

Unflued Gas Heaters

Position statement and background paper for the Canterbury District Health Board



Canterbury
District Health Board
Te Poari Hauora o Waitaha

Prepared by the Information
Team Community and Public
Health.
Adopted by the Canterbury
District Health Board July 2015

Contents

Position statement on unflued gas heaters.....	2
Executive Summary.....	3
Background paper.....	4
What are unflued gas heaters?.....	4
Current policy environment.....	4
Who uses unflued gas heaters?	5
Inequity of distribution	5
Problems with unflued gas heaters	6
Health effects.....	6
Water vapour	7
Nitrogen dioxide	8
Sulphur dioxide	8
Carbon monoxide.....	8
Benzene, butadiene, and formaldehyde.....	8
Fine particulates.....	9
Cost	9
Fire risk.....	10
Summary	11
References	11

Position statement on unflued gas heaters

The first six points included in this draft position statement are taken directly from the existing Canterbury District Health Board position statement on home heating and air quality. Five additional points are presented below. These points were developed based on the information provided in the background paper which follows this position statement.

1. The Canterbury District Health Board (CDHB) acknowledges that a warm home is vital for comfort and good health whilst also recognising that many New Zealand homes tend to be cold with temperatures regularly falling below the World Health Organization's recommendations.¹
2. The CDHB acknowledges that the direct effects of cold homes on health include excess mortality from cardiovascular and respiratory disease amongst the elderly, increased respiratory problems in children, increased illnesses such as colds, influenza and mental health problems, and the exacerbation of existing conditions such as arthritis.
3. The CDHB recognises that home heating (temperature, humidity and ventilation), energy costs and fuel poverty are key housing issues with implications for health outcomes.
4. The CDHB wishes to emphasize the importance of home heating and energy efficiency, as a health protection measure, due to the significant public health impacts that result when dwellings do not provide a healthy environment for occupants.
5. The CDHB considers the human right to housing to be much more than simply a right to shelter but also the right to have somewhere to live that supports good health outcomes. The CDHB therefore acknowledges the inextricable link between the right to housing and the need for warm and dry, affordable, culturally appropriate and accessible housing that is part of a wider community with easy access to essential services within a healthy environment.
6. The CDHB wishes to highlight the risks of unflued gas heaters to human health, due to the high levels of moisture and harmful combustion products which are produced by these appliances and the associated significant reduction in the quality of the indoor environment.
7. The CDHB will take every opportunity to highlight the health and safety risks associated with unflued gas heaters.
8. The CDHB will advocate for and support initiatives that help households maintain a healthy indoor temperature without the use of unflued gas heaters.
9. The CDHB will advocate for policy options that prohibit the installation of fixed unflued gas heaters in new or existing homes.
10. The CDHB will advocate for policy changes that prohibit the installation of gas bayonet fittings in new or existing homes (these fittings can only be used with unflued gas heaters).
11. The CDHB will advocate for policy changes that will limit or prohibit the sale of unflued gas heaters and/or work with retailers to explore opportunities for the voluntary removal of unflued gas heaters from sale.

¹ The World Health Organization has recommended a minimum indoor temperature of 18°C and a 2-3°C warmer minimal temperature for the very young and the very old. World Health Organization. (1987). Health impact of low indoor temperatures: Report on a WHO meeting, Copenhagen, 11-14 November 1985. Copenhagen: WHO.

Executive Summary

This paper has been prepared for the Canterbury District Health Board in support of the Board's intention to provide leadership in the area of housing and health in Canterbury. This background paper is intended to be read in conjunction with the existing CDHB position statement, Home Heating and Air Quality² and the associated briefing paper³.

Unflued gas heaters generate heat by burning gas, but have no flue or chimney to transfer the combustion products outside. Instead, waste products are released inside households, reducing indoor air quality. Most unflued gas heaters used in New Zealand are portable LPG cabinet heaters, but some are permanently installed or plugged into a gas bayonet fitting.

Warnings about the dangers of unflued gas heater use have been issued by the New Zealand Energy Safety Service, the Ministry of Health, the Energy Efficiency and Conservation Authority, local authorities and regional public health services².

