Residential Space Heaters in Australia & New Zealand

Product Profile

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A joint initiative of Australian, State and Territory and New Zealand Governments.

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Introduction: Summary

Space heating accounts for around a third of residential energy use in Australia and New Zealand. There is considerable opportunity to help consumers compare the energy efficiency performance of space heaters on the market. For space heating, energy efficiency can most simply be understood as how much energy is required to perform the heating task. The energy efficiency performance of residential space heaters on the Australian and New Zealand markets could be compared within and across heating products. However, the lack of accessible and comparative information restricts the ability of consumers to identify and compare the efficiency, greenhouse gas emissions and operating costs of space heaters. This is especially the case for comparisons across heating technologies.

The Equipment Energy Efficiency (E3) Program is planning to develop energy rating labelling and complementary tools to help consumers compare the operating costs of space heaters. This document will inform the development of the space heating labelling scheme and supporting tools by providing a common basis of information about the space heating market in Australia and New Zealand on which policy options and technical frameworks can be developed. It provides an overview of the space heater market and products, outlines existing and proposed government policies for space heaters, reviews international approaches to space heaters, and identifies the scope for consumers to be assisted to identify and select more efficient space heaters. It does not explore policy options or technical frameworks for developing the energy rating labelling and supporting tools, but rather forms a foundation of information to inform that work. As such, options on the form that the comparative labelling may take and how it could be calculated are yet to be developed, and this will be done in consultation with stakeholders.

Purpose

Space heating accounts for around a third of residential energy use in Australia (35 per cent) and New Zealand (32 per cent) (EnergyConsult, 2015), making it the single largest energy end use in Australian homes, and a major energy end use in New Zealand homes. The use of space heaters is also a major driver of household energy costs, especially in colder regions. Increased uptake of efficient heating would result in reductions in residential energy use, household energy costs and greenhouse gas emissions.

Energy efficiency labelling can support consumers to compare products and make more informed decisions to best meet their heating needs. Energy efficiency labelling requirements apply to only some heater types in Australia and New Zealand, and labelling is not comparative across heater types. Greenhouse and Energy Minimum Standard (GEMS) determinations cover air conditioners, of which the majority sold on the market have a heating function. Air conditioners with a heating function are commonly called reverse cycle air conditioners in Australia and heat pumps in New Zealand. Most residential air conditioner types are required to have GEMS Energy Rating Labels (or at least energy ratings). In Australia, gas-ducted and gas room heaters carry energy labels required by states and territories for product certification. In Australia, solid fuel combustion heaters are also required to mark efficiency information on the product nameplate as part of state and territory compliance legislation. No energy labelling requirements apply to gas decorative appliances, electric resistance heaters, hydronic/boiler central systems and in-slab central heating. Surveys of household heating showed 59 per cent of Australia's households (BIS Oxford Economics, 2020) and over 50 per cent of New Zealand's households (Stats NZ, 2020) use gas, solid fuel and electric resistance heaters not regulated under GEMS legislation.

Consumer research conducted in 2020 investigated how consumers evaluate space heater alternatives (Kantar/Colmar Brunton, 2020). The qualitative component of the research indicated that the typical evaluation process can be broken down into three levels: the product type, sub-type, and model or brand. Research participants described the highest level of evaluation—attempting to understand the different heating product types available for their home—as the most challenging and time-consuming. Allowing for comparison between space heating product types and products when it comes to energy efficiency is something participants considered would be useful and important (Kantar/Colmar Brunton, 2020). The research also identified that the ongoing cost of operating a space heater is an important factor in purchasing decisions (Kantar/Colmar Brunton, 2020).

There is variation in the efficiency of products on the Australian and New Zealand market within and across heater types. A range of market barriers and failures in the space heater market have contributed to limiting the uptake of energy efficient products.

On 25 February 2019, the Australian Government announced its Climate Solutions Package. Under the package, the Government is providing $6.5 million to examine options to expand energy rating labelling to include space heating appliances such as gas and electric heaters. The labelling scheme will be supported by complementary tools, to help consumers compare the operating costs of covered heaters. This work is being undertaken under the Equipment Energy Efficiency (E3) Program.

The New South Wales Department of Planning, Industry and Environment has allocated $7 million to aid in progressing E3 Program work, including the key area of residential space heaters.

Short history of energy efficiency programs and the regulatory framework

The National Appliance and Equipment Energy Efficiency Program (NAEEEP) started in 1992. The program focused on improving the energy efficiency of equipment and appliances in Australia and New Zealand and operated with the support of the Australian and New Zealand Minerals and Energy Council and Australian states. Under the NAEEEP, state-based regulations and New Zealand national regulation were used to implement any mandatory energy rating labelling and minimum energy performance standards (MEPS).

In the early 2000s the program name changed to the Equipment Energy Efficiency (E3) Program, with support from the Ministerial Council on Energy and New Zealand Energy Ministers. The E3 Program continues the work of NAEEEP and focuses on improving the energy efficiency of new equipment and appliances sold in Australia and New Zealand.

On 1 October 2012, the *Greenhouse and Energy Minimum Standards Act 2012* (the GEMS Act) came into effect, creating a national framework for product energy efficiency in Australia. The GEMS Regulator replaced the previous state regulators and is the sole party responsible for administering the legislation in Australia. The GEMS regulator is based in the Australian Government's Department of Industry, Science, Energy and Resources.

The GEMS Act is the underpinning legislation for the E3 Program in Australia. It enables the Australian and New Zealand Governments to set MEPS for new products supplied to the market, which helps drive greater energy efficiency and excludes the poorest performing products from the market. It also allows the Australian and New Zealand Governments to set nationally consistent energy rating labelling requirements.

Energy Rating Labels (ERL) provide a comparison tool for consumers when purchasing a product. Retailers must display an ERL on a product at the point of sale if they are sold through an appliance retail store to enable the comparison of like products on the basis of energy consumption. For manufacturers, importers and retailers, ERLs provide a competitive marketing tool to promote efficiency improvements. ERLs increase consumers' awareness of options to improve energy efficiency and reduce energy consumption, energy costs and greenhouse gas emissions. GEMS Determinations establish the MEPS or energy rating labelling requirements applicable to covered product types.

In New Zealand, the *Energy Efficiency and Conservation Act 2000* and the Energy Efficiency (Energy Using Products) Regulations 2002 have a similar role to the GEMS Determinations and are administered by the Energy Efficiency and Conservation Authority (EECA) on behalf of the Ministry of Business, Innovation and Employment.

The E3 Program is a cross jurisdictional program under which the Australian Government, states and territories and the New Zealand Government collaborate to deliver a single, integrated program on energy efficiency standards and energy labelling for equipment and appliances. An Inter-Governmental Agreement provides the framework for national cooperation on the E3 Program. A similar arrangement has also been developed to ensure alignment with New Zealand.

In conjunction with the GEMS Regulator, the E3 Program is also managed by the Energy Efficiency Advisory Team (EEAT), which comprises representatives of the Commonwealth, state and territory governments and the New Zealand Government. Industry and consumer groups participate through the E3 Review Committee.

Next steps

This document provides an overview of space heater technologies in the Australian and New Zealand markets. It discusses the characteristics of the products and their markets and presents estimates of their energy use and related greenhouse gas emissions. It also discusses issues affecting the uptake of energy efficient space heaters, outlines existing standards, and presents initial analysis of the average efficiencies of common residential space heaters in Australia and New Zealand.

This document does not explore policy options or technical frameworks for developing the energy rating labelling scheme and supporting tools, but rather forms a foundation of information to inform that work. As such, options on the form that the comparative labelling may take and how it could be calculated are yet to be developed, and this will be done in consultation with stakeholders.

Your feedback on the contents of this paper are welcomed.

Have your say

We invite submissions on the Product Profile: Residential Space Heaters in Australia and New Zealand.

The instructions for making a submission, and the Privacy Collection Statement, are provided on the energyrating.gov.au/consultations website.

The closing date for written submissions is 5pm AEST, Monday 5 July 2021.

The purpose of the product profile is to provide a foundation of information to inform the development of comparative labelling for residential space heaters. With this in mind, some of the questions stakeholders may wish to consider in responding to the product profile are set out below.

1. Are there any major gaps in the data included in the product profile of residential space heaters? If so, what are the gaps and how can these gaps be filled?
2. Is there more up to date information and data available on space heaters that should be included in the product profile? If so, where can this information or data be found?
3. What other sources of data and information are available and would be useful in considering the energy efficiency of space heaters?

4. The product profile presents market information on the main types of heaters in Australia and New Zealand, including the stock of products, sales of products, and fuels used for these products. Does this picture of the market for space heaters align with your understanding of the market? If not, how does your understanding differ from the perspective presented in the product profile?
5. Is there any important consideration that is missing from the product profile? If so, what else needs to be considered?

Please feel free to provide any additional information or insights that you think could assist in the development of an energy rating labelling scheme that would enable consumers to make fair comparisons across different heater types.

Technical Working Group nominations

We also invite stakeholders to nominate their interest in participating in a Technical Working Group, which will investigate potential technical frameworks for comparison of the energy efficiency of different space heaters. Nominations should be noted in the body of the email (not within the submission document). The nomination should include the nominee's name, organisation, title/position, and contact details.

After consultation

The material in this Product Profile, and the feedback received on its contents, will provide a foundation of information on which to develop policy options and suitable technical frameworks through the Technical Working Group.

Industry, business, and the public will be consulted on the development of the space heater energy rating labelling scheme and complementary tools, ensuring the views of all interested parties are considered before regulation is introduced.

Product Characteristics

Product characteristics: Summary

This report covers two main categories of heaters—room heaters and whole-of-house heaters—and discusses a broad range of heater types. The report does not cover rarer, more specialised heater types and combined space/water heaters. Heaters covered include:

Room heaters

Electric resistance: Can be portable or fixed, and include radiant, convector, fan, and underfloor heaters. All are 100 per cent energy efficient if measured at the point of end use.

Reverse cycle air conditioners - non-ducted: Also known as heat pumps, are available as split-systems, window-wall units and portables. Typically ranging from 240-570 per cent energy efficient if measured at the point of end use, based on Seasonal Energy Efficiency Ratings.

Gas space heaters: Can be either radiant, convection or combined radiant/convection, permanent or portable, and flued or flueless heaters. Typical energy efficiency 60-90 per cent if measured at the point of end use.

Gas decorative appliances: Some appliances marketed as gas fireplace or log fire style 'heaters' are certified as decorative appliances. This means they do not need to meet the efficiency requirements of gas space heaters, do not carry a gas energy label and typically have much lower energy efficiency than other gas heaters. They are not intended to provide effective heating in a room. Consumers may have difficulty differentiating decorative gas appliances from gas space heaters, which provide effective heating.

Solid fuel combustion heaters: Largely consist of slow combustion wood heaters and burners, with typical energy efficiency of 60-75 per cent in Australia and 65-80 per cent in New Zealand if measured at the point of end use. Open fire places are also a type of solid fuel heater, but are much less efficient than slow combustion wood heaters.

Whole-of-house heaters

Reverse cycle air conditioners - ducted: Consist of a central heating (and cooling) unit that supplies heating to different parts of the house via ducts. The central unit energy efficiency is similar to non-ducted air conditioners, averaging 330 per cent if measured at the point of end use, but some efficiency is lost due to heat losses from the ducting – losses are typically 15 to 20 per cent in reasonably good ductwork, but can be much *higher if the ductwork is poorly insulated, has holes or tears, or has come loose from fittings.*

Gas ducted heaters: Consist of a central furnace unit that supplies heating to different parts of the house via ducts. The furnace energy efficiency is typically 71-90 per cent if measured at the point of end use, similar to gas space heaters; but some efficiency is lost due to heat losses from the ducting – the losses are similar to ducted reverse-cycle air conditioners. Gas ducted heaters use a reasonably large fan to circulate the heated air through the ductwork, and this can have a fairly high electricity consumption in the colder climates where this type of heating is mainly used. The electricity consumption is typically around 1.5 to 4.5% of the gas consumption – the percentage is less for the least efficient heaters and highest for the most efficient heaters, because they have lower gas consumption relative to their electricity consumption.

In-slab heaters: Provide heat by electric cabling embedded in the slab. Their efficiency will vary with the insulation of the slab and the climate where they are installed.

Hydronic heaters: Consist of a central water heater, usually a gas system, and distribute the heat via water filled pipes and radiator panels. Efficiency varies, depending on the design of the heater and installation.

Scope of products included

This report is concerned with a range of space heaters suitable for residential use, which can be divided into two major categories: room heaters and whole-of-house heaters. Room heaters are characterised as being of lower heat output, non-ducted and generally used to heat a single room or open plan area, while whole-of-house heaters have higher heat outputs and use ducting or other systems to distribute their heating throughout the house. Some heaters could span both categories.

Space heating system technologies considered in this product profile include:

- electric resistance (portable and fixed)
- reverse cycle air conditioners (heat pumps) – room, multi-split, ducted
- gas space and decorative appliances
- solid fuel combustion heaters
- gas ducted
- hydronic and boiler central systems
- in-slab central heating.

Outdoor heaters, and heaters primarily designed for use in commercial or industrial settings, are not included in this profile. It is recognised that some heaters are used in both residential and commercial settings, but the focus of this product profile is on heaters suitable for the residential market and their use in residential dwellings.

Some of the product characteristics by which space heaters vary include:

- the product type, which is strongly related to the heater technology
- energy or fuel used
- the space (room or whole-of-house) they will heat
- typical efficiency, and efficiency range.

Space heater types also vary on whether they are covered by the GEMS legislation.

This section presents a summary of the main characteristics of the different residential space heater product types in Table 1 and then describes the characteristics of the product types in more detail.

Table 1: Space heater product characteristics

Product type	Subtypes	Fuel	Space heated	Technology	End-Use Efficiency	Typical sizing range	Energy Efficiency Regulation
Reverse cycle air conditioners (heat pumps) - room	split systems, multi-splits, unitary (window/wall) portable	electricity	space/room, or multiple rooms	reverse cycle heat pump	from 250%-660%, but depends on climate zone & output capacity	2kW to 14kW	GEMS legislation sets MEPS and labelling requirements (where applicable)
Reverse cycle air conditioners (heat pumps) - ducted	split systems	electricity	whole of house	reverse cycle heat pump and distribution of heated air	from 250%-570%, plus ductwork losses, but depends on climate zone & output capacity	8 kW to 30 kW	GEMS legislation sets MEPS and labelling (optional) requirements (where applicable)
Electric resistance	radiant, fan convection, convection, combined convector/ radiant, underfloor	electricity	space/room	resistance element	close to 100%	portable: 2.4kW maximum , fixed: 4.8kW maximum	Nil
Gas ducted		natural gas, LPG	whole of house	gas combustion and distribution of heated air	from 67% to 90%, not including losses from ductwork	15kW to 35kW	In Australian States, gas certification requirements impose minimum thermal efficiency and gas energy labelling requirements
Gas space	radiant, convector, combined convector/ radiant	natural gas, LPG	space/room	gas combustion Can be flued or un-flued.	from 61% to 90%	typically 3 kW up to about 9 kW	In Australian states, gas certification requirements impose minimum thermal efficiency and gas energy labelling requirements

Product type	Subtypes	Fuel	Space heated	Technology	End-Use Efficiency	Typical sizing range	Energy Efficiency Regulation
Gas decorative		natural gas, LPG	NA, as does not supply heat	gas combustion Can be flued or unflued	from 5% to 20%	NA	Nil
Solid fuel combustion heaters	wood burner, pellet burner	Wood, wood pellets	space/room	solid fuel combustion	from 60 to 90%	8 kW to 25 kW	State product safety compliance set minimum efficiency (60%) and marking requirements
Hydronic/ boiler central systems		natural gas , LPG, electricity, solar	whole of house	typically gas combustion or solid fuel and heater water distribution	75 to 90% for gas, plus distribution losses	typically greater than 15kW	Nil
In-slab central heating		electricity, natural gas	whole of house	electric wires or gas/solid fuel boiler	close to 100% for electric, not including losses from edge of slab	greater than 15kW	Nil

Product characteristics - Room heaters

Electric resistance (portable and fixed)

Electric resistance heaters operate by the resistance in their heating elements causing electrical energy to be converted to heat energy, which is disbursed as either radiant heat or convection heat, i.e. warmed air, or a combination of both.

Characteristics of residential resistance heaters:

- are electrically operated
- use a resistance element to convert electrical energy to heat
- generally, are sized to heat a single room with a heat output of up to 2.4 kW, though large fixed systems can operate at up to 4.8 kW
- are not regulated for energy rating labelling or MEPS.

Most electric resistance heaters are portable types, which are used to heat a person, small area or room. They are typically inexpensive to buy but the most expensive type to run, as they use day-rate or general electricity tariffs. Electric resistance heaters are generally grouped as follows:

- Radiant heaters, such as bar heaters, provide almost instant heat direct to occupants and do not directly heat air. They generally include simple heat output controls but a thermostat is not usually fitted.
- Fan heaters heat the air and provide convective heat. Some have thermostats and most have variable output settings.
- Convection heaters heat the air, which then rises naturally. Some have thermostats and/or timers, and most have variable output settings.
- Combined convector/radiant heaters may be larger than fan convector units (but may have a small fan to increase heat output). They have a large surface that becomes hot and radiates heat, as well as slots to allow heated air to rise into the room. Oil filled column heaters and panel heaters are an example of this type of portable heater. Some have thermostats and most have variable output settings.
- Underfloor heating consists of an electric resistance system laid under a floor covering. Underfloor heating is typically used for supplementary heating for small floor areas, e.g. under tiles in bathrooms.

Fixed electric heaters are often wall mounted, and usually are convector or combined convector/radiant heaters that are plugged into an electric outlet. They can be sized over the maximum 2.4kW input limit of portable electric resistance heaters, since they can be directly wired to the electric switch board. Once popular but now increasingly uncommon are electric off-peak storage ('night store') heaters, that store energy in a thermal mass (bricks) during off-peak times and release this energy mainly during the desired heating times. They are operated on the cheaper off-peak electricity tariff.

Figure 1: Examples of electric resistance heaters

 Electric radiant heater	 Electric fan heater
 Electric convector heater	 Electric convector/ radiant heater

Source: www.goldair.co.nz

Reverse cycle air conditioners (heat pumps) - room

Air conditioners that function as heaters are generally referred to as reverse cycle air conditioners in Australia or heat pumps in New Zealand.

Characteristics of residential room reverse cycle air conditioners, when being used for heating:

- are electrically operated

- use a vapour compression refrigerant cycle to remove heat from the external environment and transfer it to the internal environment, i.e. inside the room or dwelling
- generally, are sized to heat a single room with a heat output of 2 – 9 kW, though large systems up to 14 kW are available and could be used to heat large open areas or a small dwelling. Smaller systems operate on single-phase electricity, but the larger capacity units may require a three-phase electricity supply
- are regulated under E3/GEMS with most common types required to have the Zoned Energy Rating Label (ZERL) and MEPS.

For residential room reverse cycle air conditioners, the ZERL specifies their star rating, linked to the seasonal energy efficiency ratio, in three different climate zones: cold, average, and hot. In general, the ratings of the air conditioners are lowest in the cold zone and highest in the hot zone. The labelling scheme is undergoing a transition from the old-format label to the new ZERL (required for all new models registered after April 2020), and for several years both the old- and new-format label may appear on products in stores.

The main categories of non-ducted air conditioners are described below:

Split system (non-ducted): These are the most common type of residential air conditioners (see Figure 2). These products have an outdoor unit that houses the compressor and condenser, and an indoor unit that is commonly mounted on a wall (or on the floor). Most split-systems now sold are invertor type and have a variable speed compressor motor – these tend to be more efficient over a heating season than the older air conditioners which had a simple on/off compressor. They can range in size to suit a small bedroom, to much larger products that could suit large open plan living areas. Most split air conditioner systems are reverse cycle so they can provide heating in addition to cooling.

Figure 2: Example non-ducted split air conditioner

Source: www.applianceplus.co.nz

Multi-split systems: A variation of split systems are multi-split systems, which consist of multiple indoor units connected to a single outdoor unit. These can allow for heating/cooling several rooms and for different temperatures in different rooms. Not all indoor units need to be operated at once. Potentially multi-split air conditioners could provide whole-of-house heating for a small house, but in practice their use for this purpose is uncommon. Larger houses generally require a number of multi-split systems to be installed to get coverage of the whole home.

Multi split systems are not permitted to have ZERLs but are required to have an energy rating based on a representative configuration of the system.

Window/wall units: These products contain all parts in a single unit (rather than having a separate outdoor and indoor unit). They are installed either through windows or can be mounted into walls (where the back of the unit will be outdoors, see Figure 3). They are typically less efficient as they use the single speed compressor, but cheaper to purchase and install than split systems and are suitable for cooling or heating single rooms.

Figure 3: Example window/wall air conditioner

Source: www.strategiesonline.net/home-office-air-conditioning

Portable products: Portable reverse cycle air conditioners are rarely capable of or used for heating, so they will not be analysed in this report.

Gas space heaters

From a consumer's perspective there is a wide range of gas space heaters, as they can be either radiant or convection, permanent or portable (flueless models only), flued or flueless heaters. They can also be freestanding, fireplace inserts or inbuilt, wall or panel heaters, or gas imitation log fire heaters.

The common characteristics of residential non-ducted gas heaters:

- use natural gas or LPG as an energy source[1]
- generally, are sized to heat a single room with a typical heat output of up to 32 MJ/hour for a flued heater
- are not regulated under E3/GEMS, but in Australia the gas certification scheme requires them to display a gas energy label which allows for comparisons among gas room heaters; decorative gas heaters are not required to be labelled.

[1] Potentially hydrogen gas could become a substitute in the future. In the medium term its most likely effect on gas heating would be for reticulated natural gas to contain a small proportion of hydrogen. In that case, the greenhouse gas emissions associated with gas heater use could be reduced.

Gas space heaters are defined in *AS/NZS 5263.1.3 Gas Appliances Gas space heating appliances* as:

> 'gas space heating appliances (convectors, radiant convectors, wall furnaces) which use natural gas, town gas, liquefied petroleum gas (LPG) and tempered liquefied petroleum gas (TLP) with an energy input not exceeding 50 MJ/hr for direct fired air heaters and 150 MJ/h for other appliances'.

The Standard defines several space heater types, including:

- convection heater - an appliance with an effective output of heated air and no visible source of radiation
- radiant convection heater - an appliance with an effective output of both radiation and heated air
- radiant heater - an appliance with an effective output mainly in the form of radiation.

Gas space heaters are typically used as the primary form of heating for a room or part of a house, such as the main living areas.

Gas space heaters are composed of the gas burner(s), an ignition system, thermostat or input control settings, flame safety guard device, and some units also include a heat exchanger, combustion and air circulation fan(s) and flue(s). They vary greatly in design and appearance.

Gas heaters can be flueless, open flued or have balanced flues. A flueless heater (e.g. a portable LPG heater) uses the air surrounding it for combustion of the gas and releases its exhaust gases into its surroundings. This means if a flueless heater is used inside, sufficient ventilation must be maintained to let exhaust gases and moisture escape. Some jurisdictions have banned or restricted the use of flueless heaters due to safety concerns. In recent years there have also been safety concerns related to open flue gas heaters. In some circumstances where these are used in conjunction with exhaust fans, the fans can create a negative pressure that causes the combustion gases to be expelled into the room. [2] Both flueless gas heaters and open-flue gas heaters must be used in conjunction with sufficient fixed ventilation to ensure safe operation.

An open-flued heater also uses the air surrounding it for combustion of gas for heating, which results in air being drawn in from outside the room being heated, and has an exhaust flue that allows exhaust to be vented outside. A balanced flued heater has both a flue for the exhaust gases to be vented outside and a second flue that draws air in from outside for the combustion of the gas.

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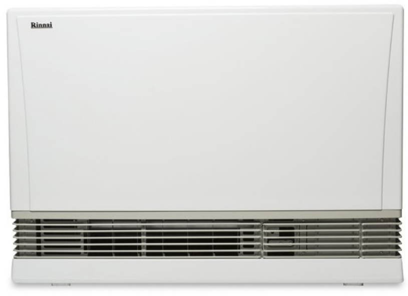
[2] Refer to Energy Safe Victoria information on flueless and open flued gas heaters at the Energy Safe Victoria web page on gas safety at home - heating your home with gas - flues and ventilation.

Figure 4: Example gas convection heater



Source: rinnai.co.nz

Gas decorative appliances

Gas decorative appliances are fireplace or log fire style gas burning appliances, which generally look like gas space heaters, but are not certified as gas space heaters. Consumers looking for a fireplace or log fire style gas heater may be unsure of the difference between these decorative appliances and certified gas space heaters of a similar appearance, nor the difference in the relative efficiency of these type of products on the market.

Some gas fireplace or log fire style 'heaters' available on the market are certified and meet *AS/NZS 5263.1.3 Gas space heating appliances* definition and minimum efficiency standards of gas space heaters. Other gas fireplace or log fire style appliances on the market are instead certified under *AS/NZS 5263.1.8 Gas Appliances Decorative effect gas appliances*. The AS/NZS 5263.1.3 certified gas space heaters can heat rooms much more effectively than the AS/NZS 5263.1.8 certified gas decorative appliances, which are not intended for heating applications. Certified gas space heaters display a gas energy label, but the decorative appliances do not. The consumer may be unsure of the relative suitability of these two different classes of appliances for heating a room or space.

AS/NZS 5263.1.8 Gas Appliance Decorative effect gas appliances, focuses on appliances designed with the prime purpose to have a decorative effect with gas consumption not exceeding 72 MJ/h. Two types of appliances covered are defined:

- Type 1: A decorative effect gas appliance without an enclosure and designed to be installed in an existing fireplace with a chimney that vents the flue gases outside the building; or
- Type 2: A decorative effect gas appliance with an enclosure for connection to a flue that vents the flue gases outside the building.

Characteristics of residential decorative gas appliances:

- use natural gas or LPG as an energy source
- operate by burning natural gas or LPG
- have gas consumption of 20 – 60 MJ/hour
- are not regulated under E3/GEMS or able to display a gas energy label.

Some gas space heaters certified under AS/NZS 5263.1.3, and gas decorative appliances certified under AS/NZS 5263.1.8, are commonly described by suppliers as a 'decorative' heater or appliance. Common descriptions used for both product types in their names and marketing include 'decorative log effect', 'log effect' or 'decorative effect' space heater. Over 70 per cent of the models certified in Australia as flued radiant/convection heaters use the term 'decorative' or 'log effect' in their model description.

The similarity in the appearance and descriptions of these product types means that it can be unclear which standard a particular model would be classified under and the consumer may be unsure which models are suitable for space heating.

Gas decorative appliances that are certified to comply with AS/NZS 5263.1.8 (i.e. decorative standard), as distinct from AS/NZS 5263.1.3 (i.e. space heater standard-compliant models that are marketed as 'decorative'), are required to be clearly labelled 'primarily a decorative and not a heating appliance'. Appropriate labelling of all gas space heaters and gas decorative appliances is essential if consumers are to easily determine the relative suitability of these two different classes of appliances for heating a room or space.

Gas decorative appliances, like space heaters, are composed principally of an ignition system, thermostat, flame safety guard device, and gas burners (i.e. jets), plus fans and flues as required. The design focuses on displaying the flames and flame effects, usually by having part of the fire box or surround made of glass. They can vary greatly in design and appearance and relative heat output.

Figure 5: Example gas decorative appliance

Source: www.escea.com

Solid fuel combustion heaters

The term solid fuel combustion heaters comprise a range of different heater types and fuel types. The main fuel types are:

- wood heaters
- multifuel burners
- pellet burners.

The most common of these heaters are wood heaters, which generally consist of a single enclosed combustion chamber made of steel or cast iron in which firewood logs are burnt.

A small number of wood pellet burners are sold in New Zealand and Australia. Multi-fuel burners are sold in even smaller numbers in New Zealand and provide the ability to burn both wood and coal.

Characteristics of solid fuel heaters:

- use wood, wood pellets or occasionally coal
- operate by burning solid fuels
- produce air pollutants, including particulate emissions (PM10 and PM2.5), which can have negative environmental and health impacts on the community
- generally, are sized to heat a large room(s) and have a typical heat output of 8 to 25 kW (28 – 90 MJ/hr)
- are not regulated under E3/GEMS, though they are regulated under the safety and emission/environmental requirements of different jurisdictions.

An important constraint affecting solid fuel heaters is that they are designed to meet dual standards of maximum allowable particulate emissions and minimum efficiency levels. The method for determining solid fuel heaters' power output and efficiency is described in AS/NZS 4012:2014. Minimum efficiency levels are included in the standard and are 60 per cent for Australia and 65 per cent for NZ. The method for determining flue gas emissions and particulate emissions is described in AS/NZS 4013:2014. In both Australia and New Zealand, the maximum particulate emissions is 1.5g/kg of fuel burnt. This is specified in individual state legislation in Australia and in NZ's National Environmental Standards for Air Quality. As neither minimising particulate emissions nor maximising energy efficiency in solid fuel heater design can be achieved without compromising the other goal, this has resulted in heater designs involving a trade-off between these dual standards.

In Australia, solid fuel heaters certified to AS/NZS 4012 are required to carry a marking identifying their overall average efficiency and maximum average heat output. Australian state and territories regulate the compliance of solid fuel heater installations.

Older style wood heaters had a wide range of control over combustion air and allowed burners to be "turned down" using the air control lever to effectively smoulder overnight and then be easily restarted the next morning. Newer models have considerably less scope to control the air flow and thus the rate of combustion. In some cases, particularly with the latest ultra-low emission burners (ULEBs) available in New Zealand, there is no air control. This reduced level of air control is a design response to achieving ever-stricter allowable particulate emissions levels in Australia and New Zealand.

Because less information has been published previously by E3 on these types of heaters, further research is provided in Appendix 1 – Detailed Information on Solid Fuel .

Pictures of a range of solid fuel heaters are shown in Figure 6.

Figure 6: Examples of wood heaters and pellet burner

Conventional low emission burner showing air control lever at the top left and handle to open door for refuelling on right side.

Source: www.woodsman.co.nz

Twin chamber ultra-low emission burner (ULEB)

Source: www.tropicair.co.nz

Pellet burner

Source: www.eenergy.co.nz

Product characteristics - Whole-of-house heating

Reverse cycle air conditioners - ducted

Ducted products can provide heating (and cooling) for an entire home, delivering warm (and cool) air via ducts positioned in various rooms (see Figure 7). These systems can usually be zoned so that only certain areas are being conditioned, for instance only living areas during waking hours. The extent to which zoning is possible depends on the design of the system, the layout of the home and the location of the return air grille.

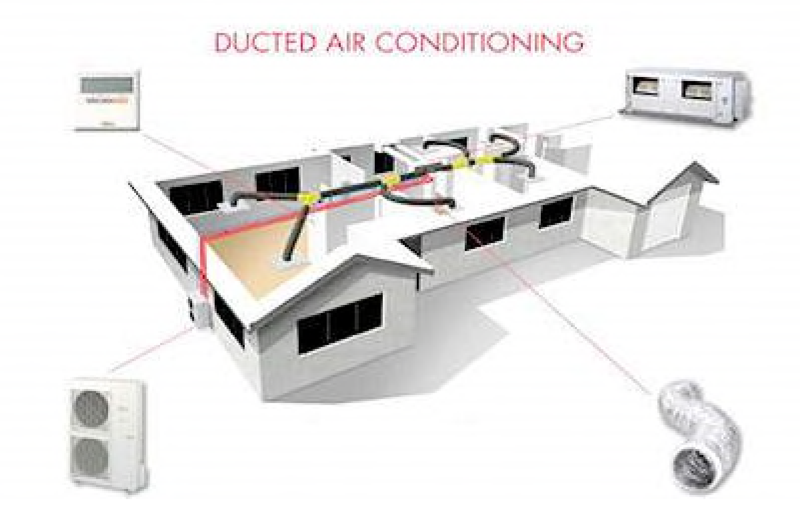
Characteristics of residential ducted reverse cycle air conditioners, when being used for heating:

- are electrically operated
- use a vapour compression refrigerant cycle to remove heat from the external environment and transfer it to the internal environment, i.e. inside the dwelling
- generally, are sized to heat most of an entire dwelling and average around 15 kW heat output
- are regulated under E3/GEMS for MEPS and may voluntarily display the Zoned Energy Rating Label (ZERL).

While ducted reverse cycle air conditioners can voluntarily carry the ZERL, their energy rating data must be measured and published on the energy rating website. As with room reverse cycle air conditioners, the systems are rated in cold, average and hot climate zones, with the systems generally having their best performance in the hot zone. The efficiency of the larger capacity units tends to be lower than the smaller capacity units.

The above characteristics are similar to those for non-ducted reverse cycle air conditioners. Ducted air conditioners differ based on their use of ducting to distribute heat to multiple rooms (which results in energy losses via the ductwork), and their size (they generally have twice the heat output of non-ducted air conditioners).

Figure 7: Example of ducted air conditioner



Source: www.fujitsugeneral.com.au

Gas ducted heaters

Gas ducted heaters (GDH) are often called 'central heating systems' because they can be used to heat a whole house, rather than 'space heaters', which are used to heat an area or single room.

Characteristics of ducted gas heaters:

- operate by burning natural gas or LPG
- use electricity to power the combustion air and air circulation fan, and controls. Typically the electricity consumption can be around 1.5 to 4.5% of the gas consumption (lowest for the least efficient systems and highest for highest efficiency ones), and in colder climates this can result in annual electricity consumption similar to a new family-sized fridge (Sustainability Victoria, 2015)
- generally, are sized to heat most of a dwelling, with a typical heat output 15 to 30 kW or 55 to 108 MJ/hour
- are not regulated under E3/GEMS, but display a gas energy label as part of state and territory certification requirements in Australia, which allows for comparisons between comparable gas ducted heaters.

The gas energy label for ducted gas heaters is based on a 1 to 6 star rating scale, with the first five stars based on the seasonal efficiency of the gas furnace, the useful heat output divided by the sum of the gas and electricity consumption. Up to one additional star is based on the heat load factor (HLF), a measure of the zoning ability of the system. The use of the HLF complicates comparisons of the thermal efficiency of the systems, because the HLF is not published. The scheme is further complicated by some manufacturers claiming star ratings between 6 to 7 stars, even though these are not officially recognised by the certification standards.

Air is heated by a gas furnace and the warm air (generally heated to 50° or 70°C) is blown through insulated flexible ducts to be discharged through air outlets (supply air registers) into nominated rooms. Colder air is drawn back to the return air grille where it may pass through a filter to collect dust before being returned to the gas furnace and reheated. There are some energy losses in the ductwork. A central heating system can be installed to heat either the whole house, part of a house or several selected zones using motorised dampers. The extent to which zoning is possible depends on the design of the system, the layout of the home and the location of the return air grille.

The main types of gas furnace used in gas ducted heating systems are as follows and are illustrated in Figure 8:

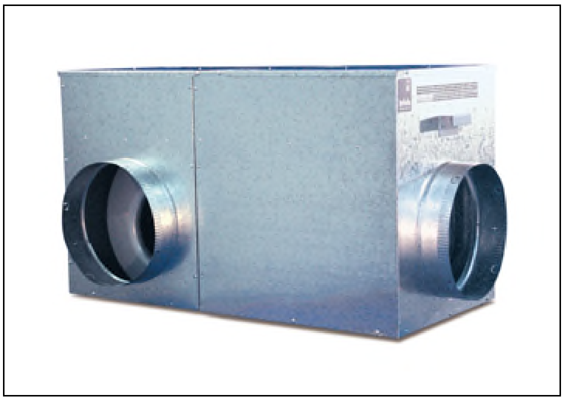
- indoor only units commonly referred to as internal heaters, which are generally installed in the roof space
- outdoor only units that have weatherproof enclosures suitable for locating outdoors, commonly referred to by industry as 'external unit's or 'external heaters'
- multipurpose heaters with enclosures suitable for installation indoors or outdoors.

The main components found in the gas furnace for a gas ducted heater:

- cabinet, insulated with aluminium foil and insulation material
- gas control valves and burners (single stage, dual stage for high and low fire and variable control)
- heat exchanger (primary and possibly a secondary condensing heat exchanger)[3]
- main air circulation fan
- spark ignition or solid-state spark ignition[4] (early models had pilot lights[5] and though some are still in service, they are no longer available for sale)
- control board—to control temperatures, gas, air purge and the main blower—with inputs for add-on air conditioning[6], and accessories such as humidifier, zoning and electrostatic air filters.

Figure 8 shows images of typical internal and external GDH units.

Figure 8: Internal and external GDH



Internal GDH

External GDH

Source: northshoreairconditioning.com.au

In-slab electric

In-slab electric systems are suited to whole house heating and consist of electric wires that are laid either in a concrete slab or in the concrete topping to a slab and provide heating to living spaces. In-slab heating systems do not include electric systems laid over a slab (under tiles or carpet) which have been previously mentioned and are a type of electric resistance heater. In-slab systems provide a combination of radiant, convective and conductive heat. They are slow to warm and cool due to the high thermal mass of the slab, and are best suited to cold climates that require 24/7 heating throughout the heating

[3] The heat exchange consists of the gas burner and a series of tubes through which the hot, burnt gas passes. Air is blown over the outside of these tubes and the heat is transferred to the air, which can then be used for heating.
[4] A spark igniter directly ignites the gas burners.
[5] In older systems a pilot light is a small jet of gas that is kept burning in order to ignite the main burners when heat is required. In more modern systems the pilot light is ignited by a spark igniter when a call is made for heat and then the main burners are then ignited from the pilot flame.
[6] Add-on air conditioning is the addition of a ducted refrigerated air conditioning unit to a gas ducted heating system and uses the existing ducting to provide cooling.

season. There are heat losses from the edge of the concrete slab, and these can be reduced to some extent with the use of edge-of-slab insulation.

Characteristics of electric in-slab heaters:

- use electricity as an energy source
- use a resistance element to convert electrical energy to heat; or gas boiler or electric heat pump to heat water
- generally are sized to heat most of a house, with a typical heat output of greater than 20 kW. They can often be zoned to some extent.
- are not regulated for energy rating labelling or MEPS.

Electric in-slab systems are connected to special or off-peak electric tariffs which only enable operation during these times and use the thermal mass of the slab to heat over the non-operational times.

