Department of Environment, Climate Change and Water (DECCW) – Cost Abatement Curves for Air Emission Reduction Actions

REPORT

- Final
- 28 May 2010

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Glossary

ABARE	Australian Bureau for Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AEI	Air Emissions Inventory
AF	Air Fuel Ratio Adjustment
AFCP	Alternative Fuel Conversion Programme
AIM	Architectural industrial maintenance
AGO	Australian Greenhouse Office
AQ	Air quality
ATC	Australian Transport Council
BASIX	Building Sustainability Index
CAC	Cost Abatement Curve
CAHC	Clean Air, Healthy Communities Program
CAIR	Clean Air Interstate Rule
CAMR	Clean Air Mercury Rule
CAPI	Clean Air Power Initiative
CAPER	Clear Air Plant Equipment Regulation 2002
CARB	California Air Resources Board
CAVR	Clean Air Visibility Rule
CBD	Central Business District
CH_4	Methane
CI	Compression ignition
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CO	Carbon monoxide
CO_2	Carbon dioxide
COAG	Council of Australian Governments
CPI	Consumer Price Index
CS	Clear Skies Bill
DECCW	Department of Environment, Climate Change and Water
DEWHA	Department of Environment, Water, Heritage and the Arts
DLN	Dry low NO_x combustor
DMPP	Demand Management and Planning Project
DoP	NSW Department of Planning
DPF	Diesel particulate filter
GAINS	Greenhouse Gas and Air Pollution Interactions and Synergies
GDP	Gross Domestic Product
GHG	Greenhouse Gases

GMR	Greater Metropolitan Region
EA	Environmental Assessment
EC4MACS	European Consortium for Modelling of Air Pollution and Climate Strategies
EGR	Exhaust Gas Recirculation
EPHC	Environment Protection and Heritage Council
ESMVI	Environmental Strategy for the Motor Vehicle Industry
FBC	Fuel Borne Catalyst
FCAI	Federal Chamber of Automotive Industries
Hg	Mercury
IC	Internal combustion
IIASA	International Institute for Applied Systems Analysis
I&M	Inspection and maintenance
ILC	Intermodal Logistics Centre
IR	Ignition timing retard
kPa	Kilopascal
LCM	Least cost model
LCV	Light Commercial Vehicles
L-E	Low-Emission Combustion
LNG	Liquefied natural gas
MACC	Marginal Abatement Cost Curve
MIR	Maximum incremental reactivity
MoT	Ministry of Transport
MSDS	Material Safety Data Sheet
MTBE	Methyl tetrabutyl ether
N_2O	Nitrous Oxide
NAAQS	National Ambient Air Quality Standards
NAFC	National average fuel consumption target
NEI	National Emission Inventory
NEPM	National Environment Protection Measure
NGGAS	New South Wales Greenhouse Gas Abatement Scheme
NH_3	Ammonia
NMIR	NOx maximum incremental reactivity
NO_x	Oxides of nitrogen
NPC	Net present cost
NRMA	National Roads & Motorists' Association
NSCR	Non-Selective Catalytic Reduction
NSW EPA	New South Wales Environment Protection Authority

NTBCP	National Travel Behaviour Change Program
O_3	Ozone
O&M	Operation and maintenance
$PM_{2.5}$	Particulate matter (less than 2.5micrometres in diameter)
PM_{10}	Particulate matter (less than 10micrometres in diameter)
PSC	Prestratisfied charge
PT	Public transport
QR	Queensland Rail
RAINS	Regional air pollution information and simulation.
RTA	Roads and Traffic Authority
SBM	Script Builder Module
SCM	Suggested control measures
SCR	Selective Catalytic Reduction
SKM	Sinclair Knight Merz
SO_2	Sulphur dioxide
ToR	Terms of Reference
Tpa	Tonnes per annum
TR	Technical Reports
TSP	Total suspended particulates
US EPA	United States Environmental Protection Agency
VKT	Vehicle Kilometres Travelled
VOC	Volatile organic compound
VR2	Stage 2 vapour recovery

Executive Summary

The NSW Government's State Plan commits the state to achieving air quality goals set in 1998 by the *National Environment Protection Measure (Ambient Air Quality)*. The Department of Environment, Climate Change and Water (DECCW) recognises that a reduction in anthropogenic emissions of volatile organic compounds (VOC) and oxides of nitrogen (NO_X) by 25% from 2003 levels must be achieved to meet this commitment.

