Environment Link

BDA Group

Economics and Environment

Wood heater Particle Emissions and Operating Efficiency Standards

Cost Benefit Analysis

Prepared for the Department of the Environment and Heritage

June 2006

Disclaimer

Executive Summary

This report assesses the benefits and costs across six urban Australian airsheds that are likely to arise from changing national standards for particle emissions and energy efficiency for wood heaters.

Currently, most Australian jurisdictions require new wood heaters to meet the 1999 emissions standard of 4 grams of particles per kilogram (g/kg) of fuel burnt as determined by the Australian / New Zealand Standards AS/NZS 4013 - *Domestic solid fuel burning appliances – Method for determination of flue gas emission.* Some jurisdictions have extra measures to curb particle emissions from wood heaters. However, no jurisdiction requires wood heaters to meet a minimum efficiency standard, as none is currently specified in the Standards.

While jurisdictions have generally imposed regulations on wood heater emissions, we found limited evidence that these regulations are being enforced. In addition, the results of a recent audit of wood heaters showed that many of the wood heaters certified as being compliant with the current standard had emissions higher than permitted. In this study we assumed that compliance with any new standards will be strictly enforced. Clearly, however, the efficacy of State enforcement programs warrants separate investigation, and there would appear to be considerable air quality and public health benefits in ensuring that the wood heaters currently on the market comply with the existing emission standard.

The changes, referenced to the Australian / New Zealand Standards AS/NZS 4013 - *Domestic solid fuel burning appliances – Method for determination of flue gas emission* and AS/NZS 4012 - *Domestic solid fuel burning appliances – Method for determination of power output and efficiency*, considered in this study are emission limits of 4.0, 3.0, 2.0, 1.5 and 1 g/kg of wood burnt, as well as options for each of these emission limits with minimum operating efficiencies of 60% or 65%. Recent studies, however, have cast serious doubts over the validity of the test protocol under the current Australian/ New Zealand Standards in providing a realistic measure of how woodheaters perform in the real world under normal user operation. In addition to these emission factors, we have therefore also used emission factors derived from laboratory results using a revised test method. This revised test method, which allows only two minutes after refuelling before the combustion air is reduced and more closely simulates heaters operated in situ, is detailed in the public comment draft of the Australian/New Zealand emission standard – DR04554.

The consultancy brief specified that the airsheds of Brisbane, Canberra, Launceston, Melbourne, Perth and Sydney be assessed for impacts. We have broadly interpreted these airsheds to be those used for national reporting purposes through both the National Pollutant Inventory (NPI) and the National Environment Protection Measure for Ambient Air Quality.

We consulted many relevant studies that make assessments of the impact of PM10 both on air quality and human health and found that often they, as we did, had difficulties in matching population, health statistics and data years to PM10 airshed emissions. It would be useful to develop a consistent data set for assessing future policy options. In addition we consulted with representatives from the jurisdictions and also the wood heater industry to determine costs associated with implementation of the various standards.

Emissions of inhalable fine particles (PM10), under each scenario, have been projected out to the year 2021, along with industry, consumer and community costs and benefits associated with the new standards.

Wood heating

In 2002 wood heater use was the main form of heating used by, on average, 11% of households in the study regions, however this varies considerably within the selected airsheds. Of the regions investigated, Launceston had the highest percentage population use of wood heaters as the primary source of household heating. Launceston households were also likely to use wood heating for more months of the year than elsewhere and their annual household wood consumption was the highest. Canberra had the lowest use of wood heating for primary heating.

Current woodsmoke contribution to PM10 levels

With the exception of Launceston, the main causes of exceedences of the national air quality standard of 50 $\mu g/m^3$ for PM10 in recent years are summer dust storms and bushfires. A brief review of monthly average PM_{10} concentrations showed that during winter monthly PM_{10} averages are not markedly affected by woodsmoke except in Launceston where the winter monthly PM10 averages are clearly much higher than those recorded in summer months.

Under a business-as-usual scenario, where wood heaters meeting AS/NZS 4013 (1999) will progressively replace older wood heaters and NPI emission factors are used, PM_{10} contributions from wood heaters across the airsheds studied are likely to fall to between 56% and 64% of 2001 levels by 2021. At the same time the phased introduction of new emission standards for new motor vehicles will see their contribution to PM_{10} emissions fall by approximately 25% compared to current levels. These projected reductions in PM_{10} emissions under the business-as-usual scenario will have a significant impact on future ambient PM_{10} levels in all airsheds with the exception of South East Queensland where the most significant source of PM_{10} is fuel reduction and other forms of vegetation burning.

Assumptions used in PM10 Projections

The projections have been undertaken in two parts:

- the first set of projections used NPI emission factors - which are those routinely used in air quality assessments.
- the second set of projections used emission factors derived from recent laboratory results on four wood heaters tested to the proposed revised test method (which is detailed in the public comment draft of the Australian/New Zealand emission standard – DR04554). Todd et al (2005) found that the proposed revised test method, which allows only two minutes between adding more fuel and turning the combustion air setting down, resulted in an overall

average increase in emissions 2.5 times that recorded when using the AS/NZS 4013 method. For our analysis we increased emission factors by 2.5 times for heaters compliant with AS/NZS 4013 (1999) and heaters compliant with AS 4013 (1992).

In undertaking these projections we assumed that wood heater numbers will remain constant throughout the study period, due to the offsetting effect of a number of factors such as population growth and lifestyle.

In addition we assumed new heaters, compliant with a new standard, will enter the market in 2007. The wood heater industry believes this is feasible for those scenarios requiring an emissions standard of 3g/kg and an efficiency standard of 60% (which some wood heaters already meet). For the more ambitious scenarios such as a 1g/kg emissions standard and the revised test method, the wood heater industry may have difficulty in undertaking the necessary research and development and incorporate the necessary production changes in time to meet a 2007 introduction date.

Key assumptions used in our analysis are detailed in the report.

Impact of standards on PM10 levels using NPI emission factors

The effect on PM10 emissions from wood heaters using the NPI emission factors has been projected to the year 2021 for each of the scenarios of changed efficiency and/or emissions standards as indicated above.

For these scenarios the greatest percentage reduction in PM10 emissions from wood heaters is seen in the Port Phillip airshed under each scenario. Under a business-as-usual scenario where the 4g/kg wood heater will replace either wood heaters that comply with the 5.5g/kg standard or earlier non compliant wood heaters, PM10 emissions from wood heaters would fall by just over 50% from current levels in the Port Phillip airshed and to around 57% compared to current levels across all six airsheds. If a 3g/kg standard were introduced PM emissions would fall to 51% compared to current emissions across the airsheds while under the most stringent scenario (a standard of 1g/kg particle emissions, 65% operating efficiency) emissions would fall to around 36% of current emissions across the airsheds.

Impact of standards on PM10 levels using revised test method emission factors

Under a business as usual scenario the difference in projected PM10 emissions based on the revised test method compared with the standard test method is a 12.2% increase across all airsheds in 2021. Greater differences between projections made with standard emission factors and those determined using the revised method were found in 2008 and 2011 due to the more significant influence of the emissions from other higher emitting heater types (open fireplaces, conventional heaters and AS 4013 (1992) compliant heaters). Implementing the revised test method would result in a decrease in PM10 emissions of 53% by 2021, across the airsheds assessed, against the 2001 base.

Health benefits associated with reductions in PM10 emissions

PM10 is associated with adverse health effects including respiratory problems, aggravation of asthma, increased hospital admissions and premature death. The risk is highest for the elderly, children and people with asthma or heart disease. Using health endpoint data for each of the airsheds for mortality, respiratory and cardiovascular diseases we conclude there are considerable health benefits to be gained from reducing PM10 emissions from wood heaters.

Importantly, available studies argue a linear relationship between PM_{10} emissions, ambient concentrations and health effects, with no minimum threshold level. This significantly simplifies the estimation of health benefits associated with emission reductions, as health benefits can be based on an average benefit per tonne of emissions reduced, derived from available data on total estimated PM10 health impacts and estimated PM10 emission loads.

The health benefit for each tonne reduction of PM10 is estimated to vary between airsheds due to climate, demographic and population exposure factors. The monetary valuations used in this study were highest for Sydney and the Port Phillip regions (approximately $133,000 and $128,000 per tonne reduction respectively) reducing to approximately $43,000 for South East Queensland.

Costs and benefits of introducing new standards

The requirement for new emission and efficiency standards will impose costs on wood heater manufacturers in developing compliant heaters, retooling and manufacturing the new units. There will be additional costs to manufacturers and Government associated with having heaters certified. Estimated costs range from around $2m (net present value) in the case of maintaining the current 4g/kg emission standard through to an estimated $25m in the case of the 1g/kg emission standard and either of the efficiency standards. However as noted above, industry sources are highly sceptical as to whether the more stringent performance standards could be attained in the proposed timeframe, if at all.

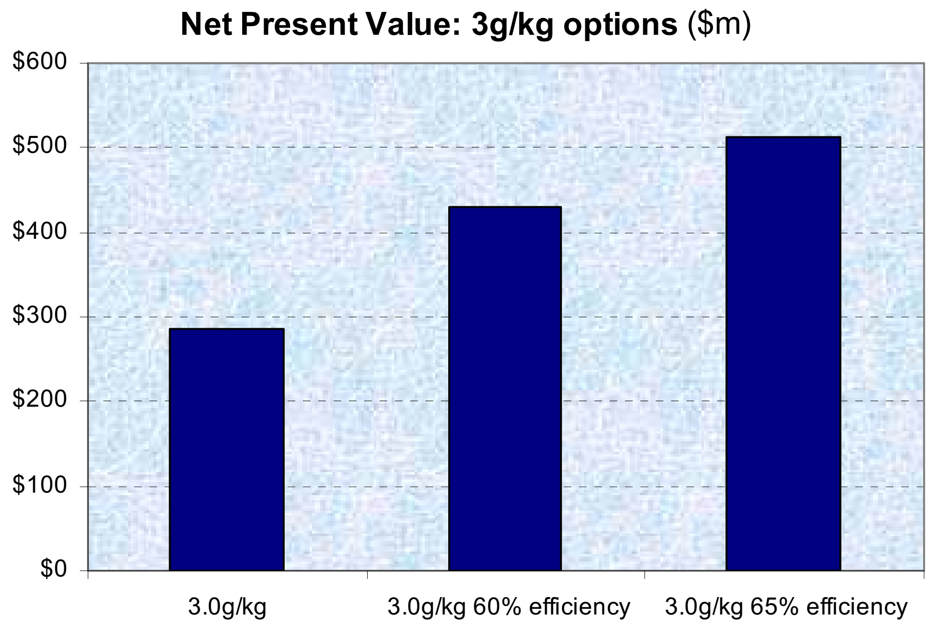
Subject to the development of compliant heaters that would allow them to enter the market by 2007, potential benefits were found to be considerable. Firstly, a key finding is that wood consumption is estimated to fall by 5.6 and 8.8% under the 60% and 65% efficiency standards by 2021 respectively. This alone is estimated to generate benefits of $38m and $67m in net present value terms over the period to 2021 that reflect the value of firewood savings.

Notably, these savings in themselves are large enough to offset the postulated compliance costs to wood heater manufacturers. In addition, these benefits do not include the potentially significant environmental benefits that may be realised with reduced firewood harvesting and collection.

Secondly, the other major component of estimated benefits from the proposed wood heater emission and efficiency standards relate to health benefits arising from lower particulate emissions.

Overall, the present value of estimated health benefits ranges from around $72m in the case of maintaining the current 4g/kg emission standard but introducing the 60% efficiency standard, to over $1b in the case of the 1g/kg emission standard and the 65% efficiency standard.

Clearly the size of the estimated health benefits alone suggests net social benefits will arise from the proposed wood heater standards and that those benefits will increase with progressively tighter standards. Estimated net benefits across the alternative options move similarly for each emission standard, and are shown in the Figure below for the case of a 3g/kg emission standard.



As some 50% of current models already comply with a 60% efficiency standard, compliant technology is already available and the likely cost impost to bring all heaters to this standard is likely to be modest. In addition to the emission reduction and health benefits that efficiency standards would provide, further environmental benefits may also be realised with reduced firewood harvesting and collection.

The estimated health benefits from the introduction of tighter emission standards were found to increase as limits were reduced. However despite the potentially high net benefits from adopting the more stringent performance standards, the risks associated with developing compliant heaters must be taken into account. The community may be better served through the introduction of more modest standards in the short-term with support for the development of improved heaters over the medium-term.

On balance, we conclude that:

1. The introduction of a 3g/kg emissions standard with a 60% efficiency standard could be introduced on a 'no regrets' basis, as it would be readily achievable within a short timeframe, it would not impose an undue burden on industry and the benefits associated with reduced wood use would ensure net benefits regardless of potential emission reduction benefits and the value the community

places on those benefits. Subject to confirming the efficacy of the revised test method, this proposed standard would be equivalent to around 4.5g/kg under that test.

2. As the potential benefits of tighter emission limits appear considerable, there are likely to be significant returns on research to develop compliant heaters. However investing in the necessary research would be difficult for many in the industry and commercially unattractive due to the public good nature of any subsequent findings. For these reasons, there would appear public benefit grounds for coordinated government support for the applicable R&D.

3. Available evidence indicates that current emission standards are not adequately being enforced by jurisdictions. While there may not be any significant disregard of the standards by the industry, the efficacy of State enforcement regimes appears to warrant inspection.

Glossary

µg	Microgram (1 µg = 10^{-6} gram = 0.000001 gram). One millionth of a gram
µg m^{-3}	Microgram per cubic metre: a unit for the concentration of a gas or particulate matter in the atmosphere based on the density approach (mass per unit volume of air).
µm	Micrometre (1 µm = 10^{-6} metre = 0.000001 metre). One millionth of a metre
ABS	Australian Bureau of Statistics
AHHA	Australian Home Heating Association
Air NEPM	National Environment Protection Measure for Ambient Air Quality - a set of uniform Australian air quality standards formulated in June 1998 -see www.ephc.gov.au/nepms/air
AQIP	Air Quality Improvement Plan
AS/NZS 2918 (1990)	Australian/New Zealand Standard - Domestic solid fuel burning appliances – Installation
AS/NZS 4012 (1999)	Australian/New Zealand Standard - Domestic solid fuel burning appliances – Method for determination of power output and efficiency
AS 4013 (1992)	Australian Standard – Domestic solid fuel burning appliances – Method for determination of flue gas emission (superseded)
AS/NZS 4013 (1999)	Australian/New Zealand Standard – Domestic solid fuel burning appliances – Method for determination of flue gas emission
AS/NZS 4014 (1999)	Australian/New Zealand Standard – Domestic solid fuel burning appliances – Test fuels
BCR	Benefits to costs ratio
EF	Emission Factor
NA	Not Available
NPV	Net Present Value
PM_{10}	Particulate matter in the air, with an aerodynamic diameter of 10 µm (micrometres) or less. Throughout this report woodheater particle emissions are assumed to be 10 µm (micrometres) or less.
PV	Present Value
Real-world test method	Refers to an emission test method, developed by Todd et al (2005) and intended to represent the way people use woodheaters in their homes.
Revised test method	Refers to the proposed test method detailed in the public comment draft of the Australian/New Zealand emission standard – DR04554 and used by Todd et all (2005).
Standard test method	Refers to the performance and emission test methods detailed in AS/NZS 4012:1999 and AS/NZS4013:1999

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1. Introduction

Inhalable particles are associated with adverse health effects including respiratory problems, aggravation of asthma, increased hospital admissions and premature death. The risk is highest for the elderly, children and people with asthma or heart disease. Major anthropogenic sources of particles include motor vehicles, domestic wood heaters, controlled burns and industrial facilities such as power stations and photochemical processes. Major natural sources of inhalable particles include bushfires, windblown dust and sea salt.

