Space Heating Comparison Methodology: Public Consultation

August 2024

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

Acknowledgement of Country

We acknowledge the Traditional Owners of Country throughout Australia and recognise their continuing connection to land, waters and culture. We pay our respects to their Elders past and present.

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Executive Summary

Space heating accounts for around a third of residential energy use in Australia and New Zealand. In colder climates, where the need for heating is greatest, the use of space heaters is a major driver of household costs. Households with energy efficient space heating have lower energy bills and contribute fewer greenhouse gas emissions.

There is currently no easy way for consumers to compare the energy use, energy efficiency, running cost or greenhouse gas emissions of different heater types, e.g. air conditioners (heat pumps), gas space heaters, and electric resistance heaters.

The Department of Climate Change, Energy, the Environment and Water (DCCEEW) is exploring options that would support consumers to make easy comparisons of residential space heaters. The comparison methodology outlined in this document is a technical foundation from which space heaters of different types can be compared for efficiency and running costs. The comparison methodology could underpin the development of accessible information resources to inform consumers and help them to choose the most suitable heating systems for their needs.

This work is being delivered through the Equipment Energy Efficiency (E3) Program. The E3 Program is a cross jurisdictional program through 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. The E3 Program undertakes a range of activities to improve the energy efficiency of appliances and equipment sold in Australia and New Zealand. These include energy rating labelling, setting minimum energy performance standards (MEPS), and providing public information.

The Greenhouse and Energy Minimum Standards Act 2012 (GEMS Act) is the underpinning legislation for the E3 Program in Australia. Its objectives include promoting the development and adoption of products that use less energy or produce fewer greenhouse gases. In New Zealand, the Energy Efficiency (Energy Using Products) Regulations 2002 (EUP Regulations) underpin the E3 Program.

This consultation seeks to obtains feedback from industry and other stakeholders on the proposed methodology.

This consultation document outlines a proposed comparison methodology for residential space heaters. The comparison methodology identifies how to define and calculate the performance of different heater types on a consistent and fair basis. It is a technical approach for generating energy consumption and efficiency performance information on heaters.

The residential space heating work program commenced in 2019. Work on the comparison methodology to date has focussed on what have been described as simple heaters. These include:

- reverse cycle air conditioners (heat pumps)
- gas space heaters
- electric resistance heaters
- gas decorative appliances

- solid fuel combustion heaters
- ducted gas heaters
- ducted reverse cycle air conditioners (heat pumps).

Proposed methods have been developed for all these heater types.

Some work has been done, and is continuing, to develop methods for the more complex heater types such as electric resistance underfloor heating systems (including directly under flooring, in-screed and in-slab) and hydronic (gas, electric resistance, solar or heat pump) heating systems. This paper focuses on describing a comparison methodology that initially applies to the more common simple heater types.

The aim in developing the space heater comparison methodology was to identify methods for calculating the comparative energy performance of different space heaters that use a common set of performance evaluation methods, based on existing space heater test standard and performance data, where possible.

This methodology is based on the GEMS Determination for air conditioners and utilises existing individual space heater test methods to define the key performance characteristics of a heater. The data inputs that are used to calculate the energy performance of the various heater types under the comparison methodology are derived from: the product test data generated from heater test standards that are applied to the products under existing regulations; or default data inputs that indicate expected product performance and that were developed in consultation with the Space Heating Equipment Technical Working Group (TWG) who assisted with the development of the methodology. The comparison methodology enables a common evaluation method to be used to calculate performance metrics, so that products can be objectively compared across technology types.

The space heating comparison methodology defines energy performance metrics that could be used to communicate key performance features of a range of heater types to consumers, including:

- Capacity (kW), or how much heat the heater can provide
- Input Power (kW)
- Annual Energy Use (kWh/y, which can also be converted into MJ/y for gas appliances)
- Heating Performance Factor

DCCEEW will use the information and feedback obtained from public consultation on this paper to refine the comparison methodology. With a suitable comparison methodology identified, DCCEEW can continue to explore options that would support consumers to make easy energy performance comparisons of residential space heaters.

DCCEEW acknowledges the contributions of EnergyConsult Pty Ltd and the Space Heating Equipment TWG in the development of this comparison methodology and the preparation of this consultation paper. The cost benefit analysis and technical advice were provided by EnergyConsult.

Introduction

Purpose of this Consultation Document

The purpose of this consultation document is to:

- provide information on the proposed space heating comparison methodology and
- provide a basis for seeking submissions from industry and other stakeholders on the proposed methodology.

Purpose of the comparison methodology for space heaters

This consultation document outlines a proposed comparison methodology for residential space heaters. The comparison methodology identifies how to define and calculate the performance of different heater types on a consistent and fair basis. It is a technical approach for generating energy consumption and efficiency performance information on heaters. The comparison methodology could underpin the development of accessible information resources to inform consumers and help them to choose the most suitable heating systems for their needs.

Background on the space heating work program

There is no easy way for consumers to compare the heat output (or capacity), energy use, energy efficiency, running cost or greenhouse gas emissions of different heater types. Space heating accounts for around a third of residential energy use in Australia and New Zealand. Space heating is important for the wellbeing and comfort of households. In colder climates, where the need for heating is greatest, the use of space heaters is a major driver of household costs. Households with energy efficient space heating have lower energy bills and contribute fewer greenhouse gas emissions.

The Department of Climate Change, Energy, the Environment and Water (DCCEEW, or the department) is exploring options that would support consumers to make easy energy performance comparisons of residential space heaters. The comparison methodology is a technical foundation from which the energy performance of different space heaters can be compared.

This work is being delivered through the Equipment Energy Efficiency (E3) Program. The E3 Program is a cross jurisdictional program through 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. The E3 Program undertakes a range of activities to improve the energy efficiency of appliances and equipment sold in Australia and New Zealand. These include energy rating labelling, setting minimum energy performance standards (MEPS), and providing public information.

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The residential space heating work program commenced in 2019. Initially, the work was jointly managed by the department (then the Department of Industry, Science, Energy and Resources), and the New South Wales Department of Climate Change, Energy, the Environment and Water (then the Department of Planning, Industry and Environment, or DPIE). NSW DPIE concluded involvement in the project in June 2022. DCCEEW continues to lead the work program. EnergyConsult Pty Ltd has undertaken the technical analysis for this work program.

Scope of heaters considered: simple heaters and complex heaters

The space heating work program encompasses all common residential heating types used in homes in Australia and New Zealand.

Work on the comparison methodology to date has focussed on what have been described as simple heaters. These include:

- reverse cycle air conditioners (heat pumps)
- gas space heaters
- electric resistance heaters
- gas decorative appliances[1]
- solid fuel combustion heaters
- ducted gas heaters
- ducted reverse cycle air conditioners (heat pumps).

Proposed methods have been developed for all these heater types as noted in the list of papers on page 5.

Some work has been done, and is continuing, to develop methods for the more complex heater types such as electric resistance underfloor heating systems (including directly under flooring, in-screed and in-slab) and hydronic (gas, electric resistance, solar or heat pump) heating systems. This paper focuses on describing a comparison methodology that initially applies to the more common simple heater types.

Basis of the comparison methodology

The work program uses established space heater standards and technical frameworks including existing Australian/New Zealand product Standards (AS/NZ Standards). The *Preliminary Technical Options Discussion Paper* identified that the Air Conditioner Comparison Methodology (ACCM), consisting of the GEMS Determination for air conditioners (Greenhouse and Energy Minimum Standards (Air Conditioners up to 65kW) Determination 2019) in Australia or EUP Regulations in New Zealand combined with AS/NZS 3823.4.2[2], could provide a suitable methodology for calculating comparative energy consumption and energy efficiency for simple space heating technology types. The ACCM provides a methodology that could be used to define the tasks, conditions, and metrics to be used to assess and compare the performance of space heaters. For each space heating technology, the technical characteristics of the space heaters have been considered and the methodology has been modified or adapted so that it remains relevant to the

[1] While these products do not have a rated heating capacity, they do provide some heat output, and are often considered by consumers to be space heaters.

[2] 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.

technology, aligns with the existing heater test standards, and uses available data on space heater performance.

Space Heating Equipment Technical Working Group

The Space Heating Equipment Technical Working Group (TWG) was formed in 2021 to assist with the development of the individual heater methods and the comparison methodology. It comprised space heating experts and representatives from major heating manufacturers, retailers, industry organisations and government agencies. The contribution from members of the TWG is acknowledged and appreciated in the development of this comparison methodology.

Over the period from October 2021 to November 2023, the TWG met on eight occasions to discuss the development and content of various options papers, product type method papers, and TWG papers on specific issues. These TWG papers include:

- Space Heating Comparisons: Preliminary Technical Options Discussion Paper (2022)
- Space Heating: Exploring a Method for Gas Space Heaters (2022)
- Space Heating: Exploring a Method for Electric Resistance Heaters (2022)
- Space Heating: Exploring a Method for Gas Decorative Appliances (2022)
- Space Heating: Exploring a Method for Solid Fuel Combustion Heaters (2022)
- Space Heating: Exploring a Method for Ducted Gas Heaters (2023)
- Hydronic and Electric Resistance Central Heating Systems: Method Options Paper (2023)
- TWG Paper 1. Types of Heaters and Definition of Load
- TWG Paper 2. Standby or Inactive Energy Consumption
- TWG Paper 3. Thermostatic Control
- TWG Paper 4. Overview of Heater Types
- TWG Paper 5. Definition of load and options
- Space Heating: Summary of Comparison Methodology (TWG Paper 6).

This consultation document incorporates the key elements of these papers and takes the input and advice of TWG members into consideration.

Making a submission

The department welcomes written submissions on this paper. The department would like to know what your views are on the comparison methodology and the reasons for your views.

Submissions should be provided by 27 September 2024.

To provide feedback on the paper, please make a submission at:
https://consult.dcceew.gov.au/space-heater-comparison-methodology

Enquiries may be emailed with the subject line “Space Heating Comparison Methodology Consultation”:

- for Australian stakeholders—to the Australian Government Department of Climate Change, Energy the Environment and Water (DCCEEW): spaceheating@dcceew.gov.au
- for New Zealand stakeholders—to the Energy Efficiency and Conservation Authority (EECA) of New Zealand: star@eeca.govt.nz

Heater Types

Residential heaters considered as part of this work program can be broadly classified as simple heaters or complex heaters. A list of the heaters considered and a brief description of the key characteristics of each type is provided below. Further detail on heater types is provided in the Residential Space Heaters in Australia and New Zealand: Product Profile (E3,2021).

Simple heaters

Solid fuel combustion 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/EUP Regulations, though they are regulated under the safety and emission or environmental requirements of different jurisdictions.

Non-ducted gas heaters:

- use natural gas or LPG as an energy source[3]
- generally, are sized to heat a single room with a typical heat output of up to 32 MJ/hour (9kW) for a flued heater
- are not regulated under E3/GEMS/EUP Regulations, but in Australia the gas certification scheme requires them to display a gas energy label which allows for comparisons among gas space heaters.

Reverse cycle air conditioners (heat pumps), 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 (7- 32 MJ/h), though large systems up to 14 kW (50 MJ/h) 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

[3] Potentially hydrogen gas could become a substitute in the future. In the medium term its most likely effect on gas heating could 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.

- the heat output, or capacity, of reverse cycle air conditioners (heat pumps) often varies significantly with outdoor temperature, typically resulting in lower capacity at lower outdoor temperatures
- are regulated under E3/GEMS/EUP Regulations with most common types required to have the Zoned Energy Rating Label (ZERL) and comply with MEPS.

Electric resistance heaters (portable and fixed):

- 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 (9 MJ/h), though large fixed systems can operate at up to 4.8 kW (18 MJ/h)
- are not regulated for energy rating labelling or MEPS.

Gas decorative appliances:

- operate by burning natural gas or LPG
- typically provide minimal heat output
- gas consumption of 20-60 MJ/h, 5-17kW
- are not regulated under E3/GEMS/EUP Regulations or able to display a gas energy label.

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). 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/EUP Regulations, 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.

Ducted reverse cycle air conditioners (heat pumps) 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, via ductwork
- generally, are sized to heat most of a dwelling, with a typical heat output 10 to 30kW (36-108 MJ/hour)
    - Smaller systems operate on single-phase electricity, but the larger capacity units may require a three-phase electricity supply.

- the heat output, or capacity, of reverse cycle air conditioners (heat pumps) often varies significantly with outdoor temperature, typically resulting in lower capacity at lower outdoor temperatures
- are regulated under E3/GEMS/EUP Regulations to comply with MEPS and may voluntarily display a Zoned Energy Rating Label.

Complex heaters

Electric resistance underfloor heaters:

- use electricity as an energy source
- use a resistance element to convert electrical energy to heat
- include in-slab or in-screed heating elements, and electric element mats which are placed directly under flooring
- in-slab or in-screed heating elements are generally sized to heat most of a house, with a typical heat output of greater than 20 kW (72 MJ/h), and they can often be zoned to some extent
- electric mats installed directly under flooring may be relatively small and localised, such as those used for bathroom heating
- are not regulated for energy rating labelling or MEPS.

