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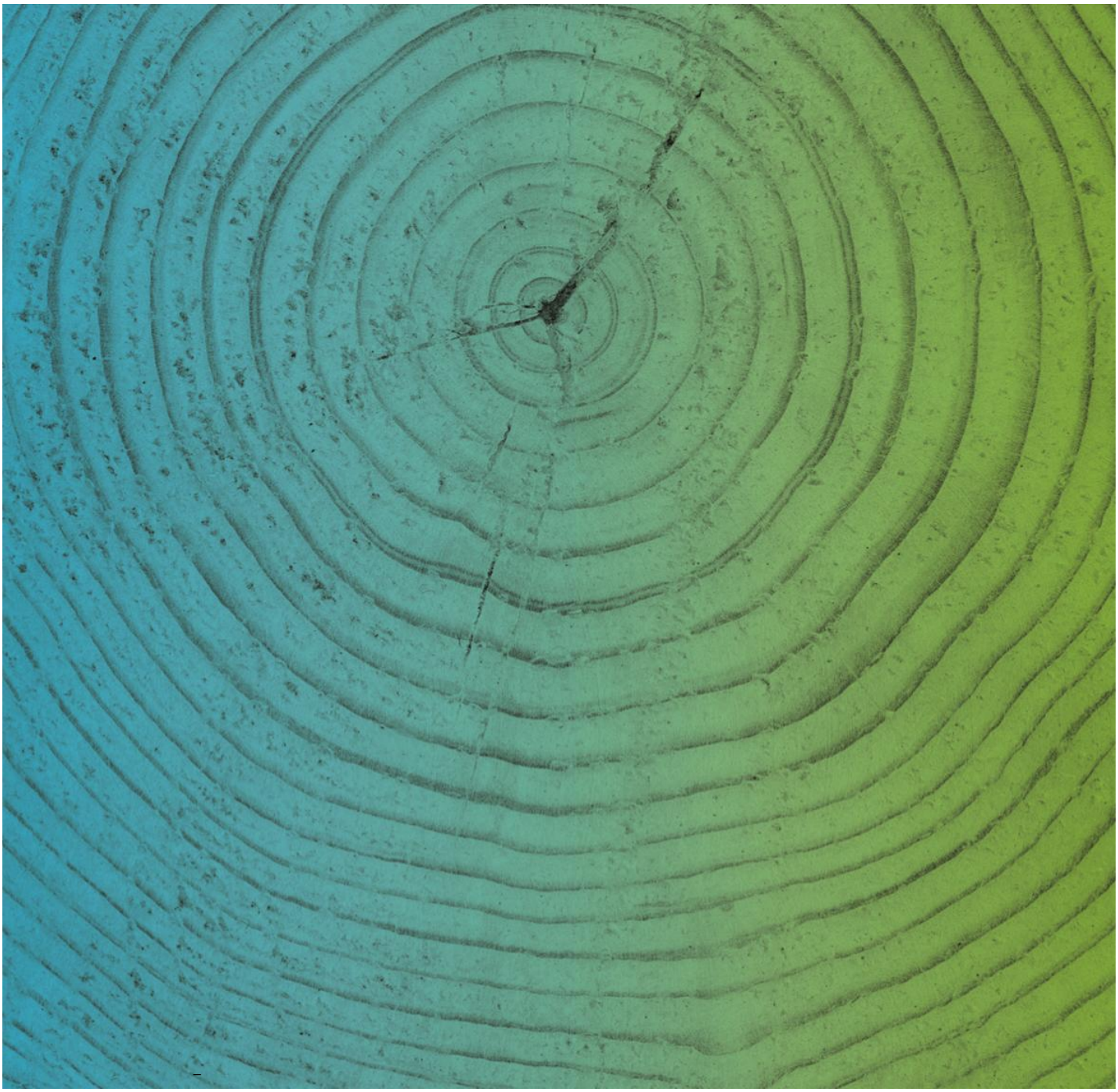
NSW Environment Protection Authority
19-Dec-2014

Wood Smoke Control Measures

Cost Benefit Analysis



Wood Smoke Control Measures

Cost Benefit Analysis

Prepared for NSW Environment Protection Authority

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Executive Summary

Introduction

In April 2014, the New South Wales (NSW) Environment Protection Authority (EPA) commissioned AECOM Australia Pty Ltd ('AECOM') to undertake an economic evaluation of a proposed new regulatory framework for controlling emissions from domestic solid fuel heaters in the *Protection for the Environment Operations (Clean Air) Regulation 2010* (herein the 'Clean Air Regulation').

The objective of this study is to evaluate the costs and benefits of a new schedule in the Clean Air Regulation that will list the additional controls that councils can choose to implement in their entire local government area (LGA) or designated areas such as high density neighbourhoods, new development precincts or localities that are likely to be affected by wood smoke because of their topography.

A range of environmental and health impacts is associated with the use of wood heaters, including reduced habitat and biodiversity impacts from firewood harvesting and collection, as well as health and environmental impacts associated with the emission of particulates and air toxics from wood heaters (NEPC, 2013). However, the most significant impact of wood heaters is the health impact of particulate pollution. During the winter months, wood heaters and woodstoves are some of the most significant sources of particulate pollution in NSW.

In order to evaluate suitable approaches to reduce particle emissions, a model was developed that assessed four proposed regulatory options developed by the EPA:

- Option 1 - Current Regulation (status quo);
- Option 2 - New Regulation;
- Option 2A - Proposed new schedule/ Regulation amendment; and
- Option 3 - No Regulation (Voluntary Industry Compliance).

This document constitutes a final report of the cost benefit analysis (CBA) of the wood smoke control measures in NSW.

The Options

A summary of the options is presented below.

Option 1 - Current Regulation (status quo)

Option 1 assumes that there is no change to the current wood smoke control measures in NSW. This means the current Regulation requirement that wood heaters sold in NSW must comply with the Australian Standard, *AS/NZS 4013:1999 – Domestic solid fuel burning appliances* (AS/NZS 1999) will remain. The control measures also include the use of local government planning instruments such as development control plans and local approval policies to place controls on installation; promoting the correct use of wood heaters; periodic wood heater replacement programs; public education; and the use of smoke abatement notices under the Protection of the Environment Operations Act 1997 ('POEO Act').

Five LGAs in NSW have currently implemented some form of wood smoke control. Any reduction in emissions attributable to these council controls are expected to be minor and, for the purpose of this study, have been assumed to already exist under the emission projections in Option 1.

For the purpose of this study, Option 1 is the "Do Nothing" Base Case.

Option 2 - New Regulation

Option 2 proposes the incorporation of more stringent limits for wood heater emissions and new efficiency limits in the updated Australian/New Zealand Standards (published in August 2014). The updated Australian Standards introduce a staged approach to setting efficiency and emissions limits for new solid fuel heaters across NSW:

- 55 per cent efficiency and 2.5 grams of particle emissions per kilogram of fuel burnt (g/kg) within twelve months after the standards are published (2015); and
- 60 per cent efficiency and 1.5 g/kg within five years after publishing (2019).

Option 2A - Proposed new schedule/ Regulation amendment

Option 2A assumes the incorporation of more stringent limits for wood heater emissions and new efficiency limits as in Option 2:

- 55 per cent efficiency and 2.5 g/kg within twelve months after the standards are published (2015); and
- 60 per cent efficiency and 1.5 g/kg within five years after publishing (2019).

In addition, Option 2A proposes the introduction of a new schedule within the Clean Air Regulation (similar to the control of burning in the open) that lists additional controls which councils can choose to implement. Option 2A assesses (above and beyond Option 2) the implementation of three different sub-options:

- **Part 1:** No new wood heaters in designated areas;
- **Part 2:** No new open fire places in designated areas; and
- **Part 3**: New wood heaters must comply with Clause 9.1.1(b) of AS/NZS 4012 (minimum efficiency of 60 per cent) and Clause 7.7.1(b) and 7.1.1.2(b) of AS/NZS 4013 (emission factor of 1.5 g/kg for non-catalytic and 0.8g/kg for catalytic heaters) within 12 months of the Regulation commencement (2015).

These controls could apply to either the entire LGA or specific designated areas, such as high density neighbourhoods, new development precincts or localities that are likely to be affected by wood smoke because of their topography.

Option 2A provides councils with the ability to control the installation of wood heaters in designated areas or across the whole LGA.

Investigations have shown that amongst the councils that consider wood smoke control measures necessary, approximately 38 per cent of councils support disallowing open fire installation, 51 per cent support requiring low emission wood heaters in designated areas, and 43 per cent support disallowing wood heaters in new release areas (EPA, 2012). For the purpose of this assessment, these councils have been identified as ‘participating councils’. The size of the population and wood heater ownership for participating councils represent around 39 per cent and 24 per cent of NSW totals respectively.

Assuming councils which responded ‘yes’ adopt the new schedules:

- The sale and installation of new fireplaces across NSW will reduce by 1.3 per cent;
- The sale and installation of new wood heaters across NSW will reduce by 16.6 per cent; and
- 18.4 per cent of new heaters in NSW will need to comply with tighter efficiency standards of 60 per cent efficiency and 1.5 g/kg by 2015.

Option 3 - No Regulation (Voluntary Industry Compliance)

Under Option 3, NSW would remove the regulatory basis for controlling sales of new wood heaters. Councils will be able to use their planning instruments to control the installation of new wood heaters and open fire places in designated areas. Control of wood smoke would need to rely on voluntary industry compliance with the Australian Standards on energy efficiency and emission limits, to be introduced under the following stages:

- 55 per cent efficiency and 2.5 g/kg within twelve months after the standards are published (2015); and
- 60 per cent efficiency and 1.5 g/kg within five years after publishing (2019).

Reliance on voluntary compliance was assumed to be reasonably effective given that various members of the industry (including the Australian Home Heating Association (AHHA)) indicated their agreement to comply with the new standards. Further, many existing models of wood heaters supplied by Australian manufacturers have already met or are expected to meet these standards. It is likely, however, that voluntary compliance would not result in full compliance by the entire industry. In general, not all suppliers and manufacturers have commercial incentives for voluntary compliance, for example, producers and importers of low cost or export models.

A proportion of heater models for sale in Australia already comply with 55 and 60 per cent efficiency standards. The efficiency levels of the heater models listed on the AHHA website indicate that 53 per cent of the existing models would comply with the requirements for 55 per cent heating efficiency and 2.5g/kg emission (“Tier 1”); and 14 per cent with the requirements for 60 per cent heating efficiency and 1.5g/kg emission (“Tier 2”).

Following consultation with the EPA and the AHHA, it was assumed that the levels of voluntary compliance with the standards would be 70 per cent following implementation.

Context of the Cost Benefit Analysis

The economic analysis of the policy options has been conducted in accordance with *NSW Treasury Guidelines for Economic Appraisal TPP 07-5* (NSW Treasury, 2007) and has been undertaken using a cost benefit analysis (CBA) framework that applies discounted cash flow techniques.

The following costs and benefits have been included in the CBA:

- Quantified costs:
    - Costs to the NSW Government and local councils such as scheme implementation costs, administration and enforcement costs and public education costs;
- Quantified benefits:
    - Benefit of avoided health costs;
    - Disbenefit of reduced consumer surplus; and
    - Disbenefit of reduced industry profitability (i.e. producer surplus).

Table 1 overleaf presents the costs and benefits included under each evaluation option. It should be noted that not all costs and benefits were relevant to all options, as is outlined below.

Table 1 Costs and benefits associated with evaluation options

Option	Option Costs	Option Benefits
Option 1 Do-Nothing Base Case	Public education costs of $30,000 per annum (undiscounted).	No change in economic benefits.
Option 2	Scheme Implementation costs of $60,000 in the first year of the scheme (2015) (undiscounted). Administration and enforcement costs of $80,000 per annum (undiscounted). Public education costs of $30,000 per annum (undiscounted).	Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 3.6% and emission efficiency of 16.4% (relating to 100% compliance across NSW) between 2015 and 2019, increasing to heating efficiency of 5.6% and emission efficiency of 28.6% (relating to 100% compliance across NSW) for 2019 onwards. No reduction in heater sales. No change in consumer surplus as there is no reduction in heater sales. No change in profitability applied as there is no reduction in heater sales.
Option 2A	Scheme Implementation costs of $60,000 (undiscounted) in the first year of the scheme (2015). Administration and enforcement costs of $80,000 per annum (undiscounted). Public education costs of $70,000 per annum (undiscounted).	Health benefits associated with $PM_{2.5}$ reduction from the reduction in new wood heaters of 16.6% and reduction in new open fireplaces of 1.3%, based on the proportion of sales in designated areas to total sales in NSW. Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 3.6% and emission efficiency of 16.4% (relating to 100% compliance across NSW) between 2015 and 2019, increasing to heating efficiency of 5.6% and emission efficiency of 28.6% (relating to 100% compliance across NSW) for 2019 onwards. Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 5.6% and emission efficiency of 28.6% (relating to LGAs that will adopt compliance for 2015 efficiency standards (Tier 2 brought forward)). Dis-benefit arising from the loss of consumer surplus of $2,062,000 per year (undiscounted) based on the proportion of the reduction in heater sales to total heater sales in NSW applied to the total NSW consumer surplus. Loss of profitability arising from reduced sales of $619,000 per year based on the proportion of the reduction in heater sales to total heater sales in NSW applied to the total NSW profit.
Option 3	Public education costs of $30,000 per annum (undiscounted).	Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 2.5% and emission efficiency of 11.5% (relating to 70% compliance across NSW) between 2015 and 2019, increasing to heating efficiency of 3.9% and emission efficiency of 20.0% (relating to 70% compliance across NSW) for 2019 onwards.

