Gas or Electricity: An Evaluation of Electricity and Natural Gas as a Residential Energy Source

The Alternative Technology Association

Sponsor

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by

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Abstract

Australian natural gas prices are projected to increase 30-50% by 2030, leaving many residential consumers with higher cooking and heating expenses. The Alternative Technology Association (ATA) recognized this impending increase and is seeking ways for consumers to reduce the costs of cooking and heating. ATA is creating a financial model to determine the cost of energy for consumers in the future. Our goal was to assist ATA in informing consumers of cost efficient cooking and heating appliances. For their model, we determined initial and consumption costs of each of three electric appliances: cooktops, hot water heat pumps, and reverse cycle air conditioners. Through a series of fact sheets, we suggested how different households could save money on their energy bills.

Acknowledgments

This project has been made possible by the contribution of several individuals. We would like to acknowledge these individuals that have supported our research and findings over the past 5 months.

We would first like to thank our sponsoring organization, the Alternative Technology Association, ATA for giving us the opportunity to complete this project. Specifically at the Alternative Technology Association, Craig Memery has been our liaison. We would like to thank him for providing us with ample opportunities to learn more about the energy market in Australia and present our data and knowledge through ATA's magazine and an Australian radio network. In addition, we would like to thank Kate Leslie for leading us in finding all necessary data to determine energy and appliance costs.

Next, we would like to acknowledge the professors at Worcester Polytechnic Institute that have made our project possible. We would like to give a special thanks to our project advisors, Andrew Klein and Seth Tuler for playing a key role in the development of our proposal and project report. Lastly, a thank you to our Melbourne project center coordinator, Holly Ault for making our Australia project experience possible.

Executive Summary

Australian residential consumers use natural gas and electricity as sources of energy to run their cooking and heating appliances. Currently, a commonly used source of energy for home cooking and heating is natural gas. To consumer's dismay, natural gas prices are predicted to increase as the Australian east coast begins exporting gas (Chambers, 2013). In the last 15 years, natural gas prices have increased 140% to about 4 dollars per gigajoule and forecasts predict that prices will increase 30-50% by 2030, making natural gas less affordable for residential consumers (ABS, 2013). When natural gas prices rise, consumers will need a more affordable source of energy to power their cooking and heating appliances.

The Alternative Technology Association (ATA) is a consumer advocacy organization trying to provide consumers with more information about how to save money on home energy bills by using more energy efficient appliances and energy sources. ATA researched the alternative of electric appliances instead of gas appliances to save money and increase energy efficiency. ATA was interested in the function of three electric cooking and heating appliances because they accommodate the highest percentage of consumer energy bills: hot water heat pumps, reverse cycle split system air conditioners, and cooktops. To support a goal of ATA's, understanding and informing consumers of what options are available to them and what is affordable, we assisted their efforts to analyze the affordability and reliability of natural gas and electricity for household energy consumers.

Methodology

The goal of our project was to assist the Alternative Technology Association's efforts to inform residential energy consumers of the most cost efficient form of energy for the use of cooktops, heat pumps, and split system air conditioners. Determining the most cost efficient form of energy was important because it aimed to help residential consumers save money on energy costs. The following objectives were accomplished to meet our goal:

1. Compiled current natural gas and electricity pricing along with existing long-term forecasts of supply, demand, and price projections in the residential sector of Australia.
2. Characterized standard natural gas and electric cooktop, heat pump, and split system air conditioner costs as they apply to initial investment, operation cost, and asset life for household use.
3. Examined specific cooktop, heat pump, and split system air conditioner appliance model performances based on climate and energy efficiency.
4. Used the compilation of project data and ATA's "Round Arm Swing Model" to create fact sheets that inform consumers about the most affordable form of household energy.

Our first three objectives focused on gathering data for ATA's "Gas Project Model" to evaluate the exact costs consumers would pay for gas and electricity. Current residential natural gas and electricity prices, current appliance costs and capabilities, and current natural gas price projections were compiled for ATA's model. The current natural gas and electricity prices were found through each of the organizations that distribute energy. The appliance costs and prices were found through a series of consumer reviews on websites such as Choice.com. After gathering a list of popular appliances, research was done to find the coefficients of performance and functionality of the appliances in different climates. Natural gas price projections were gathered from a series of presentations at the PIAC Gas Master class. At the master class, our team was able to gain an understanding of Australia's energy market and understand what will happen to gas prices if Australia decides to export more of its natural gas. All of the data provided to ATA served as inputs for their "Gas Project Model." With these inputs, ATA determined the choices consumers should make about whether to convert from gas to electric appliances and how to save money on energy bills.

In order to accomplish objective four, we created a series of fact sheets catering to ten different audiences. The first fact sheet described what is going on in the current energy market to inform consumers of gas price increases. Three fact sheets described each of the three cooking and heating appliances: cooktops, heat pumps, and split system air conditioners. Prices, installation advice, and benefits of switching to the electric appliances were indicated in these three fact sheets. Six more fact sheets were described for homeowners in certain situations, such as consumers building new homes. With consultation from ATA's modeling specialist and liaison of our project, we determined a series of messages to convey to consumers in the fact sheets.

Results and Discussion

Our results are divided into two parts, "Part 1: Gathering data for fact sheets" and "Part 2: Creating fact sheets." Part 1 included current gas and electricity prices throughout Queensland, New South Wales, Victoria, Tasmania, and South Australia. Part 1 also included current natural gas and electricity price forecasts. Through research, we discovered that residential energy consumers should expect a $40-170 increase in their annual gas bills. Residents living in Victoria will experience the highest increase in gas prices because most Australian gas consumption resides in Victoria (Jones, 2014).

We have found that the electricity market has faced price increases over the past decade, however electricity will be a successful alternative to gas in the future. By comparing the coefficient of performance of electric and gas appliances, electricity have proved to be 3-4 times more efficient than gas (Power knot, 2014).

Overall, we found three main reasons that electricity is a viable option for residents wanting to convert from household natural gas usage. First, we found that electricity is able to meet peak demand, meaning there is more than enough energy to generate and provide to residents (Hughson, 2014). Second, there is also an instantaneous match of supply and demand within the market (Hughson, 2014). Third, electricity is connected to most premises across Australia (AER, 2013). Our findings have allowed ATA to put useful tariff and projection data into their model in the hopes of determining which form of household energy will be the most affordable in the future. However, energy prices are not the only determinant of whether or not gas or electricity is the best option for most consumers. A large contribution to determine affordability and reliability is the efficiency of appliances.

To determine the efficiency of gas and electric appliances the coefficient of performance was found. The coefficient of performance relates the energy output to the energy input. After researching both gas and electric appliances for cooking, heating water, and heating spaces, we found that electric appliances are more efficient over time. For all home cooking and heating, space heating uses 45%, water heating uses 25%, and cooking uses 2-4% of total household energy. For space and water heating, electric heat pumps are significantly more efficient than gas heaters. Electric heat pumps typically have coefficients of performance of 3-5 and gas heaters have coefficients of performance of only 0.8-0.9. Based on the percentage of use of household energy, we found that when replacing appliances, consumers should first replace their space heaters, then water heaters, and lastly, cooktops.

After finding gas and electricity prices, projections, and appliances for ATA's model, we created fact sheets. The fact sheets provided suggestions and considerations that consumers should know about converting from gas to electricity. We consulted our liaison and ATA's modeling expert to determine what each audience should be told. Using their knowledge we created ten audiences that the fact sheets would target. Each audience was provided with personalized conversion information, conveying the most cost-efficient energy source and conversion plan to suit them. Using the messages determined by the ATA liaison, ATA modeler, and WPI team, we created informative and aesthetically pleasing fact sheets.

Conclusions and Recommendations

Upon the completion of this project, we identified five recommendations for ATA. Using these recommendations and suggestions could improve ATA's study and provide more accurate data. ATA will be able to help consumers save more money on their energy bills and provide adequate guidance about converting from gas to electric appliances.

The first recommendation involved gas and electricity tariffs. ***We recommend*** that ATA account for elasticity of demand in their models. Just as there are methods to forecast energy prices, there are methods to forecast the value of the dollar. Although our project group is unfamiliar with the specifics of economic modeling, we can draw the importance of this recommendation and a conclusion stating that ATA's modeling would me more accurate if elasticity of demand was taken into account. If this is done, ATA could better understand how the energy price forecasts directly affects residential energy consumers.

Our second recommendation dealt with climate zones. ***We recommend that*** ATA look into the approach taken by the 2012 Pitt & Sherry report, *Running Costs and Operational Performance of Residential Heat Pumps* (Ford, 2012). Using this report, they should analyze how the different climates across Australia showed different temperature and weather patterns. This is important because it will help ATA synthesize their data and provide accurate representations of appliance performance across the different climate zones in Australia.

The next recommendation that we generated involved appliances. ***We recommend*** to ATA that they clearly define all the model scenario parameters by focusing on specific brand name appliance models that can be identified for use in specific household types. If this is done, ATA may be able to find a way to reduce the number of assumptions that are made about appliance conversion scenarios. It is very important to reduce the amount of assumptions in a research study and modeling effort because the model will then produce more accurate data.

Next, we identified a recommendation regarding consumer appliance usage. ***We recommend*** that ATA gather a larger sample size and create a logbook for consumers to use. This logbook would allow consumers to record how long and at what intensity they use their appliances. ATA would then use the logbooks as input for their economic models to provide more accurate results. We concluded that the sample size increase and logbooks are so important because it helps eliminate the amount of assumptions throughout ATA's research and modeling efforts.

The fifth recommendation that we have identified for ATA involves fact sheets. We believe that the fact sheets that we created have very useful information on them, however they can be improved with more accurate data from ATA's "Gas Project Model". ***We recommend*** that ATA look at the modeled scenarios from their financial model and provide more specific information to the audiences specified on the fact sheets. We concluded that this is important to ATA, as well as the consumers, because with conclusive data and information on the fact sheets, consumers can take the recommendations from ATA based on accurate projections of the gas and electricity markets.

With these five recommendations, there will be more accurate information conveyed to residential energy consumers considering a household energy conversion. ATA will therefore better their efforts in informing consumers of the most cost effective form of household energy.

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Chapter 1: Introduction

Consumers throughout the world need affordable and reliable forms of household energy. Energy is essential to meet the heating and cooking needs of household residents in developed countries. However, the energy costs of important sources such as natural gas and electricity fluctuate, challenging consumers to find the most affordable source of energy. Market forces such as export demands, political policy, and global conflict can cause drastic price changes in common energy sources (CUAC, 2013).

Natural gas and electricity are common energy sources that compete to control the residential energy market (Energy, 2014). Although they are common sources, their prices are not always low. As electricity and natural gas supplies and markets evolve, future energy prices for both natural gas and electricity may influence homeowners in different countries to evaluate their type of current household energy. For example, as the wholesale price of natural gas begins to increase, retail prices for natural gas may become too expensive for many residential consumers (Carter, 2014).

This natural gas price increase is currently projected to occur in the east coast residential sector of Australia. According to the International Energy Agency, over two-thirds of the global natural gas investment is in Australia (Ward, 2013). Due to recent discoveries of extremely large natural gas reservoirs, Australia is projected to overtake Qatar to become the world's largest exporter of natural gas as soon as 2017 (Evans-Pritchard, 2013). Australia plans to export a large amount of their domestic natural gas supply, leaving a lower amount of domestic natural gas for local residents. Energy market analysts predict a significant increase in natural gas prices when Australia begins exporting natural gas (Chambers, 2013). In the last 15 years, natural gas prices have increased 140% to about 4 dollars per gigajoule and forecasts predict that prices will increase 30-50% by 2030, making natural gas less affordable for residential consumers (ABS, 2013).

Although wholesale prices of natural gas are important to observe in the market, the increase in retail prices will greatly affect the residential sector of Australia. Residents may see significant price increases in their energy bills (Grattan Institute, 2013). Because of the natural gas price increase, homeowners may seek electricity as an alternative form of energy to power their household appliances. In Australia, 99.9% of homes are connected to the electricity network (ABS, 2010). Therefore, the stage is set for dual-fuel households to convert their natural gas consuming appliances with highly energy efficient electric alternatives to heat spaces, heat water, and cook food.

The misconception that has been recognized by consumer advocacy organizations in Australia is the conventional thought of many residents that natural gas is the cheapest and most reliable source of residential energy. Although this thought has been valid since the 1970's, natural gas price forecasts are now showing large increases in price (CUAC, 2013). With the east coast market seeking to export a large amount of their domestic supply, there may be gas shortages in a few states, namely New South Wales, by 2018 (AGL, 2014). Along with the gas market, the electricity market shows prices are falling, and the efficiency of electric appliances is increasing (Powerknot, 2014).

In determining electricity as an affordable and reliable source of household energy, consumer advocacy organizations, such as The Alternative Technology Association (ATA), have begun to advocate information to consumers about a more cost effective energy source than natural gas to heat spaces, heat water and cook food. ATA recognized that consumers might not know the most affordable source of household energy and appliances. Therefore, this organization plans to use their economic "Gas Project Model" to quantify the monetary costs and savings of dual-fuel households converting to strictly electric appliances.

To support one of ATA's goals of understanding and informing consumers of what options are available to them and what is affordable to them, we assisted their efforts to analyze the affordability and reliability of natural gas and electricity for household energy consumers. Our contribution helped ATA communicate informed decision making options to consumers. ATA provided residents with accurate, evidence-based suggestions regarding energy and appliance options for homeowners to make cost effective energy choices. We first analyzed and interpreted the long-term price forecasts of the natural gas and electricity markets to understand what the prices may be by 2030. Then, we compared the performance and affordability of natural gas and electric appliances used to heat space, heat water, and cook food. This information is assisting ATA's larger modeling project in determining whether natural gas or electricity is the most cost effective option for household uses and applications. Our gathered information was input for the "Gas Project Model" by taking into account the initial cost, installation cost, maintenance cost, and continuous usage cost of three different appliance types: hot water heat pumps, split system, reverse cycle air conditioners and induction cooktops. Once the affordability and performance statistics were provided as model inputs, a series of informational materials were created to communicate the data to consumers. The informational materials, consisting of fact sheets, spread sheets and a magazine article in ATA's *ReNew Magazine* provided consumers with knowledge about which appliances and energy sources were cost effective. ATA will distribute this information to consumers and inform them of affordable and reliable sources of residential energy in order to save money. With the completion of this project, we gave ATA knowledge to inform consumers and support their own energy advocacy efforts.

Chapter 2: Background

This chapter focuses on the general aspects surrounding the current and forecasted natural gas and electricity markets in Australia. The current availability of energy supplies and the residential demand for energy in households across Australia are presented as data and analyzed. After the presentation of current energy supply and demand, the factors that influence fluctuations in demand will be highlighted. This chapter also explains how different appliances, household characteristics, and climate can affect the affordability of natural gas or electricity as a household energy that are used to heat homes, heat water, and cook food.

2.1 Current supply and demand of natural gas and electricity in Australia

According to the Australian Bureau of Statistics (ABS), natural gas and electricity are the two main household energy sources in Australia (ABS, 2013), as shown in Figure 1. Other sources such as liquid petroleum gas (LPG) and solar energy are used as residential energy, but are insignificant for an evaluation of major household energy sources due to their low usage when compared to electricity and natural gas. The natural reserves of gas in Australia are some of the largest in the world. As a result of resource availability, natural gas and electricity continue to compete as household energy sources. This section further evaluates the current supply and demand of natural gas and electricity in Australia by observing gas as an available commodity, electricity as a current supply, the distribution of both energy types, and the total residential energy demand in Australia.

2.1.1 Residential energy demand in Australia

Household energy consumption varies throughout different states in Australia. The major energy options for most residents are electricity, gas, bottled gas, and solar power. Figure 1 illustrates the type and amount of residential energy used across Australia as a whole (ABS, 2012).

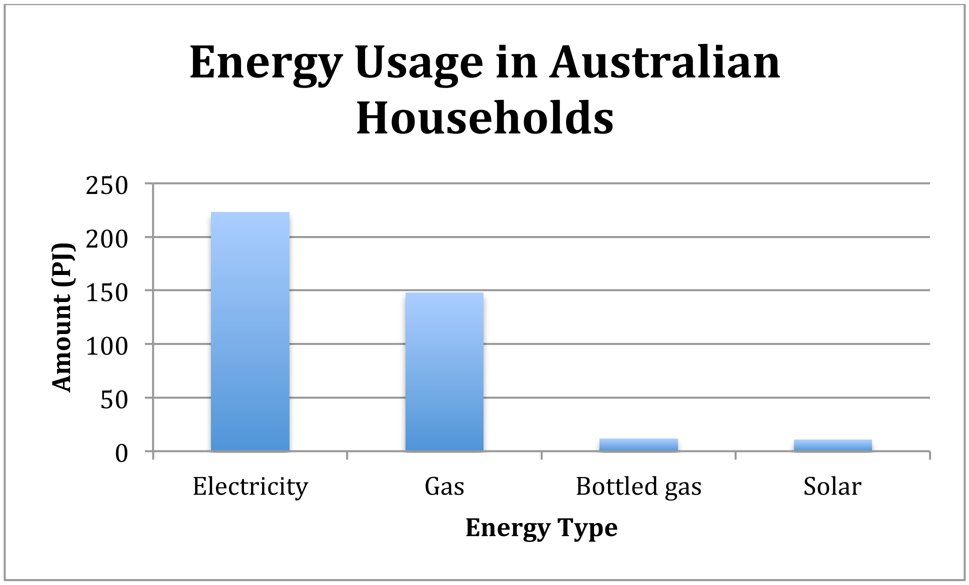


Figure 1: Energy usage in Australian households

The figure shows both electricity and natural gas are in high demand based on their usage. As seen in Figure 1, electricity is the most used energy source in homes. Although this data may seem dated, as energy consumption has shown significant changes in the last two years, electricity still remains as the highest consumed household energy option (CUAC, 2013).

Electricity is generated from a number of other energy sources. Around 89% of Australia's electricity is generated from fossil fuels, while the remaining 11% is generated from renewable sources such as hydropower, wind power and solar power (Origin, 2014). Electricity is currently the most used residential energy supply throughout Australia. Almost all (99.9%) of homes use electricity as part of their home energy use (ABS, 2010).

A major difference between the graph shown above and current data is that solar energy accounts for a larger amount of household energy consumption. Approximately 80% of household electricity is dedicated to four segments in homes (South Australian Government, 2013):

- Heating and cooling
- Water heating
- Other appliances around homes
- Refrigerators and freezers

In terms of natural gas, over 61% of homes have one or more gas appliance installed, while in Victoria that number climbs to 90% (Energy Consult, 2011). Over the past 50 years, gas source energy has become the second most popular energy type in Australia behind electricity (Australia Pacific LNG, 2014). It is estimated that Australia has over 800 trillion cubic feet of total gas resources including both conventional and unconventional gas (Appea, 2014). Pipelines and infrastructure systems, have allowed natural gas to become a form of energy that is affordable, convenient, and reliable to households across Australia.

The demand of both energy forms varies in different times of the year and throughout different climate zones due to consumer behavior and the appliances performance based on the climate it operates in. Figure 2, seen below, elaborates on the household energy demands by showing distribution of residential energy usage across Australia in respect to each state. It depicts the usage of bottled gas, natural gas and electricity residential energy types in each state or territory ("Household energy use and costs." 2012).

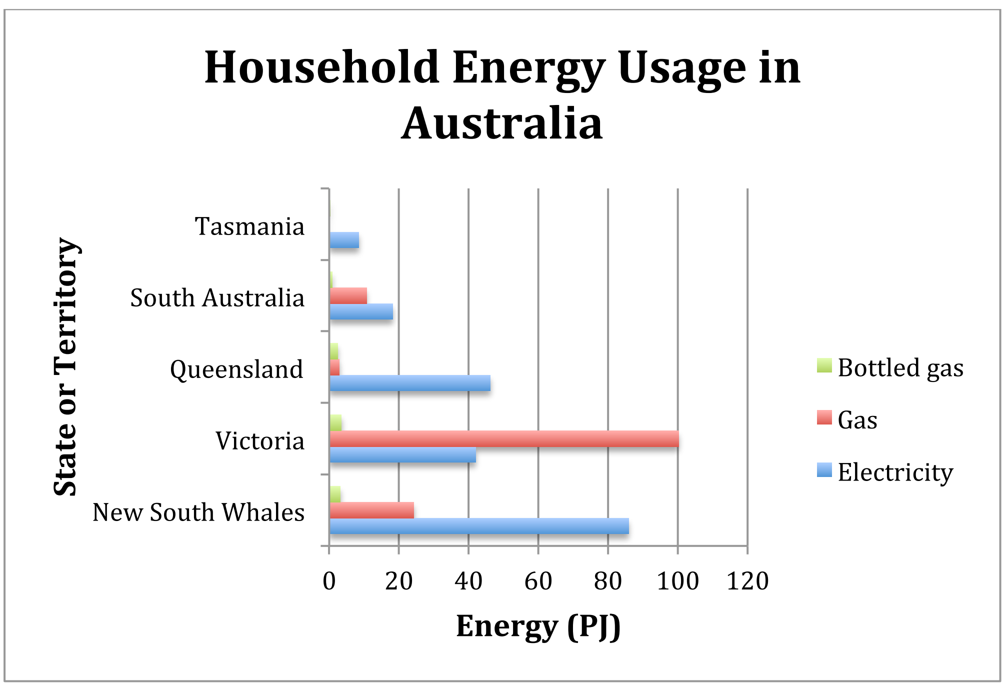


Figure 2: Different household energy usages and amounts (2012)

Figure 2 shows that the demand for each energy type varies greatly throughout Australia. It can be seen that New South Wales, Victoria, and Queensland consume the most residential energy in Australia. The variation is influenced by factors in the market that can be observed when analyzing the demand for both gas and electricity in the residential sector. Overall, types of residential energy vary greatly by location.

2.1.2 Energy distribution across Australia

The Australian Energy Market Operator (AEMO) is responsible for managing energy so that a reliable supply is delivered to energy distributors (AEMO, 2014). There are four markets that AEMO uses to source and distribute its energy:

- The National Electricity Market
- The Declared Wholesale Gas Market
- The Gas Short Term Trading Market,
- The Energy Retail Market.

Each market is based on bilateral arrangements between producers, major users, and retailers. Pipeline hubs and generators connect consumers to the gas and electricity networks (AEMO, 2014). Energy distribution across Australia is very complex because of the vast area in which consumers require energy, the process in which the energy is delivered, and the wide array of distributors within the markets.

Beginning at the generation and extraction stage, electricity and gas are sold in wholesale spot markets. Electricity is generated in the National Electricity Market (NEM) and sold in a market that covers Queensland, New South Wales, Victoria, South Australia, Tasmania and the ACT (AER, 2014). Similarly, gas is also sold in a wholesale spot market for gas in Victoria. However, gas is sold in a short term trading market for gas in Sydney, Adelaide and Brisbane (AER, 2014).

After the extraction or generation of energy, gas or electricity is transported to consumers through a series of electricity networks and gas pipelines. The electricity networks and gas pipelines have service providers that provide energy infrastructure and transportation services (AER, 2014)

Lastly, the consumer is billed for their energy usage through the retail energy market. "Energy retailers buy electricity and gas in wholesale markets, package it with transportation services and sell it to customers. This is typically the main interface between the electricity and gas industry, and the consumers," (AER, 2014). As a result of this distribution system, AEMO is able to record the supply that is delivered to consumers and overall determine the residential energy demand for different locations throughout Australia (AEMO, 2013).

2.2 Factors that influence differences in residential energy demand

Governments, energy organizations and energy advocacy organizations regularly evaluate the demand for residential energy because household energy demand fluctuates. Variations in the market demand are influenced by many factors such as building size, number of new household connections, and efficiency of building appliance systems, however for the purpose of a household energy evaluation, we focused primarily on household type, distribution network zone location, pricing, and climate.

2.2.1 Different household types across Australia

Household types influence the demand for residential energy. Households can be divided into three major categories: households containing a family, lone person households, and group households (AIFS, 2001). Figure 3 displays the different household types throughout Australia (AIFS, 2001).

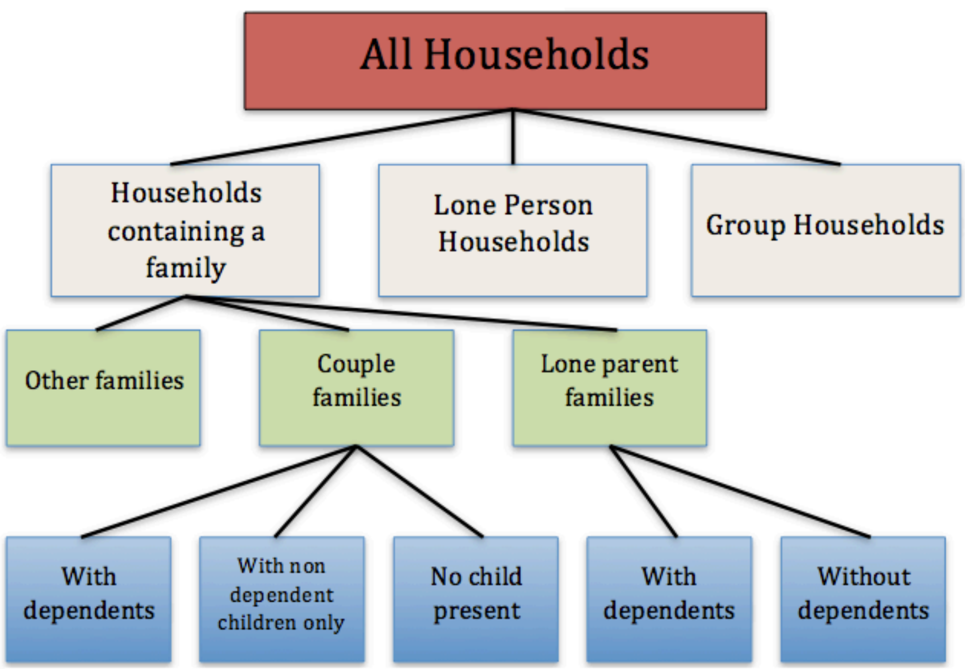


Figure 3: Household family types (AIFS, 2013)

Each household type can use a different amount of energy. The number of people in the home generally correlates with the amount of energy that is used (St. Vincent's De Paul Society, 2013). The more people there are in a home, the more energy is used. Although family size is important in determining residential energy demand, the actual location of the home and the zone in which it resides in Australia affects a consumer's energy usage. For example, zones have differently priced energy and the consumer tendencies of heating preferences, which may change as climates become warmer or colder.

2.2.2 Price differences in gas zones and electricity network areas

Gas and electricity is provided to consumers through a series of networks. The networks are divided into distribution zones. The Australian Energy Regulator (AER) regulates the distribution zones and provides information about the networks available in Australia. AER provides publications about both the gas and electricity zones, which documents the demand within, and location of each zone. The areas designated for gas distribution and electricity distribution is not the same. Figure 4, below, provided by the AER, illustrates the gas distribution networks by zone. It signifies each gas distributer and the locations they control. There are a total of 8 gas distributors in eastern Australia (AER, 2013). Not all of Australia has access to gas. The highlighted areas below show where gas is available. Gas is unavailable in other areas due to there being low population in that area or the prohibitive costs of expanding the network (AER, 2013). Such costs would be passed down to the consumers, making the energy exponentially more expensive.

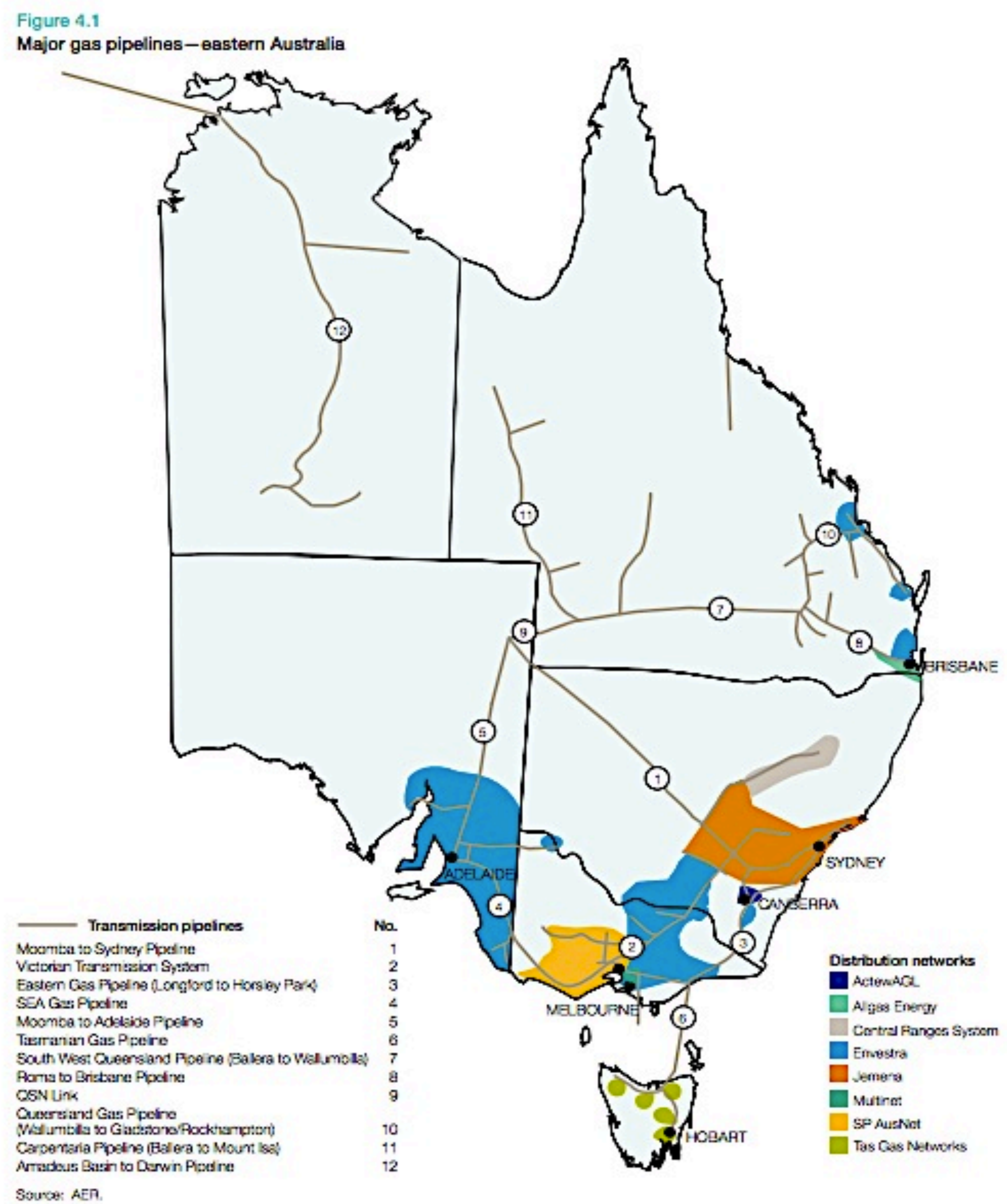


Figure 4: Map of gas distribution network (AER, 2013)

Electricity distribution is significantly more wide spread that gas distribution. The AER electricity distribution map below is divided by states and by individual distributers. There are 9 distributors across Queensland, New South Wales, the ACT and Victoria (State of the Energy Market, 2009).