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, which may be in-slab, underfloor or above floor radiators
- typically are sized to heat most of a house, with a heat output of greater than 20 kW (72 MJ/h), and they can often be zoned to some extent
- are not regulated for energy rating labelling or MEPS.

Discussion of the methodology

Basis of the methodology

The aim in developing the space heater comparison methodology was to identify methods for calculating the comparative energy performance of different space heaters that use a common set of performance evaluation methods, based on existing space heater test standard and performance data, where possible.

Work undertaken on developing a product profile for space heaters in Australia and New Zealand (E3,2021) identified energy metrics and standards that, with further work, could enable the development of comparisons across heater technologies and fuel types.

In order to objectively compare the performance of space heaters (including air conditioners), it is necessary to define common or comparable:

- nominal capacity (or rate of heat output) of the product
- tasks to be delivered (heating load[4] and operating hours)
- conditions under which the task or tasks are completed (outdoor temperature and other relevant factors)
- metric(s) by which the performance of the task or tasks would be measured, such as metrics describing the capacity (which may vary with outdoor temperature), total energy use and average efficiency.

Preliminary investigations into possible technical options for a comparison methodology identified that the Air Conditioner Comparison Methodology (ACCM), consisting of the GEMS Determination for air conditioners (Greenhouse and Energy Minimum Standards (Air Conditioners up to 65kW) Determination 2019) in Australia or EUP Regulations in New Zealand combined with AS/NZS 3823.4.2[5], could provide a suitable methodology for calculating comparative energy consumption and energy efficiency for simple space heating technology types.

The ACCM provides a methodology that could be used to define the tasks, conditions, and metrics to be used to assess and compare the performance of space heaters. For each space heating technology, the technical characteristics of the space heaters have been considered and the methodology has been modified or adapted so that it remains relevant to the technology, aligns with the existing heater test standards, and uses available data on space heater performance.

The robust measurement methodology and effective comparison method of the ACCM, combined with its straightforward approach, which does not require specialised software, make it particularly well suited to the comparison of electric resistance heaters, gas space heaters, gas decorative appliances and solid fuel combustion heaters. For these heater types, their thermal performance is only affected by load (which is dependent on outdoor temperature); they are directly heating the occupied space, and they do not

[4] The amount of heat energy that would need to be added to a space to achieve a certain temperature.

[5] 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.

typically contain significant thermal mass. For distributed heating systems such as ducted, hydronic and underfloor (including in-screed and in-slab) heating, the distribution losses and effects of thermal mass need to be considered, and the methodology adjusted appropriately for each technology type. For solar-thermal hydronic and heat pump hydronic systems, interactions with solar radiation and ambient temperature also need to be considered.

Throughout the space heater comparison methodology, equations are provided for calculating the total energy input of a heater. Depending on the heater technology, total energy input could include electric power input only, or gas plus electric power input, or solid fuel plus electric power input. But the equations could be duplicated in a way that enables the energy input from different fuels to be calculated separately for the purposes of estimating carbon emissions and operating costs.

Methodology overview

The space heater comparison methodology needs to enable the comparison of heaters:

- that have different mechanisms
- that use different fuels or combinations of fuels
- whose performance may or may not be affected by outdoor temperatures.

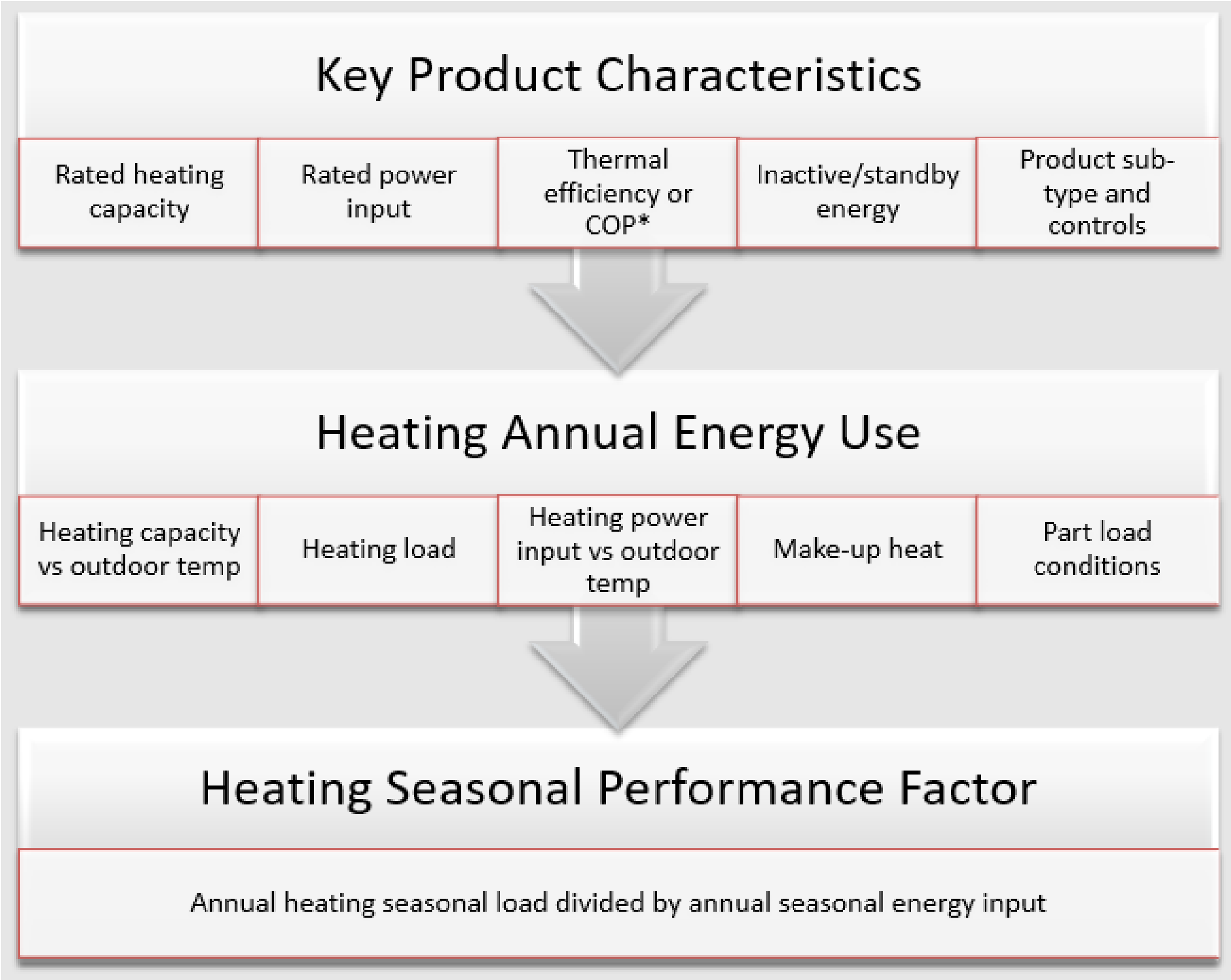
The proposed comparison methodology is flexible enough to enable this range of variation among different simpler heater types to be taken into account in the heater performance calculations. Further work is continuing to adapt the methodology for more complex heater types where the effects of distribution and system losses, thermal mass, outdoor temperature and solar radiation may need to be included.

The space heater comparison methodology comprises three stages, as shown in Figure 1:

1. Key Product Characteristics: For each space heater technology type the existing test standards are used as a basis for defining the product's key characteristics including rated heating capacity (heating output), power input, thermal efficiency, inactive energy consumption; the variation of these characteristics with load, outdoor temperature or other factors; and defining any product sub-types, particularly based on their controls which affect how well a product can match its heat output with the thermal load.
2. Heating Annual Energy Use: The way in which capacity, power input, efficiency and load vary with outdoor temperature, as described by the product's key characteristics, are then used to calculate the annual energy use. Annual energy use includes both the energy consumed during heating (the Heating Seasonal Energy Consumption, HSEC) and the inactive/standby energy consumption.
3. Heating Seasonal Performance Factor: The ratio of heating seasonal load to energy input is used to define the overall heating performance or product efficiency.

These stages progressively build to the final calculation of overall product efficiency. Firstly, the product characteristics are defined and calculated, then the heating annual energy use is calculated using the product characteristic information, and finally the Heating Seasonal Performance Factor (HSPF) is calculated. The individual definitions of the key product characteristics for each space heater technology type are provided in Appendix 2: Key Characteristics for Each Heater Type. Example data is provided in Appendix 4: Example data and results.

Figure 1: Methodology stages and key aspects



*Coefficient of Performance (COP)

One of the requirements of the comparison methodology was to include appropriate solutions for comparing weather independent heaters, whose performance *does not* depend on outdoor temperatures, with weather dependent heaters whose performance, and in particular capacity, *does* depend on weather conditions such as outdoor temperatures. Noting that the ACCM was developed for weather dependent heaters (air conditioners), this has involved deciding on ways to align the performance calculation approaches for weather independent heaters with performance calculation approaches already established by the ACCM.

Individual components of the methodology, such as the definition of capacity, load and make-up heat were discussed in detail by the TWG, and some of these are described in more detail below. The analysis presented in previous TWG papers and discussions within the TWG have yielded the following approach for the space heater comparison methodology:

- load will be defined in accordance with the ACCM based on the rated full capacity of the heater. For air conditioners the rated full capacity of the air conditioner is defined at 7°C outdoor temperature (the capacity of an air conditioner changes with outdoor temperature). This implies that an air conditioner has the same load as, and should be compared with, a weather independent heater that has the same rated capacity as the air-conditioner's rated full capacity at 7°C. For a weather independent heater, the resulting load is equal to its rated full capacity at -3°C.

- make-up heat will not be required for weather independent heaters, similar to the treatment of make-up cooling for air conditioners
- for weather independent heaters, the Heating Seasonal Energy Consumption (HSEC) of fixed-capacity or two-setting capacity heaters without thermostatic control will be calculated using a 10% and 5% penalty, respectively, from the Heating Seasonal Energy Consumption value calculated for products with thermostatic control
- for fixed (non-portable) weather independent heaters the cooling hours will be considered as inactive (standby) hours
- for portable weather independent heaters the cooling season (both the cooling hours and the inactive hours which occur during the cooling season) will be considered as disconnected hours
- the Annual Energy Use and heating performance factor will include the annual inactive (standby) energy consumption
- gas decorative appliances will be evaluated using the method for gas space heaters
- for ducted heaters (both gas and air-conditioner), the duct losses will not be included in the annual energy use and heating performance factor calculations.

The comparison methodology establishes a standardised approach for evaluating the energy performance of different heater types, based on aligning underlying calculation methods and assumptions where possible. It offers a transparent, consistent, and fair basis for comparing energy performance across different heater types and fuels.

Work will continue to develop calculation methods for more complex heaters such as electric resistance underfloor heating systems (including directly under flooring, in-screed and in-slab) and hydronic (gas, electric resistance, solar or heat pump) heating systems. The calculation methods for more complex heaters would be based on a similar approach to the calculation methods already developed for the simpler heaters, and include consideration of the distribution system losses and effects of thermal mass, outdoor temperature and solar radiation as appropriate for each complex technology type.

Definition of Nominal Capacity

Defining the nominal capacity of the product, or comparison point, is a significant challenge in developing a comparison methodology. This is because the capacity of a weather dependent heater (air conditioner) varies with outdoor temperature but the capacity of a weather independent heater (such as a gas, electric resistance or solid fuel heater) does not. The ACCM defines the nominal capacity of an air conditioner to be its full capacity at 7degC, and defines the load at which its thermal performance is evaluated based on this nominal capacity. To enable performance comparisons between weather dependent and weather independent heaters, a decision is needed on the load at which the performance of a weather independent heater is to be evaluated.

For air conditioners, heating capacity increases with increasing outdoor temperature, meaning that the colder it gets outside, the less heating capacity the product has available. The heating capacity of a fixed capacity air conditioner under non-frosting conditions (outdoor temperature < -7°C or >5.5°C) is defined in

AS/NZS 3823.4.2 as a straight line function of outdoor temperature from the heating capacity measured at 7°C, which is the rated full heating capacity of the air conditioner, down to the heating capacity at -7°C. For conditions in which frosting may occur (outdoor temperatures between -7°C and 5.5°C), this is adjusted, creating a second straight line from the heating capacity at -7°C (both frosting and non-frosting are equal at this point) through the measured frosting heating capacity at 2°C. Measuring the air conditioner performance at -7°C is optional, with a default value of heating capacity defined as 0.64 times the heating capacity at 7°C (which results in the heating capacity at 0°C being 0.82 times the heating capacity at 7°C). This default corresponds to an 18% loss in heating capacity at 0°C compared to the rated value at 7°C, and a 36% loss at -7°C.

