Our approach

Our view is that appliance installers are best placed to estimate the upfront costs that are the focus of this study. For this reason, we developed a data request for appliance installers in Victoria, and we use the responses to that data request to estimate upfront costs. This section provides more detail on this approach.

2.1 Our data request to appliance installers

To ensure consistency in responses from appliance installers, we developed a number of consumer archetypes to form the basis of our questions. The archetypes were designed to avoid ambiguity in the questions presented to installers, as there are a large number of factors that can influence the installation costs of various appliances.

The characteristics that we include in our consumer archetypes were determined by an assessment of key factors that drive costs in replacing appliances. These characteristics include:

- Housing structure type and location (free standing, number of storeys, metro/regional).
- Number of bedrooms and number of residents, determining among other things the likely capacity requirements, number of air/water outlets, and installation effort.
- Existing appliances, including appliances that are not being replaced e.g. fridge, washing machine etc. Additions to a household's existing electrical load may require power supply upgrades, from the street to the meter box and/or from the meter box to the house.
- Whether there is embedded generation or large loads (e.g. pool pumps/heating) on site. This has implications for power supply requirements.

Additional factors that drive costs in replacing appliances can be accounted for in the way appliance installers are asked to provide costs. For example, housing material (e.g. weatherboard vs double brick) is another driver of costs in installs. By asking installers to provide a low, typical and high cost estimate, these additional factors will be taken into account in the estimates provided.

The development of our customer archetypes was guided by the following principles:

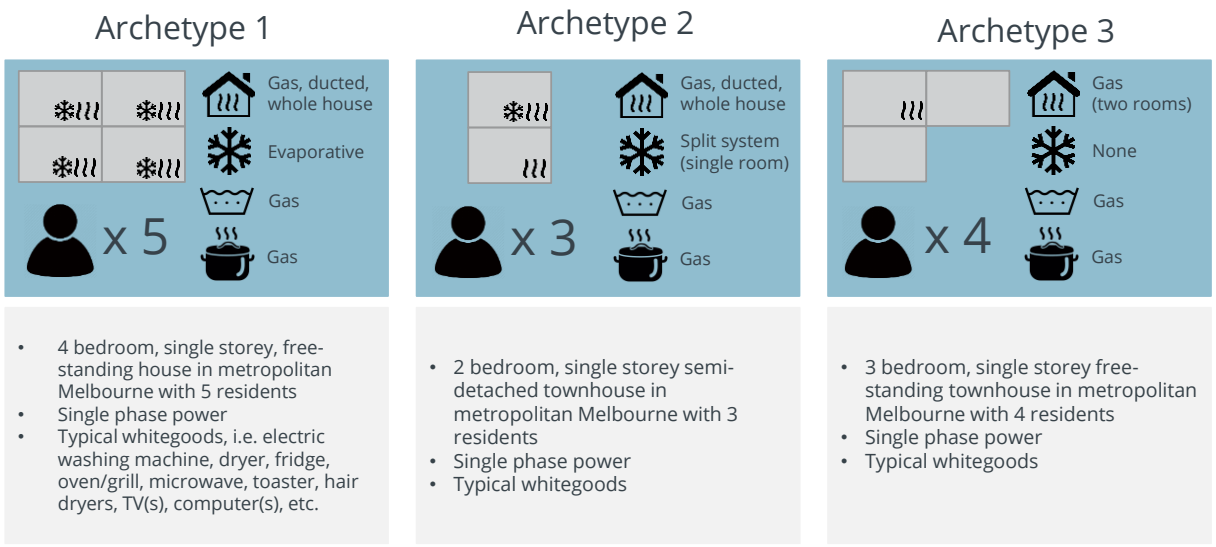
- The archetypes should be as representative as possible of Victorian consumers with gas appliances.
- The archetypes should be as detailed as possible and specific enough for installers to be able to provide accurate ranges of estimated costings.
- The archetypes should have characteristics that help us understand the potential costs of a transition to electrical appliances.
- The number of archetypes should be limited to ensure the task for installers is manageable.

There is an inherent trade-off in applying these principles – the more specific an archetype is, the less representative power it has. The characteristics of our archetypes mean it is not possible for us to ask installers about every combination of housing structure type, number of bedrooms, and existing appliance mix – the number of possible combinations is simply too great. Therefore, we have constructed our archetypes to represent as great a mix of customer characteristics as

possible, while still broadly representing the circumstances of Victorian consumers, and to be of a number that is feasible to survey installers on, without imposing too onerous a task. As a result, our cost estimates cannot be directly extrapolated to provide total costs to Victorians both because our archetypes do not capture all consumer types and the data is not available to precisely determine the number of consumers in Victoria that fall within each of these archetypes. Nevertheless, the data can be used to provide indications of the magnitude of potential costs based on these particular archetypes.

Our archetypes were not designed to represent common residence types, for example a modern free-standing brick house or a 1960s Californian bungalow. They were designed to capture the largest amount of information applicable to Victorians with gas appliances in the limited time installers could make available to respond to our questions. These archetypes are presented in **Figure 2**.

Figure 2: Customer archetypes presented to installers



- 4 bedroom, single storey, free-standing house in metropolitan Melbourne with 5 residents
- Single phase power
- Typical whitegoods, i.e. electric washing machine, dryer, fridge, oven/grill, microwave, toaster, hair dryers, TV(s), computer(s), etc.

- 2 bedroom, single storey semi-detached townhouse in metropolitan Melbourne with 3 residents
- Single phase power
- Typical whitegoods

- 3 bedroom, single storey free-standing townhouse in metropolitan Melbourne with 4 residents
- Single phase power
- Typical whitegoods

In order for our archetypes to be as representative as possible, the key characteristics are informed by data from ABS surveys on housing types and energy use:

- The majority of residences in Victoria (67%) are houses that are 2-4 bedrooms and free standing or semi-detached, with 3 bedroom, free standing being the most common[12].
- Around 83% of residences in Victoria (and 91% of residences in Melbourne) have a mains gas connection[13].

12 ABS 2016 Census, data cube with STRD Dwelling Structure by BEDRD Number of Bedrooms in Private Dwelling (ranges) for Victoria

13 2014 ABS Energy Use and Conservation Survey, Table 1; the balance of the state (excluding Melbourne) is around 62%, and the total state proportion is 83%. While this survey is now 8 years old, performing an updated calculation using customer numbers from Victorian gas network business PTRMs and household projections from Victoria in Future 2019 provides a similar total state proportion of around 79%.

- Around 40% of Victorian homes have ducted gas heating, and 31% have non-ducted gas heating[14].
- In Victoria, around 21.8% of homes have evaporative cooling, 41.5% have reverse-cycle air-conditioning, 11% have a heat pump for cooling only or another form of cooling, and 20.7% have no air-conditioning[15].

For each of our consumer archetypes, our data request asked appliance installers for estimates of the upfront costs that we consider in this study, being:

- The cost of removing existing appliances, including any rectification work that might be required
- The cost of purchasing new appliances
- The cost of installing new appliances
- The cost of electricity supply upgrades, if these are required as a result of the new electrical appliances.

For each of these consumer archetypes we asked appliance installers to estimate upfront costs for a gas appliance option and for an electric appliance option. For the gas appliance option, we asked appliance installers to assume that consumers would replace each of their gas appliances with equivalent new gas appliances, and to estimate the upfront costs of this. For the electric appliance option, we asked appliance installers to describe each of the electric appliances that they would recommend to a consumer looking to switch from gas appliances to electric appliances, and to estimate the upfront costs of this.

With the electric option, we asked installers to provide costs for three alternative heating and cooling options, and whether they thought an electrical supply upgrade was required for each. These heating and cooling options include:

- **Option 1:** Heat pump split systems capable of heating and cooling the whole house (either multiple single splits or one multi-split unit).
- **Option 2:** A heat pump split system capable of heating and cooling a living area and master bedroom (either multiple single splits or one multi-split unit).
- **Option 3:** A ducted heat pump capable of heating and cooling the whole house.

We include three space conditioning options for electric systems because these are all realistic options for electrical heating in Victoria with different cost and amenity trade-offs. We note that the heating component of at least some of these options is not "like for like" compared to our consumer archetypes' existing appliances. For example, replacing a whole-house ducted gas heating system with a split system capable of servicing two rooms (Option 2) will result in reduced amenity due to the reduced space being heated.

Additionally, we asked appliance installers to estimate typical costs as well as low cost estimates and high cost estimates. We asked appliance installers to estimate 'normal' low costs and high costs, rather than extreme low costs and high costs. That is, we asked appliance installers to estimate low costs and high costs that they would reasonably expect to encounter in their area of

14 2008 ABS Energy Use and Conservation Survey Table 4.8; the questions between the 2008 and 2014 surveys were changed, and the question about heating type was removed in the 2014 survey.

15 2014 ABS Energy Use and Conservation Survey, Table 5

operation, for example several times a year. We asked installers to provide final costs excluding GST to ensure estimates were provided on a consistent basis. All of the cost estimates in this report are GST-exclusive.