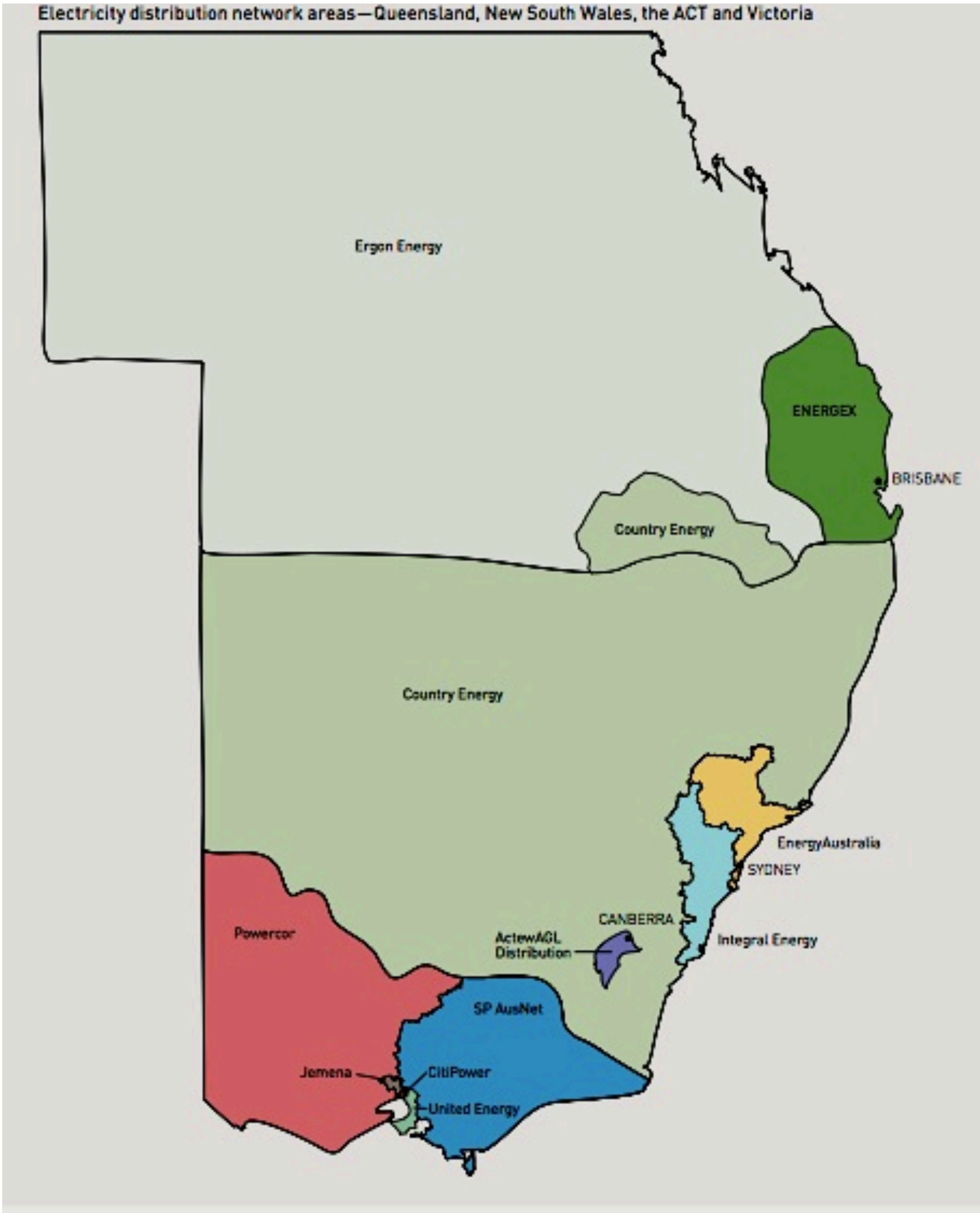


Figure 5: Map of electricity distribution network zones (AER, 2012)

Among the distributors and zones across Australia, the prices of gas and electricity differ. Australia defines the prices of gas as tariffs. A tariff is defined as the price of energy under a contract (Energy Made Easy, 2014). Tariffs have two specific parts: a fixed charge and a variable charge. A fixed charge is often called the service charge and is a fixed everyday charge that does not consider how much energy is used. The variable amounts depend on inclining and declining blocks. These blocks are based on consumer consumption of either electricity or gas. Typically, as more energy is consumed, the variable block price will change. In the case of declining blocks, the price will become lower, whereas inclining blocks cause the price to become higher (St. Vincent de Paul Society, 2014). Blocks also cover the maintenance and operational costs of the energy network. The amount of energy used is considered by the variable charge. The variable charge quantifies the price of electricity by cents per kilowatt-hour (c/kWh) (Energy Made Easy, 2014).

2.2.3 Forecast gas and electricity demand and prices due to possible LNG exports

The prices for gas and electricity within each zone described in section 2.2.2 are not stable. They are subject to change and are expected to vary within the next fifteen years. Organizations, such as AEMO, have made household natural gas and electricity demand price projections for the future of both markets (AEMO, 2013). These projections estimate substantial changes. The price changes overall affect the demand of both residential energy forms.

There is a forecasted large-scale price increase for household gas due to the expected eastern Australia gas market export (Carter, 2014). By 2017, Australia has the potential to create the world's largest LNG export industry. Australia has been considered to have low LNG prices by world standards charging in between four and six dollars per gigajoule (AEMO, 2011). European countries and Japan are recorded to charge twice as much as Australia for residential natural gas (Knoema, 2014). However, when a supplier can receive a higher price for exporting their product rather than selling it on the domestic market, the domestic price may also rise to match the export price ("LNG to push up household costs", 2013). Should Australia's eastern gas market trade internationally, the export price has the potential to raise the domestic price. Figure 6 shows the forecast prices by state in 2020 compared to recorded prices in 2010.

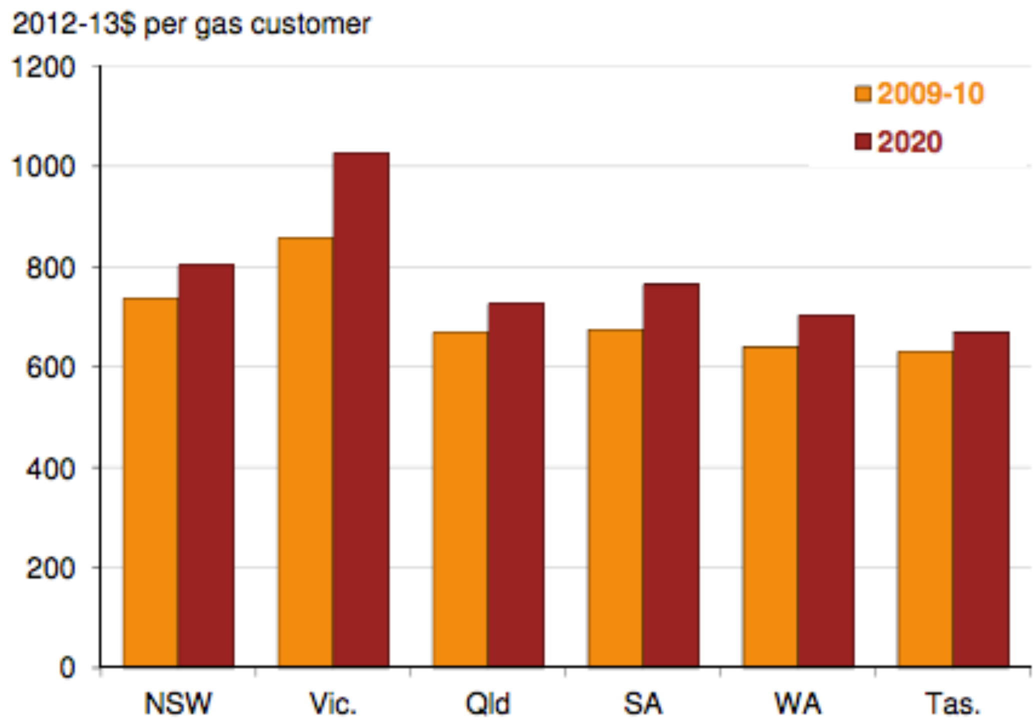


Figure 6: Forecast gas prices by state (Grattan Institute, 2013)

Australia's domestic energy price increase relates to the high demand of residential energy. There is an expected significant increase in gas demand on the east coast of Australia because of the development of LNG export facilities in Queensland (Nelson & Simshauser, 2014). Currently, domestic gas demand is around 700 PJ/a. However, with the completion of 3 LNG terminals in Gladstone in three years, the demand is expected to rise to about 1440 PJ/a (Nelson & Simshauser, 2014). Figure 7 shows this expected demand increase.

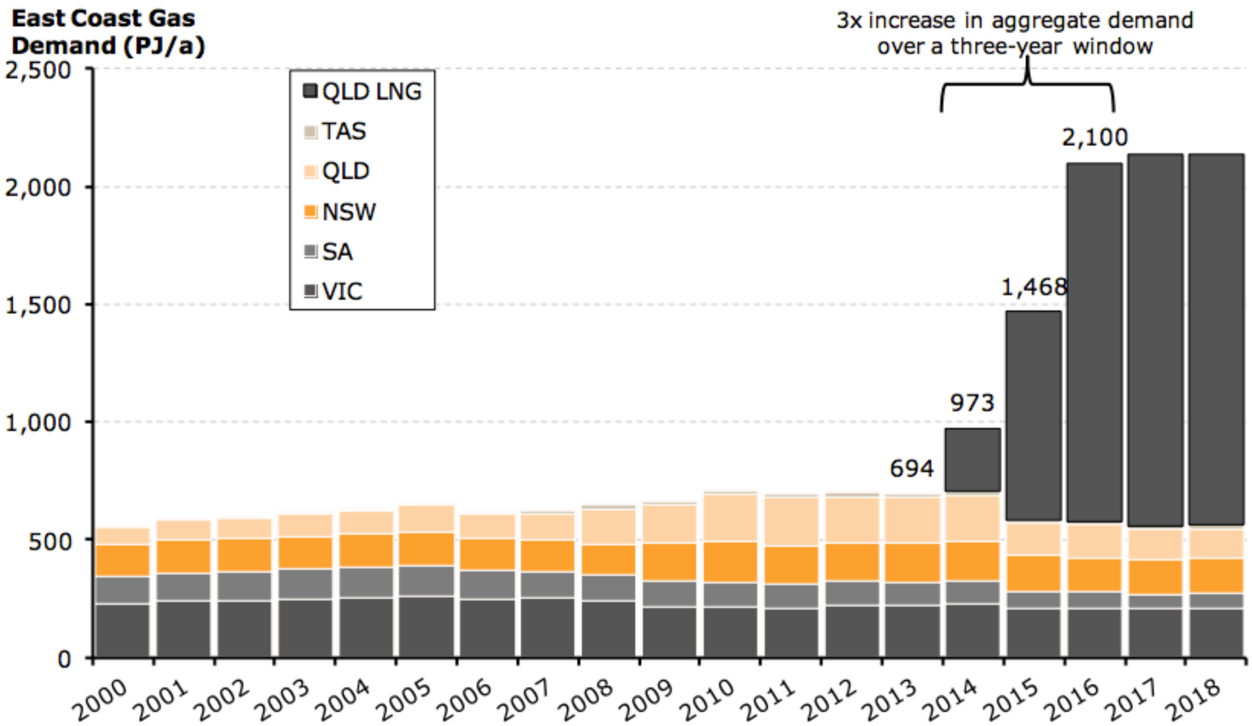


Figure 7: Forecast of east coast gas demand increases (AGL, 2014)

It can be seen from the demand forecast that there is a three-year window from 2014 to 2017 in which the demand for gas is expected to increase almost three fold. This very large demand correlates with the price increases shown in Figure 6 because as the demand increases heavily for a product and the supply remains constant, the price will significantly rise.

Increasing price and demand of gas may impact the electricity market. Currently, electricity prices are rising in the anticipation of a heavy demand for household electricity due to the projected gas price increases (Carter, 2014). Australia can meet the needs of the high electricity demand, as the country has a reliable source of electricity generation (Hughson, 2014). Over the last 8 years, there has been an average 14% annual price increase of residential electricity use (Peirce, Henderson, & Spalding, 2010). This increase in price relates to the increase of demand throughout Australia. Interestingly, a price increase is also seen in the electricity market even though consumers have been using less electricity (Carter & Wood, 2014). Even with a reduction in electricity consumption the average annual household power bill increased over 85%, causing consumers to pay upwards of

$1600 in electricity per year (Carter & Wood, 2014). It is projected that the price will plateau, however, as electricity becomes the cheaper household energy option along with higher efficiency of appliances, as described in Section 2.4. By comparing Figures 6 and 8, electricity is estimated to have a lower price increase when compared to gas. The forecasted electricity price path can be observed below in Figure 8.

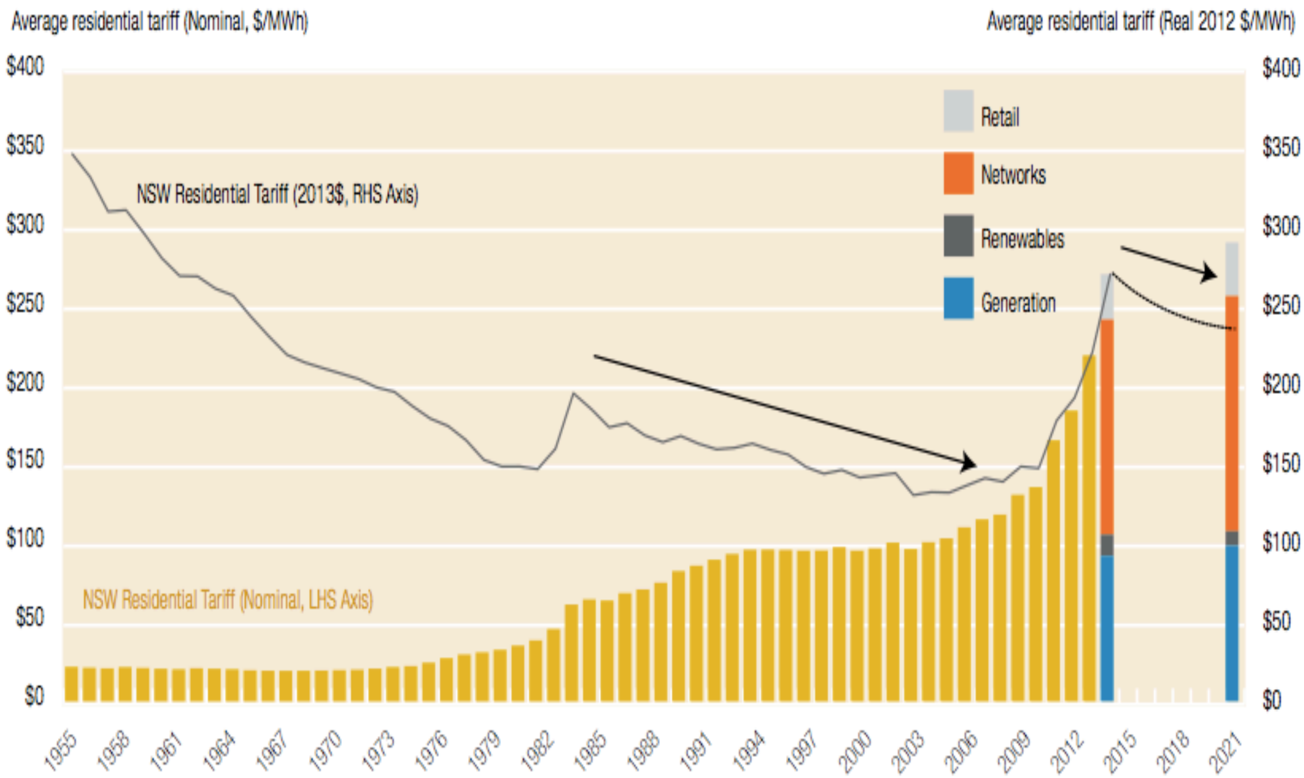


Figure 8: Electricity price forecasts (Nelson & Simshauser, 2013)

It can be seen that like gas, the electricity prices are expected to also increase. The most important aspect of the electricity forecast is to note that unlike the gas prices, electricity prices are projected to decline after 2015 (Nelson & Simshauser, 2013). Therefore, when gas prices continue to rise, as seen in Figure 6, the electricity prices will begin to fall. Combining falling electricity prices with the increased efficiency of electric appliances, described in Section 2.5, forecasts electricity to be the more affordable household energy source.

Overall, the projections that have been made about the gas and electricity market will undoubtedly change the amount of consumers in each market in the near future. However, these predictions exist only as estimates, and there are still other remaining variables that affect the total amount of residential energy consumption.

2.2.4 The effect of varying climates on residential energy consumption

Australians experience a range of different climate zones. Depending on the location of a residence, energy may be used to make a living space more comfortable by heating or cooling homes. This energy requirement causes the demand for household energy sources to vary among different climates. Climates in Australia are not just defined north to south. For example, the center of the country as a whole tends to have a desert-like climate, where as coastal areas are temperate and tropical (Bureau of Meteorology, 2014). Figure 9 shows the climate zones in Australia prepared by the Australia Government Bureau of Meteorology.

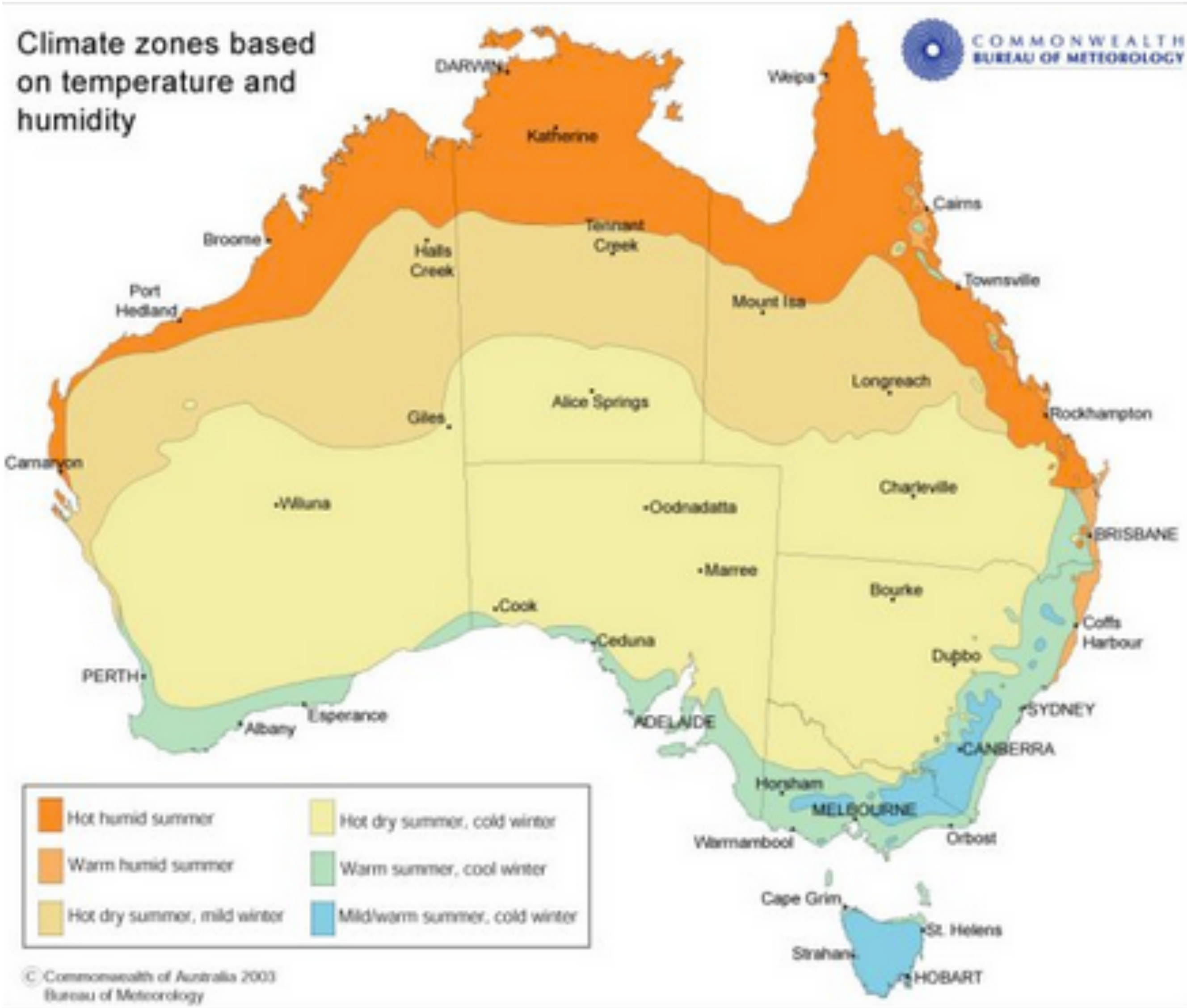


Figure 9: Australian climate zones (Bureau of Meteorology, 2013)

Climate and weather are important factors that influence demand because temperatures that deviate from the human comfort range of 20-22 °C can increase consumer use of energy. Climate information is very important in the breakdown of factors that affect demand for ATA's economic modeling.

If a consumer lives in an area that is normally very hot, yet they prefer a very cool home, the residential energy demand would be very high. However, should a consumer live in a moderate temperature climate and desire a moderate temperature home, the residential energy demand would be very low. For example, the average weekly expenditure on household energy in the dark blue climate area depicted in Figure 9 above is $47 per week. However, average weekly expenditure on household energy in the light blue climate area in Figure 9 is $30 per week (ABS, 2013). Climate, along with consumer preferences, has a very large impact on the demand and price of household energy.

2.3 Residential energy consumers are in a changing and uncertain position

The Alternative Technology Associate has found many consumers have conventional wisdom about household energy in that they believe gas is and always will be the most affordable household energy option. ATA also has noticed that gas companies and retailers promote this notion to consumers, which may eventually lead to consumers paying more then the have to in order to heat their spaces, heat their water and cook their food. Overall, the factors that affect household energy demand discussed in Section 2.2 have put residential energy consumers in an uncertain position. Residents are vulnerable in the household energy market because they are facing impending price increases that may not cause a change in their demand very quickly. Based on current pricing, gas is the cheapest household energy option. Although, based on price forecasts and the previously described primary factors, electricity is projected to be the cheapest energy option for all consumers.

Household energy price changes in a fluctuating market leave consumers with inconsistent energy bills. When choosing their household energy option, consumers may tend to pick the most affordable choice, although they may be hesitant to change what they are comfortable with. Unfortunately, for consumers using one type of household energy, prices tend to change over time. Today, with gas prices projected to increase in the near future, consumers may have to pay more for their household energy. Consumer advocacy organizations have recognized that household gas bills may rise and as a result, these organizations are exploring more affordable options for consumers, such as electricity.

2.4 The Alternative Technology Association as a consumer advocacy organization

The Alternative Technology Association (ATA) is one of few consumer advocacy organizations observing the current and projected residential energy markets. ATA's objective is to help residential energy consumers understand the most cost effective household energy options. In order to achieve this objective, ATA wants to understand the life cycle costs of using gas compared to electricity for the three appliance types: hot water heat pumps, reverse cycle split system air conditioners, and induction cooktops. ATA is planning to inform consumers of affordable household energy options in multiple ways. First, they plan to model the cost analysis of converting from natural gas to electricity in new homes as well as existing homes that are already connected to the gas network. ATA mainly wants to explore the energy options for all types of consumers. Second, in coordination with ATA, we plan to develop informational materials for consumers. Overall, by modeling the projection of household energy costs, ATA will use their "Gas Project Model" to determine whether LNG or electricity has lower lifecycle costs in order to help residential consumers understand the most cost effective energy decisions. ATA's strategy for helping consumers is to give information on different kinds of appliances available on the market today.

Currently, ATA is examining viable options to reduce consumer energy costs through the evaluation of appliance energy efficiency and other factors such as net present value. The challenge is to determine which appliances will provide residential consumers with the most cost effective appliance solutions. ATA has identified space heating, water heating and cooking as the three areas where there is a choice between gas and electricity (ATA, 2014). Their findings were based on preliminary modeling used to determine which gas appliances are used and how much energy they consumed. As a result, these energy studies focused on hot water heat pumps (HWHPs), induction stovetops, and split system, reverse cycle air conditioners and their gas equivalents

2.5 Energy efficient appliance options for consumers

Each of three previously mentioned appliances draws on recent technological improvements to limit energy consumption and provide possible energy efficient alternatives to their current equivalents. Induction cooktops use magnetic fields to utilize the cooking pot as the heating element creating a far more direct heat transfer to the food. Induction cooktops are more efficient than other units that use gas to heat a pot, thus heating the food (Kurenov, 2011). This reduces energy loses by eliminating the number of heat transfers that must occur

Hot water heat pumps store and heat water by collecting heat from the ambient air and transferring it to water (Department of Industry, 2013). They are more efficient than other hot water heaters because they only use electricity to power a pump as opposed to directly heating water. Essentially the refrigerant that absorbs the heat is compressed, increasing the heat energy while at the same time going through a phase change. It is then exchanged in the condenser. Once the heat is exchanged the refrigerant goes through another phase change and the cycle continues. Figure 10 below details the process (Department of Industry, 2013).

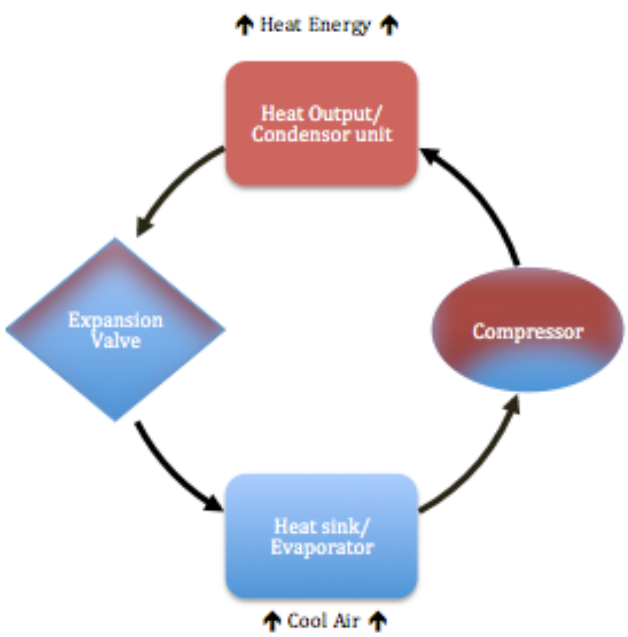


Figure 10: Heat pump function diagram

Likewise split system, reverse cycle air conditioners work on the same principle, only, they transfer heat energy from air to air. The energy draw is much less because the air conditioner is using energy to control the energy within the pump, not actually producing heat energy. Overall, the pump transfers heat energy from the outside air to the interior (E3, 2014). Reverse cycle, split system air conditioners have the added advantage of being reversible, meaning consumers can rely on one unit to provide hot and cold air conditioning throughout the year. The reduced electrical load and versatility of this unit makes it a more energy and cost-effective unit when compared to alternative heating, ventilation, and air conditioning systems (E3, 2014). Understanding the costs and savings of these appliance options are a critical aspect in determining if they are viable options for consumer trying to reduce their energy costs.