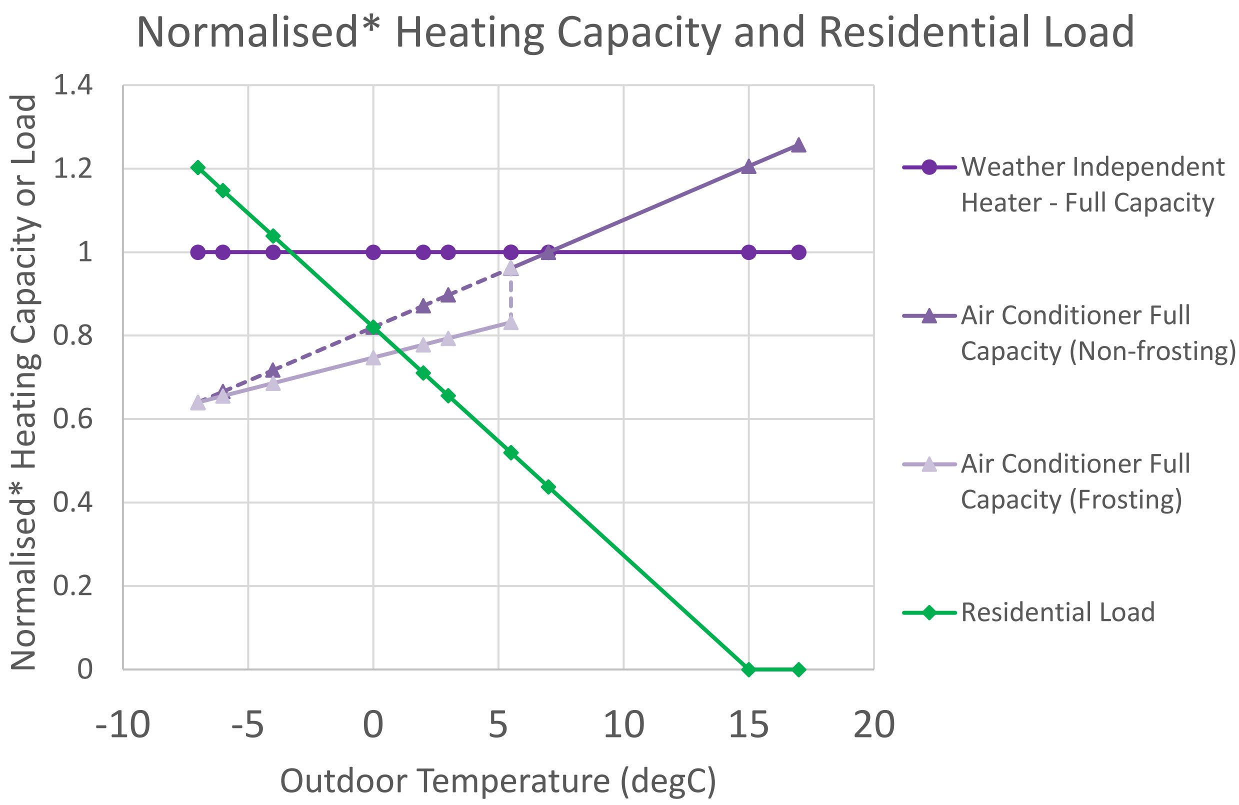
Individual air conditioners may vary significantly from these values, with registered capacity values either higher or lower than the defaults. According to GEMS data on registered reverse cycle (not cooling only) air conditioners downloaded 4/4/2024, 25% of registered air conditioners do not have any low temperature capacity data provided. Of the 75% of registered air conditioners for which a valid low temperature capacity value was provided:

- there is an almost-even split between the air conditioners with more (37%) and those with less (38%) capacity at 2°C than the 2°C default value of 0.82 times the heating full capacity at 7°C.
- 12% have more capacity at 2°C than the heating capacity at 7°C (an average of 1.12 times the heating full capacity at 7°C).

These functions are shown in Figure 2, along with the heating capacity of a weather independent heater with the same rated full heating capacity as the example air conditioner. Note that the default values result in the air conditioner having excess capacity, compared to load, for outdoor temperatures above 1°C, and requiring make-up heat for outdoor temperatures below 1°C. Essentially, in defining this load it has been assumed that the air conditioner will be sized to meet the load at an outdoor temperature of 1°C.

Comparing a weather independent heater with an air conditioner of the same full capacity at 7°C is the most straightforward and is the option preferred by the TWG. This results in no change to the methodology for air conditioners, and weather independent heaters are evaluated with a load at -3°C which is equal to their capacity.

Figure 2: Comparison of Air Conditioner Capacity, Weather Independent Heater Capacity and Residential Load



*Normalised by the full heating capacity of the air-conditioner at 7°C.

Definition of Load

The heating load for the space heater comparison methodology is proposed to be the same as for the ACCM, which is defined by AS/NZS 3823.4.2 as a straight-line function of outdoor temperature from zero load at t_0 to full load at t_{100}. This approach is based on the international standard and uses a straight line from maximum heating load at the coldest outdoor temperature to zero heating load at a defined temperature, or "zero load temperature". The maximum heating load scales with the capacity of the heater, assuming that an appropriately sized heater will be installed depending on the desired usage and house construction. For residential applications, for all climate zones, t_0 = 15°C and t_{100} = 0°C. AS/NZS 3823.4.2 defines full load at t_{100} to be 0.82 times the capacity of the air conditioner at 7°C. As discussed above, the heating capacity of an air conditioner has a strong dependence on outdoor temperature, and it is proposed that weather independent heaters (such as gas, electric resistance and solid fuel heaters) are compared with an air conditioner of the same full capacity at 7°C, meaning that for the space heater comparison methodology, full load at 0°C is 0.82 times the nominal capacity of the space heater, as shown in Figure 2.

This is a simplification of the actual operation of heaters as a function of outdoor temperature, for the purposes of providing a basis for product comparison. In the real world, as the outdoor air cools down at night after a hot day, the interior of the house will remain significantly warmer than the outdoor temperature, and may not need heating for outdoor temperatures well below 15°C, while on a cool morning the house may continue to need heating after the outdoor temperature has risen above 15°C, as the floors, walls and house contents slowly come up to temperature. There will also be variations from person to person, and house to house, with some well-designed houses maintaining indoor temperatures significantly above the outdoor temperature without additional heating.

Note that, in addition to defining the heating load, AS/NZS 3823.4.2 defines the outdoor temperature bins, or hours per year during which heating is required for each outdoor temperature. These are defined as a fraction of the total hours per year during which each outdoor temperature occurs. For example, at 10°C it is assumed that only 50% of the total annual hours counted require heating, resulting in 112 hours of heating being required at 10°C in the Average Zone, out of a total of 224 hours per year at 10°C in a typical year in that zone.

For residential applications evaluated under the ACCM: for the hot climate zone, there are no heating hours for an outdoor temperature less than 3°C; for the average climate zone there are no heating hours below -4°C; and for the cold climate zone there are no heating hours below -6°C.

The *Heating Seasonal Total Load* (*HSTL*), or total amount of heating to be supplied in each climate zone, is calculated by adding up the heating load at each outdoor temperature, multiplied by the number of hours heating is required at each outdoor temperature as defined by AS/NZS 3823.4.2, as summarised in Table 1.

$$\frac{HSTL}{Capacity} = \sum \frac{Load}{Capacity} \times Hours$$

where *HSTL* = Heating Seasonal Total Load (kWh/year), *Load* is the heating load as a function of outdoor temperature (kW), *Capacity* = *Rated Capacity* (kW), and *Hours* are the hours of operation in heating mode, as a function of outdoor temperature, as defined by the temperature bins specified in AS/NZS 3823.4.2.

Table 1: Heating Seasonal Total Load per Capacity, by Climate Zone, according to the Comparison Methodology

Heating Seasonal Total Load (HSTL)	**Hot Zone**	**Average Zone**	**Cold Zone**
HSTL per Capacity (kWh/year/kW)	83.91	543.06	1305.82
HSTL per Capacity minus Make-up Heat for Weather Independent Heaters (kWh/year/kW)	83.91	543.02	1303.31

The ACCM recognises three broad climate zones—hot, average and cold. There are 69 National House Energy Rating Scheme (NatHERS) climate zones for Australia, and 6 climate zones used in New Zealand for the purposes of the New Zealand building code. The three particular climate zones in Australia used as the reference climates representing the hot, average and cold climate zones respectively are Rockhampton, Richmond in North-western Sydney, and Canberra. The information generated for the three broad climate zones may only be indicative for much of the population living in those zones. It would also be possible to use the calculation approach described above as the basis for identifying the HSTL of more specific climate zones. This could provide a basis for providing consumers with energy performance information that is more reflective of their geographical location.

Make-up heat

Make-up heat is the additional energy consumption required to deliver load (or heating) which exceeds the capacity of the product. For air conditioners, their capacity typically decreases with decreasing outdoor temperature, while the load increases. For air conditioners without low temperature extended capacity this can result in the air conditioner's heating capacity being significantly lower than the load for temperatures below 1°C. The ACCM assumes that this additional make-up heat would be supplied by an electric resistance heater, and thereby imparts a performance penalty on any air conditioner lacking sufficient capacity at low temperatures.

For weather independent heaters, such as gas, electric resistance and solid fuel heaters, the proposed capacity and load definitions would result in a tiny amount of make-up heat being required for temperature below -3°C. However, based on TWG consultations and for simplicity, it is proposed that this make-up heat will not be included in the space heater comparison methodology for these products. This effectively reduces the heating seasonal total load for these products by 0.01% in the Average Zone and 0.2% in the Cold Zone, as summarised in Table 1.

Heating Seasonal Energy Consumption

The energy consumed during heating, or Heating Seasonal Energy Consumption (HSEC) depends on how a product adjusts its operation to match the load being demanded. AS/NZS 3823.4.2 defines HSEC for air conditioners based on whether the product is:

- fixed-capacity: on/off operation, and therefore with measurement of performance at full capacity only
- variable capacity: two-stage, multi-stage or continuously variable capacity, with measurement at full capacity, minimum capacity and optionally half capacity.

For fixed-capacity units, the Heating Seasonal Energy Consumption (HSEC) is the energy consumed by both the product and the make-up heater while in active mode, and defined as the sum of:

- the product of the full load power at each outdoor temperature, adjusted by the ratio of load to capacity (limited to a maximum of 1) and a part load factor (PLF) to account for cycling of the product when operating at partial load, and the reference bin hours; and
- the product of the make-up heat and the reference bin hours.

This is expressed in the equation below:

$$HSEC = \sum_{T \ where \ Load \leq Full \ Capacity} \frac{Full \ Power \times \frac{Load}{Full \ Capacity} \times Hours}{PLF} + \sum_{T \ where \ Load > Full \ Capacity} [Full \ Power + Make - up \ Heat] \times Hours$$

The Make-up Heat, is defined for air conditioners by the load minus the capacity (limited to a minimum of 0), at each outdoor temperature, based on the assumption that consumers will turn on an additional electric resistance heater if they require additional heating. Based on consultations with the TWG, it is proposed that for weather independent heaters (where the capacity does not vary significantly with outdoor temperature), such as gas, electric resistance and solid fuel heaters, the make-up heat will be set to zero.

The Part Load Factor (PLF) for air-conditioners is $FPL(tj) = 1 – CD(1 – X(tj))$, where the degradation coefficient, CD, is determined in accordance with Annex C of the Standard, and has a default value of 0.25, and the operation factor X(tj) is the ratio of load to capacity, limited to a maximum of 1. The PLF represents the loss of efficiency in air-conditioners due to the process of cycling on and off to meet the desired thermostat temperature. For other space heater types, it is expected that either cycling does not have a significant impact on their performance, or it is already included within their respective test standard performance values.

For variable capacity units the calculations are more complicated, including additional minimum, half and extended load capacity and power measurements and equations, but following a similar methodology. The equations for all of the HSEC Calculation Methods (1-5) are included in Appendix 3: HSEC Calculation Equations.