Current Australian Standards, implemented in most Australian jurisdictions, provide a framework for controlling particle emissions from wood heaters. There are a number of options under discussion to tighten the standards further to reduce the airshed particle load from wood heaters.

The principal objectives of this study are to determine the impacts, including quantification in monetary terms of the costs and benefits, of introducing the following wood heater emissions limits and minimum operating efficiencies in the Australian / New Zealand Standards AS/NZS 4013 and AS/NZS 4012, respectively:

- 4.0 g/kg with-
  - minimum operating efficiencies of 60% and 65%;

- 3.0 g/kg with –
  - no minimum operating efficiency specified;
  - minimum of operating efficiencies of 60% and 65%;

- 2.0 g/kg with –
  - no minimum operating efficiency specified;
  - minimum of operating efficiencies of 60% and 65%;

- 1.5 g/kg with –
  - no minimum operating efficiency specified;
  - with a minimum of operating efficiencies of 60% and 65%;

- 1.0 g/kg with –
  - no minimum operating efficiency specified;
  - with a minimum of operating efficiencies of 60% and 65%;

- 4g/kg using the revised test method detailed in the public comment draft of the Australian/New Zealand emission standard – DR04554.

In alignment with national air quality reporting and airshed emissions inventory requirements, under the National Environment Protection Measure for Ambient Air Quality (AAQNEPM) and the National Pollutant Inventory (NPI), the following air quality and inventory datasets for fine particles (PM_{10}) were used to assess the impacts of the above changes to AS/NZS 4013 and AS/NZS 4012 on the following airsheds:

- Sydney Airshed, NSW (including the Central Coast, the Illawarra and the Lower Hunter);
- Port Phillip Airshed, Victoria (including Melbourne, Geelong and the Mornington Peninsula);
- South East Queensland Airshed (including Brisbane and the Gold Coast);
- Perth Airshed, Western Australia (including the Rockingham coast);
- The Australian Capital Territory; and
- Launceston.

Specifically, this study assessed the likely impacts of changes to woodheater standards on:

- reduced particle levels in major Australian airsheds;
- health impacts, including reduced mortality and morbidity; and
- reduced total health costs.

The outcomes of this study will inform the Department of the Environment and Heritage of the costs and benefits of reducing allowable particle emissions limits and introducing a minimum operating efficiency under the current test protocol specified in the Australian/ New Zealand Standards AS/NZS 4013 and AS/NZS 4012, and also under the proposed modified test protocol specified in the Australian/New Zealand draft standard DR04554.

The study reviewed a wide range of recent literature and databases and consulted with industry, government and other sources. The results of this study should be viewed as indicative of the net benefits of introducing various new standards, rather than absolute projections. Accordingly, the key assumptions are identified and a sensitivity analysis of estimated impacts related to these assumptions has been undertaken. Despite this uncertainty, we believe the analysis provides a reasonable basis for the conclusions drawn.

2. Standards and Policies

2.1 Australian Standards

Since 1992, Australian Standard/New Zealand Standards have been introduced to improve the performance of wood heaters.

The first standard for wood heater emissions, AS4013 (1992), was published in 1992 and was revised and published as a joint Australian/New Zealand Standard in 1999; AS/NZS4013 (1999) *Domestic solid fuel burning appliances - Method for determination of flue gas emission*. This Standard provides a test method, using a dilution tunnel, to accurately measure particles emitted by residential solid-fuel burning heating appliances.

The 1992 Standard included an upper limit for acceptable particulate emissions of 5.5 grams of particles per kilogram (oven-dry weight) of fuel burnt. This emission factor was reduced to 4 g/kg in the 1999 revision of the Standard. The Standard applies to solid-fuel burning space-heating appliances (including those fitted with water heating devices) with a heat output of 25KW or less. It does not apply to masonry fireplaces, cooking stoves, central heating appliances or water-heating-only appliances. Although woodheater particle emissions are assumed to be synonymous with PM10 emissions in this report, it should be noted that the test method for AS/NZS 4013 actually measures particles greater than 0.3 μm in diameter.

AS 4013 (1999) is complemented by the following standards:

AS/NZS4014 (1999) *Domestic solid fuel burning appliances - Test Fuels*, specifies the test fuel to be used in the performance and emission test standards. The Standard sets the acceptable range for physical parameters of each fuel type for use in appliance testing. Parameters such as density, moisture content, calorific value, and piece size are specified. The standard covers test fuels for hardwood, softwood, lignite briquettes, sub-bituminous coal, and semi-anthracite coal briquettes. Virtually all the testing done in Australia is conducted with hardwood as the test fuel, as hardwoods are the predominant fuel type used in Australia.

AS/NZS4012 (1999) *Domestic solid fuel burning appliances - Method for determination of power output and efficiency* is used for measuring the heat output rate (power) and efficiency of residential solid-fuel burning heating appliances. It also requires appliance labelling of the average efficiency measured at high, medium and slow burn rates and the average heat output rate for the high burn rate cycle. This Standard is indirectly called up in State legislation because it is an integral part of the emission standard.

These Australian/New Zealand Standards are industry performance standards that use highly specified, controlled operating conditions to assess the operation of wood heaters. They simulate ‘correct’ wood heater operations using a standard fuel and do not include emissions during the lighting phase of wood heater operation. They therefore differ from 'real' world wood heater use where different types of wood and operating conditions are used that could vary particle emissions to ambient air.

Results from two recent studies (Environment Canterbury 2005, Todd 2005) cast serious doubts on the validity of the test protocol under current Australian/New Zealand Standards in providing an indication of how wood heaters perform in real world settings. Both these studies found that wood heater particle emissions as determined under the current test protocol were much lower than emissions under real world conditions. Furthermore, these studies also found that there was no consistent proportionality factor for emissions assessed under the current test protocol and real world emissions i.e. wood heaters that performed well under the current test protocol often performed poorly under real world conditions, and vice versa.

In 2004, in order to address inconsistencies between emissions performance as determined under ideal operating conditions and in the real world, a revision to the test protocol for determining particle emissions as specified in AS/NZS 4013 (1999) was proposed. The revised test protocol under the proposed Draft Standard DR04554 attempts to more closely simulate real world operating conditions by specifying that the air flow on medium and low burn cycles must be turned down to the appropriate settings two minutes after the fire is lit. The current test protocol specifies that the air flow on medium and low burn cycles must be turned down to the appropriate settings only after the fuel load is depleted by 20% (an indication of when the fire is well established). Anecdotal evidence and visual observation of woodheater operation within the home (Todd, pers comm. 2004) suggests that turning down the air flow prematurely is a common practice. The Draft Standard DR04554 is currently undergoing public consultation.

There is a two-year transitional period built into the current version of the standard for when the standard is updated. The standard is called up in various jurisdictional policies and regulations so the transitional period applies in the jurisdictions with the exception of Tasmania (and South Australia which has not enacted regulations). During the transitional period manufacturers and installers may continue to manufacture and install new heaters certified under a version of AS/NZS 4013 which has been superseded, and continue to manufacture wood heaters under the old standard until recertification is required.

2.2 State and Territory Policies

2.2.1 Australian Capital Territory

The ACT controls the sale of slow combustion heaters through the *Environment Protection Act* 1997 which requires compliance with AS/NZS 4013 for all wood heaters. The restriction applies to all sales (new and used wood heaters) and makes modification of heaters by installers illegal.

The ACT government has also regulated the supply of firewood under an amendment to the EPA legislation (ACT Government, 2000).

2.2.2 New South Wales

In NSW the Protection of the Environment Operations (Clean Air) Regulation 2002, requires that wood heaters sold in New South Wales meet the emission limits specified in the Australian Standard. Each model must have a certificate of compliance from an accredited laboratory and be marked accordingly. The Regulations also prohibit a person from tampering with heaters, however the regulations do not control the sale of used wood heaters.

2.2.3 Queensland

Queensland regulated the sale of any (new or used) solid-fuel burning equipment in 1997 through the *Environment Protection (Air) Policy* 1997. The *Environment Protection (Air) Policy* 1997 requires compliance with AS/NZS 4013 and does not allow modifications to certified heaters.

2.2.4 Tasmania

Tasmania was the first state to regulate the sale of wood heaters through its Environment Protection (Domestic Solid Fuel Burning Appliances) Regulations 1993. These regulations prohibit the sale of wood heaters not compliant to AS/NZS 4013. However, as the numerical standard (5.5g/kg) for emissions was written into the regulation, the stricter AS4013 standard introduced in 1999 had not been incorporated into Tasmanian law. In addition, the regulations did not cover the sale of second hand heaters, or prohibit modification to heaters, once installed. These requirements have recently been reviewed and Tasmania has released a draft Air Quality Strategy (DPIWE, 2005) which proposes regulations for new and second hand wood heaters. These regulations will call up AS/NZS 4013 and may restrict the installation of wood heaters in new and renovated homes.

2.2.5 Victoria

Victoria's Waste Management Policy (Solid Fuel Heating), which was made in July 2004, requires that all solid fuel heaters manufactured and sold in Victoria comply with AS/NZS 4013 and only heaters that meet these requirements can be installed (through compliance with Part 12A of the Building Act 1993 (Vic.)).

EPA is currently working with the plumbing industry to incorporate AS/NZS 4013 into the *Plumbing Regulations* 1998. It is intended that the revised regulations will require plumbers to install only solid fuel heaters that are certified as compliant with AS/NZS 4013.

2.2.6 Western Australia

The Environmental Protection (Domestic Solid Fuel Appliances and Firewood Supply) Regulations 1998 requires that heaters sold (new or second-hand) comply with AS/NZS 4013. The regulations also regulate wood moisture content and prohibit the sale of firewood that has been painted, coated with plastic, or treated with copper-chrome-arsenate. Once sold however, modification to heaters is not restricted.

3. Australian Wood Heaters

3.1 The Australian wood heater industry

In its submission to the Federal Government (2003), the Australian Home Heating Association (AHHA) estimated the industry employs 6,700 people with 415 in manufacturing, 700 in servicing and the rest in the collecting, cutting and selling of wood, wholesaling and in retail (AWHA, 1997 and AHHA, 2003). The submission documented that 70% of the workforce is unskilled and a significant proportion of workers are from rural and regional areas. The industry currently has a total revenue stream from wood heaters of approximately $75 million per year and supports the $20 million per year wood heater servicing sector and the wood collection and distribution sector ($260 million per year). In addition there are second and third tier industries that are dependent on the wood heater manufacturing industry as they supply the industry with paint, glass and steel.

According to AHHA around 30,000 wood heaters are sold in Australia annually, of which approximately 85% are manufactured in Australian and 15% imported. Australian made wood heater must have more than 80% Australian content. While there are 25 Australian manufacturers, five companies account for around 80% of the sales. Wood heater manufacture is predominantly in NSW and Victoria and most wood heater manufacturers also produce barbeques. The wood heater industry has a small fledgling export market estimated to be reaching $1 million in 2003/04 and anticipated to grow beyond this.

The industry produces 133 different fireboxes which are used to produce 240 certified models. Sales are seasonal with nearly 50% of sales occurring in the April to June quarter.

It is estimated that the capital invested by the 1.5 million households using firewood for heating is in the order of $1 to 1.5 billion (Todd, 1988). This is based on a new wood heater costing between $1500 and $2000 installed and the assumption that the current investment in woodheating is worth about half the current replacement value (Todd 1988, in EA Technical report, 2002).

3.2 Wood heater testing

There are few Australian laboratories set up to test wood heaters to the Australian / New Zealand Standards with the Australian Home Heating Association (AHHA) laboratory in South Australia undertaking the majority of the testing. AHHA indicated it costs between $8,000 and $13,000 to have a model tested for certification. This includes around $7,600 for the emissions test, usually a clearance test (AS/NZS2918 Appendix B) at a cost of just under $1,400 and allowances for freight, research and development costs associated with emissions performance and some retesting. Testing takes approximately two months and has to be renewed every five years. It currently costs $200 to obtain a national certificate of compliance for a model line.

More than one model of heater can be issued certification to AS/NZS4013 on the basis of a single series of tests as two or more models can share identical fireboxes and combustion air configurations. The test laboratory determines, from design specifications, if it is satisfied that different models with the same firebox would have the same or lower emissions to the model tested.

The AHHA acts as clearing house for wood heater certification data. According to AHHA, in 2004 a total of 283 heater models were certified as complying with AS/NZS4013 (1999). From examination of the AHHA database it was found that the mean efficiency of the 214 models where efficiency test results were supplied as 60.6%. The efficiency data is shown in Figure 1.

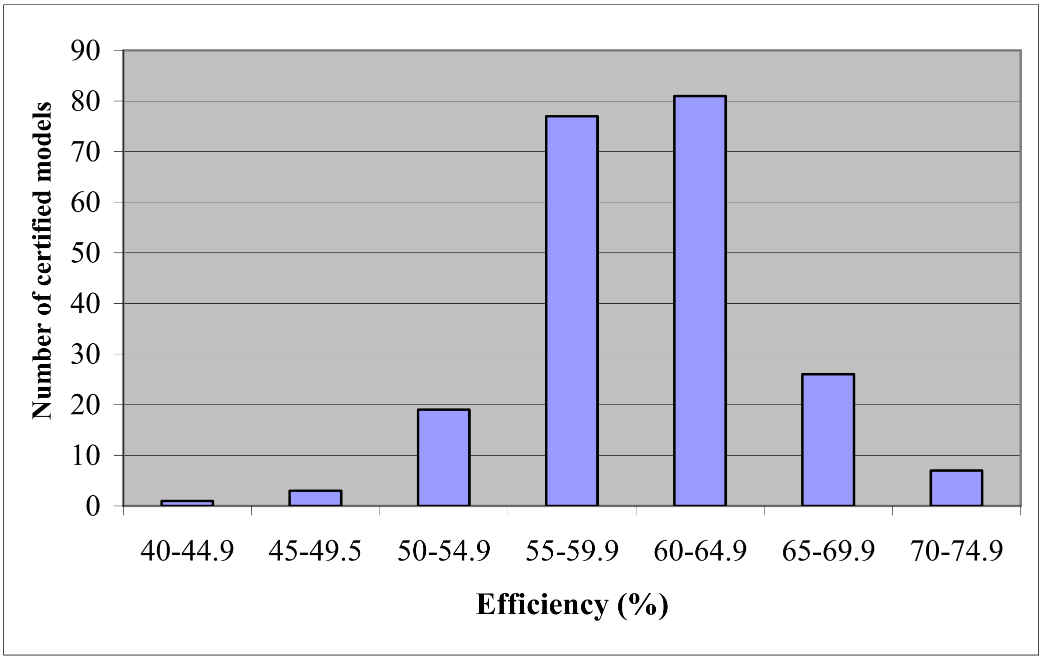

Figure 1: Efficiency of certified heater models. (Source AHHA, personal communications)

In addition, of the current 283 certified heaters, the following meet emission rates and levels of efficiency:

2g/kg & 60% efficiency — 34 heaters (16% of certified heaters)

2.5g/kg & 60% efficiency	41 heaters (19% of certified heaters)
3g/kg & 60% efficiency	41 heaters (19% of certified heaters)

Further examination of data supplied by the Department of the Environment and Heritage showed that of the wood heaters with certification to AS/NZS 4013(1999) in late 2004 the median emissions factor was 2.6 g/kg. The frequency distribution of the emission rate is shown in Figure 2.