2.5.1 Energy efficiency performance of specified appliance types

The energy performance of individual appliances varies greatly from brand and model designations. With heat pump technology, the performance does vary based on climate conditions, consumer behaviors and its energy rating. The energy efficiency performances of appliances are determined by using a coefficient of performance, or CoP. The CoP is determined by dividing the system heat output by the system electrical input (Power Knot, 2014). Using the CoP helps consumers determine which appliances are the most efficient options for their homes.

Testing specific appliance models under ideal conditions allows manufacturers to calculate the CoP. The climates in which heat pumps operate will have a significant affect on the efficiency of the unit over time. The cooler the climate is, the less efficient the unit will be (Ford, 2012). The unit has to work longer and harder to make up the difference between the outside temperature and interior temperature. In addition, frost can build up on the exterior heat transfer coil when the ambient air is at freezing temperatures and reduce the efficiency further. Therefore the climate zone conditions in which consumers operate heat pumps will greatly affect the efficiency of the heat pumps and therefore might make them less cost effective.

Additionally consumer behavior affects the cost savings of each appliance over time. Consumers that rely on large quantities of hot water or constant indoor temperatures will need to use their appliances more often, thereby increasing the energy expense (Ford, 2012). Heat pumps require more time to heat up large quantities of air or water to meet this demand.

2.5.2 Cooktop, hot water heat pump, and split system air conditioner operational costs

The day-to-day operational cost of appliances represents a significant portion of their overall cost and thereby need to be considered closely by consumers. The operational cost is inversely related to appliance performance. Induction cooktops do not have operational costs. Aspects like appliance usage during peak or non-peak hours, unit preservation heating, and standby power will increase energy consumption. For example, standby power alone accounts for 10% of the average energy bill (E3, 2014).

Seasonal appliance usage also accounts for changes in consumer energy bills. During winter month operation, it is important for heat pumps to remain warm to prevent damage to the unit (Department of Industry, 2013). Currently, many units use crude heaters to maintain a moderate temperature within the unit. In cold temperatures, this heater (often referred to as a booster) is on when the unit isn't operating, adding expenses to the operational cost (Department of Industry, 2013). Likewise, stand-by mode burdens consumers with another electrical draw for consumers while the unit is not in use. Standby power is used to maintain timers, clocks or other devises that control the temperature or operation (E3, 2014). Therefore, determining the standby power required by units is an essential part of determining the total operation cost for consumers.

2.5.3 Cooktop, hot water heat pump, and split system air conditioner maintenance costs

Long-term maintenance costs are a major consideration for consumers. Maintenance can fall into two classifications: owner maintenance and professional maintenance. Owner maintenance costs are minimal since the labor is typically routine and free of charge. Professional maintenance requires not only the expense of parts replaced, but labor costs, hazardous disposal fees, and service call charges. In order to determine yearly expenses, a licensed maintainer familiar with routine maintenance costs must assist (Department of Industry, 2013). Some systems may require yearly inspections or servicing of worn out components to ensure reliable operation.

2.5.4 Cooktop, hot water heat pump, and split system air conditioner capital cost and asset life span

The initial investment is perhaps the largest consideration for consumers seeking to replace existing appliances (ATA, 2014). The initial investment includes the unit sticker price, installation cost, shipping, and government subsidies. All of these factors contribute to either increases or decreases of the final cost of the appliance.

The most substantial cost beyond the initial sticker price is the installation cost. Due to the plumbing and electrical work required for an installation, a licensed installer must preform the work (Department of Industry, 2013). The complexity of the work will dictate the end cost. Complication such as running new pipes or electrical connections will drive up the cost. The shipping cost for the appliance may or may not be included in the purchase price. Due to the often-remote nature of Australian country dwellings, this cost may be substantial. Government substitutes promoting environmentally friendly alternative technology may provide consumers with reductions in the total cost.

While evaluating the initial investment, advocacy organizations such as ATA suggest that consumers also assess the asset lifespan of the appliance they are interested in. Consumers should know how long their investment will last and how much it will cost them per year to own. Consumers are unlikely to purchase expensive units with very short lifespans (ATA, 2014). This reduces their chance to make any returns on their investment. It is also essential in determining whether or not it is even a cost effective plan to replace their current unit.

2.5.5 Summary of cooktops, hot water heat pumps, and split system air conditioners

ATA's initiative to reduce consumer spending depends on two aspects: understanding the energy market and determining which appliances are best suited to help consumers reduce their energy cost. The cost of an appliance depends on a number of factors: unit performance, operation cost, maintenance cost, asset lifespan, and initial investment. A careful evaluation of all of these factors is key in determining whether they are truly cost effective solutions to the looming energy question.

2.6 Background information summary

Residents currently using natural gas are going to face an impending increase in price. This impending price has been forecasted and will most likely be affected by the factors discussed in 2.2:

- Household type
- Distribution network zone locations
- Energy pricing
- Climate and weather

Homeowners that are faced with the predicament of possibly converting their residential energy source may encounter a number of variables that would be beneficial to consider for a successful conversion. Consumers may face various options such as energy type and new appliance purchases. Energy advocacy organizations are attempting to inform residential energy consumers of the most affordable energy options because a whole scale conversion can be very stressful and time consuming. There is information regarding energy and appliances that can be synthesized and compared to ensure that a wide variety of consumers benefit from a cost effective form of energy.

Chapter 3: Methodology

The goal of our project is to assist the Alternative Technology Association's efforts to inform residential energy consumers of the most cost efficient form of energy for the use of cooktops, heat pumps, and split system air conditioners. Determining the most cost efficient form of energy is important because it will help residential consumers save money on energy costs. The two forms of energy we discuss are natural gas and electricity because they dominate the residential sector of energy usage in Australia.

To achieve our goal, we completed the four objectives listed below.

1. Compiled current natural gas and electricity pricing along with existing long-term forecasts of supply, demand, and price projections in the residential sector of Australia.
2. Characterized standard natural gas and electric cooktop, heat pump, and split system air conditioner costs as they apply to initial investment, operation cost, and asset life for household use.
3. Examined specific cooktop, heat pump, and split system air conditioner appliance model performances based on climate and energy efficiency.
4. Used the compilation of project data and ATA's "Round Arm Swing Model" to create fact sheets that inform consumers about the most affordable form of household energy.

Figure 11 indicates a flow of the project objectives and steps needed to accomplish our project goal. The three blue blocks represent the first three objectives that feed into a compilation of data, indicated in red. To the right, in the grey block, our final objective is stated, describing the creation of our information materials: fact sheets, spreadsheets, and magazine article. The grey block on the left, however, represents the use of our data for ATA and their "Gas Project Model". Each of these objectives contributes to ATA's overall goal of informing consumers of their most cost effective form of household energy.

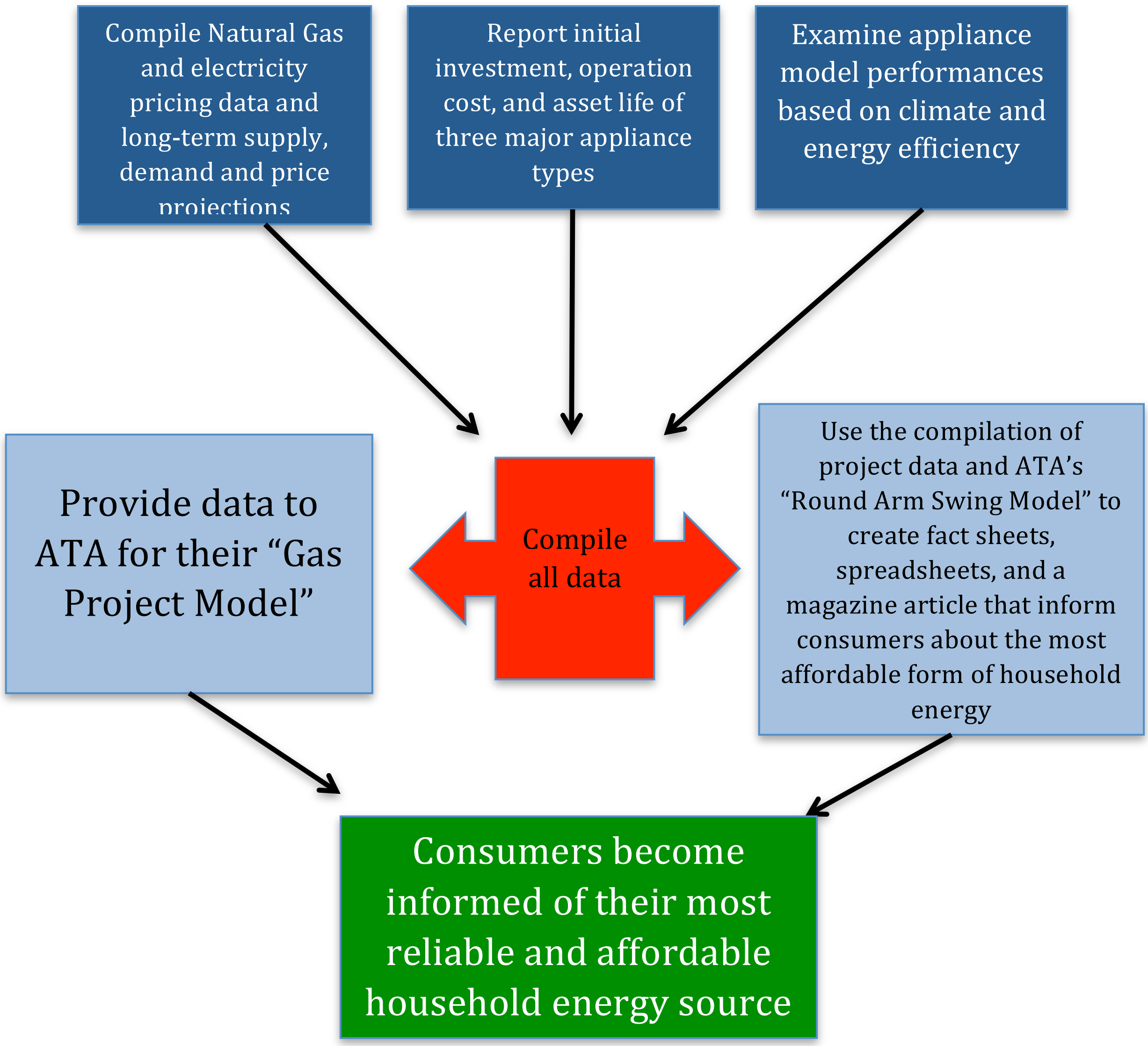


Figure 11: Flow chart of project objectives

Each objective is described in detail below. The completion of these objectives assisted ATA in their evaluation, modeling strategies, and information distribution about household energy conversion across Australia with regards to the National Energy Market.

3.1 Compile current Natural Gas and electricity pricing along with existing long-term forecasts of supply, demand, and price projections for the residential sector of Australia.

Our first objective was to aid ATA in gathering research regarding current pricing and existing forecasted information about supply, demand, and price of the natural gas and electricity residential markets. Current pricing relates to our goal because it provides ATA with information about the standard costs residents are paying right now in different locations throughout the gas networks and the National Electricity Market (NEM). Forecasted information provides anticipated prices for both forms of residential energy, which can be used when advocating the most cost efficient form of household energy in the future. Forecasted information is important because it indicates how much consumers will be paying for energy in the near future. In order to attain our objective, we divided our research into three major tasks.

The first task in completing our research involved determining the natural gas networks present in Australia. Using the Australian Energy Regulator, AER, we identified the specific distribution areas of the eight major gas networks in Table 1. A map of the gas networks is provided in Figure 3 of Chapter 2.

1	ActewAGL
2	Allgas Energy
3	Central Ranges System
4	Envestra
5	Jemena
6	Multinet
7	SP AusNet
8	Tas Gas Networks

Table 1: Gas distribution networks as defined by the Australian Energy Regulator

As previously described in Section 2.2.1, each gas network has specific zones in which their gas is distributed. Because pricing varies between the gas zones, we determined the particular price for each retailer in every zone. We found these pricings through a series of sources based on Australian states. ATA collaborated with an organization called St. Vincent De Paul Society that publishes gas pricing information on their website. When ATA could not find the exact price of gas, they sought advice from St. Vincent De Paul Society's consultants. The consultants advised us of the following sources we could find prices:

- **Victoria**: published in a gazette (explained in Appendix E)
- **New South Wales**: St. Vincent De Paul Society provided ATA with a spreadsheet indicating the specific values needed
- **South Australia**: posted on Origin Energy's website
- **Tasmania**: published on the Tas Gas Networks website and the Aurora Gas websites
- **ACT**: published on ActewAGL website.
- **Queensland**: provided by Origin Energy and AGL

All of these sources provided records of their prices based on towns and postcodes, so we were able to compile them for ATA's "Gas Project Model. With the help of St. Vincent De Paul Society, we were able to find all of the gas prices and compile them in a spreadsheet to input into ATA's "Gas Project Model."

Our second task consisted of a similar method of research for electricity pricing as was used to find natural gas pricing. Electricity distribution is also divided into specified zones throughout Australia. Each zone has differently priced electricity. Therefore, in order to provide ATA with information regarding current energy prices, we needed to analyze the prices for each electricity distribution zone. Again, we found prices from specific websites of electricity distributors and suppliers that were provided to us by ATA. The organizations used to find electricity tariffs are seen in Table 2.

Location	Organizations
Victoria	St. Vincent De Paul Society
New South Wales	Origin Energy, Actew AGL, Energy Aus
South Australia	Origin Energy
Tasmania	Aurora Energy
Australian Capital Territory	Origin Energy
Queensland	Origin Energy and AGL

Table 2: Organizations and locations for electricity tariff data

All of the electricity price values were compiled in a spreadsheet to input into ATA's "Gas Project Model."

The third task of research dealt with the projected prices for natural gas and electricity until 2030. We crosschecked sources and validated the most accurate forecasted information from a multitude of reputable sources. Research concerning energy trends, the environment, or consumer habits may have been tarnished by biases of research groups supporting an idea. Additionally, the data may have been skewed by different root sources, data, population samples, and contexts viewed differently by competing research. To reduce the opportunity for bias, we considered multiple sources of price forecasts.

AEMO is not the only source that forecasts energy prices, therefore multiple forecasted sources were used and provided various fluctuations in price predictions. Four sources were used to confirm the price projections including documents published by Energetics, the Australian Energy Market Operator (AEMO), the PIAC gas master class, and the Australian Energy Regulator. Due to the multitude of sources that forecast the price data, we chose the data that shared the most similarities to avoid any outlying data. Natural gas and electricity price projections provided ATA with helpful information about the price path that each market may take.

With the completion of this objective, we provided ATA with a summary of the residential energy market. It was our first contribution to ATA's "Gas Project Model" described in Section 3.4. Overall, our output summary for this objective included the data analysis of current pricing, as well as forecasted supply, demand, and prices of natural gas and electricity.

3.2 Characterize the standard LNG and electric cooktop, hot water heat pump, and split system air conditioner costs as they apply to initial investment, installation cost, maintenance cost, operation cost, and asset life.

In conjunction with providing ATA current and projected data regarding Australia's residential energy market, we examined natural gas and electric appliances for their "Gas Project Model" described in Section 2.3. ATA identified their gap of knowledge as the costs of standard natural gas and electric cooktops, hot water heat pumps, and split system air conditioners. As previously described in Section 2.4.4, the standard costs apply to five major variables:

- Initial investment
- Installation cost
- Maintenance cost
- Operational cost
- Asset life

We researched how each variable related to the standard cost of the three appliance types.

First, we found the initial investment required for each appliance type. We identified a list of brands and models of appliances to compare. To find commonly used appliances, we reviewed the consumer comments in the ATA forums observing the popular types of appliances being used. This provided us with initial background information, however in order to get more accurate data regarding the most efficient appliances being used today, we researched other consumer reviews from leading appliance companies for each type of unit. We used online consumer reviews such as:

- Toptenreviews.com
- Productreview.com
- Choice.com

Variations of popular hot water heat pumps were found through the following suppliers: Quantum, Siddons, and Stiebel. After we examined the reviews published by the listed suppliers, we searched for the recommended retail price (RRP) of the three major appliances and averaged the five most cost efficient units.

Second, we researched the typical installation costs for each type of appliance. We did this by contacting the communications team at ATA. We used their list of members to locate plumbers and electricians that would give us the total installation costs for cooktops, heat pumps, and split system air conditioners. The reason that we exclusively used ATA's member information is that randomly inquiring major companies, or "cold-calling", may have led to companies telling us the common knowledge of installation prices or being unwilling to share this information. Common knowledge of installation prices does not account for the extra charges that may occur, such as replacing a circuit board during installation. Our sponsor advised us that we should use people in ATA's database because they are members of ATA's advocacy efforts and will be more willing to give us information. Along with our inquiries about installation costs, we interviewed the members about the cost of maintenance for each unit. After collecting data regarding repairs from quick fixes to total replacements, we were able to add the monetary amounts to the total standard cost of the three appliances. The electricians and plumbers involved with ATA provided a comprehensive list of costs associated with installation and maintenance.

After finding the installation and maintenance costs, our third step was to determine the operational cost of cooking and heating appliances. In evaluating the operational cost of cooktops, heat pumps, and split system air conditioners, four major variables had to be analyzed.

First, the typical fuel cost to run the appliance was found. This typical fuel cost was determined by finding how much energy each appliance required to operate. The energy operation requirement was easily found on consumer and retail sites online.

Second, consumer behavior was evaluated. Behavior included energy use during peak hours as well as the number of people living in each home. This information was collected from St. Vincent's De Paul Society and the Australian Census. Our team made a general estimation of the length of time a burner is used, typical cooking times, and how many burners were used at a time. With the help of ATA, we developed the following household types to categorize habits of burner use and cooking tendencies:

1. 1 person working
2. 1 person unemployed
3. 2 people working
4. 2 retirees
5. 3 people working
6. 3 people with one parent home caring for a child
7. 4 people with 2 adults working and 2 children in school
8. 4 people with housemates or sharing a home
9. 5 people with 2 adults working and 3 children in school

To verify our energy use estimations, we distributed a survey to ATA employees and volunteers, users of ATA's online forum, and other WPI project sponsors in Australia during the same term, including the Metropolitan Fire Brigade, CERES Community Environment Park, EW Tipping Foundation, and Melbourne Museum questioning their energy use and cooking habits. Appendix B lists the questions that were asked on the survey. These questions allowed us to test our original assumptions and compile data listing family types and their tendencies to use ovens and cooktops.

Third, the climate and its affect on usage of cooking and heating were determined. Climate areas that consumers are located in effects the amount of energy households will use. This step required us to list a series of zones and states and what climates they experienced. In varying climates, heat pumps and split system air conditioners were used in different quantities.

The fourth variable we gathered values from was the asset life of each unit. Asset life was found under the specifications on the manufacturers website. The National Association of Home Builders and the Bank of America Home Equity organizations provided us with several values for asset life. These organizations released a document listing the asset life of all in home appliances that we used to find values (NAHB, 2014). Once these values were found, other sources were cross-referenced and used for validation purposes. Companies listed on Choice.com such as LG, Mitsubishi, Daikin, and Bosch was used to validate the initial asset life findings. Asset life is important in determining the standard cost because it describes how often the unit needs to be replaced.

Initial investment, operational cost, and the asset life are three important variables that contribute to the typical standard costs of all cooktops, hot water heat pumps, and split system air conditioners. By determining all three variables, we completed this objective, providing our second input for ATA's "Gas Project Model".

3.3 Examine specific cooktop, hot water heat pump, and split system air conditioner appliance model performances based on climate, and energy efficiency.

Completion of this objective provided information about energy usage efficiency, or performance of the most cost and energy effective models of cooktops, hot water heat pumps, and split system air conditioners. In order to quantify the specific performance of particular models, we analyzed both energy efficiency and climate of 120 different unit models.

Energy efficiency was analyzed by evaluating models on a specific unit basis, meaning that each unit was evaluated to determine the total cost in relation to the energy input and output. The energy efficiency was determined by first finding the coefficient of performance (CoP) for each model. The coefficient of performance is described in detail in Section 2.4.1. Next, the heating and cooling daily use, tariff costs, and heating and cooling yearly costs were collected from the model specifics on its respective website. Using the equation below, the aforementioned specifics were related to calculate a total energy usage in kWh. In the equations, EER represents the Energy Efficiency Ratio.

$$Input\ Power\ (watts) = \frac{Heating\ Ouput\ Power}{EER}$$

Where:

$$Heating\ Output\ Power = \frac{BTU}{h}$$

$$EER = \frac{Heating\ Output\ Power\ (BTU)}{Input\ Electrical\ Power\ (Wh)}$$

EER is also related to CoP by the equation:

$$EER = CoP\ x\ 3.41$$

Once the total energy usage for the appliance model was determined, the equation below was used to determine the total cost per year to operate the appliance based on performance. In this equation, the kWh is multiplied by the current energy cost per hour and hours used per year to receive the total yearly cost.

$$Total\ yearly\ cost\ \left(\frac{dollars}{year}\right)$$
$$= Power\ (kw)\ x\ Anuual\ running\ hours\ \left(\frac{hours}{year}\right) x\ Energy\ cost\ (\frac{dollars}{kWh})$$

Using the three equations above, the CoP, daily use, tariff cost, and yearly cost were all combined to calculate the yearly total cost of operating a specific model of cooktop, heat pump, or split system air conditioner.

The performance of a model unit cannot be solely determined by the yearly total cost of operating an efficient appliance. In order to completely quantify the performance, we quantified climate in relation to performance. To do this, we defined the climate zones throughout Australia. Seeing as heat pumps and split system air conditioners are strongly affected by climate, the CoP data for specific units was extracted from model user manuals. Cooktops, on the other hand, presented a problem with performance analysis because climate does not strongly affect efficiency of the unit. We overcame this problem by exclusively incorporating climate data into the calculations for the adjusted CoP. Using a study done by an organization called Sustainable Thinking, the performance of heat pumps in different climates were found from a publication called "Running Costs and Operational Performance of Residential Heat Pumps (Ford, 2012)." In this report, several graphs of different zones indicated climate tendencies in each month of the year.

Each of the graphs shows the relative humidity in relation to ambient temperatures and the amount of time in hours that these occurred. These climates indicated what the temperatures were in each zone so we could approximate where certain appliances wouldn't work well. The total yearly cost is then related to the CoP considering climate finding the cost and performance of each unit.

With the completion of this objective, the total performance for the most cost efficient appliances was determined. This relates to our goal because it allowed ATA to model different scenarios of the most cost efficient appliances that are powered by both LNG and electricity. Then, using the forecasted prices for both energy types, the performance was evaluated again. The three objectives described in Sections 3.1-3.3 all provided substantial input for ATA's "Gas Project Model". In the following Section, 3.4, the uses of the collected data and model are described.

3.4 The culmination of research for objectives 1-3 and its purpose for ATA's "Gas Project Model"

The data collected for objectives 1-3 represented a significant portion of the information ATA needed to feed into their modeling effort. The "Gas Project Model" is a model designed to compare the cost of natural gas and electricity, taking into account the initial cost, instillation cost, maintenance cost, and continuous usage cost. They wanted to establish various scenarios that determined whether natural gas or electricity would be the most cost efficient form of household energy in the future. The five major topics needed for the "Gas Project Model" were the following:

1. LNG networks

2. Electricity networks
3. LNG and electricity price forecasts
4. Standard costs of the three major appliance types
5. Performance of specific model units.

This information was fed into for ATA's "Gas Project Model" for examination. The output of this model determined the total costs associated with operating cooktops, hot water heat pumps, and split system air conditioners until 2050. In addition to providing the substantial input data for ATA's model, we reviewed a preliminary output model that they created. Because we were familiar with the data that was input into the model, it was important to see that our research and assumptions were consistent with ATA's "Gas Model Project" assumptions.

3.5 Use the compilation of project data and ATA's "Round Arm Swing Model" to create fact sheets that inform consumers about the most affordable form of household energy

This objective was devised to inform residential energy consumers of the data from our research in the topics covered in Sections 3.1-3.3. We developed a series of communication tools and fact sheet ideas that would best advocate our data regarding household energy choices to residents across Australia. Our communication strategy had to be feasible for ATA. We planned a way to distribute the information material once it was complete.

First, we needed to determine three advocacy variables: the type of consumer ATA would like to target, what information consumers should receive, and how they should receive it.

ATA has over 20,000 members that share an interest in making sustainable energy choices in their homes and communities. Our fact sheets were designed for a multitude of audiences, catering to different members. Our magazine article was written to please subscribers of ReNew, ATA's published magazine. Each fact sheet contained a target audience based on different economic variables. With the help of our ATA sponsors, we developed a list of audiences that the fact sheets may target. Appendix F provides an explanation for each audience and the information that was conveyed to them.

1. Overall gas and electricity information
2. Consumers building new homes
3. Consumers already connected to gas
4. Renter specific information
5. Landlord specific information
6. Off-grid consumers
7. Consumers seeking to replace functioning appliances
8. Considerations regarding induction cooktops
9. Considerations regarding reverse cycle, split system air conditioners
10. Considerations regarding hot water heat pumps.

Next, the information that was provided to the consumer was intended to be appealing, in that it encouraged the consumer to choose the most affordable option for them. Quite often, residents tend to use appliances they are comfortable with. For example, a resident would unlikely convert from a gas hot water tank to a hot water heat pump without reason. The best way we overcame a challenge to convince consumers to convert was to correctly evaluate the net present value (NPV) of each appliance. The NPV consists of information regarding long initial cost, asset life, operational cost, and maintenance cost. The NPV compares multiple appliances and therefore allowed us to provide accurate information to consumers. Overall, the fact sheet information provided a list of appliances that would be the most cost affective for particular consumers, along with the forecasted prices of both LNG and electricity in their geographic location.

Third, we decided how each consumer should receive their information. In order to do this, we conducted an extensive research process regarding successful ways to transmit complex information in a way that everyone can understand. We first identified examples of fact sheets and communication tools that ATA had used successfully in the past. We then selected the successful examples of these communication tools. After assessing and reviewing these tools, we discussed possible formats for our fact sheets with employees at ATA. In conjunction with ATA, we decided that two to three page information sheets targeted to all consumers were the most appropriate form of communication tools. The same information could also be transmitted electronically, which would allow members to access the fact sheets on ATA's website. Before implementing the actual fact sheet, we created mock-ups and got feedback from our liaison, as well as the graphic designer for the ReNew and Sanctuary magazines. After revisions that made the fact sheets aesthetically pleasing and fit the needs of ATA, we created multiple fact sheets that corresponded to the consumer scenarios in the ATA "Gas Project Model". These fact sheets were then provided to ATA for the use of their consumer advocacy.

3.6 Methodology summary

The overall purpose of accomplishing the four objectives in this project was to inform residential energy consumers of the most affordable form of household energy with respect to LNG and electricity. The first three objectives provided us with data inputs for ATA's "Gas Project Model". After reviewing the modeling process, we received output data specifying the household energy prices that a wide range of consumers may encounter in the future. We used this output data to create fact sheets, displaying the possible appliance conversion information to consumers. The collected data and fact sheets can be seen in Chapter 4.

Chapter 4: Results and Discussion

Residential energy consumers using natural gas as one of their household energy sources may convert their household energy type from gas to electricity in the near future due to rising gas costs. Such residents are in a vulnerable position and may be interested in our findings from this project. Throughout this chapter, we discuss the long-term forecasts of both LNG and electricity markets until 2030, the display of the three major appliances identified in Chapters 2 and 3, and the performance data averages for each appliance type. These three findings contribute to a much larger research effort being performed by ATA through their "Gas Project Model", in which they aim to determine the most cost effective form of household energy in the future. Overall, our findings served as inputs for their model.

Part 1 – Gathering data for fact sheets

4.1 Findings related to current gas and electricity prices and their market projections

Our initial findings related to the pricing of household gas and electricity. As previously explained, different energy providers divide pricing into separate zones across the country. It is estimated that current prices will drastically change over the next two decades. Therefore, the many different energy forecasters in Australia produce varying price projections for both household gas and electricity. The sources that we used to determine our results were the Australian Energy Market Operator, the Australian Energy Regulator, Energetics, the PIAC Gas Master class, the Grattan Institute, and AGL.

4.1.1 Findings about current tariffs

In order to find all relevant inputs for ATA's model, we needed to obtain all of the gas and electricity tariffs for the zones and states with gas and electricity networks. By gathering these values we were able to find a range of gas and electricity prices for residential customers across eastern Australia. These prices were used for the fact sheets in order to show consumers the consumption costs of gas and electricity in their location.

All individual tariffs for each zone and distributor can be found in Appendix A. From all of these tariffs we found ranges of prices for each state including high and low values, as shown in Table 3. Note that the electricity values are expressed in cents per kilowatt hour (c/kWh) and the gas values are expressed in cents per mega joule (c/MJ).

State	Electricity Price Range	Natural Gas Price range
Queensland	13.61-34.06 c/kWh	2.37-5.93 c/MJ
New South Wales	27.13-34.22 c/kWh	2.01-3.62 c/MJ
Victoria	16.23-35.33 c/kWh	1.46-2.28 c/MJ
Tasmania	16.17-36.56 c/kWh	3.19 c/MJ
South Australia	33.80-47.15 c/kWh	1.72-3.99 c/MJ

Table 3: Current electricity and gas tariff ranges

From the ranges listed in Table 3, we made the general assumptions that Queensland had the lowest electricity prices and South Australia had the highest electricity prices. We also identified the range of prices for natural gas as well. Victoria had the lowest natural gas prices and Queensland had the highest natural gas prices.

