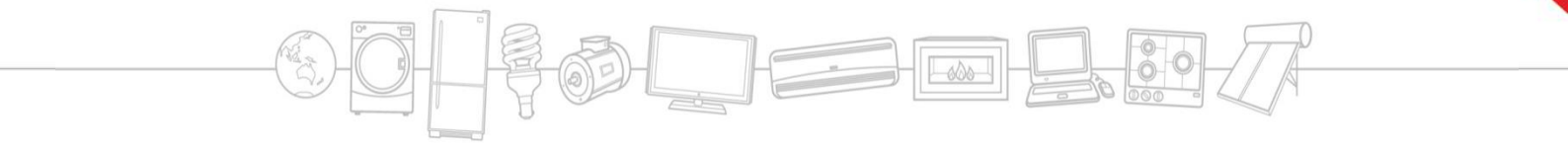
E3
Equipment Energy Efficiency

Gas space heaters – performance testing & energy labelling

Research Report

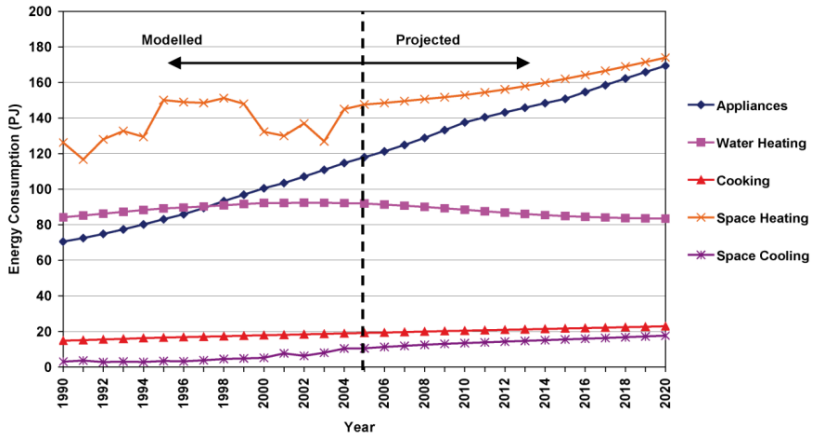
May 2015



Introduction

Gas prices have been increasing over the past years[1], impacting the 50% of Australian dwellings that use gas for energy (in Victoria, the proportion is higher at 82%). Space heating is a significant component of a household's running costs and energy use (38 per cent). Gas is the main fuel source used for space heating (accounting for 22 of the 38 per cent), ahead of wood (13) and electricity (3). Space heating and cooling energy usage by all energy sources exceeds that of all other 'appliances' (refer to Figure 1).

Figure 1: Trends in total energy consumption by major end use - Australia



Source: Energy Use in the Australian Residential Sector: 1986-2020 – 2008 report

Background

Gas heating appliances (including flued and flueless heaters, decorative and ducted products) are not regulated for energy efficiency in New Zealand or under the Australian *Greenhouse and Energy Minimum Standards Act 2012* (GEMS Act). A gas energy labelling scheme that aims to provide comparative energy efficiency information presently operates in States and territories in Australia, but not New Zealand, and covers gas space and water heaters. Gas heating appliances used in residential applications are required by State and Territory Gas Technical and Safety Regulators across Australia to be certified before they can be legally sold or installed. The labelling scheme is part of this certification process, which forms a small component of what is primarily a mandatory gas appliance safety program. The certification standards are maintained by Standards Australia's AG-001 Committee, which has representation from both the gas appliance manufacturers and gas technical regulators.

This scheme operates quite differently to the mandatory appliance energy rating label scheme managed under the GEMS Act, where a formal physical check testing program is run to test compliance with claims

[1] AER, State of the Energy Market, 2014, p 134. The national retail price index (inflation adjusted) for gas shows sharp increase since 2011-12

made by manufacturers. In addition there are financial penalties for non-compliance, although under the gas certification scheme state regulators could revoke certification if an appliance is found to be non-compliant.

A comparative energy rating label enables buyers to compare the relative energy efficiency and energy consumption of appliances at the time of purchase. Labels can encourage consumers to purchase more efficient appliances, and can provide a competitive incentive for manufacturers/suppliers to develop more efficient products. Labels are required by both Australian and New Zealand governments on many electrical domestic appliances such as fridges and washing machines under the trans-Tasman Council of Australian Governments (COAG) Equipment Energy Efficiency (E3) program. Key aims of the E3 program are to reduce energy use and greenhouse gas emissions by implementing Minimum Energy Performance Standards (MEPS) and/or mandatory Energy Rating Label (ERL) for appliances and equipment. This provides economic and environmental benefits while enabling both countries to honour their commitments as trading partners under the Trans-Tasman Mutual Recognition Arrangement (TTMRA).

Opportunities to improve the energy efficiency of gas space heating products have been identified in various technology and market reports produced by the E3 program, including product profiles on gas ducted heaters (January 2011), and gas space and decorative (fuel effect) heaters (April 2012). Other work has included investigating the desirability or feasibility of including a gas labelling program under the E3 program (April 2012 - Gas Appliance Energy Labelling discussion paper).

Why does E3 undertake performance testing?

Energy efficiency performance testing is one part of the process used by the E3 Committee to examine the potential of introducing new products into the program, including informing which policy approaches may be most appropriate, if there is a case for action.

Physical performance testing of gas space heaters was commissioned in 2013 to identify current appliance performance levels and compare these to manufacturer claims. This included electricity costs that are not visible to the end user.

Testing laboratory

E3 engaged VIPAC Engineers and Scientists Ltd Melbourne Australia (VIPAC) to test the accuracy of current energy efficiency claims made on the gas energy label through physical testing of a selection of gas space heaters against the relevant Australian Standards. VIPAC is a National Association of Testing Authorities, Australia (NATA) Accredited Laboratory (Number 676).

Units tested

Physical performance testing was undertaken on 16 gas space heating appliances (flueless and flued space heaters, ducted heaters and decorative/fuel effect gas appliances).

To better inform the E3 Program of the 'spread' of appliance performance and the accuracy of claims, the models were selected across a range of brands, heat outputs and gas label star ratings and not based on sales levels. Appliances were purchased 'off-the-shelf' from a gas appliance retail store to represent a real life consumer and installer experience in the quality and performance of a product.

Due to small sample sizes, it is recognised that results would most likely provide indicative issues and any policy based on these results would need to be tested via consultation.

Procedure

Research focused on manufacturer declared claims on industry gas energy labels and data plates through performance tests required for thermal efficiency and energy labelling. Data plates show information such as model, serial number, gas consumption etc. These specific claims include star rating, annual energy consumption, heating output and hourly gas consumption rates. Electricity consumption is included in all claims.

All testing was performed in accordance with the methods of test and relevant requirements of Australian Standard AS4553 – 2008 *Gas space heating appliances*. This incorporated all amendments up to and including Amendment 1 – 2011 for flueless and flued gas space heaters. Ducted heaters were tested against

AS4556 – 2011 *Indirect gas-fired ducted heaters*. AS4558-2011 *Decorative gas log and other fuel effect appliances* have no energy labelling requirements or performance tests for thermal efficiency.

Two rounds of testing were undertaken. The first round of laboratory tests commenced in 2013 and was finalised in 2014. It examined 14 gas space heaters, including 3 flueless, 5 flued, 3 ducted and 3 decorative products. The results of these tests raised issues over the accuracy of the manufacturer claims. However, this round took an off-the-shelf performance approach which followed manufacturer's instructions but did not include adjustments to the appliances as required by a licensed gasfitter (otherwise referred to as 'commissioning').

In response to concerns that the results would not be valid due to potentially uncommissioned units, a second round of laboratory tests was carried out. This time the appliances were tested after making the final adjustments expected of a licensed gasfitter upon installation.

