NSW GOVERNMENT | Environment, Climate Change & Water

Regulatory Impact Statement

Proposed
Protection of the Environment Operations (Clean Air) Regulation 2010

Regulatory Impact Statement

Proposed
Protection of the Environment Operations (Clean Air) Regulation 2010

Submissions

The Department of Environment, Climate Change and Water welcomes written comments on the draft Regulation and Regulatory Impact Statement.

The closing date for submissions is **5 July 2010** and these should be mailed to:

> Clean Air Regulation review
> Manager, Air Policy Section
> Department of Environment, Climate Change and Water NSW
> PO Box A290
> Sydney South NSW 1232

or emailed to:

> CleanAirRegulationMailbox@environment.nsw.gov.au

This Regulatory Impact Statement is available on the Department of Environment, Climate Change and Water website at www.environment.nsw.gov.au/air/ca2010ris.htm

Published by:

Department of Environment, Climate Change and Water NSW
59 Goulburn Street, Sydney
PO Box A290, Sydney South 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (environment information and publications requests)
Phone: 1300 361 967 (national parks information and publications requests)
Fax: (02) 9995 5999
TTY: (02) 9211 4723
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

ISBN 978 1 74232 810 2
DECCW 2010/504
June 2010

Contents

Executive summary

Under the *Subordinate Legislation Act 1989*, the Protection of the Environment (Clean Air) Regulation 2002 ('the Clean Air Regulation') is due for repeal on 1 September 2010. It is proposed to remake the Regulation, with limited changes, as the Protection of the Environment (Clean Air) Regulation 2010 ('the proposed Regulation').

The proposed Regulation contains provisions for effectively and proportionally supporting the objectives and implementation of the *Protection of the Environment Operations Act 1997* ('the POEO Act') as it concerns air quality.

Clean air is fundamental to all people's health, with air pollution particularly affecting the health of children and older people. It also affects the natural environment and the liveability of communities. State Government community research has consistently found air quality to be a key environmental issue for New South Wales residents.

The management of air quality in NSW is an integrated whole-of-government approach, which uses a mix of regulatory and non-regulatory measures and is increasingly linked with efforts to reduce greenhouse emissions. The goal of the framework is to improve regional and local air quality by meeting the air quality standards set out in the National Environment Protection Measure for Ambient Air Quality and by reducing the population's exposure to air pollution.

The Clean Air Regulation is the key regulatory mechanism in NSW for reducing emissions of harmful pollutants to the air. It is also an important part of *Action for Air*, the NSW Government's comprehensive 25-year strategy to improve air quality in Sydney, the Illawarra and the Lower Hunter. Introduced in 1998 and most recently updated in 2009, the strategy covers the full array of sources that contribute to air pollution: from urban planning, roads and public transport, to cleaner vehicles and fuel, and industrial and household emissions. It is supported by a number of other linked strategies followed by those NSW Government agencies responsible for planning and development, transport, energy and health.

The Clean Air Regulation provides regulatory measures for a number of disparate air quality issues: residential emissions are controlled by targeting woodsmoke and backyard burning; emissions associated with motor vehicles are addressed through pollution control devices on cars and measures addressing evaporative fuel emissions; and industrial emissions are controlled mainly by setting maximum emission limits.

These regulatory measures target particulate matter, volatile organic compounds, oxides of nitrogen and a range of other pollutants.

Particulate matter

'Particulate matter' (or particles) is a term used to describe liquid or solid particles suspended in the air. These are visible as brown haze. Particles can be a primary pollutant directly from emissions or a secondary pollutant, resulting from chemical reactions of primary pollutants.

Human sources of particles arise as products of combustion and mechanical processes and include emissions from motor vehicles, woodheaters, power plants, industrial processes, and industrial and domestic incinerators. Natural sources, such as sea spray, bushfires and erosion, also contribute significantly to the levels of particles in the air.

Particles are easily inhaled and can be retained in, or absorbed through, a person's lungs. The health effects of particle exposure include increased mortality rates, cardiopulmonary disease and reduced lung function.

The health benefits of controlling emissions of fine particles (PM_{10}) may be quantified. However, there are also extensive unquantifiable benefits in continuing current controls. For the whole community, these include improved visual amenity and avoidance of damage to buildings, crops and other vegetation. For industry, benefits include a streamlined and transparent regulatory system which provides certainty for making compliance and investment decisions (including technological innovation), while for government there are efficiencies in pollution regulation.

The proposed Regulation will work to reduce particles through controls on domestic solid fuel heating, burning in the open or in incinerators, and industrial emissions. Secondary particle formation is also lessened through controls on volatile organic compounds (see below).

Domestic solid fuel heaters

In Sydney, more particle pollution is caused by woodsmoke during winter than any other source. On an annual basis, woodsmoke in Sydney contributes 19% and 29% of annual PM_{10} (fine particles) and $PM_{2.5}$ (very fine particles), respectively (from both natural and human sources). On a winter weekend day, PM_{10} and $PM_{2.5}$ from woodsmoke can be as high as 48% and 60%, respectively. In colder places, such as Armidale, woodheaters can contribute over 85% of winter particles. The level of emissions from woodheaters is controlled by preventing the sale of new heaters that do not comply with Australian Standard 4013.

Using health cost estimates for both rural areas and cities, the estimated net quantifiable benefits of reduced PM_{10} emissions from the proposed Regulation range from $3.55 million to $35.80 million per year. These health benefits can be expected to be maintained each year for the life of a heater (between 15 and 20 years). The largest population with woodheater controls is located in Sydney and other urban centres and, accordingly, the real benefit is likely to be towards the upper end of the range.

Control of burning

Controls on burning over the past three decades have reduced particle emissions in Sydney from 5000 tonnes per year to 5 tonnes per year: a reduction of 99.9%. Controls on burning have been one of the major causes of the decline in levels of particulate pollution in urban areas. Burning is controlled by local councils nominating the levels of control on burning considered appropriate for the region. To support these controls, councils provide domestic waste collection services and recycling facilities.

Using health cost estimates for both rural areas and cities, the estimated net quantifiable benefits of reduced PM_{10} emissions from the proposed Regulation range from $0.1 million to $1 million each year. As with controls on woodheaters, this is a residential issue and with population concentrated in the NSW Greater Metropolitan Region (GMR), the benefit is likely to trend towards the upper part of this range. These figures assume that there would be no large-scale return to backyard burning if the controls were lifted because of long-term changes in behaviour. However this assumption may be tested in difficult economic conditions or where local councils cut waste collection services.

Motor vehicles

Motor vehicles, especially diesel vehicles, are responsible for a considerable proportion of fine particles in urban centres. In Sydney, on-road motor vehicles are responsible for around 12% of human-caused emissions. These emissions are controlled by requirements to install and maintain anti-pollution devices on vehicles and penalties for emitting excessive smoke.

Using health cost estimates for both rural areas and cities, the estimated net quantifiable benefits of reduced PM_{10} emissions from the proposed Regulation range from $1.63 million to $9.70 million each year. As the majority of vehicles will be based in the NSW GMR, the benefit is likely to trend towards the upper end of the range. However, calculation of these benefits is based on repairs undertaken as a result of enforcement action. A greater benefit would be attributable to the unquantifiable deterrence effect of the proposed Regulation.

Industry

Even with existing controls, industry is responsible for approximately 62% of human-sourced emissions of PM_{10} in the NSW GMR (both fugitive and point-source emissions). The two largest industrial point sources of human-sourced emissions in the region are electricity generation from coal (6%) and primary iron and steel production (2%, but as high as 53% in Wollongong). The proposed Regulation will control particles by setting maximum emission limits for both scheduled industry (those premises required to hold a licence under the POEO Act) and non-scheduled industry.

The net quantifiable benefit over 20 years from reduced PM_{10} emissions as a result of the proposed Regulation is estimated to be between $796 million and $3372 million for scheduled industry and between $90 million and $381 million for non-scheduled industry.

Volatile organic compounds

Volatile organic compounds (VOCs) are a wide range of carbon-based compounds that vaporise at normal temperatures. Roughly half of VOCs (53%) come from natural sources (such as trees) while the rest are produced in a wide range of processes (such as combustion and the production or use of solvents, paints or chemicals) or released from a range of products (such as petrol, paint and household cleaners). In the NSW GMR, exhaust and evaporative emissions of petrol from vehicles account for the largest proportion of human-sourced VOC emissions: around 36%. Surface coating (paint), aerosols and solvents account for a further 25% with the remainder from a number of diverse sources.

VOC emissions are controlled for two reasons: VOCs are significant as a precursor to the formation of ground-level ozone and some VOCs are individually harmful for health and the environment as ‘air toxics’.

In the NSW GMR, VOC emissions are a major contributor to ground-level ozone which harms human health and vegetation and damages building materials. Each summer the Sydney region exceeds national health-based ozone standards on an average of 12 days. Increases in ozone levels are associated with a rise in hospitalisations for respiratory diseases and mortality.

In addition to health benefits that can be valued, there are extensive unquantifiable benefits associated with reduced levels of ozone, such as healthier plants (including crops) and ecosystems, and improved condition of the built environment. Further unquantifiable health benefits are attributable to avoided exposure to VOCs that are also air toxics, which are known to cause cancer and other health impacts.

The population of the NSW GMR is forecast to grow to 6 million by 2036. This growth will increase industrial and residential development and the ownership and use of motor vehicles and fuels. Global warming is also expected to exacerbate ozone formation, making national standards even more challenging to achieve.

The proposed Regulation will reduce VOC emissions, mainly through targeting motor vehicle fuels and industry emissions. It also reduces VOC emissions through controls on woodheaters, domestic burning and emissions from motor vehicles.

Motor vehicle fuels

Motor vehicle fuels are highly volatile and evaporate easily, especially in warmer weather. The proposed Regulation addresses evaporation points for fuel, requiring vapour recovery systems for storage, distribution and the refuelling of cars. The net quantifiable benefit of these provisions is estimated at $125 million for the period up till 2040.

Evaporation is also addressed by placing limits on petrol volatility during summer, when increased temperatures would otherwise cause petrol to evaporate faster. The net quantifiable benefit of summer petrol volatility limits is $10.38 million each year.

Emissions of VOCs are also managed through controls relating to anti-pollution devices on motor vehicles and by requiring automatic overfill protection devices to be fitted to petrol pumps.

Industry

VOC emissions from industry are controlled through vapour recovery systems for the storage and distribution of volatile organic liquids, particularly in the petroleum and chemical industries. VOCs are also controlled through emission limits for newer industry (those commencing operations on or after September 2005) and by prescribing performance standards for emission control equipment for that industry. The benefits of these controls are not quantifiable at this stage.

Oxides of nitrogen

Oxides of nitrogen (NO_X) are a group of highly reactive gases produced mainly by combustion processes. Controls on NO_X emissions are in place for three reasons: NO_X are significant precursors to the formation of ground-level ozone; they are also precursors to the formation of fine particles; and NO_X are themselves significant pollutants with impacts on health and the environment. In the NSW GMR, around half of all NO_X emissions (both from natural and human sources) come from electricity generation.

The impacts of ozone on health and the environment are described above. NO_X itself can increase susceptibility to respiratory infections and exacerbate asthma. Excessive levels of NO_X can reduce plant growth and result in the death of plants, as well as have harmful effects on a variety of biological systems.

NO_X emissions are mainly controlled under the proposed Regulation by setting maximum emission limits for scheduled industry. The net quantifiable benefit of emission limits over 20 years is estimated at between $4 million and $105 million. NO_X emissions are also reduced through controls on motor exhaust emissions.

Other pollutants

A number of other pollutants will also be controlled by the proposed Regulation. Scheduled industry must comply with emission limits for sulfur oxides, hydrogen sulfide, fluorine, chlorine, hydrogen chloride, cadmium, dioxins, furans and toxic metals. Sulfur dioxide is also controlled through limits on the sulfur content of fuel. Emissions from a range of air toxics are also limited through the controls relating to woodheaters, backyard burning and anti-pollution devices in motor vehicles.

The health benefits of these avoided emissions are not quantifiable at this stage. This is for a range of reasons, including that many health impacts are similar and not necessarily cumulative, which could lead to double-counting. As with the pollutants described above, there are also unquantifiable benefits for ecosystem health.

Recommendation

This is the first time the whole Clean Air Regulation has been remade. Between 2002 and 2009, separate parts of the Regulation were reviewed prior to their incorporation. Although the no-regulation option has been fully considered in this Regulatory Impact Statement, this document does not revisit those options considered but not adopted in the previous reviews between 2005 and 2009. An exception is the control of woodsmoke: this issue is currently the subject of a review by the Environment Protection and Heritage Council of Australia and New Zealand with a view to developing a national approach. This option was considered promising but not yet developed to the stage where it can be adopted.

Given the considerable net quantifiable benefits of the proposed Regulation and the extensive unquantifiable benefits, compared with the no-regulation option, the Department of Environment, Climate Change and Water (DECCW) proposes that the provisions of the current Regulation be carried forward. Changes to the proposed Regulation include correcting typographical errors and inconsistencies, updating references and schedules (in particular, increasing the number of councils applying the levels of control on burning appropriate for local areas), and minor adjustments that remove red tape. DECCW has consulted relevant stakeholders about all of these amendments.

1. Introduction

1.1 Purpose of this document

This document is a regulatory impact statement (RIS) for the proposed Protection of the Environment Operations (Clean Air) Regulation 2010 ('the proposed Regulation'), prepared in accordance with the *Subordinate Legislation Act 1989*. As required, it also addresses the 'Better Regulation Principles' for the proposed Regulation as demonstrated in Appendix A.

The proposed Regulation would replace the current Protection of the Environment Operations (Clean Air) Regulation 2002 ('the Clean Air Regulation').

The Subordinate Legislation Act provides for Regulations to have a limited life so that their continued relevance and effectiveness can be assessed. The current Regulation is due for repeal on 1 September 2010.

When a Regulation is to be remade (with or without amendments), the responsible agency must prepare a RIS that examines the economic and social costs and benefits of regulatory proposals and their alternatives, and provide the community with an opportunity to comment on the proposed Regulation before it becomes law.

1.2 Purpose of the proposed Regulation

The proposed Regulation contains provisions for effectively and proportionately supporting the objectives and implementation of the *Protection of the Environment Operations Act 1997* ('POEO Act') as it concerns air quality. These objectives include the reduction of risks to human health and the prevention of degradation of the environment.

The proposed Regulation is principally concerned with setting standards for the emission of designated pollutants by plant, equipment and activities: industrial, commercial, households and motor vehicles. This is achieved by controlling inputs such as the content and properties of fuel; addressing the standard of equipment such as wood-fired heaters; and placing limits on industrial emissions.

It is complemented in its objective of improving air quality by the Protection of the Environment Operations (General) Regulation 2008 which uses licensing as a mechanism (including economic incentives) to improve air quality.

The proposed Regulation is also a key part of *Action for Air*, the NSW Government's comprehensive 25-year strategy to improve air quality in Sydney, the Illawarra and the Lower Hunter (NSW Government 1998). Introduced in 1998 and most recently updated in 2009 (DECCW 2009a), the strategy covers the full array of sources that contribute to air pollution: from urban planning, roads and public transport, to cleaner vehicles and fuel, and industrial and household emissions.

1.3 What is changing?

Only minor changes are included in the proposed Regulation: correcting typographical errors and inconsistencies, updating references and schedules, and minor adjustments to remove red tape. The list of proposed changes is set out in Appendix B.

The Clean Air Regulation is under continuous review. Parts of the current Regulation were incorporated relatively recently while others have been the subject of recent significant reform: Parts 5, 6 and 7 (industrial and commercial emissions) in 2005, Part 3 (control of burning) in 2006 and Part 6 (extended petrol vapour recovery) in 2009.

1.4 Structure of this document

The proposed Regulation is made up of the following Parts:

Part 1 sets out the preliminaries of the Regulation
Part 2 requires compliance with standards for domestic solid fuel heaters
Part 3 puts in place controls on burning in the open and incinerators
Part 4 covers emissions from motor vehicles and motor vehicle fuels
Part 5 regulates emissions by industrial and commercial activities and plant
Part 6 sets in place controls on volatile organic liquids
Part 7 limits the sulfur content of liquid fuel
Part 8 contains transitional provisions from preceding Regulations.

This document sets the context by surveying air quality management in NSW in Chapter 2, then discusses each relevant Part of the proposed Regulation in turn in Chapters 3–8. The discussion for each Part covers:

- the need for government action
- the management system for the relevant emissions
- for each option (including no Regulation), a detailed description and analysis of the costs and benefits
- a recommendation on the preferred option.

The Appendixes are provided to:

- demonstrate compliance with the Better Regulation Principles – Appendix A
- list the proposed amendments – Appendix B
- include details on the health and environment impacts of the air pollutants covered by the Regulation – Appendix C
- set out details of cost-benefit calculations – Appendix D.

1.5 Consultation

Targeted consultations on the proposed minor changes have been undertaken with all relevant stakeholders: local councils have themselves nominated changes to Schedule 8 designating the required level of control over burning while the petroleum industry was consulted in relation to amendments to the definition of petrol blended with ethanol.

The proposed Regulation and this RIS are available for public comment for four weeks. DECCW welcomes written submissions from the public and will carefully consider any matters raised before the Regulation is finalised.

Please send submissions by post to:

Clean Air Regulation review
Manager, Air Policy Section
Department of Environment, Climate Change and Water NSW
PO Box A290
Sydney South NSW 1232

or email to CleanAirRegulationMailbox@environment.nsw.gov.au

This RIS is also available on the DECCW website at www.environment.nsw.gov.au/air/ca2010ris.htm and from Environment Line by phoning 131 555.

Submissions will be accepted until **5 July 2010**.

2. Air quality management in NSW

2.1 Need for government action

Clean air is fundamental to all people's health, with air quality particularly affecting the health of children and older people. It also affects the natural environment and the liveability of communities. DECCW social research has consistently found air quality to be a key environmental concern for the community (DECCW 2010a, Figure 6).

Air quality in NSW is considered good by world standards. There have been significant improvements since the 1980s as a result of program and regulatory initiatives (including the Clean Air Regulation) which have reduced air pollution from industry, business, homes and motor vehicles. Concentrations of many of the most dangerous air pollutants have been reduced by nearly 30%. Monitored concentrations of carbon monoxide, lead, nitrogen dioxide and sulfur dioxide now consistently meet national air quality standards.

However meeting the standards for ground-level ozone and particle pollution set by the National Environment Protection Measure for Ambient Air Quality ('the Air NEPM') (NEPC 1998) remains a challenge in NSW, particularly in the Greater Metropolitan Region (GMR), due to increases in population, motor vehicles and economic growth,

Ground-level ozone is a secondary pollutant, created by the chemical reaction between oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) in the presence of sunlight. Continuation of existing regulatory and non-regulatory measures, together with additional emission reduction strategies, will be required to meet the ground-level ozone standard in the Air NEPM.

Parts of regional NSW also face considerable challenges meeting the particle standards. Bushfires, the burning of stubble, dust storms and woodheaters are the major emission sources in these regional areas.

Appendix C details the sources of the main air pollutants of concern – particulate matter, ozone, NO_X, VOCs and sulfur dioxide – and their impacts on health and the natural and built environment.[1]

2.2 Management framework for air quality

Air quality in NSW is managed through an integrated whole-of-government approach, using a mix of regulatory and non-regulatory measures, and is increasingly linked with efforts to reduce greenhouse gas emissions.

2.2.1 Goals

The goals of the management framework for air quality are to improve both regional and local air quality by:

- meeting the air quality standards set by the Air NEPM (see Table 2.1) and reflected in the NSW *State Plan* (NSW Government 2010) (and linked to its greenhouse goals)
- reducing the population's exposure to air pollution and the associated health costs.

---

[1] Carbon monoxide (CO) and lead have not been included. This is because CO concentrations have continued to fall over the past 20 years due to changes in motor vehicle technology and lead concentrations are also now low because of the ban on lead in petrol.

Table 2.1: Air NEPM standards and goals

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Carbon monoxide	8 hours	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day a year None
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day a year 1 day a year
Sulfur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day a year 1 day a year None
Lead	1 year	0.50 $\mu g/m^3$	None
Particles as PM_{10}	1 day	50 $\mu g/m^3$	5 days a year

2.2.2 Strategies and programs

Action for Air, the NSW Government's air quality management plan for the NSW GMR (NSW Government 1998), contains regulatory and non-regulatory initiatives to reduce emission of air pollutants. Many of these programs extend beyond the GMR. The *NSW Cleaner Vehicles and Fuels Strategy* (DECC 2008) is a sub-strategy focusing specifically on the transport sector.

Action for Air is supported by a number of other linked strategies followed by those NSW Government agencies responsible for urban planning and development, transport planning, energy and health. These include:

- *Metropolitan Transport Plan: Connecting the city of cities* (NSW Transport & Infrastructure 2010)
- *Metropolitan Strategy: City of Cities – A plan for Sydney's future* (DoP 2005) (due for review in 2010)
- *State Infrastructure Strategy New South Wales 2008–09 to 2017–18* (NSW Treasury 2008)
- *Towards 2030: Planning for our changing population* (NSW Department of Premier & Cabinet 2008)
- NSW Regional Strategies 2006 to 2009 (Department of Planning).
- Climate Change Action Plan (under preparation).

Non-regulatory initiatives to complement regulatory measures are described in Chapters 3–8, where relevant.

2.2.3 Regulatory structure

The *Protection of the Operations Act 1997* ('POEO Act') is the key piece of environment protection legislation administered by DECCW (in the name of the Environment Protection Authority or 'EPA'). The Clean Air Regulation is one of eight which support the objectives of the POEO Act. The Regulation-making powers for the POEO Act are contained in Section 323.

Emissions of air pollutants are regulated by the POEO Act, together with the Clean Air Regulation and the Protection of the Environment Operations (General) Regulation 2009 ('the General Regulation').

The Clean Air Regulation provides regulatory measures for a number of disparate air quality issues:

- domestic solid fuel heaters – Part 2
- control of burning – Part 3
- motor vehicles and motor vehicle fuels – Part 4
- industrial air emissions from plant and activities – Part 5[2]
- storage of volatile organic liquids – Part 6
- sulfur content of liquid fuel – Part 7.

There is also capacity to control air emissions through land planning: this is either through approvals made under the integrated development process where an environment protection licence may be required for the development, or by local councils within the parameters of a local approvals policy, local environmental plan or development control plan.

2.2.4 Consultation

Consultation with stakeholders on the NSW Government's management of air emissions is both a regular program through the triennial Clean Air Forum as well as an integral part of the process of developing new policy and regulatory initiatives (including revisions and remakes). The Clean Air Forum is a public forum held every three years to review the progress of *Action for Air*.

---

[2] Industrial air emissions are also the focus of the General Regulation which (together with the POEO Act) provides the system to license emissions from industrial plant and activities, including load-based licensing.

3. Domestic solid fuel heaters: Part 2

3.1 Background

3.1.1 Need for government action

Smoke from domestic solid fuel heaters (mainly woodheaters) is a major cause of air pollution in winter (DECC 2007a, Table 3.88). Burning wood without adequate controls on woodheater design, installation and use leads to incomplete combustion and this in turn results in unburnt particles and VOCs.

In 2008, the percentage of homes in NSW using wood combustion heating was 10.3% (ABS 2008a, Table 3.8). On an annual basis, woodsmoke in Sydney contributes 19% and 29% of annual PM_{10} and $PM_{2.5}$ particle pollution, respectively (from both natural and human sources). On a winter weekend day, the contribution of PM_{10} and $PM_{2.5}$ particle pollution from woodsmoke can be as high as 48% and 60%, respectively (DECC 2007b). In colder places, such as Armidale, woodheaters can contribute over 85% of winter particles.

In addition to fine particles, woodsmoke contains a number of VOCs that are known air toxics. Table 3.1 shows the annual contribution of woodsmoke to total annual emissions of significant air pollutants, from both human and naturally derived sources, in the NSW GMR and Sydney Region. This indicates that woodsmoke accounts for a significant proportion of many of the air pollutants listed.

Table 3.1: Contribution of woodsmoke to annual pollutant emissions

Air pollutant	NSW GMR (%)	Sydney region (%)
Carbon monoxide (CO)	3	5
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: DECC 2007b

Exposure to particulate matter is associated with increased mortality and hospital admissions among people with heart and lung disease. In addition, there is evidence that exposure to the VOCs in Table 3.1 is linked to cancer, birth defects, genetic damage, immune deficiency, and respiratory and nervous system disorders. See Appendix C for further information on the health and environmental impacts of particulate matter and VOCs.

There is a widespread preference in both Sydney and regional centres for woodheating as a primary or secondary heating source. This is because woodheating is relatively cheap, has the potential for high heat output and – importantly for some – has the appeal of custom and ambience. It may also be perceived as being more sustainable. In addition, many rural areas do not have access to a gas supply that would be an alternative option for lower-cost energy than electricity.

3.1.2 Management of woodsmoke emissions

Figure 3.1 shows the overall approach of the NSW Government to controlling woodsmoke pollution.

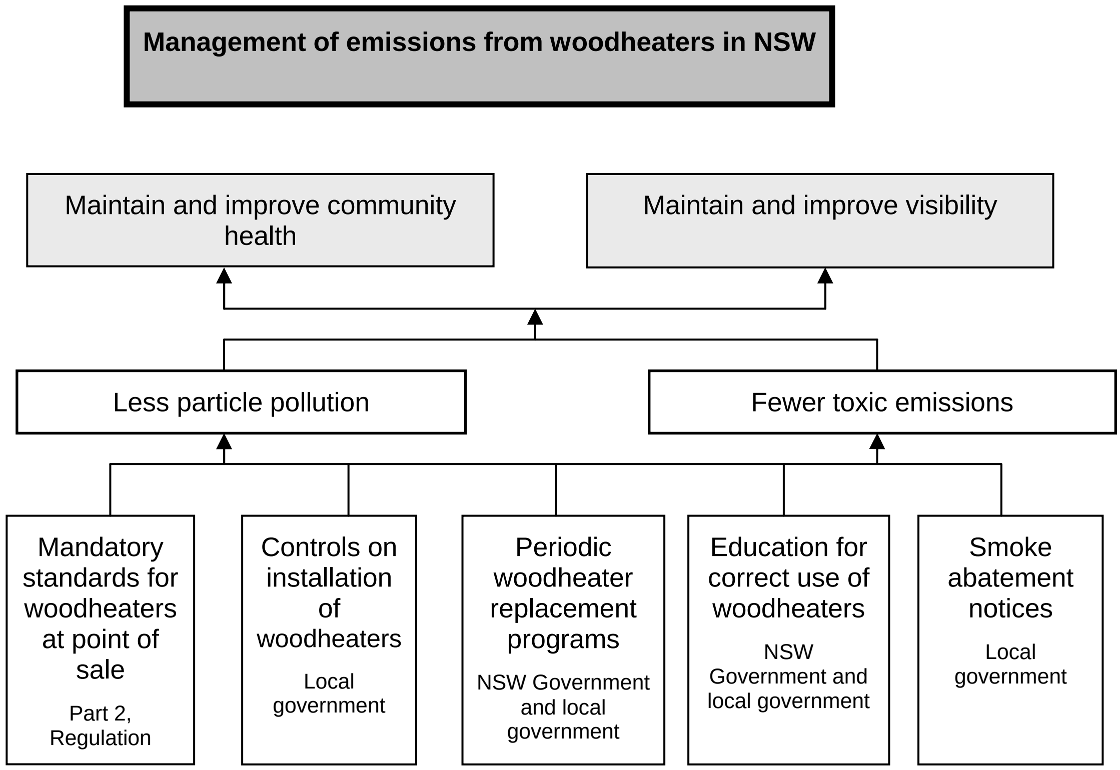


Figure 3.1: Management of emissions from woodheaters in NSW

In NSW, control of woodsmoke emissions is largely managed at the local government level, supported by NSW Government regulatory controls, funding and education initiatives. In NSW, there are five main complementary strands to the control of woodsmoke.

Firstly, appliances sold for wood heating must meet minimum emission standards as set out in Part 2 of the proposed Regulation.

Next, local government planning instruments, such as development control plans, require correct installation of woodheaters or even a ban on them in some areas.[3] Under Section 68(1) of the *Local Government Act 1993*, woodheaters cannot be installed without the approval of the local council.

Another approach is to promote the correct use of the equipment and open fireplaces, primarily through advertising and providing information to the community, including targeted households.

At times, local government and the NSW Government also run woodheater replacement programs.

---

[3] Councils that have banned the installation of woodheaters in several new release areas in their LGAs include Camden and The Hills Shire.

As a last resort, the POEO Act provides that local councils may insist on smoke mitigation measures being taken by particular households through the issue of a smoke abatement notice.

3.1.3 Range of options

Three options for government action are given detailed consideration below:

- no Regulation – discussed in Section 3.2
- the proposed Regulation – remake Part 2 of the Clean Air Regulation in its current form, as discussed in Section 3.3
- national scheme – discussed in Section 3.4.

3.2 Option 1: no Regulation (base case)

3.2.1 Description

The current Regulation provides that a woodheater cannot be sold unless the heater is marked in accordance with the Australian Standard, *AS/NZS 4013:1999 – Domestic solid fuel burning appliances* (AS/NZS 1999). Removal of this control would allow the sale of woodheaters that do not meet this standard. To the extent that these woodheaters are less expensive to purchase or operate, they may displace sales of woodheaters that conform with Standard 4013. In addition, prohibitions on interfering with existing heaters that meet the standard would also be removed.

A range of possible consequences may be anticipated:

- the amount of particle pollution may increase over time with implications for health, visual and other environmental impacts
- there may be impacts on existing industry production and importation of woodheaters that meet Australian Standard 4013, as well as opportunities for the production and importation of heaters that do not comply, with consequential impacts on local economies and employment
- a potential erosion of the certification scheme due to lack of government support for the standards.

Under the no-Regulation option, other regulatory mechanisms are in place that would still have the potential to control woodsmoke to some extent, including the POEO Act,[4] *Local Government Act 1993*[5] and *Environmental Planning and Assessment Act 1979*.[6] However, most of these controls are not able to be used to proactively prevent reduced air quality from woodsmoke because they are a response to the presence of woodsmoke and may be expected to increase the resources required by local councils in dealing with woodsmoke. The extent to which they may be used successfully is speculative and cannot be assessed.

---

[4] Through the use of smoke abatement notices or prevention notices: Sections 96, 134 and 135B of the Act. For recommended council procedures, see DECC 2010b.
[5] Through abatement of a public nuisance (Sections 124 and 125 of the Act) or, alternatively, through the approval process of the local council (Section 68(1))
[6] Through the use of a local environmental plan or development control plan: Part 3, Division 4 and Division 6, respectively, of the Act

3.2.2 Benefits

The costs set out in Section 3.3.3 would represent the benefits for households, industry and government of not remaking the Regulation.

3.2.3 Costs

The health benefits set out in Section 3.3.2 would represent the costs of not remaking the Regulation. If the controls were removed, some new woodheaters sold in NSW may still comply with Australian Standard 4013. However, in the long term, the removal of mandatory standards for woodheaters may see a return to the use of woodheaters with poorer standards of emission control. It is difficult to assess how quickly this change would occur or the extent to which the changes would be made. However, as woodheating is generally a cheaper form of energy supply, it may be anticipated that in difficult economic times this form of energy would increase in use.

Costs to government would include the use of alternative regulatory mechanisms at both state and local level. Although it cannot be estimated which of these mechanisms would be used or to what extent, it is expected that it would take more than the minimal cost currently borne by the State Government in mandating minimum standards for woodheaters. Given that many of these alternatives are reactive, it can also be anticipated that over time increased emissions would result in a loss of the health and visibility benefits set out in Section 3.3.2.

Industry producers and importers would no longer be required to comply with certification procedures for NSW but to the extent that production or importation takes place from a jurisdiction that still requires compliance with the standard, certification costs would in any case need to be borne. It cannot be anticipated in advance whether the savings resulting from any decrease in the use of certification procedures would be passed on to consumers.

Unquantified costs to the environment would be attributable to poorer visibility, increases in offensive odour and damage to buildings, crops and other vegetation.

3.3 Option 2: the proposed Regulation

3.3.1 Description

Part 2 of the proposed Regulation is designed to reduce emissions from woodheaters and support local government measures to control woodsmoke. It also complements both NSW Government and local government education initiatives on the correct purchase, installation and use of woodheaters as well as periodic local woodheater replacement programs.