The rising gas prices and plateauing electricity prices suggest that electricity is going to be the most affordable option, as shown in Table 3. All of the price range data was used to inform consumers in our fact sheets. In order to present the data in an interesting and appealing way, we created Figure 12 for the "Gas or Electricity? How will projected gas prices affect you?" fact sheet.

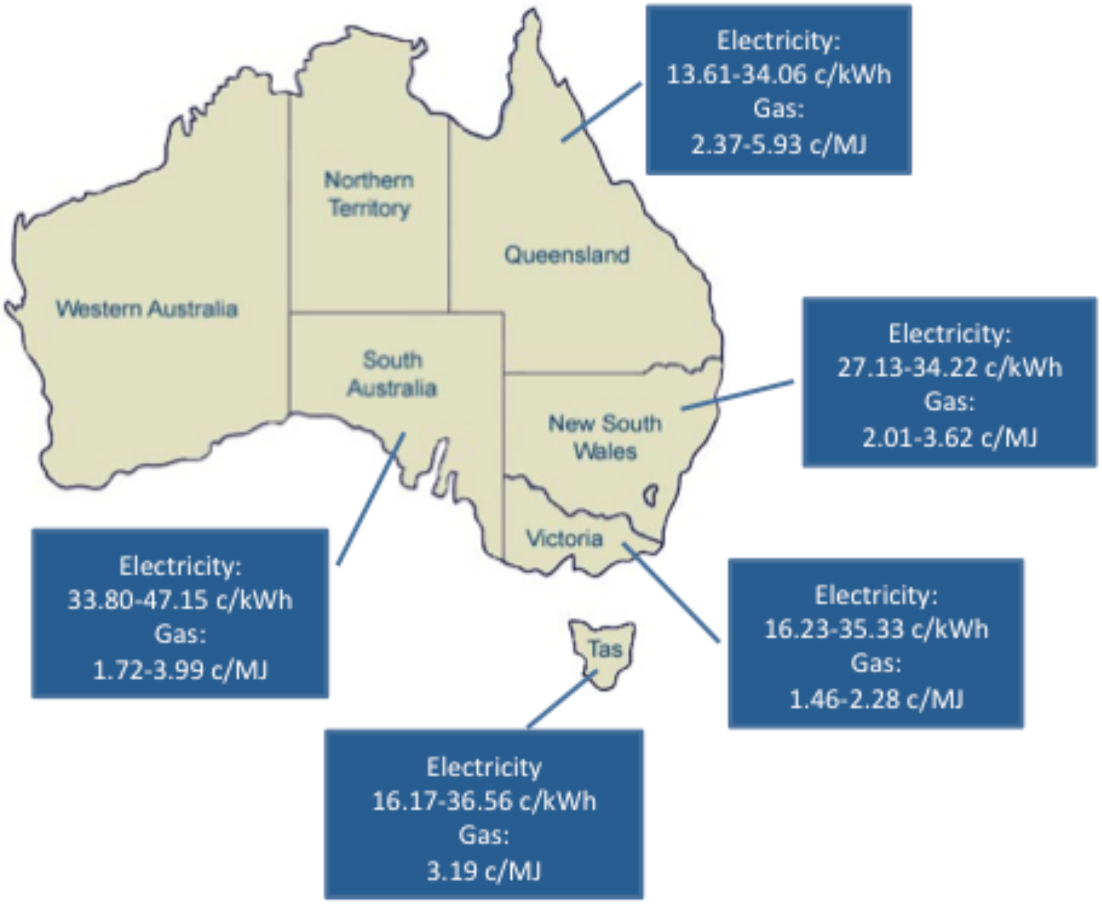


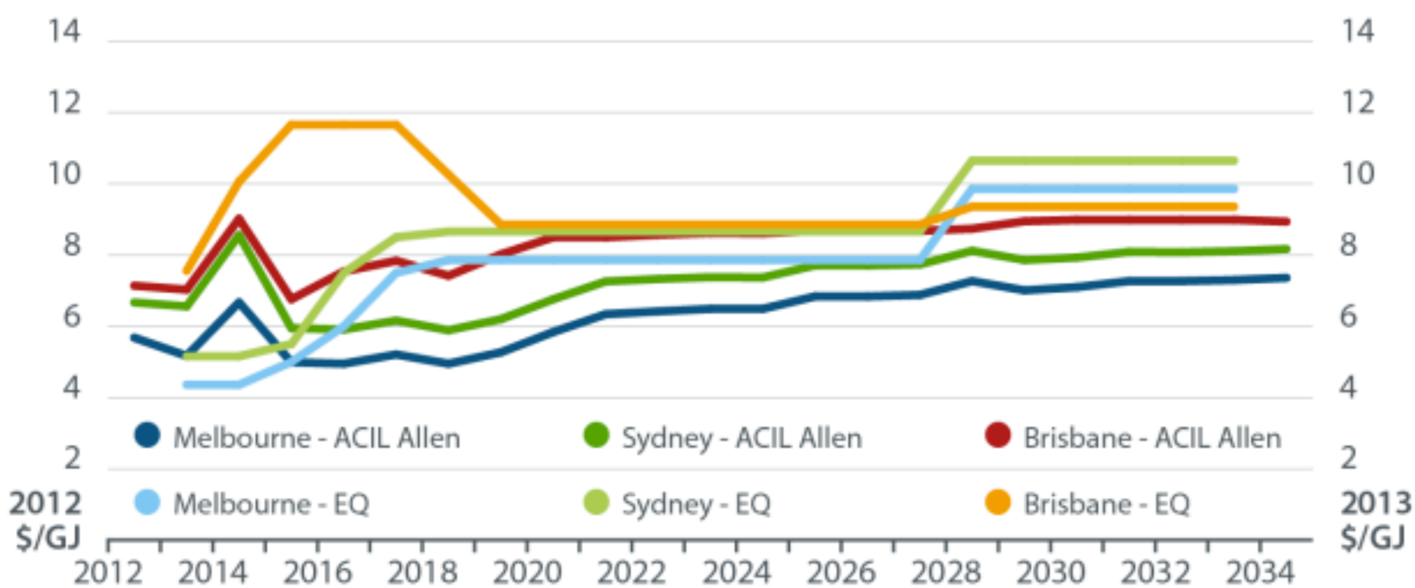
Figure 12: Map of current tariffs provided in fact sheets

As gas tariffs increase, consumers may not want to pay for gas. The prices for electricity seen in Figure 12 were informative because it shows the current comparison of energy prices for consumers in each state. Because natural gas prices begin to rise in the future, as described in Section 4.1.2 and 4.1.3, we determined that electricity might be the most cost efficient energy options for homeowners.

4.1.2 Findings about natural gas price increases

The east coast market of natural gas, including New South Wales, Queensland, Victoria, South Australia, Tasmania and ACT are planning to expand into the international gas market (Carter, 2014). Joining this gas market means that they will export a majority of their extracted conventional and unconventional gas to high-energy consumers such as Japan, Korea and a number of European countries. Until recently, Australia was under the impression that they were running low on conventional gas in their country (Carter, 2014). However, with further exploration and the extraction of unconventional gas, Australia's natural gas reserves have grown significantly (Geoscience Australia, 2013). The available data about gas supply suggest that Australia is not facing an issue of running out of gas, rather they need to be able to distribute gas where it is needed at the right time (Carter, 2014).

Historically, gas prices in eastern Australia have been traded from 3 to 4 dollars per gigajoule (Carter, 2014). Over the past few years, these prices have recently risen 30% (PIAC, 2014). In fact, New South Wales has validated the beginning of a gas price increase when a decision was made to approve gas price increases of more than 17% for consumers (IPART, 2014), Based on the increases, Australians are expected to encounter an approximate increase to 7.3 dollars per gigajoule by 2020 and 9.6 dollars per gigajoule in 2030 (Carter, 2014). Figure 13, below, shows the projections from two organizations, ACIL Allen and EnergyQuest. Each color represents a different location predicted by both economic market analysis organizations.



Note: ACIL Allen is the base scenario and is plotted on the left. EQ is EnergyQuest's $95 JCC scenario and is plotted on the right.

Figure 13: Projected gas prices until 2030 (BREE, 2013)

It can be seen in Figure 13 that the current prices are between 4 and 8 dollar per gigajoule and increase to between 8 and 10 dollars per gigajoule. The largest increases are seen in the Melbourne – EQ and the Sydney – EQ estimations.

Although this information is very useful, we encountered some issues of validity. Since projections are essentially estimates of how gas price and demand may increase in the future, we found that forecasts can change by several dollars per gigajoule with every new projection. Therefore, we used projections from 2012 to present. We also found that many forecasts vary in their numerical gas predictions, so we gathered additional data from several sources listed below (PIAC, 2014):

- Australian Energy Market Operator
- Australian Energy Regulator
- Energetics
- The Grattan Institute
- Darach Energy Consulting

Each source provided useful gas price projection data, however we found that the predictions by ACIL Allen and EnergyQuest displayed prices representing wholesale costs that were very average in relation to the aforementioned organizations. We also found another major issue with forecasting in that no organization accounted for elasticity of demand. For example, when the price of a good rises within a market, the demand for that good typically drops. The forecasts that we examined did not account for any falling demand and based their prices on the current demand that we observe today.

Overall, residential energy consumers should be expected to experience a $40 to $170 price increase in their annual gas bills (CUAC, 2013). Victoria shows the largest increase because most of the gas consumption resides in Victoria (Jones, 2014). Therefore, Victoria will experience a large price increase should the price of gas rise.

4.1.3 Findings about the cause of natural gas increase

Merely compiling the forecast data was not sufficient without a number of specific reasons for a major price increase. In order to truly analyze why these prices are facing a possible increase, we focused primarily on the east coast market consisting of the Declared Wholesale Gas Market and the Short Term Trading Market (Hughson, 2014).

As we mentioned earlier, the east coast gas market is planning to expand into the international gas market. This competition will cause the market increase three fold (Jones, 2013). The domestic consumers within Australia only make up 20% of the market as a whole. A majority of these consumers reside in Victoria, so consumers are not seen as the primary economic issue (Jones, 2013). In order to supply the export of east coast Australian gas, there will be a three-fold increase in aggregate demand over a three-year window from 2014 to 2017 (Nelson & Simshauser, 2014). New South Wales will especially feel the pressures of the three-fold increase in gas demand because the gas that they normally import from neighboring states will be exported to other countries. Therefore, the aggregate demand will increase dramatically in New South Wales, coupling the issue that the current infrastructure is unable to transport the projected amount of gas demanded by each state (Amey, 2014). Overall, the combination of projected gas export and three-fold increase in aggregate demand contributes to the price increase that is being projected by many energy organizations.

4.1.4 Findings regarding electricity price and demand projections

The National Electricity Market (NEM) operates in a gross pool market (Hughson, 2014). This means that all the sale of wholesale electricity must be put into a public financial market and traded for immediate delivery (AER, 2007). We have found that the electricity market has also faced price increases over the past decade, however, electricity will be a successful alternative to gas in that the appliances using electricity are much more efficient then that of their gas counterparts, as described in Section 2.5.

Recently, the demand for electricity has fallen (Nelson & Simshauser, 2014). Although it may seem that people are choosing different forms of energy, electric appliances are merely using less energy, with their CoP's are reaching 5.0, as described in Section 4.2.1 (Powerknot, 2014). Figure 14 below displays the demand decrease in electricity.

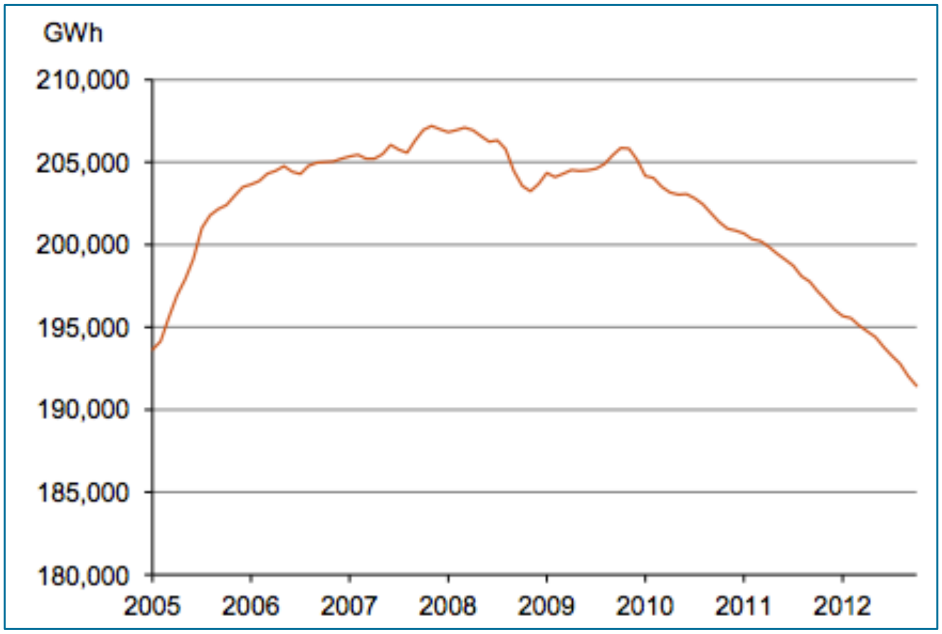


Figure 14: NEM electricity demand, 2005 to 2013 (Grattan Institute, 2013)

Along with the fall in demand, electricity prices have oddly increased, as most goods decrease in price when the demand falls. The price paths have shown similar trends to gas, as shown in Section 2.2. However, the electricity price increases should have less of an effect on consumer's energy expenses due to the increased efficiency in electric appliances, explained in Section 2.5.

Our findings show that electricity serves as a viable option for many residents that choose to convert from household natural gas usage. There are a few reasons for this. First, we found that electricity is able to meet peak demand, meaning there is more than enough energy to generate and provide to residents (Hughson, 2014). There is also an instantaneous match of supply and demand within the market (Hughson, 2014). Lastly, electricity is connected to most premises across Australia (AER, 2013). The interconnected network of the NEM can be seen below in Figure 15.

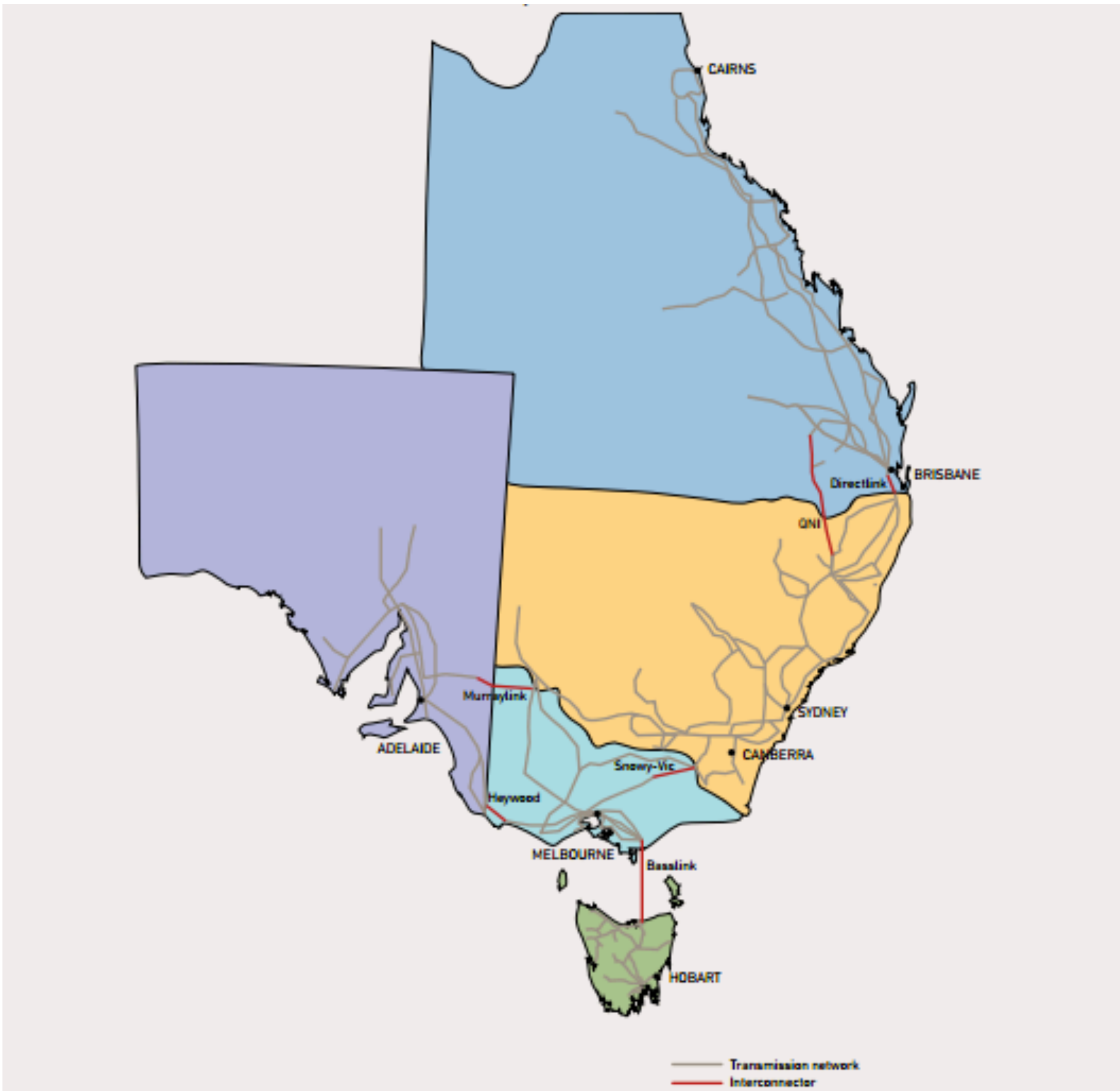


Figure 15: Electric transmission networks in the NEM (AER, 2009)

As shown in Figure 15, the populated areas of Australia are connected to the electricity network. This provides a reliable energy source to most homes, and therefore will not require additional costs that natural gas may encounter, such as connecting to the gas transmissions system. Overall, the electricity transmission system is already sufficient enough to provide energy to residents across Australia without the need for infrastructure updates (Hughson, 2014).

Our findings have allowed ATA to use tariff and projection data in their modeling to determine which form of household energy will be the most affordable in the future. However, energy prices are not the only determinant of whether or not gas or electricity is the best option for most consumers. A large contribution to determine affordability and reliability is the efficiency of appliances.

4.2 Findings related to three major appliance usage by residential consumers: hot water heat pumps, cooktops, and reverse cycle split system air conditioners

The energy efficiency of an appliance tells the consumer how much energy they get out compared to how much energy they put in. Although we have found that both gas and electricity prices are projected to increase dramatically at similar rates, the overall efficiency of electric appliances is found to be better. Throughout this study we examined specific variables that revealed the total efficiency of each appliance type. First, we examined the typical costs for the appliances to determine their affordability. Next we determined the usage of the appliances by different family types. And lastly we highlighted the overall performance of each different appliance. ATA found this data very useful because they were able to use it as the last input to their "Gas Project Model".

4.2.1 Findings about performance and costs related to the three major appliances

The appliance analysis outcomes regarding initial cost and performance provided ATA with many inputs for the "Gas Project Model". By analyzing the collected data, we were able to find trends and note several inconsistencies between sources. Specific costs, consumer experiences, and appliance specifications varied with difference source types. For example, the CoP of units published by manufacturers varied from actual real world data. We found that units were often operated at different settings when tested compared to actual use in the consumer market (Mavuri, 2014). The appliance testing work, which was conducted by a third-party testing organization, allowed "adjusted" CoP's to be published per appliance company's specifications. However, actual users reported lower performance numbers. Therefore, we found that the specified performance numbers could vary slightly from real world users.

Data about performance figures were collected from many companies and were also verified by consumer reports and forum based testimonies. Additionally, these reviews allowed us to narrow our selection of appliance manufacturers that we used to collect performance and cost data. We found that consumers were often able to highlight units that did not perform to their published specifications or were not reliable and well supported by their manufacturer. Also, they may have demonstrated extremely poor build quality. We eliminated these companies and appliances from our study and focused on units that performed well. The appliance models we chose were supported by multiple consumer reviews. The published specification coupled with reliable consumer reviews and user statements on forums. These consumer reviews allowed us to collect data and then validate the inputs for the "Gas Project Model."

Induction cooktops

All of the compiled induction cooktop information was relatively consistent for the multitude of brands we examined. The price of these appliances remained within a consistent range, while the projected asset life, warrantees, performance, and installation costs were found to have very little variation. This meant that ATA could easily establish an estimated life cycle cost to present to consumers that would accurately reflect their buying experience. For more information regarding the cost and performance specifics of induction cooktops, see Appendix C.

Split system air conditioners

We found that split system air conditioner units varied significantly with individual consumer applications. A wide range of units is available to fulfill the multitude of consumer needs and applications thereby making it difficult to establish baseline estimates for modeling use. Consumers looking to install a space heater may have needed to fit their unit to their usage requirements. As a result, we found that the performance, initial cost, and life expectancy varied significantly throughout the split system air conditioners available in the market.

We were only able to compile consistent information for maintenance costs, as there were reliable ranges for these costs and the general performance parameters. Using this data, we found that generally the performance of air conditioning units deteriorates with unit size. Larger units were seen to perform less efficiently than smaller models in the same product range. Appendix C details the specific costs and performance parameters of reverse cycle split system air conditioners.

Hot water heat pumps

We were able to determine concise and reliable baseline cost projections by dividing the available models into three size groups. This division is illustrated in Appendix C. Once this division was made, the data represented accurate price and performance ranges available for each size group. Variables such as asset life, warranty availability, and maintenance cost were consistent throughout the available products. Price ranges across each appliance size were similar and showed no drastic variation. Installation costs however could vary by a significant amount. We found that the installation cost could vary widely depending on how much work was needed for each installation. However, we found that like for like installation cost fell within a consistent range. These cost increases can be seen in Appendix C. By drawing on these finding, we concluded that the data collected would allow ATA to determine life cycle cost of particular hot water heat pump appliance models.

Performance comparisons

The overarching question for consumers and ATA is whether or not electrical appliances have the potential to be more energy efficient and cost affective than their equivalent gas units. When we examined the energy consumption rates, we saw that electricity undoubtedly exceeded the energy efficiency of gas. For example, heat pumps have a CoP of 3 to 5 whereas gas appliances have CoP's of 0.8 to .09. Therefore, with forecasted raises of gas costs, electric appliances have the potential to save significant amounts of energy and money for consumers. Initial findings regarding the model revealed that space heating accounted for the largest portion of energy consumption at 50% of the typical bill (Ford, 2012). Hot water heating accounted for around 25% and cooking accounted for a mere 2 to 4%. We concluded, along with ATA, that consumers seeking to convert should begin by converting their space heating first, and then convert hot water and cooktops at the same time. This information highlights the relevance of the potential savings for each appliance type to consumers.

Price comparisons

The life cycle costs analysis is yet to be conducted by ATA. However our initial findings suggested that over a 15-20 year period, electric appliances might cost less than comparable gas products. We concluded that despite high initial costs, the long-term costs would be able to save money by investing in these new technologies. ATA will need to focus their efforts on showing consumers the long-term benefits of electric appliances. The initial investment for these conversion units can be substantially more expensive than gas units, but the life cycle costs can be less. The data collect and presented in Appendix C accurately samples the appliance market and provides valuable data points for each appliance type.

4.2.2 Gas burner usage in regards to nine family scenarios

Prior to this study, there was little information regarding the typical family usage of gas burners and ovens and their total energy cost. Therefore, in order to gather data regarding this topic, we formulated a number of assumptions to decipher the amount of time a gas burner and oven is in use in different households. The scenarios that were used in this study are listed in Section 3.3.

We attempted to validate results for household gas usage by comparing our assumptions seen in Appendix B with the cooking survey described in Section 3.2.

In creating our assumptions for burner and gas usage in each different location, a high, medium, and low estimate was established for the calculation of weekly burner and oven costs. The results differ for each major city because gas is differently priced due to zone tariffs, as described in Section 2.2.2. Additional data regarding typical family gas usage can be found in Appendix B.

The figures in Appendix B begin by showing the high usage estimates of nine different scenarios for family types, as indicated under the yellow heading. The figures then proceed to show the data regarding total gas burner usage per household, which is located under the blue heading. This figure displays that a parent at home with an infant will have the highest burner operational cost at $9.58, due to the large usage of burner. The orange heading shows the gas oven consumption data. Housemates use the oven the most out of any scenario group, spending approximately $5.55 per week.

After using our own assumptions to estimate burner and oven usage, we compiled the results from the cooking survey. The survey results were divided into several groups:

- Couple household
- Living alone
- 1 parent with at least 1 dependent
- 2 parents with at least 1 dependent,
- Housemates or shared homes.

The survey records can be found in Appendix B.

For couple families, we received 10 responses. The responses show varied results and most of the categories received evenly split answers. For example, 1 person said they prepare 1 to 4 meals with their cooktop per week, 4 people prepare 5 to 9 meals with their cooktops per week, 3 people prepare 10 to 14 meals with their cooktops per week and 2 people prepare 15 to 19 meals with their cooktops per week. The general conclusion we gathered from this data was that there was a wide range of burner and oven usage within the same consumer group. Overall it showed that some people cooked more than others. In the "couples" example above, it can be seen that different families vary widely in how much they cook. This variation was seen throughout most of the family types and can be viewed in Appendix B.

For people living by themselves, we only received 5 survey responses. This sample size is too small to accurately represent this group. Looking at the five results received, we determined they were not conclusive. Similar to the results found for couple families, the meals prepared per week with the cooktop were not significant. Only 2 of the five results said they prepare 1 to 4 meals per week, 1 of the results said they prepare 5 to 9 meals per week, and 2 of the results said they prepare 10 to 14 meals per week. Similar to the couple households, there were no statistics signifying a majority. In other words, each person that completed the survey uses his or her cooktop and oven differently. There was no relationship between cooktops or ovens and people living alone.

Single parents with at least 1 dependent experienced the same lack of representation as the previously two mentioned households. We only received one response from a single parent with at least 1 dependent. One response is not a large enough sample for us to make accurate assumptions.

Two parent families with at least one depended were only represented by 6 survey responses and again, they lacked representation. Specifically, number of meals prepared with the cooktop varied as with each of the other categories shown in Appendix B. Because families that completed the survey did not have common tendencies, we could not assume how many or how long burners and ovens were used per week.

In regards to housemates or shared homes, only 4 surveys were completed. In order to depict an accurate amount of cooking tendencies, we needed a larger amount of responses. Having only 4 responses did not give us a large enough sample size to accurately generalize how shared households use cooktop burners and ovens.

With the completion of this survey, we expected to know approximately how many burners were used per week and how long they were used for. Because of the small sample size, approximations could not be made based on household type.

Part 2 – Creating fact sheets

In this project, we encountered a dilemma regarding our last objective: creating fact sheets. Originally, we had planned to use the output data of the "Gas Project Model" to create fact sheets that would inform consumers of the best energy choices based on the type of consumer they were. Unfortunately, the "Gas Project Model" was not fully completed in time for our team to use the information in our fact sheets. Therefore, we compiled data from our own work and ATA's "Round Arm Swing Model" to determine what type of energy would be more affordable and reliable. This model was used to determine the viability of the project by delivering early findings before ATA funded the Gas Model's creation. Our fact sheets were primarily based on price projections, performance of appliances, and typical family use of the appliance. We developed fact sheets that were specific enough to provide data to ATA and consumers. Most importantly, they allotted for ATA to input more data and make changes that are needed once the final results of the "Gas Project Model" were obtained.

4.3 Design of the Gas Project fact sheets for ATA

We created 10 fact sheets for each audience explained in Section 3.5. Each fact sheet is between two and four pages, containing material that is specific to each audience. Examples of all ten fact sheets can be found in Appendix D. These fact sheets were given to ATA for their distribution purposes. Overall, the fact sheets provided an effective way to communicate the information and data that we collected throughout this project to all consumers that may not be knowledgeable about the most cost effective form of household energy.

4.4 Summary of results

We gathered a very large amount of data to accomplish our objectives described in Chapter 3. The analysis of this data, coupled with the creation of our deliverables has led to consumers being correctly informed about gas and electricity as a household energy option. Although we found the data very useful, there are still validity issues that go along with the methods in which we collect our data. As with every research project, we still have recommendations that we suggest be taken in order to help further the validity of this household energy evaluation.

Chapter 5: Conclusions and Recommendations

With the completion of this project, we assisted the Alternative Technology Association's efforts to inform residential energy consumers of the most cost efficient form of energy for the use of cooktops, heat pumps, and split system air conditioners. Our research included finding costs for existing heating and cooking units, finding the energy consumption of all of these units, and the price of the gas or electricity needed to use them. The raw data we found will be input into ATA's "Gas Project Model" and used to develop conversion and cost scenarios. Using our knowledge of electric and gas appliances as well as tariffs, we were able to develop fact sheets suggesting how to save money and have more efficient cooking and heating appliances. These fact sheets will be distributed to consumers and presented the results of our research. In this section, we indicate a series of recommendations for ATA about how to improve and use the information we have provided.

5.1 Recommendations about gas and electricity tariffs

There is a very large amount of data for gas and electricity tariffs across the many distribution zones in eastern Australia. St. Vincent De Paul Society advised ATA of how to find all of these tariffs. We used their advice to provide tariffs for each state and distribution zone. Because we used the indicated sources and found both the gas and electricity tariffs, we recommend that ATA use these values for their model. ATA should be able to input the tariffs into their model and find how much residential customers are paying for gas or electricity. This data can also be used to compare the cost of gas to electricity for households in order to determine the more affordable option.

