

Woodheater Emissions Management Program for the Tamar Valley – Scoping Study

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Note: The information and analysis contained in this report does not necessarily reflect the views of Environment Australia.

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Abbreviations

ABS	Australian Bureau of Statistics
ACRE	Australian CRC for Renewable Energy Ltd
AGO	Australian Greenhouse Office
BAU	business as usual
BTCE	Bureau of Transport and Communications Economics
COPD	chronic obstructive pulmonary disease
DPIWE	Department of Primary Industries, Water and the Environment
EGW	electricity/gas/wood
EMRS	Enterprise Marketing & Research Services Pty Ltd
EPP	Environment Protection Policy
HE	high efficiency
LCC	Launceston City Council
LRI	lower respiratory illness
ME	medium efficiency
NatHERS	Nationwide House Energy Rating Scheme
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NPI	National Pollutant Inventory
NSW EPA	NSW Environment Protection Authority
PM	Particulate matter
PM ₁₀	Particulate Matter less than 10 microns in diameter
TSP	Total Suspended Particles
URI	upper respiratory illness

Executive summary

The purpose of this study is to provide advice on the relative cost-effectiveness and feasibility of actions to reduce emissions of particulate matter (PM₁₀) from woodheaters (including fireplaces) in the Tamar Valley region of Tasmania, with particular attention to the design of a financial incentive scheme to replace woodheaters.

Health impacts

High levels of smoke particles in the air are known to exacerbate problems experienced by bronchitis, emphysema and asthma sufferers. It irritates the eyes and triggers headaches and allergies, and can aggravate heart conditions. The people most at risk are the very young, the elderly, and people with lung or heart diseases.

There is evidence that fine particle matter causes premature deaths. Especially at risk are elderly people who suffer from chronic respiratory problems. The occurrence of respiratory illness in children has also been shown to increase with increased exposure to wood smoke. This includes infections of the lower respiratory tract such as acute pneumonia, or bronchiolitis, which are major causes of disease and death in young children.

Long-term exposure to PM₁₀ may have additional adverse health impacts, given that PM₁₀ carries carcinogens into the lungs.

Required reduction in emissions from woodheaters

In Launceston, breaches of NEPC's new air quality standard are running at 7-10 times the maximum rate that will be permitted in 2008 – that is, 36-47 exceedences per year, compared with the maximum of 5 exceedences that will be permitted in 2008. We estimate that emissions from Launceston's woodheaters need to fall by at least 55% in order to comply with the new standard, based on the following:

- Given the air quality that has been recorded in Launceston over recent years, there needs to be a 45% reduction in ambient concentrations of PM₁₀.
- Woodheaters account for 85% of the PM₁₀ that is observed in Launceston.

Arguably, a more demanding target for reducing ambient concentrations of PM₁₀ might be set, for example, to deliver compliance with NEPC's air standard under more adverse conditions of very poor dispersion. Therefore, in addition to the notional target of a 45% reduction, this report also provides figuring against a target of 55% reduction. The 45-55% range for the targeted reduction in ambient concentrations of PM₁₀ translates to a target of 55-65% for reducing emissions from Launceston's woodheaters.

For the purposes of this summary, we report solely against the target of reducing ambient concentrations of PM₁₀ by 45%, and the implicit need to reduce woodheater emissions by 55%.

Trends, developments and management options

Table 1 lists a number of current and possible future contributions to the required reduction in woodheater emissions. The report provides an assessment of the maximum contribution that might be expected from each, and an assessment of the total cost to households that use woodheaters.

Note the following in respect of table 1:

- Costs are expressed per one percentage point contribution to the emissions reduction target of 55-65%. Some items have no cost; they will occur regardless of any program of woodheater management – see the first 4 rows. And some have a negative cost. For example, insulation would provide net financial benefits to households.
- There are potentially large contributions from underlying trends, including the introduction of natural gas and the gradual phasing out of non-certified (pre-93) woodheaters.
- Insulation requirements for new houses and extensions will contribute little because the rate of new home building is expected to remain low.
- The possible contribution from a ceiling insulation retrofit of uninsulated homes is modest but useful, and also a substantial net financial benefit to households. The latter is expressed in the table as a negative cost.

Table 1 Summary of possible contributions to the required reduction in woodheater emissions

<i>Trend, development or management action</i>	<i>Maximum reduction in emissions (percentage points)</i>	<i>Cost to households (\$, annualised cost per 1% reduction in emissions)</i>
Population growth	0.0	-
General trend against woodheaters	6.0	-
Phase out of pre-93 woodheaters	26.0	-
Tasmanian Natural Gas Project	20.0	-
Insulation requirements for new houses	0.43	-\$54,000
Insulation requirements for house extensions	0.34	-\$54,000
Ceiling insulation retrofit for existing houses	5.5	-\$33,500 to -\$47,000
Reduce the moisture content of firewood	5.0	-\$2,500 to \$7,500
Improve the operation of heaters	15.0	No significant cost but may still prove difficult
Lower emissions standards for new heaters	6.0	Temporary cost for most, more difficult for some
Accelerate the scrapping of pre-93 heaters	4.0	Temporary cost for most, more difficult for some
Replace woodheaters with gas or electricity	100.0	\$0 to \$35,000

- There is no objective basis for the assessments relating to measures to reduce the moisture content of firewood or improve the operation of woodheaters; the assessments reported in table 1 are based on the informed judgement of researchers and industry experts. Consider that:
 - The relationship between moisture content and energy efficiency is unknown, except that it is negative, and also significant at high moisture levels.
 - The drying rate of unseasoned wood - which determines the required duration of storage before wood is ready to burn - is unknown.
 - The potential contribution of improved woodheater management is not objectively known. There is an assumption that a minority of households operate woodheaters in a negligent fashion and account for a large proportion of excess emissions.

Other data deficiencies include that the cost of self collected firewood is unknown because the alternative value of the householder's time cannot be observed, and the relationship between firewood prices and moisture content has not been researched.

- The crucial assumption in respect of measures to improve woodheaters – either by reducing the emission standards of new woodheaters or banning the resale and reinstallation of pre-93 woodheaters – is that there is no substantial loss of functionality and therefore no significant cost to householders. This seems to require that most people can readily learn to operate more demanding woodheaters effectively.
- Estimates for the cost of replacing woodheaters are based on a hypothetical 'average' household. There has been no detailed assessment of what it would cost householders to replace woodheaters, which would require an energy audit and some assessment of the alternative heating options and behaviours that would deliver the heating requirements of particular households. Nevertheless, it is apparent that costs may be large.

Required reduction in the number of woodheaters

Note that table 1 reports the *maximum* contributions for each of the various sources. Given the available information, there is room to debate their actual impact, for example, on the issue of whether existing nationwide trends against woodheaters will continue, the take-up of natural gas heating, or the effectiveness of measures to reduce the moisture content of firewood. Depending on what judgements are made on these and other matters, there will be a greater or lesser need to reduce the number of woodheaters in Launceston.

We consider that, on reasonable assumptions about the contributions that might be expected from the various sources, there will be a need to significantly reduce the number of woodheaters. The key findings in that respect are as follows:

- The total number of woodheaters will need to fall by about 50% in the period to 2007.
- The combined effect of the introduction of natural gas and an apparent trend away from woodheaters may deliver a 22% reduction in the number of woodheaters.
- It follows that specific incentives or other measures to convert households to alternative forms of heating would need to deliver a 28% reduction in the number of woodheaters.

Importantly, the 28% reduction in the number of woodheaters would contribute only 12 percentage points to the 55% target for reduced woodheater emissions. The disproportionate requirement reflects two considerations:

- Measures to reduce the number of woodheaters fall on new woodheaters that are assumed to have much lower emissions than the average woodheater.

- Other developments and measures independently reduce average emissions from all woodheaters, for example, measures to improve woodheater operation. These further dilute the impact of woodheater replacements in terms of the original target.

A further important finding relates to the fact that only 40-45% of the existing stock of woodheaters will be due for replacement in the period to 2007. Given a possible need to reduce the total stock by 50%, it is apparent that the requirement for conversion threatens to exceed the natural speed limit imposed by the normal pace of replacement. It is one thing to convert households to alternative forms of heating as their woodheaters fall due for replacement, but it becomes increasingly costly if the requirement is to replace equipment that is still functional and would not otherwise need to be replaced. Possibly, it will prove difficult to meet the 55% target by 2007, but feasible to aim for compliance by 2010.

That said, alternative scenarios are readily constructed. On more favourable assumptions about underlying trends and the effectiveness of regulatory measures, there may be no need for explicit measures to reduce the number of woodheaters. Under less favourable assumptions, a conversion program may need to contribute a 44% reduction in the number of woodheaters. This degree of uncertainty is regrettable, but unavoidable given the current state of knowledge.

Policy measures

For a detailed tabular summary of specific policy measures that are outlined here, refer to table 5.6 at the end of the report. The table summarises:

- Impacts on state government agencies and local government, woodheater owners, the woodheater manufacturing industry and others in the energy appliance and energy supply industry;
- Program costs;
- Whether there is a self-sustaining source of ongoing funding;
- The expected contribution to the required 55-65% reduction in woodheater emissions;
- Cost effectiveness.

Tasmania's Environment Protection Policy on Air Quality

Several regulatory measures are scheduled for inclusion in Tasmania's Environment Protection Policy on Air Quality. They can be organised into three groups:

- Measures to reduce the moisture content of firewood by:
 - regulating the moisture content of firewood sold;
 - banning the use of wet firewood.
- Measures to improve the emissions performance of new woodheaters by:
 - reducing the particle emission limit for new woodheaters;
 - banning modifications of new woodheaters.
- A measure to accelerate the scrapping of pre-93 woodheaters:
 - banning the sale and re-installation of such woodheaters.

These are statewide measures, the costs of which cannot be attributed solely to the Tamar Valley.

It seems sensible for smoke patrol officers to undertake the monitoring and enforcement activities envisaged by the proposed regulations, for example, by:

- identifying wood merchants who have falsely represented firewood as ‘ready to burn’ or falsely represented the further drying time that would be required until it is ready to burn, and taking appropriate action;
- identifying non-certified woodheaters or illegally modified woodheaters and taking appropriate action;
- identifying planned sales of pre-93 woodheaters and taking appropriate action.

These activities strongly complement the educational function of smoke patrol officers. In our view, it is not feasible to identify the separate contributions from Tasmania’s Environment Protection Policy on Air Quality and the smoke patrols.

Smoke patrols

There is broad agreement that authorised environmental health officers of the Launceston City Council need to be engaged in an active program of identifying households with consistently smoky heaters and taking appropriate action, which would include:

- identification of smoky heaters, including in the late evenings and early mornings;
- entry and inspection to determine the cause (wet wood, poor operation, faulty installation, choked flue, heater modifications);
- face-to-face instruction in the sourcing and storage of firewood, correct operation of a woodheater to ensure the heater is both functional and environmentally safe, and impact of wood smoke on air pollution and public health;
- follow-up to ensure compliance, including collection of evidence and issue of warnings and fines as appropriate;
- follow-up with firewood and equipment suppliers as appropriate, including warnings and fines as appropriate;
- development of a database to facilitate further analysis and understanding of woodsmoke causes and the effectiveness of management actions.

Costs and cost effectiveness have been estimated as follows:

- Total program costs for the period to 2007 are estimated at \$240,000. The set-up costs of \$40,000 include pilot testing of the early program designs. We consider that a key underlying assumption – which is that 10-15% of households contribute disproportionately to emissions – needs to be tested at the outset.
- The smoke patrols may be reasonably expected to contribute about 11 percentage points to the emissions reduction target of 55-65%.
- Cost effectiveness may therefore be put at \$21,000 per 1 percentage point contribution to the target (= \$240,000 / 11.4).

Given the pre-existing impact of certain favourable developments and measures, mainly the introduction of natural gas and the phasing out of pre-93 woodheaters, the smoke patrol may bring the cumulative reduction in emissions to about 43 percentage points. On this figuring, a further substantial contribution would be required from specific measures to reduce the number of woodheaters, specifically, a contribution of 12 percentage points to reach the target of a 55% reduction in emissions.

Incentive scheme for conversion to electric or gas heating

The design of an incentive scheme must take account of the fact that large numbers of woodheaters will be replaced by gas or electricity over the coming years, even in the absence of an incentive program. The contributing factors are:

- There seems to be a significant underlying trend away from woodheaters, probably due to some combination of technological and lifestyle developments.

- The pattern seems to be for many people to acquire woodheaters at a certain stage in the family's lifecycle, go through a woodheater 'stage', then dispose of the woodheater in later life.
- There will be significant conversions to gas when it arrives, which is scheduled for the winter of 2003.

Therefore, the prospect is for substantial program funds to be wasted on conversions that would have occurred anyway if a general subsidy offer were made.

We consider that a targeted offer makes more sense, provided it is conducted on a pilot scale in the first instance, with subsequent evaluation to assess the following matters:

- *Additionality:* The main purpose of the pilot would be to assess the extent of additionality that is achieved, that is, the number of induced conversions relative to the number of conversions that would have occurred anyway. This would require a survey of participants, involving face-to-face interviews to work through the process of decision-making, identify the various factors that contributed to the decision, and assess the role of the incentive payment.
- *Amount of the incentive payment:* The survey would also provide an opportunity to assess whether the incentive payment could be reduced without serious reduction in take-up. To assess the response to an increase in the amount of the incentive payment it would also be useful to include a reasonable sample of people who showed an interest in the scheme but failed to follow through. They could be identified if appropriate records are kept when inquiries are made.
- *Need for an incomes test:* It may emerge from the analysis that the households that would have made the conversion anyway share certain characteristics, for example, above average incomes. This may provide the basis for an income test or other eligibility criteria.
- *Scope for improvement:* There will probably be opportunities to improve the scheme, for example, in relation to the quality of information provided or the efficiency of processes. Widespread dissatisfaction with the actual experience with alternative heating would be a particular cause for concern.

The specific proposal for the pilot scheme is to offer a \$500 incentive payment to families with young children (say, less than 5 years old) and to restrict the pilot to a small cross-section of suburbs that are broadly representative of Launceston. We estimate the maximum program cost of a pilot scheme at \$111,500, for implementation in the winter of 2001. Again, the smoke patrol officers would have a central role. We envisage that they would conduct the required inspections – to confirm the existence of a woodheater beforehand and its removal afterwards – and approve funding applications on the spot.

Expectations for a full scale incentive scheme

Given a successful pilot, we consider that it may be reasonable to aim for the following outcomes from a full scale program:

- The scheme delivers a net reduction of 1,400 woodheaters, equivalent to 10% of the current stock.
- The upfront costs are \$40,000, comprising set-up and evaluation of the pilot scheme.
- The scheme will require further refinement and analysis to optimise subsequent offers, at a cost of \$40,000.
- The ongoing costs per successful application are \$550, comprising a \$500 incentive payment and \$50 in processing costs.
- The scheme achieves additionality of 67%. That is, two thirds of the conversions are additional, and one third would have occurred anyway.

On these assumptions, total program costs are \$1,230,000.

On the issues of cost-effectiveness and the contribution of the scheme to the 55% target for reduced emissions, the key findings are:

- A 10% reduction in the stock of woodheaters will contribute only 4.5 percentage points to the target, bringing the total reduction in emissions to 47%, still significantly short of the 55% target.
 - Each percentage point reduction in emissions would cost \$273,000 in program funds (= \$1,230,000 / 4.5).
 - Clearly, a 10% reduction in the number of woodheaters does not meet the projected requirement to reduce woodheater numbers by 28%. But there are good reasons to proceed slowly:
 - There is considerable uncertainty about the actual need for a larger scheme. Further commitments should be decided in the light of actual contributions from other favourable developments over time.
 - It is important not to exceed the speed limits imposed by the normal processes of woodheater replacement.
- At this point therefore, it is difficult to see beyond a woodheater conversion scheme that aims to replace 10% of the existing stock.

Other policy measures

Certain other policy measures have the potential to contribute significantly to the target, and to be more cost-effective than the proposed incentive scheme. However, more information is required to assess their content and cost effectiveness. There are three broad options:

- A public education program is a future option. However, there is a need to better understand the causes of excess smoke, identify effective remedies, and refine the message, before going public.
- We consider that the proposed incentive program would have little effect on space heating in rental accommodation. Not only would few landlords take up the offer, the normal market balance is likely to be quickly restored by subsequent conversions in the opposite direction. However, landlords may respond to an offer of assistance to replace existing woodheaters with low emission woodheaters. To assess that option, better information about the relative performance of different generations of woodheaters is required.
- An insulation retrofit program for uninsulated houses might make a small but useful contribution, and also provide significant financial benefits through energy savings. But the outcome could be perverse. The concern is that the combination of well insulated homes and oversized woodheaters will result in heaters being set on slow burns for longer periods, generating little or no reduction in emissions, and possibly some increase in emissions.

Importantly, the smoke patrol may contribute significantly to the resolution of these issues. There is need for authorised officers to engage directly with woodheater users, not only to instruct, but also to learn.

1. Introduction

The purpose of this study is to provide advice on the relative cost-effectiveness and feasibility of actions to reduce emissions from woodheaters and fireplaces in the Tamar Valley region of Tasmania, with particular attention to the design of a financial incentive scheme to replace woodheaters and fireplaces.

1.1 Background

Woodheaters are the major source of particle emissions in southern cities in colder months (ie ahead of transport) and are responsible for regular exceedences of the ambient air quality standard for particles, as set in the National Environment Protection Council Measure on Ambient Air Quality (Air NEPM).

The Air NEPM provides that its goals be achieved by 2008. Currently, Launceston reports exceedences of the NEPM's particulate standard at about 7-10 times the maximum rate that will be permitted in 2008 – that is, 36-47 exceedences per year, compared with the maximum of 5 that will be permitted. About 45% of Launceston households currently rely on woodheaters as their main source of heating. Further key estimates illustrating the wood heating and air quality situation in Launceston are included in table 1.1.

Unless otherwise stated, further references to woodheaters throughout this report should be taken to include open fires (fireplaces).

Table 1.1 Woodheaters and air quality in Launceston

<i>Woodheaters in Launceston, 2000</i>	<i>Number</i>	<i>%</i>
Households with wood heating (includes woodheaters & fireplaces)	13,400	45.9%
Households with fireplaces	1,400	4.9%
Households with pre-93 woodheaters	5,400	18.4%
Households with post-93 woodheaters	6,600	22.7%
Total firewood consumption (tonnes/year)	66,300	
PM ₁₀ emissions generated by woodheaters (tonnes/year)	609	
<i>Air quality in Launceston, 1997-2000</i>		
Average PM ₁₀ (µg/m ³ , winter*)	36-42	
Total annual breaches of NEPM air standard	36-47	
Required reduction in woodheater emissions, to achieve NEPM air standard** (%)		55-65%

Sources:

DPIWE, DPIWE estimates based on EMRS(2000), <http://www.environment.gov.au/epg/npi/>

Notes:

* Average for May-August

** This estimate is derived in chapter 3.

There has been significant interest in Tasmania for a more effective approach to dealing with woodsmoke. DPIWE, Launceston City Council and Tamar Region NRM have jointly made a funding application for a woodheater emissions management program under the Commonwealth Government's Natural Heritage Trust Strategic Program for Tasmania. A key feature of this proposal is a financial incentive scheme to replace woodheaters. A number of other measures could also be considered for inclusion in such a program.

1.2 Objectives of the study

The objectives of the study are as follows:

- Use existing information to summarise the health and economic impacts of wood smoke pollution in the Tamar Valley, describe the state of play in respect of woodheater numbers and operating characteristics, and provide an indication of projected air quality in Launceston by 2008 under a Business As Usual (BAU) scenario.
- Determine the infrastructure and operating requirements needed to successfully implement management actions, with particular attention to the design requirements of a financial incentive scheme.
- Identify the cost-effectiveness of each option in terms of potential emission reductions, ie the cost per unit of emission reductions for each action.
- Identify the practicality and economic sustainability of implementing each action, including an assessment of the impacts on various stakeholders, and whether or not there is a sustainable source of funding.
- Recommend at least one package of cost-effective actions that collectively could lead to compliance with the Air NEPM standard for particles by 2008, including recommendations on the design, and supporting management actions, of an effective financial incentive scheme.

1.3 Structure of the report

The report is organised in 4 further chapters:

- Chapter 2 defines the objectives of the woodheater management program in terms of a targeted percentage reduction in woodheater emissions. This involves a review of data on air quality and data on the relative importance of woodheaters as sources of PM₁₀. This chapter also includes an overview of the health impacts of PM₁₀.
- Chapter 3 provides information about a range of trends, developments and possible policy measures that will contribute to the emissions reduction target over the next 10 years. Ten separate factors are analysed.
- Chapter 4 provides indicative scenarios for various combinations of the various factors that are identified and analysed in chapter 3.
- Chapter 5 provides analysis of the main policy options. Several statewide measures are scheduled for inclusion in Tasmania's Environment Protection Policy on Air Quality. At the local level the key initiatives are a smoke patrol and a woodheater replacement incentive program.

2. Objectives for a woodheater management program

The main purpose of this section is to define the objectives of a woodheater management program in terms of the desired reduction in woodheater emissions. It is organised as follows:

- Section 2.1 provides a summary statement of the health impacts of particulate matter (PM).
- Section 2.2 reports the current situation in terms of ambient concentrations of PM₁₀, being particulate matter that is less than 10 microns in diameter. It also reports certain comparative data that indicates some improvement in air quality during the 1990s.
- Section 2.3 provides an assessment of the required reduction in woodheater emissions of PM₁₀ to meet air quality standards.
- Section 2.4 is a brief statement of the main conclusions.

2.1 Health impacts of PM₁₀

Woodheaters emit several air pollutants in addition to PM, including carbon monoxide, hydrocarbons, and polycyclic organic matter (POM). However PM, consisting of minute liquid and solid particles, is the focus of concern in the present context. Of greatest concern to public health are the particles small enough to be inhaled into the deepest parts of the lung. These particles are less than 10 microns in diameter – hence, PM₁₀.

The results of two types of studies are reviewed here - epidemiological studies and laboratory studies. The former are designed to establish the health impacts by statistical association between measured concentrations of PM₁₀ and various indicators of health status and impacts – that is, dose-response relationships. The latter are designed to understand the mechanism(s) by which PM₁₀ affects health. The following account draws on several secondary sources: Vedal (1995), NEPC (1998b), NEPC (2000), UNE Air Quality Research Group (1998), Dockery (2000) and the report of the Working Party into Air Pollution, Environmental Health and Respiratory Diseases (Working Party, 1996).

2.1.1 Epidemiological studies

Many recent epidemiological studies have observed that ambient particulate pollution is associated with adverse health effects, including increased mortality rates and hospital admissions for respiratory and cardiovascular disease. For instance, in the Harvard Six Cities Study, Dockery et al (1993) showed that city-specific mortality rates among a sample of over 8,000 adults were linearly associated with fine particle concentrations. Similarly, a Sydney study by Morgan et al (1998) showed that a 2.6% increase in daily mortality was associated with an increase in PM₁₀ of approximately 25 µg/m³. In Seattle, emergency room visits for asthma were observed to begin increasing at a PM₁₀ concentration between 20 and 30 µg/m³, at an estimated rate of 3.4% for each 10 µg/m³ (Schwartz et al, 1993). In Sydney, increases in hospital admissions of 3% for COPD (chronic obstructive pulmonary disease) and 2.5% for heart disease have been found for an increase of PM₁₀ levels of approximately 25 µg/m³ (Morgan et al, 1996).

Results of several other epidemiological studies are presented in tables 2.1 to 2.3.

Table 2.1: Association between PM₁₀ and daily mortality

<i>Location and time</i>	<i>Particle measure</i>	<i>PM₁₀ mean (range)</i>	<i>% change in mortality for each 10 µg/m³ increase in PM₁₀ (95%CI)</i>	<i>Reference</i>
St. Louis, MO (1985-86)	PM ₁₀	28 (1-97)	1.5% (0.1, 2.9)	Dockery et al, 1992
Kingston, TN (1985-86)	PM ₁₀	30 (4-67)	1.6% (-1.3,4.6)	Dockery et al, 1992
Utah Valley (1985-89)	PM ₁₀	47 (1-365)	1.5% (0.9, 2.1) total 3.7% (0.7, 6.7) respiratory 1.8% (0.4, 3.3) cardiac	Pope et al, 1992

Source: Vedal (1995)

Table 2.2: Association between PM₁₀ and daily hospitalisation rate

<i>Location</i>	<i>Particle measure</i>	<i>PM₁₀ mean (range)</i>	<i>% change in hospitalisation for each 10 µg/m³ increase in PM₁₀ (95%CI)</i>	<i>Reference</i>
Toronto	PM ₁₀	33 (N/A-96)	2.1% (-0.85, 5.1) asthma 3.4% (0.4, 6.4) total respiratory	Thurston et al, 1994
Minneapolis	PM ₁₀	36 (18-58*)	4.5% (1.8, 7.5) COPD 1.6% (0.2, 2.9) pneumonia	Schwartz, 1994c
Birmingham	PM ₁₀	45 (19-77)	2.4% (0.8, 4.1) COPD 1.8% (0.7, 2.8) pneumonia	Schwartz, 1994b

Source: Vedal (1995)

* 10th and 90th percentiles**Table 2.3: Association between PM₁₀ and respiratory symptoms**

<i>Location and time</i>	<i>PM₁₀ mean (range)</i>	<i>Population Group</i>	<i>% change in daily symptoms for each 10 µg/m³ increase in PM₁₀ (95% confidence interval)</i>	<i>Reference</i>
6 US Cities (1984-88)	30 (N/A-117)	Children	LRI* 15.2% (6.3, 24.9) URI** 6.9% (-0.7, 15.0) Cough 8.6% (2.2, 15.4)	Neas et al, 1992
Utah Valley (1989-90)	46 (11-195)	Children Asthmatics	LRI 5.1% (1.1, 9.3) URI 3.7% (0.7, 6.8) LRI 0.2% (-4.2, 4.8) URI -0.2% (-4.2, 4.0)	Pope, 1991
Utah Valley (1990-91)	76 (7-251)	Symptomatic children Asymptomatic children	LRI 4.8% (1.5, 8.3) URI 3.7% (0.6, 6.9) Cough 2.4% (-1.8, 6.8) LRI 5.2% (2.3, 8.2) URI -0.2% (4.9, 4.7) Cough 3.4% (-0.1, 7.0)	Pope et al, 1992
Wageningen, NL (1990-91)	N/A (10-175)	Children	Cough 0.7% (-0.2, 1.6)	Roemer et al, 1993

Source: Vedal (1995)

*LRI = lower respiratory illness;

**URI = upper respiratory illness

Table 2.4: Examples of short-term exposure-response relationships of PM₁₀ with various health indicators

<i>Health effect indicators</i>	<i>Percentage change in health indicator per 10 µg/m³ increase in PM₁₀</i>
Daily mortality (all cause)	1.0 ^(a)
Respiratory deaths	3.4 ^(a)
Cardiovascular deaths	1.4 ^(a)
<u>Hospital admissions</u>	
Respiratory Disease	1.96 ^(b)
COPD	3.26 ^(b)
Pneumonia	1.42 ^(b)
Heart Disease	0.4 ^(c)
Exacerbation of Asthma	3.0 ^(a)
<u>Increase in respiratory symptoms</u>	
Lower Respiratory	3.0 ^(a)
Upper Respiratory	0.7 ^(a)
Cough	1.2 ^(a)

(a) Dockery and Pope (1994); (b) Abt. Associates (1996); (c) Schwartz and Morris (1995).

Source: NEPC (1998b)

Table 2.4 provides examples of some of the observed short-term dose-response relationships between PM₁₀ and different health indicators, at various study sites. Other important results/issues arising from epidemiological studies include:

- Dose-response relationships vary between regions, possibly indicating that other factors can modify the relationship.
- Children, the elderly and those with pre-existing lung and heart disease appear to be particularly susceptible to the impacts of PM (Vedal, 1995).
- PM health effects have been associated with different ambient PM size fractions (ultrafine, fine and coarse). In analysing daily mortality rates in six Eastern US cities over 8 years, Schwartz et al (1996) found that particles between 2.5 and 10 microns had no association with daily mortality. The strongest association with daily mortality and morbidity was with PM_{2.5}, which arise mainly from combustion. Woodsmoke is almost entirely PM_{2.5} (Larson and Koenig, 1994). Autopsies have shown that PM_{2.5} are retained in human lungs (Churg & Brauer, 1997).
- There is no threshold concentration of either PM₁₀ or PM_{2.5} below which adverse health effects have not been observed (NEPC 1998b: page 135). That said, Vedal (1995) notes that most of the evidence shows increasing mortality, hospitalisations, emergency room visits and respiratory symptoms at PM₁₀ concentrations that exceed 20 µg/m³.