A sample from our data request is provided in **Box 1**.

Box 1: Sample questions from data request

To give an indication of the form of our data request, below we reproduce the section of our data request dealing with water heating options for Consumer Archetype 1. The first panel below reproduces the data requested for Consumer Archetype 1 for the electric water heating appliance option and the second panel below reproduces the data requested for Consumer Archetype 1 for the gas water heating appliance option.

Electric appliance option

Water heating	Low	Typical	High	Comment
Removal of existing hot water system and rectification work	$	$	$	
Replacement water heater				
Appliance description (e.g. storage heat pump water heater)	*Enter the type of appliance you would recommend in this situation*			
Appliance cost	$			
Appliance installation cost	$	$	$	

Gas appliance option

Water heating	Low	Typical	High	Comment
Removal of existing hot water system and rectification work	$	$	$	
Replacement water heater				
Appliance description (e.g. instant gas water heater)	*Enter the type of appliance you would recommend in this situation*			
Appliance cost	$			
Appliance installation cost	$	$	$	

2.2 The responses to our data request

With the assistance of members of GAMAA we circulated our data request to a large number of gas and electric appliance installers that work in Victoria. We received a response rate of 9% from appliance installers.

We do not present the individual results from appliance installers – instead we present average results across the responses that we received. So for instance, when we present the typical cost for installation of gas water heating for Consumer Archetype 1, we present the average of the estimates of the *typical costs* from the appliance installers. And when we present the high cost for installation of gas water heating for Consumer Archetype 1, we present the average of the estimates of the *high costs* from the appliance installers. And so on for all the other cost estimates that we requested.

2.3 Verifying responses to the data request

Where possible, we have sought to verify against public estimates the cost estimates provided by appliance installers in their responses to our data request.

We verified the purchase price of appliances against costs provided by Choice[16] (recommended appliances), Canstar Blue[17], Appliances Online[18], and related studies[19]. Installer appliance costs fit comfortably within the range of advertised appliance costs, and installer responses appear to quote for comparable appliances in terms of quality (i.e. inexpensive gas cooktops were paired with inexpensive induction cooktops, and vice versa). Installers quoted appliances at a range of price points, from low end to mid-tier according to recommended retail prices, although appliance installer quotes may reflect prices lower than recommended retail prices.

There is limited information online available about the cost of power supply upgrades. One Melbourne installer, Kenner Electrics, provides a typical cost range on its website[20], which our installer typical estimates fall comfortably within. Our installer responses costed power supply upgrades only in certain circumstances – generally, for the larger house archetypes and more demanding electrical appliances (e.g. large heat pumps). The installer responses didn't always concur on whether a power supply upgrade was required, likely reflecting that, in some instances, archetypes and appliance combinations may be close to the residence's electricity load threshold. The cost range of power supply upgrades (i.e. high, typical and low) was also significant. This reflects that power supply upgrades are considerably more variable and depend on specific consumer circumstances.

2.4 Using the cost data

We have used the cost data supplied by appliance installers to compare the cost of a gas appliance option with the cost for an electric appliance option. In doing so, we are able to inform an assessment of the upfront costs that households currently using gas will face if they electrify their energy use compared with the upfront costs these households will face if they continue to use gas appliances, assuming that their existing appliances are at end-of-life. We have not assessed a scenario where a consumer is required to replace gas appliances with electrical equivalents *before* their current appliances are end-of-life. In this scenario, relative costs of switching to electric equivalents will be higher, because the remaining value of the existing functional gas appliances has to be added to the costs.

We did not ask installers about the cost of hydrogen-compatible appliances, because these are not currently widely available. We have assumed that gas appliances capable of operating on 100% hydrogen gas will cost 30% more than natural gas appliances, i.e. we have increased the gas appliance costs from installers by 30%.

16 See, for example, the recommended induction cooktops, available https://www.choice.com.au/home-and-living/kitchen/cooktops/review-and-compare/induction-cooktops (subscription required)

17 See, for example, the average price by capacity table, available https://www.canstarblue.com.au/appliances/air-conditioners/

18 See, for example, https://www.appliancesonline.com.au/filter/cooking-appliances/cooktops/induction/

19 One of which includes the Grattan Institute's Flame Out report, Appendix D. Note the installation and ducting costs relate to a new build and appear to be online estimates rather than installer quotes.

20 See https://www.kennerelectrics.com.au/residential/supply-upgrades

To assess the switching cost, we first calculate costs for each appliance option for each Consumer Archetype so that we can compare the total upfront costs for a representative consumer. Given we have collected cost data on a disaggregated basis (by appliance and cost component), we can present costs to consumers in different ways.

Second, based on estimates of the number of households of each consumer archetype in Victoria, we calculate an indicative upfront costs for Victoria, based on our archetype costs and the number of relevant homes in Victoria.

Third, we convert the total upfront costs for our consumer archetypes into an annualised cost (based on as assumed discount rate of 7% real and a life of 10 years). This annualised cost over 10 years is another way of stating the upfront costs for each archetype, but this annualised version can be compared to potential other changes in costs arising from switching from gas to electricity. For example, if an electrical option required $15,000 of additional upfront costs compared to a gas option, the annualised cost over 10 years at 7% would be $2,136, and this figure represents the savings (e.g. via the net effect of no gas bill and a higher electricity bill) that consumers would require each year to not be worse off under the electrical option.

3 Results

This section presents our analysis of the cost estimates based on the information provided by installers.

- In Section 3.1, we present cost ranges for each archetype by cost category and by appliance type.
- In Section 3.2, we present the resulting implications of these costs for Victorian consumers as a whole.

3.1 Results by archetype

Costs in this section are presented as an average of costs estimated by the installers. We do not report estimates from individual installers, as our survey data was collected on a confidential basis.

3.1.1 Archetype 1

Archetype 1 is a four-bedroom, single storey, free-standing house in metropolitan Melbourne with 5 residents. It has whole-of-house ducted gas heating and evaporative cooling, gas hot water, and gas cooking.

Figure 3 presents the upfront cost associated with different appliance options by cost type (rectification and removal, installation etc) for Archetype 1. Low, typical and high estimates are presented along the x-axis.

For Archetype 1, we included in the installer data request an estimate of the cost of installing a replacement (electric) evaporative cooler in the gas option. We include this cost in the gas option because it enables us to compare a scenario where consumers' appliances are due for replacement, and to ensure that the consumer has both heating and cooling available in both the gas appliance case and the electrical appliance case. Depending on the context in which results are to be used, costs associated with the evaporative cooler should be considered differently – for example, these costs are not required for an electrification scenario in which the consumer's existing appliances do not need replacement.

In each of the low, typical and high groups, the ordering of the cheapest option to the most expensive option remains the same, being the gas and evaporative option, the two-room split system option, the whole-of-house split system option, and then the ducted reverse cycle option. This result is unsurprising for at least two reasons: the gas option includes a drop-in replacement of existing appliances, with little rectification and replumbing/rewiring, and gas appliances are generally cheaper than similar quality and capacity electrical appliances.

The breakdown of costs by cost type is also unsurprising. Replacement appliances and install costs are the largest cost categories in each of the options and estimation groups (low/typical/high)[21]. For difficult (high cost) installations, the install component can be larger than

[21] Note that the replacement appliance component is constant for each of the estimation groups, as we asked for a point estimate and not a range for this cost category.

