Is WA still Cooking with Gas?

An Analysis of Residential Gas versus Efficient Electric Choices for WA Households

ATA

March 2015

Document Information

Document Version	Date	Prepared By	Reviewed By	Comments
CAP Gas Research – WA Analysis – Final Report 290115 v0.1	29th Jan 2015	Kate Leslie – Energy Analyst	Damien Moyse – Policy & Research Manager	Initial Version
CAP Gas Research – WA Analysis – Final Report 040215 v0.2	4th Feb 2015	Damien Moyse – Policy & Research Manager	Kate Leslie – Energy Analyst	Second Draft
CAP Gas Research – WA Analysis – Final Report 170315 v1.0	17th Mar 2015	Damien Moyse – Policy & Research Manager		Final Version

Prepared for General Public Release

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Background

The Consumer Advocacy Panel (CAP) approved a grant to the Alternative Technology Association (ATA) to undertake research into the impact of anticipated retail gas price rises on households across the National Energy Market (NEM) and identify cost effective alternatives to gas appliances, if and where they may exist.

ATA's Final Report for the project was released in November, 2014. However as a non-NEM jurisdiction, modelling and analysis was not carried out as part of the grant-funded project for Western Australia or WA consumers.

Whilst this was in keeping with the original constraints of the grant, as an organisation with a significant number of WA members, and as a jurisdiction with a significant penetration of reticulated gas, a specific piece of analysis dedicated to understanding the WA situation was required.

As such, this report contains new modelling and analysis of relevance to the economics of gas versus efficient electric appliance choices for WA consumers.

Approach

ATA's approach to this research involved estimating the up-front and running costs of efficient gas and electric appliances for space heating, water heating and cooking, over a ten year period, to provide economic comparisons that are broadly relevant to most households in WA.

The analysis was conducted for one WA gas zone, taking into account location-specific energy and maintenance costs, along with the impact of climate on heating loads and appliance performance, for six different housing types. These housing types account for differing sizes and construction of homes and with specific regard to public housing, new homes and homes using bottled gas.

New and existing homes were considered, both for single (electric only) and dual fuel (gas and electric) use. The analysis considered other key factors such as the impact of whether or not the existing gas appliances were near the end of their asset life, the of the order of appliance replacement relative to marginal costs of energy use and the impact of off-peak electricity pricing.

Findings: New Homes & Existing All-Electric Homes

Whether newly built or existing all-electric homes should connect to the gas network and install any number of gas appliances for economic reasons is dependent on one main factor; whilst a second factor may apply to a limited number of consumers:

- whether the household is able to install efficient electric appliances; and secondly
- whether the cost of gas appliances is heavily subsidised.

Finding 1: It is not cost effective to connect a new home to mains gas when efficient electric appliances are an option.

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Findings: Existing Dual Fuel Homes

Whether dual-fuel homes should replace some or all of their gas appliances with efficient electric appliances for economic reasons is dependent on multiple factors. The main determinants are:

- the age or condition of the existing gas appliance;
- whether the replacement allows the customer to disconnect from the gas network;
- whether the household is able to install efficient electric appliances;
- whether the existing gas supply is mains or bottled gas;

Finding 6: It is significantly more cost effective to replace gas heaters with multiple reverse cycle air conditioners (RCACs) for space heating than with gas.

1.0 Introduction

The Consumer Advocacy Panel (CAP) approved a grant to the Alternative Technology Association (ATA) that focused on one of the consumer research priorities identified by consumer advocates and decision-makers at the Panel's strategic forum in August 2013.

The purpose of this research project was to understand and substantiate the impact, in particular on low income and vulnerable consumers, of anticipated retail gas price rises on households across the National Energy Market (NEM) and identify cost effective alternatives to gas appliances, if and where they may exist.

ATA's Final Report for the project was released in November, 2014. However as a non-NEM jurisdiction, modelling and analysis was not carried out as part of the grant-funded project for Western Australia or WA consumers.

Whilst this was in keeping with the original constraints of the grant, as an organisation with a significant number of WA members, and as a jurisdiction with a significant penetration of reticulated gas, it was always the ATA's intention to follow up the original work with a specific piece of analysis dedicated to understanding the WA situation.

As such, this report contains new modelling and analysis of relevance to the economics of gas versus efficient electric appliance choices for WA consumers.

1.1 Context

The opening of Liquefied National Gas (LNG) export market from Eastern Australia is expected to drive up residential gas prices as domestic gas producers supply international export markets at a higher price on offer. Whilst this may be of limited relevance to WA consumers, it has been a catalyst for significant public debate.

According to the ABS (2011), 62% of Perth households are connected to natural gas for heating water and 42% for space heating. Water and space heating are the two most energy intensive activities that residential energy consumers use reticulated gas for, particularly in cold and temperate climates. Cooking is the third – and whilst the volume of gas used for cooking is much lower than for heating, consumers typically prefer the quality of gas cook tops over electric resistance cooking.

Electrical technology used to heat air and water is becoming increasingly efficient. Residential scale reverse cycle air-conditioners (for space heating) are reaching co-efficients of performance (CoP) of 5.0 and over – which means that for every 1 unit of energy input to the system, 5 units are generated to heat air. CoPs for the most efficient electric heat pumps (for water heating) now exceed 4.0.

Compared with the most efficient equivalent gas appliance that have a CoP of around 0.8 – 0.9, an efficient air-conditioner or electric water heater now uses 1/7th to 1/5th of the input energy for the same end use. While CoPs for electric appliances may continue to improve, gas appliances are forever limited to 0.9 at best.

In addition, induction cook tops, that offer high efficiency and similar (or greater) amenity to gas cook tops, have become increasingly affordable in recent years and continue to drop in price as they gain popularity as a mass market product.

Meaningfully comparing gas with electric appliance use is complex due to the variety of economic and other considerations that households are faced with in making such a decision, particularly for cooking and space heating. Naturally these considerations have fully informed ATA’s assessment of what constitutes suitable electrical alternatives to gas appliances for most consumers.

Approximately 7% of all Australian households replace their gas hot water systems each year, in keeping with a typical asset life of 10 to 15 years. Space heaters tend to have slightly longer asset lives. As such, every year at least 1 in 10 households buy a new space or water heater. When faced with this decision, according to industry data, the majority choose a ‘like for like’ replacement.

This common approach ignores the impact of running cost, determined by technology efficiency and future energy prices, on the total cost of purchasing, owning and operating the appliance over the life of the system. Hence, consumers often choose an appliance that may cost more to run in the long term. This is particularly evident for hot water systems that have failed due to the urgency of reinstating hot water supply.

2.0 Methodology

ATA's original work modelled six different household types and compared the 10-year costs (up-front and running costs) of installing gas or electric appliances in new homes and replacing gas appliances with like-for-like new gas or efficient electric alternatives.

The analysis was conducted across 26 gas pricing zones and took into account the impact of different climate zones. For this WA analysis, the WA metropolitan gas zone of Rockingham has been modelled.

For households, the primary use of reticulated (natural) gas or bottled (LP) gas occurs for any combination of the following end-use energy services:

- space heating (warming rooms and buildings);
- water heating; and
- cooking.

An individual consumer may be considering:

- switching one or two gas appliances with electric appliances, but retaining an existing reticulated gas connection or LPG gas system for any gas appliance/s that remain;
- a complete switch from gas to electric appliances, with subsequent:
    - disconnection from the reticulated gas network; or
    - termination of the use of LPG; or
- establishing a new connection to the reticulated gas network, and purchase of new gas appliances, for:
    - an existing home without mains gas; or
    - a newly built home.

Meaningfully comparing gas with electric appliance use is complex, particularly for cooking and space heating, due to the variety of economic and other considerations that households are faced with in making decisions.

These considerations have informed ATA's assessment of what constitutes suitable electrical alternatives to gas appliances for most consumers.

2.1 Economic Variables

The economics of the gas and electric choices is sensitive to a wide range of interrelated factors, which include:

- whether or not an appliance is at or near the end of its asset life;
- whether the decision incurs the cost of a new connection or new fixed charges;
- whether the decision avoids the cost of existing fixed charges;
- current gas and electricity tariffs and tariff structures;
- forecast prices for electricity and gas;
- the annual input energy use of individual gas and/or electric appliances, which is itself influenced by:

- building type, size and thermal performance;
- the type and mix of existing appliances in the home;
- climate zone (with particular reference to space and water heading loads and the performance of electric systems); and
- consumer financial expectation, including the cost of capital and return on investment expectations for any individual consumer; and
- consumer behaviour.

2.2 Household Scenarios

In with the above, ATA developed six 'Household Scenarios' that could be applied to each location modelled.

The scenarios considered a range of housing types and sizes, with differing characteristics in terms of gas and electric appliance use and overall energy use. The exception to this is the newly built home scenario (*Scenario 6: New Build*). As there are no existing appliances in place, a consumer is assumed to choose between installing either gas or electric appliances as the initial appliance investment.

The six Household Scenarios are outlined in **Figure 2-1**.

2.2.1 Replacing Gas Appliances in Existing Homes

Household Scenarios 1 to 5 consider cases where a decision to replace one or more existing gas appliance is made, either:

- at the point where it has failed, or is highly likely to require replacement within five years. In this case, replacing it with one appliance avoids the capital expense of another in the near to medium term, hence the up-front cost impact on the consumer will be the difference in capital cost between the two appliances; or

- while the existing appliance is still in good working order and unlikely to require replacement in the next five years. In this case, the decision does not lead to any avoided capital cost in the near to medium term and up-front cost to the consumer will be the full capital cost of the new appliance.

The options are either to:

1. replace the gas appliance/s with a new, efficient gas appliance (this is considered the *Business as Usual* (BAU) case; or
2. replace the gas appliance/s with an efficient electric appliance/s.

Under option 2, there is also the case where a consumer replaces all gas appliances with efficient electric, avoiding the need for an existing gas supply. In this case, the consumer:

- avoids the ongoing fixed charge incurred by maintaining a gas connection; and
- usually incurs a charge for temporary or permanent isolation of the gas supply to their home.

2.2.2 Connecting Existing All-Electric Homes to Gas

Household Scenarios 1 to 5 also consider the case where an established all-electric home has the option to connect to an existing gas network and install gas appliances. The available options are to:

1. connect one or more efficient gas appliances to the gas network, with or without some number of efficient electric appliances. In this case, the use of any one appliance avoids the capital expense of another, hence the up-front cost impact on the consumer will be the difference in capital cost between the two appliances; or

2. install efficient electric appliance/s and not connect to the gas network. Under this option, the consumer also avoids any ongoing fixed charge incurred by maintaining a gas connection.

In option 1 above, there is also an establishment cost to connect the home to the gas network in the street, including the installation of a gas meter. On the advice of gas network businesses and in order to be conservative, ATA have not attributed this cost to the householder, as businesses are likely to subsidise this cost as an incentive to the consumer to connect to the network.

2.2.3 Choosing Appliances for New Homes

Household Scenario 6: *New Home* considers the case where a new home is built and either:

1. connects one or more efficient gas appliances to the gas network, with or without some number of efficient electric appliances. In this case, the use of any one appliance avoids the capital expense of another, hence the up-front cost impact on the consumer will be the difference in capital cost between the two appliances; or

2. installs efficient electric appliance/s and does not connect to the gas network. Under this option, the consumer also avoids any ongoing fixed charge incurred by maintaining a gas connection.

For a detailed understanding of other aspects of the methodology, including the determination of space heating, hot water and cooking loads as well as the selection of representative electricity and gas tariffs please refer to **Appendices A – D**.