The use of unflued gas heaters in New Zealand has declined over the last decade, but by 2010 they were still used by 25% of rental households and 17% of owner occupied households (Buckett, Jones, & Marston, 2012). Furthermore, the burden of unflued gas heater use is borne primarily by low-income households (Howden-Chapman, 2012). These households are more vulnerable to respiratory health problems and fuel poverty; problems that will be exacerbated by using unflued gas heaters (Howden-Chapman, 2012).

Unflued gas heaters pose a substantial health risk to the households using them. They release water vapour, nitrogen dioxide, carbon monoxide, and other pollutants into the indoor environment, reducing indoor air quality (Christian, 1994; Environmental Health Standing Committee, 2007; Howden-Chapman et al., 2008; Ministry for the Environment). Poor indoor air quality is associated with exacerbation of respiratory problems such as asthma, and with increased GP presentations, emergency department presentations, and days off school or work (Howden-Chapman et al., 2008; Pilotto et al., 2004). Elevated concentrations of carbon monoxide can cause permanent brain damage or death (Environmental Health Standing Committee, 2007; Ministry for the Environment). Furthermore, the water vapour released by unflued gas heaters makes households damp, which further exacerbates respiratory problems (Bornehag et al., 2004).

In addition to health risk from reduced indoor air quality, unflued gas heaters also pose a greater fire hazard than other forms of heating (Cowan, Burrough, & Ryan, 2010).

Unflued gas heaters are an expensive way to heat a home. Although they are relatively inexpensive to buy, they are the most expensive-to-run form of heating commonly used in New Zealand (Consumer Magazine, 2015). Furthermore, the dampness associated with unflued gas heaters, combined with the need to open a window for extra ventilation, makes a home more difficult to heat, so more energy is required to achieve an acceptable level of comfort (Cowan et al., 2010). It is more economical to buy and run plug-in electric heaters, which have zero indoor emissions, than unflued gas heaters.

The combination of health risks and high running costs mean that unflued gas heaters are unsuitable for routine household use.

² Home Heating, and Air Quality position statement <http://www.cph.co.nz/Files/CDHBPositionStatementHomeHeating.pdf>

³ Housing, Home Heating and Air Quality: A Public Health Perspective <http://www.cph.co.nz/Files/HousingHeatingAirPHPerspective.pdf>

⁴ <http://www.med.govt.nz/energysafety/appliances-fittings/gas-appliances-fittings/product-information/lpg-cabinet-heater-review?searchterm=lpg+cabinethttp://www.health.govt.nz/your-health/healthy-living/environmental-health/household-items-and-electronics/unflued-gas-heaters>
<http://www.energywise.govt.nz/products-and-appliances/heating/gas>

Background paper

This paper has been prepared for the Canterbury District Health Board in support of the Board's intention to provide leadership in the area of housing and health in Canterbury. This background paper is intended to be read in conjunction with the existing CDHB position statement on Home Heating and Air Quality⁵ and the associated briefing paper⁶.

What are unflued gas heaters?

Unflued gas heaters generate heat by burning gas, but have no flue or chimney to transfer the combustion products outside. Instead, waste products are released into the air inside homes and buildings and alter the indoor environment, which can cause health problems. Some unflued gas heaters are portable and have their own gas cylinder. Other unflued gas heaters are plugged into a gas bayonet fitting in the wall or floor, or are permanently fixed to the wall.

Patio heaters are an example of another kind of unflued gas heater that has not been designed to minimise the release of pollutants. Patio heaters should never be used indoors.

The pollutants released by unflued gas heaters pose a particular health problem because they are trapped indoors. Other heaters, such as wood-burners, pellet fires, and flued gas heaters, vent their pollutants outdoors using a chimney. Electric heaters and heat pumps release no pollutants.

Current policy environment

Fixed unflued gas heaters are regulated by the New Zealand Gas Installation standard (NZS 5261). Part two of this standard prohibits the installation of fixed unflued heaters in bedrooms and bathrooms. However, many unflued gas heaters in New Zealand are portable LPG heaters, which are not covered by this standard, and may easily be moved into bedrooms or bathrooms by the user. All gas space heaters are regulated by the New Zealand Gas Space Heating Appliances standard (NZS AS 4553), which provides minimum efficiency and maximum emissions values for unflued gas heaters sold in New Zealand. However, this standard cannot prevent inappropriate use or poor maintenance of unflued gas heaters by the end user.