Importantly, the epidemiological studies that are reported above have focused on short-term dose-response relationships. That is, the health impacts are detected in a short period after the observed increase in concentrations of PM₁₀, usually within several days. Long-term exposure to PM₁₀ may have additional adverse health impacts, given that that PM can carry carcinogens into the lungs¹. Table 2.5 presents the results of recent longitudinal studies, indicating a positive association between PM₁₀ concentrations and lung cancer death. However, the health effects arising from long-term exposure are still regarded as unclear, and further studies are currently under way in the US.

¹ Particulate matter collected from the ambient air contains condensed organic matter that is carcinogenic in animals and mutagenic in short-term bioassays (Lewtas, 1993; Cupitt et al., 1994).

Table 2.5: Recent longitudinal studies of the association between annual PM₁₀ concentrations and lung cancer death

<i>Description</i>	<i>Particle measure</i>	<i>PM₁₀ range of annual means</i>	<i>% change in lung cancer for each 10 µg/m³ increase in PM₁₀ (95% confidence interval)</i>	<i>Reference</i>
6 U.S. cities (population sample = 8,111)	PM ₁₅	18.2 - 46.5	11.8% (-7.2, 34.4)	Dockery et al, 1993
151 U.S. metropolitan areas (population sample = 552,138)	PM _{2.5} or SO ₄	14.4 - 94.0	4.0% (1.3, 6.6)	Pope et al, 1995b

Source: Vedal (1995)

Results from epidemiological studies are necessarily qualified by the possibility of ‘confounding effects’, including the influence of other pollutants and meteorological conditions that may also have adverse health effects. However, both the number of studies and variety of environmental conditions in which the studies have occurred offer compelling evidence in support of a causal link between short-term increases in particulate pollution and adverse health effects. As Pope et al (1995a) note, ‘... taken together it is unlikely that such confounding could be consistently acting in all these studies.’

2.1.2 Laboratory studies

In terms of biological explanations for the apparent health impacts of PM₁₀, there is uncertainty regarding:

- the toxic characteristics of particles that are responsible for health effects, and;
- the physiological events/responses that occur in the presence of particles, that is, the mechanisms that cause an increase in cardiovascular and respiratory related death and illness.

Laboratory studies have identified many plausible pathways, providing support for the dose-response relationships identified in epidemiological studies. One hypothesis is that bioavailable toxic agents, concentrated on the surface of fine particles and produced by high temperature combustion, may be responsible for some of the observed toxic effects of PM. This theory is based on laboratory studies in which oil and coal fly ash and collected ambient particles were instilled into the lungs of rats, showing that the metal content and their bioavailability determined the acute inflammatory response of particles (Costa & Dreher, 1997)². Other studies (Guilianelli et al, 1993; Keeling et al, 1994; and Tepper et al, 1994) have provided evidence that the concentration of surface-complexed iron (Fe³⁺) on a particle is associated with the likelihood of generating free oxygen radicals and subsequently lung inflammation.

In addition to causing structural damage to lung tissues, it has been suggested that PM induced inflammation of the lung may trigger the release of chemical mediators which affect the autonomic control of the heart (Stone and Godleski, 1999), thus accounting for

² Other observed affects (including inflammation of the lung) have been attributed to: the organic fraction of particles (Reyes et al, 2000); the presence of biological material (Targonski et al, 1995); or ultra-fine particulate constituents (Peters et al, 1997).

the cardiovascular impacts of PM. Alternatively (or additionally), laboratory analysis suggests that PM detrimentally alters the coagulability of blood (Seaton, 1996).

2.1.3 Estimates of health costs

The final impact statement for the NEPM air standard (NEPC 1998b: section 13.9) provides an indicative estimate of the dollar value of the reduced mortality that might be attributed to the NEPM standard on PM₁₀, put at \$4.3B. This comprises 600 fewer premature deaths, each valued at \$7M; the latter figure may be regarded as controversial. The estimate of 600 fewer premature deaths has been derived as follows:

- Morgan et al (1998) estimated that PM₁₀ pollution in Sydney cause 397 premature deaths per year.
- This was extrapolated to the Australian population on a per-capita basis, giving a figure of 2,400 deaths.
- To roughly adjust for the reduced health impacts in rural areas, the number was halved to 1,200.
- It was estimated that the proposed standard would halve the health impacts of PM₁₀ – ie, to 600.

This is clearly a very rough estimate of total costs and of savings that might be attributed to the NEPM. However, the following results are derived by extrapolating the Sydney results to Launceston³.

- There would be 6.3 premature deaths per year in Launceston.
- The total cost would be \$43.8 M per year.
- Compliance with the standard would deliver benefits worth \$21.9M.

Importantly, this is a very partial measure of the dollar value of health impacts. It excludes, for example, the cost of increased incidence of non-fatal illness, and the possible longer term impacts on the incidence of cancer and respiratory and cardiovascular problems.

2.1.4 Summary

Epidemiological studies overwhelmingly show that adverse health impacts are associated with increases in PM₁₀. Importantly, PM_{2.5} has been identified as having the strongest association with daily mortality and morbidity (Schwartz et al, 1996) and that woodsmoke is comprised almost entirely of PM_{2.5} (Larson and Koenig, 1994).

Although there is uncertainties surrounding the specific characteristics of PM₁₀ that are responsible for the observed health effects, and about the specific mechanisms through which these particles impact on human health, there are a number of plausible hypotheses.

Little is known about the impacts of long-term exposure of PM₁₀ to human health. But it is known is that PM_{2.5} is retained in human lungs and that PM can carry carcinogens.

³ Average annual concentrations of PM₁₀ are very similar in Launceston and Sydney (about 20µg/m³). But the seasonal distribution is probably quite different.

2.2 Air quality in Launceston

This section is organised under two headings. Section 2.2.1 reports air quality data for the period 1997-2000. Section 2.2.2 provides a comparison with data that was collected in the early 1990s.

2.2.1 Air quality, 1997-2000

Figure 2.1, figure 2.2 and table 2.6 report results of DPWIE's current air quality monitoring program in Launceston. The Department describes the program as follows⁴:

Because the overwhelming source of respirable particles in Launceston is the combustion of wood for home heating, daily monitoring of particles in Launceston's ambient air is conducted throughout the cooler months of the year.

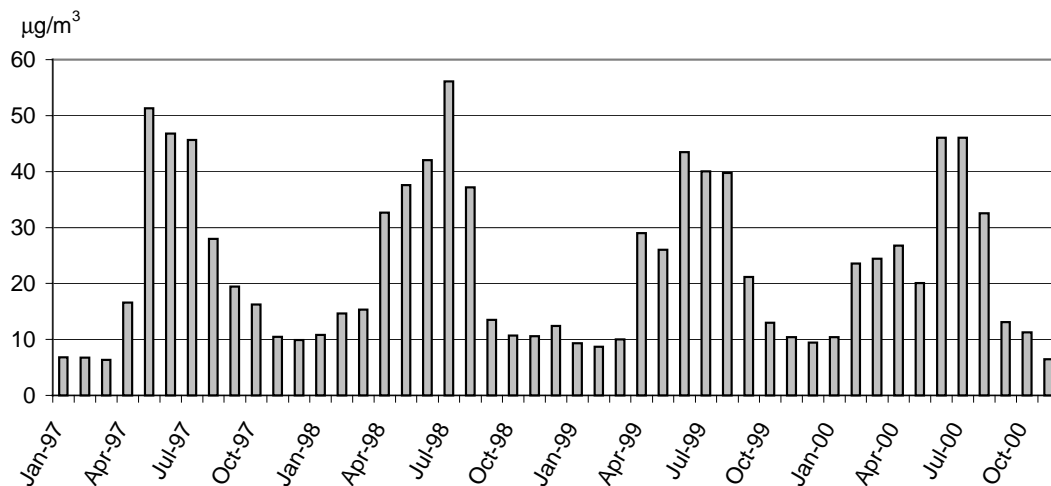
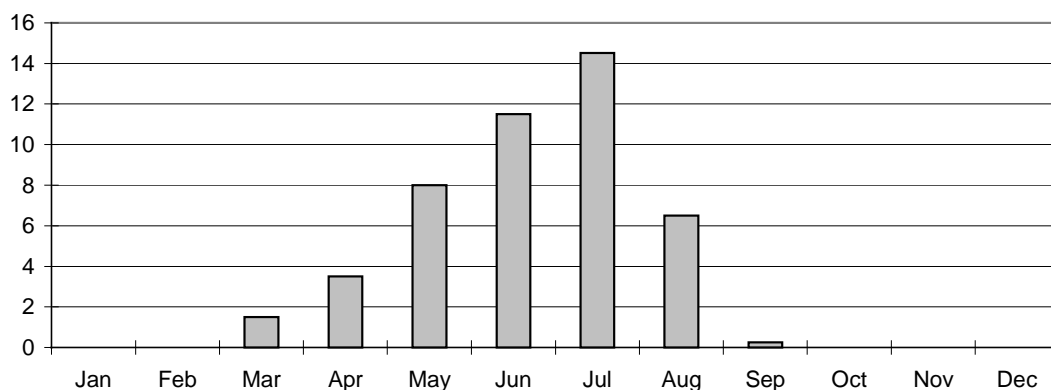
Since 1997, the Department has conducted daily monitoring of respirable particles from the start of May to the end of September. For the rest of the year, monitoring is conducted every sixth day.

Sampling for particles is conducted via the use of a high volume sampler. This involves passing air through a size selective screen to first remove the larger sized particles from the air stream, followed by particle impaction onto a filter which traps the respirable particle fraction. By measuring the weight gained by the filter and the volume of air passing through the sampler, the concentration of respirable particles in the sampled air is calculated.

In respect of the data presented in figures 2.1 and 2.2 and table 2.6, note the following:

- The NEPM air standard envisages that the ambient concentrations of PM₁₀ (measured daily, over 24 hours) should not exceed 50µg/m³ on more than 5 occasions per year.
- Taking the 1997-2000 period as a whole, Launceston's air quality failed the NEPM air standard for PM₁₀ by a substantial margin. Specifically, breaches of the 50µg/m³ standard have occurred 7-10 times more frequently than the 5 exceedences per year that are prescribed by the standard.
- The 4 months from May to August return the highest monthly average concentrations of PM₁₀ over the period 1997-2000, and account for 96% of the recorded breaches of the NEPM air standard in that period.
- Concern has been expressed that meteorological conditions over the last several years have been relatively benign, implying that higher readings would have been returned if normal meteorological conditions had prevailed in 1997-2000, and possibly much higher readings under abnormally adverse conditions. (The specific meteorological conditions that are of concern are temperature and wind speed. Higher than normal winter temperatures may reduce the amount of emissions; higher than normal wind speeds would disperse those emissions more rapidly.) However, based on preliminary analysis of the meteorological record, DPIWE has advised that meteorological conditions between 1997-2000 do not appear to have been significantly different to those of 1992-93.

⁴ <http://www.dpiwe.tas.gov.au/env/LAQ.htm>

Figure 2.1 Ambient concentrations of particulates: monthly averages, 1997-2000**Figure 2.2 Average exceedences of air standard: by month, 1997-2000****Table 2.6 Ambient concentrations of PM₁₀: Ti Tree site, 1997-2000**

	1997	1998	1999	2000
<u>Average concentrations (µg/m³)</u>				
May-August average	42	43	37	36
Annual average	22	24	22	24
<u>Extreme readings (µg/m³)</u>				
Maximum reading	121	122	92	108
6th highest reading	90	100	80	83
90th percentile	72	73	65	69
<u>Breaches of the NEPM air standard*</u>				
May-August exceedences	47	44	36	33
Total exceedences	47	45	38	36

Source: DPIWE monitoring program

Note:

* An exceedence is recorded when the observed concentration exceeds 50 µg/m³.

- The two most recent years (1999 and 2000) returned consistently lower readings than 1997 and 1998. The one statistic that has not fallen is the annual average – see table 2.6. However, inspection of figure 2.1 shows that this reflects higher readings *outside* the 4 months (May-August) that account for most of the exceedences of the NEPM air standard. The average for May-August has fallen, consistent with observed reductions in extreme readings and exceedences. Again, there is no evidence that fortuitous variations in meteorological conditions have contributed significantly to these reductions.

Table 2.7 provides some additional perspective on the air pollution problem in terms of the duration and severity of individual exceedence ‘episodes’. An exceedence episode is defined as a continuous sequence of days that breach the air quality standard. Our analysis focuses on the winter months (May-September) as this is the only period where monitoring data from Ti Tree Bend is available on a continuous daily basis. Note the following:

- 160 breaches were recorded, comprising 70 individual exceedence episodes. The duration of individual episodes ranges up to nine days.
- The 2 episodes of 7 and 9 days duration account for 10.0% of the exceedences. 25.7% of the episodes account for 53.1% of the exceedences.
- The longer episodes also return higher average pollution readings, at least for episodes of up to 5-6 days duration. (Samples of the longest episodes are very small.)

Table 2.7 Duration of exceedence episodes: May-September, 1997-2000

<i>Duration of exceedence episode (days)</i>	<i>Number of exceedence episodes</i>	<i>Cumulative total of exceedence episodes (%)</i>	<i>Number of breaches of the air standard</i>	<i>Cumulative total of air standard breaches (%)</i>	<i>Average PM₁₀ concentration (µg/m³)</i>
9	1	1.4%	9	5.6%	73
8	0	1.4%	0	5.6%	-
7	1	2.9%	7	10.0%	66
6	3	7.1%	18	21.3%	74
5	4	12.9%	20	33.8%	81
4	4	18.6%	16	43.8%	69
3	5	25.7%	15	53.1%	72
2	23	58.6%	46	81.9%	67
1	29	100.0%	29	100.0%	61
Total	70	-	160	-	-

Source: DPIWE monitoring program

2.2.2 Reduction in PM₁₀ since 1992-93

In addition to DPIWE’s data for 1997-2000, there is also some data for the early 1990s. It was collected on behalf of the Working Party into Air Pollution, Environmental Health and Respiratory Diseases (Working Party, 1996), and relates to the period 1992-93. Comparison between the two sets of data is complicated by several factors, as follows:

- The earlier data from the Ti Tree site is for TSP (total suspended particles), which is expected to return readings that are about 10% greater than for PM₁₀. The obvious adjustment is readily made.

- The earlier data was collected on every second day from May to August, compared with daily readings for the winters of 1997-2000. Fortunately, however, the earlier data was collected at several sites other than Ti Tree and, by combining the data from all 4 sites, DPIWE has been able to create a proxy daily record.
- The earlier monitoring program was interrupted in such a way that there is no single complete calendar year of data, encompassing a complete winter. For the purpose of comparing the earlier data with returns for 1997-2000, DPIWE has therefore provided summary statistics for the year July 1992 to June 1993. The relevant winter is a composite that comprises the later half of the 1992 winter and the early half of the 1993 winter.

This analysis of the 1992-93 data yields the results presented in table 2.8. On these data, ambient concentrations of PM₁₀ were 30-40% lower at the end of the 1990s compared with 1992-93⁵. This strongly suggests that a significant reduction in PM₁₀ emissions has occurred. Again, DPIWE has advised that meteorological conditions were not significantly different between the early and late 1990s, and would not account for the observed improvement in air quality.

Table 2.8 Ambient concentrations of PM₁₀: Ti Tree site, 1992-93 compared with 1999 and 2000

	1992-93	1999	2000	% change, 1992-93 to 1999-00
<u>Average concentrations (µg/m³)</u>				
Annual average	33	22	24	-30%
<u>Extreme readings (µg/m³)</u>				
Maximum reading	162	92	108	-38%
6th highest reading	131	80	83	-38%
<u>Breaches of the NEPM air standard</u>				
Total exceedences	65 ⁶	38	36	-43%

Source: DPIWE

2.2.3 Summary

Air quality monitoring conducted in Launceston during the 1990's indicated that the ambient concentrations of PM₁₀ were reaching levels high enough to be of significant concern. The monitoring revealed that ambient concentrations of PM₁₀ exceeded the 50µg/m³ standard recommended in the NEPM for Ambient Air Quality from 36 up to 65 days per year. The vast majority of these exceedences occur during winter, coinciding with the period of peak woodheater use. Although the data suggests that there has been some reduction in the concentrations of PM₁₀ over time, the levels remain significantly above the NEPM air standard.

⁵ Note that we rely on the annual average and the 6th highest reading in drawing this conclusion. The maximum reading is highly variable and provides little information about the trend in this context. Also, the number of exceedences would not be proportional to the ambient concentration.

⁶ DPWIE (2000), *Discussion Paper on Air Quality Management and Policy Development*, p3.

2.3 Required reduction in woodheater emissions

Given the above account of recent air quality in Launceston, what reduction in woodheater emissions is required to deliver compliance with the NEPM air standard? The answer depends on several factors:

- required percentage reduction in total emissions of PM₁₀;
- percentage of the total emissions during periods of poor air quality that are due to woodheaters; and
- expected percentage change in non-woodheater emissions of PM₁₀.

Consider each variable in turn.

2.3.1 Required percentage reduction in total emissions of PM₁₀

Two assessments of the required reduction in woodsmoke are available to the study, both indicating that a reduction of about 45% is required to meet the NEPM air quality standard. The first of these draws on the PhD research of Michael Power, a scientific officer with DPIWE. Mr Power employed a computer model of woodsmoke dispersion in the Tamar Valley under meteorological conditions that are associated with poor dispersion of air pollutants and high ambient concentrations. (Low wind speed is the crucial meteorological factor.) The model predicts that ambient concentrations⁷ of PM₁₀ would peak at 89.7µg/m³ in certain parts of the Launceston area. Given a NEPM standard of 50µg/m³, it follows that total emissions under these particular meteorological conditions would need to fall by about 45%.

However, a similar figure is arrived at using a more robust method suggested by DPIWE, as follows:

- The NEPM air standard allows for a maximum of 5 exceedences of the standard, which means that the 6th highest reading needs to come in under 50µg/m³.
- The 6th highest readings for 1997-2000 are recorded in table 2.6; the average over those last 4 years is 88µg/m³.
- This suggests that, under the meteorological conditions that prevailed over the last 4 years, a 45% reduction in emissions (from 88 to 50µg/m³) would have delivered substantial compliance with the NEPM air standard.

For the purposes of this report, we assume that the target is a 45% reduction in emissions of PM₁₀ under winter conditions of poor dispersion. But we also report figuring against a target of 55% reduction. The more demanding target may reflect a desire to deliver compliance with the NEPM air standard under more adverse conditions (ie, very poor dispersion), or simply earlier than envisaged in the NEPM.

2.3.2 Percentage of total emissions that are due to woodheaters

DPIWE's *Discussion Paper on Air Quality Management and Policy Development* reports that emission inventory studies '... suggest that over 90% of Launceston's PM₁₀ can be attributed to firewood use' (DPIWE 2000: page 5). DPIWE's recent direct advice to the study, which has the advantage of emissions data that has become available since the *Discussion Paper* was published in January 2000, put the woodheater contribution at 85%.

⁷ Ambient concentrations are measured as the 24 hour average concentration, which accords with the terms of the NEPM standard.

To understand this estimate it is necessary to distinguish between emissions from the immediate Launceston area and emissions for other parts of the Tamar valley that constitute the Launceston airshed, since both contribute to Launceston's air pollution. The basic facts about PM₁₀ from the immediate Launceston area are as follows:

- Estimates reported in the National Pollutant Inventory⁸ put PM₁₀ emissions from the domestic burning of solid fuel at 630 tonnes/yr or 60.3% of annual total emissions.
- About 25% of the annual total is attributed to roads. These are not direct emissions from vehicles but particles that settle on roads from original sources and are re-entrained by the passage of vehicles. These are excluded because they are not original sources, putting the woodsmoke share at about 80% of original sources.
- Woodsmoke is a winter pollutant and, if non-woodsmoke sources are allocated between winter and summer in a reasonable fashion, the woodsmoke share of winter pollution is estimated at 90%. Examples of the allocation of woodsmoke sources include:
 - allocation of all BBQ emissions to summer;
 - allocation of 25% of lawn-mower and wildfire emissions to winter.

The further complication is that some portion of Launceston's air pollution is contributed by sources outside Launceston. However, based on modelling work⁹ by Michael Power, it appears that this contribution can be no more than 5%. That is, at least 95% of the problem can be attributed to sources within Launceston. In that case the contribution of Launceston's woodheaters would be 90% of 95%, or about 85%. That said, certain qualifications of the model should be noted:

- These results only take residential woodsmoke into account. They do not take into account other PM₁₀ sources such as vehicle emissions and wind-blown dust.
- The Base scenario and this "no Launceston" scenario were run for a 2-day period only, at a time considered representative of poor dispersion conditions in winter. But it is not known whether these results represent the worst PM₁₀ concentrations currently experienced within Launceston, or at what percentile they lie at.
- The model has not been validated against real measurements.

For the purposes of this report, we assume that woodheaters account for 85% of PM₁₀ emissions under winter conditions of poor dispersion.

2.3.3 Expected percentage change in non-woodheater emissions of PM₁₀

Finally, it is necessary to consider whether trends in non-woodheater emissions will add to the management task in respect of woodheater, or ease that task.

In our view, it is reasonable to assume that changes in non-woodheater emissions will be minimal, and within the range of +/-1% per year for the foreseeable future. Relevant considerations are as follows:

- ABS projections for Tasmania's population for the period 2001-2011 range from +2% to -5%.
- Informal advice from the Launceston city council is that the local economy may grow at 1%/year over the next several years if expected energy developments eventuate.

⁸ <http://www.environment.gov.au/epg/npi/>

⁹ This involved running the air pollution model in an identical manner to the Base scenario, but in the absence of emissions from the Launceston source. Any PM₁₀ concentrations found within the Launceston region must therefore be the result of advected emissions from other sources.

- Transport emissions dominate non-woodheater sources of PM₁₀, and BTCE projections for greenhouse gas emissions from the Australian road transport sector indicate that emissions from road transport will grow only slightly faster than population, by an additional 0.2%/year.

2.3.4 Findings

Table 2.9 summarises the results of the above analysis. Note the following:

- Woodheater emissions need to fall by *at least* 50-55% in order to comply with the new NEPM air standard. This assessment is based on the assumptions that total emissions need to fall by 45% and woodheaters account for 85% of emissions. See column A.
- Under less favourable assumptions, the required reduction in woodheater emissions may of the order of 65% - that is, if the required reduction in total emissions is 55%. See column B.
- The result is not particularly sensitive to reasonable assumptions about the trend in emissions from non-woodheater sources.

For the purposes of this report, we will assume a target of 55% for the reduction in woodheater emissions, but also provide figuring against the more demanding target of 65% reduction.

**Table 2.9 Required reduction in woodheater emissions by 2007:
sensitivity analysis**

<i>Required reduction in total emissions (%)</i>	45	55
<i>Emissions due to woodheaters (%)</i>	85	85
<i>Reduction in non-woodheater emissions (+/- 1% per year)</i>	(A)	(B)
7	52	64
0	53	65
-7	54	66

2.4 Conclusions

The key points reported in Chapter 2 are:

- Ambient particulate pollution has been associated with adverse health impacts in the short term, with studies demonstrating a strong relationship to daily mortality and daily morbidity.
- Possible health effects arising from longer term exposure to particulate matter are suspected have not been demonstrated.
- PM₁₀ concentrations recorded in Launceston regularly exceed the recommended maximum level during winter. Exceedences are currently running at about 40/year.
- Air quality monitoring data suggests that air quality improved by about 30-40% between 1992-93 and 2000.

- Woodheater emissions in Launceston need to fall by at least 55% in the period to 2008 if Launceston is to comply with the new NEPM air standard.

3. Review of factors affecting woodheater emissions

Given that the target for reduction in woodheater emissions has been set at 55-65% of the estimated level of woodheater emissions in 2000, this chapter provides information about a range of trends, developments and measures that will contribute to this target over the next 10 years. Throughout the chapter, we refer to the contribution of each factor in terms of the number of percentage points that each factor might be expected to contribute. Ultimately these contributions must sum to 55-65 percentage points if the goal is to be achieved.

Four of the sections (3.1 to 3.4) refer to existing trends, past measures and expected developments, as follows:

1. population growth;
2. apparent nationwide trend against woodheaters;
3. increasing proportion of certified (post-93) woodheaters in use; and
4. Tasmanian Natural Gas Project.

The remaining 6 sections (3.5 to 3.10) deal with future management options that are designed to deliver one or other of the following:

5. reduction in firewood consumption by insulating houses;
6. reduction in the moisture content of firewood;
7. improved woodheater operation;
8. improved woodheaters; and
9. replacement of woodheaters with gas or electric heaters.

Also note the following:

- Each trend or measure is considered separately in this chapter. They are combined to generate various scenarios for future emissions in chapter 4.
- In respect of the management options, the intention here is to understand each option *from the point of view of woodheater users*. This section is not primarily concerned with how certain desired changes in behaviour might be achieved, for example, via regulatory measures or incentive programs.
- Similarly, in respect to costs, we are concerned here with the costs to woodheater users, putting aside the costs of a management program. As far as possible, the cost of each option is presented as an annual dollar cost per unit contribution to the target of reducing emissions by 55-65%. The unit is one percentage point.
- There is considerable uncertainty about the relative importance of certain factors that determine the emissions performance of a given woodheater. The available evidence is reviewed in appendix B. We refer to that material on several occasions throughout the remainder of the report.

3.1 Will population growth add to the problem?

The stock of houses in Launceston is growing very slowly, if at all. Launceston City Council¹⁰ has reported that an average of 80 new houses have been constructed annually in Launceston for the last 5 years, suggesting a gross increase in the housing stock of about 0.25%/yr. However, demolitions occur at the rate of 0.2%/yr nationwide. The net increase in Launceston's housing stock can be safely put at zero. We assume that this trend will continue and that this factor can be ignored.

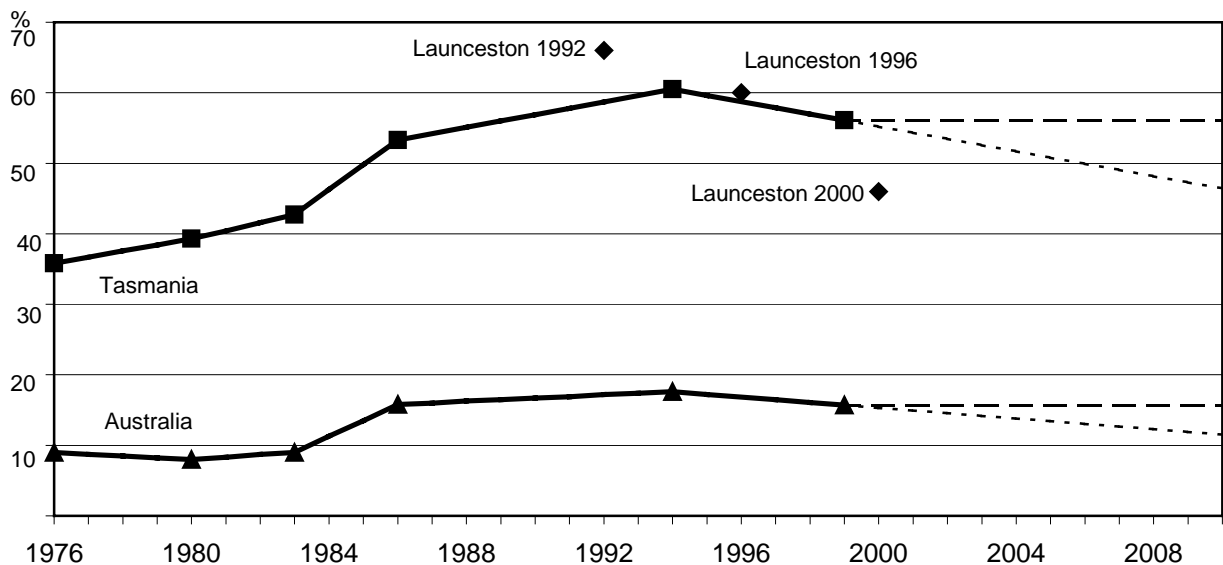
Conclusion

The impact of population growth on emissions is put at zero.

3.2 Is there a general trend against woodheaters?

Figure 3.1 summarises the available historical estimates of the proportion of households that use woodheaters – for Australia, Tasmania and Launceston. Note that the actual data points are quite sparse. These are marked on the diagram as black boxes and triangles. The straight lines that join the data points have no real meaning. The actual turning points in woodheater penetration are not known; nor is the timing of change between the data points.