Figure 2-1: Household Scenarios Modelled

	Scenario1 - Reference Home		Scenario2 - Small home		Scenario3 - Large home		Scenario4 - Public Housing		Scenario5 - LPG Home		Scenario6 - New build	
Description	*Considered typical of current housing stock*		*Considered typical of current small, detached and semi detached housing stock*		*Typical 10+ year old house on suburban fringe (3 star)*		*Concession eligible. Appliance profile aligned with DHS policy.*		*Supplied with 2*45 kg bottles*		*6 star build; Different CAPEX assumptions to Scenario 3*	
Gas usage tertile[1]	Med	-	Small	-	High	-	Med	-	Med	-	High	-
Gas services[2]	**BAU Case NG**	**All Elec**	**BAU Case NG**	**All Elec**	**BAU Case NG**	**All Elec**	**BAU Case NG**	**All Elec**	**BAU Case**	**Mainly Elec**	**Gas Option**	**Elec Alt**
Space heating	Ducted gas - Replace furnace. Sized to house[4]	New multiple RC/ACs. Sized to house	Ducted gas - Replacement furnace. Sized to house[4]	New multiple RC/ACs. Sized to house	Ducted gas - Replacement furnace. Sized to house[4]	New multiple RC/ACs. Sized to house	Two flued gas wall heaters. Sized to rooms	Two RC/ACs. Sized to rooms	LPG Heater for living room	RC/AC sized to room	Ducted gas. Sized to house[4]	Multiple RC/ACs. Sized to house
Hot water	Gas storage - New high efficiency med sized unit	Heat pump med	Gas instantaneous - New high efficiency unit	Heat pump small	Gas storage - New high efficiency large sized unit	Heat pump large	Gas instantaneous - New high efficiency unit	Heat pump med	Instantaenous LPG - new high efficiency medium unit	Heat pump med	Large gas storage - high efficiency unit	Heat pump large
Cooking[3]	Gas oven, cooktop 500MJ/Qtr	Elec oven, Induction cooktop	Gas oven, cooktop 250MJ/Qtr	Elec oven, Induction cooktop	Gas oven, cooktop 750MJ/Qtr	Elec oven, Induction cooktop	Gas oven, cooktop 500MJ/Qtr	Elec oven, Induction cooktop	LPG oven, cooktop 500MJ/Qtr	No change	Gas oven, cooktop 750MJ/Qtr	Elec oven, Induction cooktop

Notes:

1. Gas usage tertile - relative to state averages from CUAC's report. An indicative check.

2. Assumes satisfactory level of service over lifetime, whether elec or gas.

3. Cooking - additional sensitivity tests on ceramic/conduction & increased elec appliance use.

4. Household scenarios with ducted gas in Vic and ACT only. Otherwise multiple wall units.

Glossary

BAU - Business As Usual

LPG - Bottled gas

NG - Natural Gas

Glossary (cont.)

RC/AC - Reverse cycle air conditioning (heat pump tech)

Tertile - thirds

3.0 Results

Economic results for each household type are presented by the single WA gas pricing zone modelled in **Table 2-3** at the end of this chapter. Economic results include the following capital cost assumptions for each replacement case:

Table 3-1: Capital Cost Assumptions by Replacement Case

No.	Replacement Case	Capital Cost Assumptions
1	Switching a gas appliance, within 5 years of end of life, staying on gas network	Gas & Electric
2	Switching a gas appliance, not within 5 years of end of life, staying on gas network	Electric Only
3	Switching one gas appliance, of any age, disconnecting from gas network	Electric Only
4	Switching two gas appliances, at least one is within 5 years of end of life, disconnecting from gas network	1 Gas & 2 Electric
5	New & existing homes, not currently gas connected, choosing efficient electric instead of gas	3 Gas & 3 Electric
6	All gas appliances switched: one is within 5 years of end of asset life, avoiding $2,000 replacement capex	1 Gas & 3 Electric

All economic results assume a discount rate of 5.5% - reflective of the cost of residential mortgages, considered an appropriate time cost of money for household investment.

Results are presented by appliance type (i.e. space heating, water heating, cooking) and replacement case for each Household Scenario. Net Present Value (NPV) over a ten year period.

Payback time of the efficient electric alternative/s to equivalent gas appliance/s based on discounted cash flows (as per above) are indicated as per below, along with ATA's advice.

Table 3-2: Interpretation & ATA Advice Regarding Payback/NPV Outputs

Cell Colour	Economic Result	ATA Advice
$NPV	A positive NPV with a payback time of five years or less.	Definitely choose efficient electric over gas: any extra up-front cost will be recouped through savings within five years.
$NPV	A positive NPV with a payback time of between six and ten years.	Consider choosing efficient electric over gas: any extra up-front cost will be recouped through savings within ten years.
- $NPV	A negative NPV over 10 years.	Choosing electricity over gas is unlikely to save any money: any extra up-front cost will not be recouped within ten years.

Table 3-3: Economics of Choosing Efficient Electric over Gas Appliances, Rockingham, WA

Gas Zone: Mid-West and South-West			Electricity Zone: Western Power			
Example Location: Rockingham, 6168, WA			Climate Zone: Balanced Moderate Demand			
Household Scenario	Ref home	Small home	Large home	Public housing	LPG home	New build
Switching a gas appliance, within 5 years of end of life, staying on gas network.						
Space Heating	$2,195	$1,633	$2,355	$2,329	$1,719	$2,585
Hot Water	$847	-$397	$1,753	$289	$2,145	$1,861
Cooking	-$70	-$63	-$58	-$72	n/a	-$63
Switching a gas appliance, not within 5 years of end of life, staying on gas network						
Space Heating	-$605	-$567	-$1,045	-$671	$219	n/a
Hot Water	-$653	-$1,597	-$47	-$911	$945	n/a
Cooking	-$1,870	-$1,863	-$1,858	-$1,872	n/a	n/a
Switching one gas appliance, of any age, disconnecting from gas network						
Space Heating	$210	$191	-$258	$99	n/a	n/a
Hot Water	$190	-$840	$784	-$93	n/a	n/a
Cooking	-$1,216	-$1,250	-$1,182	-$1,216	n/a	n/a
Switching two gas appliances, at least one is within 5 years of end of life, disconnecting from gas network						
Space Heating + Cooking	$1,196	$542	$1,363	$1,285	n/a	n/a
Hot Water+ Cooking	-$124	-$1,489	$804	-$707	n/a	n/a
New & existing homes, not currently gas connected, choosing efficient electric instead of gas*						
All Heating & Cooking	$6,154	$3,831	$7,663	$5,254	$6,309	$7,147
All gas appliances switched: one is within 5 years of end of asset life, avoiding $2,000 replacement capex.						
All Heating & Cooking	-$286	-$1,260	-$127	-$636	$3,809	-$388

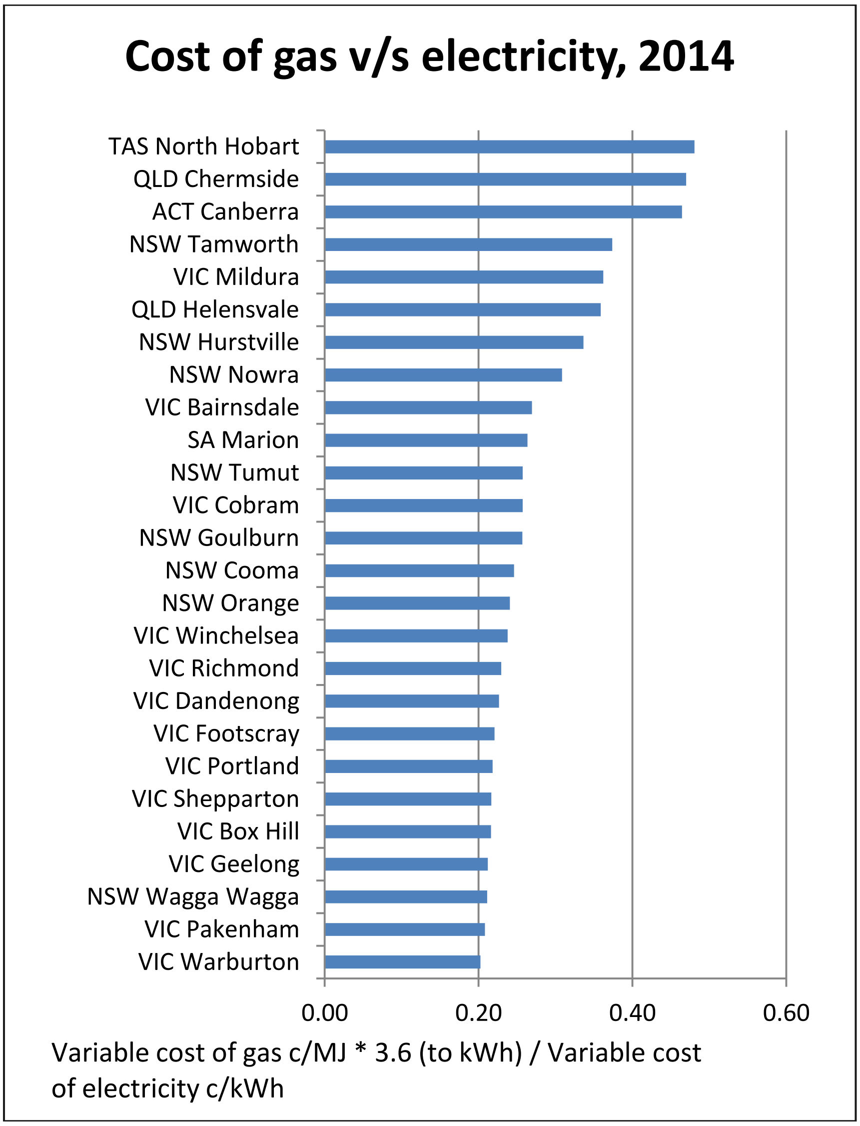
* Assumes full CAPEX on both electric and gas sides.

3.1 Relative Cost of Gas v Electricity

In the original report, ATA found that the relative cost of gas versus electricity in each gas pricing zone was an important factor to the overall economics of the case for switching to/remaining on mains gas.

In the majority of Victorian gas zones, where switching was often uneconomic, gas costs approximately 1/5th to 1/4th the price of electricity on an equivalent energy basis. In parts of NSW and QLD however, where a significant number of economic switching cases were found, gas can be up to almost half the cost of electricity. These relative costs are outlined in **Figure 3-1** below.

Figure 3-1: Relative Usage Cost of Gas v Electricity in each Gas Pricing Zone



To place WA in context, the Rockingham gas zone has relatively expensive gas but cheaper fixed connection charges. Its equivalent gas price is 13 cents per kilowatt hour – i.e. 54% of the price of WA electricity. This places reticulated gas in WA as more expensive (relatively speaking as compared with electricity) as any other jurisdiction in the NEM.

With running costs of gas appliances in WA on the high side, the same but even stronger patterns of economic results are found for WA as for the warmer NEM jurisdictions (i.e. SA, QLD and parts of NSW).

4.0 Findings

4.1 New Homes & Existing All-Electric Homes

Whether newly built or existing all-electric homes should connect to the gas network and install any number of gas appliances for economic reasons is dependent on one main factor:

Whether the household is able to install efficient electric appliances:
Installing new gas appliances and connections can no longer compete with installing efficient electric alternatives in any case.

However, the ratio of gas prices to electricity prices is unlikely to grow high enough to make inefficient electric appliances (resistance based electric water heating, non-RCAC electric space heating) competitive with gas.

The exception to this is electric resistance water heaters used in the off-peak period, which, where competitively priced off-peak electricity is available, is competitive with gas in some cases today.

A second factor may apply to a limited number of consumers:

Whether the cost of gas appliances is heavily subsidised:
Some gas businesses may offer a substantial subsidy for homes to connect to the gas network.

Where *all* of the cost of connecting gas to the home and *most* of the cost of purchasing and installing new gas appliances is not borne directly by the householder, a new gas connection may be a more cost effective alternative to efficient electric appliances.

1. **It is not cost effective to connect a new home to mains gas when efficient electric appliances are an option.**

Connecting a new home to mains gas and installing any number of gas appliances is more costly in the long term than installing efficient electric appliances for space heating, water heating and cooking.

This finding applies to most homes, with the exception being some in high density developments, as the limiting factor for efficient electric appliances in new homes is the capacity for external compressors to be installed for space and water heating.

2. **Connecting a new home to mains gas is cost effective when efficient electric appliances are not an option.**

Connecting a new home to mains gas and installing gas appliances is still less costly in the long term than installing inefficient electric appliances for space heating, water heating and cooking.

This finding applies to many homes in high density developments and some others where external compressors cannot be installed for space or water heating. The exception to this finding - homes where, in most locations, connecting to the gas network is not a cost effective option in any case - is homes that:

- have little or no space heating requirements; and
- have access to competitively priced off-peak electricity for water heating; and
- are able to install electric induction cook tops.

Homes should always be assessed on a case-by-case basis before installing gas and any benefit can be negated by gas not being available 'in the street', or the up-front cost of connecting to the gas mains being excessive.