Various public and private organisations within New Zealand and internationally have warnings or policies intended to discourage the use of unflued gas heaters:

- Within New Zealand, warnings about the dangers of unflued gas heater use have been issued by New Zealand Energy Safety Service, Ministry of Health, the Energy Efficiency and Conservation Authority, local authorities and regional public health services⁷.

<http://www.gdc.govt.nz/keep-warm-but-safe-this-winter/>

http://www.ttophs.govt.nz/healthy_homes_heating

<http://www.arphs.govt.nz/Portals/0/Health%20Information/HealthyEnvironments/HealthyHousing/Unflued%20gas%20heaters/Unflued%20Gas%20Heaters%202012.pdf>

⁵ Home Heating and Air Quality position statement <http://www.cph.co.nz/Files/CDHBPositionStatementHomeHeating.pdf>

⁶ Housing, Home Heating and Air Quality: A Public Health Perspective <http://www.cph.co.nz/Files/HousingHeatingAirPHPerspective.pdf>

⁷ <http://www.med.govt.nz/energysafety/appliances-fittings/gas-appliances-fittings/product-information/lpg-cabinet-heater-review?searchterm=lpg+cabinet>

<http://www.health.govt.nz/your-health/healthy-living/environmental-health/household-items-and-electronics/unflued-gas-heaters>

<http://www.energywise.govt.nz/products-and-appliances/heating/gas>

<http://www.gdc.govt.nz/keep-warm-but-safe-this-winter/>

- In her recent commentary on the state of air quality in New Zealand, the Parliamentary Commissioner for the Environment noted that “There could be significant health gains from replacing unflued gas heaters in households where they are used regularly” (Parliamentary Commissioner for the Environment, 2015). The Parliamentary Commissioner for the Environment has previously recommended that the Minister for Consumer Affairs implement a ban on all sales of unflued gas heaters (Parliamentary Commissioner for the Environment, 2006).
- Some New Zealand retailers have chosen to avoid selling portable LPG heaters (Cowan et al., 2010). However, unflued gas heaters are still readily available in New Zealand.
- Internationally, the use of unflued gas heaters is banned in Western Australia and some states in the United States (Cowan et al., 2010). Other Australian states have emission and/or ventilation requirements (e.g. Department of State Development, Government of South Australia, 2015).

Who uses unflued gas heaters?

Unflued gas heater use has declined markedly over the last decade, but there is still a substantial proportion of New Zealand households that reports using unflued gas heaters. The 2004 survey of New Zealand household energy use⁸ (Isaacs et al., 2010) found that 34% of households used portable gas heaters, which are all unflued. By 2010, the BRANZ house condition survey (Buckett et al., 2012) found that only 25% of rental households and 17% of owner-occupied households used unflued gas heaters. Similarly, New Zealand census data indicate that the proportion of households that ever use bottled gas for heating fell from 28% in 2006 to 15% in 2013. However, the proportion of households using unflued gas heaters remains high enough to pose a substantial health burden.

Inequity of distribution

Despite their high running costs, unflued gas heaters are relatively inexpensive to buy, and fuel is paid for in advance so budgeting is perceived to be simpler than for many other forms of heating. As such, they are the heater of choice for low-income households (Cowan et al., 2010).

Low income households are more likely to be in fuel poverty⁹, so may struggle to afford to maintain healthy indoor temperatures. Many Christchurch households experience fuel poverty: a 2008 study based on electricity prices, income data, and an average heating requirement estimated that 54,000 Christchurch households were experiencing fuel poverty (Howden-Chapman et al., 2012). Similarly, a 2013 telephone survey of 608 randomly selected Christchurch households estimated that 28,000 households were experiencing fuel poverty (Wilton, 2013), although this figure is likely to be an underestimate as telephone surveys may not include a representative sample of low income households.

http://www.ttophs.govt.nz/healthy_homes_heating

<http://www.arphs.govt.nz/Portals/0/Health%20Information/HealthyEnvironments/HealthyHousing/Unflued%20gas%20heaters/Unflued%20Gas%20Heaters%202012.pdf>

⁸ The Household Energy End-use Project (HEEP), a national random sample of 399 households, with data collection occurring between 1999 and 2005.