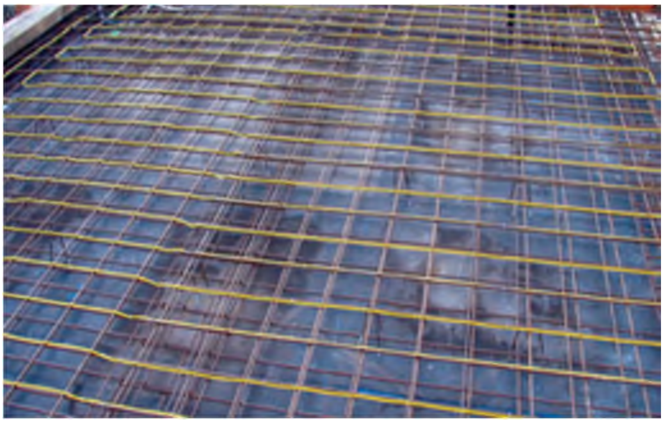
Hydronic

Hydronic systems are also suited to whole house heating. They can be in-slab systems, consisting of pipes carrying hot water that are laid either in a concrete slab or in the concrete topping. Alternatively, hydronic systems may circulate hot water through radiator panels in rooms, supplying a mix of conductive, convective and radiant heat. Hydronic heating systems commonly use a gas furnace to heat the water, or a heat pump, but they can also be heated by a wood-fired heater or solar system.

Characteristics of hydronic heaters:

- generally use electricity or gas as the main energy source, though can use solid fuels
- use electricity to pump the water around the hydronic system
- typically are sized to heat most of a house, with a heat output of greater than 20 kW. They can often be zoned to some extent.
- are not regulated for energy rating labelling or MEPS.

Figure 9: Pictures of in-slab heating



Source: www.comfortheat.com.au

Market Characteristics and Heater Purchasing

Market characteristics and heater purchasing: Summary

Market: The heater market is shaped by consumer preferences and choices regarding heating. Consumer heater choices are influenced by dwelling characteristics, location, climate, fuel availability, perceptions of comfort, and heater up-front and operating costs. Whether the consumer is a tenant or homeowner also influences purchasing decisions.

The type of fuels typically used for heating differs between localities. In Australia the main heater uses electricity in 40 per cent of households, gas in 30 per cent and wood in 7 per cent). These figures vary significantly between states, with gas the main source in Victoria and ACT.

In New Zealand the proportions of households using the three main fuels for heating are electricity (75 per cent), wood (34 per cent) and gas (18 per cent). Most homes use more than one heating fuel, as this data shows.

In both the Australian and New Zealand markets most of the existing heating stock are either electric resistance heaters (main and secondary heaters), and reverse cycle air conditioners. Likewise, sales are dominated by electric resistance heaters and reverse cycle air conditioners.

Reverse cycle air conditioners are forecast to form an increasing share of the heater stock, driven by their rising sales numbers (EnergyConsult, 2015). In 2021, most heaters in Australia are forecast to be air conditioners; while in New Zealand air conditioners could form 40 per cent of the main heaters (i.e. non-secondary heaters). The forecasts also show that the number of electric resistance heaters (main and secondary) in the heater markets of both Australia and New Zealand is expected to slowly decline as electric resistance heaters used as the main form of heating are slowly replaced by reverse cycle air conditioners.

The trends for solid fuel burners and gas heaters show no or minimal growth in sales. Their total numbers and share of the heating stock is expected to continue to decline in both the Australian and New Zealand markets.

Heater Purchase: Heater purchasing can be considered to be a four-stage process. Research has shown that consumers consider many factors when choosing a heater, but energy efficiency is an important factor considered by many consumers. The research also indicates that choosing between heater product types could be the most challenging aspect of the purchase decision, which supports the need for cross-heater type energy efficiency information to be available.

This section discusses the heater market overall and then the factors influencing heater purchasing decisions.

Heater market

The residential space heater market can be segmented and analysed in several ways and the following section looks at the market in terms of heaters by heating fuel type, heater stock and heater sales.

Heating fuels

Australia

There are three main types of fuels, or energy sources, used by Australians to heat their homes: electricity, gas and firewood. The availability of heater fuel affects the composition of heaters in the market. Electricity is available to almost all residential dwellings, but the availability of gas and firewood varies. Reticulated natural gas is available in all states, but its penetration ranges from being supplied to 83 per cent of dwellings in Victoria to only 5 per cent in Tasmania. LPG (bottled gas) is available more widely, but it is more expensive than natural gas. Firewood is available widely, but its cost is higher in metropolitan areas.

Many households will use a mix of heaters, for example with a main heater used in the living area complemented by using smaller or portable heaters as required.

According to 2014 data (ABS, 2014), the proportion of Australian households using the three main heating fuels (for the main type of space heating) were:

- electricity (38 per cent)
- gas (30 per cent)
- wood (10 per cent).

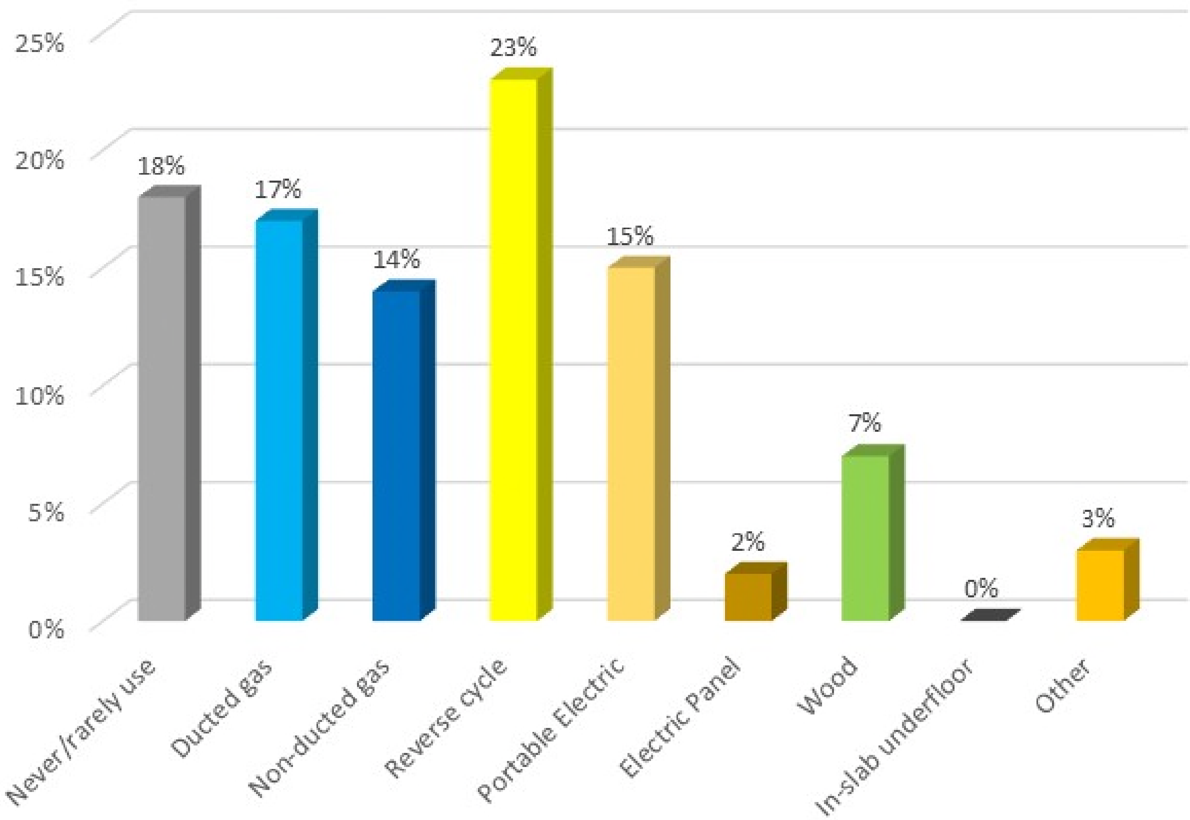
In 2014, approximately one in five households in Australia did not use any heating. This ranged from 1 per cent of households in the Australian Capital Territory to 86 per cent of households in the Northern Territory.

More recent research by BIS Oxford Economics (‘*The Climate Control Market in Australia’,* BIS Oxford Economics, 2020) on the main type of heating used in Australian households found similar energy usage patterns across heater types, but wood use appears to be declining:

- electricity (40 per cent)
- gas (31 per cent)
- wood (7 per cent).

The BIS Oxford Economics study also reports the main heater type used and the findings are presented in Figure 10.

Figure 10: Main heating appliance used - Australia 2020



Source: Obtained from 2020 data (BIS Oxford Economics, 2020), main types of heating used, excluding Tasmania

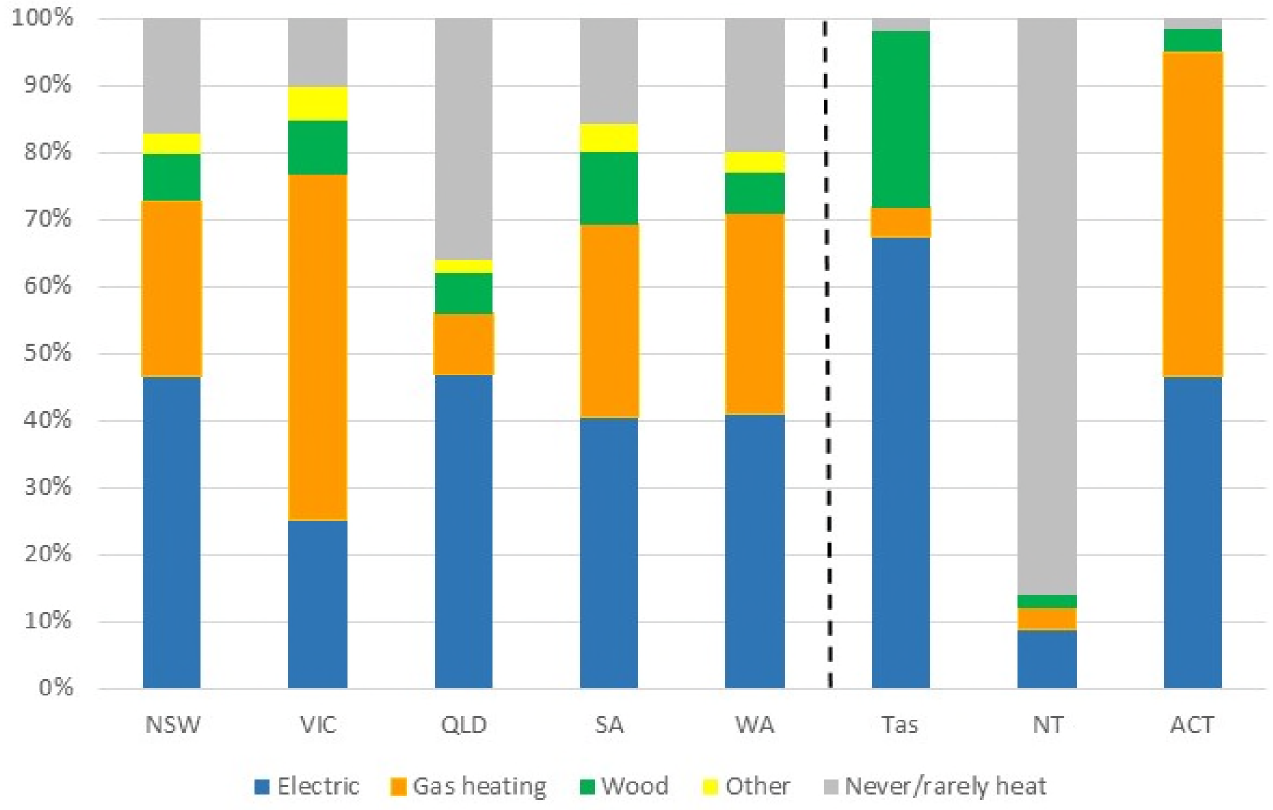
The 2020 BIS Oxford Economics data also shows that nationally, in the households with gas heating, the share of ducted gas heaters is gradually exceeding those of (non-ducted) gas space heaters. However, the shares of ducted versus non-ducted gas heaters vary dramatically between states. In Victoria there are approximately three times the number of ducted gas heaters as gas space heaters, but in Western Australia the situation is reversed, with almost three times the number of gas space heaters compared to ducted gas heaters.

Figure 11, which draws from BIS Oxford Economics 2020 data for the five larger states, and ABS 2014 data for Tasmania and the territories, shows:

- Gas is the dominant form of heating in Victoria (twice that of electricity) and in the ACT (where roughly equal numbers of households use gas and electricity). Gas heaters are an attractive heating choice for the cold climates of these two states and there is also a high penetration of natural gas connections to the home, which makes gas heating a viable choice for many homes.
- Electricity is the dominant form of heating in all the remaining states. This is consistent with them having lower heating demand and/or lacking a high penetration of gas connections.

- Tasmania has the highest penetration of wood heaters in homes, with 26 per cent of households in 2014 using wood as their main heating fuel. Wood heaters are attractive in Tasmania given its cold winters and reliable supply of firewood. It has also lacked the high penetration of natural gas connections, so gas heating has been a more limited option.
- The majority of households in the Northern Territory, and a significant proportion of households in Queensland, rarely or never use heating.

Figure 11: Main source of energy for heating: share by state and territory in 2020/2014



Source: For five large states obtained from 2020 data (BIS Oxford Economics, 2020) and from ABS, 2014, for Tas, NT and ACT.

Figure 11 shows that the main source of energy used for heating varies between states and territories in Australia. Not surprisingly, the variation in the penetration of different types of heaters varies with the availability of the heater fuel and the local climate. Local climate is a factor because this affects heating demand, and different heater types vary in their ability to meet this demand. The suitability of heater types vary as follows:

- Gas heaters are an attractive heating choice in cold climates because they have high heating outputs and have been seen as low cost to operate.
- Wood heaters have also been suitable for cold climates for the same reasons as gas-fired space heaters, and are more prevalent in regional areas due to the greater availability of fuel.

- Electric resistance heaters have been treated as a less attractive heating choice in cold climates because they have been seen as having lower heat outputs and being more costly to operate. This has meant that electric heating has been regarded as a more attractive option in moderate climates with lower heating demand, or for small rooms that are not serviced by the main heater.
- Reverse cycle air conditioners have also been treated as a less attractive heating choice in cold climates, but, because their efficiency has improved and operating costs have fallen, they are increasingly seen as a viable option for both moderate and colder climates.

New Zealand

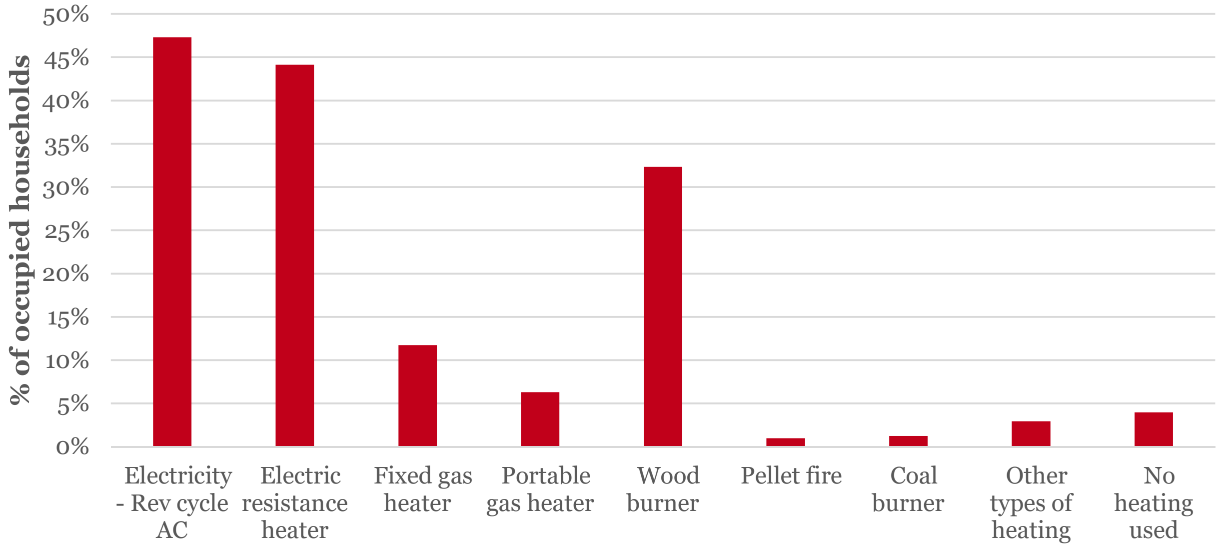
Stats NZ collects census data on fuel types used to heat private dwellings in New Zealand, with the latest available data from the 2018 Census (Stats NZ, 2020). This data indicates that the proportions of New Zealand households using three main fuels were:

- electricity (75 per cent), which consists of 47 per cent of households using reverse cycle air conditioners and 44 per cent using electric resistance heaters, with some households using both forms of heating
- gas (18 per cent), used in fixed heaters (12 per cent) and portable heaters (6 per cent)
- wood (34 per cent).

The NZ census data identifies all fuel types used for heating in occupied dwellings. Since most homes in New Zealand use more than one type of heating fuel, the percentages sum to more than 100 per cent. The data is shown in Figure 12.

Fixed gas heaters include the use of mains (natural) gas, which is only available in the North Island, and LPG in the South Island. The daily fixed charge for reticulated gas can be as high as NZ$1.30 per day. LPG is generally available in the form of bottled gas, although there are a small number of local LPG reticulation networks in the South Island. The limited extent of the reticulated gas network and the high prices of fixed charges or bottled LPG will have been contributing factors in gas heating only being used by a minority of homes (15 per cent).

Figure 12: Sources of heating energy as per cent: NZ



Source: Obtained from 2018 data (Stats NZ, 2020)

The use of electricity as a heating fuel is growing significantly, with 25 per cent more households using electricity for heating in 2013 compared with 2001 (Stats NZ, 2014, refer Figure 13). This change has been driven by the uptake of reverse cycle air conditioners in New Zealand.

In 2000, about 2 per cent of homes used a reverse cycle air conditioner for heating, increasing to 25 per cent of homes in 2013. This increase is the combined result of the replacement of existing heating systems, and the installation of reverse cycle air conditioners in new home construction.

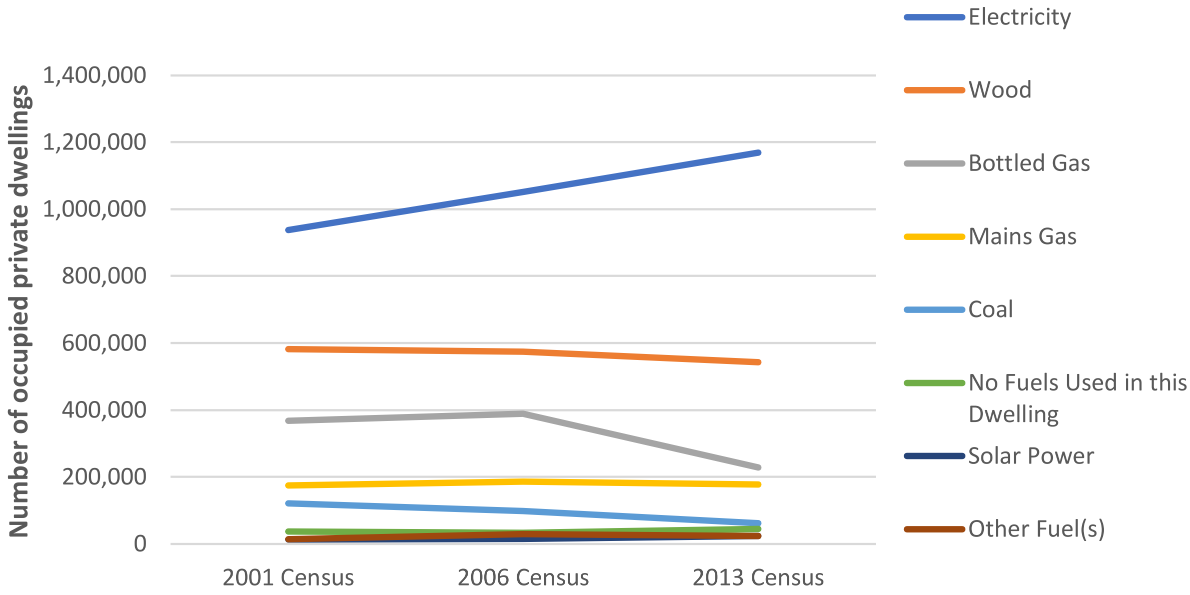
Many new homes are now being fitted with reverse cycle air conditioners as the main form of heating. This trend will have been driven by a number of factors including the perceived convenience, controllability and cleanliness of reverse cycle air conditioners, their improved efficiency and lower operating costs. The improved insulation and weather proofing of housing has also made the use of reverse cycle air conditioners more effective. Also, some local councils in New Zealand have been incentivising the replacement of older wood heaters with clean heating options, such as reverse cycle air conditioners, as part of air quality improvement initiatives; this will have accelerated the uptake of reverse cycle air conditioners.

Coal was used in 121,000 homes in 2001 but its usage has reduced by 84 per cent and it was used in only 18,800 homes in 2018. Coal is more popular in the West Coast and Southland regions of the South Island. These regions are among the last areas in New Zealand producing coal for domestic consumption.

The substantial reduction in the use of coal and, to a lesser extent, the reduction in the use of wood as a fuel, is likely to be attributable to two main factors; namely, a desire for more convenience in home heating and the tightening of regulations in relation to the use of solid fuels in towns and cities where PM_{10} air pollution has been a problem.

Bottled gas has also declined in popularity as an energy source for home heating, possibly owing to its high cost.

Figure 13: Past trends in heating energy source: occupied homes in New Zealand



Source: Obtained from census data (Stats NZ, 2014)[7]

Stock of products

The Residential Energy Baseline Study (RBS) (EnergyConsult, 2015) provides detailed information on the estimated number of products in Australia and New Zealand over the period 2000 to 2014, and projected to 2030, as shown in Figure 14. The study estimated that, in Australia in 2014, residential space heating comprised 17.8 million heaters, divided into:

- 7.0 million electric resistance heaters (approximately 78 per cent of those units are secondary heaters)
- 7.3 million reverse cycle air conditioners
- 1.6 million non-ducted gas space heaters (89 per cent are fuelled by natural (mains) gas with the balance fuelled by LPG)
- 1.2 million mains gas ducted heaters
- 0.7 million solid fuel burners.

[7] The Census question on heating fuels was changed for the 2018 Census so it is not possible to show comparative 2018 data, and therefore more recent trends.

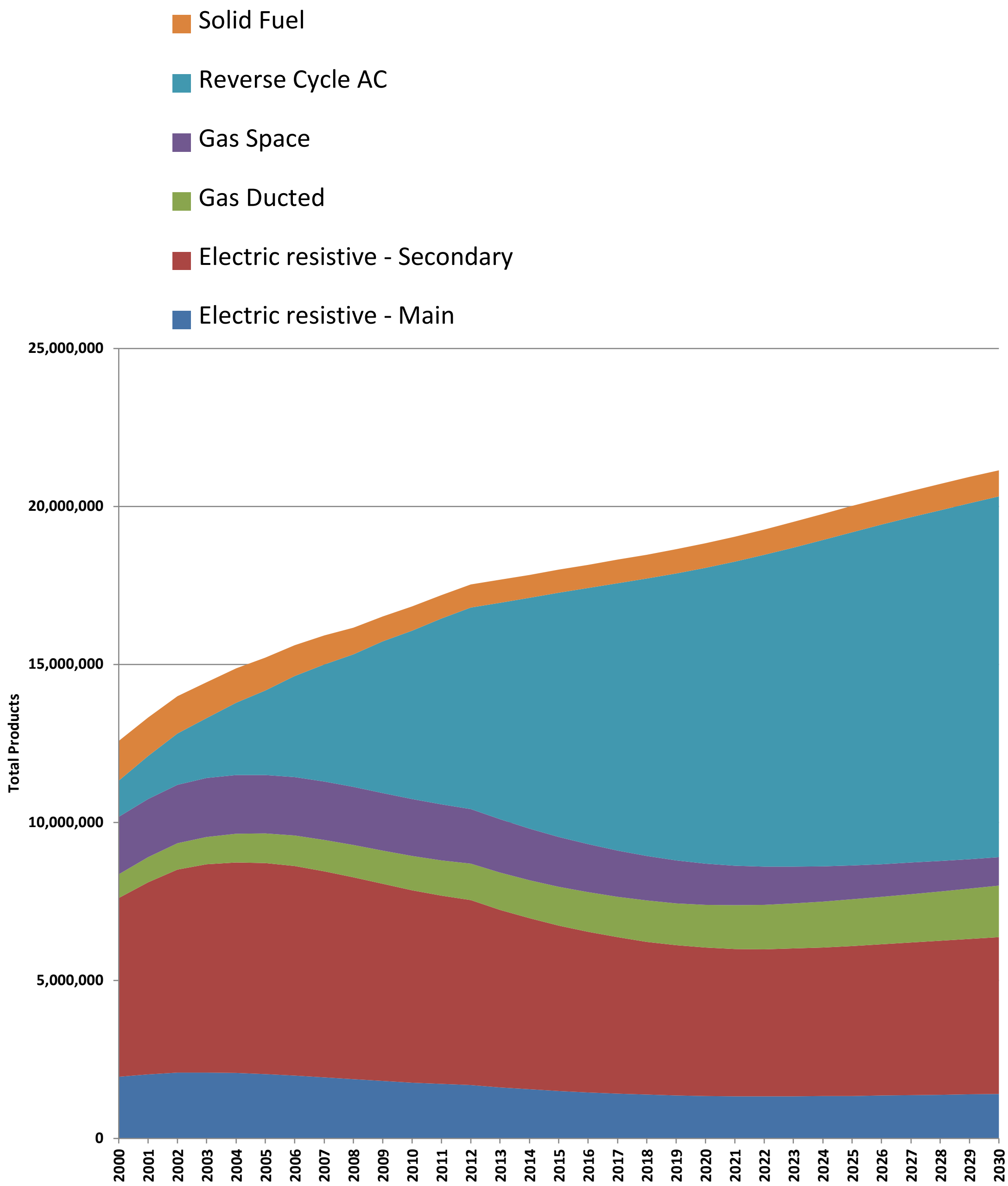
The study indicated that the total residential space heating stock was dominated by reverse cycle air conditioners and electric resistance heaters. These electricity powered heaters—many of which are secondary rather than main heaters—formed 80 per cent of the heater stock. Gas heaters formed 16 per cent of the heater stock.

These percentages differ significantly from the ABS 2014 and BIS Oxford Economics 2020 surveys of main heater used. Those studies indicate a much higher use of gas heating and much lower use of reverse cycle and electric resistance. This is not surprising, because the RBS reports estimated stock of all heaters, with many heaters regarded as secondary heaters (not just the 78 per cent of electric resistance heaters identified but probably many other reverse cycle air conditioners and other heaters as well).

It is appreciated that the RBS outputs are now over five years old. The RBS is currently being updated and more accurate information on stock numbers and trends will not be available until the RBS update is available.

A factor that may drive change in the use and purchase of heaters may be changes to fuel or energy prices. Gas and electricity prices increased significantly in Australia over the period 2014 to 2020. Over the longer term, this factor could affect the composition of stock numbers for Australia, and a decrease in gas heaters might be observed. But any change to the stock shares of fixed gas heaters (gas ducted and room heaters) would be expected to occur slowly. This is because those purchases occur primarily for new housing and for replacing older or failed equipment after many years.

Figure 14: Heater stocks by product group: Australia



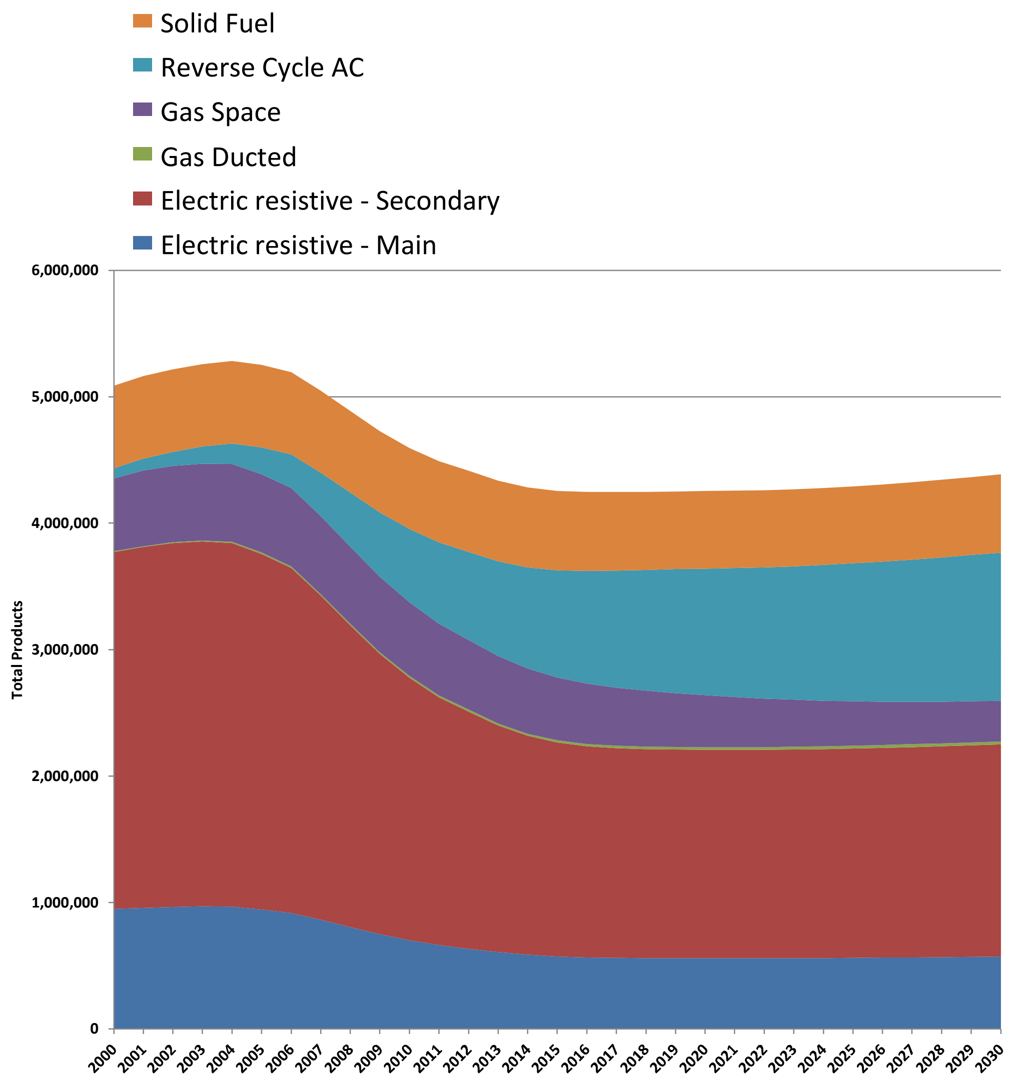
Source: RBS modelling (EnergyConsult, 2015*)*

The RBS study indicated that most main heaters in New Zealand households consisted of electric resistance heaters and reverse cycle air conditioners, as shown in Figure 15. The study estimated that in 2014 residential space heating consisted of 4.3 million heaters, in 1.8 million households, divided into:

- 2.3 million electric resistance heaters, including 570,00 electric resistance heaters (radiant and convective models) used as main heaters and 1.7 million secondary heaters
- 800,000 reverse cycle air conditioners
- 532,000 gas heaters
- 630,000 wood combustion heaters, including those in unoccupied dwellings.

The 2018 New Zealand Census (Stats NZ, 2020) results confirm the trends shown in Figure 15 below; i.e. that the number of reverse cycle air conditioners continues to grow, electric heating grows slightly, gas heater numbers are declining and solid fuel use is steady.

Figure 15: Heater stocks by product group: New Zealand



Source: RBS modelling (EnergyConsult, 2015*)*

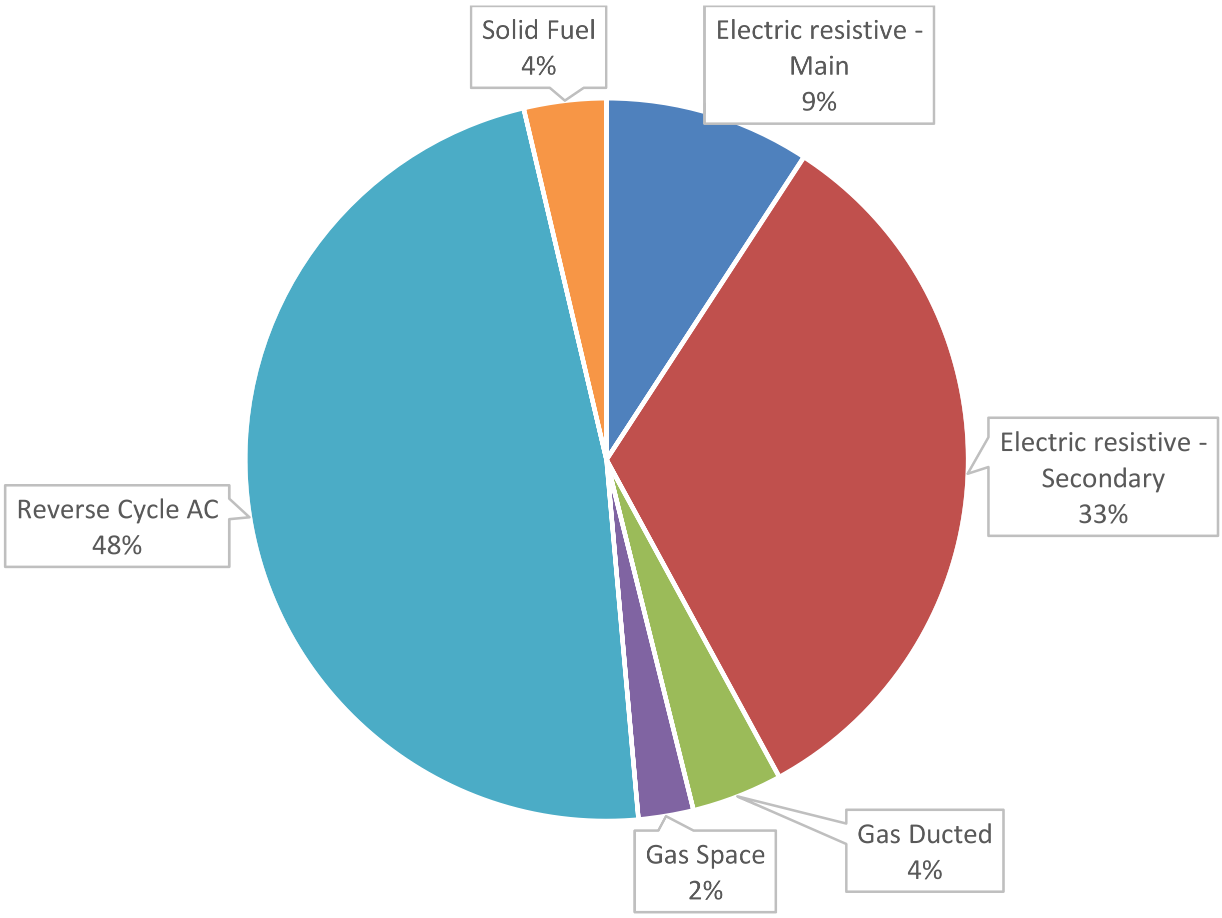
Sales of products

The Residential Energy Baseline Study (RBS) (EnergyConsult, 2015) provides detailed information on the estimated annual sales of products in Australia and New Zealand over the period 2000 to 2014, and projected to 2030.

The sales data for Australia in 2014 shows 1.5 million heaters were sold annually and the share of sales by heater type is shown in the chart below. Almost half of all heaters sold were reverse cycle air conditioners, followed by secondary electric resistance heaters and then main electric heaters. Gas heaters and solid fuel burners together form only 10 per cent of the heater sales.

Figure 16 shows the breakdown of heater sales in 2014 and reveals that most heaters installed were reverse cycle air conditioners.

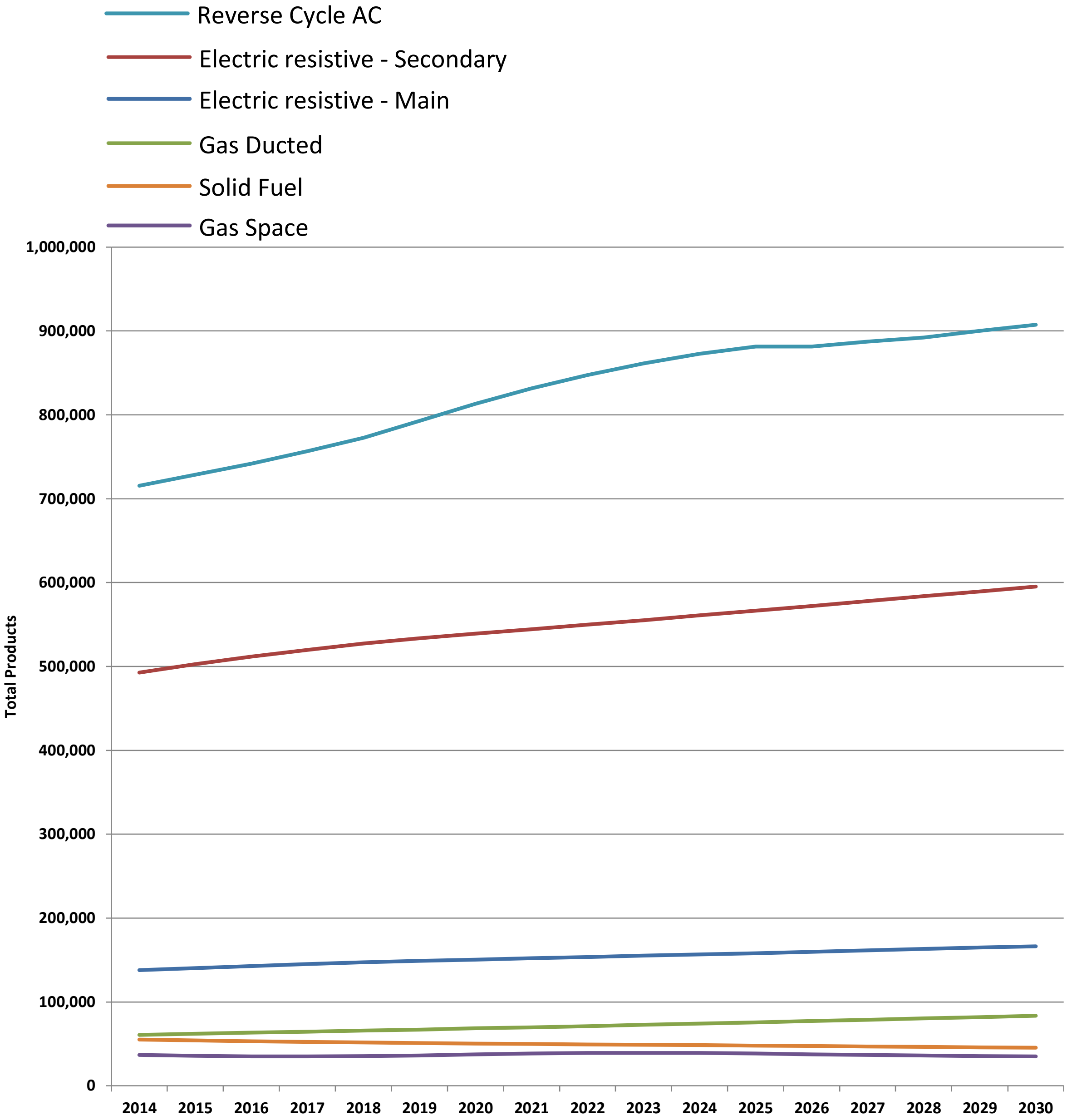
Figure 16: Share of sales by heating type 2014 - Australia



Source: RBS modelling (EnergyConsult, 2015)

The RBS sales projections for Australia are shown in Figure 17 and indicate that sales of reverse cycle air conditioners and of secondary electric resistance heaters are expected to continue to grow strongly. Much slower growth is expected for main electric resistance heaters and ducted gas heaters, while there will be minimal growth in the sales of gas space heaters and solid fuel burners.