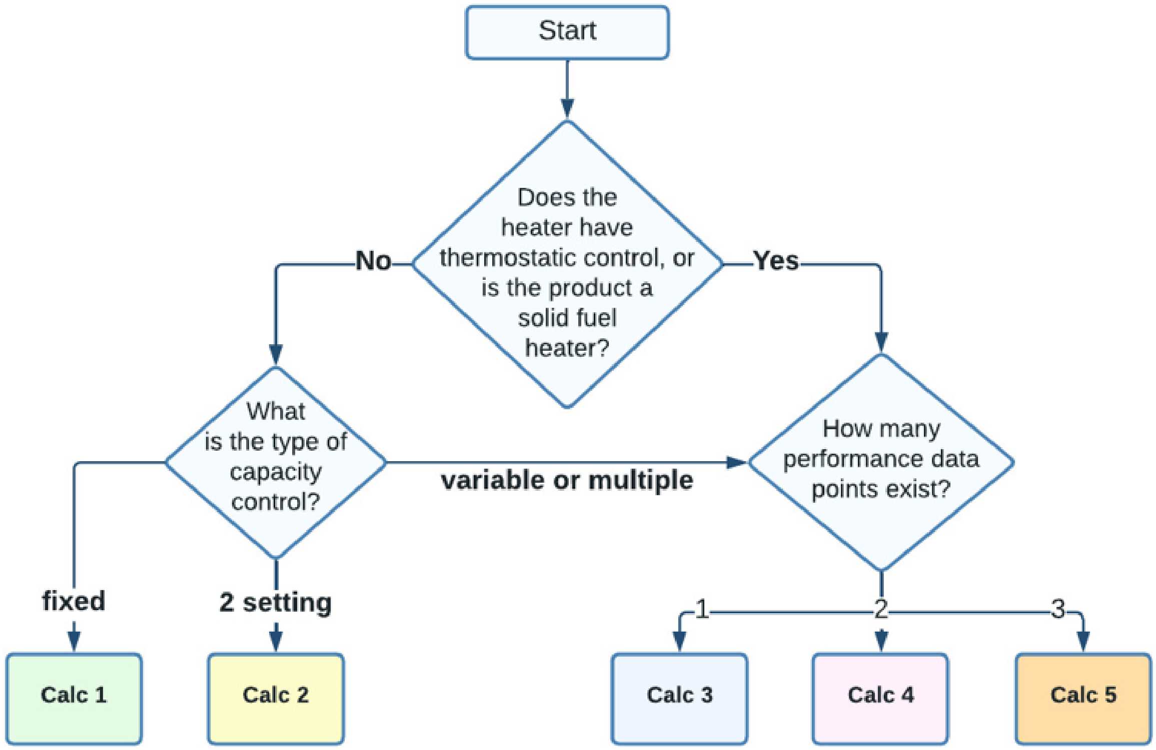
The space heater comparison methodology proposes to use the definition of HSEC that:

- best aligns with the test data available from the existing product test standards for each space heater technology type
- uses 1, 2 or 3 points of performance data, corresponding to the full, “minimum” and “half” capacity values used in the ACCM
- does not include make-up heat for weather independent (non-air conditioner) products
- does not include a part load factor (PLF) for electric resistance, gas (ducted or non-ducted) or solid-fuel combustion heaters
- applies an additional 5% (2 settings) or 10% (fixed-capacity) penalty for products that are not thermostatically controlled, not solid fuel combustion heaters, or have fewer than 3 capacity (heat output) settings.

Utilising data from more than one operating point whenever available helps to ensure that efficiency across the product’s operating range is taken into account, and reflected in the annual energy use, as per the current product test standards for each space heater technology type.

A summary of the HSEC calculation path is shown in Figure 3 below. Example HSEC calculation results are provided in Appendix 4: Example data and results.

Figure 3: Summary of HSEC calculation path based on product sub-type and controls



HSEC Calculation method 1. Fixed-capacity products without thermostatic control:

For this calculation it is assumed that there is a 10% increase in heating seasonal energy consumption (HSEC) due to less-efficient matching of capacity to load, compared to systems with thermostatic control or more than two capacity settings. The development of this calculation method was discussed in TWG Paper 3.

HSEC Calculation method 2. Two-setting capacity products without thermostatic control:

For this calculation it is assumed that there is a 5% increase in heating seasonal energy consumption (HSEC) due to less-efficient matching of capacity to load, compared to systems with thermostatic control or more than two capacity settings. The development of this calculation method was discussed in TWG Paper 3.

HSEC Calculation method 3. Variable capacity products (>2 settings) and products with thermostatic control, with one point of performance data:

For this calculation the capacity of the heater would be adjusted to match the load, with part load conditions applying until the load is equal to the full capacity of the product, and then full power would be required plus make-up heat for the remaining (cold) outdoor temperatures. Based on consultation with the TWG it is proposed that for weather independent heaters, make-up heat is not required.

This calculation method is used for electric resistance heaters, solid fuel combustion heaters with non-adjustable air controls, and gas space heaters only evaluated at maximum gas consumption.

HSEC Calculation method 4. Variable capacity products and products with thermostatic control, with two points of performance data:

For these products, the HSEC is calculated similarly to calculation 3, but because these products can be measured at minimum (or low) outputs, there is additional data on which to base the calculation of part load efficiency. It is assumed that the user adjusts the settings or fuel quantity to match loads if the product has a variable or multi-setting capacity capability, similar to thermostatic control.

This calculation method is used for gas space heaters based on their minimum and maximum gas consumption.

HSEC Calculation method 5. Variable capacity products and products with thermostatic control, with three points of performance data:

For these products, the HSEC is calculated similarly to calculation 3, but because these products can be measured at minimum (or low) outputs, and half (or medium) outputs, there is additional data on which to base the calculation of part load efficiency. It is assumed that the user adjusts the settings or fuel quantity to match loads if the product has a variable or multi-setting capacity capability, similar to thermostatic control.

This calculation method is used for solid fuel combustion heaters with adjustable air controls based on their high, medium and low burn rates, and for ducted gas heaters, based on the nominal gas consumption and thermal efficiency of the product, and the high load and low load test results.

Annual Inactive Energy Consumption

Many products continue to consume small amounts of electricity and/or gas when not operating, unless they are physically disconnected, or turned off at the power outlet or gas valve. This is often referred to as their standby or inactive energy consumption and should be included in an overall assessment of their annual energy use.

For each space heater technology type the energy consumption in standby or inactive mode is defined either by the existing product test standard, or if these measurements are not included in the standard, by default values or the use of AS/NZS IEC 62301, as summarised in Appendix 2: Key Characteristics for Each Heater Type.

The inactive power consumption, multiplied by the number of hours the product is in inactive or standby mode, can then be incorporated into the overall assessment of the product's annual energy use.

The air conditioner GEMS Determination defines the Annual Inactive Energy Consumption (IAEC) to be the product of the weighted average inactive power consumption, (P_{ia} or Standby power consumption), and the number of hours of inactive mode, (H_{ia}), as given by AS/NZS 3823.4.2:2014 and reproduced in Table 2, calculated in accordance with Annex B of AS/NZS 3823.4.2:2014 and based on rated inputs. For heating only products, the number of cooling mode hours specified in Table 2 are considered to be disconnected mode hours.

Table 2: Air Conditioner Cooling, Heating and Inactive Mode Hours by Climate Zone

Climate Zone	Cooling Mode Hours (h)	Inactive Mode Hours (h)	Heating Mode Hours (h)
Hot Zone	2247	6236	277
Average Zone	840	6629	1291
Cold Zone	545	5555	2660

*For heating only products, disconnected mode replaces cooling mode. For cooling only products, disconnected mode replaces heating mode.

Based on TWG consultations, it is proposed that under the space heater comparison methodology:

- for fixed (non-portable), heating only heaters (not reverse cycle air conditioners) the cooling mode hours will be considered as inactive (standby) hours
- for portable, heating only heaters (not reverse cycle air conditioners) the cooling season (both the cooling mode hours and the inactive mode hours which occur during the cooling season) will be considered as disconnected hours, and the heating season inactive hours considered as inactive (standby) hours.

The more detailed breakdown of cooling and heating season hours and inactive hours for each season is provided in Table 3.

Table 3: Heating and Cooling Season Hours and Inactive Hours

Climate Zone	Heating Season* Active Hours	Heating Season* Inactive Hours	Cooling Season* Active Hours	Cooling Season* Inactive Hours
Hot Zone	277	2651	2247	3585
Average Zone	1291	2381	840	4248
Cold Zone	2660	2476	545	3079

*Based on a heating season of June-September in the Hot Zone, May-September in the Average Zone and April-October in the Cold Zone, and cooling season for the balance of the year.

Applying the above definitions for fixed and portable space heaters results in the inactive hours summarised in Table 4, and compared to the effective inactive hours assigned to heating in the ACCM. The Annual Inactive Energy Consumption (IAEC) is defined as the product of the inactive power consumption Pia (or Standby power consumption) and the number of hours of inactive mode (or Standby hours).

Annual Inactive Energy Consumption (*IAEC*) = *Inactive Power Consumption* (P_{ia}) x *Inactive Hours* (H_{ia})

Example annual inactive energy consumption results are provided in Appendix 4: Example data and results.

Table 4: Heating Standby Hours, by Climate Zone, according to the Comparison Methodology

Type of Heater Standby Hours	Hot Zone	Average Zone	Cold Zone
ACCM Heating Inactive Hours = 0.4 x Inactive Hours (h)	2222	2652	2494
Portable Weather Independent Heater Inactive Hours (h)	2651	2381	2476
Fixed Weather Independent Heater Inactive Hours (h)	8483	7469	6100

Heating Annual Energy Use

The ACCM defines the Heating Annual Energy Use for air conditioners (excluding unitary single duct air conditioners) as:

Heating Annual Energy Use = *Heating Seasonal Energy Consumption* (*HSEC*)

+ 0.4 x *Annual Inactive Energy Consumption* (*IAEC*)

The factor 0.4 represents 40% of the Annual Inactive Energy Consumption, which is attributed to the heating cycle, and is a reasonable simplification of the number of inactive mode hours that occur during the heating season. The remaining 60% is included in the *Cooling Annual Energy Use*.

Based on TWG consultations it is proposed that the space heater comparison methodology will regard that for heating only products, the heating annual energy use will include the full annual inactive energy consumption as defined above (with the cooling season hours considered as inactive for fixed (non-portable) products, and disconnected for portable products).

Heating Annual Energy Use = *Heating Seasonal Energy Consumption* (*HSEC*)

+ *Annual Inactive Energy Consumption* (*IAEC*)

The effect of standby power consumption and standby hours is small for most heaters, but for individual products with higher levels of standby power consumption (particularly pilot burners) it can become significant. This is particularly the case for fixed (non-portable), smaller capacity units in the Hot Zone, with their corresponding low levels of heating load and large number of inactive hours. As discussed by the TWG, including 100% of the annual inactive energy consumption hours in the annual energy use and performance factors helps to ensure that focus on reducing inactive energy consumption is maintained.

Heating Seasonal Performance Factor

The ACCM defines the Heating Seasonal Performance Factor (HSPF) for air conditioners, in accordance with clause 6.1 of AS/NZS 3823.4.2:2014, as the ratio of the Heating Seasonal Total Load (HSTL) to the Heating Seasonal Energy Consumption (HSEC):

$$HSPF = \frac{HSTL}{HSEC}$$

HSEC is the Heating Seasonal Energy Consumption and does not include the energy consumed in inactive mode. Therefore, under the current ACCM, the calculation of HSPF for air conditioners does not include any consideration of the energy consumed in inactive mode (standby). While the standby power input for air conditioners does tend to be much smaller than the full power input, the large number of hours in inactive mode can lead to the standby energy consumption becoming a more significant, but still small, fraction of the annual energy use.

The Total Heating Seasonal Performance Factor (THSPF) is also defined in AS/NZS 3823.4.2:2014 Annex B, and includes 100% of the Annual Inactive Energy Consumption, but is not utilised by the GEMS Determination:

$$THSPF = \frac{HSTL}{HSEC + IAEC}$$

The air conditioner GEMS Determination uses TCSPF and HSPF to define a product's cooling star rating and heating star rating, including 100% and 0% of the Annual Inactive Energy Consumption respectively, as distinct to the 60% and 40% used in the calculation of Annual Energy Use. Note that, for unitary single duct air conditioners (which are rarely heaters), the above definition is not used, and their star rating is defined as being zero.

As discussed with the TWG, it is recommended that for heating-only products, the THSPF is used to evaluate annual energy efficiency, thereby including 100% of the standby energy consumed.

Distribution losses

For heaters with a distribution system (air ductwork, water pipework, radiators, or heating elements):

- there will be distribution losses (to varying degrees) and therefore additional load required to be supplied by the appliance;
- those distribution losses will often be outside of the control of the appliance manufacturer, and depend on the building design, the distribution system design (for example, ductwork diameters, lengths, materials and insulation), and the installers workmanship (for example, the sealing and insulation of ductwork)
- from a user's perspective these distribution losses are part of the heating system's performance and as such should be included in the performance calculation (as distinct from when users choose to use a single outlet heater to heat their whole house)
- the capacity of the appliance to supply load to the occupied space is reduced by these losses, i.e. an appliance that can supply 10kW at the heater may only be able to supply 9kW to the occupied space because of the distribution losses to unoccupied roof, ground or wall spaces.

Based on TWG discussions, it is proposed that for ducted gas heaters the boundary of the performance evaluation is placed at the inlet/outlet of the appliance. This defines the load as the energy to be delivered to the distribution system (rather than the occupied space), and excludes the duct losses from the assessment of the appliance's efficiency, capacity and annual energy use. The appliance efficiency evaluated in this manner will be higher than that of the overall heating system (including ductwork), and in theory, with no mitigating factors, could result in consumers and suppliers under-sizing equipment or under-estimating annual energy consumption. However it would accurately reflect the aspects of the appliance under the manufacturer’s control. This is consistent with the approach used for ducted air conditioners in the ACCM.

Regardless of whether the comparison methodology generated performance information focussed on the point of the appliance’s inlet/outlet or on the whole system including assumed duct losses, the comparison methodology would provide a foundation upon which more specific or supplementary whole system energy performance information could be generated. Default typical ductwork energy loss values could be devised to determine the overall heating system efficiency, capacity and annual energy consumption.

Work will continue to develop calculation methods for more complex heaters such as electric resistance underfloor heating systems (including directly under flooring, in-screed and in-slab) and hydronic (gas, electric resistance, solar or heat pump) heating systems, based on a similar approach, with consideration of the distribution system losses and effects of thermal mass, outdoor temperature, and solar radiation as appropriate for each technology type.