Figure 3.1 Private dwellings using wood as main form of space heating



Sources: AGO (1999), ABS 4602.0 (1999), Todd and Brett (1992), EMRS (2000b)

The Australian estimates are from ABS national surveys conducted in November 1980, June 1983 and January 1986 (ABS 8212.0 and 8213.0) and environmental issues surveys conducted in June 1994 and June 1999 (ABS 4602.0). The other major source is the 1976 census¹¹. The decline in woodheater penetration over the period 1994 to 1999 is apparent in all states except the Northern Territory, as follows:

¹⁰ Personal communication, Ian Abetnethy, Manager Strategic Development, LCC

¹¹ These sources are reviewed in a recent AGO report on residential energy use (AGO 1999).

	<u>1994</u>	<u>1999</u>
NSW	17.1	14.7
Victoria	14.0	13.8
Queensland	10.1	9.7
South Australia	19.0	17.7
Western Australia	31.6	24.7
Tasmania	60.5	56.2
Northern Territory	1.2	3.4
ACT	10.2	5.7

It is not feasible to provide a rigorous explanation of the apparent trend against woodheaters. Possible explanations are as follows:

- Natural gas has taken market share as access to the natural gas has increased nationwide. Comparison of the growth in gas customers over the 5 years to 1999 (4.7%/yr) with the growth in Australian households over the same period (1.8%/yr) shows that the proportion of Australian households connected to gas is increasing.
- Phone interviews with equipment suppliers and energy retailers throughout regional NSW and Victoria often elicited comments about the high cost of wood, generally having risen to \$150/tonne.
- General lifestyle changes may be working against woodheaters, for example, delays in family formation, or a lesser tendency for family members to be gathered together in the living room.
- Technical progress in gas and electric heating equipment may be restoring the competitive edge of other fuels, for example, automatic control, heat pumps, ducted heating systems, and gas log fires that seem to provide a realistic ‘look alike’ and ‘feel alike’ substitute for wood fires.

On this issue, the Australian Home Heaters Association has indicated that the national outlook is for woodheater production to become a stable, mature business. National sales are quite strong at the present time, compared with the mid 1990s, but the further outlook is for some moderation of current activity. Probably, the picture is complicated by the fact that it is about 15 years since the strong growth of woodheater penetration in the mid 1980s; strong replacement sales at the present time may obscure an underlying trend that is negative.

That said, the fact remains that the trend has not been explained. Regarding the future, woodheater penetration may stabilise at the 1999 level, or it may continue to fall. It seems sensible to allow for both possibilities, as shown in figure 3.1.

Turning to the Tasmanian situation, the data reported in figure in 3.1 are from the same sources as for Australia. The same pattern of growth and more recent decline is evident, except that woodheater penetration is higher in Tasmania than in any other state. It is generally considered that wood is more plentiful and cheaper than on the mainland¹². And discussions with Forestry Tasmania indicate that access to forest waste is not about to change. A major difference between Tasmania and the mainland is the absence of natural gas; bottled LPG is available but it is expensive. Interestingly, woodheater penetration is declining in Tasmania, despite the absence of natural gas and the continuing supply of relatively cheap firewood.

Turning to the Launceston situation, the three data points that are reported in figure 3.1 are the results of surveys conducted by researchers at the University of Tasmania (Todd and Brett 1992), the Launceston City Council in 1996, and EMRS (2000b and 2000c).

¹² Sourced from the website of the Regional Forestry Agreement (www.rfa.gov.au/rfa/tas/raa/soceco/ch6_5.html).

Note the apparent sharp fall in the proportion of Launceston households using woodheaters, from 66% in 1992 to 46% in 2000. However, as explained in detail in appendix A, there are serious doubts about some of the data and it would be unsafe to conclude that the trend against woodheaters is sharper in Launceston than elsewhere, or that it is any more likely to continue.

Other evidence about trends in Launceston includes the following:

- Woodheater manufacturers say that sales in Launceston are currently running at less than the replacement rate, indicating that numbers of woodheaters continue to fall. Sales are about 500/year in the entire Tamar valley¹³, compared with a minimum replacement rate of about 800-1000/year¹⁴. On this evidence, the total stock of wood heaters may still be falling at a rate of several hundred per year, in apparent continuation of the trend since the early 1990s.
- The Department of Housing¹⁵ considers that its current efforts to induce public housing tenants to convert to electric heating will have only a modest impact. Gas offers a better but still uncertain prospect of further conversions. Without gas, the outlook is that about 50% of the department's 3,500 properties will retain their wood heaters.
- The HydroHeat package offered by Aurora has now been available since 1992. Aurora claims that the package has been very successful, achieving conversions of about 2,000/year in the Launceston region in recent years. However there is no evidence that HydroHeat has induced large numbers of conversions from woodheaters; HydroHeat has not captured such a large share of the market that it has necessarily displaced woodheaters. The more likely explanation for growth has been the conversion of electrically heated houses from the standard tariff to the HydroHeat tariff.
- As described in the report of the Working Party (1996: page 10), there was a significant effort to educate the community about woodsmoke in the period to 1995, including:
 - community education as a result of intense media coverage when the issue was fresh, including regular publication of air monitoring results by the *The Examiner* throughout the winters of 1992 and 1993;
 - public educational display by concerned nursing staff from the University of Tasmania;
 - enthusiastic use of the woodheater issue by schools as subject material for tutorials, assignments and experiments - and similar interest from university staff.

However this effort has not been sustained and it is reasonable to expect that, while the earlier effort probably accounts for part of the observed reduction in ambient concentrations of PM₁₀, it is unreasonable to expect significant further contributions.

That said, these data do not provide an adequate basis for independently assessing trends in Launceston. We conclude that the ABS data for Tasmania provides the best information about past trends and possible future trends.

Conclusion

If there is an underlying trend against woodheaters, and it continued at the rate that has been observed for Tasmania in the period 1994 to 1999, we estimate that it would contribute 6 percentage points to the target of a 55-65% reduction in

¹³ Personal communication with David Wickham, Saxon Woodheaters.

¹⁴ This estimate of the replacement rate assumes that 7-8% of the current stock of about 12,000 woodheaters (excluding fireplaces) would need to be replaced each year if the stock were to be maintained.

¹⁵ Personal communication from Rick Fulton, Housing Tasmania?

woodheater emissions. We consider that a significant contribution from this source should be factored in.

3.3 What will post-93 certified heaters contribute to emissions reduction?

The proportion of post-93 woodheaters in use will continue to grow as pre-93 heaters are retired. To the extent that post-93 heaters have lower emissions, they necessarily contribute to the emissions reduction objective. Based on the assumptions set out in table 3.1, we estimate that this development will contribute a maximum of 26 percentage points to the required 55-65% reduction in woodheater emissions. These assumptions are explained in the remainder of this section.

Table 3.1 Average firewood consumption and emissions

	<i>Mix of woodheaters (%)</i>			<i>Average firewood consumption (tonnes/yr)</i>	<i>Emissions performance</i>	
	<i>Nominal mix in 2000</i>	<i>Assumed mix in 2000*</i>	<i>Projected mix in 2007</i>		<i>Per kilo of wood (g/kg)</i>	<i>Per dwelling* (kg/year)</i>
	(A)	(B)	(C)	(D)	(E)	(F)
Open fire	10.6	10.6	7	3.7	17.3	64.0
Pre-93 wood heater	40.0	55.0	20	5.1	12.2	62.1
Post-93 wood heater	49.4	34.4	73	5.1	5.5	28.0

Source: DPIWE estimates based on the NPI Survey (EMRS 2000b).

* Column F is the product of D and E

** Allows for modification of post-93 heaters to restore pre-93 characteristics.

Mix of woodheaters

The recent survey conducted by EMRS (2000b) returned the estimates reported in column A of table 3.1. However, as indicated in the previous chapter, it is generally considered that there has been large scale modification of post-93 woodheaters, effectively restoring them to pre-1993 status. Assuming that 30% of post-93 heaters have been so modified, the effective mix of heaters in 2000 would be as reported in column B of the table. The projected final mix of heaters is shown in column C. Note the following:

- It is assumed that the historical decline in the use of open fires continues¹⁶. While this is not attributable to the certification of woodheaters, it is a small effect and it is convenient to include the impact here.
- It is assumed that, while the observed decline in the proportion of pre-93 woodheaters will continue for some years yet, a significant minority will be retained (20%) over the longer term, reflecting a strong preference for the older technology by some users.

¹⁶ Comparison of the returns from NPI Survey (EMRS 2000b) and the 1992 Telephone survey (Todd and Brett 1992) suggests that the proportion of open fires has fallen from 15% of wood heating appliances in 1992 to 10% in 2000. We have assumed this trend will continue to 2007, reducing the figure to 7%.

Average firewood consumption

Given projections for the number and types of wood heating appliances, the following further information is needed to model total emissions:

- average consumption of firewood per appliance (kg/year);
- average emissions per unit of firewood for each type of appliance (g/kg).

DPIWE has provided estimates for the first variable that have been extracted from the NPI Survey (EMRS 2000b) – see column D.

Average emissions per kilogram of firewood

While quite a lot is known about emissions under laboratory conditions¹⁷, the quantity of emissions from a particular type of appliance depends on the actual mix of operating modes (including non-design modes) and the quantities of wood consumed in each mode. The estimates of average emissions per tonne of wood (column E) is essentially the consensus of the informed judgement of researchers who have been exposed to the issue.

That said, it is important to understand that the crucial issue is the *relative* emissions from dwellings with different types of wood heating appliances. In this respect, it is useful to focus on the final column in table 3.1, being average emissions per dwelling. This is the product of firewood consumption per dwelling and estimated emissions per tonne of firewood. Basically the view being expressed here is that open fires and pre-93 wood heaters are a bit more than twice as polluting as post-93 wood heaters. (The actual ratios are 2.3 and 2.2 respectively.) If these *relativities* are right, and regardless of inaccuracies in estimates of the *absolute levels* of emissions, estimates of the percentage contribution of post-93 heaters to the emissions reduction target would be reliable.

That said, it is also arguable that the certification standards that were introduced in 1993 have had no significant impact on emissions. There are several concerns:

- Modifications of post-93 may have been much more extensive than generally considered. The 30% figure is an informed guess, but informed only by anecdote.
- Lack of enforcement may have induced manufacturers and importers to supply heaters that differed significantly from the models that were tested.
- Poor operation may negate the design improvements that have been incorporated in post-93 models.

Supporting these concerns, a recent survey (Todd 2001) found no evidence that post-93 woodheaters performed better than earlier models under real-world community use. See appendix B for a further discussion of the relative importance of the various determinants of woodheater emissions.

Conclusion

Based on the assumptions set out in table 3.1, the projected replacement of pre-93 heaters by post-93 heaters will contribute a maximum of 26 percentage points to the target of a 55-65% reduction in woodheater emissions. However that potential may not be realised, in which case a significant discount should be applied. According to recent survey results (Todd 2001), the contribution might even be set to zero.

3.4 Tasmanian Natural Gas Project

The Tasmanian government has announced that it intends to finalise its Development Agreement with Duke Energy for the Tasmanian Natural Gas Project to proceed in 2002. This involves: a pipeline connecting Tasmania with the natural gas processing facility at

¹⁷ This includes AS4013 test data on 312 woodheaters that is available to DPIWE and has been provided in summary form to this study.

Longford; conversion of the Bell Bay power station to natural gas; supply of natural gas and steam to industrial customers; and development of on-shore pipelines to supply gas to other customers throughout Tasmania. Pipelines will link Bell Bay with Port Latta in the north-west and Hobart in the south. Customers will include existing industries converting to gas from other energy sources. The project timetable provides that natural gas will be available in Tasmania from early in 2002.

To gauge the magnitude and timing of gas penetration of the space heating market, we conducted a series of phone interviews with Duke Energy and with gas retailers throughout Victoria and NSW, with the following results:

- Gary Swain of Duke Energy explained that, because the Tasmanian government has yet to define the tender process for the retail franchise, it is difficult to know what retail strategies will be adopted, particularly in terms of pricing. However he considers that the winner will market gas very aggressively, reflecting the need to quickly recoup the high capital costs of distribution systems. Marketing strategies will include significant rebates on the cost of conversion. He also expects the price of gas to be competitively ‘capped’ by the price of firewood, but was unable to give an indication of the likely residential price of gas.
- That said, it is not clear that all Launceston suburbs will be reticulated with gas. Depending on how the tender process is structured, the retailer may selectively reticulate gas, bypassing suburbs where the prospects for high take-up are not good. (Similarly, some parts of Canberra have only recently obtained access to gas, over 10 years since it was first introduced.)
- Calls to Victorian retailers were not productive. Considerable historical information about the growth of the residential gas market has been lost since the privatisation of the Gas and Fuel Corporation.
- Most calls to regional suppliers of gas and equipment in NSW were similarly unproductive, with one exception. AGL’s manager for the western region of NSW emphasised that gas penetration of the space heating market depends heavily on the price of firewood. Conversion is very rapid where firewood has become scarce, but extremely difficult where it remains relatively cheap. When pressed to give an opinion of the likely penetration of gas against cheap firewood, he considered that penetration would be at least 10% and probably 20% within 5 years.

We accept the logic that gas retailers do not invest in distribution systems without expecting to sell significant quantities of gas. But customers must first have access to the network and the underlying question is how extensive the network will be. The prospect of incomplete coverage of Launceston is a significant uncertainty.

Conclusion

Despite the uncertainty, it seems unrealistic to ignore the arrival of natural gas, particularly given that the picture will become clearer in a year or two. For the purposes of this report we have assumed that gas will contribute a maximum of 20 percentage points to the target of a 55-65% reduction in emissions.

3.5 Better insulation to reduce firewood consumption

To assess the potential contribution from better insulation of woodheated houses, we referred to a recent report published by the Australian Greenhouse Office, *Australian Residential Building Sector Greenhouse Gas Emissions 1990-2010*, (AGO 1999). While the objective of that study is to provide future scenarios for greenhouse emissions, underlying estimates of the potential for improved energy efficiency may be extracted from the data, and applied in the present context.

Basically, the report provides state by state estimates of residential heating requirements (MJ/m^2), by type of dwelling construction and type of insulation (wall & ceiling, ceiling, none). For example, in respect of brick veneer houses with timber floors, the main findings are as follows:

- These dwellings account for 31% of detached houses in Tasmania.
- 24% of these dwellings have both wall and ceiling insulation, 43% have ceiling insulation only, and 33% have neither.
- In the climate zone that includes Launceston, Hobart and Canberra (Zone 5), the complete absence of insulation increases energy costs by 80% compared to a house with both wall and ceiling insulation, and the absence of wall insulation increases heating costs by 24%. This implies that the addition of ceiling insulation to an uninsulated home would reduce heating costs by about 30% [= $(1.80 - 1.24)/1.80$].

Similar results are obtained for other construction types, comprising lightweight constructions and various combinations of brick veneer or double brick construction, and timber or concrete floors. In all cases, the AGO study finds that about one third of houses have no insulation and incur a 75-85% increase in heating costs, and 30-50% of houses have no wall insulation and incur a 15-25% increase in heating costs. In all cases, the implication is that the addition of ceiling insulation to an uninsulated home would reduce heating costs by at least 30%.

The AGO report provides alternative energy consumption scenarios that can be used to estimate the potential to reduce the heating costs of woodheated houses. We examined the following scenarios from the report:

- *BAU+ projection* (business as usual), which assumes that dwellings continue to be constructed according to today's standards. In Tasmania's case this means the continued absence of minimum building insulation standards.
- *ME projection* (Medium Efficiency), which assumes the addition of a 3.5 star effective minimum building shell requirement, as defined by NatHERS, for all new dwellings.
- *HE projection* (High Efficiency), which assumes the addition of a 5 star effective minimum building shell requirement, as defined by NatHERS, for all new dwellings.
- *HE+ projection* (High Efficiency Plus), which assumes HE plus an aggressive ceiling insulation retrofit program to improve the thermal efficiency of existing dwellings.

Comparison of the BAU+ and ME scenarios provides an estimate of what would be achieved by imposing minimum insulation standards on new dwellings. And comparison of the HE and HE+ projections provides an estimate of what an insulation retrofit program would achieve. Our findings are reported below under three headings: new dwellings; extensions to existing dwellings; and retrofit of existing dwellings. Certain key assumptions need to be emphasised at the outset.

Assumptions

Householders may respond to improved energy efficiency by increasing the thermal comfort of the home, which would dilute the energy savings. The AGO reports on this issue as follows:

As the thermal performance of the building stock improves, householders in more efficient homes may decide to take some of the potential energy savings as increased thermal comfort rather than as reduced energy consumption. This is quite difficult to model and there is little data to confirm or otherwise the extent of this effect in Australia. There is some documentation regarding this effect in Europe and the United States within particular segments (typically for low income households), but this data

is unlikely to translate to Australia given the different climatic and cultural aspects.
(AGO 1999: page 20)

That said, officers of the (then) Victorian Gas and Fuel Corporation have considerable experience with insulation retrofit programs, and have reported that about 40% of the potential energy savings were realised under incentive programs that operated in the early 1990s¹⁸. We have assumed that 50% of the potential energy savings are realised; there is considerable anecdotal evidence to suggest that thermal comfort in woodheated homes often borders on the stifling, in which case there is little scope to increase thermal comfort anyway. The 50% discount is also a rough means of allowing for concerns that:

- Excess heat from woodheaters is sometimes managed by opening a window rather than turning the heat down.
- In dwellings with oversized heaters, it may not even be possible to reduce the heat output to a level that takes full advantage of improved energy efficiency.
- Insulation may sometimes have the perverse effect of increasing emissions if households respond to improved energy efficiency by increasing periods of slow burn without the benefit of an initial high burn.

Finally, it is necessary to assume that woodheated dwellings in Launceston share the general characteristics of detached dwellings in Tasmania, in terms of construction types and insulation characteristics. This reflects the fact that AGO's modelling - on which the following results rely - is for Tasmania as a whole. (ABS has advised that underlying sub-state data, such as would be needed to model Launceston explicitly, would not be statistically reliable¹⁹.)

Insulation requirements for new houses

AGO's projection is for new houses in Tasmania to add 0.67%/year to the total stock of houses and 0.97%/year to the total floor area. Applied to the stock of woodheated houses in Launceston, the AGO projections effectively assume that about 100 new woodheated households will be built each year, comprising 20,200m² of additional woodheated floorspace. (We accept that assumption for the present but make an appropriate adjustment in due course.)

It is assumed these new houses will need to comply with a 3.5 star effective minimum building shell requirement. Based on informal advice from the Sustainable Energy Authority in Victoria²⁰, this would require ceiling and wall insulation of a brick veneer home with timber floors. This would involve a cost of about \$11.50/m². Current practice departs considerably from the proposed standard; on average, only \$5.50/m² is being invested in insulation. The deficit is \$6.00/m². Applied to Launceston, the additional cost would be \$121,200/year (= 20,200 * 6).

In respect of the expected energy reductions, comparison of the relevant AGO projections (BAU+ and ME) indicate that this investment would deliver a 0.43% increase in the energy efficiency of the *total* housing stock²¹. In light of our assumption that only 50% of the potential savings are realised, this becomes a 0.22% reduction in heating energy and woodheater emissions. Accordingly, the capital cost of achieving a 1% reduction in energy use is \$550,000 (= 121,200 / 0.22).

However, from the perspective of the householder, this cost is offset by significant savings in energy costs and the benefits of improved thermal comfort. Insulation suppliers

¹⁸ Personal communication, Tony Isaacs, Victorian Sustainable Energy Authority.

¹⁹ Personal communication, Jennifer Richardson, ABS National Information Service.

²⁰ Personal communication from Tony Isaacs.

²¹ Note that the % improvement is in relation to the heating energy used by the total housing stock, not in relation to new houses.

claim pay-back periods as low as 3 years. Assuming a payback period of 5 years, the annual costs and benefits are as reported in table 3.1.

Table 3.1 Indicative costs and benefits of minimum energy performance requirements for new houses and extensions

Assumed life expectancy of insulation (years)	45
Annualised cost (\$ per 1 percentage point reduction in emissions)	56,000
Annual benefit (\$ per 1 percentage point reduction in emissions)	110,000
Annual net benefits (\$ per 1 percentage point reduction in emissions)	54,000

On advice from Launceston City Council, the rate of new home construction is only about one third of the rate implied by the AGO projections. Possibly as few as 175 new woodheated houses have been built in Launceston over the last 5 years, an average of 35 per year. If that were to continue over the next 6 years, the scope for this strategy may be described as follows:

- The maximum contribution to the emissions reduction target is 0.43 percentage points.
- Benefits would accrue to households at the rate of about \$54,000 per year for each 1 percentage point that is contributed to the target.

Clearly this is a highly beneficial option for the households concerned, but there are too few new houses being built to make a significant contribution to energy efficiency and emissions reduction.

Insulation requirements for house extensions

The AGO report does not address the possibility that the 3.5 star requirement could also be applied to house extensions. However, there seems to be no technical barrier to that option. Importantly, extensions are expected to contribute almost as much to annual growth of floorspace as do new houses; the ratio of extended floorspace to new floorspace is about 80%. Following the same procedure as above, the scope for this strategy may be described as follows:

- The maximum contribution to the emissions reduction target is 0.34 percentage points.
- Benefits would accrue to households at the rate of about \$54,000 per year for each 1 percentage point that is contributed to the target.

Again, this is a highly beneficial option for the households concerned, but there are too few extensions to make a significant contribution to energy efficiency and emissions reduction.

Ceiling insulation for existing houses

The AGO report describes its projections for retrofitting existing houses with insulation in the following terms:

Retrofitting currently occurs at a rate of approximately 1 per cent of stock numbers per annum (BIS Shrapnel 1994). The proposed level of increase has been set so as to achieve a 60 per cent -70 per cent saturation by the year 2010 (approximately 3.5 per cent per annum). This is considered to be a practical limit given that such a scheme would need to be voluntary and that retrofitting would be impractical in certain circumstances such as in the case of houses with skillion type roofs (ie no roof space).

Retrofitting of ceiling insulation was chosen as an option for this study for a number of reasons. Firstly, it is known from previous studies (eg Coldicutt et al 1977;

FARIMA 1983; Williamson 1991, Knowles 1997) that ceiling insulation retrofitting is one of the most cost effective energy efficiency strategies. Secondly, at least in the case of houses with accessible roof spaces, it is a practical, non-invasive treatment that requires no other concurrent building works to be undertaken to effect its installation. (AGO 1999: page 34)

Note that the reference to 60-70% ‘saturation’ is in relation to that part of the housing stock that has no insulation at present.

Applied to the stock of dwellings in Launceston, AGO’s projections indicate that a retrofit program would target 4,600 woodheated houses with a total floor area of 690,000m². Accepting AGO’s assessment that an aggressive campaign could achieve no more than 3.5% of the desired conversions per year, and that 1% would occur anyway, we estimate the total additional investment at \$112,000/year. This would convert an additional 115 houses per year, comprising 17,200m² of floorspace.

In respect of the expected energy reductions, comparison of the relevant AGO projections (HE and HE+) indicate that this investment would deliver a 0.46% reduction in energy use for the relevant housing stock. Given our assumption that only 50% of the potential savings are realised, this becomes a 0.23% reduction in heating energy and woodheater emissions. Accordingly, the capital cost of achieving a 1% reduction in energy use is \$487,500 (= 112,100 / 0.23).

Again, this cost is offset by significant savings in energy costs and the benefits of improved thermal comfort. Assuming a payback period of 5 years, the annual costs and benefits are as reported in table 3.2. Note that the net benefit varies according to the future expected life of the house. Newer houses with longer future lives will deliver the best return on insulation retrofits.

Table 3.2 Costs and benefits of retrofitting existing houses with ceiling insulation

House life expectancy (years)	15	25	35
Annualised cost (\$ per 1% reduction in emissions)	64,000	53,500	50,500
Annual benefit (\$ per 1% reduction in emissions)	97,500	97,500	97,500
Annual net benefits (\$ per 1% reduction in emissions)	33,500	44,000	47,000

The scope for this strategy may now be described as follows:

- The maximum contribution to the emissions reduction target is 5.5 percentage points²², with the timing depending on the aggressiveness of the replacement program.
- Benefits would accrue to households at the rate of about \$33,500 - \$47,000 per year for each contribution of 1 percentage point, depending on the expected life of the house - see table 3.2.

Conclusion

The potential for insulation of woodheated homes to contribute to the required reduction in emissions may now be described as follows:

- **The maximum contribution is:**
 - **0.43 percentage points from improved insulation of new homes;**

²² This estimate is derived as follows. It is assumed that one third of woodheated houses are nominally candidates for ceiling insulation retrofits; 70% of these are actual candidates, a retrofit being impractical in the remaining cases; and a retrofit will deliver a 23% reduction in the energy needed for space heating.

- **0.34 percentage points from improved insulation of extensions;**
- **5.5 percentage points from ceiling insulation retrofits of existing homes.**
- **Insulation provides net benefits to the community. For each contribution of 1 percentage point to the emissions reduction target, the annual net benefit is:**
 - **\$54,000/year for new homes and extensions;**
 - **\$33,500-\$47,000 per year for ceiling insulation retrofits of existing homes.**

3.6 Reduce the moisture content of firewood

Firewood may have a high moisture content because it is still green (unseasoned) or simply because it has been stored in the open and exposed to rain. The burning of such wood means less efficiency and more smoke. Although the exact relationship is unknown, it involves the following:

- Part of the explanation for reduced efficiency is that some energy is lost in burning off moisture. Based on information provided by ACRE, the energy loss is no more than 3% if the moisture content is 20% or less; such wood is generally considered 'dry' and ready to burn. However, the loss rises to about 10% if the moisture content is 40-50%.
- The temperature inside the firebox is also reduced, reducing the efficiency of the combustion process. The increase in the proportion of unburnt fuel represents a further energy loss and an increase in PM emissions.

Why wet wood is cheaper?

If dry wood were the same price as wet wood, there would obviously be a preference for the former and problems arising from the use of wet wood would be minimal. However, dry wood is more expensive, for the following reasons:

- Firewood collectors have a strong preference for collecting firewood that is unseasoned and storing that fuel until it is ready for burning²³. The key immediate consideration is that unseasoned wood is easier to cut and is easier on the chainsaw, saving time and money. By comparison, fallen dry wood tends to be dirty and damages the chainsaw.
- Seasoned wood also needs to be kept out of the rain immediately prior to use, which involves some minimal storage costs.

In short the cycle of firewood supply begins one or two years before the firewood is actually burnt, and costs are incurred in the process of turning wet wood into dry wood. For the intervening period, firewood needs to be stored with adequate ventilation to facilitate the seasoning process, which may be in the open, and subsequently shifted into a woodshed or other form of protection for at least a short period prior to use.

Necessarily, significant stocks of unseasoned firewood are held at any one time. A common practice is to cut firewood one year ahead and to stack it at the collection site if it is secure, ready for transport and use in the following year. And firewood merchants typically acquire stocks a year or two ahead of sale. The costs of storage are reflected in the relative price of unseasoned and dry wood:

- The average price of green firewood advertised in the *Launceston Examiner*²⁴ is \$35.30/m³, compared with \$42.50/m³ for dry or 'ready to burn' wood, an apparent discount of 17%.
- A survey of firewood merchants listed in the yellow pages returned an average price of \$51.50/m³ for dry wood.

²³ Personal communication with John Todd.

²⁴ For the period August 2000 to early March 2001.

Some householders take advantage of the differential by buying a year ahead of time, presumably at the cost of providing additional storage space at home.

Benefits and costs of burning wet wood

The price differential between green and dry wood – including the costs of temporary storage out of the weather - creates an incentive to burn wet wood, taking advantage of the reduced collection costs but avoiding some or all of the storage costs. However the practice also incurs certain penalties, as follows:

- As already noted, green wood provides less useful heat²⁵ than dry wood.
- Green wood may require more active management of the heater, to ensure that it does not go out.
- Green wood contributes to the build up of creosote up in the flue and requires the services of a chimney sweep, typically at a cost of \$30-50/year. Constriction of the flue may also cause the heater to operate very inefficiently for a period before the sweep is called, resulting in a considerable loss of thermal comfort for the occupants.

Given enough information about the behaviour and cost of wet wood, it would be possible to estimate the net benefit (or cost) to the householder of burning wet wood. However, the following factors are unknown:

- The relationship between moisture content and energy efficiency is unknown, except that it is negative, and also significant at high moisture levels.
- The drying rate of unseasoned wood - which determines the required duration of storage before wood is ready to burn - is unknown.
- The relationship between price and moisture content is unknown, except that it is negative and significant. Consider that:
 - Wood that is advertised as green may vary considerably in moisture content. Advertised prices range from \$30/m³ to \$40/m³ and may reflect variation in moisture content.
 - Wood that is advertised as dry may vary considerably in moisture content, even to the extent that some should be considered wet. Advertised prices range from \$35/m³ to \$50/m³; wood merchants in the Tamar Valley have quoted up to \$60/m³.