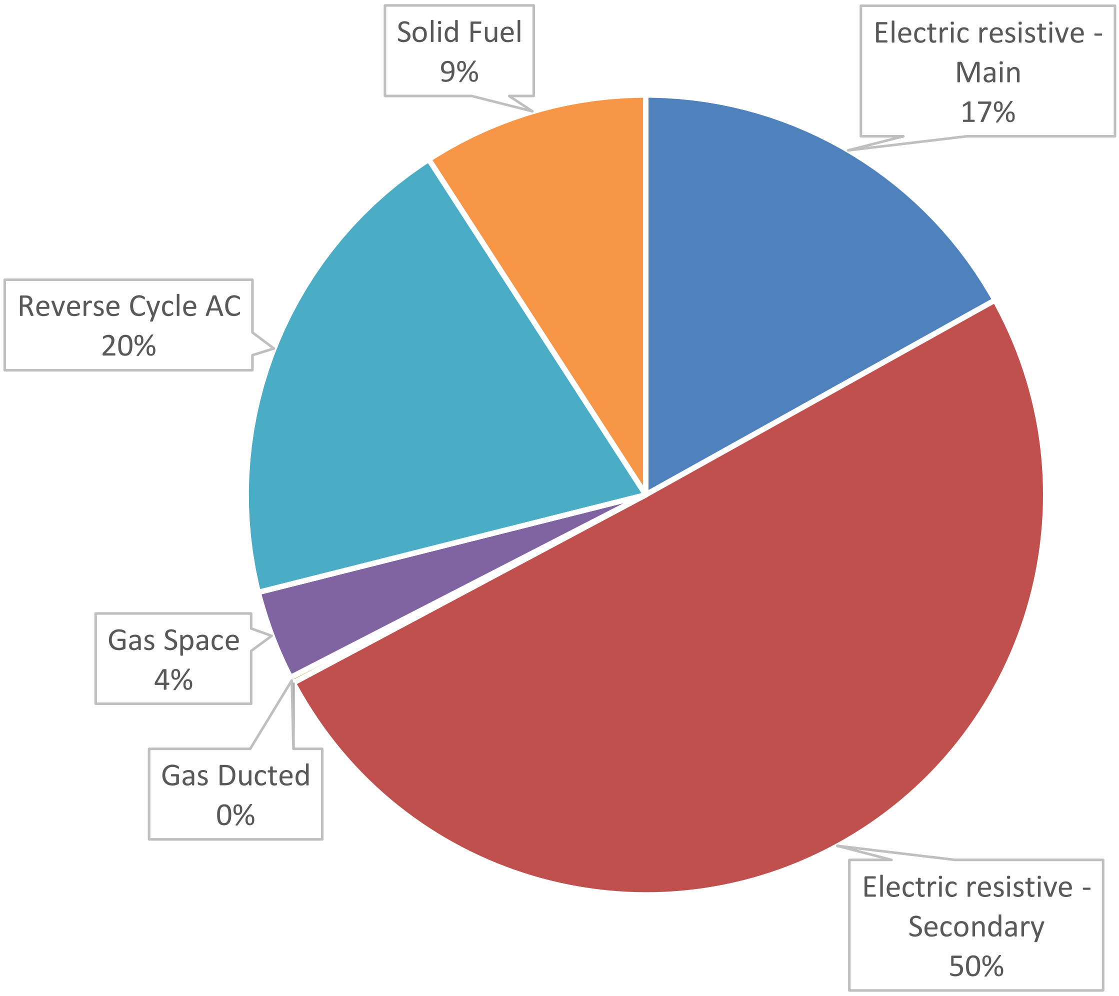
Figure 17: Projected sales by heating type – Australia



Source: RBS modelling (EnergyConsult, 2015)

The sales situation in New Zealand differs, as shown in Figure 18. In 2014, an estimated 375,000 heaters were sold, half of which were secondary electric resistance heaters. Main electric resistance heaters and reverse cycle air conditioners formed most of the remaining sales. Gas heaters and solid fuel burners together form 13 per cent of the heater sales.

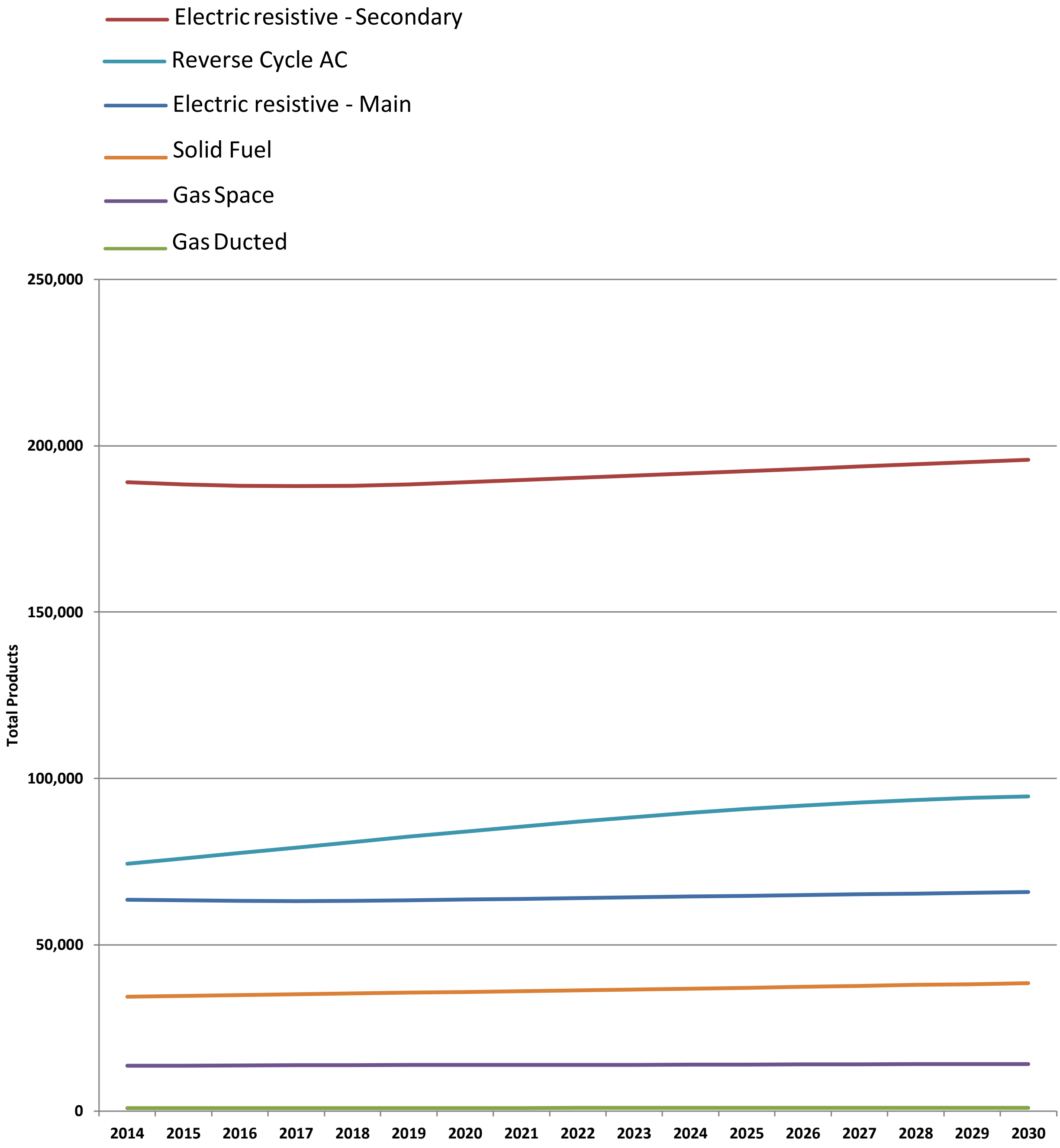
Figure 18: Share of sales by heating type 2014 - New Zealand



Source: RBS modelling (EnergyConsult, 2015)

The RBS sales projections for New Zealand are shown in Figure 19Figure 19 and they indicate that reverse cycle air conditioners are the only heater types whose sales are expected to grow strongly. Minimal growth is expected for secondary electric resistance heaters and solid fuel burners, while almost no growth is forecast for the sales of gas space heaters and main electric resistance heaters.

Figure 19: Projected sales by heating type – New Zealand



Source: RBS modelling (EnergyConsult, 2015*)*

Summary of market characteristics

In both the Australian and New Zealand markets, most of the existing heating stock are either electric resistance heaters, main and secondary, and reverse cycle air conditioners. Likewise, sales are dominated by electric resistance heaters and reverse cycle air conditioners.

Reverse cycle air conditioners will form an increasing share of the heater stock driven by their rising sales numbers. In 2021 most heaters in Australia are expected to be air conditioners, while in New Zealand they will form 40 per cent of the main heaters.

The number of electric resistance heaters, main and secondary, in the heater markets of both Australia and New Zealand is expected to slowly decline as main electric resistance heaters are slowly replaced by reverse cycle air conditioners.

The trends for gas heaters show no or minimal growth in sales, and their share of the heating stock is expected to continue to slowly decline in both the Australian and New Zealand markets.

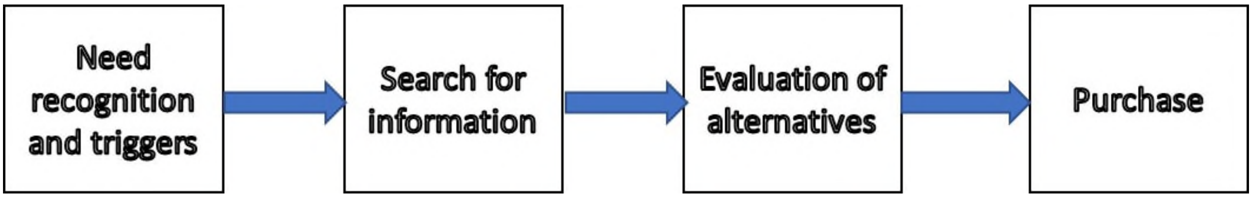
Sales of solid fuel burners are static or declining in Australia, while in New Zealand there is some growth in sales, but this may not continue given increasing concern about and regulation of heater emissions due to their air pollution impacts.

Heater purchase decision making

An appliance purchasing decision can be influenced by the purchasing journey of the consumer and by factors influencing the decision at different points in the process. Understanding the consumer purchasing process may assist in the design of an energy rating label scheme for heaters, and market research was commissioned by the Department of Industry, Science, Energy and Resources to better understand this process.

The market research (Kantar/Colmar Brunton, 2020) indicates that the purchasing journey in Australia can be divided into four stages, as shown in Figure 20. There are several aspects of these purchasing stages that are relevant to how effective heater energy rating labels may be in influencing consumers' choice of energy efficient heaters and the channels to communicate energy rating information to consumers.

Figure 20: Flow chart of typical heater purchase journey

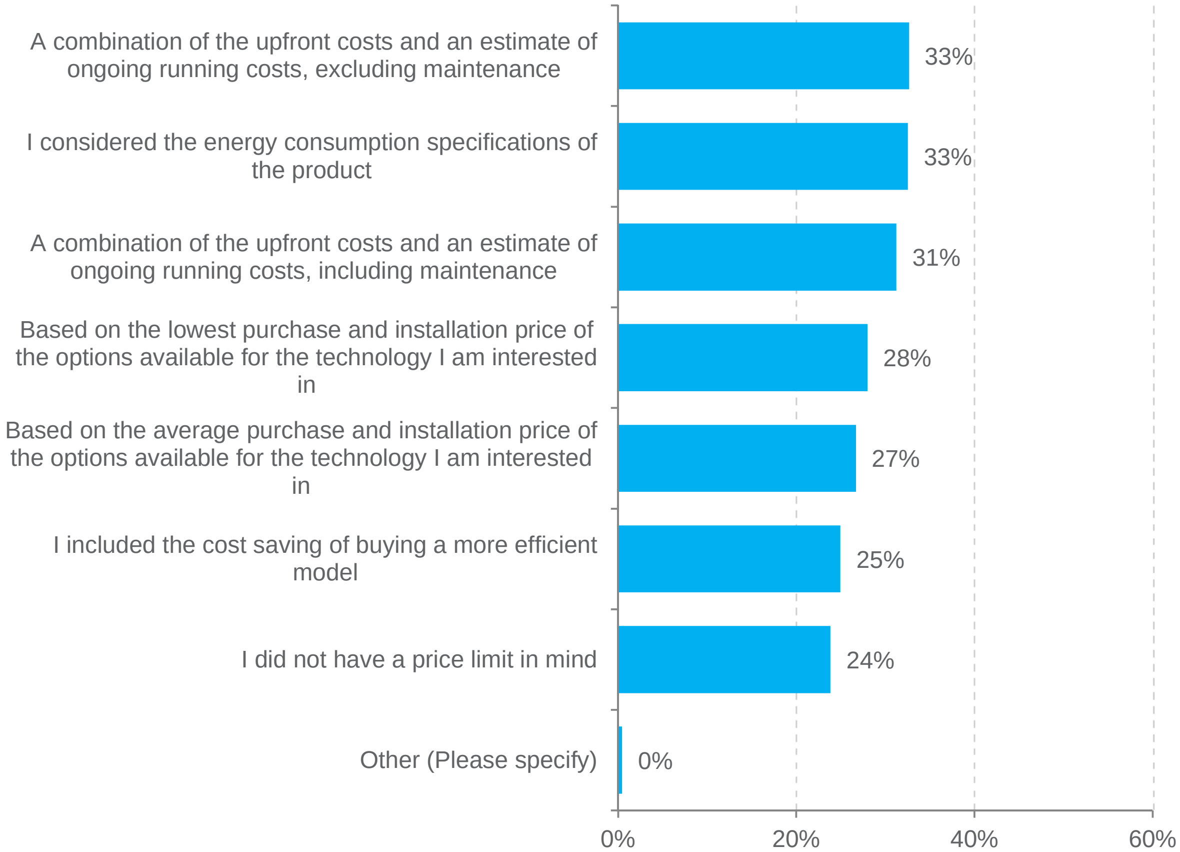


The first stage consists of the need recognition and trigger event. This consists of the trigger event which leads to the consumer deciding they have a need for a new heater. Some elements of this stage which are relevant to a potential energy rating labelling scheme are:

- Trigger event: Consumers begin the purchasing journey when the need for a new heater occurs, which can occur for several reasons e.g. an existing heater fails, the existing heater is providing insufficient heat, the need to reduce the cost of heating, lifestyle changes, moving into a new house or family and household changes. The more urgent the need created by the trigger event, e.g. an existing heater failing (28 per cent of respondents who recently purchased a heater), the less time the consumer will have to clarify their heater needs, search for heater information and to evaluate alternatives. This could affect the influence of an energy rating label scheme.
- Important factors: These are the initial, broad factors that consumers identified as the most important when purchasing their most recent or next space heater. The study identified fourteen common important factors, and the proportions of respondents mentioning these. The most frequently mentioned factor was the comfort of household members during cold weather (47 per cent). Heater running costs and purchasing costs of the heating system were the second and third most frequently mentioned factors (45 per cent and 41 per cent respectively). The desire for an environmentally sustainable solution was the tenth most frequently mentioned requirement (26 per cent).

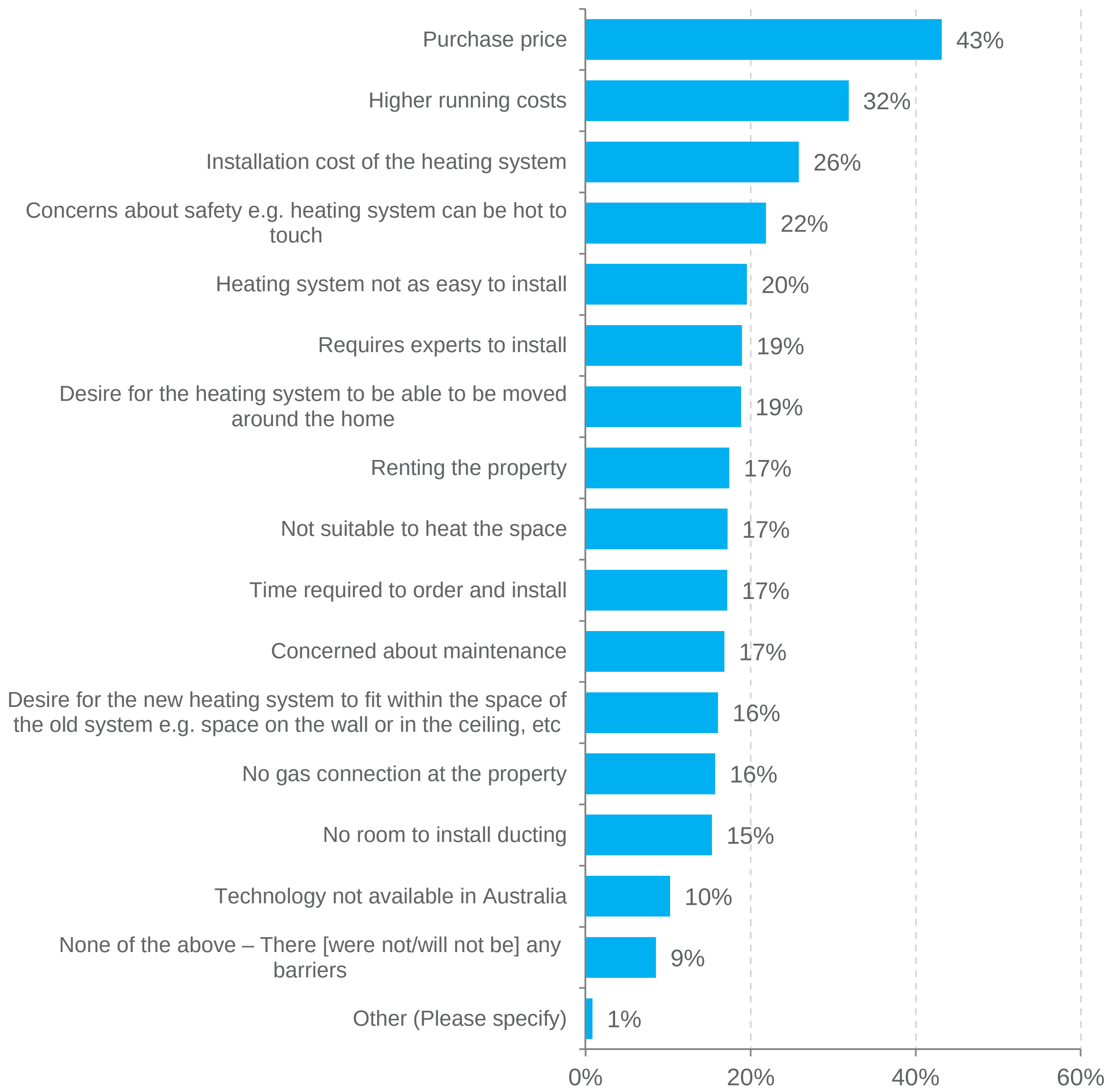
- Existing infrastructure: The research results suggest consumers can favour product options that involve less effort and fit with existing home infrastructure.
- Budget considerations: There were considerable differences in the ability and willingness of consumers to spend money on space heating. Often upfront purchase and installation costs were a key factor used to determine an initial budget for the heater, and respondents also indicated that they considered ongoing running costs and heater efficiency. The combination of ways in which respondents considered these factors is shown in Figure 21.

Figure 21: Purchasing journey budget considerations



- Practical factors affecting initial requirements and preventing the consideration of other space heating options are shown in Figure 22 below.

Figure 22: Purchasing journey practical considerations



These insights into the factors affecting consumers' requirements and clarification of their needs indicate that, even in this first stage of their purchase journey, there are many factors which influence and constrain the framing of their heater options and decision making. The efficiency of the heating system, its running costs, and its environmental impacts are some of the factors many consumers aim to address through their purchasing journey.

The second stage of the purchase journey involves the search for information. Not surprisingly, a wide range of information sources were mentioned by survey respondents. Sources often mentioned include:

- general internet search (38 per cent)
- online store website (31 per cent)
- product review website or blogs (25 per cent)
- recommendations from family or friends (25 per cent)
- supplier or manufacturers website (25 per cent)
- salesperson in store (23 per cent)
- energy utility website (20 per cent)
- supplier representative, installer, tradesperson, home developer, builder (11-15 per cent).

Only 1 per cent of respondents mentioned a government website that provides information and advice. Yet despite this, respondents indicated that a government website would be considered the second most trustworthy source of information and advice, with the most trustworthy being recommendations from family and friends.

The second stage also involved the consumer undertaking a number of steps in their research as they searched for information. Survey participants were asked to arrange the sequence of their research steps, with the purchase identified as the last step. Typically, the first step was to undertake online research of heater options, the second was to do a store visit, and then the third was to discuss their intended purchase with family and friends. Consumers usually then undertook further research steps, such as further online research, discussions with professionals, and further store visits. Both the online research and store visit steps offer potential opportunities for energy rating labelling to influence the consumers purchasing decision. Of the respondents, 36 per cent identified their purchase occurred or would occur on the third to fifth step, but 40 per cent indicated it occurred or would occur on the ninth step.

Stage three of the purchase journey involved the evaluation of alternatives. This process can be broken down into the consumer evaluating:

1. heater product type
2. product sub-type
3. model and brand.

Some participants in the qualitative research component of the study indicated that they had skipped the consideration of the product type or sub-type, because they had already decided on a specific product sub-type or model and brand before commencing their journey. The research indicated that the existing home infrastructure can direct consumers' decision making away from certain product types or subtypes, and towards particular products. The quantitative component of the research found that 20 per cent of purchasers indicated that it was an important factor that the new heater fit in the existing space of the old system. Purchasers of gas heaters and decorative non-wood heaters were significantly more likely to indicate this. Sixteen per cent of purchasers identified that a lack of a gas connection prevented or would prevent them “from considering other heating system options” (that is, presumably, gas-fueled systems).

Other participants who first chose to evaluate heater product types, indicated this was the most challenging and time-consuming step of evaluating alternatives. This finding has implications for the design of a heater energy rating labelling scheme, because it suggests information enabling consumers to compare heaters across product types would assist consumers in the most challenging stage of their heater evaluation.

In the fourth stage in the heater purchase journey, the actual purchase decision, the research identified 20 important factors in the purchase decision. Respondents on average rated energy efficiency as the fourth most important factor. This confirms the potential for energy efficiency information to play an important role in the consumer’s purchasing decision making for heaters.

Those respondents that considered the energy efficiency of their heater purchase as important in their heater choice were asked how they determined heater energy efficiency. Of the top five most frequently mentioned methods of determining energy efficiency, three concerned energy rating, energy rating labels in store and energy rating labels online.

These insights into consumers’ heater purchase decision making, from the research discussed above, are consistent with the findings of earlier research, such as:

- ABS data from 2008 (ABS, 2008) shows that the three main reasons for a householder selecting a type of heating are:
  - comfort or convenience
  - saving on energy bills
  - cost price (i.e. purchase and installation cost).
- More recent ABS research (ABS, 2012) concerning the energy labelling of space heating appliances, found that either the GEMS Energy Rating Label or the gas energy label, was considered by a third of consumers in their purchase decision.
- The majority of consumers consider information on the energy consumption of a space heating appliance to be helpful when making purchasing decisions (ACIL Allen Consulting, 2014).

A baseline market research study into the effectiveness of the E3 ERL was recently completed by Colmar Brunton/Kantar for the Department of Industry, Science Energy and Resources (the research considered the typical ERL design and did not consider the ZERL design). The key finding from this research is that the ERL is highly recognisable. The stars on the label are well understood by most, but the energy consumption, and the other elements of the ERL are less well understood.

These findings support the importance that energy efficiency information on heaters can have on consumers’ choice of heater. However, consumers are only one of the parties who buy space heating; a large proportion may be chosen and purchased by other parties. These include purchases made by property developers, project home building companies, property investors, architects, and tradespeople such as builders, plumbers, electricians, and air conditioning and heating installers. This means there is the possibility that split incentives may still influence many decisions. However, there may be opportunities for an energy rating labelling scheme and supporting tools to assist these parties to enhance consumer choice including by better informing end users of the total ownership cost of space heater options.

Energy Consumption and Greenhouse Gas Emissions

Energy consumption and greenhouse gas emissions: Summary

In Australia, natural gas is the biggest contributor (68 per cent) to total residential heating energy use, followed by wood (18 per cent) and electricity (13 per cent). By heater type, the biggest contributor to energy use is gas ducted heating, 55 per cent, which is largely driven by the large energy use per heater of ducted gas heaters, at 60,000 MJ p.a. This is almost twice that of wood heaters, 32,000 MJ p.a., three times gas space heaters, 18,000 MJ p.a., and around 20 times that of reverse cycle air conditioners or electric resistance heaters, at 1-3,000 MJ p.a. Space heating in Australia requires around 124 PJ in total of energy annually, but we are gradually using less energy for heating year on year.

Space heating is the largest single component, 35 per cent, of Australian total residential energy use and resulted in 10 Mt of greenhouse gas emissions in 2014, which is 15 per cent of Australia's residential greenhouse gas emissions. Space heating's lower contribution to greenhouse gas emissions, compared to its contribution to energy use, is largely due to the mix of fuels used for heating. This mix of fuels has a lower greenhouse gas emissions intensity than electricity, which is the energy source for most other residential end uses. Gas heating contributes over half of the total emissions from space heating (58 per cent), despite these heaters making up only 23 per cent of the total stock of main heaters. Reverse cycle air conditioning was the second biggest contributor, leading to 20 per cent of space heating greenhouse gas emissions, followed by (main) electric resistance heaters, 15 per cent.

In New Zealand, space heating is also the largest single component, around one third, of residential energy use. Wood provides the largest share of heating energy, an estimated 41 per cent, followed by electricity at 37 per cent and gas (natural and LPG), 23 per cent. The biggest contributions to energy use by heater type were solid fuel heaters, 40 per cent, gas space heaters, 18 per cent, and (main) electric resistance heaters, 18 per cent. These heater types each have only low to moderate unit energy consumption but contribute, significantly to total heating energy due to their high stock numbers.

Space heating in New Zealand produced 560,000 tonnes of CO2e greenhouse emissions in 2014, which formed 24 per cent of New Zealand's residential greenhouse gas emissions. Gas heating contributes close to half of the total emissions from space heating (45 per cent), despite these heaters making up only 20 per cent of the total stock of main space heaters. Main electric resistance heaters were the next biggest greenhouse

contributor, producing 25 per cent of the emissions from heating, followed by secondary electric resistance heaters, 15 per cent.

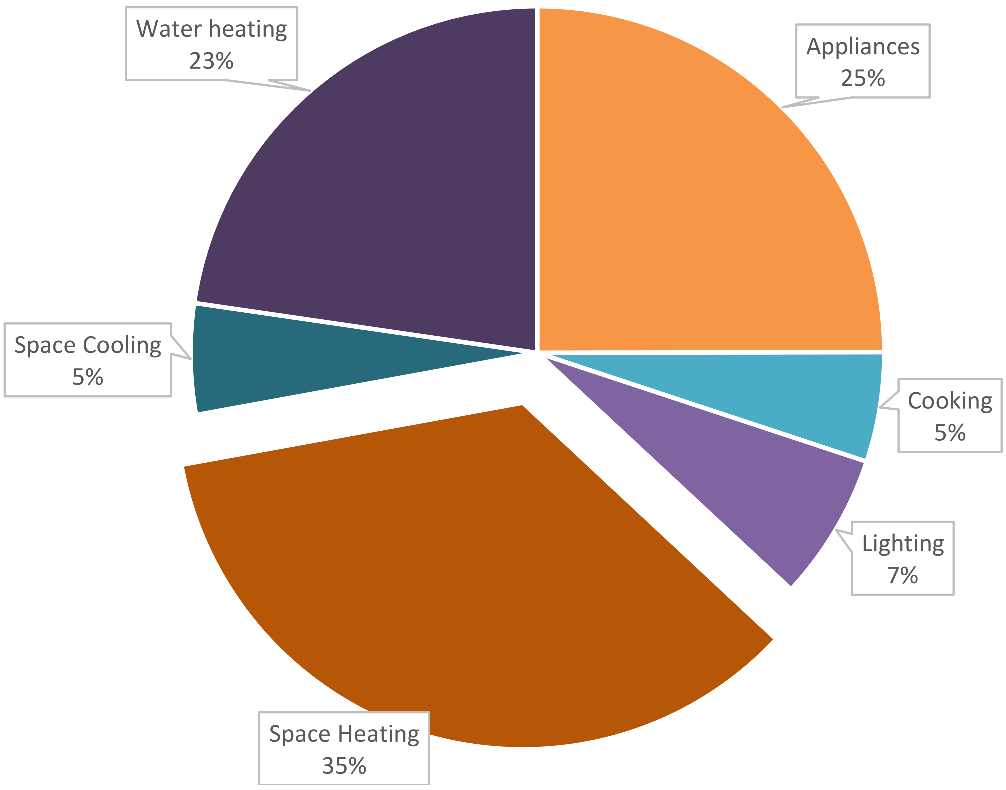
Space heating is a significant contributor to residential energy use and to greenhouse gas emissions. This section explains the energy use from space heating, the relative contribution of different fuels to space heating, the contributions of different types of heating to greenhouse gas emissions and the trends regarding types of heating. The figures and data in this section are from the RBS (EnergyConsult, 2015) which was published in 2015, unless indicated otherwise.

Australian space heating: energy consumption and greenhouse gas emissions

Energy use

Space heating is the largest single component of Australian residential energy use[8], and leads to 35 per cent of residential energy consumption, as shown in Figure 23.

Figure 23: Breakdown of energy use by average household- Australia 2014

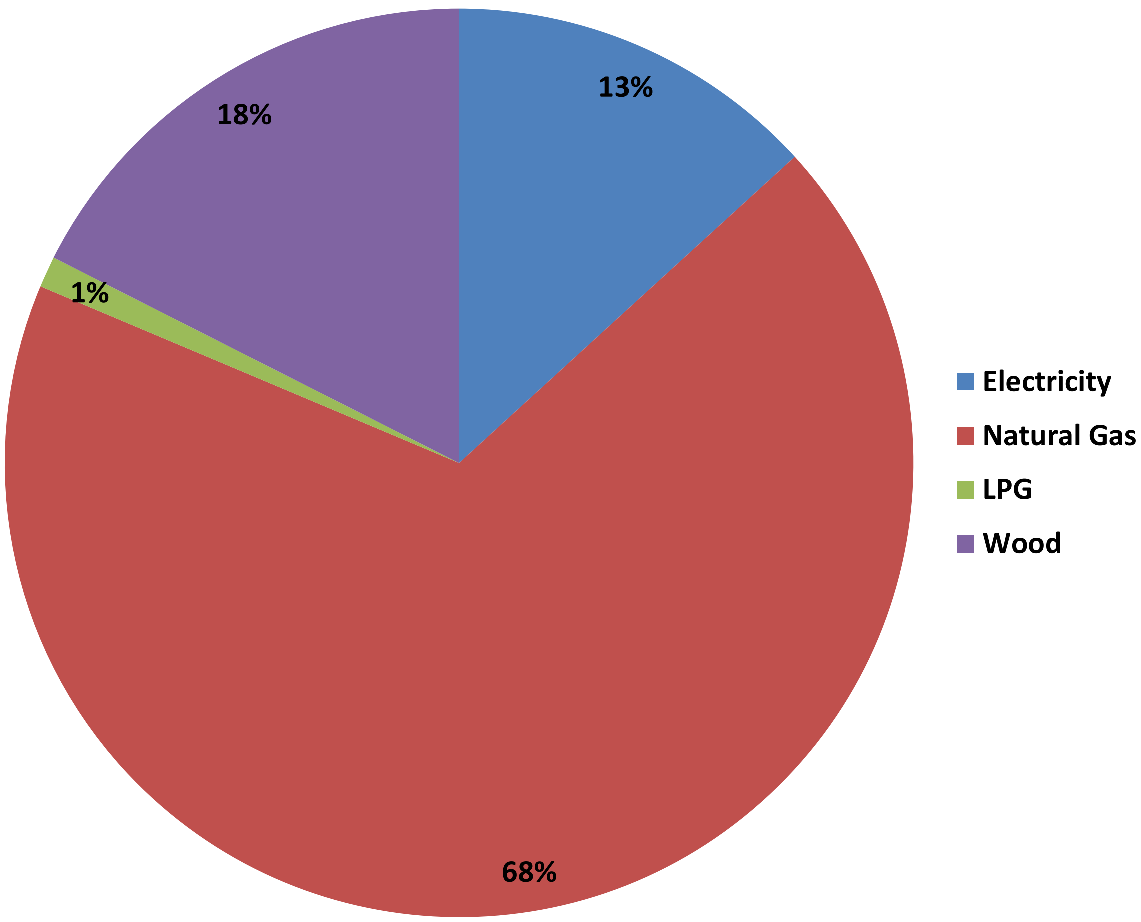


Source: RBS modelling (EnergyConsult, 2015)

[8] The term 'residential energy use' refers to energy use in residential dwellings and does not include energy used for transport or mobile equipment.

There are four main sources of the energy for space heating and the relative contribution of these fuels is shown at Figure 24 below. Natural gas supplies the bulk of heating energy, 68 per cent in 2014.

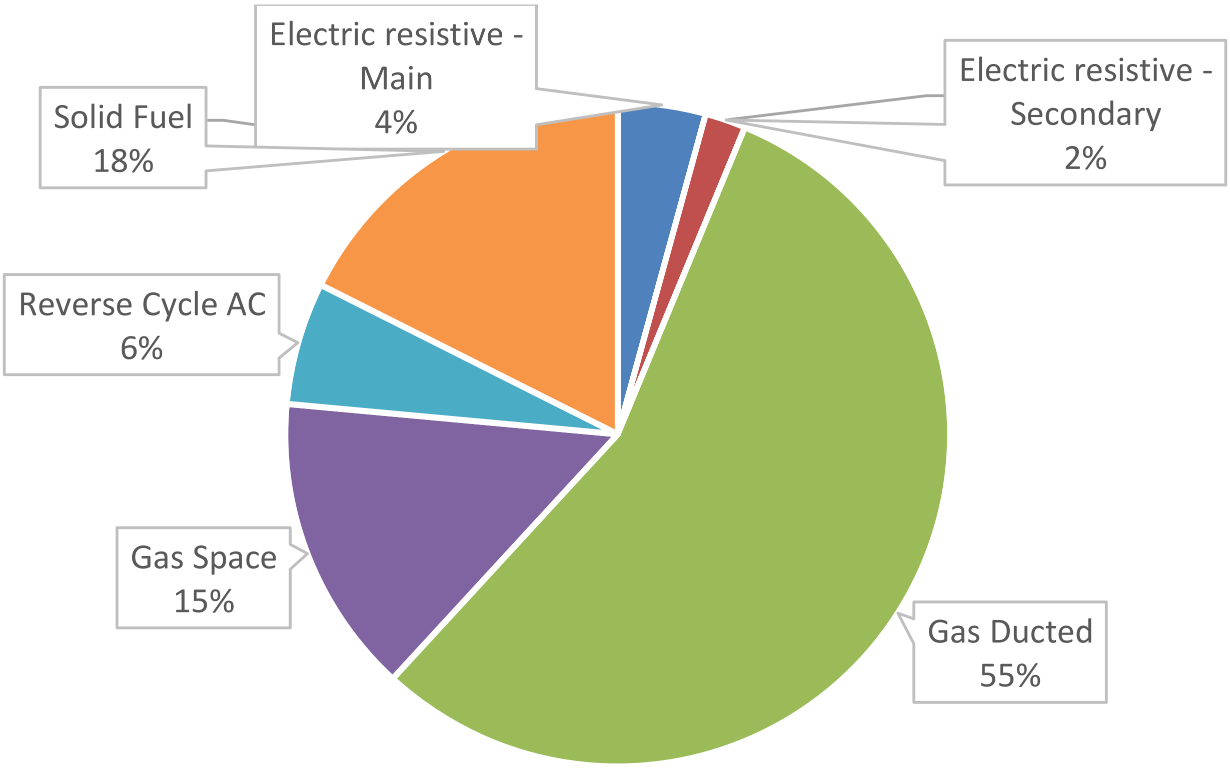
Figure 24: Percentage contribution of fuels to residential space heating- Australia 2014



Source: RBS modelling (EnergyConsult, 2015)

The energy use can be further broken down by the type of heater using the energy, as shown in Figure 25 below. This shows that ducted gas heating uses most of the space heating energy use (55 per cent), followed by solid fuel burners (18 per cent), and gas space (room) heaters (15 per cent), which also includes gas decorative appliance energy use.