Source: AECOM (2014)

The following costs and benefits were not quantified in the evaluation but have been assessed qualitatively:

- Costs to industry;
- Benefit of increased amenity;
- Benefit of reduction in fuel use;
- Benefit of reduction in Greenhouse Gas; and
- Benefit of reduction in Volatile Organic Compounds (VOCs).

Results of the Cost Benefit Analysis

Table 2 shows the costs and benefits of the three wood smoke control options incremental to Option 1 (Do-Nothing Base Case). The evaluation was based on the 20-year period from 2015 to 2034 and a real discount rate of 7 per cent per annum. The results of the evaluation are presented in terms of net present value (NPV), which measures the difference between discounted benefits and discounted costs for each option. The option with the highest NPV is the economically preferred option when options are mutually exclusive and there is no capital expenditure (refer to NSW Treasury (2007)). Furthermore, the valuation of health benefits in PV terms makes the NPV the most appropriate and comparable measure.

Table 2 Costs and benefits of wood smoke control options incremental to the Base Case (PV, $'000) [(a)]

Evaluation Results	Option 2	Option 2A	Option 3
Costs			
Capital costs [(b)]	0	0	0
Recurrent costs			
Scheme implementation (once-off)	56	56	0
Administration & enforcement of regulations	848	848	0
Public education program	0	402	0
Total costs	**904**	**1,306**	**0**
Benefits			
Health benefits associated with $PM_{2.5}$ reductions	1,557,760	2,307,894	1,101,712
Loss of consumer surplus	0	-21,842	0
Loss of profitability	0	-6,553	0
Total benefits	**1,557,760**	**2,279,499**	**1,101,712**
Net Present Value	**1,556,857**	**2,278,193**	**1,101,712**

Source: AECOM, 2014
Notes:
(a) Discounted to 2014 using a real discount rate of 7 per cent per annum.
(b) The implementation of the Options does not require capital expenditure, so no capital costs were included.
(c) Totals may not sum due to rounding.

The evaluation results indicate that Option 2A has the highest NPV of around $2.3 billion, incremental to Option 1 (the Do-Nothing Base Case). Option 2 has the second highest NPV of around $1.6 billion, followed by Option 3 of around $1.1 billion.

The contribution of the council adoption of control measures to the NPV is represented by the difference between Option 2 and Option 2A of approximately $720 million.

The contribution of the control measures to the NPV of approximately $720 million for Option 2A, compared to Option 2, is split as follows:

- Part 1 (No new wood heaters in designated areas) and Part 2 (No new open fire places in designated areas) together with voluntary compliance to the updated standards contribute approximately $702 million; and

- Part 3, which involves bringing forward the updated standards in the designated areas of participating Councils, contributes approximately $18 million.

It is recognised that Option 3 might be a more realistic 'Do-Nothing' scenario than Option 1 as industry surveys indicate that 70 per cent industry compliance is an achievable result. When Option 2 and Option 2A are compared against Option 3 as a Base Case scenario, the results are as follows:

- Option 2 has a NPV of $455.0 million (over and above Option 3); and
- Option 2A has an NPV of $1.177 billion.

When Option 2 and Option 2A are compared against Option 3 as a Base Case scenario, the options remain viable (positive NPVs) and the ranking of the options does not change.

Sensitivity tests were undertaken to understand how the economic viability of each option varies with changes to key variables. The results of the sensitivity tests indicated that the use of different discount rates of 4% and 10% and 20 per cent higher or lower $PM_{2.5}$ costs does not change the outcomes of the economic evaluation. Option 2A has the largest NPV compared to Option 1, followed by Option 2 and Option 3.

Recommendation

The results of the economic evaluation indicated that Option 2A has the highest NPV of around $2.3 billion and the largest reduction in wood smoke emissions, compared to Option 1, making it the most viable of the options assessed.

As Option 2A includes the costs and benefits associated with the voluntary adoption of the new schedule by individual councils, this option includes elements that are beyond the control of the EPA. Option 2, however, represents the scenario under which Option 2A is implemented but assumes that the councils do not choose to adopt the new schedule. Option 2 maintains a positive NPV of $1.6 billion, demonstrating that the implementation of the new regulatory framework has a positive net benefit for NSW, with or without local government intervention.

The costs of implementing both Options 2 and 2A are the same, thus reducing the risk to the NSW Government should the councils decide not to implement the new schedule.

Option 2A retains the current arrangement of giving adequate regulatory powers to councils to control wood smoke as they cause serious local pollution and health problems. This, when combined with the introduction of the updated (and soon to be published) Australian/New Zealand efficiency and emission standards, forms a targeted control approach to produce larger net public benefit.

It is recommended that Option 2A be selected as the preferred regulatory option, since a positive benefit can be achieved even if the councils do not adopt the new schedule.

1.0 Introduction

1.1 Background and objectives

In April 2014, the New South Wales (NSW) Environment Protection Authority (EPA) commissioned AECOM Australia Pty Ltd (AECOM) to undertake an economic evaluation of a proposed new regulatory framework for controlling emissions from domestic solid fuel heaters in the *Protection for the Environment Operations (Clean Air) Regulation 2010* (herein the Clean Air Regulation).

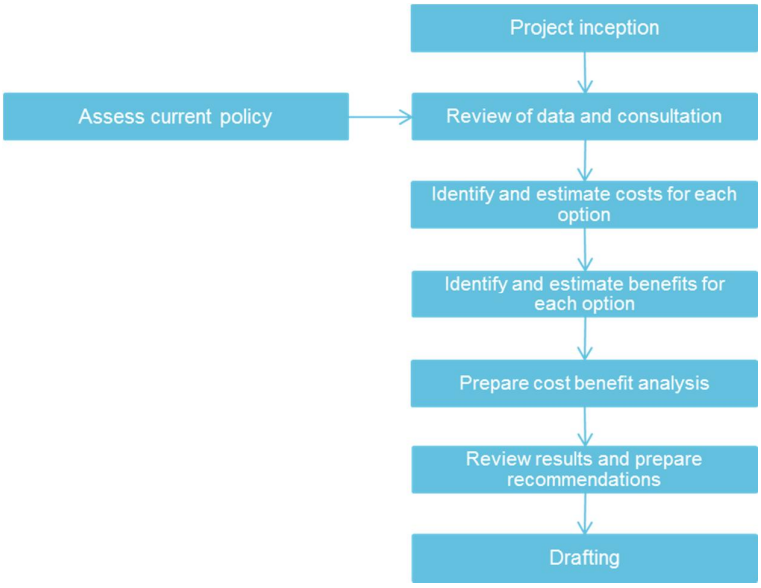
The objective of this study is to evaluate the costs and benefits of a new schedule in the Clean Air Regulation that will list the additional controls that councils can choose to implement in their entire local government area (LGA) or designated areas such as high density neighbourhoods, new development precincts or localities that are likely to be affected by wood smoke because of their topography.

This report constitutes a final report on the results of the CBA of the proposed new regulatory framework.

1.2 Methodology

Figure 1 provides a conceptual overview of AECOM's methodology for this project.

Figure 1 Study methodology



Source: AECOM, 2014

The economic analysis has been conducted in accordance with *NSW Treasury Guidelines for Economic Appraisal TPP 07-5* (NSW Treasury, 2007) and has been undertaken using a CBA framework that applies discounted cash flow techniques.

This study provides information and analysis to support the regulatory review of the control of wood smoke in areas across NSW. In particular, this report:

- Assesses the current wood smoke control policy in NSW;
- Details the baseline model and a preliminary assessment of potential control measures to be included in the CBA;
- Summarises the CBA conducted on the measures identified (detailed in Chapter 5); and
- Presents the assessment of the net public benefit of the specified options.

1.3 Previous AECOM study

In 2011, AECOM was commissioned by the NSW Office of Environment and Heritage (OEH) to examine suitable approaches to reduce particle ($PM_{2.5}$ and PM_{10}) and volatile organic compound (VOC) emissions associated with the operation of domestic wood heaters, and provide an assessment of their costs and benefits. The report (AECOM, 2011) developed several potential combined approaches for controlling wood smoke to a series of case study areas.

The report found that there was a range of factors that influenced the choice of heating system in NSW and encouraged the use of wood heaters. These factors included but were not limited to:

- heating costs;
- climatic factors;
- the availability of gas reticulation networks; and
- consumer preference.

A preliminary assessment undertaken for the report revealed a range of potential wood smoke control options. These options were:

- a ban on heater sales;
- the efficiency standards and emissions limits;
- a ‘phase out’ at the time of sale of house;
- a fuel moisture content regulation;
- a tax on new wood heaters;
- licensing fees;
- a tax on wood fuel; and
- cash incentive ‘phase out’.

A model was developed for preparing wood heater stock forecasts and emission projections. The model took into account the stock and mix of wood heaters (slow combustion heater, open fireplace and potbelly stove) and their emission rates.

AECOM has been asked to apply the methodology and analytical model developed in the 2011 study to prepare the assessment of the options specified in this study.

2.0 The need for wood smoke control

A range of environmental and health impacts is associated with the use of wood heaters, including reduced habitat and biodiversity impacts from firewood harvesting and collection, as well as health and environmental impacts associated with the emission of particulates and air toxics from wood heaters (NEPC, 2013). The most significant impact of wood heaters is the health impact of particulate pollution. Furthermore, during the winter months, wood heaters and woodstoves are some of the most significant sources of particulate pollution in NSW. Particulate pollution is therefore a regulatory consideration for the NSW EPA, and the focus for this CBA.

The following sections provide a summary of the justifications for wood smoke control in NSW, as outlined in NEPC, 2013; AECOM, 2011; US EPA, 2013; and EPA, 2014.

2.1 Contribution of wood heater emissions to particulate pollution in NSW

Wood smoke consists of particulate matter (PM) and other air pollutants, which when inhaled into our lungs can have negative health effects. Based on data from the National Pollutant Inventory, domestic solid fuel burning (including wood heaters) is among the top eight sources of PM_{10} in Australia. Of the main non-industrial sources of PM_{10}, vegetation burning / wildfires is the most significant contributor (38 per cent), followed by windblown dust (31 per cent) and road dust (26 per cent). However, these sources are largely beyond regulation and not easily mitigated. Domestic solid fuel burning contributes more PM_{10} emissions per year than motor vehicles (20,000 tonnes and 12,000 tonnes respectively).

On a winter weekend day, wood smoke from domestic solid fuel heaters in Sydney contributes as much as 48 and 60 per cent of fine (PM_{10}) and very fine ($PM_{2.5}$) particle pollution respectively. In colder climates, such as in Armidale, wood heaters can contribute over 85 per cent of winter particles pollution (DECCW, 2010).

2.2 Ambient levels of particulates are exceeding national standards

NSW does not meet the Ambient Air Quality National Environmental Protection Measure goals for fine particles in parts of NSW. The standard for particles with a diameter of less than 10 micron (PM_{10}) is 50 µg/m_3 averaged over a day. The 2008 goal was to meet the standard allowing for five exceedance days each year (accounting for unforeseen events such as bushfires and dust storms).

Wood smoke has also been a major contributor to exceedances in Canberra and Launceston (although no exceedances of the standard have been observed in Launceston since 2006).

As well as contributing to regional air pollution, a poorly operated wood heater can create localised smoke and odour nuisance.

2.3 Health effects associated with failure to meet particulate standards

Particulate matter is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles (US EPA, 2013).

Particles can vary in size, composition and origin, with the particles of greatest concern to public health being those with a diameter of less than 10 micrometers (µm) (PM_{10}) as they can be inhaled into lungs. Particles with a diameter of less than 2.5 µm ($PM_{2.5}$) are small enough to be inhaled deep into the lungs where they can directly enter the bloodstream (NEPC, 2013).