3. It is not cost effective to connect an existing all-electric home to mains gas when efficient electric appliances are an option.

Connecting an existing home to mains gas and installing any number of gas appliances is more costly in the long term than installing efficient electric appliances for space heating, water heating and cooking.

This finding applies to homes in low and medium density areas, and some in high density area, where external compressors can be installed for space and water heating.

Homes should always be assessed on a case-by-case basis before installing efficient electric appliances to determine if major rewiring that is required.

4. Connecting an existing all-electric home to mains gas is cost effective when efficient electric appliances are not options.

Connecting an existing home to mains gas is less costly in the long term than using electric appliances for space heating, water heating and cooking when efficient electric appliances cannot be installed cost effectively. Reasons for this may include:

- the cost of electrical work for new efficient electric appliances is excessive due extensive rewiring in older homes;
- external compressors cannot be installed for space heating with split systems; and/or
- external tanks or compressors cannot be installed for hot water.

In the situations where restrictions on external units are a limiting factor, gas ducted or hydroponic heating is also unlikely to be suitable either due to the requirement for an external heating unit, limiting the gas space heating option to wall mounted gas heaters.

Homes should always be assessed on a case-by-case basis before installing gas as any benefit can be negated by:

- gas not being available 'in the street', or the up-front cost of connecting to the gas mains being excessive;
- the cost of installing gas pipes and fittings in the home being excessive due to unfavourable access for plumbing or unsuitable housing design; or
- the installation of new gas appliances being complicated.

5. Connecting an existing all-electric home to mains gas may be more cost effective when the cost of new appliances is heavily subsidised.

Connecting an existing home to mains gas is may be less costly in the long term than using efficient electric appliances for space heating, water heating and cooking, where a substantial subsidy is offered to connect to the gas network, such that:

- the costs of connecting gas to the property; and
- some or all of the cost of reticulating gas throughout the home;

are not borne directly by the householder.

For example, if the distribution business does not charge for connecting gas to the premises and heavily subsidises the installation of new gas appliances, gas is likely to be the more cost effective option.

Homes should always be assessed on a case-by-case basis.

4.2 Existing Dual Fuel Homes

Whether dual-fuel homes should replace some or all of their appliances with efficient electric appliances for economic reasons is dependent on multiple factors.

The main determinants are:

The age or condition of the existing gas appliance:
Where an appliance is due for replacement immediately or in the next few years, replacing it with one appliance effectively avoids the capital expense of the other. In this case, the real capital cost to the consumer is the difference between the two. However where an existing appliance is in good working order and unlikely to fail in coming years, the full capital cost of the replacement is the real cost to the consumer.

Whether the replacement allows the customer to disconnect from the gas network:
In the case of mains supplied gas (as distinct from bottled gas) where there is only one gas appliance, replacing it with an electric appliance allows consumers to avoid the fixed charges associated with being connected to the gas network. In many cases this represents a further saving of around $200 per year.

Whether the household is able to install efficient electric appliances:
While RCAC space heating is - and heat pump water heating is becoming - competitive with gas equivalents, the ratio of gas prices to electricity prices is unlikely to grow high enough to make inefficient electric appliances (resistance based electric water heating and non-RCAC electric space heating) competitive with gas.

The exception to this is electric resistance water heaters used in the off-peak period, which, where competitively priced off-peak electricity is available, is competitive with gas in some cases today.

Whether the existing gas supply is mains or bottled gas:
Bottled gas is more expensive on a unit basis than mains gas, however for consumers with low gas requirements (for example, cooking only), the absence of fixed charges may negate this higher cost.

6. It is significantly more cost effective to replace gas heaters with multiple reverse cycle air conditioners (RCACs) for space heating, in any case.

ATA found less than five year paybacks for switching space heating from gas to RCAC where the existing gas heater is within five years of end of asset life.

Switching space heating and cooking as the middle and last appliance; or space heating on its own as the last appliance; and disconnecting from the gas network altogether, was also economic for the majority of Household Scenarios.

5.0 Appendix A: Methodology – Space Heating

This Chapter outlines the methodology for calculating the annual and lifetime energy loads and costs of gas and electric appliances for space heating.

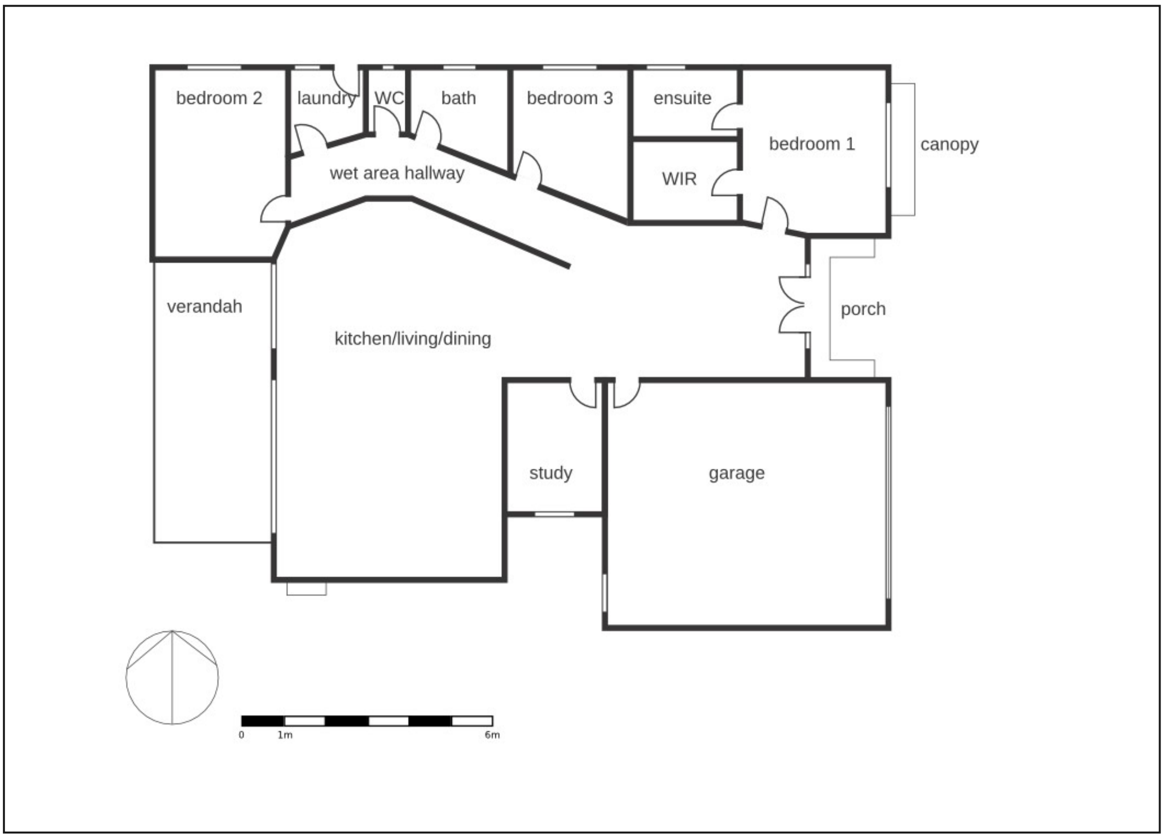
5.1 Determination of Heating Load

In order to understand the heating load requirements for different homes, ATA reviewed a range of research and analysis. This review identified that the heat load modelling recently undertaken by Beyond Zero Emissions (BZE) in their *Zero Carbon Australia Buildings Plan*[1] represented the most up-to-date and robust analysis of the characteristics of Australian housing stock that are of greatest relevance to this research.

Accordingly, ATA drew on this analysis in developing our Reference Household Scenario. ATA undertook further analysis to ensure that the modelled scenarios are broadly representative of Australian energy consumers.

BZE applied a single reference home as previously modelled by Energy Efficient Strategies (EES). The reference home was a three-bedroom, single-storey detached dwelling – with a number of variations based on orientation and building construction. The floor plan common to all variants is shown below:

Figure 5-1: Floor Plan, BZE Reference Home



[1] http://media.bze.org.au/bp/bp_appendix_7.pdf. Supporting model files and related resources are at: http://media.bze.org.au/bp/bp_appendix_7.zip

BZE developed six variants of the base model, corresponding to construction type as per the table below:

Table 5-1: Building Constructions, BZE Reference Home Model

House Type	Wall Construction	Floor Construction
1	Weatherboard	Timber
2	Weatherboard	Concrete Slab
3	Brick Veneer	Timber
4	Brick Veneer	Concrete Slab
5	Cavity Brick	Timber
6	Cavity Brick	Concrete Slab

The modelling previously completed by EES considered an uninsulated dwelling as a base case; and two other cases representing incremental improvements (identified as Modification levels 1 - 3 respectively). BZE added two further cases in their modelling for the Buildings Plan (Mod levels 4 and 5). The components of each modification level are outlined below:

Table 5-2: EES/BZE House Modification Levels

Mod Level	Modification Description	Comment
1	Baseline, uninsulated	
2	Mod Level 1 plus: - R2.5 insulation added to ceiling **This level is most broadly representative of current building stock*	
3	Mod Level 2 plus: - insulation added to walls to +R1.5 (except +R1.0 for brick cavity walls)	
4	Mod Level 3 plus: - ceiling to +R6.0, and walls to +R2.5 (except walls to +R1.5 for brick cavity)	
5DG	Mod Level 4 plus: - double glazing (ex garage) & ventilated downlights eliminated; - self-sealing exhaust fans, weather sealing & curtains / pelmets.	Relevant for cool climate
5SG	Mod Level 4 plus: - high-performance single glazing (ex garage); - ceiling fans in living areas & bedrooms; - ventilated downlights eliminated; - self-sealing exhaust fans, weather sealing & curtains / pelmets.	Relevant for warm climate

Modification Level 2 was considered by BZE as broadly representative of current housing stock.

Given the thermal performance standards required for new homes in Australian states and territories (5 to 6 Stars), Modification Level 4 was considered by ATA as the most appropriate for Household Scenario 6: New Build.

BZE 's analysis modelled the heating load of the reference home for each construction type and for modification level. The residential building models were tested using the 'AccuRate' software package (version 1.1.4) across ten locales, selected as being collectively representative of most Australian locations.

Heat loads (MJ/m^2) for house Modification levels 2 and 4 across the representative Australian climate zones are described below:

Table 5-3: BZE Reference Home Heating Loads by Construction Type, Mod Level 2&4 (MJ/m^2)

Climate / Location	House Modification Level 2						House Modification Level 4					
	House Construction Type						House Construction Type					
	1	2	3	4	5	6	1	2	3	4	5	6
Balanced Moderate Demand												
Adelaide	167	130	135	111	106	98	68	63	63	61	49	55
Mascot	108	83	86	69	64	60	43	38	39	37	28	31
Cooling dominated – humid												
Darwin	0	0	0	0	0	0	0	0	0	0	0	0
Townsville	3.9	1.7	2.1	1	0.2	0.1	1	0	1	0	0	0
Heating Dominated												
Melbourne	257	211	222	192	188	178	113	118	107	116	93	111
Moorabbin	309	255	267	231	228	215	136	144	129	142	114	138
Tullamarine	330	275	285	249	243	230	148	156	141	153	124	148
Heating dominated High Demand												
Canberra	390	335	337	301	285	278	174	190	166	186	146	180
Orange	523	450	459	412	402	385	244	271	234	267	214	261
Low Demand												
Brisbane	54	37	38	27	22	19	19	13	17	12	9	8

From this heating load dataset for Modification levels 2 and 4, ATA used appropriate heating loads for each representative climate zone/location to apply to the six Household Scenarios.

For existing dwellings (Household Scenarios 1 - 5), ATA took the average heating load of all house construction types in a given location from the Modification level 2 results above.

For new dwellings (ATA's Household Scenario 6), ATA used the average heating load of all house construction types in a given location using the modelled results for BZE's Modification level 4 reference home.

NatHERS energy loads take into account both heating and cooling requirements; whilst the EES/BZE modification levels take into account heating requirement only.

As such, ATA utilised the NatHERS energy loads in heating dominated climates, whilst Modification Levels 2 & 4 were used for Balanced (similar heating and cooling loads) and Low Demand (low heating load) climate locations.