Part 2 prevents the sale of new solid fuel home heaters that do not comply with emission standards. The mechanism used focuses on the point of sale. The sale of a heater is prohibited unless it is marked in accordance with the current Australian Standard 4013.[7]

In addition, a certificate of compliance certifying that a model complies with Standard 4013 must be in force and a copy provided to all retailers selling the unit. Interfering with a heater that is subject to a certificate of compliance is prohibited as is marking a heater as complying with the Standard when it does not.

The proposed Part 2 is exactly the same as the current Part 2.

---

[7] The current standard provides for emissions of no more than 4 grams of particles per kilogram of fuel, a 25% reduction on the previous standard.

3.3.2 Benefits

The quantifiable benefits of the emission standards for woodheaters relative to the no-Regulation option are lower emissions of PM_{10} leading to improved human health.

Estimated avoided PM_{10} emissions are between 67 and 153 tonnes each year. Using health cost estimates for rural areas and cities, the estimated quantifiable health benefits range from $3.74 million to $35.99 million per year. This benefit is expected to be maintained each year for the life of the heater (between 15 and 20 years). Appendix D contains the detailed calculations of these benefits. The majority of households with woodheaters are located in Sydney and other centres of urban population and, accordingly, the real benefit is likely to be towards the upper end of the range.

Additional, but unquantifiable, health benefits may be attributable to the avoidance of emissions of VOCs that are air toxics (see Table 3.1).

Other health and environmental benefits for controlling emissions of particles include improved visibility, healthier vegetation, crops and ecosystems and an improved condition of the built and natural environment. See Appendix C for further details on the contribution to the health and environmental impacts of particulate matter and VOCs.

In addition, the benefits of emission standards for woodheaters include:

Cost-effective household heating: Emission standards allow continued reliance on a valued source of energy, particularly in rural areas and where firewood is sourced from a sustainable supplier. In a 2008 survey it was found that 50% of woodheaters users did so primarily because of cost (ABS 2008a).

Efficiencies in regulation: Government costs would be saved by avoiding the need for each local council to put in place equivalent controls on woodheaters based on their powers under the Local Government Act and POEO Act. The proposed Regulation may also reduce the number of complaints of excessive smoke that councils have to deal with. This benefit has not been estimated.

3.3.3 Costs

Potential costs for Part 2 of the proposed Regulation relative to the no-Regulation option arise for government, industry and households.

DECCW administration of the current Regulation includes providing information to woodheater retailers and auditing compliance with the Regulation. This is estimated to cost $6200 per year. There are a range of costs to local councils associated with managing woodheaters but most of these would continue to be incurred if the Regulation was not remade.

Compliance with Australian Standard 4013 is required for new woodheaters sold in NSW, Western Australia, Queensland, Victoria, Tasmania and the Australian Capital Territory. The manufacturer/importer arranges compliance testing and certification of the woodheater by the Australian Home Heating Association and makes the certificate available to retailers, often via the internet.

The average cost attributable to NSW of Standard 4013 compliance testing and certification is estimated to be $188,320 per year. Households buying woodheaters would pay about $20 per woodheater if all of this cost was passed on by the manufacturer/importer.

Appendix D contains the detailed calculation of these costs.

3.4 Option 3: national scheme

3.4.1 Description

Some environment protection policy issues are more effective if approached at a national level. The Environment Protection and Heritage Council of Australia and New Zealand (EPHC) addresses broad national policy issues relating to environment protection, particularly in regard to air, water and waste.

Using National Pollutant Inventory data, the EPHC has identified the woodheater emission sources with the greatest impact on populations across jurisdictions and agreed to develop a national approach to regulating them. Possible options include a National Environment Protection Measure or national laws.

3.4.2 Benefits

The control of emissions from woodheaters would benefit from a uniform national approach because it may:

- offer consistency and certainty for industry
- overcome the difficulty of mutual recognition requirements.[8]

A uniform national approach would be expected to provide the same or greater emission reduction benefits as the proposed Regulation.

3.4.3 Costs

Given the range of structural options under consideration for a national scheme, it is not currently possible to estimate the costs of a national scheme.

3.5 Conclusion

Particle pollution in Sydney and many regional centres has a more significant impact on air quality in winter than summer. Reducing emissions from woodheating has the greatest potential for improving air quality in winter.

There is scope to address this issue efficiently at a national level and work toward this is under way with NSW playing a key role. However, this process takes place outside the legislative review time frames for NSW.

At present, the preferred option is the proposed Regulation that would continue to use the existing Australian Standard 4013 to control the further growth in emissions. Remaking the Regulation, an effective and proportional measure within the limitations of state jurisdiction, would prevent a regression from existing controls until such time as a national approach is finalised and assessed.

Using health cost estimates for both rural areas and cities, the estimated net quantifiable benefits alone range from $3.55 million to $35.80 million per year. The health benefits can be expected to be maintained each year for the life of the heater (between 15 and 20 years). The

[8] Under mutual recognition, when a product is sourced from another state that has lower standards than NSW, the product can still be lawfully sold in NSW. This means that standards for new products and equipment are only fully effective if they are introduced nationally and no other State or Territory has less stringent standards. South Australia and the Northern Territory do not require compliance with Standard 4013.

majority of the population with woodheater controls are located in centres of urban population and, accordingly, the real benefit is likely to be towards the upper end of the range. Additional unquantifiable benefits would arise for health (through the avoidance of emissions of VOCs which are air toxics), the natural and built environment, improved visibility, cost-effective household heating and efficiencies in regulation.

The proposed Regulation allows the substantial cumulative reductions made in emissions from woodheaters to be sustained and continued.

4. Control of burning: Part 3

4.1 Background

4.1.1 Need for government action

Backyard burning of waste and leaf litter was once a widespread weekend practice in the NSW GMR. It has been estimated that in 1984, before the introduction of any significant regulatory controls or education targeted at open burning, the contribution of backyard burning to brown haze in the Sydney region was 5000 tonnes a year, of which a high proportion was fine particulates (Dean & Ferrari 1990). The contribution of backyard burning to fine particulate pollution is now less than five tonnes a year: a reduction of 99.9%.

Burning in the open or in inadequately controlled incinerators results in incomplete combustion, generating small particles that are suspended in the atmosphere and may be transported over large areas. Depending on the composition of the waste burnt, emissions from backyard burning may include VOCs and metals. See Appendix C for further details on the health and environmental effects of particulate matter, VOCs and metals.

4.1.2 Management of emissions from burning

Figure 4.1 sets out the management framework for emissions from domestic burning.

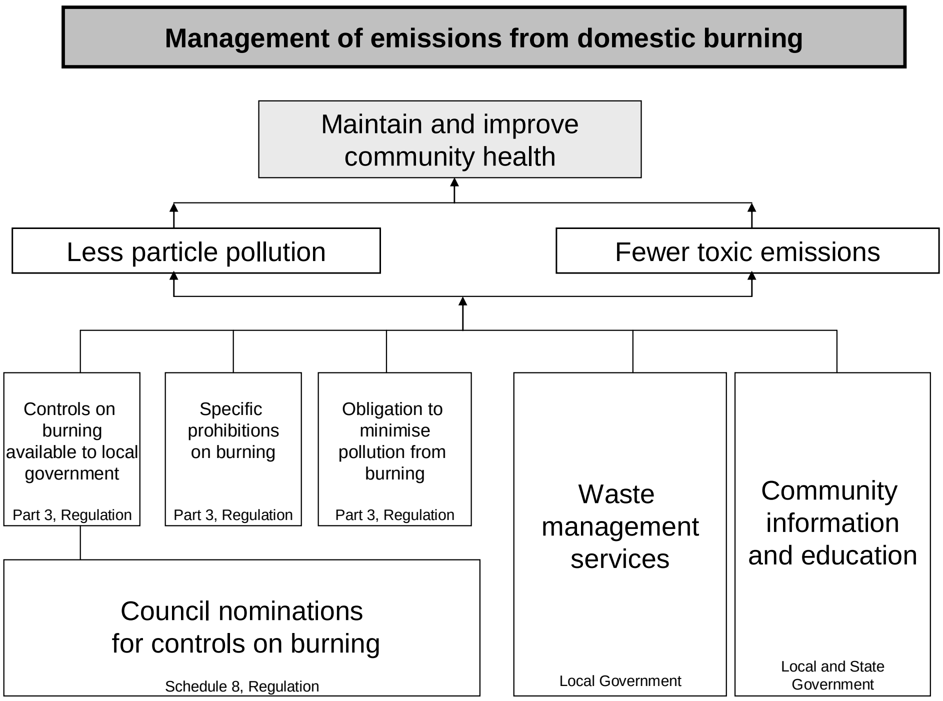


Figure 4.1: Management of emissions from domestic burning in NSW

Domestic burning is a waste management issue. To encourage changes in the behaviour of local residents in managing their domestic waste (including plastics and other packaging, newspapers, food waste and garden refuse), local councils provide domestic waste collection services and recycling facilities and associated community information services. Most urban households in NSW now have access to a kerbside recycling service, which often includes green waste. Other alternatives to the burning of waste include local tips and recyclable waste transfer stations.

Under the current approach, Part 3 of the Clean Air Regulation provides a framework for local government actions and has been structured to allow councils to adopt a level of control of burning appropriate to local conditions.

The current approach, developed in consultation with councils, incorporates both regulatory and non-regulatory options and is the culmination of many years of educational and regulatory initiatives by councils and DECCW. Devolving responsibility to local government is also consistent with government action on backyard burning in other jurisdictions in Australia, New Zealand, the United States and Canada: see Queensland Government 2010; NZ Ministry for the Environment 2010; US EPA 2010a; and Government of British Columbia 2010.

4.1.3 Range of options

Two options for government action are given detailed consideration below:

- no Regulation – discussed in Section 4.2
- the proposed Regulation – remake Part 2A of the Clean Air Regulation in its current form as Part 3 of the proposed Regulation and, in line with requests from local government, change the listings of councils in Schedule 8, as discussed in Section 4.3.

4.2 Option 1: no Regulation (base case)

4.2.1 Description

Allowing the current Regulation to lapse would result in the absence of controls on open burning of household waste or vegetation or its burning in an incinerator.

It is unlikely that there would be an immediate and widespread return to the levels of backyard burning prevalent before regulatory controls were introduced, because of the convenience of domestic waste collection and recycling services, and changes in community behaviour. However, failure to continue the controls on burning could result in environmental deterioration as a proportion of the community becomes aware that sanctions no longer apply to this type of activity. Efforts by some councils to encourage more recycling by reducing waste collection services for general household waste may also lead to an increase in burning in the absence of the Regulation.

This deterioration would be manifested in more particle pollution with impacts on health, visibility, odour and accidental fires. This may lead to an increased reliance on alternative regulatory mechanisms that are already in place. Other regulatory mechanisms that have the potential to control burning to some extent are the Local Government Act[9] and the POEO Act.[10] However most of these controls are not able to be used proactively to prevent reduced air quality from burning (particularly the location and types of substances being burnt) and may be expected to inflate the resources required by local councils in dealing with domestic burning. The extent to which they may be used successfully is speculative and cannot be assessed quantitatively.

---

[9] Through abatement of a public nuisance: Section 125 of the Act
[10] Through the use of prevention notices, orders prohibiting burning in certain weather conditions, orders to extinguish a fire: Sections 96, 133 and 134 of the Act

4.2.2 Benefits

The costs set out in Section 4.3.3 would represent the benefits of not remaking the Regulation. However these may be offset (or even exceeded) by the need for local councils to rely on the largely reactive controls currently available under the Local Government Act and the POEO Act. There may be a minor saving for those residents (and consequently councils) who choose to burn their waste rather than take advantage of council waste disposal services, but this benefit may also be offset to some degree by increased health costs, both for those residents as well as their neighbours.

4.2.3 Costs

The health benefits set out in Section 4.3.2 would represent the costs of not remaking the Regulation. In the short term, most residents could be expected to continue to use waste disposal services. However, over the long term, the removal of the controls provided by the current Regulation could see a return to backyard burning by many residents in urban areas of NSW where it is currently prohibited, resulting in a significant deterioration in air quality and an increased incidence of neighbourhood nuisance smoke, odour and fallout. A return to backyard burning would not, however, significantly reduce waste management costs since most residents would expect existing waste collection and recycling services to continue.

This is likely to increase administration and enforcement costs as local councils and DECCW respond to an increase in complaints and neighbour disputes related to smoke, odour and fallout. Community tolerance of these impacts is likely to be significantly lower than when controls on burning were first introduced. As noted in Section 4.2.1, tools under the Local Government Act and the POEO Act are largely reactive rather than preventative and are subject to other significant limitations.

Unquantified costs to the environment would be attributable to poorer visibility, increases in offensive odour and damage to buildings, crops and other vegetation.

4.3 Option 2: the proposed Regulation

4.3.1 Description

The aim of Part 3 is to reduce or prevent emissions from domestic burning. It does this by:

- imposing a general obligation to prevent or minimise air pollution when burning in the open or in an incinerator
- prohibiting the burning of certain articles, such as tyres and wood treated with copper chromium arsenate (CCA) or pentachlorophenol (PCP), with certain limited exceptions
- including a framework for councils to exercise a level of control over burning that is appropriate to local conditions.

Councils exercise controls over burning through nominating their local government area (LGA) for listing on various parts of Schedule 8 of the Regulation:

- Part 1 of Schedule 8 lists LGAs having the highest level of control where all open burning is effectively prohibited without approval from the Environment Protection Authority (EPA).
- Part 2 of Schedule 8 lists LGAs where the burning of vegetation requires approval by the council. For example, in many of the LGAs listed in Part 2, generalised approvals prohibit the burning of vegetation in urban areas, but allow this type of burning on rural lots that are not serviced by green waste collection.

- Part 3 of Schedule 8 lists LGAs where domestic waste burning (but not of vegetation) requires approval by the EPA.

Where a council wishes to be able to approve the burning of vegetation and still have a high level of control on open burning, it is possible to be listed on both Part 2 and Part 3 of the Schedule. The changes to Schedule 8 of the proposed Regulation were in response to a survey of councils conducted in 2009.

The structure of Schedule 8 was developed in consultation with councils and provides certainty for them in relation to controls on waste and vegetation burning. This facilitates comprehensive management of the issues related to burning. Councils work closely with the NSW Fire Brigades and NSW Rural Fire Service to manage local burning issues, including air quality, protection of life and property, and bushfire hazard reduction.

Councils have been included on Schedule 8 at their own request, in response to encouragement from DECCW and their local communities. These voluntary responses by councils have led to complete coverage in the NSW GMR and broad coverage in other areas of the state, particularly in larger urban centres.

The proposed Regulation contains a range of exemptions, including for bushfire hazard reduction.

The proposed Part 3 is exactly the same as Part 2A of the current Regulation except for the changes to the council listings in Schedule 8. These changes have been made at the request of the relevant councils and are set out in Appendix B. There are also updated cross-references to other Acts referred to in Part 3. These changes have not been itemised.

4.3.2 Benefits

The quantifiable benefits of the controls on burning relative to the no-Regulation option are lower emissions of PM_{10} leading to improved human health. The health benefit of the avoided PM_{10} has been estimated at between $279,135 and $1,176,305 per year. These figures are conservative because it is assumed that current waste management practices would act as a control on increased burning, at least for a significant period of time. Appendix D contains the detailed calculation of these benefits.

In addition to the health benefits of avoided PM_{10}, other benefits include:

Increased sustainability in waste management practices: The current Regulation (and its antecedents) has promoted the development of the sophisticated range of waste management and recycling services seen today. Most NSW councils provide domestic waste collection services (including for green waste and recyclables), recycling facilities and associated community information services. According to DECCW 2008–09 data, 93% of NSW households have access to a kerbside recycling service and 1,606,500 tonnes of organic material is recycled and reused each year.

Reduction in odours, smoke and ash: Before being phased out in the Sydney region, local councils reported that the nuisance effects of backyard burning resulted in a significant number of complaints.

Reduction in air toxics from the burning of tyres and CCA-treated wood

Fewer accidental fires: For example, the NSW Fire Brigades attended eight fires in 2006–07 where an incinerator was considered to be the cause of the fire, down from 16 in 2001–02 (NSW Fire Brigades 2007 & NSW Fire Brigades 2002). If burning was not controlled, it is likely the number of these incidents would be higher.

Possible greenhouse gas benefits, depending on the end-use of recovered and reused carbon wastes

Improved visibility and condition of the natural and built environments

Depending on the composition of the waste burnt, **additional health benefits** may be attributable to the avoidance of VOCs and metal emissions.

See Appendix C for further details on the contribution to the health and environmental impacts of particulate matter, VOCs and metals.

4.3.3 Costs

Potential costs for Part 3 of the proposed Regulation arise for government and residents.

Costs to government

DECCW (through the EPA) and local councils are responsible for issuing approvals and notices related to burning. This is carried out in consultation with the Rural Fire Service, local councils and other fire management agencies. DECCW will consider approving an open burn only in exceptional circumstances, such as ecological burns to stimulate or assist regeneration of native vegetation or to implement an appropriate fire regime to maintain or improve biodiversity; and special effects for filming or large-scale events which require open burning or the production of smoke. The costs of these approvals are now negligible and have not been estimated.

The quantifiable cost to councils of administering the current Regulation is estimated at $160,000 per year. Costs vary depending on the local policies followed by a council. Some councils require residents to submit an application for each proposed open burning of vegetation, while others have a standing approval for burning on rural lots but prohibit this type of burning in residential zoned areas. Appendix D contains the detailed calculations of these costs.

Compared with the no-Regulation option, the proposed Regulation would lead to some increase in waste collection and recycling services (as a substitute for the practice of burning). This in turn would have some cost implications for local councils and also lead to increased income from the sale of recycled material, such as mulch. The waste disposal costs and income stream have not been quantified as it is not possible to attribute these costs to the proposed Regulation.

Costs to residents

Community expectations have grown that council management of waste will continue and improve. This has been accompanied by a change in community perceptions about the importance of air quality since controls on backyard burning were first introduced. Developments over the last 25 years in the control of burning and waste management make it harder to attribute waste disposal costs to the regulation of control of burning. The additional cost of remaking the current Regulation in the form of the proposed Regulation for residents is likely to be minimal.

There may, however, be incremental savings if more burning occurs, as there would be less waste to collect. It is estimated that the cost to residents of collecting waste instead of burning it is $20,000 per year. Appendix D contains the detailed calculations of these costs.

4.4 Conclusion

The preferred option is the proposed Regulation, an effective and proportional measure that would continue the controls on burning that over the past three decades have seen a reduction in emissions from backyard burning in Sydney from 5000 tonnes per year to 5 tonnes per year: a reduction of 99.9%. Maintenance of significant benefits in improved health, visibility and odour have been achieved at the cost of the provision of waste management services, mitigated by income streams from recycling and composting, and recovered from residents in conformity with the ‘polluter pays’ principle.

Using health cost estimates for both rural areas and cities, the estimated net quantifiable benefits alone range from $0.1 million to $1 million each year. As with controls on woodheaters, this is a residential issue and, given population concentrations in the NSW GMR, the benefit is likely to trend towards the upper part of this range. These figures assume that there would be no large-scale return to backyard burning if the controls were lifted, owing to long-term changes in behaviour. However, this assumption may be tested in difficult economic conditions or where local councils cut waste collection services in order to encourage sustainable practices.

Additional benefits accrue from improvements in visibility and reductions in odour and nuisance from smoke and ash fallout, as well as reduction in the incidence of accidental fires.

5. Motor vehicles and motor vehicle fuels: Part 4

5.1 Background

5.1.1 Need for government action

Cleaner vehicles and fuels have made a significant difference to the levels of air pollution emitted from individual vehicles, with ambient concentrations of carbon monoxide and nitrogen dioxide generally well below the Air NEPM standards (NEPC 2009). Even so, motor vehicles continue to be the main source of air pollution in Sydney as the city grows and the number of vehicles increases (by more than 50% over the last 20 years). This means that meeting the ground-level ozone and particle NEPM standards remains a challenge.

In Sydney, air pollutants associated with motor vehicles are major sources of the ozone-forming pollutants visible as summertime haze (71% of NO_X and 38% of VOCs) (DECC 2007b). They are also responsible for a considerable proportion (12%) of the airborne particles visible as brown winter haze (DECC 2007b).

Some VOC emissions are also air toxics. For the health and environmental impacts of particulate matter, ozone, VOCs and NO_X, see Appendix C.

5.1.2 Management of emissions from motor vehicles and motor vehicle fuels

Figure 5.1 outlines the management of emissions associated with motor vehicles in NSW. The current management strategy is a mix of regulatory and non-regulatory measures with the regulatory measures shared between the NSW and Australian Governments.

National legislation covers fuel quality standards (DEWHA 2010) and emission standards for new motor vehicles (DITRDLG 2010). Health issues that are of concern across Australia are also addressed at the national level, such as limiting the benzene content of fuel to 1%.

Regulation at the state level is able to take into account regional characteristics, such as the role that the geography and meteorology of the Sydney basin plays in forming higher concentrations of ozone. Reducing petrol volatility (see Section 5.3.6) or requiring vapour recovery systems (see Chapter 7) reduces ozone formation in the Sydney basin, but involves costs for industry. As a result, the proposed Regulation will require compliance with those provisions only in the NSW GMR rather than across the state. Even within that region, compliance is tailored to areas of high population density. In practice, some provisions are better regulated at state level, such as those covering smoky vehicles and tampering with pollution equipment.

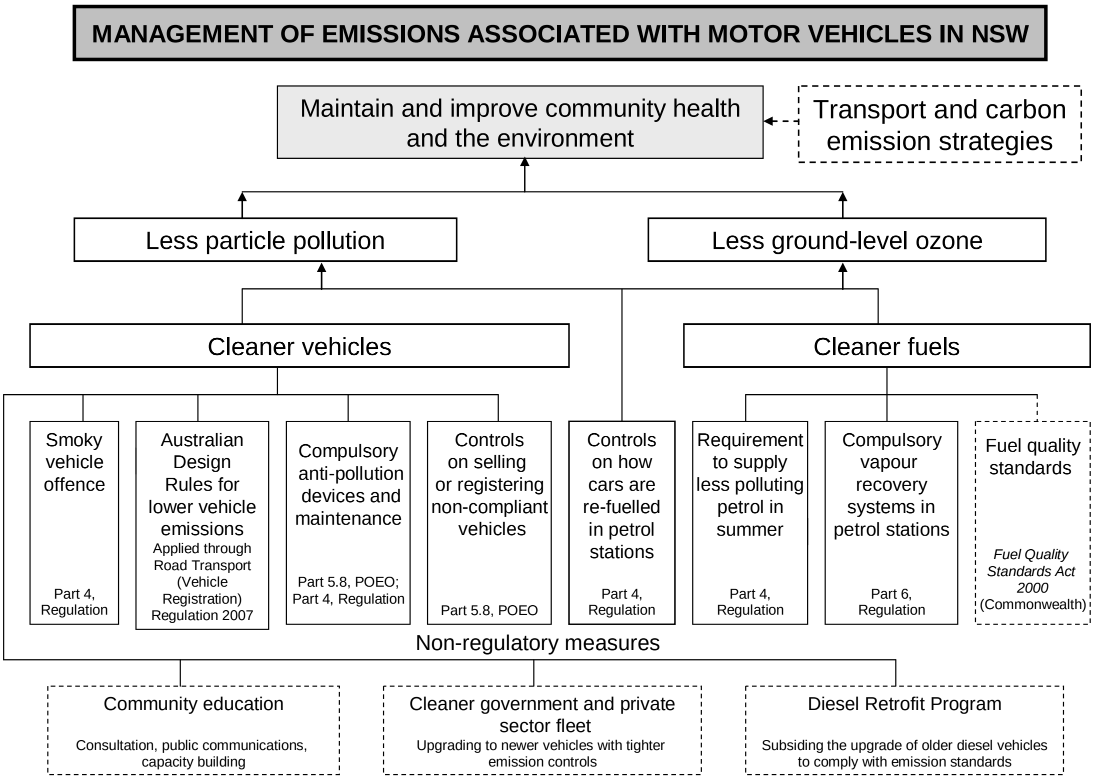


Figure 5.1: Management of emissions from motor vehicles in NSW

The following goals and strategies specific to motor vehicles are in place:

- The National Environment Protection Measure for Diesel Vehicle Emissions (NEPC 2009) establishes guidelines to assist jurisdictions develop programs that minimise exhaust emissions from diesel vehicles. NSW puts this measure into effect both through regulatory measures (smoky vehicle offences) and non-regulatory measures, such as the Diesel Retrofit Program, implemented by DECCW, the Roads and Traffic Authority and State Transit Authority.
- The *NSW Cleaner Vehicles and Fuels Strategy* (DECC 2008) outlines actions for cleaner fuels and a cleaner motor vehicle fleet. The plan also links with transport and planning actions to reduce vehicle dependence and traffic congestion. Program initiatives include community education, cleaner government and private sector fleets, and the retrofit of older diesel engines.

Regulatory measures

In NSW, regulatory measures to control emissions associated with motor vehicles are principally contained in Part 4 of the Clean Air Regulation and Part 5.8 of the POEO Act.

Part 4 of the Clean Air Regulation works to minimise motor vehicle emissions through measures targeting smoky vehicles and vehicles where anti-pollution devices have been tampered with, and reducing evaporative fuel emissions, especially in summer.

Part 5.8 of the POEO Act largely relies on the definitions contained in the Clean Air Regulation and works to reduce emissions by:

- prohibiting from sale those motor vehicles which emit excessive air impurities; those not fitted with prescribed anti-pollution devices; and those which are not serviced, maintained or adjusted in the manner specified in the Regulation

- prohibiting tampering with anti-pollution devices fitted to motor vehicles as well as servicing or repairing motor vehicles in certain manners specified in the Regulation
- enforcement powers including –

  notices to service or repair vehicles or fit and maintain anti-pollution devices

  suspension or prohibition of the registration of non-complying vehicles

  prohibition by the Minister of the use of certain motor vehicles to prevent or minimise harm to the environment or injury to public health

  powers to inspect and test motor vehicles.

Other key provisions regulating motor vehicle emissions are:

- vapour recovery systems in petrol stations – provided for in Part 6 of the proposed Regulation (see Chapter 7)
- Australian Design Rules (Commonwealth) which set emission limits for new vehicles according to their date of manufacture
- fuel quality standards (Commonwealth) covering a broad range of environmental issues related to fuel composition.

5.1.3 Range of options

Two options for government action are given detailed consideration below:

- no Regulation – discussed in Section 5.2
- the proposed Regulation – remake Part 3 of the Clean Air Regulation in its current form as Part 4 of the proposed Regulation and make very minor changes, as discussed in Section 5.3.

5.2 Option 1: no Regulation (base case)

5.2.1 Description

Under this option, although the Australian Design Rules would continue to control emissions from new motor vehicles, regulation of emissions from in-service motor vehicles and limits on petrol volatility during summer would be removed. There are no existing alternative regulatory mechanisms that would achieve the same objectives as Part 4 of the proposed Regulation. This is likely to result in:

- an increase in smoky vehicles because vehicle owners either fail to maintain or repair their vehicles and/or remove or interfere with anti-pollution devices (usually to enhance vehicle power)
- an increase in exhaust emissions at the level of pedestrians, cyclists and motorists due to lack of maintenance or removal of vertical exhausts on older diesel vehicles
- an increase in petrol spills where automatic overfill protection devices are removed or not maintained on petrol pumps

- higher VOC emissions as a result of the removal of limits on petrol volatility during summer – In the absence of regulatory limits, it is unlikely that low volatility petrol would be supplied during summer due to the processing cost and effort involved in reducing petrol volatility, leading to increases in VOC emissions. For the purpose of this RIS, the no-regulation case has used a petrol vapour pressure of 70 kiloPascals (kPa) as a base level. (Prior to the commencement of regulation in 2004, this was 76 kPa in the GMR.)

5.2.2 Benefits

Avoidance of the costs set out in Section 5.3 for compliance and enforcement represent the benefits for motorists, industry and government of not remaking the Regulation.

5.2.3 Costs

The quantified health benefits set out in Chapter 5.3 represent the quantifiable costs of not remaking the Regulation. Additional health costs may be attributable to increased diesel exhaust emissions at street level (vertical exhaust requirements) and petrol spills at service stations (automatic overfill protection devices). Unquantified costs to the environment would be attributable to poorer visibility, increases in offensive odour and damage to buildings, crops and other vegetation.

Allowing the Regulation to lapse would do more than remove the net benefits attributable to the Regulation. It would extend to removing parts of the benefits of the POEO Act as well because some of the Act's provisions rely for effect on definitions contained in the Regulation.

5.3 Option 2: the proposed Regulation

5.3.1 Introduction

Part 4 of the proposed Regulation aims to reduce emissions from motor vehicles and motor vehicle fuels. The measures complement other regulatory and non-regulatory tools for the control of emissions associated with motor vehicles (see Figure 5.1). These measures address smoky vehicles, anti-pollution devices (including vertical exhausts), petrol overfill protection, and the supply of less-polluting petrol.

The proposed Part 4 is the same as the current Part 3 of the Clean Air Regulation except it:

- removes reporting and record-keeping provisions relating to benzene content in fuel which have been superseded and are no longer operative
- updates exemptions from vertical exhaust provisions which recognises technological improvements in emission controls for vehicles that supersede the regulatory requirements and provides regulatory consistency
- redefines 'prescribed blended petrol' as petrol blended with an ethanol content of 4–10%, instead of the present 9–10% (see Section 5.3.6)
- removes references to superseded 2004 requirements.

Each of the changes is considered very minor and is described more fully where relevant below. A listing of the changes and the reasons is provided in Appendix B. There are also changes that update the current names of local government authorities and other external bodies or documents, together with minor drafting adjustments. These changes have not been itemised.

5.3.2 Smoky vehicles

Description

The aim of the smoky vehicle offence is to reduce excessive emissions from smoky vehicles and encourage the regular maintenance of vehicles. It does this by:

- making it an offence to use motor vehicles which emit excessive air impurities with a maximum of 400 penalty units for a corporation and 200 penalty units for an individual
- defining ‘excessive air impurities’ to mean continuous visible emissions for more than 10 seconds.

The smoky vehicle offence complements the POEO Act provisions described in Section 5.1.2 that rely on the definition of excessive air impurities in the Regulation in order to take effect.

The smoky vehicle offence is one of the key instruments controlling vehicle emissions. It is enforced by officers from DECCW, the RTA, local councils and the police. In addition, members of the public can make reports and large numbers are received each year.[11] Reports are followed up by DECCW and appropriate action taken where necessary, including issuing an advisory letter to the registered owner (fines are not issued unless an enforcement officer witnesses the offence).

The proposed provisions relating to smoky vehicles are exactly the same as those in the current Regulation.

Benefits

Controlling smoky vehicles limits the emission of air pollutants from motor vehicles relative to the no-Regulation option, especially particulate matter, nitrogen dioxide and VOCs (including air toxics). See Appendix C for general health and environmental impacts.

Using figures from enforcement action taken, it is estimated that the smoky vehicle provisions result in a reduction of approximately 43.92 tonnes of particulate emissions with an estimated health benefit of $2.45 million to $10.33 million per year, based on a health cost range of rural to urban, and 4.68 tonnes of VOCs each year with an estimated health benefit of $0.02 million per year. These annual benefits are expected to accrue for the life of the repaired vehicle component. Appendix D contains the detailed calculation of these benefits.

The majority of the population affected by these provisions is located in Sydney and other urban population centres and, accordingly, the real benefit is likely to be towards the upper end of the range.

These benefits are based on repairs undertaken as a result of enforcement action. The greater benefit will be attributable to the provisions acting as an incentive to motorists to maintain their cars (and the fact that the provisions are seen to be enforced). However this is unquantifiable since it cannot be separated out from other factors that may motivate motorists to properly maintain their vehicles.

Costs

The costs associated with the smoky vehicle provisions are borne by government in enforcement and motorists in maintenance and repairs.

The cost to government of enforcing the smoky vehicle provisions is estimated to be $0.22 million per year.

To comply with the smoky vehicle provisions, vehicle owners are required to repair their vehicles. The cost of repair related to enforcement is estimated to be $0.84 million per year. Appendix D contains the detailed calculation of these costs.

