Victorian residential case study

A note for Gas Energy Australia (GEA) and the Australian Gas Industry Trust (AGIT) – 18 January 2023

For LPG to play a role in the transition to net zero, it is not only important that the emissions intensity of LPG falls over time, so that continuing to use LPG is consistent with achieving net zero emissions, but also that LPG remains competitive as a source of energy to customers.

In this note we provide a case study that investigates the financial impacts of LPG use for a typical residential LPG customer in regional Victoria, using LPG for cooking, space heating and water heating.

Methodology

In undertaking this residential case study we assume that the alternative to LPG use for residential customers is to switch to electricity, and our case studies compare the costs to customers of continuing to use LPG with the cost of switching to electricity. The difference between these alternatives depends on:

- **Differences in household energy bills**. Electrification will bring about changes in the costs to households of purchasing energy. Electrification of household use of LPG will mean that households will no longer purchase LPG but will face higher electricity bills reflecting higher electricity consumption. The total energy bills that households face is one part of the financial impact to households of electrification.
- **Differences in household appliance costs**. Electrification will also bring about changes in the costs of appliances that households use. Electrification of household use of LPG will mean that households will need to purchase and install electrical appliances for cooking and heating rather than using LPG appliances.

We calculate energy bills and appliance costs based on publicly available information on LPG consumption, retail prices for LPG and electricity and appliance costs.

We estimate the financial impacts for households from both of these changes – changes in energy bills and appliance cost – for two alternative cases:

- **Electricity and LPG case**: In this case, the representative household uses LPG for cooking, space conditioning and water heating appliances with all other household energy use powered by electricity. Conventional LPG is assumed to be replaced by low emissions and zero emissions alternatives, consistent with the transition scenario detailed in our final report to GEA and AGIT.[1] A cost premium on the wholesale price of alternative LPG is also assumed.

[1] Frontier Economics, *Pathway to zero emissions for LPG*, A Report for Gas Energy Australia and the Australian Gas Industry Trust, 5 December 2022.

- **Electricity only case**: In this case the representative household's energy consumption is 100% electrified. Residential customers that choose to electrify their LPG appliances can choose between different types of electrical appliances. We look at two alternatives for these customers:
  - Higher efficiency appliances. These include heat pumps for space heating, heat pumps for water heating and induction cooktops. These are typically more expensive to purchase but use less electricity to operate.
  - Lower efficiency appliances. These include electric panel heaters, traditional electric storage water heaters and electric coil cooktops. These are typically less expensive to purchase but use more electricity to operate.

The result of this is that we compare three appliance cases for each of our residential case studies: LPG appliances, higher efficiency electricity appliances and lower efficiency electricity appliances.

Assumed wholesale price premium for bioLPG, rDME and renewable LPG

As discussed, for the electricity and LPG case we calculate bills having regard to the premium on the wholesale price of lower emissions alternatives to conventional LPG. This means that the wholesale price of LPG increases as the energy mix shifts over time from conventional LPG to alternatives, according to the transition scenario detailed in our final report to GEA and AGIT.[2]

To our knowledge there are no recent, publicly available estimates of the future production costs of the lower emissions alternatives to conventional LPG that we consider in our transition scenario. However, there are estimates of the relative production costs of biodiesel and SAF, from which bio-LPG is likely to be produced as a by-product. We use these estimates of the relative production costs of biodiesel and SAF, relative to conventional liquid fuel, as an estimate of the cost premium of lower emissions alternatives to conventional LPG.

For the household case studies we assume a 50% wholesale price premium for bioLPG, rDME and renewable LPG and undertake sensitivity analysis for each state and electrical appliance efficiency case at 25% and 100%.

These assumptions are based on several studies and reports, including analysis undertaken by the Clean Energy Finance Corporation (CEFC) and Australian Renewable Energy Agency (ARENA),[3] the Gas Technology Institute,[4] the International Energy Agency,[5] Transport Environment[6] and Doliente et al.[7]

2 Frontier Economics, *Pathway to zero emissions for LPG*, A Report for Gas Energy Australia and the Australian Gas Industry Trust, 5 December 2022.