Table 5-4 below summarises the source data for heating loads by representative climate zone for the six ATA Household Scenarios:

Table 5-4: ATA Selected Approaches to Determine Heating Loads

Climate Type	City	Scenario 1-5	Scenario 6: New Build
Balanced Moderate Demand	Perth/Mascot/Sydney	BZE Mod L2	BZE Mod L4

The selected approaches result in the following assumed space heating loads for each of the representative locations:

Table 5-5: Heating Load by Climate Location (MJ/m^2/annum)

Climate Type	City	Scenario 1-5	Scenario 6: New Build
Balanced Moderate Demand	Perth/Mascot/Sydney	78.3	35.9

5.1.1 Application of Heating Load

The heating load for the most representative climate location in **Table 5-5** above was then applied to each gas pricing zone, for each of the Household Scenarios.

When selecting heating loads for specific locations, ATA calculated heating degree days (using monthly Bureau of Meteorology data) for the locations in **Table 5-5** above and correlated these with heating degree days for the specific location within the gas pricing zone. Heating degree days at Jandakot airport in southern Perth were found to be directly comparable with Sydney.

5.1.2 Required Heating Area

The six Household Scenarios take into account a range of different house sizes and other attributes to be representative of most Australian homes. The heated area and maximum number of heated rooms for each scenario are outlined in the table below:

Table 5-6: No. of Rooms, Rooms Size & Total Heated Area, per Household Scenario

	Scenario 1: Reference Home	Scenario 2: Small House	Scenario 3: Large House	Scenario 4: Public Housing	Scenario 5: LPG House	Scenario 6: New Build (6 Star)
No. Rooms to be Heated	Up to 6	Up to 4	Up to 8	Up to 4	Up to 2	Up to 8
Total Heated Area (m^2)	**120**	**70**	**160**	**70**	**40**	**160**

The total heated area, heating loads per m^2 for each climate location and number of rooms provide the basis for the total heating loads and appropriate appliance configuration for each of the Household Scenarios.

5.2 Reverse Cycle Air Conditioners

Also called ‘split systems’ and in some locations ‘heat pumps’ (but not to be confused with heat pump water heating systems), reverse cycle air conditioners (RCACs) have become a common feature for heating and cooling in Australian homes.

RCACs provide convective heat, meaning they heat the air directly, and contain heat pumps, which use heat exchange and compression to provide space heating and cooling.

A heat exchanger is a piece of equipment built for heat transfer from one medium to another. In the case of RCAC in heating mode, the source medium (from which heat is being transferred) is the ambient air outside the building.

A compressor stores energy from the source in a fluid, turning it from a gas to a liquid. The fluid returns to a gaseous state on release of the heat. This process allows for temperatures to be reached that are higher than that of the source medium. Hence an RCAC can maintain a comfortable room temperature, even when the outside temperature is below freezing.

5.2.1 Performance

The amount of electrical energy input required to achieve and maintain a desired temperature varies with the temperature difference between the inside and outside air. The colder the outside temperature, the greater the electrical energy input required to achieve the same level of heat energy output from the system.

The ratio between the energy input (energy consumed by an appliance) and the heat energy output from the heat exchanger system is known as the Co-efficient of Performance (CoP). CoP is a measure of how efficiently the appliance converts electricity into heat. The CoP of an appliance is usually expressed as a number equal to the energy output (as heat transferred to the air inside a building) divided by the energy consumption (from electricity or gas consumed).

Efficient RCACs are reaching CoPs of 5.0 and over – which means that for every 1 unit of energy input to the system, 5 units are created to heat air.

Compared with the most efficient equivalent gas appliance that have a CoP of around 0.8 – 0.9, an efficient air-conditioner or electric water heater now uses 1/7th of the input energy for the same end use. While CoPs for electric appliances may continue to improve, gas appliances are forever limited to 0.9 at best.

5.2.2 RCAC Costs

Optimising the size and number of RCACs in a home is a three-way trade off between up-front cost, running cost and convenience or effectiveness. Generally speaking, small RCAC units operate with a higher CoP than larger systems and cost less per unit to purchase.

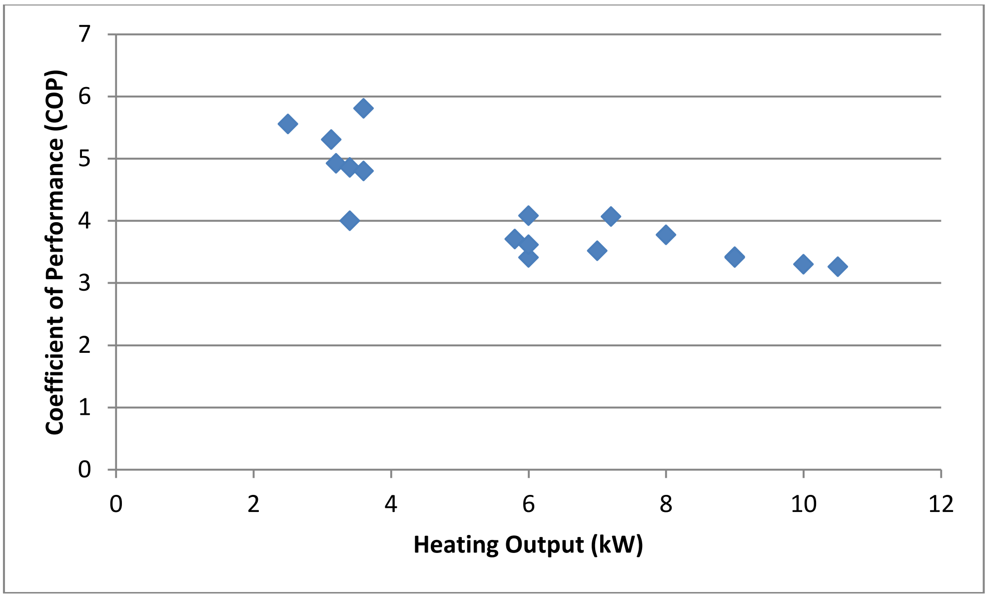
However, smaller systems are designed to heat smaller spaces. In inefficient buildings or during very cold weather an undersized system may not maintain a comfortable temperature and as such, two small RCAC units are required to heat the same space as one large unit.

As a single unit is typically not effective at heating more than two rooms, multiple RCACs are required for whole-of-house heating, particularly if they are to be considered as a replacement for ducted heating systems.

In order to understand how best to size RCACs, ATA developed a sample of 18 different actual models currently available from the Australian Government's *Energy Rating* website[2]. Analysis of the dataset found that small and medium systems (2.5-3.5 kW nameplate capacity) have higher average CoPs; whilst a number of the more efficient larger-sized systems are not far behind.

Figure 5-2 below highlights how the CoP of these 18 RCAC systems varies with heating output:

Figure 5-2: Variation of Average CoP with kW Heat Output

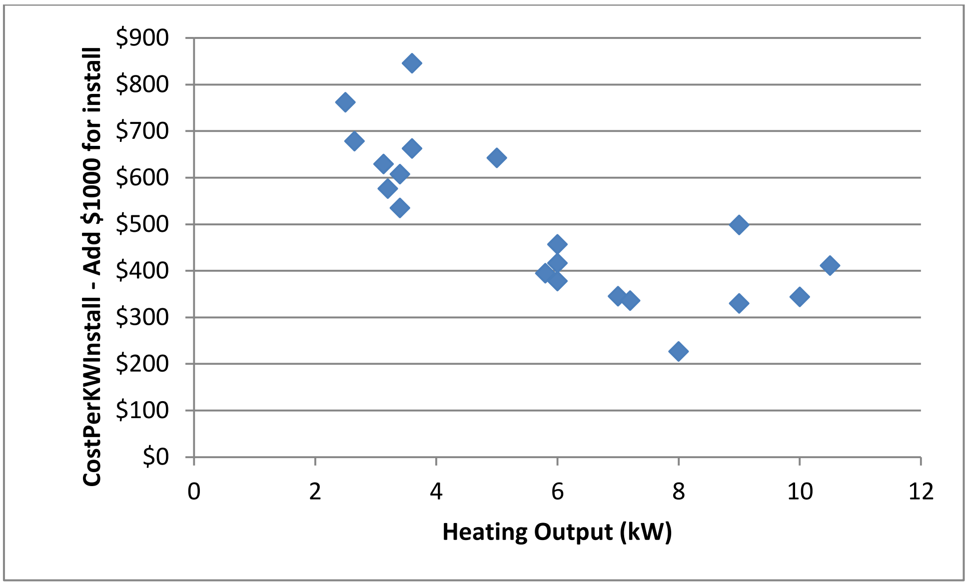


The installation cost of RCAC varies little with system size[3]. Taking this into account, the cost per unit of nameplate heating capacity is markedly higher for smaller units that for larger units:

[2] Located at: http://reg.energyrating.gov.au/comparator/product_types/64/search/

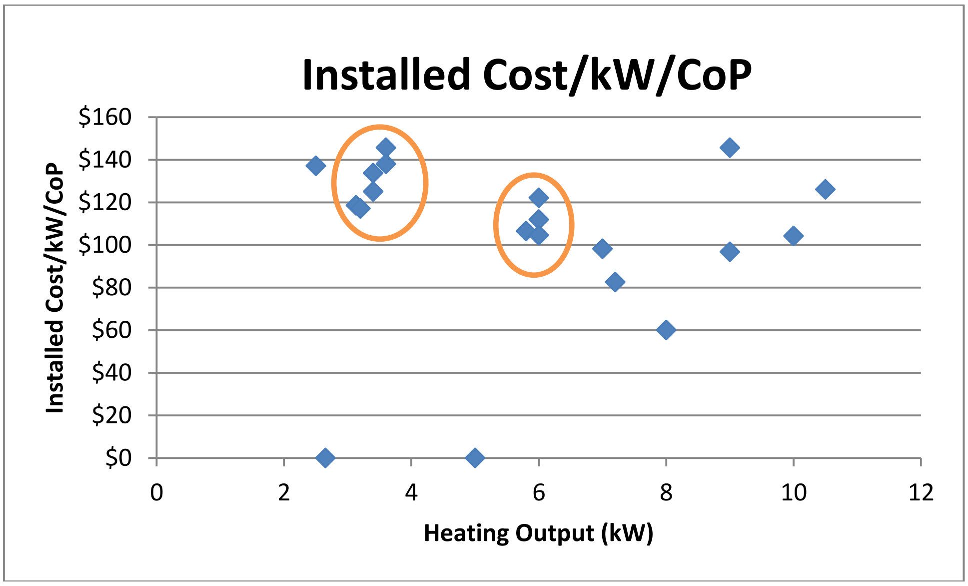
[3] Assuming same type of installation - i.e. ground level v first/second floor; similar cable and piping runs, etc.

Figure 5-3: System Cost per kW (Retail + Installation Cost)



Though effectively more expensive, smaller systems perform more efficiently than larger systems. In order to choose optimally sized systems, ATA quantified the cost versus size versus efficiency trade-off by dividing the installed cost/kW by the CoP:

Figure 5-4: Installed Cost per kW per CoP



This provided an installed system cost per kW adjusted according to its CoP – and ultimately an indication of a system's true value taking into account both its total cost (retail and installation) and its performance.

Of the 18 air con units in the figure above, 14 have an installed cost/kW/CoP of between (just under) $100 and $140. Two units are more expensive than $140/kW/CoP and two are significantly cheaper than $100.

Interestingly, one of the two most expensive systems is also a larger unit (i.e. 9.0kW).

The two cheapest models ($60 and $80/kW/CoP) are larger sized systems (i.e. 7.0kW and 8.0kW units). While these are more cost effective, in the interest of maintaining a conservative approach, credible analysis, we did not choose them for our modelling in case the lower price reflected temporary retail pricing strategies.

Ignoring those outliers, the analysis demonstrates that there is no significant difference in value of the remaining 14 units – irrespective of their size. At best, it could be argued that a slight value proposition exists in favour of larger systems.

5.2.3 RCAC Choice

Overall, ATA found a relatively level playing field between the real economic value of smaller and larger sized systems. This means cost assumptions regarding RCACs can be generalised on the basis of the heated floor area of a building, which is a key determinant of the overall installed heating capacity required.

The system specification for a home will be based on the best combination of systems with respect to heating requirements. For more open-plan homes, a smaller number of larger systems will be more appropriate. For a less open-plan home of the same floor area, the opposite will be preferable.

Due to the consistency of the true value across different sized systems, ATA's economic analysis is applicable to either.