Thirteen (13) heaters were tested: 4 flueless, 7 flued and 2 ducted heaters. Of the 13 units 3 were not previously tested (Units P, Q and R). The laboratory deemed that 4 of the first round units did not require retesting as received units did not require adjustments. These were Units A, C, G and K.

Decorative heaters were not tested a second time however some flame effect or gas log units which look like decorative heaters but are registered as space heaters (such as Unit B) were retested. While there is some anecdotal evidence that some consumers use decorative products as space heaters despite their lack of suitability, this project focused instead on products sold as space heaters (flued, flueless and ducted space heaters).

Australian Standards require decorative heaters to specify in their markings, in a prominent position, that they are primarily a decorative appliance and not certified as a space heater[2]. Of the 3 decorative heaters purchased, only 1 had reasonably visible advice. One had advice in 'fine print' on the data plate but was not easily visible to the consumer and 1 did not appear to have any advice. A summary of notes from testing decorative heaters are provided later in the report under 'Summary results per type of space heater'.

Performance results provided are based on Round 2 testing only. Issues identified regarding certification information, appliance defects and manufacturers' documentation following both Round 1 and 2 testing are discussed in the section 'Summary results per type of space heater'.

Product details such as brand and model are not identified as this research project was not compliance check testing as these products are not regulated under the GEMS Act. This project was focused on evaluating manufacturers' claims against actual physical performance results.

Results

Industry gas space heater energy labels on flued and flueless heaters declare the star rating within a red arched band, the annual energy consumption (AEC) and the heating output (in kW). In the case of ducted heaters, heating output is not required to be declared on the label.

For all heaters, gas consumption rate is required to be declared on the data plate and also in installation instructions or manuals. These declared elements have been tested in accordance with the relevant Australian Standard (AS 4553 and AS4556).

Test results provided at Attachment 1 capture for each product results for star ratings, heating output, annual energy consumption (AEC) and gas consumption. Attachment 2 contains a breakdown of electricity use.

[2] AS 4558-2011, 2.11.2 *Markings and Labels*

1. Gas consumption and thermal efficiency

1a. Gas consumption

Context

The energy labelling calculation applies gas consumption rates, electricity use and thermal efficiency rates. All heaters have their consumption rates measured at high settings and if applicable also at low settings. In ducted heaters however, the energy labelling test also takes into account the performance of the heater at heavy and light loads. This is measured by simulating varying periods of on and off modes for either: a) at nominal gas rate for a fixed flow rate burner; or b) at 2 discrete (lower) settings for a modulating flow rate burner.

Given that the purpose of this project was to show what the consumer and installer may experience, and as 1 unit's instructions recommended either a thermostat or their ideal controller Method A (single fixed input rate) was chosen for testing. For Method B to be representative, detailed adjustment instructions are needed (not provided for 1 unit tested) and the appropriate controller specified by the manufacturer must be utilised.

Several issues were identified as part of the testing:

- Controllers are not provided with all ducted units as a standard item. They can be bought separately despite their potential to affect the operation of the unit and therefore the claimed efficiency. It was also identified that a range of controllers with varying degrees of control may be bought for the 1 unit i.e. basic controller with manual thermostat, electronic programmable thermostats and fully automated networkers. These range in price from approximately $70 to $200.
- It is not always clear to the consumer particularly those buying >5 star units, that a specified controller is required for the ducted unit to perform to the declared star rating.
- Factors such as zoning and turn down settings are installation specific; not all installations will utilise these features resulting in the energy efficiency benefits awarded for the heater not being realised.

These investigative tests were conducted using single fixed input rates for both units in order to provide independent and comparable information for the tested samples with the settings and equipment as supplied.

The laboratory tests measured gas consumption at high setting, low setting (where applicable) and standby. All gas heaters are required to declare their gas consumption rates on the data plate and in installation and instruction manuals. In most cases, only the high consumption rate is declared.

The tolerance range specified by the AS is ±5% for gas consumption at a high setting. Thus, if a unit exceeds a variance of 5% against the declared value, it fails the gas consumption test and certification.

There is no established tolerance at low settings in the AS. Consequently, manufacturers do not normally declare these. Only 1 flued gas space heater indicated its low setting gas consumption rate on the data plate (Unit J). None of the flueless heaters tested declared low consumption gas rates. However for most of the flued and flueless products tested, this information was found in other literature (e.g. webpages and product brochures). Both ducted units were treated as a fixed rate input burner and therefore were only tested on high.

Findings

High gas consumption

85% of heaters (11 units) recorded high setting gas consumption rates within the acceptable range (5%).

At a high setting: 5 units consumed more MJ/hour than declared and 8 units consumed less. Two units, J and L (15%) would have failed to comply with the Australian Standard 4553 and 4556 gas consumption test with variances >5% from the declared value.

- Flued heaters – Unit J, 1 out of 7 flued heaters, failed (consuming less MJ/hour than declared).
- Ducted heaters – Unit L, 1 of 2 ducted heaters, failed the high gas consumption test. Both ducted heaters however consumed less MJ/hr than declared.
- One ducted heater (Unit L) failed to declare its gas consumption rate on the data plate.

Low gas consumption

The AS does not indicate a tolerance range for gas consumption at a low setting. However, for research purposes and to illustrate any significant difference between any values for low gas consumption rates declared by manufacturers on websites or brochures, the same 5% tolerance applied to high consumption rates was applied by project officers to the measured low consumption rate test results.

Of the 11 units (4 flueless and 7 flued) 2 units (Units Q-flueless and D- flued) did not publicly disclose low gas consumption rates. Due to certification details not matching with unit information, it was difficult to obtain accurate information on gas consumption for 1 unit (Unit R). As a consequence we do not provide test results for these units.

Only 3 units were within this range at a low setting. This shows that variability in gas consumption is highest at the low settings. 5 heaters had consumption rates beyond the variance of 5% applied for research purposes. At a low setting: 6 units consumed more MJ/hour than declared and 2 consumed less (ducted heaters not included).

- Flueless heaters – All 3 flueless units (A, C and G) had a greater than 5% variance at low settings. It is noted that all flueless units consumed more MJ/hr than what they declared on a low setting.
- Flued heaters - Two flued heaters (Unit H and P) with a low gas consumption variance >5% also consumed more MJ/hr than declared for a low setting.

As a product group, 3 out of 5 flued heaters generally performed within the 5% tolerance at the low setting. This compares with 3 of the 3 flueless heaters having variances of greater than 5% at the low setting. Since flueless heaters consumed more MJ/hour than declared and with variances >5%, these heaters would not only cost more to operate but are also not performing to their declared rate of performance.