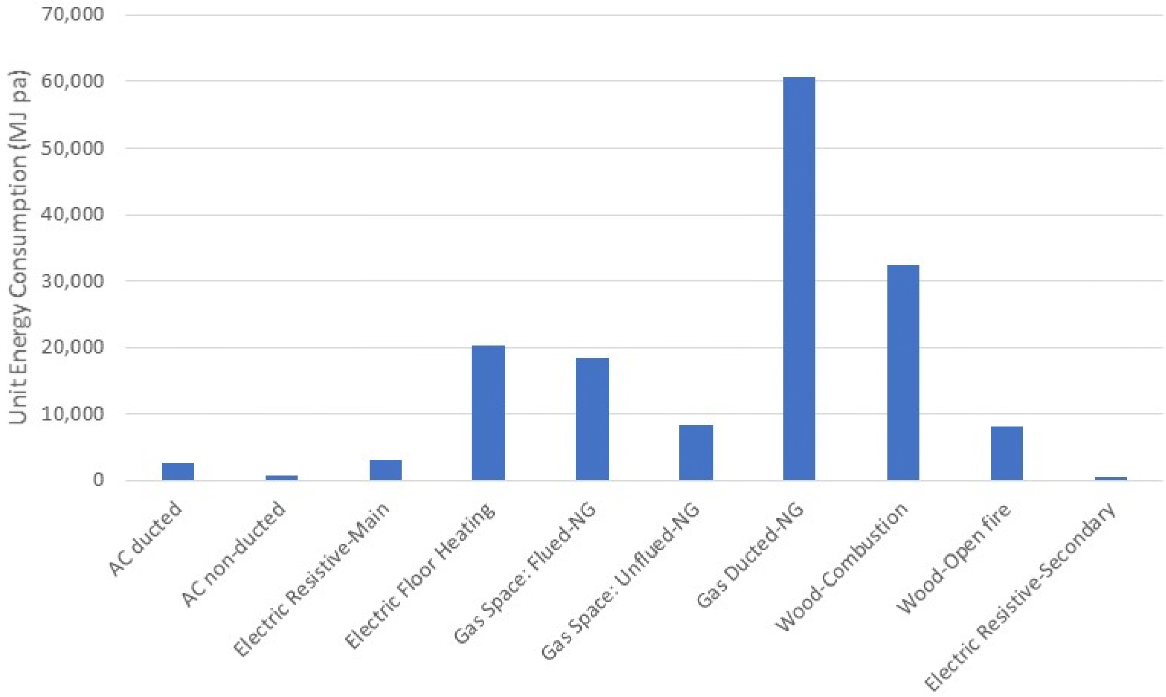
Figure 25: Percentage contribution of heater type to residential energy use- Australia 2014



Source: RBS modelling (EnergyConsult, 2015*)*

The contribution of different heater types to Australia's energy use is a product of the numbers of heaters and their average unit energy consumption[9]. Figure 26 below shows the high unit energy consumption of gas ducted heaters. Gas ducted heaters consume most energy per heater, which is due to their high heating capacity and to being used for heating whole dwellings in colder climates; this is driving their contribution to total energy for residential heating. The significant total energy usage by solid fuel heaters and gas non-ducted heaters also reflects the higher unit energy consumption of these two types of heaters compared to other commonly used heaters shown in Figure 26.

Figure 26: Average unit energy consumption for heater types- Australia 2014

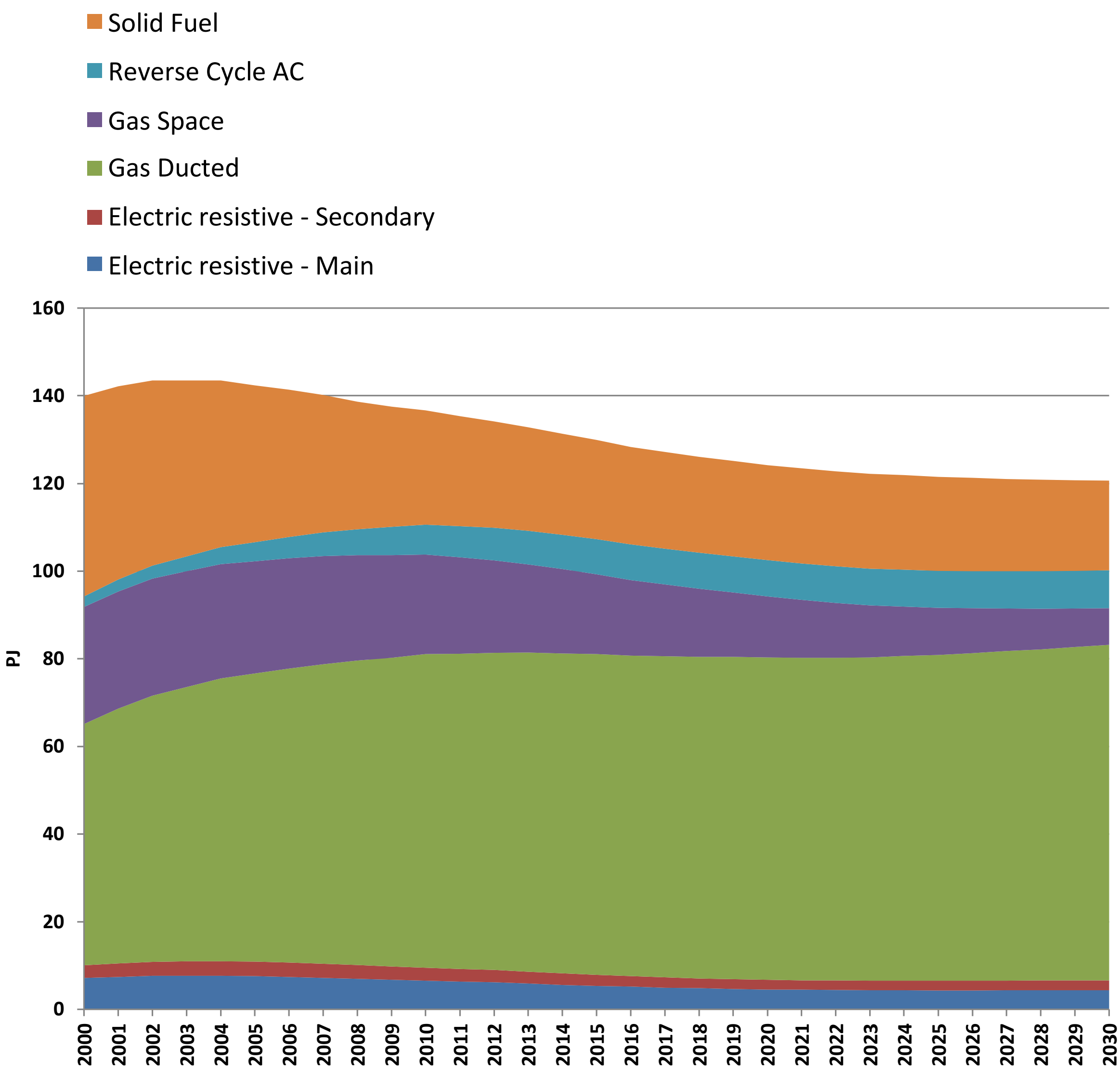


Note: Unit energy consumption is shown in MJ, which can be converted to kWh by dividing by 3.6. Source: RBS modelling (EnergyConsult, 2015*)*

[9] Unit energy consumption refers to the amount of energy one appliance (e.g. heater) will use in a year, assuming average usage behaviour across the seasons.

Space heating in Australia consumes around 124 PJ of energy annually. Yet, as Figure 27 shows, the absolute energy used for residential heating is gradually decreasing (even though sales of heaters are increasing, see Figure 17). The decline is largely the result of the increased use of reverse cycle air conditioners, which are displacing the use of less energy efficient heaters, and the effect of improving thermal performance of housing. The energy used by all heater types is forecast to decline or remain steady, except for gas ducted heating, which is forecast to increase its energy use due to an increasing number of installations.

Figure 27: Projected annual residential energy use by heater type –Australia



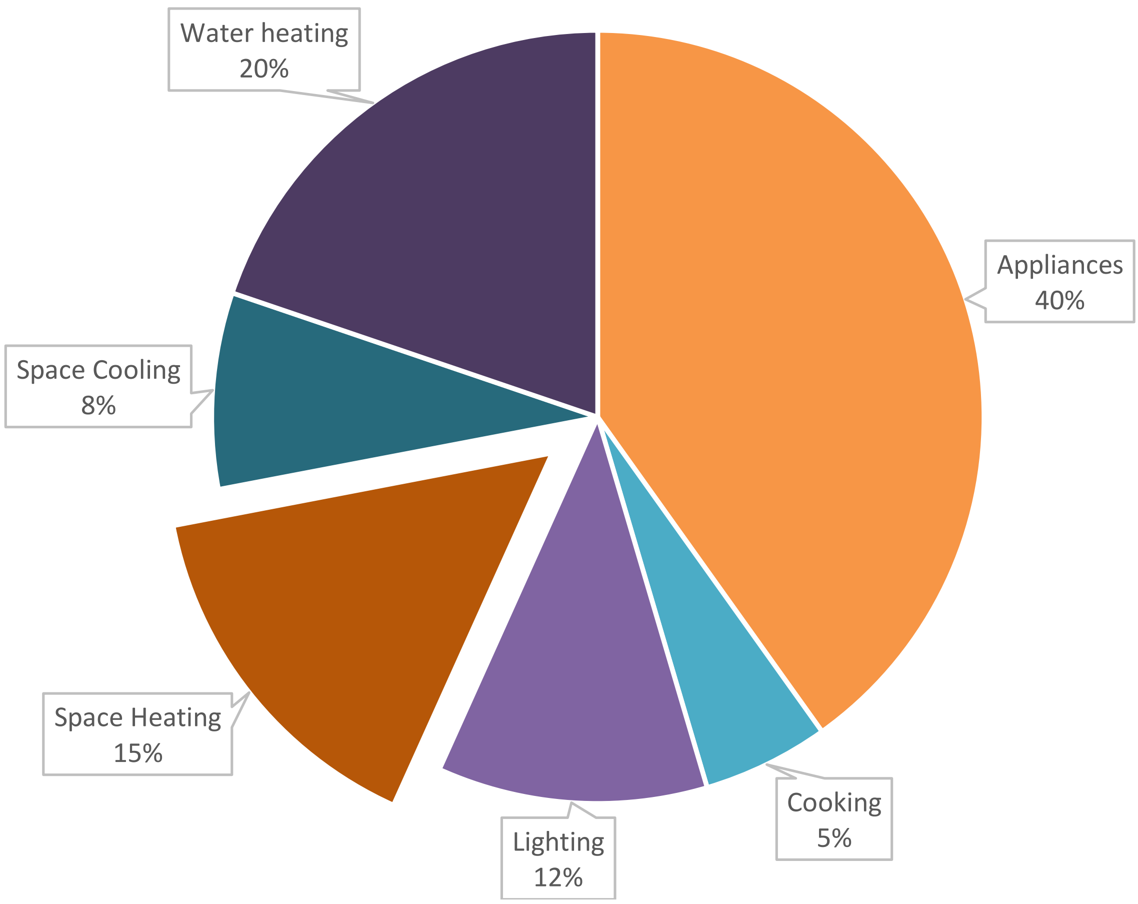
Source: RBS modelling (EnergyConsult, 2015*)*

Greenhouse gas emissions

Space heating is estimated to have produced 10 Mt of CO_2e greenhouse gas emissions in 2014 and Figure 28 below shows that this formed 15 per cent of Australia's residential greenhouse gas emissions.

The contribution of space heating to residential emissions varies significantly across Australian states, and in fact 20 per cent of households use no heating (ABS, 2014).

Figure 28: Residential greenhouse gas emissions by end use: Australia 2014



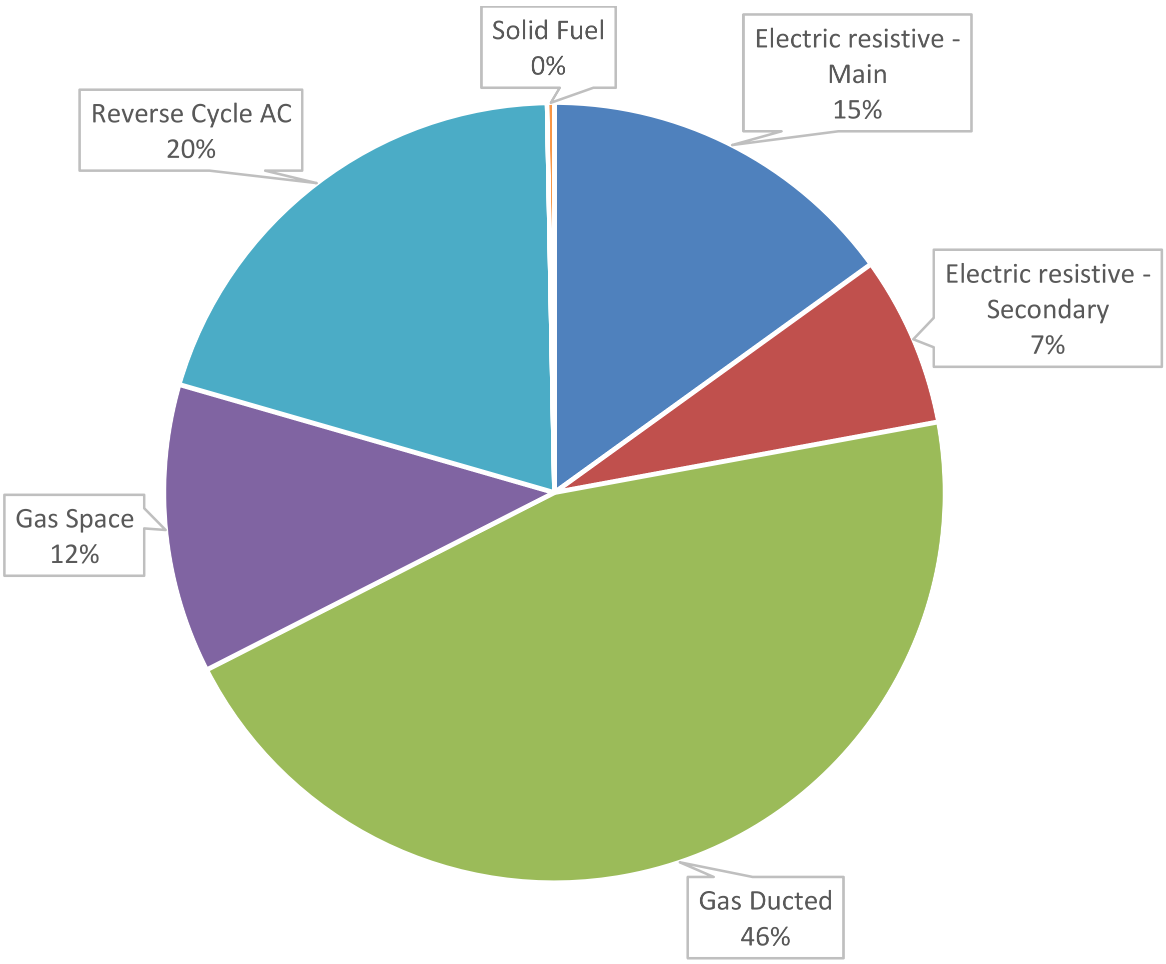
Source: RBS modelling (EnergyConsult, 2015)

The contribution from space heating to residential greenhouse gas emissions of 15 per cent is considerably lower than its contribution to residential energy use (35 per cent). This difference occurs because the majority of energy used for heating is obtained from gas and wood fuels, which both have lower greenhouse gas emissions intensity than electricity from the grid. Wood fuel in particular has a very low emissions intensity and therefore solid fuel heaters produce less total greenhouse gas emissions compared with electric powered heaters. However, gas heaters are estimated to produce more total greenhouse gas emissions than electric powered heaters, despite gas as a fuel having a lower greenhouse gas intensity than electricity, as the following analysis shows.

The contribution to the total greenhouse gas emissions caused by different types of heaters is a reflection of both the contribution of the heater type to the total energy used for heating, and the greenhouse gas intensity of the fuel or energy the heater uses. These two factors in combination determine the resulting contribution of the different heater types to total greenhouse gas emissions which is shown in Figure 29.

Gas heating contributes over half of the total emissions from space heating (58 per cent), followed by electric powered heating (42 per cent, comprising electric resistive at 22 per cent and reverse cycle heating at 20 per cent).

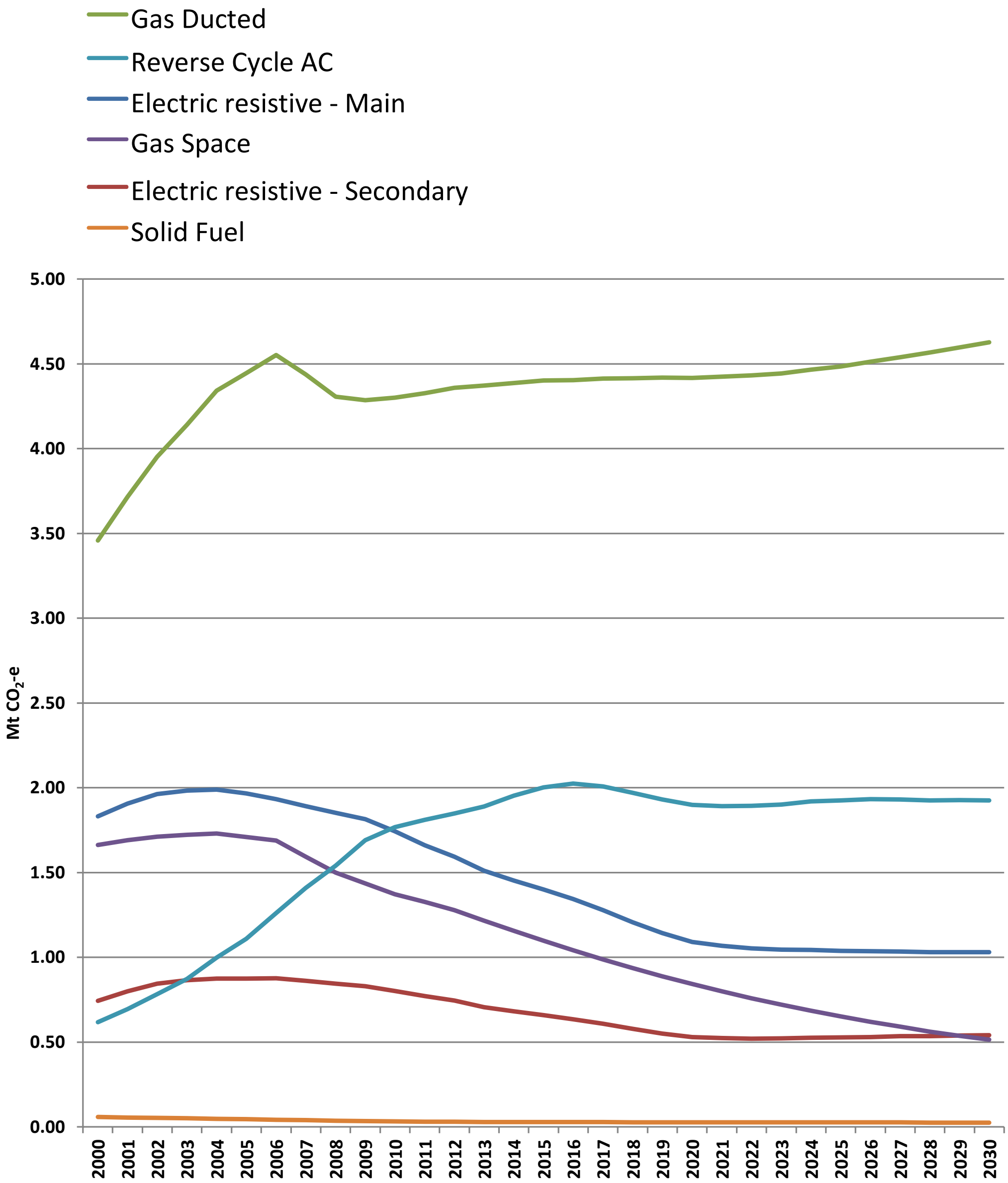
Figure 29: Heater type contribution to residential space heating greenhouse gas emissions: Australia 2014



Source: RBS modelling (EnergyConsult, 2015)

The projected trends for the contribution of different heating types to greenhouse gas emissions are shown in Figure 30 below. These trends are based on the modelling undertaken for the Residential Energy Baseline Study (EnergyConsult, 2015) using projected stock numbers and greenhouse emission factors published in 2014, which are now likely to have changed[10]. The projections indicate greenhouse gas emissions from gas ducted heating is forecast to grow. Emissions from other heater types are expected to decline or remain unchanged from their contribution in 2014.

Figure 30: Projections for residential greenhouse gas emissions by space heater type: Australia



Source: RBS modelling (EnergyConsult, 2015)

[10] The Residential Energy Baseline Study is currently being updated and expanded, and is expected to be published in 2021

State variations in greenhouse gas emissions contributions from heating

There is considerable variation in the greenhouse gas emissions contributions from heating in different states and territories due to variations in climate and the types of heaters used in each state and territory. In addition, there is considerable variation in the contributions from electrically powered heating, i.e. reverse cycle air conditioning and electric resistance heating, across states and territories due to differences in the methods used to generate electricity in each region.

Regions with higher proportions of renewable energy and low-emission electricity generation will produce less greenhouse gas emissions when using electricity for heating than similar regions that are supplied with power from higher-emission generation. These differences in the greenhouse gas emissions contribution made from consuming electricity are expressed as the greenhouse gas emissions factor of electricity, with a smaller emission factor indicating that less emissions are produced. Table 2 below indicates the latest greenhouse gas emissions for electricity from the grid in 2020 (DISER, 2020).

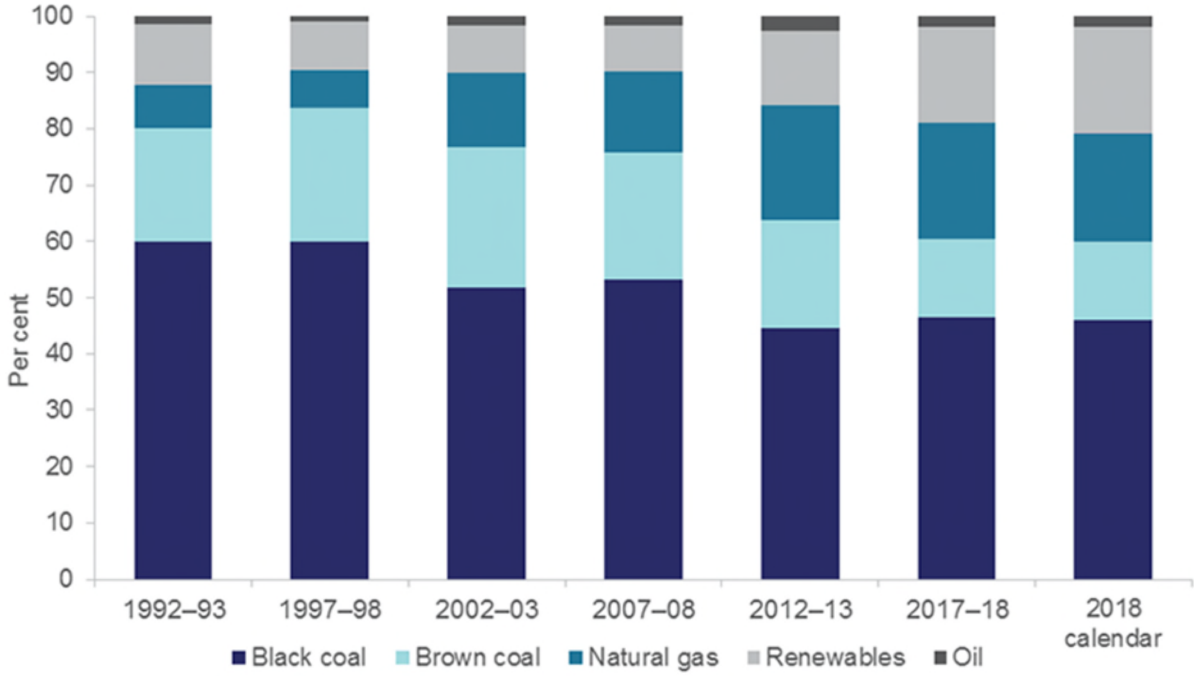
Table 2: Electricity greenhouse gas emissions factors by state (published 2020)

Region	National Average	NSW & ACT	Vic	Qld	SA	WA	Tas	NT
Greenhouse Gas Emissions Factor (kg CO2-e/kWh)	0.87	0.89	1.09	0.93	0.52	0.70	0.17	0.70

Source: (DISER, 2020)

A number of existing and proposed policies at various levels of government in Australia are aiming to drive and support increases in the proportion of electricity generation from renewable and low emission sources. This trend towards an increasing proportion of renewables in the generation mix is shown in the chart below and future projections also indicate Australian electricity emission factors will continue to decline (Department of the Environment and Energy, 2019a). This means the greenhouse gas emissions factors for electricity will decrease over time.

Figure 31: Changes in Australian electricity generation fuel mix



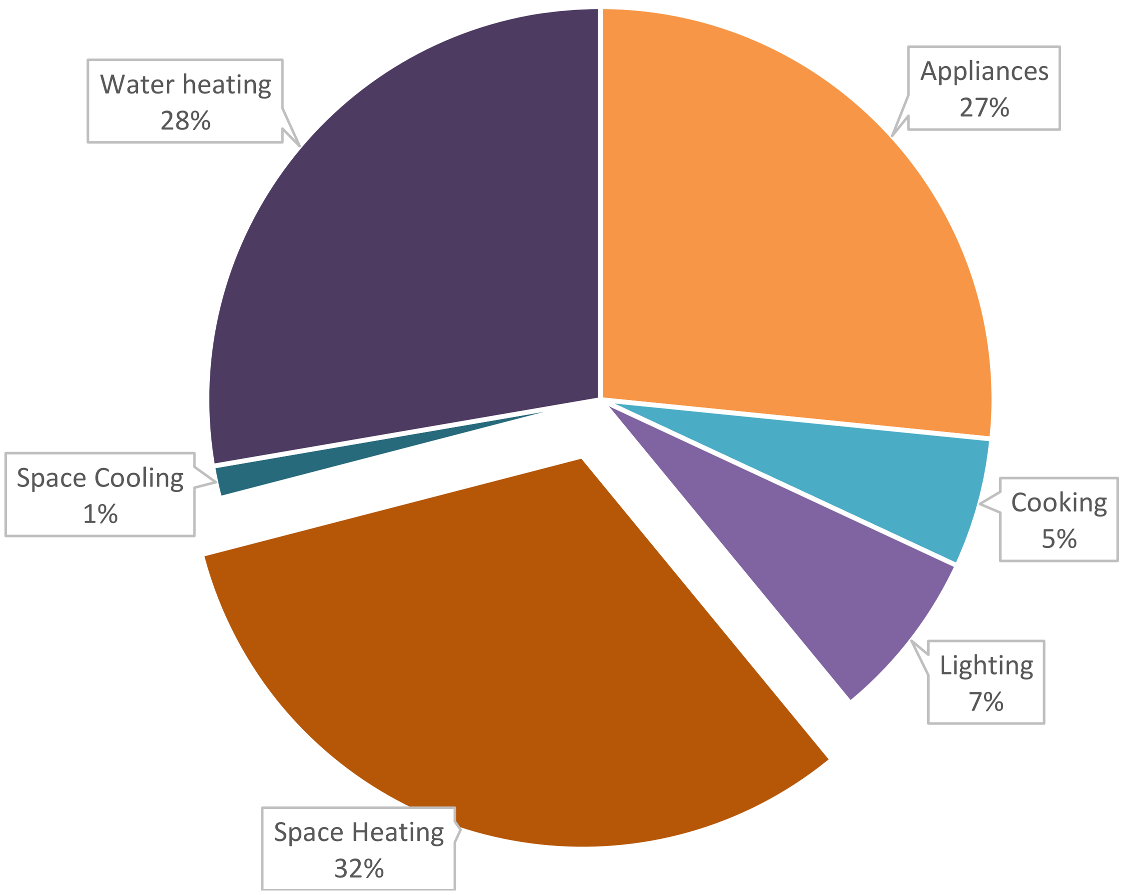
Source: (Department of the Environment and Energy, 2019b)

New Zealand space heating: energy use and greenhouse gas emissions

Energy use

Space heating in New Zealand consumes around 18PJ in energy annually and is the largest single component of residential energy use (32 per cent) in New Zealand (EnergyConsult, 2015), as shown in Figure 32.

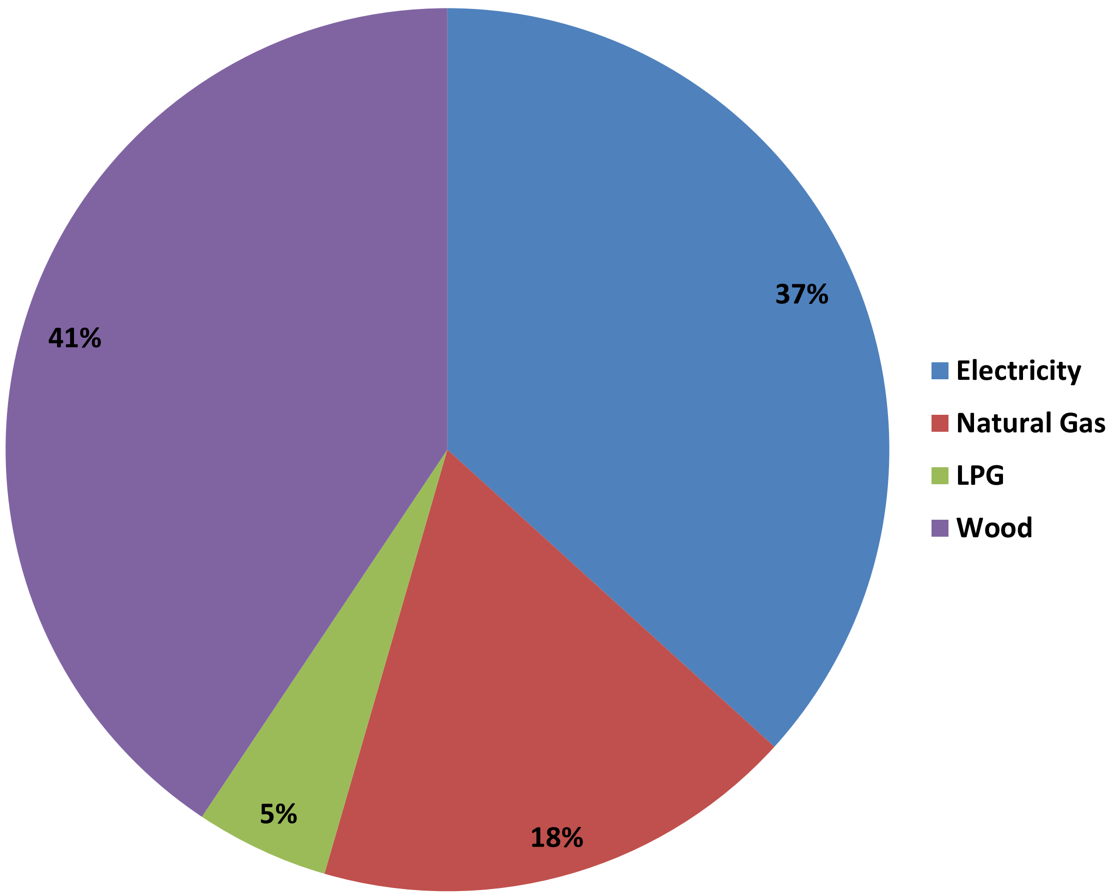
Figure 32: Breakdown of energy use by average household- New Zealand 2014



Source: RBS modelling (EnergyConsult, 2015*)*

There are four main fuels and energy sources used for space heating. The relative contribution of these fuels is shown in the Figure 33 below. In 2014, wood accounted for 41 per cent of the energy used for heating, followed by electricity at 37 per cent, then natural gas (18 per cent) and LPG (5 per cent).

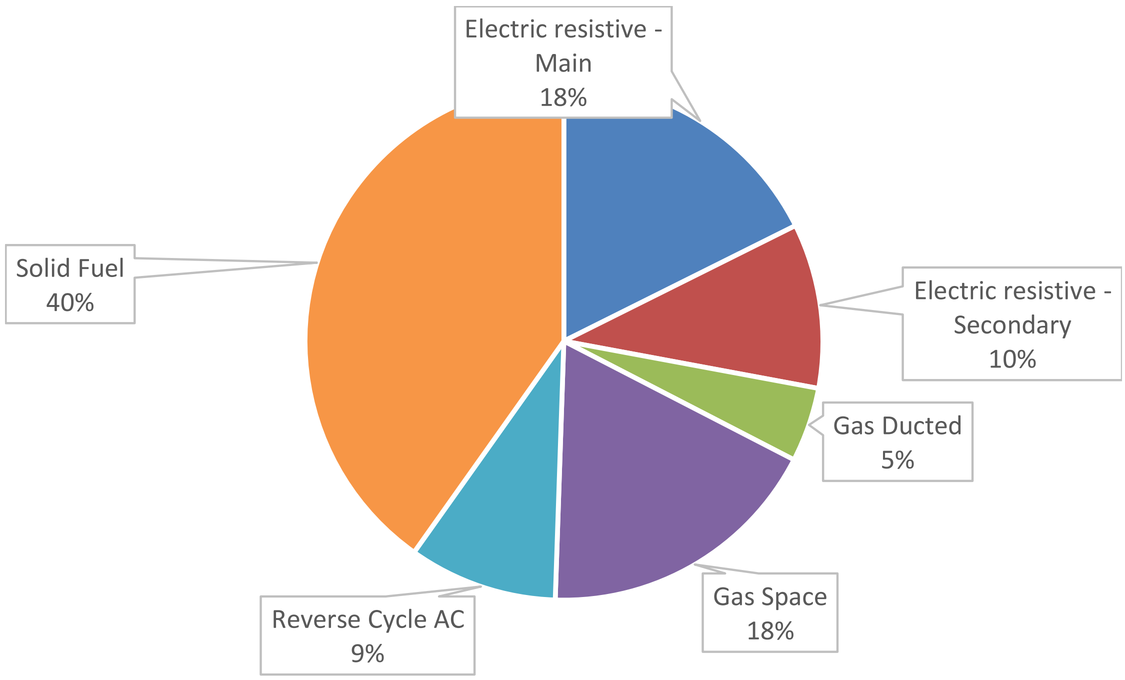
Figure 33: Percentage contribution of fuels to residential space heating- New Zealand 2014



Source: RBS modelling (EnergyConsult, 2015*)*

Energy use figures can be further broken down by the type of heater using the energy, as shown in Figure 34. This shows that solid fuel burners alone contribute the largest proportion to space heating energy consumption, at 40 per cent, followed by electric resistance main heaters and gas space heaters, both at 18 per cent.

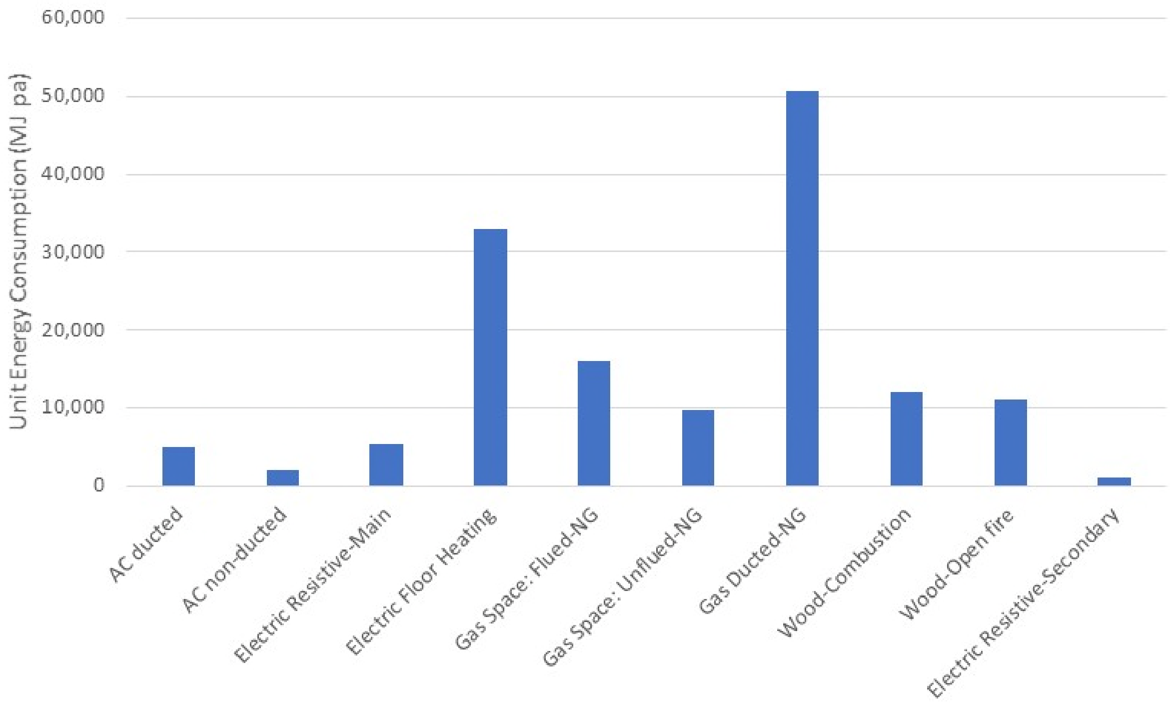
Figure 34: Percentage contribution of heater type to residential energy use- New Zealand 2014



Source: RBS modelling (EnergyConsult, 2015*)*

The total amount of energy used by the different heater types is a product of the numbers of heaters in use and their energy consumption per unit (see Figure 35). The relatively high unit energy consumption of the three commonly used heaters – solid fuel heaters, electric resistance-main heaters, and gas space heaters – contributes to these heater types using a large share of the total energy used by space heating. Electric floor heating and gas ducted heating have the highest unit energy consumption, but there are small numbers of these installed.

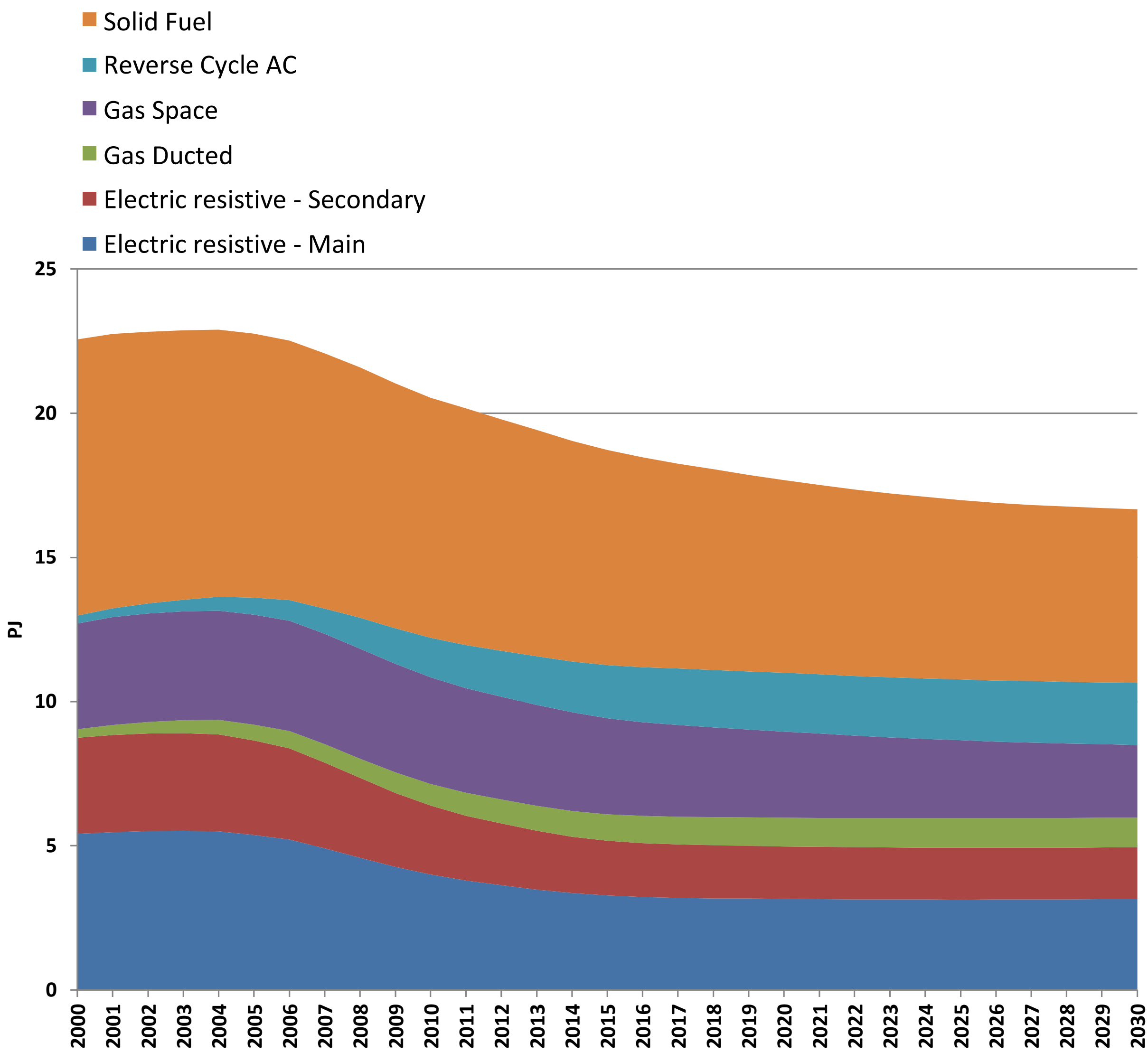
Figure 35: Average unit energy consumption for heater types- New Zealand 2014



Source: RBS modelling (EnergyConsult, 2015*)*

Figure 36 (EnergyConsult, 2015) shows that the energy used by space heating in New Zealand is in slow decline. The energy used by all heater types is forecast to decline or remain steady, except for reverse cycle air conditioning, which is forecast to slowly increase its total energy use. The projected declining energy use of most heaters is due to the increased use of reverse cycle air conditioners, which are displacing the use of less efficient heaters, and also due to improvements in the thermal efficiency of housing.