⁹ “Fuel poverty” has been defined as the condition when the cost of fuel to adequately heat the home to achieve a satisfactorily warm environment is more than ten percent of a household’s income.

The use of unflued gas heaters in low-income households further exacerbates the health challenges already faced by these households, and amplifies the negative health effects of unflued gas heaters. Furthermore, low-income households may be less likely to be able to prioritise servicing of unflued gas heaters, so their heaters are more likely to be in poor condition and to release even higher levels of pollutants.

Problems with unflued gas heaters

Unflued gas heaters release water vapour and other pollutants into indoor air, contributing to a wide variety of health problems. They are also a fire hazard (Wakelin, 2004), and are the most expensive form of frequently-used home heating in New Zealand (Consumer Magazine, 2015). Many people using unflued gas heaters use them inappropriately (Wakelin, 2004), compounding the problems associated with the heaters.

Health effects

The most marked health effects of using unflued gas heaters are increased severity of any pre-existing respiratory conditions. However, unflued gas heater use is associated with increased rates of a wide variety of health conditions, as well as with hospital admissions and days off school or work (Howden-Chapman et al., 2008; Pilotto et al., 2004). The negative health effects of unflued gas heater use include:

- increased severity of respiratory conditions such as asthma, coughing, wheezing, and general nose, throat, and lung irritation (Bornehag et al., 2004; Howden-Chapman et al., 2008)
- increased rates of fevers, nausea, vomiting, headaches, sore throats, lung infections, skin conditions, constipation, back ache, aching joints, and fainting (Bornehag et al., 2004)
- reduced lung function in later life (Environmental Health Standing Committee, 2007; Ministry for the Environment)
- increased risk of death or permanent disability from carbon monoxide poisoning (Environmental Health Standing Committee, 2007; Ministry for the Environment)
- increased risk of developing cancer (Environmental Health Standing Committee, 2007; Ministry for the Environment), and
- increased rates of hospital admissions, emergency department presentations, days off school or work, and mortality (Howden-Chapman et al., 2008; Pilotto et al., 2004).

Studies in Australia and New Zealand show that replacing unflued gas heaters helps to manage respiratory diseases such as asthma. In the New Zealand Housing, Heating and Health study (Howden-Chapman et al., 2008), unflued gas heaters (55%) or plug-in electric heaters (45%) were replaced with more effective clean heaters in 409 low-income households with children diagnosed with asthma. Children in the intervention group experienced improved asthma symptoms, better sleep, fewer days off school, fewer visits to the doctor, and fewer visits to the pharmacy compared to the control group (Howden-Chapman et al., 2008). In an Australian study (Pilotto et al., 2004), unflued gas heaters in classrooms were replaced with clean heating. Students in the intervention classrooms experienced fewer days off school and reduced respiratory symptoms compared to students in the control classrooms.

The majority of negative health effects caused by unflued gas heaters are the result of reductions in indoor air quality due to pollutants released by the heaters. On average, New Zealanders spend over 70% of their time in their home environment (Baker, Keall, Au, & Howden-Chapman, 2007). People at greater-than-average risk of health problems, such as young children and the elderly, are likely to spend an even greater proportion of their time at home and indoors. As such, a high quality indoor environment, free from pollution and with appropriate temperature and humidity, is vital for maintaining good health.

Unflued gas heaters release a range of pollutants, which can be concentrated when the heater is used indoors. Pollutants released indoors are approximately 1000 times more likely to be inhaled than pollutants released nearby but outdoors (Bennett et al., 2002; Lai, Thatcher, & Nazaroff, 2000). Replacing unflued gas heaters with cleaner forms of heating results in improved health outcomes and reductions in condensation, mould, damp, and nitrogen dioxide concentrations (Howden-Chapman et al., 2008).

