Pellet Heaters for Sustainable Domestic Heating

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Pellet Heaters Australia
The Pollution Solution in Home Heating

Introduction

The issue of climate change is forcing society to 'decarbonise' the economy, with new solutions required for energy, transport and land management. The use of renewable energy is essential if greenhouse gas reduction targets are to be met. One such source of renewable energy is biomass – most commonly recognised as wood. Biomass removes carbon from the atmosphere during its growth phase (photosynthesis plus sunlight and water converts carbon dioxide into plant material and oxygen), creating a carbon neutral balance when the biomass is used as an energy source.

The most common form of renewable biomass use is wood for domestic heating and cooking. Open fireplaces and slow combustion stoves are most commonly utilised to burn wood for heating. Although being a renewable source of energy, these types of heaters contribute to a wood-smoke problem which increases fine particles in the air, resulting in possible ill health effects among residents. Improvements in air quality, including a reduction in wood-smoke, is currently a high priority with government at all levels.

Alternative heaters which run on fuels such as gas and electricity can overcome the wood-smoke problem through their operation with much lower localised particulate emissions. However, these forms of heating use fossil fuels that directly contribute to global warming.

A solution is required that uses wood as a renewable fuel source, and at the same time has lower particulate emissions. Pellet heating systems are a relatively new technology that shows strong potential in being able to use renewable fuel (pellets) while achieving particulate emission levels comparable to that of natural gas.

Warnken ISE has been commissioned to investigate and summarise the characteristics and emissions of pellet heaters. This paper presents wood pellet heaters as a sustainable approach to home heating. It compares emissions of pellet heaters to that of wood fires and natural gas.

This paper also highlights the importance of specifically excluding pellet heaters from legislative action to ban wood fires in urban and suburban areas, which produce significantly higher levels of pollution in the form of particulates, greenhouse gases, and carbon monoxide.

Pellet Heaters

Pellet heaters (also called pellet stoves) are relatively new to the Australian market, however they are well established in Europe, North America and increasingly in New Zealand.

Pellet heaters use 'pellets' as a fuel source (see Figure 1), which are generally manufactured from sawdust and wood shavings from sawmills, although corn pellets are common in USA and pellets can also be made from a variety of other agricultural residues including nutshells. Pellet fuel is generally standardised and substantially more uniform in composition than traditional firewood. Pellets are dry, which means they have a greater energy value than 'green' wood and generally only use the naturally occurring resins in wood as binders to hold the pellets together, which means no chemical additives.

Figure 1 – Wood pellets manufactured by Pellet Heaters Australia are a dry, safe, and clean burning fuel manufactured from sawmill residues.

Pellet heaters operate under controlled conditions without the need for constant refuelling and without any visible wood smoke. Pellets are automatically fed in a controlled manner to the combustion chamber (see Figure 2 for a schematic of the pellet heater operation). In a stand-alone space heater, the fuel pellets are generally stored in a hopper within the heater. Electronic controls feed pellets via an auger into the combustion zone where the heater delivers radiant and convective heat with an electrically assisted fan, similar in operation to a small blast furnace. Importantly the pellets are fed through an under-grate system, which ensures optimal combustion conditions including a high air to fuel ratio with higher burn temperatures, producing cleaner and more efficient combustion.

Efficiencies of pellet heaters range from 70%-95%, and are independent of operator skill, making the efficiencies simple to achieve for the owner. Particulate emissions from pellet heaters are also much lower than other forms of wood heating. Comparative emissions from heating options are given in Table 1. An example of a pellet heater is shown in Figure 2.[1]

Some of the drivers for increased use of pellets include reducing air pollution, resource recovery, and sustainability considerations. Using sawdust and wood shavings from sawmills as a value added 'carbon neutral' pellet fuel for home heating, reduces the demand for firewood and delivers space heating to homes more cleanly than by using firewood.