Results of the methodology

The space heating comparison methodology defines energy performance metrics that could be used to communicate key performance features of a range of heater types to consumers and suppliers (including specifiers, heating and cooling businesses, and installers):

- **Capacity (kW)**: The rate at which a product is able to supply heat, under a common set of defined conditions. This enables consumers and suppliers to compare similar capacity products. It may assist in selection of the right sized products for a consumer's needs. However, often consumers will require the guidance of experienced professionals to calculate optimal sizing requirements to account for a complex combination of climate, building structure and orientation, and consumer usage.
- **Input Power (kW)**: The amount of power (energy per unit time) the product uses, under a common set of defined conditions. This provides a guide to the typical amount of power it is likely to consume, however, is not necessarily the maximum value of power required.
- **Annual Energy Use (kWh/y)**: The amount of energy the product will use to deliver a standard load, under standard conditions, in each of the three defined climate zones (Hot, Average and Cold – noting that the load values from more specific climate zones could be used to deliver more specific annual energy use information). These values can be calculated separately for each fuel type (e.g. gas, electricity or wood), enabling consumers to compare running costs and greenhouse gas emissions. Kilowatt hour figures could also be converted into GJ for gas appliances.
- **Heating Performance Factor**: The heating performance factor is the ratio of the total heating (energy) load delivered by the product to the annual energy use of the product. It conveys the annual efficiency for each climate zone. This value provides a point of comparison for identifying which product most efficiently converts the consumed energy into heat.

Table 5 provides a summary of example outputs based on total energy. These outputs can be separated out by fuel type, and the more detailed results used to estimate running costs and greenhouse gas emissions. Example results are provided for a range of technology types, sizes (capacity), configurations (fixed or portable), and controls (with or without thermostatic control). The size (capacity) of the example heater units have generally been selected to represent products typically available in the market, however, in some cases they represent the combined effect of multiple smaller heaters, such as 3 electric resistance heaters used in separate rooms of a house (e.g. Heater Unit 10). The results are provided to give indicative comparisons of multiple smaller systems, such as electric resistance heaters, split system air conditioners or gas space heaters with a single large product, such as a ducted gas heater or air conditioner.

The air conditioner results are based on averaged values from the GEMS register, while the other technology types are typical values identified from reviewing specifications of products in the marketplace. Detailed key product characteristics for each of the heater units are included in the relevant technology type subsection of Appendix 2: Key Characteristics for Each Heater Type.

These examples demonstrate how test report results can be used as inputs to the space heater comparison methodology, and that this methodology is straightforward to apply to each of these technology types.

The space heater comparison methodology could be used as the basis for developing additional and more detailed performance information. For example, information could be customised according to a consumer's geographic location and usage profile by applying a wider range of load profiles and weather files.

Table 5: Summary of example space heating comparison methodology outputs, by product size, technology type and climate zone

Heater Unit	Technology Type	Characteristics	Size	Full Capacity: Rated Capacity (kW)	Full Capacity: Rated Input Power [6](kW)	Full Capacity: Rated Efficiency	Annual Energy Use: Hot (kWh /y)	Annual Energy Use: Average (kWh/y)	Annual Energy Use: Cold (kWh/y)	Overall Product Efficiency: HSPF_ hot	Overall Product Efficiency: HSPF_ avg	Overall Product Efficiency: HSPF_ cold
1	Air Conditioner* (Non-ducted)	Avg GEMS Register 1.75-2.25kW non-ducted	Small	2	0.5	426%	47	292	742	4.06	3.80	3.55
2	Electric Resistance	Portable, Thermostatic control	Small	2	2	100%	181	1098	2619	0.93	0.99	1.00
3	Electric Resistance	Portable, Two-setting, No thermostatic control	Small	2	2	100%	189	1152	2749	0.89	0.94	0.95
4	Electric Resistance	Portable, One-setting, No thermostatic control	Small	2	2	100%	198	1207	2880	0.85	0.90	0.91

[6] Note: Capacity, Input Power, Energy Use and Product Efficiency are all based on the total energy use (e.g. gas plus electricity for gas space heaters). Input Power and Energy Use would also be separated out by fuel type in order to calculate running costs and greenhouse gas emissions.

* Explanation of air conditioner values are provided in Appendix 4: Example data and results.

5	Gas Space Heater	Portable, Thermostatic Control, 2 data points	Small	2	2.5	80.6%	203	1311	3159	0.83	0.83	0.83
6	Solid Fuel Heater	Fixed, Adjustable Air Control, 3 data points	Small	2	3.03	66.1%	281	1802	4276	0.60	0.60	0.61
7	Gas Decorative App.	Fixed, Thermostatic Control, 2 data points	Small	2	4.4	45.8%	358	2310	5561	0.47	0.47	0.47
8	Air Conditioner* (Non-ducted)	Avg GEMS Register 6.5-7.5kW non-ducted	Medium	7	1.8	390%	135	918	2499	4.8	4.2	3.7
9	Ducted Air Conditioner*	Avg GEMS Register 6.5-7.5kW ducted	Medium	7	1.8	388%	165	1009	2689	4.4	3.9	3.4
10	Electric Resistance	Multiple Portable (e.g. 2.4kW + 2.4kW + 2.2kW), Thermostatic Control	Medium	7	7	100%	627	3837	9160	0.94	0.99	1.00

11	Electric Resistance	Multiple Fixed (e.g. 3kW + 4kW), Thermostatic Control	Medium	7	7	100%	715	3913	9215	0.82	0.97	0.99
12	Gas Space Heater	Fixed, Thermostatic Control, 2 data points	Medium	7	8.9	78.6%	750	4824	11576	0.78	0.79	0.79
13	Ducted Gas	Fixed, Thermostatic Control, 3 data points	Medium	7	9.33	75.0%	787	4942	11884	0.75	0.77	0.77
14	Solid Fuel Heater	Fixed, Adjustable Air Control, 3 data points	Medium	7	10.59	66.1%	1025	6346	14996	0.57	0.60	0.61
15	Air Conditioner* (Non-ducted)	Avg GEMS Register 11-13kW non-ducted	Large	12	2.9	391%	248	1563	4253	5.0	4.3	3.7
16	Ducted Air Conditioner*	Avg GEMS Register 11-13kW ducted	Large	12	3.0	392%	274	1684	4494	4.5	4.0	3.5

17	Electric Resistance	Multiple Fixed (e.g. 4kW + 4kW + 4kW), Thermostatic Control	Large	12	12	100%	1134	6628	15731	0.89	0.98	1.00
18	Gas Space Heater	Multiple Fixed (e.g. 6kW + 6kW), Thermostatic Control, 2 data points	Large	12	15.3	78.6%	1282	8267	19841	0.79	0.79	0.79
19	Ducted Gas	Fixed, Thermostatic Control, 3 data points	Large	12	15.75	75.0%	1299	8315	20036	0.76	0.77	0.77
20	Solid Fuel Heater	Fixed, Adjustable Air Control, 3 data points	Large	12	18.46	65.0%	1343	8761	21399	0.75	0.74	0.73

Conclusion

A detailed space heating comparison methodology has been developed with the specialist technical input and guidance of the Space Heating Equipment Technical Working Group. This methodology is based on the GEMS Determination for air conditioners; utilises existing individual space heater test methods to define the key performance characteristics of a heater; and enables a common evaluation method to be used to calculate performance metrics, so that products can be objectively compared across technology types.

This paper provides a summary of the space heating comparison method, definitions of the key performance characteristics for each technology type, and example results for a range of technology types and climate zones. These results demonstrate that the methodology can generate comparable performance information for different technologies by using existing test results. The methodology could therefore be implemented in a straightforward manner without requiring significant additional testing for most product types. The outputs of the method could be used to communicate to consumers the heating capacity of space heaters, their annual energy use, and their overall efficiency, all determined on a common basis.

Work will continue to develop calculation methods for more complex heaters such as electric resistance underfloor heating systems (including directly under flooring, in-screed and in-slab) and hydronic (gas, electric resistance, solar or heat pump) heating systems. The calculation methods for more complex heaters would be based on a similar approach to the calculation methods already developed for the simpler heaters, and include consideration of the distribution system losses and effects of thermal mass, outdoor temperature and solar radiation as appropriate for each complex technology type. The department will consult with relevant stakeholders for these technologies as part of developing these product methods. Once ready, the product method papers for more complex heaters would be published for broader consultation.

The department will use the information and feedback obtained from public consultation on this paper to refine the comparison methodology. With a suitable comparison methodology identified, the department can continue to explore options that would enable consumers to make easy energy performance comparisons of residential space heaters.

References

E3 2021, *Product Profile: Residential Space Heaters in Australia and New Zealand*

Sustainability Victoria 2015, *Energy Efficiency Upgrade Potential of Existing Victorian Houses*

Appendix 1: Glossary of Terms

Term	Description
ACCM	Air Conditioner Comparison Methodology is a term used in this paper to collectively refer to documents and regulations that operate in combination as a comparison methodology for air conditioners, and consists of the Greenhouse and Energy Minimum Standards (Air Conditioners up to 65kW) Determination 2019 in Australia or the EUP Regulations (Schedule 2A, Air Conditioners up to 65kW) in New Zealand, and AS/NZS 3823.4.2.
Annual inactive (standby) energy consumption (IAEC)	This is the total amount of energy consumed in standby (or inactive) mode, in a year, and is calculated from the number of hours of inactive (standby) mode multiplied by the inactive (standby) power consumption. For air conditioners the inactive (standby) power consumption is defined by a weighted average over multiple air temperatures.
Appliance (or heater)	The part or parts of the heating system as manufactured or imported and sold as a single unit or package. "Appliance" is used interchangeably with "heater".
Capacity (or heating capacity)	The rate at which a product is able to supply heat, to the conditioned space. Heating capacity is used for air conditioners to distinguish it from cooling capacity. Capacity is used both as a general term for the useful thermal output of a heater (the amount of heating it provides), and more specifically for the rated capacity based on testing to a specific standard (such as AS/NZS 3823.1.1: 2012 for air conditioners or AS/NZS 5263.1.3: 2021 for gas space heaters), at a specified temperature condition and load. For air conditioners, it most commonly refers to the value at H1 (7°C outdoor temperature) at full load. The capacity of a heater may vary due to a number of factors including weather dependence and controller setting: - For most heaters, the user or a thermostatic controller may be able to adjust the heater output from a minimum capacity to half capacity and to full capacity (maximum for most heaters), depending on whether the product is fixed-capacity, two-setting capacity, multi-capacity or variable capacity. - For air conditioners, heating capacity is also dependent on outdoor temperature, and there may be a low temperature extended capacity which is larger than the low temperature full capacity, and due to limitations of air conditioner technology may only be available at low outdoor temperatures.
- Extended capacity, or low temperature extended capacity	Typically extended capacity, or low temperature extended capacity, refers to an air conditioner's heating capacity when tested at 2°C, at extended-load operation, but may also be generally used to refer to the air-conditioner's capacity at any temperature while at extended-load

Term	Description
	operation. Extended-load operation may only be available at lower outdoor temperatures.
- Fixed-capacity heater	A fixed-capacity heater is one which only has a single mode of operation or setting.
- Frosting capacity	The capacity of an air conditioner including consideration of the effects of frosting (frosting is typically considered to occur between -7°C and 5.5°C).
- Full capacity	Typically full capacity refers to a heater's maximum capacity when tested at a standard test condition, such as 7°C for air conditioners. Full capacity may also be generally used to refer to the heater's capacity at any temperature while operating in the same mode as during its full capacity test. For most heaters this operating mode is maximum output, however, air conditioner's may have an extended-load operation for use at low outdoor temperature which provides more heat output than their full capacity.
- Half capacity	For multi-capacity and variable capacity heaters where the output can be adjusted to more than two levels, the thermal performance of the heater can be evaluated at a medium level of output or "Half Capacity". The specific evaluation point is aligned with existing standards and may not be either half of the full capacity, nor half of the power input. For example, for solid-fuel combustion heaters the medium burn rate is used.
- Minimum capacity	For two-setting, multi-capacity and variable capacity heaters where the output can be adjusted, the thermal performance of the heater can be evaluated at a minimum level of output or "Minimum Capacity". The specific evaluation point is aligned with existing standards and may not be actual minimum output of the product, nor the minimum power input. For example, for solid-fuel combustion heaters the low burn rate is used.
- Multi-capacity	A multi-capacity heater is one which where the output can be switched between three or more discrete modes of operation or settings.
- Nominal capacity	The nominal capacity of a product is the capacity as stated by the manufacturer, and typically displayed on labels, packaging and brochures. It is often, but not necessarily, the rated capacity of the product.
- Rated capacity	The capacity of a product when tested under standard rating conditions. For air-conditioners, the rated full capacity is tested at 7°C outdoor temperature.
- Two-Setting capacity, or two-stage	A two-setting capacity, or two-stage, heater is one where the output can be switched between two output settings or modes of operation.
- Variable capacity	A variable capacity heater is one where the output of the heater can be continuous varied, however, it is also often used to refer to both multi- and variable capacity heaters, and more generally to any heater where the output can be varied.
Cooling hours	The hours of the year during which cooling is required. Also used to refer to the number of hours per year cooling is required.
Cooling season	The season or period of the year during which cooling is required. The cooling season includes both cooling hours and inactive hours (hours when cooling is not required). In concept, the cooling season and heating season could overlap, however, those defined by the ACCM and utilised for the space heating comparison methodology do not.