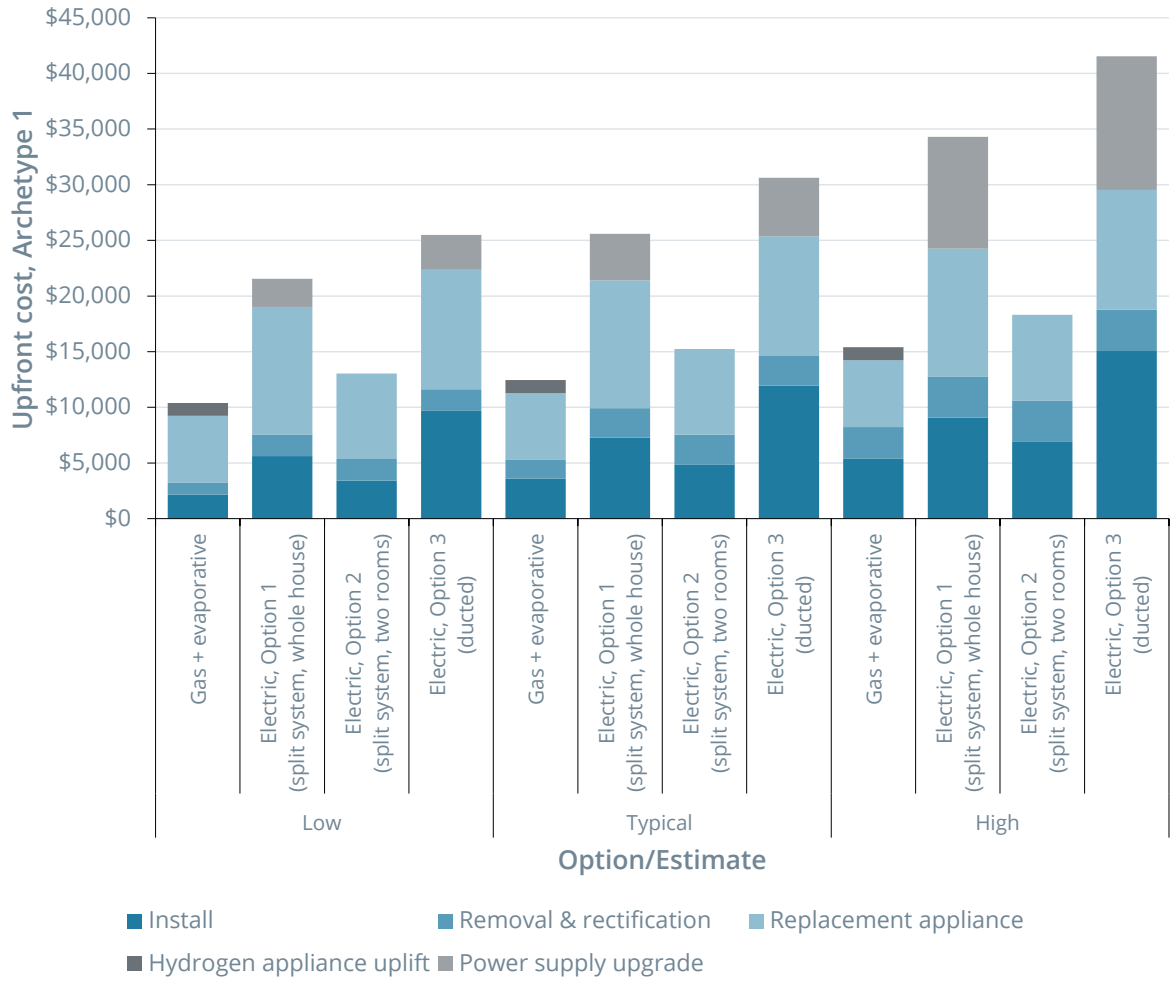
the appliance component (e.g. High, Option 3), whereas typically and in less difficult installations, the appliance component is the largest cost component. The removal and rectification component is smaller, but still significant, especially for the electricity options. Based on the installer responses, this is because the rectification cost in moving from gas to electrical appliances is significantly more than the cost of replacing gas with gas appliances.

As to whether power supply upgrades were required, the responses we received are nuanced:

- For options 1 and 3, involving whole-of-house electrical heating and cooling, responses indicated that a power supply upgrade would be required, costing somewhere between approximately $2,500 (Low, Option 1) and $12,000 (High, Option 3), which includes work associated with upgrades from the street to the meter box (via the Distribution Network Service Provider) and from the meter box to the house (e.g. including switchboard upgrades and changes).
- For Option 2, responses were mixed as to whether a power supply upgrade was required, so the cost of power supply upgrades are not reported here. For those installers that did provide a cost for power supply upgrade for Option 2, the provided costs were generally about 75% of the cost under Option 3 (for example, the average *typical* cost was $4,025 for Option 2).

As noted in Section 2.1, while Option 2 (a split-system heating and cooling option for two rooms) is the most similar to the gas option cost-wise, the amenity offered by Option 2 is significantly less than what whole-of-house ducted gas heating and evaporative cooling would provide.

Figure 3: Upfront costs for different appliance options by cost type, Archetype 1



Source: Frontier Economics analysis of installer responses

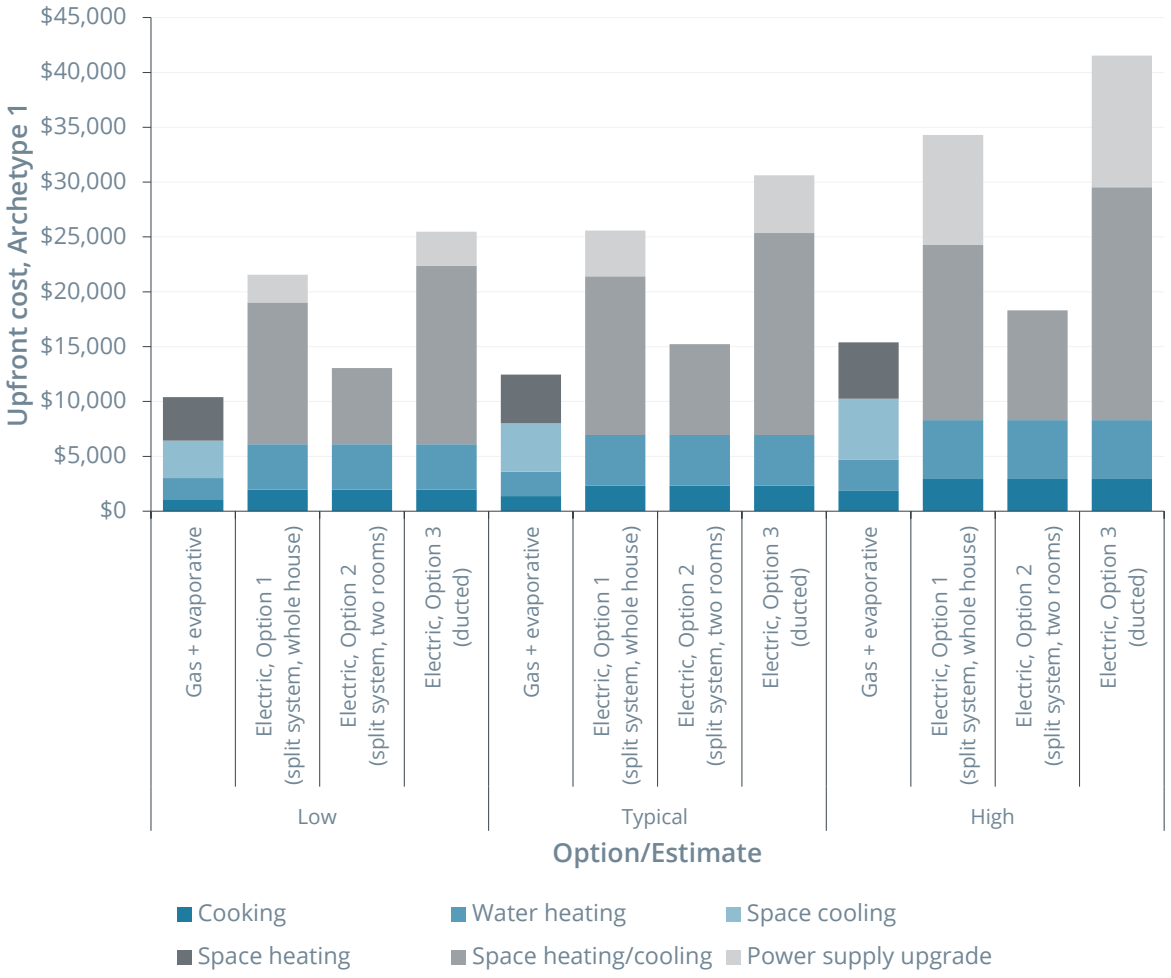
Note: Excludes power supply upgrade costs for Option 2 because there was not unanimous agreement that these were required. If required, the estimate costs range from $2,150 (low case) to $10,000 (high case).

Figure 4 presents the upfront costs for different appliance options by appliance type for Archetype 1. The total value of each column in this chart is the same as in **Figure 3**, but the breakdown is by appliance type rather than by cost category.

From **Figure 4**, it is clear that the largest upfront cost relates to the choice of space conditioning (i.e. heating and cooling). The cost of evaporative cooling and a replacement ducted gas heating system dominates the gas option at about 72% of the total cost, and the cost of electric space heating/cooling is more than 50% of the total cost in each of the electric options. If the cost of power supply upgrades is attributed to the cost of space conditioning (the most electrically demanding of the appliances considered), this proportion rises to 70-80%.

The cost of replacing gas cooking and water-heating appliances with new gas appliances is also relatively very small when compared to replacing with similar quality and capacity electric appliances.

Figure 4: Upfront costs for different appliance options by appliance type, Archetype 1



Source: Frontier Economics analysis of installer responses

Note: Excludes power supply upgrade costs for Option 2 because there was not unanimous agreement that these were required. If required, the estimate costs range from $2,150 (low case) to $10,000 (high case).

3.1.2 Archetype 2

Archetype 2 is a two-bedroom, single storey, semi-detached townhouse in metropolitan Melbourne with 3 residents. It has whole-of-house ducted gas heating, a split system servicing one room, gas hot water, and gas cooking.