Figure 36: Projected annual residential energy use by heater type -New Zealand

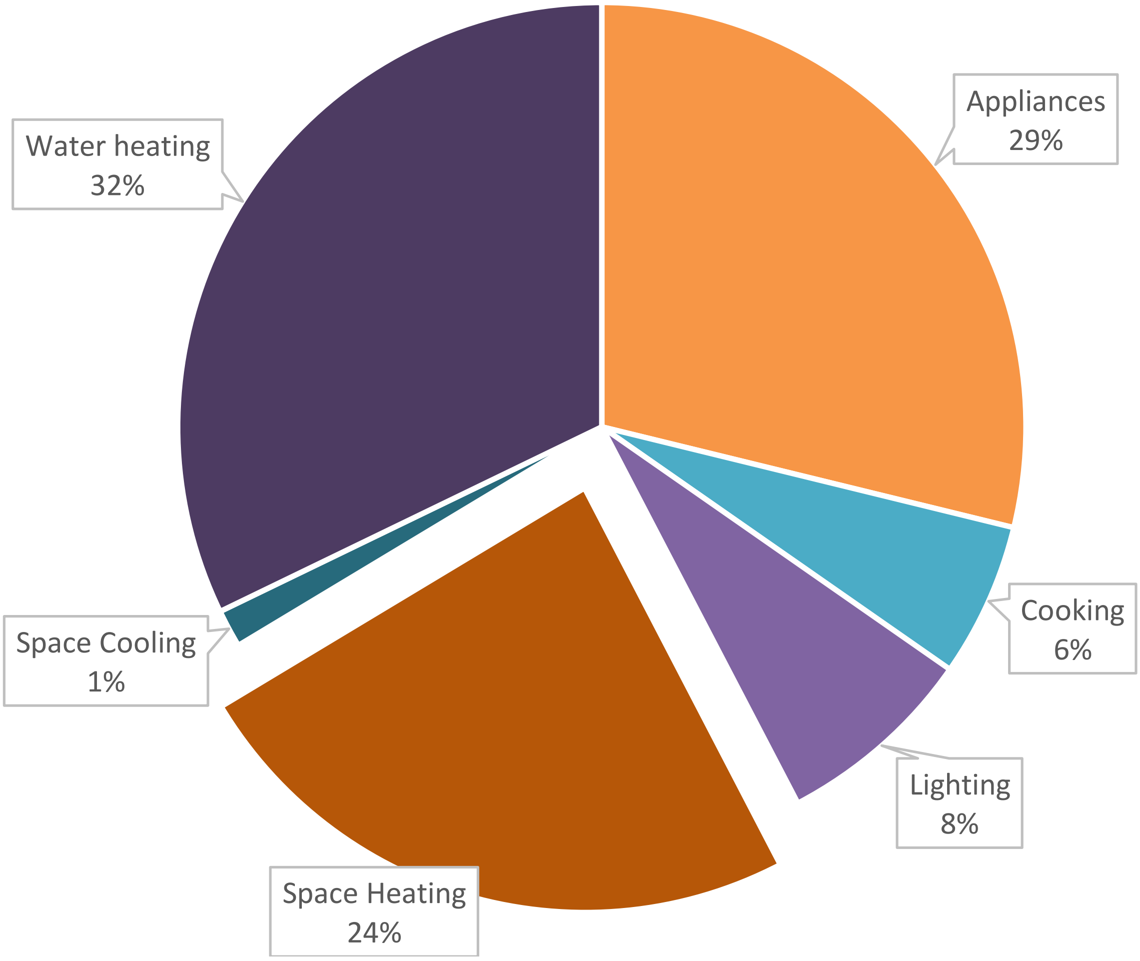


Source: RBS modelling (EnergyConsult, 2015)

Greenhouse gas emissions

Space heating in New Zealand is estimated to have produced 560,000 tonnes of CO_2e greenhouse gas emissions in 2014 (EnergyConsult, 2015)[11]. As Figure 37 shows, this formed 24 per cent of New Zealand's residential greenhouse gas emissions.

Figure 37: Residential greenhouse gas emissions by end use: New Zealand 2014



Source: RBS modelling (EnergyConsult, 2015)

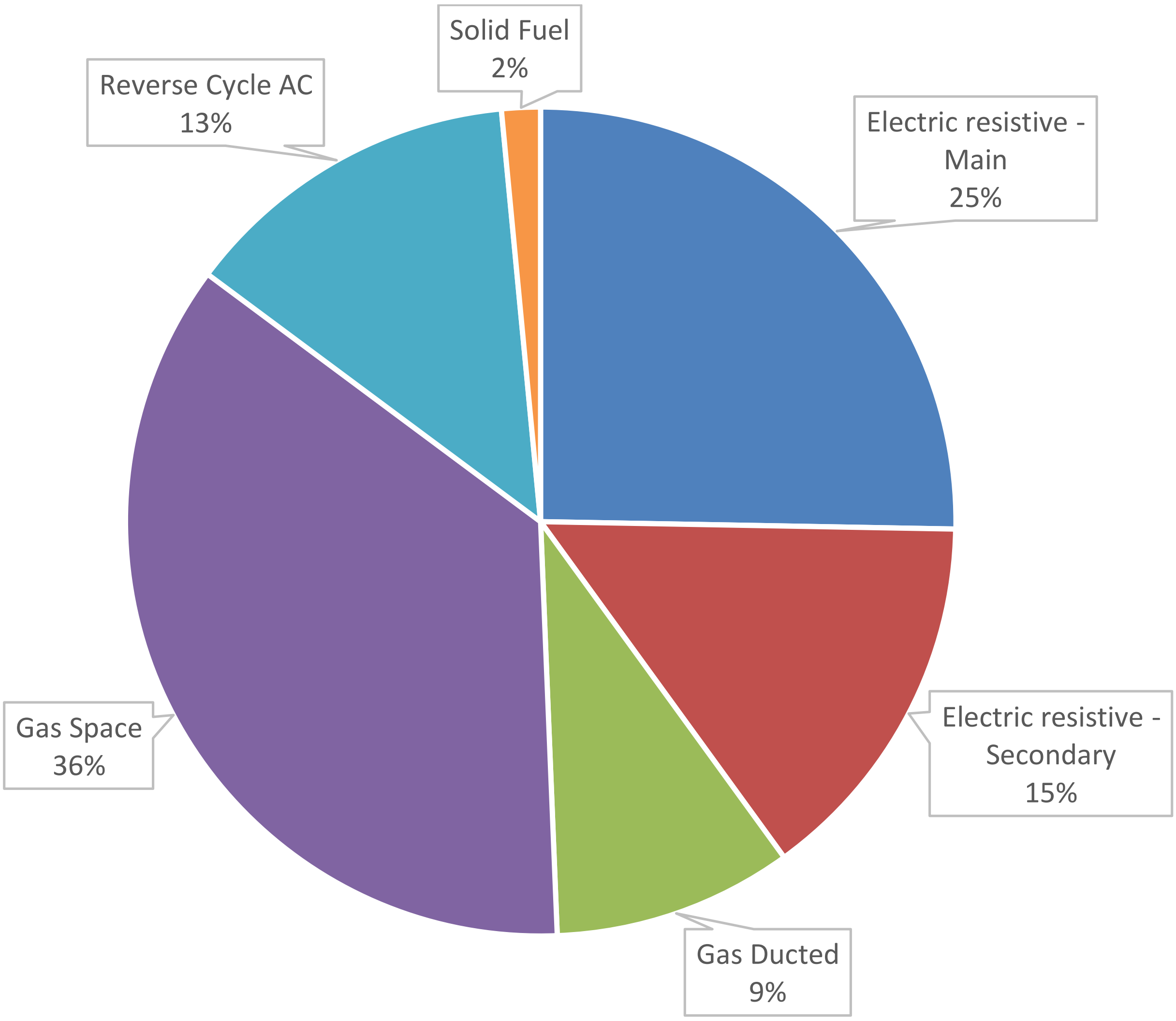
The contribution of space heating to residential greenhouse gas emissions, at 24 per cent, is less than the share of space heating use of residential energy, approximately 33 per cent. The difference is largely due to wood supplying 41 per cent of the energy used in space heating and burning wood producing minimal greenhouse gas emissions, which reduces the effect of space heating on greenhouse gas emissions.

The contribution to total greenhouse gas emissions from the different types of heaters is shown in Figure 38 below. Gas heating contributes close to half of the total emissions from

[11] The emission factors or intensity of some fuels, especially electricity, is changing over time but all projections are based on 2014 emission factors for consistency with the other modelling data.

space heating (45 per cent), which largely reflects the relatively high greenhouse gas emissions intensity of gas compared to electricity in New Zealand, leading to their contribution to greenhouse emissions being larger than their contribution to heating energy use. Electric resistance heaters are the next biggest greenhouse contributor, making up 40 per cent of the emissions from heating.

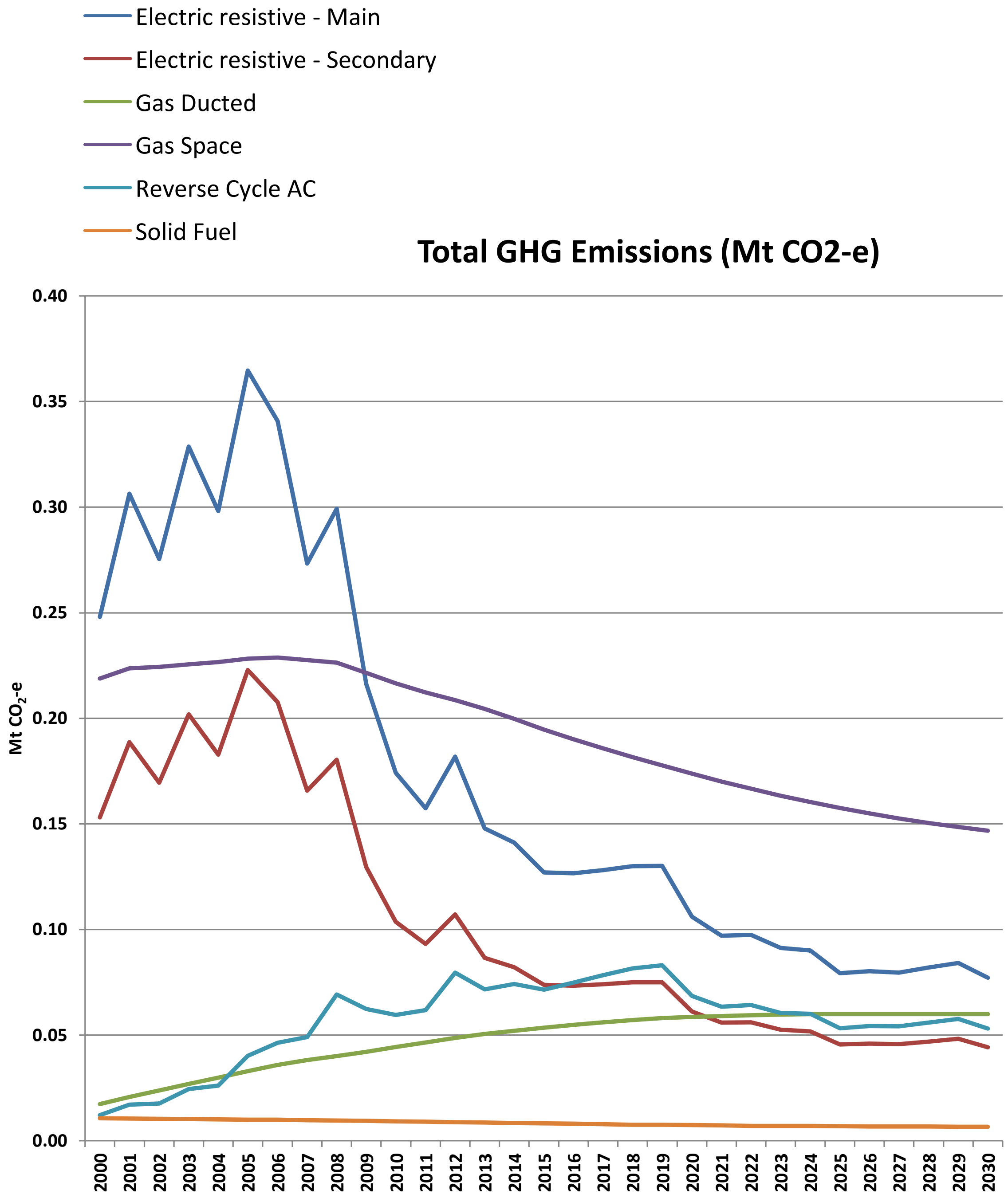
Figure 38: Heater type contribution to residential space heating greenhouse gas emissions: New Zealand 2014



Source: RBS modelling (EnergyConsult, 2015)

The projected trends for the contribution of different heating types to greenhouse gas emissions are shown in Figure 39 below. The chart indicates that, post-2020, gas ducted heating is the only heating type which is forecast to increase greenhouse gas emissions, with the contribution from all other heater types declining. This reflects a forecast decline in total space heating energy use and a projected decline in the greenhouse gas emission factor of grid electricity.

Figure 39: Projections for residential greenhouse gas emissions by space heater type: New Zealand



Source: RBS modelling (EnergyConsult, 2015*)*

Policies and Standards Relating to Space Heaters

Policies and standards: Summary

A range of existing government regulations, policies and standards affect the design, construction, installation and operational performance of space heaters. However, the requirements to meet energy performance measurement, minimum performance, and energy labelling requirements differ between heater types and between Australia and New Zealand.

Specific product regulations and standards include:

- *Reverse cycle air conditioners are required to be energy rated and to meet MEPS, and certain types are required to provide a Zoned Energy Rating Label (ZERL). Requirements are set in Australia by Greenhouse and Energy Minimum Standards (Air Conditioners up to 65kW) Determination 2019 and specified in AS/NZS 3823.4. In New Zealand the requirements are set out in the Energy Efficiency (Energy Using Products) Regulations 2002 which reference the AS/NZS 3823.4. Display of the ZERL is not required on-line, only in stores.*
- *Solid fuel combustion heaters must meet a minimum thermal energy efficiency of 60 per cent in Australia, as defined in AS/NZS 4012, and 65 per cent in New Zealand, as required by the National Environmental Standards for Air Quality Regulations 2004*[12]*.*
- *Gas heaters are not covered by the E3 Program. To be legally sold or installed in Australia and New Zealand, these appliances must be tested and certified against Australian Standards in accordance with State and Territory safety regulations. Certification standards include minimum energy efficiency levels for Australia only. In Australia, the regulations also require suppliers to display a gas energy label on gas room and ducted heaters intended for residential heating. In New Zealand, consumers are encouraged to look for the gas energy rating label – more stars means it's more efficient.*

Building regulations and codes indirectly influence heating by stipulating insulation and building envelope thermal efficiency requirements. Some government energy efficiency schemes also incentivise the uptake of more efficient heaters.

[12] New Zealand emission standards are under review and new regulations may impact on efficiency requirements in the future.

Separate, technology-specific testing and performance measurement standards apply to the different types of space heaters, making comparisons across heater types difficult.

There are two existing standards which might be adapted to enable the energy performance of multiple heater types to be assessed and compared in a fair and consistent basis:

- *AS 5389:2019: Space heating and cooling and ventilation systems - Calculation of energy and comfort performance; which provides a calculation methodology for the input energy required to provide space heating or cooling to a standard residential or commercial building in several locations throughout Australia, and*
- *AS/NZS 3823.4 which provides a measurement and calculation methodology for determining the energy consumption, capacity and performance (efficiency) of air-cooled air-conditioners and air-to-air heat pumps in specified climate zones.*

Both standards would need further work to be able to be adapted for multiple heater types.

Introduction to policies and standards

A range of existing government regulations, policies and standards affect the design, construction, installation and operational performance of space heaters. These regulations and standards cover safety compliance aspects and minimum operational, energy performance and labelling requirements. The scope of these regulations is specific to the type of fuel or energy source used by the products and varies between Australia and New Zealand. Table 3 at the end of this section provides a summary of the standards and regulations related to energy use by product type. Compliance and safety standards are noted, because in some cases they include energy performance measurements, minimum requirements and energy labelling.

Product specific requirements

Australia and New Zealand regulate space heaters to ensure the products are safe, reliable and consistently perform the way they are described. In some cases, they also regulate to ensure products meet certain energy performance levels. Product standards are published documents that set out the specifications and testing procedures relevant to regulation of products. The legislative processes used to regulate heaters for minimum energy performance standards and energy rating labelling in Australia and New Zealand differ. In Australia, determinations under the GEMS Act set out specific product requirements. Requirements are described either directly in the determination, or the determination will refer to the applicable clause in a product standard. In New Zealand, the product requirements are specified in the relevant standard, which is referenced in the *Energy Efficiency (Energy Using Products) Regulations 2002*.

This section focuses on the product energy performance requirements in Australia and New Zealand, including MEPS and energy rating labelling regulations. It does not cover the safety, design, installation or other aspects of product regulation and compliance, unless this is linked to energy performance requirements.

Reverse cycle air conditioners

Most air conditioners with a heating mode have been subject to labelling (and MEPS) since 2004 and to requirements under the GEMS Act since 2012.

- 1987: residential air conditioners first required to carry an energy rating label.
- 2001: larger three-phase air conditioners—which include large, ducted household units (and units for non-residential buildings)—subject to MEPS and can use the label on a voluntary basis.
- 2004: single phase air conditioners required to carry an energy rating label and became subject to MEPS requirements (cooling cycle only).
- 2007: MEPS levels increased for most air conditioning types (cooling cycle only).
- 2011: MEPS levels for the heating mode for all air conditioners with a heating function introduced, at the same level as cooling mode MEPS.
- 2020: Zoned Energy Rating Label (ZERL) introduced to provide information on performance by climatic zone. Updates were made for certain types of products to meet MEPS (multi-split, single-duct portables, revisions for double-duct portables) or display a label (single-duct portables). The energy performance data is provided in the GEMS registry.

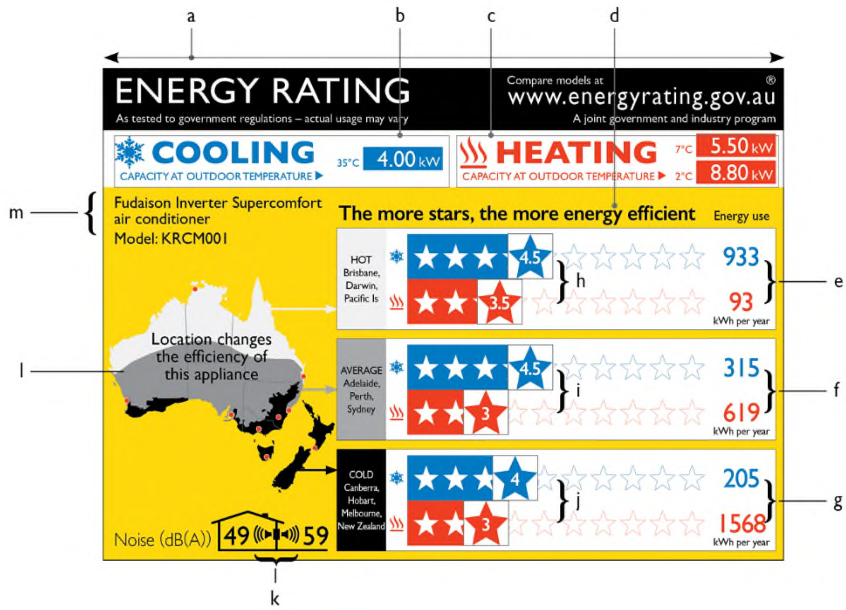
Several performance and labelling requirements apply to reverse cycle air conditioners. Requirements differ depending on the output capacity, kind of product and the characteristics of the product within the class. There are 23 classes of products in the GEMS determination. Since 1 April 2020, updated requirements apply, including:

- the performance of products is to be tested against the Seasonal Energy Efficiency Ratio (SEER) standard for energy efficiency rating purposes
- some products are to carry a Zoned Energy Rating Label, which replaces the previous Energy Rating Label and uses SEER data as an input (note: certain product types are required to test and register the information, but not display the ZERL).

The ZERL labelling is mandatory for some products covered by the updated regulation, voluntary for some (three-phase and ducted) and prohibited for other products (>30kW output or multi-split systems).

The introduction of the ZERL means labels now show energy ratings for three climate zones, as shown in Figure 40. For devices capable of both heating and cooling, the ZERL will show heating and cooling ratings for each of the three climate zones. The Heating Seasonal Performance Factor (HSPF) is calculated in accordance with clause 6.1 of AS/NZS 3823.4.2:2014 and derived from the use of rated values. The star rating corresponds directly to the HSPF according to a table of values within certain ranges.

Figure 40: Example of the Zoned Energy Rating Label (ZERL)



AS/NZS 3823.4 provides a measurement and calculation methodology for determining the energy consumption, capacity and performance (efficiency) of air-cooled air-conditioners and air-to-air heat pumps in specific climate zones.

AS/NZS 3823.4 defines multiple (up to four) indoor and outdoor measurement conditions for both heating and cooling to enable the range of a product's performance to be captured at full and part load, particularly for multi-stage and variable capacity units. Mathematical equations are then used to describe the product's performance across a range of outdoor temperatures and loads, including adjustments for cyclic behaviour, frosting and other performance degradations.

The ZERL (and AS/NZS 3823.4) defines three climate zones:

- a hot/humid zone (called Hot), based on the Nationwide House Energy Rating Scheme (NatHERS) climate file for Rockhampton, Queensland
- a mixed zone (called Average), based on the NatHERS climate file for Richmond, New South Wales
- a cold zone (called Cold), based on the NatHERS climate file for Canberra, in the Australian Capital Territory.

The climate zones define the number of hours a product is used, as a function of outdoor temperature.

A product's heating and cooling seasonal energy efficiency performance is defined as the ratio of the total load (heating or cooling energy delivered) to the total energy consumed. The total load (heating and cooling energy delivered) or energy consumption of the product is calculated by adding up the load or energy consumption at each outdoor temperature, multiplied by the number of hours the product is expected to be used at that outdoor temperature. This is done over multiple outdoor temperatures in which heating would be used. Both heating and cooling seasonal performances are defined, and can be calculated separately, or combined into an annual performance value. A methodology for including standby energy is also provided.

For ducted air conditioners, a limitation of the ZERL (and AS/NZS 3823.4) approach will be that the efficiency of the central air conditioning unit is measured, but this unit is only part of the ducted air conditioning system. Heat losses in other parts of the ducted air conditioning system, especially from the ducting, can significantly reduce the overall efficiency of the system, but are not included in the measurement of efficiency. In addition, the display of a ZERL is voluntary for ducted air conditioners.

Gas ducted

Gas heaters (including flued and flueless heaters, decorative and ducted products) are not regulated for energy efficiency in New Zealand or under the GEMS Act. A gas energy label is required to be affixed to certified products in Australia, but not New Zealand. Gas heaters used in residential applications are required by the State and Territory Gas Technical and Safety Regulators[13] to be certified before they can be legally sold or installed. The gas energy label is part of this certification process, which forms a small component of what is primarily a mandatory gas appliance safety program (E3, 2015). The gas energy label for gas heating appliances has been in place since the 1990s and the minimum energy efficiency levels within these certification standards have not been updated for at least two decades. However, for gas space (room) heating a new standard has been published (2021) that changes to the calculation methodology for obtaining the energy star rating and the gas energy label.

The relevant product standards for gas appliances is the AS/NZS 5263 series. The focus of these standards is on product quality and safety, but they contain some minimum thermal efficiency requirements and include test standards, energy rating algorithms and a requirement for a gas energy rating label. New Zealand has similar safety legislation for the certification of gas appliances and for such appliances to be compliant with the standards but does not require them to meet the AS/NZS 5263 energy efficiency and related labelling requirements. But New Zealand consumers are encouraged to look for the gas energy rating label – more stars means it's more efficient.

In the case of ducted gas heaters, they must meet the requirements of AS/NZS 5263.1.6 to be certified, which specifies a minimum thermal efficiency of 70 per cent. There are two measures of efficiency used in the standard for gas ducted heaters – thermal efficiency and seasonal operating efficiency:

- The thermal efficiency of the ducted heater is determined by analysing the flue products and calculating the heat content, according to methods defined in the

[13] The Gas Technical Regulators Committee is an association of government agencies responsible for the safe use of gas. The committee includes representatives from every State and Territory in Australia and New Zealand. See www.gtrc.gov.au

AS/NZS 5263.1.6. This approach measures the efficiency of the heat exchanger, i.e. the part of the system that heats the air. This is a limited measure of the gas ducted system efficiency because the heat exchanger is only one part of the total system. Heat losses in other parts of the gas ducted system, especially from the ducting, can significantly reduce the overall efficiency of the system but are not included in the measurement of efficiency.

- The seasonal operating efficiency (SOE) is used to determine the star rating and annual energy consumption for the gas energy label. It is calculated based on the useful heat output divided by total energy input (gas and electricity) over two heating cycles, one based on approximately a 25 per cent duty cycle and one on a 75 per cent duty cycle. The calculation also takes into account gas and electricity consumption in standby mode, and electricity consumption during operation. The SOE is calculated from the average of efficiencies measured for a 70-80 per cent duty cycle and a 20-30 per cent duty cycle, based on a 20-minute heating cycle.

The certification of gas ducted heaters requires the appliance to have a gas energy label affixed according to the requirements of the AS/NZS 5263.1.6 standard. The standard contains a methodology for calculation of the stars to be shown on the gas energy label, with the number of stars relating to the efficiency of the heater. Gas ducted gas heaters can also obtain up to one additional star which relates to the energy saving potential of them providing a ‘zoning’ function (i.e. not heating un-occupied areas by closing off some outlet registers or a zone damper). This is included in the star calculations via the ‘heat load reduction factor’ (HLR). A maximum of 5 stars can be given for the appliance operating efficiency (Appliance Stars), and up to an extra 1 star is possible depending on the HLR factor. This means a gas ducted heater can obtain a maximum of 6 stars.

The calculated comparative energy consumption (CEC) used in the gas energy label is shown as the energy input per metre cubed of space (MJ/m^3) per year. The CEC is based on the heater operating for 600 hours per year to deliver $0.2MJ/h/m^3$ of heat output using the appliance’s calculated appliance operating efficiency and HLR. The output capacity of the gas ducted heater is not displayed on the gas energy label, but is measured as part of the testing and is usually provided in supplier brochures in kW.

Gas space and decorative

Gas space and decorative heaters, like gas ducted heaters, are not covered by the E3 Program. They are, however, required by Australian state and territory legislation and New Zealand national legislation to be tested and certified that they meet the relevant product standards. These gas heaters are required to be certified using the same process described above for ducted gas heaters.

The standards for gas space heaters (AS/NZS 5263.1.3-2016) and decorative appliances (AS/NZS 5263.1.8-2016) include a common Australian and New Zealand standard test method and specific energy efficiency country requirements applicable to Australia or New Zealand. For gas space heaters, the energy label and thermal efficiency requirements of

AS/NZS 5263.1.3-2016 only apply to Australia (section 2.14 Markings and section 5.13 Thermal efficiency). For gas decorative appliances, there are no minimum thermal efficiency or gas energy labelling requirements under AS/NZS 5263.1.8-2016, so these appliances are not required to affix a gas energy label.

The gas energy labelling requirements for gas space heaters described in the AS/NZS 5263.1.3-2016[14] standard include the calculated comparative energy consumption (CEC) which is based on a heater performing the task of releasing heat into a room for a heating period of 5 hours per day, (2½ hours at high setting and 2½ at low [turndown] setting), with a standby period of 19 hours per day for a heating season of 100 days per year. This means the CEC is based on a 500 hours of heating season, which often will be much less than the hours heaters are operated in the colder climates where gas heaters are mainly used, and could result in the calculated annual energy consumption underestimating actual heater consumption.

The CEC is calculated to represent the comparative energy consumption (gas and electricity) of the space heater when operated for one heating season. The CEC is not directly calculated from the net efficiency and net heat energy output, but a ratio of the tested product's net efficiency to a reference heater efficiency of 80 per cent (CEC = 100 (days) x Q_{in} x 80%/$\acute{\eta}_{net}$). The daily energy input (Q_{in}) is effectively the 5-hour operating energy input (weighted equally for high/low settings) plus the standby energy over the remaining 19 hours. The maximum heater output capacity (in kW) is displayed on the gas energy label. These calculations are likely to change with the introduction of the new AS/NZS 5263.1.3-2021, and will be examined in later work.

In addition to these product standards, gas space heaters are required by state and territory legislation to be installed in accordance with AS/NZS 5601.1 *Gas installations Part 1: General installations*. This standard requires the gas space heating appliance (other than a room-sealed type[15]) to meet minimum ventilation requirements to enable safe gas combustion. The ventilation requirements, although required for safe operation, cause additional heat losses in the room, which reduces the effectiveness and efficiency of gas heaters. This heat loss is not included in the current calculations of AEC, efficiency or gas energy label stars, but may be included in future revisions of the calculations as gas heater standards are being reviewed.

[14] AS/NZS 5263.1.3-2021 has recently been published (Feb 2021) and no data for products measured to this new standard have been utilised in this profile.

[15] This describes a heater which draws air from outside for combustion and is often called a balanced flue type heater.

Solid fuel combustion heaters

In Australia, emissions and efficiency limits form part of product certification requirements required under state legislation. The limits are:

- a particulate emission factor not exceeding 1.5g/kg of fuel burnt, based on testing to Australian New Zealand Standard AS/NZS 4013: Domestic solid fuel burning appliances – method for determination of flue gas emission
- an efficiency factor of not less than 60 per cent based on testing to Australian New Zealand Standard AS/NZS 4012: Domestic solid fuel burning appliances – method for determination of power output and efficiency.

In New Zealand, the National Environmental Standards for Air Quality (NESAQ) specify the requirements that must be met for solid fuel burners to be installed in homes on a property of less than 2 hectares:

- a particulate emission factor not exceeding 1.5g/kg of fuel burnt, based on testing to AS/NZS 4013
- an efficiency factor of not less than 65 per cent based on total heat output divided by energy input based on testing to AS/NZS 4012.

NZ's NESAQ is under review with a proposal to reduce the national maximum particulate emissions factor to 1.0g/kg, but leave the efficiency threshold at 65 per cent. Public consultation on proposed changes was open until 31 July 2020, and no announcement of the result of this proposal has been made.

In recognition of the different firewood species used in Australia and New Zealand, the relevant test standards AS/NZS 4012:2014 and AS/NZS 4013:2014 specify softwood for testing in New Zealand and hardwood for testing in Australia.

Some regions of New Zealand specify a more stringent particulate emissions limit as part of local air quality initiatives. For example, the maximum emissions for solid fuel burners installed in Rotorua is 0.60 g/kg. Solid fuel burners being installed in most urban parts of Canterbury must achieve a combined emissions and efficiency standard of 38 mg/MJ (equivalent to 0.5 g/kg and 65 per cent efficiency), based on testing to a simulated real-life method known as the Canterbury Method (CM1).

There are Australian and New Zealand standards for the measurement of particulate emissions and efficiency from pellet fires (AS/NZS 4886:2007 and AS/NZS 5078:2007 respectively). These standards are now 12 years old and a committee has been formed to review them. However, because there is little or no testing to these standards, the review of them has been made a low priority. Most pellet fires arriving in New Zealand are tested to a European standard, such as EN 14785: 2006 *Residential Space Heating Appliances Fired by Wood Pellets - Requirements and Test Methods*.

More details on solid fuel combustion heaters are provided in Appendix 1 – Detailed Information on Solid Fuel Heaters.

Electric resistance (portable and fixed)

There are no energy performance test methods, minimum energy performance requirements or energy rating label requirements for electric resistance heaters. Only electrical safety standards (ASNZS 60335.2.30 2015) are required for compliance and sale. Although electric resistance space heaters are generally considered to convert all electric energy input to thermal energy (100 per cent efficiency), there are different factors that may affect energy use and the comfort of occupants. These include the type of heater (convection, radiant or both), the fan speed (for convection only) and the ability to control the heat output, by a simple linear or fixed heat output control or a thermostatic control.

Hydronic and central boiler systems

Gas boiler central systems, like gas appliances, are not covered by energy performance or energy labelling legislation or by the E3 Program. They are required under Australian and New Zealand gas safety legislation to be tested, certified and to meet the relevant product standards. The Australian gas energy labelling requirement does not apply to these heaters, if they are used for space heating only.

Gas boiler central systems are included in AS/NZS 5263.1.2:2020, which also includes gas fired water heaters for water supply or central heating. Central heating boiler systems are not required to have a gas energy label, but combination appliances (a central boiler that is used for both potable water and hydronic heating systems) in Australia are required to display a gas energy label. The standard includes requirements for testing and calculating the stars and information to be displayed on a gas energy label for potable water heaters. This means that certain gas hydronic systems (those that have a gas consumption rate of less than or equal to 50/MJ/h) are required to carry a gas energy label (water heaters), but if the appliance is only used for a hydronic space heater, the label is not required.

For Australia only, the thermal efficiency of a central heating boiler operating at its nominal gas consumption shall not be less than 75 per cent, when the appliance is tested in accordance with the Test Method in the standard. Alternatively, appliances that are tested and certified to European (EN 15502-2-1, EN 15501-2-2) or North American standards (ANSI Z21.13) and have a declared thermal efficiency over 75 per cent are deemed to conform to this requirement.

In-slab

No energy performance standards or regulations are applicable to electric in-slab heating systems. For hydronic in-slab systems, the only standards applicable are for gas central boilers (minimum 75 per cent thermal efficiency), as discussed above. The Building Code of Australia's National Construction Code (NCC) Volume 2 requires that a concrete slab-on-ground with an in-slab or in-screed heating or cooling system must be insulated with a minimum R-vale of 1.0 around the vertical edge of its perimeter, while the equivalent New Zealand Building Code also has minimum insulation requirements.

Building regulations in Australia and New Zealand

Building regulations apply to the construction and alteration of homes, under Australia's NCC (which includes some state and territory specific requirements) and the New Zealand Building Code. These regulations affect space heating by establishing minimum performance requirements for the building envelope, which affects the heating demand for the building, which in turn affects the size and type of heater that may be suitable for the building.

The regulations also affect heating under the NCC Vol 2. Minimum performance requirements apply to the installation of:

- central heating water piping (the regulations set minimum insulation requirements)
- heating and cooling ductwork (the regulations set minimum insulation requirements)
- electric resistance space heating (the regulations set requirements for separate switches, temperature controls, and time switches for heated rooms).

An updated version of the NCC is under development and expected to be released in 2022 (ABCB, 2019). The changes would update the NCC energy efficiency provisions in consideration of the Trajectory for Low Energy Buildings (the Trajectory). The Trajectory is a plan developed and endorsed by the former Council of Australian Governments Energy Council in 2019, which aims to achieve zero energy and carbon-ready commercial and residential buildings in Australia (COAG, 2019b). For residential buildings the Trajectory suggests increasing the thermal performance and introducing an annual energy usage budget for space conditioning, hot water, lighting and pool pumps.

The changes to the NCC being considered for NCC 2022 include:

- increasing the stringency of the energy efficiency provisions for residential buildings, and
- developing quantified Performance Requirements and compliance pathways enabling compliance using a whole-of-house approach.

Complementary work is underway to Australia's Nationwide House Energy Rating Scheme (NatHERS) to enable it to assess and rate the energy performance of the whole home. This will enable the scheme to cater for the potential future energy efficiency requirements in NCC 2022. The expanded NatHERS will continue to provide information and a star rating of a home's thermal performance. In addition, it will also provide information about the energy performance of a home's appliances and the overall energy performance of the home—that is, the home's thermal performance combined with appliances, including heating appliances. Whole of home tools accredited under NatHERS will help professionals and consumers consider how to balance the overall energy use and budget of new homes to meet the potential updated NCC 2022 energy efficiency requirements, achieve lower energy bills, and a home that is more comfortable and resilient.

In NSW, new residential buildings and large renovations are subject to BASIX (the Building Sustainability Index), the web-based planning tool designed to assess the potential performance of these buildings against a range of sustainability indices, including thermal comfort and energy. BASIX calculates an energy score that meets or exceeds the energy savings target, and considers the type, fuel and efficiency of the heating (and cooling) services.

Other Australian Government programs

There are four energy efficiency schemes operating in Australia that provide incentives for improving the efficiency of appliances, equipment and buildings. The schemes are the ACT Energy Efficiency Improvement Scheme, NSW Energy Saving Scheme, South Australian Retailer Energy Efficiency Scheme and Victorian Energy Upgrades program. These schemes encourage businesses and householders to undertake energy efficiency activities, some of which include upgrading space heating equipment.

The activities supported vary between the schemes. The largest scheme is the Victorian Energy Upgrades program and it has five eligible heating appliance upgrade activities and one gas heating ductwork upgrade activity. The South Australian Retailer Energy Efficiency Scheme is similar with four heating appliance upgrade activities and one gas heating ductwork upgrade activity. The NSW Energy Saving Scheme has three air conditioning and heater upgrade activities for households and one for businesses. The ACT Energy Efficiency Improvement Scheme offers two activities which encourage households to switch from gas heating to reverse cycle air conditioning.