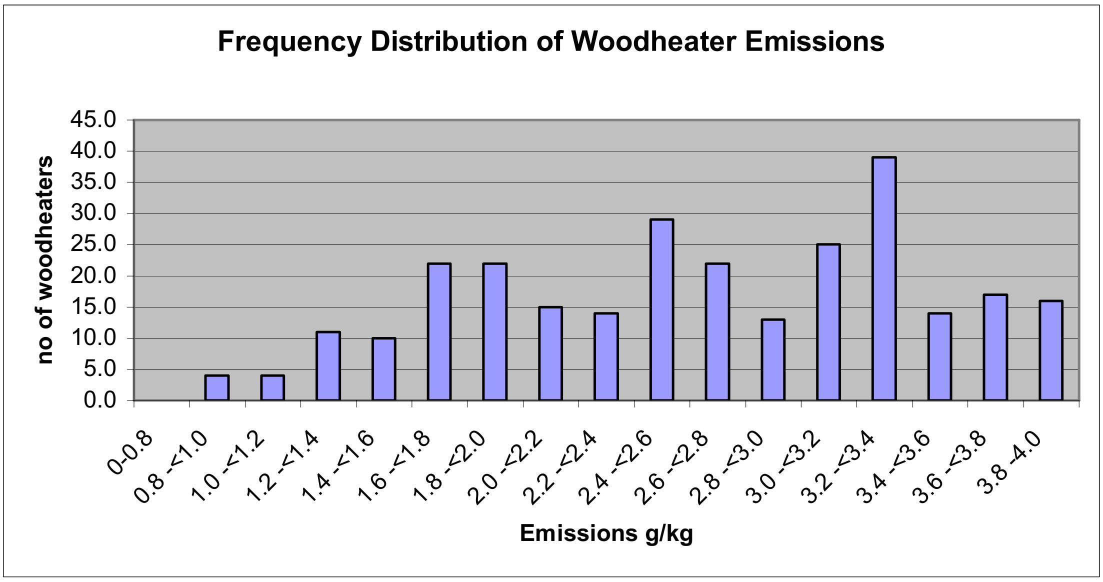

Figure 2: Frequency Distribution of Wood Heater Emission Rates

The Department of the Environment and Heritage commissioned an audit of the most nationally popular wood heaters (DEH, 2004). Seven of the 12 wood heaters tested at the AHHA Testing Laboratories failed to meet the AS/NZS 4013 particle emission limit. In addition, the design specifications of these 12 wood heaters plus an additional 35 wood heaters were tested for design specifications and labeling compliance (for example, specifying the correct fuel type and the power output). 55% (or 26 models) were found to have deviations from the original design and 72% had labeling faults that could adversely affect emissions performance. The most common engineering fault found was primary air inlets that were smaller than that specified in the original design specifications. The industry indicated that most of the faults were minor and easily corrected (AHHA, personal communications).

In practice, wood heater efficiencies (AS/NZS4012: 1999) and performance may differ from their certified performance because the wood heater sold may differ from the model tested in the laboratory or the wood heater may have been modified, for example, to achieve longer burn times between refueling. Emissions from in situ wood heaters also differ to the emissions measured in the laboratory because of different fuels used and because householders operate heaters differently to the standard test method. In particular, householders generally switch the heater to medium or low before the fire is established. This adds to the uncertainty in estimating particle emissions from wood heaters.

3.3 Current wood heater usage

Australians have a preference for wood heaters with large fireboxes compared to the fireboxes sold in New Zealand and Europe, and Australian wood heaters are designed to use hardwoods whereas wood heaters manufactured overseas are designed to use softwoods. The average lifespan of an Australian wood heater is estimated to be 15-20 years. Figure 3 presents ABS data on the type of wood heater used in the various jurisdictions.

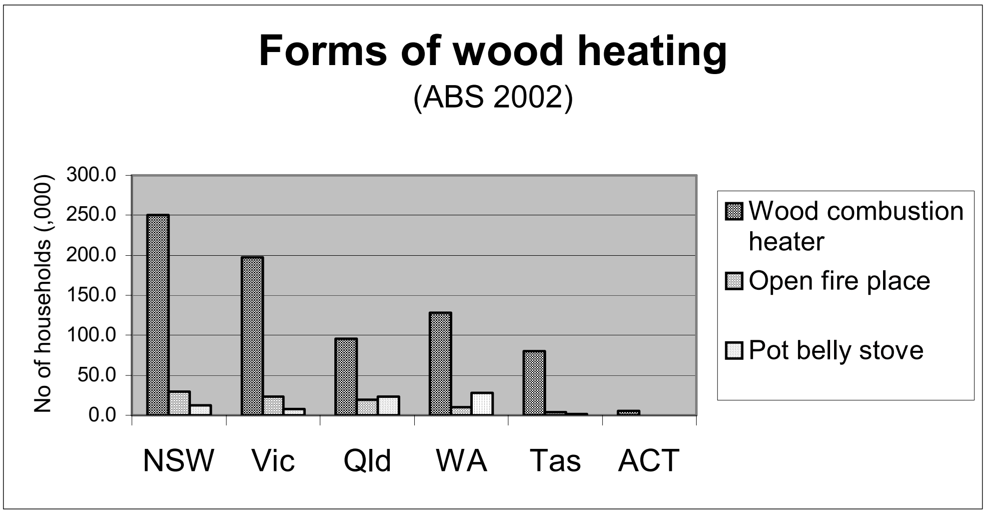

Figure 3: Types of Wood heaters used as Main Heating Source

Data from Australian Bureau of Statistics (ABS) surveys of *People's Views and Practices on Environmental Issues* provides an overview of the main forms of heating used by households. In 2002, ABS estimated that the Australia-wide total number of dwellings that used wood fell to 13.7% from 15.7% in 1999 and 17.6% in 1994 (Figure 4). That is, an annual average decline of 0.4% between 1994 and 1999, increasing to 0.7% for the period 1999 to 2002. ABS data, provided on a state-by-state basis (Figure 5), shows that the decline in the proportion of households using wood heating as the main form of heating was reflected in all states that formed part of this investigation.

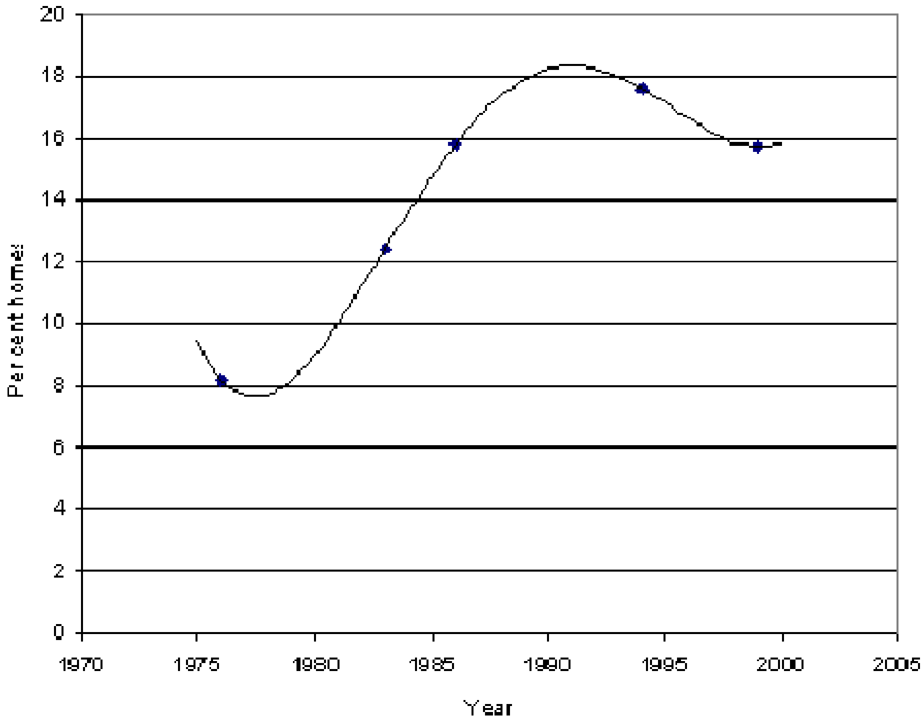

Figure 4: Trend in the proportion of Australian households using firewood as their main heating fuel. (Source: ABS data, presented in Environment Australia, 2002a)

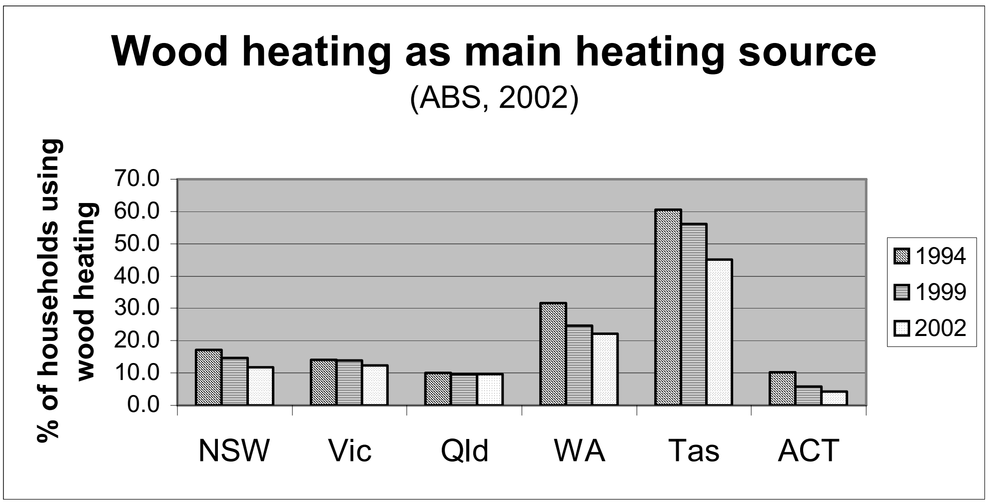

Figure 5: Percentage of Households in Selected Jurisdictions that use Wood Heating as the Main Heating Source (Source: ABS, 2002).

The falling popularity of wood heaters in recent years is against an average Australian population increase of 1.2% per annum during the period 1991 –2001. Consequently, total wood heater numbers are unlikely to have fallen over this period. It is arguable that the current shift away from wood heaters would continue due to a range of factors including:

- lifestyle changes (higher density housing, convenience)
- improved alternative heating options available (central heating, gas-fired log fires)
- increasing price of wood heaters relative to other heating options
- Government programs such as buy-back schemes and 'don't light tonight' programs

On the other hand, greenhouse emissions and higher energy prices may cause a swing back to wood heating, similar to the one seem in the 1980's which was on the back of the oil crisis. On balance, we believe total wood heater numbers will remain steady as these factors and continued population growth offset those factors above.

The ABS data shown in Figure 6 indicates that, as would be expected, the months of use of household heating (all forms) is for a larger part of the year in Tasmania and is less in the warm states of Queensland, Western Australia and New South Wales.

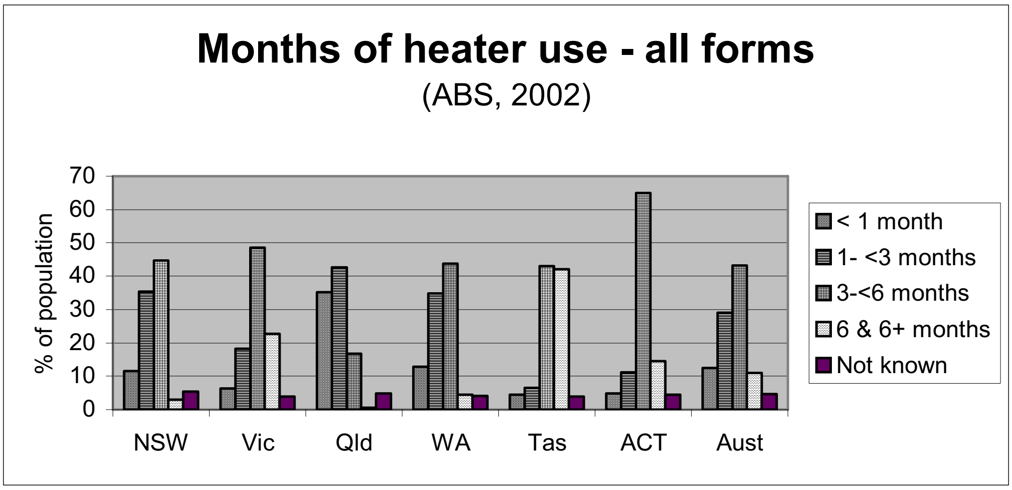

Figure 6: Months of wood heater use, by jurisdiction

In 2002, AHHA commissioned AC Neilsen (AHHA, 2003) to survey householders in Armidale (NSW) and Launceston (Tasmania) about wood heating. The survey found that 44% of households relying on wood heating were low-income households (less than $30,000 per annum) and the main reasons for using wood heaters were: they are cheaper to run (28%); they have efficient heat production (20%); and, they have a pleasant warmth (18%). 72% of respondents believed that their heating costs would rise if wood heating were no longer an alternative.

Within the airsheds that were examined in this study, there are detailed survey results on wood heater use for Launceston and Sydney.

Sydney

The NSW Department of Environment and Conservation (formerly EPA) periodically undertakes telephone surveys, supplemented by focus groups, on environmental issues. Community attitudes to solid fuel home heating were the focus of surveys undertaken in 1995, 1998 and 2000. The surveys questions were not exactly the same in each survey. The relevant results are summarised as follows:

Table 1: Summary of the selected data from NSW Community Surveys (Source: DEC, 1995, 1998, 2000)

	1995	**1998**	**2000**
Wood as main heating source			
State-wide	19%	17%	NA
MAQS*	13%	12%	12%
Sydney metro	NA	NA	11%
Wood as secondary heating source	6%	3%	NA
Types of wood heaters used by those with wood heaters			
Open fireplace	29%	NA	28%
Slow combustion heater	66%	NA	66%
Pot belly	4%	NA	6%

* MAQS study area includes Sydney, Central Coast and Newcastle and Wollongong

In the 1995 survey the reasons for using solid fuel heating were as follows:

- cheap to run (35%)
- effectiveness (33%)
- atmosphere (25%)
- comfortable/pleasant/even (21%)
- plentiful fuel available (21%)

Almost one third of households using wood heating (22% in the Metropolitan Air Quality AQS study area (MAQS) and 43% in country NSW) said they use wood heating 24 hours per day and a further 22% of households using wood heating between 8 hours and 24 hours a day. The majority, statewide, using wood heating said they used hardwood (58% specified hardwood, 5% softwood and 18% whatever wood available and 12% just wood).

Respondents to the 2000 survey indicated that the 21% of wood heaters were less than 5 years old, 41% were 5 years or old and the rest of respondents were unsure of the age of their wood heaters. Sydney respondents used an average of 1.9 tonnes of wood per year, with 37% purchasing wood and 61% harvesting wood from forests.