Noting the above, ATA then selected two specific RCAC models – one small/medium, and one large – for the purposes of determining purchase price and performance for the modelling.

There are hundreds of models of RCACs available on the market. ATA expanded its existing RCAC sample from the Energy Rating website to capture a wider range of brands (35 small/medium [<3.6kW] and 28 large [>5.5kW]) as well as the existence of at least two of the higher performing models for each size range.

Within the sample, ATA found:

- a number of 6.0-7.0kW systems with a CoP of 4.0; and
- a number of 3.0-3.5kW systems with a CoP of between 5.0 and 6.0.

Those higher performing models, and their associated retail price[4], are outlined below:

---

[4] Current retail price estimates were taken from:
http://www.woodpecker.com.au/woodpecker-products/daikin-ururu-sarara-split-system
http://appliancecentral.com.au/shop/index.php?route=product/product&product_id=380
http://www.getcool.com.au/d43/daikin-ftxs60l
http://www.webprice.com.au/online-store/daikin-ftxs60l-6-0kw-cooling-7-0kw-heating-split-system-air-conditioner?utm_source=myshopping&utm_medium=cpc&utm_campaign=Air+Conditioners&utm_term=Daikin+FTXS60L+6+0kW+Cooling+7+0kW+Heating+Split+System+Air+Cond
http://www.arrowairconditioning.com.au/DAIKIN-FTXS60L-Split-Inverter-Air-Conditioner-p/ftxs60l.htm
http://www.airconditioningsales.com.au/mitsubishi-air-conditioner-srk60zmxa-s.html
http://www.lawsonair.com.au/online-shop/all-product-categories/ururu-sarara-splits/daikin-ftxz50n-buy-online
http://www.airconditioningsales.com.au/mitsubishi-air-conditioner-srk50zma-s-1.html

Table 5-7: Higher Efficiency RC Air Cons, Large & Small

Model	Size (kW)	CoP	Price ($)
Medium to Large (6.0-7.0kW) Models			
Daikin FTXZ50N / RXZ50N	6.3	4.5	3369
Mitsubishi SRK50ZJX-S1 / SRC50ZJX-S	6	4.25	1420
Mitsubishi SRK50ZMXA-S / SRC50ZMXA-S	6	4.25	1450
Mitsubishi SRK60ZJX-S1 / SRC60ZJX-S	6.8	4	1568
Daikin FTXS60L	7	4	1976
LG UTN21WH/UU21WH	7	4	n/a
Fujitsu ASTG22KMCA/AOTG22KMCA	7.2	4	1419
Mitsubishi SRK60ZMXA-S / SRC60ZMXA-S	6.8	4	1716
Price chosen for modelling			***1600***
Small (3.0-4.0kW) Models			
Daikin FTXZ25N / RXZ25N	3.6	7	2045
LG K09AWN-NM12/K09AWN-UM12	3.2	6	874
Mitsubishi SRK25ZJX-S	3.13	5.5	1118
Mitsubishi SRK25ZMXA-S / SRC25ZMXA-S	3.13	5.5	964
Mitsubishi ELECTRIC MSZ-FB25VA	3.2	5	1245
Daikin FTXS25L / RXS25L	3.4	5	1103
Fujitsu ASTG09KMCA/AOTG09KMCA	3.2	5	810
Fujitsu ASTG09KUCA/AOTG09KUCA	3.2	5	870
Samsung Electronics AR09FSSSBWKN/AR09FSSSBWKX	3.2	5	836
Samsung Electronics AR09FSSSCURN/AR09FSSSCURX	3.2	5	795
Price chosen for modelling			***850***

Reflecting the selection criteria outlined in Section **Error! Reference source not found.**, and with particular emphasis on the appliance choice being representative of most commonly available models, the following systems were chosen for analysis:

- Large RCAC – the average price of the second and third most cost effective larger models (6.8kW Mitsubishi models SRK60ZJX-S1 and SRC60ZJX-S), excluding the cheapest Fujitsu ASTG22KMCA (to account for any potential limitations of consumer choice) – at **$1,600**;

http://appliancecentral.com.au/shop/index.php?route=product/product&product_id=368
http://www.airconditioning-online.com.au/mitsubishi-heavy-industries-SRK50ZMXA-S
http://www.lawsonair.com.au/online-shop/all-product-categories/ururu-sarara-splits/daikin-ftxz25n-buy-online

- Small RCAC – the average price of the 6 most cost effective systems ranging between 3.1 and 3.2kW and CoP 5.0-5.5 – this being **$850**.

For the purposes of choosing a realistic CoP for the above units, ATA chose:

- Large RCAC: 4.0;
- Small RCAC: 4.5[5].

These figures represent de-rating below the collected sample to account for:

- performance deterioration over time;
- sub optimal installation, such as longer pipe runs in which more heat is lost within the system;
- homes with higher gas heating needs may be more common in cooler climates that the average test conditions of RCACs; and
- appliance choice may be limited for some consumers, particularly in regional areas.

In locations that experience the coldest temperatures, ATA further de-rated the CoP by 0.5 to account for lower performance in cold climates. Refer to **Section 0** for more detail on this.

5.2.4 Installation Cost

To account for variations in installation cost, ATA obtained a sample from a range of RCAC installers and retailers, which indicated the following results:

Table 5-8: Indicative Installation Costs, RC Air Cons

Complexity of Install	Installation Price ($)	Comments
Low	800	Uncomplicated, back to back, single storey.
Medium	1,200	Above plus at least one of following variations: More electrical work / upper storey / long pipe-run with lagging / complex header installation.
High	1,800	Above plus two or more of the above variations.

On the basis of the above, ATA chose to use an average installation cost of $1,000 per RC air con unit installed. The sample of data indicated that the majority of actual installations fall below this value.

Additionally, it would be reasonable to assume the cost of a high complexity installation will be a disincentive for most consumers to install one or more RCAC systems.

5.2.5 Maintenance

[5] Arguably, an indicative efficient commonly-available small RCAC system could be assumed to have a CoP above 5.

Due to a lack of reliable publically available data, ATA undertook a survey to gather information of maintenance costs for gas and electric heating and cooking appliances.

Participants included ATA members, newsletter recipients and the general public, accessed primarily through other stakeholder communications channels including the network of energy consumer advocates. Data from about 50 respondents was used to inform maintenance costs for space heating and cooking.

ATA asked questions relating to the type and age of the space heating appliance, length of tenure of the householder and the money they had spent on maintenance to date. After excluding outliers and adjusting for absent data, ATA used the annual average maintenance cost for each appliance as the input for the model:

Table 5-9: Annual Maintenance Cost Assumptions, Gas & RC Air Con

Heating	Min ($)	Max ($)	Average	Count	Zero Spend[6]	Zero Spend %
Gas Ducted	0	154	**63**	11	1	9%
Gas Wall/Space	0	80	**24**	11	5	45%
RC/AC			**27**	22	13	59%

5.2.6 Asset Life

The asset life of RCACs varies with quality of construction, maintenance and usage. The National Association of Home Builders in consort with Bank of America produced a report in 2007 called 'Home Equity Study of Life Expectancy of Home Components'. It reports a 16 year average lifetime for RCACs. ATA assumed RCACs should last a minimum of 10 years and average 12 years.

5.2.7 Attribution of Cooling Value to Capital Cost

RCACs provide the benefit of cooling – indeed many consumers are more familiar with this function of RCAC than heating. In warmer climates, cooling is often the sole motivator for a consumer to purchase an RCAC.

To account for the different value placed by consumers on cooling in certain locations, ATA chose a portion, ranging from 0 to 100%, to reflect the capital value attributable to the heating function of RCAC for each location.

For example, where 50% is attributable, half of the capital cost of the RCAC is attributable to heating and included in the analysis, while the other half is attributed to cooling – a function that is not provided by equivalent gas fuelled appliances.

Where 100% is attributable, the RCAC is purchased for heating purposes and any cooling benefit is incidental. Where 0% is attributable, the RCAC is purchased for cooling purposes and any heating benefit is incidental.

6 No maintenance required over whichever period is shorter of a. the period of tenure and b. the age of the appliance.

To reflect the range of consumer motivations for appliance choice within each climate zone, ATA then applied a sensitivity value in order to understand the economic impact of the relative value placed by a consumer on heating versus cooling. These default and sensitivity values were as follows:

Table 5-10: Default Capex & Sensitivity for Heating, by Location

Climate	Location	Default Capex (Heating)	Capex Sensitivity (Heating)
Balanced Moderate Demand	Perth/Mascot/Sydney	50%	100%

5.2.8 RCAC Configuration & Sizing

ATA selected a specific number and size of RCAC units for each of the Household Scenarios. The choices were based on:

- floor area: 1kW of heating capacity per 10 m^2 of floor area is adequate for housing of the type selected throughout most of the study area.
- In high demand heating climates (Canberra and Orange), the standard industry advice is 1kW per 8.5m^2. In low demand heating climates (Brisbane), the industry advice is 1kW for each 16m2; and
- number of rooms: a single unit is typically not effective at heating more than two rooms.

ATA used these benchmarks[7] as a check that adequate RCACs for heating are installed for the households.

Table 5-11: Number & Size of Air Con Units, by Household Scenario

	Scenario 1: Reference Home	Scenario 2: Small House	Scenario 3: Large House	Scenario 4: Public Housing	Scenario 5: LPG House	Scenario 6: New Build (6 Star)
Total Heated Area (m^2)	**120**	**70**	**160**	**70**	**40**	**160**
No. Rooms to be Heated	Up to 6	Up to 4	Up to 8	Up to 4	Up to 2	Up to 8
No. 7.0kW Systems	1	1	2	1	1	2
No. 3.0kW Systems	2	1	2	1	-	2

[7] http://www.elgas.com.au/blog/476-gas-heater-sizing-facts

5.2.9 Zoning

ATA's analysis accounts for the relative operating time of different RCACs to reflect how multiple units are typically used within a home.

In typical home, RCAC used for heating living areas are likely to be operational for the majority of the heating time required. However, given the potential for zoning[8], ATA assumed:

- a primary, large heating unit will be operating during all heating hours;
- any second large unit (if present) is in operation 90% of heating hours; and
- small units, more likely to be used in bedroom and other non-living areas, are in operation for 50% of heating hours.

To account for this, ATA adjusted the operational time and energy use for relevant RCACs accordingly.

5.2.10 Electricity Use per Climate Zone per Household Scenario

Taking into account the approach and assumptions described in this section, the following annual electricity consumption figures were calculated for RCACs across the climate zones and Household Scenarios:

Table 5-12: Annual RC Air Con Energy Use by Climate Location & Household Scenario, kWh

Climate	Location	Scenario 1: Reference Home	Scenario 2: Small House	Scenario 3: Large House	Scenario 4: Public Housing	Scenario 5: LPG House	Scenario 6: New Build (6 Star)
Balanced Moderate Demand	Perth/Mascot/Sydney	488	290	607	290	218	278

5.3 Energy Use – Gas

To ensure consistency in the analysis, the approach to identifying annual fuel consumption for gas ducted and wall furnace space heaters drew on much of the underlying logic developed for electric RCAC where relevant.

The most relevant heating load was used from Table 5-5 and applied to the heated area of each home.

The burner efficiency, for both gas ducted and wall furnace systems, was determined and applied to each Household Scenario. These estimates drew from previous work done by Energy Consult[9] and BZE. The assumed burner efficiencies are:

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[8] Space heating or cooling only of areas that require temperature control.

- 80% for ducted heating systems (Household Scenarios 1, 2, 3 and 6);
- 70% for wall furnace systems (Household Scenarios 4 and 5).

The 2012 Energy Consult report showed that the sales were clustered around 25MJ-30MJ gas wall furnaces with 67%-70% efficiency. ATA also accounted for heat losses through the ducting system for Household Scenarios where ducted systems were modelled (Household Scenarios 1, 2, 3 and 6 in Victoria and the ACT).

Old, poorly maintained ducting systems can incur heat loss of up to 50%, due to leaks, obstructions and poor insulation of ducts and fittings; whilst new ducting is in the range of 15 to 20% (the higher end of that range applying to larger homes with longer duct systems)[10].

Noting the above, the assumed ducting losses are:

- 20% for brand new ducting (Household Scenario 6);
- 25% for existing ducting in small and medium sized homes (Household Scenarios 1 & 2); and
- 30% for existing ducting in larger homes (Household Scenario 3).