The complicating factor in all of this is that there are not two classes of wood, wet and dry, but a continuum from the very wet to the bone dry.

Self collected firewood

It has been implicitly assumed to this point that firewood is delivered, and it remains only for the householder to stack and store the fuel. However, self collection offers an important opportunity to trade time for dollars. The attractiveness of this opportunity depends on several factors:

- distance to collection site - for which we have examined the range 10-40km, one way;
- carrying capacity of trailer or vehicle, which determines the number of trips per tonne - for which we have examined options of 1/3tonne, 1/2tonne, and 2/3tonne;
- vehicle costs, including trailer – which we have put at 30 cents per kilometre²⁶;

²⁵ By 'useful' heat we mean energy that is actually used to heat the dwelling, as opposed to energy that is absorbed in burning off moisture or is otherwise vented from the dwelling.

²⁶ This estimate is based on NRMA (2000) estimates of vehicle operating costs, including depreciation, interest, fuel tyres, service and repairs – for privately owned vehicles that are 5-10 years old. This includes a small allowance for depreciation and interest on the trailer – 2 cents/km.

• costs of chainsaw, log splitter and safety gear – which we put at \$10 per tonne²⁷. Table 3.3 reports our figuring for various combinations of the above factors. Clearly, time costs are sensitive to assumptions about the distance travelled and the trailer capacity. Inspect table 3.3 to see that the dollars/hours combinations range from \$19/tonne & 3.5hrs/tonne through to \$82/tonne & 7.0hrs/tonne.

Based on interviews with chainsaw suppliers in the Launceston area and with local staff of Forestry Tasmania, it seems that distances vary considerably. Some sources may be 15 minutes from Launceston, others 30-45 minutes, and yet others up to 1 hour away. “About half an hour” seems representative, which indicates a distance of about 30 kilometres, allowing for a significant proportion of off highway travel. Hence, our best guess at a representative combination is that marked in bold in table 3.3.

Table 3.3 Financial and time costs of self-collected firewood (per tonne)

<u>Assumptions</u>			
Vehicle cost (cents per km)			30
Equipment costs (\$ per tonne)			10
Average vehicle speed (km/hr)			60
Collection, cutting, splitting, loading (hours/tonne)			3
<u>Financial cost (\$/tonne)</u>			
		<u>Capacity (tonnes/trip)</u>	
<i>Distance (km, one-way)</i>		0.33	0.50
		0.67	
10	28	22	19
20	46	34	28
30	64	46	37
40	82	58	46
<u>Time cost (hrs/tonne)</u>			
		<u>Capacity (tonnes/trip)</u>	
<i>Distance (km, one-way)</i>		0.33	0.50
		0.67	
10	4.0	3.7	3.5
20	5.0	4.3	4.0
30	6.0	5.0	4.5
40	7.0	5.7	5.0

Now consider that combination more closely. It says that the self collector is spending \$46 and 5 hours to collect a tonne of wood that, assuming it is green, could be delivered for about \$60. In effect, this self collector would be working for about \$3/hour. To make sense of that it seems necessary to assume one or more of the following:

- Self collection may be combined with family trips, in which case most of the financial costs and time expenditures would have been incurred anyway. In the extreme case, that reduces the financial costs to \$10/tonne and the time costs to 3 hours; and earnings increase to \$17/hour.
- People may positively enjoy self collection, if only for the exercise.
- Some people find it difficult to budget for large periodic bills, for example, winter electricity bills or 2-4 tonne loads of timber. They put a high value on the ability to ‘pay as you go’, involving the collection of firewood in relatively small loads.
- The behaviour may be partly irrational. For example, people may not take full account of vehicle or equipment costs particularly if some of those costs – such as

²⁷ This estimate is based on hire costs for this equipment – about \$100/day. We assume an experienced collector, capable of finding and cutting 10 tonnes in a day.

vehicle repairs – are not immediately apparent. The immediate cash costs may be no more than a few dollars worth of petrol.

- Finally, self collection may be organised as semi-commercial operation. For example, John Todd cites the example of self-collectors who team up to cut 10 tonnes of wood in a day, and store it on site for collection and use the following year. If a large capacity truck is used to transport the seasoned firewood – as opposed to a trailer – the difference between self collection and commercial activity is minimal.

Taking these factors into account, it makes no sense to try to determine ‘the’ financial cost of self collected firewood. All that can be reasonably concluded is that self collection gives households direct access to firewood, possibly at a very low cost. If cut when green, that firewood would generally need to be stored, possibly for use in the following year, or the year after that.

Analysis

In respect of the design of management action, it seems sensible to allow for two broad possibilities. For some people the net financial benefit from the burning of wet wood is small or possibly negative, in which case the substantive explanation for the practice of burning green wood would be along the following lines:

- People may not understand the impact of green wood on the efficiency of the heater and the real cost of the energy that is extracted from their fuel. In effect, they are deceived by the apparent cheapness of wet wood.
- People who buy ahead of time may mistake the required lead time, and find that they have a load of fuel that is not ready to burn, but without the storage space or cash to accommodate an additional load of dry fuel.
- Self collectors may lack one or more of the following:
 - adequate storage to stockpile fuel sufficiently in advance of need;
 - the required discipline and capacity to plan ahead;
 - the judgement needed to make the appropriate trade off between ease of collection and duration of storage.

On this analysis, there is potential for education and the provision of information in the expectation that this would lead to better decisions in the acquisition and storage of firewood.

The more difficult situation is where there is also significant financial benefit in burning wet wood. A significant financial penalty, and a high probability of detection, would be needed to eliminate the financial incentive. It appears that such penalties would fall most heavily on self collectors. According to Driscoll (2000), about 40% of Tasmania’s firewood is self collected.

These findings are represented in the first row of table 3.4. As shown, the benefits that accrue to households from the use of wet wood may vary from +\$15/tonne to -\$5/tonne. The negative figure is for woodheater users who find that they would benefit by converting from wet wood to dry wood. Obviously, these estimates may also be regarded as the *cost of foregoing* the use of wet wood, which is how they are presented in table 3.4.

The second row of table 3.4 reports an estimate of the total amount of firewood that would need to be converted from wet to dry use in order to deliver an emissions reduction of 1 percentage point. Note that there is no objective basis for this estimate; the relationship between moisture content and emissions is not objectively known. (For further discussion of this issue, see appendix B.) Rather, the estimate is based on informed judgement on three matters (Todd 1997: page 4), as follows:

- the main categories of woodheater users, characterised by particular combinations of woodheater models, operation and moisture content of firewood;

- the emissions performance of the various categories; and
- the relative size of the different categories.

Combining Todd's judgement with our estimate of the cost to households of converting to dry wood, the total cost to the community (per 1% reduction in emissions) is as reported in the final row of table 3.4.

Table 3.4 Cost to households of converting from wet to dry wood

Cost to households of converting from wet to dry wood (\$/tonne)	15	5	-5
Quantity of firewood that needs to be converted from wet to dry use in order to reduce emissions by 1 percentage point (tonnes)	500	500	500
Cost per 1% reduction in emissions (\$)	7,500	2,500	-2,500

Finally, what is the maximum possible contribution to emissions reduction? It is implicit in Todd's figuring that he attributes about 20% of woodsmoke to the *additional* emissions from poorly used woodheaters *or* very wet fuel, compared with the average emissions of all other possible combinations of woodheaters and operator behaviour. The separate contribution of *additional* emissions from wet fuel is not assessed in his 1997 report; the two causes may not be easily separated. However, subsequent work (Todd 2001) suggests that poor operation is the major contributor to the 20% of woodsmoke that has been attributed to this combination of factors. In discussion with the Steering Committee, it was agreed that the maximum contribution to emission reduction that might be expected by reducing the moisture content of firewood is 5% of the total emissions observed in the late 1990s, that is, one quarter of the 20% identified by Todd.

Conclusion

For the purposes of this exercise, the scope for measures to reduce the moisture content of firewood may be described as follows:

- **The maximum contribution to the emissions reduction target is 5 percentage points.**
- **Self collectors may incur significant costs if they are forced to abandon self collection and purchase supplies from wood merchants. For other households, however, it is also feasible that there are net financial benefits – see table 3.4.**

3.7 Improve the operation of heaters

The efficient operation of a woodheater might be regarded as a reasonably demanding task, but only in comparison with other forms of heating. It is not inherently difficult, given an adequate understanding of what is required and why. ACRE has provided the following list of do's and don'ts, which seem simple enough:

- Run the heater on high for 20-25 minutes after reloading; it is essential to re-heat the firebox and dry the new load before efficient combustion can occur. If kept on low, the firebox will not become hot enough to burn the fuel efficiently and the heater will smoke.
- Don't overfill the heater. There must be enough space for air to move down the glass and into the base of the fire, and enough space at the top of the load to allow a flame to develop and burn off gasses released from the wood.
- Use sufficient dry kindling and smaller logs to establish a good fire quickly.

- Leave at least 2 centimetres between logs to allow air to get into the hot area of the fire.
- Periodically check the flue for smoke, particularly when getting to know a new heater.

Presumably, poor operation reflects ignorance, or inability or unwillingness to give woodheater operation the attention that it needs. In respect of the latter, it is difficult to see how the time demands of woodheater operation could be a significant impediment to good operation. It seems reasonable to hope that most people will respond positively to a moderate stimulus to improve woodheater operation, say, in response to 1 or 2 visits from a smoke patrol officer. In effect, improved woodheater management imposes no significant costs on the household.

That said, the issue may prove to be more difficult. For example:

- Some users may be concerned that fuel will be wasted if, after refuelling, they inadvertently leave the heater on high for more than the recommended 20 minutes. Hence the problem may not be the amount of time required to operate heaters correctly, but simply the problem of remembering to do the right thing at the right time.
- Similarly, users may fail in not planning ahead, for example, to avoid the situation where the heater is reloaded and turned down immediately before going out or before going to bed.
- Another possibility is that users believe that they can save fuel by not running the heater on high for 20-25 minutes after reloading. We understand that this is a false belief; correct practice does not significantly alter fuel use over the 4-6 hour period of the burn. But people may prefer to believe the evidence of their eyes, which is that fuel seems to be consumed more quickly when the heater is set on high for the first 20-25 minutes after reloading.

The potential contribution of improved heater management to the emissions reduction target is not objectively known. But informed opinion is that it is probably significant. Again, we rely on Todd's assessments as reported in his 1997 and 2001 reports. Referring to the 1997 report, it is implicit in his figuring that he attributes about 20% of woodsmoke to the *additional* emissions from poorly used woodheaters *and/or* very wet fuel, compared with the average emissions of all other possible combinations of woodheaters and operator behaviour. As discussed in relation to wet fuel, a reasonable interpretation of his 2001 study is to regard poor operation as the primary cause. Consistent with the judgement made in respect of wet wood, the maximum contribution to emission reduction that might be expected from improved operation is 15% of the total emissions observed in the late 1990s.

Conclusion

For the purposes of this exercise, the scope for measures to improve woodheater operation may be described as follows:

- **The maximum contribution to the emissions reduction target is 15 percentage points.**
- **While woodheaters demand some attention, the demands are not onerous and seem to be mostly a matter of developing a reasonable understanding of what goes on inside a firebox and developing appropriate routines and habits. But that may be easier said than done; it may still prove difficult to achieve significant reductions.**

3.8 Improve woodheaters

A certain number of new woodheaters will be acquired in the period to 2007, either as replacements for existing woodheaters or other forms of heating that are retired, or for installation in new homes. This creates two broad opportunities to improve the quality of the woodheater stock:

- Improve the emissions performance of new woodheaters.
- The rate of replacement may be increased, which involves increased retirements of existing woodheaters.

Reduced emissions from new woodheaters

A range of measures may be employed to improve the emissions performance of new woodheaters, including lower emissions standards, random inspections to ensure that the models on sale correspond to the specific designs that have been tested, and measures to discourage the modification of heaters to reduce the air flow. The fact that these measures are resisted indicates that they impose costs on householders in terms of reduced functionality of woodheaters.

Expert advice to the study²⁸ agrees that, in principal, the cost in terms of reduced functionality need not be large. There are two main considerations:

- Correctly operated, it is possible to keep a low emission heater burning overnight without generating excessive smoke. Modern heaters can be operated to run for 8 hours on a single load of fuel.
- The recommended practice of turning a heater to high for 20-25 minutes after refuelling does not accelerate the consumption of fuel and truncate the burn period – provided of course that the heater is subsequently turned down.

In other words, the expert view is that consumer resistance to low emission heaters largely reflects their lack of operating skills and the false assumption that they need to be able to turn the air flow to very low settings in order to save fuel or delay reloading.

On this thinking, the costs incurred by households depends on their response to the apparent reduction in functionality:

- Some, probably most, will learn to operate their new woodheaters correctly after some initial period of inconvenience and frustration.
- Those who fail to learn will suffer a loss of functionality. They will find that they need to relight the heater every morning and possibly use supplementary heating more frequently. Dissatisfaction may ultimately contribute to a decision to adopt an alternative form of heating.
- Some will modify the new heater, although that has become increasingly difficult.
- Some will refuse the new equipment and turn to the second hand market to obtain older types of woodheater when a replacement is needed.

While it is not feasible to quantify these costs, they may nevertheless be significant. For example, the value that users put on the overnight burn is indicated by the fact that overnight burns may account for one third of firewood costs. Specifically, John Todd estimates that the average user burns 30kg of wood each day, about 10kg of which is consumed overnight.

The contribution that improved woodheaters might make to emissions reduction can be estimated as a variation of the scenario that is outlined in section 3.3, which examines the

²⁸ From John Todd, Bill Yeo from the Australian Home Heaters Association, and Vic Neave from the SA Energy Information Centre.

expected future contribution of post-93 woodheaters to emissions reduction. The following further information is required:

- An estimate of sales of new woodheaters over the period to 2007 is required. On the usual assumption that woodheaters have an effective life of 15 years, and assuming the new standard operated from 2001, it follows that 40% of existing woodheaters will be replaced in the period to 2007 (40% = 6/15). They will be replaced by ‘post-2001’ woodheaters, as opposed to post-93 models. The new mix of woodheaters in 2007, compared with the ‘no change’ alternative, is as follows:

	<u>No change</u>	<u>New standard</u>
– Open fires:	7.0%	7.0%
– Pre-93 woodheaters	20.0%	20.0%
– Post-93 woodheaters	73.0%	33.0%
– Post-2001 woodheaters	0.0%	40.0%

- We assume that average emissions from post-2001 heaters will be 73% of emissions from post-93 heaters, in line with the reduction in the emissions standard from 5.5g/kg to 4g/kg that is specified in the revised Australian Standard AS4013.

In respect of this last assumption, DPIWE has indicated that 70% of the woodheaters that are currently certified for sale in Tasmania already comply with the revised standard. And the remaining 30% of certified woodheaters do not greatly exceed the new standard; they have an average emission level of 4.6g/kg²⁹. Arguably, therefore, the introduction of new standards will have little additional effect. But that ignores the following considerations:

- It is generally the case that manufacturers seek to anticipate regulatory changes and to develop appropriate technology. For example, the industry has been negotiating with CSIRO for new R&D that promises a further significant breakthrough in woodheater design. To maintain the pressure for technological development, it is important that the regulatory bar be steadily raised, and that further tightening be signalled ahead of time. Accordingly, adoption of the revised standard and automatic adoption of future revisions would send a signal to the industry that it needs to keep improving.
- The proposed measures go beyond the adoption of the revised AS4013. They include measures to discourage both woodheater modification and the sale of woodheater models that differ from the models that have actually been tested and certified.

Obviously there is considerable uncertainty about the potential for further improvements in woodheater technology.

Based on the assumptions outlined above, we estimate the scope to reduce emissions by improving the emissions performance of new woodheaters as follows:

- The maximum contribution to the emissions reduction target is 6 percentage points.
- For most householders the costs will be relatively minor, provided they quickly learn to operate the new heaters efficiently. However a significant minority may not cope well, possibly to the point of adopting an alternative form of heating, or decide to retain their existing heaters for a considerably longer period.

Accelerate replacement of pre-93 woodheaters

It may be possible to effectively regulate against the resale and re-installation of second-hand pre-93 woodheaters. By denying householders the opportunity to acquire a non-certified woodheater in this fashion, the intention is to force them to buy a post-2001

²⁹ Note that we refer to the number of certifications, which may be quite different to actual sales. The proportion of sales of woodheaters that already comply with the revised standard is unknown.

woodheater or a second-hand post-93 woodheater, or turn to some alternative form of heating.

The costs that attend this forced upgrading are similar to those that attend the upgrading that accompanies lower emission standards on new heaters. Some will quickly learn to efficiently operate more demanding woodheaters that they are forced to acquire. Others will suffer significant loss of functionality or seek to acquire a post-93 woodheater that can be readily modified. It is not feasible to estimate the costs, except to say that they are variable and probably not trivial for some people.

In respect of the potential contribution to the emissions reduction task, the impact of such measures is not clearcut. One possibility is that some intending sellers of pre-93 heaters would respond to the loss of resale value by retaining their woodheaters for a further considerable period. Most people feel a need to get value from their possessions, either by using them up or recouping reasonable value on the second-hand market. There is an aversion to simply throwing things away. Another possibility is that some intending buyers would have replaced an even older pre-93 heater with a ‘new’ second-hand heater. They may also respond by retaining their old equipment even longer, possibly by having the firebox replaced.

That said, it is difficult to imagine that the impact of such measures would actually be perverse, that is, cause pre-93 woodheaters to be retained in service for longer than otherwise.

It is not feasible to model the impact of resale prohibitions on heater replacement decisions. However, recall the earlier estimate that about 20% of the woodheater stock in 2007 will comprise pre-93 woodheaters, including a proportion of modified post-93 woodheaters. The question is, what proportion of these would owe their continued use to having been recycled through the second-hand market in the period 2001 to 2007? We consider that, at most, one quarter of that 20% would be in that category. Relevant considerations are as follows:

- A large proportion of durable goods are replaced before they fail irretrievably, often associated with some change in family circumstances. Over time, an increasing proportion of any given cohort of durable goods will have changed hands at least once, and, by 2007, the remaining stock of pre-93 heaters will be quite old.
- In discussion with the steering committee, it was agreed that a significant minority of pre-93 woodheaters will survive through to 2007 regardless of what action is taken. That was put at 15% of the total stock. That leaves, at most, 5% of the stock of heaters that may be caught by a prohibition on re-installation.
- On this thinking, the relevant comparison is as follows:

	<u>No change</u>	<u>Resale prohibition</u>
– Open fires:	7.0%	7.0%
– Pre-93 wood heaters	20.0%	15.0%
– Post-93 wood heaters	33.0%	33.0%
– Post-2001 woodheaters	40.0%	45.0%

Using the earlier assumptions about relative emissions, we put the scope to reduce emissions by prohibiting the resale and reinstallation of pre-93 heaters as follows:

- Forced upgrades from pre-93 heaters may contribute 4 percentage points to the emissions reduction target of 55-65%.
- As in the case of lower emissions standards for new woodheaters, the cost to most householders will be minor; they will quickly adjust.

Conclusion

The scope for measures to improve woodheaters may be described as follows:

- **The maximum contribution to the emissions reduction target is:**
 - 6 percentage points from the introduction of new woodheaters that meet lower emissions standards;
 - 4 percentage points from measures to ban the resale and reinstallation of pre-93 woodheaters.
- **Forced upgrading of woodheaters should not impose significant costs on most households. However a significant minority may not cope well, possibly to the point of adopting an alternative form of heating, or deciding to retain their existing heaters for a considerably longer period.**

Given the possibility that there is no significant difference between pre-93 and post-93 woodheaters, as discussed in section 3.3, it seems necessary to also acknowledge the possibility that a new standard will be similarly ineffective. In that case, the potential gains from these initiatives would be heavily discounted and possibly set at zero.

3.9 Replacement of woodheaters

A decision to replace a woodheater by alternative heating options has well defined costs and benefits. The intention here is to provide as much quantitative information as possible, including where educated guesswork is necessary. However the figuring is purely hypothetical. It is not based on real world data; that would require a program of energy audits to assess realistic options for different types of households. No doubt the cost of switching to gas or electricity would be found to vary considerably, depending on dwelling characteristics and patterns of use.

3.9.1 Cost of woodheating

Most household activities have both financial costs and time costs. The time cost of woodheating is significant. More importantly, woodheating presents the opportunity of trading time for dollars, as discussed in relation to firewood collection in section 3.6. The cost of woodheating therefore presents as a menu of alternative combinations of financial and time costs, depending on the quantity of firewood that is self collected rather than delivered by a firewood merchant – see table 3.5.

Table 3.5 Trade-off between financial and time costs

<i>Self collected firewood (tonnes)</i>	0	1	2	3	4	5
Financial cost (\$ per year)	800	762	724	685	647	609
Time cost (hours per year)	73	78	83	88	93	98

To explain, if the household uses 5 tonnes of firewood per year, all of which is delivered, we estimate the total financial costs at \$800/year. Associated with this financial cost there is an unavoidable minimum of time costs, comprising the costs of stacking wood, refuelling the heater, monitoring and adjustment, and disposal of ash and cleaning. We put the latter at 73 hours per year, equivalent to 2 weeks work at standard hours (40 hours). However, time costs can be traded for financial costs through self collection of firewood. Based on certain assumptions about distances travelled to collect wood, carrying capacity of the vehicle, equipment and vehicle operating costs, we put the alternative extreme option at \$609/year and 98 hours. In other words, the householder might be able to earn \$191/year (= \$800 - \$609) in exchange for 25 hours work (= 98 – 73). Importantly these ‘earnings’ are tax-free, reflecting the fact that neither GST nor

income tax is payable on the value that is created by expending time in this fashion. Table 3.5 reports the two extreme options plus a number of intermediate options, the latter representing combinations of delivered and self-collected firewood.

The remainder of this section explains the basis for the estimate that anchors table 3.5, that is, the combination of \$800/year and 73 hours/year, and makes clear that a number of assumptions have been made. Refer now to table 3.6.

Table 3.6 Financial and time costs of woodheating, assuming firewood is delivered, not self collected

<u>Dwelling characteristics</u>	
Floorspace (m ²)	150
Construction type	Brick veneer, timber floor with carpet
Insulation	Ceiling R2.5 – walls R1.5 - floor none
<u>Heater characteristics</u>	
Energy rating (kW)	12
Energy efficiency (%)	65
Expected life (years)	10
Heater operation (days)	150
Supplementary heating	Only in b/room - insignificant
<u>Financial costs</u>	
Unit cost, including installation (\$)	1,900
Inspection and maintenance cost (\$/year)	20
<u>Time costs</u>	
Lighting, refueling (minutes/day)	15
Heater monitoring and adjustment (minutes/day)	10
Additional cleaning of dirt, soot, bark (minutes/day)	2
Collection and disposal of ash (minutes/year)	30
<u>Fuel characteristics</u>	
Energy content (MJ/kg)	16
Fuel consumption (tonnes/year)	5
<u>Financial costs</u>	
Unit cost of fuel (\$/tonne)	84
Unit cost of woodshed (\$)	500
<u>Time costs</u>	
Self collection (hours/tonne)	0
Stacking, etc (hours/tonne)	1
<u>Annual financial costs (\$/year)</u>	
Annualised capital cost of heater	309
Annualised capital cost of woodshed	50
Heater maintenance	20
Firewood	421
Total	800
<u>Annual time costs (hours)</u>	
Woodheater operation	68
Firewood collection and stacking	5
Total	73

Dwelling characteristics

When collecting information from equipment and fuel suppliers, we asked the respondent to consider an average house of 150m² with recommended levels of insulation and reasonable energy efficiency measures in place, as described in the table 3.6.

Heater characteristics

Information about the capacity and efficiency of the woodheater that would be required in this situation was collated from industry sources and is reported in the table. The estimated capital cost, including installation cost, is based on discussions with equipment suppliers. The small additional maintenance cost (\$20/year) is the estimated cost of periodic replacement of the baffle plate. There is no allowance for chimney sweeping, based on advice that chimney sweeping is unnecessary if woodheaters are operated and fuelled correctly.

The operation of a woodheater also requires a certain expenditure of time. The estimates in the table are based on the following pattern of use:

- one 2 hour period of high burn in the morning, one 8 hour period of low burn overnight, 4 periods of medium burn throughout the day and evening – requiring the heater to be refuelled 6 times per day;
- the heater is set on high for 20-25 minutes after refuelling, subsequently reset to low or medium as required, and monitored and adjusted as appropriate throughout the day.

This is a significant daily routine in comparison to other heating options, and we have conservatively put the time cost at 27 minutes per day, including a small allowance for additional cleaning. In respect of collection and disposal of ash from the firebox, we are advised that a correctly operated heater should not need to be cleaned more than twice per year, and is an insignificant task.

Fuel characteristics

For dry firewood, the prices quoted in the Launceston Examiner since August 2000 range from \$35-50/m³, with an average of \$42.50 and the majority of prices in the range \$40-45. On average, these data probably underestimate the cost, for several reasons:

- At least some of the lower prices will be illusory; the firewood supplied is simply short weighed or not completely dry.
- Wood merchants indicate the prices may be several dollars higher during the winter season. (Most of our data is for the off season or the tail end of the 2000 season.)

The issue of short weights can be disregarded in this context, since there will be an offsetting error in buyer estimates of the amount of firewood consumed. However, to allow for higher winter prices and discounts for wood that is not completely dry, we have used the most common price from the higher end of the range, which is \$45/m³. Including GST, the price is \$49.50/m³. Also, two direct quotes from firewood merchants listed in the yellow pages – for dry firewood supplied during winter - were for \$45/m³ without GST and \$49.50 with GST. Wood merchants report that 1.7m³ of firewood make a tonne, in which case the equivalent price per tonne is \$84.

3.9.2 Woodheaters compared to electric and gas heating

Comparison of running costs

Table 3.7 updates Todd's 1997 estimates of the comparative running costs of different types of heaters. Note the following:

- The running costs of woodheaters and electric heat pumps are very similar, particularly at the HydroHeat rate, and provided the firewood is not self collected.

- While self collected firewood has a sharp price advantage relative to the other fuels, time costs are ignored.
- The price of natural gas, which is scheduled to arrive in Launceston in 2 or 3 years, is unknown. However, it is clear from discussions with Duke Energy that prospective gas retailers fully understand the need to be competitive with wood, and that the price of natural gas will be capped to be competitive with wood. On the figuring presented in table 3.7, the price would need to be of the order of 0.75cents/MJ, which is comparable with Melbourne prices.
- In terms of running costs, delivered firewood has a clear competitive edge only in respect of electric heaters (resistance type) and LPG.

Table 3.7 Comparative running costs for different types of heaters, Launceston prices, 2001

<i>Heating choice</i>	<i>Fuel unit</i>	<i>Fuel cost (cents/fuel unit)</i>	<i>Energy content of fuel (MJ/fuel unit)</i>	<i>Energy efficiency (%)</i>	<i>Unit cost of useful heat (c/MJ)</i>	<i>Cost of one evening's heating (\$)</i>
<u>Electricity</u>						
<i>Household rate</i>						
Electric heater	KWh	8.432	3.6	100	2.34	2.81
Electric heat pump	KWh	8.432	3.6	250	0.94	1.12
<i>HydroHeat rate</i>						
Electric heater	KWh	7.078	3.6	100	1.97	2.36
Electric heat pump	KWh	7.078	3.6	250	0.79	0.94
<i>Off-peak rate</i>						
Electric heater	KWh	6.520	3.6	100	1.81	2.17
<u>Gas</u>						
LP gas	Kg	175	50	75	4.67	5.59
Natural gas	MJ	0.75	1	75	1.00	1.20
<u>Firewood</u>						
<i>Delivered firewood</i>						
Good heater	Kg	8.5	16	65	0.82	0.98
Poor heater	Kg	8.5	16	50	1.06	1.28
<i>Self collected firewood</i>						
Good heater	Kg	4.6	16	65	0.44	0.53
Poor heater	Kg	4.6	16	50	0.58	0.69

Comparison of total costs

Table 3.8 provides estimates of comparative total costs, including estimates of annualised capital costs and maintenance costs. Note the following:

- It is assumed that the woodheater is replaced by electric or gas heating that provides the same amount of useful heat, being 65% of the energy content of 5 tonnes of wood. (65% is the assumed energy efficiency of the woodheater.)
- Woodheaters are typically replaced by a main unit and a supplementary heater, the latter assumed to be a standard electric panel heater.
- The annualised total cost of an electric heat pump is somewhat more than the cost of woodheating with delivered fuel, reflecting the higher capital costs.