We found that **every organization forecasts information differently**, and this can lead to a very confusing interpretation of where the market may proceed to and why. Our results also show that energy organizations that forecast price and demand for the gas and electricity market do not account for elasticity of demand. Although our project group is unfamiliar with the specifics of economic modeling, we recommend that models would be much more **accurate** if organizations that forecasted prices and demand accounted for the elasticity of demand. There are methods that can be used to forecast the value of money in the future, just as there are methods to forecast the price and demand of energy sources.

5.2 Recommendations for Climate Zones

Attempting to define the climate zones for every consumer across Australia and input them into the model presents challenges for gathering accurate data for each area. We recommend that ATA look into the approach taken by the 2012 Pitt & Sherry report, *Running Costs and Operational Performance of Residential Heat Pumps* (Ford, 2012). This report examined 10 residential areas with different climates and used their specific climate information to create accurate data points. Following this type of method would allow ATA to observe the various climates that consumers live in. Then, once the climate types were determined, usage projections can be made for different consumer types. Overall, a large amount of assumptions still have to be made regarding consumer appliance usage. However, studying the different climate types reveal some consumer appliance usage characteristics.

5.3 Recommendations for Appliances

The analysis of the three appliance types revealed that the highest energy usage and potential for saving can be gained by focusing on space heating first, hot water heating second, and lastly cooking. Additionally, it revealed that establishing a consistent baseline conversion estimate that accounts for every appliance cost variable is based on assumptions that cannot accurately account for all variables. Consumer home specifications, preferences and installation requirement are not easily defined into specific groups, as they are individually unique to each consumer. Every consumer experience has the potential to vary widely from the ATA projections, which could lead to validity challenges for ATA in the future.

Based on these conclusions, we suggest that ATA focus on the three appliance types in the order listed above as well as clearly defining model scenario parameters. For most consumers, space heating and hot water are the best areas to invest in buying new appliances as they yield the greatest energy and cost savings, while at the same time requiring little or no lifestyle changes. Induction cooktops on the other hand yield minimal savings for the high investment. To clearly define the model scenario parameters, we recommend that ATA focus on specific brand name models that can be identified for use in specific household types. For example, we recommend Quantum 150L, 270L, and 340L models as the most cost effective quality heat pump for consumers. Appendix C has more specific model recommendations.

Modeling the performance of the three appliance types depends on the assumed parameters surrounding appliance usage, climate, and number of residents, among many other fine points. As a result, modeling this many assumptions may discredit some of the outcomes. We recommend that ATA find a way to reduce the number of assumptions that are made about appliance conversion scenarios. The greatest area we noticed this issue was with cooktop usage. Too many assumptions were made on very limited consumer reporting. Additionally, assumptions about split system air conditioner use cannot be tailored to the extreme range of space heating methods being used throughout Australia. Establishing clearly defined, fixed assumptions available to the consumer may help clarify the model and reduce the risk of validity challenges.

5.4 Recommendations for the cooking survey

During this project we distributed an online survey. We posted this survey to three online forums: Whirlpool, Energy Matters, and ATA. We collected a series of 27 responses. A total of 27 responses provided a decent overall data sample, but did not provide a large enough sample to examine household types. When sorting the responses into the five household types: couple, living alone, 1 parent with at least 1 dependent, 2 parents with at least 1 dependent, and housemates or shared homes, our sample size decreased significantly. As mentioned in Section 4.2.2, most of the household types had between 4 and 6 responses and one of the household types only had 1 response. Having so few responses did not provide us with large enough sample sizes to accurately determine the average burner and oven usage.

In order to obtain a larger sample size and more accurate results, we recommend performing another study. In order to estimate better records of burner and oven use, we recommend having a large amount of consumers per household type record their cooking directly after use. This could be done using a logbook where consumers write down what and how they cook each meal. Using a log or daily record would provide ATA with exact usage and would be more influential in their study. This would also allow for a higher number of consumers to participate; at least 20 results per household type. Because ATA has a limited budget for this type of research, it may not be feasible to do this exact type of study. If they are unable to support this type of project we recommend distributing the previously distributed survey to a wider audience. The audience could be subscribers to ATA's magazines or ATA members. Regardless of how more results are obtained, the responses we received in our online survey do not provide us with a large enough sample size to make necessary conclusions about burner and oven usage.

5.5 Recommendations for fact sheets

In order to begin the fact sheets, we established a series of 10 audiences to attract. Each fact sheet described how a consumer should take action in order to save money and have more efficient cooking and heating appliances. Our major recommendation for ATA's use of these fact sheets is to compare the assumptions that were made about different consumer audience energy usage with the output data from the "Gas Project Model". Although we used our data and price projection knowledge to generate consumer recommendations, the fact sheets will become validated with the data from ATA's modeling efforts.

5.6 Report Summary

The conventional thought of natural gas being the most cost effective form of household energy in Australia is changing. It is time well spent for dual-fuel households to consider a residential energy conversion from natural gas to electric appliances. For most consumers, the decision to invest in electric appliances can be difficult. However, with natural gas becoming more expensive, consumers who act sooner rather than later may experience the greatest savings. Throughout this project, we contributed to one of ATA's goals to inform residential consumers of the most cost effective form of energy for the use of cooktops, heat pumps, and split system air conditioners. The data we collected for ATA was provided for their "Gas Project Model" and then conveyed to consumers in fact sheets. The Alternative Technology Association will continue to provide advocacy information to residential energy consumers across Australia.

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Appendix A – Electricity and natural gas tariffs

Energy tariffs differ depending on the zone and state the energy is being provided to. Each zone and state has a combination of distributors providing gas or electricity. Gas and electricity have different tariffs and these tariffs were collected separately in our research.

With the help of ATA and their outside contacts, we first collected the gas tariffs. Tariffs were organized based on each Australian state. We started by listing the prices for Victoria given by St. Vincent De Paul Society. The tariffs are shown below.

Retailer	Zone	Time	GST Inclusive	Units
AGL	AGL South	peak consumption- first 3,000 MJ/60 days	2.2165	c/MJ
		peak consumption - next 3000 MJ/60 days	1.9305	c/MJ
		peak consumption - next 3000 MJ/60 days	1.5851	c/MJ
		peak consumption - next 6000 MJ/60 days	1.4476	c/MJ
		peak consumption - balance/ 60 days	1.4234	c/MJ
		off-peak consumption- first 3,000 MJ/60 days	2.0746	c/MJ
		off peak consumption - next 3000 MJ/days	1.8392	c/MJ
		off peak consumption - next 3000 MJ/days	1.5345	c/MJ
		off peak consumption - next 6000 MJ/60 days	1.408	c/MJ
		off peak consumption - balance/60 days	1.3695	c/MJ
		supply charge	59.235	c/day
	AGL North	peak consumption- first 6,000 MJ/60 days	2.1175	c/MJ
		peak consumption - next 6000 MJ/60 days	1.7677	c/MJ
		peak consumptions- next 72000 MJ/60 days	1.6148	c/MJ
		peak consumption - balance/ 60 days	1.3937	c/MJ
		off-peak consumption- first 6,000 MJ/60 days	1.892	c/MJ
		off-peak consumption - next 6000 MJ/60 days	1.6115	c/MJ
		off-peak consumptions - next 72000 MJ/60 days	1.5334	c/MJ
		off-peak consumption - balance/60 days	1.3244	c/MJ

		supply charge	62.128	c/day
	Origin Metro	peak consumption- first 3,000 MJ/60 days	2.1791	c/MJ
		peak consumption - next 3000 MJ/60 days	1.8997	c/MJ
		peak consumption - next 3000 MJ/60 days	1.5213	c/MJ
		peak consumption - next 6000 MJ/60 days	1.3222	c/MJ
		peak consumption - balance/ 60 days	1.2342	c/MJ
		off-peak consumption- first 3,000 MJ/60 days	2.0691	c/MJ
		off peak consumption - next 3000 MJ/days	1.7908	c/MJ
		off peak consumption - next 3000 MJ/days	1.4773	c/MJ
		off peak consumption - next 6000 MJ/60 days	1.3046	c/MJ
		off peak consumption - balance/60 days	1.2034	c/MJ
		supply charge	67.122	c/day
	Origin North	All consumption- first 1,644 MJ/60 days	2.2319	c/MJ
		All consumption- next 1,314 MJ/60 days	2.0306	c/MJ
		All consumption- balance/ 60 days	1.6984	c/MJ
		supply charge	68.827	c/day
	Origin south east	All consumption- first 1,644 MJ/60 days	2.2781	c/MJ
		All consumption- next 1,314 MJ/60 days	1.9547	c/MJ
		All consumption- balance/ 60 days	1.5609	c/MJ
		supply charge	68.717	c/day
	Tru East	All consumption- first 1,644 MJ/60 days	2.2506	c/MJ
		All consumption- next 1,314 MJ/60 days	2.1505	c/MJ
		All consumption- balance/ 60 days	1.463	c/MJ
		supply charge	66.946	c/day
	Tru Central	peak consumption- first 6,000 MJ/60 days	2.1714	c/MJ
		peak consumption - next 6000 MJ/60 days	1.6467	c/MJ
		peak consumptions- next 72000 MJ/60 days	1.3728	c/MJ
		peak consumption - balance/ 60 days	1.2749	c/MJ
		off-peak consumption- first 6,000 MJ/60 days	2.0152	c/MJ
		off-peak consumption - next 6000 MJ/60 days	1.4729	c/MJ
		off-peak consumptions - next 72000 MJ/60 days	1.3321	c/MJ
		off-peak consumption - balance/60	1.2496	c/MJ

		days		
		supply charge	64.185	c/day
	True West	peak consumption- first 6,000 MJ/60 days	1.969	c/MJ
		peak consumption - next 6000 MJ/60 days	1.8447	c/MJ
		peak consumptions- next 72000 MJ/60 days	1.65	c/MJ
		peak consumption - balance/ 60 days	1.4905	c/MJ
		off-peak consumption- first 6,000 MJ/60 days	1.8612	c/MJ
		off-peak consumption - next 6000 MJ/60 days	1.5224	c/MJ
		off-peak consumptions - next 72000 MJ/60 days	1.4223	c/MJ
		off-peak consumption - balance/60 days	1.4047	c/MJ
		supply charge	64.416	c/day
Origin Energy	AGL South	supply charge	60.775	c/day
		Winter peak		
		first 3500 MJ/2 months	2.1758	c/MJ
		over 3500 MJ/2 months	1.7435	c/MJ
		off peak		
		first 3500 MJ/2 months	1.9701	c/MJ
		over 3500 MJ/2 months	1.4707	c/MJ
	AGL North	supply charge	63.052	c/day
		Winter peak		
		first 3500 MJ/2 months	2.4431	c/MJ
		over 3500 MJ/2 months	1.9613	c/MJ
		off peak		
		first 3500 MJ/2 months	1.9371	c/MJ
		over 3500 MJ/2 months	1.6775	c/MJ
	Origin Metro	supply charge	66.715	c/day
		winter peak		
		first 6000 MJ/2 months	2.2088	c/MJ
		next 3000 MJ/2 months	1.7556	c/MJ
		Over 9000 MJ/2 months	1.2001	c/MJ
		off peak		
		first 6000 MJ/2 months	1.9844	c/MJ
		next 3000 MJ/2 months	1.5136	c/MJ
		Over 9000 MJ/2 months	1.1176	c/MJ
	Origin North	supply charge	62.403	c/day
		Winter peak		
		first 4000 MJ/2 months	2.0581	c/MJ
		next 8000 MJ/2 months	1.9745	c/MJ
		Over 12000 MJ/2 months	1.5576	c/MJ
		off peak		
		first 4000 MJ/2 months	1.9558	c/MJ
		next 8000 MJ/2 months	1.9261	c/MJ
		Over 12000 MJ/2 months	1.5059	c/MJ

	Origin south east	supply charge	61.215	c/day
		Winter peak		
		first 4000 MJ/2 months	2.123	c/MJ
		next 8000 MJ/2 months	1.8832	c/MJ
		Over 12000 MJ/2 months	1.6071	c/MJ
		off peak		
		first 4000 MJ/2 months	2.0724	c/MJ
		next 8000 MJ/2 months	1.8227	c/MJ
		Over 12000 MJ/2 months	1.5433	c/MJ
	Tru East	supply charge	60.698	c/day
		Winter peak		
		first 3200 MJ/2 months	2.1241	c/MJ
		over 3200 MJ/2 months	1.7721	c/MJ
		off peak		
		first 3200 MJ/2 months	2.0229	c/MJ
		over 3200 MJ/2 months	1.7204	c/MJ
	Tru Central	supply charge	65.428	c/day
		Winter peak		
		first 3200 MJ/2 months	2.4607	c/MJ
		over 3200 MJ/2 months	1.8799	c/MJ
		off peak		
		first 3200 MJ/2 months	2.1076	c/MJ
		over 3200 MJ/2 months	1.705	c/MJ
	Tru West	supply charge	63.866	c/day
		Winter peak		
		first 3200 MJ/2 months	2.2286	c/MJ
		over 3200 MJ/2 months	1.9261	c/MJ
		off peak		
		first 3200 MJ/2 months	1.8348	c/MJ
		over 3200 MJ/2 months	1.6214	c/MJ
Energy Australia	AGL South	supply charge	69.3	c/day
		first 50 MJ/day (peak)	2.145	c/MJ
		next 50 MJ/day (peak)	1.969	c/MJ
		next 50 MJ/day (peak)	1.716	c/MJ
		next 100 MJ/day (peak)	1.551	c/MJ
		balance MJ (peak)	1.54	c/MJ
		first 50 MJ/day (off-peak)	1.881	c/MJ
		next 50 MJ/day (off-peak)	1.683	c/MJ
		next 50 MJ/day (off-peak)	1.496	c/MJ
		next 100 MJ/day (off-peak)	1.364	c/MJ
		balance MJ (off-peak)	1.254	c/MJ
	AGL North	supply charge	68.2	c/day
		first 100 MJ/day (peak)	2.068	c/MJ
		next 100 MJ/day (peak)	1.848	c/MJ
		next 1200 MJ/day (peak)	1.562	c/MJ
		balance MJ (peak)	1.43	c/MJ
		first 100 MJ/day (off-peak)	1.958	c/MJ
		next 100 MJ/day (off-peak)	1.782	c/MJ

		next 1200 MJ/day (off-peak)	1.518	c/MJ
		balance MJ (off-peak)	1.386	c/MJ
	Origin Metro	supply charge	71.5	c/day
		first 50 MJ/day (peak)	2.167	c/MJ
		next 50 MJ/day (peak)	1.958	c/MJ
		next 50 MJ/day (peak)	1.551	c/MJ
		next 100 MJ/day (peak)	1.43	c/MJ
		balance MJ (peak)	1.265	c/MJ
		first 50 MJ/day (off-peak)	2.079	c/MJ
		next 50 MJ/day (off-peak)	1.892	c/MJ
		next 50 MJ/day (off-peak)	1.518	c/MJ
		next 100 MJ/day (off-peak)	1.342	c/MJ
		balance MJ (off-peak)	1.21	c/MJ
	Origin North	supply charge	68.2	c/day
		first 100 MJ/day (peak)	2.068	c/MJ
		next 100 MJ/day (peak)	1.848	c/MJ
		next 1200 MJ/day (peak)	1.562	c/MJ
		balance MJ (peak)	1.43	c/MJ
		first 100 MJ/day (off-peak)	1.958	c/MJ
		next 100 MJ/day (off-peak)	1.782	c/MJ
		next 1200 MJ/day (off-peak)	1.518	c/MJ
		balance MJ (off-peak)	1.386	c/MJ
	Origin south east	supply charge	71.5	c/day
		first 100 MJ/day (peak)	2.101	c/MJ
		next 100 MJ/day (peak)	1.782	c/MJ
		next 1200 MJ/day (peak)	1.551	c/MJ
		balance MJ (peak)	1.309	c/MJ
		first 100 MJ/day (off-peak)	2.024	c/MJ
		next 100 MJ/day (off-peak)	1.738	c/MJ
		next 1200 MJ/day (off-peak)	1.452	c/MJ
		balance MJ (off-peak)	1.221	c/MJ
	Tru East	supply charge	68.2	c/day
		first 100 MJ/day (peak)	2.046	c/MJ
		next 100 MJ/day (peak)	1.859	c/MJ
		next 1200 MJ/day (peak)	1.672	c/MJ
		balance MJ (peak)	1.364	c/MJ
		first 100 MJ/day (off-peak)	1.958	c/MJ
		next 100 MJ/day (off-peak)	1.749	c/MJ
		next 1200 MJ/day (off-peak)	1.551	c/MJ
		balance MJ (off-peak)	1.331	c/MJ
	Tru Central	supply charge	64.9	c/day
		first 100 MJ/day (peak)	2.453	c/MJ
		next 100 MJ/day (peak)	2.079	c/MJ
		next 1200 MJ/day (peak)	1.683	c/MJ
		balance MJ (peak)	1.419	c/MJ
		first 100 MJ/day (off-peak)	2.079	c/MJ
		next 100 MJ/day (off-peak)	1.903	c/MJ
		next 1200 MJ/day (off-peak)	1.562	c/MJ

		balance MJ (off-peak)	1.17	c/MJ
	Tru West	supply charge	62.7	c/day
		first 100 MJ/day (peak)	2.178	c/MJ
		next 100 MJ/day (peak)	2.024	c/MJ
		next 1200 MJ/day (peak)	1.815	c/MJ
		balance MJ (peak)	1.573	c/MJ
		first 100 MJ/day (off-peak)	1.903	c/MJ
		next 100 MJ/day (off-peak)	1.672	c/MJ
		next 1200 MJ/day (off-peak)	1.573	c/MJ
		balance MJ (off-peak)	1.507	c/MJ

Table 4: Victoria residential gas tariffs

Table 4 lists the eight distributors of gas in the state of Victoria: AGL South, AGL North, Origin Metro, Origin North, Origin South East, Tru East, Tru Central, and Tru West (Printer, 2013a, 2013b, 2013c). The distributors classify their gas prices in a series of increments of energy used by the household. Each increment is different based on the distributor; the increments are listed in the Time column of Table 1. Times that indicate peak consumption refer to rates applicable from 1 May to 31 October, while Off-peak consumption refers to all other months of the year.

There are two components to the tariffs in Table 1. The first component is the consumption cost, measured in cents per Mega Joule. The second component is fixed, charging customers a daily connection cost for gas. Fixed costs are represented as cents per day in Table 4.

Again, the gas tariffs in Table 4 only correspond to the state of Victoria. A series of Victorian postcodes were grouped based on what distributor they fall under. These postcodes can be seen below.

Distributor	Postcodes
AGL South	3150, 3152, 3156, 3158, 3160, 3161, 3162, 3163, 3165, 3166, 3167, 3168, 3169, 3170, 3171, 3172, 3173, 3174, 3175, 3177, 3178, 3179, 3180, 3182, 3183, 3184, 3185, 3186, 3187, 3188, 3189, 3190, 3191, 3192, 3193, 3194, 3195, 3196, 3197, 3202, 3204, 3205, 3206, 3207, 3775, 3785, 3786, 3802

AGL North	3011, 3012, 3013, 3015, 3016, 3018, 3019, 3020, 3021, 3022, 3023, 3025, 3026, 3027, 3028, 3031, 3032, 3033, 3034, 3036, 3037, 3038, 3039, 3040, 3041, 3042, 3043, 3044, 3045, 3046, 3047, 3048, 3049, 3055, 3058, 3059, 3060, 3061, 3062, 3063, 3064, 3428
Origin Metro	3004, 3006, 3097, 3101, 3102, 3103, 3104, 3105, 3106, 3107, 3108, 3109, 3111, 3113, 3114, 3115, 3116, 3122, 3123, 3124, 3125, 3126, 3127, 3128, 3129, 3130, 3131, 3132, 3133, 3134, 3135, 3136, 3137, 3138, 3140, 3141, 3142, 3143, 3144, 3145, 3146, 3147, 3148, 3149, 3151, 3153, 3154, 3155, 3159, 3175, 3181, 3201, 3765, 3766, 3767, 3770, 3781, 3782, 3783, 3787, 3788, 3789, 3791, 3792, 3793, 3795, 3796, 3804.
Origin North	3521, 3522, 3523, 3561, 3564, 3607, 3608, 3614, 3616, 3617, 3618, 3620, 3621, 3622, 3623, 3624, 3629, 3630, 3631, 3633, 3658, 3659, 3660, 3662, 3663, 3664, 3665, 3666, 3669, 3672, 3673, 3675, 3677, 3678, 3682, 3683, 3688, 3690, 3691, 3694, 3726, 3747, 3749, 3753, 3756, 3758, 3764.
Origin South East	3198, 3199, 3200, 3755, 3760, 3761, 3777, 3803, 3805, 3806, 3807, 3808, 3809, 3810, 3816, 3818, 3820, 3822, 3823, 3824, 3825, 3840, 3842, 3844, 3847, 3850, 3851, 3852, 3854, 3856, 3857, 3858, 3859, 3860, 3862, 3869, 3873, 3910, 3911, 3912, 3913, 3915, 3916, 3918, 3919, 3920, 3921, 3926, 3927, 3928, 3929, 3930, 3931, 3933, 3934, 3936, 3937, 3938, 3939, 3940, 3941, 3942, 3943, 3944, 3975, 3976, 3977, 3978, 3980, 3981, 3984, 3987.
Tru East	3000, 3001, 3002, 3003, 3005, 3008, 3050, 3051, 3052, 3053, 3054, 3055, 3056, 3057, 3065, 3066, 3067, 3068, 3070, 3071, 3072, 3073, 3074, 3075, 3076, 3078, 3079, 3081, 3082, 3083, 3084, 3085, 3087, 3088, 3089, 3090, 3091, 3093, 3094, 3095,

	3096, 3097, 3099, 3121, 3201, 3750, 3752, 3754, 3759, 3770
Tru Central	3024, 3029, 3030, 3211, 3212, 3214, 3215, 3216, 3217, 3218, 3219, 3220, 3221, 3222, 3223, 3224, 3225, 3226, 3227, 3228, 3335, 3337, 3338, 3427, 3429
Tru West	3249, 3250, 3260, 3266, 3277, 3280, 3282, 3284, 3300, 3305, 3340, 3342, 3350, 3352, 3355, 3356, 3357, 3363, 3364, 3377, 3380, 3430, 3431, 3434, 3435, 3437, 3438, 3440, 3442, 3444, 3450, 3451, 3460, 3461, 3462, 3464, 3465, 3550, 3551, 3555, 3556

Table 5: Victorian post codes categorized by gas distributor

The postcodes listed in Table 5 indicate the areas of residents that are paying the tariffs in Table 4 (Printer, 2013a, 2013b, 2013c).

The second state we gathered tariffs for was New South Wales (NSW). ATA was advised by consultants at the St. Vincent De Paul Society that tariffs for NSW were located among the websites of three distributors. The three distributors were Jemena/AGL, Actew AGL 1, and Country Energy (Mauseth, 2014). The gas tariffs for NSW are shown in Table 6 below.

Distributor	Location	Time	GST Inclusive	Units
Jemena/AGL	Greater Sydney	c/MJ 1st block	3.6157	c/MJ
	Supply charge	day fixed charges	51.799	c/day
Actew AGL 1	1: Boorowa, Goulburn, Yass and Young	c/MJ 1st block	3.1878	c/MJ

		day fixed charges	49.797	c/day
	2: Queanbeyan and Bundgendore region	c/MJ 1st block	2.3254	c/MJ
		day fixed charges	63.745	c/day
	3: Shoalhaven	c/MJ 1st block	2.3254	c/MJ
		day fixed charges	59.73	c/day
Country Energy	1: Cooma & Bombala	c/MJ	2.3375	c/MJ
		day fixed charges	63.492	c/day
	2: Henty, Holbrook, Culcain & Walla Walla	c/MJ	2.3254	c/MJ
		day fixed charges	68.09	c/day
	3: Temora	c/MJ	2.3254	c/MJ
		day fixed charges	68.09	c/day
	4: Tumut & Gundagai	c/MJ	2.4453	c/MJ
		day fixed charges	73.403	c/day
	5: Wagga Wagga & Uranquinty	c/MJ	2.0053	c/MJ
		day fixed charges	78.023	c/day

	6: Tamworth	c/MJ	3.5552	c/MJ
		day fixed charges	57.167	c/day

Table 6: New South Wales residential gas tariffs

Table 6 lists the three gas distributors in New South Wales and the areas that each of the distributors service. Similar to the Victoria tariffs in Table 4, the distributors have two prices for gas, one fixed (day fixed charges) and the other variable (c/MJ). The day fixed charges are measured in cents per day and the variable charges are measured in cents per Mega Joule.

The locations in New South Wales are indicated for each distributor. Jemena/AGL has one location it distributes to in Greater Sydney. The variable cost of gas in Greater Sydney is the highest of the areas in New South Wales. Actew AGL 1 services three different zones: the first, Boorowa, Gouldburn, Yass and Young, the second, Queanbeyan and Bundegendore region, and the third, Shoalhaven. These three zones have different supply and consumption costs. Country Energy distributes gas to six different zones. The first Country Energy zone includes Cooma and Bombala, the second includes Henty, Holbrook, Culcain and Walla Walla, and the third includes Temora. The fourth zone Country Energy is responsible for distributing to is Tumut and Gundagai, the fifth is Wagga Wagga and Uranquinty, and the sixth is Tamworth. Country Energy zone five has the highest daily fixed charge in New South Wales (Mauseth, 2014). The gas tariffs in Table 3 show how much residents are paying for gas in 2014.

The third State evaluated was South Australia. South Australia only has one distributor of gas among residential consumers. This distributor is known as Origin Energy, which covers the location of Port Pirie (Origin Energy, 2014). The tariffs found for South Australia are shown in Table 7 below.

Distributor	Time	GST Inclusive	Units
Origin Energy	Consumption- first	3.9908	c/MJ

	4,500 MJ/qrt		
	Consumption-Balance MJ/qrt	1.7248	c/MJ
	Daily Supply Charge	71.5	cents per day

Table 7: South Australia residential gas tariffs

Origin Energy listed their gas standing offers including the fixed and variable prices. The variable price depended on how much energy was consumed. As shown in the table, the first 4,500 MJ per quarter consumed was more expensive than the remaining MJ consumed by households (Origin Energy, 2014). Origin Energy also required a daily supply charge for each day that gas is used in a household. The consumption rates were evaluated in units of cents per Mega Joule and the daily supply charge was calculated in cents per day. The tariffs were not as extensive for South Australia than in other states because South Australia does not have as high of a gas supply.

The fourth state we needed tariffs for was Tasmania. Two different gas distributors control Tasmania. The first distributor is Tas Gas and the second is Aurora. Locations that these distributors provide gas to are Hobart, Launceston, Westbury, and Longford (Tas Gas, Aurora Energy, 2014). The prices for each of these distributors are shown in Table 8 below.

Distributor	Time	GST Inclusive	Units
Tas Gas	Energy rate	11.5	cents per kWh
		3.19	c/MJ
	Fixed fee	21.76	cents per day
		79.42	dollars per annum
Aurora	Tariff for residential gas customers	3.19	c/MJ

	Daily charge	21.5	cents per day

Table 8: Tasmania residential gas tariffs

Tas Gas had fixed and variable gas costs. Their energy or consumption rate was listed in both cents per kWh and cents per Mega Joule. Their fixed fee was listed in both cents per day and dollars per annum (Tas Gas). Aurora is the other distributor in Tasmania. They have one set variable cost measured in cents per Mega Joule. Aurora's daily charge is measured in cents per day (Aurora Energy, 2014). These two distributors have very similar tariff standing offers. Tas Gas and Aurora both effectively distribute gas to residential customers in Tasmania.

The fifth area we needed gas prices for is not a state, but instead it is a territory: Australian Capital Territory (ACT). ACT uses only one of the distributors in its state of New South Wales. ActewAGL is the only residential gas distributor among the Australian Capital Territory (ActewAGL, 2013). The tariffs for ACT are shown in Table 9 below.

Distributor	Time	GST Inclusive	Units
ActewAGL	First 41.0959 MJ/day	2.7764	c/MJ
	Next 2,704.1096 MJ/day	2.5608	c/MJ
	Next 10,964.3836	2.497	c/MJ
	Thereafter	2.2825	c/MJ
	Supply fee	64.009	c/day

Table 9: Australian Capital Territory residential gas tariffs

ActewAGL had multiple variable tariffs depending on the Mega Joules of gas used per day. The prices were divided by the first 41.0959 MJ/day, next 2,704.1096 MJ/day, next 10,964.3836 MJ/day, and the MJ/day consumed thereafter. In addition to the consumption fee, the supply fee was applicable and measured in cents per day. ActewAGL published these tariffs, making it possible for ATA to find how much the ACT residential gas customers were paying (ActewAGL, 2013). The tariffs published supported ATA's "Gas Project Model."

The six and final Australian state or area whose gas tariffs were recorded was Queensland. Queensland had two distributors of residential gas, Origin Energy and AGL (NELSON & SIMSHAUSER, 2013). AGL distributed to two different zones. The first zone consists of the Gold Coast areas, Toowoomba, and Oakey. The second zone consists of North Brisbane and Ipswitch. The gas tariffs for Queensland are displayed in Table 10 below.