These figures assume the ducting in existing systems is in good repair.

Ducted gas heating is common only in Victoria and the ACT (41-42% of households[11]). For climate zones outside these states, the ATA assumed multiple gas wall units for all household scenarios. Less than 2% of households in NSW rely primarily on gas ducted heating and it is not known whether these households cluster into the very cold climates.

In the interests of making conservative assumptions for this report, the ATA has assumed gas wall units across NSW. In a few instances, the best match for heating demand for a gas zone outside Victoria or the ACT was determined by the ATA to be Melbourne or Canberra. (For example, Tasmania has a comparable heating load to Canberra and Wagga Wagga has a comparable heating load to Melbourne.) Consequently another series of heating loads with gas wall units for all household scenarios was calculated.

The electricity use associated with the fan in both gas ducted and wall furnace heating systems was also included. ATA gathered the average annual operating hours by gas appliance and state defined by Energy Consult[9], reviewed the power and energy associated with gas fan use from a range of sources including Whirlpool forums as well as ATA internal sources, to indicate typical fan motor rated capacity and running time to estimate electrical energy consumption.

ATA did not analyse thermostat or controller loads. As well as being minor, these are common to both gas ducted and RCAC systems and therefore can be considered to cancel out for the purpose of comparing one system type with another.

The above approach led to the following gas appliance fuel use estimates in each of the climate zones and for each of the Household Scenarios:

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[9] EnergyConsult. (2012). Product Profile: Gas Space & Decorative (Fuel Effect) Heaters: Equipment Energy Efficiency Program.

[10] Pears, A. (2013). 'Winter comfort, Not just a heater choice', ReNew 127 & 128.
Palmer (2008). 'Field study on gas ducted heating systems in Victoria', RMIT thesis, September 2008.

[11] Australian Bureau of Statistics, 4602.0.55.001 Environmental Issues: Energy Use and Conservation - More Tables, March 2011, Table 8.

Table 5-13: Annual Gas Appliance Energy Use by Climate Location & Household Scenario

Climate	Location		Scenario 1: Reference Home	Scenario 2: Small House	Scenario 3: Large House	Scenario 4: Public Housing	Scenario 5: LPG House	Scenario 6: New Build (6 Star)
Balanced Moderate Demand	Perth/Mascot/Sydney	MJ pa	10,767	6,179	13,050	6,187	4,500	5,946
		kWh pa	69	43	84	43	29	84

5.3.1 Gas Capital & Installation Costs

As with RCACs, ATA reviewed an online sample[12] of 17 gas wall furnaces and flued convection space heaters; as well as five gas ducted heaters, in order to understand appropriate capital costs for the modelling.

Indicative installation costs were drawn by many of the same suppliers, as well as direct discussions with gas installers in Victoria, WA and online. With regards to installation assumptions, it should be noted that for ducted systems (relevant to Household Scenarios 1-3), only the cost associated with burner replacement is used in the analysis in the context of understanding capital cost of replacement gas heating systems – as these homes will already have ducts in place.

This analysis led to the following capital and installation cost inputs for gas heaters:

[12] Current retail price estimates were taken from:
http://www.billyguyatts.com.au/braemar-eco-superstar-wf25-wall-furnace-090061.html
http://www.gstore.com.au/heating-cooling/gas-space-heaters
http://www.gascentral.com.au/collections/space-heaters/products/braemar-wall-furnace
http://www.elgas.com.au/appliances/gas-heaters-gas-fireplaces-gas-log-fires/flued-gas-heaters/braemer-sh18-space-heater-price
http://www.wonders.com.au/page/gas_space_heating.html
http://www.appliancewarehouse.com.au/showProduct.aspx?SEName=rinnai-energysaver-561ft-natural-gas-heater-free-flue-kit&ProductID=5613
http://forums.whirlpool.net.au/archive/1697698
http://www.ductedheatingandcooling.com.au/heating/braemar-ducted-heating/braemar-th-56-star-series/
http://forums.whirlpool.net.au/archive/1908792
http://forums.whirlpool.net.au/archive/2256975

Table 5-14: Capital & Installation Cost Assumptions, Gas Heaters

Scenario	Replace GDH Furnace	Replace GDH Furnace (MJ)	Wall Units (No.)	Purchase Price ($)	Installation Cost ($)	Total ($)
1 – Reference Home	1	80		2,100	700	2,800
2 – Small Home	1	50		1,600	600	2,200
3 - Large Home	1	120		2,600	800	3,400
4 - Public Housing			2	2,400	600	3,000
5 - LPG House			1	1,200	300	1,500
6 - New Build						4,000

5.3.2 Asset Life

Energy Consult profiled gas ducted heaters in 2011 and gas wall heaters in 2012 for the Equipment Energy Efficiency (E3) program with the same results for both: i.e. expected asset lives of 15 to 25 years. Industry sources suggest that about 50% of heaters are replaced within 20 years.

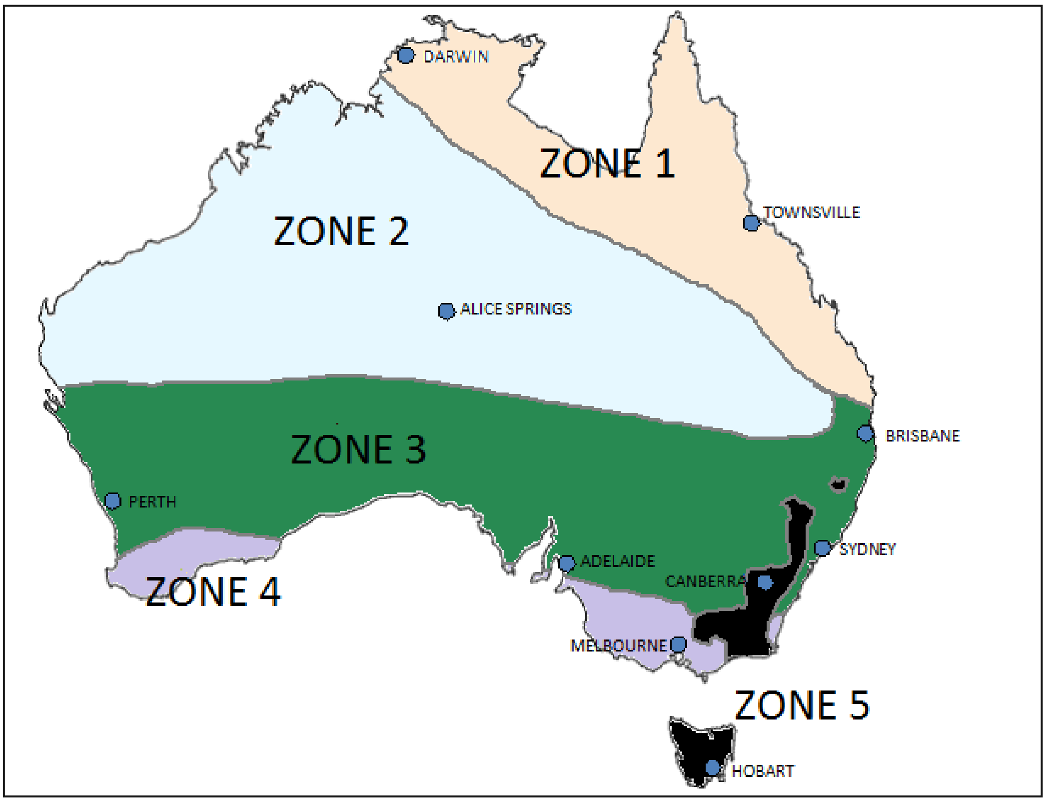
6.0 Appendix B: Methodology – Water Heating

6.1 Annual Energy Use: Gas

In order to understand the potential economic value of replacing existing gas water heaters with electric heat pump alternatives, ATA first needed to consider the annual energy use of gas water heaters.

Input energy usage of gas storage and gas instantaneous hot water systems was informed by a report done by Energy Consult (EC) for Sustainability Victoria in 2009[13]. EC modelled the annual input energy of both storage and instantaneous systems within Zones 3 & 4 of the Australian water heating climate zones:

Figure 6-1: Australian Water Heating Climate Zones



Given its task to advise a Victorian agency, EC's report categorised Zone 3 as 'northern Victoria. In reality, Zone 3 extends through New South Wales, up to (and including) Brisbane and across to Perth and a significant proportion of WA. As such, Zone 3 was used for this analysis.

Gas instantaneous systems use both input gas and input electricity, whilst storage systems use only input gas. EC's annual gas and electricity usage of medium (providing 200 litres of hot water per day) and small (120 litres per day) systems in Zones 3 & 4 are as follows:

[13] Energy Consult, 2009 *'Estimated Hot Water System Running Costs in Victoria'*: http://solarthermalworld.org/content/estimated-hot-water-system-running-costs-victoria-2010

Table 6-1: Annual Gas Consumption, Medium Gas Systems providing 200L/Day

Medium Households (200 Litres/day)	Perth (Zone 3)	
	Electricity kWh pa	Gas MJ pa
Gas storage (3 stars)	0	22680
Gas storage (5 stars)	0	19170
Gas instantaneous (3 stars)	71	22400
Gas instantaneous (5 stars)	71	18700

Table 6-2: Annual Gas Consumption, Small Gas Systems providing 120L/Day

Small Households (120 Litres/day)	Perth (Zone 3)	
	Electricity kWh pa	Gas MJ pa
Gas storage (3 stars)	0	16410
Gas storage (5 stars)	0	13180
Gas instantaneous (3 stars)	67	13420
Gas instantaneous (5 stars)	67	11220

6.2 Annual Energy Use: Electric

The most up-to-date independent research on the input electrical energy requirements of heat pump hot water systems was conducted by Pitt & Sherry (2012)[14].

P&S tested nine different models of electric hot water systems, including five resistance and four efficient heat pump systems, for comparative purposes. Small, medium and large models were tested, in 10 different Australian locations (and therefore climatic conditions) and under different hot water loads, in order to understand annual electricity usage.

Table 6-3 below contains the annual electricity usage of the four heat pump systems, compared with comparatively sized resistance systems, for the two closest locations of relevance to Perth – i.e. Adelaide and Sydney. ATA ultimately used Adelaide as the most representative climate for Perth.

[14] Pitt & Sherry, 2012 *'Running Costs and Operational Performance of Residential Heat Pump Water Heaters'*: http://www.pittsh.com.au/assets/files/CE%20Showcase/Residential_heat_pump_water_heaters.pdf

Table 6-3: Annual Electricity Consumption (kWh), Resistance & Heat Pump Systems

City	Vol L/day	HP Model 1	MedElecResist	HP Model3	SmallElecResist	HP Model 7	HP Model 9	LgElecResist
Sydney	136	1204	2165	887	2360	1049	983	2249
Sydney	264	1940	3610	1467	3838	1590	1543	3690
Sydney	384	2597	4989	2013	5223	2075	2039	5070
Adelaide	136	1340	2290	963	2494	1184	1068	2377
Adelaide	264	2119	3833	1592	4068	1771	1669	3915
Adelaide	384	2831	5303	2168	5544	2335	2203	5383

The annual electricity use figures for the medium-sized Model 1 system were consistently higher than for the larger sized systems (i.e. Models 7 & 9), except where Model 1 provided 136 litres of hot water per day. As such, Model 1 was considered unreliable and subsequently excluded from further analysis.

Model 3 was a smaller sized system. The annual energy use figures for Model 3 for delivering 136 litres per day is directly comparable to the required heat pump system for the **Small House - Scenario 2**, and was subsequently used for this household scenario.

The large Models 7 & 9, tested to deliver 384 litres per day, was directly comparable to the required heat pump system for the **Large House - Scenario 3**. The average of the annual usage figures for Models 7 & 9 was subsequently used for this Household Scenario.

6.3 Synthesis

The P&S and EC analyses used different daily hot water loads to understand annual energy usage for each system type, as follows:

Table 6-4: Assumed Daily Hot Water Loads, P&S & EC

	Daily Hot Water Load (Litres per day)		
	Small	Medium	Large
Pitt & Sherry – heat pumps	136	264	384
Energy Consult – gas storage & instant.	120	200	N/A

In order to directly compare gas and electric systems for the same daily hot water load, ATA:

- converted the annual gas usage for the small EC gas storage and instantaneous systems (i.e. annual MJ at 120L/day hot water load) into an equivalent annual gas usage for providing 136L/day[15];

[15] ATA calculated the increased energy use by a straight line method that increased energy use commensurate with the increase in hot water load.