Table 3.8 Comparative total costs for different types of heaters, Launceston prices, 2001

Heating choice	Wood heater		Electricity		Natural gas	
	Delivered fuel	Self collected fuel	Electric heater	Electric heat pump	Vertical heater	Gas log fire
<u>Useful heat (MJ/year)</u>						
Main heater	52,000	52,000	41,600	41,600	41,600	41,600
Supplementary heater	0	0	10,400	10,400	10,400	10,400
Total	52,000	52,000	52,000	52,000	52,000	52,000
<u>Main heater</u>						
Unit fuel cost (c/MJ of useful heat)	0.82	0.44	1.97	0.79	1.00	1.15
Total fuel cost (\$/year)	425	230	818	327	416	480
Capital costs	1,900	1,900	1,500	3,200	1,600	2,250
Annualised capital cost (\$/year)	309	309	244	521	260	366
Maintenance costs (\$/year)	50	50	20	50	20	20
Annualised total cost (\$/year)	784	589	1,082	898	696	866
<u>Supplementary heating</u>						
Unit fuel cost (c/MJ of useful heat)			2.34	2.34	2.34	2.34
Total fuel cost (\$/year)			244	244	244	244
Capital costs			250	250	250	250
Annualised capital cost (\$/year)			41	41	41	41
Maintenance costs (\$/year)			0	0	0	0
Annualised total cost			284	284	284	284
Total cost	784	589	1,366	1,182	981	1,150

- Natural gas looks more competitive in terms of total cost, reflecting lower capital costs. But this is simply an assumption, based on advice that gas will be priced to be competitive with firewood.

Other factors that affect the comparison between wood, electricity and gas cannot be readily factored into a financial analysis, as follows:

- Pre-1980 houses may need to have the electricity mains upgraded in order to accommodate the additional load required by electric space heating. Some houses may also need to be rewired. The additional cost is of the order of \$500-\$1,500.
- Woodheaters have a wide range of effective operation, delivering good performance on the coldest nights when heat pumps may be found wanting.
- Several respondents have noted that woodheaters give people better control over their energy budgets. For example, the stock of firewood is readily monitored and the cost of restocking is known. By comparison electricity and gas bill are relatively unpredictable.
- Woodheaters have particular characteristics that are not readily factored into a financial analysis. Some are positive, relating to the aesthetic characteristics of a wood fire. And some are negative, relating to the additional work and attention that is required.

Given the information presented in table 3.8, and keeping in mind that it relates to a hypothetical situation, it seems reasonable to expect that households may incur additional costs in the range of -\$250 to +\$250 per year by switching from woodheaters to gas or electricity. To make sense of this assessment, consider that:

- As discussed in section 3.2, there is an apparent trend away from woodheaters; some people are choosing alternatives because, all things considered, they regard the alternatives as cheaper. And, as discussed further in chapter 5, it is apparent that households adopt woodheating at particular stages in the lifecycle and abandon it later. This is the sense in which we can say that, for some people, there is a negative cost in converting from woodheaters to the electric or gas alternatives.
- Some households will be, for all practical purposes, indifferent between woodheaters and either an electric or gas alternative, provided they are able to finance any additional capital costs. Such households may need minimal encouragement to make the conversion.
- Progressively, however, larger financial incentives would be needed to induce other households that, for some combination of financial and non-financial reasons, put a higher value on the retention of their woodheaters.

The distribution of woodheated households between these various categories is unknown at this stage. By implication, the response to financial incentives is unknown, except that it will attract significant numbers of people who already plan to make the conversion.

Conclusion

Putting aside those households that will make the conversion anyway, how many households would need to be converted in order contribute 1 percentage point to the emissions reduction target, and what would it cost? Relevant considerations are:

- **A 1% reduction in emissions requires approximately 140 conversions, being 1% of the houses with woodheating.**
- **At one extreme, some conversions may be achieved at little or no cost to the affected households; they are indifferent between woodheaters and the alternative.**
- **At the other extreme the cost may be of the order of \$35,000 per year, being 140 households that would incur additional costs of \$250/ year each.**

It follows that the cost of induced conversions from woodheaters to alternative forms of heating is in the range \$0 to \$35,000 per 1 percentage point contribution to the emissions reduction target.

3.10 Summary

Table 3.9 summarises the main findings of this chapter. Note the following:

- Cost is reported in terms of the cost to households of delivering a 1% reduction in emissions.
- In some cases there are net benefits (reported in table 3.9 as negative costs) or the possibility of net benefits. Insulation is an example of the former. As an example of the latter, it appears that some woodheater users are mistaken in thinking that green firewood is a cheaper fuel than dry firewood when all things are considered, and would financially benefit by converting to dry wood.
- There is a considerable range of costs in most cases. For example:
 - The (negative) cost for retrofitting ceiling insulation to existing houses depends on the life expectancy of the house.
 - Avoiding the use of green firewood may be a net financial cost to self-collectors, but a benefit to other users of green wood.
 - While most households would incur only small or temporary costs to adopt better operating practices or design, others may find the transition quite difficult, if only because they cannot get organised to attend properly to their woodheaters.

Table 3.9 Summary of possible contributions to the required reduction in woodheater emissions

<i>Trend, development or management action</i>	<i>Maximum reduction in emissions (percentage points)</i>	<i>Cost to households (annualised \$ cost per 1% reduction in emissions)</i>
Population growth	0.0	-
General trend against woodheaters	6.0	-
Phase out of pre-93 woodheaters	26.0	-
Tasmanian Natural Gas Project	20.0	-
Insulation requirements for new houses	0.43	-\$54,000
Insulation requirements for house extensions	0.34	-\$54,000
Ceiling insulation retrofit for existing houses	5.5	-\$33,500 to -\$47,000
Reduce the moisture content of firewood	5.0	-\$2,500 to \$7,500
Improve the operation of heaters	15.0	No significant cost but may still prove difficult
Lower emissions standards for new heaters	6.0	Temporary cost for most, more difficult for some
Accelerate the scrapping of pre-93 heaters	4.0	Temporary cost for most, more difficult for some
Replace woodheaters with gas or electricity	100.0	\$0 to \$35,000

- Importantly, relative costs will be affected by the sequence in which initiatives are undertaken. For example, suppose that there has been a ceiling insulation retrofit for existing houses, contributing 5.5% to the targeted reduction in emissions. That will leave less work for the remaining initiatives, and reduce their cost effectiveness relative to the original target. Accordingly each of the measures in table 3.9 has been costed on the assumption that none of the other measures have been implemented.

Finally, we consider that the key point to take from this analysis is that there are two dimensions to variation in costs. The general differences between broad measures are the more obvious. For example, contrast the net benefits from insulation measures to the possibility of large net costs to convert to electric or gas heating. The less obvious variation, which relates to differences between households that adopt certain changes, is equally important. For example, some households may need very little encouragement to convert to electric or gas heating; others will find it very difficult. Ideally, a woodheater management program would endeavour to make progress across several dimensions of the problem, taking care to avoid further effort in one direction if that same effort would yield a better return by pursuing alternatives. Unfortunately, the optimisation of a management program in that respect requires cost-effectiveness information that is not yet available.

4. Emission scenarios: 2001-2007

This chapter is organised around table 4.1, which contains three panels:

- The first panel reports the separate effects of each of the factors that are identified and analysed in chapter 3, with the exception of specific measures to replace woodheaters.
- The second panel reports various emission scenarios, being combinations of the separate effects.
- The final panel reports estimates of the required contribution from specific measures to reduce the number of woodheaters. This is a residual requirement that is determined in the light of expected contributions from all other developments and measures listed in the first panel.

4.1 Separate effects

Note the following about the separate effects that are reported in the first panel:

- The maximum possible contribution of each to the emissions reduction target is copied from table 3.9.
- Some of these developments and measures will operate throughout the full period, 2001 to 2007. Others would have no impact until 2002 or 2003. For example, gas from the Tasmanian Natural Gas project is scheduled to be available for the 2003 winter, and certain regulatory measures would not be in effect until 2002. Similarly, the full impact of some factors may be achieved before 2007. For example, it seems likely that measures to reduce the moisture content of wood or to improve woodheater operation may have substantially run their course by 2005. (Of course, program expenditures would be needed beyond 2005 in order to prevent backsliding.)
- The ‘Achievement factor’ is set to reflect a view about the extent to which the maximum possible contribution from each development or measure will be achieved. For example, a factor of 1.0 expresses the view that the full impact will be achieved; a factor of 0.5 cuts the impact in half. Logically, the achievement factor can be set greater than 1.0, expressing a view that the ‘maximum’ impact has been set too conservatively. To a large extent, the achievement factors that are given in table 4.1 reflect assessments of the likely success of proposed policy measures. The table therefore anticipates the policy discussion in chapter 5.
- The expected reduction in woodheater emissions from each development or measure is reported in columns E and F, being the product of columns A and D.

4.2 Combined effects (scenarios)

The combined effect of multiple developments and measures is not necessarily the simple sum of the separate effects. For example:

- Two measures may be separately capable of contributing a 10% reduction in emissions, but their combined effect may not be a 20% reduction. Consider that the second measure may address the remaining 90% of the problem – after allowing for the impact of the first measure – and contribute only an additional 9% to the solution ($9\% = 10\% * 90\%$).

Table 4.1 Business As Usual Scenarios and the required contribution from the replacement of woodheaters

	<i>Maximum contribution to reduction target (percentage points)</i>	<i>Start date</i>	<i>End date</i>	<i>Achievement factor</i>	<i>Expected reduction in emissions (% of emissions in 2000)</i>		<i>Expected reduction in the number of woodheaters (% of woodheaters in 2000)</i>		
					<i>2004</i>	<i>2007</i>	<i>2004</i>	<i>2007</i>	
					(A)	(B)	(C)	(D)	(E)
<u>Each factor considered separately, 2000-2007</u>									
1	Population change	0.0	2001	2007	0.00	0.0	0.0	0.0	0.0
2	Underlying trend	6.0	2001	2007	0.50	1.7	3.0	1.7	3.0
3	Phase out of pre-93 heaters	26.0	2001	2007	0.75	11.1	19.5		
4	Tasmanian Natural Gas Project	20.0	2003	2007	1.00	8.0	20.0	8.0	20.0
5	Insulation requirements for new houses	0.43	2003	2007	1.00	0.2	0.4		
6	Insulation requirements for house extensions	0.34	2003	2007	1.00	0.1	0.4		
7	Ceiling insulation retrofit for existing houses	5.5	2002	2007	0.00	0.0	0.0		
8	Reduce the moisture content of firewood	5.0	2002	2005	0.50	1.9	2.5		
9	Improved operation of heaters	15.0	2002	2005	0.50	5.6	7.5		
10	Lower emission standards for new heaters	6.0	2002	2007	0.50	1.5	3.0		
11	Ban on re-installation of pre-93 woodheaters	4.0	2002	2007	0.50	1.0	2.0		
<u>Scenarios (combined effects), 2000-2007</u>									
12	BAU1 scenario (items 1-3)					12.0	21.0	1.7	3.0
13	BAU2 scenario (BAU1 plus item 4)					15.9	30.7	9.6	22.4
14	BAU3 scenario (BAU2 plus items 8, 10, 11)					20.0	37.3	9.6	22.4
15	BAU3 plus selected management actions (BAU3 plus items 5, 6, 7 and 9)					24.8	42.6	9.6	22.4
<u>Required reduction in emissions from specific measures to replace woodheaters (% of emissions in 2000)</u>									
16	55% target						12.4		
17	65% target						22.4		

- Measures that reduce the number of woodheaters interact negatively with measures that are designed to improve the emissions performance of new woodheaters. This is because a reduction in the number of woodheaters has the effect of reducing the proportion of new woodheaters in operation, through reduced sales of new heaters.

We dealt with these interactions as follows:

- The effects of developments and measures that alter the mix of woodheaters – that is, the mix of pre-1993 heaters, post-1993 heaters and post-2001 heaters – have been estimated in such a way that they can be simply added together to obtain the combined effect of such developments and measures. These are items 3, 10 and 11 in table 4.1.
- The additional effects of developments and measures that reduce the number of woodheaters (items 1, 2, 4 and 16/17 in table 4.1) have been estimated on the assumption that the emissions from any woodheater that is replaced would have been 50%³⁰ of the average level of emissions in 2000. This substantially dilutes the impact of prospective reductions in the number of woodheaters.
- Conversely, it is important to restore the full impact of such developments and measures where it is assumed that there is no significance difference in the emissions performance of the different generations of woodheaters. (These variations on the base case are reported in table 4.3.)
- The additional effects of measures to improve woodheater operation and reduce the moisture content of firewood (items 8 and 9 in table 4.1) are assumed to be independent of the mix of woodheaters. That is, these measures are assumed to have an equal proportional effect on emissions from all types of woodheaters.
- Likewise, the additional effects of measures to improve house insulation (items 5, 6 and 7 in table 4.1) are assumed to be independent of the mix of woodheaters. That is, these measures are assumed to have an equal proportional effect on emissions from all types of woodheaters.

Allowing for those interactions, the second panel of table 4.1 reports the combined effect of alternative combinations of the various developments and measures. There are 3 Business-As-Usual (BAU) scenarios, as follows:

- BAU1 assumes the continuation of current trends, no change in the energy supply situation, and no change in the policy environment affecting woodheaters – see line 12.
- BAU2 assumes the continuation of current trends, the introduction of natural gas via the Tasmanian Natural gas project, but no change in the policy environment affecting woodheaters - see line 13.
- BAU3 assumes the continuation of current trends, the introduction of natural gas via the Tasmanian Natural gas project, and implementation of the proposed measures under Tasmania's Environment Protection Policy on Air Quality - see line 14.

Lines 15, 16 and 16 relate to further possible measures. Specifically, line 15 reports the impact of adding, to the BAU3 scenario, measures to improve insulation and measures to improve the operation of woodheaters. Finally, lines 16 and 17 report the percentage reduction in emissions that needs to be contributed by measures to reduce the number of woodheaters, taking all other expected developments and measures into account. This is

³⁰ If reductions in the number of woodheaters fell entirely on post-93 woodheaters, the appropriate figure would be 55%, consistent with the baseline assumptions that have been adopted throughout the report. The appropriate figure would be 40% if reductions fell entirely on post-2001 woodheaters. We adopt a figure of 50% as a reasonable approximation to the average of both effects.

the difference between the targeted reduction and the reduction that is expected to be achieved without specific measures to reduce the number of woodheaters. The difference is 12.4 percentage points if the target is a 55% reduction - see row 15. The difference is 22.4 percentage points if the target is a 65% reduction - see row 16.

4.3 Required contribution from specific measures to replace woodheaters

Importantly, the required proportional *reduction in the number of woodheaters* is considerably larger than the required proportional *reduction in emissions*. As reported in table 4.2, we estimate that specific measures to reduce the number of woodheaters must remove 27.8% of the woodheaters in existence in 2000 in order to contribute 12.4 percentage points to the targeted reduction in emissions, assuming a target of 55%. The disproportionate requirement reflects two considerations that have been signalled above:

- Measures to reduce the number of woodheaters fall on new woodheaters that are assumed to have much lower emissions than the average woodheater. As indicated above, we assume a ratio of 50%.
- Other developments and measures independently reduce average emissions from all woodheaters, for example, measures to improve woodheater operation. These further dilute the impact of woodheater replacements in terms of the original target.

Table 4.2 also reports the *total* reduction in the number of woodheaters, combining the effects of existing trends, expected competition from natural gas and the required contribution from specific measures to replace woodheaters. Importantly, this total is large, comprising 50% of the stock in 2000 if the target is a 55% reduction, and 72.6% of that stock if the target is a 65% reduction. Given that only 40-45% of the stock will be due for replacement in the period to 2007, it follows a proportion of woodheaters would need to be replaced before they would normally be due for replacement. This is an increasingly expensive option for woodheater users, since cost increases with earlier scrapping of functional equipment. Very probably, it would be difficult to meet the lesser target by 2007, and impossible to meet the larger target. However it may be feasible to meet the lesser target before 2010.

Table 4.2 Required reduction in the number of woodheaters

Targeted reduction in emissions (% of 2000 level)	55	65
Required reduction in emissions to be contributed by specific measures to reduce the number of woodheaters (percentage points)	12.4	22.4
Required reduction in the number of woodheaters to be contributed by specific measures to reduce the number of woodheaters (% of stock in 2000)	27.8	50.2
Total reduction in the number of woodheaters from all anticipated developments and measures (% of stock in 2000)	50.2	72.6

4.4 Sensitivity analysis

The outcomes that are reported in table 4.2 reflect the particular combination of ‘Achievement factors’ that are reported in column D of table 4.1. This profile is necessarily subjective, although informed by consideration of costs to households and the likely effectiveness of proposed policy measures. Possible alternative views are presented in table 4.3.

Table 4.3 Comparison of alternative assessments of the impact of expected developments and measures

	<i>Maximum contribution to reduction target (percentage points)</i>	<i>Worst case</i>	<i>Base case</i>	<i>Best case</i>
<u>Each development or measure considered separately</u>				
		<u>Achievement factor</u>		
Population change	7.0	0.00	0.00	0.00
Underlying trend	6.0	0.25	0.50	1.00
Replacement of pre-93 heaters	26.0	0.25	0.75	1.00
Tasmanian Natural Gas Project	20.0	0.00	1.00	1.00
Insulation requirements for new houses	0.44	0.00	1.00	1.00
Insulation requirements for house extensions	0.35	0.00	1.00	1.00
Ceiling insulation retrofit for existing houses	5.5	0.00	0.00	1.00
Reduce the moisture content of firewood	5.0	0.25	0.50	1.00
Improved operation of heaters	15.0	0.25	0.50	1.00
Lower emission standards for new heaters	6.0	0.00	0.50	1.00
Prohibition of re-installation of pre-93 woodheaters	4.0	0.00	0.50	1.00
<u>Scenarios for combined effects, % reductions achieved by 2007</u>				
BAU1 scenario		8.0	21.0	29.0
BAU2 scenario		8.0	30.7	38.4
BAU3 scenario		9.1	37.3	51.0
BAU3 plus selected management options		12.6	42.6	61.3
<u>Required contribution from specific measures to replace woodheaters</u>				
<u>55% target</u>				
Required additional reduction in emissions (% of 2000 level)		42.4	12.4	-6.3
Required additional reduction in number of woodheaters (% of 2000 stock)		44.6	27.8	0.0
Total reduction in number of woodheaters (% of 2000 stock)		46.1	50.2	24.8
<u>65% target</u>				
Required additional reduction in emissions (% of 2000 level)		52.4	22.4	3.7
Required additional reduction in number of woodheaters (% of 2000 stock)		55.2	50.2	9.8
Total reduction in number of woodheaters (% of 2000 stock)		56.7	72.6	34.6

Note the following about the results presented in table 4.3:

- The scenario that is described in tables 4.1 and 4.2 is reported as the ‘base case’ in table 4.3. Total woodheater numbers would fall by 50%, about half of which would be delivered by specific measures to replace woodheaters.
- A more optimistic assessment of prospective developments and measures would deliver a 55% reduction in woodheater emissions without the benefit of any specific measure to replace woodheaters. In fact, this ‘best case’ delivers more than the required reduction. It would probably deliver against the more demanding target (65% reduction) before 2010.
- Now consider the ‘worst case’ that is presented in table 4.3. Clearly, the bulk of the work of delivering the required reduction in emissions will fall to a woodheater replacement program if it turns out that other developments or measures contribute very little. As shown, a replacement program may need to deliver a 44% reduction in the number of woodheaters in order to achieve the lesser target.

The range of possible outcomes that is presented in table 4.3 suggests considerable uncertainty about the impact of prospective developments and measures. This is regrettable but we consider this to be the actual state of affairs given the current state of knowledge.

We reiterate that the achievement of the target within the desired timeframe is doubtful if it turns out that the total reduction in the number of woodheaters exceeds the number of woodheaters that would normally fall due for replacement in the period to 2007. It is only in the best case scenario that this outcome is clearly avoided. In all other cases, accelerated scrapping of woodheaters threatens to become excessively costly, and suggests a trade-off between cost and delayed achievement of the target.

Finally, it is important to draw attention to a further assumption underlying the worst case scenario in table 4.3, and the consequences of that assumption. Consider that developments or measures that alter the mix of woodheaters are assumed to contribute little or nothing in the worst case scenario. (These include the phasing out of pre-93 woodheaters and tighter emissions standards for post-2001 woodheaters.) It follows that measures to replace woodheaters are not diluted by below average emissions from the new woodheaters that are actually being replaced by gas or electricity³¹. As noted in section 4.1, this restores the full value of developments and measures that reduce the number of woodheaters. In turn, this accounts for the fact that the *total* reduction in the number of woodheaters is *smaller* in worst case scenarios than in base case scenarios – see table 4.3.

³¹ Note that, while the gas or electric heater would seem to replace an old woodheater, the real alternative to a new gas or electric heater is a new woodheater. The old woodheater is assumed to be due for replacement anyway.

5. Policy analysis

Management options are discussed here under five headings:

- Tasmania's Environment Protection Policy on Air Quality – section 5.1;
- Smoke patrol – section 5.2;
- Incentive scheme – section 5.3;
- Ceiling insulation retrofit program – section 5.4;
- Summary – section 5.5.

It is envisaged that the smoke patrol officers will have a central role in all management options. Readers who are not familiar with the basic idea of a smoke patrol should refer briefly to the first 2 pages of section 5.2.

5.1 Tasmania's Environment Protection Policy on Air Quality

Certain regulatory measures concerning domestic solid fuel burning appliances are scheduled for inclusion in Tasmania's Environment Protection Policy on Air Quality. In terms of the analysis presented in chapters 3 and 4, these measures can be organised into three groups:

1. *Measures to reduce the moisture content of wood:* Two measures are planned – banning the sale of firewood with a moisture content of more than 20%, and a ban on the use of wet firewood.
2. *Measures to improve the emissions performance of new woodheaters:* Two measures are planned, a reduction in the particle emission limit for new woodheaters to comply with the 1999 revision of AS4013, supported by a ban on modifications of woodheaters in such a way that emissions will be increased.
3. *A measure to accelerate the retirement of non-certified woodheaters:* The proposed measure is to ban the resale and re-installation of pre-93 woodheaters.

DPIWE provided this study with an analysis of the cost effectiveness of the proposed measures.

5.1.1 Measures to reduce the moisture content of firewood

While most firewood is supplied by wood merchants, a substantial minority of woodheater users (25-30%) collect their own firewood. The proposed ban on the sale of wet firewood will regulate the former; the ban on the use of wet firewood will regulate the latter.

The main difficulty is that, as discussed in chapter 3, there are good reasons to harvest firewood before it is dry. Green wood does less damage to chainsaws and the work can be completed more quickly. The downside is the need to subsequently store the wood until it is ready to burn, which creates obvious incentives to burn it wet. However the important considerations for any regulatory proposals are that:

- Both wood merchants and self-collectors have good reasons for holding stockpiles of wet wood, even if there is no intention of selling or using that wood until it is dry.

- It is customary for wood merchants to supply wet wood against future needs, for example, to supply wood, in summer, that will be ready for burning in the following winter. Logically, wood may be reasonably sold at various levels of moisture content depending on when it is needed. Such wood is generally sold at a discount, the basis of which is that the practice makes use of the storage space that is available to households and would otherwise need to be provided by merchants. The practice may also save some handling costs, relating to the movement of stocks in and out of supplier storages.

These considerations suggest that it may not be feasible to ban the sale of wet wood without substantially affecting the normal processes of firewood supply, and adding to costs. The alternative would be to require suppliers to clearly inform buyers about the moisture content of wood, possibly by indicating when it will be ready to burn. And wood that is advertised as ready to burn would need to comply with specific moisture requirements. This is a more complicated arrangement than a simple ban. The details would need to be negotiated directly with the wood merchants.

Given appropriate regulatory measures at the state level, it seems sensible for smoke patrols, as defined in section 5.2, to take the lead role in education and enforcement. Over time, patrol officers will develop an understanding of the contribution of wet wood to excessive smoke, and regular contact with the owners of smoky woodheaters would enable them to identify the suppliers and supply practices at fault. They would be in a good position to assess the appropriate response in terms of some combination of monitoring, education, warnings and fines.

In the light of this discussion and the analysis provided in chapter 3, the proposed measures can be summarised as shown in table 5.6 – see section 5.5.

5.1.2 Measures to improve the emissions performance of new woodheaters

The proposal is to reduce the particle emission limit for new woodheaters to comply with the 1999 revision of AS4013, supported by a ban on woodheater modifications that increase emissions. Subsequent revisions of AS4013 would be automatically adopted. The immediate effect of adoption of the revised standard would be to reduce the emissions limit from 5.5g/kg to 4.0g/kg.

DPIWE has indicated that 70% of the woodheaters that are currently certified for sale in Tasmania already comply with the revised standard. And the remaining 30% of certified woodheaters do not greatly exceed the new standard; they have an average emission level of 4.6g/kg³². Clearly, manufacturers can meet the demands of the revised standard, which may indicate that the introduction of new standards will have little additional effect. However, it is generally the case that manufacturers seek to anticipate regulatory changes and to develop appropriate technology. For example, the industry has been negotiating with CSIRO for new R&D that promises a further significant breakthrough in woodheater design. To maintain the pressure for technological development, it is important that the regulatory bar be steadily raised, and that further tightening be signalled ahead of time. Accordingly, adoption of the revised standard and automatic adoption of future revisions would send a signal to the industry that it needs to keep improving.

That said, new standards can be accommodated in two ways:

- There can be genuine technological advance in the sense that both the functionality of new heaters is maintained *and* the new emissions standards are met. The key dimension of functionality that needs to be preserved is the ability of

³² Note that we refer to the number of certifications, which may be quite different to actual sales. The proportion of sales of woodheaters that already comply with the revised standard is unknown.

the heater to stay alight overnight on one load of fuel, so that the house is still warm in the morning and the fire does not need to be restarted.

- Or the slow burn option can be disabled, basically for the purposes of passing the certification test, but with the obvious intention that the slow burn option will be restored by the retailer, installer or owner. That would require the removal of a stopper on the air control or other simple modification of the heater.

The best response to the latter strategy might be to further tighten the standard, requiring that new heaters demonstrate both low emissions and high functionality, including the ability to stay alight for 8 hours on one load of fuel. It may be feasible for Tasmania to proceed independently in that respect, but that option has not been investigated here. It would require additional certification requirements and continued operation of a separate Tasmanian certification process. (As it stands, the current proposal would remove the need for separate Tasmanian certificates and rely instead on National Certificates issued by the Energy Information Centre in SA, which is an administrative saving for Tasmania.)

Failing that, it is important that suppliers and installers understand their responsibilities in respect of modifications, and that action will be taken against both them and their customers if smoke patrols identify heaters that have been modified. This is the intention of the proposed measures under Tasmania's Environment Protection Policy on Air Quality. Presumably the threat of unhappy customers, who have been denied the functionality promised by retailers and installers, would be a substantial disincentive. However, detection may be a problem. Modified woodheaters may perform well enough to escape the attention of smoke patrols, or the modifications might not be obvious.

Given the necessary regulatory measures at the state level, it seems sensible for smoke patrol officers to take the lead role in education and enforcement. LCC might also examine options for identifying newly installed woodheaters for the attention of the smoke patrol, for example, through revised building approval requirements or better enforcement of existing requirements. Alternatively, it may be feasible to visually identify all new homes with flues and arrange a visit by a smoke patrol officer. (Similar initiatives by councils in other parts of the state with more building activity might more quickly identify models that have been modified, and identify the manufacturers that need to be brought into line.)

In the light of this discussion and the analysis provided in chapter 3, the proposed measures can be summarised as shown in table 5.6 – see section 5.5.

5.1.3 Ban on the sale and reinstallation of pre-93 woodheaters

The proposed ban is straightforward. In principal, it could have a small but not insignificant effect on emissions. However the detection of prohibited sales will probably be difficult. Based on our review of woodheater advertisements in *The Launceston Examiner*, the certification status or age of second-hand woodheaters is not generally stated in advertisements. Moreover, there are other ways of disposing of old heaters, for example:

- Retailers and installers may also be directly involved in recycling a significant proportion of old heaters; they often remove old heaters free of charge when selling or installing new heaters.
- Old heaters may be recycled through informal networks of family and friends, or via notice boards at places of work.

It may be reasonable to hope that many people will simply choose to 'do the right thing'. This requires that people understand their obligations and know how to distinguish between certified and non-certified heaters, which is by means of a permanent aluminium plate attached to the heater. This may require, for example:

- advertisements in the ‘for sale’ sections of local papers, warning potential buyers and sellers of their obligations and explaining how to identify pre-93 heaters;
- educating retailers and installers who advise replacement buyers about opportunities for disposing of old heaters.