Numerous scientific studies have linked particle pollution exposure to a variety of health problems, including (US EPA, 2013):

- premature death in people with heart or lung disease;
- non-fatal heart attacks;
- irregular heartbeat;
- aggravated asthma;
- decreased lung function; and
- increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

Current scientific research indicates that there is no clear threshold for adverse health effects from particulate matter in the atmosphere, and that adverse effects can be experienced after both short-term and long-term exposures. As there is no clear level below which adverse health effects from particulates would not be observed, any reduction in ambient air concentrations of particulates will reduce population exposure and risk, resulting in a positive health benefit (NEPC, 2013).

2.4 The 'Consultation regulation impact statement for reducing emissions from wood heaters' report

The National Environment Protection Council Service Corporation released the '*Consultation Regulation Impact Statement for Reducing Emissions from Wood Heaters*' report in April 2013. The report explores options for a national policy and/or regulatory framework for reducing emissions from wood heaters. It was intended to help community, interested parties and other stakeholders to identify potential impacts of various policy and regulatory options presented in the report.

The policy options considered in the report fall into three major categories:

- wood heater design or performance standards;
- measures to promote compliance of retail models against these standards; and
- measures influencing the in-service operational performance of wood heaters.

All of these measures could be delivered through a range of policy 'vehicles'. The policy delivery approaches examined are a voluntary national program, a collaborative approach or a national regulatory approach. The policy options that were considered are outlined in the table overleaf.

Table 3 Policy options considered in Consultation Regulation Impact Statement (CRIS) for reducing emissions from wood heaters (2013)

Option	Type of approach	Policy Vehicles	Policy Actions		
			Standards	Compliance	In-service
1	Voluntary	National program		- National audits	- Education (targeted at critical airsheds)
2	Voluntary			- National audits	- Education Wood heater replacement incentives
3	Collaborative	Enhanced jurisdictional regulatory arrangements calling up Australian Standards, with complementary Commonwealth programs	- Emissions labelling (compliance plate)	- Nationally coordinated funding for state-based standard audit and enforcement	- Education
4	Collaborative		- Emissions labelling (compliance plate) - National star rating labelling scheme	- As above	- As above
5	Collaborative		- Emissions labelling (compliance plate) - National star rating labelling scheme - Efficiency standard (60%)	- As above	- As above
6	National regulatory approach	Sub-options: A. NEPM B. Commonwealth legislation C. Mirror legislation		- Independent testing and national certification - National audits	- Education
7	National regulatory approach			- As above	- Education - Common definition of excessive smoke - Controls on modification and installation - Controls on 2nd-hand heaters - Wood heater replacement incentives
8	National regulatory approach			- As above	- As above
9	National regulatory approach			- As above	- As above

Source: National Environment Protection Council Service Corporation (NEPC), 2013, *Consultation regulation impact statement for reducing emissions from wood heaters*, released April 2013

The report states that sales of wood heaters in Australia have dropped from a peak of 120,000 units per year in 1988 to around 25,000 units per year currently. Sales around this level are expected to continue. National turnover of the existing stock of wood heaters is estimated to be less than 2 per cent per annum, with turnover highest in rural areas where wood is cheaper and reticulated natural gas is often not available. Therefore, the report argues there is a need to consider policy options for both in-service heaters and those entering the market.

In total, current particulate emissions from the 1.1 million wood heaters in service in Australia are estimated at around 40,000 tonnes per annum. This is twice the amount of emissions estimated under the National Pollution Inventory, which uses design standard emission factors which have not been adjusted for differences in design compliance and operating practices.

2.4.1 Impacts of policy options

The assessment of the policy options outlined in Table 3 is summarised below:

- **Economic outcomes**:
    - The main economic impacts of the options are the costs to government of implementing the various measures to reduce emissions from wood heaters; the costs to manufacturers to meet changes to standards applicable to new wood heaters; and the health benefits for communities arising from lower particulate emissions from wood heaters.
    - The estimated costs to government of implementing the options range from $15 million over the twenty years under Option 1 (for national audits and education programs in critical airsheds) to around $39 million under Options 7 to 9 (for setting up and administering a national regulatory framework including national certification and independent auditing as well as education and wood heater replacement programs in critical airsheds).
    - The estimated benefits far outweigh the estimated costs of all options included in the analysis. The present value of the net benefits ranges from around $750m to $1,800m.
- **Social outcomes**:
    - As well as the cost implications identified above for governments and manufacturers, the suite of measures incorporated in each policy option will have implications for wood heater prices, employment within the wood heater manufacturing sector and the broader community in urban and rural and regional areas in Australia.
    - The estimated impact of the options on wood heater prices is estimated to range from $20 - $230 per heater. A tightening of efficiency and emissions standards to 60 per cent and 3 g/kg respectively under Options 6 and 7 may have an impact on small wood heater producers. It is difficult to predict the likely outcome for the industry of any further tightening of standards; however, a move to a 1.5 g/kg emissions standard examined under Option 9 would be expected to have a much greater impact.

3.0 Background

3.1 Wood heaters in NSW

Wood smoke is a prominent source of air pollution in urban and semi-rural settings in NSW (DECCW, 2010). While a small percentage of homes use wood heating in Sydney, smoke from wood heaters account for 48 per cent of fine (PM_{10}) and 60 per cent of very fine ($PM_{2.5}$) winter particle pollution. In colder climates, such as in Armidale, wood heaters can contribute over 85 per cent of winter particulate pollution (DECCW, 2010).

The Australian Bureau of Statistics (ABS) regularly collects data on heating sources within homes. The results of the latest surveys are reported in *Environmental Issues: Energy Use and Conservation* (ABS, 2008 and 2011). The percentage of NSW households using wood heaters as a source of heating is summarised in Table 4.

Table 4 Estimated wood heater usage, 2011, NSW

Wood heater type	Per cent of NSW Households(1)	Estimated Number of Heaters
Combustion	12.10	335,679
Open fire	1.20	29,782
Pot-belly	0.40	10,701
Total	13.70	376,163

Source: ABS, 2008 and 2011

(1) ABS 2011 reported wood heating represents 11.4 per cent of main source of energy for heating for households or an increase of 1.1 per cent over the 2008 data. Only the 2008 data provided a break up by heater type

As noted above, there are approximately 376,000 wood heaters in use in NSW. The Regulatory Impact Statement: *Proposed Protection of the Environment Operations (Clean Air) Regulation 2010* (DECCW, 2010) identified the sale of wood heaters in NSW as approximately 9,600 per year in 2008. AECOM has estimated that sales could have been as high as 11,500 wood heaters in 2014.

Estimates of wood heater ownership by area in NSW are shown in Table 5.

Table 5 Wood heater ownership by Area

	Ownership ratio (%)	Number of Heater Owners	Number of Dwellings
Sydney areas			
Botany to Arncliffe	1.2	906	73,815
Lakemba to Hurstville	1.8	1,493	80,904
Concord to Lane Cove	2.5	1,197	48,476
Villawood to Cabramatta	2.7	1,429	53,145
City	2.7	1,911	69,734
Eastern Suburbs	3.4	3,578	105,984
Balmain to Strathfield	3.9	4,877	124,621
North Sydney to Manly	4.3	4,379	101,757
Bankstown to Georges Hall	5.5	3,344	61,140
North Rocks to Parramatta	5.6	4,378	77,980
Baulkham Hills to Rouse Hill	14.0	13,991	99,583
Liverpool	6.7	5,408	80,438
Blacktown to Penrith	7.0	10,999	158,134
The Shire	7.2	5,675	78,308
Collaroy to Palm Beach	8.0	4,952	61,591
Ryde to Hornsby	8.4	11,503	137,578
Other inner areas			
Gosford	8.7	5,095	58,590
Lake Illawarra	11.3	3,398	30,068
Campbelltown to Mittagong	11.8	6,013	50,920
Wyong	6.9	3,599	52,315
Blue Mountains	27.6	7,188	26,042
Wollongong	6.7	5,747	85,498
Outer regions			
Richmond-Tweed and Mid-North Coast	43.2	58,098	134,386
Northern, North Western and Central West	23.1	53,210	230,225
South Eastern	9.0	32,786	363,616
Murray-Murrumbidgee	6.9	6,735	98,259
Far West	1.3	1,500	112,570
Hunter	30.6	18,953	61,925
Illawarra	13.5	34,756	257,395

Source: AECOM estimates based on data provided by ABS and IPART.

3.2 Factors influencing heating choice

There are a range of factors that influence the choice of heating system in NSW and promote the use of wood heaters. These factors include but are not limited to:

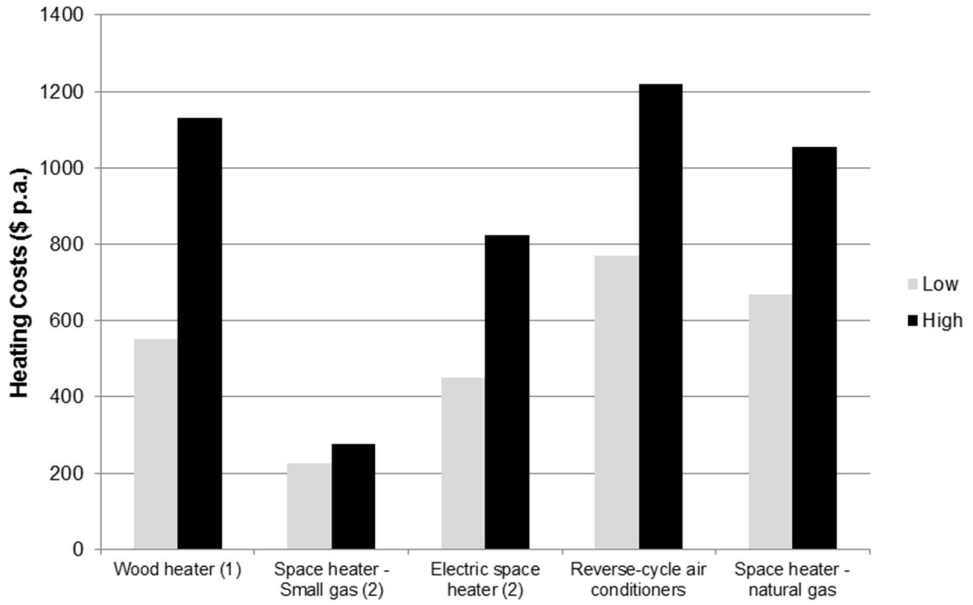
- Heating costs;
- Climatic factors;
- The availability of gas reticulation networks; and
- Consumer preference.

3.2.1 Heating costs

The cost of wood heating as a source of primary heating for a home is one of the factors in the use of wood heaters. A detailed assessment has been undertaken on the operating costs associated with different heating systems by the Victorian Government based on a Thermal Simulation program for a typical new home with R2.5 ceiling insulation and R1.0 wall insulation.

An update of this assessment is presented in Figure 2, based on information from Sustainability Victoria website together with heating cost estimates for wood heaters prepared by AECOM. The running costs are presented as high and low due to the range of variables that affect operating costs, including the size of the heater, operating temperature, hours of operation, energy efficiency and home conditioning area. The assessment is considered to be indicative of the price differences between heating types.

Figure 2 Indicative Operating Costs of Heating Systems



Source: AECOM estimates, Sustainability Vic, Website: http://www.sustainability.vic.gov.au/services-and-advice/households/energy-efficiency/at-home/heating//heating-running-costs

Notes: (1) Cost of wood purchase varies significantly across areas

(2) Heating type suitable for smaller areas

Heating and operating costs for wood heaters are comparable to those for efficient reverse-cycle air conditioners and natural gas space heaters. The factors that affect the relative heating costs include: recent increases in electricity prices in NSW (and Victoria), increased energy efficiency of air conditioners and the increased price of wood.