The reduction in air quality caused by unflued gas heaters depends on how much they are run, how frequently they are serviced, and the size and ventilation of the room where they are used. Without regular servicing, unflued gas heaters are markedly less efficient and more polluting. New Zealand servicing centre data indicate less than a quarter of heaters are regularly serviced. (Cowan et al., 2010). Using unflued gas heaters in bedrooms or other small rooms, rather than larger living areas, results in higher concentrations of pollutants. However, a 2004 inquiry into the use of portable LPG heaters found that, despite safety advice, many households did use them in bedrooms, increasing household members' exposure to pollutants (Wakelin, 2004).

The pollutants released by unflued gas heaters include:

- water vapour¹⁰
- nitrogen dioxide
- sulphur dioxide
- carbon monoxide
- benzene
- butadiene
- formaldehyde, and
- fine particulates (PM₁₀ and PM_{2.5}).

Water vapour

Water vapour is not hazardous in and of itself. However, releasing water vapour into the indoor environment makes a home damp, which in turn contributes to numerous health problems. Damp homes are also more difficult to heat. This means that more heat is required to achieve the same feeling of warmth with an unflued gas heater compared to other forms of heating (Environmental Health Standing Committee, 2007).

¹⁰ Although water vapour is not hazardous in and of itself, it promotes mould growth and increases the cost of heating, so is considered a pollutant in an indoor environment Auckland Regional Public Health Service. (2014). Unflued Gas Heaters Fact Sheet. Auckland: ARPHS, Cowan, V., Burrough, L., & Ryan, V. (2010). Unflued Gas Heater Fact Bank. Auckland: Beacon Pathway.

A 4 kW unflued gas heater produces between 0.5 L and 0.6 L of water vapour each hour (Cowan et al., 2010). This means that an unflued gas heater run 8 hours per day will increase the total amount of water vapour released in a typical home by about 50% (Christian, 1994). Releasing extra water vapour makes a home more likely to have problems with damp – and exacerbates the problems already experienced in many New Zealand homes.

People living in damp housing are more likely to be unwell, regardless of other factors. Health problems associated with damp homes include respiratory problems, fevers, sore throats, headaches and skin problems, nausea, vomiting, constipation, blocked noses, breathlessness, backache, aching joints and fainting (Bornehag et al., 2004). People living in cold, damp houses experience higher rates of hospital admissions and more days off school and work (Chapman, Howden-Chapman, Viggers, O’dea, & Kennedy, 2009).

Nitrogen dioxide

In children, breathing air contaminated with nitrogen dioxide increases susceptibility to lung infections, aggravates asthma, and can cause poor lung function in later life. Furthermore, increased nitrogen dioxide concentration is associated with increased rates of hospital admissions and death (Environmental Health Standing Committee, 2007; Ministry for the Environment).

Research by Beacon Pathway showed that concentrations of nitrogen dioxide in some homes with unflued gas heaters reached five times World Health Organization recommendations. Concentrations of nitrogen dioxide were highest when unflued gas heaters were running, and fell when they were turned off (Cowan et al., 2010). Similar results were found in the New Zealand Housing, Heating and Health study (Howden-Chapman et al., 2008). When effective clean heaters were installed in low income households, the intervention group experienced an average 46% reduction in indoor nitrogen dioxide concentrations and a reduction in household children’s respiratory symptoms, despite only just over half of the intervention group having unflued gas heaters originally (Howden-Chapman et al., 2008).

Sulphur dioxide

Sulphur dioxide causes respiratory problems such as bronchitis, coughing, wheezing, phlegm, asthma attacks, and general nose, throat, and lung irritation. Sulphur dioxide may also be associated with cardiovascular disease (Ministry for the Environment).

Carbon monoxide

Carbon monoxide attaches to the haemoglobin in blood, preventing it from carrying oxygen around the body. Carbon monoxide poisoning can cause dizziness, nausea, weakness, confusion, loss of consciousness, coma, brain damage, and death (Environmental Health Standing Committee, 2007; Ministry for the Environment). A 2004 Environmental Risk Management Authority inquiry identified eighteen deaths from carbon monoxide poisoning as a result of using unflued gas appliances in New Zealand between 1992 and 2004 (Wakelin, 2004).