---

[11] There were 2451 complaints about smoky vehicles to DECCW’s Environment Line in 2008–09.

5.3.3 Vertical exhaust pipe requirement

Description

The vertical exhaust provision was first introduced in 1976 and applies to older diesel vehicles (with some exceptions) built before the introduction of improved heavy vehicle emission standards.[12] As shown in Table 5.1, a significant proportion of commercial diesel vehicles that are still being used were built before the introduction of the ADR 80/00 (Euro3) heavy vehicle emission standard in 2003.

Table 5.1: NSW heavy vehicles on the road manufactured before 2003

Commercial diesel vehicles	Built before 2003
Heavy rigid trucks	67%
Articulated trucks	74%
Light rigid trucks	61%

The aim of the vertical exhaust requirement for diesel vehicles is to disperse diesel vehicle exhaust (especially particulate matter) high into the air away from the level of pedestrians, cyclists and motorists in urban streets. It does this by:

- requiring diesel vehicles over 4.5 tonnes (with specified exemptions) to be fitted with a vertical exhaust (a prescribed anti-pollution device)
- requiring the vertical exhaust to be maintained
- making it an offence for an owner to use (or allow to be used) a vehicle that should have a vertical exhaust as a ‘prescribed anti-pollution device’ but does not – maximum of 400 penalty units for a corporation and 200 penalty units for an individual.

By virtue of the inclusion of a vertical exhaust in the definition of ‘prescribed anti-pollution device’, the anti-tampering provisions relating to anti-pollution devices (see Section 5.3.4) apply.

As a vertical exhaust is a requirement specified in the Regulations, it is an offence under the POEO Act to sell a vehicle that should have a vertical exhaust but does not or where the vertical exhaust has not been maintained.

The proposed provisions relating to the vertical exhaust requirement are exactly the same as the current Regulation except for the following changes relating to exemptions from the requirement:

- updated references to Australian Design Rules (ADRs) to extend beyond ADR 80/01 to new and future ADRs, including ADR 80/02 and ADR 80/03, provided they impose the same or more stringent emission limits as ADR 80/02
- extend automatic exemption from the vertical exhaust requirement to vehicles manufactured before 1 January 2007 that comply with a relevant ADR[13]

[12] Since 2007, all new model diesel vehicles, and since 2008 all new vehicles, need to comply with stricter emission limits set out in the Australian Design Rules.
[13] Only a few vehicles manufactured before 1 January 2007 are compliant with ADR 80/01 or 80/02 emission limits. This amendment will simplify current administrative arrangements and provide a more consistent approach to vertical exemption arrangements, bringing then into line with other ADR-compliant vehicles manufactured after that date which do not require a certificate.

- extend automatic exemption from the vertical exhaust requirement to rigid table-top trucks that are usually garaged on farms and are used predominantly to transport hay or other flammable farm produce.[14]

Each of these changes is considered to be minor.

Benefits

The primary benefits of the vertical exhaust provisions are less direct human exposure to exhaust (especially particulate matter) and improved amenity because of the greater dispersion of diesel exhaust emissions. Although these benefits may be significant, they are not readily quantifiable and have not been estimated.

The position of the exhaust outlet has no effect on regional air quality as exhaust location does not change pollution emission rates. However it helps disperse exhaust emissions and can significantly affect local concentrations of pollutants. Studies have found that the use of a vertical exhaust greatly reduces the concentration of exhaust pollutants at breathing level and thus human exposure to high local concentrations (Colucci & Barnes 1986; Weaver et al. 1986).

Reliable values for the lower health risks due to reductions in daily exposure from roadside air are not available. The heath estimates available relate to changes in pollution in ambient air. At this stage it is not possible to adequately quantify the benefits of reducing roadside exposure.

Costs

The vertical exhaust provisions are generally enforced in conjunction with the smoky vehicle provisions and costs are not separately attributable.

There is no longer any cost for new vehicles to meet this regulatory requirement. From 2007, all new vehicles comply with relevant Australian Design Rules that incorporate more stringent emission controls, superseding the need for the vertical exhaust requirement. Older vehicles that do not meet these standards are still required to fit and maintain a vertical exhaust. The cost of maintaining existing vehicle exhausts on older vehicles can be considered a normal part of a truck maintenance program.

5.3.4 Tampering with anti-pollution devices

Description

The aim of these anti-tampering provisions is to discourage interference with the anti-pollution mechanisms required by law or installed by the manufacturer. It does this by:

- making it an offence for an owner to use (or allow to be used) a vehicle that has been fitted with an anti-pollution device where the device has been removed or adjusted, resulting in the emission of excessive air impurities
- defining 'prescribed anti-pollution device' to encompass systems controlling evaporative emission, fuel supply, engine ignition, engine management, smoke-limiting throttle, exhaust gas recirculation, catalytic converters and vertical exhausts.
- prescribing a notice to repair a vehicle (for use in conjunction with POEO Act motor vehicle provisions).

[14] Currently owners of rural table-top trucks are required to apply for exemption from the vertical exhaust requirement. DECCW receives an average 30 applications a year. Providing automatic exemption will bring a more consistent approach and relieve both the regulatory burden for the rural community and the administrative burden for DECCW.

The anti-tampering provisions complement the POEO Act provisions described in Section 5.1.2 that rely on the definition of excessive air impurities in the Regulation in order to take effect.

The control of emissions from vehicles relies on the efficient operation of either discrete devices or key components of a variety of integrated systems. A number of these are defined as ‘prescribed anti-pollution devices’ and it is an offence for an owner to use (or allow to be used) a vehicle that should have such a device fitted but does not. Once the anti-pollution device has been fitted, the owner cannot use, or allow to be used, a vehicle where the anti-pollution device has been removed or modified.

The proposed provisions relating to anti-pollution devices are exactly the same as the current provisions.

Benefits

As with the smoky vehicle provisions, discouraging tampering with anti-pollution devices on motor vehicles limits the emission of air pollutants from motor vehicles.

Using figures for enforcement actions taken, it is estimated that the anti-tampering provisions lead to the reduction of approximately 0.81 tonnes of particulate emissions each year with an estimated health benefit of $0.05 million to $0.19 million per year based on a health cost range from rural to urban; and 6.36 tonnes of VOCs each year with an estimated health benefit of $0.03 million per year. The majority of the population subject to these provisions is located in Sydney and other urban population centres and, accordingly, the actual benefit is likely to be towards the upper end of the range. Appendix D contains the detailed calculation of these benefits.

It is expected that the greater benefits are achieved through deterrence. However, this is unquantifiable since the extent to which tampering would otherwise occur cannot be estimated.

The anti-tampering provisions also provide safety benefits by reducing the number of vehicles that have been modified to an extent that this may affect safety. This not only relates to the vehicles that are detected and repaired, but also to the modifications that are prevented as a result of the existence of the provision. Modified vehicles may pose a risk to the driver, occupants or other road users by either changing the way the vehicle operates or increasing the risk of fire because of higher levels of petrol vapour in the engine bay. These benefits are not quantifiable.

Costs

To comply with the anti-tampering provisions, vehicle owners are required to repair vehicles found to have their emission system altered. The cost of repair is estimated to be $0.05 million per year.

The cost to government of enforcing the anti-tampering provisions is estimated to be $0.06 million per year. Division 5, Appendix D contains the detailed calculation of these costs.

5.3.5 Automatic overfill protection device

Description

The requirement to install and correctly operate automatic overfill protection devices aims to ensure safety and minimise the escape of VOCs into the atmosphere when motor vehicles are refuelled. It does this by requiring the provision and proper use of automatic overfill protection devices on the nozzles of petrol delivery hoses at service stations.

All new and existing petrol dispensing pumps must be equipped to prevent accidental spills of petrol during the refuelling of a vehicle. To ensure the effective operation of these devices, it is an offence to fill a vehicle's fuel tank unless the nozzle of the hose is inserted as far as it can go into the fuel tank's fill-pipe.

The proposed provisions relating to automatic overfill protection devices are exactly the same as the current provisions.

Benefits

The principal benefit is in the reduction of emissions of VOCs that might otherwise occur without a properly maintained overfill protection device or through careless operation of the petrol delivery hose. As well as controlling localised air toxics, lower evaporative emissions means a potential reduction in ozone formation and the health impacts associated with ozone. The level of emissions avoided is not quantifiable.

By preventing vehicle fuel tanks overflowing, an overfill protection device avoids inadvertent waste of fuel by motorists who are also saved the expense of wasted petrol.

Other benefits include savings in after-spill cleaning costs for petrol station proprietors and vehicle owners. To the extent that spills are avoided, this offers protection from runoff causing water contamination.

Costs

The costs directly attributable to this clause are not likely to be significant, as existing petrol pump nozzle design would probably continue for occupational health and safety reasons to minimise hazards relating to fire risk, exposure to petrol and accidents. Further, nozzles without overfill protection are no longer generally available in the market.

5.3.6 Summer petrol volatility limits

Description

The aim of the summer petrol volatility provisions is to reduce ozone formation by limiting the volatility of petrol supplies in summer. A secondary aim is to reduce the emissions of air toxics. It does this by requiring petrol refiners, importers and blenders to supply petrol to the low volatility zone (Sydney, the lower Hunter and the Illawarra)[15] which meets specified volatility limits in summer (15 November to 15 March) and to also keep records and information indicating their compliance with this.

Petrol is highly volatile and evaporative emissions from motor vehicles, terminals and service stations in summer are significant sources of emissions of VOCs. On an average summer day evaporative emissions of VOCs represent about 30% of total emissions from motor vehicles. This can increase to 60% on very hot summer days.

Limiting the volatility of petrol reduces petrol evaporation and hence emissions of VOCs.[16] Because petrol evaporates more readily when it is hot, control of petrol vapour pressure is only necessary during summer months.

While the Australian Government has established national fuel quality standards as determinations under the *Fuel Quality Standards Act 2000*, it was agreed that the states and

---

[15] Comprising the local government areas of *Sydney* – Ashfield, Auburn, Bankstown, Baulkham Hills, Blacktown, Blue Mountains, Botany Bay, Burwood, Camden, Campbelltown, Canterbury, Canada Bay, Fairfield, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kogarah, Ku-ring-gai, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, North Sydney, Parramatta, Penrith, Pittwater, Randwick, Rockdale, Ryde, South Sydney, Strathfield, Sutherland, Sydney, Warringah, Waverley, Willoughby and Woollahra; *Illawarra* – Wollongong, Wollondilly, Wingecarribee, Shellharbour, Kiama, Shoalhaven; *Hunter* – Gosford, Wyong, Newcastle, Lake Macquarie, Maitland, Cessnock, Singleton, Muswellbrook, Port Stephens, Greater Lithgow.

[16] The vapour recovery systems (VR1 and VR2) described in Chapter 7 also reduce evaporation of VOCs and hence the formation of ozone.

territories would retain responsibility for the management of petrol volatility which takes into account regional climatic and seasonal factors.

All Australian states (apart from Tasmania) apply petrol volatility limits. Sydney and Melbourne have a vapour pressure limit of 62 kPa. Overseas limits are often much lower than those in Australia: in the USA, for example, limits range from 48 kPa to 54 kPa.

Reduced summer fuel volatility is the single largest current measure to reduce ozone formation in summer when ozone exceedences occur. Internal DECCW data indicates that compliance with the existing regulated limits reduces VOC emissions equivalent to removing 20% of cars from the road in summer (over 4000 tonnes each summer). Lowering petrol volatility also reduces air toxics and has greenhouse gas benefits.

A number of factors affect the capacity of local refiners to reliably and consistently produce petrol to a specified vapour pressure limit. These include the availability and price of suitable crude stock, and options for the disposal of product removed from the petrol stream to reduce its volatility.

To accommodate these factors, an averaging approach is used which enables flexibility in production, particularly for local manufacturers. Compliance with the 62 kPa limit in the NSW low volatility zone is based on monthly volumetric average vapour pressure, with the proviso that the vapour pressure of any batch of petrol cannot be more than 2 kPa above this.

Ethanol blends (making up around 20% of all petrol sold in the low volatility zone) have limits set at 7 kPa higher with a maximum allowable vapour pressure of 71 kPa. This is because, although ethanol/petrol blends produce lower particle emissions, the ethanol content increases volatility by 7 kPa for those with a 5–10% ethanol blend. However, VOC emissions from ethanol petrol blends, while higher, are less reactive compared to neat petrol. Similar provisions apply in Queensland and the US.

The present summer petrol volatility limits came into effect in June 2004 and are currently under review in consultation with industry stakeholders.

To enable monitoring of summer petrol volatility limits and the ethanol waiver provisions, petrol suppliers are required to keep records and report monthly to the EPA on petrol vapour pressure.

The proposed provisions relating to summer volatility limits are exactly the same as the current provisions except for the following changes:

- definition of ‘prescribed blended petrol’ changed from 9–10% ethanol content to 4–10% ethanol content: Recent research (CSIRO 2008) shows there is little discernible impact on volatility and the formation of ozone in the NSW GMR between blended petrol containing 5% ethanol or that with 10%. While most ethanol petrol blends are E10, some are supplied as 5% ethanol (E5) and changing the definition will ensure that equally clean E5 blends are not disadvantaged in the marketplace.

  Also, while the Commonwealth has set the upper level of ethanol in petrol in Australia to a maximum of 10% (E10), a lower limit of 4% is set to manage potential water-induced engine operability issues. This lower limit has additional value as prevents suppliers taking advantage of the ethanol waiver provisions by adding negligible amounts of ethanol.

- remove references to superseded 2004 requirements: When summer petrol volatility limits were first introduced, the first year (2004) had a slightly higher limit than subsequently. This interim limit has now been superseded.

These changes are considered minor.

Benefits

Imposing summer petrol volatility limits reduces the emission of VOCs which in turn helps to lower the levels of ozone and air toxics. It is estimated that limits on summer petrol volatility would lead to a reduction of approximately 4554 tonnes of VOCs each year with quantifiable health benefits of $19.12 million per year.

Lower volatility also means less fuel is lost to the atmosphere at service stations and terminals and directly from motor vehicles. This benefits motorists with petrol savings of $2.82 million per year and petrol distributors with $0.31 million per year.

Appendix D contains the detailed calculation of these benefits.

Costs

The costs to industry associated with the limits on summer petrol volatility are estimated to be $11.82 million per year. Costs to government are those associated with monitoring supplier compliance with the vapour pressure limits, estimated at $0.05 million per year. Quantifiable costs total $11.87 million per year. Appendix D contains the detailed calculation of these costs.

5.4 Conclusion

The regulation of motor vehicles and motor vehicle fuels in NSW is an established and effective set of rules designed to complement Commonwealth legislation and is itself complemented by a suite of non-regulatory measures (see Section 5.1.2). Where national measures supersede those in NSW, such as with benzene reporting (see Section 5.1.2), and improved Australian Design Rules, such as with the vertical exhaust requirement (see Section 5.3.3), the NSW legislation is adjusted.

Remaking the Regulation in the proposed form rather than allowing it to lapse would result in a net quantifiable benefit of between $11.75 million and $19.78 million per year. Extensive unquantifiable benefits include improved visual amenity, decreases in offensive odours, and avoidance of damage to buildings, crops and other vegetation. Unquantified health benefits arise in relation to the deterrence effect of the provisions as well as localised health benefits for overfill protection in refuelling and the vertical exhaust requirement.

Remaking the current Regulation in the proposed form is the preferred option as an effective and proportional component of a larger framework for the management of air pollutants from motor vehicles and motor vehicle fuels.

6. Industrial emissions from plant and activities: Part 5

6.1 Background

6.1.1 Need for government action

Industrial air pollution emissions make a major contribution to total air emissions in NSW, significantly affecting ambient and local air quality. Even with existing controls, industry is responsible for approximately 62% of all emissions of particulate matter (PM_{10}) and 60% of the anthropogenic emissions of NO_X in the NSW GMR (DECC 2007b). Industry is also a principal source of air toxics in the region (DECC 2007b).[17]

These substances are associated with significant health and environmental effects (see Appendix C). The emission standards for industrial air pollutants that have been introduced and progressively tightened over the last few decades are responsible for many of the improvements in air quality that NSW currently enjoys.

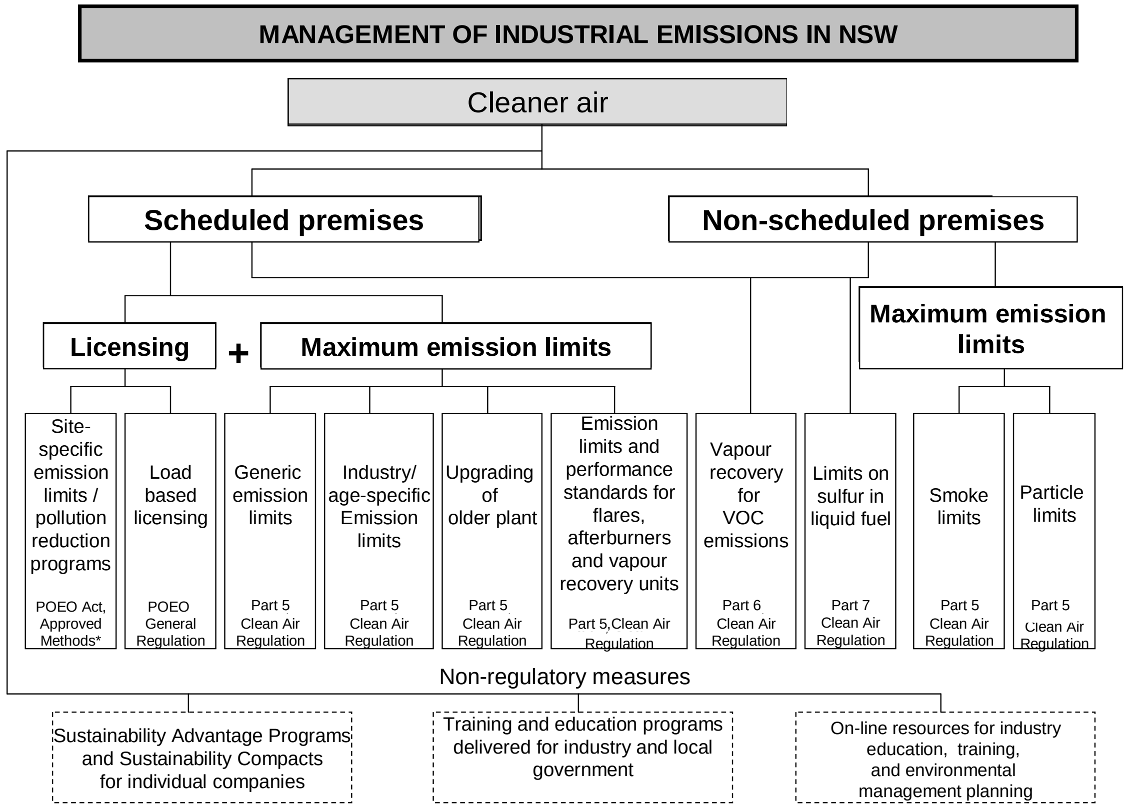
6.1.2 Management of industrial emissions

The current management strategy for industrial emissions in NSW is a mix of prescriptive maximum emission limits and regulatory and non-regulatory incentives, together with a range of programs providing both targeted and generalised assistance to encourage industry to integrate sustainability into its operations (see Figure 6.1).

A range of non-regulatory initiatives is in place to assist and motivate industry to reduce emissions, generally focusing on overall sustainability. This includes the Sustainability Advantage Program which assists businesses that sign up to improve their environmental performance by reducing risks, lowering costs, improving productivity and enhancing reputation (DECCW 2010c). At present, over 380 companies are engaged in the program. A further three companies have entered into a Sustainability Compact with DECCW. These are voluntary agreements with leading Australian companies that operate in NSW involving the joint implementation of sustainability projects that deliver tangible environmental results in the sector in which they operate (DECCW 2010d).

DECCW also provides a range of training courses and resources (including online) for industry and local government on environmental compliance, resource efficiency and sustainability (DECCW 2010d). There are generic courses and resources for all industries as well as those customised to the needs of particular industry sectors. Training courses range from half-day workshops to competency based four-day courses.

[17] Industry produces at least 38 %of anthropogenic emissions of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, tin and vanadium and at least 11 % of anthropogenic emissions of benzene, formaldehyde, polycyclic aromatic hydrocarbons, toluene and xylenes (DECC 2007b).



* Impact assessment criteria in *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005c)

Figure 6.1: Management of industrial emissions in NSW

Regulatory measures

In NSW, industrial air emissions are regulated through the setting of maximum emission limits, together with a licensing system for individual industrial premises. The principal regulatory instrument is the POEO Act, supported by the Clean Air Regulation, which sets maximum emission limits, and the Protection of the Environment Operations (General) Regulation 2009, which allows for load-based licensing.

The POEO Act[18] contributes towards reducing air emissions from industry by:

- requiring industrial emissions to comply with emission standards set in the Clean Air Regulation or, where no standards are applicable, requiring air pollution to be minimised
- requiring environment protection licences for specific premises and activities which may include emission standards additional to, or more stringent than, those specified in the Clean Air Regulation and contain conditions requiring the holder to undertake pollution studies or comply with a pollution reduction program determined by DECCW
- offences for air pollution because of failures in maintenance or in proper and efficient operation or handling
- offences for odours emitted from licensed premises except in accordance with the conditions of the licence.

[18] Sections 48, 49, 68, 124, 125, 126, 128 and 129

Part 5 of the Clean Air Regulation contributes to minimising emissions from industry through:

- generic emission standards as a ‘catch-all’ for all industry
- specific emission standards related to industry and the age of the emissions unit
- a process for reviewing emission standards that apply to older scheduled plant
- performance standards for newer afterburners, flares and vapour recovery units.

The Clean Air Regulation also works to minimise industrial emissions by regulating the storage and distribution of volatile organic liquids (Part 6 – see Chapter 7) and restricting the use of high-sulfur liquid fuel (Part 7 – see Chapter 8).

Parts 2 and 4 of the Protection of the Environment Operations (General) Regulation 2009 (‘the POEO General Regulation’) contributes to minimising emissions from industry by:

- providing incentives for specified industries to reduce emissions through fees based on their emissions load (load-based licensing or ‘LBL’) (DECCW 2010e)
- providing incentives for reducing emissions through load reduction agreements (LRAs), which allow fee rebates in return for measures taken to reduce pollution in the future
- providing for the aggregation of emissions for two or more licences (bubble licence arrangements)
- setting administrative fees for environment protection licences
- establishing administrative and review processes in connection with environment protection licences
- giving effect to the National Environment Protection (National Pollutant Inventory) Measure (NEPC 2008) by requiring the submission of relevant industrial emissions data.

Comparing emission limits under the Clean Air Regulation with those under licensing

The Clean Air Regulation sets maximum emission limits for all industry. Under the POEO Act, many industries (but not all) require an environment protection licence for their activities. An environment protection licence may contain conditions that require specific emission standards more stringent than those that would apply under the Clean Air Regulation.

Under the POEO General Regulation, a subset of holders of environment protection licences are also subject to the LBL scheme which links licence fees to the level of emissions as an incentive to reduce emissions and limit annual pollutant loads.

Whereas LBL focuses purely on the annual mass of pollutants, the Clean Air Regulation also targets localised and acute impacts of emissions. It applies short-term concentration standards to individual stacks at the point of discharge to the atmosphere and reflects the proper and efficient operation of the technology installed. This sets a minimum standard of performance to reduce the risk of localised and acute pollution episodes in addition to longer term impacts.

Table 6.1 summarises the role of the Clean Air Regulation, the licensing provisions of the POEO Act and the POEO General Regulation in reducing emissions at licensed activities.

Table 6.1: Emission standards for industry under the Clean Air Regulation, POEO Act and POEO General Regulation

<table>
<tr><th colspan="2">Point of discharge standards</th><th rowspan="2">POEO General Regulation: Load-based licensing</th></tr>
<tr><th>Clean Air Regulation</th><th>POEO licences</th></tr>
<tr><td>Applies to all activities</td><td>Applies to licensed activities</td><td>Applies to a subset of licensed activities</td></tr>
<tr><td>Sets emission concentration standards as minimum performance standards</td><td>Sets emission concentration standards at the same or more stringent levels</td><td>Sets fees by reference to annual emission loads to create an incentive to reduce loads emitted</td></tr>
<tr><td colspan="2">Applies to individual emission points</td><td>Applies to entire premises or sites</td></tr>
<tr><td colspan="2">Emissions averaged for specified periods</td><td>Emission load over 12 months</td></tr>
<tr><td colspan="2">Protects against localised and acute impacts of emissions; protects local air quality; protects ambient air quality against cumulative increases in emissions</td><td>Protects ambient air quality against cumulative increases in emissions</td></tr>
<tr><td colspan="2">No aggregation</td><td>Option for aggregation of LBL emissions for more than two licences (with approval of EPA)</td></tr>
</table>

6.1.3 Range of options

Two options for government action are given detailed consideration below:

- no Regulation – discussed in Section 6.2
- the proposed Regulation – remake Part 4 of the Clean Air Regulation in its current form with some minor typographical and clarification changes as Part 5 of the proposed Regulation, as discussed in Section 6.3.

6.2 Option 1: no Regulation (base case)

6.2.1 Introduction

Part 5 of the Clean Air Regulation is the foundation of a number of regulatory measures designed to maintain and improve public health and the environment through the control of industrial pollutants.

In the absence of the Regulation, there are a number of alternative regulatory mechanisms that might, to varying extents, be used to contribute to the goal of improved air quality by avoiding short-term localised emissions from industry. These alternatives are significantly more resource-intensive for both government and industry and, at the same time, achieve poorer health outcomes.

The benefits and costs set out in Section 6.3 represent the cost and benefits, respectively, of not remaking the Regulation.

6.2.2 Scheduled premises emission standards – no Regulation

Allowing the Regulation to lapse would remove the maximum emission limits for the main air pollutants, together with requirements to upgrade the oldest plant and meet improved emission standards upon replacement of plant in the Greater Metropolitan Area (as defined in

Section 3 of the proposed Regulation) or its alteration. The benefits and costs of emission standards for scheduled premises set out in Section 6.3.2 would represent the costs and benefits, respectively, of allowing the current Regulation to lapse.

For scheduled premises – where an environment protection licence is required to carry on an activity – the principal alternative regulatory mechanism is to specify emission standards in the licence. About a third of licences already contain one or more site-specific emission standards. These may be the same or more stringent than the relevant standards prescribed in the Clean Air Regulation. As outlined in DEC 2005a, site-specific emission standards may be included in an environment protection licence to take into account:

- existing ambient levels of a pollutant
- local topographic and meteorological factors
- proximity of public facilities or residential areas
- levels of toxicity.

Emissions could also be controlled to an extent by the general provisions of Part 5.2 of the POEO Act that create offences for polluting. The most serious offences attract penalties of up to $5 million and 7 years' gaol. Use of these provisions would be reactive and involve a very significant administrative burden for the EPA.

Section 128(2) of the POEO Act requires, in the absence of specific emission standards, the use of such 'practicable means' as may be necessary to prevent or minimise air pollution. There are a number of problems in relying on this general provision:

- The absence of an emission standard removes the need for emission control equipment to achieve a minimum performance level and thus provides no incentive for development of the best available technology or sourcing it in the market. This ultimately limits the practicable means of emission control available.
- 'Practicable means' is not defined in the POEO Act and switches the focus from the level of emissions to how practicable it is to control emissions for an individual emissions point. It would involve determining what constitutes the best practicable means in a case-by-case approach.

In the absence of the Regulation, the requirement that existing industry use all practicable means to control emissions would not increase emissions immediately since maintaining existing emission controls is clearly within the meaning of 'practicable'. Further, Sections 124–126 of the POEO Act require 'proper and efficient' operation and maintenance of plant and handling of materials in order to avoid committing an offence when emitting air impurities.

For new industry, in the absence of the Regulation, sourcing plant with appropriate controls is also likely, at present, to come within the meaning of practicable means. However, over time it may be anticipated that there would be a gradual deterioration in emission levels for pollutants and that the parameters of the term 'practicable' would be tested using cost as a factor.

Some, but not all, industries may gain a benefit from reduced costs by acquiring plant that is not equipped with emission controls. Offsetting this benefit would be additional compliance costs relating to the need for each emissions point to be assessed against the practicability test rather than by reference to set emission standards. Regulatory compliance costs are a significant factor in investment decisions.

The remaining offences do not deal with the acquisition of plant but focus instead on keeping a working system in good order and designed to complement other regulatory provisions.[19] The extent to which alternative regulatory mechanisms may be successfully used is speculative and cannot be assessed quantitatively.

6.2.3 Non-scheduled premises emission standards – no Regulation

For non-scheduled premises – small commercial and manufacturing businesses regulated by local government – the current Regulation is the only source of specific emission standards for smoke and solid particles. The benefits and costs of emission standards for non-scheduled premises set out in Section 6.3.3 would represent the costs and benefits, respectively, of allowing the current Regulation to lapse.

As with scheduled premises, in the absence of the Regulation, there are a number of pollution offences that could be used to regulate non-scheduled premises. See Section 6.2.2 for a discussion of these alternatives and the impacts for government and industry. The deficiencies in relying on enforcement as the primary regulatory option are heightened in the absence of a licensing regime.

6.2.4 Performance standards: afterburners, flares and vapour recovery units – no Regulation

Without the Regulation, there would be neither performance standards nor maximum emission limits for afterburners, flares and vapour recovery units. These controls principally limit VOC, sulfide and odour emissions as well as a number of other pollutants.

Since emission standards for afterburners, flares and vapour recovery units are in place for scheduled premises only, the impacts described in Section 6.2.2 apply. Additional emissions may be attributable to the absence of performance standards for afterburners, flares and vapour recovery units that would otherwise ensure that these facilities are designed and operated for maximum efficiency. These emissions have not been quantified.

6.3 Option 2: the proposed Regulation

6.3.1 Introduction

The aim of Part 5 of the proposed Regulation is to reduce industrial emissions. It does this by setting maximum emission limits by industry category and the age of plant, complementing the role of the environment protection licence in its capacity to set customised emission standards and load-based fee incentives (see Table 6.1). These measures are:

- industry-specific emission standards for scheduled premises, where the occupier is required to hold an environment protection licence
- generic emission standards as a ‘catch-all’ for all premises, both scheduled and non-scheduled

[19] Offences for air pollution where it is caused by the failure to maintain plant in an efficient condition or failure to operate plant in a proper and efficient manner, failure to carry out maintenance work in a proper or efficient manner, failure to deal with materials in a proper or efficient manner, and, for licensed premises, emitting odours except where those emissions are in accordance with the licence: Sections 124, 125, 126 and 129 of the POEO Act

- emission standards differentiated by age, with standards for new plant, and within the GMA replacement plant, that reflect contemporary technology
- a process for reviewing emission standards that apply to older scheduled plant
- a requirement that when any emissions unit on a scheduled premises is altered, it will meet contemporary emission performance standards
- performance standards for newer afterburners, flares and vapour recovery units.

The proposed Part 5 is exactly the same as Part 4 of the current Regulation except for some minor typographical and clarification changes. A listing of the changes is provided in Appendix B. There are also very minor drafting adjustments which have not been itemised.

The regulation of industrial emissions in NSW is the most highly developed and streamlined system in Australia. The state has the largest population and is host to a large proportion of the nation's industry. This means that getting the regulation of industrial emissions right is important for health and environmental costs associated with a larger population.

NSW and Victoria have adopted similar emission standards based on the same data. In addition NSW has a regulatory framework for upgrading older plant and equipment (linked to maintenance and repair cycles) so that industry has certainty for forward planning. At the same time, flexibility in the system allows exemptions from upgrading, where appropriate. Other Australian jurisdictions adopt a mix of approaches including 'best practice' (or 'most appropriate') technology, tailored regulatory requirements for each activity based on technology, and regulation by industrial area or types of activity. Significantly, a recent review of the regulation of industrial emissions in South Africa, including a comparison of international regulatory regimes, recommended adoption of the NSW system of regulation (South African Department of Environmental Affairs and Tourism 2009).

Sections 6.3.2–6.3.4 discuss the specific provisions of Part 5 in detail.

Schedules 2, 3, 4 and 6 of the proposed Regulation set out the maximum emission limits. Table 6.2 summarises the applicable emission standards that apply to various industry categories.