DECCW engaged Sinclair Knight Merz (SKM) to undertake a study which identifies and analyses a range of emission abatement initiatives across the Greater Metropolitan Region (GMR) and sub-regions of NSW. SKM developed a Marginal Abatement Cost Curve (MACC) model to assist in assessing the practicability of each identified initiative from a number of perspectives including economic, environmental and social impacts as well as technical feasibility. Separate MACC curves were developed for each of the substances considered in this study, VOC, NO_X and particulates (PM_{10}), showing the cost and abatement quantity from a range of potential initiatives to reduce emissions in the NSW GMR. Health benefits were not included in the assessment.

The curves identify potential sets of strategies that could be applied to achieve target emission reductions at the least estimated cost, and are intended to provide a guide to prioritising potential actions for further investigation. The cost and emission abatement estimates for actions on which the curves are based are indicative and not always readily compared across actions, given that they are drawn from a range of studies and jurisdictions. Further full analysis of potential actions is required to determine the actual costs and emission abatement potential of the actions identified, as well as other benefits that may contribute to a program's value. The study includes direct benefits to the company or person undertaking the action, such as lower fuels costs, but excludes broader social benefits such as avoided health costs. For example, the air toxics reductions associated with actions to reduce VOC emissions represent a significant health benefit but are not included in the current analysis.

The MACC modelling exercise has yielded abatement cost curves that provide a range of measures, impacts and costs that can be considered as policy options to reduce ozone and particulates in the NSW GMR.

Key components of the report include:

- A methodology for developing MACCs for measures to reduce anthropogenic NO_X, VOCs and PM_{10} emissions in the GMR;
- A list of identified emissions abatement initiatives;
- Assessment of each initiative to determine important costing information and emissions abatement likely to be achieved by each initiative;

- Cost curves for NO_X, VOCs and PM_{10}; and
- Optimisation of the curves to consider the multi-pollutant framework of emissions abatement.

The reference case used for the MACC modelling represents emissions for the GMR (i.e. Sydney, Newcastle, Wollongong and Non Urban sub regions), projected from 2003 to 2031, under the assumption that prior trends in emissions profiles and drivers continue as they have previously, and adjusted for existing or highly likely policies or industry projects. In this sense, the reference case shows future emissions profiles excluding any abatement efforts beyond those reasonably expected through business as usual. The reference case is based on the emissions projections which were developed for the NSW Air Emissions Inventory (2003 base year) and which forecast emissions across five anthropogenic sectors including:

- Industrial;
- Commercial;
- Domestic-Commercial;
- On-Road Mobile; and
- Non-Road Mobile.

The methodology involved sequential and complementary steps, as follows:

- The construction of a reference case for abatement of NO_X ,VOCs and PM_{10} in the GMR, based on the emissions projections developed for the NSW Air Emissions Inventory 2003;
- The identification of priority emission sources with reference to NSW Air Emissions Inventory 2003, ranked by total mass of NO_X, VOCs and PM_{10} emissions;
- The identification of abatement options, costs and the magnitude of emission reductions for single and multiple pollutants, available from relevant actions, to deliver agreed reduction goals, e.g. reduction in anthropogenic emissions in Sydney region of NO_X ,VOCs and associated reduction in $PM_{10;}$
- The development of the cost abatement curve model that provides spreadsheets which graphically present incremental and total abatement cost schedules for each pollutant; and
- The construction of marginal abatement cost curves using the multi-pollutant framework that accounts for interdependencies between pollutants and across sectors. The methodology is informed by a review of integrated pollution management programs and models developed by international agencies.