Figure 5 presents the upfront cost associated with different appliance options by cost type for Archetype 2. On the whole, costs for Archetype 2 are lower than costs for Archetype 1. There are likely several contributing factors to this:

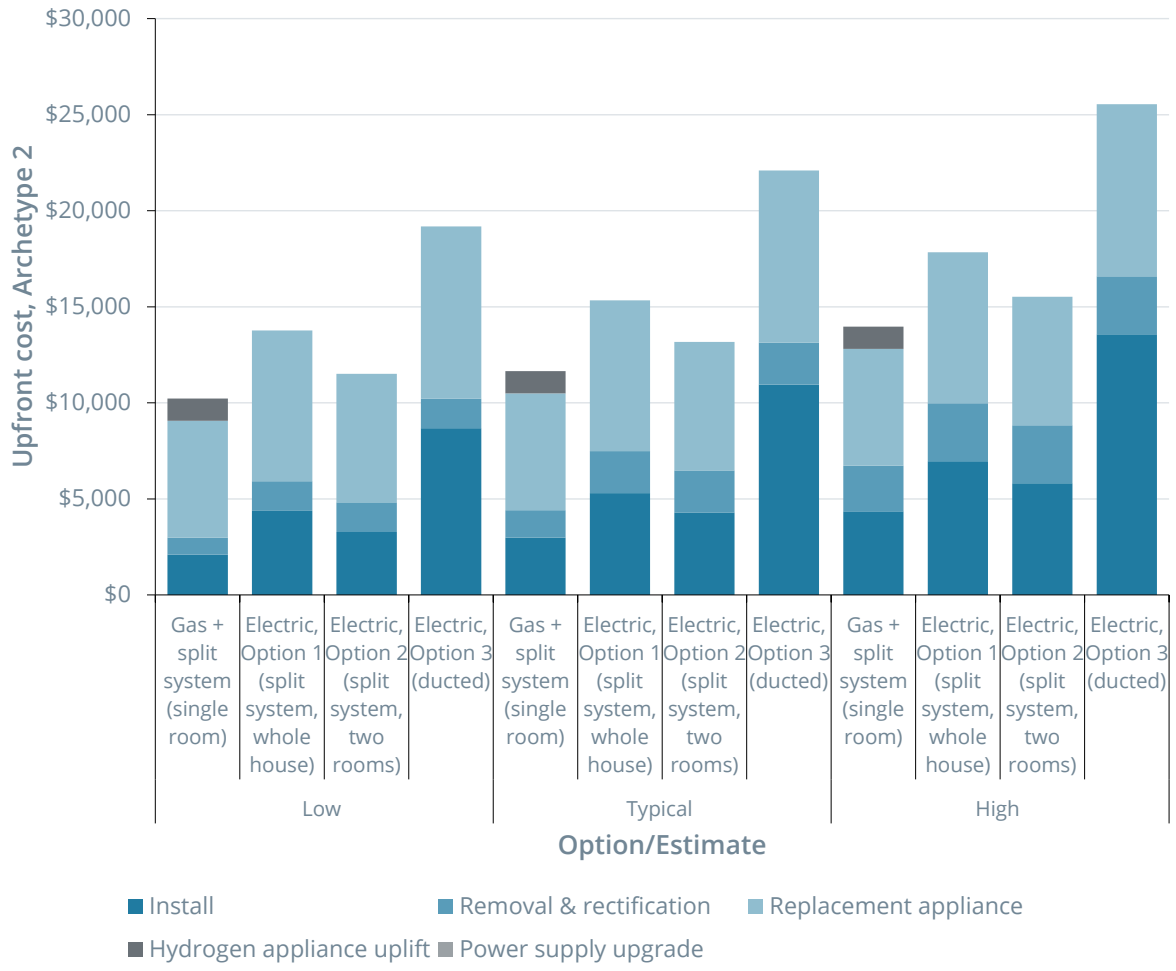
- Power supply upgrades are less likely to be required for Archetype 2. We received mixed responses on whether a power supply upgrade was likely, so we have omitted this cost category in these charts. For those installers that did provide a cost for power supply upgrade for Option 2, the provided costs ranged from $2,150 (low case, Option 1) to $12,250 (high case, Option 3).

- Archetype 2 is a smaller residence (in number of bedrooms and residents) than Archetype 1, so appliance requirements are smaller.
- Archetype 2 already has an existing electrical split system, which may defray some installation cost for new split-systems.
- Archetype 2 is a different house type to Archetype 1 (semi-detached vs free standing), which may have both downside (difficult installation) and upside (smaller footprint) cost implications.

For the Archetype 2 gas option, we include the cost of a replacement split system servicing one room, under the assumption that all of the consumer's appliances are due to be replaced at the same time. For Archetype 2, the different options imply different amenity; the gas option only includes cooling for one room, and some of the electric options only provide limited heating.

Despite the difference in magnitude, the ordering of the cheapest to the most expensive option for Archetype 2 is the same as Archetype 1.

Figure 5: Upfront costs for different appliance options by cost type, Archetype 2



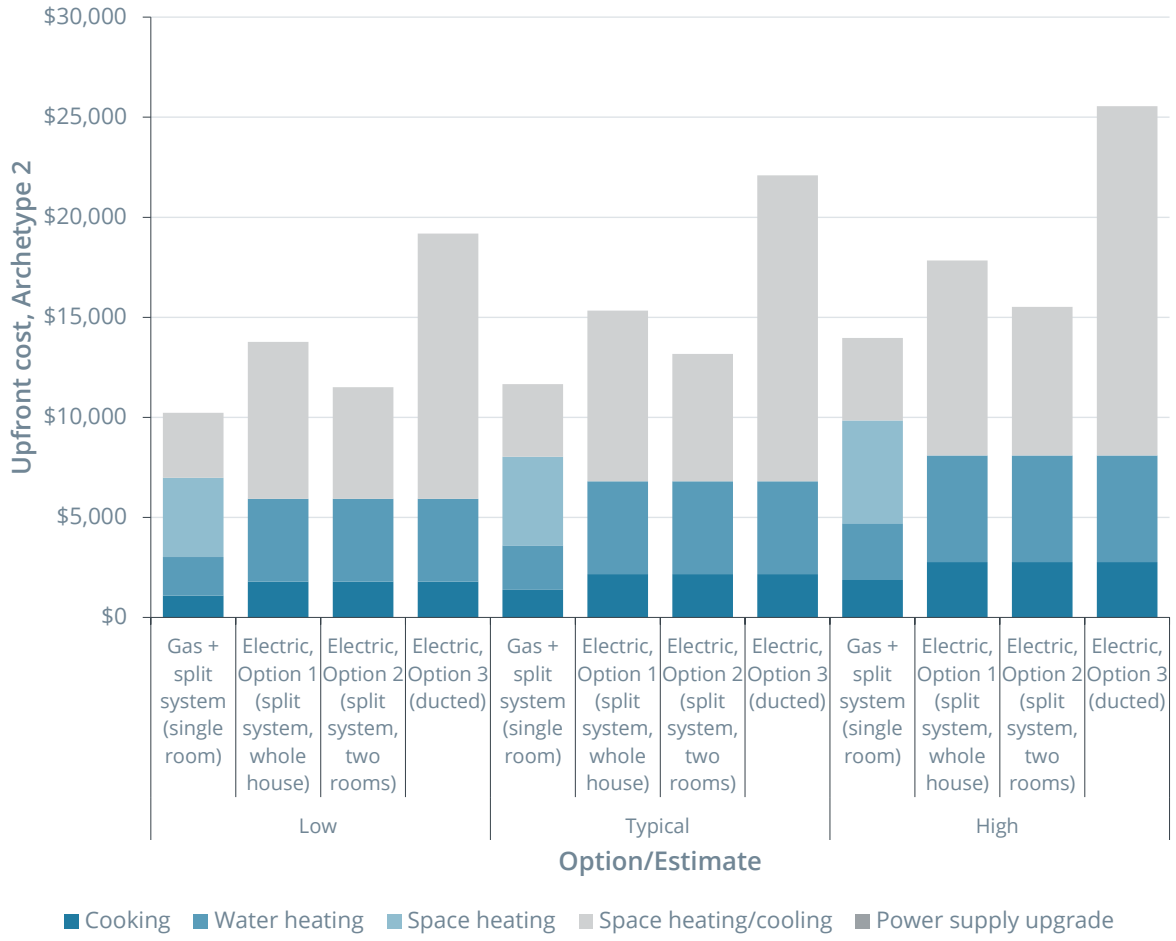
Source: Frontier Economics analysis of installer responses

Note: Excludes power supply upgrade costs because there was not unanimous agreement that these were required. If required, the estimate costs range $2,150 (low case, Option 1) to $12,250 (high case, Option 3)

Figure 6 presents the upfront costs for different appliance options by appliance type for Archetype 2. The total value of each column in this chart is the same as in **Figure 5**, but the breakdown is by appliance type rather than by cost category.