Benzene, butadiene, and formaldehyde

These chemicals are all hazardous substances which can cause a range of symptoms including irritation of eyes, skin, throat, and lungs. They can also cause headaches, nerve and organ damage, and are associated with increased risk of cancer (Environmental Health Standing Committee, 2007; Ministry for the Environment).

Fine particulates

Airborne particles smaller than about 10 µm diameter (PM₁₀ and PM_{2.5}) pass through the body's natural filters and can enter the lungs, causing respiratory problems. These particles can cause eye, throat, and lung irritation, increase susceptibility to lung infections, and can exacerbate existing conditions such as bronchitis and asthma. Increased PM₁₀ and PM_{2.5} concentrations are associated with increased rates of hospital admissions, emergency department presentations, days off school and work, days of restricted activity, and increased mortality (Ministry for the Environment).

Cost

Unflued gas heaters are the most expensive form of heating commonly used in New Zealand. **Figure 1** shows that in 2015 it cost between 31 and 41 cents to produce 1 kWh of heat using an unflued gas heater. Unflued gas heaters are even more expensive to run than the zero-indoor-emission plug-in electric heaters they are often bought to replace.

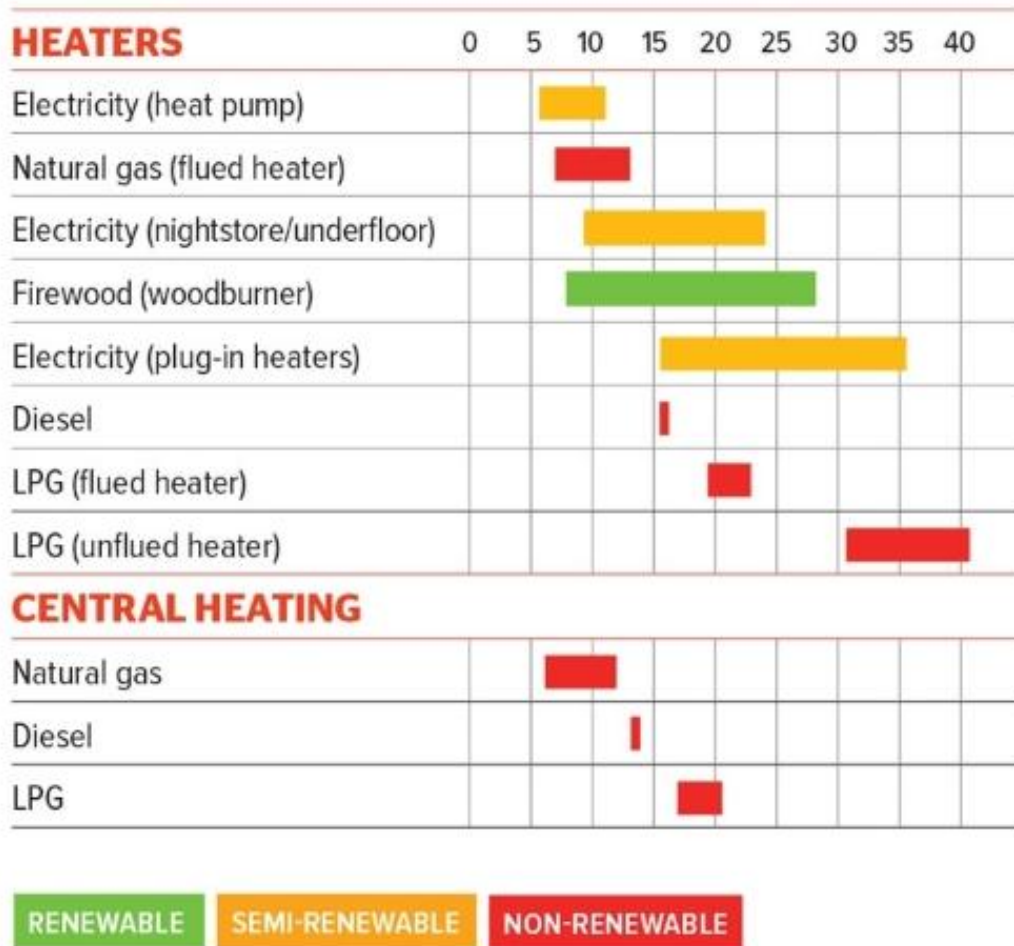
The cost of heating using an unflued gas heater is further increased by the need for adequate ventilation. To use an unflued gas heater safely, a window must be left open resulting in rapid loss of heat, or an expensive ventilation system must be installed. Both of these options add considerable cost when using an unflued gas heater.