Launceston

The percentage of private dwellings that used wood as the main form of heat in Launceston was estimated to decrease over time: 66% in 1992, 60% in 1996, 47% in 2000 and 30% in 2004 (reported in CSIRO, 2004) with the total number of wood heaters estimated to be 13,166. Using various estimates of the wood heater population in Launceston, CSIRO (2004) provided the following wood heater projections:

Table 2: Projected wood heater use in Launceston (CSIRO, 2004)

	2005	**2006**	**2007**
% of dwellings with wood heaters	27%	23%	20%
Types of wood heaters			
Compliant	69.2%	72.6%	75.9%
Non Compliant	24.5%	21.6%	18.1%
Open fireplaces	6.3%	6.1%	6.0%

3.4 Wood use

Wood heating is cheaper than most forms of heating – per year it costs between $350 and $900 – with costs being greatest in regions facing higher wood costs, where wood heaters are operated for much of the day and for up to half the year (for example in Melbourne and Canberra). Table 3 shows current wood costs, wood use and annual heating costs by study region.

Table 3: Wood Use and Cost Data

	Price[a] ($/tonne)	**Wood use** tonnes	**Annual heating cost** $
Canberra	$171	3.7 [b]	633
Launceston	$110	4.8 [c]	528
Perth	$140	2.5 [d]	350
Port Phillip	$204	4.3 [d]	877
SE Queensland	$138	1.1 [f]	152
Sydney	$182	1.9 [e]	346

Sources: a Recycledfuels.com.au (updated to 2004 and benchmarked with various sources)
b EA, 2004
c DEH, 2004
d ABS 2002
e EPA NSW surveys (Keys Young 1995, NSW EPA 1998, NSW EPA, 2000)
f Based on author's assessment

4. Ambient Levels of PM_{10} in Selected Airsheds

The national ambient air quality standard for particles as PM_{10} is 50 µg/m^3 averaged over a 1-day period. The goal is to meet the standard within a 10-year time frame. Five exceedance days are allowed each year, to allow for unforeseen events such as bushfires and dust storms. Table 4 summaries the compliance status in recent years of a number of airsheds, with the national air quality standard for PM_{10}.

Table 4: Summary of recent compliance with PM_{10} National Air Quality Standard for selected airsheds (Source: DEH, 2004)

	1998	**1999**	**2000**	**2001**	**2002**	**2003**
CANBERRA	0	4	1	4	5	NA
2008 goal	Met	Met	Met	Met	Met - 2 due to wood burning	NA
LAUNCESTON	47	43	39	28	14	26
2008 goal	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met - 19 due to woodsmoke
PERTH	1	0	0	1	2	1
2008 goal	Met	Met	Met	Met	Met - both in summer	Met - exceedance in summer
PORT PHILLIP	4	1	5	3	8	13
2008 goal	Met	Met	Met	Met - one during winter	Not met - most due to bushfires and dust	Not met -4 exceedences in winter
SE QUEENSLAND	0	1	1	1	8	4
2008 goal			Met	Met	Not met	Met - none due to wood smoke
SYDNEY	16	0	4	5	17	NA
2008 goal	Not Met - one in winter	Met - one in winter	Met - one in winter	Met - one in winter	Not Met - most due to bushfires, one in winter	NA

The above Table shows that, with the exception of Launceston, the main cause of PM_{10} exceedences in recent years has been dust and bushfires during the summer period.

The impact of changing the wood heater standard to reduce PM_{10} emissions is most likely to reduce the average load on the airsheds during the winter months. A brief review of the monthly average PM_{10} concentrations, as highlighted in Table 5 by the Port Phillip summary for 2002, shows that in many of the airsheds there is little variation in the average monthly PM_{10} concentrations except in Launceston (Table 6) where there is higher per capita wood heater usage than elsewhere.

Table 5: Port Phillip monthly average PM_{10} data for 2002 - concentrations in µg m^{-3} (Source: EPA Vic 2004)

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Average	20.1	17.0	17.8	24.3	24.3	15.7	19.4	18.4	22.0	20.5	22.3	22.2	20.4
Maximum	28.6	34.2	38.7	46.4	41.0	31.7	33.2	35.7	43.6	47.6	52.6	38.9	52.6

Table 6: Launceston monthly average PM_{10} data for 1997 onwards - concentrations in µg m^{-3} (Source: CSIRO, 2004)

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Average	9	11	14	18	33	33	41	32	15	8	9	9

Table 7 shows the maximum annual average PM10 concentration in each airshed and indicates the applicable monitoring station. The Table also gives the airshed average annual average PM10 concentration for the period 1998-2001. TEOM results are given where available.

Table 7: Maximum and average airshed annual average PM_{10} concentrations ($\mu g/m^3$) based on TEOM 1-hour averages unless specified (Source: jurisdiction AAQ NEPM reports)

	1998	**1999**	**2000**	**2001**	**Stations where maximum recorded**
	Av/max	**Av/max**	**Av/max**	**Av/max**	
Canberra*	17.9	24.0/26.5	17.6/18.5	18.0/19.2	Civic Monash (from 1999)
Launceston*	34.1	31.3	29.6	22.1	Ti-Tree Bend
Perth	18.3	16.4	15.5/18.4	15.6/17.1	Duncraig South Lake
Port Phillip	18.3/20.3	17.2/18.8	16.6/18.6	15.5/17.8	Alphington, Footscray, Brighton, Dandenong, Richmond
SE Queensland	14.7/17.1	13.8/15.7	17.2/18.5	15.7/16.8	Springwood (from 1999), Rocklea, Flinders View, Helensvale (from 2000)
Sydney	16.5/18.0	15.6/16.9	16.3/17.8	19.1/21.5	Blacktown, Bringelly, Lidcombe, Liverpool, Richmond, Woolooware, Beresford

* based on Hi Vol measurements taken once every six days

5. Airshed PM_{10} Contributions for Emissions Inventories

5.1 Emission factors

Much has been written about emission factors and estimates of the 'real life' emission factors for various wood heater types currently in use. The emission factors used in this study are from the National Pollutant Inventory (Environment Australia, 1999), except for the updated projections based on the revised test method – see section 7.3. While it could be argued that these emission factors do not present 'real life' and underestimate the emissions from wood heaters, they have been used to allow comparisons with aggregated emissions data from the National Pollutant Inventory for the selected airsheds.

Table 8: Aerosol emission rates adopted for this study (Source: Environment Australia, 1999)

Heater Type	Emission Factor $g\ kg^{-1}$
Compliant 1992	5.5
Compliant 1999	4.0*
Non-Compliant	12.0
Open Fireplace	17.3

* NPI, which was published in 1999, only gives one emission factor for controlled heater of 5.5 $g\ kg^{-1}$ – it is assumed that it predates the AS/NZ4013:1999

5.2 PM_{10} emissions inventories

In determining the aggregated sources, the National Pollutant Inventory (NPI) requires that jurisdictions, at a minimum, estimate and report on a core set of emission sources which include motor vehicles and solid fuel burning. It is left up to the jurisdictions' discretion to report non core sources (for example backyard incinerators). Currently, not all jurisdictions report all core emission sources and there is variation on emissions from the non-core sources reported. Therefore, for airshed comparisons only those sources that have been reported by all jurisdictions are identified in Table 9 and the other reported sources are included in one category for completeness.

The jurisdictions use standard methodologies which are specified in Emission Estimation Techniques Manuals, for determining the emissions from each source category. However another confounding factor in the interpretation of the NPI aggregated source data results is the variation in the base years from which the data is derived. Determining the aggregated source data for NPI is an intensive process and there is unlikely to be significant variations from year to year therefore the jurisdictions may only update an emissions category on a needs basis. For example the aggregated source data for the Port

Phillip region is based on the original emissions estimates for 1995/96 with updates based on calculations rather than the collection of primary data. There are similar issues for the other jurisdictions with the year of original emissions estimates varying from jurisdiction to jurisdiction.

The jurisdictions recently made some minor revisions to their 2002-2003 estimates. These revisions are reflected in the following Table with the exception of EPA Victoria which updated its 2002-2003 estimate for domestic solid fuel combustion using emission factors that differ significantly from those used by the other jurisdictions. We have preferred to use the result based on the generally accepted methodology for Victoria. EPA Victoria's justification for the use of these different emission factors is that these new emission factors give more accurate air quality modelling outcomes.[1]

Table 9: 2002-3 PM10 emissions estimates (tonnes/year) for core aggregated sources (Source: National Pollutant Inventory)

2002-3 PM10 Emissions Estimates (tonnes and % contribution)												
	Port Phillip		**Sydney GMR***		**SE QLD**		**Perth**		**ACT**		**Launceston**	
Solid Fuel Burning Domestic	6,904	46%	3,088	16%	89	<1%	2,300	26%	64%	58%	1,200	58%
Motor Vehicles	3,532	24%	5,790	29%	2,200	10%	1,600	18%	92	8%	120	6%
Lawn Mowing	206	1%	171	1%	94	<1%	33	<1%	6	<1%	3	<1%
Burning (fuel reduction, wildfires, agricult'l)	593	4%	1,450	7%	15,000	69%	1,900	22%	46	4%	74	4%
Industry	3,643	24%	9,180	47%	4,255	20%	2,926	33%	316	29%	661	32%
Total	**14,878**	**99%**	**19,679**	**100%**	**21,638**	**100%**	**8,759**	**100%**	**1,100**	**100%**	**2,067**	**100%**
Other reported sources	8,122		321		362		441		100		633	

* Sydney GMR includes Sydney, Newcastle and Wollongong.

The estimated wood heater contributions to PM_{10} in Table 10 have been derived using the solid fuel contribution and the annual average PM_{10} levels in Table 9 to provide a nominal estimate of the PM_{10} contribution made to each airshed by wood heaters.

[1]Yuk Leong Ng, EPA Victoria, Personal Communications

Table 10: Estimated wood heater contribution to PM_{10}

	Annual Average PM_{10} ($\mu g/m^3$), 2001	Wood heater PM_{10} Inventory contribution	Nominal contribution to PM_{10} by wood heaters ($\mu g/m^3$)
Canberra	18.0	58%	10.4
Launceston	22.1	58%	12.8
Perth	15.6	26%	4.1
Port Phillip	15.5	46%	7.1
SE Queensland	15.7	<1%	<0.1
Sydney	19.1	16%	3.1

The above assumes that monthly ambient PM_{10} levels are similar to the annual average throughout the year. This may be a reasonable approach for the Port Phillip (see Table 3) and South East Queensland, and possibly Canberra, Perth and Sydney where, presumably, during summer months road dust and dust storms replace the PM_{10} wood heater contributed to the airshed during winter. The work by CSIRO (2004) indicates that it is not the case for Launceston where there is a significant increase in average monthly PM_{10} levels in the winter months (see Table 4). Nevertheless, to aid consistency in methodology the above estimates for contributions were applied when developing projections.

6. Projections for Other Sources of PM10

As can be seen in Table 9, motor vehicles contributed 24 % of the total PM_{10} load to the Port Phillip airshed based on our interpretation of NPI data. Diesel vehicles contributed about 73% of these emissions (NPI, 2004). The percentage PM_{10} load contribution made by motor vehicles varied within the other airsheds but it is likely that diesel vehicles contributed a similar proportion to the 73% of PM_{10} in the Port Phillip airshed. Between 2002 and 2006, Australia will be adopting new emission standards for diesel vehicles and between 2003 and 2005 new emission standards for petrol vehicles. Projection work undertaken by EPA Victoria (Ng et al, 2003) for the Port Phillip region indicates that, with the introduction of the new motor vehicle emission standards, annual PM_{10} contributions from the motor vehicle sector will reduce from approximately 3,500 tonnes per year in 1995/6 to 1500 t/yr in 2008 and 910 t/yr in 2021. These projections take into account composition and market share of different fuels, projected growth in the amount of travel, vehicle turnover rates and expected future emissions from each vehicle type. They are indicative predictions.

It could be assumed that a similar trend in reduction in motor vehicle PM_{10} emissions to the 57% reduction by 2008 and 74% reduction 2021 from the 1995/96 base year in the Port Phillip would be anticipated for the other airsheds in this study. In addition Ng et al (2003) projected that emissions of PM_{10} by industry in the Port Phillip region will decline by about 5% by 2008 but projections for 2021 are seen as highly uncertain. Without detailed analysis it is difficult to project the trend for PM_{10} emissions contribution from industry for the other airsheds.

Ng et al (2003) also projected that wood heater emissions under a business-as-usual scenario for the Port Phillip region, where regulatory control on wood heaters has only recently been introduced. These projections indicate an approximate 40 -50% reduction in PM_{10} emissions from wood heaters in the Port Phillip airshed by 2021 based on the assumption that 10% of heaters are either non compliant or the controls have been tampered with.

In summary, in recent years the main causes of exceedences of the national PM_{10} standards were dust storms and bushfires in all the study areas except for Launceston, where wood heaters are the main cause. It also appears that with the exception of Launceston there is little variation in the average monthly PM_{10} levels throughout the year which implies that the contribution made by 'summer' time sources of PM_{10} (eg bushfires and dust storms) are similar to the contributions made by wood heaters during the colder months. Over time, under a business-as-usual scenario, PM_{10} levels in the regions are likely to decrease due to decreased PM_{10} emissions from motor vehicles and the increasing number of AS/NZS4013 (1999) complaint wood heaters.

7. Implications of New Emission Limit / Operating Efficiency Option

Emission projections were developed for years 2008, 2011 and 2021 for the following scenarios:

- 4.0 g/kg with-
  - no minimum operating efficiency specified (the base case); and
  - minimum operating efficiencies of 60% and 65%.

- 3.0 g/kg with –
  - no minimum operating efficiency specified; and
  - minimum operating efficiencies of 60% and 65%.

- 2.0 g/kg with –
  - no minimum operating efficiency specified; and
  - minimum of operating efficiencies of 60% and 65%.

- 1.5 g/kg with –
  - no minimum operating efficiency specified; and
  - minimum operating efficiencies of 60% and 65%.

- 1.0 g/kg with –
  - no minimum operating efficiency specified; and
  - minimum operating efficiencies of 60% and 65%.

- using emission factors derived from the revised test method results obtained by Todd et al (2005).

7.1 Assumptions Used for the Projections

7.1.1 Population

The population figures used for our projections were determined from ABS data or other relevant sources. In the case of Sydney we used the population from the NSW Metropolitan Strategy (which includes Sydney, Newcastle and Wollongong). For Port Phillip, we used the population for the Port Phillip Air Quality Improvement Plan (EPA Victoria, 1998).

To simplify the projections, we did not incorporate population increases nor did we incorporate changes in the proportion of houses with wood heaters. This is a reasonable assumption, as over the past decade these factors have largely offset each other and this will likely result in overall wood heater numbers remaining constant in the future (see 3.3 above).

7.1.2 Emission factors

As already mentioned, there are a variety of estimates made for emission factors that attempt to take into account ‘real-life’ operating conditions such as the type and moisture content of wood. However for comparative purposes we have used the NPI emission factors for the above projections, except for the revised test method projections where emission factors derived from the recent work of Todd et al (2005) have been used. The emission factors and projections based on the work by Todd et al (2005) are discussed separately in section 7.3.

7.1.3 Assumptions: base case and wood heater mix

From previous work on projections for the Port Phillip region, the heater mix for each of the projection years was available and these have been used. For Launceston the base heater mix was based on CSIRO’s (2004) recent work.