Figure 2 Variances in low gas consumption

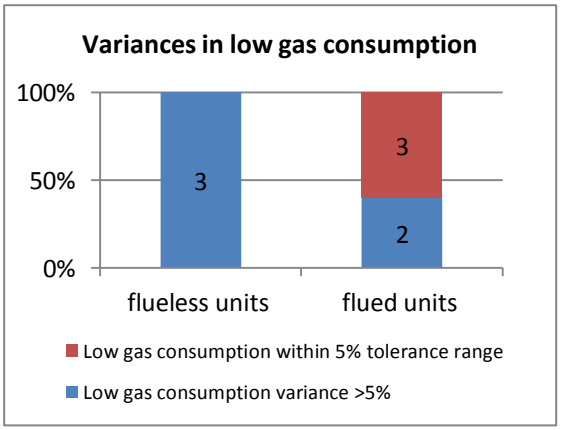


Figure 3 Measured gas consumption rates against declared rates (low setting)

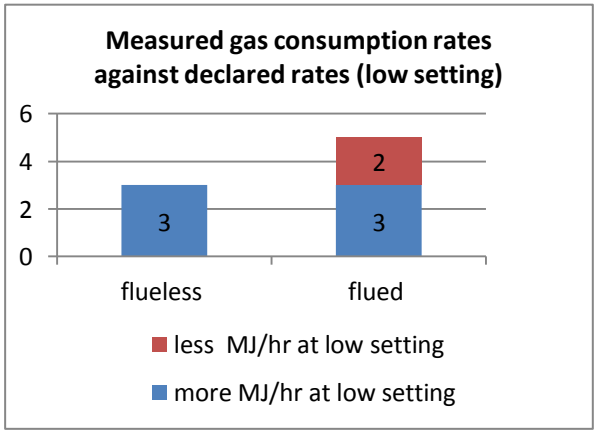


Figure 4 Variances in high gas consumption

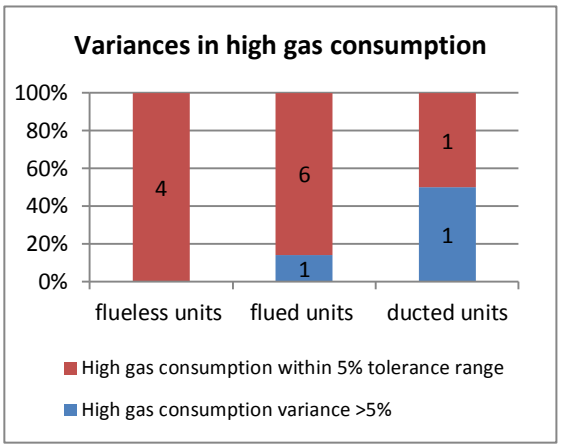
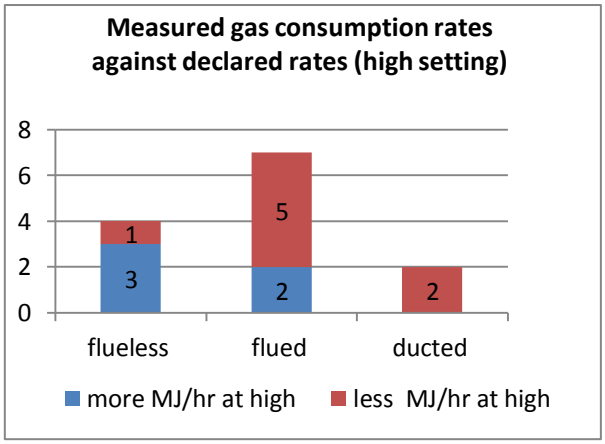


Figure 5 Measured gas consumption rates against declared rates (high setting)



Considering that all flueless heaters consumed more gas than declared at low setting, and 2 out of 5 flued heaters were also not within tolerance, introducing a tolerance for this setting might improve the reliability of the energy label for these products.

The precedence of other space heating products such as reverse cycle air-conditioners in applying clear tolerances at both low and high settings could be applied to gas heaters. Air-conditioning AS/NZ 3823:2-2013 indicates clear tolerances for rated power and rated capacity under Section 2 *Calculations for the Energy Label*; and at Section 3 *Performance Criteria* provides clear indications as to tolerances for MEPS Validity (Check Testing).

Pilot light technology and gas consumption

Two of 3 heaters certified as decorative heaters and tested during Round 1 used continuous pilot lights (Units M and N). The third unit used an intermittent pilot light. Products certified as space heaters use technology such as directly ignited burners or intermittent pilot lights. These were found to consume negligible gas or electricity in comparison to the decorative heaters tested which had an average of standby gas consumption of 1 MJ/hour. If these decorative heaters remain on standby all year round with their pilot lights left on, depending on the consumer's tariff, these appliances could be costing anywhere from $157 in Victoria to $957 in Western Australia for a full year (in the case of Unit N) or $157 (Vic)- $1,284 (WA) (in the case of Unit M). For more information on indicative tariffs, see Attachment 3.

Table 1 Standby energy consumption of decorative heaters tested in Round 1

Unit Reference	Pilot Gas Consumption MJ/hour	Electrical kW	electricity converted into MJ	Total MJ/hour	Indicative tariff range ($/MJ) (see Attachment 3 for details on tariffs)	Total hours per year	Range of costs per year
Unit M	0.82	0	0	0.82	0.016372 - 0.133250	8760	$117 - $957
Unit N	1.1	0.0002	0.00072	1.10072	0.016372 - 0.133250	8760	$157 - $1,284

Refer to Attachment 3 for detailed tariffs used.

1b. Thermal efficiency

Context

Thermal efficiency indicates how well energy is converted or transferred and is the ratio between the useful energy output and its energy input. For gas heaters, thermal efficiency is always less than 100% due to combustion inefficiencies and heat losses. The Australian Standards specify different thermal efficiency minimum requirements that must be met for flued and ducted heaters to be certified. All flued heaters tested are required to pass applicable thermal efficiency tests. Refer to Clause 5.3 Thermal Efficiency in AS 4553-2008 and AS 4556 – 2011 for detail.

For energy labelling purposes AS 4553-2008 assumes all flueless heaters burn the gas at the theoretical combustion efficiency of natural gas (90.4%) to generate heat. However, the Standard does not appear to include a penalty or a means to estimate the heat loss due to the requirement of operating these products with ventilation as prescribed for safety purposes, e.g. an open window or other form of room ventilation. Note: discussion with a member of Gas Standards Committee AG-001 indicated that a minor penalty may have been introduced to the Standard over 10 years ago. The Standard however provides no explanation to indicate this is the case.

In flued heaters, thermal efficiency is calculated as 100%, less the percentage of flue loss. In flued heaters specifically, the reduction in thermal efficiency is measured through a 4.5 metre vertical flue pull test or as prescribed in the Standard for that type of heater.

AS 4556-2011 5.3 *Thermal Efficiency* describes the method of test for ducted heaters.

Results

Only 1 flued heater (Unit B) failed to achieve the 70% thermal efficiency required of a forced convection or radiant convection heater, with a result of 69.9%.

Average efficiencies achieved during the thermal efficiency tests were:

- Open flued heaters with forced convection achieved an average 76.13% efficiency.
- Room sealed heaters achieved an average 87.15%.
- The thermal efficiency of flued forced convection or radiant convection heaters with all fan speeds was on average 79.77%.
- The average thermal efficiency achieved using a 4.5 metre vertical flue was 78.96%.
- Ducted heaters achieved an average efficiency of 81.75%.

2. Annual Energy Consumption (AEC)

Context

The gas label declares the total energy consumption of the appliance, both electricity and gas. This informs consumers of overall energy consumption and enables a better informed judgment on its comparative affordability. AEC is derived by converting all forms of energy used by the appliance into equivalent MJ terms.

The AEC for flued and flueless heaters is calculated on usage rates of 2.5 hours/day for high setting, 2.5 hours/day for low/turndown setting and 19 hours/day on standby (or 3.75 hours on high and 20.25 on standby if there is no low setting), over 100 days (heating season) per year. AEC differs from the star rating in that it illustrates the overall energy consumption of the space heater and not its comparative efficiency.[3] A unit's energy consumption is based on operation for one heating season, including its electricity usage, and does not take into account additional standby usage that may occur during warmer months.

AEC for ducted heaters is calculated based on seasonal operating efficiency over 600 heating hours. The star rating and red band shading represent the seasonal operating efficiency of the unit when at heavy (75% duty) and light (25% duty) loads. Operating efficiency is calculated from the ratio of the heat delivered by the appliance against the total energy consumed, and includes a penalty for appliances that incorporate any standby energy consumption.[4]

The AEC metrics applied across different appliances differ: flued/flueless heaters use MJ/year; while ducted heaters use MJ/m^3/year. They both incorporate different estimates of inoperative energy use such as standby power. Flued and flueless heaters extrapolate measured energy consumption over 500 hours of operation or 375 hours for units with no low setting. Ducted heaters apply a thermal efficiency calculation to an assumed heating load per cubic meter over 600 hours of operation. This means consumers need to know the volume of their home to be able to estimate running costs.