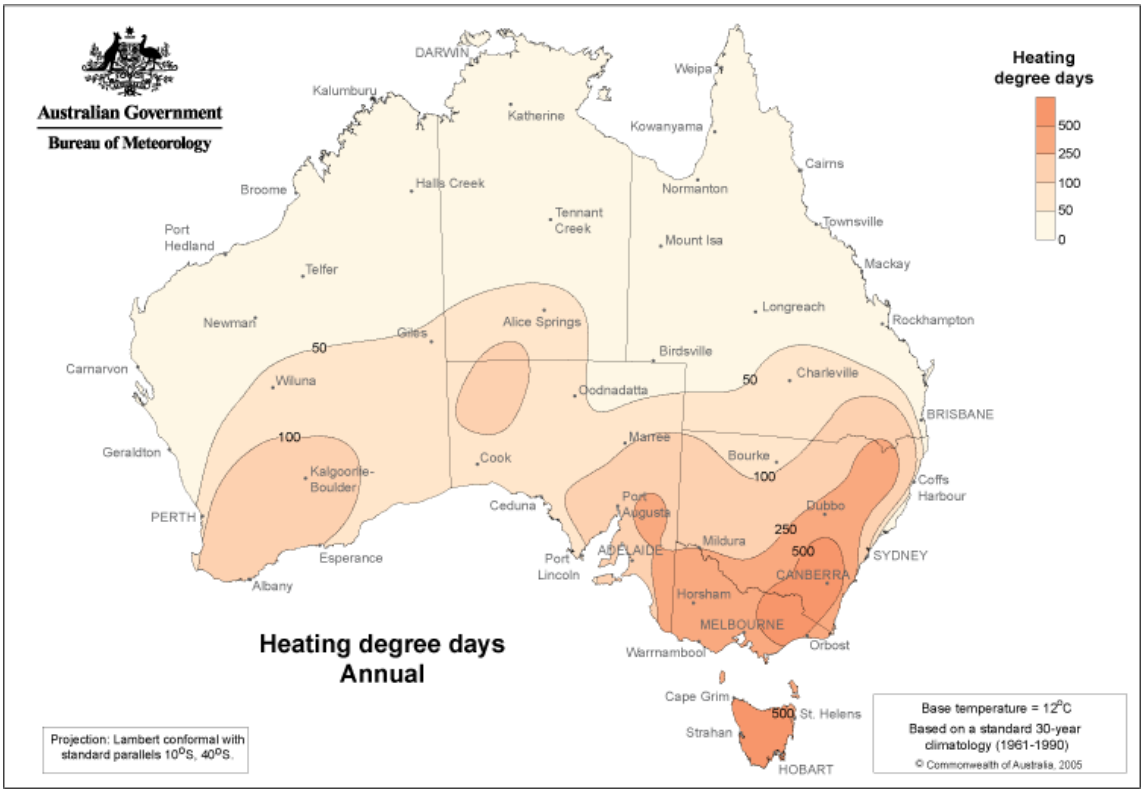
Wood heating is likely to be significantly cheaper in non-urban areas of NSW where fuel costs are lower and in areas that do not have gas reticulation (and therefore the choice of natural gas space heaters is not available). This lack of heating alternatives may be further exacerbated by the fact that heat pump heating (through split-

system and reverse-cycle air conditioning) is an inefficient heating source in very cold climates with temperatures less than 4.4°C (US DOE, 2011). The cost difference may also be affected by the fact that a significant proportion of wood heater users source free wood fuel through scavenging. A survey for the NSW EPA in 2003 shows that the over 50 per cent of the respondents sourced fuel from friends/relatives or through local scavenging (Todd, 2003).

3.2.2 Climatic factors

The varying climatic regions of NSW mean that household heating use varies across the state. The Bureau of Meteorology has developed a process to record the number of heating degree days[1] in a year that households in an area would require home heating. A national map for heating degree days is presented in Figure 3.

Figure 3 National annual heating degree days



Source: Australian Bureau of Meteorology, 2012

The heating degree day map reveals that parts of NSW, such as the South East and Riverina regions as well as parts of North East have relatively high heating requirements in comparison to areas in the North West and coastal areas.

3.2.3 Gas reticulation network

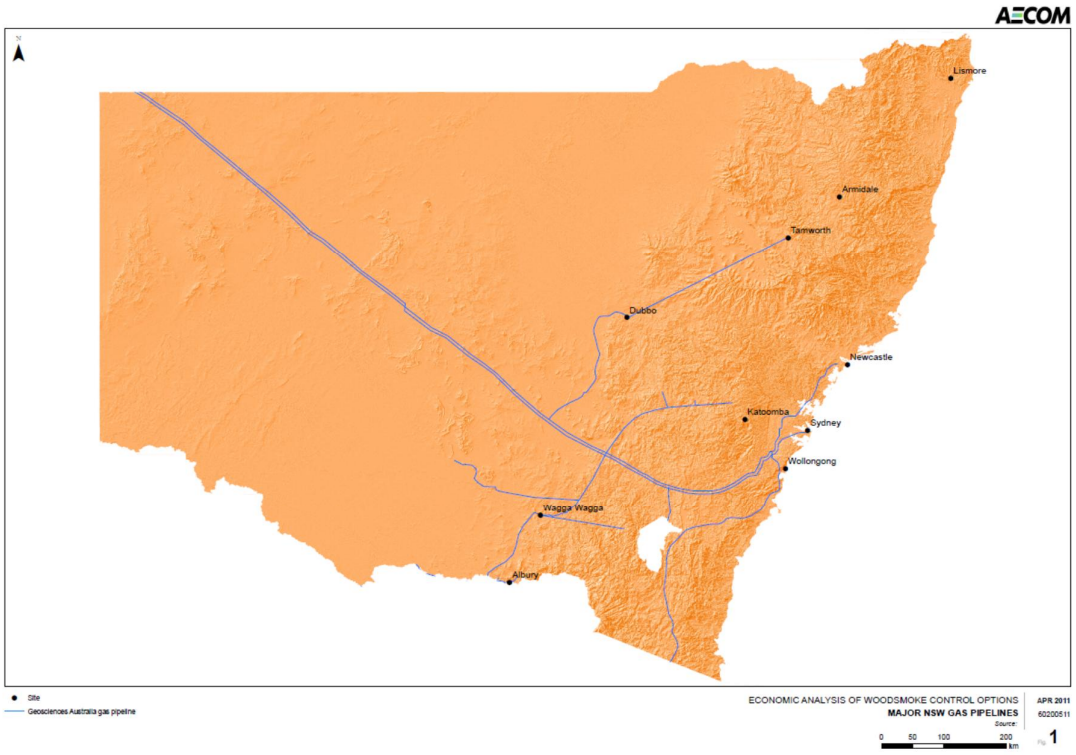
The spatial distribution of wood heaters may also be influenced by the availability of a gas reticulation network. As noted in Figure 2, space heating using natural gas can have similar operating costs to wood heaters. The cost of alternative systems such as electrical heating is significantly higher than wood heaters.

[1] The heating degree days are determined by the difference between the average daily temperature and the comfort level temperature. For example, if heating is being considered to a temperature comfort level of 18 degrees, and the average daily temperature for a particular location was 14 degrees, then heating equivalent to 4 degrees (4 heating degree days) would be required to maintain a temperature of 18 degrees for that day. However, if the average daily temperature was 20 degrees then no heating would be required, so the number of heating degree days for that day would be zero.

Geoscience Australia maintains a map of the reticulated gas network in NSW (Geoscience Australia, 2010) replicated in Figure 4. The map shows that the gas network is located in eastern NSW and concentrated around Sydney and Canberra. The northern and a large proportion of southern NSW have no gas network reticulation and rely on LPG deliveries.

The combination of high heating requirements and lack of access to low cost gas heating may create greater incentives for meeting heating requirements through wood heaters. These areas may also have higher wood heater use and subsequently higher levels of wood smoke than other areas.

Figure 4 Major Natural Gas Pipeline Map



Source: AECOM, 2011

3.2.4 Consumer preference

The Australian Home Heating Association reports that over 1.1 million Australian households prefer wood heating as their main source of heating for their homes (AHHA, no date). There is consumer sentiment associated with the ambience provided by a wood fire that cannot be replaced by gas heating. Some consumers consider wood fires decorative and believe they provide a level of comfort and homeliness. Other factors that influence consumer preference for wood heaters include household income, age of residence, comfort and convenience.

3.3 Current NSW policy settings

3.3.1 Policy and regulatory measures

Currently the control of wood smoke emissions in NSW is largely managed by local government because wood smoke is mostly a localised problem (EPA, 2012). Notwithstanding, both the NSW Government and local governments have implemented regulatory measures, local planning controls, financial incentive programs and education programs for wood heaters and wood smoke (DECCW, 2010).

These policies, programs and regulations include:

- preventing the sale of new wood heaters that are not certified under the *Australian Standard, AS/NZS 4013:1999 – Domestic solid fuel burning appliances (AS/NZS 1999);*
- the use of local government planning instruments such as development control plans (DCPs) or local policies to prohibit the installation of new wood heaters or mandate stricter emissions standards on new wood heaters;
- promoting the correct use of wood heaters achieved through advertising and providing information to the community (including targeted education of households);
- periodic wood heater replacement programs;
- the use of smoke abatement notices under the *Protection of Environment Operations* (POEO) *Act 1997,* which are issued by local councils that require households to undertake smoke mitigation measures; and
- the inclusion of wood heaters in the *Building Sustainability Index* (BASIX).

The EPA administers the current regulatory framework for wood smoke control. They do so in conjunction with other Australian jurisdictions and the Commonwealth to improve standards for heating appliances (EPA, 2012).

3.3.2 Consultation with councils, community and industry

The EPA in November 2012 undertook consultation with local councils, community and industry regarding the current wood smoke controls in place in NSW, the proposed additional controls and the methods for implementing them. A discussion paper, *Options for Wood Smoke Control in New South Wales*, was produced and distributed to stakeholders. This paper outlined the following six potential options for wood smoke control:

- **Option 1**: Permitting the installation of only low-emission, high-efficiency wood heaters in designated areas – wood heaters would have maximum emissions of no more than 2–3 grams of particles for each kilogram of wood burnt and operate at a minimum efficiency standard of 65–70 per cent.
- **Option 2**: Removal of open fireplaces by the owners of dwellings in designated areas before the sale of the property – this would require owners to either block out fireplaces, rendering them inoperable, or convert the space for gas or electric heating.
- **Option 3**: Removal of older or high-emission wood heaters in designated areas before the sale of dwellings.
- **Option 4**: Disallow the installation of open fireplaces in designated areas.
- **Option 5**: Disallow the installation of wood heaters in designated areas.
- **Option 6**: Disallow all new installations of solid fuel combustion heaters, such as wood heaters and open fireplaces, within the LGA.

The results of the consultation indicated the strongest support for the following wood smoke control options:

- the introduction of low emission and high efficiency wood heaters;
- removal of older or high emission heaters; and
- disallow installations of open fireplaces.

Approximately 38 per cent of councils that responded to the EPA survey supported disallowing open fireplace installation, 51 per cent supported requiring low emission wood heaters in designated areas, and 43 per cent supported disallowing wood heaters in designated areas.

4.0 Wood smoke control options under consideration

The following regulatory options have been modelled for the purposes of this evaluation:

Option 1: 'Do-Nothing' Base Case – This is based on the status quo of current regulation, i.e. business as usual.

- **Option 2**: Implementation of proposed new standards:
  - **Tier 1 (2015)**: 2.5g/kg of particulate emissions and 55 per cent efficiency wood heaters;
  - **Tier 2 (2019)**: 1.5g/kg of particulate emissions and 60 per cent efficiency wood heaters.
- **Option 2A:** Implementation of proposed new standards:
  - **Tier 1 (2015)**: 2.5g/kg of particulate emissions and 55 per cent efficiency wood heaters;
  - **Tier 2 (2019)**: 1.5g/kg of particulate emissions and 60 per cent efficiency wood heaters;

  Plus the option of voluntary adoption by individual councils of:
  - **Part 1:** No new wood heaters in designated areas;
  - **Part 2:** No new open fire places in designated areas; and
  - **Part 3**: New wood heaters must comply with minimum efficiency of 60 per cent emission factor of 1.5 g/kg for non-catalytic and 0.8g/kg for catalytic heaters within 12 months of the Regulation commencement.
- **Option 3:** No regulation and rely on voluntary industry compliance or a national fine particle emission and efficiency standard for wood heaters.

More details on each of the options are provided in the following sections.

4.1 Option 1 – 'Do-Nothing' Base Case/Current Regulation (Status Quo)

Option 1 assumes that there is no change to the current wood smoke control measures in NSW. The measures in the current regulation (business as usual option) include:

- preventing the sale of new wood heaters that do not comply with emission standards in Australian Standard 4013 (Protection of the Environment Operations (Clean Air) Regulation 2010, Part 2);
- the use of local government planning instruments such as development control plans to place controls on installation, either through installation restrictions (for example, by Camden Council in some new release areas), or by ensuring that wood heaters are installed correctly;
- promoting the correct use of wood heaters achieved through advertising and providing information to the community, including targeted households;
- periodic wood heater replacement programs; and
- the use of smoke abatement notices under the POEO Act issued by local councils to require that smoke mitigation measures be taken by a particular household.

It is acknowledged that there are currently five councils in NSW implementing some form of wood smoke control. Any reduction in emissions attributable to these council controls are expected to be minor and, for the purpose of this study, have been assumed to already exist under the emission projections in Option 1.

Option 1 does not include the adoption of new standards and has been used as the Base Case for comparing the effect of the other wood smoke control measures.