For the other airsheds the base year heater mix was derived from ABS (2002) survey data. A marginal decrease in the conventional and open fireplaces was used for future years and a small allowance made for some compliant wood heaters not being operated correctly or being tampered with. In addition, the replacement cycle of heaters of 5% of old wood heaters to new compliant wood heaters per annum was used and this is shown in Table 11.

Table 11: Wood heater replacement cycle

	% of wood heaters meeting standard		
Year	**5.5g/kg**	**4.0g/kg (AS/NZS4013 (1999))**	**New standard***
2001	95	5	0
2002	90	10	0
2003	85	15	0
2004	80	20	0
2005	75	25	0
2006	70	30	0
2007	65	30	5
2008	60	30	10
2009	55	30	15
2010	50	30	20
2011	45	30	25
2012	40	30	30
2013	35	30	35
2014	30	30	40
2015	25	30	45
2016	20	30	50
2017	15	30	55
2018	10	30	60
2019	5	30	65
2020	0	30	70
2021	0	30	70

* New Standard is dependent on standard introduced under the various scenarios.

Based on these assumptions the adoption of wood heaters compliant with a new standard are shown in the Figure below. In net terms, the annual assumed turnover rate ranges between 3.5% and 4.5% of all wood heaters.

As indicated in sections 3.3 and 7.1.1, no decline in wood heater numbers have been factored into the analysis under a business-as-usual scenario. It is likely price increases attributable to the new standards may prompt wood heater purchases to fall. While price effects have not been considered, a greater shift to alternative heater systems would serve to increase benefits attributable to reduced particle emissions, as emissions associated with alternative heating options are considerably lower.

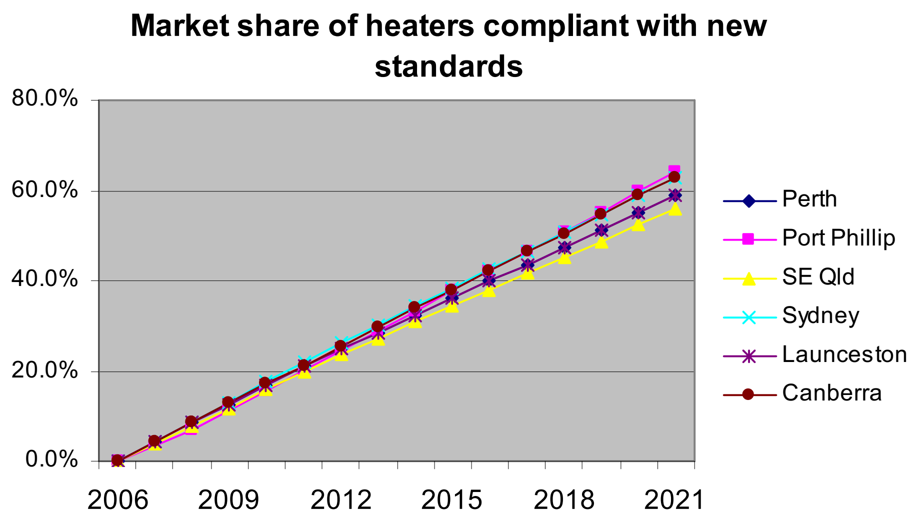

Figure 7: Market share of heaters compliant with new standards

7.1.4 Improving efficiency of wood heaters

There is limited data available on the current efficiency of wood heaters. The most comprehensive information found is the efficiency results from AHHA which are shown in Figure 1 of this report. The data shows that the mean efficiency of the models was 60.6% with the median value being 60.3%. The identified distribution in efficiency performance implies that if a standard were introduced requiring all AS/NZS4013 (1999) heaters to achieve a 60% efficiency level then this would be equivalent to an approximate overall improvement of 10% in the efficiency of the wood heater population (based on advice and literature). In our cost-benefit assessment we assumed that the introduction of a 60% efficiency standard as equivalent to reducing wood consumption by 10% in each airshed. This appears to be a reasonable approach as Todd (EA, 2002a) indicates that increasing the average efficiency by 5 percentage points would reduce firewood use by 8 percent.

To incorporate the projection for an efficiency standard of 65%, we assumed an equivalence of a 15% reduction in wood consumption for each airshed
The wood consumption scenarios used to estimate emissions under the various scenarios for the selected airsheds is shown in Table 3 in Section 3.4. Wood consumption is based on wood used by those using wood as a primary heating source.

Total wood consumption is shown in Figure 8. As 50% of current new heater models already achieve 60% heat efficiency, and wood heater sales are assumed to remain unchanged, total wood use is assumed to fall under the base-case (or business as usual) scenario. Under the 60% and 65% efficiency standards, total wood use is estimated to fall by 5.6 and 8.8% respectively by 2021.

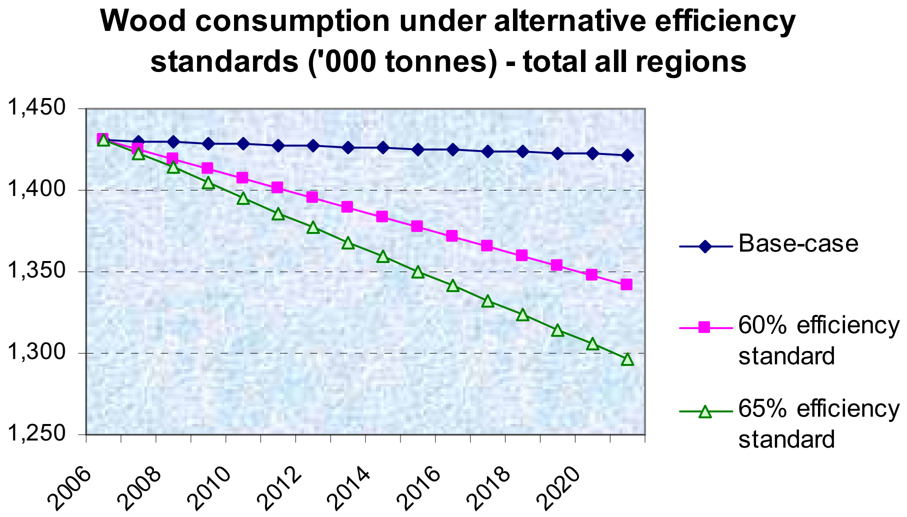

Figure 8: Wood consumption under alternative efficiency standards

7.2 Projections under various scenarios

The following Figures show the projections of emissions to the year 2021. The first Figure shows the impact on the individual airsheds whereas Figures 10-12 show the overall impact of the various standard options.

It should be noted that our 2001 PM_{10} estimates showed very good agreement with the NPI estimates in Table 9 for the Port Phillip region, Perth, and the Sydney Greater Metropolitan Region however the PM_{10} estimates for Launceston were approximately half the NPI estimates, the ACT was about one quarter and SE Queensland was 343 tonnes per year compared to the NPI estimate of 89 tonnes per year. There could be a variety of reasons for these discrepancies, the most probable being the use of different rates of annual wood use or different heater mixes. When the total of all airshed PM_{10} emissions from domestic solid fuel burning for our projections are compared to the NPI estimates the differential is less than 15%.

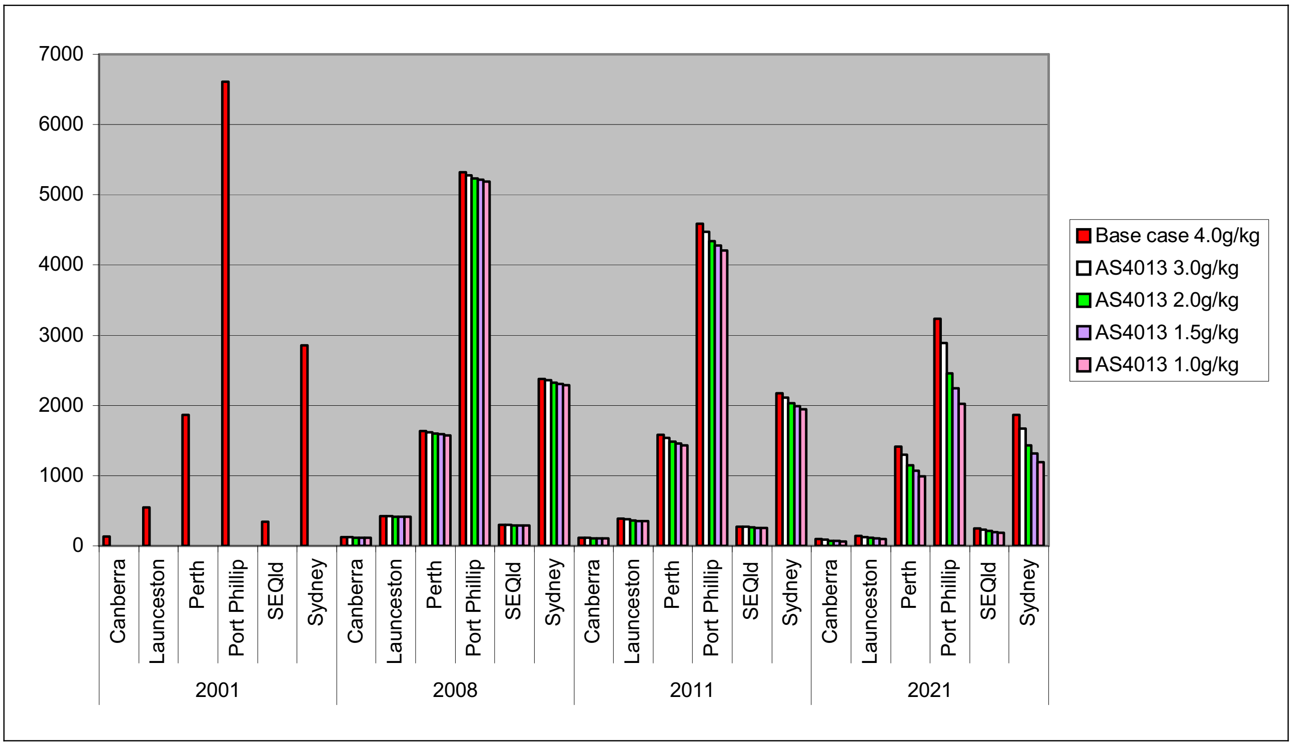

Figure 9: Reductions in PM10 emissions from woodheaters, in tonnes per annum, in selected airsheds, through the implementation of tighter emission standards

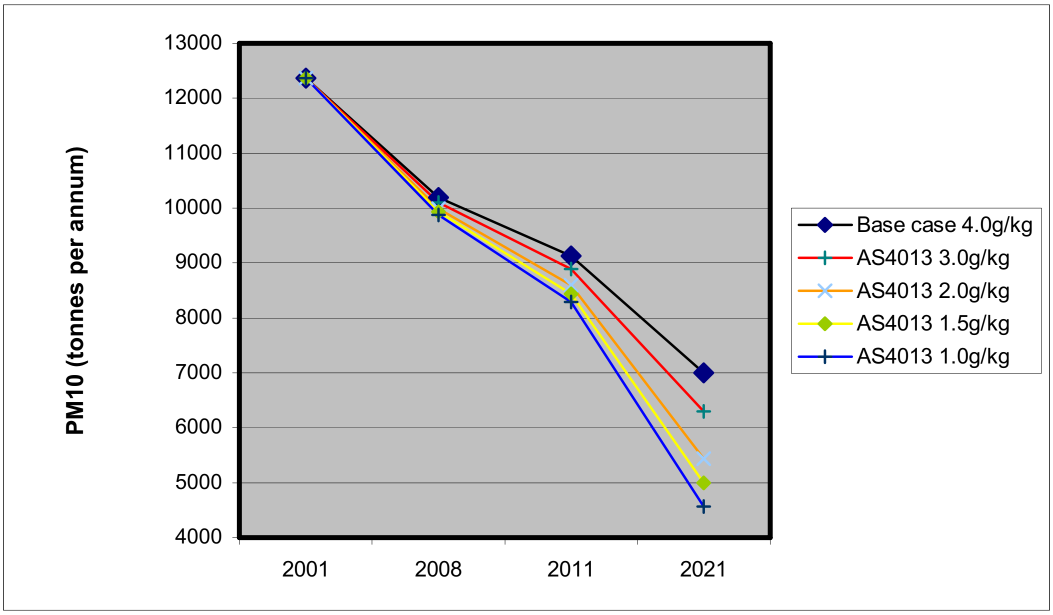

Figure 10: Overall reductions in PM10 emissions, in tonnes per annum, through the implementation of tighter emission standards

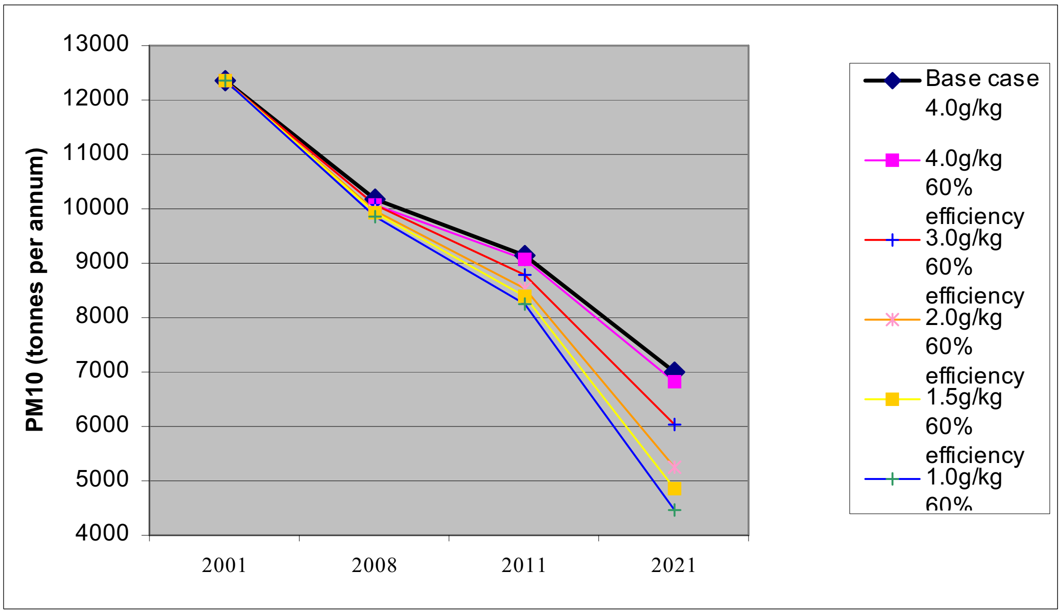

Figure 11: Overall reductions in PM10 emissions, in tonnes per annum, through the implementation of tighter emission standards and a 60% efficiency standard