The Australian Standards do not indicate a tolerance range for the AEC. It is presumed that the declared figures approved at certification would be reproducible when tested.

Findings

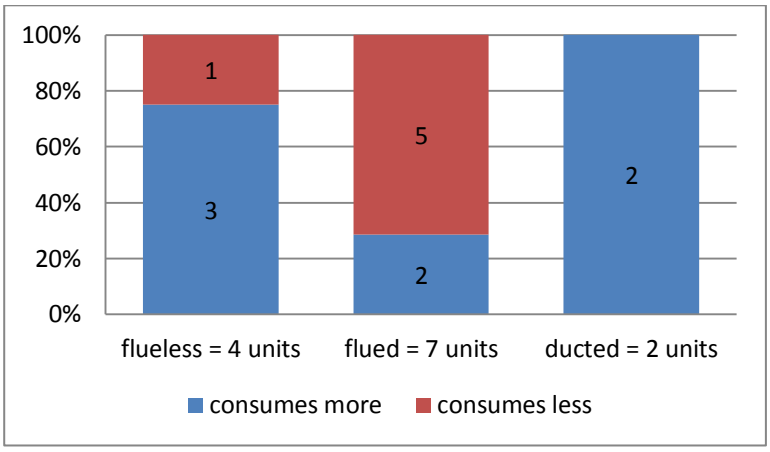
The test found only 1 flued unit (Unit K) declared its AEC accurately. Twelve (12) out of 13 heaters had different AEC results than declared.

Variations in AEC relate to the unit's heating capacity or cost of operating:

- The test results of 1 flueless heater (Unit G) determined that it would be consuming 1,299 MJ (18%) more than declared per year. As a consequence it would be costlier to run than expected given the additional volume of gas being consumed.
- Two (2) flued heaters consumed substantially less energy per year than declared, with 1 (Unit R) consuming 2,109 MJ (12%) less and the other (Unit B) consuming 1,449 MJ (11%) less. While these units would cost less to run than expected, both heaters would also be producing less heat output (kW). These units are not performing to their declared values/claims.

[3] AS 4553-2008, 5.16 *Energy Labelling*
[4] AS 4556-2011 5.17 *Energy Labelling*

Figure 6 Declared versus tested annual gas consumption



3. Heat output (kW)

Context

All flued and flueless heaters declare their heating capacity on the energy label. Heat output is the combined outcome of net heater efficiency and gas consumption. Heating output is also often declared to the accuracy of 1 decimal point in product websites. In ducted heaters however, the kW output is not required to be stated on the energy label. Therefore, this section of the report will only consider a comparison between declared and determined heat output results for flued and flueless heaters (a total of 11 units). For these heaters, the maximum heat output is calculated by multiplying the maximum gas consumption (MJ/hour) by the net heater efficiency and converting a megajoule output to its kilowatt equivalent. The electrical input to the unit for fans etc. is also added to the heat output.

The AS does not identify any tolerance in heating output. Like AEC, it is presumed that declared figures would be reproducible when tested.

It is noted that only 1 of the ducted heaters (Unit L) explicitly recorded its heating output (kW) on its data plate. The other ducted heater (Unit E) implied the heat output in its model number. Information requirements for heating output for ducted heaters outlined in the AS are not explicitly stated.

Findings

Only 2 units (18%) met their declared heating outputs. These were Units C and Q, both flueless heaters.

Of the remaining 9 heaters:

- Flueless heaters – 2 units produced more heat (Units A +3% and G +5%).
- Flued heaters – 3 units produced more heat output (Units H +3%, K +1% and P +8%) and 4 heaters produced less (Units B, D and J all -7% and R at -2%).

The heating output on the labels or data plates are useful guides for consumers and installers to choose an appropriately sized heater to meet their requirements. Based on the test results, the information on the majority of units was unreliable for comparative purposes and consumer decision making.

Figure 7 Accuracy of declared heat output (raw scores)

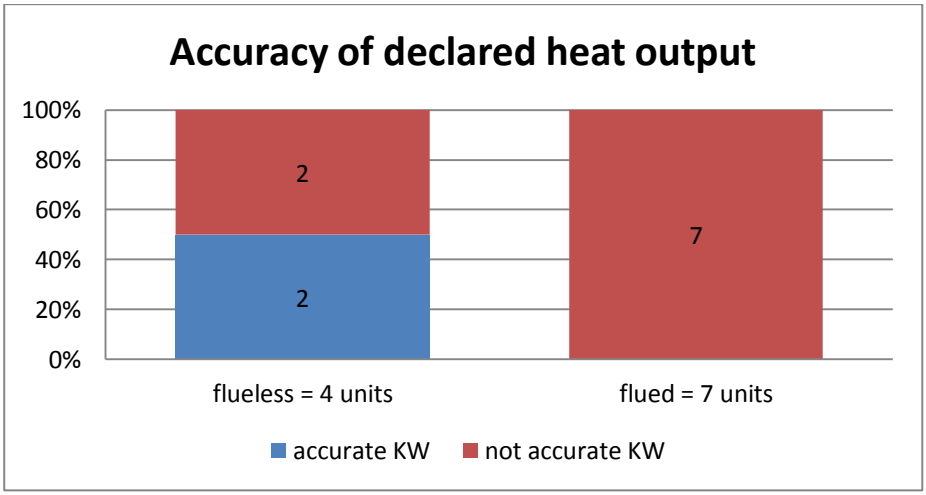
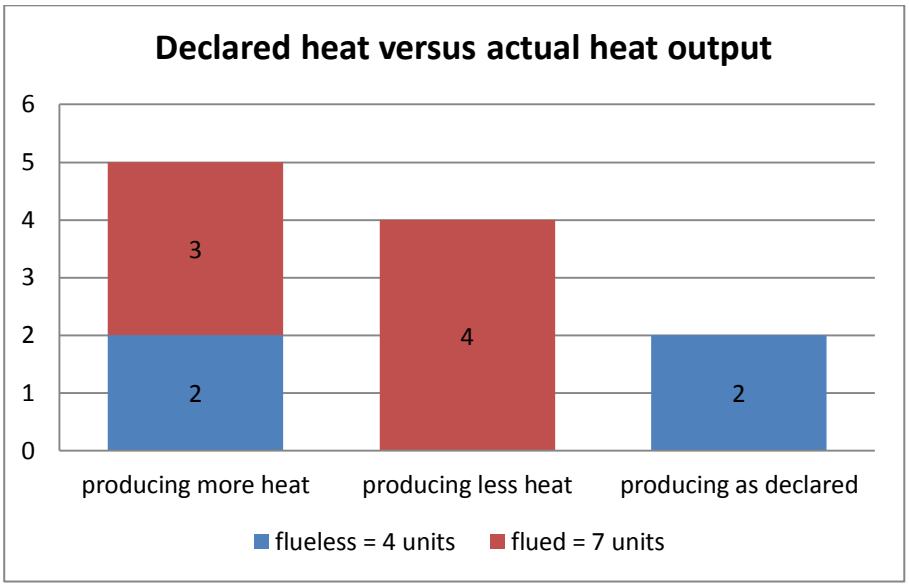


Figure 8 Declared heat versus actual heat output



4. Electrical consumption in space heaters

Most appliances consume electricity through components such as motors, fans and electric time clocks. Electricity consumption by each type of appliance at high setting, low setting and standby was also measured. Electricity consumption is included in the calculations to determine the energy label's AEC and star rating.