The breakdown illustrated in **Figure 6** for Archetype 2 is proportionately similar to that seen in Archetype 1 after accounting for the omission of power supply upgrade costs. Space conditioning is the largest appliance cost category in each of the options. The difference between Option 1 and Option 2 is smaller for Archetype 2 than for Archetype 1, likely because the house type and size leads to more similar appliance configurations (e.g. same placement of the outdoor unit(s), with one option having more indoor units).

Figure 6: Upfront costs for different appliance options by appliance, Archetype 2



Source: Frontier Economics analysis of installer responses

Note: Excludes power supply upgrade costs because there was not unanimous agreement that these were required. If required, the estimate costs range $2,150 (low case, Option 1) to $12,250 (high case, Option 3)

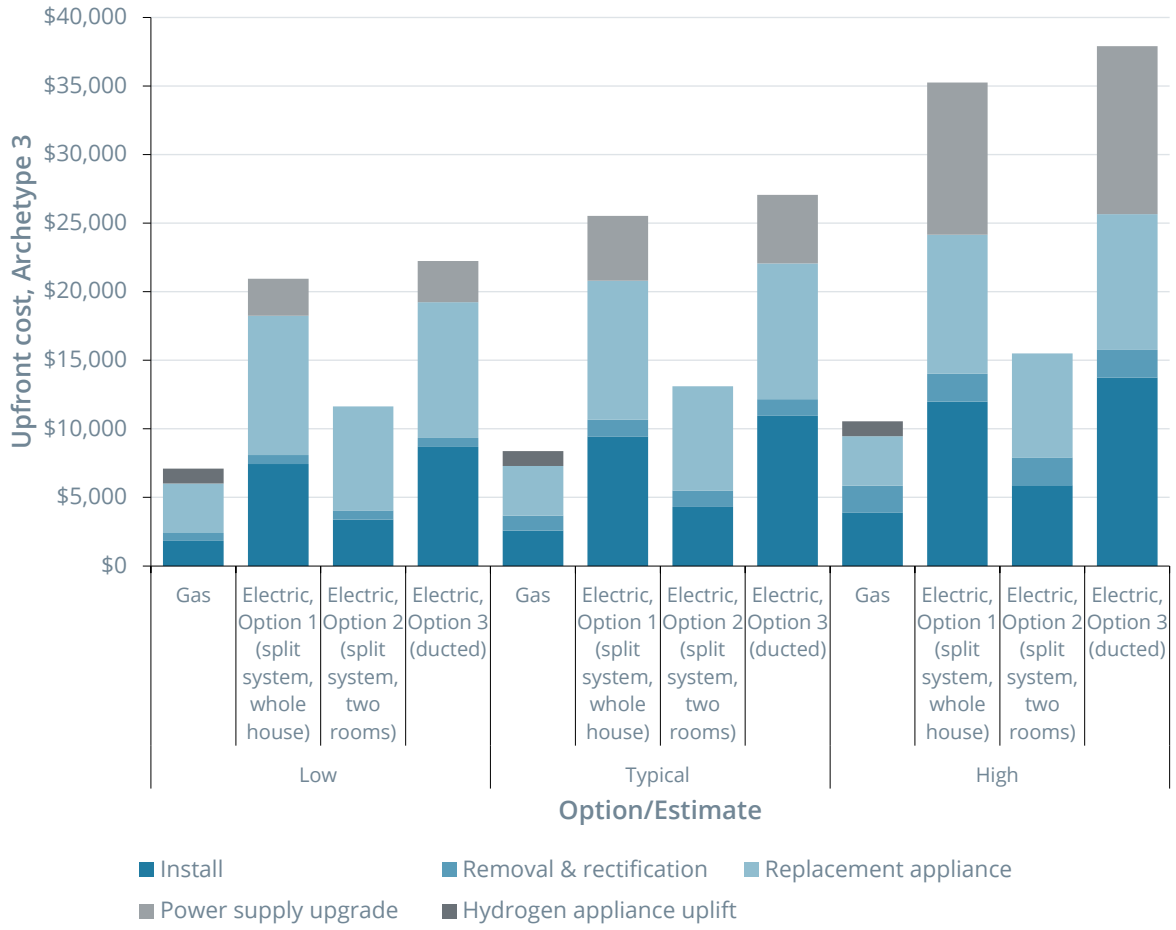
3.1.3 Archetype 3

Archetype 3 is a three-bedroom, single storey, free-standing townhouse in metropolitan Melbourne with 4 residents. It has gas room heating in two rooms, no air-conditioning, gas hot water, and gas cooking.

Figure 7 presents the upfront cost associated with different appliance options by cost type for Archetype 3. On the whole, costs for Archetype 3 are lower than costs for Archetype 1 but higher than costs for Archetype 2. In terms of dwelling size, Archetype 3 is larger than Archetype 2 but smaller than Archetype 1, so appliance requirements are in-between the two.

Despite the difference in magnitude, the ordering of the cheapest to the most expensive option remains unchanged across all archetypes.

Figure 7: Upfront costs for different appliance options by cost type, Archetype 3



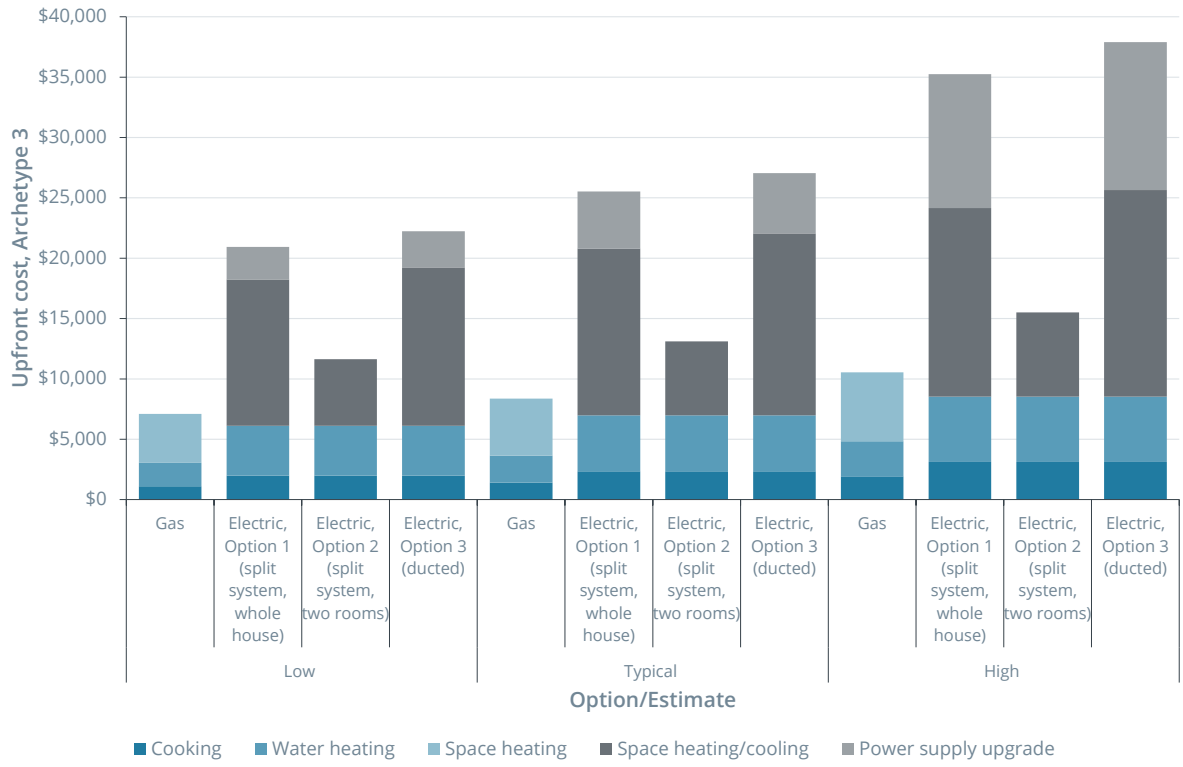
Source: Frontier Economics analysis of installer responses

Note: Excludes power supply upgrade costs for Option 2 because there was not unanimous agreement that these were required. If required, the estimate costs range from $2,175 (low case) to $10,250 (high case).

Figure 8 presents the upfront costs for different appliance options by appliance type for Archetype 3. The total value of each column in this chart is the same as in **Figure 7**, but the breakdown is by appliance type rather than by cost category.

The breakdown illustrated in **Figure 8** for Archetype 3 is proportionately similar to that seen in Archetypes 1 and 2 (after accounting for the omission of power supply upgrade costs in Archetype 2). Space conditioning is the largest appliance cost category in each of the options.

Figure 8: Upfront costs for different appliance options by appliance, Archetype 3



Source: Frontier Economics analysis of installer responses

Note: Excludes power supply upgrade costs for Option 2 because there was not unanimous agreement that these were required. If required, the estimate costs range from $2,175 (low case) to $10,250 (high case, with the average typical cost $4,025).