3 Clean Energy Finance Corporation and the Australian Renewable Energy Agency, *Biofuels and Transport; An Australian Opportunity*, 2020, p.16.

4 Gas Technology Institute, *Expert Analysis of the Concept of Synthetic and/or Bio-LPG*, 2010, p.27.

5 International Energy Agency, *Renewable 2021: Analysis and Forecast to 2026*, 2020, p.159.

6 Transport Environment, *Billions wasted on biofuels*, 2022, p.3.

7 Doliente et al. 2020, 'Bio-aviation Fuel: A comprehensive study review and analysis of the supply chain components', *Frontier in Energy Research*, vol. 8, doi: 10.3389/fenrg.2020.00110

We also undertook analysis of the data presented in some of these reports to understand the range of potential price premiums on the wholesale cost of bioLPG, rDME and renewable LPG production under different sets of assumptions e.g. different average oil prices.

For example, utilising analysis undertaken by the CEFC and ARENA, at oil prices ranging from approximately USD110/barrel to USD60/barrel we find that the wholesale production of biodiesel/bioLPG is roughly 35% to 55% more expensive than conventional gasoline/LPG.

Further analysis of data sourced from other studies and reports find that wholesale cost premiums for a range of alternative biofuel sources range from as low as 25% to in excess of 130%.

The selection of 25%, 50% and 100% as the wholesale cost premiums for alternative LPG are intended to reflect the range of estimates for the actual and forecast wholesale cost premiums.

Assumed consumption

Our estimate of LPG consumption for a representative Victorian household is based on data from the Residential Baseline Study.[8] We use this to calculate average consumption of LPG for cooking, space heating and water heating. These are shown in **Table 1**.

Table 1: Estimated average household LPG consumption – Victoria

Application		2022
Cooking	MJ/annum	876.64
Space Conditioning	MJ/annum	13,399.49
Water Heating	MJ/annum	11,686.23
Total	MJ/annum	**25,962.36**

Source: Frontier Economics analysis of data from the Residential Baseline Study (RBS)

For electricity, we calculate average consumption based on the assumption that the household requires the same output (heat) as when using LPG. This means that the amount of additional consumption of electricity due to electrification of LPG use is determined by the relative efficiency of electrical appliances and LPG appliances. **Table 2** details the assumed efficiencies.

[8] 2021 Residential Baseline Study for Australia and New Zealand for 2000 – 2040. https://www.energyrating.gov.au/document/report-2021-residential-baseline-study-australia-and-new-zealand-2000-2040

Table 2: Appliance Efficiencies

LPG Appliance Efficiency	Efficiency/CoP	Appliance
Cooking	40%	Gas hob
Space Conditioning	85%	Indoor flued gas heater
Water Heating	85%	Instantaneous
Higher Efficiency Electrical Appliances		
Cooking	75%	Induction cooking
Space Conditioning	2.50	Electrical heat pump
Water Heating	2.00	Electrical heat pump
Lower Efficiency Electrical Appliances		
Cooking	75%	Electric coil cooktops
Space Conditioning	100%	Electric panel heaters
Water Heating	95%	Electrical storage water heating