The calculations, however, convert electrical consumption into megajoule values. Since gas labels do not separately indicate the level of electrical consumption, consumers are unable to estimate the cost of electricity associated with using the appliance, in addition to the cost of gas consumption.

Table 2 Average electricity consumption – flued and flueless

Average electricity consumption - 7 flued and 3 electrical flueless heaters tested							
Consumption setting	**Flueless Average (kW)**	**Flueless Average (Watts)**	**Flueless range (kW)**		**Flued Average (kW)**	**Flued Average (Watts)**	**Flued range (kW)**
High setting	0.024	24	0 - 0.032		0.068	68	0.044-0.129
Low setting	0.017	17	0 - 0.021		0.050	50	0.018-0.113
Standby	0.0008	1	0.0005-0.0009		0.0026	3	0.0007-0.006

1 kW = 1000 watts

Table 3 Electrical consumption for ducted heaters

Unit	Electricity consumed (heavy load test 20 mins) kWh	Electricity consumed (light load test 20 mins) kWh	Average Fan Power at high setting (kW)	Average electrical standby power (watts)
E	0.238	0.071	1.010	6.0
L	0.218	0.075	0.854	6.2

Table 4 Electricity consumption for flueless and flued heaters

Unit Reference	High setting electricity consumption (kW)		Low setting electricity consumption (kW)	
Flueless	**kW**	**watts**	**kW**	**watts**
A	0.021	21	0.017	17
C	0.000	0	0.000	0
G	0.032	32	0.021	21
Q	0.018	18	0.012	12
Flued				
B	0.069	69	0.045	45
D	0.067	67	0.051	51
H	0.044	44	0.018	18
J	0.129	129	0.113	113
K	0.048	48	0.045	45
P	0.056	56	0.033	33
R	0.061	61	0.044	44

As a percentage of daily input (converted into MJ), electricity is on average about 0.5% of total energy consumed in flueless heaters tested and on average 1.2% in flued heaters. It is noted that flueless heaters consume on average 1 watt and flued heaters consume on average 6 watts. In ducted heaters tested, the electrical component at heavy or light load is about 3% - 4% of the total energy consumed at either load. However, electricity is 100% of total energy consumed while the ducted heater is on standby. In the case of the 2 ducted units tested, 6 watts on average are consumed on standby. Refer to Attachment 2 *Electrical consumption of gas space heaters tested* Tables 6 and 7.

Of the 4 flueless heaters tested, 3 of them used an electric fan. The units with a fan used on average 24 watts on a high setting and 17 watts on a low setting. The flued heaters tested used an average of about 68 watts on a high setting and 50 watts on a low setting. Ducted heaters tested consumed a significant number of watts during a heavy load test. The test runs for 20 minutes. Unit E used 0.238kWh and Unit L 0.218 kWh . The power consumption of these fans is also significant as indicated by Table 3. This is indicative of the power required by the large fans that help push the warm air through the duct into the dwelling.

Some findings of note were:

- Ducted heaters can consume large amounts of electricity due to the fan eg Unit E uses on average 1,010 watts while Unit L uses on average 854 watts.
- Unit J (a flued heater) used a substantial 129 watts at a high setting and 113 watts at a low setting - not a big difference in electrical load between the two settings. This unit is a 5 star rated wall furnace and uses electricity for potentially the fan/s or another component. This unit consumes 23 MJ/hr and produces 5.6 kW of heat.
- This compares with Unit R, a 1.9 star wall furnace that uses 61 watts at a high setting and 44 watts at a low setting and consumes 28.9 MJ/hr and produces 5.6 kW of heat. While Unit J appears to be more efficient in gas consumption requiring less MJ/hour, Unit J is drawing on more electrical power than Unit R. This means that a component/s is drawing substantial amounts of electricity in Unit J. Both heaters produce roughly the same heat output, but the cost of electricity associated with Unit J would be higher than that for Unit R.
- Unit K consumes a similar level of electricity whether at high (48w) or low (45w) settings. This may be influenced by the type of fan load built into the heater.

Consumers may not be aware that a gas space heater draws on electrical power, nor understand the amount of electricity use required by components in gas space heaters (e.g. motors, fans). Consumers are not able to determine the ongoing electrical cost of each appliance as there is no information of this element on the energy rating label. In addition, the conversion from electrical kilowatts to megajoule values does not make it clear that gas is not the only energy consumed by the appliance. Electricity is also consumed. For example based on a 600 hour or 2 month operation of a ducted heater, the fan alone could cost somewhere between $163 (Unit E) and $137 (Unit L) per annum. This is based on the national average retail electricity cost of $0.2683 per kWh identified in the Australian Energy Market Commission *2014 Residential Electricity Price Trends Report*. This would be greater if the heater operates for more than two months per year.

The amount of electrical power used by the heater if identified on the label would enable a consumer to identify what contribution the appliance makes to the electricity bill. Lastly, test results indicate that the overall electrical consumption of a heater could be influenced by the efficiency of components such as fans and the design of these products themselves. This declaration would also provide an incentive for manufacturers to use more energy efficient electrical components.

Refer to Attachment 2 – *Electrical consumption of gas space heaters tested* for individual results.

5. Stars on the gas energy label

Context

Gas energy efficiency star ratings are presented on the label within a red band shaded to a specific angle and are not stated in number form. The star number however is promoted in product literature, i.e. websites, product brochures, and provided on publicly available certification registers. The appliance's star rating and degree to which the red band is shaded are determined according to the calculated value of the overall efficiency of the heater. The Standard allows for six stars only on the label.

Star ratings are declared and shaded to the precision of one decimal point and calculated according to the Australian Standard 4553 for flued and flueless and AS 4556 for ducted heaters. The procedure for calculating these stars is slightly different between flueless and flued, and entirely different for ducted heaters. The Australian Standard requires manufacturers to affix the label on all their appliances.

Flueless and flued

For flued heater gas energy labelling, the testing results of gas consumption, electrical use and thermal efficiency tests are applied to allocate stars. Flueless heater star ratings are calculated using only measured gas and electrical consumption with the theoretical combustion efficiency for natural gas (90.4%) as its equivalent thermal efficiency.

Ducted

The calculation of stars for ducted heaters is based on two elements: the appliance operating efficiency and the system factor (also known as the Heat Load Reduction (HLR) factor).

A maximum of 5 stars is allowed for the appliance operating efficiency. Measurements include standby energy consumption, overall operating efficiency and seasonal operating efficiency during heavy and light load operation.

A maximum value of 1 star is allowed for the system, or HLR factor. HLR is 'based on an equation for calculating the manufacturer's minimum number of warm air outlets that can be left open at any one time and reflects the ability of the appliance to reduce energy consumption by directing heat only to the areas required[5]. The HLR requires knowing the manufacturer's recommended minimum and maximum number of warm air outlets that can be left open at any one time or as determined by a specified equation in the Standard. In the absence of adequate performance instructions or recommendations from the manufacturer, a HLR factor of zero (0) is awarded.

It must be noted that this system factor is application specific; not all applications will utilise zonation. This could be due to a number of reasons, including: the consumer not understanding that 1 star on the label is given for the ability to zone and therefore:

- not wanting to pay the extra money for the zoning duct work;
- the consumer not seeing a benefit to utilising zonation;
- the necessary controller not being used/included/separately purchased, or;
- a floorplan or application that simply does not lend itself to being zoned.

This leads to a situation where a consumer will not receive the benefit of this extra star. Any energy saving will only be realised if consumers actually make use of this zoning capability. Furthermore, the fact that it is impossible for a consumer to distinguish system factor stars from efficiency stars can lead to poor outcomes for consumers. For instance, if a consumer, who for any reason will not be utilising a zoned installation, is

[5] AS 4556-2011, 1.3.46 *Definitions*

looking at two 5-star ducted heaters and one of them has 5-star efficiency while the other has 4-star efficiency and an extra star for its ability to 'zone', they will not realise that for them one of these heaters would be considerably more efficient than the other.