3.2 Implications for Victorian consumers

We have used installer responses to estimate a range of upfront costs for replacing gas appliances or switching from gas to electrical appliances for individual households. In this section, we apply the costs for the archetypes over an estimate of the number of applicable households in Victoria to provide an indication of the magnitude of costs across all of Victoria. Because our archetypes do not capture all household types, and data to precisely determine the number of households in Victoria that fall within each of our archetypes is not available, we are unable calculate a single point estimate of the additional upfront costs imposed for electrifying gas appliances for Victoria. However, our results indicate that these costs are likely to be significant.

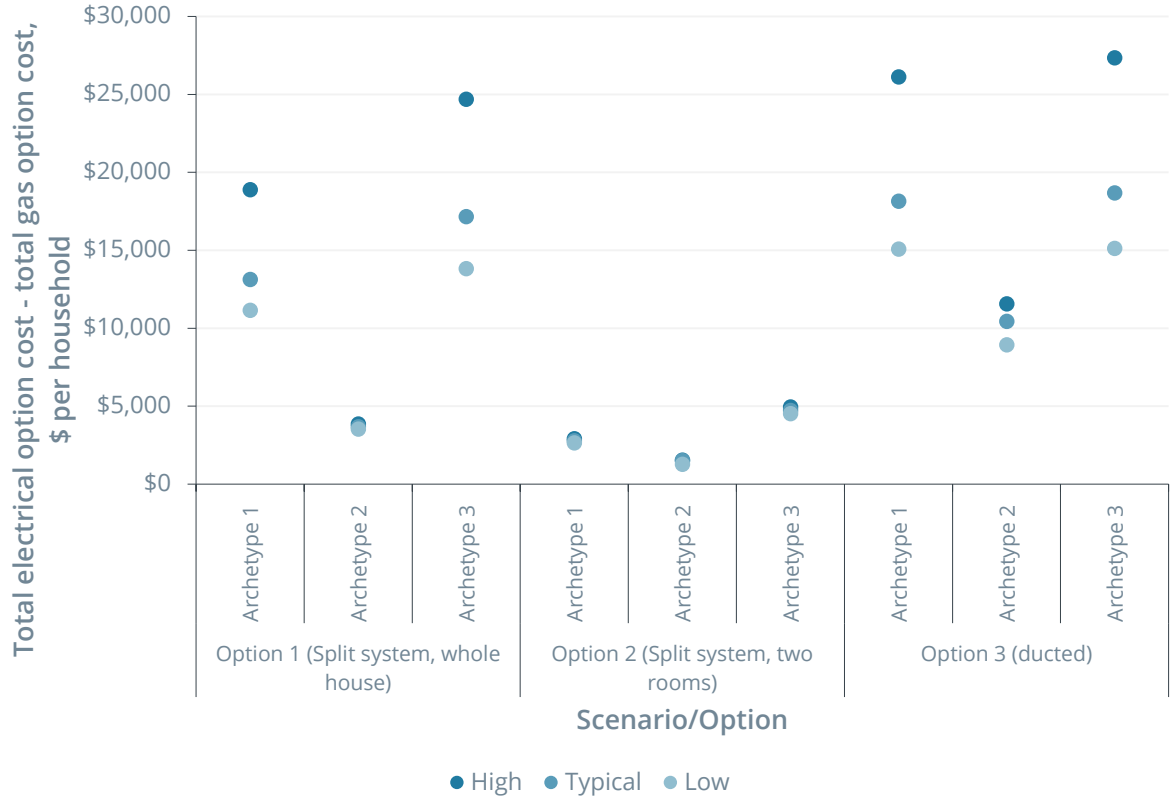
Before considering the cost across all of Victoria, we consider the cost difference between electrical and gas appliances for each archetype and each electrical appliance option. These costs are calculated by subtracting the total gas option costs from the total electrical option costs. The result of this calculation is presented in **Figure 9**. We subtract the high gas option cost from the high electricity option costs, the typical from the typical and so on, which means the ordering of high, typical and low costs are not always preserved (there may be a smaller difference in typical to typical than low to low, for example).

Option 1 is an expensive option for archetypes 1 and 3, adding approximately $13,000 and $17,000 respectively to upfront installation costs for the typical case. This is primarily due to the additional costs associated with space heating and cooling, as well as associated electricity supply upgrades. The cost for Consumer Archetype 2 is significantly smaller, because Consumer Archetype 2 is a smaller residence (2 bedroom townhouse) and the cost of replacing a split system servicing a single room is included in the gas option. Cooling amenity is improved under this option for archetypes 2 and 3.

Option 2 is a relatively inexpensive option for all archetypes, adding around $1,500-$5,000 to upfront costs. Upfront costs are lower under this option because appliance and install costs are significantly lower for the electrical appliances, and in at least some cases (here we have assumed all cases) power supply upgrades are not required. However, heating amenity is lower in this option for archetypes 1 and 2, which, under the gas option, have whole of house ducted heating. Cooling amenity under this option is improved for archetypes 2 and 3.

Option 3 is on average the most expensive option, adding between approximately $10,000 and $19,000 to typical upfront costs. This option is expensive for three primary reasons – the heat pump appliance is expensive, the costs of installation, including ducting, are high, and power supply upgrades are generally required and can be expensive. Cooling amenity is improved under this option for archetypes 2 and 3.

Figure 9: Difference between the total electrical option costs and the total gas option cost by Archetype



Source: Frontier Economics analysis of installer responses

Note: Excludes power supply upgrade costs where there was not unanimous agreement that these were required.

To calculate an indicative magnitude of the upfront cost of electrifying all gas appliances for all of Victoria, we average the cost difference between the electric options and the gas option for the 3 archetypes, and multiply this average value by the number of 2+ bedroom free standing/semi-detached houses in Victoria (2.01 million) and the proportion of houses with ducted gas (40%) and non-ducted gas heating (31%). We do this for each of the low case, typical case and high case costs.

The result of this process is illustrated in **Figure 10**. For each option and estimate, the result of applying the average individual household cost across archetypes by the number of applicable households is presented as a point on the chart. Each option assumes that all Victorian households with gas heating adopt that option, so the results should be read as a range (e.g. the cost to Victoria is somewhere between Option 2 and Option 3) and are not additive. Representativeness was only one consideration in developing our archetypes, and data linking housing size and type and heating appliance type is limited, so these results are strictly indicative. However, they imply that the potential cost of electrification of gas appliances across all of Victoria is large.

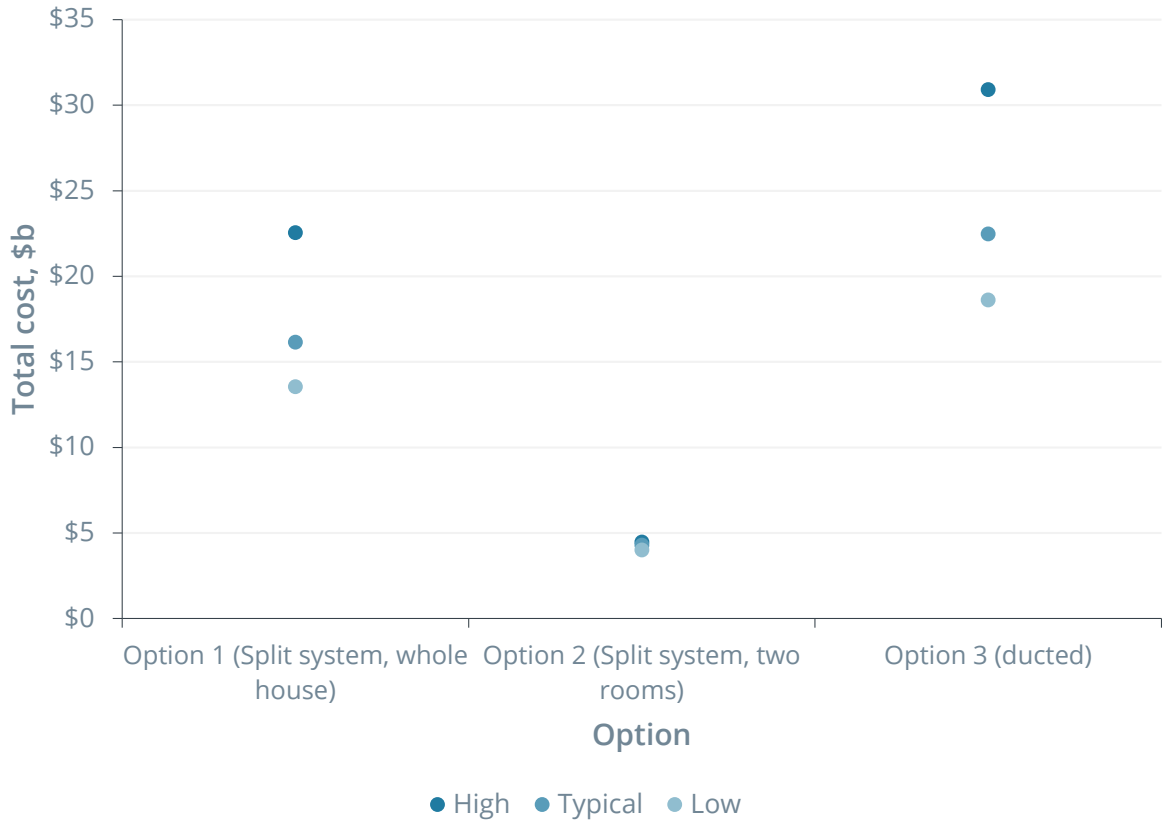
Unsurprisingly, the incremental costs for Option 2 (split system servicing two rooms) are the smallest, because Option 2 installs the smallest space conditioning system (the largest cost

component observed in all archetypes), effectively reducing space heating amenity. The typical costs for our archetypes for Option 2 are around $4 billion.