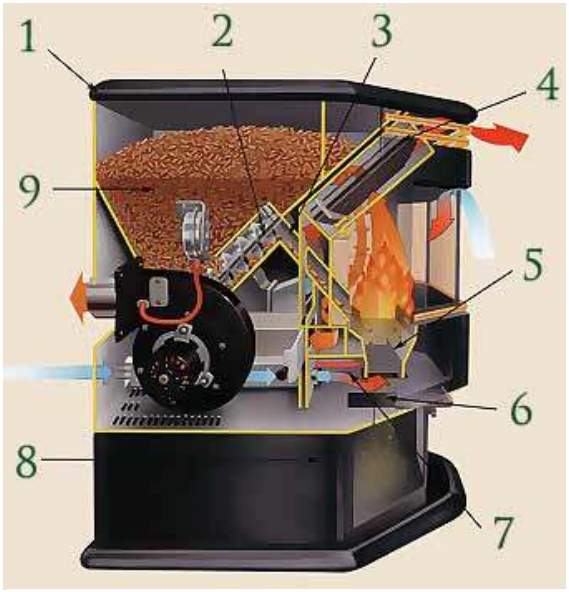

Figure 2 – Schematic diagram of a standard pellet heater. Labels: 1. High temperature paint 2. Auger 3. Flame monitor 4. Heat exchanger 5. Grate 6. Ash release 7. Igniter 8. Ash pan 9. Hopper.

National and International Usage of Pellet Heaters

The pellet industry is relatively new in Australia compared with other countries, suggesting a significant potential for further uptake of the technology. The pellet industry in Europe and North America have been established for around 10 and 20 years respectively and New Zealand is also a few years ahead of Australia.

2006 saw 150,000 new pellet heaters installed across the US, taking the US demand for pellets in the heat market up to 1.4 million tonnes. In the same year demand for pellets used for heating in Europe reached an all time high of 3 million tonnes; the nations demanding the highest volume of pellets were Sweden, Italy, Germany, Denmark and Austria[2].

Increasing recognition in Australia of pellet heaters as a cleaner heating alternative is evident from The Solid Fuel Heater Buy Back Program[3] (2003 – December 2007) run by the Roads and Traffic Authority NSW in conjunction with the Southern Sydney Regional Organisation of Councils (SSROC). The program offers one off rebates of $500 to ratepayers from the Botany Bay, Canterbury, Hurstville, Marrickville and Rockdale local government areas, to replace existing older style wood heaters, open fireplaces, and pot-belly stoves with cleaner heating

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[1] *Country Hearth and Fireplace, accessed at www.countryhearth.ca/whitfield.html, accessed October 2007.*

[2] *Christian Rakos, proPellets Austria, 2007, Recent developments in European pellet markets, Intl. Conference "Pellets for Bioenergy: addressing the challenges", Utrecht, accessed at http://www.aebiom.org/IMG/pdf/Rakos.pdf. Link checked October 2007*

[3] *Southern Sydney Regional Organisation of Councils (SSROC), 2003, The Solid Fuel Heater Buy Back Program, accessed at http://www.ssroc.nsw.gov.au/uploads/documents/buyback%20application%20form.pdf. Link checked October 2007.*

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alternatives. Pellet heaters were not only included in a list of available alternatives to residents, but were more importantly given a better environmental performance review than both gas and electric forms of heating.

Australia's first dedicated wood pellet production plant was established by Pellet Heaters Australia at Woodburn (NSW). It is capable of producing 1,500 tonnes of pellets annually,[4] using saw mill residues from plantation timbers, which are immediately regrown once harvested.

Emission Comparisons

Some wood heating systems give rise to significant fine particle emissions, which cause a wood-smoke problem for neighbours and contribute to increased levels of particulates in the air throughout the town or city. Traditional wood heaters and slow combustion wood heaters are capable of showing good results, but they are highly dependent on a variety of factors. Factors known to influence the amount and composition of emissions include:

- fuel properties. These include the fuel species, it's calorific value, density, and water content
- fuel loading , for example log size and spacing, volume of chamber used, and chamber temperature design and mode of operation, including airflow rates, frequency of loading, and the method of kindling
- geographic factors including altitude may also be important, although less so for Australia than other countries with greater populations living at high altitudes.