Findings

Raw test results were used to determine the reliability of claimed star ratings. There are no tolerances applied in determining the calculations as specified in the relevant Australian Standards.

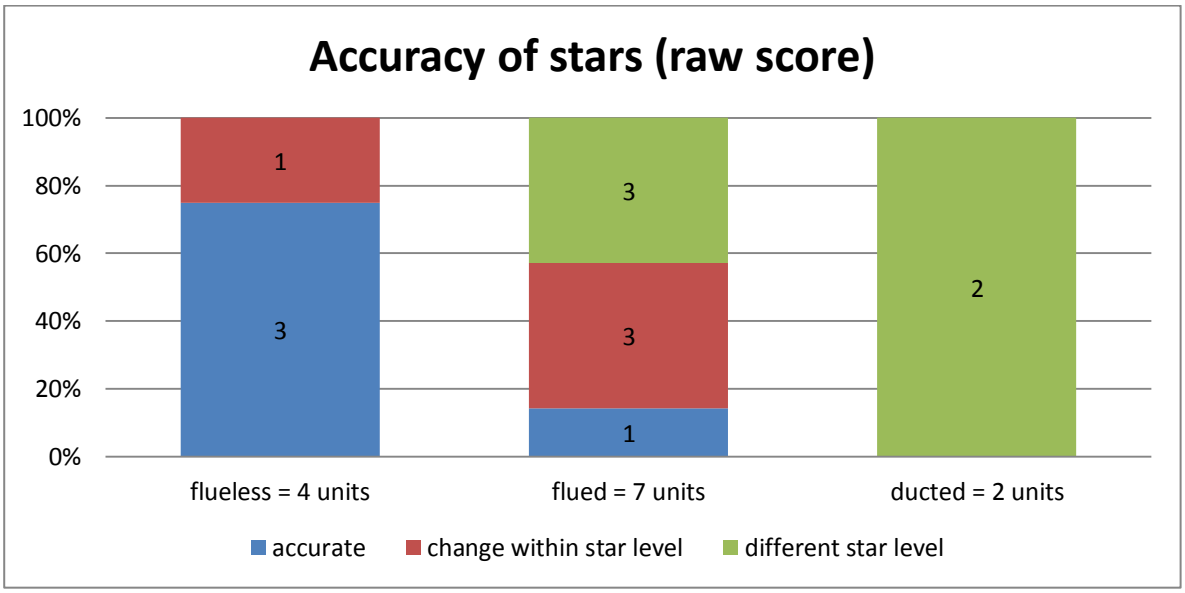
Raw scores

Refer to Attachment 1 for laboratory test results.

All star ratings are declared to one decimal point. Test results were grouped according to raw star results rounded to 1 decimal point (as per the Standard) and in the following way:

- Accurate if the claimed star rating on the appliance matched the tested result to one decimal point (eg the unit claimed 5.9 stars and tested to 5.9 stars);
- Change within the same star level (eg the unit declared to be 4.2 stars but when tested it was determined to be 4.6 stars); or
- In a different star level (eg. the unit declared 4.2 stars but tested to 3.7 stars).

Figure 9 Accuracy of stars



The tests results found that star ratings were inaccurately declared by 69% (9 of 13) of the tested gas space heaters.

- Four units over-claimed their star rating:
  - One unit claimed a larger fraction of a star (the flued unit H);
  - Three units claimed 1 or more entire stars (the flued unit D and ducted units E and L).
- Five units under-claimed their star rating:
  - Three units claimed a smaller fraction of a star (the flueless unit A and the flued units K and R);
  - Two units claimed an entire star less (flued units J and P)

Results indicated that any over or under claiming of results was sometimes due to variations in actual performance. For example, as annual energy usage and power outputs are calculated with gas consumption, if an appliance fails to operate at its nominated gas consumption rate, the AEC and output listed cannot be

accurate. Furthermore, 1 ducted heater (Unit L) claimed 6 stars on the label on the basis of 1 additional star for HLR. As explained in Section 1a *Gas Consumption*, the test method used to allow comparability between heaters and independent verification of claimed performance provided different results than those obtained for the same product when operated with its optimal controller.

The result using independent testing however illustrates the issue that the consumer and retailer cannot compare and disaggregate HLR from actual system efficiency and the HLR claim is based on improving efficiency indirectly. It also shows that ducted heater installations affect energy use. The ability to disaggregate what the stars represent is now an even greater concern given some gas appliance manufacturers are making claims beyond 6 stars, even though the Australian Standards do not allow for this. This highlights issues with compliance with the Standard and issues of interpretation of the stars (stars being used to represent comparative efficiency for flued and flueless units, but also representing a non-efficiency factor in ducted). To reflect the true efficiency of a heater, any changes to the star ratings would require a change to the other information provided on the label.

6. Summary results per type of space heater

Flueless heaters

- Three heaters (Units C, G and Q) claimed their stars accurately, while 1 unit under claimed. Unit A could have claimed an additional 0.1 of a star.
- Most of the flueless heaters were rated 5.8 or 5.9 stars, creating a 'bunching' of stars at the top level. These heaters can claim very high star ratings aided by a theoretical efficiency rate of 90.4% applied in the energy labelling test.
- None of the units accurately declared their AEC. Of particular concern was the test results of 1 flueless heater (Unit G) determined to be consuming 1,299 MJ/year (18%) more than declared, making it quite costly to run.
- Only 2 units accurately declared their kW heat output (Units C and Q).
- Flueless heaters all passed the gas consumption test on a high setting within the 5% tolerance.
- On a low setting, 3 units consumed more MJ/hr than declared on product literature. One unit did not declare any low gas consumption. The 3 units that did declare this figure consumed greater than a 5% tolerance, if applied (Units A, C and G).

Flued heaters

- Only 1 out of 7 of the flued gas heaters (Unit B) accurately reported their star rating.
- Six out of 7 heaters had variations to their star ratings: 3 units at entirely different star levels (Units D, J and P) and 3 units rated differently within the same star level (Units K, R and H).
- One unit (Unit J) failed the gas consumption test at a high setting.
- On a low setting, 3 flued heaters (Units K, H and P) consume more MJ/hr than declared on product literature. Two units consumed greater than a 5% tolerance, if applied (Units H and P).
- Unit B consumes 13,605 MJ/year and Unit D consumes 10,964 MJ per year. At such high rates of gas consumption, it would be important that claims are reliable. Unit B consumed 10% less MJ/year than claimed, while Unit D consumed 2% more. Unit B failed the thermal efficiency test at 69.9% (required efficiency is 70%). This would result in the unit requiring review by a certification body and possibly not being certified. Both units had significant variance in kW heating output (producing less kW than claimed).
- Only 1 heater (Unit K) achieved an accurate AEC test result. Two heaters consumed substantially less energy per year than claimed: Unit R at 2,109 MJ less and Unit B at 1,440 MJ less. These results indicate that while these units would cost less to run, both heaters correspondingly produce less heat than claimed.
- Greater variations in electricity consumption between flued heaters were noted. For example, Unit J consumed more than double the electricity for high and low settings than Unit R whilst both heaters produced roughly the same heat output.
- None of the units met their declared heating output (to 1 decimal place).
- Three heaters (Units D, J and K) did not provide information regarding the minimum flue length recommended in their manuals. Three heaters (Units B, K and R) did not provide the information on maximum flue length in the manuals.
- Some registration details for 2 units (Units R and D) did not match with publicly available details on certification registers.
- Product quality issue – 1 unit (Unit K) had a flue that did not seal properly (gaps at flue junctures). Units P and K have been referred to Energy Safe Victoria for further investigation on behalf of all State and territory safety regulators. The relevant manufacturers have been advised by Energy Safe Victoria about the investigation.