Some of these programs draw upon the GEMS legislation, for example by:

- referring to GEMS efficiency standards to define program activities (i.e. referencing types of equipment changes that will save energy) or to define values used in calculating the energy saving from the activities
- using MEPS to specify the minimum performance of equipment approved to be installed, or
- referring to equipment star ratings to calculate energy savings.

Summary of policies and standards

Table 3 provides a summary of the labelling, standards and regulations for the various heater types

Table 3: Standards and regulations related to energy use by product type

Product Type	Safety and Compliance	Minimum Energy Performance	Energy Labelling	Relevant Legislation
Reverse cycle air conditioners	AS/NZS 60335.2.40:2019, Household and similar electrical appliances - Safety, Part 2.40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers	GEMS Determination and NZ regulations referring to test methods in AS/NZS 3823.4, Performance of electrical appliances - Air conditioners and heat pumps	GEMS Determination and NZ regulations referring to test methods in AS/NZS 3823.4, Performance of electrical appliances - Air conditioners and heat pumps	Australia: GEMS Act, Greenhouse and Energy Minimum Standards (Air Conditioners up to 65kW) Determination 2019. NZ: Energy Efficiency (Energy Using Products) Regulations 2002. Relevant parts of regulations currently being amended.
Gas ducted heaters	AS/NZS 5263.1.6:2020, Gas appliances, Part 1.6: Indirect gas-fired ducted air heaters.	Part of certification / compliance, AS/NZS 5263.1.6, Gas appliances, Part 1.6: Indirect gas-fired ducted air heaters. Minimum thermal efficiency (Australia only) – 70%	Part of certification / compliance, AS/NZS 5263.1.6, Section 2.14.102 Energy label (Australia only)	Australia: States and Territories administer legislation requiring gas products to be certified NZ: Gas (Safety and Measurement) Regulations 2010
Gas space heaters	AS/NZS 5263.1.3., Gas appliances part 1.3: Gas space heating appliances	Part of certification / compliance, AS/NZS 5263.1.3, Gas appliances part 1.3: Gas space heating appliances. Minimum total efficiency (Australia only) – 30% radiant, 60% natural convection, 70% forced convection and room sealed	Part of certification / compliance, AS/NZS 5263.1.3 Section 2.14.102 Energy label (Australia only)	Australia: States and Territories administer legislation requiring gas products to be certified NZ: Gas (Safety and Measurement) Regulations 2010
Gas decorative appliances	AS/NZS 5263.1.8:2016, Gas appliances, Part1.8: Decorative effect gas appliances	No	No	Australia: States and Territories administer legislation requiring gas products to be certified NZ: Gas (Safety and Measurement) Regulations 2010

Product Type	Safety and Compliance	Minimum Energy Performance	Energy Labelling	Relevant Legislation
Wood heaters	Australia: Installations must be carried out in accordance with the Building Code of Australia (BCA) and meet the requirements of AS/NZS 2918. NZ: Building consent from their building consent authority under section 40 of the Building Act 2004.	Part of compliance, AS/NZS 4012, Domestic solid fuel burning appliances - Method for determination of power output and efficiency, for efficiency and AS/NZS4013 Domestic solid fuel burning appliances - Method for determination of flue gas emission, for particulate emissions. Standards for Australia are minimum 60% efficiency and maximum 1.5g/kg emissions. Standards for NZ are minimum 65% efficiency and maximum 1.5g/kg emissions.	AS/NZS 4012 and AS/NZS 4013 detail the requirements for compulsory labelling. AS/NZS 4012 provides separate template labels for Australia and NZ.	Australia: States and Territories administer their own legislation requiring wood heater to meet minimum 60% efficiency and maximum particulate emissions of 1.5g/kg based on testing to AS/NZS 4012 and AS/NZS4013 respectively. NZ: Resource Management (National Environmental Standards for Air Quality) Regulations 2004
Electric Resistance	AS/NZS 60335.2.30 2015, Household and similar electrical appliances - Safety, Part 2.30 Particular requirements for room heaters	No	No	Australia: States and Territories administer identical regulations requiring heater to meet Electrical Equipment Safety Scheme requirements. NZ: Electricity (Safety) Regulations 2010 under the Electricity Act 1992.
Hydronic- Gas	AS/NZS 5263.1.2:2020, Gas appliances, Part 1.2: Gas fired water heaters for hot water supply and/or central heating.	Part of compliance, if gas, central boiler efficiency must be a min of 75% according to AS/NZS 5263.1.2:2020 (for Australia only).	Part of compliance, if gas is used for heating potable water, must meet gas water heater requirements, if in scope of gas consumption (for Australia only).	Australia: States and Territories administer legislation requiring gas products to be certified NZ: Gas (Safety and Measurement) Regulations 2010

Product Type	Safety and Compliance	Minimum Energy Performance	Energy Labelling	Relevant Legislation
Hydronic- Electric	For hydronic fan coil units, AS/NZS 60335.2.40:2019, Household and similar electrical appliances - Safety, Part 2.40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers. Australian standard AS 2870 – Residential Slabs and Footings Construction for hydronic heating	No	No	Australia: States and Territories administer identical regulations requiring heater to meet Electrical Equipment Safety Scheme requirements. NZ: Electricity (Safety) Regulations 2010 under the Electricity Act 1992.
In Slab- Electric	AS/NZS 3100 for electrical in-slab BCA NCC Vol 2 for minimum slab insulation. Building Code for NZ.	No	No	Australia: States and Territories administer identical regulations requiring heater to meet Electrical Equipment Safety Scheme requirements. The NCC is implemented, with variations, under State building regulations. NZ: Electricity (Safety) Regulations 2010 under the Electricity Act 1992. Building requirements in Building Code contained in the Building Act 2004.
In Slab- Hydronic (gas)	Australian standard AS 2870 – Residential Slabs and Footings Construction for hydronic heating	See Hydronic - gas	No	See above

International Approaches

International approaches: Summary

The European Union has Energy Labelling requirements applicable to heating equipment under the Energy Labelling Directive (2010/30/EU) and minimum performance requirements regulations under the Eco Design Directive (2009/125/EC). These apply to reverse cycle air conditioners, local space heaters and central space heaters (which typically distribute heat via heated water), and they are labelled under differing regulations. The energy labelling program varies with technology type, but all technologies use a common label format and efficiency rating scale. The energy label conveys the relative seasonal energy efficiency of the equipment, based on the delivered[16] *energy used by the equipment. For local heaters and central heating, the seasonal energy efficiency is based on primary*[17] *energy.*

In the United States of America (US), appliance labelling and minimum performance requirements apply to heaters. The mandatory labelling program is called the EnergyGuide label. This label requirement applies to all central ducted air conditioners and heat pumps (i.e. split systems and packaged air conditioners) with an output of less than 19kW and the label shows both cooling and heating efficiency, using the Seasonal Energy Efficiency Ratio (SEER) and the Heating Seasonal Performance Factor (HSPF). The EnergyGuide label requirements also apply to central furnaces and boilers used for ducted central heating and their efficiency is measured by annual fuel utilisation efficiency (AFUE). The AFUE is the ratio of annual heat output of the furnace or boiler compared to the total annual fossil fuel energy consumed. The EnergyGuide label has a common label format for all heater types covered.

The US also has a voluntary labelling scheme for higher performance products: the ENERGY STAR program. Products can be certified under ENERGY STAR and carry the label if they use a specified amount less energy than non-certified models. The specified amount of reduced energy consumption required for certification varies with heater type. A version of ENERGY STAR program, used only in the southern US states, specifies lower heater efficiencies, reflecting the milder climates where these heaters are used.

There is no international consensus on whether it is more effective to use nominal primary energy consumption (like the EU) or energy efficiency metrics (like the US) as the basis for the metric on comparative labels.

[16] Delivered energy refers to the energy that arrives at or is delivered to the appliance or equipment that will use the energy. Any energy losses in generating and transmitting the energy are not considered in the energy measure.

[17] Primary energy refers to the total energy used, including upstream losses. So primary energy is the sum of the energy used to generate/convert the transmitted energy, losses in transmission and the final delivered energy.

Europe

The European Union applies both Energy Labelling and minimum performance requirements regulations to heating equipment. The Energy Labelling Directive is implemented under the Energy Labelling Directive (2010/30/EU) while the minimum performance requirements are implemented under the Eco Design Directive (2009/125/EC). Energy Labelling Regulations only cover residential products, but Ecodesign Regulations cover products ranging from residential to commercial and industrial, as shown in Table 4.

Table 4: European energy labelling and minimum energy performance regulations by type of heater

Scope	Energy Labelling Regulations	Ecodesign Regulations (for minimum performance)
Air-to-air heat pumps ≤ 12 kW	(EU) 2011/626	(EU) No 206/2012
Air-to-air heat pumps > 12 kW	NA	(EU) No 626/2011
(Industrial/commercial) air heating products, cooling products, high temperature process chillers and fan coil units	NA	(EU) 2016/2281
Local space heaters (domestic) ≤ 50 kW	(EU) 2015/1186	(EU) 2015/1185 (EU) 2015/1188
Local space heaters (commercial) ≤ 120 kW	NA	(EU) 2015/1185 (EU) 2015/1188
Solid Fuel boilers	(EU) 2015/1187	(EU) 2015/1189
(Central) Space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device	(EU) No 811/2013 (Updated 2017)	(EU) No 813/2013

Source: www.ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products/list-regulations-product-groups-energy-efficient-products

Reverse cycle air conditioners, local space heaters (gas space and wood heaters) and central space heaters are labelled under different regulations. There are differences in the design of the label depending on the technology, but all labels use a common format and include an efficiency rating scale. The basis for measuring the energy efficiency (or seasonal space heating energy efficiency) is different for each of the energy labelling regulations. In summary the energy efficiency is measured as follows:

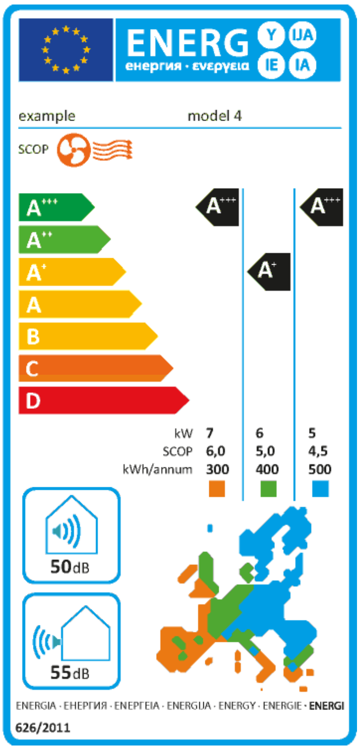
- air conditioners (air-to-air heat pumps)
- heat output divided by the delivered (electric) energy consumption
- local space heaters (gas space heaters, solid fuel heaters but excluding electric resistance heaters)
- heat output divided by the primary energy consumption
- solid fuel boilers (used in central heating systems)
- heat output divided by the primary energy consumption

- central (hydronic) heating systems (gas, electric resistance/heat pump, solid fuel, biomass or fossil fuels)
- heat output divided by the primary energy consumption.

The energy efficiency is converted into an Energy Efficiency Index (EEI) for use in the label scale of A+++ to G. For air conditioners, the EEI is based on the seasonal energy performance, which takes into account the part load conditions and outside climate conditions. For other products, the EEI includes adjustment factors for use of different types of temperature controls, solar and biomass (if applicable).

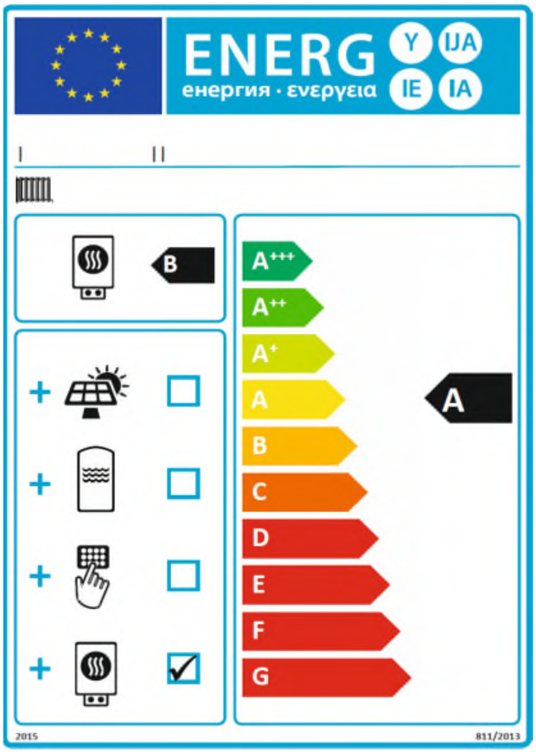
The label for reverse cycle air conditioners includes a climate zone map. An example for a heating only air conditioners is shown in Figure 41. The energy label conveys the relative seasonal energy efficiency of the equipment, based on the delivered energy used by the equipment.

Figure 41: EU Energy Rating label for reverse cycle air conditioner (heating only)



In the EU, homes are commonly heated by central heating systems, which use heated water to distribute heat throughout the home. In relevant EU legislation, these central heaters are called 'space heaters' and are defined as: "provides heat to a water-based central heating system in order to reach and maintain at a desired level the indoor temperature of an enclosed space such as a building, a dwelling or a room; and is equipped with one or more heat generators". This means the EU space heater label applies to boilers and components of the boiler central heating systems. An example of the label for central boiler space heater systems is shown in Figure 42.

Figure 42: EU Energy Rating label for package of central boiler, temperature control and solar device

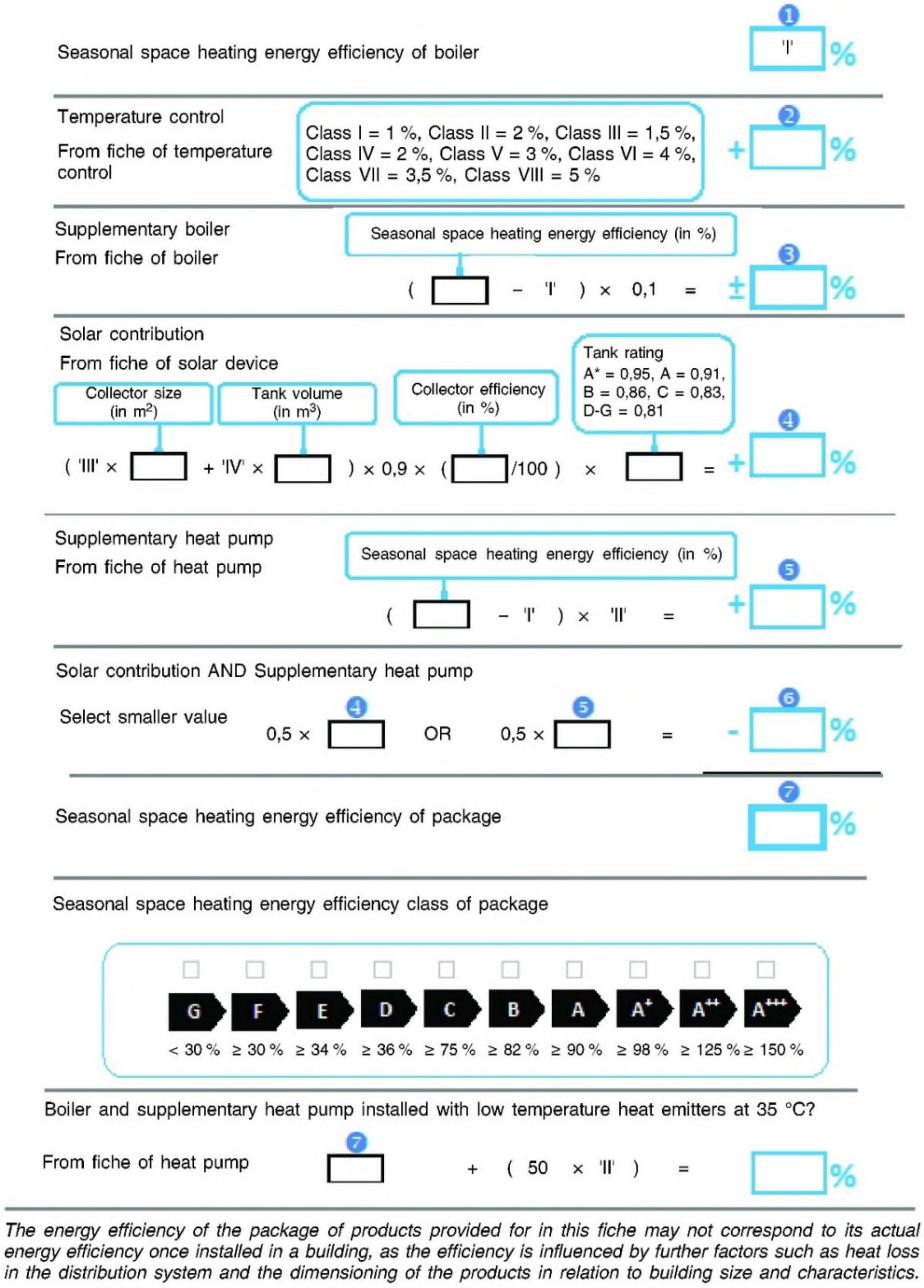


The energy label for central boilers is prepared for each installed boiler, based on a calculation of the energy efficiency of the system, i.e. on the boiler and associated heating components. A calculation algorithm incorporates the boiler's seasonal space heating energy efficiency and various negative and positive correction factors related to the specific system, such as (negative) auxiliary electricity consumption, standby heat losses, and ignition burners; (positive) cogeneration and temperature control type. The dealer supplies information on the components of the system, based on fiche or label information on each component, and uses this information to calculate the energy efficiency of the package.

The complexity of the calculation for boilers with a solar device is simplified for each component of the heating system so that installation contractors and suppliers can calculate the label, as shown in Figure 43. The dealer provides the consumer with the heater label reflecting the mix of components used in their heating system.

For heat pump water heaters and other electric boilers, the electric energy is converted to primary energy by a conversion coefficient (CC). The CC—set at 2.5—reflects the estimated average performance of power generation in the EU of 40 per cent. The CC is being updated in 2020 to 2.1 (European Commission, 2020).

Figure 43: Package of space heater, temperature control and solar device calculations



Delivered and primary energy use in efficiency measures

Delivered energy is the amount of energy delivered into the home without adjustment for any energy loss in its generation, transmission, or distribution. Primary energy is energy in its original form, which has not been converted to another form by human intervention. Some energy sources, such as natural gas and wood, may not need to be converted before they are used, but other energy sources used in the home may be the result of energy conversion processes, such as electricity.

The conversion of energy from one form to another will not be 100 per cent efficient, so the conversion results in energy losses. In the case of coal or gas fired electricity generation, the conversion efficiency is generally 40 per cent or less. The transmission or transportation of the energy or fuel to the home is also not 100 per cent efficient, and results in energy losses. This means the amount of delivered energy, i.e. the energy that arrives to be used by an appliance or equipment, will be less than the primary energy used to supply the delivered energy.

If energy efficiency is measured in terms of primary energy use, the measures take into consideration the energy efficiency of the equipment, plus the energy efficiency of the energy conversion and delivery process. Primary energy efficiency measures therefore can be regarded as a more comprehensive measure of energy efficiency, because they include the energy losses in generation, conversion, distribution and transportation.

The difference between the primary energy efficiency and delivered energy efficiency of appliances that directly burn their fuel, such as gas heaters and wood heaters, is usually minimal as the fuel is a primary energy source (i.e. not converted) and transport losses are small. There are large differences, however, for the primary energy efficiency and delivered energy efficiency of appliances that use electricity. Generation of electricity from primary fuels creates large energy losses in the conversion to electricity, and electricity distribution may involve significant energy losses.

An example of the use of a primary versus delivered energy efficiency measurement for heaters will help to illustrate the differences between the two approaches. The average energy efficiency of gas space heaters and electric resistance heaters in Australia is as follows:

- Gas heater (flued): has a delivered energy efficiency of 77 per cent, and a 77 per cent primary energy efficiency if 100 per cent conversion efficiency is assumed.
- Electric Resistance Heater: has a delivered energy efficiency of 100 per cent, and a 47 per cent primary energy efficiency, based on an average Australian electricity generation efficiency of 50 per cent and 5 per cent network losses.

Using delivered energy efficiency, the electric resistance heater appears the most efficient, but if primary energy efficiency measures are used the opposite result is obtained and the gas heater appears more efficient. The choice of energy efficiency measure therefore can have a significant impact on the measure of energy efficiency for an appliance and the message to the consumer an energy label based on that measure will have.

The EU uses primary energy efficiency measures in their energy labelling program for central and local space heaters, and delivered energy efficiency measures for reverse cycle air conditioners. Most non-European nations though use delivered energy efficiency measures of appliances and equipment for their energy labelling schemes (e.g. Australia, United, States, Canada, Japan, South Korea). Delivered energy measures are also used in the Australian gas energy labels.

The United States

Central air conditioners and heat pumps

Labels

Under *US Energy Policy and Conservation Act 1975* (EPCA), the Department of Energy's (DOE) energy conservation program consists of four parts: (1) testing, (2) labelling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures.

There are two levels of labelling applied to space heaters in the US, namely the EnergyGuide label and the ENERGY STAR label. Both labels communicate the energy efficiency of heating products based on the energy directly used by the product (delivered energy), and do not consider primary energy use. The EnergyGuide label provides consumers with information on the relative efficiency of their heaters, while the ENERGY STAR label in an endorsement label indicating the product is a high efficiency product.

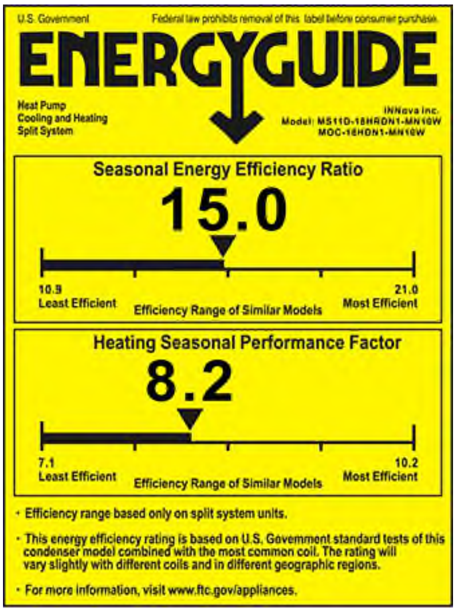
The EnergyGuide label applies to central air conditioners and heat pumps with an output of less than 65,000 BTU[18]/hr (19kW), and to boilers and furnaces, as discussed in the next section. The label shows both cooling and heating efficiency, using the Seasonal Energy Efficiency Ratio (SEER) and the Heating Seasonal Performance Factor (HSPF) for the heater on two scales that range from the least efficient model in the relevant product category to the most efficient.

HSPF is the total heat supplied to the conditioned space during the annual heating season, expressed in BTU, divided by the total electrical energy consumed by the air conditioner or heat pump during the same season, expressed in watt-hours. It is therefore a ratio of heat energy output to electrical energy input.

SEER is just like HSPF, except it describes energy efficiency over a cooling season. SEER is the total heat removed from the conditioned space during the annual cooling season, expressed in BTU, divided by the total electrical energy consumed by the air conditioner or heat pump during the same season, expressed in watt-hours. An example EnergyGuide label for a split system heat pump is shown at Figure 44.

[18] BTU stands for British Thermal Units, with one kWh = 3,412 BTU.

Figure 44: Example of US EnergyGuide label for central air conditioning



The ENERGY STAR program applies to heat pumps, central air conditioners and to gas boilers. ENERGY STAR certification means that an appliance will use less energy than non-certified models. The requirements for certification for air source heat pumps and for central air conditioners are shown in Table 5.

Table 5: ENERGY STAR minimum efficiency requirements for heat pumps, central air conditioners

Equipment Type	Heating Minimum Efficiency	Cooling Minimum Efficiency
Air-Source Heat Pumps - Split	≥ 8.5 HSPF	≥15 SEER and ≥12.5 EER
Air-Source Heat Pumps - Packaged	≥ 8.2 HSPF	≥15 SEER and ≥12 EER
Central Air Conditioners - Split	Not Applicable	≥15 SEER and ≥12.5 EER
Central Air Conditioners - Packaged	Not Applicable	≥15 SEER and ≥12 EER

Note: Energy Efficiency Ratio (EER) is the average rate of space cooling delivered divided by the average rate of energy consumed. Central Air Conditioners are cooling only.

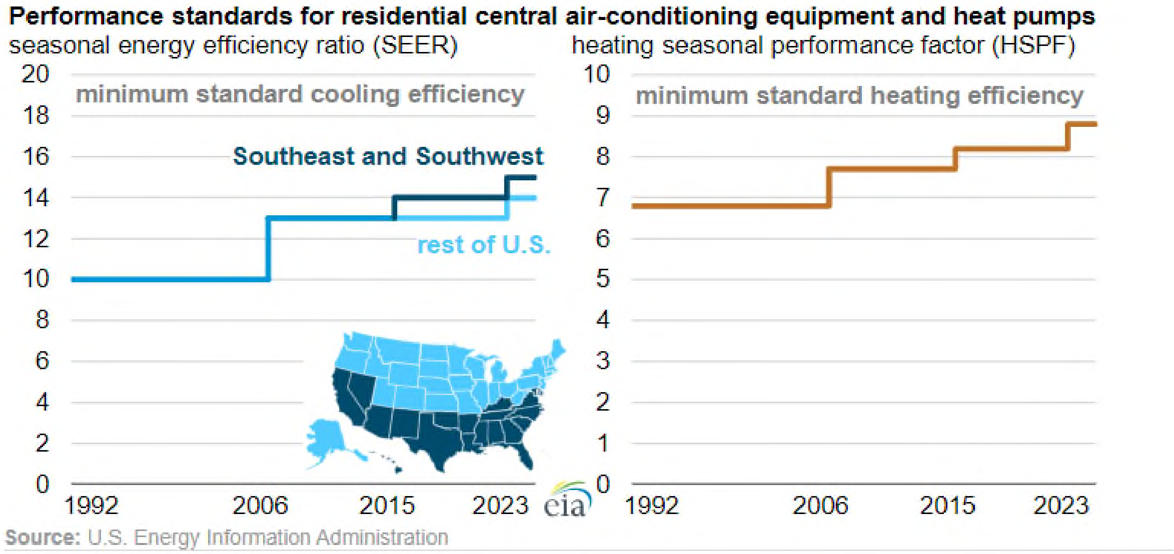
Appliances meeting the ENERGY STAR criteria are entitled to have an ENERGY STAR sticker affixed to them to show that they meet the higher efficiency standard, as shown in Figure 45.

Figure 45: ENERGY STAR logo

Energy conservation standards

Minimum energy efficiency performance standards for air conditioners and heat pumps have been increased periodically over the last 28 years as shown in Figure 46 below.

Figure 46: Performance standards for residential central air conditioners and heat pumps



The National Appliance Energy Conservation Act of 1987 established the first minimum efficiency requirements for central air-conditioning and heat pump equipment sold in the US. These standards went into effect in 1992, and later updates went into effect in 2006 and 2015. The minimum energy efficiency standards cover both ducted and non-ducted split system central air conditioners and heat pumps, single package central air conditioners and heat pumps, small-duct high-velocity products, and space constrained products.

From 1 January 2023, new minimum energy efficiency standards will apply for all new residential central air-conditioning and air-source heat pump systems sold in the US. The new standards require an increase in the minimum heating efficiency of air-source heat pumps (measured by the equipment's HSPF). The minimum HSPF will be 8.8 (compared with 8.2). The new standards also require a SEER of no less than 14 for residential systems in the northern part of the United States and of no less than 15 in the southern part, where cooling loads are a larger share of home energy use. The new standards will also require higher levels of cooling efficiency to apply for central air conditioners sold in the northern parts of the United States and those sold in the southern parts.

Boilers and furnaces

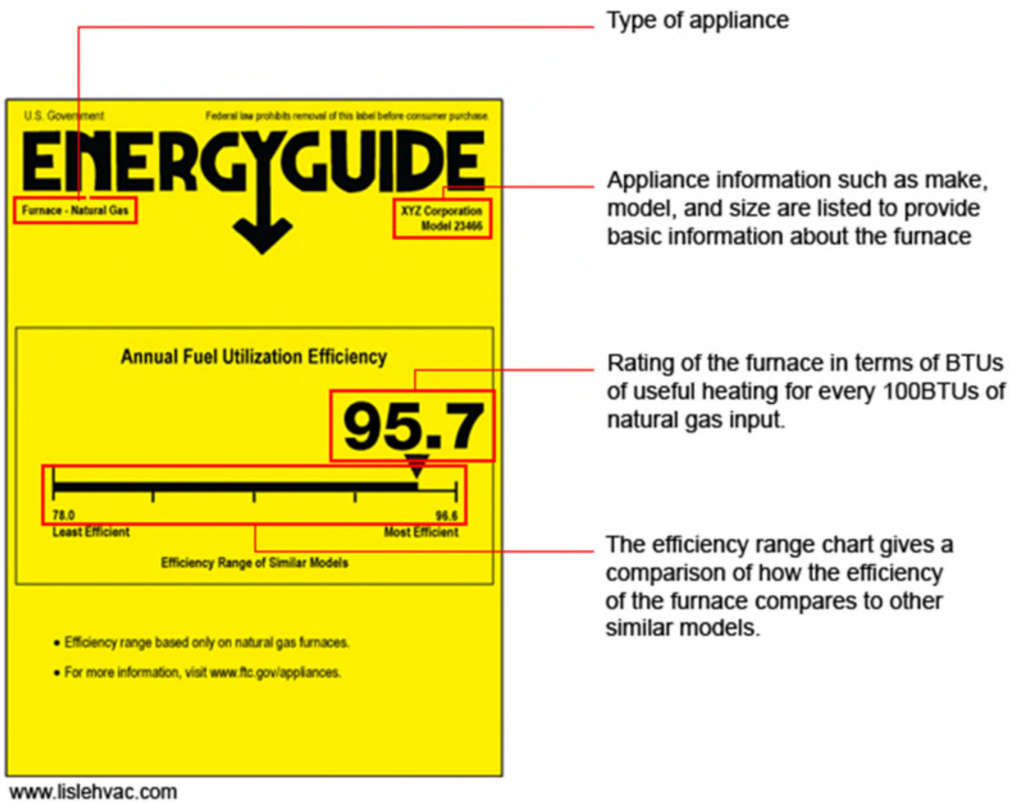
Most United States homes are heated by either furnaces or boilers. Furnaces heat air and distribute the heated air through the house using ducts while boilers heat water which is distributed as either hot water or steam for heating. Both can use gas or oil as a fuel or electricity.

The EnergyGuide label for furnaces or boilers shows their energy efficiency, which is expressed as annual fuel utilisation (AFUE). AFUE is the ratio of annual heat output of the furnace or boiler compared to the total annual delivered energy consumed by the furnace or boiler.

The AFUE does not allow consumers to easily compare the energy efficiency of different boiler or furnace technologies, because different efficiency ranges apply depending on the type of product and fuel. The AFUE also does not account for efficiency losses in duct and piping systems, meaning it is difficult to discern the energy efficiency of an entire heating system that uses a boiler or furnace.

More broadly, EnergyGuide labels use different information to convey the energy efficiency of air conditioners and heat pumps (SEER and HSPF), and boilers and furnaces (AFUE). This means consumers are unable to easily compare energy efficiency performance across those product types. An example of an EnergyGuide labels for gas furnaces is shown in Figure 47.

Figure 47: Example of an EnergyGuide label for a gas furnace.



AFUE is tested in accordance with ANSI/ASHRAE 103-2017, Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers in the US. This test method is applicable to central furnaces with inputs less than 225,000 Btu/h (65.9 kW) and boilers with inputs less than 300,000 Btu/h (87.9 kW). They are typically:

- low-efficiency older heating systems, typically 56 per cent to 70 per cent AFUE
- mid-efficiency heating systems, typically 80 per cent to 83 per cent AFUE
- high-efficiency heating systems incorporating sealed combustion and condensing flue gases in a second heat exchanger, and typically 90 per cent to 98.5 per cent AFUE.

Electric furnaces and boilers have a 100 per cent AFUE.

New minimum energy performance standards for residential hot water boilers will come into effect in 2021. They will raise the minimum efficiency standard for gas-fired equipment to 84 per cent (from 82 per cent) and for oil-fired equipment to 86 per cent (from 84 per cent).

ENERGY STAR certified boilers have annual fuel utilisation efficiency (AFUE) ratings of 90 per cent or greater for gas boilers and 87 per cent or greater for oil boilers. ENERGY STAR certified gas furnaces in the southern half of the United States, where homes require less heat, are labelled with a unique "U.S. South" ENERGY STAR logo shown in Figure 48. These furnaces are up to 11 percent more efficient than standard models available in that region and can save an average of US$30 in energy costs each year.

Figure 48: ENERGY STAR US south label

Certified gas furnaces in the northern half of the U.S. are labelled with the standard ENERGY STAR logo. These furnaces are up to 15 percent more energy efficient than baseline models in that region and can save up to US$85 a year in energy costs.

Comparing the two approaches

Table 6 summarises the labelling approaches Europe and the US.

Table 6: International label summary

Name of label	Energy Labelling (Europe)	EnergyGuide (US)	ENERGY STAR (US)	ENERGY STAR (Southern US)
Products covered	Air to air heat pumps <= 12 kW, local space heaters <= 50 kW, solid fuel boilers, central space heaters and package/combination heaters	Central air-conditioning and heat pumps <19 kW; central boilers and furnaces	Central air-conditioning and heat pumps <19 kW; gas/oil boilers and furnaces	Gas furnaces only
Jurisdiction	EU	All USA	All USA, except for gas furnaces in southern states.	Southern states only
Efficiency metrics used	Seasonal Energy Efficiency: Based on delivered energy for reverse cycle air conditioners, Based on primary energy for local space heaters and central space heaters Calculation for central space heaters incorporates efficiency of most of heating system, not just the boiler	Seasonal Energy Efficiency Ratio (SEER) and the Heating Seasonal Performance Factor (HSPF) for central air-conditioning and heat pumps Annual fuel utilization efficiency (AFUE) for boilers and furnaces All metrics are based on delivered energy	HSPF, SEER, energy efficiency ratio (EER) for central air-conditioning and heat pumps AFUE for gas/oil boilers and furnaces All metrics are based on delivered energy	AFUE for gas furnaces All metrics are based on delivered energy
Relevant standards / regulations	Energy Labelling Directive (2010/30/EU)	US Energy Policy and Conservation Act 1975, and 16 CFR Part 305	US ENERGY STAR Guidelines	US ENERGY STAR Guidelines
Comments	Covers residential scale products. Reverse cycle air conditioners include a climate zone map			In recognition of homes in southern states requiring less heat, the AFUE criteria is less stringent

The largest difference between the two approaches is the EU's use of primary energy efficiency measures in their energy labelling program for local and central heating systems, which differs from that of the United States and other nations with labelling schemes that use delivered energy efficiency measures.

Another difference between the two approaches is the EU approach to central space heaters. The EU require dealers to calculate the heating package energy efficiency, so it includes the effect of the components of the system as well as boiler efficiency. In comparison the United States simply rate and label the heater boiler or furnace.

Both the US and European approaches to energy labelling are different to the E3 labelling approaches adopted by Australia and New Zealand.

Neither the EU nor the US energy efficiency measures support comparisons between central (boilers and furnaces) and “local” or room-based heaters, or reverse cycle air conditioners. These limitations reduce the effectiveness of the labels to help consumers compare the energy use and efficiency of the range of space heaters available on the market.

Variations in Heater Performance

Variations in heater performance: Summary

There are a wide range of heaters available on the market in Australia and New Zealand. An effective energy rating labelling scheme covering all heater types could enable consumers to compare the energy use and efficiency of products to make a more informed decision to best meet their heating needs. Consumers would be better able to identify and choose more energy efficient heater types and models.

This section of the document presents information on the energy efficiency of heaters available in Australia and New Zealand. This includes analysis—conducted for this Product Profile—on the variation in energy efficiency among product types (i.e. between technologies) and within each product type (i.e. between models). The results indicate significant variation in the energy efficiency of the available heater types, and in the energy efficiency of models within each heater type (except for electric resistance heaters). This indicates there is scope for introducing effective energy rating labelling and supporting tools to help consumers identify more energy efficient products. Over time this could raise the average efficiency of the heaters in use in Australia and New Zealand.

The analysis in this section also examines the efficiency of heaters in terms of their operating costs and greenhouse gas emissions. This revealed:

- *Operating cost measures show a consistent pattern between Australia and New Zealand, with reverse cycle air conditioners the most cost efficient, followed by wood and gas heaters, with electric resistance heaters being the most cost inefficient.*
- *Greenhouse gas efficiency measures of heater types showed different results between Australia and New Zealand, largely due to the differing greenhouse emission factors of electricity in the two countries.*

Efficiency of heaters

Different models of heaters of a similar heater type can vary significantly in their energy efficiency. The variation in efficiency across different types of heaters, however, can be of greater magnitude.

At present the energy labelling, both GEMS and gas energy labelling, compares the efficiency of particular types of heaters with other heaters of a similar type, e.g. gas space heaters to other gas space heaters. These comparisons rely on specific testing methods, calculations of efficiency, methods of comparison and labelling approaches orientated for that type of heater.

The benefits of this information and labelling are that they enable the consumer to compare the efficiency of different heaters of the same type. They also provide manufacturers and retailers with a marketing tool to promote efficiency improvements. However, the current efficiency rating and labelling does not provide consumers with easy access to consistent and fair comparisons across different heater types.

A directly comparative labelling scheme would need to be based on a common definition of energy efficiency applicable across heater types. Existing energy labelling programs define energy efficiency using either a primary energy metric or a secondary energy metric. The following discussion and indicative analysis uses the delivered energy metric as its common energy efficiency measure, that is, the ratio of heat energy out to energy in the appliance (E out / E in). Unless otherwise indicated the findings apply only on the basis of the delivered energy metric. It should be noted that this means that the efficiency of the electrical heating options is higher than would be the case with a primary efficiency metric, while the efficiency of the gas and wood heaters would be largely the same. Primary energy comparisons are discussed earlier on page 82.

The analysis is not a full or comprehensive assessment of the energy efficiency performance of space heaters (either within or across heater types). It does not consider a range of variables that can change how energy efficiency performance is defined or calculated. Some of these variables may include the heating task and typical output capacities (noting that the typical maximum heat output values of certain product types can be very different). Other variables include the effect of location or climate, and certain efficiency losses, such as from ducting. It does not address the implications for using a delivered or primary energy metric as the basis for comparison. It also does not describe the scope and format of energy performance information that the space heater labelling and supporting tools could provide to consumers. It is intended to provide initial information on the performance of residential space heaters and the scope for improvement. Policy options for developing comparative space heating labelling and supporting tools will be explored in further work and in consultation with stakeholders.