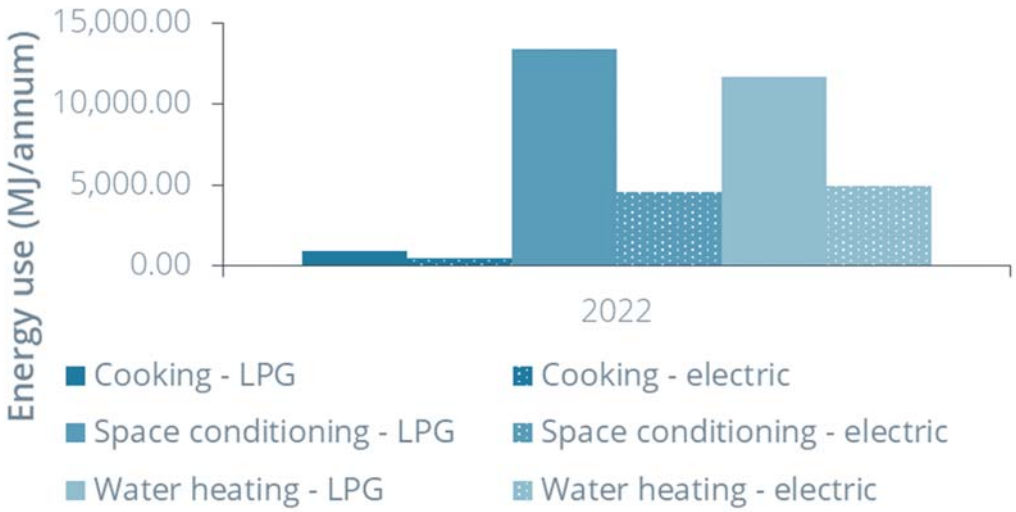
Source: GHD Advisory and ACIL Allen, Economic and Technical Modelling of the ACT Electricity Network, Strategic Report, EPSDD, 26 April 2022; appliances specifications

These efficiencies imply, for instance, that:

- using a higher efficiency electrical appliance for space heating will only require 34% of the energy relative to an LPG indoor flued gas heater, and
- using a lower efficiency electrical appliance for space heating will only require 85% of the energy relative to an LPG indoor flued gas heater.

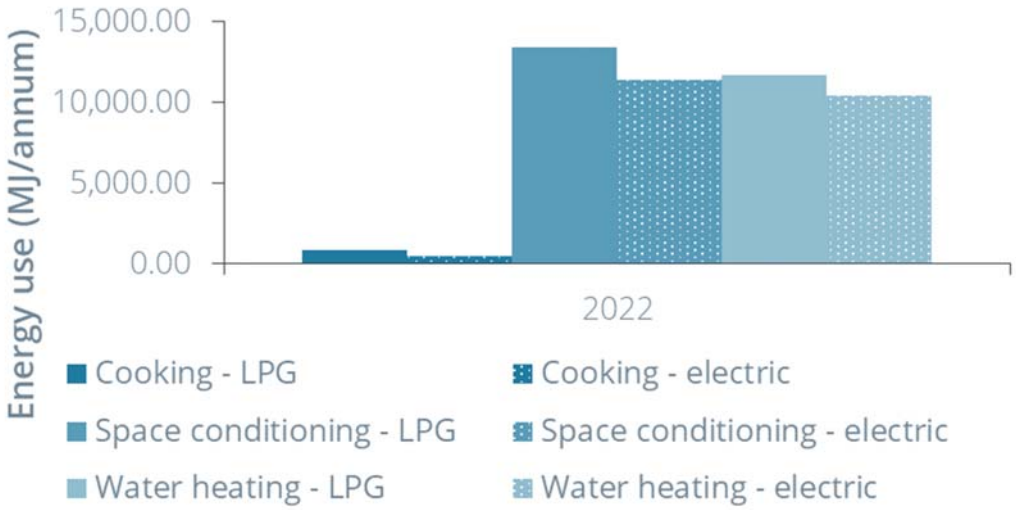
A full comparison of appliance energy use for LPG and electrical appliances is shown for higher efficiency electrical appliances in **Figure 1** and for lower efficiency electrical appliances in **Figure 2**.

Figure 1: Energy usage – LPG and **higher-efficiency electrical appliances** – Victoria



Source: Frontier Economics

Figure 2: Energy usage – LPG and **lower-efficiency electrical appliances** – Victoria



Source: Frontier Economics

Assumed retail prices

We assume our representative Victorian household is located in Swan Hill and use estimates of LPG and electricity retail prices for Swan Hill.