Many people using unflued gas heaters also run dehumidifiers to help remove some of the water vapour produced. Households using an unflued gas heater have a statistically significantly higher likelihood of also using a dehumidifier (Isaacs et al., 2010). A dehumidifier has a similar purchase price to an unflued gas heater, and running a dehumidifier costs between \$0.14 and \$0.42 per litre of water removed, so creates an extra cost for keeping warm. Furthermore, the dehumidifier removes only water vapour, so ventilation is still required to remove other more toxic pollutants (Cowan et al., 2010).

Figure 1. Cost to produce one kWh of heat using different forms of heating

Home heating costs 2015

(cents per kWh)



Source: (Consumer Magazine, 2015)

Fire risk

Unflued gas heaters present a greater fire risk than other forms of heating. A Beacon analysis of Fire Service data shows that the average rate of fire incidences involving portable LPG heaters is 6.2 per 100,000 per year, compared to 2.3 per 100,000 per year for electric heaters ($p < 0.001$ for difference, Cowan et al., 2010). An Environmental Risk Management Authority inquiry identified six deaths from fires directly attributable to using unflued gas heaters in New Zealand between 1992 and 2004 (Wakelin, 2004). Furthermore, there is a small additional fire risk associated with using a dehumidifier in conjunction with an unflued gas heater (WorkSafe New Zealand, 2012).

Summary and Conclusion

Unflued gas heaters pose a substantial health risk to households using them. They release water vapour, nitrogen dioxide, carbon monoxide, and other pollutants into the indoor environment, reducing indoor air quality. Poor indoor air quality is associated with exacerbation of respiratory problems such as asthma, and with increased GP presentations, emergency department presentations, and days off school or work. Elevated concentrations of carbon monoxide can cause permanent brain damage or death. Furthermore, the water vapour released by unflued gas heaters, and the need to open a window for extra ventilation, make it more difficult to heat houses using unflued gas heaters than using clean heaters. In addition to health risk from reduced indoor air quality, unflued gas heaters also pose a greater fire hazard than other forms of heating.

Unflued gas heaters are also an uneconomical way to heat a home. Although they are relatively inexpensive to buy, they are the most expensive-to-run form of heating commonly used in New Zealand. It is more economical to buy and run a plug-in electric heater than an unflued gas heater.

The health and economic burden of using unflued gas heaters is borne primarily by low-income households. These households are vulnerable to respiratory health problems and fuel poverty, both of which will be exacerbated by using unflued gas heaters.

Unflued gas heaters should never be used as the primary form of heating for a household.