The incremental costs for Option 1 are much more substantial, with higher appliance costs and electricity supply upgrades often required. Incremental costs range from $13 to $23 billion. Incremental costs for Option 3 range from $18-$31 billion.

In short, this comparison suggests that the additional cost to Victorian consumers of replacing existing gas appliances with electric appliances (rather than replacing them with new gas appliances that are hydrogen compatible) is somewhere between $4 billion and $31 billion. Where within this range the actual cost falls depends on the mix of consumer types within Victoria and the appliance options adopted. Further work would be required to calculate a single point estimate of the additional upfront costs imposed for electrifying gas appliances for Victoria.

Figure 10: Indicative additional costs to Victoria, $b



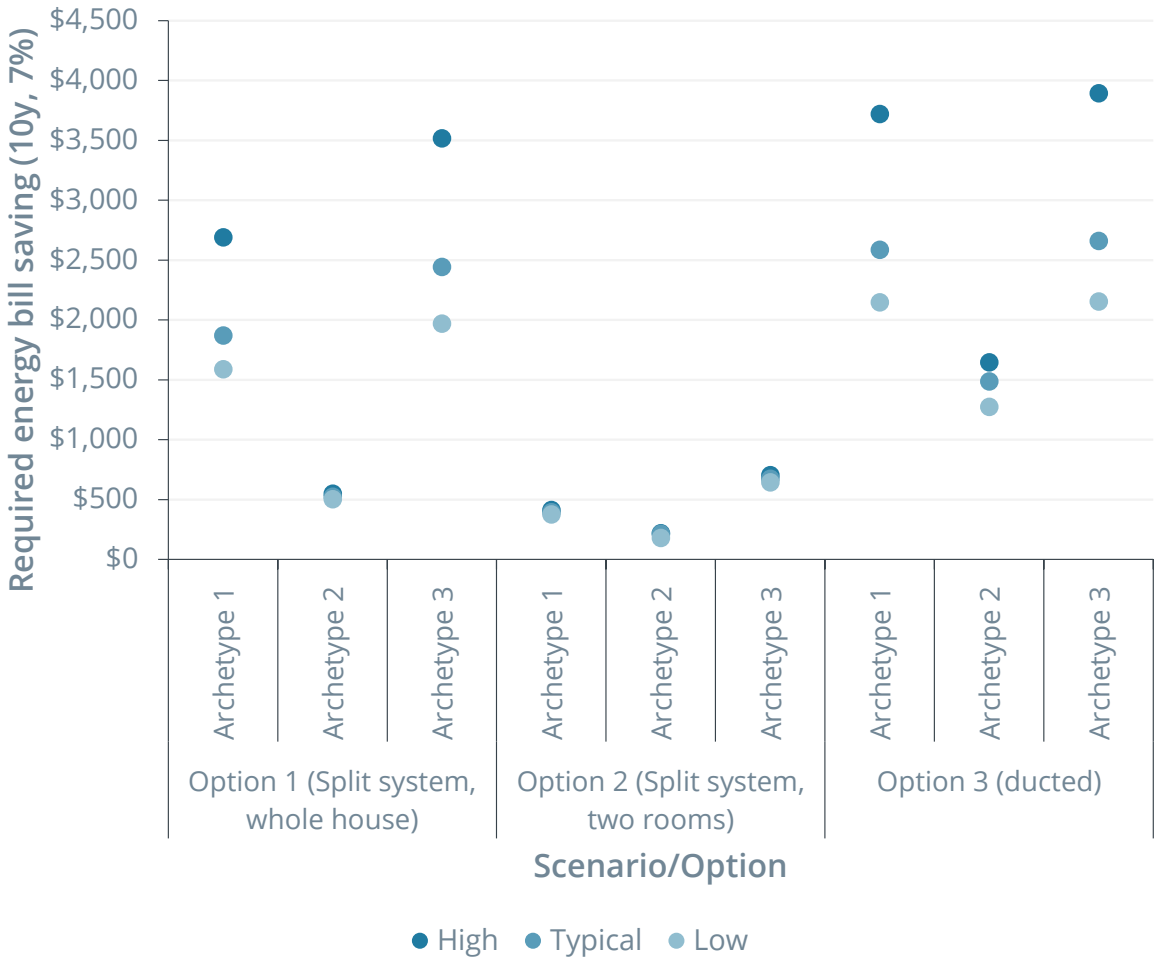
Source: Frontier Economics analysis of installer responses

Note: Excludes power supply upgrade costs where there was not unanimous agreement that these were required.

As discussed in Section 1.2, upfront costs are not the only costs associated with consumer appliance choices. For example, there may be energy bill savings associated with a switch from gas appliances to high-efficiency electrical appliances, i.e. the net of no gas bill and a higher electricity bill.

To put energy bill savings into context, we calculate the required energy bill savings for each option, estimate and archetype assuming a consumer discount rate of 7 per cent and a 'payback' period of 10 years. The result of this calculation is presented in **Figure 11**.

Figure 11: Required energy bill savings with a discount rate of 7 per cent over 10 years



Source: Frontier Economics analysis of Installer responses

Note: Excludes power supply upgrade costs where there was not unanimous agreement that these were required.

We understand that modelling undertaken for the Victorian Gas Substitution Roadmap suggests that household bill savings could be between $360 per year and $840 per year for consumers whom electrify their current gas load.[22] If it clear from **Figure 11** that for most archetypes and most options, these potential bill savings will be insufficient to recover the estimated cost to consumers of replacing gas appliances with electric appliances. For Option 2, the potential bill savings may be sufficient to recover the estimated cost to consumers of replacing gas appliances but, as we have discussed, the electrical appliances under Option 2 generally provide lower amenity than the equivalent gas appliances.

22 Victoria's Gas Substitution Roadmap, Stakeholder Forum slides, February 2022, p16

3.3 Discussion

It is not surprising that there is little detailed public information on removal and rectification, install, and power supply upgrade costs. As the installer responses have shown, costs are sensitive to context and can vary widely.

It may also be no surprise that the cost of replacing appliances like-for-like is cheaper than installing new appliances with a different fuel type. Replacing a gas hob with a new gas hob requires little plumbing; replacing a gas hob with an induction cooktop is likely to require first decommissioning the existing gas plumbing safely, then wiring a dedicated circuit of 20+ amps for the new cooktop. These costs are more substantial when it comes to space heating and ducting – it is much easier and cheaper, for example, to replace a furnace for gas heating than to decommission existing floor ducts and install a new ducted heat pump with ducts in the roof space. In short, there are a lot of gas-related costs that have been sunk in Victorian homes that still have value while gas appliances are in use, but that value is lost when converting to electrical appliances.

The key contribution of this report is to begin filling the information gap on the true upfront cost of converting existing Victorian dual fuel homes to electric only, and demonstrate that these additional cost categories are significant. For a significant number of Victorian consumers, these costs in conjunction with appliance costs will make the cost of electrification a challenging financial prospect.