Estimates of LPG prices are from a price comparator website.[9] Taking an average of prices reported on the price comparator website provides an estimate of average LPG prices of 4.47 c/MJ and 10.54 c/day. We assume that wholesale bioLPG, rDME and renewable LPG will have a cost premium of 50% relative to conventional LPG, as discussed above. Estimates also suggest that the cost premium could be between 25% and 100%, so we also discuss scenarios with these higher and lower cost premiums.

Estimates of electricity prices are from Victorian *Energy Compare.*[10] The average of the lowest flat rate tariffs provides an estimate of average electricity prices of 20.75 c/kWh and 116.69 c/day. We include discounted controlled load for storage water heaters based on the same tariff offers. We assume that retail electricity prices will change over time according to AEMO's forecasts of retail electricity prices for Victoria for the Step Change scenario.

Case study results

Energy bills

Based on these assumptions, the representative household in Victoria that switches to electrical appliances will face lower energy bills relative to continuing to use LPG appliances. This is the case regardless of whether the representative household switches to higher efficiency or lower efficiency appliances, although the bill savings are greater when switching to higher efficiency appliances.

This outcome is driven by both differences in retail prices and differences in consumption: despite LPG being cheaper than electricity per unit of energy, this benefit of LPG use is outweighed by the lower energy consumption enabled by electrical appliances.

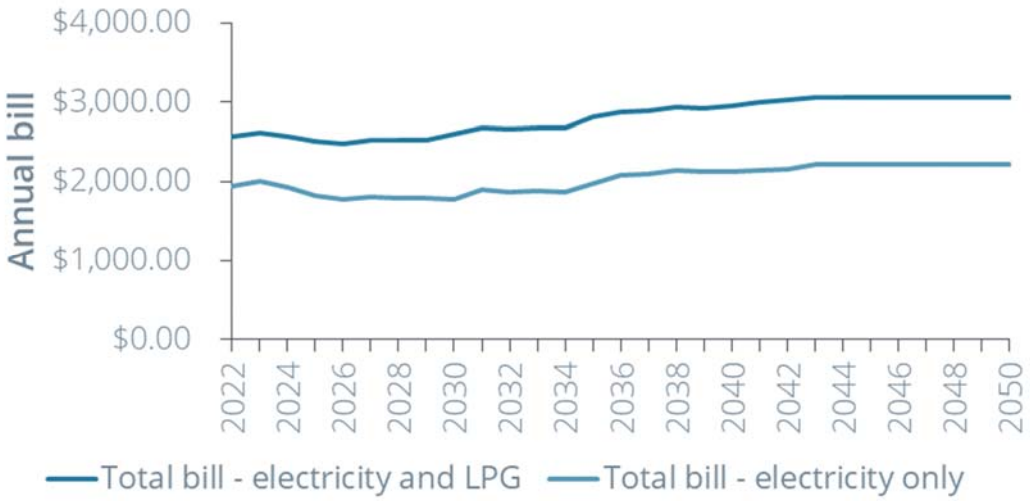
For **higher-efficiency electrical appliances**, the energy bill savings of switching to electricity are initially around $625/annum and increase to approximately $845/annum by the 2040s. **Figure 3** shows the trend in energy cost savings under these assumptions.

It should be noted that part of this energy cost saving from switching is driven by the assumption that wholesale bioLPG, rDME and renewable LPG will have a cost premium of 50% relative to conventional LPG. For a scenario in which wholesale bioLPG, rDME and renewable LPG will have a cost premium of 25% relative to conventional LPG, the energy cost savings will initially be around the same level of $620/annum, but those savings will only reach around $700/annum in the long-term. For a scenario with a cost premium of 100%, those savings will initially be around the same level of $620/annum but will reach around $1,145/annum in the long-term.