Table 6.2: Applicable emission standards according to industry category

Standards of concentration		Additional regulatory requirements
Scheduled premises: Occupier required to hold an environment protection licence (activities listed in Schedule 1 of the POEO Act)		
Afterburners, flares and vapour recovery units	Schedule 2	For Group 6 only: Division 4 – design and operational specifications
Industry-specific standards	Schedule 3	–
General plant and activity standards	Schedule 4	–
Non-scheduled premises: Occupier not required to hold an environment protection licence (activities not listed in Schedule 1 of the POEO Act)		
All plant (including marine vessels) and activities in connection with the burning of fuel	Schedule 6 (smoke concentrations)	–
All other plant and activities	Schedule 6 (solid particle concentrations)	–

Within each Schedule, emission standards are differentiated according to the date an activity or plant commenced operation. Table 6.3 sets out the applicable 'groupings' of emission standards based on date of commencement.

Table 6.3: Emission standards according to date of commencement

	Scheduled premises				Non-scheduled premises	
Time period	**Default**	**Transition**	**Replacement (GMA only)/ Alteration**	**Lower standard for licence variation***	**Default**	**Replacement (GMA only)**
Before 1 Jan 1972	Group 2	Group 5 from 1 Jan 2012	Group 6	Group 1**	Group A	Group C
1 Jan 1972–30 June 1979	Group 2	Group 5 from 1 Jan 2012	Group 6	Group 2		
1 July 1979–30 June 1986	Group 3	N/A	Group 6	Group 3		
1 July 1986–31 July 1997	Group 4	N/A	Group 6	Group 4		
1 Aug 1997–31 Aug 2005	Group 5	N/A	Group 6	Group 5	Group B	Group C
On or after 1 Sept 2005	Group 6	N/A	Group 6	N/A	Group C	Group C

* Licence variations may apply to standards in relation to the alteration or replacement of emission units (Group 6) or the transition of standards from Group 1 to Group 5.
** Under the current Regulation, former Group 1 plant became subject to Group 2 standards on 1 January 2008. Licence variations allow some plant to retain former Group 1 standards.

6.3.2 Scheduled premises emission standards

Industrial premises are known as 'scheduled premises' where the occupier is required to hold an environment protection licence under Schedule 1 of the POEO Act. A broad spectrum of industries is required to hold environment protection licences because of their potential to have a significant impact on the environment.

Description

The aim of setting maximum emission limits for scheduled premises is to curb the emission of specified pollutants that have a significant impact on air quality, reducing the risk of acute local episodes of the discharge of pollutants and improving ambient air quality. The pollutants with maximum emission limits imposed were selected because of their potential to significantly impact air quality by assessing their typical volumes, frequency of emissions and inherent toxicity.[20]

[20] The specified pollutants are solid particles (total); nitrogen dioxide or nitric oxide or both (as NO_2 equivalent); sulfur dioxide, sulfuric acid mist or sulfur trioxide or both (as SO_3 equivalent); hydrogen sulfide; fluorine and any compound containing fluorine (as total fluoride HF equivalent); chlorine; hydrogen chloride; hazardous substances – Type 1 (in aggregate); hazardous substances – Type 1 and Type 2 (in aggregate); cadmium or mercury individually; dioxins or furans; VOCs. Type 1 substances are antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those

Section 128 of the POEO Act prohibits exceedence of the standards set in the Clean Air Regulation. For scheduled industry, these standards vary according to the activity or industry category and pollutants emitted; age; requirements for upgrading; and approved variation for emission standards. The groupings and dates are set out in Table 6.3.

Depending on which activity or industry is involved and the types of emissions, one of three sets of maximum emission limits for some or all of the specified pollutants is prescribed:

- for afterburners, flares and vapour recovery units – Schedule 2
- industry-specific standards – Schedule 3
- general standards for emissions not otherwise specified in Schedules 2 and 3 – Schedule 4.

In order to measure emissions for the purposes of the Regulation, procedures and methods have been prescribed for:

- determining whether emission standards have been exceeded, using the test methods, averaging periods and reference conditions specified in Schedule 5 of the proposed Regulation
- additional test methods for dioxins and furans, together with specification of the toxic equivalence factors for dioxins and furans for the purpose of meeting emission standards
- sampling, analysis and monitoring through *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW* (DECC 2007c)
- methods of dispersion modelling and assessment through *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005a).

Benefits and costs

All stakeholders benefit from transparent government decision-making via stated maximum emission limits determined through the consultative processes involved in making or remaking a Regulation. Prescribing standards for the emission of pollutants ensures that existing industry maintains and replaces emission control equipment that meets a specified minimum standard. These standards are set on a graduating scale, depending on when the activity started. This benefits the community in improving air quality while, at the same time, keeping capital costs for industry at a minimum by requiring emission standards that were achievable through technology available at the date of commencement or upgrading cycles.

For industry, maximum emission limits have the following benefits:

- They set a level playing field, providing both equity as well as certainty for industry in making investment decisions.
- They promote technological advances in emission controls and processes by providing stable markets for products with the requisite design features.
- They avoid the need for each licensee to negotiate separate emission standards for each relevant pollutant.

Maximum emission limits also provide an efficient mechanism for government regulation by avoiding the need to negotiate and set individual standards with each licensee. The majority of industrial emission stacks in NSW are regulated only through the Clean Air Regulation, without which emission limits for each relevant pollutant would need to be incorporated in the environment protection licence.

---

elements. Type 2 substances are beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements.

Since PM_{10} and ozone levels are regularly exceeded in the NSW GMR, they are the two pollutants of greatest concern. Industry accounts for the largest proportion of NO_X emissions (a precursor for ozone) and a significant proportion of PM_{10} emissions (see Appendix C). Accordingly, emissions of PM_{10} and NO_X have been selected as the basis for modelling projected emissions and estimating health costs. Division 7 of Appendix D outlines the methodology used to estimate the reduced emissions and provides the detailed calculation of the benefits and costs. The damage cost estimates per tonne used to calculate the benefit of these avoided emissions are presented in Division 1 of Appendix D.

The health benefit from reduced PM_{10} emissions as a result of the Regulation is estimated to be between $801 million and $3377 million over 20 years at present values. Similarly, the cost of abatement for industry of PM_{10} emission limits is estimated at $5 million over 20 years.

The health benefit from reduced NO_X emissions as a result of the Regulation is estimated to be between $17 million and $118 million over 20 years at present values. Similarly, the cost of abatement for industry for NO_X emission limits is estimated at $13 million over 20 years.

Although there are significant additional health benefits attributable to the control of other pollutants, particularly given their high toxicity levels relative to PM_{10} and NO_X, it is not possible to separate out quantitatively the benefits of controlling these from PM_{10} and NO_X. This is because:

- Many health impacts are similar, and not necessarily cumulative, which could lead to double-counting.
- Emission standards for the other pollutants are frequently replicated (and sometimes tightened) in site-specific emission standards in the relevant environment protection licences, particularly newer licences, and this makes it difficult to allocate benefits and costs between the regulatory measures in the proposed Regulation and the substantive regulatory measures in the POEO Act.
- The emissions of some pollutants (such as fluorine, hydrogen sulfide, sulfuric acid mist and sulfur trioxide) may also be reduced by occupational health and safety measures.

The benefits and costs attributable to the control of other pollutants are therefore assessed *qualitatively* in Table 6.4.

Table 6.4: Other pollutants with maximum emission limits

Emission sources[a] and health and environmental impacts	Abatement
Sulfur dioxide	
See Division 6, Appendix C	Controlled largely through the POEO General Regulation by requiring use of low-sulfur coal. Costs not separately attributed to proposed Regulation. Sulfur is also controlled through Part 7 of the proposed Regulation by requiring the use of low-sulfur fuel.
Sulfuric acid mist/sulfur trioxide	
Sources: Used widely across industry in a variety of applications, including metal smelters, phosphate fertiliser producers, oil refiners and the chemical industry **Impacts:** Discussed in Division 6, Appendix C	Abatement costs generally included in the cost of controlling other pollutants. These emissions are generally a subset of those that emit sulfur dioxide and emission control equipment (such as scrubbers) is common. Augmentation of this equipment may be required to meet emission standards.

Emission sources[a] and health and environmental impacts	Abatement
Dioxins and furans	
Sources: Formed in many combustion processes where organic materials and materials containing chlorine are present, such as metallurgical processing and electricity generation **Impacts:** They resist degradation and are known as persistent organic pollutants. Linked to impairment of the immune system, the developing nervous system, the endocrine system, reproductive functions and the risk of cancer.[b] High concentrations of dioxins and furans in agricultural products may have implications for international trade.[c]	Abatement controls needs to be tailored to the process in question. Can be achieved through process controls, engineering modifications and cleaner production principles. For some facilities, the principal means of abatement is through the control of other pollutants, such as particulates and acid gases. Hence, abatement costs cannot necessarily be attributed to controlling dioxins and furans alone.
Metals	
See Division 7, Appendix C	Metals occurring in the atmosphere are primarily solid particles, so equipment used to control particles may also be used for them.[d] Compliance with solid particle emission limits also generally meets metal emission limits. Emission standards are replicated in the environment protection licence, particularly for newer facilities. Hence abatement costs cannot necessarily be attributed to the Regulation.
Hydrogen sulfide (H_2S)	
Sources: Include electricity generators, oil refineries, pulp and paper mills, sewage treatment plants, cement kilns, waste landfills, coke ovens, sulfur products and hydrogen sulfide and asphalt production **Impacts:** H_2S has adverse odour and amenity impacts. Exposure at low levels can cause eye and respiratory irritation, nausea, and shortness of breath. Higher concentrations tend to be fatal. H_2S is highly toxic to aquatic life, birds and mammals.	Emission standards (particularly for newer facilities) are replicated in the environment protection licence. Control equipment for H_2S emissions is also used for a number of pollutants, including sulfur dioxide and sulfur acid mist. Hence abatement costs cannot necessarily be attributed to the Regulation. The Regulation also allows site-specific H_2S emission standards to be set, where warranted[e] such as where it can be demonstrated that a facility's stack is high enough to allow less stringent standards. This introduces a flexibility that could reduce incremental costs should any be incurred.

Emission sources[a] and health and environmental impacts	**Abatement**
Fluorine (F_2)	
Sources: Industries that manufacture fluorine or use it in production include the aluminium industry, oil drilling and refining, the chemical and plastics industries, agricultural and pesticide chemical manufacturers, glass and dye manufacturers, and manufacturers of metal parts **Impacts:** At low levels, F_2 or hydrogen fluoride gas can irritate the eyes, skin and lungs. At high levels, these gases can cause muscle spasms, harm the lungs and heart and cause death. Even at relatively low concentrations, F_2 can cause yellowing of leaves and reduce plant growth.	Emission standards are replicated in the environment protection licence (particularly for newer facilities) so abatement costs cannot necessarily be attributed to the Regulation.
Hydrogen chloride (HCl)	
Sources: Both prepared for commercial use and a by-product of the manufacture of chlorinated organic chemicals. Major point sources of HCl include manufacturers of industrial inorganic chemicals, electric services, combustion of fuels and refuse incineration. **Impacts:** HCl released into the atmosphere as a gas undergoes wet and dry deposition, and is readily incorporated into cloud, rain and fog water, forming a component of acid rain. It can also contribute to the processes that cause photochemical smog.	Emission standards are replicated in the environment protection licence (particularly for newer facilities) so abatement costs cannot necessarily be attributed to the Regulation.
Chlorine (Cl_2)	
Sources: Industries producing, using or handling Cl_2 such as the manufacture of chlorinated organic chemicals, plastics and chlorinated lime **Impacts:** Inhalation of small amounts of Cl_2 causes few or no symptoms. In larger amounts, Cl_2 is a powerful respiratory irritant, especially for people with breathing and lung conditions. In high concentrations, Cl_2 causes emphysema and damage to blood vessels in the lungs, and cardiac arrest may occur secondary to oxygen deficiency.	Advances in technology mean that the emission standard for Cl_2 is relatively easily achieved and costs for emission control equipment can be offset to a degree by the recovery of Cl_2 from production processes. Moreover, particularly for newer facilities, emission standards are replicated in the environment protection licence. This means that abatement costs cannot necessarily be attributed to the Regulation.

Emission sources[a] and health and environmental impacts	Abatement
VOCs	
See Division 4, Appendix C	These emission standards are not expected to have a significant impact on industry as increasing combustion efficiency is sufficient to reduce VOC or carbon dioxide emissions to the proposed regulatory standards. Increasing combustion efficiency usually provides a net benefit to industry through more efficient use of fuel.

[a] DEWHA 2009
[b] DEH 2004 and WHO 2010
[c] WHO 2010
[d] Possible rare exceptions are emissions of cadmium (Cd) and mercury (Hg) vapours from non-combustion processes with alternative control options, including installation of a chemical scrubber or reducing the Cd or Hg content of fuel used.
[e] To date, only one facility has taken advantage of this provision.

The costs of monitoring, testing and reporting costs for industry and the costs of DECCW administration and enforcement are distributed between monitoring of licence conditions under the POEO Act, the LBL scheme and the proposed Regulation.

6.3.3 Non-scheduled premises emission standards

Non-scheduled industrial premises are those where the occupier is not required to hold an environment protection licence under the POEO Act. They are principally small-scale commercial or manufacturing premises such as dry-cleaners, clothing manufacturers, service stations, hospitals or marine vessels which are regulated by the relevant local government authority.

Description

The aim of setting emission standards for non-scheduled premises is to limit the impact of particle pollution on air quality, reducing the risk to local communities from both site-specific particulate matter and significant ambient levels of particulate matter accumulated from multiple small sources. These standards are set by:

- prescribing maximum emission limits for concentrations of solid particles and smoke for the purposes of Section 128 of the POEO Act which prohibits exceedences of those limits) –

  smoke from the burning of solid fuel, differentiating ‘approved circumstances’ (see below) or otherwise

  smoke from the burning of liquid or gaseous fuel, differentiating ‘approved circumstances’ (see below) or otherwise

  solid particles, except where the minimum standards for smoke apply

- setting out ‘approved circumstances’ where smoke emissions are permitted to reach a different maximum limit, taking into account essential higher emission phases such as the start-up of plant
- differentiating emission standards according to the commencement date for a plant or activity:

  Group A – before 1 August 1997

Group B – between 1 August 1997 and 31 August 2005

Group C – on or after 1 September 2005

- setting out the procedures for determining whether prescribed standards of concentration have been exceeded.

Unlike the regulatory regime for scheduled premises, there is no requirement for existing industry to upgrade to more stringent emission standards, although upon replacement, an emission unit in the GMA belonging to Group A or Group B is then regarded as belonging to Group C.

Benefits

Maximum emission limits for smoke and solid particles have the following benefits for health and the environment, industry and government.

Health and the environment

Smoke and particle emissions (including metals) affect health, amenity, visibility and ecosystems: see Divisions 2 and 7 of Appendix C.

Estimated quantifiable benefits in the form of avoided health costs are between $91 million and $382 million over 20 years at present values. See Appendix D for more details.

Industry

Setting maximum emission limits provides a streamlined regulatory system for industry by:

- setting a level playing field, providing both equity as well as certainty for industry in making investment decisions
- promoting technological advances in emission controls and processes by providing stable markets for products with the requisite design features.

Government

Maximum emission limits provide efficiencies in government regulation by significantly reducing potential administrative costs and avoiding over-reliance on enforcement provisions (see Section 6.3.2).

All stakeholders

All stakeholders benefit from a system that promotes transparency in government decision-making through making known the minimum standards that would be applied and, through the consultative processes involved in making or remaking a Regulation, permitting broad stakeholder involvement.

Costs

The potential costs associated with smoke and particle emission standards for non-scheduled industry would be borne by industry for equipment and maintenance costs and by government for enforcement.

Monitoring and enforcement of non-scheduled activities is generally the responsibility of local government (see Section 6, POEO Act) but it is not possible to separately quantify the extent that these responsibilities are carried out in response to the Clean Air Regulation from the process of integrated development applications and the provisions of the POEO Act.

Existing plant that is replaced in the GMA would have the replacement plant subject to the Group C particles emission standard. The estimated costs associated with replacing equipment in the GMA and for new industry are $0.53 million over 20 years. See Appendix D for more details.

6.3.4 Performance standards: afterburners, flares and vapour recovery units

The aim of performance standards for afterburners, flares and vapour recovery units is to complement the emission standards of Schedule 2 of the proposed Regulation by guiding the future design of them.

This is done by setting performance standards (or design goals) for the operation of Group 6 plant (those that commenced after 1 September 2005) relating to residence times, combustion temperature and destruction efficiency, and setting operational parameters.

These performance standards ensure the most efficient performance of these facilities. The cost of meeting these performance standards is not additional to the costs of meeting the Group 6 emission standards since their role is principally to assist in meeting those standards. They are intended to guide the design of new equipment and, having been in place since 2005, any design modifications originally required should already be incorporated as standard. Accordingly, there would be negligible additional cost to industry and the benefit of a reduction in emissions is included in the estimated presented in Section 6.2.2.

6.4 Conclusion

Remaking Part 5 of the current Regulation would provide continuity of a proportional and effective regulatory system that is designed to act as a foundation for the control of industrial pollutants and complement a range of both incentive-based and prescriptive regulatory and non-regulatory measures in improving air quality.

Quantifiable costs and benefits relate to emissions control equipment and improved health, respectively. For scheduled industry, quantifiable costs and benefits cover PM_{10} and NO_X. It is estimated that the proposed Regulation would deliver a net benefit of between $801 million and $3478 million over 20 years. For non-scheduled industry, quantifiable costs and benefits cover $PM_{10.}$ It is estimated that the proposed Regulation would deliver a net benefit of between $90 million and $381 million.

The no-regulation option for industrial emissions for scheduled industry would increase both red tape and government and industry costs because regulatory alternatives would involve setting site-specific emission standards on a case-by-case basis.

Extensive unquantifiable benefits include:

- improved visual amenity, decreases in offensive odours, avoidance of damage to buildings, crops and other vegetation, and reduction in the contribution of ozone formation to global warming
- improved human health from the control of the range of pollutants (in addition to controls on particles and NO_X quantified above), especially in the avoidance of localised emissions
- a streamlined and transparent regulatory system providing certainty for industry for compliance and investment decisions, together with efficiencies in pollution regulation by government.

7. Control of volatile organic liquids: Part 6

7.1 Background

7.1.1 Need for government action

Volatile organic liquids (VOLs), including petrol, contain VOCs that evaporate inside a storage vessel, saturating the air space above the liquid.[21] When a storage vessel for volatile organic liquids, such as a tank or tanker, is refilled, these vapours are displaced by the incoming liquid and, unless controlled, escape into the atmosphere as VOCs, contributing to the formation of ozone.

Vessels storing VOLs are found in a range of industries that consume, produce, store or transport VOLs, including the petroleum, petrochemical, chemical and bulk storage industries. VOC emissions can occur at three points:

- from road tankers being filled at a terminal
- from underground storage tanks during delivery of petrol by road tankers to service stations
- from fuel tanks when vehicles are filled at a petrol service station – the vapours displaced are the source of the visible haze and strong odour evident at petrol dispensers when vehicles refuel.

In 2007, service stations in the Sydney region emitted over 7500 tonnes of VOCs, or about 4–5% of the region's total human-related VOC emissions. These emissions from service stations are increasing with fuel usage at a rate of about 1.5% per year. With the tightening over time of national vehicle emission standards, refuelling emissions have increased relative to other vehicle-related emissions commensurate with the growth in fuel use (DECCW 2009b).

As well as contributing to ozone formation, VOCs in petrol vapour can have direct impacts on the health and amenity (odour) of service station employees and people living and working nearby. Petrol contains up to 1% benzene, a human carcinogen. There is no safe level of human exposure to benzene, which has been linked to an increased incidence of leukaemia with long-term exposure.

Recent Australian research has found that vehicle refuelling is associated with exposure to benzene concentrations up to 1000 times higher than typical ambient concentrations (Horton et al. 2006). The research also found that vehicle refuelling makes the most significant contribution to the population's non-occupational exposure to benzene, accounting for 85% of it during summer.

7.1.2 Management of volatile organic liquids

In the Clean Air Regulation, VOLs are managed through Stage 1 vapour recovery (VR1) controls, which cover storage and distribution of VOLs in underground storage tanks and road tankers, and Stage 2 vapour recovery (VR2) controls, which apply to the refuelling of vehicles at service stations.

---

[21] Organic liquids in the petroleum industry, such as petrol and crude oil, are mixtures of hydrocarbons having dissimilar true vapour pressures. Organic liquids in the chemical industry, such as benzene or a mixture of isopropyl and butyl alcohols, are composed of pure chemicals or mixtures of chemicals with similar true vapour pressures.

Large storage tanks have been covered by VR1 controls in the Sydney, Newcastle and Wollongong Metropolitan Areas since 1986. Since this time, VR1 controls have also applied to distribution terminals, smaller storage tanks[22] and large road tankers, but only in the Sydney Metropolitan Area. Under provisions for petrol service stations introduced in the Protection of the Environment Operations (Clean Air) Amendment (Vapour Recovery) Regulation 2009, VR1 is now being extended throughout the Illawarra and lower Hunter regions, as well as the Blue Mountains.

A number of new and newly refurbished service stations in the Newcastle, Central Coast and Wollongong regions have installed VR1, even though this has not previously been a legal requirement. This has been done for occupational health and safety reasons, and because it is cost-effective to do so when fuel is delivered by road tanker from a terminal in the Sydney region.

VR2 technology was introduced in Europe and the United States in the early 1990s and is required in numerous countries where petrol vapour emissions are also the cause of local and regional air pollution. As introduced in the 2009 amendments to the current Regulation, VR2 controls will be phased in from July 2010 in the metropolitan areas of Sydney, Newcastle, Wollongong and the Central Coast.

The use of VR1 and VR2 technology is considered best practice for the management of petrol vapour at petrol stations.

7.1.3 Range of options

Two options for government action are given detailed consideration below:

- no Regulation – discussed in Section 7.2
- the proposed Regulation – remake Part 5 of the Clean Air Regulation in its current form as Part 6 of the proposed Regulation, as discussed in Section 7.3.

A comprehensive review of the vapour recovery provisions contained in Part 6 of the Clean Air Regulation, as they apply to petrol service stations, was conducted over the period 2002 to 2009, involving extensive stakeholder consultation and culminating in extensive amendments to these provisions in November 2009.

7.2 Option 1: no Regulation (base case)

7.2.1 Introduction

Allowing the current Regulation to lapse is likely to lead to deterioration in air quality with consequential impacts on public health and the environment. There are no alternative regulatory mechanisms for petrol service stations. VOC emission standards are currently included in the environment protection licences of some petroleum refineries and bulk storage facilities.

The benefits and costs set out in Section 7.3 would represent the costs and benefits, respectively, of not remaking the Regulation. The calculations were made without offsetting the costs and benefits involved in the use of environment protection licences as an alternative regulatory mechanism for VR1 controls on petroleum refineries and bulk storage facilities.

[22] With a capacity of between 8 kilolitres and 150 kilolitres

7.2.2 Stage 1 vapour recovery: storage and distribution – no Regulation

In the absence of a regulatory requirement, the response from industry is likely to be uneven. For petrol storage and distribution, it is likely that allowing the Regulation to lapse would not significantly change existing VR1 systems, which are often relied on to satisfy other requirements like occupational health and safety, fuel recovery and emission fee reductions as part of load reduction agreements (see Section 6.1.2). For industries other than petrol storage and distribution, VR1 may be removed or the maintenance of equipment may decline over time, reducing its effectiveness.

7.2.3 Stage 2 vapour recovery: vehicle refuelling – no Regulation

The benefits and costs of VR2 set out in Chapter 7.3.3 would represent the costs and benefits, respectively, of allowing the current Regulation to lapse.

The no-Regulation option would also result in continued costs from localised exposure to air toxics and damage to visual amenity and the built and natural environment. Appendix C details the health and environmental effects of these air pollutants.

No alternative regulatory mechanisms are available to achieve the same objectives as the proposed Regulation.

7.3 Option 2: the proposed Regulation

7.3.1 Introduction

The aim of Part 5 of the current Regulation is to reduce emissions from service stations and vessels storing VOLs. Under the proposed Regulation, the existing part 5 would be remade as Part 6, as amended in 2009 except that the actual date of commencement of Division 5 of this Part has been included where relevant. These changes have not been itemised.

The requirements for VR1 and VR2 controls are subject to minimum thresholds that exempt some facilities from compliance.

7.3.2 Stage 1 vapour recovery: storage and distribution

Description

The aim of the Stage 1 vapour recovery controls (VR1) is to reduce the emission of VOCs during storage and distribution of VOLs. It does this by:

- requiring that equipment or plant is only used or operated with prescribed mandatory control equipment fitted and specifications for installation, commissioning, operation, maintenance and decommissioning are complied with (unless exempted in writing by the EPA)
- requiring adherence to compliance mechanisms in the form of periodic testing, log books and reporting to the EPA for VR1 controls phased in from 1 July 2010
- prescribing mandatory control equipment for storage tanks, distribution terminals, large road tankers and petrol service stations.

Controls that are currently in force have been in place since 1986. Other controls are being phased in over a four-year period. This is in order to minimise compliance costs and permit owners of existing equipment or premises to align VR1 installation with scheduled refurbishment (DECCW 2010f).

Additional requirements (as required by the proposed Regulation), together with guidelines, are set out in *Standards and Best Practice Guidelines for Vapour Recovery at Petrol Service Stations* (DECCW 2009c) and referred to as ‘Standards and Guidelines’ in Part 6, subdivision 2 of the proposed Regulation.

Benefits

VR1 control equipment limits the emission of VOCs (and therefore the formation of ozone), including air toxics. The quantifiable emission reductions attributable to new VR1 systems installed as a result of the phase-in of VR2 are included in the estimates for VR2. Existing VR1 systems would not be expected to be un-installed if there was no Regulation: most would remain in operation for safety and VOL recovery reasons.

Costs

For new VR1 systems, the costs to industry of installation are included in the estimates for VR2. For those facilities that do not install an automatic monitoring system, there may be a marginal additional cost of monitoring and reporting. Existing VR1 systems incur costs for operation, maintenance and replacement, but the value of the recovered VOLs is considered to exceed these.

7.3.3 Stage 2 vapour recovery: vehicle refuelling

Description

The aim of the VR2 controls is to reduce the emission of VOCs during vehicle refuelling. It does this by:

- requiring that equipment or plant is only used or operated with prescribed mandatory control equipment fitted and specifications for installation, commissioning, operation, maintenance and decommissioning are complied with (unless exempted in writing by the EPA)
- prescribing mandatory control equipment for petrol service stations
- requiring adherence to compliance mechanisms in the form of periodic testing, log books, compliance notification on premises and dispensers and reporting to the EPA.

Additional mandatory control equipment, together with mandatory testing and reporting requirements are set out separately in DECCW 2009c and referred to as ‘Standards and Guidelines’ in Part 6, subdivision 2 of the proposed Regulation. These controls are being phased in over a seven-year period. Their phased introduction is to minimise compliance costs and enable much of the required VR2 installation to occur during scheduled refurbishments.

Benefits

The quantifiable benefits of the VR2 provisions of Part 6 of the proposed Regulation are lower emissions of VOCs, resulting in the formation of less ground-level ozone and improving human health, and the recovery of vapours as liquid fuel, which benefits industry.

By the year 2015, VR2 controls would save 7.8 million litres of petrol a year. This is estimated to provide a health benefit from reduced ground-level ozone of $231 million over the period till 2040 (DECCW 2009b). The petrol saved also represents a significant benefit for industry in recovered fuel. For the purposes of this analysis, this benefit has been calculated as an offset to industry against the costs to industry in VR2 implementation. Division 9 of Appendix D contains further details of these calculations.

Reducing petrol vapour at service stations also reduces people's exposure to benzene, an air toxic. Vehicle refuelling currently accounts for most of the Australian population's summertime exposure to benzene (Horton et al. 2006). This health benefit is not currently quantifiable.

Costs

The quantifiable costs of the VR2 provisions of Part 6 arise for industry, motorists and government.

The cost to industry, including that of capital equipment and installation, ongoing operations and compliance through inspection and certification, is estimated to be $106 million over the period till 2040. The Regulation results in an estimated additional cost to service station operators of less than 0.2 cents per litre of petrol sold. Much of this cost would be passed on to motorists through higher petrol prices.

Government costs include some additional monitoring and auditing. These costs are expected to be minimal.

Division 9 of Appendix D contains the detailed calculation of these costs.

7.4 Conclusion

Vapour recovery systems significantly reduce VOC emissions and, therefore, ground-level ozone. The preferred option is the proposed Regulation, an effective and proportional measure that requires vapour recovery systems to be used to minimise VOC emissions from volatile organic liquids.

The proposed Regulation reduces VOC emissions from motor vehicle fuels and is estimated to provide a quantifiable net benefit to society of $125 million over the period till 2040.

Extensive unquantifiable benefits include improved visual amenity, decreases in offensive odours, and avoidance of damage to buildings, crops and other vegetation. Unquantified localised health benefits also apply to a reduction in people's exposure to air toxics, particularly benzene.

8. Sulfur in liquid fuel: Part 7

8.1 Background

8.1.1 Need for government action

Liquid fuel containing sulfur is used in motor vehicles as well as for combustion in industrial facilities such as boilers, furnaces and generators. Fuel is both brought to Australia as well as produced domestically at oil and gas refineries and agricultural premises (oil and biodiesel). Sulfur in liquid fuel is emitted as sulfur dioxide when the fuel is burnt, with impacts on health and the environment. See Appendix C for further details.

When the original Clean Air Regulations were introduced in 1964, the use of liquid fuel with a high sulfur content was common in medium to large furnaces. However, this is no longer the case for a number of reasons including the requirement now for lighter liquid fuel by automatic burner controls, a trend away from steam to internal combustion, the more extensive use of natural gas and LPG, and the preferred type of imported crude oil.

Moreover, motor vehicle exhaust is no longer a significant source of sulfur dioxide. Since 1999 when the average sulfur content of diesel was 1300 parts per million (ppm), progressive introduction of new standards for the fuel have reduced sulfur levels in diesel to just 10 ppm.

Hence, most liquid fuel currently in use in NSW already has sulfur content below the current limits for reasons other than the controls imposed by the existing Regulation. However, there are gaps in the coverage of fuel quality standards. In addition, use of high-sulfur liquid fuels could increase in the future if the price of low-sulfur liquid fuels increases relative to them.

8.1.2 Management of sulfur content in liquid fuel

Government action to place limits on the sulfur content of liquid fuel aims to reduce risks to human health and the environment by ensuring that the use of high-sulfur liquid fuel in NSW only occurs in highly restricted circumstances.

This objective contributes to the overall management of emissions from industry. Section 6.1.2 discusses the NSW framework for managing industrial emissions.

8.1.3 Range of options

Two options for government action are given detailed consideration below:

- no Regulation – discussed in Section 8.2
- the proposed Regulation – remake Part 6 of the Clean Air Regulation in its current form as Part 7 of the proposed Regulation, as discussed in Section 8.3.

8.2 Option 1: no Regulation (base case)

Reductions in the sulfur content of liquid fuel (and hence sulfur emissions) have occurred independently of the Regulation. Limits are included in some environment protection licences and there are national controls on sulfur in liquid fuel are through the *Fuel Quality Standards Act 2000* (Cwlth). Allowing the existing regulatory requirement to lapse would probably not result in a short-term increase in sulfur emissions. However, removal of regulatory controls could result in the use of high-sulfur liquid fuel in isolated instances with potentially significant local air quality impacts since Federal controls apply only to the ‘supply’ of fuel and not its use where the fuel has been produced by the user (Section 12, Fuel Quality Standards Act). This is possible for refineries and the producers of biofuels.

8.3 Option 2: the proposed Regulation

8.3.1 Description

The aim of Part 7 of the proposed Regulation is to reduce emissions of sulfur dioxide from using liquid fuel. Subject to exceptions, it does this by:

- prohibiting the operation in the NSW GMR of any fuel-burning equipment which uses liquid fuel with a sulfur content greater than 0.5% by weight
- prohibiting the operation outside the NSW GMR of any fuel-burning equipment which uses liquid fuel with a sulfur content greater than 2.5% by weight.