Electric resistance heaters

Electric resistance heaters are regarded as 100 per cent efficient because the energy they use is converted into heat in the space where they are used. Due to their technology, there is no technical potential for their efficiency to change and improve.

At 100 per cent efficient, electric resistance are more energy efficient on average than solid fuel or gas heaters, but not as efficient as reverse cycle air conditioners.

It is worth noting that other factors along with the energy efficiency of a heater combine to determine the running costs and greenhouse gas emissions of operating a heater. These include the applicable energy tariffs and the greenhouse gas emission factor of the electricity. These factors are discussed in the section 'Operating cost efficiency and greenhouse gas emissions comparisons', page 102.

Reverse cycle air conditioners

Reverse cycle air conditioners are required to meet minimum energy efficiency standards and to display energy rating labels in both Australia and New Zealand. The GEMS/E3 Registration Database for air conditioners was used to analyse the efficiency of air conditioners on the market.

Data was extracted and analysed for approved reverse cycle single split systems and window wall units, where performance data met the SEER determination 2019 requirements. Single split systems are the vast majority of air conditioners, particularly those used as a space heater, but there are a small number of window wall units and multi split systems also used for heating.

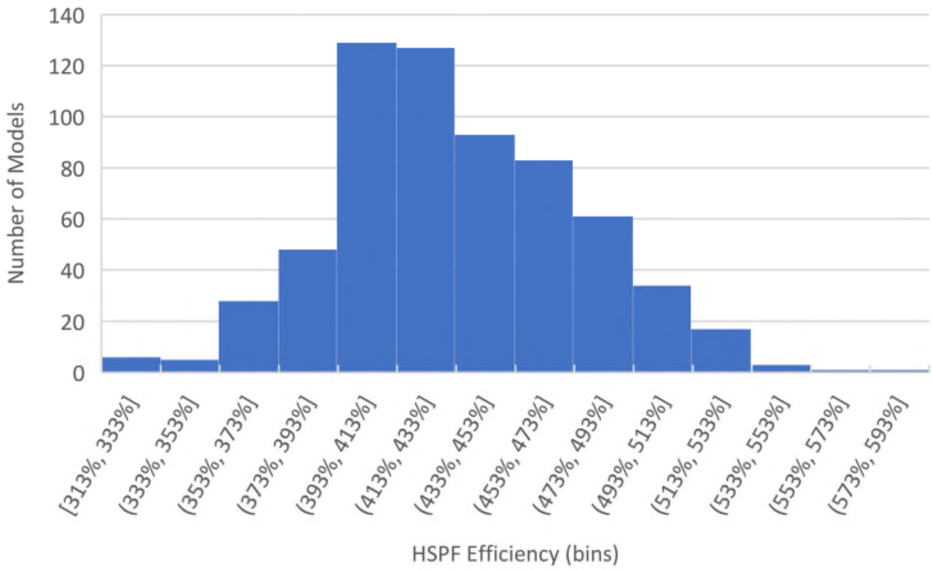
The analysis of the air conditioner data used the residential heating seasonal performance factor (HSPF) in the average climate zone as a measure of heating efficiency and showed they had a high overall efficiency as follows:

- average efficiency was 433 per cent
- minimum efficiency was 313 per cent
- maximum efficiency was 573 per cent.

These figures would be somewhat lower in colder zones (less efficient) and somewhat higher in hotter zones (more efficient). The above 100 per cent efficiency values occur because air conditioners work by extracting heat from the external environment and transferring it into the internal environment, the dwelling. This means their effective heat output can exceed 100 per cent. The energy efficiency of the average air conditioner is much higher than that of all other heating product types.

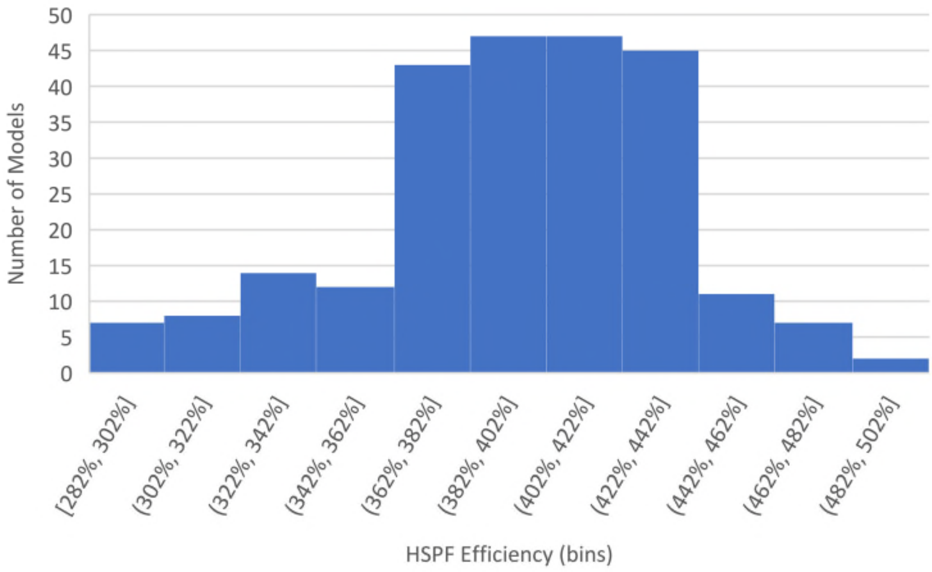
The efficiency values of single split air conditioners indicate large variations in their efficiency (see Figure 49 for non-ducted and Figure 50 for ducted). Within the split systems there is a wide variation in the efficiency of models and many highly efficient models are available. This suggests there is the technical potential for consumers to choose higher efficiency split system products and if undertaken this would raise the average efficiency of split systems sold. Data on window/wall systems did not indicate a similar potential as the spread of efficiency is limited, although this is based on the small number of models with SEER ratings.

Figure 49: Distribution of single split non-ducted air conditioner efficiency ratings



Source: GEMS registry HSPF for average zone, March 2021

Figure 50: Distribution of single split ducted air conditioner efficiency ratings



Source: GEMS registry HSPF for average zone, March 2021

Analysis of the ducted reverse cycle air conditioner data showed they also have a high overall efficiency with an average efficiency (HSPF) of 396 per cent, and a wide range of performance above and below the average.

It should be noted that the method for determining the efficiency of ducted air conditioning systems considers only the air conditioning package or central unit. The efficiency of the entire system, including ducting, to deliver heat to a dwelling is not assessed.

Summary

- The average energy efficiency of reverse cycle air conditioners is very high compared with all other types of heaters.
- For single split systems, which form most of the air conditioner stock in the market, there is technical potential for consumers to choose higher efficiency products and to raise the average efficiency of split systems sold—noting that the GEMS Zoned Energy Label already applies to these heaters.
- The rated efficiency of ducted air conditioners is lower than non-ducted air conditioners, as they are typically larger in size, and efficiency of smaller units is higher. The overall efficiency of ducted systems is likely to be still lower in practice due to the heat losses from ducting (typically 15 to 20 per cent) and other aspects of ducted systems that are not assessed.

Gas heater efficiency

For the gas energy label, the gas heater efficiency is determined by measuring the heat or energy loss of a heater in its exhaust gases via its flue. By comparing the heat lost from the exhaust compared to the energy input, via the gas consumed, an estimate of energy efficiency is obtained. The smaller the heat lost, the greater the efficiency.

In theory, if no heat is lost in the exhaust gases, the heater will be rated 100 per cent efficient. Flueless gas heaters do not lose heat to the external environment, so they are taken to be 90.4 per cent thermally efficient (according to AS/NZS 5263.1.3, 90.4 per cent, which is based on the theoretical combustion efficiency for natural gas to account for the heat that is lost in water vapour when the gas is combusted). However, rooms must be ventilated where flueless heaters are used, which decreases the overall heating efficiency of flueless heaters. The new gas space heating standard (2021) results in new measurement approaches that should lower the rated efficiency of flueless heaters; however, data is not yet available to assess the impact of the new standard.

Non-ducted gas heaters are measured for the efficiency of the gas heater and heat exchanger and are allocated from one to six stars according to their energy efficiency. The star ratings represent energy efficiency scores ranging from 60 per cent to 91 per cent.

Gas ducted heaters are measured for the efficiency of the gas furnace and heat exchanger and are allocated from one to five stars according to their efficiency. The star ratings represent energy efficiency scores ranging from 50 per cent to 90 per cent.

Gas ducted heaters may also receive up to one extra star if they offer a zoning function[19], so some ducted heaters may receive a six star rating. It is noted that some manufacturers are claiming higher than six stars. However the labelling scheme does not allow for these units to record such values. This measurement approach does not account for ducting energy heat losses which could be 15 to 20 per cent in a new installation.

Overall gas heaters as a product type have energy efficiency approximately comparable to solid fuel heaters, but less than the 100 per cent efficiency of electric resistance heaters and much less than 300 per cent of reverse cycle heaters.

Table 7: Energy efficiency statistics for types of gas heaters

Product	25 Percentile Efficiency	Mean Efficiency	75 Percentile Efficiency
Flueless	90%	90%	90%
Radiant/Convection	71%	76%	80%
Wall Furnace	65%	68%	78%
Balanced Flue	71%	77%	82%
Ducted[1]	77%	80%	84%

Note 1: Efficiency of heat exchanger only is calculated for ducted heating, and GTRC data (2020) does not record >6 stars

Databases of certified gas heaters provide information on the star ratings for certified models under five gas heater categories, as well as their comparative energy consumption. Using this information[20], Table 7 shows the estimated mean net efficiency and distribution statistics for the different gas heater types.

This table indicates that according to the gas energy label ratings:

- all flueless heaters are 90 per cent efficient (consistent with the efficiency test's default assumption that they have no heat losses)
- wall furnaces have an average efficiency of 68 per cent
- radiant and convection heaters and balanced flue heaters have higher mean efficiencies at 76 and 77 per cent
- gas ducted mean efficiency is estimated to be 80 per cent.

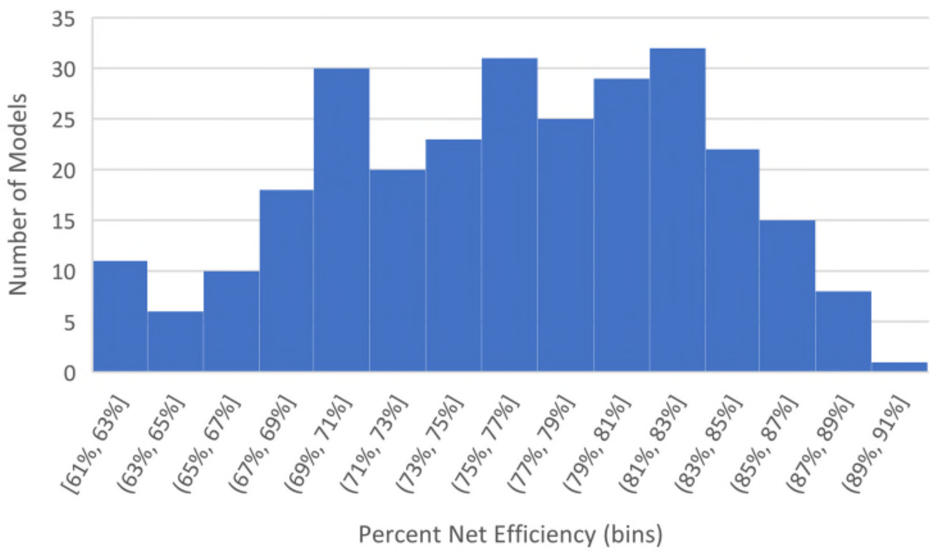
The differences between the mean efficiency and the 75 per cent percentile indicates some limited technical potential for consumers to choose heaters with efficiencies above the average efficiency of all space (non-ducted) heaters, which if undertaken, could improve the average efficiency of heaters sold in the future. As shown in Figure 51, there is a large number of higher efficiency gas space heaters available, which indicates that such heaters

[19] Note: In the analysis of ducted gas heater efficiency it has been assumed heaters with more than 5 stars were allocated an extra star, while those from 4 to 5 stars were allocated an extra 0.5 stars for their zoning capabilities and therefore the star rating was discounted accordingly to calculate the net efficiency.

[20] Gas Technical Regulators Committee (GTRC) holds a database of certified products. This was provided for the analysis in February 2020. See www.equipment.gtrc.gov.au

are commercially viable. However, the technical potential for increased average performance is limited, and estimated to be at best in the order of 5-10 per cent.

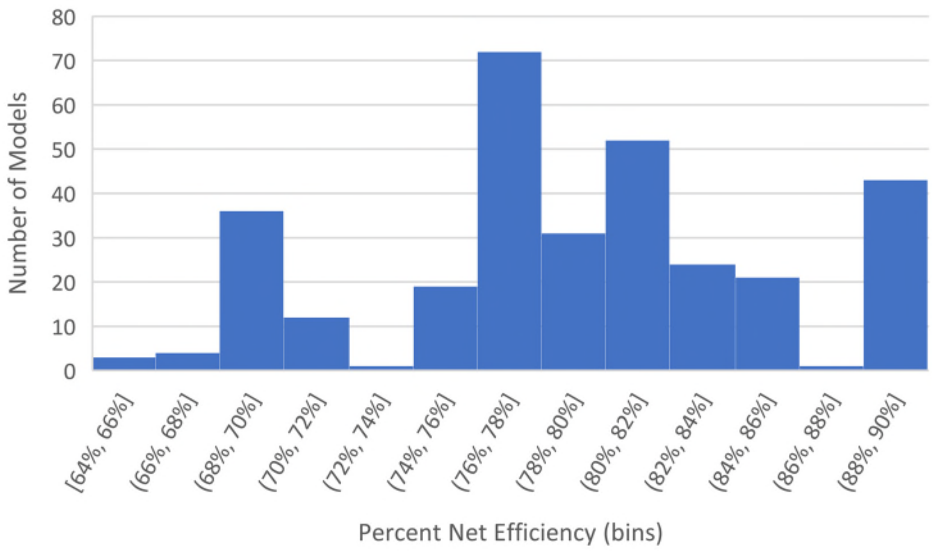
Figure 51: Natural gas space heaters distribution by efficiency (excluding flueless)



There is also some technical potential for the average efficiency of ducted gas heaters to be improved, as indicated by the difference of 4 per cent between the mean efficiency and the 75 per cent percentile. Figure 52 shows that there is a large number of ducted space heaters available with higher efficiency, which indicates such heaters are commercially viable.

Only the efficiency of the heat exchanger is measured in a ducted heating system. When heat losses from ducting are considered, the overall efficiency of ducted gas heaters may be considerably lower.

Figure 52: Gas ducted heaters distribution by efficiency



Summary

- The average energy efficiency of gas heaters is between 68 - 90 per cent, depending on heater type.
- There is some technical potential for the average efficiency of gas space heating to be improved, if consumers choose heaters of above average efficiency, but the potential improvement in the average efficiency of heaters sold is estimated to be only 5-10 per cent.

Solid fuel heaters

In both Australia and New Zealand, solid fuel heaters are subject to efficiency testing as part of the process for meeting national emission and energy efficiency standards. Databases of certified wood heaters are maintained in both countries and can be used to determine the efficiency of heaters and trends in heating efficiency.

The energy efficiency of solid fuel heaters ranges from around 60 to 87 per cent. This means the energy efficiency of the average solid fuel heater is less than the 100 per cent efficiency of electric resistance heaters and comparable to gas heaters.

Australian heaters

In Australia, all wood and pellet burners must be certified as meeting the required standards. The Australian Home Heating Association appears to have the most comprehensive database[21] of solid fuel heaters with over 300 heater models listed.

Analysis of the wood burner efficiency on the AHHA database showed:

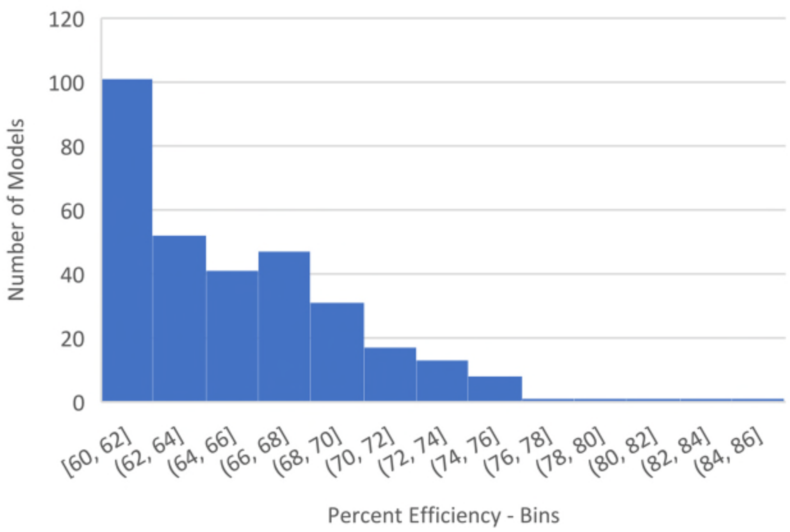
- minimum overall efficiency was 60 per cent[22]
- average overall efficiency was 66 per cent
- maximum overall efficiency was 85 per cent.

This indicates that there is some limited variation in the efficiency of wood burners and, as indicated by Figure 53, there are many models available with above average efficiency. This suggests there is potential for consumers to choose heaters of above-average efficiency and to thereby improve the average efficiency of the wood burners in use.

[21] www.homeheat.com.au/wood-heaters/certified-wood-heaters

[22] ASNZS 4012:2014 require heaters in Australia to meet a minimum efficiency of 60 per cent.

Figure 53: Distribution of wood burner efficiency ratings - Australia

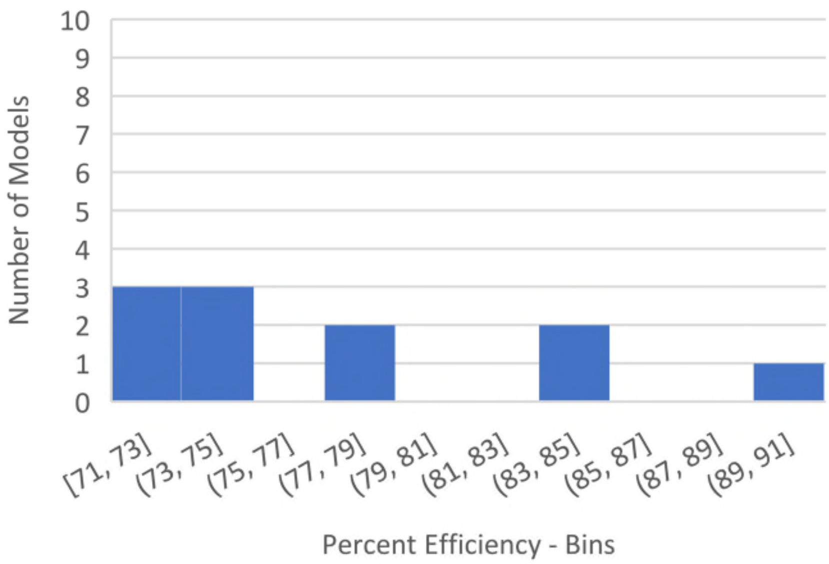


Analysis of the wood pellet burner data, as indicated by Figure 54, showed a higher average efficiency to wood burners but a more limited range of efficiencies and number of models:

- minimum efficiency was 71 per cent
- average efficiency was 77 per cent
- maximum efficiency was 90 per cent.

This indicates there is some limited variation in the efficiency of wood pellet burners but there are few models available with above average efficiency. This suggests there is limited technical potential for the average efficiency of wood pellet burners sold to increase.

Figure 54: Distribution of wood pellet burner efficiency ratings- Australia



New Zealand heaters

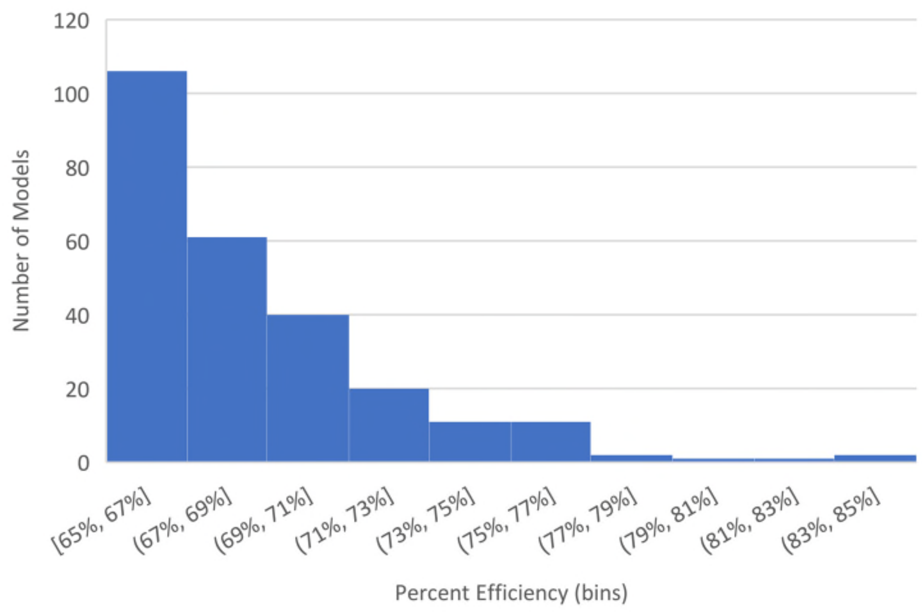
In New Zealand, the Ministry for the Environment provides a database of solid fuel heater models that have been tested and found to meet the National Environmental Standards for Air Quality. Over 340 heater models are listed and most listings contain energy efficiency measurement data.

Analysis of the wood burner data showed:

- minimum overall efficiency was 65 per cent[23]
- average overall efficiency was 69 per cent
- maximum overall efficiency was 85 per cent.

This indicates limited variation in the efficiency of wood burners on the New Zealand market. Figure 55 below shows there are many models available with above average efficiency. This suggests limited technical potential exists for the average efficiency of wood burners to increase. However, there is considerable bunching of models in the 65-67 per cent efficiency range. This may indicate some pressures on the market leading to a focus on the less efficient wood burners. This could be driven by cost or technical factors, and possibly is the result of regional regulations which are restricting the installation of heaters with higher particulate emissions. Designing a low particulate emissions burner generally involves a trade-off between particulate emissions and efficiency levels, which results in the cluster of burners just meeting or exceeding the minimum efficiency level (Strategic Energy Ltd, 2020).

Figure 55: Distribution of wood burner efficiency ratings- New Zealand



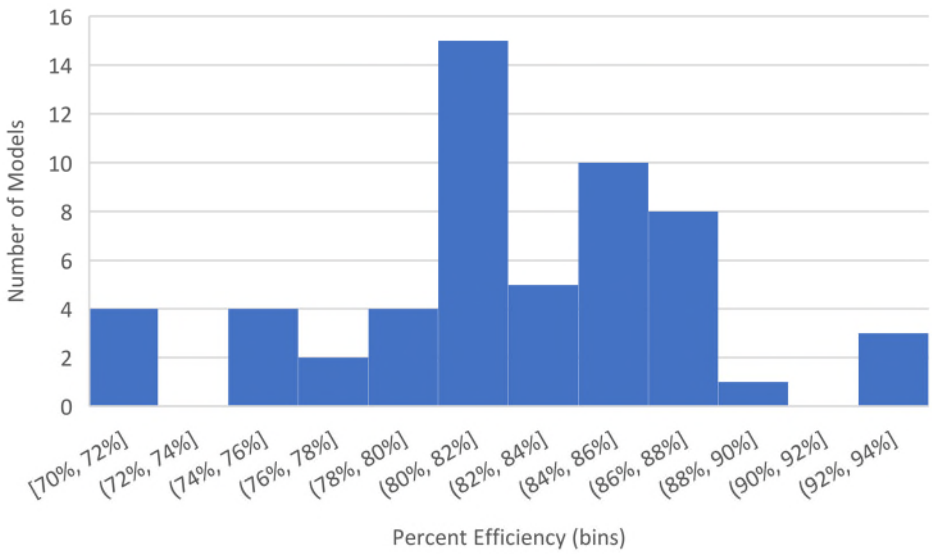
[23] ASNZS 4012:2014 require heaters in New Zealand to meet a minimum efficiency of 65%.

Analysis of the wood pellet burner data showed a higher average efficiency compared to wood burners and a similar range of efficiency variation:

- minimum efficiency was 70 per cent
- average efficiency was 82 per cent
- maximum efficiency was 94 per cent.

This also indicates there is limited variation in the efficiency of wood pellet burners and, as indicated by Figure 56, there are a range of models available with above average efficiency. This suggest there is some limited potential for consumers to choose heaters with above-average efficiency and for the future average efficiency of wood pellet burners sold to increase.

Figure 56: Distribution of wood pellet burner efficiency ratings- New Zealand



Summary

- The average energy efficiency of solid fuel heaters is lower than other heater types.
- There is potential for consumers to choose solid fuel heaters with above-average efficiency and for the future average efficiency of wood pellet burners sold to increase.
- The technical potential for increases in energy efficiency may be limited by requirements for the heaters to meet particulate emissions standards.

Operating cost efficiency and greenhouse gas emissions comparisons

Earlier sections of this product profile have examined the performance of heater types and models according to their energy efficiency. Other aspects of heater performance, including their operating cost efficiency and greenhouse gas emissions intensity, are considered in this section.

Operating cost efficiency

Comparisons of household appliance product operating costs are provided by a variety of energy efficiency and consumer information services, including by the Energy Rating Calculator on the E3 Program's energy rating site. An analysis was undertaken of operating costs of heaters to develop a measure of operating cost efficiency that expressed the average operating costs of different heater types in a common metric. This allowed the relative cost efficiency of the heaters to be compared. A measure of cost efficiency was produced that expresses heat output in terms of dollar energy input, with a higher value indicating greater cost efficiency.

Table 8 and Table 9 below present the analyses for the different heating types in Australia and New Zealand.

Table 8: Operating cost efficiency of heater types-Australia

Australia	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Energy Cost ($/kWh)	0.08	0.08	0.08	0.28	0.28	0.28
Cost Efficiency (kWh heat/$)	9.17	9.53	8.43	3.57	15.47	14.15

Source: Weighted average electricity prices from (ESC, 2020; AER, 2021) default offers (using 2020/21), weighted average gas prices from AER Annual Retail Markets Report 2019-20 (AER, 2020), wood estimated at $350/tonne

Table 9: Operating cost efficiency of heater types-New Zealand

New Zealand	Gas space heaters (excluding flueless)	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	69%	100%	380%	349%
Energy Cost ($/kWh)	0.13	0.09	0.29	0.29	0.29
Cost Efficiency (kWh heat/$)	5.74	7.77	3.44	13.05	11.99

Source: Energy prices from (MBIE (NZ), 2021), wood estimated at $400/tonne, note, the cold zone is used for efficiency of AC

This analysis shows that, on average, reverse cycle air conditioning (AC) is the most cost-efficient heater type, followed by wood or gas (depending on the country) with electric resistance heaters being the most expensive to operate. There are wide variations in the cost of energy across Australia and this could affect the relative cost efficiency of some heater types. See Appendix 2 – Operating Cost Efficiency and Greenhouse Gas Efficiency for Heaters by State.

This analysis assumes firewood is purchased and the wide variation in wood prices may mean that in some situations, if wood can be obtained cheaply, then wood heating could provide more cost-effective heating. A similar situation would occur for homes with solar PV electricity generation, as this could also lower the cost of operating a reverse cycle air conditioner.

The analysis is also based on the rated efficiency of the heaters (for reverse cycle air conditioners, based on performance in the average climate zone). For ducted heaters, it ignores efficiency losses due to ductwork losses. In practice, flueless gas heaters are also less efficient, due to the need to ventilate the room where they are operating, which would lower their effective heating efficiency. This may mean flueless gas heaters are more expensive to operate than electric resistance heaters.

Greenhouse gas emissions intensity in Australia

Numerous online sites offer consumers advice about the greenhouse gas emissions of residential appliances, including heating. The greenhouse gas emissions intensity of heaters can be determined by considering both the energy efficiency of the heating equipment and the greenhouse gas emissions intensity of the fuel. This is expressed in greenhouse gas emissions produced per kWh of heat output, and emissions expressed in grams of carbon dioxide-equivalent greenhouse gas emissions (CO_2e). A lower value of this greenhouse measure indicates greater efficiency, i.e. less greenhouse gas emissions per unit of heat output.

Table 10 shows that nationally, wood heaters are by far the most efficient in terms of producing minimal greenhouse gas emissions. Reverse cycle air conditioners have the next best emissions intensity, with non-ducted reverse cycle being slightly more efficient than ducted. Gas heaters are less greenhouse efficient than reverse cycle air conditioners and electric resistance heaters are the least greenhouse efficient by a large margin.

The greenhouse emission intensity of electricity also varies between regions, so a State based analysis of greenhouse efficiency has been provided in Appendix 2 – Operating Cost Efficiency and Greenhouse Gas Efficiency for Heaters by State. This analysis reveals that, for States such as Victoria which have a higher electricity emission intensity than the national average, the current greenhouse efficiency of reverse cycle heaters compared to gas heaters is comparable.

The electricity greenhouse gas emissions factors used for the heater calculation are from 2020 (DISER, 2020). Since emissions from electricity generation are falling, the emission intensity of reverse cycle air conditioners and electric resistance heaters is expected to fall over time.

Table 10: Greenhouse gas emissions efficiency by heater type – Australia

Australia	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.0043	0.87	0.87	0.87
Greenhouse Intensity (gm CO2-e /kWh heat)	260	250	7	870	201	220

Source: Scope 2, 3 emission factors from (DISER, 2020)

Australia's National Hydrogen Strategy (COAG, 2019a) identifies the potential to add hydrogen to the natural gas fuel mix in the future. If hydrogen produced from renewable sources was added to the fuel mix, this would lower the greenhouse intensity of natural gas and make gas heaters less emissions intensive.

Greenhouse gas emissions intensity in New Zealand

In New Zealand, as Table 11 below shows, wood heaters are the most efficient in terms of producing minimal greenhouse gas emissions, followed by reverse cycle air conditioners and then electric resistance heaters. Gas heaters produce the most greenhouse gas emissions. Electrically powered heaters have lower greenhouse gas emissions than gas heaters due to the lower greenhouse gas emissions intensity of electricity generation in New Zealand.

The average greenhouse gas emissions intensity of wood heaters and electrically powered heaters for New Zealand differs significantly to averages for Australia. This is due to the different greenhouse emissions factors applying to wood heaters and to electrical grid power in Australia and New Zealand.

Table 11: Greenhouse gas emissions efficiency by heater type – New Zealand

New Zealand	Gas heaters (excluding flueless)	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	69%	100%	380%	349%
Greenhouse Emission Factor (kg/kWh)	0.21	0.015	0.11	0.11	0.11
Greenhouse Intensity (gm CO2-e /kWh heat)	268	22	110	29	31

Source: Scope 3 emission factors from (MfE (NZ), 2020)

Summary

- Energy efficiency metrics can be used as an input for determining other efficiency performance measures.
- Operational cost efficiency metrics show a consistent pattern between Australia and New Zealand, with reverse cycle air conditioners the most cost efficient, wood and gas heaters moderately efficient and electric resistance heaters the least efficient.
- Greenhouse gas efficiency metrics show considerable differences between the performance of heaters in Australia and New Zealand.
- Reverse cycle air conditioners operated in Australia have higher greenhouse gas emissions than similar heaters operated in New Zealand, due to the lower emission intensity of electricity in New Zealand, but they are less emissions intensive to operate than gas heating in both countries.
- Electric resistance heaters have the highest greenhouse gas intensity of heaters in Australia, but in New Zealand have moderate greenhouse gas emissions and a lower greenhouse intensity than gas heating.
- Wood heaters have a low level of greenhouse gas emissions in both countries, although there are differences in how emission factors are calculated, resulting in higher greenhouse gas emissions in New Zealand. Local air pollution is a problem with wood heaters, but this issue is not captured in greenhouse gas efficiency measures.

Future Work

This product profile provides a public set of information on the space heating market in Australia and New Zealand, and on the relevant policies, standards, and existing space heating energy rating schemes. Analysis undertaken for this product profile indicates that the energy efficiency performance of residential space heaters varies within and across heating product types.

Consumer research shows that consumers want energy efficiency and operating cost information to assist them. But the limited availability and presentation of heater energy and operating cost data is a barrier to considering energy efficiency in their heater choice.

Introducing energy rating labelling and supporting tools that provide comparative energy rating labelling information across heater types would enable consumers to compare models and technologies, and make a more informed decision which best meets their heating needs.

The Department of Industry, Science, Energy and Resources and the NSW Department of Planning, Industry and Environment will consult with stakeholders and technical organisations on the development of an energy rating labelling scheme for space heaters. This includes consultation on:

- policy options, including options for how to effectively convey comparative heater performance information
- technical frameworks, including suitable energy efficiency measurement methods and standards.

A Regulation Impact Statement (RIS) process would need to be completed and a decision made by Energy Ministers prior to the introduction of new labelling regulation in Australia and New Zealand. A RIS would analyse the costs, benefits and other effects of proposed regulation. Consultation will be undertaken with stakeholders prior to any final decisions being made. Final decisions on policy will be made by Energy Ministers through the Energy Ministers' Meeting and by the New Zealand Cabinet.

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List of Acronyms

ABS	Australian Bureau of Statistics
AEC	Annual Energy Consumption
AFUE	Annual Fuel Utilisation Efficiency
AHHA	Australian Home Heating Association
BASIX	Building Sustainability Index (NSW)
BTU	British Thermal Unit
CM1	Canterbury Method of wood burner testing
E3	Equipment Energy Efficiency
EECA	Energy Efficiency and Conservation Authority (NZ)
EER	Energy Efficiency Ratio
ESS	Energy Savings Scheme (Australia)
GCV	Gross Calorific Value (of fuel)
GDH	Gas Ducted Heater
GHG	Greenhouse Gas
HSPF	Heating Seasonal Performance Factor
LEB	Low Emission Burner
LPG	Liquefied Petroleum Gas
MEPS	Minimum Energy Performance Standard
MFB	Multi Fuel Burner
MJ	Megajoule
NatHERS	Nationwide House Energy Rating Scheme
NCC	National Construction Code (Australia)
NCV	Net Calorific Value (of fuel)
NZHHA	NZ Home Heating Association
RBS	Residential Baseline Study
SEER	Seasonal Energy Efficiency Ratio
SOE	Seasonal Operating Efficiency
ULEB	Ultra-low Emission Burner
US DOE	United States Department of Energy
VEU	Victorian Energy Upgrades
ZERL	Zoned Energy Rating Label

List of Relevant AU/NZ and international Standards

AS 2870 – Residential Slabs and Footings Construction

AS/NZS 4234:2008 Heated water systems - Calculation of energy consumption

AS 4553-2008 Gas space heating appliances

AS 4558-2011 Decorative gas log and other fuel effect appliances

AS 5263.0-2013 Gas appliances General requirements

AS/NZS 2918: Domestic solid fuel burning appliances - Installation.

AS/NZS 3100:2017 Approval and test specification - General requirements for electrical equipment

AS/NZS 3823.4.2:2014 Performance of electrical appliances - Air conditioners and heat pumps - Part 4.2: Air-cooled air conditioners and air-to-air heat pumps - Testing and calculating methods for seasonal performance factors - Heating seasonal performance factor

AS/NZS 4012: Domestic solid fuel burning appliances – method for determination of power output and efficiency.

AS/NZS 4013: Domestic solid fuel burning appliances – method for determination of flue gas emission.

AS/NZS 4886:2007 Domestic solid fuel burning appliance - Pellet heaters - Determination of flue gas emission

AS/NZS 5078:2007 Domestic solid fuel burning appliances - Pellet heaters - Method for determination of power output and efficiency

AS 5389:2019 Space heating and cooling and ventilation systems - Calculation of energy and comfort performance

AS/NZS 5141: Residential heating and cooling systems - Minimum applications and requirements for energy efficiency, performance and comfort criteria

AS/NZS 5263.1.6:2020 Gas appliances Indirect gas-fired ducted air heaters

AS/NZS 5601.1:2013 – Gas Installations, Part 1: General Installations.

AS/NZS 60335.2.30:2015 Household and similar electrical appliances - Safety Particular requirements for room heaters

AS/NZS 60335.2.40:2019, Household and similar electrical appliances - Safety, Part 2.40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers

ANSI/ASHRAE 103-2017, Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers

ANSI Z21.13-2017/CSA 4.9-2017 - Gas-Fired Low-Pressure Steam and Hot Water Boilers

BS EN 15501:2015 Thermal insulation products for building equipment and industrial installations. Factory made expanded perlite (EP) and exfoliated vermiculite (EV) products.

EN 15502-2-1: 2012 + A1 2016 Gas-Fired Central Heating Boilers - Part 2-1: Specific Standard for Type C Appliances and Type B2, B3 And B5 Appliances of A Nominal Heat Input Not Exceeding 1000 kW

Appendix 1 – Detailed Information on Solid Fuel Heaters

Introduction

Solid fuel heaters are used in 10 per cent of Australian and 30 per cent of New Zealand dwellings but these heaters and their market have not been researched under the E3 Program. Product profiles and other research documents investigating air conditioners and gas heating have previously been undertaken under the E3 Program, so it is appropriate that similar information and research be made available for solid fuel burners. This appendix addresses this lack of publicly available information.

The types of solid fuel heaters available in Australia and New Zealand include wood heaters, multifuel burners and pellet burners. The characteristics of these are discussed in more detail below.

Solid fuel burner efficiency standards and trends

A minimum level of thermal efficiency of 65 per cent has been specified in New Zealand since 2004 under the National Environmental Standards for Air Quality) Regulations 2004. The minimum level in Australia had been 55 per cent and was increased to 60 per cent in 2019, as specified in AS/NZS 4012.

While at first glance the minimum efficiency levels of 60 per cent for Australia and 65 per cent for New Zealand may seem low, it should be recognised that this is measured on a dry fuel basis. This typically results in reported figures used in Australia and New Zealand being around 8 to 10 percentage points below that obtained using a wet fuel basis. European burners tested to European standards e.g. EN303-5:2012[24] have their efficiency reported on a wet fuel basis.

While there is a clear trend for reducing particulate emissions levels, there are no obvious trends with wood heater efficiency levels other than to meet the specified minimum efficiency levels. The burner design process is effectively an optimisation to achieve the required standards of particulate emissions and efficiency. As the allowable particulate emissions level has been reduced over the years, there has been an ongoing trade-off between particulate emissions and heating efficiency. Manufacturers adjust their burner designs to achieve the required level of particulate emissions, generally by increasing the air supply to the burner. However, an increased supply of air results in more heat being

[24] Heating boilers. Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW: Terminology, requirements, testing and marking

lost up the flue (and reduced efficiency). Manufacturers may then find that, in order to meet the efficiency criterion, they need to make changes to regain some of the efficiency lost.