References

- Auckland Regional Public Health Service. (2014). Unflued Gas Heaters Fact Sheet. Auckland: ARPHS.
- Baker, M., Keall, M., Au, E. L., & Howden-Chapman, P. (2007). Home is where the heart is—most of the time. *New Zealand Medical Journal*, 120(1264).
- Bennett, D. H., McKone, T. E., Evans, J. S., Nazaroff, W. W., Margni, M. D., Jolliet, O., & Smith, K. R. (2002). Defining intake fraction. *Environmental Science & Technology*, 36(9), 206A-211A.
- Bornehag, C.-G., Sundell, J., Bonini, S., Custovic, A., Malmberg, P., Skerfving, S., . . . Verhoeff, A. (2004). Dampness in buildings as a risk factor for health effects, EUROEXPO: a multidisciplinary review of the literature (1998–2000) on dampness and mite exposure in buildings and health effects. *Indoor air*, 14(4), 243-257.
- Bucket, N. R., Jones, M. S., & Marston, N. J. (2012). BRANZ 2010 house condition survey - condition comparison by tenure. Porirua: BRANZ.
- Chapman, R., Howden-Chapman, P., Viggers, H., O’dea, D., & Kennedy, M. (2009). Retrofitting houses with insulation: a cost–benefit analysis of a randomised community trial. *Journal of epidemiology and community health*, 63(4), 271-277.
- Christian, J. E. (1994). Moisture sources *Moisture control in Buildings, ASTM Manual Series: MNL* (Vol. 18, pp. 176-182).
- Consumer Magazine. (2015). Home Energy Costs. Retrieved 9 June, 2015, from <https://www.consumer.org.nz/topics/home-energy-costs>
- Cowan, V., Burrough, L., & Ryan, V. (2010). Unflued Gas Heater Fact Bank. Auckland: Beacon Pathway.
- Department of State Development, Government of South Australia,. (2015). Unflued gas heater safety. Retrieved 11 June, 2015, from <https://www.sa.gov.au/topics/water-energy-and-environment/electrical-gas-and-plumbing-safety-and-technical-regulation/electricity-and-gas-safety-for-consumers/gas-safety/unflued-gas-heater-safety>
- Environmental Health Standing Committee. (2007). The health effects of unflued gas heater use in Australia. Canberra: Department of Health, Australian Government.
- Howden-Chapman, P. (2012). *Co-benefits of Making Housing Healthier*. Paper presented at the NZ Respiratory Conference, Wellington. <http://asthmafoundation.org.nz/wp-content/uploads/2012/03/Philippa-Howden-Chapman-Housing-and-health-research.pdf>
- Howden-Chapman, P., Pierse, N., Nicholls, S., Gillespie-Bennett, J., Viggers, H., Cunningham, M., . . . Crane, J. (2008). Effects of improved home heating on asthma in community dwelling children: randomised controlled trial. *The British Medical Journal*, 337, online. doi: 10.1136/bmj.a1411
- Howden-Chapman, P., Viggers, H., Chapman, R., O’Sullivan, K., Barnard, L. T., & Lloyd, B. (2012). Tackling cold housing and fuel poverty in New Zealand: a review of policies, research, and health impacts. *Energy Policy*, 49, 134-142.

- Isaacs, N., Camilleri, M., Burrough, L., Pollard, A., Saville-Smith, K., Fraser, R., . . . Jowett, J. (2010). Energy Use in New Zealand Households: Report on the Year 8 Analysis for the Household Energy End-use Project (HEEP) *BRANZ Study Report 221*. Porirua: BRANZ.
- Lai, A. C., Thatcher, T. L., & Nazaroff, W. W. (2000). Inhalation transfer factors for air pollution health risk assessment. *Journal of the Air & Waste Management Association*, 50(9), 1688-1699.
- Ministry for the Environment. Air: Specific Air Pollutants. Retrieved 25 May, 2015, from <http://www.mfe.govt.nz/air/specific-air-pollutants>
- Parliamentary Commissioner for the Environment. (2006). Healthy, wealthy, and wise: A health impact assessment of "Future currents: Electricity scenarios for New Zealand 2005–2050". Wellington: Parliamentary Commissioner for the Environment.
- Parliamentary Commissioner for the Environment. (2015). The state of air quality in New Zealand: Commentary by the Parliamentary Commissioner for the Environment on the 2014 Air Domain Report. Wellington: Parliamentary Commissioner for the Environment.
- Pilotto, L. S., Nitschke, M., Smith, B. J., Pisaniello, D., Ruffin, R. E., McElroy, H. J., . . . Hiller, J. E. (2004). Randomized controlled trial of unflued gas heater replacement on respiratory health of asthmatic school children. *International journal of epidemiology*, 33(1), 208-211.
- Wakelin, W. S. (2004). Report of Inquiry into the Use of LPG Cylinders in Indoor Situations (INQ03014) To ERMA New Zealand. Wellington: Environmental Risk Management Authority.
- Wilton, E. (2013). Assessing the impact of prohibiting wood burner use on fuel poverty levels in Christchurch. Christchurch: Environment Canterbury and Canterbury District Health Board.
- WorkSafe New Zealand. (2012). Dehumidifier Safety Message. Retrieved 27 May, 2015, from <http://www.med.govt.nz/energysafety/consumer/safety-alerts/dehumidifier-safety-message>
- World Health Organization. (1987). Health impact of low indoor temperatures: Report on a WHO meeting, Copenhagen, 11-14 November 1985. Copenhagen: WHO.