The proposed Part 7 is exactly the same as Part 6 of the current Regulation.

8.3.2 Benefits

Avoiding localised (or ambient) exposure to sulfuric acid would maintain human health and prevent irritation or damage to eyes, nose, throat and lungs. It also avoids potential instances of damage through exposure of ecological systems (especially aquatic) to sulfuric acid mist. It is not possible to assess the extent to which these isolated instances would occur, hence the benefits have not been quantified.

The proposed Regulation also facilitates the monitoring of liquid fuel supplies, which is cheaper and can be more reliable than monitoring for emissions of sulfur dioxide.

8.3.3 Costs

The costs of the Regulation are likely to be small as low-sulfur liquid fuel is readily available in Australia and at only a slightly higher price than high-sulfur fuel. Further, any costs of using low-sulfur liquid fuel relate mostly to the requirements of the Fuel Quality Standards Act.

8.4 Conclusion

Given the negligible costs of the existing regulatory requirements and the potential localised health and environmental benefits in restricting the use of high-sulfur liquid fuel, it is considered prudent to remake this provision of the Regulation in its current form. It is both an effective and proportionate response to preventing localised emissions of sulfur dioxide.

Appendix A: Better regulation compliance

Under *M2009-20: Guide to Better Regulation* (BRO 2009a), where new regulations are significant, associated regulatory impact statements are required to address the Better Regulation Principles set out in the *Guide to Better Regulation* (BRO 2009b). This is in addition to meeting the requirements of the *Subordinate Legislation Act 1989*. These principles have been applied throughout this report. Compliance with the specific principles is as set out in Table A1.

Table A1: Compliance with Better Regulation Principles

Better Regulation Principles	Air quality issue	Compliance
Principle 1: The need for government action should be established	General	2.1
	Domestic solid fuel heaters	3.1.1
	Control of burning	4.1.1
	Motor vehicles and motor vehicle fuels	5.1.1
	Industrial emissions from plant and activities	6.1.1
	Control of volatile organic liquids	7.1.1
	Sulfur in liquid fuel	8.1.1
Principle 2: The objective of government action should be clear	General	1.2
	Domestic solid fuel heaters	3.3.1
	Control of burning	4.3.1
	Motor vehicles and motor vehicle fuels	5.3.1
	Industrial emissions from plant and activities	6.3.1
	Control of volatile organic liquids	7.3.1
	Sulfur in liquid fuel	8.3.1
Principle 3: The impact of government action should be properly understood by considering the costs and benefits of a range of options, including non-regulatory options	Domestic solid fuel heaters	3.2–3.5
	Control of burning	4.2–4.4
	Motor vehicles and motor vehicle fuels	5.2–5.4
	Industrial emissions from plant and activities	6.2–6.4
	Control of volatile organic liquids	7.2–7.4
	Sulfur in liquid fuel	8.2–8.4
Principle 4: Government action should be effective and proportional	Domestic solid fuel heaters	3.5
	Control of burning	4.4
	Motor vehicles and motor vehicle fuels	5.4
	Industrial emissions from plant and activities	6.4
	Control of volatile organic liquids	7.4
	Sulfur in liquid fuel	8.4
Principle 5: Consultation with business and the community should inform regulatory development		1.5 2.2.4

Better Regulation Principles	Air quality issue	Compliance
Principle 6: The simplification, repeal, reform or consolidation of existing regulation should be considered	See discussion for Principle 7. Repeal (allowing to lapse) considered in:	
	Domestic solid fuel heaters	3.3
	Control of burning	4.3
	Motor vehicles and motor vehicle fuels	5.3
	Industrial emissions from plant and activities	6.3
	Control of volatile organic liquids	7.3
	Sulfur in liquid fuel	8.3
Principle 7: Regulation should be periodically reviewed, and if necessary reformed to ensure its continued efficiency and effectiveness	This is the first time the whole Regulation has been remade. The Regulation is subject to a continuous process of review. Each Part of the Regulation is at any one time at a different stage of the review cycle owing to: • the size and extensive coverage of the Clean Air Regulation in 2010 • the differing time periods since the incorporation and most recent review of each Part • optimal workflow and management systems. Between 2002 and 2009 separate parts of the Regulation have been reviewed prior to their incorporation in the Regulation (Part 3 and Part 5 were previously contained in separate Regulations). The review status for each Part is as follows:	
	Domestic solid fuel heaters	National review process: RIS due early 2010
	Control of burning	Incorporated in 2006
	Motor vehicles and motor vehicle fuels	Review 2009 (changes incorporated in proposed Regulation)
	Industrial emissions from plant and activities	Incorporated in 2005
	Control of volatile organic liquids	Incorporated in 2005 and 2009
	Sulfur in liquid fuel	Incorporated in 2005

Appendix B:
Proposed amendments to the current Regulation

Current Part 2A: Schedule 8

Substitute the existing Schedule 8 with the following:

Part 1: Areas in which all burning (including burning of vegetation and domestic waste) is prohibited except with approval

Ashfield
Auburn
Bankstown City
Blacktown City
Botany Bay City
Broken Hill City
Burwood
Campbelltown City
Canada Bay City
Canterbury City
Fairfield City
Gosford City
Holroyd City
Hunters Hill
Hurstville City
Kogarah City
Ku-ring-gai
Lake Macquarie City
Lane Cove
Leichhardt
Liverpool City
Manly
Marrickville
Mosman
Newcastle City
North Sydney
Parramatta City
Pittwater
Queanbeyan City
Randwick City
Rockdale City
Ryde City
Shellharbour City
Strathfield
Sutherland Shire
Sydney City
Warringah
Waverley
Willoughby City
Wollongong City
Woollahra
Wyong Shire

Part 2: Areas in which burning of vegetation is prohibited except with approval

Albury City
Armidale Dumaresq
Ballina Shire
Balranald Shire
Bathurst Regional
Bega Valley Shire
Bellingen Shire
Bland Shire
Blue Mountains City
Boorowa
Bourke Shire
Brewarrina Shire
Camden
Cessnock City
Clarence Valley
Coffs Harbour City
Cooma-Monaro Shire
Coonamble
Dubbo City
Dungog Shire
Eurobodalla Shire
Forbes Shire
Goulburn Mulwaree
Great Lakes
Greater Taree City
Gunnedah Shire
Gwydir Shire
Hawkesbury City
Hay Shire
Hills Shire, The
Hornsby Shire
Junee Shire
Kiama
Leeton Shire
Lismore City
Lithgow City
Liverpool Plains Shire
Maitland City
Mid-Western Regional
Muswellbrook Shire
Nambucca Shire
Narrabri Shire
Narromine Shire
Orange City
Penrith City
Port Macquarie-Hastings
Port Stephens
Richmond Valley
Tamworth Regional
Tumut Shire
Tweed Shire
Upper Lachlan Shire
Uralla Shire
Wagga Wagga City
Warren Shire
Warrumbungle Shire
Wellington
Wentworth Shire
Wingecarribee Shire
Wollondilly Shire

Part 3: Areas in which all burning (other than burning of vegetation) is prohibited except with approval or in relation to certain domestic waste

Albury City	Great Lakes	Oberon
Armidale Dumaresq	Greater Taree City	Palerang
Ballina Shire	Gunnedah Shire	Penrith City
Balranald Shire	Guyra Shire	Port Macquarie-Hastings
Bathurst Regional	Gwydir Shire	Port Stephens
Bega Valley Shire	Harden Shire	Richmond Valley
Bland Shire	Hawkesbury City	Shoalhaven City
Blue Mountains City	Hay Shire	Tamworth Regional
Boorowa	Hills Shire, The	Temora Shire
Bourke Shire	Hornsby Shire	Tumut Shire
Brewarrina Shire	Inverell Shire	Tweed Shire
Cessnock City	Junee Shire	Upper Hunter Shire
Clarence Valley	Kiama	Upper Lachlan Shire
Coffs Harbour City	Kyogle	Uralla Shire
Coolamon Shire	Leeton Shire	Urana Shire
Cooma-Monaro Shire	Lismore City	Wagga Wagga City
Coonamble Shire	Lithgow City	Wakool Shire
Cootamundra Shire	Maitland City	Walcha
Dubbo City	Mid-Western Regional	Warren Shire
Dungog Shire	Muswellbrook Shire	Warrumbungle Shire
Eurobodalla Shire	Nambucca Shire	Wellington
Forbes Shire	Narrabri Shire	Wentworth Shire
Greater Hume Shire	Orange City	Wingecarribee Shire
Glen Innes Severn	Narrandera Shire	Wollondilly Shire
Goulburn Mulwaree	Narromine Shire	Yass Valley

Current Part 3

Current Regulation	Amendment	Reason
Vertical exhaust pipe requirement		
Clauses 12(2)(i) and (j)	Amend current clauses 12(2)(i) and (j) to exempt, without the need for certification by the EPA, a motor vehicle manufactured in compliance with ADR 80/01, ADR 80/02 or any subsequent ADR that imposes emission limits.	The current wording of clause 12(2)(j) is outdated as it only refers to ADR 80/01. It needs to apply to new and future ADRs relating to emission limits for heavy vehicles, including ADR 80/02 and ADR 80/03. Providing an automatic exemption for the small number of vehicles that are manufactured before 1 January 2007 but are compliant with the ADR80/01 or 80/02 emission limits reduces red tape. This is instead of requiring a certificate of compliance from the EPA.
Additional exemption in clause 12(2)	Insert an additional exemption in the current clause 12(2) that applies to rigid table-top trucks used predominantly to transport hay or other flammable farm produce and usually garaged on farms.	Reduce red tape by providing an automatic exemption for owners of rural table-top trucks from the vertical exhaust requirement. This is instead of a requirement to apply for exemption under clause 13. Only around 30 applications are received each year, and these vehicles are typically located in rural areas where few pedestrians would be affected by the lack of a vertical exhaust.
Clause 13	Omit clause 13	See above
Benzene reporting		
Clauses 19A-19C	Omit clauses 19A, 19B and 19C	These provisions, relating to reporting the benzene content of petrol, only applied until 31 December 2005 and are now superseded by the Fuel Standard (Petrol) Determination 2001 that mandates a 1% benzene limit for petrol.

Current Regulation	Amendment	Reason
Prescribed ethanol petrol blends definition		
Clause 19D	In the definition of 'prescribed blended petrol' substitute '9 per cent' with '4 per cent'. The amended definition would read: '*prescribed blended petrol* means petrol containing 4 per cent or more of ethanol by volume but not more than 10 per cent of ethanol by volume.'	At present, petrol blended with ethanol content of between 9% and 10% (called 'prescribed blended petrol') is regulated differently from other petrol. Recent research (CSIRO 2008) has demonstrated that there is little discernible difference in the volatility of blended petrol containing 5% or 10% ethanol by volume and therefore their impacts on the ozone exceedences in the NSW GMR. To take into account blended petrol that contains 5% ethanol by volume, it is proposed to amend the definition of prescribed blended petrol to mean petrol containing between 4 and 10% of ethanol by volume.
Vapour pressure of petrol		
Clause 19F	Replace paragraphs (a) and (b) with: '(a) 71 kPa in the case of prescribed blended petrol, or (b) 64 kPa in the case of any other petrol.'	When summer petrol volatility limits were first introduced, the first year (2004) had a slightly higher limit than subsequently. This interim limit has now been superseded.

Current Part 4

The following amendments are either typographic corrections or clarifications and therefore self-explanatory.

<table>
<tr><th>Current Regulation</th><th>Amendment</th></tr>
<tr><td>Clause 51(6)</td><td>Replace ‘large storage tanks’ with ‘large loading plant’</td></tr>
<tr><td>Schedule 3:
Paper, paper pulp or pulp products industries</td><td>Replace ‘40 mg/m^3 VOCs and 125 mg/m^3 CO’ with ‘40 mg/m^3 VOCs or 125 mg/m^3 CO’</td></tr>
<tr><td>Schedule 3:
Iron and steel: secondary production</td><td>Replace ‘Type 2 substances (in aggregate)’ with ‘Type 1 substances and Type 2 substances (in aggregate)’</td></tr>
<tr><td>Schedule 6:
Standards of concentration for non-scheduled premises</td><td>Reformat table to move ‘smoke’ to second ‘Air impurity’ row as follows:
<table>
<tr><th>Air impurity</th><th>Activity or plant</th><th>Group</th><th>Concentration</th></tr>
<tr><td rowspan="3">Solid particles</td><td rowspan="3">Any activity or plant (except as listed below)</td><td>Group A</td><td>400 mg/m^3</td></tr>
<tr><td>Group B</td><td>250 mg/m^3</td></tr>
<tr><td>Group C</td><td>100 mg/m^3</td></tr>
<tr><td rowspan="8">Smoke</td><td rowspan="3">Any activity or plant in which, or in connection with which, solid fuel is burnt</td><td>Group A</td><td>Ringelmann 2 or 40% opacity</td></tr>
<tr><td>Group B</td><td>Ringelmann 1 or 20% opacity</td></tr>
<tr><td>Group C</td><td>Ringelmann 1 or 20% opacity</td></tr>
<tr><td rowspan="3">Any activity or plant in which, or in connection with which, liquid or gaseous fuel is burnt</td><td>Group A</td><td>Ringelmann 1 or 20% opacity</td></tr>
<tr><td>Group B</td><td>Ringelmann 1 or 20% opacity</td></tr>
<tr><td>Group C</td><td>Ringelmann 1 or 20% opacity</td></tr>
<tr><td rowspan="2">Any activity or plant in connection with which solid fuel is burnt</td><td>Group A in relation to marine vessels or premises, in approved circumstances</td><td>Ringelmann 3 or 60% opacity</td></tr>
<tr><td>Group A in relation to marine vessels or premises in other circumstances</td><td>Ringelmann 2 or 40% opacity</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Current Regulation</th><th>Amendment</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td></td><td>Group B or C, in relation to marine vessels or premises, in other circumstances</td><td>Ringelmann 1 or 20% opacity</td></tr>
<tr><td></td><td rowspan="2">Any activity or plant in connection with which liquid or gaseous fuel is burnt</td><td>Group A, B or C in relation to marine vessels or premises in approved circumstances</td><td>Ringelmann 3 or 60% opacity</td></tr>
<tr><td></td><td>Group A, B or C in relation to marine vessels or premises in other</td><td>Ringelmann 1 or 20% opacity</td></tr>
</table>
</td></tr>
<tr><td>Schedule 7, Part 3: Table titled – ‘Reference conditions relating to Group B or C</td><td>Replace ‘CO_2’ with ‘O_2’ in both instances</td></tr>
<tr><td>Schedule 3, Schedule 4 and Schedule 5</td><td>Replace ‘(HF) equivalent’ with ‘(HF equivalent)’</td></tr>
<tr><td>Schedule 5, Part 1: Test methods</td><td>Replace TM-9 air impurity:

‘Fluorine (F_2) or any compound containing fluorine, as total fluoride (HF) equivalent, except where emitted by a primary aluminium smelter while manufacturing aluminium from alumina’

with:

‘Fluorine (F_2) or any compound containing fluorine, as total fluoride (HF equivalent), except where emitted from pot line roof vents at a primary aluminium smelter while manufacturing aluminium from alumina’</td></tr>
<tr><td>Schedule 5, Part 1: Test methods</td><td>Replace TM-10 air impurity:

‘Hydrogen fluoride (HF) emitted by a primary aluminium smelter while manufacturing aluminium from alumina’

with:

‘Hydrogen fluoride (HF) emitted from pot line roof vents at a primary aluminium smelter while manufacturing aluminium from alumina’</td></tr>
<tr><td>Division 4, clause 37</td><td>Currently the Regulation specifies that new treatment plant must be operated to meet the specified residence time and combustion temperature and destruction efficiency.

Amend the provisions of Division 4, clause 37 to allow new treatment plant (afterburners, flares, vapour recovery units and other non-thermal treatment plant) to be operated to meet either the specified residence time and combustion temperature or destruction efficiency.</td></tr>
</table>

Appendix C:
Health and environmental impacts of air pollutants

Division 1: Frame of reference

1.1 Introduction

This division sets out a number of concepts common to studies on the health and environmental impacts of air pollutants. The following divisions should be read in conjunction with this division.

The material in this division includes a survey of the health and environmental impacts of particulate matter, NO_X, VOCs, ozone, sulfur oxides and metals. Health costs attributable to particulate matter and oxides of nitrogen have been estimated in Appendix D.

1.2 Comparability of studies of impacts

General effects reported by studies into air pollutants mostly hold true for other locations. However, any estimated costs of these effects may not hold true for other locations because of several factors (as discussed in Appendix D). These include:

- the presence and impacts of co-pollutants
- the potential for, and impacts of, secondary pollutants (such as ground-level ozone)
- local topographic and meteorological factors
- population density and demographic profile
- differing parameters in data collection or methodology in statistical analysis (such as the use of a threshold).

In addition, studies of the effects of a specific air pollutant invariably use sampling from air that has multiple pollutants. Substances may interact with each other in the air or within organisms, such as humans, animals or plants, or other components of the ecosystem. These interactions may change the effects on the environment or human health.

1.3 Types of studies

Studies of the effects of pollutants can be epidemiological or controlled. Epidemiological studies seek relationships between exposure levels in communities and human health. They can study the acute or chronic effects associated with real-time air pollution exposures while measuring health end-points. Confounding variables include age profile, pre-existing respiratory or cardiac disease, diet, occupational exposure and tobacco smoke exposure, although these become less important with a large sample size.

Other methods of research include animal exposure studies and controlled human studies, although these methods can be constrained by the duration of exposure and the difficulty in extrapolating results to humans, respectively.

1.4 Short-term and long-term effects

The health effects of air pollution are generally classified as short-term (‘acute’) or long-term (‘chronic’). Short-term exposure may have acute and/or chronic effects. Long-term exposure has chronic effects.

Studies on acute health effects examine daily changes in illness (‘morbidity’) and death (‘mortality’) and their correlation with exposure to air pollution. Data on acute health effects are drawn from episodes of respiratory symptoms, asthma and other impacts on lung function, days of restricted activity, hospitalisation and death.

Studies on chronic health effects can examine the statistical correlation of a range of illnesses and premature death in a target population compared with broader population statistics. These illnesses include lung and heart ('cardiopulmonary') conditions and cancer. Chronic health effects are often studied in relation to long-term exposure to ambient air pollution but may also apply to short-term exposure (single incident or episodic) for some pollutants. Chronic health effects may be observed for both short-term and long-term exposures.

1.5 Susceptibility

Everyone has the potential to be affected by air pollution when concentrations of pollutants are very high; however some groups of the population are more susceptible to certain air pollutants (either as a causal factor or an aggravating factor) than others. Different pollutants affect these groups differently. For example, several of the pollutants may trigger symptoms in people with asthma, whereas people with heart disease are most likely to be affected by particle pollution. Susceptible groups include:

Children: The exposure of children to air pollutants is generally higher than for healthy adults because children inhale more air per minute and have a larger contact lung surface area relative to their size. Children also spend more time outdoors and more time exercising. Finally, their elevated metabolic rate and immature immune system make them more susceptible to air pollution (NSW Health 2010).

Elderly people: The elderly have reduced respiratory reserve as a result of the ageing process. This is also often exacerbated by pre-existing cardiorespiratory conditions.

Asthmatics: Asthma is an inflammatory disease of the air passages, which makes them prone to narrowing and increased mucus production. It becomes difficult to move air in and out of the lungs. Many pollutants have the effect of triggering or exacerbating asthma attacks in people with the condition.

People with cardiorespiratory conditions: Chronic obstructive pulmonary disease (where the lung is damaged, making it hard to breathe because the airways are partly obstructed) and cardiovascular disease (diseases of the heart and blood vessels, including coronary heart disease, stroke, heart failure and peripheral vascular disease) can be exacerbated by pollutants such as particles.

People who are exercising: Exercise increases the amount of air breathed in. In addition, it increases the amount of mouth breathing, allowing deeper penetration of air into the respiratory tract and dries the airways, which in turn can increase the absorption of pollutants.

Division 2: Particulate matter

2.1 Particulate matter and its sources

Particulate matter (or particles) is a term used to describe liquid or solid particles suspended in the air. It can be a primary pollutant (from emissions) or a secondary pollutant (resulting from atmospheric reactions on primary pollutants).

Each Part of the Clean Air Regulation is relevant to the control of particulate matter.

Particles come from both natural and human sources. The size, shape and chemical composition of particles varies greatly, depending on their source and other factors, such as time, location and weather. They include acids, organic chemicals, metals, soil or dust, and allergens. Particles are visible as brown haze.

Primary pollutants from natural (biogenic) sources of particles include sea spray, bushfires, erosion, mould spores, pollens, and viruses and bacteria. Human (anthropogenic) sources come from products of combustion and mechanical processes and include emissions from motor vehicles, woodheaters, power plants, industrial processes, and industrial and domestic incinerators.

Secondary particle formation can also contribute significantly to particle levels. These include sulfates (derived from sulfur dioxide emissions), nitrates (derived primarily from NO_X emissions) and organic aerosols (derived primarily from volatile organic compound emissions).

Particles are measured using their aerodynamic diameter and range in size from 0.001 to 500 micrometres (µm) in diameter but particles larger than 10 µm do not usually enter the human respiratory system.[23] Particles are categorised according to size because different sizes behave differently both in the atmosphere and the human respiratory system: for example, smaller particles are more easily inhaled with a potentially stronger impact on human health. Table C1 sets out the categories of particulate matter by size, principal human sources and differences in mobility.

Table C1: Categorisation of particulate matter

Category				Principal human sources	Mobility
PM_{10} 0-10.0 µm Fine particles	Particles with a diameter of between 2.5 and 10 µm			Mechanical activity, such as roads, farming, mining	Settles relatively quickly (within minutes to hours)
	$PM_{2.5}$ 0-2.5 µm Very fine particles	Particles with a diameter of between 0.1 and 2.5 µm		Combustion processes, used in industry, power generation, and vehicles; transformations of primary pollutants (SO_x, NO_x and VOCs)	$PM_{2.5}$ can normally remain airborne for several hours to several weeks and may be transported thousands of kilometres from the original source
		$PM_{0.1}$ ≤ 0.1 µm Ultra fine particles	Particles with a diameter less than 0.1 µm	Vehicle emissions and atmospheric photo-chemical reactions	Can accumulate into $PM_{2.5}$; removed through rain

[23] An aerodynamic diameter is used because particles have a very wide variety of regular shapes (such as spheres and cubes) and irregular shapes. These shapes can impact on visibility.

PM_{10} is one of the six key pollutants for which health-based Air NEPM goals have been set – see Table C2. Some regional centres exceed the standards as a result of bushfires, drought, stubble burning or broadacre cultivation.

Table C2: NEPM goals for PM_{10} / Advisory reporting standard for $PM_{2.5}$

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Particles as PM_{10}	1 day	50 µg/m^3	5 days a year
Particles as $PM_{2.5}$	1 day 1 year	25 µg/m^3 8 µg/m^3	Not applicable – purpose is to gather national data

In the NSW GMR, coal mining is the major source of anthropogenic PM_{10} (Figure C1) but in Sydney, especially in winter, domestic solid fuel heaters (woodheaters) account for the largest percentage of emissions (Figure C2). The two largest industrial point sources in the NSW GMR are electricity generation from coal (6%) and primary iron and steel production (2%, but as high as 53% in Wollongong) (DECC 2007b).

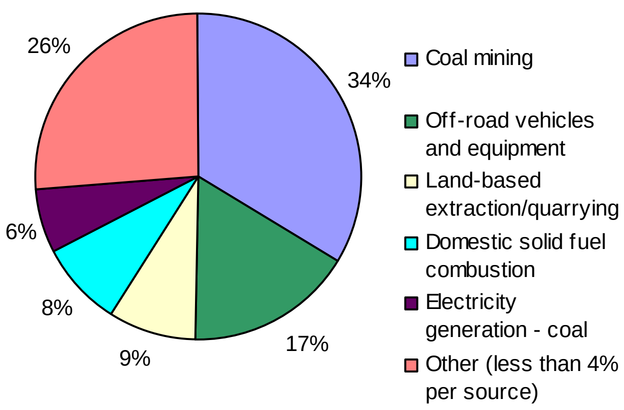


Figure C1: Anthropogenic sources of PM_{10} emissions, NSW GMR

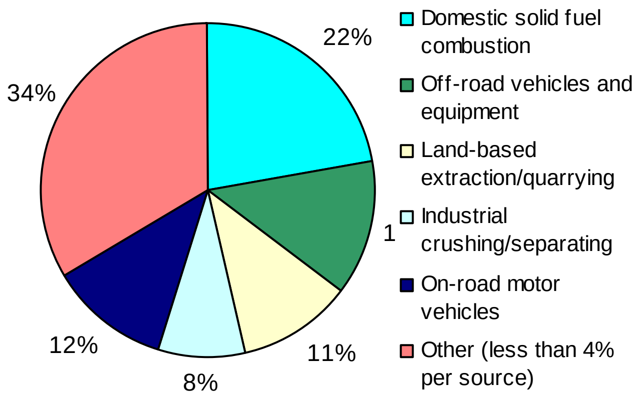


Figure C2: Anthropogenic sources of PM_{10} emissions, Sydney

2.2 Impacts on human health

Epidemiological studies worldwide have shown that increases in particle pollution are associated with a range of health outcomes, including increases in daily mortality, hospital admissions and attendances at emergency rooms. Problems from short-term exposures include respiratory symptoms, such as irritation of the airways, coughing and difficulty breathing; aggravated asthma; irregular heartbeat; heart attacks; and premature death in people with heart or lung disease. Long-term exposures may result in decreased lung function; development of chronic bronchitis; and increased cardiovascular risk.

Significantly, there is no safe concentration threshold for exposure to PM_{10} or PM $_{2.5}$ where adverse health effects have not been observed (NEPC 1998). This means that even low levels may have an adverse impact on human health.

Depending on the concentration and length of exposure, healthy people can experience symptoms from exposure to particle pollution. However, some groups are particularly susceptible: children, older people, asthmatics, people with existing cardio-respiratory conditions and those who are exercising. For further information on these susceptibilities, see Division 1.

2.3.1 The impact of size

Health studies frequently focus on the impacts of a particular size: PM_{10}, $PM_{2.5}$ or $PM_{0.1}$. Older studies focused on PM_{10} while more recent studies have concentrated on $PM_{2.5}$.

PM_{10}

The Air NEPM levels were set by reference to a number of studies, both in Australia and overseas, that consistently showed a 1% increase in daily mortality (from all causes) per 10 $\mu g/m^3$ increment in PM_{10}. For respiratory and cardiovascular mortality, the observed increases are higher, with values of 3.4% and 1.4% per 10 mg/m^3 increase in PM_{10}, respectively (NEPC 1998). A New Zealand study found a 4.3% increase in *annual* mortality per 10 $\mu g/m^3$ increase in annual PM_{10} from all air pollution sources (vehicle, industry and domestic) in people aged over 30 (Fisher et al. 2007).

$PM_{2.5}$

A 2006 review of epidemiological studies worldwide on the health effects of $PM_{2.5}$ pollution found that long-term repeated exposure has larger, more persistent cumulative effects than short-term transient exposures (Pope & Dockery 2006). Long-term exposure has been associated with increased cardiovascular risk and mortality as well as chronic inflammatory lung injury. Short-term exposures were linked with cardiovascular and stroke mortality and hospital admissions.

In a 2009 study covering 51 cities in the United States, using data from the late 1970s to the early 2000s, a decrease of 10 $\mu g/m^3$ of $PM_{2.5}$ was associated with an estimated increase in mean life expectancy of between 0.61 and 0.20 years (Pope et al. 2009).

$PM_{0.1}$

A US study (Araujo et al. 2008)[24] found evidence that exposure to ultrafine particles is significantly more likely than exposure to fine particles to be conducive to the formation of deposits, especially on the innermost layer of arterial walls, and may constitute a greater significant cardiovascular risk factor. Further, recent studies indicate that ultrafine particles may enter the circulation system and be transported to the heart where they can affect performance of the heart and coronary flow (Simkhovich et al. 2008).

[24] Note that this paper uses the term ‘ultrafine’ to mean < 0.18 µm. For related studies, see Samet et al. 2009.

2.3.2 The impact of composition

The health impact of particles not only differs with size, but also composition, although each size range of particles typically has a different general chemical composition. US EPA 2009a found that:

- toxicity varies by size and composition in both metals and organic chemicals
- diesel particles from different engines can have diverse chemical signatures which affect the potential of the particle to produce toxic, mutagenic and allergic reactions
- particle-associated metals exert their toxicity in part due to their bioavailability (the degree to which, or rate at which, a substance is absorbed) and pro-oxidant potential (the potential to produce oxygen by-products that can cause damage to cells).

In New Zealand, it has been found that particle emissions from vehicles were more mutagenic than those from woodheaters (Cavanagh et al. 2009). For a review of the health and environmental impacts of metals, see Division 7 of this appendix.

2.3 Impacts on the natural and built environment

Particles have an impact on the natural and built environment as follows:

Vegetation and ecosystems: Particles can be carried over long distances and settle on the ground or in water. The effects of this settling has the potential to change the nutrient balance in aquatic environments; deplete nutrients in soil; damage sensitive forests and farm crops; and affect the diversity of ecosystems. Of particular concern are deposition of metals (see Division 7 of this appendix) and acids (see Divisions 3 and 6).

Visibility: Particles scatter and absorb light and are responsible for brown haze. Poor visibility caused by particle pollution has a direct impact on the attractiveness of a location for living, tourism and investment as well as reducing residents' sense of well-being.

Building materials: Particle pollution can stain and damage stone and other building materials, including heritage buildings.

Global warming: Black carbon, the main component of soot particles, is also considered to be a powerful global warming agent (Highwood & Kinnersley 2006).

For a detailed review of environmental impacts, see US EPA 2004 and USA EPA 2008a.

Division 3: Oxides of nitrogen

3.1 Oxides of nitrogen and their sources

Oxides of nitrogen (NO_X) are a group of highly reactive gases that include nitric oxide (NO) and nitrogen dioxide (NO_2). These gases are produced mainly by combustion processes. Combustion of fossil fuels converts atmospheric nitrogen and any nitrogen in the fuel into its oxides, mainly to nitric oxide, which slowly oxidises to nitrogen dioxide in the atmosphere. This reaction occurs more rapidly in the presence of ozone (NEPC 1998).

Emissions of NO_X are principally controlled through Parts 4 and 5 of the Clean Air Regulation.

Controls on NO_X emissions are in place for three reasons:

- NO_X is significant as a precursor to ground-level ozone formation – see Division 5 of this appendix for the health and environmental impacts of ground-level ozone.
- NO_X is significant as a precursor gas to the formation of secondary fine particle pollution, including nitric acid – see Division 2 for the general health and environmental impacts of particulate matter.
- NO_X is itself a significant pollutant with impacts on health and the environment.

NO_2 is a pungent acidic gas which is corrosive and strongly oxidising. NO_2 is one of the six key pollutants for which Air NEPM goals have been set. The goals for NO_2 are set out in Table C3. The NEPM standards for NO_2 are consistently met with the annual averages well below the maximum concentration (NEPC 2009).

Table C3: NEPM goals for NO_2

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day a year None

Figures C3 and C4 (based on DECC 2007b) show the main emission sources of NO_X in the NSW GMR and Sydney, respectively. Around 4% of total NO_X emissions in the NSW GMR are attributable to bushfires.

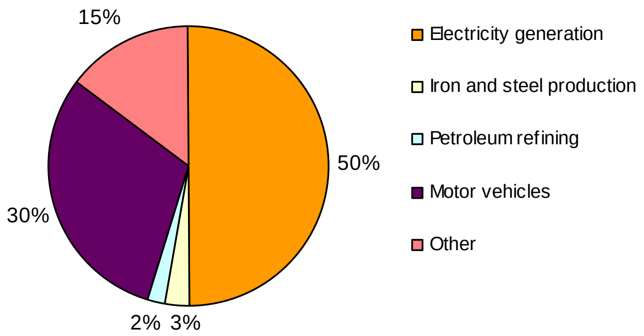


Figure C3: Sources of NO_X emissions, NSW GMR

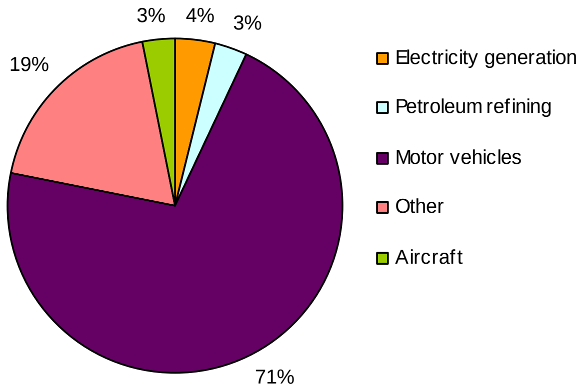


Figure C4: Sources of NO_X emissions, Sydney

3.2 Impacts on human health

The health effects of NO_X are divided into two groups. The first group are those resulting from ozone formation at ground-level and these are discussed in Division 5 of this appendix. The second group are those effects caused by exposure to NO_X and these are discussed below.