Periodic inspection of storage areas of retailers and installers may also help to identify pre-93 heaters that are destined for resale.

Again, smoke patrol officers are probably best placed to undertake monitoring and enforcement activities.

In the light of this discussion and the analysis provided in chapter 3, the proposed measures can be summarised as shown in table 5.6 – see section 5.5.

5.2 Smoke patrol

Purpose

A smoke patrol would have several objectives:

- The primary objective would be to improve operating practices (including the use of dry firewood), mainly through face-to-face instruction but also involving the use of enforcement measures where appropriate.
- Patrol officers would also support Tasmania’s Environment Protection Policy on Air Quality, as follows:
 - identifying wood merchants who have falsely represented firewood as ‘ready to burn’ or falsely represented the further drying time that would be required until it is ready to burn, and taking appropriate action;
 - identifying non-certified woodheaters or illegally modified woodheaters and taking appropriate action;
 - identifying planned sales of pre-93 woodheaters and taking appropriate action.
- There may also be a role for patrol officers to promote financial incentives for conversion to electric or gas heating, for example, by providing information about eligibility and administrative arrangements, and possibly information about alternative forms of heating and sources of advice.
- Finally, patrol officers would collect and analyse information about the nature and extent of the woodheater problem, to fine tune education and regulatory initiatives as appropriate.

Operation of a smoke patrol

Based on discussions with Alan Rosevear (Environmental Health Officer, Launceston City Council), a smoke patrol may be organised as follows:

- Two officers, working separately and operating mostly in the afternoon and evenings during the coolest 6 months of the year, would work systematically through Launceston, identifying smoky chimneys (possibly with the assistance of streetlights or a spotlight). These patrols, comprised of authorised officers of the council with full powers to issue environmental infringement notices and fines, would visit offending houses to diagnose the problem, educate households on the correct operation/use of woodheaters, and if deemed necessary, issue warning notices or fines.
- A register or database of smoky woodheaters would be established, along with a program of revisiting woodheaters that have been previously observed to be smoky. It is expected that repeat offenders would face harsher fines and/or a summons to appear in court. In terms of this latter outcome, the observations of two officers, or one officer and another witness, may be needed to satisfy the court.

- It seems feasible for the smoke patrol to identify and visit the 10% of households that are generally thought to be consistently smoky, numbering about 1,400 in Launceston. This would require each of the two officers to deal comprehensively with about 6 smoky heaters per day over a 6-month period. We assume that a proportion would require revisits, and there would be a significant proportion of visits outside normal working hours.

In addition, smoke patrol officers would also undertake other activities in support of Tasmania's Environment Protection Policy on Air Quality, as discussed in section 5.1.

Training of patrol officers

The success of this program relies on the ability of officers to change the operating practices of offending households. Clearly they need appropriate training to understand the relationships between woodheater operation, visible smoke, particulate pollution and health effects. They also need appropriate investigation and communication skills in respect of the following matters:

- identification of the source of the problem for each offending household, whether it be the use of wet firewood, problems with the flue, a faulty woodheater, or poor operation;
- the specific means by which households can correct their actions, for example, how to ensure that firewood merchants supply firewood that is ready to burn;
- the need to persuade users that they can 'make a difference' and that they can 'make a difference by correcting their actions', for example, by pointing out that a small minority of users account for a significant proportion of the pollution problem, or that small changes to kindling or refuelling practice make a big difference to total emissions;
- the need to motivate people by identifying discrepancies between attitudes and actions, that is, where a household expresses an attitude of concern about particulate pollution and its health impacts but acts in a manner contrary to those attitudes.

It is envisaged that training would occur over a period of approximately 5 days, involving site visits to homes, firewood merchants and woodheater manufacturers, and expert instruction in areas such as woodheater maintenance and operation, particulate pollution, and community education. Visits to houses that are observed to deliver consistently low emissions may provide useful information about the rules of thumb or habits that these households have developed to ensure efficient operation and low emissions.

Pilot tests and program evaluation

The above proposal is based on the key assumption that a small proportion of woodheater users account for a large proportion of the woodsmoke problem. It seems feasible to embark on a program of face-to-face instruction if 10%-15% of the woodheater users comprise the target population. But the proposal may not be workable if the target turns out to be 50% or more of the population. It is desirable to test this assumption before committing resources to a full scale program.

On this issue, we note Todd's finding in a recent Hobart study (Todd 2001) that 11% of observed households emitted an average amount of smoke that "might be considered higher than is reasonable". This may be interpreted as supporting the assumption about the behaviour of a relatively small proportion of woodheater users. However, as discussed in appendix B, it might also be argued that the assumption is still largely untested. One concern is that the woodheaters that were observed to be smoky in Todd's study may not be substantially different from the rest of the study sample, except that they happened to be observed at particular stages of their daily operation. The reality might be that most woodheaters are similarly smoky at different times. It may not be possible to effectively differentiate between woodheater performance in the basis of a small number of observations (about 3), each of short duration (2-3 minutes). Moreover, even accepting

Todd's data, it is not obvious that there is a distinct group of poor operators whose woodheaters perform very differently from the rest of the population. Woodheater emissions present as a continuum from low levels to high, with no obvious breaks.

To test the hypothesis that a large proportion of the smoke problem is due to a small proportion of households, we recommend that a further observational study of smoke levels be conducted early in the coming winter. Relative to Todd's study, each house should be observed more intensely (for a period longer than 2 to 3 minutes per observation) and on more occasions (more than 2 or 3 times), including overnight observations. And standard statistical tests should be applied to ensure that measured differences between households are not substantially due to chance. If the underlying assumption is not confirmed, the design of the smoke patrol program may need to be re-considered.

Assuming that first hurdle is overcome, early program design should probably be subject to further pilot testing. Consider that the impact of the smoke patrol on emissions from specific households should be virtually immediate if the issue is one of operating practice, and that revisits to observe smoke levels should confirm the success or otherwise of the intervention. Failure to have a significant impact should trigger immediate investigation and redesign of the program. Specifically, the program is based on the assumption that one or two visits, involving face-to-face instruction, will be effective in changing behaviour. However the problem may lie deeper in entrenched attitudes or beliefs, inability to get organised to attend properly to the woodheater, or financial costs to woodheater users.

Over the longer term, smoke patrols are likely to provide information that can be used to develop a better understanding of the relative importance of the different possible causes of woodsmoke, and to better understand impediments to changed behaviour. This should feed back into other policy initiatives, for example, relating to the moisture content of firewood, woodheater modifications, and the need to remove pre-93 woodheaters. Given constant interaction with woodheater operators, smoke patrol officers would be well equipped to comment on the effectiveness of media and education campaigns, and provide input to new campaigns.

Finally, it is not clear that the impact of a smoke patrol would necessarily be detected in air quality data, unless the impact is large. The difficulty is that there are other confounding effects on emissions levels, including variations in meteorological conditions and underlying trends away from woodheaters.

Program cost

Indicative set-up costs of the program are as follows, and total \$40,000:

- Training - \$5,000. Literature is readily available at low cost and certain industry experts may also provide their services at little or no cost. Costs might be shared with other local government areas if they see value in having their environmental health officers participate.
- Pilot testing - \$25,000. We consider that it would be important to engage a professional statistician, possibly from the University of Tasmania, to help design data collection instruments and to advise on appropriate sampling regimes for detecting the most smoky woodheaters and testing for program impacts.
- Systems development - \$5,000. This would include the development of databases and arranging for appropriate flows of information both within Launceston CC, and between Launceston CC and DPIWE.
- Campaign launch - \$5,000. It is assumed that the smoke patrol program will be given a high profile launch, including for example, appropriate political involvement, media briefings and participation in talk-back radio sessions.

Indicative ongoing costs of the program are as follows, and total \$54,000/year for the first 2 years (2001 and 2002):

- Instructional pamphlets and other educational material - \$1,000/year.
- Labour costs - \$48,000/year. This estimate assumes an annual wage of \$40,000 paid to two officers for 6 months of the year, and includes labour on-costs.
- Vehicles - \$5,000. This assumes two vehicles, costed at \$20/day, for 6 months, and is based on advice from Launceston CC.

We assume that the program can be scaled back to 50% of this level in the period 2003-2005, and to 25% of the initial level in 2006 and 2007. The total cost for the period to 2007 is about \$240,000.

Summary

See table 5.6 for a summary statement of the impact, cost and cost effectiveness of smoke patrols.

5.3 Incentive scheme for woodheater conversion and/or replacement

An incentive scheme is necessarily a temporary measure. If nothing else changes in the longer term, the termination of an incentive scheme will see a substantial unwinding of the positive impacts. That is, the underlying incentive structure in terms of the relative cost of alternative heating options will reassert itself. However that is a long process when it involves durable goods. It is reasonable to expect that any additional conversions that are achieved in the period to 2007 will endure for at least 10 years and unwind slowly after that. In the meantime, longer term trends may deliver more enduring improvements in air quality. These include longer term increases in the penetration of natural gas and improvements in woodheater technology. Failing that, some form of regulatory cap on the number the woodheaters may need to be devised in the longer term, to preserve the gains that are made.

This section is organised to deal with a range of design issues, in sections 5.3.1 to 5.3.13. Our conclusions are in section 5.3.14. For the most part it is assumed that the incentive payment will be available only for *conversion* to an alternative form of heating. The option of providing assistance for the *replacement* of existing woodheaters with low emission woodheaters is first discussed in section 5.3.11.

5.3.1 Incentive instrument

In principle, the incentive payment can be directed at the capital costs of the conversion, or at the ongoing costs, or both. (Ongoing costs comprise increases in energy bills and debt servicing charges on loans taken out to finance the up-front costs.) However, we assume that it is not feasible to subsidise on-going energy costs, which would require the scheme to fund rebates on energy bills over an extended period. The effective options are therefore as follows:

- A capital grant funded directly from the scheme.
- An interest free loan, with the full interest cost charged to the scheme.
- A reduced interest loan, with the cost of the subsidy charged to the scheme.

Each of these options would be supplemented by discounts and rebates from equipment suppliers and energy retailers.

5.3.2 Subsidy equivalent loans

Clearly a capital grant of \$100 is more valuable to a participant than an interest free loan of the same amount; the latter has to be paid back. And an interest free loan is more valuable than a reduced interest loan of the same amount. Table 5.1 provides a comparison of the various schemes in terms of ‘equivalent subsidies’. That is, it reports the amounts that could be loaned for different periods and rates of interest, but still provide a subsidy that is equivalent to a capital grant of a fixed amount. The 3 panels report separately for three capital amounts - \$100, \$300 and \$500.

The table has been constructed on the assumption that participants will be eligible for personal bank loans, at a real interest charge of 10%/yr³³. The value of an interest free or reduced interest loan to the participant is the present value of the reduced loan repayments that are payable under the scheme, relative to the same loan charged at the full rate. Note the following:

- Over 2 years, a loan of \$1,501 at 5% is ‘subsidy equivalent’ to an interest free loan of \$756. That is, each increase in the interest subsidy is at the cost of some reduction in the loan amount that the scheme can afford to pay.
- An interest free loan of \$756 over 2 years is ‘subsidy equivalent’ to an interest free loan of \$365 over 6 years. That is, each extension of the payment period is at the cost of some reduction in the loan amount that the scheme can afford to pay.

Table 5.1 Amount of loans that could be provided under interest free or reduced interest arrangements (\$)

<i>Subsidy equivalent (\$)</i>	<i>100</i>		<i>300</i>		<i>500</i>	
	<i>0%</i>	<i>5%</i>	<i>0%</i>	<i>5%</i>	<i>0%</i>	<i>5%</i>
<i>Interest rate (%)</i>						
<i>Period of loan (years)</i>						
2	756	1,501	2269	4503	3781	7505
3	585	1,152	1754	3456	2923	5760
4	482	943	1446	2829	2409	4714
5	413	804	1240	2411	2067	4019
6	365	705	1094	2114	1824	3523

In principle, the subsidy offer need not be fixed in terms of either the interest rate or the period of the loan, or even in terms of whether the subsidy is taken as a cash grant or an interest subsidy. Within limits, that decision could be left to participants, provided only that the package does not exceed the fixed ‘subsidy equivalent’ for which the participant is eligible. Certain limits might apply - for example, to the minimum value of a loan, to keep processing costs under control.

One issue that may need further investigation relates to the fact that many suppliers of alternative heating equipment already offer interest free loans. The question arises ... would an incentive scheme simply displace an option that is already available in the market? We consider that this is not a significant concern. If equivalent or better loan arrangements are offered by equipment retailers, scheme participants are free to take the incentive payment as a cash grant and either put it towards the early loan repayments or use it to reduce the amount of the supplier loan. An efficient arrangement in that context might be to allow scheme participants to sign over their claims to the incentive payment to retailers, who would then claim it from the scheme.

³³ This is a reasonable approximation to rates charged by banks on unsecured loans, adjusted for inflation.

It would be important for the scheme to adopt an explicit ‘buyer beware’ approach, for example, by providing explicit advice about how participants might extract maximum value for money from the incentive payment. This might include, for example, advice to obtain written quotes from alternative suppliers and not to disclose to suppliers that the transaction will attract an incentive payment.

5.3.3 Involvement of a local financial institution

The offer of financial assistance could be organised through a local financial institution, although that possibility has not been specifically investigated. Importantly, such institutions are best placed to minimise processing costs, including assessments of credit ratings, processing of loan applications, and arrangement of repayment schedules and methods, etc. In effect, the scheme would pay the subsidy equivalent to the financial institution, who would pass that onto the participant in the form preferred by the participant. There may be an additional charge to the scheme if the processing of these loans is expected to be particularly costly, for example, due to their relatively small size. On the other hand, the financial institution may itself be willing to contribute, either by absorbing such costs or by offering a further discount on interest charges – in return for additional exposure as a supporter of an air quality initiative in the local area. In that case, the value to the participant would exceed the cost to the scheme.

A further possibility is that the government provide the financier with a loan guarantee. This may substantially reduce the processing costs, which savings would be passed back to the scheme, but at the cost of some additional financial risk to the government in respect of defaults. The question of who is best placed to assess and bear these risks would be a matter for further discussion with interested financial institutions.

5.3.4 Revolving fund

This scheme is readily presented as a revolving fund, at least to the extent that participants choose to access their subsidy entitlement in the form of a loan. At any one point the loan-related element of the scheme’s balance sheet could be presented as follows:

- total amount of loans, including number of loans and average size;
- total repayments to date;
- total funds available for new lending.

This would be something of a fiction, since the loans would be on the books of the financial institution and the loan repayments would be made to the financial institution, but the remaining funds available for new lending would be retained by the scheme.

That said, a revolving fund can provide only a finite amount of assistance. Each loan would be a net cost to the scheme and the fund would be gradually dissipated. The main point is that decisions about the *size* of the subsidy can be separated from decisions about the *form* in which the subsidy is provided. The former is a decision for scheme managers. Within reason, the latter can be left for the participants to decide in consultation with the financial institution.

5.3.5 Equipment discounts and energy rebates

An incentive scheme necessarily operates to the advantage of suppliers of alternative heating equipment and fuels, primarily electricity and gas. It may be possible to negotiate special discounts with such suppliers, in return for some form of explicit recognition or participation in the scheme. For example, they may be listed as ‘participating’ suppliers in promotional material.

While not individually large, rebates and discounts might still make a significant contribution to the incentive package. For example, Melville Council in Perth has organised a woodheater conversion initiative in cooperation with Alinta Gas³⁴. It comprises the following, with an approximate total value of \$200:

- discounts from selected appliance suppliers;
- discount on cost of new connections and the installation of bayonet points;
- \$50 deducted from the first gas bill.

Access to the discount is conditional on a pre-inspection to confirm that a woodheater is being used, and a post-inspection to ensure that a gas heater has been installed. Successful applicants will be issued with a certificate that can be redeemed with participating suppliers. The requirement to actually remove the woodheater is being reconsidered. Removal imposes significant additional costs associated with the physical removal of the unit and replacement of carpet. And participants may prefer to retain the woodheater as a hedge against high energy bills, and be reluctant to participate otherwise.

It is recognised that the level of incentive payment is quite small. But the Council considers (or hopes) that many users are considering conversion anyway, and the scheme will help bring them to a decision. There is no quantitative basis for that assessment.

The administrative costs of the scheme are probably no more than \$27,000/year. The Council will provide the scheme's point of contact with the public, a part-time officer who will undertake inspections, and simple marketing activities using local media and a Council newsletter. The number of enquires elicited by early marketing activities is considered encouraging.

In respect of any incentive scheme that is devised for Launceston, it is assumed that the scheme would not seek to endorse particular types of equipment but would strongly endorse a buyer beware approach to the selection of alternative heating arrangements.

5.3.6 General offer or targeted offer?

The choice between a general offer and a targeted offer is crucial. Whereas a general offer necessarily includes households that would have converted to alternative heating anyway, a targeted offer would aim to restrict the offer to households that would not otherwise have made the conversion. The targeted offer may significantly reduce the cost in terms of program funds.

General offer

In respect of a general offer, a recent survey commissioned by DPIWE (EMRS 2000a) provides information about possible responses to specific subsidy amounts. The implied scheme design is straightforward; it offers a fixed cash amount for the conversion of woodheaters. Putting aside householders who are unsure about their replacement intentions, respondents to the survey reported their replacement intentions as follows:

<u>Replacement intentions</u>	<u>%</u>
No intention to replace woodheater	11.5
Another woodheater	46.7
Gas heater	10.5
Electric heater	31.4

Note that 40% of these householders expressed an intention to replace their woodheaters with gas or electric heaters. They would have first call on scheme funds (in the absence of

³⁴ Personal communications with Nathan George (08) 9364 0666 and Janet Armarego (08) 9364 0622 at Melville Council, and Cheyenne Martin, Manager (Marketing and Communication), Alinta (03) 9486 3360.

any measures to exclude them), without any impact on the numbers of woodheaters in operation.

Respondents who had no intention of converting to gas or electricity were subsequently asked if they would change their mind if offered an incentive payment, with these results:

<u>Amount of cash inducement</u>	<u>% accepting</u>
\$100	11
\$200	15
\$500	35

Accepting these data, table 5.2 provides estimates of the average program cost *per induced conversion*, that is, excluding conversions that would have occurred without the scheme. (We assume a total population of 14,000 households, corresponding to the total number of woodheaters in Launceston.) Keeping in mind the possible scale of the need to replace woodheaters, as discussed in chapter 4, note that only 6% of users indicate a willingness to take up an offer of \$100; and only 9% of users would respond to the offer of \$200. There is a more substantial response – about 20% – to an offer of \$500. The key outcomes in this case are as follows:

- The total cost is approximately \$3M.
- The average cost per induced conversion (\$1,530) exceeds the subsidy payment (\$500) by a factor of 3. This reflects the additional cost of payments made to households that intend to convert anyway.

The obvious conclusion is that, since only one third of the scheme funds are actually paid to households that convert in response to the incentive payment, better targeting of the scheme has the potential to save the remaining two thirds of scheme funds (\$2M). Moreover, the response to another question in the survey indicates that a larger proportion of households intend to convert (without the incentive payment) when reticulated gas becomes available. This would further increase the average cost of induced conversions.

Table 5.2 Average program costs per induced woodheater conversion

Incentive payment (\$)	\$100	\$200	\$500
Proportion of total households that respond to the incentive payment (%)	6	9	20
Total cost in scheme payments (\$)	483,000	1,012,000	3,111,000
Average cost per induced conversion (\$)	755	1,161	1,530
Ratio of average cost to incentive payment	7.55	5.81	3.06

In addition, we have a number of reservations about a scheme design that is based on these data, as follows:

- A telephone survey is not an appropriate tool for gathering information about choices that need to be well informed and require some consideration. For example, how can people indicate their likely response to the introduction of gas when the residential price of gas is unknown? Do some feel obliged to signal a preparedness to contribute to a reduction in air quality by converting from woodheaters? Do others inflate their demands for compensation to signal their disapproval?
- It is reasonable to assume that the required amount of the subsidy depends on the amount of financial benefit derived from the use of woodheaters, and that the amount of financial benefit is positively related to the amount of wood consumed. That is, the larger users will require a more substantial incentive. By implication,

the respondents to any offer will be dominated by relatively small users of firewood; the ‘typical’ user will not come forward. Reductions in woodheater numbers would not translate into proportional reductions in emissions.

- Finally, the calculations presented in table 5.2 implicitly assume that households do not change the timing of their replacement decision in response to the incentive scheme. That is unrealistic, given that the offer cannot be maintained indefinitely and that enquiries about how long the offer is available must be met with the response that there are limited funds available and the offer is of limited duration. It follows that there will be some incentive to bring replacement decisions forward to take advantage of the offer, and households who are already thinking of abandoning their woodheaters will be best placed in that respect. Importantly, on reasonable assumptions about underlying trends and the response to natural gas, 1 in 4 woodheater users (4,300) will abandon their woodheaters in the period to 2007 and are in some sense ‘primed’ to make the transition. A proportion of those will bring their replacement decision forward, further reducing the number of induced conversions.

Targeted offer – families with young children

A targeted incentive scheme may substantially improve the cost effectiveness of the scheme. The targeted group would need to offer significant advantages along the following lines:

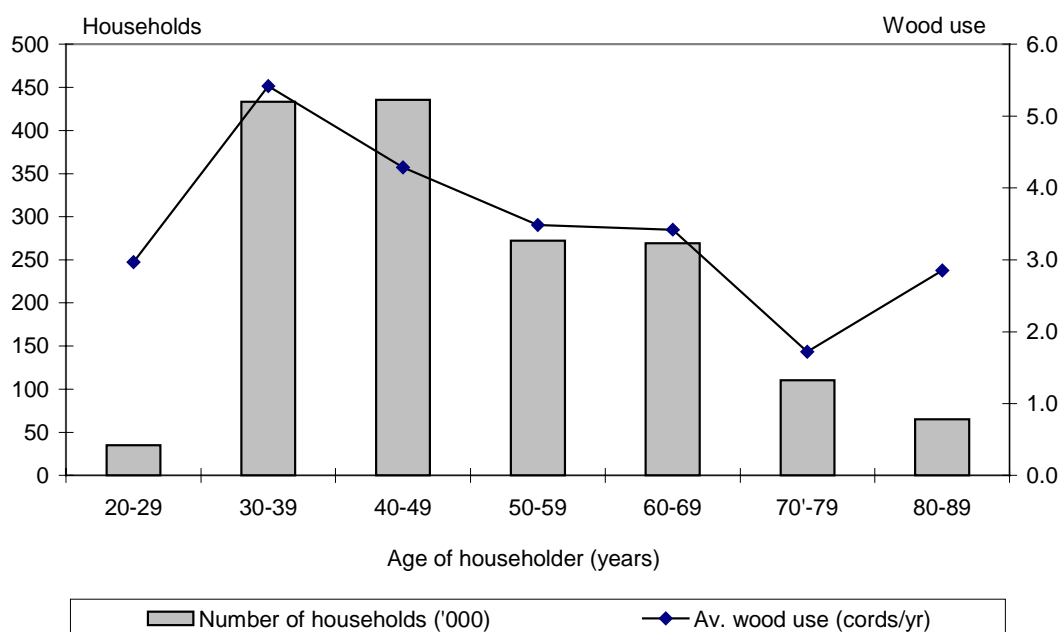
- higher incidence of households that would not make the conversion in the absence of the subsidy;
- higher than average wood use or emissions;
- lower administrative costs.

One possibility is to target households at particular stages in the lifecycle. The logic is suggested by the data presented in figure 5.1. (These data have been extracted from public use data files of the 1997 Residential Energy Consumption Survey, conducted by the US Energy Information Administration. It is reasonable to expect that similar patterns characterise Launceston.) Note that average firewood consumption varies considerably across the lifecycle. The average for the 60-69 age group is about two-thirds that of the 30-39 age group. It is reasonable to speculate that a scheme directed at young families – say, in the 25-35 age group – would deliver a superior return on scheme funds, for these reasons:

- These households are high energy users.
- These households are making energy use and lifestyle decisions that may lock them into particular patterns of energy use for 10-20 years, and will be imparted to their children to some extent.
- There may be high additionality amongst young families, being a period in life typically characterised by tight budgets.

The available information about the socioeconomic characteristics of woodheater users in Launceston is much less detailed, but tells a consistent story – see table 5.3. On this evidence, it appears that the following household characteristics correlate with the use of woodheaters:

- size of household – positively;
- presence of children – positively;
- age of household head – negatively.

Figure 5.1 Number of households and average wood use by age of householder (woodheater used as main heater)

Source: US Energy Information Administration, 1997 Residential Energy Consumption Survey, available from the USEIA website – www.eia.doe.gov

Table 5.3 Households with woodheaters by family type, 2000 (%)

	<i>Families with children</i>	<i>Couples</i>	<i>Singles</i>
Sole parent	63		
Married, all children < 17 years	68		
Married, some children > 17 years	66		
Couple, no children		58	
Married, no children at home		55	
Never married			46
Separated or divorced			36
Widowed			33

Source: (EMRS 2000a)

Targeted offer – low income households

An alternative form of targeting would aim to exclude higher income households from the scheme. Such households are more likely to be able to afford conversion if that is their preference, in which case the level of additionality³⁵ may be improved by redirecting program resources to lower income households. This is not an argument based on equity considerations, but simply a matter of efficient use of scheme funds. In support of an income test, we note that:

³⁵ Additionality refers to the proportion of induced conversions, that is, conversions that would not otherwise have occurred.

- There is a generally held view that woodheating is particularly valued by low income families, especially if they have the option to collect their own fuel.
- Housing Tasmania advises that able-bodied tenants consistently choose new woodheaters when due for replacement, mainly for reasons of economy³⁶.

That said, the need for an income test depends on other aspects of the scheme's targeting arrangements. For example, an income test may contribute little to additionality if the scheme is restricted to young families, the majority of which would be financially constrained. By contrast, an income test may be essential if eligibility is extended to families at later stages in the life cycle. Many such families decide to dispose of their woodheaters anyway; they exercise underlying preferences for alternative forms of heating as financial constraints become less severe.

Turning to the practicalities of income testing, it would be feasible to define an income test for families with children in terms of entitlements to Family Tax Benefits, which is administered through the Family Assistance Office. Part A of Family Tax Benefits is organised as follows:

- Families with incomes under \$28,200/year are entitled to the maximum payment per child, with maximum payments varying with the age of each child.
- The payment is reduced by 30 cents for each dollar of family income over \$28,200/year, until the payment reaches a base rate.
- The payment remains at the base rate until family income reaches \$73,000/year (plus \$3,000 for each child after the first), after which it is reduced by 30 cents for every dollar over that amount, until the payment reaches zero.

It seems that few families would not qualify for at least a partial benefit. It would therefore be necessary to define a specific cut-off point within the scale of Family Tax Benefit payments³⁷, possibly at one of the breaks between categories. Applicants for the woodheater conversion subsidy would then establish their eligibility by submitting a copy of their family assistance statement (provided by the Family Assistance Office), which includes a statement of their income-determined Family Tax Benefit entitlements.

Similarly, for older users of woodheaters, entitlements could be defined in terms of age pension entitlements. Logically, such arrangements would be extended to other long term recipients of social security payments.

Having said all that, however, there is no objective basis for determining the optimal cut-off point in terms of income; the relationship between income and woodheater use is unknown. The administrative feasibility of incomes testing should not obscure that basic point.

Targeted offer – households in certain areas of Launceston

It would also be feasible to target particular areas of Launceston. One such option is discussed in the following section. It requires the scheme to enter into certain arrangements with gas and electricity retailers to implement a woodheater conversion scheme, with the objective of exploiting their market research to identify areas that are most likely to respond to additional financial incentives.

³⁶ Often, that decision is taken in the full knowledge that woodheaters may adversely affect the health of children, and the decision is regretted. Housing Tasmania's properties account for 1,700 of the woodheaters in Launceston, or 13% of the NPI estimate for Launceston. Informal advice from Housing Tasmania is that there is little prospect of significant decline in those numbers, certainly before gas arrives, and possibly not much movement afterwards.

³⁷ Basic information about the number of families in each category is available at a cost from Centrelink. The contact is Natalie Robbins, Knowledge and Enabling Services, 02 6244 7270.

Another version of geographical targeting would require further airshed modelling to identify parts of Launceston that contribute more heavily to poor air quality. To explain, emissions from an upwind woodheater affect the air quality of the entire urban area, whereas the emissions from a downwind woodheater have little or no impact. Potentially, therefore, a relatively small number of woodheater conversions would have a major impact, and others would have virtually no impact. If those variations exist and can be credibly documented, they may suggest target suburbs within Launceston that will deliver major gains in cost effectiveness.