This scenario includes a natural trend for wood smoke reduction as users replace older heaters with new heater models that have higher levels of heating efficiency and lower emissions. This option is expected to bring about a natural reduction in wood heaters and a natural reduction in pollution emission over the evaluation period.

4.2 Option 2 – New Regulation

Option 2 proposes the incorporation of more stringent limits for wood heater emissions and new efficiency limits in the updated Australian/New Zealand Standards. The updated Australian Standards would introduce a staged approach to setting efficiency and emissions limits for new solid fuel heaters:

- 55 per cent efficiency and 2.5 grams of particle emissions per kilogram of fuel burnt (g/kg) within twelve months after the standards are published; and
- 60 per cent efficiency and 1.5 g/kg within five years after publishing.

These controls would apply to all councils in NSW.

Option 2 is expected to bring about a reduction in pollution emission over and above the natural reduction in Option 1. It has been assumed that the new regulation will not affect the sale of wood heaters or open fireplaces.

4.3 Option 2A – Proposed new schedule / regulation amendment

Option 2A assumes the incorporation of more stringent limits for wood heater emissions and new efficiency limits as in Option 2:

- 55 per cent efficiency and 2.5 g/kg within twelve months after the standards are published; and
- 60 per cent efficiency and 1.5 g/kg within five years after publishing.

In addition, Option 2A proposes the introduction of a new schedule within the Clean Air Regulation (similar to the control of burning in the open) that lists additional controls which councils can choose to implement. These controls could apply to either the entire LGA or specific designated areas within the LGA, such as high density neighbourhoods, new development precincts or localities that are likely to be affected by wood smoke because of their topography. Councils would have the option of choosing one or more control options in their LGA. The additional controls include: disallowing installation of new open fire places in designated areas, disallowing installation of new wood heaters in designated areas and allowing installation of low emission wood heaters only in designated areas.

The CBA of Option 2A assesses (above and beyond Option 2) the implementation of three different combinations of implementation options:

- **Part 1:** No new wood heaters in designated areas;
- **Part 2:** No new open fire places in designated areas; and
- **Part 3**: New wood heaters must comply with Clause 9.1.1(b) of AS/NZS 4012 (minimum efficiency of 60 per cent) and Clause 7.7.1(b) and 7.1.1.2(b) of AS/NZS 4013 (emission factor of 1.5 g/kg for non-catalytic and 0.8g/kg for catalytic heaters) within 12 months of the Regulation commencement.

Part 1 of Option 2A provides councils with the ability to control installation of all wood heaters in designated areas. Part 2 controls only the installation of new open fire places in designated areas.

On the basis that the updated Australian/New Zealand Standards are implemented as per their specified schedule, Part 3 of Option 2A provides the ability for councils to bring forward the implementation of the updated set of standards by four years within the designated areas.

Option 2A is expected to bring a reduction in pollution emission over and above the reduction realised under Options 1 and 2.

4.3.1 Option uptake analysis

Option 2A allows the councils to determine whether they wish to implement the controls available under Option 2A. Therefore, an assumption was made of the likely uptake of the Option. This was based on councils' responses during public consultation as detailed in Section 3.3.2. A summary of councils' responses shows that approximately 38 per cent of councils support disallowing open fire installation, 51 per cent support requiring low emission wood heaters in designated areas, and 43 per cent support disallowing wood heaters in new release areas.

Table 6 Summary of council's response

Council response	Disallow open fire installation	Low emission WH in designated areas	Disallow WH installation in new release area
Yes	14	19	16
No	13	9	12
Unknown/Unsure	6	6	6
Nil/NA	4	3	3
Proportion of Yes	**38%**	**51%**	**43%**

Source: Based on results of NSW Local Government wood smoke survey undertaken by EPA, 2011

For councils that provided a 'Yes' response, their population and wood heater ownership represent around 39 per cent and 24.1 per cent of the NSW totals respectively. These proportions are used to estimate the impact on wood heaters stock and sales, as shown in Table 7.

Table 7 Number of heaters affected

Proposed measure	2016	2021	2026	2031
Reduction in wood heater stock				
Part 1 - Disallow open fire installation	5,126	5,188	5,217	5,224
Part 2 - Disallow WH installation in new release area	63,612	64,347	64,212	63,717
Part 3 - Low emission WH in designated areas	69,419	69,434	69,359	68,993
Reduction in wood heater sales				
Part 1 - Disallow open fire installation	162	188	217	251
Part 2 - Disallow WH installation in new release area	2,014	2,330	2,672	3,064
Part 3 - Low emission WH in designated areas	2,198	2,514	2,887	3,317

Source: AECOM estimates, based on results of NSW Local Government wood smoke survey undertaken by EPA, 2011

Assuming councils which responded 'Yes' adopt the new schedules:

- The sale and installation of new fireplaces across NSW will reduce by 1.3 per cent.
- The sale and installation of new wood heaters across NSW will reduce by 16.6 per cent.
- 18.4 per cent of new heaters in NSW will need to comply with tighter efficiency standards of 60 per cent efficiency and 1.5 g/kg by 2015.

4.4 Option 3 - No Regulation (voluntary industry compliance)

Under Option 3, New South Wales would remove the regulatory basis for controlling the sales of new wood heaters. Councils would be able to use their planning instruments to control the installation of new wood heaters and open fire places in designated areas. However, the control of wood smoke would need to rely mostly on voluntary industry compliance with the Australian standards on energy and emission efficiency limits, to be introduced under the following stages:

- 55 per cent efficiency and 2.5 g/kg within twelve months after the standards are published (2015); and
- 60 per cent efficiency and 1.5 g/kg within five years after publishing (2019).

Reliance on voluntary compliance can be reasonably effective given that various members of the industry (including the Australian Home Heating Association (AHHA)) have indicated their agreement to comply with the new standards. Some existing models of wood heaters supplied by Australian manufacturers have already met or are expected to meet these standards.

It is, however, likely that voluntary compliance would not result in full compliance by the entire industry. In general, not all suppliers and manufacturers have commercial incentives for voluntary compliance, for example, producers

and importers of low cost and/or export models. The extent of voluntary compliance would further reduce if some parts of the industry do not participate in the voluntary certification scheme.

Assuming that the existing level of compliance provides an indication of the likely level of voluntary compliance to the updated standards, AECOM collated the efficiency levels of the heater models listed on the Australian Home Heating Association website in Table 8.

Table 8 Measures of heating efficiency

Heating Efficiency [1]	Particulate Matter Emission				Total
	PM > 2.5g	1.5g < PM < 2.5g	PM < 1.5g	Unknown	
X<55	16	11	7	0	34
55<X<60	40	35	10	0	85
X> 60	79	83	44	0	206
Unknown	47	46	10	49	152
Total	**182**	**175**	**71**	**49**	**477**

Source: Australian Home Heating Association website (no date)

(1) X denotes heating efficiency

The data in Table 8 indicate that 53 per cent of existing models would comply with the requirements for 55 per cent heating efficiency and 2.5g/kg emission ("Tier 1"); and 14 per cent with the requirements for 60 per cent heating efficiency and 1.5g/kg emission ("Tier 2"), after adjustment for the unknown data.

A survey of wood heater manufacturers conducted by Walter Turnbull (2009) provides information on the design profile of wood heaters sold in Australia in 2007-08. The results suggest an average design emission level of around 2.6 grams per kilogram and an average design efficiency of 59.6 per cent.

In practice, wood heater efficiencies and performance may differ from their design performance because the wood heater sold may differ from the model tested in a laboratory or the wood heater may have been modified. DEH (2004b) found that 58 per cent (7 out of 12) of wood heaters failed to meet AS/NZ 4013 particle emission limits. This results in a compliance level of 42 per cent.

A study undertaken by CSIRO (2005) study found that the emission rate determined by the AS/NZ 4013 compliance test does not give a good indication of the real world performance of domestic wood heaters installed in houses (mainly because of poor wood heater operation practices), probably underestimating it by at least a factor of 2.

Given that the proposed control measures would involve setting and monitoring compliance with updated design standards, and not heaters' performance in real life situations, the predicted level of compliance is measured with respect to design standards. It has been assumed that, as design compliance increases, there will be a corresponding increase in actual heater performance efficiency. The overall compliance level should be higher for Option 2 as the standards will be enforced in a number of designated areas.

Consultation undertaken with the AHHA indicated that the Association has initiated actions to introduce the updated efficiency standards. Under a voluntary compliance arrangement, the compliance level amongst the AHHA members (representing 70 per cent of the industry) is expected to be very high for both tiers 1 and 2. In contrast, compliance amongst non-AHHA suppliers is expected to be low. This suggests that the level of voluntary compliance with the updated standards would be around 70 per cent following their implementation.

5.0 Cost benefit analysis of options

5.1 Introduction

This chapter presents the results of the CBA in accordance with *NSW Treasury Guidelines for Economic Appraisal TPP 07-5* (NSW Treasury, 2007).

The general assumptions which underlie the CBA include:

- **Evaluation period**: A 20 year evaluation period had been used for this appraisal from FY2015 to FY2034.
- **Base year**: The evaluation has used the financial year 2014/15 as the base year for this appraisal. All costs and benefits have been discounted to arrive at a present value for FY2014/15.
- **Unit of account / price year**: The CBA was undertaken in real terms (that is, excluding inflation). All benefits and costs are expressed in constant FY2014/15 prices.
- **Discount rates**: A real discount rate of 7 per cent per annum was applied in the economic and financial analysis, consistent with NSW Treasury guidelines. Sensitivity tests were undertaken at real discount rates of 4 per cent and 10 per cent per annum.

5.2 Option costs

5.2.1 Capital costs

The implementation of the options does not require capital expenditure. Therefore, capital costs were not included in the evaluation.

5.2.2 Recurrent costs

The following recurrent costs have been identified for the evaluation options:

- Scheme implementation costs (once-off);
- Costs associated with administration and enforcement of regulations; and
- Costs associated with the public education program.

Scheme implementation costs

Scheme implementation costs are incurred only once when establishing the policy, regulation or legislation. The introduction of a regulation will be necessary as well as the establishment of relevant standards, registration procedures and/or compliance process. These costs are assumed to be around $60,000 and only apply to Option 2 and Option 2A.

Administration and enforcement costs

Administrative costs include the ongoing cost mainly to local government to manage and enforce the policy, regulation or program. These costs are assumed to average around $80,000 per annum for Option 2, allowing for an increasing number of participating councils over the years.

Public education costs

Public education costs are incurred under all evaluation options, including Option 1 'Do-Nothing' Base Case. Public education costs are assumed to be around $30,000 per annum under Options 1, 2 and 3. The focus of the public education campaign is likely to change under Option 2A and is assumed to be around $70,000 per annum.

5.3 Option benefits

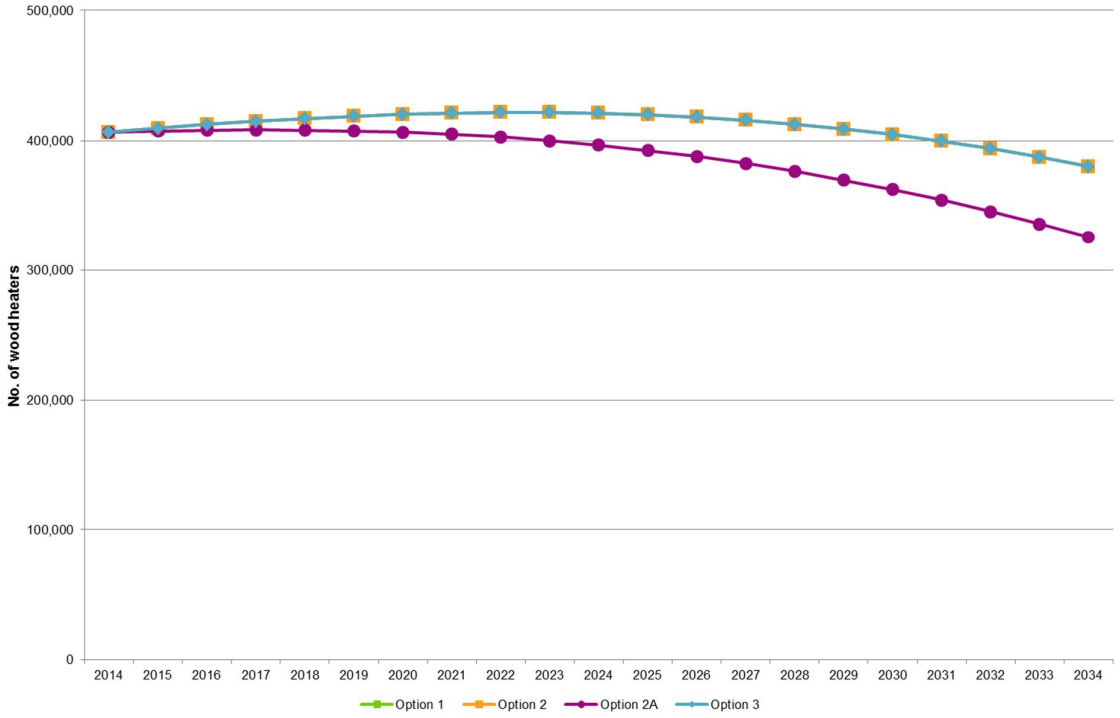
5.3.1 Projections of wood heater stocks and emissions

The impacts of wood smoke pollution strongly depend on the projected size of wood heater stocks in NSW and their associated emissions. These projections vary across the options analysed:

- Option 1 assumes a natural reduction in wood heaters and associated emissions as consumers move to new heater models that have higher levels of heating efficiency and lower emissions.
- Option 2 assumes no reduction in wood heaters above and beyond the natural decline anticipated under Option 1. Emission pollution is expected to decrease due to the increased efficiency and improved performance of new wood heaters across NSW compared to Option 1.
- Option 2A assumes a decline in the future stocks of wood heaters compared to Option 1 due to the control on installation of wood heaters in designated areas. Emission pollution is expected to decrease due to:
    - The decline in future stock of wood heaters;
    - The increased efficiency and improved performance of new wood heaters across NSW above and beyond Option 1; and
    - The increased efficiency and improved performance of new wood heaters in designated areas above and beyond Option 2.
- Option 3 assumes no reduction in wood heaters above and beyond the natural decline anticipated under Option 1. Emission pollution is expected to decrease as industry voluntarily adopts the new standards.