Due to the fact that so many variations of the basic independent variables are possible in homes, no single test methodology can realistically hope to fully capture the whole range of elements that might constitute "typical" operation. Unfortunately this complicates comparisons of test results and the evaluation of test results against standards that are written around different test methods.[5] Table 1 provides a comparison and summary of the emissions of pellet heaters to that of open wood fires, closed wood fires (slow combustion), and natural gas heaters on a gram of emissions per kg of fuel used basis.[6]

Particular matter emissions are measured using PM_{10} nomenclature. This number refers to particles with an aerodynamic diameter less than 10 microns. PM_{10} emissions are also sometimes referred to as inhalable particles, and have been shown to have short-term and long-term adverse impacts on health. Short-term effects include eye, nose and throat irritations with particular difficulties for asthmatics, while long-term effects include an increased risk of heart and lung disease.[7]

As seen in Table 1, particulate emissions for pellet heaters are 0.3-1 grams of emissions per kilogram of fuel used (g/kg), an average of nearly six times lower than when compared to the current emission standard AS/NZS4013:1999 of up to 4.0g/kg allowable for slow combustion heaters. This is a marked improvement in emissions compared to traditional wood fires. Pellet heaters produce comparable amounts of particulates to that of natural gas heaters in many applications. (Note that in all tests of fuels and emissions there are variations according to appliance use, elemental composition of fuel, testing conditions and operating conditions (lab versus 'real life'). However the overall order of emission profiles is generally consistent across the literature surveyed, with open fires having the most particulate emissions, followed by enclosed wood burners, and then pellet heaters and natural gas, with pellet heaters closer to natural gas than to enclosed wood burners.)

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[4] *Bioenergy Australia, 2004, Januaray Newsletter, accessed at http://www.bioenergyaustralia.org/newsletters/Newsletter21_Jan04.pdf. Link checked October 2007.*

[5] *Environment Australia, 2002, Technical Report No. 5: Emissions from Domestic Solid Fuel Burning Appliances, accessed at http://eied.deh.gov.au/atmosphere/airquality/publications/report5/chapter8.html, October 2007*

[6] For a comprehensive list of wood emission studies we refer the reader to a report by J. Houck and D. Broderick, August 2003, titled "Compilation of Residential Wood Combustion Surveys and Related Studies", available at *http://www.omni-test.com/publications/Comp2.pdf. Link checked October 2007*.

[7] *Markos J. 2004, Australian Lung Foundation. Transcript of 'The 7.30 report' for 09/06/2004, accessed at www.abc.net.au/7.30/content/2004/s1128403.htm, October 2007.*

Table 1 – Comparisons of emissions between types of heating

Source	*Open Wood Fire*	*Enclosed Wood Burner*	*Natural Gas Heaters*[8]	*Pellet Heaters*
PM_{10} Particulate Emissions (g/kg)	9-17[9]	0.5-12[13]	~0.68[10]	0.3-1.0[11]
Gas Emissions[11] (g/kg):				
CO_2[12]	0	0	2500	0
SO_x	0.2	0.2	-	0.2
NO_x	1.4	0.5-1	1.5	1.0-5.2[13]
CO	68	34-98	0.2	4.44[11]-15

In regard to carbon emissions (CO_2), the burning of wood is carbon neutral, provided that forest resources are being managed and harvested in a sustainable practice – such as the use of sawmill residues from plantation timber. As trees grow they sequest carbon in into their wood structure, through the exchange of carbon dioxide for oxygen with the atmosphere. When trees die and decompose, the carbon is relased to the atmosphere and soil through decomposition, maintaining a net neutral carbon balance in terms of the contribution to greenhouse gas concentrations in the atmosphere. Similarly, when wood is used as a fuel the stored carbon is returned to the atmosphere, largely through carbon dioxide and other gases, and the same natural carbon cycle is maintained.[14]

Addressing the Environmental and Health Impacts of Wood Smoke

The problem of particulate pollution in densely populated areas is increasing. Although wood heaters (such as slow combustion heaters) are capable of being operated efficiently, this is rarely the case because of operational issues such as wet fuel, overloading, incorrect air balances and low temperatures of combustion. As such, a large factor contributing to particulate pollution is wood smoke produced by traditional wood fire heaters and open fire places. In order to combat the wood smoke problem and reduce ill health effects caused by wood smoke, changes need to be made to these heating systems.