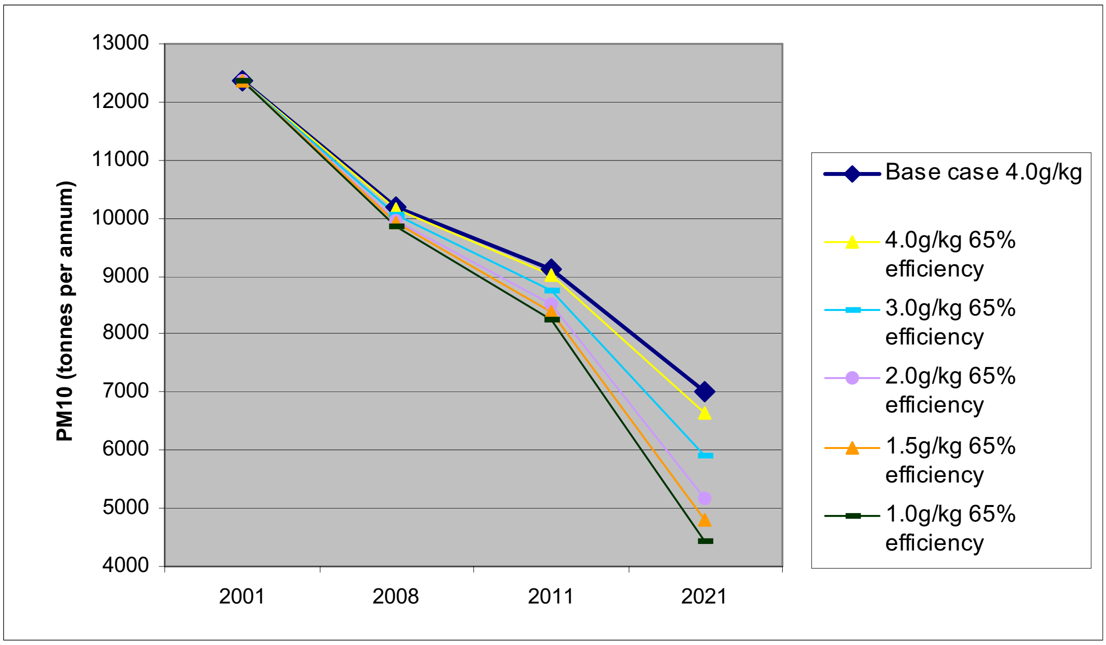

Figure 12: Overall reductions in PM10 emissions, in tonnes per annum, through the implementation of tighter emission standards and a 65% efficiency standard

7.3 Emissions Projections Based on Revised Test Method

7.3.1 Modification to AS/NZS 4013 test procedure on "low" and "medium" test cycles

The AS/NZS 4013 test method includes three test burns for each of three flow settings (high, medium and low) and includes a conditioning burn for each change of conditions. For each burn cycle, a single uniform charge of fuel is placed onto a prepared coal bed, with emission factors determined as an integral over combustion of this fuel charge. For burns on low and medium settings, although particle emissions are measured immediately on the loading of the fuel charge, the primary air flow setting is set to the relevant setting (low or medium) after the fuel load has decreased by 20% (ie when the fire is well established). In notes by Associate Professor John Todd (2004) prepared for a meeting with Environment Canterbury and others in September 2004, Todd suggests that about "one in three households with operating woodheaters emit visible smoke at the time of observation." The anecdotal and empirical evidence, therefore suggests that a significant percentage of householders do not wait for their fire to become well-established before turning down air flow controls.

Proposed amendments to AS/NZS 4013 include changes to the test procedure such that, when measuring emissions on low and medium settings, the primary air flow is set at the relevant setting two minutes after the fuel charge is loaded, rather than when the fuel charge has been depleted by 20% (generally after around 20 minutes). This procedure more closely resembles the "worst case scenario" when a woodheater within the domestic setting is refuelled.

Recent work by CSIRO (EA, 2002b) measured emissions shortly after refuelling on two compliant wood heaters on high and low setting. The results, as would be expected, show that fire at the start of combustion is chaotic. With the heaters on high flow emissions stabilised after about twenty minutes but with the heater on the low flow setting the emissions took one to two hours to stabilise. CSIRO also measured emissions from a grossly overloaded heater on the lowest flow setting (with no initial burn-off) on a compliant and non-compliant heater. These tests were designed to simulate heaters being loaded up late in the evening. Test results showed that emissions for the compliant heater were around 5g/kg/hr for around 2.5 hours before stabilising. Todd corroborates this finding in his report for the NSW EPA, where he states that "if good combustion is not achieved within the first 20 minutes, high emission rates and high opacity continue for much longer periods". He estimated that emissions over the complete test cycle (combining high, medium and low burns) would be increased by a factor of between 6 and 8 under the proposed test program (Personal Communication).

7.3.2 Laboratory tests using Revised and 'Real-world' test methods

The Department of the Environment and Heritage commissioned research to 'investigate the proposed changes to the Australian and New Zealand Standard for the measurement of particulate emissions from wood-burning residential heating appliances (AS/NZS4013)' (Todd et al 2005). For this project Todd et al (2005) measured emissions from four wood heater models were over a total of 108 test cycles. The tests were conducted to:

(a) the AS/NZS4013 methodology
(b) the proposed revised methodology - the proposed revised method is a modified version of the AS/NZS 4013 test method and attempts to provide a test method that is closer to the way householders operate their wood heaters. It allows only two minutes between adding a new fuel load and turning the combustion air to the medium or low setting whereas AS/NZS4013 method allows 10 to 20 minutes delay before turning the setting down.
(c) a new real-world protocol methodology - the 'real- life' protocol was developed to even more closely reflect wood heater use in people's homes. It includes the measurement of emissions during the light-up phase as well as high, medium and low burn-cycles and, during the low burn phase, larger logs and a larger fuel load, than those specified in AS/NZS4013, are used.

The results of the tests are shown in Table 12.

Table 12: Comparison of selected physical and performance parameters of the four heaters (Todd et al 2005)

	A	B	C	D	Average
Efficiency (average all burn rates)	67%	56%	62%	60%	**61.3%**
AS/NZS4013 emission factor (g/kg)	1.8	2.7	2.5	2.9	**2.5**
Revised method emission factor (g/kg)	3.5	5.1	7.6	9.1	**6.3**
Real-world emission factor (g/kg)	5.8	6.7	4.8	7.8	**6.3**

The key findings of the study were that:

- All four woodheaters recorded significantly increased emission factors when tested to the revised method. This strongly supports the view that the revised test method is more stringent than the current test method.
- Only one of the four models tested was found to comply with the 4g/kg emissions limit under the revised test method without modification. This suggests that some existing models would comply with the revised method without modification.
- The revised test method resulted in an average increase in the emission factor of 2.5, when compared to the current the AS/NZS4013 method. This suggests that when wood heaters tested under the revised method are compared to those tested under the current method, those tested under the revised method will produce, on average, emission factors that are 2.5 times lower i.e. an emission factor of 4 g/kg under the revised test method is equivalent to 1.6 g/kg under the current test method.
- Two of the three heaters that failed the revised method were modified by the addition of an automated air supply mechanism (starter control). After modification, both these wood heaters achieved emission factors of less than 4g/kg when tested to the revised method.
- A further emission test method, referred to as a “real world” test protocol was developed and trialled. Emission factors for the real world test method, when averaged over all four heaters, were the same as the four heater average emission factor for the revised method. Both the real world and revised methods produced emission factors that were 2.5 times higher than the four heater average for the current test method. However, the ranking of the four heaters from cleanest to smokiest were different for each of the three methods. This was unexpected, and could not be adequately explained by the authors and requires further research to reach firm conclusions.

The above findings suggest that the revised test method is a considerable advance on the current AS/NZS 4013 test method, in terms of driving wood heater design improvements that will result in lower emissions from homes, and that adopting a 4g/kg emissions limit under the revised test method would translate to a significant reduction in emissions. However, further work is required to fully refine the test parameters that accurately reflect real life operation.

In another project, in New Zealand and funded by Environment Canterbury, Nelson City Council and the Ministry for the Environment, Scott (2005) tested low emission residential wood heaters to determine 'real-life' emissions data from laboratory and field tests that could be used for air quality assessments and to determine whether there is a conversion factor that could be used to estimate 'real-life' emissions from AS/NZS4013 results. Scott concluded that AS/NZS4013 test method is not indicative of real-life emissions because of the wide range of variables, behaviours and installations in the field. Furthermore Scott's indicated that 'real-life' emission factors are likely to be substantially underestimated but no conversion factor could be estimated.

7.3.3 Projections using revised test method emission factors

In Section 3.2, data supplied by the Department of the Environment and Heritage showed that the median emissions rate was 2.6 g/kg for wood heaters certified to AS/NZS4013 (1999) in late 2004. This implies that 50% of the heaters had higher emission factor than 2.6g/kg and 50% had emission rates that were lower than 2.6g/kg. Given the limited testing undertaken and the closeness of the average AS/NZS4013 emission factor for the four heaters tested to the median of all certified heaters we assumed that if all heaters were tested using either the proposed revised test method or the 'real-world' test that this would result in an emission factor of 6.3g/kg (from Table 12). In the analysis we also factored up the 5.5g/kg emission factor to 8.7g/kg on the basis that the median of the heaters certified to 5.5g/kg and tested using the standard AS/NZS4013 method is likely to be approximately 3.4g/kg and the 8.7g/kg results from factoring up to reflect 'real-world' tests.

Table 13: Comparison of NPI emission factors and emission factors based on revised test method

Heater Type	NPI Emission Factor g kg^{-1}	Based on revised test method g kg^{-1}
Compliant 1992	5.5	8.7**
Compliant 1999	4.0*	6.3
Non-Compliant	12.0	12
Open Fireplace	17.3	17.3

* NPI, which was published in 1999, only gives one emission factor for controlled heater – it is assumed that it predates the AS/NZ4013:1999

** = (5.5 X 6.3)/4.0

Given that there is no basis for amending the emission factors for pre 1992 heaters and for the open fireplaces under the revised test method analysis the same emissions factors have been used.

The outcomes from this modeling are shown in Figures 13 and 14. In Figure 13 the percent difference varies over time due to variations in the heater mix in the various airshed over time. By 2021, in our estimations, we assumed that there will no longer be any heaters that are compliant with the older 5.5g/kg standard still operating, although a small number of open fireplaces and conventional heaters will still being used. Therefore 80-90% of the heaters (depending on the airshed), in operation in 2021, will be 4g/kg compliant using the revised AS/NZS4013 method. The difference in results when comparing standard emission factor results with the real world/ revised method results is 12.2% in 2021. Given that this conclusion is based on results from revised test method results on only four heaters plus the other assumptions made, such as heater mixes in each airshed and compliance dates, the outcomes from our assessment should be seen as only an indication of 'real- world' PM_{10} emission reductions compared to reductions in PM_{10} emissions when modeled using NPI emission factors. **Caution is advised in reviewing the impact of the results of the revised test method scenario.**

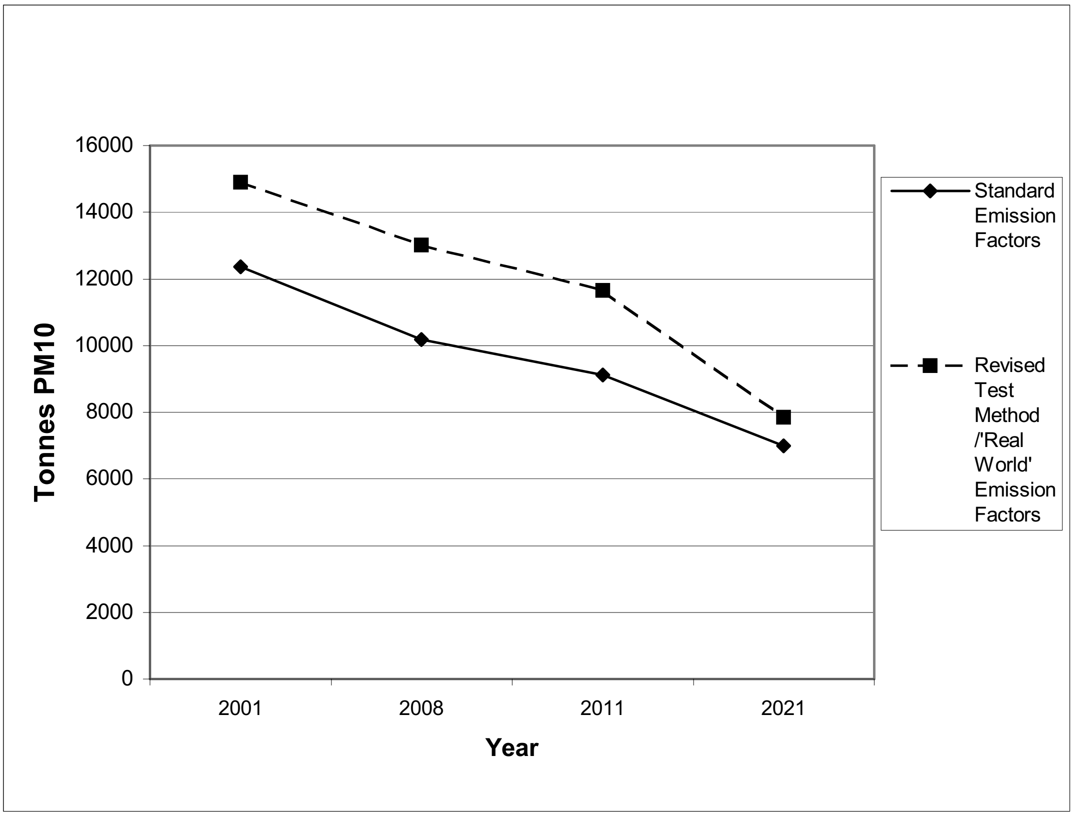

Figure 13: Comparison of Emission Estimates for All Airshed – Standard Test Method versus Revised Test Method/ 'Real-World' Method Emission Factors

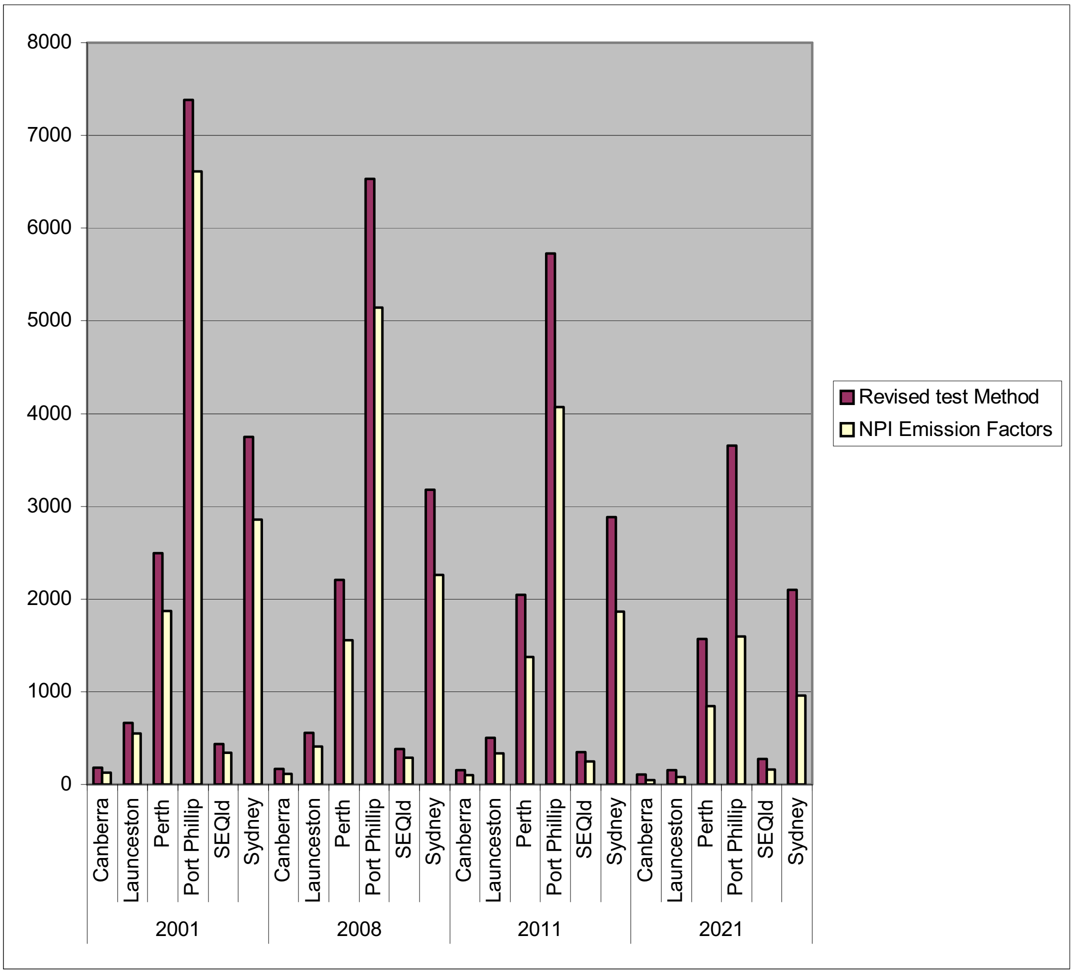

Figure 14 Comparison between Projections made using Revised Test Method Emission Factors and NPI Emission Factors for 6 Airsheds

8. Impacts of Standards on the Wood Heater Industry

8.1 Tightening wood heater emissions standard

Currently, there are a number of models that could meet lower emission standards under the current test method. As indicated in Section 3.2, 50% of heaters on the market have an emission factor of 2.6g/kg or less, with 41 of 283 heaters having a 2.5g/kg emissions factor and an efficiency of 60% and, furthermore, 34 heaters could meet a 2g/kg emissions factor coupled with 60% efficiency standard.