Projections of the stock of wood heaters and particulate matter emissions in NSW under Options 1 to 3 are shown in Figure 5 and Figure 6 respectively.

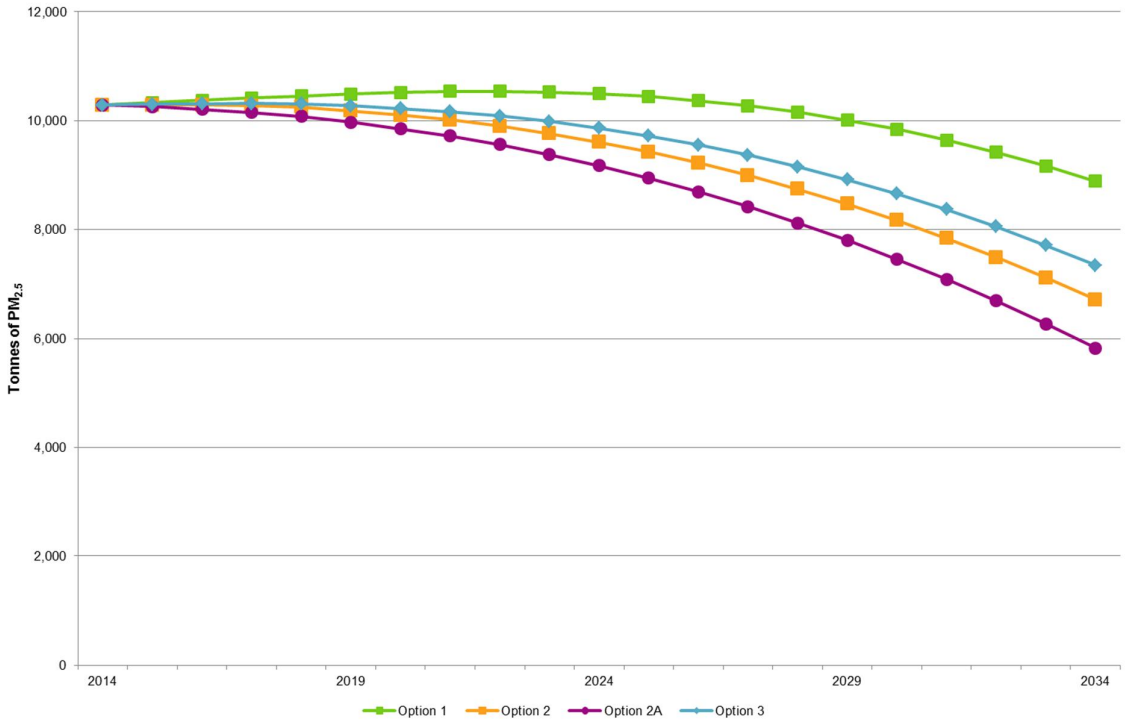
Figure 5 Projected stock of wood heaters



Source: AECOM, 2014

Note: The projected stock of wood heaters under Options 1, 2 and 3 are identical and are therefore represented under the single blue, orange and green line on the above graph.

Figure 6 Projected $PM_{2.5}$ emissions from wood heaters



Source: AECOM, 2014

5.3.2 Benefits of avoided health costs

5.3.2.1 Health impacts of wood smoke emission

The contribution of wood smoke to total annual pollutant emissions in the NSW Greater Metropolitan Region (GMR) and the Sydney region is highlighted in Table 9 (DECCW, 2010).

Table 9 Contribution of wood smoke to annual pollutant emissions

Air pollutant	NSW GMR (%)	Sydney region (%)
Carbon monoxide (CO)	3	5
Nitrogen oxide	0.16	0.39
Particulate Matter		
Particulate matter ≤ 10 microns (PM_{10})	7	19
Particulate matter ≤ 2.5 microns ($PM_{2.5}$)	13	29
VOCs (air toxics)		
1,3-butadiene	6	8
Benzene	17	18
Formaldehyde	36	36
Isomers of xylene	1	1
Polycyclic aromatic hydrocarbons (PAHs)	17	19
Toluene	2	2

Source: DECCW, 2010

Wood smoke contains particulate matter (PM_{10} and $PM_{2.5}$), toxic volatile organic compounds (VOCs), carbon monoxide and nitrogen oxides. A number of studies have been conducted on the correlation (relationship) between morbidity and mortality, and exposure to these substances.

Particulates

Particulates are a broad class of chemically and physically diverse substances and are derived from natural sources (dusts from soil, pollens and fungi, sea salt, forest fires) as well as anthropogenic sources (combustion of fossil fuels from both stationary and mobile sources, biomass burning and industry) (Coffey, 2003).

The health effects of PM_{10} and $PM_{2.5}$ include:

- increased mortality, particularly respiratory and cardiovascular diseases;
- inflammation of lungs;
- increased respiratory illness (e.g., bronchitis, asthma) and symptoms (e.g. cough);
- adverse effects on cardiovascular system; and
- increased medication use and hospitalisation.

While the number of people susceptible to hospitalisation due to acute PM exposure is probably small, the number of people susceptible to less serious health effects such as increased respiratory symptoms, decreased lung function, or other physiologic changes may be large (Pope, 2000).

Volatile Organic Compounds

Wood smoke also contains a range of VOCs that can be hazardous for human health. VOCs such as Benzene, Formaldehyde and Polycyclic Aromatic Hydrocarbons (PAHs) can be released into the air from the combustion of wood. Some of these VOCs such as Benzene have been classified by the US EPA as a known human carcinogen (cancer causing) and the PAHs as a probable human carcinogen (US EPA IRIS, 2011).

Carbon Monoxide

Carbon Monoxide (CO) is a clear, odourless gas that reduces the blood's capacity to carry oxygen to tissues in the body. CO impairs perception and judgment at low levels, with effects increasing to include drowsiness or

headaches and general discomfort as levels rise, leading ultimately to convulsions and coma at high concentrations (Coffey, 2003).

5.3.2.2 Benefits of avoided health costs

Air pollution released by the burning of wood in wood heaters has been shown to impact on human health. These health impacts can be converted into health costs through a willingness-to-pay (WTP) assessment or human capital assessment. These two assessments determine an economic cost for a particular health impact which can be used to determine the cost of the health impact or the benefit of avoided health cost.

A meta-analysis of cohort-based long-term United States studies by Kunzli et al in 2000 derived a series of exposure-response functions for a range of air pollutants and health outcomes. An exposure-response function provides an estimate of the increase in risk of a health outcome with an incremental increase in exposure to a particular air pollutant. For example, the exposure-response function for mortality associated with PM_{10} was calculated to be a 4.3 per cent increase in mortality for each 10 $\mu g/m^3$ increase in exposure to PM_{10}.

These exposure-response functions were used by the Bureau of Transport and Regional Economics (BTRE) to calculate the health cost and environmental effects of ambient concentrations of air pollution. The analysis, conducted using 2000 data, estimated the impacts attributable to air pollutants (BTRE, 2005). This study estimated that, in 2000, motor vehicle particulate pollution accounted for between 900 and 4500 morbidity cases - cardio-vascular disease, respiratory disease, and bronchitis - and for between 900 and 2000 early deaths. The range of estimates is a result of the range of exposure-response functions developed by Kunzli et al. BTRE also used a WTP economic assessment to calculate the value of human health.

A CBA on transport fuel quality and vehicle standards conducted for the MVEC Review of Vehicle Emissions and Fuels Standards Post 2006 used exposure-response functions based on a review of Australian and international epidemiological studies to measure the health improvements associated with four options for vehicle emissions and fuel quality standards in Australia (Coffey, 2003). The exposure-response functions used in the CBA by Coffey included the functions developed by Kunzli et al (2000). The CBA adopted a range of cost estimates for health impacts, primarily relying on WTP studies from Australia and abroad.

Beer (2002) also undertook an assessment of pollutants based on published assessments of Australian health impacts from air pollutants. A separate assessment by the BDA Group (2006) used health costs per tonne based on data supplied by the Australian Department of the Environment and Heritage. The data provided health costs per tonne of PM_{10} by capital city.

The Australian Department of Infrastructure, Transport Regional Development and Local Government (DITRDLG) undertook an assessment of the health costs conducted to date including Beer (2002), BTRE (2005) and Coffey (2003). The results of the assessment were presented as health costs adjusted for 2010 in the *Draft Regulatory Impact Statement for the Review of Euro 5/6 Light Vehicle Emissions Standards* (DITRDLG, 2009). DITRDLG accounted for the fact that the scale of the impact depends on the area where the air pollutant is present with greater health impacts seen in more populated centres such as capital cities.

The US EPA released an approximate health cost for $PM_{2.5}$ (US EPA, 2010) which has been included in this assessment. The range of health cost assessments are summarised in Table 10.

Table 10 Health costs by air pollutant type

Air Pollution Studies		VOCs	PM_{10}
		$/tonne	$/tonne
DITRDLG, 2010	Rural	105	55,825
	Capital City	8,830	235,260
Beer, 2002	Lower	11,700	108,300
	Best	19,331	147,429
	Upper	72,500	221,100
Coffey, 2003	Capital City	2,200	232,000
BDA, 2006	Sydney	N/A	133,543

Sources: DITRDLG, 2010; Beer, 2002; BDA Group, 2006 and Coffey, 2003, US EPA 2010

PAE Holmes (2013) provides an estimate of the unit (health) damage costs by significant urban area (SUA) in NSW. A summary of these damage costs is provided in Table 11 below.

Table 11 Total health costs and avoided health costs from BAU (PV $ million)

SUA code	SUA name	Area (km^2)	Population	Population density (people/km2)	Damage cost/tonne of $PM_{2.5}$ (A$)
1030	Sydney	4064	4,028,525	991	$280,000
1009	Central Coast	566	304,755	538	$150,000
1035	Wollongong	572	268,944	470	$130,000
1027	Port Macquarie	96	41,722	433	$120,000
1013	Forster - Tuncurry	50	19,501	394	$110,000
1023	Newcastle - Maitland	1019	398,770	391	$110,000
1014	Goulburn	65	21,485	332	$93,000
1003	Ballina	73	23,511	320	$90,000
1018	Lismore	89	28,285	319	$89,000
1016	Griffith	56	17,900	317	$89,000
1033	Ulladulla	47	14,148	303	$85,000
1010	Cessnock	69	20,262	294	$82,000
1034	Wagga Wagga	192	52,043	272	$76,000
1025	Orange	145	36,467	252	$71,000
1022	Nelson Bay - Corlette	116	25,072	217	$61,000
1012	Dubbo	183	33,997	186	$52,000
1017	Kurri Kurri - Weston	91	16,198	179	$50,000
1015	Grafton	106	18,360	173	$48,000
1004	Batemans Bay	94	15,732	167	$47,000
1024	Nowra - Bomaderry	202	33,340	165	$46,000
1029	St Georges Basin - Sanctuary Point	77	12,610	164	$46,000
1031	Tamworth	241	38,736	161	$45,000
1005	Bathurst	213	32,480	152	$43,000
1032	Taree	187	25,421	136	$38,000
1001	Albury - Wodonga	628	82,083	131	$37,000
1011	Coffs Harbour	506	64,242	127	$36,000
1028	Singleton	127	16,133	127	$36,000
1007	Broken Hill	170	18,519	109	$30,000
1019	Lithgow	120	12,251	102	$29,000
1006	Bowral - Mittagong	422	34,861	83	$23,000
1002	Armidale	275	22,469	82	$23,000
1020	Morisset - Cooranbong	341	21,775	64	$18,000
1026	Parkes	235	10,939	47	$13,000
1021	Muswellbrook	262	11,791	45	$13,000
1008	Camden Haven	525	15,739	30	$8,400

Source: PAE Holmes (2013)

Note: The absolute health costs refer to the amount of health costs incurred across NSW as a result of the composition of the wood smoke. The total health costs are the PV of the health costs for BAU and each option. The avoided health costs are the benefits of each option and are calculated as the difference between the total health costs in each option and the health costs under BAU.