9 https://home-lpg-prices.com.au/about/

10 https://compare.energy.vic.gov.au/

Figure 3: Energy bill forecasts for switching from LPG to **higher-efficiency electrical appliances** – Victoria

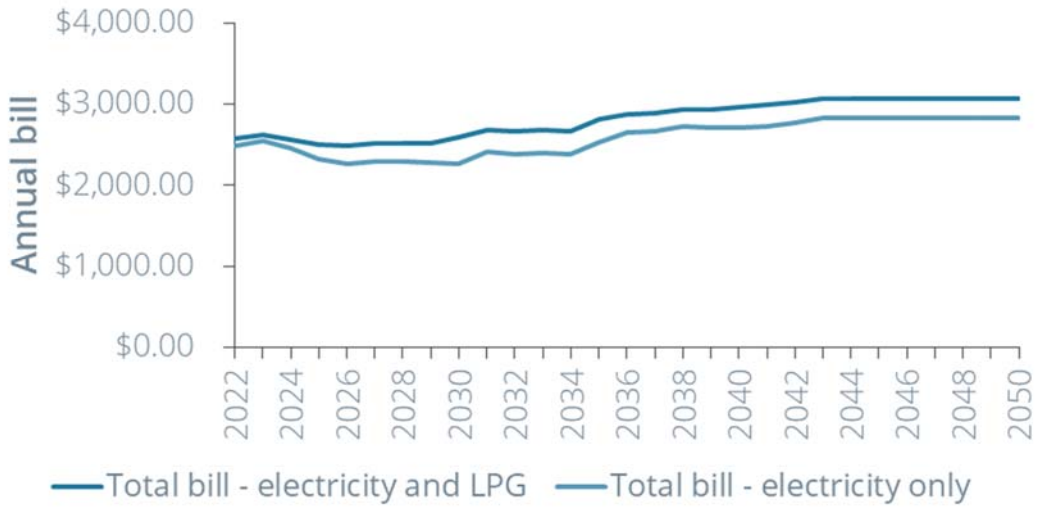


Source: Frontier Economics

For **lower-efficiency electrical appliances**, the energy bill savings of switching to electricity are much lower: initially around $90/annum, increasing to approximately $240/annum by the 2040s. **Figure 4** shows the trend in energy cost savings under these assumptions.

Again, part of this energy cost saving from switching is driven by the assumption that wholesale bioLPG, rDME and renewable LPG will have a cost premium of 50% relative to conventional LPG. For a scenario in which wholesale bioLPG, rDME and renewable LPG will have a cost premium of 25% relative to conventional LPG, the energy cost savings will initially be around the same level of $90/annum and remain around this same level in the long-term. For a scenario with a cost premium of 100%, those savings will initially be around the same level of $90/annum but will reach around $535/annum in the long-term.

Figure 4: Energy bill forecasts for switching from LPG to **lower-efficiency electrical appliances** – Victoria



Source: Frontier Economics

Appliance costs

The costs that households face extend beyond energy bills to also include appliance costs – the 'cost of switching'. Further, the costs of appliances that households face extend beyond just the cost of purchasing new appliances. Households will also face a number of other costs associated with appliance replacement and installation. The potential appliance costs that we consider in this study are:

- 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, including labour and materials.

Estimates of LPG and electrical appliance costs for a representative household are based on Frontier Economics' recent study for the Gas Appliance Manufacturers Association of Australia (GAMAA)[11] and from retail store prices for lower-efficiency appliances. These costs are shown with the detail results of this case study in Appendix A. Note that these appliance costs assume that our representative customer needs to replace all of their LPG appliances in any case – so that costs we are comparing are the costs of purchasing and installing new LPG appliances with the costs of purchasing and installing new electrical appliances. For customers that have LPG appliances that they are happy to continue using, the *additional cost* of switching to electrical appliances is higher.

[11] 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. Available here: https://gamaa.asn.au/

As seen in Appendix A, the cost of electrical appliances depends on whether the customer chooses to purchase higher-efficiency or lower-efficiency appliances.

Higher-efficiency electrical appliances (induction cookers and heat pump water heaters, in particular) are more expensive to purchase than LPG alternatives and are also more expensive to install in houses that are currently using LPG appliances. This results in substantially higher upfront costs for electrical appliances. Amortising these higher upfront costs over the lifetime of these appliances (assumed to be 10 years) at a discount rate of 7% results in an *additional* annualised cost for higher-efficiency electrical appliances of around $1690/annum – $850/annum higher than for LPG appliances.