Term	Description
COP	Coefficient of performance. This is the ratio of heating output to energy input.
Distribution losses	Heaters with a distribution system (air ductwork, water pipework, radiators, or heating elements) will lose heat through these systems so the delivered heat to the occupied space will be less than that produced by the heating system. The extent of distribution losses will be dependent on a number of factors outside the control of the heating system manufacturer.
Energy efficiency	A general term which is typically calculated by dividing the energy obtained (useful energy or energy output) by the initial energy (energy input).
EUP Regulations	Energy Efficiency (Energy Using Products) Regulations 2002, which apply in New Zealand.
Fixed heaters	Heaters which are permanently installed and non-portable. These heaters are assumed to be less likely to have their energy source isolated (turned off completely) during the cooling season, and therefore assumed to use inactive (standby) energy throughout the cooling season.
Heating hours	The hours of the year during which heating is required. Also used to refer to the number of hours per year heating is required.
Heating season	The season or period of the year during which heating is required. The heating season includes both heating hours and inactive hours (hours when heating is not required). In concept, the cooling season and heating season could overlap, however, those defined by the ACCM and utilised for the space heating comparison methodology do not.
Heating system	All of the components of a heater and distribution system, including the heater (or appliance) plus additional components required to distribute heat, such as ductwork, pipework or radiators.
Gas energy label	A label that illustrates the energy consumption of a gas appliance shown as a number of stars that allows consumers to compare the energy consumption and running costs of various gas appliances based on testing in accordance with the relevant standard (AS/NZS 5263.1.6 for ducted gas heaters).
GEMS	Greenhouse and Energy Minimum Standards, which apply in Australia.
Heating annual energy use	This is the total annual amount of energy consumed by the equipment in order to deliver heating, including energy consumed in both heating mode and inactive (standby) mode.
HSEC	Heating Seasonal Energy Consumption. This is the total annual amount of energy consumed by the equipment in heating mode, including make-up heat (additional heating required above the maximum capacity of the heater).
HSPF	Heating Seasonal Performance Factor. This is the ratio of the total annual amount of heat, including make-up heat, that the equipment can add to the conditioned space when operated for heating in active mode to the total annual amount of energy consumed by the equipment in heating mode.
HSTL	Heating seasonal total load, is the total amount of energy delivered as heating, per year, which is calculated by adding up the heating load at each outdoor temperature, multiplied by the reference bin hours.

Term	Description
Inactive (standby) mode	Inactive (standby) power refers to the energy that is used by devices even when they appear to be turned off. Inactive power allows electronics to turn on quickly, but means that they are constantly drawing some power from the electrical grid. Pilot burners are less common, but consume significant amounts of gas when the product is not actively heating.
Load, or heating load	Load is a general term referring to the demand or need for heating. It is also used to specifically refer to a standard amount of heating, as a function of outdoor temperature, which is used to evaluate and compare heaters.
- Full load, or full-load operation	Full load, or full-load operation, typically refers to when a heater is operating at its maximum output. For air conditioners, at low temperatures, full load is not the maximum if the product also has an extended-load operation.
- Partial load, or part-load operation	Partial load, or part-load operation, typically refers to when a heater is operating at less than its maximum output, such as when it is switched to a lower setting, or the gas consumption rate is reduced.
- Extended load, extended-load operation	Air conditioners may have an extended-load operation, which is typically only available at lower outdoor temperatures, and enable the air conditioner to supply more heat than its full-load operation.
Make-up heat	Additional heating required above the maximum capacity of the heater.
MEPS	Minimum Energy Performance Standard.
Nominal gas consumption (MJ/h), NGC	The appliance's gas consumption, in megajoules per hour (MJ/h), as stated in the manufacturer's specifications, instructions, in general communications and on the appliance.
Operating range	A general term referring to the range of external and/or internal variables across which the product is able to operate, such as outdoor temperature, compressor speed, gas setting (e.g. minimum through to maximum).
Portable heaters	Heaters which are portable, able to be moved from room to room, or put away in storage when the heating season ends, and therefore unlikely to use inactive (standby) energy during the cooling season.
Power input	Power input is a general term for the energy (electricity, gas or solid-fuel) consumed by a product. Power input also means more specifically the rated energy consumed based on testing to a specific standard (such as AS/NZS 3823.4.2:2014) at a specified temperature condition and load. For air conditioners, it most commonly refers to the value at7°C outdoor temperature and full load.
Rated	A rated value or amount is one that is claimed by the manufacturer and that is based on a tested value or amount.
TCSPF	Total Cooling Seasonal Performance Factor. This is the ratio of the total annual amount of heat that the equipment can remove from the conditioned space to the total annual amount of energy consumed by the equipment, including the active and inactive energy consumption.
Thermal efficiency	This can be used as a general term, and typically refers to the ratio of useful thermal output to energy input. It can also refer specifically to the combustion thermal efficiency, overall operating efficiency, or seasonal operating efficiency of an appliance. The combustion thermal efficiency of a gas appliance determined from the energy contents of the flue gas. This

Term	Description
	calculation assumes that any energy not exiting via the flue gas is useful heating (thermal output). For ducted gas heaters an overall efficiency and seasonal efficiency are also determined to take into account appliance heat losses and standby energy consumption.
Thermal output (or output or heat output)	A general term referring to the heating, cooling and/or dehumidification provided by a product.
Thermal performance	A general term referring to thermal (heating, cooling and/or dehumidification) performance metrics such as how much heating is provided (capacity), how efficiently it is delivered, and how much energy is consumed (power input).
THSPF	Total Heating Seasonal Performance Factor. This is the ratio of the total annual amount of heat that the equipment can deliver to the conditioned space to the total annual amount of energy consumed by the equipment, including the active and inactive energy consumption.
Weather dependent heaters	Heaters whose capacity may vary significantly with weather conditions, such as outdoor temperature or solar radiation. Air conditioners and heat-pump hydronic heating systems are weather dependent heaters because their capacity may vary significantly with outdoor temperature, and solar-thermal hydronic heating systems also depend on solar radiation.
Weather independent heaters	Heaters whose capacity does not vary significantly with weather conditions, such as outdoor temperature or solar radiation. Electric resistance, gas (ducted or non-ducted) and solid-fuel heaters are considered to be weather independent heaters for the purpose of the space heating comparison methodology.
ZERL	Zoned Energy Rating Label for air-conditioners. This provides a seasonal efficiency rating for three distinct climate zones — hot, average, and cold. The label displays performance information to help consumers select a product that is suitable for their climate zone. Ratings are up to a maximum of 10 stars for both heating and cooling.

Appendix 2: Key Characteristics for Each Heater Type

There are several inputs to the comparison methodology which describe the key characteristics of each heater type. An overview of the sources of inputs for each heater type is provided below.

For any heater type only two of capacity, power input and efficiency need be defined as the third value can be calculated from the other two, i.e. efficiency = heating capacity/power input.

Gas space heaters (non-ducted) and gas decorative appliances

Based on TWG consultations, it is proposed that if gas decorative appliances are included in the scope of this methodology, then they should be evaluated using the test standards for gas space heaters (non-ducted).

Heating Capacity - Maximum heat output measured at maximum gas rate as per AS/NZS 5263.1.3

Power Input - Maximum gas and electricity input (power input) measured at the maximum gas rate as per AS/NZS 5263.1.3

Efficiency - Efficiency = Heating Capacity / Power Input.

Multiple Capacities - Evaluation at maximum and minimum (turndown) gas rates, as per AS/NZS 5263.1.3

Inactive/Standby Power - Standby gas and electricity input from AS/NZS 5263.1.3

Product sub-type and controls – Number of settings, with or without thermostatic control, as declared by manufacturer, and supported by AS/NZS 5263.1.3 test report.

HSEC Calculation method: 1, 2, 3 or 4.

Reverse cycle air conditioners (heat pumps), both non-ducted and ducted

Heating Capacity - Measured at 7°C and 2°C (and optionally at - 7°C) outdoor temperatures as per the appropriate AS/NZS 3823.1 test standard.

Power Input - Measured at 7°C and 2°C (and optionally at - 7°C) as per the appropriate AS/NZS 3823.1 test standard.

Efficiency - Efficiency = Heating Capacity / Power Input.

Multiple Capacities - Evaluation at full, half, minimum and/or extended capacities, as per AS/NZS 3823.4.2 and appropriate AS/NZS 3823.1 test standard.

Inactive/Standby Power - Weighted average of measured results at 5°C, 10°C, 15°C and 20°C, as per AS/NZS 3823.4.2.

Product sub-type and controls – Fixed, Two-setting, Multiple or Variable capacity as declared by manufacturer and supported by appropriate AS/NZS 3823.1 test standard report.

HSEC Calculation method: 3, 4, 5 or calculation including extended capacity, all of which are unchanged from the current ACCM.

Electric resistance heaters (portable and fixed)

Heating Capacity - Heating Capacity = Power Input x Efficiency

Power Input - Nameplate input power as per AS/NZS 60335.1

Efficiency - Assume to be 100%.

Multiple Capacities - Manufacturer declaration of number of settings.

Inactive/Standby Power – Default value of 5 W, or as per AS/NZS IEC 62301

Product sub-type and controls – Number of settings, with or without thermostatic control, as declared by manufacturer and supported by AZ/NZS 6035.1 test report.

HSEC Calculation methods: 1, 2 or 3.

Solid fuel combustion heaters

Heating Capacity – Maximum Average Heat Output Burning (kW) as marked on product, from AS/NZS 4012. Where multiple fuel types and/or options are listed on the marking, the highest value will be used.

Power Input – Solid fuel power input = Maximum Average Heat Output Burning (kW) / Average Efficiency (%) at high burn rate, or from Average Fuel Consumption Rate (kg/h) of fuel at high burn rate, as per AS/NZS 4012.

Electrical input power:

* Default (100W or 50W/10kW Rated Heating Capacity); or
* Nameplate input power as per AS/NZS 60335.1

Efficiency – Efficiency = Heating Capacity / Power Input.

Multiple Capacities – Evaluation at high, low and medium burn rates for products with adjustable air controls, as per AS/NZS 4012, otherwise just at high burn rate.

Inactive/Standby Power - Default value of 5W, or as per AS/NZS IEC 62301, if there is an electrical connection, otherwise zero.

Product sub-type and controls – Adjustable or non-adjustable air controls, as declared by manufacturer and supported by number of test points in AS/NZS 4012 test report.

HSEC Calculation methods: 3 or 5.

Ducted gas heaters

Heating Capacity – Nominal gas consumption as defined by AS/NZS 5263.0 multiplied by the thermal efficiency at nominal gas consumption, as defined by AS/NZS 5263.1.6: 2020 Test Method ZC.102 Thermal Efficiency Test.

Power Input – Nominal gas consumption as defined by AS/NZS 5263.1.6: 2020 plus high load electricity consumption measured during the high (70-80%) load test of AS/NZS 5263.1.6: 2020 Test Method ZC.107.

Efficiency – Efficiency = Heating Capacity / Power Input.

Multiple Capacities – Evaluation at nominal gas consumption, and during high (70-80%) and low (20-30%) load tests of AS/NZS 5263.1.6: 2020 Test Method ZC.107.

Inactive/Standby Power – Standby gas consumption plus standby electricity consumption as defined by AS/NZS 5263.1.6: 2020 Test Method ZC.107.

Product sub-type and controls – Number of settings, with or without thermostatic control, as declared by manufacturer and support by AS/NZS 5263.1.6 test report.

HSEC Calculation methods: 1, 2 or 5.

Appendix 3: HSEC Calculation Equations

The energy consumed during heating, or Heating Seasonal Energy Consumption (HSEC), depends on how a product adjusts its operation to match the load being demanded.

The space heater comparison methodology proposes to use the definition of HSEC that:

- best aligns with the test data available from the existing product test standards for each space heater technology type
- uses 1, 2 or 3 points of performance data, corresponding to the full, "minimum" and "half" capacity values used in the ACCM
- does not include make-up heat for weather independent (non-air conditioner) products
- does not include a part load factor (PLF) for electric resistance, gas (ducted or non-ducted) or solid-fuel combustion heaters
- applies an additional 5% (2 settings) or 10% (fixed-capacity) penalty for products that are not thermostatically controlled, not solid fuel combustion heaters, or have fewer than 3 capacity (heat output) settings.

Utilising data from more than one operating point whenever available helps to ensure that efficiency across the product's operating range is taken into account, and reflected in the annual energy use, as per the product test standards for each space heater technology type.

The HSEC calculation for air conditioners is already specified in the ACCM. The HSEC calculation for gas decorative appliances is the same as for gas space heaters.