The estimates provided in Table 11 are consistent with AECOM's (2011) approach of adjusting the health cost by population density. PAE Holmes (2013) has estimated an average cost per tonne of $PM_{2.5}$ to be $190,000 across NSW. This value was adopted for this assessment.

The benefits of avoided health costs were calculated based on the valuation of the reduced emissions from each control option as presented above. These estimates are shown in Table 12.

Table 12 Benefits of avoided health costs incremental to Option 1 Base Case

Options	PV ($'000) [(a)]
Option 2	1,557,760
Option 2A	2,307,894
Option 3	1,101,712

Source: AECOM, 2014
Note: (a) Discounted to 2014 at a real discount rate of 7 per cent.

It is noted the majority of the health benefit arises from the implementation of efficiency and emission standards. Compared to corresponding estimates in AECOM's 2011 study, the estimated benefits have increased due to the use of the higher estimate of $PM_{2.5}$ unit damage cost calculated by PAE Holmes.

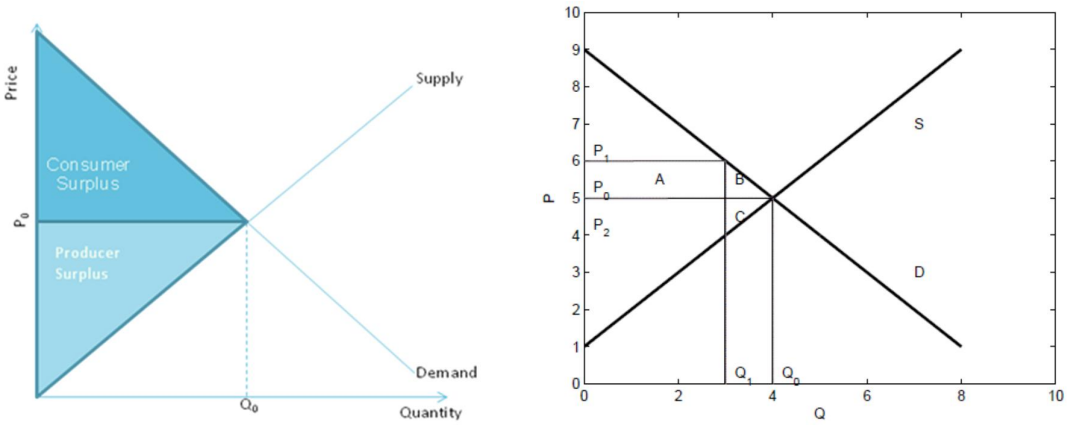
5.3.3 Impact on consumers

The consumer surplus for a customer in a market is the difference in the amount that a customer would be willing to pay for a good or service (i.e. new wood heater) and the price that they actually pay (ACMA, 2009). This is graphically represented as the dark blue area in the chart on the left of Figure 7.

The amount that a customer is willing to pay is that customer's 'walk-away' valuation of the good or service, that is, the price beyond which they will no longer be willing even to negotiate. Another term for 'willingness to pay' is reservation price. This value or 'price' is information privately held by the customer and not revealed to a seller. The price actually paid by a customer is equal to or lower than a customer's reservation price and the larger the gap between the two, the greater the feeling the customer has of having received a 'bargain'. The size of the gap (the consumer surplus) is consequently a measure of a customer's relative 'happiness' or 'benefit' arising out of the transaction. The consumer surplus for a whole market is derived by adding the consumer surpluses of all customers.

The assessment of the net public benefit flowing from the control measures will include their impact on the consumer surplus. Figure 7 shows the loss of consumer surplus as a result of ban on sales or replacement of new wood heaters (e.g. in designated areas).

Figure 7 Consumer Impact of Sale Ban on Wood Heaters



Source: AECOM, 2014

Control or ban of heater sales or replacement will shift the supply curve to the left leading to a reduction in the quantity of wood heaters demanded. The reduction is shown in the chart on the right hand side of Figure 7, as follows:

- Consumer surplus is measured by the area below the demand curve and above the price; and
- As the supply quantity is reduced from Q_0 to Q_1, the consumer surplus area becomes smaller (i.e. by the sum of areas A and B).

The amount of consumer surplus loss is dependent on the extent of the sale control and the elasticity of demand by users. The reduction in consumer surplus generally appears as reduction in the value that people gain from the consumption of goods and services. In this case, less people would be able to purchase wood heaters and experience the private benefits of relatively cheap heating and aesthetics.

Consumer surplus will be altered with a change in price or with a change in a non-price characteristic (such as quality or delivery time) of a good or service. The differences between a change in price and a change in a non-price characteristic have implications for the process for measuring the impact on consumer surplus.

Assuming that the average cost of a wood heater is around $1,200 and price elasticity of demand for wood heaters is 0.5 (which indicates inelastic demand), the loss of consumer surplus per restricted sale is equal to $1,200 (i.e. users lose the benefit of low cost heating or aesthetic enjoyment, etc.).

Options 1, 2 and 3 do not reduce the sale of open fireplaces or wood heaters and therefore will not impact on consumer surplus. A reduction in consumer surplus is expected to occur under Option 2A due to the ban on wood heaters and open fireplaces in designated council areas.

The net loss of consumer surplus for Option 2A is estimated to be approximately $2.1 million per annum in undiscounted terms.

5.3.4 Impact on profitability

Industry impacts can be assessed in terms of number of employees affected or loss of profitability for the industry. An assessment of the number of employees affected may exaggerate the impacts because the industry and its employees are expected to shift their resources to other productive sectors. This evaluation used loss of profit as the measurement of impact, assuming that current utilisation of capital and labour resources achieves higher margin and productivity respectively in the industry than they would if required to move to other sectors.

Options 1, 2 and 3 do not reduce the sale of open fireplaces or wood heaters and therefore will not impact profitability. A reduction in industry profitability is expected to occur under Option 2A due to the ban on wood heaters and open fireplaces in designated council areas.

The net loss of industry profitability under Option 2A is estimated to be approximately $620,000 per annum in undiscounted terms.

5.4 Summary of quantified costs and benefits

Table 13 summarises the quantified costs and benefits included in the CBA.

Table 13 Summary of quantified costs and benefits

Option	Option Costs	Option Benefits
Option 1 Do-Nothing Base Case	Public education costs of $30,000 per annum (undiscounted).	No change in economic benefits.
Option 2	Scheme Implementation costs of $60,000 in the first year of the scheme (2015) (undiscounted). Administration and enforcement costs of $80,000 per annum (undiscounted). Public education costs of $30,000 per annum (undiscounted).	Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 3.6% and emission efficiency of 16.4% (relating to 100% compliance across NSW) between 2015 and 2019, increasing to heating efficiency of 5.6% and emission efficiency of 28.6% (relating to 100% compliance across NSW) for 2019 onwards. No reduction in heater sales. No change in consumer surplus as there is no reduction in heater sales. No change in profitability applied as there is no reduction in heater sales.
Option 2A	Scheme Implementation costs of $60,000 (undiscounted) in the first year of the scheme (2015). Administration and enforcement costs of $80,000 per annum (undiscounted). Public education costs of $70,000 per annum (undiscounted).	Health benefits associated with $PM_{2.5}$ reduction from the reduction in new wood heaters of 16.6% and reduction in new open fireplaces of 1.3%, based on the proportion of sales in designated areas to total sales in NSW. Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 3.6% and emission efficiency of 16.4% (relating to 100% compliance across NSW) between 2015 and 2019, increasing to heating efficiency of 5.6% and emission efficiency of 28.6% (relating to 100% compliance across NSW) for 2019 onwards. Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 5.6% and emission efficiency of 28.6% (relating to LGAs that will adopt compliance for 2015 efficiency standards (Tier 2 brought forward)). Dis-benefit arising from the loss of consumer surplus of $2,062,000 per year (undiscounted) based on the proportion of the reduction in heater sales to total heater sales in NSW applied to the total NSW consumer surplus. Loss of profitability arising from reduced sales of $619,000 per year based on the proportion of the reduction in heater sales to total heater sales in NSW applied to the total NSW profit.
Option 3	Public education costs of $30,000 per annum (undiscounted).	Health benefits associated with $PM_{2.5}$ reduction from increased heating efficiency of 2.5% and emission efficiency of 11.5% (relating to 70% compliance across NSW) between 2015 and 2019, increasing to heating efficiency of 3.9% and emission efficiency of 20.0% (relating to 70% compliance across NSW) for 2019 onwards.

Source: AECOM, 2014

5.5 Unquantified costs and benefits

The following costs and benefits were not quantified in the evaluation but have been assessed qualitatively in the following sections:

- Costs to industry;
- Benefit of increased amenity;
- Benefit of reduction in fuel use;
- Benefit of reduction in Greenhouse Gas; and
- Benefit of reduction in Volatile Organic Compounds.

5.5.1 Costs to industry

The CRIS (NEPC, 2013) estimated that the Australian industry will incur heater model development costs of around $17 million to meet an efficiency standard of 60 per cent as well as an emission limit of 1.5 g/kg, if this is to be implemented five years after publishing.

This cost relates to the development of the Australian standards and not to the specific implementation of these standards to NSW. It will be incurred in all options and therefore has been omitted from the cost-benefit analysis.

It is assumed that the industry would be capable of supplying the required products if tighter standards are brought forward by four years in a number of designated areas in NSW under Option 2A.

The wood smoke control options are unlikely to have a significant impact on the sales volumes of the wood heater industry.

5.5.2 Benefit of increased amenity

A reduction in domestic wood smoke has positive amenity benefits for local communities. Smoke from wood heaters and open fireplaces can be an environmental nuisance for neighbours, impacting visual amenity and air quality. Above and beyond the health impacts from wood smoke pollution, wood smoke can cause low visibility and odours that can be of annoyance to the local community.

5.5.3 Benefit of a reduction in fuel use

Increased efficiency and decreased wood heater sales has the potential to provide significant environmental benefits through the reduction in fuel use. Firewood collection is not only appears to be unsustainable in Australia, it also has a significant impact on the habitat and biodiversity of several species of flora and fauna (CSIRO Sustainable Ecosystems, 2000). A reduction in the harvesting and collection of firewood will reduce the environmental impact this industry has on the Australian ecosystem. It is beyond the scope of this CBA to assess and quantify the magnitude of this benefit and has therefore been excluded from the economic evaluation.

5.5.4 Benefit of reduced greenhouse gas emissions

The assessment of a reduction of GHG emissions was conducted for each option based on an assessment conducted by the US EPA (2006) and includes carbon dioxide (CO_2), methane and nitrous oxide (NO_2) expressed as tonnes of carbon dioxide equivalent ($CO_{2\text{-}e}$). These factors account for the emissions associated with the combustion of the wood fuel unlike the National Greenhouse Account factors that assume the combustion of wood is a neutral greenhouse gas emission activity. Table 14 presents the factors as presented by the US EPA (2006).