Lower-efficiency electrical appliances are much more similar to the cost of LPG appliances. Our estimate is that the *additional* upfront costs relative to LPG appliances are in total, relatively modest, at around $600. Amortising these higher upfront costs over the lifetime of these appliances (assumed to be 10 years) at a discount rate of 7% results in an additional annualised appliance cost for lower-efficiency electrical appliances of around $930/annum – $90/annum higher than for LPG appliances.

Rooftop solar and battery storage

We note that in this case study we assume the average Victorian residential LPG customer does not have rooftop solar panels installed and does not have battery storage.

In principle, customers that have rooftop panels installed may be able to make greater use of the electricity generated by these panels (rather than exporting it to the grid) by electrifying their LPG use. This could improve the payoff on their rooftop panels. In practice, however, it is likely that LPG use is not well correlated with times of generation from rooftop solar panels. LPG is used by residential households for cooking, water heating and space heating. These appliances all tend to be used more in the morning and evening than during the daytime, and more in the winter than the summer. This means that customers are less likely to be using these appliances at times when rooftop solar panels are generating at high enough levels to export to the market.

We would also expect that AEMO's forecasts of future retail electricity prices account for the expected high level of investment in renewable generation over the coming decade, so that these electricity prices already assume that pricing during the day (when customers with rooftop solar panels would make use of the electricity generated by these panels) will be relatively low. This will reduce the relative benefit from rooftop solar panels.

It is possible, of course, that customers with rooftop solar panels could also install a battery so that they would be able to make use of the electricity generated by these panels even during the evening (when they are likely to make greater use of the cooking, water heating and space heating appliances). However, the cost of residential batteries is currently very high, and investing in these batteries is unlikely to pay off for many residential customers.

Conclusion

Considering both energy bills and appliance costs, whether remaining with LPG appliances or switching to electrical appliances is lower cost depends on the type of electrical appliances that the customer would choose:

- For customers that would choose **higher-efficiency electrical appliances**, continuing to use LPG appliances remains lower cost for our representative household in Victoria until the 2040s, at which point using LPG appliances and using electrical appliances are very similar in cost. A summary of the results for a representative household choosing today between replacing existing, end-of-life LPG appliances with new LPG appliances or replacing existing, end-of-life LPG appliances with new higher-efficiency electrical appliances is detailed in **Table 3** in Appendix A. This considers outcomes for this household over the next 10 years (the assumed life of their new appliances). As seen in **Table 3**, the upfront cost of electrical appliances is materially higher, so that even though energy bills over the next 10 years will be lower on average with higher efficiency electrical appliances, the total cost over 10 years is lower if the customer remains with LPG appliances. However, total emissions from the use of these appliances (cooking, space heating and water heating) over the next 10 years are higher if the customer continues to use LPG appliances, relative to higher-efficiency electrical appliances, by around 5 tCO2e.

  Assuming cost premiums of 25% and 100% for bioLPG, rDME and renewable LPG still results in remaining with LPG appliances being cheaper over the next 10 years. The only difference is the magnitude of the average total cost savings. Remaining with LPG appliances would result in an average total annual cost saving of around $70/annum and $165/annum respectively under 100% and 25% cost premiums.

- For customers that would choose **lower-efficiency electrical appliances**, continuing to use LPG appliances is slightly higher cost for our representative household in Victoria. A summary of the results for a representative household choosing today between replacing existing, end-of-life LPG appliances with new LPG appliances or replacing existing, end-of-life LPG appliances with new lower-efficiency electrical appliances are detailed in **Table 4** in Appendix A. This considers outcomes for this household over the next 10 years (the assumed life of their new appliances). As seen in **Table 4**, the upfront cost of lower-efficiency electrical appliances is slightly higher, but the forecast savings in energy bills over the next 10 years are greater, so that total costs will be slightly higher on average if the customer remains with LPG appliances. However, total emissions from the use of these appliances (cooking, space heating and water heating) over the next 10 years are much lower if the customer continues to use LPG appliances, relative to lower-efficiency electrical appliances, by around 10 tCO2e.