- averaged the annual electricity usage of the P&S medium sized Models (7 & 9), at both 136L/day and 264L/day, in order to calculate annual heat pump electricity usage for a 200L/day system – which is directly comparable to the medium sized EC gas systems (and the average of 136L & 264L). This is also directly comparable to the required heat pump system for the **Reference House - Scenario 1**, and was subsequently used for this modelling scenario;
- used the task efficiency of the 5 star gas storage system providing 200L/day (i.e. 66% from Wilkenfeld 2007) and applied a 10% efficiency gain for providing the larger daily volume of 384 Litres. (As the storage losses will be averaged across more hot water, the system should be more efficient at this level of hot water demand) This resulted in a task efficiency of 72.7% being applied to this system size).

These conversions provided the following annual energy usage figures, for the modelled gas storage (5 stars), gas instantaneous (5 stars) and heat pump systems, for the three daily hot water loads and for the relevant modelled house scenarios:

Table 6-5: Annual Gas & Electricity Consumption, ATA Modelled Hot Water Systems

City	Household Size	Hot Water Load	Gas Storage (5 stars)	Gas Instantaneous (5 stars)		Heat Pump
		L/day	MJ pa	kWh pa	MJ pa	kWh pa
Perth/Adelaide	Small	136	N/A	68	12716	963
Perth/Adelaide	Medium	200	19170	71	18700	1423
Perth/Adelaide	Large	384	27788	N/A	N/A	2269

6.3.1 Gas Capex & Opex

For new, 5 star gas storage and instantaneous systems, ATA reviewed a sample of a range of system prices available on four different online supplier websites[16] comprising 16 gas storage models and 12 gas instantaneous models in total.

ATA also reviewed installation costs, for 'like-for-like' gas hot water system replacements with Bunnings and with a number of individual hot water suppliers. This data review provided the following purchase and installation costs for the two types of gas hot water systems per Household Scenario:

[16] http://www.gstore.com.au/hot-water.html
http://www.elgas.com.au/appliances/gas-hot-water-heaters
http://www.bunnings.com.au/hotwater-gas-unit
http://www.hotwaterprofessionals.com.au/

Table 6-6: Gas Hot Water Purchase & Installation Costs by Household Scenario

Household Scenario	Appliance Type / Size	Purchase Price ($)	Installation Cost ($)	Total Upfront Cost ($)
Scenario 1 - Reference Home	Storage Med	1,200	300	1,500
Scenario 2 - Small House	Instant	900	300	1,200
Scenario 3 - Large Home	Storage Large	1,500	300	1,800
Scenario 4 - Public Housing	Instant	900	300	1,200
Scenario 5 - LPG House	Instant	900	300	1,200
Scenario 6 - New Build	Storage Large	1,500	300	1,800

6.3.2 Heat Pump Capex

For new heat pump hot water systems, ATA reviewed a sample of a range of system prices available on two online supplier websites[17] as well as from previous reviews by both BZE and Choice[18]. ATA reviewed 16 heat pump models from these sites in total.

ATA also reviewed installation costs for heat pump systems from the same sites (where available), as well as using information (labour time) from one manufacturer and another supplier (EcoShop).

This data review provided the following purchase and installation costs for the two types of gas hot water systems per Household Scenario:

Table 6-7: Heat Pump Hot Water Purchase & Installation Costs by Household Scenario

Household Scenario	Heat Pump Size	Purchase Price ($)	Installation Cost ($)	Total Upfront Cost ($)
Scenario 1 - Reference Home	Med	4080	600	$4,680
Scenario 2 - Small House	Small	3980	600	$4,580
Scenario 3 - Large Home	Large	4190	600	$4,790
Scenario 4 - Public Housing[19]	Med	4080	600	$4,680
Scenario 5 - LPG House	Med	4080	600	$4,680
Scenario 6 - New Build	Med	4080	600	$6,080

For Victoria, ATA assumed no discount to the purchase price on the basis of the VEET scheme, as this is due to end in 2015. For other jurisdictions, no energy efficiency scheme incentives were assumed either.

17 http://www.enter-shop.com.au
www.energymatters.com.au

18 BZE (2013)
Choice (2008), Heat Pump Buyers Guide

19 The SA Government's Solar Hot Water Rebate Scheme offers a $500 rebate to low income households. ATA included this for the concession-eligible Household Scenario 4 for Adelaide.

Given current status of the Renewable Energy Target (and particularly the SRES), ATA assumed the current purchase price, including the discount associated with STCs for heat pumps, remains. The number of STCs varies by heat pump size and climate zone, but at $34 per certificate reduce out of pocket expenses by $1,000-$1,200.

6.3.3 Maintenance

For both gas and electric hot water, maintenance is a significant factor during appliance asset life.

For both gas and heat pump technologies, periodic routine servicing is assumed to reach the intended asset life and maintain good performance. In regards to heat pump maintenance, the Australian Government's Department of Industry[20] states:

> "Talk to your installer about having your water heater regularly inspected and serviced, checking the integrity of the refrigeration system and replacing the pressure relief valves where required. Refer to manufacturer's instructions and installer's advice on when your system should be inspected and serviced."
>
> "Most tanks have a sacrificial anode (a metal rod that protects the metal hot water tank by attracting corrosion) that a licensed service person needs to replace approximately every five years."

For gas hot water, ATA assumed $30 per annum for anode replacement every 5 years (i.e. approx. $150 anode replacement cost). For heat pumps, enquiries with manufacturers and installers conversations suggested servicing and re-gassing should occur at least every five years, and costing in the order of $150-$200 per service. Accordingly $40 per annum for re-gassing was assumed.

While some suppliers and plumbers recommend more frequent routine scheduled maintenance, there is no evidence to suggest that the benefits of doing so outweigh the costs over the longer term.

6.3.4 Asset Life

The asset life of a water heater typically ranges from 10-15 years, 'depending on the material and lining of storage vessels, and on water pressure and quality)'.[21]

After reviewing the literature and consulting with industry, Wilkenfeld (2010)[22] concluded that gas instantaneous (12 years) would last a little longer than gas storage (10 years). Heat pump electric storage also average about 10 years. Accordingly, ATA have assumed asset lives of:

- gas instantaneous (12-15 years);
- gas storage (10-12 years);
- heat pump (10 years).

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[20] 'Heat Pump Water Heater Guide for Households', 2013, p9: http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Water_Heating/Heat_Pump_Water_Heaters/HeatPumpWaterHeaterGuide_toWeb.pdf

[21] George Wilkenfeld and Associates, "Specifying the Performance of Water Heaters for New Houses in the Building Code of Australia" December 2007.

[22] George Wilkenfeld and Associates, "Regulation Impact Statement: for Decision Phasing Out Greenhouse-Intensive Water Heaters in Australian Homes" Prepared for the National Framework for Energy Efficiency by George Wilkenfeld and Associates with National Institute of Economic and Industry Research, 15 November 2010.

7.0 Appendix C: Methodology – Cooking

While different in a number of ways, gas and electric induction cook tops are considered to be of similar enough quality to be interchangeable for the purposes of this research. While each has its clear pros and cons in terms of the user experience, electric induction cook tops are considered to be at least as user-friendly as gas cook tops in most respects, and have some advantages over gas.

Gas cook tops remain the appliance of choice for consumers over electric resistance (non-induction) cook tops; yet electric induction cook tops are overwhelmingly preferred over gas by consumers who are familiar with both gas and induction. This is reflected in the fact that many consumers with access to gas still choose electric induction in spite of it being (until recently) the more expensive option.

7.1 Energy Use

ATA found very little useful information available on the typical energy consumption of gas or induction cook tops. Of the literature that does exist, it does generally agree that gas use for cooking is a very small proportionate part of a household's overall annual gas bill.

According to the NSW Independent Pricing and Regulatory Tribunal (IPART)[23], household use of gas for cooking is around 500 MJ per quarter. This estimate agreed closely with the findings of ClimateWorks Australia in their '*Low Carbon Lifestyles*' reports (2012) that assumed 1552 MJ per annum throughout Australia.

Taking the figure of 2000 MJ per annum, ATA apportioned this between gas cook top use and gas oven use (60/40) and considered high and low usage levels for sensitivity (high: 3,000 MJ pa; low: 1,000 MJ pa). ATA converted the MJ/pa figure into electricity (kWh/pa) for induction and ceramic-based cook tops and ovens and applied an efficiency factor at the point of use for each cooking appliance type:

Table 7-1: Energy Use & Efficiency of Gas and Electric Cooking Appliances

Type	Energy input	Energy input	Efficiency at point of use	Energy Output
Cook top	*MJ/pa*	*kWh/pa*	*%*	*MJ/pa*
Natural Gas	1,200	333	40%	480
Induction	600	167	80%	480
Ceramic	667	185	72%	480
LPG	691	192	70%	480
Oven				
Natural Gas	800	222	7%	56

23 http://www.ipart.nsw.gov.au/Home/For_Consumers/Compare_Energy_Offers/Typical_household_energy_use

Electric	400	111	14%	56
LPG	560	156	10%	56
Total				
Natural Gas	2,000	556		
Electric Induction	1,000	278		
Electric Ceramic	1,067	296		

The efficiency factors were referenced from a variety of sources as per the table below:

Table 7-2: Point of Use Efficiency Factors of Gas and Electric Cooking Appliances

Type	Power Source	%	Reference
Oven	Elec	14%	BZE 2013
Oven	Natural gas	7%	BZE 2013
Oven	Natural gas	5.2-5.3%	US DoC
Oven	Elec	9.3-9.6%	US DoC
Oven	LPG Gas	21%	Ehow
Oven	LPG Gas	10%	Gas company (www.alliantgas.com)
Cook top	Natural gas	40-45%	Choice 2013
Cook top	Elec -Ceramic Radiant	65-85%	Choice 2013
Cook top	Elec - Induction	85-90%	Choice 2013
Cook top	Elec -Ceramic Radiant	79%	BZE 2013
Cook top	Natural gas	40%	UBC students citing US DoE
Cook top	Elec - Radiant	71%	UBC students citing US DoE
Cook top	Elec - Induction	84%	UBC students citing US DoE
Cook top	Elec - Radiant	57%	Wuppertal 2013
Cook top	Elec - Induction	80%	Wuppertal 2013
Cook top	LPG - kitchen - cold start	76%	Aprovecho (test results)
Cook top	LPG - kitchen - simmer	63%	Aprovecho (test results)
Cook top	"Trad electric"	60%	Alan Pears
Cook top	LPG standard cook tops	40%	Gas company (www.alliantgas.com)
Cook top	Natural gas	Approx. 30%	US DoC
Cook top	Elec	77-82%	US DoC

7.2 Capital Costs

As with RCACs and heat pumps, ATA reviewed an online sample[24] of 34 gas cook tops and ovens; and 32 electric cook tops and ovens, in order to understand appropriate capital and installation costs for the modelling. As a result of this analysis, the following capital and installations costs were chosen as model inputs:

Table 7-3: Capital & Installation Cost Assumptions, Gas & Induction Cooking

	Purchase Price ($)	Installation Cost ($)
Gas:		
Cook Top	400	170
Oven	1,000	230
Electric:		
Oven	500	150
Induction Cook Top	700	250
Ceramic Cook Top	450	150

7.3 Asset Life

The US benchmarking study (National Association of Home Builders/ Bank of America) indicate that gas ovens and cook tops are among the longest lived of home appliances. It reports that gas ovens typically last 10-18 years and gas (cooking) ranges 15-17 years. The same source reports the lifespan of electric ranges at 13 years.