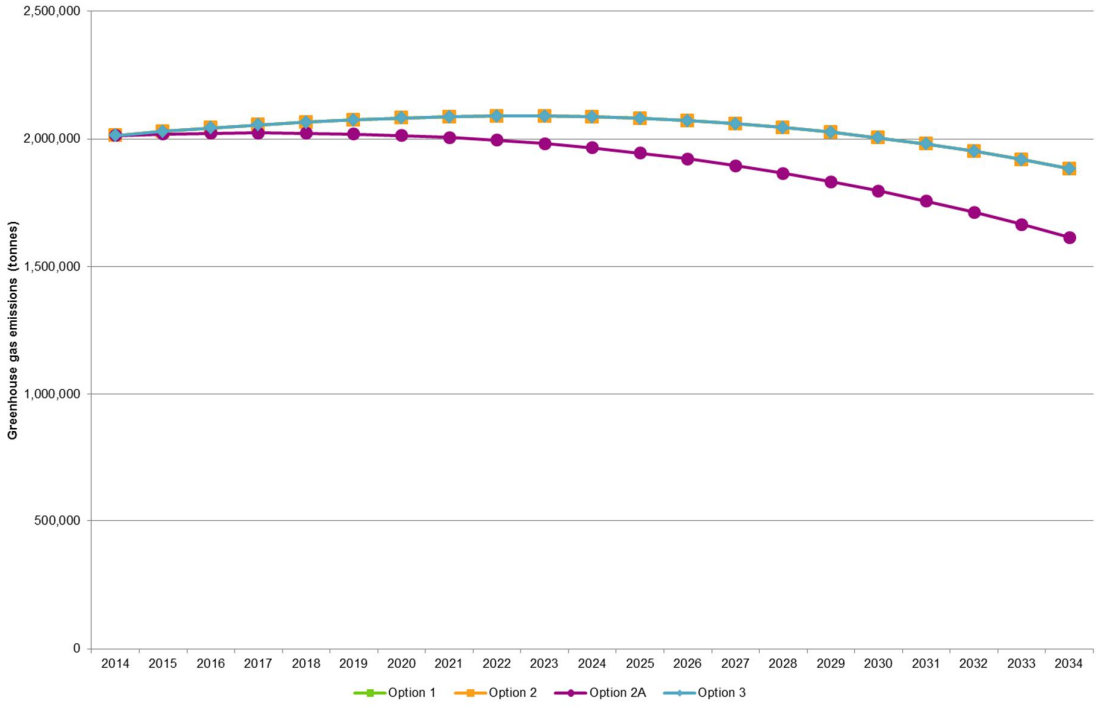
Table 14 Greenhouse Gas Emissions

	Carbon Dioxide (kg/t)	Methane (kg/t)	Methane-CO_2 Equivalent Factor	NO_2 (kg/t)	NO_2- CO_2 Equivalent Factor	GHG Emissions per year (t CO_{2-e} per heater)
Slow combustion heater with compliance plate	1387.7	14.20	21.00	0.15	310.00	5.03
Slow combustion heater without compliance plate	1146.1	32.00	21.00	0.15	310.00	5.40
An open fireplace	1357.8	7.20	21.00	0.15	310.00	3.13
Potbelly stove	1146.1	32.00	21.00	0.15	310.00	4.32

Source: US EPA, 2006

The direct greenhouse gas emission (GHG) reductions attributable to each option are presented in Figure 8.

Figure 8 Projected GHG emissions for wood heaters in NSW under the options



Source: AECOM, 2014

Note: The GHG reductions attributable to Options 1, 2 and 3 are identical and are therefore represented under the single blue, orange and green line on the above graph.

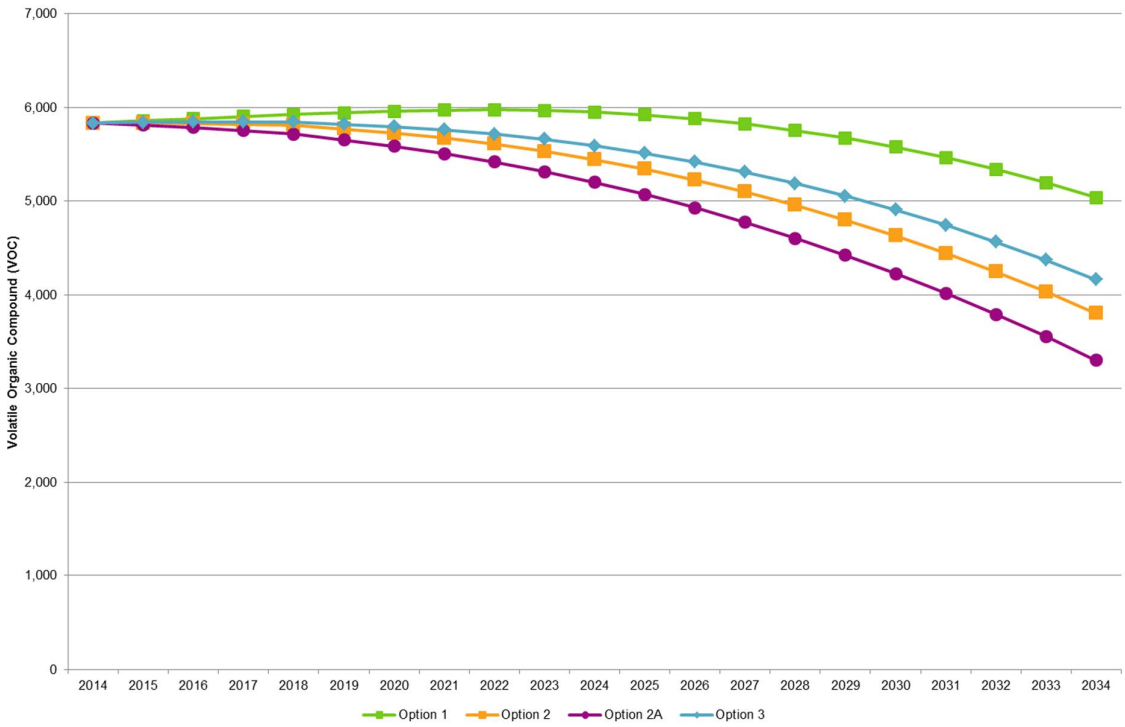
The GHG reduction attributable to each option is based on reduced wood fuel use. The GHG emissions associated with alternative heating systems has not been included as there is limited information on heating choices. The economic cost associated with GHG emission is relatively small, compared to the overall health cost of wood smoke, so it was not explicitly quantified in the CBA.

5.5.5 Benefit of reduction in volatile organic compounds

The impact of volatile organic compounds (VOCs) is presented in Section 4.3.1. The reduction in VOCs has been estimated under the options and is presented in Figure 9.

Due to lack of up-to-date available data on the health cost of VOCs in NSW, the calculation of the benefit from a reduction in VOCs under the project options has been excluded from the economic evaluation.

Figure 9 Projected Volatile Organic Compounds from wood heaters in NSW under the options



Source: AECOM, 2014

5.6 Cost benefit analysis results

The following criterion has been used to evaluate the options:

- **Net present value (NPV)** - NPV measures the difference in benefits and costs for each option (i.e. the net benefit), whilst accounting for their varying timing. Net cash flows are discounted at a specified discount rate, reflecting the concept that future benefits and costs have less value compared to current benefits and costs. A project with a NPV greater than zero means that the present value of benefits exceeds the present value of costs and is considered economically worthwhile.

The absence of capital expenditure for the evaluation options means that evaluation criteria such as benefit-cost ratio, net present value of investment and internal rate of return prescribed by NSW Treasury Guidelines are not appropriate for this study.

The estimated costs and benefits associated with the wood smoke control options are presented in Table 15. The evaluation was based on the 20-years period from 2015 to 2034 and a real discount rate of 7 per cent per annum. All costs and benefits are expressed in 2014 prices.

Table 15 Costs and benefits of wood smoke control options (PV, $'000, 2014 prices) [(a)]
Incremental to Option 1 (Do-Nothing Base Case)

Evaluation Results	Option 2	Option 2A	Option 3
Costs			
Capital costs [(b)]	0	0	0
Recurrent costs			
Scheme implementation (one-off)	56	56	0
Administration & enforcement of regulations	848	848	0
Public education program	0	402	0
Total costs	**904**	**1,306**	**0**
Benefits			
Health benefits associated with $PM_{2.5}$ reductions	1,557,760	2,307,894	1,101,712
Loss of consumer surplus	0	-21,842	0
Loss of profitability	0	-6,553	0
Total benefits	**1,557,760**	**2,279,499**	**1,101,712**
Net Present Value	**1,556,857**	**2,278,193**	**1,101,712**

Source: AECOM (2014)
Notes:
(a) Discounted to 2014 using a real discount rate of 7 per cent per annum.
(b) The implementation of the options does not require capital expenditure, so no capital costs were included.
(c) Totals may not sum due to rounding.

The results of the evaluation are presented in terms of incremental net present value (NPV), which measures the difference between discounted benefits and discounted costs for each option, incremental to Option 1 (the Do-Nothing Base Case). The option with the highest NPV is the economically preferred option when options are mutually exclusive and there is no capital expenditure (refer to NSW Treasury (2007)). Furthermore, the valuation of health benefits in present value (PV) terms makes NPV the most appropriate and comparable measure.

The evaluation results indicate that Option 2A has the highest NPV of around $2.3 billion, incremental to Option 1 (the Do-Nothing Base Case). Option 2 has the second highest NPV of around $1.6 billion, followed by Option 3 of around $1.1 billion.

The contribution of the council adoption of control measures to the NPV is represented by the difference between Option 2 and Option 2A of approximately $720 million.

The contribution of the control measures to the NPV of approximately $720 million for Option 2A,compared to Option 2, is split as follows:

- Part 1 (No new wood heaters in designated areas) and Part 2 (No new open fire places in designated areas) together with voluntary compliance to the updated standards contribute approximately $702 million; and
- Part 3, which involves bringing forward the updated standards in the designated areas of participating Councils, contributes approximately $18 million.

It is recognised that Option 3 might be a more realistic 'Do-Nothing' scenario than Option 1 as industry surveys indicate that 70 per cent industry compliance is an achievable result. When Option 2 and Option 2A are compared against Option 3 as a Base Case scenario, the results are as follows:

- Option 2 has a NPV of $455.0 million (over and above Option 3); and
- Option 2A has an NPV of $1.177 billion.

When Option 2 and Option 2A are compared against Option 3 as a Base Case scenario, the options remain viable as reflected in the positive NPVs and the ranking of the options does not change.

5.7 Sensitivity analysis

Sensitivity tests were undertaken to understand how the economic viability of each option varies with changes to key variables. The following tests were undertaken:

- Discount rate (4 per cent and 10 per cent); and
- $PM_{2.5}$ cost (20 per cent higher and 20 per cent lower).

5.7.1 Discount rates

The results of the CBA using the alternative real discount rates of 4 per cent and 10 per cent are shown in Table 16.

Table 16 Cost benefit analysis using 4% and 10% discount rate (NPV, $'000, 2014 prices)

	Incremental NPVs		
Sensitivity Test	**Option 2**	**Option 2A**	**Option 3**
Central Scenario (7% discount rate)	1,556,857	2,278,193	1,101,712
4% Discount Rate	2,273,614	3,307,027	1,609,255
10% Discount Rate	1,096,425	1,614,913	775,725

Source: AECOM, 2014

The use of different discount rates does not change the outcomes of the economic evaluation. Option 2A still has the largest NPV compared to Option 1, followed by Option 2 and Option 3.

5.7.2 Different values of $PM_{2.5}$ costs

The results of the CBA undertaken using different $PM_{2.5}$ costs is provided in Table 17 below.

Table 17 Cost benefit analysis using different $PM_{2.5}$ costs (NPV, $'000, 2014 prices)

	Incremental NPVs		
Sensitivity test – $PM_{2.5}$ costs	**Option 2**	**Option 2A**	**Option 3**
Central Scenario	1,556,857	2,278,193	1,101,712
$PM_{2.5}$ cost is 20% lower	1,245,305	1,816,615	881,369
$PM_{2.5}$ cost is 20% higher	1,868,409	2,739,772	1,322,054

Source: AECOM, 2014

The use of different $PM_{2.5}$ costs does not change the outcomes of the economic evaluation. Option 2A has the largest NPV compared to Option 1, followed by Option 2 and Option 3.

6.0 Review recommendation

The results of the economic evaluation indicated that Option 2A has the highest NPV of around $2.3 billion and the largest reduction in wood smoke emissions, compared to Option 1, making it the most viable of the options assessed.

As Option 2A includes the costs and benefits associated with the voluntary adoption of the new schedule by individual councils, this option includes elements that are beyond the control of the EPA. Option 2, however, represents the scenario under which Option 2A is implemented but assumes that the councils do not choose to adopt the new schedule. Option 2 maintains a positive NPV of $1.6 billion, demonstrating that the implementation of the new regulatory framework has a positive net benefit for NSW, with or without local government intervention.

The costs of implementing both Options 2 and 2A are the same, thus reducing the risk to the NSW Government should the councils decide not to implement the new schedule.

Option 2A retains the current arrangement of giving adequate regulatory powers to councils to control wood smoke as they cause serious local pollution and health problems. This, when combined with the introduction of the updated Australian/New Zealand efficiency and emission standards (August 2014), forms a targeted control approach to produce larger net public benefit.

It is recommended that Option 2A be selected as the preferred regulatory option, since a positive benefit can be achieved even if the councils do not adopt the new schedule.

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