The effects of exposure to NO_X are similar to some of the effects observed for exposure to ozone and particulate matter and, as these other pollutants are generally also present at the same time, earlier studies found it difficult to attribute particular impacts to NO_X. However, more recent studies have presented evidence to find a likely causal link between NO_X and respiratory illness. For a review of studies relating to NO_X, see US EPA 2008b and WHO 2006.

At low levels of exposure, NO_X can irritate eyes, nose, throat and lungs, leading to coughing, shortness of breath, tiredness and nausea. Exposure can cause a build-up of fluid in the lungs for 1–2 days after exposure. Longer term exposure can lead to the destruction of lung tissue, leading to chronic inflammatory lung disease.

At high levels of exposure, NO_X can cause rapid burning, spasms and swelling of tissues in the throat and upper respiratory tract, reduced oxygenation of tissues, a build-up of fluid in the lungs, and maybe even death. Asthmatics and children are particularly susceptible.

3.3 Impacts on the natural and built environment

Excessive levels of NO_X, particularly NO_2, can reduce the growth rate of plants, damage the leaves of crops and cause death in plants and roots. It lowers the pH of rain, thus increasing its acidity, resulting in lower pH levels in surface and ground waters and soil. The lowered pH can have harmful effects on a variety of biological systems, possibly even death.

NO_X can also deteriorate fabrics, corrode dyes and reduce visibility.

For a review of the effects of NO_X on the environment, see US EPA 2008c.

Division 4: Volatile organic compounds

4.1 Volatile organic compounds and their sources

Volatile organic compounds (VOCs) are a broad grouping of carbon-based compounds that vaporise at normal temperatures.[25]

The proposed Regulation controls evaporative emissions of VOCs principally through Part 4 and Part 6. Other emissions of VOCs are controlled by ensuring combustion efficiency or controlling combustion through Parts 2, 3, and 5.

Controls on VOC emissions are in place for two reasons:

- VOCs as a group are significant as a precursor to the formation of ground-level ozone – see Division 5 of this appendix for the health and environmental impacts of ground-level ozone.
- Some VOCs are individually significant for health and the environment as air toxics.

Roughly half of VOCs (53%) comes from biogenic sources with the remainder produced in a wide range of processes (such as combustion or the production or use of solvents, paints or chemicals) and released from a range of products (such as petrol, paint and household cleaners). In the NSW GMR, exhaust and evaporative emissions of petrol from vehicles account for the largest proportion of VOC emissions: around 36%. Surface coating (paint), aerosols and solvents account for another 25% with the rest from a number of diverse sources.

Figure C5 (based on DECC 2007b) shows emissions of VOCs from anthropogenic sources in the NSW GMR.

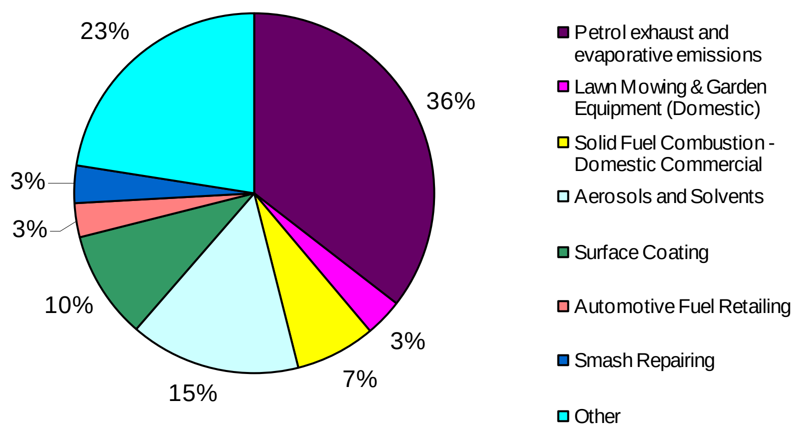


Figure C5: Anthropogenic sources of VOC emissions, NSW GMR

---

[25] For the purposes of controlling industrial emissions, the proposed Regulation defines 'volatile organic compound' as:

'... any chemical compound that:
(a) is based on carbon chains or rings, and
(b) contains hydrogen, and
(c) has a vapour pressure greater than 2mm of mercury (0.27 kPa) at 25°C and 101.3 kPa,

and includes any such compound containing oxygen, nitrogen or other elements, but does not include methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides and carbonate salts.'

Table C4 sets out the sources of VOCs of principal concern as air toxics.

Table C4: VOC (air toxic) sources

Pollutant	Emission sources
Benzene	Industries producing, using or handling benzene, such as rubber industry, oil refineries, chemical plants, footwear manufacturing, petrol; diffuse emissions from vehicle evaporative and exhaust emissions and service stations; and cigarette smoke and some household consumer products containing benzene as a contaminant
Polycyclic aromatic hydrocarbons (PAHs)	Petroleum refineries, fossil fuel power plants (coal, oil), production plants for coal-tar, coking, bitumen and asphalt production plants, paper, wood products, aluminium and industrial machinery; diffuse emissions from motor vehicle exhausts, roads and fires of all types; and a range of household and personal consumer products
Formaldehyde	Manufacturing plants that produce or use formaldehyde, such as mining, wood and paper industries and electricity supply; fuel combustion sources, such as boilers, furnaces and engines in manufacturing; diffuse emissions from motor vehicle exhausts and a wide range of household and personal consumer products, such as carpets. Also a secondary pollutant as a result of the photochemical oxidation of reactive organic gases in polluted atmospheres containing ozone and NO_X
Toluene	Industries that manufacture toluene or use it in production, such as oil refiners, chemical industry, rubber manufacturers, pharmaceutical industry, metal degreasing, printing, manufacturers of paints, varnishes and lacquers; diffuse emissions from vehicle exhausts, vapours and spilling of petrol, paint, varnish and lacquer removal, tobacco smoke, and a wide range of household and personal consumer products
Xylenes (as total of ortho, meta and para isomers)	Chemical and petrol manufacture, polyester manufacture, manufacture of paints, dyes, and lacquers; diffuse sources from vehicle emissions, paint, wood burning stoves and fireplaces and an extensive range of household and personal consumer products

Source: principally DEWHA 2009

4.2 Impacts on human health

The health effects of VOCs are divided into two groups. The first group are those resulting from the formation of ozone which is discussed in Division 5 of this appendix.

The second group are those effects caused by exposure to VOCs. The health impacts of VOCs depend on the composition of the VOCs present, their concentration and the length of exposure. General effects of exposure to VOCs include irritation to the eyes, nose and throat; headaches; loss of coordination; nausea; and damage to the liver, kidney and central nervous system. Some VOCs are known or suspected to cause cancer in humans.

4.3 Impacts on the natural and built environment

Environmental effects depend on the composition of the VOCs present, their concentration and the length of exposure. Some VOCs can have serious effects on animals and plants. Effects may also arise from secondary impacts, such as the effect of photochemical smog (ozone) caused in part by VOCs.

Although there are significant gaps in the data for some VOCs, specific effects include:

- **Aquatic life** – acute and/or chronic toxic effects (PAHs, xylene, benzene, toluene, formaldehyde) with some of these bio-accumulating (PAHs, xylene, toluene)
- **Animals** – chronic effects on life span and reproduction, cancer (formaldehyde)
- **Birds** – short-term toxicity (PAHs)
- **Plants** – injury to agricultural and ornamental crops (PAHs, xylene, benzene), membrane damage to leaves (toluene).

Division 5: Ozone

5.1 Ozone and its sources

Ozone is a relatively insoluble gas, composed of three oxygen atoms, with a characteristic sharp odour. It is a strong oxidising agent capable of reacting with a variety of substances. Ozone is present both in the stratosphere high above the earth (where it has a beneficial effect in filtering out ultraviolet light) and at ground-level (principally as a pollutant). At ground level it is one of the components of summertime smog, which harms human health, vegetation and building materials.

As a secondary pollutant, ozone emissions are not dire04ctly regulated but its precursor pollutants, NO_X and VOCs, are – see Divisions 3 and 4 of this appendix.

Ozone is one of the six key pollutants for which Air NEPM goals have been set, as shown in Table C5. Each summer the Sydney region exceeds the national health-based ozone standards on an average of 12 days (NEPC 2009).

Table C5: NEPM goals for ozone

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Photochemical oxidants* (as ozone)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day a year 1 day a year

* ‘Photochemical oxidants’ is the term used to describe a complex mixture of chemicals produced in the atmosphere by the action of sunlight. It is commonly known as photochemical smog. The principal component of photochemical oxidants is ozone (NEPC 1998).

Ground-level ozone is created by a chemical reaction between oxides of nitrogen (NO_X) and VOCs in the presence of sunlight, so it is a secondary pollutant. A principal reason for controlling emissions of NO_X and VOCs is to prevent the formation of ozone. Motor vehicle use is the main anthropogenic emission source of NO_X in Sydney and a major source of VOCs. In the NSW GMR, however, around half of NO_X emissions are attributable to coal-fired power stations. See Divisions 3 and 4 for further information on emission sources of NO_X and VOCs.

The population of the NSW GMR is forecast to grow to 6 million by 2036, a 40% increase on 2006 levels (DoP 2008). This growth is expected to increase industrial and residential development, and see continued growth in the ownership and use of motor vehicles. If the Sydney region is to meet national ozone standards, the Department of Environment, Climate Change and Water estimates that NO_X and VOC emissions need to be reduced by at least 25% from present levels.

Global warming would be expected to increase ozone formation because the higher the temperature, the greater the evaporative emissions of precursor VOCs from both biogenic and anthropogenic sources. Slower cloud formation and increased light associated with global warming may also accelerate the ozone-formation process. Modelling from a study in Sydney indicates that the impact of global warming on ozone formation (assuming that anthropogenic emissions stay constant at 2003 levels) will cause exceedences of the Air NEPM standards to increasing by 27–30% between 2021 and 2030 and 45–92% in the decade from 2051 (Cope et al. 2008). These trends have been mirrored in studies published in 2009 in the United States (US EPA 2009b).

The 2008 Sydney study further predicted that decreasing precursor emissions by 40–70% would lead to a 25–36% reduction in peak ozone concentrations by 2060 (which would still not comply with the NEPM standards).

A further factor in ozone exposure has also emerged: increases in background ozone levels. Background ozone levels measured at Cape Grim in Tasmania have been increasing at the rate of 6% per decade (Galbally 2009)[26] and an upward trend in background ozone levels has been observed in Sydney (Duc & Azzi 2009).[27] The trend has been also observed globally (AQEG 2009, paragraph 3.1.2). A higher background level of ozone would result in higher daily levels of ozone concentration.

5.2 Impacts on human health

Ozone can be highly irritating for those who inhale it. Exposure to concentrations above the Air NEPM limits can be harmful to people's health. Increases in levels of ozone are associated with a rise in hospitalisation for respiratory diseases and mortality. Repeated exposure to ozone can make people more susceptible to respiratory infection and aggravate pre-existing respiratory diseases such as asthma (US EPA 2006a; WHO 2006).

Long-term exposure to ozone causes an increase in mortality (Jerrett et al. 2009; COMEAP 2009; Smith et al. 2009). The US EPA also reports some preliminary epidemiologic evidence that long-term ozone exposure may induce new asthma. This is supported by animal toxicological evidence that co-exposure to ozone can enhance sensitisation to known allergens as well as have an impact on lung development (US EPA 2010b).

In Sydney, as a result of expected global warming, ozone formation is projected to increase (see Division 5.1). It is projected that increases in hospital admissions due to ozone exposure will increase by 40% between 2020 and 2030 and 200% between 2050 and 2060 (Cope et al. 2008).

5.3 Impacts on the natural and built environment

Ground-level ozone damages plants, ecosystems and buildings. These effects include:

- interfering with the ability of sensitive plants to produce and store food, making them more susceptible to certain diseases, insects, other pollutants, competition and harsh weather
- damaging the leaves of trees and other plants
- reducing forest growth and crop yields, potentially affecting species diversity in ecosystems
- corrosion of building materials and monuments.

For detailed information on the impact of ground-level ozone on the natural and built environment, see US EPA 2006a (Volume I, Chapters 9 and 11).

Ground-level ozone formation would not only be affected by global warming (see Division 5.2) but is itself a potent global warming gas after carbon dioxide and methane (IPCC 2007).

Ozone precursor emissions are not directly controlled under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. However, in recognition of the role these pollutants have as greenhouse gases, parties are required to report on their emissions of VOCs, NO_X and carbon monoxide.

---

[26] This paper noted that one of the findings of the Royal Society's 2008 report into background ozone was that the reason for the increase in background ozone is unknown.
[27] This paper suggested that the source of increasing levels may be increasing global emission, especially in North Asia.

Division 6: Sulfur dioxide

6.1 Sulfur dioxide and its sources

Sulfur is found in raw materials, including crude oil, coal and ore that contains common metals like aluminium, copper, zinc, lead and iron. Sulfur oxide gases are formed when fuel containing sulfur, such as coal and oil, is burned; petrol is extracted from oil; and metals are extracted from ore.

Sulfur dioxide (SO_2) is a colourless gas with a strong odour that reacts easily with other substances to form harmful compounds, such as sulfuric acid, sulfurous acid and sulfate particles. Emissions of SO_2 are principally controlled through Parts 4 and 6 of the Clean Air Regulation.

SO_2 is one of the six key pollutants for which Air NEPM goals have been set, as shown in Table C6. NEPM monitoring stations for SO_2 show annual averages below the maximum concentration (NEPC 2009).

Table C6: NEPM goals for sulfur dioxide

Pollutant	Averaging period	Maximum concentration	Goal within 10 years: maximum allowable exceedences
Sulfur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day a year I day a year None

SO_2 causes a wide variety of health and environmental impacts both in its gaseous form and because of the way it reacts with other substances in the air. SO_2 dissolves in water vapour to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and the environment. Impacts can arise from SO_2 in its gaseous form; when it reacts with other chemicals in the air to form sulfate particles; and when absorbed onto fine particulate matter.

Adverse health and environmental effects of SO_2 have mainly been observed overseas, where SO_2 levels are higher than found in Australia. Within Sydney, SO_2 is present in emissions from motor vehicles and petroleum refining but is at low levels for a number of reasons, including the increasingly stringent Federal controls on sulfur in fuels. Emissions of SO_2 are also controlled through Part 7 of the proposed Regulation: see Chapter 8. However in NSW, by far the largest contribution of SO_2 is from coal-fired power stations located outside Sydney. Figure C6 (based on DECC 2007b) shows the sources of SO_2 emissions in the NSW GMR.

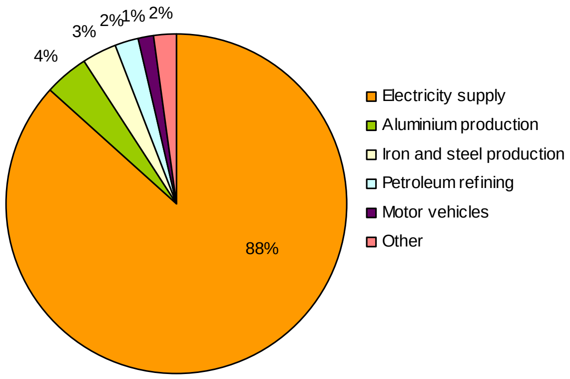


Figure C6: Sources of SO_2 emissions, NSW GMR

6.2 Impacts on human health

Controls on SO_2 are in place for two reasons:

- SO_2 is a significant precursor gas to the formation of fine particles or it can be absorbed onto fine particulate matter – see Division 2 of this appendix for the general health and environmental impacts of particulate matter.
- SO_2 is itself a significant pollutant with impacts on health and the environment.

Exposure to ambient levels of SO_2 results in reduced lung function, increased incidence of respiratory symptoms and diseases, irritation of the eyes, nose and throat, and premature mortality. Children, the elderly and those suffering respiratory ailments are particularly susceptible. For more information, see US EPA 2008d, WHO 2006 and Streeton 1997.

At very high levels sulfur dioxide may cause wheezing, tightness of chest and shortness of breath, even in healthy people who do not have asthma. Long-term exposure to sulfur dioxide can cause respiratory illness, alter the lung’s defence mechanisms, and aggravate existing cardiovascular disease.

Exposure to sulfuric acid mist can irritate the eyes, nose, throat and lungs, and at higher levels cause a build-up of fluid in the lungs (pulmonary oedema). Asthmatics are particularly sensitive to pulmonary irritation. Repeated exposures may cause permanent damage to the lungs and teeth. The International Agency for Research on Cancer has classified ‘occupational exposures to strong-inorganic-acid mists containing sulfuric acid’ as carcinogenic to humans (IARC 2010).

In many instances, it is difficult to separate the adverse effects from exposure to SO_2 from those related to the concurrent exposure to mixtures of other known irritant pollutants, such as ozone, NO_2 and, in particular, ultrafine particles. However, results from controlled exposure studies support the epidemiological findings with respect to exacerbation of asthma, increases in respiratory symptoms and decreases in lung function (WHO 2006).

6.3 Impacts on the natural and built environment

Sulfur dioxide can also damage both the natural and built environment. Even low concentrations of sulfur dioxide can harm plants and trees and reduce crop productivity.

Higher levels, and especially the acidic deposits from acid rain, would adversely affect both land and water ecosystems. SO_2 and NO_X react with other substances in the air to form acids, which fall to earth as rain, fog, snow or dry particles. Some may be carried by the wind for hundreds of kilometres. Although acid rain from sulfur dioxide has not been documented in Australia, in the USA and Europe, SO_2 is a primary contributor to its formation. For a full review of the effects of sulfur oxides on the environment, see US EPA 2008c.

Studies in the United States and elsewhere have shown that plants exposed to high ambient concentrations of SO_2 may lose their foliage, die prematurely or become less productive. Plants in the immediate vicinity of emission sources are most vulnerable. The most sensitive species of plants begin to demonstrate visible signs of injury at concentrations of about 1850 $\mu g/m^3$ for 1 hour, 500 $\mu g/m^3$ for 8 hours and 40 $\mu g/m^3$ for the growing season (World Bank Group 1999).

Division 7: Metals

7.1 Metals and their sources

Metals occur in the atmosphere primarily in the form of solid particles originating from combustion, incineration and metallurgical activities. Emissions of metals are principally controlled through Parts 3 and 4 of the Clean Air Regulation. For a review of the health and environmental impacts of metals as particles, see Division 2 of this appendix.

The major sources of metals are heavy industry, especially power generation, iron and steel manufacturing, petroleum and coal product manufacturing, and manufacturing where a metal is used. Metals normally exist at relatively low concentrations in urban airsheds, with significantly elevated levels only occurring near specific sources, such as roads subject to heavy traffic and some industrial sites.

Metals (and metalloids[28]) may be present in ambient air in a diversity of chemical forms because of their presence in various compounds in differing oxidation states. Coal combustion tends to produce metal and metalloid oxides in their highest oxidation states. Atmospheric chemical processes may also change the chemical nature of the metal or metalloid after emission to the atmosphere. These differences may affect not only the behaviour of metals in the environment but also their behaviour once inhaled or ingested (EPAQS 2009).

Metals (as an element or part of a compound) controlled by the proposed Regulation are grouped into ‘Type 1 substances’ and ‘Type 2 substances’ for the purposes of setting emission limits. For facilities that commenced operation before 31 July 1997 (Groups 1-4) (see Table 6.3), an aggregate limit is set for all Type 1 substances. For facilities that commenced after this date (Groups 5 and 6), an additional list of metals is included in a revised aggregate limit. Where there are limits on metal emissions, both cadmium and mercury also have individual limits.

Table C7 sets out the metals regulated by the proposed Regulation and their principal anthropogenic sources.

Table C7: Sources of air emissions of metals regulated by the proposed Regulation

Metal	Anthropogenic source
Type 1 substances	
Antimony	Coal-fired power stations, by-product of smelting lead and other metals; motor vehicle emissions and burning of fossil fuels
Arsenic	Coal-fired power stations, mining and metal manufacturing; electricity supply, water supply, sewerage and draining surfaces; manufacturing industries where arsenic may be used include food, paper and paper products, glass and glass products, petroleum and coal products and chemicals; diffuse emissions from roads, motor vehicles and lawn-mowing
Cadmium	Coal and oil burning power plants; by-product from the treatment of zinc, copper, lead and iron ores; diffuse emissions from small industrial domestic use of cadmium products

[28] Such as arsenic: metalloids (sometimes called semi-metals) are elements which have both metallic and non-metallic properties.

Metal	Anthropogenic source
Lead	Mining and metal manufacturing; electricity supply; water supply, sewerage and draining surfaces; oil and gas extraction; coal mining; manufacture of various products, including steel, cement, lime, plaster and ceramics; other manufacturing industries where lead may be used; diffuse emissions from roads, motor vehicles and lawn-mowing
Mercury	Fossil-fuel power plants; metal smelters; cement manufacture; precious metal mining; municipal landfills; sewage; metal refining; chemical manufacturing; diffuse emissions from home heating, disposal of mercury containing products
Type 2 substances	
Beryllium	Combustion of coal and oil in power plants; mining of ores containing beryllium
Chromium	Combustion of coal and oil; leather tanning; chemical manufacturing; metal finishing; diverse manufacturing, including pharmaceuticals, glass products, electrical products
Cobalt	Production of steel and other alloys; diffuse emissions from automotive repair shops and the mining or refining of nickel, copper, silver, lead and iron
Manganese	Mining, crushing and smelting of ores, during steel production, and from battery factories
Nickel	Combustion of coal and other fossil fuels; mining and refining operations; steel production, nickel alloy production, electroplating; incineration of municipal waste
Selenium	Combustion of coal and petroleum fuels (e.g. in coal-fired power stations); smelting and refining of metals such as copper, lead and zinc; glass and ceramics manufacturing; refuse incinerators; also accumulates in the residues from the manufacture of sulfuric acid
Tin	Combustion of coal and other fossil fuels
Vanadium	Steel production

Source: principally DEWHA 2009

7.2 Impacts on human health

Each of the metals regulated as Type 1 or Type 2 substances by the proposed Regulation are classified as toxic pollutants by the World Health Organization (WHO 2000). Toxic or hazardous air pollutants are those known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. The following summary of the health effects of metallic emissions is mainly sourced from the Public Health Statements of the US Agency for Toxic Substances and Disease Registry (ATSDR 2010) and the International Agency for Research on Cancer (IARC 2010).

Antimony

Exposure to antimony at high levels can result in a variety of adverse health effects. Its toxicity depends on its chemical form and oxidation state. Breathing high levels for a long time can irritate eyes and lungs and cause heart and lung problems, stomach pain, diarrhoea, vomiting and stomach ulcers. Antimony trioxide is a possible carcinogen.

Arsenic

Depending on its chemical form, particle size and solubility, arsenic is readily absorbed from the lungs into the bloodstream. Very high levels of arsenic can result in death. Arsenic is a human carcinogen.

Exposure to lower levels of arsenic, particularly sustained exposure, can cause a number of health effects, including skin disorders, stomach and digestive tract disorders, decreased production of red and white blood cells, damage to blood vessels, abnormal heart rhythms, abnormal foetal development, liver and kidney damage. Children and pregnant women may be especially susceptible to health effects from arsenic: see EPAQS 2009, Chapter 2 and US EPA 2009c.

Cadmium

Cadmium is a human carcinogen and may also cause reproductive damage. Exposure to cadmium can result in respiratory and lung irritation. Long-term exposure can result in anaemia, fatigue, loss of the sense of smell, and lead to a build-up of cadmium in the kidneys that can cause kidney disease. High exposures (only likely in the case of industrial accidents) can cause rapid lung damage, shortness of breath, chest pain and a build-up of fluid in the lungs. In severe cases death or permanent lung damage occurs. High exposure may also cause nausea, vomiting, cramps and diarrhoea.

Lead

Lead[29] is a very toxic element, causing a variety of effects at low dose levels. It can affect almost every organ and system in the body. Brain damage, kidney damage, and gastrointestinal distress are seen from short-term exposure to high levels of lead in humans. Long-term exposure to lead results in effects on the blood, central nervous system, blood pressure, kidneys and metabolism of Vitamin D.

Children are particularly sensitive to the chronic effects of lead, with slowed cognitive development, reduced growth and other effects reported. Reproductive effects, such as decreased sperm count in men, have been associated with high lead exposure. The developing foetus is at particular risk from maternal lead exposure, with low birth weight and slowed post-natal neuro-behavioural development noted. Lead is a probable carcinogen.

Mercury

Mercury in the air can fall to the ground with rain or snow, and eventually make its way into waterways. When mercury enters waterways, biological processes transform it to a highly toxic form that builds up in fish and animals that eat fish. Most people are exposed to mercury primarily by eating fish although they can also be exposed by breathing in gaseous emissions.

Mercury accumulates in the body and is highly toxic. Exposure to high levels of any types of mercury can cause permanent brain and kidney damage and adversely affect the developing foetus, particularly at critical periods of development. Exposure to mercury vapour may cause chest pain, damage the lining of the mouth and irritate the lungs and airways, and cause shortness of breath and a build-up of fluids in the lungs resulting in death. The nervous system is also very sensitive to all forms of mercury. Contact with mercuric chloride can cause burns to the skin and permanent damage to the eyes. Other effects from exposure to mercury vapour include nausea, vomiting, diarrhoea, increases in blood pressure or heart rate, skin rashes and eye irritation.

Beryllium

Beryllium is carcinogenic and all beryllium compounds are highly toxic. Exposure can be irritating to eyes, the respiratory system and skin. Breathing high levels of beryllium dust or fumes may irritate the respiratory tract, causing chemical pneumonitis (inflammation of the lungs) in short-term exposures. Longer term exposures can cause ‘chronic beryllium disease’. Both conditions can result in death. For more, see EPAQS 2009.

---

[29] While lead is one of the six key pollutants for which Air NEPM goals have been set, airborne levels have fallen dramatically since the banning of lead in petrol in 2002.

Chromium

Chromium (VI) is a carcinogen and is toxic in both short-term and long-term inhalation. Respiratory difficulties and allergic reactions have been associated with short-term high concentrations, while longer term exposure can result in damage to the respiratory and immune systems and cause lung cancer. Other effects include stomach upsets, ulcers, convulsions, kidney and liver damage. For more, see EPAQS 2009.

Cobalt

Exposure to high concentrations of cobalt may cause respiratory irritation, asthma and pneumonia. It is a possible carcinogen and may cause skin problems and damage the kidneys, lungs and heart. Repeated exposures can cause scarring of the lungs (pulmonary fibrosis). Cobalt is also a possible carcinogen.

Manganese

Long-term exposure to manganese can result in bronchitis, pneumonitis and ‘manganism’ (chronic manganese poisoning, usually seen only in the workplace, arising from damage to the central nervous system with behavioural changes and other nervous system effects). After exposure stops, chronic effects may still be present in some speech and balance problems. Damage to the reproductive system has also been observed in men exposed to high levels of manganese in workplace air.

Nickel

Low concentrations can result in asthma attacks for sensitised persons. Exposure to high concentrations can irritate the eyes, nose and throat and result in respiratory irritation, chronic bronchitis, reduced lung function, and lung or sinus cancer. Some nickel compounds are carcinogens. For more, see EPAQS 2009.

Selenium

Exposure to high concentrations of selenium causes respiratory irritation, bronchitis, headaches, dizziness and fatigue. Selenium hydride is the most acutely toxic selenium compound, resembling arsenic in its physiological reactions. Short-term exposure to selenium hydride can result in severe respiratory illnesses, such as bronchitis and bronchial pneumonia.

Tin

Some organo-tin compounds are harmful to humans, but the specific effects depend on the particular compound. Some organo-tins are possible or confirmed carcinogens. Harmful acute and/or chronic effects for short-term exposures of high concentrations include respiratory irritation, skin and eye irritation, gastrointestinal effects and neurological problems.

Vanadium

In addition to being a possible carcinogen, short-term and long-term exposure to high concentrations of vanadium can cause lung irritation, chest pain and other respiratory conditions. These effects cease soon after those exposed stop breathing the contaminated air.

7.3 Impacts on the natural and built environment

Environmental effects of metals and their compounds are variable, depending on their differing qualities, the concentration and length of exposure. Some metals can have serious effects on animals, plants and ecosystems. Acute toxic effects may include the death of animals, birds or fish, and death or low growth rate in plants. Acute effects are seen two to four days after animals or plants come into contact with a toxic chemical substance. Bioaccumulation can be a significant effect of some metals, affecting ecosystems.

Although there are significant gaps in the data for some metals and their compounds, some specific effects include:[30]

- **Aquatic life:** acute and/or chronic toxic effects (arsenic, cadmium, lead, mercury, beryllium, chromium (VI), cobalt, manganese, nickel, selenium, organo-tin) with some of these bioaccumulating (arsenic, cadmium, lead, mercury, cobalt, vanadium)
- **Animals:** acute and/or chronic toxicity (arsenic, lead, chromium (VI), selenium), bioaccumulation, shortened life span (lead) and reproductive problems (lead, vanadium)
- **Birds:** acute and/or chronic toxicity (arsenic, lead, chromium (VI), selenium), bioaccumulation (cadmium)
- **Plants:** acute and/or chronic toxicity (lead, chromium (VI)), bioaccumulation (antimony) reduced plant growth and crop yields (arsenic, chromium (VI), selenium, vanadium).

[30] See generally, DEWHA 2009

Appendix D:
Cost benefit calculations

Division 1: Introduction

This appendix contains details of the quantifiable costs and benefits of the proposed Regulation. It does not discuss costs or benefits that are either currently unquantified or unquantifiable: these are described in the substantive chapters.

1.1 Conventions

The following conventions are used throughout this appendix:

Base case: The ‘no-regulation’ option has been used as the base case for the purpose of these calculations.

Fines: The value of any fine paid has not been included as this is not a benefit or a cost to the NSW economy as a whole, but rather a transfer payment.

Rate of discount: Benefits and costs that span multiple years have been discounted to a present value at a discount rate of 7% per year as recommended by NSW Treasury (NSW Treasury 2007).

1.2 Valuation methods for health benefits

The principal benefit of reducing air pollution emissions occurs through the consequent reduction in air pollution and the associated reduction in damaging health impacts. The economic impact of air pollution on health can be estimated using the impact pathway approach or the damage cost approach.

The **impact pathway approach** is a bottom-up approach that involves:

- dispersion modelling that identifies the change in air pollution from a change in emissions, defined both temporally and spatially
- dose-response analysis that connects the air pollution exposure of affected populations to the health outcomes of that population through relative risk modelling which identifies the number of adverse health outcomes attributable to a level of air pollution exposure
- valuation that links the change in health outcomes with a cost per-case to derive the change in costs from the change in emissions.

The impact pathway approach connects the source of emissions, via any change in air quality, to physical impacts, before expressing the benefits and costs of these physical impacts in monetary terms. For example, US EPA 2006b uses emissions inventory data in models like the Regional Modelling System for Aerosols and Deposition model (REMSAD) to estimate a change in ambient air pollution, which is then used in the BenMAP model to estimate the health impact and associated economic value of the change (US EPA 2010c). There are, however, uncertainties in the impact pathway approach, including the availability and quality of the required data, the state of knowledge of atmospheric dispersion and chemistry, and the health effects of air pollution and the associated economic costs.