The calculation methods specified below are for total input power, from all fuel types. The same calculation would also need be carried out separately for each fuel type in order to define running costs and greenhouse gas emissions.

HSEC Calculation method 1. Fixed capacity products without thermostatic control:

For this calculation it is assumed that there is a 10% increase in heating seasonal energy consumption (HSEC) due to less-efficient matching of capacity to load, compared to systems with thermostatic control or more than two capacity settings. The development of this calculation method was discussed in TWG Paper 3, and it is proposed that these products are modelled as having a heating seasonal energy consumption equal to 110% of that which would be calculated for the same product if it had thermostatic control, using either HSEC Calculation Method 5, HSEC Calculation Method 4, or HSEC Calculation Method 3, with a requirement to use the highest calculation number (most performance data points).

$$HSEC = 1.1 \times HSEC^*$$

where *HSEC* = Heating Seasonal Energy Consumption (kWh/year); 1.1 = penalty for lack of thermostatic control; *HSEC** is determined using either HSEC Calculation Method 5, HSEC Calculation Method 4 or HSEC Calculation Method 3 in accordance with the equations below, for the relevant product type.

HSEC Calculation method 2. Two-setting capacity products without thermostatic control:

For this calculation it is assumed that there is a 5% increase in heating seasonal energy consumption (HSEC) due to less-efficient matching of capacity to load, compared to systems with thermostatic control or more than two capacity settings. The development of this calculation method was discussed in TWG Paper 3, and it is proposed that these products are modelled as having a heating seasonal energy consumption equal to 105% of that which would be calculated for the same product if it had thermostatic control, using either HSEC Calculation Method 5, HSEC Calculation Method 4, or HSEC Calculation Method 3, with a requirement to use the highest calculation number (most performance data points).

$$HSEC = 1.05 \text{ x } HSEC^*$$

where *HSEC* = Heating Seasonal Energy Consumption (kWh/year); 1.05 = penalty for lack of thermostatic control; *HSEC** is determined using either HSEC Calculation Method 5, HSEC Calculation Method 4 or HSEC Calculation Method 3 in accordance with the equations below, for the relevant product type.

HSEC Calculation method 3. Variable capacity products (>2 settings) and products with thermostatic control, with one point of performance data:

For this calculation the capacity of the heaters would be adjusted to match the load, with part load conditions applying until the load is equal to the full capacity of the product, and then full power would be required plus make-up heat for the remaining (cold) outdoor temperatures. Based on TWG consultations, it is proposed that for weather independent heaters make-up heat is not required.

For outdoor temperatures, t_j, where the load is less than or equal to capacity, the part load option is used, reducing the *full power* of the product by the ratio of load to capacity (limited to between 0 and 1). For the remaining (cold) outdoor temperature where load exceeds capacity the *full power* of the unit is used.

$$HSEC = \sum_{t_j \text{ where } Load \leq Capacity} Full\ Power \times \frac{Load}{Full\ Capacity} \times Hours + \sum_{t_j \text{ where } Load > Capacity} Full\ Power \times Hours$$

where *HSEC* = Heating Seasonal Energy Consumption (kWh/year); *Full Power = Rated Power Input* (kW); *Load* is the heating load as a function of outdoor temperature (kW); *Full Capacity = Rated Capacity* (kW); COP_{ful} is the Coefficient of Performance (ratio of capacity to power input) at full capacity; t_j = outdoor temperature (°C); and *Hours* are the hours of operation in heating mode, as a function of outdoor temperature, as defined by the temperature bins specified in AS/NZS 3823.4.2 for residential applications.

This calculation method is used for: electric resistance heaters; solid fuel combustion heaters with non-adjustable air controls; and gas space heaters which were only evaluated at maximum gas consumption.

HSEC Calculation method 4. Variable capacity products and products with thermostatic control, with two points of performance data:

For these products, the HSEC is calculated similarly to calculation 3, but because these products can be measured at minimum (or low) outputs, there is additional data on which to base the calculation of part load efficiency. It is assumed that the user adjusts the settings or fuel quantity to match loads if the product has a variable or multi-setting capacity capability, similar to thermostatic control.

For outdoor temperatures, t_j, where the load is less than or equal to minimum capacity, the part load option is used, reducing the *minimum power* of the product by the ratio of load to capacity (limited to between 0 and 1).

For outdoor temperature, t_j, where the load is between the minimum capacity and the full capacity, the power used is defined by the load divided by the COP, where the COP is interpolated between the COP at minimum capacity (COP_t = minimum capacity / minimum power) and the COP at full capacity (COP_f = full capacity / full power).

For the remaining (cold) outdoor temperature where load exceeds capacity of the gas space heater, the *full power* of the unit is used.

$$HSEC = \sum_{t_j \text{ where } Load \le Minimum\ Capacity} Minimum\ Power \times \frac{Load}{Minimum\ Capacity} \times Hours$$

$$+ \sum_{t_j \text{ where } Minimum\ Capacity < Load \le Full\ Capacity} Power \times Hours$$

$$+ \sum_{t_j \text{ where } Load > Full\ Capacity} Full\ Power \times Hours$$

where *HSEC* = Heating Seasonal Energy Consumption (kWh/year)*: Full Power* and *Full Capacity* are the rated capacity and power measured at maximum gas rate (kW)*; Load* is the heating load as a function of outdoor temperature (kW)*; Hours* are the hours of operation in heating mode, as a function of outdoor temperature, as defined by the temperature bins specified in AS/NZS 3823.4.2 for residential applications*; Minimum Capacity* and *Minimum Power* are the capacity and power measured at turndown gas rate (kW), and

Power = *Load*/*COP*(t_j)

where $COP(t_j) = COP_{ful} + (COP_{min} - COP_{ful}) \times (t_j - T_{full})/(T_{min} - T_{full})$

where COP_{min} = *Minimum Capacity* / *Minimum Power*; COP_{ful} = *Full Capacity* / *Full Power;* T_{min} is the outdoor temperature for which the heating load is equal to *Minimum Capacity*; and T_{full} is the outdoor temperature for which the heating load is equal to *Full Capacity*.

This calculation method is used for gas space heaters based on their minimum and maximum gas consumption.

HSEC Calculation method 5. Variable capacity products and products with thermostatic control, with three points of performance data:

For these products, the HSEC is calculated similarly to calculation 3, but because these products can be measured at minimum (or low) outputs, and half (or medium) outputs, there is additional data on which to base the calculation of part load efficiency. It is assumed that the user adjusts the settings or fuel quantity to match loads if the product has a variable or multi-setting capacity capability, similar to thermostatic control.

For outdoor temperatures, t_j, where the load is less than or equal to minimum capacity (low burn rate or low load test), the part load option is used, reducing the *minimum power* of the product by the ratio of load to capacity (limited to between 0 and 1).

For outdoor temperature, t_j, where the load is between the minimum capacity and the half capacity (medium burn rate for solid fuel combustion heaters or high load test for ducted gas heaters), the power used is defined by the load divided by the COP, where the COP is interpolated between the COP at minimum capacity (COP_m = minimum capacity / minimum power) and the COP at half capacity (COP_h = half capacity / half power).

For outdoor temperature, t_j, where the load is between the half capacity and the full capacity (high burn rate or nominal gas consumption), the power used is defined by the load divided by the COP, where the COP is interpolated between the COP at half capacity (COP_h = half capacity / half power) and the COP at full capacity (COP_f = full capacity / full power).

For the remaining (cold) outdoor temperature where load exceeds capacity of the heater, the *full power* of the unit is used.

$$HSEC = \sum_{t_j \text{ where } Load \leq Minimum\ Capacity} Minimum\ Power \times \frac{Load}{Minimum\ Capacity} \times Hours$$

$$+ \sum_{t_j \text{ where } Minimum\ Capacity < Load \leq Half\ Capacity} Power_{min-half} \times Hours$$

$$+ \sum_{t_j \text{ where } Half\ Capacity < Load \leq Full\ Capacity} Power_{half-full} \times Hours$$

$$+ \sum_{t_j \text{ where } Load > Full\ Capacity} Full\ Power \times Hours$$

where *HSEC* = Heating Seasonal Energy Consumption (kWh/year)*; Full Power* and *Full Capacity* are the rated capacity and input power (kW)*; Load* is the heating load as a function of outdoor temperature (kW)*; Hours* are the hours of operation in heating mode, as a function of outdoor temperature, as defined by the temperature bins specified in AS/NZS 3823.4.2 for residential applications*; Minimum Capacity* and *Minimum Power* are the capacity and power during the low burn rate or low load test (kW)*; Half Capacity* and *Half Power* are the capacity and power during the medium burn rate or high load test (kW); and

$Power_{min-half} = Load/COP(t_j)$

where $COP(t_j) = COP_{half} + (COP_{min} - COP_{half}) \times (t_j - T_{half})/(T_{min} - T_{half})$

where COP_{min} = *Minimum Capacity / Minimum Power*; COP_{half} = *Half Capacity / Half Power;* T_{min} is the outdoor temperature for which the heating load is equal to *Minimum Capacity*; and T_{half} is the outdoor temperature for which the heating load is equal to *Half Capacity*.

$Power_{half\text{-}full} = Load/COP(t_j)$

where $COP(t_j) = COP_{ful} + (COP_{half} - COP_{ful}) \times (t_j - T_{full})/(T_{half} - T_{full})$

where COP_{half} = *Half Capacity* / *Half Power*; COP_{ful} = *Full Capacity* / *Full Power*; T_{half} is the outdoor temperature for which the heating load is equal to *Half Capacity*; and T_{full} is the outdoor temperature for which the heating load is equal to *Full Capacity*.

This calculation method is used for: solid fuel combustion heaters with adjustable air controls based on their high, medium and low burn rates; and ducted gas heaters based on the nominal gas consumption and thermal efficiency of the product, and the high load and low load test results.

Appendix 4: Example data and results

There are several inputs to the comparison methodology which describe the key characteristics of each heater type. Example data for each heater type is provided below, along with calculation results. The example data is based on GEMS registry data for air conditioners, and for other heater types was identified from reviewing specifications of products in the marketplace. The example heaters in this Appendix correspond to those presented in Table 5. The example data and results demonstrate the input values used to generate Table 5.

Gas space heaters (non-ducted) and gas decorative appliances

Product Type and HSEC Calculation Method:

Heater Unit	Technology Type	Characteristics	HSEC Calculation Method
5	Gas Space Heater	Portable, Thermostatic Control, 2 data points	4
7	Gas Decorative App.	Fixed, Thermostatic Control, 2 data points	4
12	Gas Space Heater	Fixed, Thermostatic Control, 2 data points	4
18	Gas Space Heater	Fixed, Thermostatic Control, 2 data points	4

Test Data:

Heater Unit	Maximum Gas Rate: Maximum Gas Consumption (MJ/h)	Maximum Gas Rate: Thermal Efficiency (%)	Maximum Gas Rate: Electrical Energy Consumption (kW)	Turndown Gas Rate: Turndown Gas Consumption (MJ/h)	Turndown Gas Rate: Thermal Efficiency (%)	Turndown Gas Rate: Electrical Energy Consumption (kW)	Standby: Standby Gas Consumption (MJ/h)	Standby: Standby Electrical Energy Consumption (kW)
5	8.83	80.36	0.029	4.19	83.17	0.012	0.0000	0.0004
7	15.53	45.20	0.051	7.37	46.78	0.021	0.0000	0.0004
12	31.87	78.50	0.050	16.22	78.70	0.047	0.0000	0.0007
18	54.64	78.50	0.085	27.80	78.70	0.080	0.0000	0.0007

Reverse cycle air conditioners (heat pumps), both non-ducted and ducted

Product Type and HSEC Calculation Method:

Heater Unit	Technology Type	Characteristics	HSEC Calculation Method
1	Air Conditioner (Non-ducted)	Avg GEMS Register 1.75-2.25kW non-ducted	ACCM
8	Air Conditioner (Non-ducted)	Avg GEMS Register 6.5-7.5kW non-ducted	ACCM
9	Ducted Air Conditioner	Avg GEMS Register 6.5-7.5kW ducted	ACCM
15	Air Conditioner (Non-ducted)	Avg GEMS Register 11-13kW non-ducted	ACCM
16	Ducted Air Conditioner	Avg GEMS Register 11-13kW ducted	ACCM

Test Data (Further test data is required to evaluate HSEC, as per ACCM. These are the GEMS average values used for example calculations):

Heater Unit	Technology Type	Full Capacity: Rated Capacity at 7degC (kW)	Full Capacity: Rated Capacity[□] at 2degC (kW)	Full Capacity: Rated Input Power[□] (kW)	Full Capacity: Rated Efficiency□	Inactive Power Consumption, Pia (W)
1	Air Conditioner (Non-ducted)	2	Default = 1.6 GEMS Data 2.5	0.5	426%	2.4
8	Air Conditioner (Non-ducted)	7	Default = 5.7 GEMS Data 6.5	1.8	390%	4.9
9	Ducted Air Conditioner	7	Default = 5.7 GEMS Data 6.5	1.8	388%	12.1
15	Air Conditioner (Non-ducted)	12	Default = 9.8 GEMS Data 10.1	2.9	391%	19.2
16	Ducted Air Conditioner	12	Default = 9.8 GEMS Data 10.0	3.0	392%	20.7

[□] For air conditioners, an average of the GEMS register data was used to define inputs; the two values of rated capacity at 2°C are the default value provided by the ACCM and the average of the GEMS data for this product size; the rated input power is defined at 7°C; and the rated efficiency is the average ACOP.