However the solution must be both sustainable and with a low environmental impact. Banning wood as a fuel source and turning to gas and electricity heating systems is not a long term sustainable solution because of the greenhouse impact of fossil fuels.

Wood itself is not the cause of the problem. The problem is the lack of efficient methods of wood burning and proper operation of wood burners.

Wood is a superior sustainable resource with long term benefits to the environment when used as a sustainable and renewable source of energy. As such, innovations to wood burning technology need to be continuously developed. One such technology developed in recent times is pellet heaters. Pellet heaters have many

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[8] Natural gas heaters include convection heaters, flame (enclosed) heaters, radiant heaters, and gas fired central heaters.

[9] Houch, J. Air emissions from residential wood combustion, accessed at http://www.omni-test.com/publications/Air%20Emissions%20from%20RWC.pdf, October 2007.

[10] This figure is based on 1.18 kg PM_{10} emissions from the production of 100GJ energy from natural gas combustion. A natural gas energy density of 55,600 kJ/kg, and combustion efficiency of 90% were assumed for the conversion calculations.

Data obtained from: Dinca C., Rousseaux P., Badea, A., 2007, A life cycle assessment of the natural gas used in the energy sector in Romania, Journal of Cleaner Production, 15, p.1451-1462, accessed at www.sciencedirect.com. Access date October 2007.

[11] Warm Homes Technical Report: Detailed Study of Heating Options in New Zealand Phase 1 Report, Ministry for the Environment (Manatu Mo Te Taiao),Wellington, New Zealand, 2005, accessed at http://www.mfe.govt.nz/publications/energy/warm-homes-heating-options-phase1-nov05/warm-homes--heating-options-phase1.pdf, October 2007

[12]Burning wood can be considered as carbon neutral provided that forest resources are being managed and harvested in a sustainable practice.

[13] Note that this is a relatively high level, but it is based on the only available data (Scott A, Gunatilaka M. 2004. 2002 Christchurch Inventory of Emissions to Air. Environment Canterbury: Christchurch.). Scott uses data derived from work carried out in 1998, which may well overstate the level of NOx emissions from a current model pellet fire.

[14] Seacoast NRG, 2007, Is burning wood really carbon neutral?, accessed at http://www.seacoastnrg.org/2007/01/30/is-burning-wood-really-carbon-neutral/. Link checked October 2007.

advantages, as discussed in this report, and have been proven to produce emissions far lower than that of traditional wood fire heaters.

Although natural gas has low PM_{10} emissions due to its low carbon to hydrogen ratio, it is a non-renewable resource and contributes directly to global warming in comparison to wood. Electricity also produces low localised pollution, but more often than not this is displaced to the power station and other levels of pollution associated with electricity production from fossil fuels. (Coal fired electricity is even more greenhouse gas intensive than using gas).

Conclusion

The need exists for sustainable and environmentally friendly methods of home heating. Traditionally wood fires have been viewed as more economical and carbon neutral than other forms of non-renewable resources, although negative effects on air quality due to the production of fine particulate matter have resulted in increasing calls to ban wood fires from urban and suburban areas.

Pellet heaters, however, have been shown to be an efficient and renewable source of heating, with PM_{10} emissions significantly lower than that of slow combustion wood heaters and comparable to that of natural gas heaters.

Increasing awareness and steps toward promoting these heating devices should be taken to ensure that pellet heating is not disadvantaged under current and future wood fire legislation, and is not overlooked when considering replacing traditional wood fire heaters with more cleaner and efficient heating sources.

Further Information

Pellet Heaters Australia manufacture wood pellets, cat litter, and spill absorbents in Australia. The company was incorporated in 2002. In 2003 Pellet Heaters Australia built Australia's first dedicated wood pellet mill in Woodburn NSW to give a local source and consistent quality supply of pellets to their customer base. Pellet Heaters Australia are committed to promoting the use of biomass as an environmentally friendly renewable energy source, which will aid in the reduction of fossil fuel usage, reduce the production of greenhouse gases, and ultimately improve the air quality in Australia.

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