<table>
<tr><th>Distributor</th><th>Time</th><th>Supply</th><th>GST Inclusive</th><th>Units</th></tr>
<tr><td rowspan="4">Origin Energy</td><td>First 748 MJ/qtr</td><td>-</td><td>5.929</td><td>c/MJ</td></tr>
<tr><td>Next 1752 MJ/qtr</td><td>-</td><td>3.916</td><td>c/MJ</td></tr>
<tr><td>Balance</td><td>-</td><td>2.365</td><td>c/MJ</td></tr>
<tr><td>Supply Charge</td><td>-</td><td>75.933</td><td>c/day</td></tr>
<tr><td rowspan="8">AGL</td><td rowspan="4">Gold Coast areas, Toowoomba, Oakey</td><td>First 8.5 MJ per day</td><td>4.1085</td><td>c/MJ</td></tr>
<tr><td>Next 17 MJ per day</td><td>2.9348</td><td>c/MJ</td></tr>
<tr><td>Thereafter</td><td>2.7489</td><td>c/MJ</td></tr>
<tr><td>Daily supply charge</td><td>102.113</td><td>c/day</td></tr>
<tr><td rowspan="4">North Brisbane & Ipswitch</td><td>First 8.2 MJ per day</td><td>5.4197</td><td>c/MJ</td></tr>
<tr><td>Next 19.2 MJ per day</td><td>4.0821</td><td>c/MJ</td></tr>
<tr><td>Balance per day</td><td>3.5057</td><td>c/MJ</td></tr>
<tr><td>Daily supply charge</td><td>79.233</td><td>c/day</td></tr>
</table>

Table 10: Queensland residential gas tariffs

Origin Energy had multiple consumption tariffs for residents in Queensland depending on their MJ of gas used per day. They divide their consumption prices by the first 748 MJ/qtr, the next 1752 MJ/qtr, and the balance. All of Origin Energy's consumption costs depended on the units, cents per Mega Joule. Origin Energy also had a fixed supply charge contributing to the overall cost of gas distributed, accounting for the cents per day cost. AGL Gold Coast, Toowoomba, and Oakey zones had different consumption tariff guidelines than the other two zones. The consumption prices for AGL's areas were charged by the first 8.5 MJ per day, the next 17 MJ per day, and the MJ used thereafter. A daily supply charge was also present for residencies receiving gas in this zone; this charge was measured in cents per day. AGL's other zone in Queensland contains North Brisbane and Ipswitch and organizes their consumption rates based on the first 8.2 MJ per day used, the next 19.2 MJ per day used, and the balance per day in cents per Mega Joule.

The gas tariffs across Victoria, New South Wales, South Australia, Tasmania, ACT, and Queensland were crucial for creating ATA's "Gas Project Model." The tariffs listed in Tables 3-10 display all of the data that ATA needed regarding gas tariffs.

For the "Gas Project Model," ATA not only needed to know all of the gas prices and zones in each of the indicated states, but they also needed to know the electricity prices. The tariffs are listed above for all of the found gas prices. They were found through a series of gas distributors located across Victoria, New South Wales, South Australia, Tasmania, the Australian Capital Territory, and Queensland. Some of the same distributors also provide electricity to residential customers in addition to electricity specific companies. Similar to how the gas tariffs were presented in previous paragraphs of this section, Section 4.1.2, the electricity tariffs are presented in the succeeding paragraphs.

The first state observed for electricity tariffs was Victoria. Victoria had three distributors of electricity. The distributors were the three major companies in Australia: AGL, Origin Energy, and Energy Australia. Each of these companies was responsible for five zones. The five zones were: Jemena distribution zone, United Energy distribution zone, Citipower distribution zone, Powercore distribution zone, and SP Ausnet distribution zone (Printer, 2013a, 2013b, 2013c). Each of these residential zones charged customers a different tariff depending on their controlling distributor. For example, The GST Inclusive tariff for the Jemena zone under AGL is different than the GST Inclusive tariff for the Jemena zone under Origin Energy. The tariffs for Electricity in Victoria are listed in the table below.

Distributor	Zone	Time	GST Inclusive	Uni
AGL sales	Jemena Distribution Zone	Peak consumption	30.173	c/kV
		Supply charge	128.876	c/da
	United Energy Distribution Zone	Peak consumption	28.402	c/kV
		Supply charge	114.411	c/da
	Citipower Distribution Zone	Peak consumption - first 1,020 kWh/91 days	26.158	c/kV
		Peak consumption - balance/ 91 days	27.313	c/kV
		Supply charge	104.797	c/da
	Powercor Distribution Zone	Peak consumption - first 1,020 kWh/91 days	30.206	c/kV
		Peak consumption - balance/ 91 days	30.778	c/kV
		Supply charge	113.707	c/da
	SP Ausnet Distribution Zone	Peak consumption - first 1,020 kWh/91 days	31.339	c/kV
		Peak consumption - balance/ 91 days	29.513	c/kV
		Supply charge	138.82	c/da
Origin Energy	Jemena Distribution Zone	All consumption	30.349	c/kV
		Daily Supply Charge	113.663	c/da
	United Energy Distribution Zone	All consumption	29.414	c/kV
		Daily Supply Charge	110.539	c/da
	Citipower Distribution Zone	Consumption of first 1020 kWh/qtr	23.969	c/kV
		Remaining consumption kWh/qtr	25.938	c/kV
		Daily Supply Charge	105.391	c/da
	Powercor Distribution Zone	Consumption - first 1000 kWh/qtr	29.656	c/kV
		Consumption - balance kWh/qtr	31.537	c/kV
		Daily Supply Charge	114.169	c/da
	SP Ausnet Distribution Zone	Peak consumption - first 1020 kWh/qtr	29.832	c/kV
		Peak consumption - balance kWh/qtr	35.332	c/kV
		Daily Supply Charge	130.581	c/da
		Dedicated Circuit (Where	16.225	c/kV

		Applicable)		
Energy Australia	Jemena Distribution Zone	Supply Charge	110	c/da
		All peak consumption	29.535	c/kV
	United Energy Distribution Zone	Supply Charge	105.05	c/da
		All peak consumption	27.665	c/kV
	Citipower Distribution Zone	Supply Charge	103.62	c/da
		First 11.178 kWh/day peak consumption	24.574	c/kV
		Balance peak consumption	27.445	c/kV
	Powercor Distribution Zone	First 10.959 kWh of Peak usage per day	29.425	c/kV
		Balance peak consumption	29.975	c/kV
		Daily Supply Charge	112.42	c/da
	SP Ausnet Distribution Zone	Supply Charge	115.72	c/da
		All peak consumption	31.416	c/kV

Table 11: Victoria residential electricity tariffs

As shown in Table 11 above, there were several different electricity tariffs in Victoria. Each zone had a different supply charge and consumption charge based on usage. A major difference between the measurement of gas and electricity usage were the units that they are measured in. As shown in previous paragraphs of Section 4.1.1, gas is measured in cents per Mega Joule, but as shown in Table 11 above, electricity is measured in cents per kilo-Watt-hour.

The second state electricity tariffs were found for was New South Wales (NSW). Residents in New South Wales received their electricity from one of two distributors. The distributors that were available to NSW residents were Origin Energy and ActewAGL (Australia, 2014 ; Energy Australia, 2014; Origin Energy, 2013a, 2013b, 2014a). The electricity tariffs found for all of the NSW zones are shown in the table below.

Distributor	Zone	Time	GST Inclusive	Units
Origin Energy	AusGrid Distribution Zone	consuption of first 1,000 kWh/qtr	27.39	c/kWh
		Consumption of next 1,000 kWh/qrt	29.018	c/kWh
		Ramaining consumption kWh/qtr	31.328	c/kWh
		Daily Supply Charge	78.1	c/day
	Essential Energy Distribution Zone	All consumption	34.221	c/kWh
		Daily Supply Charge	137.269	c/day

	Endeavour Energy Distribution Zone	Consumption of first 1,750 kWh/qtr	27.126	c/kWh
		Remaining consumption kWh/qtr	30.151	c/kWh
		Daily Supply Charge	76.868	c/day
ActewAGL	ActewAGL-Residential Basic Network	A network access charge per day	23.584	c/day
		All Energy Consumption	7.777	c/kWh
Energy Australia	AusGrid	First 10.9589 kWh of Peak usage per day	27.39	c/kWh
		Next 10.9589 kWh of Peak usage per day	29.018	c/kWh
		Balance	31.328	c/kWh
		Daily Supply Charge	78.1	c/day

Table 12: New South Wales residential electricity tariffs

As seen in Table 12 above, Origin Energy and ActewAGL separated their distribution networks into zones. The three zones that Origin Energy distributes to are the AusGrid distribution zone, the Essential Energy distribution zone, and the Endeavor Energy distribution zone. Each of these zones used different consumption charges. AusGrid's consumption charges changed depending on the first 1,000 kWh/qtr used, the next 1,000 kWh/qtr used, and the remaining kWh/qtr used. Essential Energy's consumption tariffs were at a single rate for all residential consumption. Endeavour Energy's consumption tariffs are divided based on the consumption of the first 1,750 kWh/qtr, and the remaining consumption thereafter in kWh/qtr. Each of Origin Energy's three zones had a fixed daily supply charge in addition to a consumption charge. These fixed charges were measured in cents per day. ActewAGL only had one distribution zone in New South Wales. The single zone was known as ActewAGL's residential basic network. The residential basic network had a single consumption charge and a single access charge per day (Australia, 2014 ; Energy Australia, 2014; Origin Energy, 2013a, 2013b, 2014a). For all electricity consumption charges, energy was measured in cents per kilo-Watt-hour.

The third Australian state we found electricity tariffs for was South Australia. South Australia had only one electricity distributor, known as Origin Energy (Origin Energy, 2013c). Electricity tariffs found for South Australia are listed in the table below.

Distributor	Zone	Time	GST Inclusive	Units
Origin Energy	SA Power Networks Distribution Zone	Summer 1 Jan- 31 Mar		
		Consumption - First 300 kWh/qtr	35.607	c/kWh
		Consumption - Next 700 kWh/qtr	38.764	c/kWh
		Consumption - Next 1,500 kWh/qtr	43.758	c/kWh
		Consumption - Next 2,500 kWh/qtr	47.146	c/kWh
		Consumption - Balance	47.146	c/kWh
		Winter 1 Apr - 31 Dec		
		Consumption - First 300 kWh/qtr	33.803	c/kWh
		Consumption - Next 700 kWh/qtr	34.441	c/kWh
		Consumption - Next 1,500 kWh/qtr	39.413	c/kWh
		Consumption - Next 2,500 kWh/qtr	42.801	c/kWh
		Consumption - Balance	42.801	c/kWh
		Daily Supply Charge	78.166	c/day

Table 13: South Australia residential electricity tariffs

As shown in Table 13 above, Origin Energy only had one distribution zone in South Australia. The distribution zone that Origin Energy was responsible for was called SA (South Australia) Power Networks distribution zone. Tariffs for this zone were divided into summer and winter usage. Summer included the dates from January 1st to March 31st. Winter included the dates from April 1st to December 31st. For each of these seasonal intervals, residential customers were charged for the first 300 kWh/qtr, the next 700 kWh/qtr, the next 1,500 kWh/qtr, the next 2,500 kWh/qtr, and the remaining balance of consumption. The consumption tariffs were charged in cents per kWh. Similar to all of the tariffs recorded in previous states, South Australia's Origin Energy distributor charged a daily supply charge in cents per day.

The fourth state we gathered electricity tariffs for was Tasmania. Tasmania only had one distributor of electricity. The tariffs are divided into separate payments based on what the electricity is used for in each residency. Tariff prices for Tasmania are listed in the table below.

Distributor	Time	GST Inclusive	Units
Aurora	Residential light and power - Tariff 31		
	Fixed charges	95.09	c/day
	Energy (all kWh)	25.807	c/kWh
	Heating discount - Tariff 42 (residential hot water and space heating		
	Fixed charges	18.417	c/day
	Energy (all kWh)	16.167	c/kWh
	General - Tariff 22		
	Fixed charges	102.725	c/day
	First 500 kWh per quarter	36.564	c/kWh
	Remainder	26.841	c/kWh

Table 14: Tasmania residential electricity tariffs

Table 14 above shows each tariff that Aurora used including the consumption and fixed charges. Unlike tariffs found in other states, Tasmania had multiple tariffs based on what electricity was used for. One tariff was 31, which was used for residential light and power. Another tariff was 42, which was for heating using residential hot water and space heating. Also listed in Table 10 is the general electricity tariff, tariff 22. Tariff 31 had one consumption cost of all energy used. Tariff 42 also had one consumption cost for all kilo-Watt-hours of energy used. Tariff 22 had multiple consumption charges, one for the first 500 kilo-Watt-hours of energy used per quarter and another for the remainder of the kilo-Watt-hours of energy used per quarter (Aurora Energy, 2014a). Each of these three tariffs also had a fixed supply charge for cents charged per day of electricity distribution.

The fifth geographic area we separated our tariffs into was the Australian Capital Territory (ACT). ACT had only one electricity distributor for residential areas known as Origin Energy. Within Origin Energy's distribution network, there was only one zone that they used for distribution called the ActewAGL distribution zone. The tariffs for the Australian Capital Territory are shown in the table below.

Distributor	Zone	Time	GST Inclusive	Units
Origin Energy	ActewAGL Distribution Zone	All consumption	20.13	c/kWh
		Daily Supply Charge	73.48	c/day

Table 15: Australian Capital Territory residential electricity tariffs

Table 15 above, shows the tariffs present in the ACT. Origin Energy's ActewAGL distribution zone was broken up into two individual charges. The variable charge was for consumption. All consumption is charged the same fee determined by cents per kilo-Watt-hours. A fixed charge was included in the overall tariff for a cents per day daily supply charge (Origin Energy, 2014a). Origin Energy in the ACT was a simple tariff with one consumption cost and one supply cost.

The sixth state or area examined for ATA's "Gas Project Model" was Queensland. Two distributors controlled Queensland's electricity industry; Origin Energy and AGL. Each of these distributors had one zone they were responsible for. Origin Energy was responsible for the Energex distribution zone and AGL is responsible for the Australian Power and Gas zone. All of the tariffs found for Queensland are presented in the table below.

Distributor	Zone	Time	GST Inclusive	Units
Origin Energy	Energex Distribution Zone	All Consumption	29.403	c/kWh
		Daily Supply Charge	55.2409	c/day
AGL	Australian	Tariff 11 - Domestic		

	Power & Gas	Supply Charge	16.8	$/month
		All kWh	29.4	c/kWh
		Tariff 11+31 - Domestic + Night Rate (super Economy)		
		All off Peak kWh	13.61	c/kWh
		Tariff 11+31 - Domestic + Controlled Supply (Economy)		
		All off Peak kWh	19.86	c/kWh
		Tariff 12/13		
		Supply Charge	38.11	$/month
		All Peak kWh	34.06	c/kWh
		All Shoulder kWh	24.65	c/kWh
		All off Peak kWh	18.92	c/kWh

Table 16: Queensland residential electricity tariffs

Table 16 above displays each of the tariffs we found for Queensland. Energex distribution zone was straight forward, only listing the electricity consumption and daily supply charge. The Australian Power and Gas zone had a series of four different tariffs. Tariff 11 was for domestic charges, Tariff 11 and 31 were for domestic and night rates, Tariff 11 and 31 were for domestic and controlled supply, and Tariff 12/13. Tariff 11 had a single consumption charge and a daily supply charge. Tariff 11 and 31 for the domestic and night rate only charged residential customers with cents per kilo-Watt-hours of all off peak kilo-Watt-hours. Tariff 11 and 31 for domestic and controlled supply charge with the same assumptions of all off peak kilo-Watt-hours. Tariff 12/13 divided the consumption charge by all peak kilo-Watt-hours used, all shoulder kilo-Watt-hours used, and all off peak kilo-Watt-hours used (Australian Power & Gas, 2013; Origin Energy, 2013c). Each of the tariffs included a supply charge of dollars per month needed for distribution.

Appendix B – Cooking survey and results

The following represents the cook top and oven usage survey.

1	Do you use gas cooktops, electric cooktops, or both for cooking needs? a. Gas b. Electricity c. Both d. Neither
2	Do you have a cooktop in your residence? If yes, how many meals do you prepare with your cooktop per week? a. 0 or I do not have a cooktop b. 1-4 c. 5-9 d. 10-14 e. 15-19 f. 20-29 g. 30+ h. Fill in the blank
3	If you have a cooktop in your residence, how many instances per week do you use it for boiling tea or coffee, boiling for sterilization purposes, or other purposes besides cooking? a. 0 or I do not have a cooktop b. 1-4 c. 5-9 d. 10-14 e. 15-19 f. 20-29 g. 30+ h. Fill in the blank
4	On average, how many times a week do you use your cooktop for the following meal durations (length of time necessary to cook): a. Short duration. Example: eggs, tea, coffee, etc. i. Fill in the blank b. Medium duration. Example: Boiling pasta, pan-frying chicken,

	etc. i. Fill in the blank c. Extended duration: Example: Making soup from scratch, making homemade pasta sauce, etc. i. Fill in the blank
5	When using your cooktop, how many times a week does your burner remain on the following settings: a. Simmer (low heat) i. Fill in the blank b. Medium (half heat) i. Fill in the blank c. High (full heat) i. Fill in the blank
6	On average, how much time does your cooktop spend in the on position during each use? a. Fill in the blank
7	Do you have an oven in your residence? If yes, how many meals do you prepare with your oven per week? a. I do not have an oven b. 0 c. 1-4 d. 5-9 e. 10-19 f. 20+
8	On average, how much time does your oven spend in the on position during each use? a. Fill in the blank
9	1. Are you typically home or away during the day? Please select all that apply. a. Home on the weekdays b. Away on the weekdays c. Home on the weekends d. Away on the weekends

	e. Fill in the blank
10	How do you classify your household? a. Living by yourself b. Couple c. Housemates/shared home d. 2 parents with at least 1 dependent e. Single parent with at least 1 dependent f. Other- fill in the blank
11	Do you have any further information that you wish to share? a. Fill in the blank

Table 17: List of questions asked for cooking survey

The results were compiled to show data based on household type. The following answers were received for couples:

Scenario Data		Cooking data				Cooktop durations per week			Burner usage per week			Oven Usage	
Household type	Home or away during the day	cooktop type	Meals prepared per week with cooktop	cooktop used for boiling water	Time the burner spends in the on position	Short	Medium	Long	Simmer	Medium	High	Meals prepared per week	Average time spent in the on position during each use
Couple	away on weekends	gas	5 to 9	5 to 9	25 min	5	5	2	5	3	5	0	35 min
	Home	both	10 to 14	0	60 min	2	4	2	4	4	0	1 to 4	60 min - electric oven
	home weekdays, away weekends	both	5 to 9	0	20 min	0	X	0	0	0	X	1 to 4	90 min
	away on weekdays	both	5 to 9	1 to 4	10 min	0	chicken	0	0	0	high	10 to 19	N/A
	away weekdays, home weekends	electric	5 to 9	0	10 min	3	5	0	5	3	0	1 to 4	30 min
	away weekdays, home weekends	gas	15 to 19	5 to 9	20 min	10	5	4	8	8	3	1 to 4	60 min
	away weekdays, home weekends	gas	15 to 19	0	15 min	all	all	all	0	most	most	10 to 19	35 min
	home	gas	1 to 4	0	N/A	-	-	-	-	-	-	1 to 4	120 min
	home (retired)	gas	10 to 14	30+	10 min	through day	through day	through day	10	0	30+	0	0 min
	home weekends, home some weekdays	both	10 to 14	1 to 4	20 min	5	14	1	40%	30%	30%	5 to 9	45 min

Table 18: Cooking data for couple families

Many conclusions were made from this data and compared to the estimated data in Section 4.2.2. Survey results were also gathered for people living by themselves. The following table includes this survey results:

Scenario Data		Cooking data				Cooktop durations per week			Burner usage per week			Oven Usage	
ousehold pe	Home or away during the day	cooktop type	Meals prepared per week with cooktop	cooktop used for boiling water	Time the burner spends in the on position	Short	Medium	Long	Simmer	Medium	High	Meals prepared per week	Average time spent in the on position during each use
ing by urself	home weekdays, away weekends	gas	10 to 14	1 to 4	30 min	occassionally	everyday	rarely	occassionally	everyday	occassionally	1 to 4	40 min
	away weekdays, home weekends	electric	5 to 9	0	30 min	0	7	0	0	0	7	1 to 4	30 min
	away weekdays, home weekends	gas	1 to 4	10 to 14	5 min	14	2	1	1	16	0	1 to 4	10-15 min
	away weekdays, home weekends	gas	1 to 4	0	N/A	-	-	-	-	-	-	5 to 9	-
	home	gas	10 to 14	0	25 min	4	6	2	6	6	0	10 to 19	40 min

Table 19: Cooking data for consumers living by themselves

Results for consumers living by themselves are described in Section 4.2.2.

Households with 1 parent and at least 1 dependent are recorded as follows:

Scenario Data		Cooking data				Cooktop durations per week			Burner usage per week			Oven Usage	
Household type	Home or away during the day	cooktop type	Meals prepared per week with cooktop	cooktop used for boiling water	Time the burner spends in the on position	Short	Medium	Long	Simmer	Medium	High	Meals prepared per week	Average time spent in the on position during each use
1 parent with at least 1 dependent	home on weekend	electric	1 to 4	0	30 min	4	0	0	5	0	0	1 to 4	20 min

Table 20: Cooking data for one parent and at least one dependent families

Results for households with 1 parent and at least 1 dependent can be found in Section 4.2.2. Households with 2 parents and at least 1 dependent are as follows:

Scenario Data		Cooking data				Cooktop durations per week			Burner usage per week			Oven Usage	
Household type	Home or away during the day	cooktop type	Meals prepared per week with cooktop	cooktop used for boiling water	Time the burner spends in the on position	Short	Medium	Long	Simmer	Medium	High	Meals prepared per week	Average time spent in the on position during each use
parents with at least 1 dependent	away weekdays, home weekends	gas	5 to 9	0	20 min	1	7	1	7	1	1	1 to 4	40 min
	away weekdays, home weekends	gas	30+	0	10 min	5 to 10	30	7	7	30	5 to 10	5 to 9	30 min
	home	gas	5 to 9	0	15 min	0	mostly	0	heat quickly and turn down to low			1 to 4	120 min
	away weekdays, home weekends	gas	5 to 9	5 to 9	N/A	5	3	3	-	-	-	1 to 4	30 min
	some weekdays home, some away	electric	10 to 14	0	a few minutes	a mix			30%	40%	30%	1 to 4	20 min
	home	gas	5 to 9	0	6 minutes	4	5	2	half heat to bring to boil then low heat to simmer			1 to 4	30 min

Table 21: Cooking data for two parents with at least one dependent families

Conclusions for households with 2 parents and at least 1 dependent can be found in Section 4.2.2. Households with housemates or shared homes recorded results as follows:

Scenario Data		Cooking data				Cooktop durations per week			Burner usage per week			Oven Usage	
Household type	Home or away during the day	cooktop type	Meals prepared per week with cooktop	cooktop used for boiling water	Time the burner spends in the on position	Short	Medium	Long	Simmer	Medium	High	Meals prepared per week	Average time spent in the on position during each use
housemates or shared home	home	both	5 to 9	1 to 4	20 min	4	4	2	4	6	2	1 to 4	35 min
	away weekdays, home weekends	gas	10 to 14	5 to 9	10 min	15	10	4	10	10	9	1 to 4	50 min
(3 generations)	away weekdays	gas	10 to 14	0	N/A	mostly	mostly	0	5	5	0	1 to 4	30 min
	away	electric	15 to 19	0	30 min	2	14	0	0	4	12	1 to 4	60 min

Table 22: Cooking data for two parents with at least one dependent families

Conclusions for households with housemates or a shared home can be found in Section 4.2.2.

Before we generated the cooking survey, we determined nine different family scenarios. We used these scenarios and determined how much they would use their burners and ovens for in a typical week. The results for the different locations across Australia can be seen below.

Greater Sydney NSW										
Scenario Data		Gas Burner Consumption Data				Gas Oven Consumption Data				Tariff Data
Number of people in home	Type of family in home	# Burners Used per Week	Energy Consumption For One Burner (MJ/h)	Total Energy/Week (MJ) (Half hour per burner)	Weekly Burner Operational Cost (cents)	# Oven Uses Per Week	Energy Consumption for Oven (1 hour at 176.667C)	Total Energy/Week for Oven Use (MJ)	Weekly Oven Operational Cost (cents)	Gas Energy Tariff (c/MJ)*
1	Working	27	10	135	488.1195	7	11.82	82.74	299.163018	3.6157
1	Unemployed	14	10	70	253.099	4	11.82	47.28	170.950296	3.6157
2	Working	31	10	155	560.4335	9	11.82	106.38	384.638166	3.6157
2	Retirees	34	10	170	614.669	9	11.82	106.38	384.638166	3.6157
3	Working	34	10	170	614.669	10	11.82	118.2	427.37574	3.6157
3	Home Parent with Infant	53	10	265	958.1605	11	11.82	130.02	470.113314	3.6157
4	Trad. Fam. (gone all day)	36	10	180	650.826	10	11.82	118.2	427.37574	3.6157
4	Housemates/Shared Home	42	10	210	759.297	13	11.82	153.66	555.588462	3.6157
5	Trad. Fam. (gone all day)	38	10	190	686.983	10	11.82	118.2	427.37574	3.6157

Table 23: Greater Sydney burner and oven usage

Greater Melbourne VIC										
Scenario Data		Gas Burner Consumption Data				Gas Oven Consumption Data				Tariff Data
Number of people in home	Type of family in home	# Burners Used per Week	Energy Consumption For One Burner (MJ/h)	Total Energy/Week (MJ) (Half hour per burner)	Weekly Burner Operational Cost (cents)	# Oven Uses Per Week	Energy Consumption for Oven (1 hour at 176.667C)	Total Energy/Week for Oven Use (MJ)	Weekly Oven Operational Cost (cents)	Gas Energy Tariff (c/MJ)**
1	Working	27	10	135	303.831	7	11.82	82.74	186.214644	2.2506
1	Unemployed	14	10	70	157.542	4	11.82	47.28	106.408368	2.2506
2	Working	31	10	155	348.843	9	11.82	106.38	239.418828	2.2506
2	Retirees	34	10	170	382.602	9	11.82	106.38	239.418828	2.2506
3	Working	34	10	170	382.602	10	11.82	118.2	266.02092	2.2506
3	Home Parent with Infant	53	10	265	596.409	11	11.82	130.02	292.623012	2.2506
4	Trad. Fam. (gone all day)	36	10	180	405.108	10	11.82	118.2	266.02092	2.2506
4	Housemates/Shared Home	42	10	210	472.626	13	11.82	153.66	345.827196	2.2506
5	Trad. Fam. (gone all day)	38	10	190	427.614	10	11.82	118.2	266.02092	2.2506

Table 24: Greater Melbourne burner and oven usage

Brisbane QLD										
Scenario Data		Gas Burner Consumption Data				Gas Oven Consumption Data				Tariff Data
Number of people in home	Type of family in home	# Burners Used per Week	Energy Consumption For One Burner (MJ/h)	Total Energy/Week (MJ) (Half hour per burner)	Weekly Burner Operational Cost (cents)	# Oven Uses Per Week	Energy Consumption for Oven (1 hour at 176.667C)	Total Energy/Week for Oven Use (MJ)	Weekly Oven Operational Cost (cents)	Gas Energy Tariff (c/MJ)***
1	Working	27	10	135	731.6595	7	11.82	82.74	448.425978	5.4197
1	Unemployed	14	10	70	379.379	4	11.82	47.28	256.243416	5.4197
2	Working	31	10	155	840.0535	9	11.82	106.38	576.547686	5.4197
2	Retirees	34	10	170	921.349	9	11.82	106.38	576.547686	5.4197
3	Working	34	10	170	921.349	10	11.82	118.2	640.60854	5.4197
3	Home Parent with Infant	53	10	265	1436.2205	11	11.82	130.02	704.669394	5.4197
4	Trad. Fam. (gone all day)	36	10	180	975.546	10	11.82	118.2	640.60854	5.4197
4	Housemates/Shared Home	42	10	210	1138.137	13	11.82	153.66	832.791102	5.4197
5	Trad. Fam. (gone all day)	38	10	190	1029.743	10	11.82	118.2	640.60854	5.4197

Table 25: Brisbane burner and oven usage

Adelaide SA										
Scenario Data		Gas Burner Consumption Data				Gas Oven Consumption Data				Tariff Data
Number of people in home	Type of family in home	# Burners Used per Week	Energy Consumption For One Burner (MJ/h)	Total Energy/Week (MJ) (Half hour per burner)	Weekly Burner Operational Cost (cents)	# Oven Uses Per Week	Energy Consumption for Oven (1 hour at 176.667C)	Total Energy/Week for Oven Use (MJ)	Weekly Oven Operational Cost (cents)	Gas Energy Tariff (c/MJ)❖
1	Working	27	10	135	538.758	7	11.82	82.74	330.198792	3.9908
1	Unemployed	14	10	70	279.356	4	11.82	47.28	188.685024	3.9908
2	Working	31	10	155	618.574	9	11.82	106.38	424.541304	3.9908
2	Retirees	34	10	170	678.436	9	11.82	106.38	424.541304	3.9908
3	Working	34	10	170	678.436	10	11.82	118.2	471.71256	3.9908
3	Home Parent with Infant	53	10	265	1057.562	11	11.82	130.02	518.883816	3.9908
4	Trad. Fam. (gone all day)	36	10	180	718.344	10	11.82	118.2	471.71256	3.9908
4	Housemates/Shared Home	42	10	210	838.068	13	11.82	153.66	613.226328	3.9908
5	Trad. Fam. (gone all day)	38	10	190	758.252	10	11.82	118.2	471.71256	3.9908

Table 26: Adelaide burner and oven usage

Canberra ACT										
Scenario Data		Gas Burner Consumption Data				Gas Oven Consumption Data				Tariff Data
Number of people in home	Type of family in home	# Burners Used per Week	Energy Consumption For One Burner (MJ/h)	Total Energy/Week (MJ) (Half hour per burner)	Weekly Burner Operational Cost (cents)	# Oven Uses Per Week	Energy Consumption for Oven (1 hour at 176.667C)	Total Energy/Week for Oven Use (MJ)	Weekly Oven Operational Cost (cents)	Gas Energy Tariff (c/MJ)❖❖
1	Working	27	10	135	374.814	7	11.82	82.74	229.719336	2.7764
1	Unemployed	14	10	70	194.348	4	11.82	47.28	131.268192	2.7764
2	Working	31	10	155	430.342	9	11.82	106.38	295.353432	2.7764
2	Retirees	34	10	170	471.988	9	11.82	106.38	295.353432	2.7764
3	Working	34	10	170	471.988	10	11.82	118.2	328.17048	2.7764
3	Home Parent with Infant	53	10	265	735.746	11	11.82	130.02	360.987528	2.7764
4	Trad. Fam. (gone all day)	36	10	180	499.752	10	11.82	118.2	328.17048	2.7764
4	Housemates/Shared Home	42	10	210	583.044	13	11.82	153.66	426.621624	2.7764
5	Trad. Fam. (gone all day)	38	10	190	527.516	10	11.82	118.2	328.17048	2.7764

Table 27: Canberra burner and oven usage

Appendix C – Appliance Findings and Recommendations

Costs

Hot Water Heat Pumps

Initial Investment

The principle cost of a hot water heat pump is dependent on the initial "sticker price" and installation cost. We found that there were 4 major manufacturers of hot water heat pumps that received good reviews and recommendations from installers and user alike. By examining the product ranges, we were able to determine the typical expenses for varying sized systems.