Electric resistance heaters (portable and fixed)

Product Type and HSEC Calculation Method:

Heater Unit	Technology Type	Characteristics	HSEC Calculation Method
2	Electric Resistance	Portable, Thermostatic control	3
3	Electric Resistance	Portable, Two-setting, No thermostatic control	2
4	Electric Resistance	Portable, One-setting, No thermostatic control	1
10	Electric Resistance	Portable, Thermostatic Control	3
11	Electric Resistance	Fixed, Thermostatic Control	3
17	Electric Resistance	Fixed, Thermostatic Control	3

Test Data:

Heater Unit	Nameplate Input Power (kW)	Inactive Power Consumption, Pia (W)
2	2	5
3	2	5
4	2	5
10	7	15
11	7	15
17	12	15

Solid fuel combustion heaters

Product Type and HSEC Calculation Method:

Heater Unit	Technology Type	Characteristics	HSEC Calculation Method
6	Solid Fuel Heater	Fixed, Adjustable Air Control, 3 data points	5
14	Solid Fuel Heater	Fixed, Adjustable Air Control, 3 data points	5
20	Solid Fuel Heater	Fixed, Adjustable Air Control, 3 data points	5

Test Data:

Heater Unit	High Burn Rate: Maximum Heat Output = Full Capacity (kW)	High Burn Rate: Thermal Efficiency	High Burn Rate: Electrical Energy Consumption (kW)	Medium Burn Rate: Heat Output = "Half" Capacity (kW)	Medium Burn Rate: Thermal Efficiency	Medium Burn Rate: Electrical Energy Consumption (kW)
6	2	67%	0.04	1.6	63%	0.016
14	7	67%	0.14	5.6	63%	0.056
20	12	65%	0	9.6	70%	0

Test Data, continued

Heater Unit	Low Burn Rate: Heat Output = Min Capacity (kW)	Low Burn Rate: Thermal Efficiency	Low Burn Rate: Electrical Energy Consumption (kW)	Standby: Electrical Energy Consumption (W)
6	1.2	60%	0.008	0
14	4.2	60%	0.028	5
20	8.4	75%	0	0

Ducted gas heaters

Product Type and HSEC Calculation Method:

Heater Unit	Technology Type	Characteristics	HSEC Calculation Method
13	Ducted Gas	Fixed, Thermostatic Control, 3 data points	5
19	Ducted Gas	Fixed, Thermostatic Control, 3 data points	5

Test Data:

Heater Unit	Full Capacity: Nominal Gas Consumption (MJ/h)	Full Capacity: Electrical Energy Consumption (kW)	Full Capacity: Efficiency	Full Capacity: Maximum Heat Output = Full Capacity (kW)	High Load (70-80%) Test Results: High Gas Consumption Rate (MJ/h)	High Load (70-80%) Test Results: Electrical Energy Consumption (kW)	High Load (70 80%) Test Results: Efficiency	High Load (70-80%) Test Results: Heat Output = "Half" Capacity (kW)
13	32.82	0.22	75%	7	24.61	0.22	75%	5
19	55.38	0.37	75%	12	41.54	0.37	75%	9

Test Data, continued

Heater Unit	Low Load (20-30%) Test Results: Low Gas Consumption Rate (MJ/h)	Low Load (20-30%) Test Results: Electrical Energy Consumption (kW)	Low Load (20-30%) Test Results: Efficiency	Low Load (20-30%) Test Results: Heat Output = Min Capacity (kW)	Standby: Standby Energy Consumption (kW)
13	8.20	0.05	80%	2	0.005
19	13.85	0.09	80%	3	0.005

Calculation Results:

Heater Unit	Technology Type	Full Capacity: Rated Capacity (kW)	Full Capacity: Rated Capacity at 2degC (kW)	Full Capacity: Rated Input Power (kW)	Full Capacity: Rated Efficiency	Standby, Pia (W)	Heating Season Total Load: HSTL_hot (kWh/y)	Heating Season Total Load: HSTL_avg (kWh/y)	Heating Season Total Load: HSTL_cold (kWh/y)
1	AC◊ (Non-ducted)	2	1.6, 2.5	0.5	426%	2.4	168	1086	2612
2	Electric Resistance	2	2	2	100%	5	168	1086	2612
3	Electric Resistance	2	2	2	100%	5	168	1086	2612
4	Electric Resistance	2	2	2	100%	5	168	1086	2612
5	Gas Space Heater	2	2	2.5	80.6%	0.4	168	1086	2612
6	Solid Fuel Heater	2	2	3.03	66.1%	0	168	1086	2612
7	Gas Decorative App.	2	2	4.4	45.8%	0.4	168	1086	2612
8	AC◊ (Non-ducted)	7	5.7, 6.5	1.8	390%	4.9	587	3801	9141
9	Ducted AC◊	7	5.7, 6.5	1.8	388%	12.1	587	3801	9141
10	Electric Resistance	7	7	7	100%	15	587	3801	9141
11	Electric Resistance	7	7	7	100%	15	587	3801	9141
12	Gas Space Heater	7	7	8.9	78.6%	0.7	587	3801	9141
13	Ducted Gas	7	7	9.33	75.0%	5	587	3802	9142
14	Solid Fuel Heater	7	7	10.59	66.1%	5	587	3801	9141
15	AC◊ (Non-ducted)	12	9.8, 10.1	2.9	391%	19.2	1007	6517	15670
16	Ducted AC◊	12	9.8, 10.0	3.0	392%	20.7	1007	6517	15670
17	Electric Resistance	12	12	12	100%	15	1007	6517	15670
18	Gas Space Heater	12	12	15.3	78.6%	0.7	1007	6517	15669
19	Ducted Gas	12	12	15.75	75.0%	5	991	6416	15429
20	Solid Fuel Heater	12	12	18.46	65.0%	0	1007	6517	15670

◊ For air conditioners (AC), an average of the GEMS register data was used to define inputs; the two values of rated capacity at 2°C are the default value provided by the ACCM and the average of the GEMS data for this product size; the rated input power is defined at 7°C; and the rated efficiency is the average ACOP.

Calculation Results, continued

Heater Unit	Technology Type	Heating Season Energy Consumption: HSEC _hot (kWh/y)	Heating Season Energy Consumption: HSEC _avg (kWh/y)	Heating Season Energy Consumption: HSEC _cold (kWh/y)	Inactive Energy Consumption: IAEC _hot (kWh/y)	Inactive Energy Consumption: IAEC _average (kWh/y)	Inactive Energy Consumption: IAEC _cold (kWh/y)
1	AC^ (Non-ducted)	41	286	736	6	6	5
2	Electric Resistance	168	1086	2607	13	12	12
3	Electric Resistance	176	1140	2737	13	12	12
4	Electric Resistance	185	1195	2867	13	12	12
5	Gas Space Heater	202	1310	3158	1.1	1.0	1.0
6	Solid Fuel Heater	281	1802	4276	0.0	0.0	0.0
7	Gas Decorative App.	355	2307	5559	3.4	3.0	2.4
8	AC^ (Non-ducted)	123	905	2488	12	13	11
9	Ducted AC^	135	977	2662	30	32	27
10	Electric Resistance	587	3801	9123	40	36	37
11	Electric Resistance	587	3801	9123	127	112	92
12	Gas Space Heater	744	4819	11572	6	5	4
13	Ducted Gas	745	4904	11853	42.4	37.3	30.5
14	Solid Fuel Heater	983	6308	14965	42.4	37.3	30.5
15	AC^ (Non-ducted)	200	1512	4211	48	51	43
16	Ducted AC^	223	1629	4448	52	55	46
17	Electric Resistance	1007	6516	15640	127	112	92
18	Gas Space Heater	1276	8261	19837	6	5	4
19	Ducted Gas	1257	8278	20005	42.4	37.3	30.5
20	Solid Fuel Heater	1343	8761	21399	0.0	0.0	0.0

^ For air conditioners (AC), an average of the GEMS register data was used to define inputs; inactive energy consumption was calculated from the 0.4 multiplied by the standby power (Pia) times inactive hours, as per the ACCM; HSEC was determined from Annual Energy Use minus Inactive Energy Consumption; and Overall Product Efficiency was calculated from the ratio of HSTL to HSEC.

Calculation Results, continued

Heater Unit	Technology Type	Annual Energy Use: Hot (kWh/y)	Annual Energy Use: Average (kWh/y)	Annual Energy Use: Cold (kWh/y)	Overall Product Efficiency: HSPF _hot	Overall Product Efficiency: HSPF _average	Overall Product Efficiency: HSPF _cold
1	AC^ (Non-ducted)	47	292	742	4.06	3.80	3.55
2	Electric Resistance	181	1098	2619	0.93	0.99	1.00
3	Electric Resistance	189	1152	2749	0.89	0.94	0.95
4	Electric Resistance	198	1207	2880	0.85	0.90	0.91
5	Gas Space Heater	203	1311	3159	0.83	0.83	0.83
6	Solid Fuel Heater	281	1802	4276	0.60	0.60	0.61
7	Gas Decorative App.	358	2310	5561	0.47	0.47	0.47
8	AC^ (Non-ducted)	135	918	2499	4.8	4.2	3.7
9	Ducted AC^	165	1009	2689	4.4	3.9	3.4
10	Electric Resistance	627	3837	9160	0.94	0.99	1.00
11	Electric Resistance	715	3913	9215	0.82	0.97	0.99
12	Gas Space Heater	750	4824	11576	0.78	0.79	0.79
13	Ducted Gas	787	4942	11884	0.75	0.77	0.77
14	Solid Fuel Heater	1025	6346	14996	0.57	0.60	0.61
15	AC^ (Non-ducted)	248	1563	4253	5.0	4.3	3.7
16	Ducted AC^	274	1684	4494	4.5	4.0	3.5
17	Electric Resistance	1134	6628	15731	0.89	0.98	1.00
18	Gas Space Heater	1282	8267	19841	0.79	0.79	0.79
19	Ducted Gas	1299	8315	20036	0.76	0.77	0.77
20	Solid Fuel Heater	1343	8761	21399	0.75	0.74	0.73

Appendix 5: Relevant AU/NZ Standards

AS/NZS 3823.1.1:2012 Performance of electrical appliances – air conditioners and heat pumps – Part 1.1: Non-ducted air conditioners and heat pumps – Testing and rating for performance (ISO 5151:2010, MOD).

AS/NZS 3823.1.2:2012 Performance of electrical appliances – air conditioners and heat pumps – Part 1.2: Ducted air conditioners and air-to-air heat pumps – Testing and rating for performance (ISO 13253:2011, MOD).

AS/NZS 3823.1.3:2005 Performance of electrical appliances – air conditioners and heat pumps – Part 1.3: Water-source heat pumps – Water-to-air and brine-to-air heat pumps - Testing and rating of performance (ISO 13256-1, Ed. 01 (1998) MOD).

AS/NZS 3823.1.4:2012 Performance of electrical appliances – air conditioners and heat pumps – Part 1.4: Multiple split-system air conditioners and air-to-air heat pumps – Testing and rating for performance (ISO 15042:2011, MOD).

AS/NZS 3823.1.5:2015 Performance of electrical appliances – air conditioners and heat pumps – Part 1.5: Non-ducted portable air-cooled air conditioners and air-to-air heat pumps having a single exhaust duct – Testing and rating for performance.

AS/NZS 3823.4.1:2014 Performance of electrical appliances – Air conditioners and heat pumps. Part 4.1: Air-cooled air conditioners and air-to-air heat pumps–Testing and calculating methods for seasonal performance factors – Cooling seasonal performance factor (ISO 16358-1:2013, (MOD)).

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 (ISO 16358-2:2013, (MOD)).

AS/NZS 4012:2014 Amdt 1 Domestic solid fuel burning appliances – Method for determination of power output and efficiency.

AS 4553: 2008 Gas Space Heating Appliances.

AS/NZS 5263.0:2017 Gas appliances. Part 0: General requirements.

AS/NZS 5263.1.3:2016 Gas appliances. Part 1.3: Gas space heating appliances.

AS/NZS 5263.1.3:2021 Amdt1 Gas appliances. Part 1.3: Gas space heating appliances.

AS/NZS 5263.1.6:2020 Gas appliances. Part 1.6: Indirect gas-fired ducted air heaters.

AS/NZS 5263.1.8:2020 Gas appliances. Part 1.8: Decorative effect gas appliances.

AS/NZS 60335.1:2020 (Excludes IEC text) Household and similar electrical appliances - Safety - Part 1: General requirements.

AS/NZS 60335.2.102:2018 (Excludes IEC text) Household and similar electrical appliances – Safety – Part 2.102: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections.

AS/NZS IEC 62301: 2014 Household electrical appliances – Measurement of standby power.