The industry argue that achieving a 3.0g/kg standard (or about 4.7g/kg using the revised test method) for all certified fireboxes is achievable within 18 months, whereas requiring all wood heaters to meet a lower standard of 2.0g/kg or 1.5 g/kg would require additional research and development and take 2 to 3 years. They believe that requiring fireboxes to meet a 1.0g/kg could be impossible to achieve and, if achievable, would require 5 years or more of research and development. A 1.0g/kg standard would also result in higher priced wood heaters and most probably industry contraction. The difficulty, or even impossibility, of meeting a 1.0g/kg standard for Australian styled wood heaters was confirmed by Associate Professor John Todd (personal communications).

In terms of testing, lowering the emissions standard would require no change to the testing procedure and this option would still only require the firebox to be tested rather than the complete model.

8.2 Improving efficiency

Meeting an efficiency standard is currently not required under the current standard, however AS/NZS 4012 (1999) *Domestic Solid Fuel Burning Appliances – Method for determination of power output and efficiency* provides a test method to measure heater efficiency and requires that the results be included on the heater label. As this Standard is an integral part of emissions testing and is indirectly called up in jurisdiction legislation heaters have been tested to AS/NZS 4012 (1999) and have been included on the AHHA database. From the AHHA database the median efficiency of all heaters tested that meet AS/NZS 4013(1999) was found to be 60.3% which means that more than 50% of all current models on the market meet a 60% efficiency standard. Furthermore, from examination of Figure 1, approximately 15% of models could meet a 65% efficiency standard. From the information available it is not possible to indicate the percentage of models that would meet a tighter emission standard coupled with a 65% efficiency standard.

From comments by industry and through examination of the AHHA database, achieving a 60% efficiency standard coupled with either a 4g/kg or 3g/kg emissions factor is achievable within a reasonable timeframe. Improving efficiency to 65% with an emissions factor of 4g/kg or 3g/kg is also possible but a 65% efficiency couple with an emission factor of 2.0g/kg or less may require considerable research and development and longer timeframes.

In terms of testing, introducing an efficiency standard would require all heaters to be tested except perhaps where there are only minor decorative differences between models, and this will incur significant extra expenditure on testing. The unit testing cost, however, is unlikely to change significantly.

8.3 Modified AS/NZS 4013 test procedure on “low” and “medium” test cycles

Initially this project investigated the effects of introducing an automatic combustion air control (starter control). The type of options that could be used to ensure that a heater is operated on high flow for a specified period of time after refuelling include door opening control on operations, gas sensors or temperature sensors. Reportedly there are least two overseas companies fitting some heater models with automatic controls designed to minimise smoke emissions through control of combustion air (Todd et al, 2005).

The testing on several heaters by Todd et al (2005) indicates that additional research is needed to further assess air quality benefits that could be achieved by using these controls.

While there has been limited testing to date using the revised test method if the revised method is approved then it is likely very few heaters currently on the market would be able to achieve an emissions rate of 4g/kg when test to the revised method.

8.4 Industry costs to meet new wood heater standards

As indicated above, the development and production of wood heaters to meet the standards being investigated in this study would require expenditure on research and development, retooling of production processes and possibly higher production and assembly costs.

As heaters similar to those currently sold in Australia and using similar fuels but compliant with the new standards being proposed are not known to be produced elsewhere, it is difficult to postulate the nature of likely costs involved as there are no obvious comparisons that could provide a guide. The more limiting emission standards are not required elsewhere, and where standards do appear similar, the type of heaters being used and fuels are very different. In particular, wood heaters in New Zealand are typically smaller and fuelled with softwoods.

One large manufacturer has already budgeted around $300,000 for research and development and $400,000 for additional AS/NZS 4013 testing and compliance with the possible revised emission and efficiency standards. The manufacturer is not sure if a tighter standard is achievable but if research and development is successful, then there will be an additional cost for retooling. For testing and compliance to the revised method the industry indicates, from a preliminary assessment, that research and development and retesting costs would be in excess of $500,000. This manufacturer also estimates that the revised method will take two test laboratories in excess of two years to retest all current models. However onerous this seems, it is usual practice for a phase-in period for a new standard and heaters to be tested when being launched onto the market.

The company also indicated it is likely to reduce the number of models it retails and that firms which produce less than 1500 units per year would not find it viable to invest in the necessary research and development and most likely would cease production.

The industry indicated that when AS/NZS 4103 (1999) was introduced, there was an industry contraction with four manufacturers being taken over. With even more stringent standards there may be further significant industry contraction. For the revised test method, the industry argues that 5-7 years would be needed and suggest a ten year sunset clause for current models.

By increasing the market share of each remaining manufacturer, research and development and retooling costs would be spread across fewer models and arguably reduce the cost per heater of meeting the new standards

Industry sources speculated that the new standards or revised test method could represent an increase of $300 - $600 in the retail cost per heater. This seems very high, but may reflect the significant uncertainty (and therefore risk) in being able to develop complying technologies. In addition, with a likely contraction in the number of manufacturers and on-going risk of falling demand (such as with the various buy-back schemes, competition from other forms of heating, or if heaters were banned in some jurisdictions), manufacturers may seek a very short ‘pay-back' period.

So, for example, if a 3 year payback period was sought and at a 10% cost of capital, then based on current sales volumes the indicated cost would be equivalent to $16 – $32 million in current terms.

In the absence of robust data on the likely costs that would be incurred by manufacturers from complying with the new standards, we have assumed the following industry costs:

Table 14: Industry production costs associated with introducing new standards

	Emission standard (To AS/NZS 4013 1999)							
	4g/kg		**3g/kg**		**2g/kg**		**1.5 or 1 g/kg**	
	Cost per heater $	Total cost NPV $m	Cost per heater $	Total cost NPV $m	Cost per heater $	Total cost NPV $m	Cost per heater $	Total cost NPV $m
No efficiency limit	n.a.	n.a.	$50	$2.9	$200	$11.6	300	$17.4
Efficiency limit (60 or 65%)	$25	$1.4	$100	$5.8	$250	$14.5	$450	$26.2

All new heaters must currently comply with a 4g/kg emission standard determined by the standard AS/NZS 4013 test method. As around 50% of current models already comply with a 60% efficiency standard, only modest costs were assumed likely to bring all models to this standard. Similarly, almost 20% of current models would comply with a 3g/kg emission limit and 60% efficiency standard. Consequently, achieving this performance across the industry was also considered readily achievable.

While some 16% of current models already meet a 2g/kg emission limit and 60% efficiency standard, this would represent a significant step for many producers, and assumed costs have been adjusted accordingly. Significantly higher costs were assumed to meet either the 1.5 or 1g/kg emission standards, particularly if accompanied with efficiency standards. As indicated earlier, industry sources are highly sceptical that these performance standards could be attained in the proposed timeframe, if at all.

Based on a simple arithmetic calculation it is likely that less than 10% of heaters currently on the market would meet a 4g/kg emissions limit if tested to the revised test method. If it becomes a requirement that wood heaters meet a 4g/kg emission factor using the revised test method then this would result in retooling costs being incurred by nearly all manufacturers. It has tentatively been assumed that costs will be similar to those incurred in achieving an emissions rate of 1.5g/kg using the standard AS/NZS4013 method, which has been postulated at $17m.

Given the significant uncertainty about likely compliance costs we firstly imputed the above cost estimates into the cost-benefit assessment, and secondly undertook a threshold analysis of breakeven health benefits under each option.

8.4.1 Number of manufacturers and models

Currently there are some 25 manufacturers producing 133 different fireboxes and 240 different certified models. It costs manufacturers $9,000 to get a model certified. However, several models using the same firebox can be included in the one certification process. While manufacturers meet certification costs, State governments provide regulatory oversight through activities such as auditing and complaints investigation. It has been assumed that the cost to government is equivalent to $200 per certification. As no additional requirements will be placed on local government, it is assumed that there are no additional costs to local government. This is a conservative estimate, as the number of wood smoke complaints received by Councils is likely to fall. Accordingly, introduction of the standards may lead to a reduction in local government costs investigating complaints.

With the introduction of the new standards, it is assumed that 50% of models can be certified at the time of their scheduled retesting, obviating any new costs. It is also assumed that the ratio of fireboxes to models certified increases from 55% currently to 80%, due to a contraction in the number of models and perhaps stricter certification requirements.

The number of models requiring certification under each option and the cost to manufacturers are shown in Table 15, based on general discussions with industry sources and assuming complying technologies can be readily developed. While there is some arbitrariness in the assumed number of models under each scenario, final results are not sensitive to this assumption.

Table 15: Estimated certification costs to manufacturers and government associated with introducing new standards

	Number of models	Number of models to be certified	Total industry new certification costs
4g/kg revised test method	190	76	$684,000
4g/kg no efficiency (Base case)	240		
4.0g/kg 60% efficiency	230	92	$828,000
4.0g/kg 65% efficiency	230	92	$828,000
3.0g/kg	220	88	$792,000
3.0g/kg 60% efficiency	210	84	$756,000
3.0g/kg 65% efficiency	210	84	$756,000
2.0g/kg	200	80	$720,000
2.0g/kg 60% efficiency	190	76	$684,000
2.0g/kg 65% efficiency	190	76	$684,000
1.5g/kg	190	76	$684,000
1.5g/kg 60% efficiency	180	72	$648,000
1.5g/kg 65% efficiency	180	72	$648,000
1.0g/kg	185	74	$666,000
1.0g/kg 60% efficiency	175	70	$630,000
1.0g/kg 65% efficiency	175	70	$630,000

9. The Impacts of Air Pollution on Health

Streeton (1997) and Denison (2000) provided the following list of the adverse health effects associated with PM_{10}:

- increases in total, respiratory, and cardiac mortality (by about 1% for a 10 µg/m^3 increase in ambient levels, but see the discussion on short term and long term effects below);
- increased hospital, surgery and casualty admissions for respiratory disease, bronchitis, asthma, cardiovascular disease and chronic obstructive pulmonary disease (COPD);
- increased limitations to functional activity, either as absence from school (children) or work loss days and other restrictions for adults;
- increased in the daily numbers of respiratory symptoms;
- pulmonary function decreases in healthy children or adults with obstructive airways problems (small).

They have indicated that some sub-groups are more sensitive than others, and may dominate results from an overall population. For particles, sensitive subgroups include the elderly (generally defined as 65 years and older), persons with pre-existing heart and lung problems, and children who have respiratory tract symptoms.

These health impacts are widely acknowledged by other health experts who have examined the health impacts of PM_{10}.

The choice of health end-points followed the selection reported in Künzli *et al* (1999):

- total mortality (long-term, 30 years and over)
- respiratory hospital admissions (all-ages)
- cardiovascular hospital admissions (all ages)
- chronic bronchitis (adults 25 years and over)
- acute bronchitis (last 12 months in children under 15 years)
- restricted activity days in adults (20 years and over)
- asthma attacks (children less than 15 years, adults 15 years and over)

9.1 Summary of health data

Table 16 provides a summary of the current levels of mortality and morbidity for each of the six airsheds. For Sydney, South East Queensland and Perth data supplied by the Department of the Environment and Heritage has been used however the population data used in the Table below for the Port Phillip region differs, the data is the same as that used by EPA Victoria for its emissions inventory work. The Table and estimates have also been extended to include Canberra and Launceston.

Table 16: Number of cases/year in each airshed for relevant health endpoints

End-point (age)	Sydney	Port Phillip	S.E. Qld	Perth	Launceston	Canberra
Population (all)	3,600,373	4,333,635	2,372,104	1,310,000	100,000	311,100
Mortality (30+)	20,202	26,515	9,402	6,970	1,563	2,373
Hospital admissions						
Respiratory (all)	19,325	30,943	8,139	9,235	4,308	13,402
Cardio-vascular (all)	18,453	39,479	4,621	9,673	4,308	13,402
Bronchitis						
Chronic (25+)	110,728	124,347	67,194	25,200	2,434	10,074
Acute (<15)	24,876	29,605	16,843	8,907	666	2,681
Asthma attacks					30,600	97,997
Children (<15)	357,843	441,184	250,996	95,142		
Adults (15+)	1,306,434	1,634,248	885,597	332,663		
RADs (20+)*	13,004,300	10,487,710	8,905,844	4,170,189	389,871	1,220,146

*RADS – Reduced activity days

Sources:

Population: ABS Census 2001, NSW Metropolitan Strategy, EPA Victoria, Perth Air Quality Management Plan, CSIRO, www.qld.gov.au

Mortality: AIHW for 2001 and 2002

Hospital admissions: State health agencies, various years but pre-2000 for non NSW airsheds

Chronic bronchitis: ABS (2001) for prevalence in 2001 (combined with emphysema)

Acute Bronchitis: based on general practitioner statistics for 2002 in Stocks *et al* (2004)

Asthma attacks: based on general practitioner statistics in ACAM (2003)

RADs: National Health Survey, ABS (2001) for 2001

Importantly, many studies on health impacts from air pollution commonly assume a simple linear relationship between PM_{10} emissions, ambient concentrations and health effects, with no minimum threshold level. This significantly simplifies the estimation of health benefits associated with emission reductions, as health benefits can be based on an average benefit per tonne of emissions reduced, derived from available data on total estimated PM10 health impacts and estimated PM10 emission loads. Table 17 outlines assumed health costs per tonne used in this study based on data supplied by the Department of the Environment and Heritage. As no data was available for Canberra and Launceston, the average cost per tonne across the other airsheds was used. Given the relatively small populations in these latter regions, final results are not sensitive to this assumption.