24 Current retail price and installation cost estimates were taken from:
http://www.ebay.com.au/itm/like/111257445502?clk_rvr_id=666054824171&crlp=1_262691&mt_id=641&mid=428969&sdc_id=1405318213z521353z51073b0a574zzz&fitem=111257445502&linkin_id=8080378&kw={query}&crdt=0&sortbid=35
http://www.electroseconds.com.au/browse-products/cooking-appliances/gas-cooktops/
http://www.buysmarte.com.au/
http://www.getprice.com.au/6-gas-kitchen-cooktops-gpc115t1376t2378.htm
http://www.whitfordshomeappliances.com.au/
http://www.wyz.com.au/Install.aspx
http://www.aus-appliances.com.au/emilia-sec64gwi-gas-cooktop-with-wok-burner.html
http://www.appliancesonline.com.au/600mm60cm-emilia-gas-wall-oven-emf61mvi/
http://www.frog.net.au/gas_cook_tops.html
http://www.2ndsworld.com.au/oven-cooktop-rangehood-stove/oven/gas-oven/
http://www.stancash.com.au/
http://www.pricepirate.com.au/
http://www.billyguyatts.com.au/westinghouse-single-oven-gor474wlp.html
http://www.handycrew.com.au/wp/cooking/
http://www.wyz.com.au/Install.aspx
http://www.theelectricdiscounter.com.au/Cooking-Appliances/Gas-Or-Electric-Wall-Ovens
http://www.harveynorman.com.au/
http://www.bunnings.com.au/our-range/kitchen/appliances/ovens-cooktops
http://forums.whirlpool.net.au/archive/1278748
http://forums.whirlpool.net.au/archive/1781669

As a relatively new technology, the lifespan of induction is somewhat unknown; however some models (such as LG[25]) come with a 10 year warranty, suggesting manufacturer confidence in similar life spans to gas equivalents.

7.4 Maintenance Costs

In order to obtain realistic estimates of ongoing maintenance costs, ATA undertook a survey of ATA members and members of the public accessed through other stakeholders. ATA used this survey of 49 respondents to inform maintenance costs for space heating and cooking.

Given that induction cooking is relatively new, ATA did not receive enough responses back for this cooking appliance, suggesting a zero maintenance cost. In order to be conservative, ATA used the average maintenance cost for gas cook tops would also apply to induction cook top maintenance.

Table 7-4: Maintenance Cost Assumptions, Gas & Induction Cooking

Cooking	Min ($)	Max ($)	Average	Count	Zero Spend	Zero Spend %
Gas Cook top	0	43	**2**	25	16	64%
Gas Oven	0	64	**14**	15	5	33%
Induction Cook top	0	0	**0**	4	3	75%
Electric Oven	0	70	**11**	7	3	43%

[25] http://www.lg.com/au/built-in-appliances/lg-KA68030F-cooktop

8.0 Appendix D: Methodology – Energy Prices

8.1 'Year 0' Prices

ATA's original analysis was structured by gas pricing zone – with relevant electricity prices available within those gas zones used for modelling electric alternatives.

ATA set a date for the gas and electricity pricing analysis of January 2014 – however adjusted these for the repeal of the carbon tax (July, 2014).

In WA, as at July 2014, gas tariffs were capped at 25 cents per day ($91 per year) and price cap rates are published in kWh, but converted to MJ, are 3.9c for first 43MJ /day & 3.5c/MJ for rest.

ATA assumed a Year 0 electricity tariff of 24.6 cents per kilowatt hour.

It should be noted that economic results of the original modelling showed significant sensitivity to the availability of off-peak electric rates (in order to run heat pump hot water systems). In the WA gas zone modelled, hot water heating is available on a tariff of 12.71 cents per kilowatt hour to existing customers.

8.1.1 Price Forecasts: Gas

Price forecasting is an inherently complex exercise and not one that ATA sought to conduct any primary investigations into as part of this project. Instead, ATA drew on existing price forecasts available in the public domain.

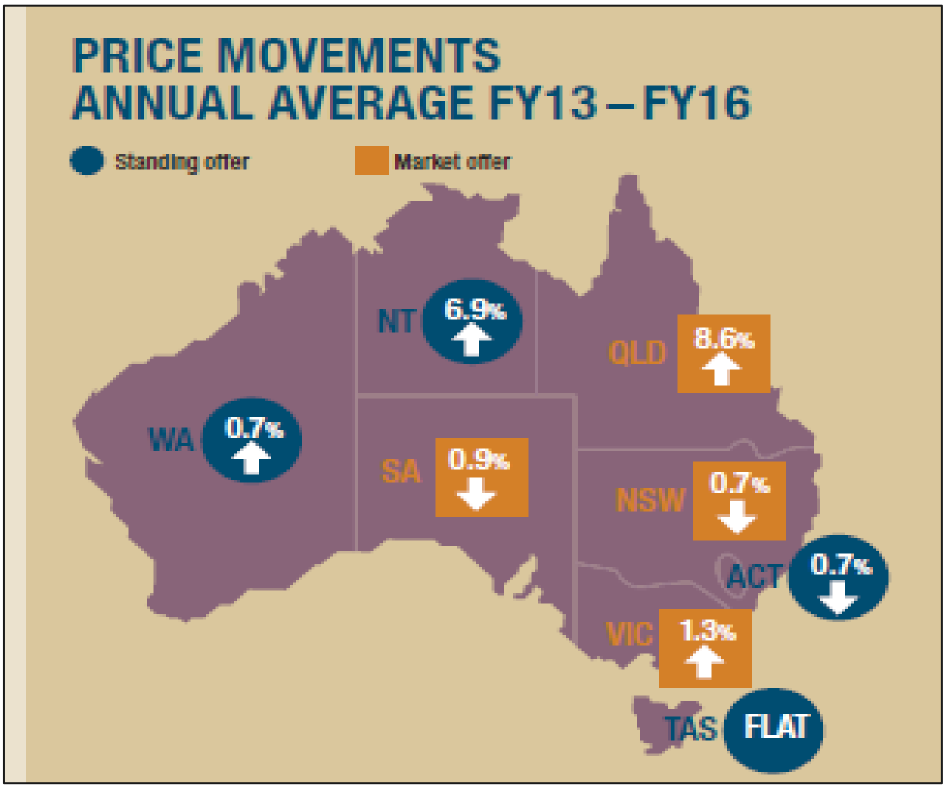
For WA, ATA assumed retail gas price rises in line with CPI. Whilst some flow on effects from the eastern state gas export issue may become a driver in WA, in order to be conservative, ATA chose to use CPI to test model results.

8.1.2 Price Forecasts: Electricity

ATA utilised electricity price projections compiled by the AEMC[26] as part of their Market Review of 2013 Residential Electricity Price Trends. These forecasts are outlined in the infographic below:

[26] http://www.aemc.gov.au/market-reviews/completed/retail-electricity-price-trends-2013.html

Figure 8-1: AEMC Residential Electricity Price Trends, Dec 2013



As mentioned, ATA adjusted the 1 January 2014 electricity prices to account for carbon tax repeal.

8.2 LPG

LPG wholesale prices in Australia are set with reference to the international benchmark of Saudi Aramco Contract Price and vary from month to month. Retail prices for bottled gas of LPG vary from location to location based on a number of factors including degree of market competition, transport costs and number of existing customers.

ATA consulted with Origin Energy in order to try and understand relevant price ranges for LPG in September 2014. The prices listed below were quoted to ATA and are presented on the basis of rental per 45kg cylinder per year:

Table 8-1: LPG Bottle Rental & Refill Prices, by Location

Location	Delivered from	Bottle Rental ($)	Refill Price - Low ($)	Refill Price - High ($)
Victoria	Dandenong	35	115	145
	Shepparton	35	102	141
Tasmania	Hobart	35 / 21[27]	99	159
	Devonport	35 / 21	99	159
	Launceston	35 / 21	99	159
SA	Metro	39.50	99	135
	South Coast	39.50	105	140
	Riverina	39.50	105	140
NSW	Sydney	39	101	140
	Lightning Ridge	39	134	157
	Wagga Wagga	39	117	137
QLD	Brisbane	37.50	110	148
	North QLD	37.50		156
	Remote Inland	37.50		172

ATA assumed:

- The current Origin Energy rental annual fees by state of $70-79 for two cylinders;; and
- $110 refill for a 45 kg cylinder (which comes to 5c/MJ).
- A flat outlook for LPG prices, which appear to be in line with Treasury forecasts of long run terms of trade[28].

For the WA analysis, ATA ultimately assumed 5 cents per megajoule, in line with price findings for the NEM jurisdictions.

[27] Discount to pensioners.

[28] Bureau of Resources and Energy Economics forecasts oil prices to be down 1.8%-3.6% by the end of 2014. In May 2014 Treasury forecast long term terms of trade. Beyond 2023 they project real oil prices to be flat (rising with inflation). Before that, Treasury used 'Consensus Economics' projections (based in London). Tidbits on the Consensus Economics website to Jan 2015 show Brent projections are flat.

8.3 Connection & Disconnection Costs

The cost to disconnect from the reticulated gas network, on either a temporary or permanent basis, is also a relevant consideration.

ATA found that the existence of both temporary and permanent disconnection fees were relatively common. Temporary disconnection fees were levied on a once off basis and were mostly less than $100, however this varied by distributor. Permanent disconnection fees typically involved complete decommissioning of meters.

ATA assumed that households with existing gas connections choosing to disconnect from gas would do so paying the relevant temporary disconnection charge in their distribution network. ATA found the following connection and disconnection charges in the WA gas zone:

Table 8-2: Connection & Disconnection Charges by Location & Distributor

State	Source	Service	Fee (inc GST)
WA	DNSP	Temporary Disconnection	90.00
WA	DNSP	Meter Removal	270.00
WA	DNSP	New pipe run to a meter (for new build homes) of less than 20 metres	Free

9.0 Appendix E: Glossary

Co-efficient of performance (CoP): A measure of the heating efficiency of heat pump systems. This is a ratio of the heat moved to the electrical energy input.

Outdoor unit: A complete heat pump reverse cycling air-conditioner system comprises an air handling unit and an outdoor unit (and a remote control). In heating mode, the outdoor unit could be called a compressor. These units are usually in separate locations (hence the term 'split-systems'). Sometimes one compressor can manage several air handling units.

Efficient electric appliances: Heat pumps for water heating, AC split systems for space heating, and induction cook tops.

Electric appliances: Resistant electric water heating, electric systems other than AC split systems for space heating, and resistance cook tops.

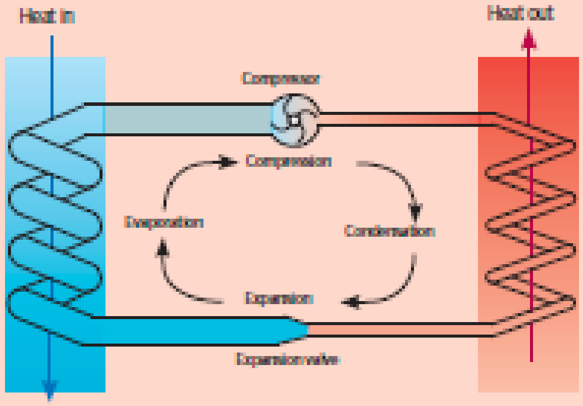
Heat pump: Process explained in ReNew 120:

Heat pump basics

Heat pumps use a closed system that contains a liquid with a low boiling point, called the refrigerant. A compressor adds energy to the refrigerant as well as increasing the pressure, forming a superheated vapour. This enters a set of coils known as the condenser where the vapour forms back into a liquid, giving up some of its heat energy in the process. It then flows through an expansion valve where the pressure is abruptly reduced, causing some of the refrigerant to form a vapour. It then flows into another coil called the evaporator where it absorbs heat and flows back to the compressor and the cycle repeats.

In a cooling-only air conditioner, or a fridge or freezer, the evaporator is inside the house or fridge cabinet and the condenser is outside. This is why the back of the fridge gets warm.

In a reverse-cycle system, the system uses a reversible expansion valve and so the inside cooling coils can be either evaporator for cooling or condenser for heating. Of course, the same applies for the outdoor coils.



Inefficient electric appliances: Resistant electric water heating, electric systems other than AC split systems for space heating, and resistance cook tops.

Mains gas: A distributed reticulated gas system in the National Energy Market.

Physical CoP (for heat pump HW):	There is an Australian Standard for testing and establishing the performance of heat pump hot water systems, AS/NZS 5125: *"The COP values given are usually in the range 3.5 to 4.5, values which can only be achieved at the temperature and humidity conditions which are the most favourable for HPWH performance."* Commonwealth of Australia (2012a)
Task CoP (for heat pump HW):	Annual energy imparted to the hot water load divided by the annual electricity supplied to the water heater: *"The Task COPs of HPWH models calculated using AS/NZS 4234 modelling results are significantly lower than the physical COPs measured at the AS/NZS 5125 Test Conditions."* Commonwealth of Australia (2012a)

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