Estimating health effects using the impact pathway approach requires large investment by way of resources. When resource constraints do not permit use of the impact pathway approach, benefit or effect estimates from existing impact pathway empirical studies are used with suitable modifications. This benefit transfer approach is also referred to as the **damage cost approach** and uses values of the health cost caused by each additional tonne of pollutant emitted, and conversely the benefit from reducing emissions by one tonne. Critical to this approach is the choice of a marginal damage cost. Studies that estimate damage costs base their estimates on a range of site-specific factors, including the study area population and population density, the amount and composition of air pollution in the study area, and income levels and medical costs faced by people living in the study area. Using estimated damage costs in a different location or context implicitly assumes that there is no significant difference in these factors at the two sites. This may under- or over-estimate the relevant value. In particular, where an estimated damage cost from an overseas jurisdiction is used, it implies that the local damage pathway and health effects are identical to that of the overseas jurisdiction. Additional uncertainty with the damage cost approach comes from aggregating the benefit of reductions in multiple pollutants. Although the damage cost approach is not as sophisticated as the impact pathway approach, it still provides information useful for estimating the benefit of reducing air pollution emissions.

As a very large volume of information is required for the impact pathway approach and much of the required data is not available for Australia, the damage cost approach was used in this analysis to estimate the impact of changes in air pollution emissions. In this analysis, the possibility of double-counting was minimised by only estimating the benefit of reductions in particulate matter emissions and ground-level ozone precursor emissions. Even so, aggregating benefits across multiple emission sources or across multiple policy measures may still under- or over-estimate the total benefit.

1.3 Estimates of damage costs per tonne

Selected damage cost estimates are presented in Tables D1–D4. This list is not meant to be exhaustive: rather it summarises the estimates used in comparable jurisdictions, and illustrates the range of estimates used.

Table D1: United States damage cost estimates

Pollutant	US estimate in US$/ton		Equivalent A$/tonne*	
	Lower-bound	Upper-bound	Lower-bound	Upper-bound
NO_X (stationary source)	$370	$3,800	$595	$6,115
NO_X (mobile source)	$1,100	$11,600	$1,770	$18,670
Hydrocarbons (e.g. VOCs)	$600	$2,700	$965	$4,345
Particulate matter	$10,000	$100,000	$16,095	$160,935

Source: US Government 2006
* US$ value per ton/907.1847 kg x 1,000 kg x 1.46 PPP factor = A$ value per tonne. Purchasing Power Parity (PPP) factor from OECD 2009, Table 4

Table D2: European Union damage cost estimates

Pollutant	EU estimate in €/tonne		Equivalent A$/tonne*	
	Lower-bound	Upper-bound	Lower-bound	Upper-bound
NO_X	€4,400	€12,000	$7,560	$20,610
VOCs	€950	€2,800	$1,630	$4,810
Particulate matter ($PM_{2.5}$)	€26,000	€75,000	$44,660	$128,820

Source: Holland et al. 2005
* EU value per tonne/0.85 PPP factor x 1.46 PPP factor = A$ value per tonne. Purchasing Power Parity (PPP) factors from OECD 2009, Table 4

Table D3: United Kingdom damage cost estimates

Pollutant	UK estimate in £/tonne		Equivalent A$/tonne*	
	Lower-bound	Upper-bound	Lower-bound	Upper-bound
NO_X	£680	£1,980	$1,480	$4,315
Particulate matter ($PM_{2.5}$)	£20,155	£72,395	$43,925	$157,750

Source: DEFRA 2009
* UK value per tonne/0.67 PPP factor x 1.46 PPP factor = A$ value per tonne. Purchasing Power Parity (PPP) factors from OECD 2009, Table 4

Table D4: Damage cost estimates in the draft Vehicle Emission Standards RIS*

Pollutant	A$/tonne (range: rural to capital city)
NO_X	$155 to $1,055
Hydrocarbons (e.g. VOCs)	$105 to $8,830
Particulate matter (PM_{10})	$55,825 to $235,260

Source: DITRDLG 2009
* EPA 1997

Except for VOCs (where a more specific estimate of $4200 per tonne of VOCs was available), the damage cost estimates in Table D4 were used in this analysis to estimate the health benefits from avoided air pollution emissions. These estimates were based on an analysis of three recent studies into the health impact of transport-related air pollution emissions in Australia. The range represents estimates for capital city areas (upper-bound) and estimates for rural areas (lower-bound).

The damage cost estimates in Table D4 are relatively consistent with the estimates used within comparable jurisdictions overseas. The estimates are also broadly consistent with the DECC 2005b study, *Health Costs of Air Pollution in the Greater Sydney Metropolitan Region*, which estimated the health damage cost of particulate matter emissions to be $28,000 to $235,000 per tonne of PM_{10} in Sydney. While this study used PM_{10} as an index pollutant to quantify the health costs of the ambient air pollution mix, it did not quantify the additional health costs of ozone – an air quality concern in summer – or air toxics.

The estimate of $4200 per tonne of VOCs was recommended by McLennan Magasanik Associates Pty Ltd in their recent evaluation for DECCW of Stage 2 vapour recovery (MMA 2008).

Division 2: Domestic solid fuel heaters

2.1 Benefits

The quantifiable benefits of the minimum emission standards for domestic solid fuel heaters are lower emissions of particulate matter, leading to improved human health.

2.1.1 Reduction in pollutants

An estimated 30,000 new woodheaters are sold in Australia each year (BDA 2006). Of the 1,108,900 households in Australia that use wood as a source of energy in their home, 32% are within NSW (ABS 2008a). Based on this proportion, it is estimated that 9600 new woodheaters are sold in NSW each year.

An average household with a woodheater in NSW is assumed to use approximately 2 tonnes of fuel per year (BDA 2006). Compliance with Australian Standard 4013 (AS/NZS 1999) is estimated to avoid between 3.5 and 8 grams of particulate matter emissions per kilogram of fuel burnt (Atech 2001). This equates to 7–16 kilograms of avoided particulate matter emissions each year by an average household with a woodheater.

Between 67 and 153 tonnes of particulate matter emissions would be avoided each year from the estimated 9600 new woodheaters sold each year in NSW. Benefits from a woodheater complying with AS4013, however, would continue over the life of the woodheater. It has been estimated that the average lifespan of a woodheater in Australia is between 15 and 20 years (BDA 2006).

2.1.2 Health benefits

Using the damage cost estimates per tonne of PM_{10} set out in Division 1 of this appendix, the health benefit of woodheaters complying with AS4013 is estimated at between $3.74 million and $35.99 million per year.

2.2 Costs

The quantifiable costs of the minimum standards for domestic solid fuel heaters are the costs of government administration and the costs of testing and certification borne by industry and consumers.

2.2.1 Costs to government

DECCW administration of the woodheater provisions includes providing information to woodheater retailers and auditing compliance. It is estimated that 0.06 EFT time is taken up by these activities each year, with an estimated cost of $6200 per year.[31]

2.2.2 Costs to industry

In 2009, about 275 woodheater models on the market were certified as compliant with AS4013 (AHHA 2010). With compliance testing required to be renewed every five years, on average, 55 woodheater models would require compliance testing and certification each year. Manufacture and design costs to meet AS4013 were not expected to be significant and have not been estimated.

The average cost of AS4013 compliance testing and certification is $10,700 per woodheater model (BDA 2006). For the estimated 55 woodheater models compliance tested in Australia each year, the annual cost to industry would be $588,500. The share of this Australia-wide

[31] Less than one month per year (0.06 equivalent full-time) for an EPA officer with an annual salary of $79,992, plus 30% on-costs.

cost attributable to NSW is estimated to be $188,320 per year using the 32% proportion of NSW homes with woodheaters relative to all Australian homes with woodheaters (ABS 2008a).

2.2.3 Costs to households

The proposed woodheater provisions would result in costs for woodheater testing and certification. This represents an average cost of about $20 per woodheater if all of this cost was passed on to consumers of woodheaters.[32] However, as the woodheater provisions in the proposed Regulation are the same as those that currently apply, woodheater prices are not expected to increase as a result of the proposed Regulation.

2.3 Summary

The net quantifiable benefit of the woodheater provisions is estimated at between $3.55 million and $35.80 million per year. The health benefits can be expected to be maintained over the life of the heater (between 15 and 20 years), past the expected five-year life of the proposed Regulation. The majority of the population with woodheater controls are located in Sydney and other centres of urban population and, accordingly, the real benefit is likely to be towards the upper end of the range.

[32] NSW industry cost of $188,320 pa/9600 estimated new woodheaters are sold in NSW each year.

Division 3: Control of burning

3.1 Benefits

The quantifiable benefits of controls on burning are lower emissions of particulate matter, leading to improved human health.

3.1.1 Reduction in pollutants

Current particulate matter emissions from the burning that remains in the Sydney region are less than 5 tonnes of PM_{10} per year. The extent to which people would choose to burn domestic waste and vegetation if the controls provided by the current Regulation were to lapse is not known. For the purposes of this analysis, the effect of an increase from 5 tonnes to 10 tonnes of PM_{10} per year in the current contribution of open burning is assessed.

3.1.2 Health benefits

Using the damage cost estimates per tonne of PM_{10} set out in Division 1 of this appendix, the health benefit of the avoided particulate matter pollution is estimated at between $0.28 million and $1.18 million per year.

3.2 Costs

The quantifiable costs of controls on burning are the costs of government administration and waste collection costs to residents.

3.2.1 Costs to government

The cost to councils of administering the controls on burning is estimated to be $160,000 per year.[33]

3.2.2 Costs to residents

Less burning means that more waste has to be collected and disposed of. Using the estimated collection and disposal cost of $76 per tonne of waste (DEC 2005c), it is estimated that the cost to residents of controls on burning is $4000 per tonne of PM_{10} avoided.[34]

Assuming the controls on burning result in an avoided 5 tonnes of particulate matter emissions each year, the cost to residents of the avoided particulate matter pollution is estimated to be $20,000 per year.

3.3 Summary

The net quantifiable benefit of controls on burning is estimated at between $99,140 and $996,310 per year. The majority of the population subject to controls on burning are located in Sydney and other centres of urban population and, accordingly, the real benefit is likely to be towards the upper end of the range.

---

[33] Estimated to be equivalent of 2 full-time employees across all councils listed on the schedules at an estimated $80,000 per employee per year including 30% on costs

[34] Emission factor for municipal waste is estimated to be 53 tonnes of waste to one tonne of PM_{10} (i.e. $76 x 53 = $4028) derived from US EPA 2001.

Division 4: Smoky vehicles

4.1 Benefits

The quantifiable benefit of the smoky vehicles provisions are lower health costs as a result of a decrease in emissions of pollutants from vehicles repaired in response to an infringement notice or notice to repair a smoky vehicle.

4.1.1 Reductions in pollutants

A smoky vehicle emits higher concentrations of pollutants than an average vehicle. Smoky diesel vehicles emit higher than usual quantities of fine particles while smoky petrol vehicles emit higher concentrations of ozone precursors like VOCs. Table D5 presents the estimated air pollutants emitted by both an average vehicle and a defective one.

Table D5: Vehicle emission factors

	Air pollutant	Emissions for an average vehicle (g/km)	Emissions for an average defective vehicle (g/km)	Emissions avoided when vehicle repaired (g/km)
Petrol vehicles	VOCs	1.10	3.40	2.30
Diesel vehicles	PM_{10}	0.19	2.56	2.37

Source: unpublished DECCW data

Between 2002 and 2008, approximately 740 diesel and petrol vehicles were repaired each year as a result of the enforcement of the smoky vehicle provisions. The estimated avoided emissions per year are presented in Table D6.

Table D6: Avoided emissions from the smoky vehicle provisions

	Petrol vehicles	Diesel vehicles
Average vehicle kilometres travelled per year*	13,763	31,195
Number of smoky vehicles repaired each year	148	594
Avoided emissions (grams/kilometre)	2.30	2.37
Annual avoided emissions (tonnes/year)	4.68 tonnes of VOCs	43.92 tonnes of PM_{10}

* ABS 2008b: NSW values from Table 4, p. 12 – petrol km per year = 47,771 million passenger km/ 3,470,965 passenger vehicles; diesel km per year = (2655 million rigid truck km + 1419 million articulated truck km) / (114,340 rigid trucks + 16,257 articulated trucks)

4.1.2 Health benefits

The estimated health benefit resulting from the smoky vehicle provisions is calculated from the tonnes of avoided VOCs from petrol vehicles and the tonnes of avoided PM_{10} from diesel vehicles. Health benefit calculations were based on the estimated health damage costs presented in Division 1 of this appendix.

Table D7: Health benefits from the smoky vehicles provisions

Pollutant	VOCs	Lower-bound PM_{10} (rural)	Upper-bound PM_{10} (capital city)
Annual avoided emissions (tonnes/year)	4.68	43.92	43.92
Health cost per tonne	$4,200	$55,825	$235,260
Health benefit per year	**$19,660**	**$2,451,820**	**$10,332,660**

4.2 Costs

The quantifiable costs of the smoky vehicles provisions are the costs of government administration and the costs of repairing vehicles.

4.2.1 Costs to motorists

Typical repairs to a smoky diesel vehicle include tuning, filter replacements, new injectors and possibly engine reconditioning. The average cost to repair a smoky diesel vehicle is estimated to be $1150 per vehicle repaired.[35]

Typical repairs to a smoky petrol vehicle include re-tuning, head gasket replacement and possibly engine reconditioning or rebuilding. The average cost to repair a smoky petrol vehicle is estimated to be $1065 per vehicle repaired.[36]

Defective vehicle notices require the vehicle owner to undertake the necessary mechanical repairs or else have the vehicle registration cancelled. Penalty infringement notices may also be issued for smoky vehicles. The average number of smoky vehicle repairs each year is presented in Table D8.

Table D8: Repair costs of smoky vehicles repaired

	Petrol vehicles	Diesel vehicles	Total
Average annual number of smoky vehicles repaired	148	594	742
Average repair cost per vehicle	$1,065	$1,150	–
Total repair cost per year	**$157,620**	**$683,100**	**$840,720**

Source: DECCW internal reporting data averaged over the period 2002–08

4.2.2 Costs to government

The estimated annual cost of enforcing the smoky vehicle and anti-tampering provisions of the Regulation is $0.28 million. These costs include staff salaries and on-costs, provision of vehicles for use in enforcement activities, costs of stationery and postage, administration of the website reporting system, training of authorised officers and prosecutions.

Approximately 80% of this total cost is attributable to the enforcement of the smoky vehicle provisions, with an estimated cost to government of $224,386 per year. Of this, 20% ($44,877) is attributable to petrol vehicles and 80% ($179,509) to diesel vehicles. This distribution is calculated using the proportions of vehicles subject to enforcement action.

[35] Average diesel vehicle repair costs have been taken from NEPC 2001 and updated to 2009 values.
[36] Based on an estimation of automotive repair costs and frequencies

4.3 Summary

The net quantifiable benefit of the smoky vehicle provisions is estimated at between $1.41 million and $9.29 million per year as set out in Table D9.

Table D9: Summary of the annual costs and benefits of the smoky vehicle provisions

	Annual costs and benefits
Cost to government per year	$0.22 m
Cost to motorists per year	$0.84 m
Total costs	$1.06 m
Health benefit (VOCs) per year	$0.02 m
Health benefit (PM_{10}) per year	$2.45 m to $10.33 m
Net benefit per year	**$1.41 m to $9.29 m**

The majority of the population subject to the smoky vehicles provisions are located in Sydney and other urban population centres and, accordingly, the real benefit is likely to be towards the upper end of the range. Moreover, as the repairs for a smoky vehicle are likely to last beyond a year, there are additional health benefits over the life of the repair.

Division 5: Tampering with anti-pollution devices

5.1 Benefits

The quantifiable benefits of the anti-tampering provisions are lower health costs as a result of a decrease in emission of pollutants from vehicles repaired in response to an infringement notice or notice to repair a vehicle that have been tampered with.

5.1.1 Reductions in pollutants

Tampering with anti-pollution devices causes affected vehicles to emit higher concentrations of pollutants than those that have not. Table D5 presents estimates of the pollutants emitted by both an average and a defective or tampered vehicle.

Between 2002 and 2008, approximately 200 vehicles were repaired each year as a result of the enforcement of the anti-tampering provisions. The estimated avoided emissions per year are presented in Table D10.

Table D10: Avoided emissions from the anti-tampering provisions

	Petrol vehicles	Diesel vehicles
Average vehicle kilometres travelled per year (see Table D6)	13,763	31,195
Number of tampered vehicles repaired each year	201	11
Avoided emissions when vehicle repaired (grams/kilometre)	2.30	2.37
Annual avoided emissions (tonnes/year)	6.36 tonnes of VOCs	0.81 tonnes of PM_{10}

5.1.2 Health benefits

The estimated health benefit resulting from the anti-tampering provisions is calculated from the tonnes of avoided VOCs from petrol vehicles and tonnes of avoided PM_{10} from diesel vehicles.[37] Health benefit calculations were based on the estimated health damage costs presented in Division 1 of this appendix.

Table D11: Health benefits from the anti-tampering provisions

	VOCs	Lower-bound PM_{10} (rural)	Upper-bound PM_{10} (capital city)
Annual avoided emissions (tonnes/year)	6.36	0.81	0.81
Health cost per tonne	$4,200	$55,825	$235,260
Health benefit per year	**$26,710**	**$45,220**	**$190,560**

5.2 Costs

The quantifiable costs of the anti-tampering provisions are the costs of government administration and the costs to repair vehicles.

[37] While cumulative particle emissions from petrol vehicles may be significant and are expected to be addressed in revised Australian Design Rules, amounts per vehicle are relatively small and calculations based on fines or notices to repair do not make a material difference to the analysis.

5.2.1 Costs to motorists

The average cost of repairing a vehicle that has been tampered with is estimated to be $249.[38] Defective vehicle notices require the vehicle owner to undertake the necessary mechanical repairs or else have the vehicle registration cancelled. The average number of tampered vehicles repaired each year is presented in Table D12.

Table D12: Repair costs of tampered vehicles

	Petrol vehicles	Diesel vehicles	Total
Average annual number of tampered vehicles repaired	201	11	212
Repair cost per year	$50,050	$2,740	$52,790

5.2.2 Costs to government

The estimated annual cost of enforcing the smoky vehicle and anti-tampering provisions of the Regulation is $0.28 million.

Approximately 20% of this total cost is attributable to the enforcement of the anti-tampering provision with an estimated cost to government of $56,100 per year. Of this, 95% ($53,300) is attributable to petrol vehicles and 5% ($2800) to diesel vehicles. This distribution is calculated using the proportions of vehicles subject to enforcement action.

5.3 Summary

The net quantifiable benefit of the anti-tampering provisions is estimated at between (–) 0.04 million and $0.11 million per year as set out in Table D13.

Table D13: Summary of the annual costs and benefits of the anti-tampering provisions

	Annual costs and benefits
Cost to government per year	$0.06 m
Cost to motorists per year	$0.05 m
Total costs	*$0.11 m*
Health benefit (VOC) per year	$0.03 m
Health benefit (PM_{10}) per year	$0.05 m to $0.19 m
Net benefit per year	**– $0.04 m to $0.11 m**

The majority of the population subject to the anti-tampering provisions is located in Sydney and other urban population centres and, accordingly, the actual benefit is likely to be towards the upper end of the range. Moreover, as the repairs for a tampered vehicle are likely to last beyond a year, there are additional health benefits over the life of the repair. Further, these benefits are calculated based on repairs undertaken as a result of enforcement action, and do not include avoided tampering as a result of the deterrent effect of the provision.

---

[38] The average repair cost of vehicles subject to tampering was estimated in the 1997 Motor Vehicles and Motor Vehicle Fuels RIS (EPA 1997) and has been CPI-adjusted to 2009.

Division 6: Petrol volatility

6.1 Benefits

The quantifiable benefits of the limits on petrol volatility over summer are:

- lower emissions of VOCs resulting in less ozone at ground level and less damage to human health
- less fuel lost to the atmosphere, benefiting motorists and petrol distributors.

6.1.1 Reductions in pollutants

Lower petrol volatility over summer reduces the amount of petrol vapour lost during petrol distribution and the transfer of the petrol to a motor vehicle at a service station. The lower petrol volatility also reduces both the amount of petrol vapour that evaporates from a car's petrol tank and the amount that is emitted in the car's engine exhaust.

Table D14 sets out the projected reductions in VOC emissions using a baseline of 70 kPa.

Table D14: Avoided summer VOC emissions

	Avoided VOC emissions (tonnes/year)
Reductions in exhaust VOC emissions from vehicles	294
Reductions in evaporative VOC emissions from vehicles	3,308
Reductions in VOC emissions at distribution	362
Reduction in VOC emissions from off-road sources	590
Total reduction in emissions	**4,554**

6.1.2 Health benefits

The estimated health benefit resulting from lower petrol volatility over summer is calculated from the tonnes of avoided VOCs. Health benefit calculations were based on the estimated health damage costs presented in Division 1 of this appendix.

Reduced ground-level ozone from lower petrol volatility over summer is estimated to provide a health benefit of $19.12 million per year.

6.1.3 Fuel savings for motorists and industry

Savings from evaporative emissions have been calculated on the basis that one tonne of emissions is equivalent to 1518.5 litres of fuel. This has been derived from averaging the densities of petrol and butane. The density of petrol is 0.73 tonnes/cubic metre (m^3) and the density of butane is 0.6 t/m^3, which translates into 1369.9 litres per tonne of petrol and 1666.7 L/t of butane (Perry & Green 1984).

Petrol savings were estimated using the wholesale petrol price of 62.55 cents per litre. The wholesale petrol price equals the retail petrol price of $1.20 per litre (AAA 2009), less the 10% GST, less the fuel excise of 38.14 cents per litre, and less the gross retail margin of 7% of the retail petrol price.

Table D15 presents the avoided emissions and the savings to motorists and the petrol distribution industry estimated to result from lower petrol volatility over summer.

Table D15: Petrol savings from lower petrol volatility over summer

	Annual avoided VOC emissions and resulting savings
Reductions in evaporative VOC emissions from vehicles	3,308 tonnes
Motorist savings (millions)	$2.82 m
Reductions in VOC emissions at distribution	362 tonnes
Distributor industry savings (millions)	$0.31 m

An additional petrol saving is the petrol saved by off-road users, such as boats, garden equipment and off-road vehicles. These savings were not, however, included because of the uncertainty in attributing them to avoided evaporative emissions that represent saved petrol, or avoided exhaust emissions that occur because of changes in the combustion of the petrol in the engine.

6.2 Costs

The quantifiable costs of the limits on petrol volatility over summer are the costs to industry and the costs of government administration.

6.2.1 Costs to industry

The cost of compliance with petrol volatility limits is approximately $11.82 million per year. These costs were estimated from information provided to DECCW by Caltex, Shell, BP and Mobil. Refiners are readily able to reformulate petrol to meet the current petrol volatility limits without additional capital costs as the requisite management systems have already been developed. This reformulation results in more of the lighter hydrocarbons like butane being separated out during the refining of oil to petrol. The cost to industry represents forgone profit from redirecting butane away from its highest value end-product (petrol) and instead selling it as fuel gas.

These costs are very dependent on prevailing oil prices and exchange rates. Under a general assumption that the price of oil will increase over the next few years, the costs to industry would increase.

6.2.2 Costs to government

Costs to government are those associated with monitoring supplier compliance with the volatility limits, either through reviewing industry reports or checking compliance at retail outlets, refineries or terminals, and any enforcement activities that result. These annual government costs are estimated to be $50,000.

6.3 Summary

The net quantifiable benefit of lower petrol volatility over summer is estimated at $10.38 million per year as set out in Table D16.

Table D16: Summary of the annual costs and benefits of limits on petrol volatility over summer

Annual costs and benefits	
Total reduction in emissions	4,554 tonnes
Costs ($million/year)	
Industry costs	$11.82 m
Government costs	$0.05 m
Total costs	*$11.87 m*
Benefits ($million/year)	
Health costs avoided	$19.12 m
Motorist savings	$2.82 m
Distributor savings	$0.31 m
Total benefits	*$22.25 m*
Net benefit	$10.38 m

Division 7: Scheduled industry

The benefits and costs of the industrial emissions limits arise from the difference in industrial emissions with and without the Regulation. The approach to modelling future emissions both with and without the Regulation is outlined below.

7.1 Emissions modelling

Quantitative modelling was undertaken for oxides of nitrogen (NO_X) and particulate matter (PM_{10}) only. Other pollutants were assessed qualitatively.

7.1.1 Without the Regulation

Estimating the difference in emissions with and without the Regulation involves estimating how future emissions would vary if each of the main elements of the Regulation ceased to exist. The elements include:

- the requirement for Group 2 activities and plant to upgrade to meet Group 5 emission limits by 2012
- the requirement for any replaced or altered activities and plant to meet Group 6 emission limits
- the requirement for activities and plant to meet age-based emission limits.

No upgrading to meet Group 5 by 2012

Industrial emissions of PM_{10} and NO_X in NSW would increase if the requirement for Group 2 plant and equipment to meet Group 5 in 2012 did not exist. This increase was estimated using the following assumptions:

- 30% of total PM_{10} and NO_X industrial emissions in NSW are from plant and equipment in Group 2. This was estimated from the industry survey completed for the Air Emissions Inventory where the age of each item of plant and equipment was reported (DECC 2007b).
- The percentage of Group 2 plant and equipment that would need to upgrade to Group 5 is 11%. This assumption was based on the results of the phase-out of Group 1 by 2008.
- The reduction in NO_X emissions from Group 2 plant and equipment moving to Group 5 is 20%.
- The reduction in PM_{10} emissions from Group 2 plant and equipment moving to Group 5 is 60%.

No replacement or alteration to meet Group 6

Industrial emissions of PM_{10} and NO_X in NSW would increase if the requirement for replaced or altered activities and plant to move to Group 6 did not exist. This increase was estimated using the following assumptions:

- 50 items of plant and equipment are modified each year across NSW and would need to meet Group 6. This assumption is based on the average number of licence alteration applications received each year.
- Older plant is more likely to be replaced or altered than newer plant. In particular, the 50 items of plant and equipment altered or replaced each year were estimated to be distributed as follows:

  Group 2 – 20 items

  Group 3 – 10 items

Group 4 – 10 items

Group 5 – 10 items

- The reduction in NO_X emissions from Group 2, Group 3 and Group 4 activity or plant moving to Group 6 is 86%, with no reductions assumed for Group 5 activity or plant moving to Group 6.
- The reduction in PM_{10} emissions from Group 2, Group 3 and Group 4 activity or plant moving to Group 6 is 80%, with a 50% reduction assumed for Group 5 activity or plant moving to Group 6.

No age-based emission limits

Industrial emissions of PM_{10} and NO_X in NSW would increase if the age-based emission limits did not exist. This increase was estimated by assuming a 1% proportional increase in emissions from existing and new activities and plant when the age-based emission limits were removed. Emissions are unlikely to increase more than this as other measures like EPA operating licences, the POEO Act, LBL and local government planning controls limit potential emission increases.

7.1.2 With the Regulation

Projected PM_{10} and NO_X emissions from industrial activities in NSW over the next 20 years were estimated assuming that the Regulation remains in place. Current annual emissions were extracted from the NSW Air Emissions Inventory (for the NSW GMR) (DECC 2007b) and the National Pollutant Inventory (for other areas in NSW). Activities not controlled by the Regulation, such as coal mining, coal loading and quarrying of hard rock gravel, were then excluded. Future annual emissions were estimated using Air Emissions Inventory projections factors (DECC 2007b).

7.1.3 Emissions avoided by the Regulation

The difference between the emissions with and without the Regulation represents the avoided emissions attributable to the Regulation. Table D17 presents these differences in tonnes per year for selected years over the 20-year period modelled.

Table D17: Industrial emissions avoided by the Regulation

Year	2010	2015	2020	2025	2029
NO_X avoided by the Regulation (tonnes/year)	8,273	10,544	11,267	11,965	12,503
PM_{10} avoided by the Regulation (tonnes/year)	736	1,415	1,506	1,596	1,669

Source: unpublished DECCW emissions modelling

7.2 Benefits and costs

7.2.1 PM_{10} benefits

The estimated present value of the health benefit from the reduced PM_{10} emissions over 20 years as a result of the Regulation are presented in Table D18. Health benefit calculations were based on the estimated health damage costs for PM_{10} presented in Division 1 of this Appendix.

Table D18: Present value of health benefit estimates for PM_{10} over 20 years

	Health benefit
Benefit using lower-bound PM_{10} damage cost	$801 m
Benefit using upper-bound PM_{10} damage cost	$3,377 m

7.2.2 PM_{10} costs

For industry, costs of abatement of PM_{10} were based on fabric filter technology that would be required to meet the most recent PM_{10} emission limits in the Regulation. Installing self-cleaning fabric filters was estimated to cost $US148 per ton of PM_{10} abated (Pechan & Associates 2006). Adjusted to metric tonnes and Australian dollars, this equates to $326 per tonne of PM_{10} abated. The present value of the abatement cost of PM_{10} emission standards over 20 years is estimated to be $5 million.

7.2.3 NO_X benefits

The estimated present value of the health benefit from the reduced NO_X emissions over 20 years as a result of the Regulation are presented in the following table. Health benefit calculations were based on the estimated health damage costs for NO_X presented in Division 1 of this appendix.

Table D19: Present value of health benefit estimates for NO_X over 20 years

	Health benefit
Benefit using lower-bound NO_X damage cost	$17 m
Benefit using upper-bound NO_X damage cost	$118 m

7.2.4 NO_X costs

For industry, costs of abatement of NO_X were based on low NO_X burner technology that would be required to meet the most recent NO_X emission limits in the Regulation. Installing low NO_X burners was estimated to cost $115 per tonne of NO_X (unpublished industry data provided to DECCW in 2010). The present value of the abatement cost of NO_X emission standards over 20 years is estimated to be $13 million.

7.3 Summary

The net quantifiable benefit of emission standards for scheduled industry is estimated at between $801 million and $3,478 million over 20 years as set out in Table D20. This may be split into the net quantifiable benefit attributable to the emission standards for PM_{10} of between $796 m and $3372 m and the net quantifiable benefit attributable to the emission standards for NO_X of $4 m to $105 m.

Although PM_{10} emissions show no discernible trend in distribution between rural and urban areas, NO_X emissions are concentrated in rural areas so that health benefits attributable to emission standards for NO_X are likely to trend towards the lower-bound benefit.

Table D20: Summary of the costs and benefits of emission standards for scheduled industry (present value over 20 years)

	Lower-bound	**Upper-bound**
Health benefit PM_{10}	$801 m	$3,377 m
Health benefit NO_X	$17 m	$118 m
Total health benefits	*$819 m*	*$3,496 m*
Abatement costs PM_{10}	$5 m	$5 m
Abatement costs NO_X	$13 m	$13 m
Total costs	*$18 m*	*$18 m*
Net benefit	**$801 m**	**$3,478 m**

Note: Figures may not add up due to rounding.

Division 8: Non-scheduled industry

8.1 Emissions modelling

Modelling was undertaken for particulate (PM_{10}) emissions from both new non-scheduled industry and existing non-scheduled industry over a 20-year analysis period as recommended by NSW Treasury (NSW Treasury 2007). The following assumptions were used in the modelling.

8.1.1 New non-scheduled industry

- DECCW air emissions inventory data show that commercial facilities emit approximately 230 tonnes of PM_{10} from point sources in the NSW GMR each year (DECC 2007b). This equates to about 300 tonnes of PM_{10} for NSW as a whole, assuming that, in line with the state's population distribution, the NSW GMR is responsible for 75% of NSW emissions from commercial facilities.
- The NSW air emissions inventory data shows that emissions from commercial facilities are expected to increase by approximately 3 tonnes per year for the next 20 years. This is equivalent to approximately a 1% per year increase in total PM_{10} emissions from new premises that are non-scheduled.
- There is a direct relationship between emission concentration performance and annual pollutant load, i.e. upgrading from Group A to Group C would reduce the annual particulate matter emissions of plant and equipment by 75%.
- Sydney's share of PM_{10} emissions from non-scheduled industry is 53% (DECC 2007a).

8.1.2 Existing non-scheduled industry

Existing plant that is replaced in the GMA (Greater Metropolitan Area) would have the replacement plant subject to the Group C particulate matter emission standard (100 mg/m³). The estimated life of commercial plant and equipment of point sources covered by the Regulation is 14 years based on average data for asset life published by the Australian Tax Office. Asset life data for commercial point sources is presented in Table D21.