Ducted heaters

- Neither ducted heaters (Units E and L) reported star ratings accurately. Both were determined to have less stars than claimed and as a consequence would be rated at different star levels. Unit E claimed 4.3 stars and tested to 3.9 stars. Unit L claimed 6 stars and tested to 4.8 stars.
- Using the single fixed input rate methodology when testing the ducted heaters, Unit L was determined not to be eligible for the Heat Load Reduction factor.
- Unit E indicated its gas consumption rate on its data plate, with the gas consumption of Unit L having to be derived from its website listing.
- One unit failed the gas consumption test (Unit L).
- Neither of the ducted heaters declared their AEC accurately with both consuming more MJ/year than declared.
- Both ducted heaters tested drew a significant amount of electrical power when running the fans on high. Unit E 1,010 watts and Unit L 854 watts.
- Product quality issue – a number of injectors in 1 unit (Unit E) were suspected to be partially blocked with what appeared to be injector sealant.
- Unit L was incorrectly labelled. The label referred to a 6 star product in another series.

Decorative heaters (based on test results from first round)

- Certification details were unable to be found for 2 units (Unit O and M).
- Decorative heaters were the only products tested that used continuous pilot lights and so their standby energy consumption was consistently higher (around 1 MJ/hour compared to a negligible amount for all other heater types tested). Changing the type of pilot light used would reduce the amount of gas consumed while in standby mode making the appliance cheaper and more efficient to run.
- Decorative heaters could improve compliance with the Australian Standard (AS4558 – 2011) requirement to display in a prominent position a marking/ label to clearly indicate to consumers if the product is not a space heater. Of the 3 decorative heaters tested in the first round, only 1 (Unit N) had a reasonably visible plate. One heater (Unit O) had the marking in fine print at the bottom of its name plate. Although it was on the name plate, its location is such that a consumer would be unlikely to see it without deliberate examination. The other decorative heater (Unit M) did not have a label on the appliance itself.

7. Conclusions

Physical performance testing of 4 types of gas space heaters (decorative, flued, flueless and ducted) has identified a number of issues that warrant further investigation. Issues identified ranged from poor test outcomes, incomparable energy efficiency claims, Australian Standards methodology and/or interpretation issues and product quality issues. More detailed conclusions are outlined following:

1. The claims made on the label were found to be largely unreliable for consumer decision making. For star ratings, 69% (9 of 13 units tested) were found to be inaccurate, with some units over-claiming and others under-claiming. Only 1 unit tested to its declared Annual Energy Consumption (AEC) (variations in AEC impact on the unit's heating capacity and/or cost of operating) and only 2 units tested to their declared kW heating output. The ways stars are awarded to ducted heaters is also an issue. Changes to the label to reflect tested results would also require adjustments to other information provided to reflect the actual performance of the appliance.

2. Label design issues were identified. For consumers, the exact star rating is unclear as stars are shaded to represent results to a decimal point, but the manufacturer's claimed rating is not shown numerically. For example, the efficiency rating number may be 3.3 but the label shading is difficult to interpret to that degree, which makes comparisons between products less clear.

3. All product groups use a virtually identical label with a range of 6 stars across a red band which makes them appear comparable, though they are only meant to compare within a product group. This visual similarity is misleading as the underlying data to calculate the stars differs across product groups. Some findings that illustrate this point are:

    a) Label metrics used are inconsistent (MJ/m^3/year versus MJ/year), so the label can only be used to compare products within a product group and not between all product groups (e.g. space heater or ducted). A 5 star ducted heater is not comparable with a 5 star flueless or a 5 star flued heater, however this would not be clear to consumers.
    b) Flued and flueless heaters can use a 6 stars scale for efficiency, while ducted heaters may only claim 5 for efficiency with 1 extra star available for a system factor Heat Load Reduction (HLR).
    c) The assumptions on thermal efficiency are applied differently between flued and flueless space heaters, resulting in incomparable star ratings.
    d) AEC is calculated using 1 of 3 different assumptions for hours of use.

4. While heat loss through the flue is accounted for in ducted and flued units, flueless units are awarded the theoretical combustion rate of natural gas of 90.4% as their equivalent thermal efficiency with no or little reduction due to heat loss. However, it is a requirement of operating these products that ventilation be provided to help vent waste gases and replenish the room's oxygen. The only appliances that do not require external ventilation are room sealed flued space heaters and external ducted heaters. Note, however, that ventilation requirements may be different between States.

    This results in a number of problems for consumers, including incomparable labels, unrealistic heating capacities and a lack of differentiation in star ratings. Given modifications to the standard on this issue occurred over 10 years ago, it is understood that with modern testing technology and improved unit design, options exist to address and overcome this issue. This would provide an incentive for the best performers in this category. For instance, two areas worth investigation are:

a) The reduction of radiative and convective heat losses.
b) The heat loss from flueless products could be based on the required fresh air ingress into a room. This could be linked to the unit's gas consumption (ie, higher gas consumption requires more fresh air). If the temperature of the outside air can be assumed, then the heat required to overcome this cold air could be deducted from the rated heating capacity.

5. Testing raised issues of Standards methodology that can lead to debatable energy efficiency claims and lack of reproducibility. Some findings that illustrate this point are:

   a) In flued heaters, the energy label is calculated using the lowest thermal efficiency results derived from tests with different flue configurations including a 4.5 metre vertical flue which often yields the lowest efficiency results. Differences in flue length used in the test could impact on efficiency results.
   b) As explained in point 3b, ducted heaters can only claim 5 stars for efficiency. The Standard requires that results over 5 are deemed to equal 5, and the 6th star is applied based on numbers of vents and their operation (HLR). To get the benefit of the HLR factor a home must be able to be zoned. This may not be readily understood by retailers, consumers and installers.
   c) Ducted gas heater testing is subject to numerous variables and from a compliance point of view, testing must not involve the need for manufacturer interaction to obtain key information, which reduces the independence of results. In addition the product tested and sold should contain all components as standard to perform to the rating displayed on the label and not require optional upgrades of components to reach the advertised performance.
   d) The Australian Standards 4553 and 4556 apply ±5% tolerance for gas consumption at high settings, while no tolerance is identified for low settings. This gives potential to high levels of variation, as the test results indicate. The absence of a tolerance at low setting means appliances may not run as efficiently or cheaply on a low setting as claimed or expected and has contributed to a widely variable AEC value.

6. All flued and flueless heaters declare their heating output on the gas energy label but this is not required for ducted products. This information is important for consumers and installers to enable correct sizing of a unit. Testing showed noticeable variations in actual performance. Five units in particular showed variances 5% and over between claimed and tested heating output. Two produced more heat and 3 produced less.

7. For flueless heaters, 'bunching' at high star ratings was observed. The 2013/14 financial year GfK Gas Heater retail data shows that approximately 90% of flueless heaters are rated at 5.8 or 5.9 stars (due to the thermal efficiency rate applied for these appliances). The current star rating scheme and Standard does not challenge these products to any further improvement in performance. Flued heaters, on the other hand, are found at a range of star ratings with some bunching in the 4 star level. While roughly 55% of ducted heaters sold in the 2013/14 financial year were between 4.7-5.6 stars, about 18% were rated 6 stars, indicating that a number of ducted heaters are claiming the extra system factor star on the basis of HLR. Also those heaters rated below 6 stars could be claiming 1 star on the basis of the HLR.

8. Ducted heaters and some flued heaters can consume a greater amount of electricity than realised, possibly as a result of fan operation. By presenting all energy use in megajoules, the label prevents consumers from clearly identifying this electrical component which will have an impact on their electricity bill. The contribution based on a 600 hour or 2 month operation of a ducted heater could be somewhere between $137 and $163 per annum. This would be greater if the heater operates for more than two months per year. Opportunities exist for greater electrical component operational and standby efficiencies.