  Assuming cost premiums of 25% and 100% for bioLPG, rDME and renewable LPG still results in remaining with LPG appliances being more expensive over the next 10 years relative to switching to lower-efficiency electrical appliances. The only difference is the magnitude of the average total cost savings. Switching to lower-efficiency electrical appliances would result in an average total annual cost saving of around $90/annum and $185/annum respectively under 25% and 100% cost premiums.

Key uncertainties

There are, of course, a range of uncertainties with this case study that should be noted:

- **Costs of electricity**: forecasts of electricity prices, and hence energy bills, are based on AEMO's forecast of retail electricity prices under the Step Change scenario. These forecasts

predict electricity prices to fall over the next 10 years. We note, however that expectations following recent market events are that retail electricity prices will increase materially (at least in the near term) which would affect the results of this case study significantly (improving the financial outcomes from remaining with LPG relative to electrical appliances).

- **Speed of emissions reductions**: emissions forecasts with respect to electricity usage are also based on AEMO forecasts, specifically the Step Change scenario. This scenario has been identified as the most likely by industry stakeholders. However, there is still significant uncertainty about whether the rapid emissions reductions from electricity generation over the next 10-years will be achieved as forecast. The relative performance of LPG appliances with respect to emissions would improve if emissions reduction was less than in the Step Change forecast.
- **Speed and costs of transition away from conventional LPG**: there is still considerable uncertainty with respect to how the technological and commercial readiness of several alternative LPG sources will develop over coming years and decades. If given technologies were to under-perform or over-perform relative to the assumptions made in the transition pathway, this would have significant impacts on the both the cost and emissions intensity of using LPG in our this case study.

A Household Case Study Summary Results

Higher-efficiency electrical applications

Table 3: Summary of results – customers that choose **higher-efficiency** electrical appliances

	Upfront appliance cost *	Annualised appliance cost (10 years, 7%)	Average annual bill 2023 to 2032 (real dollars)	Average total annual cost (2023 - 2032)	Total emissions over 10 years
LPG and electricity case					
Cooking (LPG hub)	$1,200.00				
Space heating (LPG indoor flued heater)	$2,799.00				
Water heating (LPG instantaneous)	$1,900.00				
Total	$5,899.00	$839.88	$2,565.19 **	$3,405.08	35.38
Electricity only case					
Cooking (induction)	$2,346.67				
Space heating (heat pump)	$4,925.00				
Water heating (heat pump)	$4,600.00				
Total	$11,871.67	$1,690.26	$1,846.86	$3,537.12	30.71 ***

** Includes removal of existing appliance, new appliance purchase and installation) ** includes LPG costs and electricity bills *** Step Change scenario*

Lower-efficiency electrical applications

Table 4: Summary of results – customers that choose **lower-efficiency** electrical appliances

	Upfront appliance cost *	Annualised appliance cost (10 years, 7%)	Average annual bill 2023 to 2032 (real dollars)	Average total annual cost (2023 - 2032)	Total emissions over 10 years
LPG and electricity case					
Cooking (LPG hub)	$1,200.00				
Space heating (LPG indoor flued heater)	$2,799.00				
Water heating (LPG instantaneous)	$1,900.00				
Total	$5,899.00	$839.88	$2,565.19 **	$3,405.08	35.38
Electricity only case					
Cooking (electric coil cooktops)	$1,733.33				
Space heating (electric panel heaters)	$1,197.00				
Water heating (electrical storage water heating)	$3,590.00				
Total	$6,520.33	$928.35	$2,353.53	$3,281.88	44.98 ***

** Includes removal of existing appliance, new appliance purchase and installation) ** includes LPG costs and electricity bills *** Step Change scenario*

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