Conclusion

There are serious doubts that a general subsidy offer will be an efficient use of program funds. The proportion of induced conversions – that is, in addition to conversions that would have occurred anyway - is likely to be unacceptably low. However, while there are various promising options for a targeted scheme, there is limited information on which to base the detailed design of such a scheme. A possible way forward is to run a pilot scheme in selected areas of Launceston, and take that opportunity to gather more information. The possible design of a pilot scheme is discussed in section 5.3.13.

5.3.7 Incentives paid to energy retailers rather than households

Rather than provide incentive payments direct to woodheater users, it is conceivable that the scheme would instead make the incentive payment direct to electricity and/or gas retailers. This out-sourcing of the scheme would take advantage of retailers' superior knowledge of the market, particularly in terms of identifying groups that are unlikely to abandon woodheaters without a subsidy, and in designing an appropriate incentive offer.

Consider the possibility of entering into negotiations with Aurora Energy. Aurora's Rod Taylor has indicated that the existing business plan for promoting electrical heating is well documented and can be made available. If that is a credible and verifiable record of what Aurora plans to do in the BAU case, it should be possible to negotiate an expansion of those activities to target areas of Launceston that have resisted the trend to electric heating, but may respond to a significant further offer. Aurora would need to report its market research in detail to the negotiating team and explain exactly how it would identify and approach customer groups and areas that it currently considers to be beyond its reach³⁸. That would involve making a special offer to the targeted groups, an offer that would not be generally available to the rest of the community.

The proposed arrangement could be piloted in one year, with a renewal of the arrangement in subsequent years depending on Aurora providing convincing evidence that its additional efforts in Launceston had the desired effect, possibly in comparison to progress in other areas of the state.

Gary Swain of Duke Energy has also offered a suggestion along these lines. He proposed that the tendering process that will select Tasmania's gas retailer be organised in two parts. The first part would comprise the normal bid, including the timing and coverage of the intended roll-out. In the second part, the bidder would define the additional coverage or accelerated roll-out that they would provide if a particular sum of money (say, \$1M) were made available. In the present case, the additional coverage would be defined in terms of certain Launceston suburbs that would otherwise be bypassed. Assuming that the successful retailer will be offering attractive conversion subsidies, those incentives would necessarily be extended to the suburbs that otherwise would not have immediate access to gas.

³⁸ It appears the Aurora's market research brings together census information and market penetration data at the level of Census Collector's Districts.

Alternatively, when the successful gas retailer is known, the government could enter into similar negotiations as with Aurora, and essentially invite competitive bids for effective use of the available funds.

5.3.8 Amount of the offer

Woodheater owners will vary considerably in the amount of the minimum offer that will be required to induce conversion. This is the thinking behind the phone survey that is reported in table 5.2 (EMRS 2000a). It returned estimates that 6% of woodheater owners would convert in response to an offer of \$100, and that 9% and 20% would convert in response to offers of \$200 and \$500 respectively. While one may doubt that a phone survey provides credible data, the logic is sound. And, just as it is preferable not to pay anything at all to those who would convert in the absence of a conversion scheme, it is also preferable to avoid paying more than the minimum necessary to achieve any particular conversion. Is it feasible to discriminate between woodheater owners in this fashion?

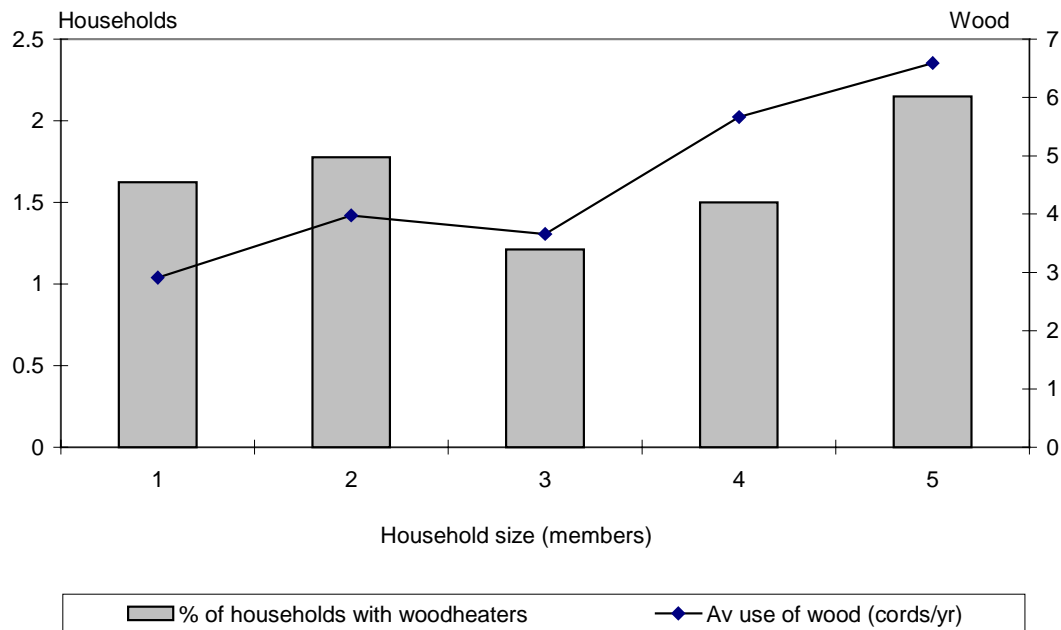
Differential payments may be organised in several ways:

- Assuming that the conversion scheme is conducted over several years, the early offers could be kept deliberately low and increased to a higher level, as necessary, in later years. Obviously, it would be important not to signal any intention to increase the later offers, but without being deceitful. Probably the situation would be that neither the continuation of the scheme nor the amount of the later offers would be guaranteed, depending on the success of the early offers. Potential applicants would need to weigh the possibility of a higher offer in later years against the possibility that the scheme would be discontinued in later years.
- The offer could be varied according to some indicator of financial need. For example, building on the discussion in section 5.3.6, a multi-stage income test could be organised to not only disqualify certain high income groups, but also to offer a partial subsidy to middle income groups, reserving the full subsidy for low income groups. Alternatively, the offer could be varied according to the size of the household. According to the US data reported in figure 5.2, wood consumption is positively related to household size. This suggests that the financial attraction of woodheating increases with household size, and it may be efficient to adjust the offer amount according to household size.
- Finally, if the conversion scheme were organised through the agency of gas and electricity retailers – as discussed in section 5.3.7 – one of the attractions of such an arrangement is the ability of retailers to fine tune the offers that are made to particular sub markets.

Possibly, some combination of these strategies is optimal. It seems sensible to make a relatively conservative offer in the first instance, leaving open the possibility of more generous offers in subsequent years.

We consider that these are reasonable principles to apply to the issue. In respect of the actual amounts, the broad advice to the study has been that the offer needs to be financially significant, of the order of \$500. However there is no objective data on which to base a specific recommendation.

Figure 5.2 Average wood use by household size (woodheater used as main heater)



5.3.9 Duration of the scheme

The woodheater conversion scheme will not be open ended. Access will be curtailed by some combination of the following:

- It will be available for a certain period of time.
- It will be capped in terms of the number of conversions that are subsidised, or equivalently, in terms of total scheme cost.
- It will be liable to termination in the light of the results of periodic assessments of cost effectiveness.

A likely scenario is that the scheme will be offered in a number of ‘rounds’ or annual offers over several years, with each new offer depending on the success or otherwise of the earlier round. And the terms of each offer will be judged to ensure that the remaining program budget will not be exceeded in the coming year. The explicit constraint would therefore be in terms of time, being the end of the current round. But the underlying constraint will be the targeted number of conversions and the total program budget, which, in turn, will be influenced by ongoing evaluations of costs and benefits.

The question arises - what considerations govern the optimal number of rounds and the overall duration of the scheme? The adage ‘haste makes waste’ probably applies. Specifically, for any given number of conversions, total costs will increase as the duration of the program is reduced and the conversion program is accelerated. Our thinking is that the cost of conversion (to the user) depends significantly on whether the woodheater is actually due for replacement. If it is due for replacement immediately, the household necessarily faces a significant replacement cost anyway. If replacement would otherwise be deferred for several years, the cost of replacement is increased by the need to bring forward the replacement expenditure. It follows that the amount of the incentive must be increased to compensate for that acceleration of the replacement schedule. Other considerations also favour a gradual approach, as follows:

- The incentive offer may be gradually increased with each round. As already noted, this strategy helps to discriminate between participants according to the minimum amount of incentive payment that is needed to induce conversion.
- A gradualist approach provides more opportunities for redesign, optimisation and review of the scheme.
- A gradual approach minimises the prospect of creating bottlenecks in the supply of replacement heaters or the availability of competent installers. There is the potential for an aggressive conversion program to crowd out BAU conversions and replacements, and possibly inducing a counter flow from alternate heating back to woodheaters. The introduction of gas and the pace of BAU conversions to gas may create a particularly sensitive period in that respect.

On the other hand, a truncated scheme (of, say, only 2 or 3 rounds) may reduce administrative costs. Unfortunately it is not possible to quantify the trade-off at this stage. But it is important to be aware of the significant risks that attach to a scheme that attempts to achieve its targets too quickly, and does not take sufficient account of the normal pace of woodheater replacement or other developments in the replacement market.

5.3.10 Disposal of old woodheaters, and related inspections

Apart from the need for a pre-inspection to confirm that an applicant has a woodheater and uses it as the main form of heating, it is not clear what the exact terms of the conversion agreement should be. The toughest terms would be to require that the existing woodheater is not only removed but also disabled or otherwise prevented from resale or reinstallation; this would be confirmed at a post-inspection before the incentive payment is finally approved. However a case can be argued for weaker terms, for example:

- Participants in the scheme may be allowed to keep their old woodheaters provided they are disabled when they are eventually disposed of. The concern here is that the requirement to immediately dispose of the old woodheater may significantly discourage participation in the scheme, and increase the amount of the required incentive payment. For example:
 - The option of reverting to woodheating provides valuable reassurance to users who have residual doubts about the cost of gas or electric heating.
 - Immediate disposal may add significantly to the costs of conversion; there may be unused firewood, or costs incurred to replace carpets and fill gaps in walls.

Aurora Energy advises that, in their experience, households that retain their woodheaters still make the full conversion to electric heating in a relatively short period and dispose of their old woodheaters after a period of disuse. If that judgement is accepted, the proposed scheme should probably copy Aurora's practice of requiring the installation of a minimum alternative heating capacity that is a realistic replacement for the old woodheater.

- In addition to retaining their old woodheaters, participants may be further allowed to resell post-93 woodheaters on the second hand market, when they are eventually disposed of. (We exclude pre-93 heaters from this concession; they are to be banned from the second-hand market under proposed measures to be included in Tasmania's EPP on Air Quality.) Again, this reduces the cost of the conversion, since the loss of resale value may be a significant barrier to conversion. The downside is, of course, that the older heater remains in use and, presumably, displaces the new woodheater that would otherwise have been acquired by whoever buys the second-hand heater. The impact on emissions is correspondingly reduced.

In line with the general philosophy outlined in respect of the amount of the offer, we consider that it would appropriate to drive a hard bargain in the first instance, including

immediate destruction of the old woodheater, and relax those terms as required in the light of experience.

5.3.11 Inclusion of low emission woodheaters

To this point it has been assumed that the incentive scheme would be available only for the conversion of woodheaters to gas or electric heaters. The alternative is to include low emission woodheaters in the list of eligible replacement equipment. Eligible woodheaters might be required to meet either the revised AS4013 or some more demanding standard.

The attraction of this concession is that it may be highly cost effective. For example, suppose that it costs \$500 to induce one household to completely abandon its woodheater, reducing that household's emissions to zero. And suppose also that 2 households can be induced to convert to low emission heaters that cut emissions by half each, at a cost of \$150 each. The latter strategy achieves the same effect as the former, but at a cost of \$300 rather than \$500.

Unfortunately, it is not possible to assess cost effectiveness with the available information. Key considerations are as follows:

- As noted already, Todd (2001) has cast doubt on the general expectation that the in-service performance of post-93 woodheaters is superior to that of pre-93 woodheaters. Logically, similar doubts must extend to woodheaters that meet the revised AS4013 or to any other model that has been certified to meet particular standards. The first step is therefore to ensure that there is a woodheater switch that can be confidently expected to reduce emissions.
- The oldest and dirtiest woodheaters may be due for replacement within a relatively short period of time, in which case the gain would be short lived.
- Probably, the implicit endorsement of the latest woodheater technology would cause woodheaters to be regarded more favourably by people who are otherwise planning to convert. Some of the positive impacts of earlier public education and information campaigns would be undone.
- The incentive payment itself would also induce some people to reverse their plans to convert.
- Finally, while the concession would reduce the unit cost of emission reductions, it is possible that the ultimate target is not achievable if this option is allowed.

These are such key issues that better information about the in-service performance of woodheaters and replacement behaviour is urgently required. Consistent with the option put in section 5.3.7 (regarding the possibility of competitive bids from electricity and gas retailers), it may be sensible to put the issue to woodheater manufacturers. The industry has a clear interest in demonstrating the in-service performance of their latest designs.

In respect of the design of an offer that extends to low emission woodheaters, consideration should be given to the following:

- Obviously there would need to be clear evidence that the identified woodheater is the main form of space heating. And the old heater would need to be permanently disabled.
- It may be feasible to devise criteria to identify woodheaters that are no longer serviceable and will necessarily be replaced within a short period. These would be denied the incentive offer, thereby reducing the payment of incentives for BAU replacements.
- The concession would be clearly aimed at users who cannot not afford full conversion, regardless of the amount of the incentive that attaches to gas and electricity. It would therefore be sensible to impose an incomes test, probably a

- more severe incomes test than would be imposed on conversions to electricity or gas. There are three reasons:
- A tough incomes test sends a clear signal that this is a concessional provision and does not otherwise endorse the use of woodheaters.
 - It eliminates the potential for the concession to induce higher-income users to reverse existing decisions to convert to gas or electricity at the next opportunity.
 - It eliminates the potential for higher-income users to receive incentive payments for replacements they would have made anyway.
- It does not seem useful to restrict the offer in terms of the type of heater that is replaced, for example, to pre-93 heaters. The implicit loss of resale value on newer woodheaters, because they are destroyed, should insure that they are not offered for replacement under the scheme.

In summary, we envisage a dual scheme with minimal overlap. One part is targeted at groups that, at reasonable cost, can be induced to make the full conversion. The other part is targeted at remaining groups that, at reasonable cost, can only be induced to replace their woodheaters with low emission woodheaters. Whether there is merit in the second part of the scheme, and what its scope should be, depends on the magnitude of the actual in-service difference between existing woodheaters and potential replacements.

5.3.12 Woodheater replacement in rental housing

To this point it has been implicitly assumed that the incentive offer is made to owner-occupiers, disregarding the stock of rental housing that is woodheated. However rental housing is probably a significant part of the problem. Consider that:

- ABS housing surveys³⁹ indicate that about 20% of Tasmania's detached or semi-detached housing is rental accommodation. (We assume that the incidence of woodheating in flats, units and apartments is minimal and can be ignored.)
- An informal survey of real estate agents indicates that about 90% of rented houses are woodheated⁴⁰.
- Rental housing tends to be dominated by the older and least energy efficient elements of the housing stock.
- Landlords have little incentive to replace woodheaters before they physically fail, in which case the woodheaters in rental accommodation are likely to be the oldest and dirtiest technology.

That said, there are two concerns about the response of landlords to an incentive offer for full conversion to gas or electricity. Firstly, the response from landlords may be very poor, for example:

- Because landlords are less likely to be cash constrained, they will generally have made the conversion if it is in their financial interests to do so.
- Because tenants tend to be low income families with strong financial preferences for woodheaters, only a small portion of the rental market may respond to the offer.

A second concern is the relative ease with which any positive response may be offset in the short to medium term. Recall the point made at the outset of section 5.3, which is that an incentive scheme is essentially temporary. The termination of the incentive scheme will see the gradual unwinding of the impact as underlying incentive structures and relative prices reassert their influence on space heating decisions. In the rental market,

³⁹ ABS Cat 4181.0

⁴⁰ Personal communication from Heath and Debbie Rainbow (All Area Chimney Sweeps) who conducted the survey.

however, a reduction in the woodheated rental stock (and a corresponding rise in the electric and gas heated stock) will be felt immediately as an increase in the occupancy rates and rentals of the former, and a reduction in the occupancy rates and rentals of the latter. This will induce a reverse flow of conversions to restore the market balance. For example, as existing electric heaters fall due for replacement, it is more likely that they will be replaced with woodheaters.

For these reasons we consider there is merit in allowing landlords to replace existing woodheaters with low emission woodheaters, provided of course that a significant in-service improvement is demonstrated. Given the impediments to complete conversion in rental accommodation, simple replacement may be the best outcome that can be achieved. It does not follow that the concession should be extended to owner-occupiers; that issue should be decided separately.

In respect of the design of the offer that is made to landlords, consideration should be given to the following:

- Obviously there would need to be clear evidence that the identified woodheater is the main form of space heating. And the old heater would need to be permanently disabled.
- Landlords would not be offered assistance with full conversions. As indicated, we expect any positive impact on the proportion of woodheated rental housing on offer would be small, quickly reversed, or both. Landlords would only be offered the replacement option.
- As discussed in section 5.3.11, there is no need limit the offer to older heaters (such as pre-93 heaters), but it would be useful to devise objective criteria for rejecting any unserviceable units that are offered for replacement.
- The socio-economic characteristics of landlords, including their incomes, are irrelevant. Specifically, there is no case for incomes testing, even if such a test is applied to owner-occupiers. This is despite the fact that most landlords would not 'need' financial assistance in the usual sense. The important consideration is that the heating choices of landlords are determined, not by their own preferences (as in the case of owner-occupiers), but by the impact on investment returns through occupancy rates and rentals. It follows that a test of the *ability* to finance replacement would not help the scheme to identify landlords that plan to make the replacement anyway, which is the role of such a test in respect of owner-occupiers.
- An active smoke patrol could be used to indirectly increase the cost to landlords of not replacing older woodheaters. These costs would take the form of tenant complaints about heating equipment that cannot be operated in such a way as to both satisfy the smoke patrol and deliver reasonable functionality.

That said, it remains unclear that landlords can be induced to replace woodheaters before it is physically necessary, and therefore to substantially accelerate the normal rate of replacement. Of course it is always possible to elicit a significant response by making a sufficiently attractive financial offer. But that amount is unknown, as is the cost-effectiveness of such an offer in terms of reduced emissions.

5.3.13 Need for a pilot scheme

A number of feasible designs for an incentive scheme may be extracted from the above discussion. In our view, however, information gaps are such that the best design is not apparent. At this point, it is difficult to see beyond the need for a pilot scheme. The essence of a pilot scheme is to restrict the incentive offer to a subset of the broader population in the first instance, in order to assess the take-up rate and cost effectiveness of early designs.

Specific design features

We propose the following for the pilot scheme:

- The incentive payment would be available either as a capital grant or as a subsidy equivalent loan. It would be useful to test the administrative arrangements that are proposed for the longer term, including the involvement of a local financial institution and the establishment of a revolving fund.
- Based on the data presented in figure 5.1 and table 5.3, it is proposed that the pilot scheme be restricted to households with relatively young children, either children aged 0-4 or children aged 0-9⁴¹. It is apparent that woodheaters are often abandoned in later stages of the lifecycle.
- Energy retailers would not be directly involved in the delivery of the pilot scheme.
- The offer amount would be \$500.
- The offer would be kept open for 12 months, allowing sufficient time for people who had not otherwise planned to convert to consider the option.
- Old woodheaters would need to be disposed of immediately.
- Low emission woodheaters would not be included. Neither would landlords be eligible for assistance.

In respect of the last provision, the in-service performance of woodheaters needs to be better understood before this option can be given serious consideration.

Targeted suburbs

One option for selecting a subset of the Launceston population for the purposes of the pilot scheme is to restrict the offer to certain suburbs. Table 5.4 presents 1996 census information for certain socio-economic indicators, by suburb. Our analysis does not reveal particular suburbs that are obviously representative of Launceston as a whole. However, the middle ranking suburbs in terms of specific socio-economic characteristics are as follows:

- Income – Prospect, Launceston, Youngtown and West Launceston.
- Unemployment rate – Trevallyn, Newstead, Youngtown and East Launceston.
- Owner occupied houses (%) – Alandale, East Launceston, West Launceston and Punchbowl.
- Number of children aged 0-4 years (per household) - Invermay-Inveresk, Prospect, Youngtown and Elphin.

The suburbs that occur two or more times in this list are Prospect, Youngtown, East Launceston and West Launceston. For the purposes of this exercise we will assume that the pilot scheme is restricted to these suburbs.

We estimate that there are 650-750 families with children aged 0-4 years in these four suburbs⁴², in which case it seems likely that 300-400 woodheaters are in use. This seems to be a reasonably sized target for a pilot scheme. If it were considered too small, however, a simple way to expand the target by 50-60% would be to redefine eligibility to include all families with children aged 0-9 years.

The offer would be advertised in the media, and explained as a pilot scheme that has been tightly targeted to limit the scheme's financial exposure until the take-up rate and effectiveness of the offer had been assessed. The government would make known its

⁴¹ The criterion is the presence of such children, not that all children in the family are of that age.

⁴² The 1996 census recorded 1,142 children in these suburbs. We assume that the average number of children aged 0-4 in such families is of the order of 1.5-1.7.

intention to gradually expand the offer to include other types of families and other parts of Launceston, but depending on a favourable evaluation of cost effectiveness.

Table 5.4 Socio-economic indicators, Launceston suburbs, 1996 census

<i>Suburb</i>	<i>Households</i>	<i>Weekly income of \$500-999 (%)</i>	<i>Un-employment (%)</i>	<i>Owner-occupied houses (%)</i>	<i>Children aged 0-5 (per household)</i>
Alanvale	1284	16.8	10.2	70	0.19
Blackstone Heights	323	33.1	4.7	86	0.39
East Launceston	1407	20.9	9.3	70	0.14
Elphin	490	10.6	15.7	63	0.18
Hadspen	652	17.5	5.9	85	0.34
Invermay-Inveresk	1248	6.3	18.7	54	0.16
Kings Meadows	1082	12.4	11.1	75	0.15
Launceston	1228	15.2	11.6	47	0.14
Mayfield	987	9.5	18.2	55	0.19
Mowbray	1296	7.6	17.5	60	0.19
Newstead	590	17.6	9.1	79	0.15
Norwood	1158	22.4	5.9	84	0.16
Prospect (a)	673	15.0	7.8	66	0.17
Prospect (b)	1407	18.3	7.0	72	0.24
Punchbowl	1020	12.3	10.0	71	0.15
Ravenswood	1720	7.2	21.2	48	0.30
Riverside	1385	19.6	7.2	84	0.16
Rocherlea	553	2.2	31.1	29	0.34
Sth Launceston	1193	12.3	11.0	58	0.11
St Leonards	423	18.9	6.8	80	0.25
Summerhill	984	18.3	8.1	78	0.20
Trevallyn (a)	763	22.7	6.7	78	0.13
Trevallyn (b)	1124	20.1	8.7	73	0.19
Waverley	714	6.2	19.1	58	0.26
West Launceston	1894	16.5	8.3	71	0.16
Youngtown	1130	15.8	9.2	79	0.18
Total	26728	14.9	11.0	67	0.19

Source: Launceston City Council (1998)

Evaluation

The matters that need to be evaluated by the pilot scheme are as follows:

- *Additionality*: The main purpose of the evaluation would be to assess the extent of additionality that is achieved, that is, the number of induced conversions relative to the number of conversions that would have occurred anyway. This would require a survey of participants, involving face-to-face interviews to work through the process of decision-making, identify the various factors that contributed to the decision, and assess the role of the incentive payment.
- *Amount of the incentive payment*: The survey would also provide an opportunity to assess whether the incentive payment could be reduced without serious reduction in take-up. To assess the response to an increase in the amount of the incentive payment it would also be useful to include a reasonable sample of people who showed an interest in the scheme but failed to follow through. They might be identified if appropriate records are kept when inquiries are made.
- *Need for an incomes test*: It may emerge from the analysis that the households that would have made the conversion anyway share certain characteristics, for

example, above average incomes. This may provide the basis for an income test or other eligibility criteria.

- *Scope for improvement:* There will probably be opportunities to improve the scheme, for example, in relation to the quality of information provided or the efficiency of processes. Widespread dissatisfaction with the actual experience of alternative forms of heating would be a particular cause for concern.

Cost of the pilot scheme

The actual cost of an incentive scheme depends on the take-up rate, which is one of the variables that a pilot is designed to measure. However, it is important to have some sense of what the maximum cost of the pilot might be, to be sure that is affordable. We proceed as follows:

- In the normal course of events, a maximum of 10% of the existing stock of woodheaters may be replaced in any one year.
- We suppose that two thirds of these are replaced by electric heaters, which will be the main option for the period of the pilot. In other words, one third of the target population cannot be tempted to abandon their woodheaters.
- In addition, some conversion decisions will be brought forward from future years to take advantage of the incentive payment. We suppose that triples the cost of the pilot scheme.

Under these assumptions, the maximum cost of a pilot scheme that is restricted to families with children less than 5 years old would be \$40,000, and would subsidise up to 80 conversions. And the maximum cost of a pilot that is restricted to families with children less than 10 years old would be \$65,000, and would subsidise up to 130 conversions.

In addition to the subsidy payments, the other main costs would be:

- Program set-up - \$15,000. We assume that program set-up will require six weeks' work from one senior project officer and one junior officer, on annual salaries of \$70,000 and \$35,000 respectively, with labour on-costs of 20%. Their tasks will be to:
 - negotiate with a financial institution to provide a funding arrangement along the lines described in section 5.1.2;
 - negotiate with LCC to provide the required inspections and approvals arrangements, probably using smoke patrol officers, and including the completion of questionnaires that will be used for evaluation purposes;
 - media campaign and literature, including inserts in electricity bills from Aurora Energy;
 - briefings for equipment and energy suppliers on the operation of the pilot scheme;
 - design of application forms;
 - public relations.
- Inspections and approvals - \$6,500. We have budgeted for 130 successful applications, each of which will require 2.5 hours processing at \$20/hour. The tasks are as follows:
 - receiving inquiries, mail-out of information on request, and arranging inspection/approval visits by a smoke patrol officer;
 - initial inspection and approval by the smoke patrol officer, including completion of any preliminary questionnaire that might be required for evaluation purposes;
 - final inspection by the smoke patrol officer, including approval of the payment and completion of any further questionnaire that might be required for evaluation purposes.
- Evaluation - \$25,000. These tasks include:

- initial design of an evaluation process, including design of questionnaires administered by the smoke patrol during inspection/approvals visits;
- follow-up survey as required, for example, to interview applicants who did not follow through on the offer after receiving an initial approval;
- consultation with stakeholders on the operation of the scheme, eg, Launceston CC, DPIWE, Tamar NRM and Aurora Energy;
- recommendations for redesign of the scheme.

On this figuring the maximum total cost of the pilot incentive scheme is \$111,500, comprising \$40,000 in program set-up and evaluation costs, and \$71,500 for incentive payments and processing costs.

5.3.14 Conclusion

Assuming that the pilot scheme is successful and a targeted incentive payment is eventually offered, the cost effectiveness of a full scale scheme can only be guessed at now; the pilot scheme is designed to answer that question. However, it is reasonable to aim for the following outcome, which incorporates the impact of the pilot scheme:

- The scheme delivers a net reduction of 1,400 woodheaters, equivalent to 10% of the current stock.
- The upfront costs are \$40,000, comprising set-up and evaluation of the pilot scheme.
- The scheme will require further refinement and analysis to optimise subsequent offers, at a cost of \$40,000.
- The ongoing costs per successful application are \$550, comprising a \$500 incentive payment and \$50 in processing costs.
- The scheme achieves additionality of 67%. That is, two thirds of the conversions are additional, and one third would have occurred anyway.

On these assumptions, total program costs are \$1,230,000.

On the issues of cost-effectiveness and the contribution of the scheme to the 55% target for reduced emissions, it is necessary to refer back to the analysis presented in section 4.3. The key findings are:

- Based on the specific assumptions of the base case that is presented in section 4.3, a woodheater conversion scheme would need to contribute 12.4 percentage points to the targeted reduction in emissions, but need to deliver a net 27.8% reduction in the number of woodheaters in order to do so. The disproportionate requirement is due to the fact that (a) measures to replace woodheaters fall on new woodheaters that have lower emissions than average, and (b) other developments and measures independently reduce emissions from all woodheaters, further diluting the impact of woodheater conversions.
- It follows that a 10% reduction in the stock of woodheaters will contribute only 4.5 percentage points to the target.
- Each percentage point reduction in emissions would cost \$273,000 in program funds (= \$1,230,000 / 4.5).