AS/NZS 4012 and AS/NZS 4013 specify requirements for a permanent label to be attached to each heater in a position that is readily visible after installation. The labels contain a variety of information relevant to the appliance and require the words OVERALL AVERAGE EFFICIENCY followed by the calculated efficiency figure. AS/NZS 4012 includes template labels, one each for Australia and NZ.

Data and graphs of efficiency levels from wood heaters and pellet fires for sale in Australia and New Zealand are also shown in this appendix.

Solid fuel heater products

Wood heaters (firewood logs)

Enclosed wood heaters are the most common form of solid fuel combustion heaters in Australia and New Zealand.

Wood heaters generally comprise a single enclosed combustion chamber made of steel or cast iron and lined by firebrick. There are usually one or more air controls which can be manually or automatically operated depending upon the design. The wood heater is typically initially lit manually by the user using a mixture of paper, kindling wood or fire starters[25] and logs. Once the fire is established, the user must place additional logs into the combustion chamber, and can control the amount of heat produced by the wood heater by adjusting the air control position.

Wood heaters release heat through a combination of heat radiation, which heats objects, and convection which heats the air. The amount of each type of heat delivery varies with some models being predominantly one type or the other. A convection heater has a casing around the firebox, and allows air to flow in the space in between. As the air passes the firebox, it is heated by convection. A radiant fire transfers about two thirds of its heat by radiation and one third by convection.

Older style enclosed burners had a wide range of control over combustion air and allowed burners to be ‘turned down’ using the air control lever to effectively smoulder overnight and then be easily restarted the next morning.

Newer models have considerably less scope to control the air flow and thus the rate of combustion. In some cases, particularly with the latest ultra-low emission burners (ULEBs) available in New Zealand, there is no air control. ULEBs were conceived in Canterbury, New Zealand around 10 years ago as an initiative to help address air quality

25 A solidified emulsion of a liquid hydrocarbon

concerns. Their reduced level of air control is a design response to achieving ever stricter allowable particulate emissions levels in Australia and New Zealand.

Multi-fuel burners

MFBs are not sold in Australia but are still sold in New Zealand in small numbers. New regulations proposed for New Zealand in 2020 will effectively ban the installation of new MFBs in New Zealand if the regulations are implemented as currently proposed. Multi-fuel burners (MFBs) can burn firewood logs and coal, although these are unable to be installed in some parts of New Zealand and sales volumes are low. MFBs are a compromise design and have to deal with the quite different combustion characteristics of wood and coal.[26]

The fundamental difference between an MFB and a conventional wood heater is that an MFB incorporates a grate for fuel to burn on whereas a dedicated wood heater is designed for the fuel to burn on a bed of ash. Many MFBs are operated using solely wood as a fuel and thus represent a less clean way of burning wood compared with a modern wood heater. Emissions of modern MFBs are of the order of 3-4 g/kg and thermal efficiency is in excess of 65 per cent.

Wood pellet burners

Pellet fires are designed to burn a standardised fuel, being a pellet made of compressed sawdust or wood waste, in a controlled combustion device. Pellet fires are manufactured overseas (generally Europe and China) and tested to European standard EN 14785. Pellet fires can produce a steadier and more controllable heat output and operate at higher efficiency and lower particulate emissions compared with a conventional wood heater.

Pellet burners provide convenient, easily controllable heating. Their heat output is comparable to conventional wood heaters. Most units have a remote control, thermostat and timer, and light automatically using an electric ignitor coil to ignite the extremely flammable wood pellets.

Pellet burners require an electricity connection in order to drive an auger that feeds pellets from a storage hopper at the back of the unit into the burner. Pellet burners also often incorporate one or more fans to assist with the convection of hot air.

Fuels

Solid fuel heaters can use a range of fuels, but the main solid fuel type in Australia and New Zealand is wood. The type of wood, and especially whether the wood is properly seasoned/dried, will affect its burning properties and heat output. Wood is sourced from commercial suppliers and privately, which may influence its quality and the degree it is seasoned, hence its calorific value. These variations in the quality of the wood will affect

[26] Coal has a high level of fixed carbon and a low level of volatiles whereas wood is the opposite with low fixed carbon and high volatiles. This affects the requirements for primary and secondary combustion air and can result in poor emissions performance if wood and coal are burnt simultaneously or interchangeably in quick succession.

the energy used by the heater and the efficiency of the heater. Heaters designed for wood pellets are generally more efficient than wood log heaters. The type of fuel used by the heater will also affect greenhouse gas emissions, with coal producing significantly more compared to wood logs or wood pellets.

Coal was once a popular fuel for home heating in New Zealand, but its use has declined rapidly. As at the 2018 Census, 1818,800 homes—about 11 per cent of New Zealand homes—used coal for heating, down from 160,000 homes in 1996. In Australia, coal is rarely used for space heating (if ever). In New Zealand, coal is usually burnt in either a MFB or an open fireplace. The combustion of coal for home heating produces a relatively high level of particulate emissions as well as a range of other pollutants such as sulphur dioxide, nitrogen oxides and other toxic contaminants. Because of this, coal burning will likely face increasing restrictions and decline further as a heating fuel.

The following graphs show the distribution of particulate emissions and efficiency for all currently authorised wood heaters and pellet burners in Australia.

Solid fuel burner particulate emissions standards and trends

In both Australia and New Zealand, allowable particulate emissions levels have been continually tightened over recent years as part of moves to reduce air pollution. Some jurisdictions specify a lower maximum emissions limit than specified in New Zealand's NESAQ to help meet their local air quality targets (e.g. Canterbury region). Some Australian local Governments have implemented programs to address air quality issues (e.g. Launceston region in Tasmania).

As shown in Table 12, the allowable level of particulate emissions at a national level has steadily reduced over time. This has encouraged manufacturers and suppliers to continue to design lower particulate emission burners or to source them from overseas, e.g. Europe.

Table 12: Allowable particulate emissions from new wood heaters

Year	AU emissions limit	NZ emissions limit
1992		5.5 g/kg
1999	4.0 g/kg	4.0 g/kg
2004		1.5 g/kg
2015	2.5 g/kg	
2019	1.5 g/kg	
2020 (proposed)		1.0 g/kg

Note that prior to 2015 not all Australian states adhered to the emissions limit in AS/NZS 4013 as this is a voluntary standard. All jurisdictions now support the national emissions limit referred to in the standard.

Certain burner types are not able to be tested using AS/NZS 4012 and AS/NZS 4013, e.g. gasification boilers for central heating systems. These can be tested using a "functionally equivalent method". This is generally a European standard such as EN 303-5:2012

A new European set of standards (EN 16510-1 Residential solid fuel burning appliances - Part 1: General requirements and test methods) is in the process of being developed. This standard is structured to have a set of general requirements and test methods, supplemented by specific procedures for a variety of burner types. This recognises that some aspects of the standard should be common across all types, e.g. calculation approaches, while other aspects are tailored to the particular requirements of a range of different heater types. Efficiency measurement is included in Part 1 of this standard, and Parts 2-1 to 2-6 address the specific requirements that apply to various forms of solid fuel burners such as boilers or pellet fires.

ULEBs represent a step change in the level of allowable particulate emissions. For example, to be classified as ULEB under Environment Canterbury Regional Council, heaters must meet maximum emissions of 38 milligrams per megajoule of useful energy and have a thermal efficiency of 65 per cent or greater, as determined using Canterbury Method 1.[27] This ULEB performance test is a much tougher test than wood burner performance testing under AS/NZS 4013. ULEB burner designs are different to LEB designs in that they generally involve a larger volume of combustion air supplied. Some designs use two combustion chambers (instead of one), where firewood is partially burnt and gasified in the top chamber and then clean combustion of the gases occurs in the bottom chamber. Other ULEB designs have a circulation fan or catalytic combustor[28] fitted in order to improve efficiency or reduce emissions.

As previously mentioned, ULEBs were developed in New Zealand to help address air quality concerns. A new test standard was developed as the basis for testing the particulate emissions of ULEBs before they could be approved for installation as ULEBs in the Canterbury Region. This regional testing method (the Canterbury Method, or CM1) is based on the same test equipment and laboratory set-up as specified in AS/NZS 4012 and AS/NZS 4013 and with changes made to how the appliance is operated. This includes adding a 'real life' component, i.e. changing those specifications from the AS/NZS 4013 standard that relate more closely to how a typical householder might operate their fire in real life. Particulate emissions and efficiency are measured and calculated in the same way as for AS/NZS 4012 and AS/NZS 4013.

CM1 is used throughout Canterbury and is recognised in other parts of New Zealand such as Rotorua, Otago and Nelson. It is not a national standard.

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[27] Available from https://www.ecan.govt.nz/document/download?uri=3109737

[28] A catalytic combustor is a device with a ceramic honeycomb design and is usually coated with palladium or another noble metal to withstand the harsh environment of heating applications. It causes smoke to be burned instead of going up the flue into the atmosphere.

Environment Canterbury's use of the mg of particulate emissions per MJ of total useful heat allows manufacturers some scope to optimise their design to be both clean and efficient. However, all burners installed in New Zealand must also meet a minimum thermal efficiency standard of 65 per cent, based on testing to AS/NZS 4012. Because of the trade-off between particulate emissions and efficiency in the design process the 65 per cent efficiency requirement is constraining the ability of manufacturers to produce burners that meet the tough particulate emissions standards required for burners in some relatively polluted towns and cities.

Solid fuel burner installation standards

All wood heater installations in Australia must be carried out in accordance with the Building Code of Australia (BCA) and meet the requirements of AS/NZS 2918: Domestic solid fuel burning appliances - Installation.

In New Zealand building owners planning to install, replace or modify a solid fuel heater are required to obtain a building consent from their building consent authority under section 40 of the Building Act 2004.

The ultra-low emission burner era in New Zealand

The first Ultra-Low Emission Burners (ULEBs) to be authorised around 2015 were of a downdraught design effectively using two chambers for combustion. Wood is placed into the top chamber where it is partially burnt and gasified. When the fire has reached a high enough operating temperature, the operator pulls a handle (or this is done automatically in the case of the RAIS Bionic Fire) to switch the burner to downdraught mode. This diverts primary combustion gases from the top chamber into the bottom chamber, where secondary gas combustion takes place.

More recently, various New Zealand manufacturers have developed single chamber designs that, in some cases, are variations to an existing low emission burner design made in order to meet the ULEB criteria. This has generally involved design modifications that increase the primary and secondary air supply and improve the air distribution within the combustion chamber to improve combustion and reduce the particulate. However, this has the effect of reducing efficiency, as a greater air supply in the chamber results in more heat being lost up the flue. Design changes are required to mitigate this, such as increasing the heat transfer surface area or incorporating an air circulation fan into the design.

Another design concept that has appeared in the last two years is a single chamber design with primary air supply only, supplemented by the incorporation of a catalytic combustor in the base of the flue. This type of burner achieves low particulate emissions by channelling the combustion gases through a catalytic combustor while in normal operating mode which combusts unburnt components thereby reducing particulate emissions entering the flue.

Pellet burners

Pellet burners are designed to burn a standardised fuel, being a pellet made of compressed sawdust or wood waste, in a controlled combustion device. Pellet burners are manufactured overseas and generally tested to European standard EN 14785. Because of the standardised nature of the fuel and the controlled combustion occurring in a pellet burner, there is likely to be little difference between test results and real-life operation of the burner and certainly much less than would be the case for a conventional wood heater.

Wood pellet fuel is made from waste wood shavings, sawdust and offcuts (typically pine), sourced from New Zealand's plantation forestry sector and the timber processing industry. Wood pellets are essentially compressed sawdust parcels that are uniform in size and shape and are typically held together with 100 per cent naturally occurring lignin. They also have a relatively standard moisture content, which is lower than that generally found with firewood logs. The standardised nature of the product means that they can be burnt reliably and consistently in a pellet burner to deliver not only a consistent level of heat, but also predictable levels of particulate emissions and efficiency.

Domestic scale pellet fuelled boiler systems are available in New Zealand for producing hot water that can be circulated through a radiator system for home heating.

Pellet fuel is manufactured in New Zealand as well as in Tasmania and Victoria.

Multi-fuel burners (MFBs)

Firewood may also be burnt in multi-fuel burners (MFBs). MFBs are an enclosed burner design with air controls, like wood heaters but can burn a range of solid fuels, generally wood and coal. MFBs burning wood and coal are available in the New Zealand market from suppliers such as Yunca, Harris Home Fires and Jayline.

MFBs are a compromise design and must deal with the quite different combustion characteristics of wood and coal. Coal has a high level of fixed carbon and a low level of volatiles whereas wood is the opposite with low fixed carbon and high volatiles. This affects the requirements for primary and secondary combustion air and can result in poor particulate emissions performance if wood and coal are burnt simultaneously or interchangeably in quick succession.

Particulate emissions rates for MFBs are at least two to three times that of pure wood burners. As a result of this, it is likely that MFBs will have a limited future in NZ.

MFBs are not sold in Australia.

Sales data

In Australia there is no national collation of sales data on wood heaters. The Australian Home Heating Association (AHHA) monitors volumes of wood heaters sold by their members and their membership fee is based on a $10/burner fee which provides an easy way to monitor total sales by members. However, two major suppliers are not members of the AHHA and estimates of their sales volumes are required to provide an estimated total sales figure for the country as a whole.

National wood heater sales over the last eight years have varied between 33,000 and 38,000 pa. There is no trend over this time with sales volumes varying because of factors such as winter temperatures and economic conditions. The AHHA considers that sales will rebound to around 40,000pa.

Recent sales figures are well down from earlier data which shows a peak sales volume of 120,000 in 1988. There is no recent split of sales by state available, but the following split of sales data from 2007/08 is available (NEPSC, 2013) as shown in Table 13.

Table 13: Wood heater sales share by state

State	Percent Share
NSW/ACT	38%
VIC	26%
QLD	11%
TAS	10%
WA	9%
SA/NT	6%

The AHHA reported that around 85 per cent of new heater sales in 2012/13 were for homes in rural and regional areas. Replacement rates for wood heaters vary from 0.3 per cent in Adelaide to 3.5 per cent in rural and regional Tasmania.

The average lifespan of a wood heater operated in Australia or New Zealand is estimated to be 15-20 years.

In New Zealand, as for Australia, there is no formal national collation of sales data on wood heaters. Individual territorial authorities (TAs) around New Zealand are responsible for issuing consents for the installation of wood heaters and hold data for their respective jurisdictions. However, there are 67 TAs in New Zealand and they each hold data in different formats and to varying degrees of quality. It would potentially be possible to compile data from each TA, but this would be a time-consuming process. Alternatively, BRANZ have data on wood burner penetration that could be used to estimate numbers.

The New Zealand Home Heating Association (NZHHA) has provided an estimate of the current sales volume of wood heaters in New Zealand of 10,000pa. The current trend is for a softening in sales volumes. Possible reasons for this softening include:

- an increasing desire for the simplicity of reverse cycle air conditioners
- improving energy efficiency of new homes meaning that less heat is required, so smaller heaters such as reverse cycle air conditioners can be installed
- confusion and lack of awareness as to what forms of heating are allowed in various regions. Regulations vary from region to region and change from time to time within a region. For example, there is still a belief by some that solid fuel burners are not able to be installed in Christchurch, despite the law having changed to allow ULEBs in 2012 and the first ULEBs appearing on the market at the beginning of 2015.

The New Zealand market comprises sales from a range of New Zealand manufacturers as well as European imports. Increasingly now, manufacturing is also done in countries such as India and China in a bid to keep prices affordable. In Australia, 75 per cent of wood heaters sold in 2007/08 were manufactured in Australia. By 2019 this figure has reduced to just 20 per cent Australian manufacture with most imported wood heaters being manufactured in China.

In New Zealand and Australia there is a clear trend in declining levels of particulate emissions from wood heaters over time. This has been driven largely by ongoing reductions in the allowable level of particulate emissions at a national level and in those set by various regional councils.

In New Zealand, the latest range of single chamber ULEBs has simplified manufacturing and led to further cost reductions. The latest single chamber ULEB from Harris Home Fires retails for $3400. This compares with similar specification LEBs in their ranges from $1650 to $2675. Pioneer Manufacturing offers a 15kW wood heater for $2675 in ULEB specification or $1749 in LEB specification, representing a price premium of $926 for the ULEB version. These costs exclude installation and Council permits which would typically be of the order of $1000 and $400 respectively. So, while ULEBs are still more expensive than LEBs, the price premium is declining.

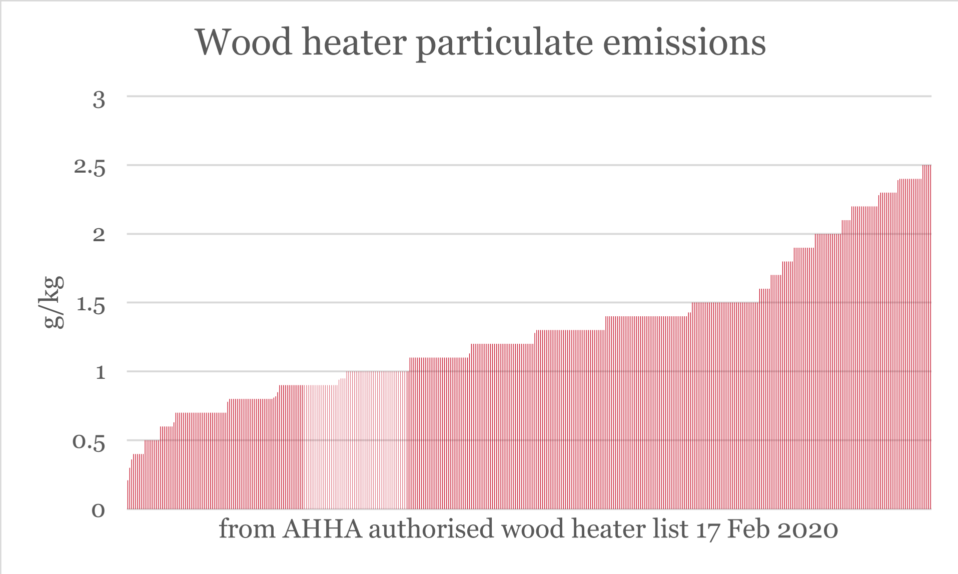
In New Zealand approximately 350 pellet fires are sold annually. Pellet fires offer consumers a simpler, more controllable form of heating than a conventional wood heater, yet still having the desired flame effect. In New Zealand there are two distinct sales groupings for pellet fires: a “high end” where products are typically European models and a more budget oriented sector where products are typically sourced from China. The popularity of pellet fires varies considerably from place to place and is driven by the strength of retailers of pellet fires in various locations such as Christchurch, Timaru, Dunedin and the central North Island. An observed trend with pellet fires is a move towards smaller units, e.g. 6kW, likely as a result of new homes becoming more energy efficient and needing less heating.

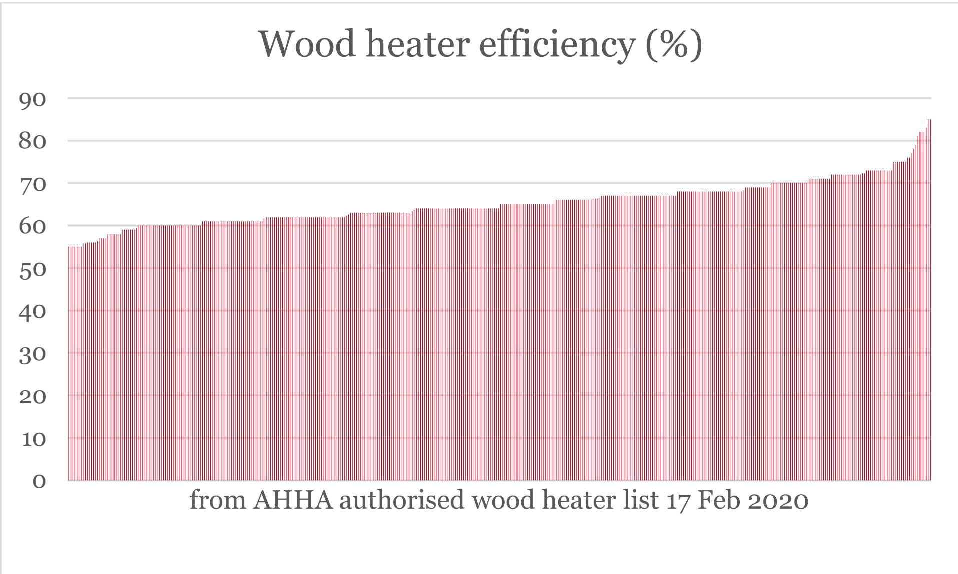
Pellet fire sales in Australia are very low, of the order of 100 pa. There are small pockets of pellet fire sales in regions such as Tasmania and Victoria driven by the availability of fuel and strength of pellet fire retailers.

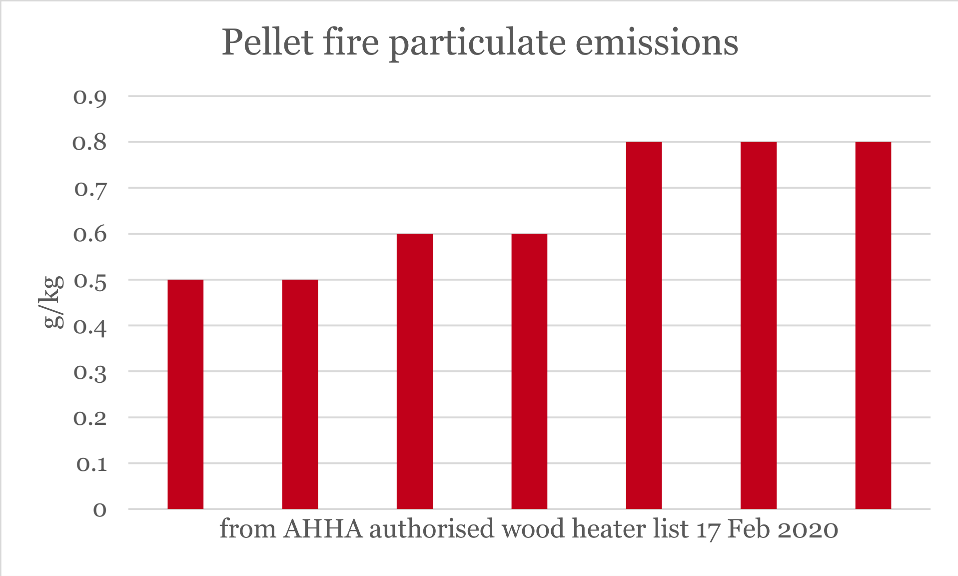
Sales of open fires and MFBs are low and declining in NZ. Should they be brought under the National Environmental Standards for Air Quality (NESAQ) as is proposed, then they will effectively be prohibited in New Zealand as they will not meet the particulate emissions and/or efficiency standards.

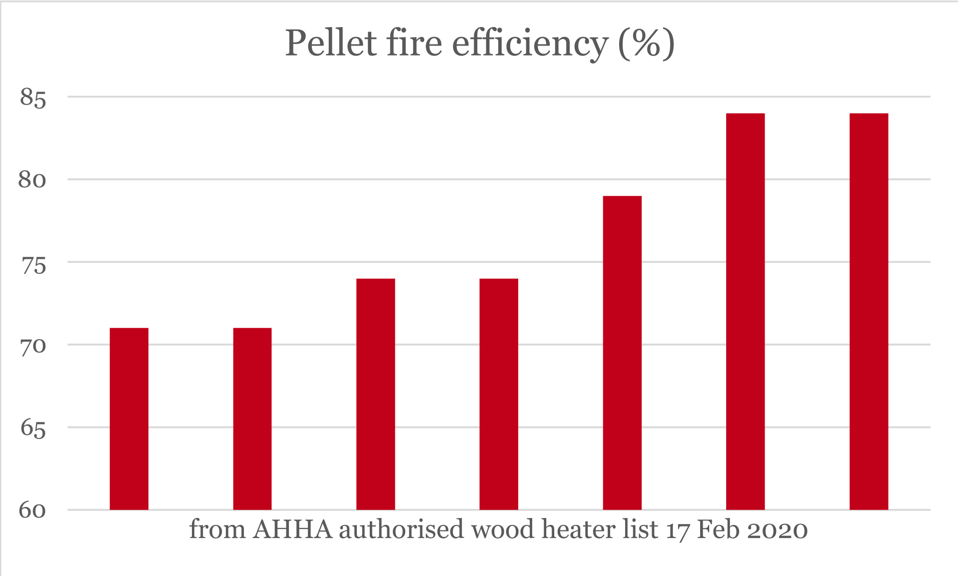
Particulate emissions and efficiency of Australian and New Zealand solid fuel combustion heaters

The following figures provide graphical representation of the stated particulate emissions and energy efficiency of solid fuel combustion heaters in Australia and New Zealand, sourced from public datasets.

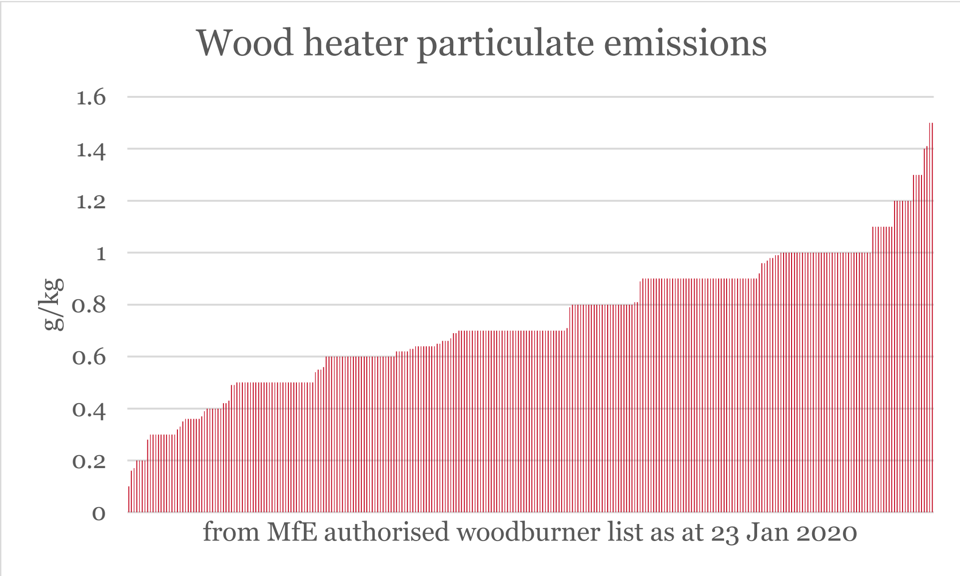


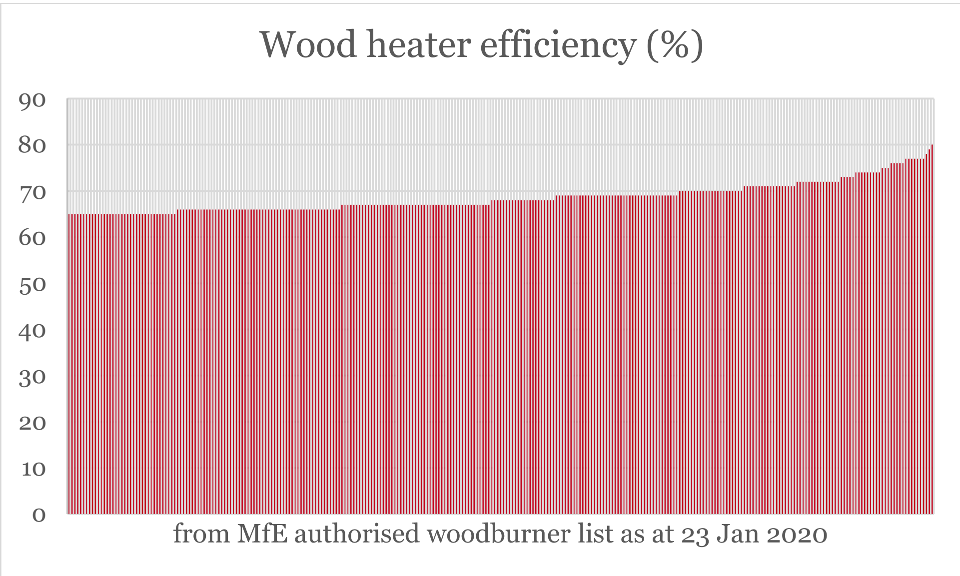


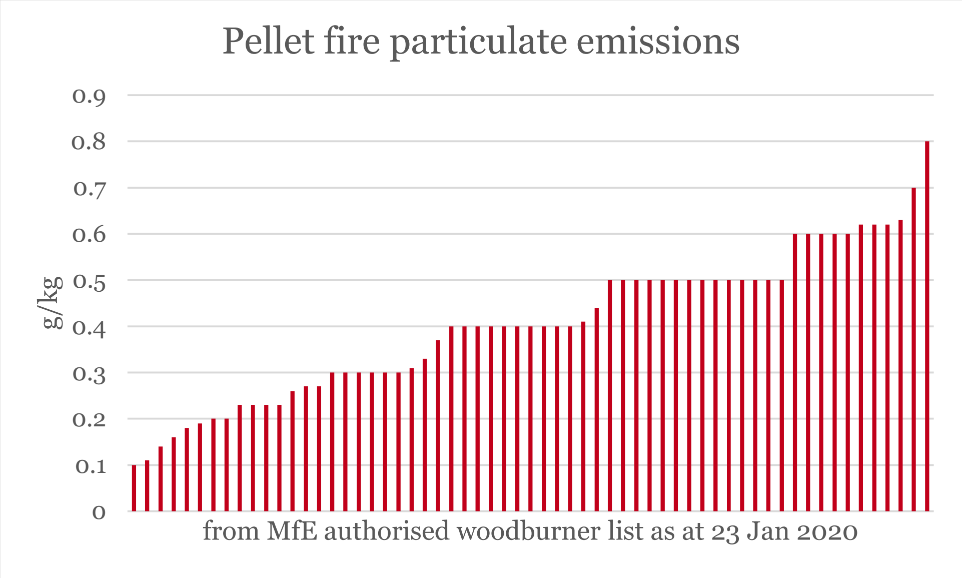

Pellet fire particulate emissions
g/kg
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
from AHHA authorised wood heater list 17 Feb 2020

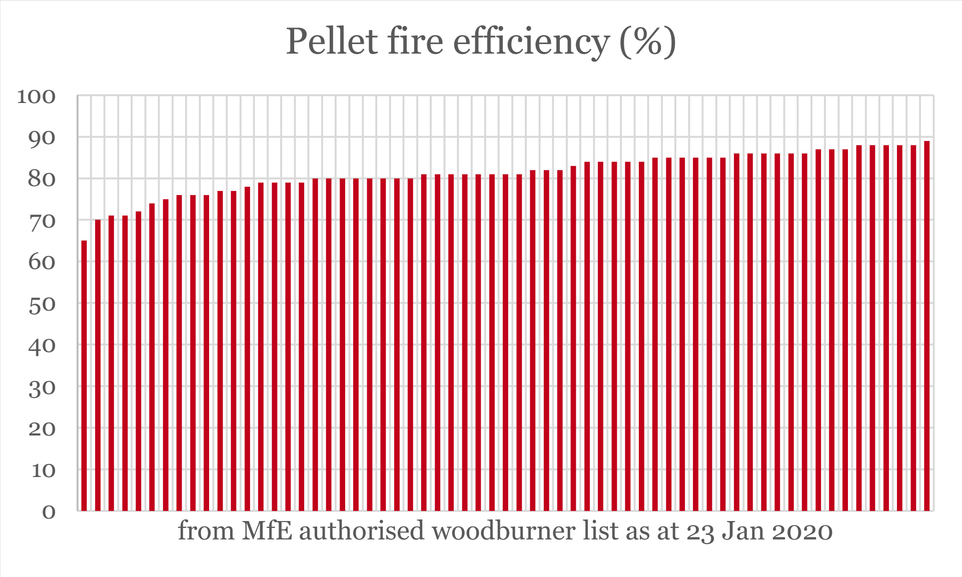

Pellet fire efficiency (%)
85
80
75
70
65
60
from AHHA authorised wood heater list 17 Feb 2020

The following graphs show the distribution of particulate emissions and efficiency for all currently authorised wood heaters and pellet burners in NZ.






Pellet fire particulate emissions
g/kg
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
from MfE authorised woodburner list as at 23 Jan 2020


Pellet fire efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
from MfE authorised woodburner list as at 23 Jan 2020

Appendix 2 – Operating Cost Efficiency and Greenhouse Gas Efficiency for Heaters by State

Introduction

The state and territory energy prices and greenhouse gas emission factors are used in the following tables to provide information on how the operating cost efficiency and greenhouse gas emission comparisons vary. The efficiency of the reverse cycle air conditioner is selected for each zone according to the ZERL climate zone. The efficiency of the other heaters does not vary.

NSW (Average ZERL Climate Zone)

Table 14: Operating cost efficiency of heater types-NSW

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Energy Cost ($/kWh)	0.095	0.095	0.078	0.312	0.312	0.312
Cost Efficiency (kWh heat/$)	8.09	8.40	8.43	3.21	13.90	12.71

Source: average electricity prices from (AER, 2021) default offers (using 2020/21), average gas prices from AER Annual Retail Markets Report 2019-20 (AER, 2020) and exclude fixed supply charges, wood estimated at $350/tonne

Table 15: Greenhouse gas emissions efficiency by heater type – NSW

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.0043	0.89	0.89	0.89
Greenhouse Intensity (gm CO2-e /kWh heat)	260	250	7	890	206	225

Source: Scope 2, 3 emission factors from (DISER, 2020)

VIC (Cold ZERL Climate Zone)

Table 16: Operating cost efficiency of heater types-VIC

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	380%	349%
Energy Cost ($/kWh)	0.075	0.075	0.078	0.229	0.229	0.229
Cost Efficiency (kWh heat/$)	10.31	10.71	8.44	4.36	16.56	15.21

Source: average electricity prices from (ESC, 2020)default offers (using 2020/21), average gas prices from AER Annual Retail Markets Report 2019-20 (AER, 2020), wood estimated at $350/tonne

Table 17: Greenhouse gas emissions efficiency by heater type – VIC

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	380%	349%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.0043	1.09	1.09	1.09
Greenhouse Intensity (gm CO2-e/kWh heat)	260	250	7	1,090	287	312

Source: Scope 2, 3 emission factors from (DISER, 2020)

QLD (Hot ZERL Climate Zone)

Table 18: Operating cost efficiency of heater types-QLD

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	492%	453%
Energy Cost ($/kWh)	0.175	0.175	0.078	0.259	0.259	0.259
Cost Efficiency (kWh heat/$)	4.39	4.56	8.44	3.86	19.00	17.50

Source: average electricity prices from (AER, 2021) default offers (using 2020/21), average gas prices from AER Annual Retail Markets Report 2019-20 (AER, 2020), wood estimated at $350/tonne

Table 19: Greenhouse gas emissions efficiency by heater type – QLD

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	492%	453%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.005	0.93	0.93	0.93
Greenhouse Intensity (gm CO2-e /kWh heat)	260	250	8	930	189	205

Source: Scope 2, 3 emission factors from (DISER, 2020)

SA (Average ZERL Climate Zone)

Table 20: Operating cost efficiency of heater types-SA

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Energy Cost ($/kWh)	0.134	0.134	0.078	0.376	0.376	0.376
Cost Efficiency (kWh heat/$)	5.74	5.97	8.44	2.66	11.53	10.54

Source: average electricity prices from (AER, 2021) default offers (using 2020/21), average gas prices from AER Annual Retail Markets Report 2019-20 (AER, 2020), wood estimated at $350/tonne

Table 21: Greenhouse gas emissions efficiency by heater type – SA

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.0043	0.52	0.52	0.52
Greenhouse Intensity (gm CO2-e /kWh heat)	260	250	7	520	120	131

Source: Scope 2, 3 emission factors from (DISER, 2020)

WA (Average ZERL Climate Zone)

Table 22: Operating cost efficiency of heater types-WA

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Energy Cost ($/kWh)	0.137	0.137	0.078	0.288	0.288	0.288
Cost Efficiency (kWh heat/$)	5.62	5.84	8.44	3.47	15.02	13.74

Source: electricity prices from WA Energy (www.wa.gov.au/organisation/energy-policy-wa/household-electricity-pricing) (using 2020/21), gas prices from WA Energy (www.wa.gov.au/organisation/energy-policy-wa/household-gas-pricing), wood estimated at $350/tonne

Table 23: Greenhouse gas emissions efficiency by heater type – WA

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	433%	396%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.005	0.7	0.7	0.7
Greenhouse Intensity (gm CO2-e /kWh heat)	260	250	8	700	162	177

Source: Scope 2, 3 emission factors from (DISER, 2020)

TAS (Cold ZERL Climate Zone)

Table 24: Operating cost efficiency of heater types-TAS

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	380%	349%
Energy Cost ($/kWh)	0.144	0.144	0.078	0.266	0.266	0.266
Cost Efficiency (kWh heat/$)	5.36	5.57	8.44	3.76	14.29	13.13

Source: electricity prices from Aurora Energy (www.auroraenergy.com.au/residential/products/residential-all-prices) (using 2020/21), gas prices from TAS Gas (www.tasgas.com.au/residential/tariffs-charges), wood estimated at $350/tonne

Table 25: Greenhouse gas emissions efficiency by heater type – TAS

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	380%	349%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.0043	0.17	0.17	0.17
Greenhouse Intensity (gm CO2-e /kWh heat)	260	250	7	170	45	49

Source: Scope 2, 3 emission factors from (DISER, 2020)

ACT (Cold ZERL Climate Zone)

Table 26: Operating cost efficiency of heater types-ACT

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	380%	349%
Energy Cost ($/kWh)	0.109	0.109	0.078	0.247	0.247	0.247
Cost Efficiency (kWh heat/$)	7.07	7.34	8.44	4.04	15.36	14.11

Source: electricity prices from ACTEW.AGL (www.actewagl.com.au/plans-and-connections/pricing-information/act-home-prices) (using 2020/21), average gas prices from AER Annual Retail Markets Report 2019-20 (AER, 2020), wood estimated at $350/tonne

Table 27: Greenhouse gas emissions efficiency by heater type – ACT

	Gas space heaters (excluding flueless)	Gas ducted heaters	Wood heaters	Electric resistance heaters	Non-ducted AC	Ducted AC
Mean Energy Efficiency	77%	80%	66%	100%	380%	349%
Greenhouse Emission Factor (kg/kWh)	0.20	0.20	0.0043	0.89	0.89	0.89
Greenhouse Intensity (gm CO2-e /kWh heat)	260	250	7	890	234	255

Source: Scope 2, 3 emission factors from (DISER, 2020), Using the NSW emission factors

E3 Equipment Energy Efficiency

Product Profile: Residential Space Heaters in Australia & New Zealand

www.energyrating.gov.au

A joint initiative of Australian, State and Territory and New Zealand Governments