A Figure data

Table 1: Figure data for **Figure 3**: Upfront costs for different appliance options by cost type, Archetype 1

Category	Install	Removal & rectification	Replacement appliance	Hydrogen appliance uplift	Power supply upgrade	Total
Low						
Gas + evaporative	$2,150	$1,067	$6,017	$1,165		$10,398
Electric, Option 1 (split system, whole house)	$5,617	$1,933	$11,480		$2,525	$21,555
Electric, Option 2 (split system, two rooms)	$3,417	$1,933	$7,697		$0	$13,047
Electric, Option 3 (ducted)	$9,683	$1,933	$10,747		$3,125	$25,488
Typical						
Gas + evaporative	$3,600	$1,667	$6,017	$1,165		$12,448
Electric, Option 1 (split system, whole house)	$7,267	$2,667	$11,480		$4,175	$25,588
Electric, Option 2 (split system, two rooms)	$4,867	$2,667	$7,697		$0	$15,230
Electric, Option 3 (ducted)	$11,950	$2,667	$10,747		$5,250	$30,613
High						
Gas + evaporative	$5,383	$2,833	$6,017	$1,165		$15,398
Electric, Option 1 (split system, whole house)	$9,067	$3,717	$11,480		$10,030	$34,293
Electric, Option 2 (split system, two rooms)	$6,900	$3,717	$7,697		$0	$18,313
Electric, Option 3 (ducted)	$15,067	$3,717	$10,747		$12,000	$41,530

Table 2: Figure data for **Figure 4**: Upfront costs for different appliance options by appliance type, Archetype 1

Category	Cooking	Water heating	Space cooling	Space heating	Space heating/cooling	Power supply upgrade	Total
			Low				
Gas + evaporative	$1,092	$1,930	$3,417	$3,960			$10,398
Electric, Option 1 (split system, whole house)	$1,980	$4,117			$12,933	$2,525	$21,555
Electric, Option 2 (split system, two rooms)	$1,980	$4,117			$6,950	$0	$13,047
Electric, Option 3 (ducted)	$1,980	$4,117			$16,267	$3,125	$25,488
			Typical				
Gas + evaporative	$1,375	$2,230	$4,417	$4,427			$12,448
Electric, Option 1 (split system, whole house)	$2,347	$4,600			$14,467	$4,175	$25,588
Electric, Option 2 (split system, two rooms)	$2,347	$4,600			$8,283	$0	$15,230
Electric, Option 3 (ducted)	$2,347	$4,600			$18,417	$5,250	$30,613
			High				
Gas + evaporative	$1,858	$2,830	$5,567	$5,143			$15,398
Electric, Option 1 (split system, whole house)	$2,947	$5,350			$15,967	$10,030	$34,293
Electric, Option 2 (split system, two rooms)	$2,947	$5,350			$10,017	$0	$18,313
Electric, Option 3 (ducted)	$2,947	$5,350			$21,233	$12,000	$41,530

Table 3: Figure data for **Figure 5**: Upfront costs for different appliance options by cost type, Archetype 2

Category	Install	Removal & rectification	Replacement appliance	Hydrogen appliance uplift	Power supply upgrade	Total
Low						
Gas + split system (single room)	$2,100	$883	$6,083	$1,165		$10,232
Electric, Option 1 (split system, whole house)	$4,383	$1,533	$7,857		$0	$13,773
Electric, Option 2 (split system, two rooms)	$3,283	$1,533	$6,692		$0	$11,508
Electric, Option 3 (ducted)	$8,683	$1,533	$8,967		$0	$19,183
Typical						
Gas + split system (single room)	$2,983	$1,425	$6,083	$1,165		$11,657
Electric, Option 1 (split system, whole house)	$5,300	$2,183	$7,857		$0	$15,340
Electric, Option 2 (split system, two rooms)	$4,300	$2,183	$6,692		$0	$13,175
Electric, Option 3 (ducted)	$10,950	$2,183	$8,967		$0	$22,100
High						
Gas + split system (single room)	$4,358	$2,367	$6,083	$1,165		$13,973
Electric, Option 1 (split system, whole house)	$6,967	$3,017	$7,857		$0	$17,840
Electric, Option 2 (split system, two rooms)	$5,817	$3,017	$6,692		$0	$15,525
Electric, Option 3 (ducted)	$13,567	$3,017	$8,967		$0	$25,550

Table 4: Figure data for **Figure 6**: Upfront costs for different appliance options by appliance, Archetype 2

Category	Cooking	Water heating	Space cooling	Space heating	Power supply upgrade	Total
Low						
Gas + split system (single room)	$1,092	$1,930	$3,960	$3,250		$10,232
Electric, Option 1 (split system, whole house)	$1,800	$4,133		$7,840	$0	$13,773
Electric, Option 2 (split system, two rooms)	$1,800	$4,133		$5,575	$0	$11,508
Electric, Option 3 (ducted)	$1,800	$4,133		$13,250	$0	$19,183
Typical						
Gas + split system (single room)	$1,375	$2,230	$4,427	$3,625		$11,657
Electric, Option 1 (split system, whole house)	$2,167	$4,633		$8,540	$0	$15,340
Electric, Option 2 (split system, two rooms)	$2,167	$4,633		$6,375	$0	$13,175
Electric, Option 3 (ducted)	$2,167	$4,633		$15,300	$0	$22,100
High						
Gas + split system (single room)	$1,875	$2,830	$5,143	$4,125		$13,973
Electric, Option 1 (split system, whole house)	$2,767	$5,333		$9,740	$0	$17,840
Electric, Option 2 (split system, two rooms)	$2,767	$5,333		$7,425	$0	$15,525
Electric, Option 3 (ducted)	$2,767	$5,333		$17,450	$0	$25,550

Table 5: Figure data for **Figure 7**: Upfront costs for different appliance options by cost type, Archetype 3

Category	Install	Removal & rectification	Replacement appliance	Hydrogen appliance uplift	Power supply upgrade	Total
Low						
Gas	$1,833	$567	$3,617		$1,085	$7,102
Electric, Option 1 (split system, whole house)	$7,433	$658	$10,147	$2,700		$20,938
Electric, Option 2 (split system, two rooms)	$3,383	$658	$7,597	$0		$11,638
Electric, Option 3 (ducted)	$8,683	$658	$9,897	$3,000		$22,238
Typical						
Gas	$2,583	$1,083	$3,617		$1,085	$8,368
Electric, Option 1 (split system, whole house)	$9,450	$1,208	$10,147	$4,725		$25,530
Electric, Option 2 (split system, two rooms)	$4,300	$1,208	$7,597	$0		$13,105
Electric, Option 3 (ducted)	$10,950	$1,208	$9,897	$5,000		$27,055
High						
Gas	$3,900	$1,950	$3,617		$1,085	$10,552
Electric, Option 1 (split system, whole house)	$11,983	$2,025	$10,147	$11,100		$35,255
Electric, Option 2 (split system, two rooms)	$5,883	$2,025	$7,597	$0		$15,505
Electric, Option 3 (ducted)	$13,733	$2,025	$9,897	$12,250		$37,905

Table 6: Figure data for **Figure 8**: Upfront costs for different appliance options by appliance, Archetype 3

Category	Cooking	Water heating	Space cooling	Space heating	Power supply upgrade	Total
Low						
Gas	$1,108	$1,930	$4,063			$7,102
Electric, Option 1 (split system, whole house)	$1,980	$4,133		$12,125	$2,700	$20,938
Electric, Option 2 (split system, two rooms)	$1,980	$4,133		$5,525	$0	$11,638
Electric, Option 3 (ducted)	$1,980	$4,133		$13,125	$3,000	$22,238
Typical						
Gas	$1,408	$2,230	$4,730			$8,368
Electric, Option 1 (split system, whole house)	$2,347	$4,633		$13,825	$4,725	$25,530
Electric, Option 2 (split system, two rooms)	$2,347	$4,633		$6,125	$0	$13,105
Electric, Option 3 (ducted)	$2,347	$4,633		$15,075	$5,000	$27,055
High						
Gas	$1,925	$2,913	$5,713			$10,552
Electric, Option 1 (split system, whole house)	$3,113	$5,417		$15,625	$11,100	$35,255
Electric, Option 2 (split system, two rooms)	$3,113	$5,417		$6,975	$0	$15,505
Electric, Option 3 (ducted)	$3,113	$5,417		$17,125	$12,250	$37,905

Table 7: Figure data for **Figure 9**: Difference between the total electrical option costs and the total gas option cost by Archetype

Archetype	High	Typical	Low
Option 1 (Split system, whole house)			
Archetype 1	$18,895	$13,140	$11,157
Archetype 2	$3,867	$3,683	$3,542
Archetype 3	$24,703	$17,162	$13,837
Option 2 (Split system, two rooms)			
Archetype 1	$2,915	$2,782	$2,648
Archetype 2	$1,552	$1,518	$1,277
Archetype 3	$4,953	$4,737	$4,537
Option 3 (ducted)			
Archetype 1	$26,132	$18,165	$15,090
Archetype 2	$11,577	$10,443	$8,952
Archetype 3	$27,353	$18,687	$15,137

Table 8: Figure data for **Figure 10**: Indicative additional costs to Victoria, $b

Option	High	Typical	Low
Option 1 (Split system, whole house)	$22.56	$16.15	$13.56
Option 2 (Split system, two rooms)	$4.48	$4.29	$4.02
Option 3 (ducted)	$30.92	$22.48	$18.62

Table 9: Figure data for **Figure 11**: Required energy bill savings with a discount rate of 7 per cent over 10 years

Archetype	High	Typical	Low
Option 1 (Split system, whole house)			
Archetype 1	$2,690	$1,871	$1,588
Archetype 2	$551	$524	$504
Archetype 3	$3,517	$2,443	$1,970
Option 2 (Split system, two rooms)			
Archetype 1	$415	$396	$377
Archetype 2	$221	$216	$182
Archetype 3	$705	$674	$646
Option 3 (ducted)			
Archetype 1	$3,721	$2,586	$2,148
Archetype 2	$1,648	$1,487	$1,275
Archetype 3	$3,894	$2,661	$2,155

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