Range	Model	Capacity (L)	Price	Averages by Size
	Quantum Compact 150L	150	2400	
	Sanden 160L	160	3700	Average Size 1
Size 1 (<100L)	Quantum Compact 200L	200	2520	2873.333333
	Sanden 250L	250	3760	
	Quantum Split 270L	270	3390	
	Siddons 270L	270	3650	
	Quantum Compact 270L	270	3225	Average Size 2
Size 2 (200-300L)	WWK 300A Hot Water Heat Pump	300	2999	3404.8
	Sanden 315L	315	3850	
	Quantum Compact 340L	340	2780	
	Quantum Titan Compact 340L	340	4350	
Size 3 (>300L)	Quantum Split 340L	340	3650	Average Size 3

	Siddons 340L	340	3915	3709

Table 28: Heat pump initial cost

As seen in the above table, we were able to determine the average principle cost for a new hot water system ranged from $2873-$3709 AUD, depending on brand and system size. The average tank sizes ranged from 100L to 340L, with most companies offering 150L, 270L, and 340L sizes. We found that these different sized tanks correlate to different applications and households. Consumer guides that detailed the correct methods for consumers to choose a system size allowed us to define what kinds of households would require specific tank sizes. As seen below, the house type, number of residents living in the house, the number of daily showers, and the physical size of the house determined these classifications (Department of Industry, 2013).

Water Heater House Classification			
Range	**Size 1**	**Size 2**	**Size 3**
Description	Apartment/Small Home	Mid Size house	Large house
Number of People	2	3	6-Apr
House Size	1 Bath, 2 BR	1 Bath, 3 BR	2 Bath, 4 BR +
Number of Showers (8-9 min)	2	4	6

Table 29: Water heat size classification

As the table shows, purchasing a hot water heat pump represents a significant investment. In an effort to promote environmentally friendly, energy efficient appliances, the Australian government provides many consumers with rebates. For example, the rebate for hot water heat pumps in Victoria ranges from $300-$1500 in the city and up to $1600 in the region. The rebate is calibrated by system size and performance (Hot Water Rebate, 2014). In addition to rebates, the Australian government also offers Small scale Technology Certificates (STC). These STCs carry a fixed rate. Each appliance type is awarded a number of STCs, which is then multiplied by the fixed rate. For heat pumps, consumers can save anywhere from $100 to $1000 AUD.

The installation of a hot water heat pump will add a significant amount to the initial cost of the appliance conversion. A simple installation in place of an existing hot water tank with all of the proper hookups installed is expected to cost about $600 AUD (Woolley, 2014). This would be a viable price for any consumers seeking to replace an existing hot water tank. New builds or consumers looking to move their hot water system will need to install new connections, both water and electric, which can cost as much as $2000 AUD for services (Woolley, 2014). In conclusion, we found that hot water heat pumps will incur a substantial initial investment. However, utilizing the services and incentives from local and federal governments can significantly reduce the total price for the consumer.

Operational cost

Our study concluded that there are four major heat pump manufacturers that provide reliable, high quality consumer heat pumps:

- Quantum
- Siddons
- Stiebel
- Sandens

Published consumer reviews and installer recommendations praised these companies while providing clear evidence for us to avoid products such as Dux and Rheem. We were able to further validate these finding by reading consumer reviews posted on energy and appliance forums (Whirlpool, 2014). The forums provided key information about system faults or benefits from all the companies we examined.

We found that many of these faulty systems significantly raised the operational costs of heat pump systems and therefore should not be included in our study.

With the exception of maintenance costs, the major operational cost for hot water heat pumps is standby power. Standby power is used to manage the heat pumps internal water levels and temperatures. Heat pumps must maintain 60 degrees Celsius to prevent bacteria build up. The standby power regulates the tank temperature to ensure it does not drop below the needed temperature. Additionally, standby power manages all time settings for the system. This regulates what time the heat pump operates to minimize energy costs. The average standby power for hot water heat pumps range from 0.75 to 1 kW per day, as seen in the table below (Canton, 2014). Assuming a tariff expense of $0.16/kWh, standby power accounts from $43.20 to $63.36 each year.

System Type	Standby Mode	Min (W)	Max (W)	Other Mode	Min (W)	Max (W)
HW Heat Pumps	**Passive Standby**	0.1	1	**Sump Heater**	2	15
Split System A/C	**Passive Standby**	0.2	10	**Off Mode**	0	5
				Sump Heater	30	50
Induction Cooktops	**Passive Standby**	<2	8			

Table 30: Standby energy consumption by appliance type

While energy management and regulation is the primary use of standby power, it is also used to keep the unit warm in freezing climates. We found that sump heaters are needed to keep the oil and refrigerant in the compressor unit from mixing, leading to permanent unit damage. As shown in the above figure, this electric resistance coil, or sump heater, will draw an average 15 watts (Rasmussen, 2011). We also found that sump heaters are defined as frost protection heaters or more commonly, crankcase heaters. The efficiency of these heaters varies in different units depending on the insulation of the compressor. However, high quality units are consistent with the 15-watt average. We concluded that the standby power loses could represent a significant energy loss that could result in substantial loss of efficiency.

Maintenance cost

The maintenance of hot water heat pumps is extensive when compared to other household appliances. As a result, we concluded that they might not be suitable to consumers seeking a carefree appliance. Due to the complexity of heat pump systems, yearly inspections are required to ensure minor issues do not significantly damage the unit. These service calls cost around 66 dollars, plus an addition 42 dollars for 15 minutes of work depending on service providers (Jim's Plumbing, 2014). This yearly expense will reduce the overall operation cost while improving the reliability of the unit. In addition, heat pump systems will require regular replacement of compressor belts, sacrificial anodes, and filters. These components range from $20-$150 plus labor (Siddons, 2014). The consumer must also carry out basic routine maintenance to ensure that the hot water heat pump operates reliably. The most important task is to ensure that the outside unit is free from obstructions that may reduce the airflow around the unit (Department of Industry, 2013). Cleaning the unit clean and clear is a simple job that will incur no addition cost to the homeowner.

Asset Life

The operational lifespan of hot water heat pumps can be affected by a number of variables that contribute to either a premature failure or to successful operation beyond the manufacturers projections. Due to complex design theory of the hot water heat pump, vigilant maintenance must be followed. Additionally, the amount of service use the appliance endures will directly affect the lifespan of the item. Appliances that are used continually will wear out before appliances that are only used periodically. Furthermore, some appliances may be rendered obsolete before they fail. Below is Table 31, displaying the range of expected asset life.

	Hot Water Heat Pump (Years)
Asset Life Projection	6
(Low, Mid, High)	10
	16
Warranty	3
(Low, Mid, High)	10-15
	15

Table 31: Asset life of hot water heat pumps

In conjunction with Bank of America, the National Association of Home Builders (NAHB) conducted a study of individual household components to determine their lifespans. Using these sources, we were able to establish the principle life expectancies of heat pumps and hot water tanks. Provided that the unit is cared for, Heat pumps can be expected to last for 10-16 years, seen in Table 31. Research into consumer reviews validated this projection based on owner use and experience. Some variation existed with significant outliers. For heat pumps lasting less than 5 years, poor maintenance, manufacturing practices, or neglect can be attributed to the failures. We concluded that good maintenance practices contributed to users finding that their heat pumps met or exceeded the published life expectancy.

Warranties for heat pumps vary greatly by manufacturer and specific models. Most models carry a 5-10 year warranty. This is the standard warranty for an average quality system. Various components of the system may carry different warranties. A cheaper outdoor heat exchange unit may for example only carry a 3-

year warranty while a stainless steel tank may have a 15-year warranty (Quantum, 2014). Generally, the warranty for a good quality heat pump system should range 10-15 years.

Split system, reverse cycle air conditioners

Initial Investment

The initial cost of split system, reverse cycle air conditioner is contingent on two aspects: size and efficiency. A simple, small space unit can cost as little as 905 AUD whereas a large, multi-room unit can cost well past 3000 AUD. The cost is due to the number of wall-mounted head units needed to distribute air throughout the space. As a result, we found that the costs of these larger systems are proportional to the complexity of the system. Table 32 below shows the average costs for a small, medium and large split system, reverse cycle air conditioner.

Split system, Reverse Cycle, Air Conditioner Costs				
	High	Mid	Low	Average
Cost (AUD)	3318	1200	905	1619.28

Table 32: Initial cost for split system, reverse cycle air conditioners

The next cost-driving factor is the quality and efficiency of the unit. Cheaper, less efficient units may be available for significantly less money than other units, but we found the losses in CoP render these less effective than slightly more expensive units. As a result, we focused on quality units with comparably high CoP's. The average cost for a mid sized unit with a CoP between 3.2 and 6 is 1600 AUD. Units yielding CoP’s of 5+ can be attained for as little as 905 AUD (Mitsubishi, 2014). The cost for the individual consumer will vary largely with consumer need. The individual heating needs for the household will dictate the units purchased. Larger houses will require larger units, driving cost up. However, small residences or apartments can utilize inexpensive, highly efficient units. Despite the large range of

CoP's shown throughout our market sample of units, the efficiency of these units far exceeded the energy efficiency of comparable gas units.

The other major component of the initial cost is the installation cost. We found that the cost of the installation for a split system, reverse cycle air conditioners vary greatly depending on the specific installation. Specific costs depend on whether or not new wires or plumbing need to be installed or special configurations need to be adapted. However, in speaking with several installers we were able to establish a baseline for average installation costs. Depending on the size of the unit, we found the cost ranges from 600 AUD for a similar replacement cost to 720 AUD for a new installation requiring new wiring and plumbing (Ray Light On Electrical, 2014). As seen in Table 33, the installation cost of an appliance varies with the size of the system. For a complex installation requiring new plumbing, complex mounting, and new wiring, the cost may be as high as 2000 AUD (Woolley, 2014). The costs are dependent on the situation surrounding the installation, but for modeling purposes, we found 600 to 720 AUD to be a healthy range, backed by consumer reports on various forums (Whirlpool, 2014).

We concluded that gauging an accurate price projection for space heaters are extremely difficult due to the number of variables that need to be accounted for. Each consumer has different home and use requirements, creating a large number of scenarios for principle investment costs.

Installation Projections Split System Air Conditioners				
Company	Number	Low	Medium	High
Climate Select	0412 732 406	600	700	2000
Ray light on Electrical	0407 223 320	600	650	720

Table 33: Installation projects of split system air conditioners

Operational cost

The standby power consumption of split system air conditioner units varies depending on the mode setting it's in. We found that when the unit is not operating, there are three modes that the unit can be in. The first mode is the “off mode”. Off mode will consume zero to five watts. Off mode is when the unit is off and remote control operation is not available. However, the sump heater controller will operate in this mode to prevent unit damage, accounting for the five-watt consumption (National Greenhouse Strategy, 2012). This regulates when the sump or crankcase heater will engage to prevent damage.

The next available mode is the passive standby mode. This mode consumes 0.2 to 10 watts on average (National Greenhouse Strategy, 2012). Passive standby mode provides the power allotment to operate a remote control function. Additionally, this mode allows for limited programing. These programs allow for settings that control when the unit will turn on or off, or allow for thermostat control inputs (National Greenhouse Strategy, 2012). The final mode is the sump or crankcase heater consumption. When the heater engages, it will draw between 30 to 50 watts, depending on the unit (National Greenhouse Strategy, 2012). This will not happen unless the core temperature of the compressor unit drops to freezing, which will cause damage or significant loss of efficiency.

Maintenance cost

Split system, reverse cycle air conditioners are easy and cost effective to maintain. The homeowner can accomplish most of the maintenance needs, reducing or eliminating the need for a technician. Monthly cleaning and filter changes can ensure proper function throughout the life of the unit. Furthermore, homeowners can perform ducting cleanings, saving as much as 500 AUD each year (Whirlpool, 2014). Dirty units can reduce as much as 5% of a unit’s efficiency each year if it is not maintained (Whirlpool, 2014). Many manufacturers recommend yearly inspections. On site annual inspections may cost between 200 to 300 AUD depending the number and price of replacement parts needed (Woolley, 2014). By performing these simple maintenance practices, we found that homeowners can significantly reduce their yearly operational costs while increasing the life of their units at a minimal expense.

Asset Life

Like hot water heat pumps, split system air conditioner asset life greatly depends on the quality of the product and the maintenance of the unit over time. Assuming that the appliance receives the proper, regular maintenance, undergoes regular use, and proper function, the unit should last 10-15 years, as seen in Table 34.

Unit Type	Split System R/C A/C (Years)
Asset Life Projection (Low, Mid, High)	10
	12
	15
Warranty (Low, Mid, High)	2
	5
	5

Table 34: Asset life of reverse cycle split system air conditioners

Cheap units that suffer from poor build quality can only be expected to operate 3-5 years before replacement (NAHB, 2007). The environmental conditions will also play into the longevity of the unit. In salty, humid climates, the components of a split system, reverse cycle air conditioner will be susceptible to corrosion, reducing its affective live.

We found that warranties for split system, reverse cycle air conditioners vary by brand and distributers. For component parts, nearly all companies offer a 2-year warranty. This warranty covers anything that malfunctions due to design faults on the air condition. Beyond the 2-year warranty, only the compressor is covered under warranty (Whirlpool, 2014). The established average compressor warranty is 5 years. In general, and despite minor variance, we found that the majority of companies abide by these warranty standards.

Induction Cooktops

Initial Investment

From a sampling of 20 consumer recommended units, we found that the initial purchase price of an induction cooktop over average is twice as expensive as a traditional gas cooktop. The below tables highlight the differences.

Induction Cooktop Cost			
	High	Low	Average
Cost (AUD)	2820	105	1580.88

LNG Gas Cooktop Cost			
	High	Low	Average
Cost (AUD)	4999	199	920.19

Table 35: Initial cooktop prices for induction versus gas operation

The installation cost of each appliance is minimal due to the simplicity of the unit. Additional costs will incur when switching a gas appliance to an induction cooktop, should a switch or wire need to be run to accommodate the unit. Electric units being converted should be a similar switch, which will incur no additional cost for electrical work. If a consumer is replacing an existing electrical unit, it is possible for the consumer to perform the installation and therefore incur no installation fee (Whirlpool, 2014) For consumers not willing or able to do the installation themselves, we found that installers will preform the installation for around 200 to 750 AUD, seen in Table 36. Consumers with a simple installation not requiring additional wiring or significant carpentry work can expect to pay around 200 to 280 AUD whereas installations requiring new circuits will run as high as 750 AUD (OnlineAppliance, 2014). These costs do not factor in replacing counter tops or cabinetry if the unit is not a similar installation as the replaced appliance, seeing as the cost varies greatly.

Induction Cooktop Installation Costs			
Company	Number	Low	High
Stokes	1300 652 100	275	275
Appliance Online	1300 000 500	200	280
Woolley	1300 367 626	250	750

Table 36: Induction cooktop installation costs

We found that an additional expense for some consumers will be the purchase price of compatible cookware for induction cooktops. Induction cooktops require an iron based alloy pan to operate. Costs for this upgrade can range from 100 AUD for less expensive units to around 1000 dollars for an induction purpose set (Kitchenwaredirect, 2014). The cost is largely dependent on the consumers existing set of kitchenware and their specific preference for new kitchenware.

Operational cost

The operational cost of an induction cooktop relies solely on the standby power consumption over time. According to a 2003 study on household appliance standby power consumption, induction cooktops on average consume less than two to four watts when powered off (Bush, 2003). This energy powers the clock or any other minor function of the cooktop. For example, we found that cooktops may have touch style controllers than are active in standby mode (Bush, 2003). Furthermore, induction cooktops can consume up to eight watts when actively in standby mode, meaning they are turned on but the coil is not being used. As a result, they consume more standby power than gas stove tops. We concluded that standby power must be an important consideration since it may render any energy savings that are less affective over long-term use.

Maintenance cost

Induction cooktops need little to no routine maintenance. Assuming proper cleaning and usage instructions are followed, the unit should operate for the duration of its asset life maintenance free. Consumers must only ensure that the unit is use with care and properly cleaned between uses.

Asset Life

The asset life spans of induction cooktops are estimated to be around 19 years. This projection was consistently cited by studies conducted by the US Department of Energy and the National Association of Home Builders in partnership with the Bank of America (Kurenov, 2011). These independent studies both concluded that induction cooktops should last as long as convention electric stove tops, about 19 years, provided that they are not subjected to unusual abuse or neglect.

Unit Type	Induction Cooktops (Years)
Asset Life Projection (Low, Mid, High)	-
	19
	-
Warranty (Low, Mid, High)	2
	2
	10

Table 37: Asset life of induction cooktops

The warranties for these units are consistent to the other warranty life spans we found for other household appliances. As seen in Table 37, the warranty for general parts replacements or manufacturing error replacements was consistently two years. However, warranties exclusively for the induction coils extended up to 10 years (Electrolux, 2014).

Performance Data Averages

Hot water heat pumps

Our research identified 3 major considerations affecting the performance of hot water heat pumps: climate, usage, and size. The performance of heat pumps is measured with a coefficient of performance (CoP). To address the performance of different size heat pumps, we divided the heat pumps into 3 category classifications: less than 200L, 200L-300L, and 300L+. We found that the energy consumption of the hot water heat pumps were similar to smaller units. This was true mostly for products from the same manufacturer, as identical heat pump components were installed throughout the model range. For example, the Quantum Compact 270L and 340L both have the same CoP of 3.88 because they use the same components coupled with a larger tank (Quantum, 2014). Even though they have the same CoP, the 340L tank uses more energy. This is because it takes more time to heat a larger quantity of water.

Climate has a substantial affect on heat pump performance. Research shows that the temperature of the ambient air and the humidity level affect the CoP of heat pumps. However, a study conducted by Douglas Ford concluded that for the entire range of Australian climates, heat pumps were capable of maintaining an efficiency level surpassing gas appliances in energy economy (Ford, 2013). This means that the performance of these hot water heaters are capable of providing Australian consumers with a feasible alternative to gas no matter where they are situated on the continent.

Lastly, the daily usage of the system largely impacts the energy efficiency and cost of operating the system. As the tank depletes its water supply, it is refilled with cool ground water. When a tank becomes too low, it will take more time and energy to recharge and reach 60 degrees Celsius. A well-insulated tank will maintain the temperature of the water with little or no addition energy consumption while not in use (Ford, 2012).

Split system, reverse cycle air conditioners

According to ATA's initial model, space heating accounts for the largest percentage of home energy consumption. Depending on the climate and equipment set up, space heating can account for 50-75% of the electricity needs in a household. The performance of heat pump, split system, reverse cycle air conditioners provide significant energy savings over comparable gas ducted systems.

The coefficient of performance (CoP) allowed us to determine which appliances consumers should use. An efficient gas heating system has a coefficient of performance of approximately 0.8 to 0.9 (Choice, 2014). We found comparable split system air conditioners that had CoP's of 3.2 to 5.9. However, the performance of these split system air conditioners has two limitations. First, the performance of these units tends to vary with climate and temperature conditions. Secondly, as the size of the unit increases, the energy performance decreases.

Climate is the most significant cause for a CoP variation. However, the range of Australian climate zones provide suitable conditions for heat pump based appliances. As a result, the variation throughout the Australian climate range will not significantly increase the energy costs (Sustainablethinking, 2012). Even in areas with decreased CoP's, the heat pumps still run more efficiently than gas-ducted systems. We concluded that heat pumps were able to heat the same volume of space more efficiently than comparable gas units.

Based on the CoP numbers collected in our research, we discovered that the energy performance decreased inversely with the heating capacity (size) of the unit. In essence, the smaller units had higher CoP’s than comparable units from the same manufacturers. For example, a smaller Daiken unit from the same model range will have a CoP of 4.62, whereas the largest unit in that range only has a CoP of 3.26 (Daiken, 2014). The low CoP can be attributed to manufacturing faults with the compressor and components (Choice, 2014). Despite these inefficiencies, the larger units still have a CoP of around 3, which is better than the comparable gas units at 0.8-0.9.

In review, our study concluded 3 major performance parameters of split system, reverse cycle air conditioner units: they are consistently more energy efficient than comparable gas ducted systems, the climate performance is acceptable for all regions of Australia, and the size of the unit is an important consideration for maximizing energy efficiency.

Induction cooktops

Induction cooktops are more efficient than equivalent gas systems because they heat up quicker, cook faster, and consume less energy. When the induction process uses the pot as the heating element, it reduces the number of heat transfers that have to occur. For example, induction cooktops have been tested to boil 1 liter of water in 2 minutes, while gas cooktops take upwards of 8 minutes (Consumer, 2014). While the energy prices increase for gas and electricity, the induction cooktops sparing use of electricity to complete the same tasks contributes to significant energy savings over times.

The most important finding regarding induction cooktops was the need to manage standby power. Over the monthly operation of these appliances, the standby power is capable of depleting any savings an induction cooktop yields (Bush, 2003). To make up for this expense a kill switch can be installed to terminate any standby power draw thereby reducing the energy expense of the unit. The performance of the induction cooktop otherwise is only slightly better (around $10-$15 AUD a year) than gas stove tops. This however assumes that the cook times are the same, which they are not. With the reduction or complete removal of standby power draw, the savings of induction cooktops increases. While it may represent a significant upfront investment, the more this appliance is utilized, the more it will provide viable energy saving benefits for residential consumers.

Appendix D – Fact sheets

General gas or electricity fact sheet (3 pages)

Gas or Electricity

How will projected gas prices affect you?

What is going on with the Australian gas market?

Your gas prices are predicted to increase significantly in the next 15 years. Learn why and what is going to happen.

Depending on your location, your gas bill may rise 30-50%

Australia may start exporting gas to other countries. This means that less gas will be available to people living in New South Wales, Queensland, South Australia, Victoria, and Tasmania. If this export happens, residential gas prices will increase and you may have to pay a higher gas bill. Many organisations have predicted what gas prices will be and they think there will be a large price change. At the most, gas prices may double by the 2020s. At the least, gas prices may increase 30%.

Lack of supply due to high export could also lead to gas shortages in Australia. There are predictions saying New South Wales may experience up to 118 days of gas shortages unless something is done about the gas that is transported between states in the eastern gas market.

Key Points

Forecasts	Natural gas may not be the cheapest option for you in the future
Electricity	Electricity may serve as an affordable and efficient alternative
Location Pricing	The price of gas and electricity changes across Australia

An efficient alternative to natural gas in your home

By now you understand that your gas bill may increase. To save money, there are other sources of energy that you can use. Electricity is becoming a very efficient form of energy in many households. Conveniently, most homes are connected to electricity, or the "grid". Therefore, should you choose to switch from gas to electric appliances, there are not many extra costs for installing new systems.

Electric appliances, such as hot water heat pumps, split system, reverse cycle air conditioners, and induction cooktops use less energy than gas appliances and therefore, cost less. For further information regarding energy efficiency, review the appliance specific fact sheets about the three electric appliances mentioned above.

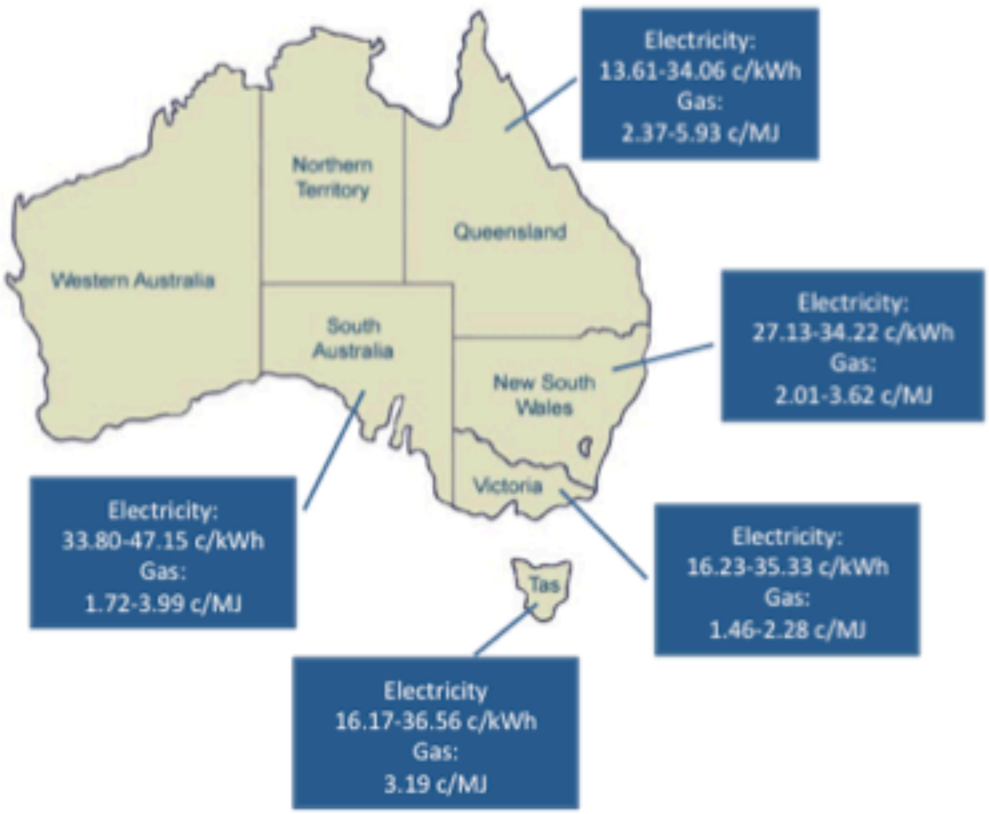
Overall, electricity could save your household money. The total demand for electricity has gone down significantly over the past four years. The reason for the lower demand is due to more efficient appliances. Although many people may benefit from converting from gas to electric appliances, there are still a number of consumers that should stay connected to gas for the time being. Refer to the further fact sheets for more information about what you can do to make affordable household energy decisions.

"Electric appliances, such as hot water heat pumps, split system, reverse cycle air conditioners, and induction cooktops provide higher energy efficiency than their gas equivalents."

Note: ACIL Allen is the base scenario and is plotted on the left. EQ is EnergyQuest's $95 JCC scenario and is plotted on the right.

This graph shows gas projections from two organizations in dollars per Giga Joule.

Consumption prices vary depending on what state you live in



Gas and electricity prices are different in each Australian state. The map shown above indicates a range of electricity and gas consumption prices for each of the five eastern Australian states. There are ranges of prices because there are multiple distributors of gas and electricity throughout each state.

In addition to consumption prices (cents/kWh or cents/MJ), all gas and electricity distributors require a daily supply charge (cents/day) as well. Further prices can be found from the following: Victoria Gazette, Origin Energy, Energy Australia, Tas Gas Networks, Aurora Gas, Aurora Energy, ActewAGL, and AGL.

Building a new home fact sheet (2 pages)

Building a New Home?

Install electric appliances instead of gas

Electricity is the better option

If you are building a new home and debating whether to hook up to gas or simply use electricity, this fact sheet will give you advice.