Table D21: Asset life data for commercial point source plant and equipment

Sector	Asset	Life in years
Nursery and floriculture production	Boiler (including piping) Steam boilers	20 15
Mushroom growing	Boilers (for humidification)	10
Poultry hatcheries	Boilers	20
Oil and gas extraction	Boilers Oil production asset boiler	10 10
Meat and meat production	Refrigeration and boiler	10
Soft drink cordial and syrup manufacturing	Boilers	10
Beer manufacturing	Boilers	10
Wine manufacturing	Boilers	15
Reconstituted wood product manufacturing	Heat plant and boiler assets	25
Average		14

Source: ATO 2009, Table A – Effective lives (industry category)

Based on the average life for commercial point source plant and equipment, it was estimated that 7% of the total plant and equipment is replaced each year from commercial facilities.

Projected total PM_{10} point source emissions from non-scheduled industry in NSW with and without the two standards in the Regulation, i.e. for new sources and for replacement of equipment, were then derived. The avoided emissions from the new source standard and the replacement of equipment standard are presented in Table D22.

Table D22: Non-scheduled point source PM_{10} emissions

	Non-scheduled point source PM_{10} emissions (NSW)			Avoided emissions	
Year	**No Regulation (tonnes)**	**With standard for new sources only (tonnes)**	**With standard for replacement of equipment only (tonnes)**	**New sources standard (tonnes)**	**Replacement of equipment standard (tonnes)**
2010	307	296	223	11	84
2011	310	297	220	13	90
2012	313	298	217	15	96
2013	316	299	213	17	103
2014	319	300	209	19	110
2015	322	301	205	21	117
2016	325	302	201	24	124
2017	329	303	197	26	132
2018	332	304	192	28	140
2019	335	305	187	30	148
2020	338	306	182	32	156
2021	341	306	184	35	157
2022	344	307	187	37	158
2023	347	308	189	39	158
2024	350	309	191	41	159
2025	353	310	194	43	159
2026	357	311	197	46	160
2027	360	312	199	48	161
2028	362	313	01	50	161
2029	365	313	204	52	162
Total				**627**	**2,734**

Source: unpublished DECCW emissions modelling

8.2 Benefits

These emission reductions have been used to calculate the benefits and costs of limits on particulate matter emissions from non-scheduled industry. The present value of the health benefits from the proposed Regulation over 20 years is set out in Table D23. Health benefit calculations were based on the estimated health damage costs for PM_{10} presented in Division 1 of this appendix.

Table D23: Health benefit estimates over 20 years

	Avoided particulate matter emissions (tonnes)	Health benefit (present value) lower-bound	Health benefit (present value) upper-bound
Replacement of equipment	2,734	$75 m	$316 m
New sources	627	$16 m	$66 m
Total	**3,361**	**$91 m**	**$382 m**

8.3 Costs

For industry, costs of abatement of PM_{10} were based on fabric filter technology that would be required to meet the most recent PM_{10} emission limits in the Regulation. Installing self-cleaning fabric filters is estimated to cost $US148 per ton of PM_{10} abated (Pechan & Associates 2006). Adjusted to metric tonnes and Australian dollars, this equates to $326 per tonne of PM_{10} abated.[39]

The present value of the abatement cost of emission standards for non-scheduled industry over 20 years is set out in Table D24.

Table D24: Costs to non-scheduled industry over 20 years

	Avoided particulate matter emissions (tonnes)	Abatement cost (present value)
Replacement of equipment	2,734	$0.44 m
New sources	627	$0.09 m
Total	**3,361**	**$0.53 m**

8.4 Summary

The net quantifiable benefit of emission standards for non-scheduled industry is estimated at between $90 million and $381 million over 20 years as set out in Table D24.

Table D25: Summary of the benefits and costs of emission standards for non-scheduled industry (present value over 20 years)

	Lower-bound	Upper-bound
Total health benefits	$91 m	$382 m
Total industry cost	$0.53 m	$0.53 m
Net benefit	**$90 m**	**$381 m**

[39] US$148 in 1998 dollars x June 2009 index number of 166.3 / June 1998 index number of 121.4 / 907.1847 kg x 1,000 kg x 1.46 PPP factor = A$326. Purchasing Power Parity (PPP) factor from OECD 2009

Division 9: Stage 2 vapour recovery

Modelling of the costs and benefits of the Stage 2 vapour recovery (VR2) provisions was undertaken over the period until 2040 as the provisions are being phased in from 2010 and major refurbishments of service stations occur about every 30 years.

9.1 Benefits

The quantifiable benefits of VR2 are:

- lower emissions of VOCs resulting in less ground-level ozone and less damage to human health
- recovery of fuel vapours as liquid fuel, benefiting industry.

The value of the recovered fuel has been included as an offset against industry costs.

9.1.1 Reductions in pollutants

VR2 is estimated to result in fewer VOC emissions than would otherwise be the case, as shown in Table D26. By the year 2015, VR2 would save 7.8 million litres of petrol a year (MMA 2008).

Table D26: Avoided VOC emissions for selected years (tonnes per year)

Year	2010	2015	2020	2025	2030	2035	2040
Avoided VOC emissions	660	4,570	5,990	6,840	7,400	7,850	8,450

Source: MMA 2008

9.1.2 Health benefits

Reduced ground-level ozone from VR2 is estimated to provide a health benefit of $231 million, expressed in present values for the period till 2040 (derived from benefit estimates in MMA 2008).

9.2 Costs

The quantifiable costs of VR2 are:

- industry costs for equipment, installation, operations, maintenance and compliance
- motorists costs passed through by industry
- government costs for monitoring and enforcement.

9.2.1 Costs to industry

The cost of the VR2 provisions, including the cost of capital equipment and installation, ongoing operating costs and compliance costs of ongoing inspection and certification is estimated to be $106 million expressed in present value terms for the period till 2040.[40] The value of the recovered fuel has been included as an offset against these costs.

While an individual service station may experience a loss of business if VR2 installation does not coincide with a scheduled refurbishment, this may be made up when other nearby stations

[40] Costs of this option from MMA 2008 (p. 77) less disruption costs of $34 million derived from cost estimates in MMA 2008

install VR2. Over the total population of service stations, there is likely to be no net loss of sales.

Cost estimates used in this analysis exclude disruption costs. If a service station has to close for the sole purpose of allowing VR2 installation, there would be some forgone profit from sales that did not occur at that service station. Customers may also be inconvenienced as they would have to find another service station to use. It can be assumed, however, that petrol not bought from one facility, would be purchased from another nearby facility.

The VR2 provisions result in an estimated additional cost to service station operators of less than 0.2 cents per litre of petrol sold (MMA 2008). Much of this cost would be passed on to customers through higher petrol prices than would otherwise be the case.

The cost of installing VR2 at a service station varies depending on the size of the station and the number of bowsers, whether the installation occurs during construction or a scheduled refurbishment, and the location of the service station. Depending on these factors, the total cost of implementing VR2 is estimated at between $20,000 and $450,000 per service station (MMA 2008). It is cheaper to install VR2 during construction or refurbishment as the underground pipes would already be exposed.

9.2.2 Costs to motorists

The VR2 provisions result in an estimated additional cost to service station operators of less than 0.2 cents per litre of petrol sold (MMA 2008). Much of this cost would be passed on to customers through higher petrol prices than would otherwise be the case.

9.2.3 Costs to government

Government costs include some additional monitoring and auditing. However, these costs are expected to be minimal and have not been estimated for this analysis.

9.3 Summary

The net quantifiable benefit of the VR2 provisions is estimated at $125 million over the period till 2040.

Acronyms and abbreviations

Air NEPM: National Environment protection Measure for Ambient Air Quality

CSIRO: Commonwealth Scientific and Industrial Research Organisation

DEC: Department of Environment and Conservation NSW (2004–07)

DECC: Department of Environment and Climate Change NSW (2007–09)

DECCW: Department of Environment, Climate Change and Water NSW (formerly DECC)

EPA: Environment Protection Authority NSW (part of DECCW)

EPHC: Environment Protection and Heritage Council

GMA: Greater Metropolitan Area (section 3, proposed Regulation)

GMR: Greater Metropolitan Region comprising the Sydney, Illawarra and lower Hunter regions[41]

LBL: Load-based licensing

LGA: Local government area

NEPC: National Environment Protection Council

NEPM: National Environment Protection Measure

OECD: Organisation for Economic Cooperation and Development

PAH: Polycyclic aromatic hydrocarbon

POEO Act: *Protection of the Environment Operations Act 1997*

RTA: Roads and Traffic Authority NSW

RIS: Regulatory impact statement

VOC: Volatile organic compound

VR1: Stage 1 vapour recovery (motor vehicle emissions)

VR2: Stage 2 vapour recovery (motor vehicle emissions)

WHO: World Health Organization

Units

µ	micro (10^{-6})
µg	microgram (10^{-6} grams)
µg/m^3	micrograms per cubic metre
µm	micrometre
CO_2	carbon dioxide
kg	kilogram
km	kilometre
m	metre
m^3	cubic metre
mg	milligrams (10^{-3} grams)
mg/kg	milligrams per kilogram
mm	millimetre
N	nitrogen
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
O_3	ozone
PM	particulate matter
PM_{10}	particulate matter less than 10 µm
$PM_{2.5}$	particulate matter less than 2.5 µm
$PM_{0.1}$	particulate matter less than 0.1 µm
ppb	parts per billion
ppm	parts per million
SO_2	sulfur dioxide
t	tonne
t/y	tonnes per year
y	year

[41] For the purpose of the NSW Emissions Inventory, the GMR is the area having Australian Map Grid (AMG) coordinates at the south-west corner at Easting: 210000, Northing: 6159000, Zone 56 and north-east corner at Easting: 420000, Northing: 6432000, Zone 56

References

AAA 2009, ‘Pricing summary for unleaded petrol’, Sydney metro average in November 2009, available at www.aaa.asn.au/petrol/nsw.xls

ABS 2008a, *Environmental Issues: Energy Use and Conservation*, Australian Bureau of Statistics, available at www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/C70521268BC1B3D4CA25750E001131EF/$File/4602055001_mar%202008.pdf

ABS 2008b, *Survey of Motor Vehicle Use: Australia – 12 months ended 31 October 2007*, Australian Bureau of Statistics Catalogue 9208.0, available at www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/40BA5EB0863D18F8CA2574B2000FD936/$File/92080_12%20months%20ended%2031%20october%202007.pdf

AHHA 2010, *Certified Wood Heaters*, Australian Home Heating Association Inc., available at www.homeheat.com.au/certified.php#

AQEG 2009, *Ozone in the United Kingdom,* Air Quality Expert Group, published by Department for the Environment, Food and Rural Affairs, available at www.defra.gov.uk/environment/quality/air/airquality/publications/ozone/documents/aqeg-ozone-report.pdf

Araujo, JA, Barajas, B, Kleinman, M, Wang, X, Bennett, BJ, Gong, KW, Navab, M, Harkema, J, Sioutas, C, Lusis, AJ & Nel, AE 2008, ‘Ambient particulate pollutants in the ultrafine range promote early arthrosclerosis and systemic oxidative stress’, *Circulation Research*, 102: 589–96

AS/NZS 1999, *AS/NZS 4013:1999 – Domestic solid fuel burning appliances: Method for determination of flue gas emission*, Standards Australia and Standards New Zealand 1999

Atech 2001, ‘Woodheater Emissions Management Program for the Tamar Valley’, scoping study prepared for Environment Australia by the Atech Group Pty Ltd, available at www.environment.gov.au/atmosphere/airquality/publications/tamar/pubs/tamarstudy.pdf

ATO 2009, *Taxation Ruling TR 2009/4 Income tax: effective life of depreciating assets*, Table A – Effective lives (Industry Category), Australian Taxation Office, available law.ato.gov.au/atolaw/view.htm?DocID=TXR/TR20094/NAT/ATO/00001

ATSDR 2010, *Public Health Statements*, Agency for Toxic Substances and Disease Registry, United States Department of Health and Human Services, available at www.atsdr.cdc.gov/phshome.html

BDA 2006, ‘Woodheater Particle Emissions and Operating Standards Cost Benefit Analysis’, report prepared for the Department of the Environment and Heritage, BDA Group and Environment Link, available at www.environment.gov.au/atmosphere/airquality/publications/pubs/wood-particle-emissions.pdf

BRO 2009a, *M-2009-20 Guide to Better Regulation*, Better Regulation Office, NSW Department of Premier and Cabinet, available at www.dpc.nsw.gov.au/publications/memos_and_circulars/ministerial_memoranda/2009/m2009-20_guide_to_better_regulation

BRO 2009b, *Guide to Better Regulation*, Better Regulation Office, NSW Department of Premier and Cabinet, available at www.betterregulation.nsw.gov.au/__data/assets/pdf_file/0009/16848/01_Better_Regulation_eGuide_October_2009.pdf

Cavanagh, JE, Trought, K & Brown, L 2009, ‘Relative toxicity of particulates emitted from individual source and ambient air particulates’ and ‘Chemical composition of particulates emitted from individual sources compared with ambient air particulates’, *Proceedings of the 19th International Clean Air and Environment Conference of the Clean Air Society of Australia and New Zealand*, Olinda, Victoria

Colucci, JM & Barnes, GJ 1986, 'The effect of exhaust system geometry on exhaust dilution and odour intensity' in Faiz, A, Weaver, CS & Walsh, PM 1996, *Air Pollution from Motor Vehicles – Standards and Technologies for Controlling Emissions*, World Bank, Washington DC, available at www.walshcarlines.com/pdf/air_pollution_from_moto.a72.pdf

COMEAP 2009, 'The effects on health of long-term exposure to ozone' in *Ozone in the UK: Health Implications*, provided in advance in 2009 as background

Cope, ME, Lee, S, Physick, B, Abbs, D, Nguyen, K & McGregor, J 2008, 'A methodology for determining the impact of climate change on ozone levels in an urban area', report by Commonwealth Scientific and Industrial Research Organisation, Division of Marine and Atmospheric Research, Aspendale Victoria for the Department of the Environment, Water, Heritage and the Arts (Clean Air Research Program), Canberra, available at www.environment.gov.au/atmosphere/airquality/publications/pubs/climate-change/climate-change.pdf

CSIRO 2008, *Evaluating the Health Impacts of Ethanol Blend Petrol*, Final Report KW48/17/F3.3F to Department of the Environment, Water, Heritage and the Arts, Canberra, available at www.environment.gov.au/atmosphere/fuelquality/publications/pubs/ethanol-health-impacts.pdf

Dean, M & Ferrari, L 1990, *Reduction in Sydney's Brown Haze from Refuse Burning Controls*, State Pollution Control Commission, Sydney

DEC 2005a, *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*, Department of Environment and Conservation NSW, Sydney, available at www.environment.nsw.gov.au/appmethods.htm

DEC 2005b, *Air Pollution Economics: Health Costs of Air Pollution in the Greater Sydney Metropolitan Region*, Department of Environment and Conservation NSW, Sydney, available at www.environment.nsw.gov.au/resources/air/airpollution05623.pdf

DEC 2005c, *Assessment of Garden Organics Collection Systems*, Department of Environment and Conservation NSW, Sydney, available at www.environment.nsw.gov.au/resources/warr/2005137_ORG_AssessOrgCollectSystems.pdf

DECC 2007a, *Air Emissions Inventory for the Greater Metropolitan Region in NSW: Domestic-Commercial Emissions Module*, Department of Environment and Climate Change NSW, Sydney, available at www.environment.nsw.gov.au/air/airinventory.htm

DECC 2007b, *Air Emissions Inventory for the Greater Metropolitan Region in NSW*, Department of Environment and Climate Change NSW, Sydney, available at www.environment.nsw.gov.au/air/airinventory.htm

DECC 2007c, *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*, Department of Environment and Climate Change NSW, Sydney, available at www.environment.nsw.gov.au/air/appmethods.htm

DECC 2008, *NSW Cleaner Vehicles and Fuels Strategy*, Department of Environment and Climate Change NSW, Sydney, available at www.environment.nsw.gov.au/air/actionforair/drftcvfstrat.htm

DECCW 2009a, *Action for Air: 2009 Update*, Department of Environment, Climate Change and Water NSW, Sydney, available at www.environment.nsw.gov.au/air/actionforair/ActionforAir2009.htm

DECCW 2009b, *Better Regulation Statement: Expansion of Vapour Recovery at Petrol Service Stations in the NSW Greater Metropolitan Region*, Department of Environment, Climate Change and Water NSW, Sydney, available at www.environment.nsw.gov.au/resources/air/BROstatement.pdf

DECCW 2010a, *Who Cares About the Environment in 2009?* Department of Environment, Climate Change and Water NSW, Sydney, available at www.environment.nsw.gov.au/community/whocares2009.htm

DECCW 2010b, *Woodsmoke: Resources for councils and other local authorities*, Department of Environment, Climate Change and Water, Sydney, available at www.environment.nsw.gov.au/woodsmoke/resources.htm

DECCW 2010c, *Sustainability Advantage*, Department of Environment, Climate Change and Water, available at www.environment.nsw.gov.au/sustainbus/sustainabilityadvantage.htm

DECCW 2010d, *Sustainable Business*, Department of Environment, Climate Change and Water NSW, Sydney, available at www.environment.nsw.gov.au/sustainbus/index.htm

DECCW 2010e, *Load-based Licensing*, Department of Environment, Climate Change and Water NSW, Sydney, available at www.environment.nsw.gov.au/licensing/lbl/lblicences.htm

DECCW 2010f, *Vapour Recovery at Petrol Stations*, Department of Environment, Climate Change and Water NSW, Sydney, available at www.environment.nsw.gov.au/air/petrolvapour.htm

DEFRA 2009, *Interdepartmental Group on Costs and Benefits: Air quality damage costs per tonne, 2008 prices*, UK Department for Environment, Food and Rural Affairs, London, available at www.defra.gov.uk/environment/quality/air/airquality/panels/igcb/guidance/damagecosts.htm

DEH 2004, *National Dioxins Program: Dioxins in Australia – a summary of the findings of studies conducted from 2001 to 2004,* Department of the Environment and Heritage, available at www.environment.gov.au/settlements/publications/chemicals/dioxins/community-summary/pubs/community-summary.pdf

DEWHA 2009, *National Pollutant Inventory Substance Fact Sheets*, Australian Department of the Environment, Water, Heritage and the Arts, available at npi.gov.au/substances/factsheets.html

DEWHA 2010, *Fuel Quality Standards,* Australian Department of the Environment, Water, Heritage and the Arts, available at www.environment.gov.au/atmosphere/fuelquality/standards/index.html

DITRDLG 2009, *Draft Regulation Impact Statement for Review of Euro 5/6 Light Vehicle Emission Standards*, Department of Infrastructure, Transport, Regional Development and Local Government, available at www.infrastructure.gov.au/roads/environment/euro.aspx

DITRDLG 2010, *Australian Design Rules*, Australian Department of Infrastructure, Transport, Regional Development and Local Government, available at www.infrastructure.gov.au/roads/motor/design/index.aspx

DoP 2005, *Metropolitan Strategy: City of Cities – A plan for Sydney's future*, Department of Planning, Sydney, available at www.metrostrategy.nsw.gov.au

DoP 2008, *New South Wales State and Regional Population Projections: 2006–36*, Department of Planning, Sydney, available at www.planning.nsw.gov.au/population/pdfs/nsw_state_regional_population_projections_2006_2036_2008release.pdf

Duc, H & Azzi, M 2009, 'Analysis of background ozone in the Sydney Basin', *Proceedings of the18th World IMACS/MODSIM Congress*, Cairns, available at mssanz.org.au/modsim09http://www.mssanz.org.au/modsim09/F10/duc.pdf

EPA 1997, *Regulatory Impact Statement: Proposed Clean Air (Motor Vehicles and Motor Vehicle Fuels) Regulation 1997*, Environment Protection Authority, Sydney

EPAQS 2009, *Metals and Metalloids,* Expert Panel on Air Quality Standards, UK Department for Environment, Food and Rural Affairs, London, available at www.defra.gov.uk/ environment/quality/air/airquality/panels/aqs/documents/metals-and-metalloids.pdf

EPHC 2009, *National Environment Protection Measure for Diesel Vehicle Emissions*, Environment Protection and Heritage Council, available at www.ephc.gov.au/taxonomy/ term/69

Faiz, A, Weaver, CS & Walsh, PM 1996, *Air Pollution from Motor Vehicles: Standards and Technologies for Controlling Emissions*, World Bank, Washington DC, available at www.walshcarlines.com/pdf/air_pollution_from_moto.a72.pdf

Fisher, G, Kjellstrom, T, Kingham, S, Hales, S & Shrestha, R 2007, *Health and Air Pollution in New Zealand*, available at www.hapinz.org.nz/

Galbally, IE 2009, 'Is background ozone changing, and what is its significance for Australia?', *Proceedings of the 19th International Clean Air and Environment Conference of the Clean Air Society of Australia and New Zealand,* Olinda, Victoria

Government of British Columbia 2010, *Backyard Burning*, available at www.env.gov.bc.ca/epd/bcairquality/topics/backyard-burning.html

Highwood, EJ & Kinnersley, RP 2006, 'When smoke gets in our eyes: The multiple impacts of atmospheric black carbon on climate, air quality and health', *Environment International*, 32: 560–66

Holland, M, Pye, S, Watkiss, P, Droste-Franke, B & Bickel, P 2005, *Damages per tonne emission of $PM_{2.5}$, NH_3, SO_2, NO_X and VOCs from each EU25 Member State (excluding Cyprus) and surrounding seas: A cost-benefit analysis of air quality related issues, in particular in the clean air for Europe (CAFE) programme*, prepared for the European Commission DG Environment, available at www.cafe-cba.org/assets/marginal_damage_03-05.pdf

Horton, A, Murray, F, Bulsara, M, Hinwood, A, & Farrar, D 2006, 'Personal exposure monitoring of benzene in Perth, Western Australia: The contribution of sources to non-industrial personal exposure', *Atmospheric Environment*, 40: 2596– 606

IPCC 2007, 'Summary for policymakers', *Climate Change 2007: The Physical Science Basis,* contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S, Qin, D, Manning, M, Chen, Z, Marquis, M, Averyt, KB, Tignor, M & Miller, HL (eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

IARC 2010, *Monographs on the Evaluation of Carcinogenic Risk to Humans, Overall Evaluations of Carcinogenicity to Humans*, International Agency for Research on Cancer, available at monographs.iarc.fr/ENG/Classification/crthgr01.php

Jerrett, M, Burnett, TR, Pope, CA, Ito, K, Thurston, G, Krewski, D, Shi, Y, Calle, E & Thun, M 2009, 'Long-term ozone exposure and mortality', *New England Medical Journal*, 360: 1085–95, available at content.nejm.org/cgi/content/full/360/11/1085

MMA 2008, 'Cost Benefit Analysis of Implementing Stage 2 Vapour Recovery', report to the Department of Environment and Climate Change NSW by McLennan Magasanik Associates Pty Ltd.

NEPC 1998, *National Environment Protection Measure and Revised Impact Statement for Ambient Air Quality*, National Environment Protection Council, available at www.ephc.gov.au/sites/default/files/AAQ_ImpStat__AAQ_NEPM_Revised_Impact_Statement_Final_199806.pdf

NEPC 2001, *In-Service Emissions Testing: Pilot Study – Fault Identification and Effect of Maintenance*, National Environment Protection Council, available at www.ephc.gov.au/sites/default/files/DVE_PrepWk__Project7_PilotStudy.pdf

NEPC 2009, *National Environment Protection Council Annual Report 2008–09*, NSW report, available at www.ephc.gov.au/sites/default/files/annual_reports/2009/ AR_Jur_AAQ_NSW_08-09.pdf

NSW Department of Premier & Cabinet 2008, *Towards 2030: Planning for our changing population*, available at www.dadhc.nsw.gov.au/dadhc/Publications+and+policies/

NSW Fire Brigades 2002, *New South Wales Fire Brigades Annual Statistical Report 2001–02*, available at: www.fire.nsw.gov.au/gallery/files/pdf/statistical_reports/ statisticsreport_0102.pdf

NSW Fire Brigades 2007, *New South Wales Fire Brigades Annual Statistical Report 2006–07*, available at www.fire.nsw.gov.au/gallery/files/pdf/statistical_reports/ASR_2006_07.xls

NSW Government 1998, *Action for Air: The NSW Government's 25-Year Air Quality Management Plan*, Sydney, available at www.environment.nsw.gov.au/air/actionforair/

NSW Government 2010, *State Plan: A new direction for NSW*, Premier's Department, Sydney, available at www.nsw.gov.au/sites/default/files/pdfs/ chapters/5.%20Green%20State_WEB.pdf

NSW Health 2010, *Environmental Health/Air Quality/Sensitive Groups*, available at www.health.nsw.gov.au/PublicHealth/environment/air/sensitive_groups.asp

NSW Transport & Infrastructure 2010, Metropolitan Transport Plan: Connecting the city of cities, available at www.nsw.gov.au/metropolitantransportplan

NSW Treasury 2007, *Economic Appraisal: Principles and Procedures Simplified*, available at www.treasury.nsw.gov.au/__data/assets/pdf_file/0018/7416/tpp07-6.pdf

NSW Treasury 2007, *State Infrastructure Strategy New South Wales 2008–09 to 2017–18*, available at www.treasury.nsw.gov.au/sis/state.infrastructure.strategy

NZ Ministry for the Environment 2010, *Air Quality Roles and Responsibilities*, New Zealand Ministry for the Environment, available at www.mfe.govt.nz/issues/air/responsibilities.html

OECD 2009, *OECD Stat Extracts*, Organisation for Economic Co-operation and Development, available at stats.oecd.org/Index.aspx?datasetcode=SNA_TABLE4

Perry, RH & Green, D 1984, *Perry's Chemical Engineers' Handbook*, International Edition, 6th edition, McGraw-Hill Inc.

Pechan, EH & Associates 2006, *AirControlNet Documentation Report*, prepared for US Environmental Protection Agency Office of Air Quality Planning and Standards, pp. III-1173 and III-1179

Pope, CA & Dockery, DW 2006, 'Health effects of fine particulate air pollution: lines that connect', *Journal of the Air and Waste Management Association*, 56: 709, available at www.noaca.org/pmhealtheffects.pdf

Pope, CA, Ezzat, M & Dockery, DW 2009, 'Fine-particulate air pollution and life expectancy in the United States', *The New England Journal of Medicine*, 360: 376–86, available at content.nejm.org/cgi/content/short/360/4/376

Queensland Government 2010, *Caring for our Air*, available at www.epa.qld.gov.au/environmental_management/air/caring_for_our_air/?format=print

Samet, JM, Rappold, A, Graff, D, Cascio, WE, Berntsen, JH, Huang, YT, Herbst, M, Bassett, M, Montilla, T, Hazucha, MJ, Bromberg, PA & Devlin, RB 2009, 'Concentrated ambient ultrafine particle exposure induces cardiac changes in young healthy volunteers', *American Journal of Respiratory and Critical Care Medicine*, 179: 1034–42, available at ajrccm.atsjournals.org/cgi/content/abstract/179/11/1034

Simkhovich, BZ, Kleinman, MT & Kloner, RA 2008, 'Air pollution and cardiovascular injury', *Journal of the American College of Cardiology*, 52: 719–26

Smith, KR, Jerrett, M, Anderson, HR, Burnett, RT, Stone, V, Derwent, R, Richard, W, Atkinson, RW, Cohen, A, Shonkoff, SB, Krewski, D, Pope, CA, Thun, MJ & Thurston, G 2009, 'Public health benefits of strategies to reduce greenhouse-gas emissions: health implications of short-lived greenhouse gases', *The Lancet*, 374/9707: 2091–103, available at www.thelancet.com/journals/lancet/article/PIIS0140-6736(09)61716-5/abstract

South African Department of Environmental Affairs and Tourism 2009, *AQA Implementation: Listed Activities and Minimum Emission Standards*, Output B.4 Final Review Report, Draft 2

Streeton, J, 1997, 'A Review on Existing Health Data on Six Pollutants', prepared for the National Environment Protection Council, available at www.ephc.gov.au/sites/default/files/AAQ_Rpt__Review_Existing_Health_Data_6_Pollutants_Report_Streeton_199705_reprint_200006.pdf

The Royal Society 2008, *Ground-level Ozone in the 21st Century: Future Trends, Impacts and Policy Implications*, Science Policy Report 15/08, available at royalsociety.org/Ground-level-ozone-in-the-21st-century-future-trends-impacts-and-policy-implications-/

US EPA 2001, *Open Burning*, Volume III, chapter 16, EIIP Document Series, United States Environmental Protection Agency, Washington DC, available at www.epa.gov/ttn/chief/eiip/techreport/volume03/iii16_apr2001.pdf

US EPA 2004, *Air Quality Criteria for Particulate Matter*, Final Report, EPA 600/P-99/002aF-bF, United States Environmental Protection Agency, Washington DC, available at cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903#Download

US EPA 2006a, *Air Quality Criteria for Ozone and Related Photochemical Oxidants*, Final report, EPA/600/R-05/004aF-cF, United States Environmental Protection Agency, Washington DC, available at cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=149923

US EPA 2006b, *Draft Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources*, United States Environmental Protection Agency, Washington DC, available at www.epa.gov/otaq/regs/toxics/chapter12.pdf

US EPA 2008a, *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria*, Final Report, EPA/600/R-08/071, United States Environmental Protection Agency, Washington DC, available at cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=194645

US EPA 2008b, *Integrated Science Assessment (ISA) for Oxides of Nitrogen and Sulfur Ecological Criteria*, Final Report, EPA/600/R-08/082F, United States Environmental Protection Agency, Washington DC, available at cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=201485

US EPA 2008c, *Integrated Science Assessment for Particulate Matter*, External Review Draft, United States Environmental Protection Agency, Washington DC, available at cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=201805

US EPA 2008d, *Integrated Science Assessment (ISA) for Sulfur Oxides: Health Criteria*, Final Report, EPA/600/R-08/047F, United States Environmental Protection Agency, Washington DC, available at cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=198843

US EPA 2009a, *Studies Examine Role of Composition in Particulate Matter (PM) Health Effects*, Clean Air Research Program, United States Environmental Protection Agency, Washington DC, available at www.epa.gov/airscience/pdf/ca-factsheet-pmcomp.pdf

US EPA 2009b, *Assessment of the Impacts of Global Change on Regional US Air Quality: A Synthesis of Climate Change Impacts on Ground-Level Ozone: An Interim Report of the U.S. EPA Global Change Research Program*, United States Environmental Protection Agency National Center for Environmental Assessment, available at cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=203459

US EPA 2009c, *Arsenic Compounds*, United States Environmental Protection Agency, available at www.epa.gov/ttn/atw/hlthef/arsenic.html#N_1

US EPA 2010a, *Backyard Burning*, United States Environmental Protection Agency, available at www.epa.gov/epawaste/nonhaz/municipal/backyard/index.htm

US EPA 2010b, *Health Effects of Ozone in the General Population*, United States Environmental Protection Agency, available at www.epa.gov/o3healthtraining/population.html

US EPA 2010c, *BenMAP Basic Information*, United States Environmental Protection Agency, available www.epa.gov/air/benmap/basic.html

US Government 2006, *Report to Congress on the Costs and Benefits of Federal Regulations: Appendix B*, Office of Management and Budget, available at www.whitehouse.gov/omb/inforeg/2006_cb/2006_cb_final_report.pdf

Weaver, CS, Klausmeier, RJ, Erickson, LM, Gallagher, J & Hollman, T 1986, ‘Feasibility of retrofit technologies for diesel emissions control’ cited in Faiz, A, Weaver, CS & Walsh, PM 1996, *Air Pollution from Motor Vehicles – Standards and Technologies for Controlling Emissions*, World Bank, Washington DC, available at www.walshcarlines.com/pdf/air_pollution_from_moto.a72.pdf

WHO 2000, WHO Regional Office for Europe Air Quality Guidelines, 2nd Edition, World Health Organization, Copenhagen, swww.euro.who.int/document/e71922.pdf

WHO 2006, *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide: Global Update 2005 – Summary of Risk Assessment*, World Health Organization, available at whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf

WHO 2010, *Dioxins and Their Effects on Human Health*, World Health Organization, available at npi.gov.au/substances/factsheets.html

World Bank Group 1999, *Pollution Prevention and Abatement Handbook 1998 – Toward Cleaner Production*, Washington DC