9. Decorative heaters that utilise a continuous pilot light could add hundreds of dollars per year to a consumer's energy bill for this component of operation alone. Refer Table 1. Changing continuous pilot lights to intermittent or other technologies would make these appliances more energy efficient.

10. Given that decorative heaters are often used for space heating, consideration should be given to incorporating energy labelling requirements or performance tests for thermal efficiency.

11. Poor compliance with labelling requirements for decorative heaters was observed. Australian Standard (AS4558 – 2011) requirements include prominent and clear marking that identifies them as 'Primarily a decorative appliance not certified as a space heater'. One unit was found to have no marking and another with a label that was difficult to read and not clearly visible.

12. Quality and certification documentation issues were observed. In total, from the 17 gas appliances tested, product quality concerns were found for 2 units and certification documentation issues with 5 units. These issues included a unit with a flue whose dimensions did not match the heater's flange and 1 unit with a number of injectors partially blocked with what appeared to be injector sealant. Certification documentation issues raised were: 2 decorative heaters were found not to be certified, and 2 flued units had information on the appliances not matching the publicly available details on certification registers. One ducted heater had another product's label applied. The ill-fitting flue also raises certification concerns. Either the dimensions of the flue have changed or the heater has changed since their certification 10 years ago and this appears to have not been picked up through the certification process in subsequent years.

Attachment 1: Laboratory test results

Table 5

Unit details			Results expressed as percentage variances against declared values (negative indicates less than declared)						Thermal Efficiency (also refer to Note 2)					
Unit Code	Heating capacity class (kW)	Product Type	Percentage Variance in gas consumption (MJ/h) at high setting	Percentage Variance in gas consumption (MJ/h) at low setting (Note 3)	Percentage Variance in Annual Energy Consumption	Difference in Annual Energy Consumption - flued/less= MJ/year; ducted=MJ/ m^3/year	Percentage Variance in Heater Output (kW)	Percentage Variance in star rating	A Natural convection, 60% minimum required	B Forced convection, 70% minimum required	C Room sealed heaters , 70% minimum required	D Flued forced convection heaters at all fan speeds, 70% minimum required	E Thermal efficiency with 4.5m vertical flue (minimum 60%)	F Ducted heaters not less than 70% required
A	3 to 4	Flueless	5%	13%	4%	191	3%	2%		90.4%				
C	3 to 4	Flueless	-1%	7%	2%	95	0%	0%	90.4%					
G	5 to 7	Flueless	2%	17%	18%	1,229	5%	0%		90.4%				
Q	3 to 4	Flueless	3%	n/a	-2%	-91	0%	0%		90.4%				
B	7 to 9	Flued	-1%	-4%	-11%	-1,449	-7%	-2%		71.1%		69.9%	70.9%	
D	4 to 6	Flued	-2%	n/a	2%	227	-6%	-6%		81.1%		79.7%	78.7%	
H	1 to 3	Flued	3%	6%	3%	133	5%	-2%			79.2%	83.8%	80.4%	
J	4 to 6	Flued	-8%	-2%	-8%	-836	-7%	4%			84.9%	82.5%	85.5%	
K	7 to 9	Flued	3%	5%	0%	-4	1%	3%					81.8%	
P	4 to 6	Flued	-1%	12%	-6%	-490	7%	28%			89.4%	89.7%	87.0%	
R	4 to 6	Flued	-3%	n/a	-12%	-2,109	-2%	14%		73.1%		73.0%	68.4%	
E	25 to 30	ducted	0%	n/a	5%	7		-9%						74.9%
L	20 to 25	ducted	-5%	n/a	14%	17		-20%						88.6%

Note 1: The tested star rating of Unit B when rounded to one decimal space, equated to the star rating as declared on the appliance.

Note 2: Per AS-4553, the flueless efficiency figures are not tested results. They correspond to the theoretical combustion efficiency for natural gas.

Note 3: There is no variance for Units Q. D and R because there are no declared values for turndown or low gas consumption. Ducted units were not tested at turndown rates.

Attachment 2: Electrical consumption of gas space heaters tested

Table 6 Flueless and flued

Unit Reference FLUELESS	High setting electricity consumption (kW) kW	Low setting electricity consumption (kW) kW	Standby electricity (kW) = e_s kW	Daily total kW consumed (high x 2.5 hrs)+ low x 2.5 hrs)+(Stby x 19) kW	Watts consumed at high settings only 1 kW = 1000 watts	Kilowatt to megajoule per hour (kW to MJ/h): 3.6 × PkW = PMJ/h 3.6 conversion factor for kW to MJ	Total daily energy input MJ/h (which includes gas, electricity and standby	Equivalent electricity component as % of energy input	Average per type of heater
A	0.021	0.017	0.0009	0.112	21	0.404	51.33	0.8%	0.5%
C	0.000	0.000	0.0000	0.000	-	0.000	53.58	0.0%	
G	0.032	0.021	0.0009	0.150	32	0.539	90.62	0.6%	
Q	0.018	0.012	0.0005	0.085	18	0.304	59.07	0.5%	
FLUED									
B	0.069	0.045	0.0038	0.357	69	1.286	106.91	1.2%	1.2%
D	0.067	0.051	0.0020	0.333	67	1.199	109.32	1.1%	
H	0.044	0.018	0.0004	0.163	44	0.585	50.04	1.2%	
J	0.129	0.113	0.0047	0.694	129	2.499	101.33	2.5%	
K	0.048	0.045	0.0007	0.246	48	0.885	117.21	0.8%	
P	0.056	0.033	0.0004	0.230	56	0.828	83.19	1.0%	
R	0.061	0.044	0.0060	0.377	61	1.355	129.79	1.0%	

Ducted heaters

Table 7 Ducted - at heavy load test (20 minutes)

Unit	electricity consumed (heavy load test) kWh	convert kWh to MJ	total energy consumed heavy load MJ	% electricity
E	0.238	0.8568	30.24	3%
L	0.218	0.7848	21.5	4%

Table 8 Ducted - at light load test (20 minutes)

Unit	electricity consumed (light load) kWh	convert kWh to MJ	total energy consumed light load MJ	% electricity
E	0.071	0.2556	8.56	3%
L	0.075	0.2700	7.05	4%

Table 9 Ducted - in standby

Unit	standby electricity consumption kW	Watts	convert kW to MJ	Total standby energy (adjusted to MJ/h)
E	0.0060	6.0	0.0216	0.02
L	0.0062	6.2	0.0223	0.02

1000 Watts = 1 kW

Attachment 3: Gas tariffs used for the report

Table 8: Indicative average residential tariffs (May 2015) used for report.

State/Territory	Energy Provider	Tariff ($/MJ, GST incl.)	Tariff (cents/MJ, GST incl.)
VIC	Origin Energy Retail Ltd	0.016372	1.6372
ACT	Origin Energy Retail Ltd	0.026501	2.6501
SA	Origin Energy Retail Ltd	0.032137	3.2137
QLD	Origin Energy Retail Ltd	0.042434	4.2434
NSW	Origin Energy Retail Ltd	0.027569	2.7569
TAS	Aurora Energy	0.031200	3.1200
WA	Kleenheat Gas	0.133250	13.325

Notes:

Supply charges not included.

Based on average of all daily consumption tariffs from one supplier for each jurisdiction. For example, for Victoria, Origin 'DailySaver' Peak period (1 May to 31 October) rates were used. It is the average of: the first 98,6301 MJ/Day rate of 0.021131 $/MJ; the second 49,3151 MJ/Day rate of 0.016709 $/MJ; and the remaining daily rate of 0.011275 $/MJ. Exact costs will depend on household usage patterns.

Gas space heaters – performance testing & energy labelling

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