Installing electric appliances will save you money

Energy suppliers predict that gas prices are likely to double around 2030 because Australia is going to export a large amount of their domestic gas supply. With higher prices, the yearly cost of gas will be more expensive than electricity. Since you are in the process of building a new home, you have the choice of installing the cheaper option. Choosing electric appliances will mean lower energy consumption and supply costs in the next 15 years and beyond.

The range consumption costs for each state can be found on page 3 of the fact sheet "Gas or Electricity: How will projected gas prices affect you?" For more information about these prices and how they will affect you, please refer to this fact sheet.

Key Points

Gas Subsidies	Gas subsidies are currently in place
Choose Electricity	Hook up to the electricity network because installing electric appliances will save you money in the long term
Comparing prices	Cost of electric appliances compared to gas appliances

Gas vs. Electricity
Prices and Efficiency

Electric cooking and heating appliances are more energy efficient than gas appliances. They require less energy to work and therefore less money to operate. In order to determine specific sizes and models to fit your home, look at "Hot Water Heat Pumps," "Split System Air Conditioners," and "Induction Cooktops" fact sheets.

There may be a higher initial cost depending on the types of appliances you purchase. The table below shows a series of gas appliances and electric appliances and their typical initial costs. After having electric appliances, you may see a decrease in your cost of energy.

Gas Appliances	Electric Appliances
Water Heating $500-1500	**Hot Water Heat Pump** $2400-3915
Space Heating $500-6000	**Split System Reverse Cycle Air Conditioner** $905-3318
Cooktops $199-4999	**Induction Cooktop** $105-2820

Gas Subsidies

Gas suppliers recognize that the consumption cost of gas is increasing. As a result, they are providing subsidies to residential consumers hooking up their homes to gas.

Don't let gas subsidies fool you. They lower the initial cost, but they do not lower the energy bill you have to pay every month.

Choose Electricity

If you are buying a new home, or are not currently hooked up to the gas network, consider installing electric appliances. Electricity will be more energy efficient and will save you money in the next 15 years when gas prices increase significantly.

For more information on any of these topics, refer to the various other fact sheets provided about gas and electricity. Helpful fact sheets may include: "Gas or Electricity: How will the projected gas prices effect you?" "Hot Water Heat Pumps," "Split System Air Conditioners," and "Induction Cooktops."

Induction cooktop installation fact sheet (2 pages)

Induction Cooktops

What will they do for you?

Consider an induction cooktop

If you are looking to replace your current cooktop, installing an electric induction cooktop may be beneficial in your home. Read to find out what an induction cooktop has to offer.

Why should you consider an induction cooktop?

Induction cooktops are run by electricity. They can perform the same functions as gas cooktops, but use less energy. If you use less energy, your energy costs will be lower and you will therefore spend less money to cook.

What are the benefits of induction cooktops?

- Use less energy than gas cooktops
- Cook food faster
- Easy to clean, no maintenance
- 19 year lifespan if properly cared for
- Cool to the touch surface, even when turned on
- Easy to install

What to consider when buying an induction cooktop?

- High-end induction cooktops may cost up to twice as much as a comparable gas cooktop.
- Iron based pots and pans are required for the induction cooktop. Other materials will not work.

Energy Efficiency

Induction cooktops are more energy efficient for the cooking process than equivalent gas appliances. This is because they warm up faster, cook faster, and consume less energy than gas cooktops.

What to do

While your installing your induction cooktop unit, be sure to install a separate, full unit ON/OFF or kill switch that cuts power to the entire unit. This will eliminate all standby power consumption while providing you with energy savings that can reduce your cooking.

The initial cost

The initial cost of a cooktop varies by brand and special features. High and low prices are shown below.

Induction Cooktop Cost			
	High	Low	Average
Cost ($)	2820	105	1580.88
Natural Gas Cooktop Cost			
	High	Low	Average
Cost ($)	4999	199	920.19

A typical consumer can expect to pay anywhere from $200-1500 for a cooktop.

Installation costs

Installing an induction cooktop is fairly inexpensive. The typical installation cost ranges between $200-$280. You also have the option of installing the cooktop yourself.

Warranties

Typically cooktops have a 2-year warranty for parts and labor. The induction coil in the cooktop may also have an additional 10-year warranty.

What are the benefits of disconnecting from gas?

Cooking only accounts for 2-4% of home energy consumption. So, what is the big incentive of not using it? Gas service has two components, the consumption cost and the service fee. By creating a gas free home, you cannot only benefit from energy costs, but also from service fees. These fees can save you an additional $0.49-$1.02 per day off your energy costs. You could save up to $350 per year by using electricity.

Removing your gas connection lowers the chance of gas related accidents. Specifically with induction cooktops, the surface is cool to touch, so you have less chance of getting burned.

Standby power

Induction cooktops lose a lot of energy through standby power. Standby power is the energy used by an appliance while it is not on. Energy used by standby power will increase the cost to run your cooktop.

In order to avoid the cost of standby power, you can install a master or kill switch. A kill switch prevents energy from being used by the clock, controller units and touch controls. Installing a kill switch can cost up to $200 in addition to the installation cost. Although the standby power kill switch is expensive, it is worthwhile to avoid extra energy costs.

Hot water heat pump installation fact sheet (2 pages)

Hot Water Heat Pumps

What will they do for you?

Considering a hot water heat pump ?

If you are looking to replace your current hot water heating system, a hot water heat pump may be a good choice for your home.

Why should you consider a hot water heat pump?

Hot water heat pumps use electricity instead of gas to heat water. Heating water typically accounts for 25% of your energy bill. By avoiding the costs of gas, using an electric hot water heat pump can save you money on your energy bill.

What are the benefits of hot water heat pumps?

- Reduce energy consumption 63-75%
- More efficient than gas appliances in all Australian climate zones
- Eligible for Government STC's and rebates, go to http://www.hotwaterrebate.com.au for information regarding your area
- Life expectancy of around 16 years with proper maintenance
- Warranties extending to 10-15 years depending on brand

Considerations

- Space: Heat pumps need to located in open areas with good airflow and no obstructions
- Heat pumps make light humming noises, be sure to account for bedrooms and neighbors
- Yearly inspection recommended for long life and efficient operation
- Higher initial cost than comparable gas units (Quantum systems may cost between $2400 and 2750 depending on size)
- Proper sizing required for optimum performance

Energy Efficiency

How does gas compare to electricity?

A typical gas hot water system will have a coefficient of performance of 0.8-0.9. Hot water heat pumps have coefficients of performance between 3.88 and 4.5. Higher efficient systems are more expensive, but even the 3.88 systems have better energy ratings than gas systems.

Does climate affect performance?

The efficiency of your hot water heat pump is affected by climate. However, a recent study has proved that, heat pumps provide justifiable savings throughout each of the Australian climate zones.

What size hot water heat pump do I choose?

Getting the proper sized water tank based on your consumption is essential for ensuring the unit performs at its peak. To pick a size right for your house, look at the table below:

Water Heater House Classification			
Range	**Size 1**	**Size 2**	**Size 3**
Description	Apartment/Small Home	Mid Size house	Large house
Number of People	2	3	4-6
House Size	1 Bath, 2 BR	1 Bath, 3 BR	2 Bath, 4 BR
Number of Showers (8-9 min)	2	4	6

What model should I consider?

Choosing a hot water heat pump model depends on the size of your household. Using the size descriptions above, you will need a size 1, 2, or 3. A list of available hot water heat pumps is shown below with their price.

Range	Model	Price
	Quantum Compact 150L	2400
	Sanden 160L	3700
Size 1 (<100L)	Quantum Compact 200L	2520
	Sanden 250L	3760
	Quantum Split 270L	3390
	Siddons 270L	3650
	Quantum Compact 270L	3225
Size 2 (200-300L)	WWK 300A Hot Water Heat Pump	2999
	Sanden 315L	3850
	Quantum Compact 340L	2780
	Quantum Titan Compact 340L	4350
	Quantum Split 340L	3650
Size 3 (>300L)	Siddons 340L	3915

Initial Investment

Ready to invest in a heat pump? The prices vary widely between brands and sizes. The best deal for you money is likel Quantum, offering you a full range of size and application types that can be tailored to your specific needs. If you want to maximize your efficiency, Sanden offers the most efficient system.

Installation Considerations

Installing a heat pump can be expensive. Depending on your current system, you can pay anywhere from $600-$2000. The cost depends on the amount of extra worl needed to install your unit. If you are replacing an existing water tank, it will be cheaper than installing a heat pump in a new location. The cost will vary with the amount of new installation work required

Split system, reverse cycle air conditioner fact sheet (2 pages)

Split System, Reverse Cycle Air Conditioners

What will they do for you?

Consider a split system, reverse cycle air conditioner

If you are looking to replace your current air conditioner, installing a split system, reverse cycle air conditioner may be a good choice for your home.

What is a split system, reverse cycle air conditioner?

A split system, reverse cycle air conditioner is an electric appliance used to control the temperature of your rooms. It can be used to heat and cool a living space.

What are the benefits of split system reverse cycle air conditioners?

- Provides both heating and cooling
- Directly replaces existing appliances
- More energy efficient than gas
- More cost efficient than gas
- Easy to purchase and find qualified installers

What to consider when buying a spilt system, reverse cycle air conditioners?

- Can require extensive installation
- Larger systems are less energy efficiency
- Standby power reduces the efficiency

Energy Efficiency

How do I know I have an efficient split system, reverse cycle air conditioner?

Air conditioners are given star ratings to show how well they perform. Current systems generally have 3-4 stars with some system achieving as high as a 7 star rating. If you are looking for a highly efficient system should, you should buy a system with 3.5-5 stars.

Installation considerations

- A licensed installer is required.
- Larger systems will cost more to install. For example, a 3.5 kW system will cost around $600 to install, where a 7 kW system will cost $720 to install.
- Additional installation costs can cost as much as $3000 for additional electrical circuits, mounting hardware and labor.
- Some systems are eligible for government rebates. Check with your installer for more information.

How often will it need to be replaced?

The quality of the appliance will determine when a replacement is necessary. High and average rated split system, reverse cycle air conditioners typically last 10-15 years. Lower rated products may last as little as 3-5 years before they need to be replaced.

How do I maintain my air conditioner?

Maintenance for split system air conditioners is very easy. Following these steps will greatly increase the lifetime and efficiency of your unit:

- Changing filters and cleaning screens regularly
- Clearing any plant growth or obstructions from the unit
- Shut of the unit during seasons it is not used
- Inspect the appliance yearly to ensure proper function
- Recharge the refrigerant through a licensed installer if the efficiency decreases

If you do not maintain your unit correctly the efficiency can decrease 5% every year.

Why should I replace an existing unit or consider a new installation?

Space heating accounts for the largest percentage of the average home energy expenditure. The greatest energy savings can be achieved by ensuring new or efficient units are in use. As technology progresses, the star ratings are updated to account for the changes. Therefore, an older system with a relatively high-energy star rating may not perform to the standards of the new energy-rating index. Additionally, older units are not as well insulated as current unit, meaning they may have heat energy loses.

Living off grid fact sheet (2 pages)

Living Off-Grid

What type of energy is more efficient and affordable?

Bottled gas or electricity?

If you are considering converting your gas appliances to electricity, and you are off the grid, there are a number of things to consider.

Off grid options

Electric appliances are typically more energy efficient than gas appliances, but that might not be the case for off grid households. Limited use of gas in off grid homes might mean that converting to electricity is not the best option. If you currently use battery, solar, or wood as your household energy, it may be your best option to stay with your current energy source.

Benefits of Electric Appliances

- Higher energy efficiency than gas appliances
- Lower life cycle costs than gas appliances

Considerations for Electric Appliances

- You may need to upgrade your solar system
- Not an exact replacement for wood heating and cooking appliances
- Bottled gas can be stored for long period of time without use while electricity needs more complex storage

Available Off-Grid Energy Source

Wood: Not environmentally friendly, but a decent option for an off grid home.

- Very inexpensive
- Good heating qualities
- No winter use restrictions

Bottled Gas: A relatively clean energy source for most areas.

- Can be stored until needed
- Easy to transport and use
- No winter use restrictions
- Reliable

Solar Energy: Electricity generated by the sun that has been collected for household use.

- Sustainable
- Low cost
- Variable power capacities
- Require complex storage

Reasons not to consider electric appliances

The energy efficiency of electric appliances is better than gas appliances. However, electric appliances have a high initial cost and winter energy demand. In the winter, your solar system will not function at its best. At the same time, the energy demand of your heating systems will be high. As a result, you will need to upgrade your battery storage and solar panels to have the most savings.

Your energy bill

Space heating, water heating and cooking take up the following amounts of your energy bill. These needs can be replaced by alternate forms of energy:

- Space heating (more than 50%)
- Water heating (around 25%)
- Cooking (around 2-4%)

As shown by these statistics, relying on solar energy to heat your living space or water would use a lot of solar energy. However cooktop stoves may have less yearly gas consumption.

Possibility for Cooktops

Since cooktops only account for a small amount of energy, replacing your gas equivalent with an induction cooktop may save you money. The benefits of induction cooktops for off grid homes are:

- Reduced gas consumption
- Lower life cycle than comparable gas units
- Ease of installation
- Faster cooking time

Considerations for converting to induction cooktops

- More energy from your home solar system
- High initial cost
- Possible new circuit or wiring required
- Need to use regularly to save money

Installation of an induction cooktop can reduce the amount of gas you consume each year using solar systems. For more information on these cooktops, please refer to "Considering Induction Cooktops."

Conclusions

- Hot water heat pumps and split system air conditioners are not cost effective alternatives to gas or wood energy sources
- Induction cooktops may be a viable way to reduce annual gas consumption
- Exploring other sources such as wood may provide a cost affective solution to heating needs.

Replacing working appliances fact sheet (2 pages)

Should I replace my appliance?

Deciding whether to replace working appliances

Did you know electric appliances could save you money?

You want to save on energy expenses but you just invested in new systems or appliances? Should you cut your loses and re-invest or wait and look forward to saving for the future?

Why should I consider electric appliances?

Gas prices are forecasted to rise significantly by 2030. Your home gas bills will be expensive so why not consider changing to more affordable electric appliances? Electric appliances are more efficient than gas appliances. This means they use less energy than your gas appliances. Typical energy bills are made up of the following costs:

- **Space Heating:** 45-50% of your typical energy bill
- **Hot Water Heating:** 25% if your typical energy bill
- **Cooking:** 2-4% of your typical energy bill

Converting your space heater to electricity will save you the most money on your energy bills.

How much more efficient are electric appliances?

- Electric water space heaters can be 3-5 times more energy efficient than equivalent gas appliances.
- Induction cooktops take less time to cook food and have less heat loss.

What to Consider with Investments

A number of factors make up the life cycle cost of an appliance:

Asset Life: How long something will last after being used.

Performance: How much energy an appliance uses. Climate, usage, maintenance, and consumer habits will all affect performance.

Initial Cost: The upfront cost of buying an appliance. The initial cost may be expensive, but having a more efficient appliance will save you money in the long term.

Maintenance: will be a regular expense needed to ensure your appliance functions correctly. Maintenance will need to be done often to keep your appliance working properly.

What are the available appliance replacements?

Space heaters: Split system, reverse cycle air conditioners provide heat 3-7 times more efficiently than gas heaters. There are replacements for existing space heaters, or new space heaters to install in your home. See the "Split System, Reverse Cycle Air Conditioners" factsheet for more information about which model to choose.

Hot Water Heaters: Hot water heat pumps are 3-4 times more efficient than gas hot water heaters because they use heat energy from the air. They can be installed in any home. Please refer to the *Hot Water Heat Pump* factsheet for more information about life cycle costs and efficiency.

Cooktops: Induction cooktops provide a modern alternative to gas cooktops. They cook food faster than gas cooktops while using less energy. Induction cooktops are very easy to install. For more information please refer to the *Induction Cooktop* fact sheet.

What are the benefits of converting to electric?

- No gas service fee
- Reduced energy expense
- Greener, sustainable living style
- Long asset life for appliances

Considerations for converting to electric

- High initial cost
- Possible loss of investment on current appliances
- Possible extra installation fees required

What are my options?

Convert immediately: It will be expensive to convert all of your appliances immediately. There are government rebates that can help you save money on the initial cost. The sooner you convert, the faster you can save money on energy costs.

Convert as your existing appliances break: Begin switching out appliances as they fail. This would maximize your investment in your current appliances and prepare you for a future of purely electric appliances. The efficiency of appliances is only going to improve in the future.

Convert in steps: Start by converting your space heater to electricity. Next, invest in a water heater and when you are able to afford another appliance, your cooktop can be replaced. This gradual transition would spread out the initial investment while still allowing you to enjoy the benefits of your energy saving appliances.

The decision to convert can allow you to reduce your energy use and save money in the future. How you go about converting is a matter of your budget and preference. If you can invest right now, you can maximize you savings, but waiting may allow you to purchase even more efficient appliances that come out in the future.

Already connected to gas fact sheet (2 pages)

Connected to Gas

Consider unhooking to connect to the electricity network

Are you considering unhooking from the gas network?

If your home is connected to gas and you are considering unhooking, learn about your options. Experience the best way to switch to electricity.

How should you convert from gas to electricity?

The way you convert from gas to electricity depends on your needs. In order to save money on your energy bills and increase the efficiency of your appliances, there are multiple steps you can take.

There are a series of 3 major cooking and heating appliances to keep in mind when thinking about replacement:

- Hot water heat pumps
- Split system, reverse cycle air conditioners
- Induction cooktops

When your gas alternatives to these appliances age and no longer work properly, consider installing these appliances. Even it it's not time to install new appliances, think about your options ahead of time so you are prepared to make the right decision when the time comes.

If all of your appliances need to be replaced

If your heating and cooking appliances are ready for replacement, it will be worthwhile to install all new electric appliances. This is also the case for people that want to buy new cooking and heating appliances right now.

Circumstances

Replace all appliances	What should you do if you want to replace all of your appliances or if they all need to be replaced?
Replace 1 appliance	What should you do if you need to replace 1 of your appliances?
Replace 2 appliances	What should you do if you need to replace 2 of your appliances?

Converting from gas to electricity, continued…

In order to decide which appliances to purchase, a series of electric hot water heat pumps, reverse cycle split system air conditioners, and induction cooktops are compared in the fact sheets: "Hot Water Heat Pumps," "Split System Air Conditioners," and "Induction Cooktops."

If only one of your appliances needs to be replaced

If one of your heating or cooking appliances needs to be replaced, we suggest that you wait to install electric appliances. Installing only 1 electric appliance will not be cost effective and you will not benefit from the payback of the efficiency of electricity.

If two of your appliances need to be replaced

If two of your heating or cooking appliances are in need of replacement your best option will be to exchange all three of your gas appliances with electric appliances. It will be easier to install all of them at the same time and will make your payback time and savings on efficiency worthwhile.

Want more information about wh you should switch to electricity?

For more information about why you should consider electricity, refer to the fact sheets provided. For information about why gas prices are rising refer to "Gas or Electricity: How will the projected gas prices effect you?". For specific information about electric appliances, please refer to "Hot Water Heat Pumps," "Split System Air Conditioners," and "Induction Cooktops."

What do I convert first?

If money is a problem and you are unable to replace all of your appliances at once, start by replacing your space heater. Space heating makes up 45% of your energy bill. When you are able to install another appliance, replace your water heater. Water heaters make up 25% of your energy bill. By switching these two appliances, you can save a significant amount on your monthly energy costs. When you are able to install a third appliance, replace your old gas cooktop with an electric cooktop. Cooktops only make up 2-4% of your energy costs and will be the least effective on your energy bill.

Fact sheets for renters (2 pages)

Converting to Cost Effective Appliances for the Renter

Tired of costly energy bills?

Convincing your landlord to covert your current rental properties gas space heating, water heating, and cooking appliances to electric appliances might be your solution.

Why Convert from Gas?

Tired of spending too much on your monthly utility costs? Converting to high efficiency appliances can help. Gas prices are project to increase by 30% through 2020. Converting your appliances will help ease the increasing cost of energy for your apartment or rental property. New advances in electrical appliances offer units that are significantly more energy efficient than comparable gas units.

What to consider:

- How long will you remain at your property?
- How will you approach your landlord?
- What steps can you take to convince your landlord about an energy conversion?
- Where can you find the information you need?

How long will you remain at your property?

If you are only planning on living at your existing property for a short period, converting appliances will only serve to increase your rent before any savings benefits are enjoyed. However, if you plan on remaining at your property for 5 or more years, consider talking with your landlord about the possibility of converting your gas appliances to electric appliances.

Energy Use in Your Home

Gas is typically used to fulfill three major functions in a typical Australian domestic property: space heating, water heating, and cooking. The gas consumption in a typical household is:

- Space Heating: 50-75%
- Water Heating: 25%
- Cooking: 2-4%

In addition to these expenses, gas use in your properties also incurs a fixed service fee. While electricity use also has this fee, switching off gas will eliminate this extra fee.

What are the system choices?

There are three electric appliances that will dramatically out perform your current gas appliances:

- Hot water heat pumps provide hot water 3-4 times more efficiently than comparable gas systems.
- Split system, reverse cycle air conditioners will heat your home 3-5 times more efficiently than gas space heating systems.
- Induction Cooktops provide faster cooking with 65% better heating efficiency

Considerations for landlords

- Contact your landlord with a plan
- Get his/her permission before performing any alterations
- Look up available rebates or taxes for your area that might affect you

What steps can you take?

- Evaluate how long you will remain in your current residency
- Begin communication with your landlord to discuss the possibility of converting and gauge his/her interest in investing in new appliances
- Provide your landlord with a copy of "Gas or Electricity? A Landlords Investment Guide." It is a fact sheet that details everything your landlord will need to know before beginning
- Follow up with your landlord about the progress or status of the possible conversion.

Benefits for the Renter

- Reduced energy costs
- Modernized appliances
- Cleaner emissions and reduced fire risk

Benefits for the Landlord

Be sure to stress these benefits while you talk to your landlord.

- Lower energy bills
- Modern appliances appeal to tenants
- Reduces number of energy providers in the residence
- Property appeals to environmentally minded tenants
- Long service life for each appliance
- Reduced utility costs attracts tenants

Considerations of converting to electricity

- High initial investment
- Subject to failure during electric outages
- Long pay-back period

Fact sheets for landlords (2 pages)

Gas or Electricity? A Landlord's Energy Investment Guide

Return on Investments

Upgrading your properties with electric appliances could reduce the overall energy consumption and yearly energy expense while increasing property value.

Why consider switch from gas to electricity?

With east coast Australian gas exports, the price of domestic gas is projected to increase substantially through 2030. While electricity may have seen similar trends, projected prices are estimated to drop. Also, recent advancements in appliance technology offer electric appliances that have much higher energy efficiency compared to their natural gas equivalents. As a result, you can save yourself and your tenet's money while increasing the value of your property.

What are the Facts?

Gas is typically used to fulfill three major functions in a typical Australian domestic property: space heating, water heating, and cooking. The gas consumption is typically:

- Space Heating: 50-75%
- Water Heating: 25%
- Cooking: 2-4%

In addition to these expenses, gas use in your properties also incurs a fixed service fee. While electricity use also has this fee, switching off gas may help you save money.

Appliance Savings By Type

Space Heaters

Split system, reverse cycle air conditioners have the largest potential to provide energy savings. Boosting efficiency ratios 500-700% higher than comparable gas systems, they provide a cost effective way to reduce energy costs. One unit can provide both heating and cooling for your property.

Water Heating

Hot water heat pumps are capable of converting a low input power to a output power 3-4 times higher, whereas gas heaters will actually incur a loss. This translates into savings for the consumer.

Cooking

Induction cooktops can be more energy efficient than gas cooktops. They also add value to your property by introducing modern and sleek appliances.

Benefits of Electricity

- Lower energy bills
- Cleaner emissions and decreased fire risk
- Modern appliances appeal to tenants
- Reduces number of energy providers in your properties
- Property appeals to environmentally minded tenants
- Long service life for each appliance
- Reduced utility costs may attract tenants

Considerations of Converting to Electricity

- High initial investment
- Subject to failure during electric outages
- Long pay-back period

How do I go about converting?

Space Heating

As highlighted above, starting with space heating is an ideal approach. For information concerning a space heating conversion, please refer to the "Considering Split System, Reverse Cycle Air Conditioners" fact sheet. Here you will find what out everything you need to know about these systems. If you can only invest in one area, start here. Expect the purchase of this conversion to cost between $500 and $3000 depending on your property size and requirements.

Water Heating

Next, we recommend you invest in hot water and cooking services at the same time. Hot water heating costs can be reduced significantly by installing a hot water heat pump. For more information about these systems, please refer to the "Considering Hot Water Heat Pumps" fact sheet. A new installation can cost anywhere from $600-$2000. Be sure to utilize Small Scale Technology Certificates and your local governments energy rebates to save additional expenses.

Cooking

Induction cooktops can provide the lowest savings on your energy bill and represent a significant investment ($500-$1500). So why bother? This investment will make your property independent of gas, saving you the monthly service fee. This coupled with energy savings, means you will enjoy a significant reduction in your energy expenses.

Induction cooktops also have the benefit of modernizing your property. This will increase the value of your property, thereby translating into additional profits. For more information about converting your gas cooktop, please refer to the "Considering Induction Cooktops" factsheet.

Conclusions

- System conversions may save you and your tenants money on energy expenses in the future
- Gas prices are estimated exceed electricity prices
- Electric appliances out perform comparable gas appliances in space heating, water heating, and cooking uses.
- While the initial cost of converting your appliances will exceed the costs of updating your gas appliances, the money savings should pay back your investment.

Appendix E – Gazette Information

Information regarding gazettes was taken from the Victorian Government home page. The following is the Victorian Government's explanation of gazettes:

"The Victoria Government Gazette provides official notification of decisions or actions taken by, or information from, the Governor of Victoria, Government Authorities, Government Departments, Local Councils, companies and individuals (Victoria Government Gazette, 2014)."

We were able to use the gas and electricity tariffs, published by the Victorian Government Gazette for our data collection seen in Appendix A.

Appendix F – Fact Sheet Audiences and Explanations

Audience	Message in Fact Sheet
1. Consumers that want to know specifics about the current gas and electricity markets.	Description of what is going on in the energy market and how consumers will be affected by it. The gas projections were shown and current gas prices in each of the states.

Table 38: General fact sheet information

Audience	Message in Fact Sheet
2. Consumers that are in the process of building new homes and trying to decide whether to hook up to gas or join the electricity network.	You should not hook up to the gas network at all and instead consider installing all electric appliances.
3. Consumers already connected to natural gas and have appliances that need to be replaced.	Do not replace one appliance at a time. If more than one of your appliances dies, then replace them all three appliances with electric.
4. Consumers who rent their home or apartment and are interested in how to save money on energy bills.	Talk to your landlord about the potential of installing electric appliances. Promote electricity as a way to save money on energy expenses and promote property value.
5. Landlords and the steps they can take to convert the residencies they rent.	Emphasizes that installing electric appliances can increase property value and attract more tenants. Explains how they should go about converting based on their budget and which appliances they should install.
6. Consumers that are off the gas grid and use bottled gas, wood, or battery power.	You should stick to bottled gas, solar and battery powered. It is not worth it for a consumer off the grid to connect to the electricity network.
7. Consumers that have fully functioning appliances and want to replace them all with electric.	If you have the budget to replace all of your appliances at once, do so. If your budget only permits one at a time, start with space heating, then water heating, and then cooking.

Table 39: Varied consumer fact sheets

Audience	Message in Fact Sheet
8. Consumers looking to replace a gas cooktop with an induction cooktop.	Description of the benefits of using an electric induction cooktop as apposed to a gas cooktop. Lists specific models to install and how much they cost.
9. Consumers looking to replace a gas space-heating unit with an electric reverse cycle, split system air conditioner.	Description of the benefits of using an electric split system air conditioner as apposed to a gas space heater. Lists specific models to install and how much they cost.
10. Consumers looking to replace a gas heat pump with an electric hot water heat pump.	Description of the benefits of using an electric hot water heat pump as apposed to a gas water heater. Lists specific models to install and how much they cost.

Table 40: Appliance specific fact sheets

Appendix G- Authorship Page

Abstract: Ashleigh Collins

Acknowledgements: Ashleigh Collins

Executive Summary: Ashleigh Collins & Jake Brown

Introduction

Andrew Andraka, Jake Brown, Ashleigh Collins

Background

2.1: Jake Brown
2.2: Jake Brown and Ashleigh Collins
2.3: Jake Brown
2.4: Jake Brown and Andrew Andraka
2.6: Jake Brown

Methodology

3.1: Ashleigh Collins and Jake Brown
3.2: Andrew Andraka and Jake Brown
3.3: Andrew Andraka, Jake Brown, and Ashleigh Collins
3.4: Andrew Andraka, Jake Brown, and Ashleigh Collins
3.5: Jake Brown
3.6: Jake Brown

Results and Analysis

4.1: Jake Brown and Ashleigh Collins
4.2: Jake Brown and Andrew Andraka
4.3: Jake Brown
4.4: Jake Brown

Conclusions and Recommendations

5.1: Jake Brown and Ashleigh Collins
5.2: Andrew Andraka & Ashleigh Collins
5.3: Andrew Andraka & Ashleigh Collins
5.4: Ashleigh Collins & Jake Brown
5.5: Ashleigh Collins & Jake Brown

Bibliography

Andrew Andraka, Jake Brown, and Ashleigh Collins

Appendices

Andrew Andraka, Jake Brown, and Ashleigh Collins