Table 17: Summary of comparative costs and emissions between this study

	Sydney	Port Phillip	SE Qld	Perth	Canberra	Launceston
PM10 emissions (tonnes per annum)	19679	14878	21830	8889	1163	2067
Health cost per tonne	$133,543	$128,310	$43,106	$80,211	$81,847	$81,847

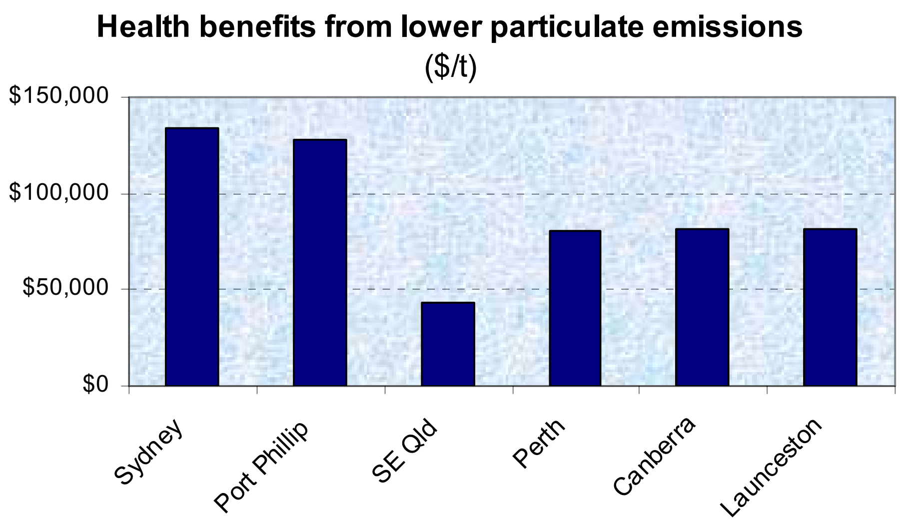

Figure 15: Health benefits from lower particle emissions from wood heaters

10. Economic Impacts

The requirement for new emission and efficiency standards will impose costs on wood heater manufacturers in developing compliant heaters, retooling and manufacturing the new units. There will be additional costs to manufacturers and Government associated with having heaters certified. It was assumed that the former of these costs would be incurred in 2005 while certification costs would be incurred in 2006.

The magnitude of costs were canvassed in earlier sections, and in total range from around \$2m (net present value) in the case of maintaining the current 4g/kg emission standard but introducing either of the efficiency standards, to \$25m in the case of the 1g/kg emission standard and either of the efficiency standards. In the case of meeting a 4g/kg emission rate using the revised test method, it was tentatively assumed that this would be similar to those incurred in achieving an emissions rate of 1.5g/kg using the standard AS/NZS4013 method, which has been estimated at \$17m.

The benefits from the new emission and efficiency standards will arise from savings in wood costs under those options incorporating efficiency standards, and health benefits associated with lower particulate emissions. The typical breakdown of estimated benefits is shown in Figure 16. There are no wood cost savings directly attributable to the revised test method as this will not significantly affect fuel efficiency.

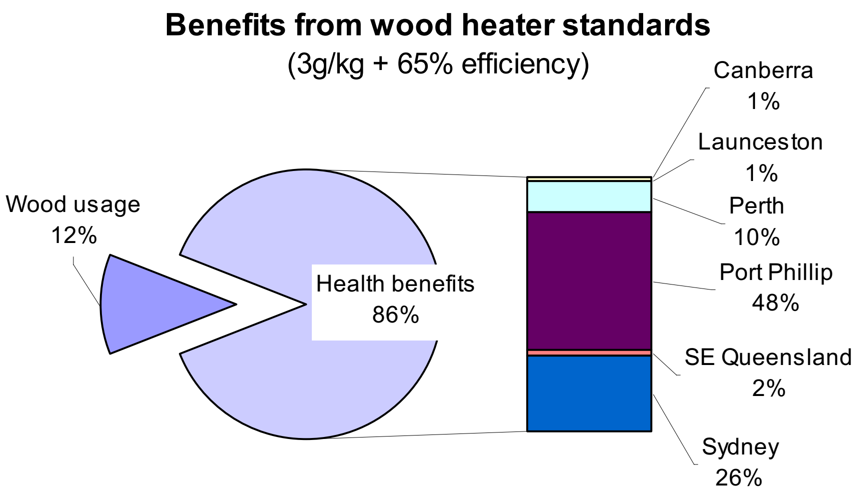

Figure 16: Benefits from wood heater standards

As shown earlier in Figure 8, wood consumption is estimated to fall by 5.6 and 8.8% under the 60% and 65% efficiency standards by 2021. This is estimated to generate benefits of \$38m and \$67m in net present value terms over the period to 2021 that reflect the value of firewood savings. Notably, these savings in themselves are large enough to offset the estimated compliance costs to wood heater manufacturers.

In addition, these benefits do not include the potentially significant environmental benefits that may be realised with reduced firewood consumption. Firewood harvesting and collection in Australia leads to a range of habitat and biodiversity impacts. For example, the Victorian Regional Forest Agreement Biodiversity reports for the North East, West and Gippsland Forest Regions (RFA 1998, 1999, 2000a, source NRE) that the collection of firewood is threatening 49 plant communities, among them are 30 woodland communities, 23 forest communities and one mallee community. There is evidence that at least 16 bird species are threatened by firewood collection in Victoria (NRE); eight mammals are listed as being at risk due to firewood harvesting including species of gliders, bats and wallabies; and species of pythons, snakes, skinks and lizards are among the eleven reptiles threatened.

The other major component of estimated benefits from the proposed wood heater emission and efficiency standards relate to health benefits arising from lower particulate emissions. As shown in Figure 16, these benefits are dominated by the Port Phillip and Sydney regions. The estimated health benefit per tonne of particulates reduced in these regions is 2 to 3 times that of the other regions, due to factors such as population demographics and airshed factors. However the over-riding factor is the size of the populations in these regions exposed to particulate pollution.

Overall, the present value of estimated health benefits ranges from around $72m in the case of maintaining the current 4g/kg emission standard but introducing the 60% efficiency standard, to over $1b in the case of the 1g/kg emission standard and the 65% efficiency standard.

Clearly the size of the estimated health benefits alone suggest net social benefits will arise from the proposed wood heater standards, and that those benefits will increase with progressively tighter standards. The total net benefits of lowering emission standards is shown in Figure 17, while the total net benefits of the various sub-options are shown in Figure 18. The health benefits of reducing the total emissions through compliance with the revised test method can tentatively be assumed to be similar to those achieved by requiring an emissions rate of 1.5g/kg using the standard AS/NZS4013 method, some $830m.

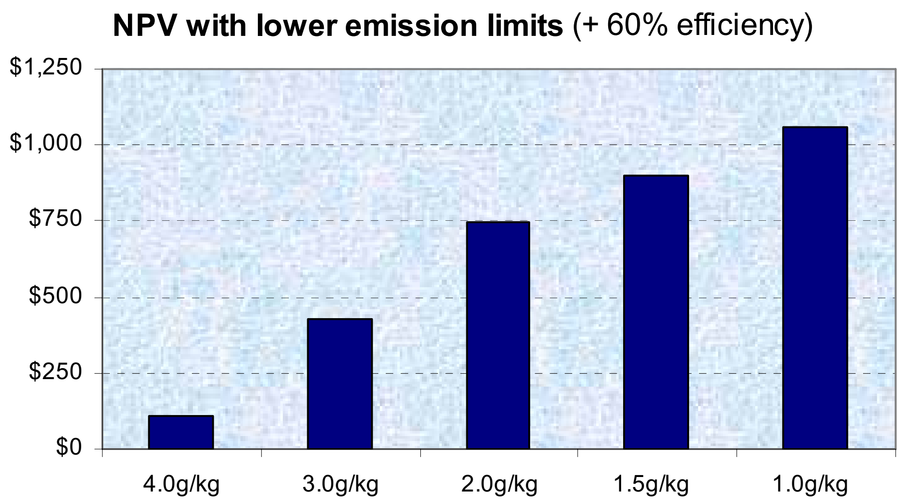

Figure 17: Net Present Value for lower emissions and a 60% efficiency

The key difference under the sub-options is the reduced wood usage associated with the efficiency standards, as these standards deliver benefits by way of both reduced wood costs and reduced total emissions.

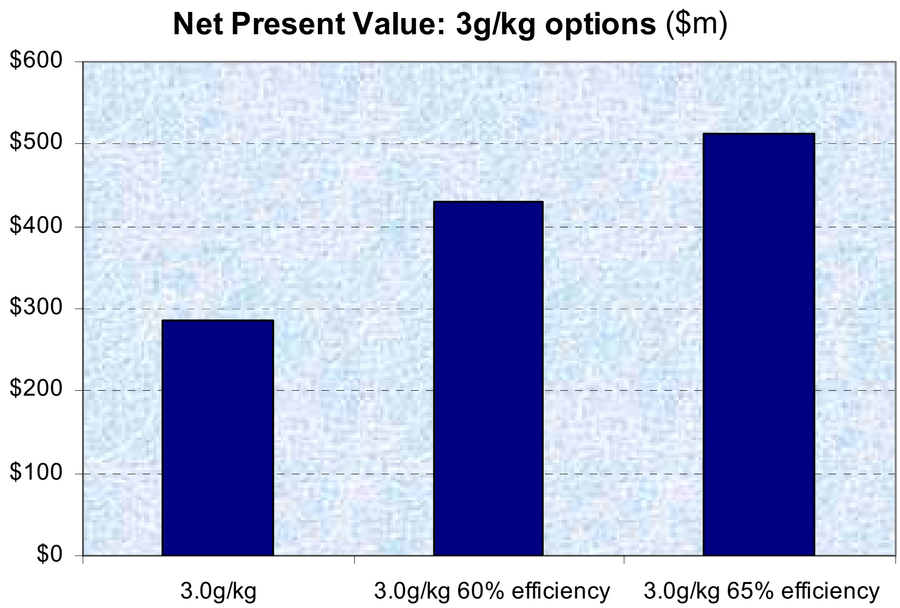

Figure 18: Net Present Value for alternative efficiency options and 3.0g/kg emission standard

The performance of each of the options, in terms of the present value of costs, benefits, net present value and benefit-cost ratio are shown in Table 18. A discount rate of 7% has been used and an evaluation period of 2004 to 2021.

Table 18: Costs and benefits by option (expressed in year 2004 $)

Standard*	PV costs $m	PV benefits $m	NPV $m	BCR
4.0g/kg 60% efficiency	$2	$111	$109	52.8
4.0g/kg 65% efficiency	$2	$211	$209	100.8
3.0g/kg	$3	$289	$285	84.3
3.0g/kg 60% efficiency	$6	$435	$429	71.3
3.0g/kg 65% efficiency	$6	$518	$512	84.9
2.0g/kg	$11	$650	$638	56.5
2.0g/kg 60% efficiency	$14	$760	$746	53.6
2.0g/kg 65% efficiency	$14	$825	$811	58.1
1.5g/kg	$17	$830	$813	49.1
1.5g/kg 60% efficiency	$25	$923	$898	36.9
1.5g/kg 65% efficiency	$25	$978	$953	39.1
1.0g/kg	$17	$1,010	$993	59.8
1.0g/kg 60% efficiency	$25	$1,085	$1,060	43.4
1.0g/kg 65% efficiency	$25	$1,132	$1,107	45.3

The estimated benefits in Table 18 above relate only to the six study regions. However as new standards would be adopted nationally and applicable to all heaters sold, significant additional benefits would be realised in a number of regional (albeit smaller) centres currently impacted by particulate pollution. Additional costs in supplying heaters to these other centres would be insignificant as most costs were assumed to be associated with research and development, and retooling production processes.

10.1 Threshold analysis in relation to health benefits

The estimated net benefits of the proposed emission and efficiency standards, on the assumptions used in this report, provide overwhelmingly positive support for their adoption. However the uncertainties surrounding the available data on health impacts are considerable. For this reason, threshold analysis has been conducted to identify the sensitivity of estimated results and the reasonableness of key assumptions against available benchmarks.

For options which include either a 60 or 65% energy efficiency standard, the estimated benefits from savings in wood costs is greater than the estimated costs in redesigning, certifying and producing compliant heaters. Accordingly, these options are estimated to deliver a positive net benefit regardless of assumed health benefits. Data on commercial wood costs have been used. While a significant proportion of firewood used each year in Australia is collected directly by householders rather than via a wood merchant, this wood nevertheless has an opportunity cost that is reasonably shadow priced by commercial prices.

For those options comprising stricter emission limits but not including efficiency standards, it was estimated that net benefits would be generated as long as health benefits per tonne of emissions (averaged across all regions) were greater than $1,400 for the 3g / kg option, $2,100 (2g/kg), $2,400 (1.5g/kg) and $2,000 (1g/kg).

The values for health benefits used in this report were sourced from the Department of the Environment and Heritage. Its unpublished data canvassed the available literature on the impacts of air pollution on human health, and derived estimates specifically for the larger airsheds included in this analysis. Consequently it provides the best available estimates of potential health benefits. Those estimates are at least an order of magnitude greater than the estimated threshold values under all emission limit options.

For comparative purposes, a recent study by Nolan-ITU (2004), *National Benefits of Implementation of UR-3R Process - A Triple Bottom Line Assessment,* used an estimate of PM_{10} (fine particles) health impacts of $18,500 / tonne, based on NSW EPA (1998), Regulatory Impact Statement, Proposed Pollution Control Regulation 1998. They note that:

> *'These (NSW EPA) valuations have subsequently been critiqued as being significantly too low by CSIRO atmospheric research scientist Tom Beer (Beer, 2002). The best estimate valuation proposed by Beer for PM_{10} is A$147,400 per tonne'.*

Again, all estimated threshold values are significantly below the NSW EPA estimate of $18,500 and the higher value suggested by CSIRO.

10. Conclusions

The key objective of this study has been to determine whether or not the introduction of new wood heater emission and energy standards are likely to provide a net benefit to the Australian community, when all relevant costs and benefits are considered.

This modest desk-top study has faced significant data limitations and a number of simplifying assumptions have been necessary. However because of the size of the potential emission reductions and value placed on associated health impacts, the overall net benefit of all options is likely to be significant.

As some 50% of current models already comply with a 60% efficiency standard, compliant technology is already available and the likely cost impost to bring all heaters to this standard is likely to be modest. In addition to the emission reduction and health benefits that efficiency standards would provide, further environmental benefits may also be realised with reduced firewood harvesting and collection.

The estimated health benefits from the introduction of tighter emission standards was found to increase as limits were reduced. However despite the potentially high net benefits from adopting the more stringent performance standards, the risks associated with developing compliant heaters must be taken into account. The community may be better served through the introduction of more modest standards in the short-term with support for the development of improved heaters over the medium-term.

On balance, we conclude that;

1. The introduction of a 3g/kg emissions standard with a 60% efficiency standard could be introduced on a ‘no regrets’ basis, as it would be readily achievable within a short timeframe, it would not impose an undue burden on industry and the benefits associated with reduced wood use would ensure net benefits regardless of potential emission reduction benefits and the value the community places on those benefits. Subject to confirming the efficacy of the revised test method, this proposed standard would be equivalent to around 4.5g/kg under that test.

2. As the potential benefits of tighter emission limits appear considerable, there are likely to be significant returns on research to develop compliant heaters. However investing in the necessary research would be difficult for many in the industry and commercially unattractive due to the public good nature of any subsequent findings. For these reasons, there would appear to be public benefit grounds for coordinated government support for the applicable R&D.

3. Available evidence indicates that current emission standards are not being enforced by jurisdictions. While there may not be any significant disregard of the standards

by the industry, the efficacy of State enforcement regimes appears to warrant inspection.

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