Clearly, a 10% reduction in the number of woodheaters does not meet a ‘requirement’ to reduce woodheater numbers by 27.8%. However, as discussed in section 4.3, the total reduction in woodheater numbers in the base case threatens to exceed the speed limit that is imposed by the number of replacements that will naturally occur over the period. Moreover there is considerable uncertainty about the actual need for a larger scheme, as is made clear in section 4.4. At this point therefore, it is difficult to see beyond a woodheater conversion scheme that aims to replace 10% of the existing stock.

5.4 Ceiling insulation retrofit program

Discussions with the insulation industry, and with energy retailers with relevant experience, indicate that government can play a role in coordinating an aggressive program of ceiling insulation retrofit. The government's role would be to:

- negotiate a standard rebate with suppliers who agreed to be involved;
- negotiate accreditation arrangements with suppliers, probably taking the form of independent documentation of the quality and effectiveness of the materials that would be supplied;
- provide a minimal subsidy, say, \$100 per woodheated house;
- market the program, including 'before and after' comparisons of energy costs;
- encourage a 'buyer beware' approach to the selection of an insulation supplier, for example, comprising advice on what questions to ask, appropriate R ratings, etc.; and
- negotiate with LCC for the provision of inspectors who would confirm that insulation of adequate quality had been installed correctly, and sign off on the payment of any government subsidy.

However, it was decided not to proceed with this option, given uncertainties about the actual reductions in energy use and the possibility of perverse effects on emissions. The former relates to the fact that a large proportion of potential energy savings may be lost to improvements in thermal comfort. The latter refers to the concern that woodheater users may respond to better insulation by setting their equipment on low settings for longer periods. The effect on emissions is therefore doubtful.

Conceivably, smoke patrol officers may be able to test the perverse scenario that is outlined above. It may be the case that the underlying cause of excessive smoke is an oversized heater in a well insulated house, with the heater usually turned to its lowest setting.

5.5 Summary

This section contains two tables – 5.5 and 5.6 – that summarise the main findings of the study. Taking these in reverse order, table 5.6 is a lengthy schedule that summarises the impacts, cost and cost effectiveness of the various management options. It is organised under the following headings:

- Part A: Measures included in Tasmania's Environment Protection Policy on Air Quality
 - Action A.1: Measures to reduce the moisture content of firewood
 - Action A.2: Measures to improve the emissions performance of new woodheaters
 - Action A.3: Measures to accelerate the retirement of pre-93 heaters
- Part B: Measures to be substantially implemented by Launceston City Council
 - Action B.1: Smoke patrol
 - Action B.2: Woodheater conversion program

Table 5.5 provides a briefer statement of the main findings. Before turning to that table, however, consider that the menu of management actions can be reduced to two items at this stage:

- The smoke patrol is not only the main means for improving woodheater operation, it is also essential to the success of proposed regulatory measures affecting the quality of woodheaters in use and the moisture content of firewood that is being

burned. That is, action B.1 is the ‘front’ for actions A.1, A.2 and A.3. These four sets of actions cannot be evaluated separately because they essentially form a single cost item.

- If the smoke patrol cannot deliver the required reduction in emissions, the only remaining weapon at this stage is an incentive scheme to convert from woodheaters to electric or gas heating.

Table 5.5 reports key findings in respect of the two management options, assuming the base case originally presented in table 4.1. Note the following:

- The outlook is for certain favourable trends and developments to deliver significant reductions in emissions at zero cost – 31.2 percentage points. The dominant contributors are the introduction of natural gas and the phasing out of pre-93 heaters.
- The smoke patrol is the most cost effective option in terms of total program funds, delivering an additional 11.4 percentage points at a cost of \$21,000 for each percentage point, and taking the total to 42.6 percentage points.
- A woodheater incentive scheme is the least effective option in terms of total program funds, each contribution of 1 percentage point coming at a cost of \$273,000. The reasons have been rehearsed in section 5.3.5.
- The contrast between the cost effectiveness of the smoke patrol and the incentive scheme is marked. Clearly, the smoke patrol is a highly targeted initiative; it is intended to target the worst woodheaters and take effective action at relatively low cost per woodheater.
- It is recognised that the cumulative impact (47 percentage points) falls short of the target (55 percentage points). At this point, however, it is difficult to see beyond a first round of a woodheater conversion scheme, aimed to replace 10% of the existing stock of woodheaters. Even then, a pilot scheme is needed to optimise the design of a first round.

Table 5.5 Cost effectiveness of the main options (base case)

<i>Management action</i>	<i>Marginal contribution to emissions reduction target (percentage points)</i>	<i>Cumulative contribution to emissions reduction target (percentage points)</i>	<i>Cost effectiveness at the margin (program funds per percentage point)</i>
1. Favourable trends and developments requiring no specific management action (eg, natural gas, phase out of pre-93 woodheaters)	31.2	31.2	\$0
2. Smoke patrol, including implementation of Tasmania’s EPP on Air Quality	11.4	42.6	\$21,000
3. Woodheater conversion program, targeting 10% of the existing stock	4.5	47.1	\$273,000

It makes obvious sense to pursue the smoke patrol option vigorously, and use it to gather information to inform the design of other management options. These include the following:

- A public education program is a future option. But we consider that the content of such a program should be decided in the light of experience with the smoke patrol. There is a need to better understand the causes of excess smoke, identify effective remedies, and refine the message, before going public.
- Smoke patrol officers should be able to collect valuable information to inform assessments of the need for special action to address woodheaters in rental accommodation.
- It may even be possible for officers to collect information about the need for insulation and the impact of insulation on woodheater operation, which, as already noted, may not be beneficial.

Table 5.6 Schedule of policy measures, impacts, costs and cost effectiveness**A. Measures included in Tasmania's Environment Protection Policy on Air Quality**

Action A.1	Measures to reduce the moisture content of firewood <ul style="list-style-type: none"> Regulate the moisture content of firewood sold Ban the use of wet firewood
Impact on:	
<ul style="list-style-type: none"> State government agencies 	DPIWE to formulate appropriate regulations in consultation with industry, taking account of the apparent role of wet wood in harvesting and supply arrangements.
<ul style="list-style-type: none"> Local government agencies 	Launceston City Council to ensure that smoke patrols have the required investigation skills and work instructions to enforce the measure.
<ul style="list-style-type: none"> Woodheater owners 	Given the hidden costs of using wet wood, as discussed in chapter 3, many users may benefit financially. Self collectors are the most likely to incur costs, if it means they are effectively discouraged from self collection.
<ul style="list-style-type: none"> Woodheater manufacturing industry 	None.
<ul style="list-style-type: none"> Other energy appliance & energy supply industry 	Wood merchants to inform customers about moisture content of firewood and whether it is ready to burn.
Program costs	DPIWE: This is a statewide policy, the cost of which cannot reasonably be attributed to Launceston. Launceston CC: The cost of smoke patrols are accounted for separately – see part B
Self-sustaining source of ongoing funding	Not applicable.
Emissions reduction (expected contribution to the required 55-65% reduction in woodheater emissions)	2.5 percentage points, being the separate effect of this action in the base case. Given the likely resistance from self collectors of firewood, it seems likely that measures to reduce the moisture content of firewood will not achieve the maximum reductions in emissions that might otherwise be expected. We therefore applied a 50% discount to the maximum contribution that might be expected from the proposed measures – see table 4.1. Any emissions reductions that are achieved will be the joint product of the proposed measures and the activities of the smoke patrol.
Cost effectiveness (program costs per 1 percentage point reduction in emissions)	Cannot be assessed separately from the cost effectiveness of smoke patrols.

Action A.2	<p>Measures to improve the emissions performance of new woodheaters</p> <ul style="list-style-type: none"> • Reduce the particle emission limit for new woodheaters • Ban modifications of woodheaters that increase particle emissions
Impact on:	
<ul style="list-style-type: none"> • State government agencies 	DPIWE to formulate appropriate regulations, and ensure that woodheater suppliers and installers understand the possible consequences for themselves and their customers if certified heaters are modified. DPIWE to investigate options for providing smoke patrols with information about the heater designs that are most likely to be modified ⁴³ , and the likely means of modification.
<ul style="list-style-type: none"> • Local government agencies 	Launceston City Council to ensure that smoke patrols have the required investigation skills and work instructions to enforce the measure.
<ul style="list-style-type: none"> • Woodheater owners 	It is possible that a significant number of modified woodheaters will be identified by smoke patrols. Their owners will incur either the significant cost of replacing a heater that is necessarily quite new, or they will suffer a loss of functionality when the modification is reversed. But this should not be ongoing; adverse publicity and customer complaints should ensure that dysfunctional models are discontinued.
<ul style="list-style-type: none"> • Woodheater manufacturing industry 	<p>The proposed measures will add to the pressures on manufacturers to achieve further technological advances in woodheater design.</p> <p>Manufacturers that rely on woodheater modifications to maintain functionality may need to restore some models and find new designs that will deliver both functionality and low emissions.</p>
<ul style="list-style-type: none"> • Other energy appliance & energy supply industry 	None.
Program costs	<p>DPIWE: This is a statewide policy, the cost of which cannot reasonably be attributed to Launceston.</p> <p>Launceston CC: The cost of smoke patrols are accounted for separately – see part B</p>
Self-sustaining source of ongoing funding	Not relevant.
Emissions reduction (expected contribution to the required 55-65% reduction in woodheater emissions)	<p>3 percentage points, being the separate effect of this action in the base case.</p> <p>Reflecting concerns about the difficulty of detecting woodheater modification, we applied a 50% discount to the maximum contribution that might be expected from these measures – see table 4.1.</p> <p>Any emissions reductions that are achieved will be the joint product of the proposed measures and the activities of the smoke patrol.</p>
Cost effectiveness (program costs per 1 percentage point reduction in emissions)	Cannot be assessed separately from the cost effectiveness of smoke patrols.

⁴³ Certification test data on the duration of slow burns may be a useful guide, if that exists.

Action A.3	Ban on the sale and reinstallation of pre-93 woodheaters
Impact on:	
<ul style="list-style-type: none"> • State government agencies 	DPIWE to devise appropriate regulations, and conduct an information campaign directed at both the buyers and sellers of pre-93 heaters, and at intermediaries like retailers and installers.
<ul style="list-style-type: none"> • Local government agencies 	Launceston City Council to ensure that smoke patrols have the required investigation skills and work instructions to enforce the measure.
<ul style="list-style-type: none"> • Woodheater owners 	Owners of pre-93 heaters will incur a loss of resale value.
<ul style="list-style-type: none"> • Woodheater manufacturing industry 	Manufacturers benefit to the extent that accelerated retirement of woodheaters increases demand for new woodheaters.
<ul style="list-style-type: none"> • Other energy appliance & energy supply industry 	None.
Program costs	DPIWE: This is a statewide policy, the cost of which cannot reasonably be attributed to Launceston. Launceston CC: The cost of smoke patrols are accounted for separately – see part B
Self-sustaining source of ongoing funding	Not applicable.
Emissions reduction (expected contribution to the required 55-65% reduction in woodheater emissions)	2 percentage points, being the separate effect of this action in the base case. Overall, the difficulty of detecting prohibited sales is such that we applied a 50% discount to the maximum contribution that might be expected from the proposed measure – see table 4.1. Any emissions reductions that are achieved will be the joint product of the proposed measures and the activities of the smoke patrol.
Cost effectiveness (program costs per 1 percentage point reduction in emissions)	Cannot be assessed separately from the cost effectiveness of smoke patrols.

B. Measures to be substantially implemented by Launceston City Council

Action B.1	Smoke patrol
Impact on:	
<ul style="list-style-type: none"> State government agencies 	DPIWE to formulate regulations and information campaign to complement the activities of the smoke patrol – see actions A.1, A.2 and A.3. Also assist with program design, evaluation, technical advice and training, and information exchange.
<ul style="list-style-type: none"> Local government agencies 	Launceston City Council responsible for detailed design and implementation of the smoke patrol program, including training of smoke patrol officers.
<ul style="list-style-type: none"> Woodheater owners 	<p>Most woodheater users will not be affected. For those who are visited by the smoke patrol, some will find that the required changes are beneficial. Others may find the changes difficult or costly, requiring for example:</p> <ul style="list-style-type: none"> conversion to alternative form of heating; reversal of heater modifications; cessation of self collection of firewood. <p>It is not expected that fines will be imposed to any significant extent.</p>
<ul style="list-style-type: none"> Woodheater manufacturing industry 	<p>Industry experts contribute to the training of smoke patrol officers.</p> <p>Increased sales to the extent that the retirement of pre-93 woodheaters is accelerated.</p> <p>Withdrawal of woodheater models that need to be modified in order to maintain functionality.</p>
<ul style="list-style-type: none"> Other energy appliance & energy supply industry 	Wood merchants to inform customers about moisture content of firewood and whether it is ready to burn.
Program costs	<p>Total cost is \$240,000, comprising:</p> <ul style="list-style-type: none"> Program set-up - \$40,000 Ongoing costs of \$54,000/year for 2001 and 2002. Ongoing costs at 50% of the 2001 level for 2003-2005. Ongoing costs at 25% of the 2001 level for 2006-2007.
Self-sustaining source of ongoing funding	Launceston City Council to provide ongoing funding.
Emissions reduction (expected contribution to the required 55-65% reduction in woodheater emissions)	<p>11.4 percentage points (base case), being the additional impact on emissions when all other actions have been taken, with the single exception of specific measures to reduce woodheaters.</p> <p>This is the combined effect of:</p> <ul style="list-style-type: none"> improved woodheater operation; reduction in the moisture content of firewood; improved emissions performance of new woodheaters; accelerated retirement of pre-93 heaters. <p>This is the combined impact of the smoke patrol and state measures under the Environment Protection Policy on Air Quality.</p>
Cost effectiveness (program costs per 1 percentage point reduction in emissions)	\$21,000 per 1 percentage point reduction in emissions

Action B.2	Woodheater conversion incentive scheme, designed to replace 1,400 woodheaters, comprising 10% of the stock of woodheaters in 2000.
Impact on:	
• State government agencies	DPIWE to assist with program design, evaluation, and information exchange.
• Local government agencies	Launceston CC to implement the program, reflecting the central role that is envisaged for smoke patrol officers in inspections and approvals.
• Woodheater owners	No effect on households that choose to retain their woodheaters.
• Woodheater manufacturing industry	Reduction in sales of woodheaters.
• Other energy appliance & energy supply industry	Increased sales of non-wood heating appliances.
Program costs	Total cost is \$1,230,000, comprising: <ul style="list-style-type: none"> • Set-up and evaluation of the pilot scheme - \$40,000. • Optimisation of subsequent offers - \$40,000. • \$1,150,000 to fund 2090 conversions at \$550 each, of which 1,400 are addition to conversions that would have occurred anyway.
Self-sustaining source of ongoing funding	Not applicable – program will be of limited duration.
Emissions reduction (expected contribution to the required 55-65% reduction in woodheater emissions)	4.5 percentage points (base case), being the additional impact on emissions when all other actions have been taken. The target of 1,400 woodheaters comprises 10% of the current stock of woodheaters.
Cost effectiveness (program costs per 1 percentage point reduction in emissions)	\$273,000 per 1 percentage point reduction in emissions.

Appendix A:

Number and type of woodheaters

As discussed in section 4.2 of the report, there have been three surveys of woodheater operation and use in Launceston since the early 1990s. Taken at face value, they suggest a sharp fall in woodheater penetration of the Launceston market over the period, in comparison with the trend in Tasmania. This appendix provides a review of the available data, including the results of ABS energy surveys for Tasmania and the results of a survey conducted in the North/North East region that includes Launceston.

A.1 ABS energy surveys: Tasmania, 1983-99⁴⁴

ABS survey and census data indicate that about 35% of Tasmanian households used woodheaters as the main form of heating in the 1970s. Table A.1 summarises key results from ABS energy surveys conducted over the last 20 years. Note the following:

- The use of wood heaters as the main form of heating seems to have peaked at around 60% of households in the early 1990s, following strong growth through the 1980s, and is now declining steadily. The annual average rate of decline over the period 1994-99 was 0.86 percentage points per year.
- There is a strong trend to having only one heater in the dwelling; 50% of homes had only one heater in 1999, compared with about one third in 1994. This probably reflects increased use of ducted heating systems and a general trend towards single person and smaller households.
- About 40% of main heaters were less than 5 years old in 1994, indicating significant replacement spending in the early 1990s. In 1999, however, about 30% of main heaters were less than 5 years old in 1999, indicating a substantial fall in the rate of replacement spending in second half of the 1990s.

A.2 Woodheater replacement research report

Survey results are provided in a recent report on wood heater replacement (EMRS 2000a) that was commissioned by DPIWE. Results are available for Tasmania as a whole and for three regional areas – South, North/North East, and North West/West Coast. The key questions were phrased as follows:

- *What types of heating do you use to heat your home? Do you have a: wood heater; open fire; gas; electricity; diesel/oil; other?* (The interviewer was instructed to probe for and record multiple heaters.)
- *How old is your wood heater? Is it: 1 or 2 years old; 3 but less than 5 years old; 5 but less than 7 years; 7 but less than 10 years; 10 or more years; unsure?*

This phone survey involved 1,245 households of which 300 were in the North/North-East region, which comprises Launceston, the Tamar Valley and the North East.

⁴⁴ This material was summarised for the Scoping Study in a personal communication from Professor John Todd, University of Tasmania.

Table A.1 Characteristics of the main form of space-heating: ABS energy surveys, Tasmania

	1983	1986	1994	1999
<u>Private dwellings with wood as main heating (% of dwellings)</u>				
Tasmania	43.2	53.3	60.5	56.2
Hobart		41.5		
Rest of Tasmania		61.8		
<u>Number of heaters in the dwelling (all types of heater, % of dwellings with:)</u>				
1 heater			34.8	51.4
2 heaters			31.2	29.6
3+ heaters			33.8	17.8
<u>Age of main heater (all types, % of main heaters)</u>				
<1 year			7.7	5.2
1-<5 years			30.6	23.6
5-<10 years			28.7	25.2
10+ years			28.6	36.2
Don't know			4.2	8.7
<u>Type of woodheater (% of woodheaters)</u>				
CCH				50.5
Open fire				4.0
Pot belly				1.2

Table A.2 Woodheater Replacement Research Report, 2000

	Tasmania	North & North West
<u>Private dwellings using wood for space heating (% of dwellings)</u>		
CCH	57	60
Open fire	7	7
Approx. total (assuming no dwellings use both)	64	67
<u>Age of wood heaters (% of dwellings with wood heaters)</u>		
1 or 2 years	11	
3 to < 5 years	16	
5 to < 7 years	18	
7 to < 10 years	17	
10+ years	36	
Unsure	2	
<i>Memo: Woodheaters less than 7 years old (post-93)</i>	45	

Source: EMRS 2000a

Table A.2 summarises key results. Note the following:

- The incidence of woodheater ownership in the North/North East Region seems similar to that for Tasmania as a whole.
- 45% of wood heaters were recorded as less than 7 years old in 1999, indicating that about 45% were post-93 heaters and 55% were pre-93 heaters.
- There is broad concordance with the 1999 ABS survey for Tasmania on the proportion of heaters that are less than 5 years old - about 28%-29%. However the omnibus survey relates to wood heaters, whereas the ABS survey relates to all heaters.

- The omnibus survey put woodheater use at about 64% of the population, compared with 56% returned by the ABS survey. However the latter was restricted to woodheaters used as the main form of heating, whereas the former recorded all heaters.

A.3 Surveys of woodheater use and operation in Launceston

Four surveys provide information about woodheater use in Launceston in the 1990s, as follows:

- *Fuelwood Report Survey, phone survey of 99 households, April/May 1992 (Todd and Brett 1992)*: While this was notionally a survey of the greater Launceston area, the sample seems to have been selected exclusively from suburbs in the Launceston urban area. Key questions were phrased as follows:
 - What is the main type of heating in your living area? (electric, wood, gas, other, no heating)
 - What other forms of heating do you use? (electric, wood, gas, other, no heating)
 - What sort of appliance do you burn firewood in? (open fire, freestanding heater, fireplace insert, CH furnace, other) Make/model: How old is it?
- *LCC Survey, mail questionnaire, October 1996 (summary results provided by LCC)*: This survey achieved a response rate of only 58% (292 responses from a mail-out to 500 residents). The key question was phrased as follows:
 - Do you use an open fire or solid fuel heater for home heating at this address? If yes, what sort of heater(s) does the household use? (No, no solid fuel heating; Yes, open fire(s); Yes, pot bellied stove(s); Yes, slow combustion heater; Yes, other solid fuel heating)
- *NPI survey, June 2000, phone survey of 632 households of which 370 were in the Launceston Urban Centre*: Results from this survey are provided in a recent report on Launceston air quality (EMRS 2000b) that was commissioned by DPIWE. Key questions were phrased as follows:
 - I want to confirm that your household burns/does not burn fuel for either heating or cooking purposes at home. By fuel I mean firewood, coal or coke, gas, diesel, oil or kerosene. Do you burn fuel in: an open fire; pot bellied conventional heater; controlled combustion?
 - Which solid fuels do you use? (Multiple responses, answered separately for open fire, pot bellies and controlled combustion – and separately for firewood and briquettes.)
 - How many tonnes would you use in a year? (Multiple responses, answered separately for open fire, pot bellies and controlled combustion – and separately for firewood and briquettes.)
- *Firewood consumption survey, November 2000, phone survey of 508 households in Launceston City Area*: This survey that was commissioned by DPIWE (EMRS 2000c). Key questions were phrased as follows:
 - Do you use firewood in your house for heating or cooking excluding BBQs?
 - Do you ever use firewood for a BBQ at your home?
 - How many tonnes of firewood in total would you use in a year?

This survey was follow up to the NPI survey, which returned a surprisingly low incidence of woodheaters. The later survey in fact returned a lower estimate than the former, 43% rather than 46%.

Table A.3 summarises key results. Note the following:

- These data indicate that there has been a large reduction in woodheater penetration of the Launceston market, compared with the more gradual reversal that the ABS surveys indicate for Tasmania as a whole.
- The turnover rate is consistently high. 70% of the woodheaters identified in the 1992 survey were purchased in the previous 6 years; and 55% of the woodheaters identified in the 2000 survey were purchased since 1993.

Table A.3 Woodheater use - Launceston surveys, 1992-2000

	1992 Phone Survey (Uni Tas)	1996 Mail Survey (LCC)	2000 NPI Survey (DPIWE)
Private dwellings using wood for space heating (% of dwellings)			
Main heating	63	-	-
Secondary heating	3	-	-
Total	66	60	46*
Type of heater			
Open fire	10	17	5
CCH	55	48	41
Other	na	5	na
Age of wood heaters (% of dwellings with wood heaters)			
< 2 years	31	-	-
2 - 6 years	40	-	-
> 6 years	16	-	-
Unknown	12	-	-
<i>Memo: Woodheaters less than 7 years old (post-93)</i>	0	-	55

Sources: Todd and Brett (1992); Summary of results of the LCC survey provided by the Council; EMRS (2000b)

* This is the approximate total, assuming that very few households use both open fires and wood heaters.

Has there been a sharp reduction in woodheater use in Launceston?

There are various flaws and inconsistencies in the Launceston surveys that make it unsafe to conclude that there has a sharp reduction in the number of woodheaters, as follows:

- The 1992 survey is relatively small, comprising interviews with 99 households. Taking sampling variability into account, the real proportion of woodheaters could easily be somewhat lower. For example, the 90% confidence interval would be the range 55% to 81%. That is, given the size of the sample and the sample proportion (63%), one can be 90% confident that the true proportion lies somewhere between 55% and 81%.
- The 1992 survey may also have a significant non-response bias. Specifically, when there was no answer to the selected phone number, an alternative was immediately substituted, with no attempt to follow-up on phone numbers that did not answer. This practice would have introduced a bias if the non-answering households were more likely to be group households, young working couples without children, or other households that are less likely to have woodheaters.
- Similarly, there may be a large non-response bias in returns to the LCC's 1996 mail survey. Only 58% of the questionnaires were returned and, possibly, non-respondents were less likely to have woodheaters. For example, the survey form is headed 'Solid Fuel Heater Survey', which may have led households without

woodheaters to conclude that the survey did not relate to them. As with the earlier phone survey, there was no follow-up with non-respondents.

- In respect of the two recent surveys conducted by EMRS (2000b and 2000c), table A.4 reports comparative results for 4 sub-regions within Launceston. Note the large discrepancy between the June and November survey returns for region 4. The June survey returned a woodheater proportion of 60%, whereas the November survey returned a proportion of 38%. There is virtually no chance for samples of this size to return such different results. This suggests some problem with the underlying survey methodology or implementation.

We conclude that there remains a considerable degree of uncertainty about the current number of woodheaters in Launceston, and about trends during the 1990s.

Table A.4 Comparative returns from EMRS surveys, June and November 2000

	<i>Region</i>				<i>Total</i>
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	
June survey					
Sample size	90	89	103	88	370
Number with woodheaters	43	35	33	53	164
Proportion with woodheaters	0.48	0.39	0.32	0.60	0.44
November survey					
Sample size	129	126	125	128	508
Number with woodheaters	75	42	53	48	218
Proportion with woodheaters	0.58	0.33	0.42	0.38	0.43
Combined surveys					
Sample size	219	215	228	216	878
Number with woodheaters	118	77	86	101	382
Proportion with woodheaters	0.54	0.36	0.38	0.47	0.44

Appendix B:

Determinants of emissions performance

Total emissions from a particular woodheater is generally taken to be a function of several variables:

- woodheater size and the amount of wood consumed;
- woodheater design, including the impact of modifications;
- condition of the flue;
- moisture content of firewood;
- operating practice.

For the most part, the relative importance of these factors has been assessed on the basis of informed judgement. The clearest expression of this is in Todd's (1997) work on the estimated emission factors of various categories of woodheater and different types of user behaviour. It is evident from Table A.1 that the relationship between wet wood and smoke emissions is believed to be positive and significant, as is the relationship between uncertified woodheaters and smoke emissions.

Table A.1: Emission estimates

<i>Category of woodheater and/or user behaviour</i>	<i>Emission factor(g/kg)</i>
Poorly used woodheaters or very wet fuel	30
Old model woodheaters used thoughtlessly	15
Old model woodheaters used carefully	7
AS4013 woodheaters used thoughtlessly	7
AS4013 woodheaters used carefully	3.5
Best heater and best use	1.5

Source: Todd, 1997

Similar views are expressed by All Areas Chimney Sweeps (2000). Their recommendations to improve air quality in the Tamar Valley include:

- the eventual removal all pre 1993 woodheaters;
- the sale of only dry seasoned wood; and
- the burning of only seasoned wood.

However, results from a recent study of residential wood heating in Hobart (Todd, 2001) found:

- a weak correlation between average visible smoke and firewood moisture content; and
- no apparent correlation between average visible smoke and age of woodheaters - results of the study indicate that AS4013 certified heaters do not produce less visible smoke.

By implication, the overriding determinant of emissions is operating practice.

That said, we consider that more work is needed to objectively establish the relative importance of the various factors that influence the level of woodheater emissions. The results of Todd's 2001 study are qualified by the following considerations:

- As seems to be recognised by Todd (2001: page 8), it is not clear that the method used to measure woodheater performance would reliably distinguish between woodheaters. For the most part, smoke was observed for 2 or 3 minutes on 3 separate occasions, and ranked on a scale of 1 to 5. However there may be considerable variation in the density of visible smoke from a particular woodheater. For example, woodheaters that are generally operated well may be ranked poorly because they happen to be observed at start up or reloading, at which point all woodheaters emit more smoke. Conversely, poorly operated woodheaters may be ranked highly because they happen to be observed at a more fortuitous stage in the burn cycle. Hence one possibility is that the attempt to identify the contributions of different factors was simply overwhelmed by the amount of variation introduced to the data by the limited number of observations of the smoke emitted by each woodheater.
- Ideally, all explanatory variables would be measured (including indicators of operating practice) and their relative importance would be assessed in a multivariate analysis of the data. However, piecemeal analysis is reported in the study. That is, each factor is separately assessed for its ability to explain the observed variation in observed smoke, which can result in severe underestimates of separate contributions. For example, there may be positive interactive effects, that is, where a combination of factors has greater effect than the sum of their separate contributions. Or, negative correlations between different factors can have the effect of disguising the positive impact of one variable behind the negative impact of another.
- Todd also recognises certain other difficulties in terms of the size of the woodheater sample and missing observations. For example:
 - Firewood moisture content was measured at only 51 households, from a total sample of 121.
 - The best performing woodheaters may have been omitted from the study because no smoke could be observed at all.

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