Separate pollutant MACCs were developed for the GMR, Sydney and Wollongong. A total of 35 abatement initiatives were developed for the GMR with a smaller subset of these applicable in the

Sydney and Wollongong regions. A summary of the abatement initiatives identified and the pollutants affected by the measure are shown in the following table:

Initiative	No.	Pollutants		
		PM_{10}	NOx	VOCs
On-road Mobile – Technology Initiatives				
▪ Reduce summer petrol volatility (62kPa to 60kPa)	4			✓✓✓
▪ Truck and bus diesel retrofit	5	✓		
▪ Euro 5/6 emission standards for new vehicles	27	✓✓	✓✓✓	
▪ SmartWay Program	28	✓✓	✓✓	✓✓
On-road Mobile – Travel Demand Initiatives				
▪ Increased cycleways	11	✓	✓✓✓	✓✓
Non-road Mobile				
▪ Locomotives: existing -> US Tier 2	2	✓	✓✓✓	
▪ Locomotives: US Tier 2 -> US Tier 4	3	✓✓	✓✓✓	
▪ Recommission and electrify Enfield-Port Botany rail line	15	✓	✓✓	
▪ Port Botany shore side power	17	✓	✓✓✓	
▪ US Tier 4 Standards for non-road vehicles (ind/comm/const)	18	✓✓	✓✓✓	
▪ Small engines: (2 stroke to 4 stroke) – boats and mowers	25	✓	X	✓✓✓
Industrial				
▪ Coal fired power station DLN control (Group 6 CAPER)	1		✓✓✓	
▪ Refinery Vapour Recovery and Leak Detection and Repair	19			✓✓✓
▪ Emission Limits for Industry (NOx and PM10)	29	✓✓	✓✓✓	
▪ Open cut coal mines – buffer zone initiative	30	✓✓✓		
▪ Coal fired power station SCR	31		✓✓✓	
▪ Gas engine electricity SCR	32		✓✓✓	
▪ Cement industry NOx control	33		✓	
▪ CARB, 2008 Metal plating and coating works	34			✓✓✓
▪ Printing VOC emission control	35			✓✓✓
Domestic-Commercial				
▪ CARB, 2008 Regulation consumer solvents and aerosols	20			✓✓✓
▪ Wood heaters – reduce moisture content of wood	22	✓✓		
▪ National Standards for Wood Heaters (3 g/kg)	23	✓✓		
▪ National Standards for Wood Heaters (1 g/kg)	24	✓✓		
Commercial				
▪ CARB, 2008 Regulation for surface coatings	21			✓✓✓
▪ CARB 2008 Regulation for smash repairing	26			✓✓✓

Key:
✓✓✓ Strong abatement
✓✓ Moderate abatement
✓ Low abatement
X Emission increase

Note: the ticks (✓) provide a qualitative representation of the abatement potential for each measure. The crosses (x) indicate an increase in emissions.

The following table represents the % reduction from 2003 levels in regional emissions that could be abated through the full implementation of all initiatives[1]:

Maximum Identified Reductions of 2003 Emissions			
Region	**NO_X**	**PM_{10}**	**VOC**
GMR	58 %	25 %	18 %
Sydney	27 %	10 %	18 %
Wollongong	8 %	4 %	17 %

From its analysis, SKM has been able to generate three separate single pollutant Marginal Abatement Cost Curves (MACCs), showing the relative cost and size of potential abatement for each of the identified initiatives. Because it is problematic to allocate costs to one pollutant or another, SKM has constructed the three individual MACCs as if each pollutant was the only one being considered, and bears the full cost of each initiative (even where that initiative reduces other pollutants). Reconciliation of costs and abatement of all three pollutants is then conducted in a subsequent optimisation phase described below.

SKM's MACC model has the capability to generate both "simple" and "complex" MACC curves the latter taking into account interactions between initiatives that may reduce the effective total abatement from multiple measures that apply to the same sources. The effect is minimal for the suite of initiatives identified in this study, having an impact of between 0.1% and 6% for the various substances. Because the suite of initiatives identified does not exhibit significant interactions between initiatives, SKM has used the Simple MACC results in this report and the LP Optimisation, unless otherwise noted.

Note that the MACC curves can include "negative abatement" (ie an increase in substance emissions) because of interactions between the three substances. A single-substance MACC study would normally exclude initiatives that would increase emissions of that substance. In a multi-substance MACC study, an initiative may abate one substance while *increasing* emissions of another substance. SKM has developed an approach that allows "negative abatement" to be captured and considered in the MACC developed for each substance, such that it can be accurately considered in the final multi-substance optimisation stage. "Negative abatement" is possible in both the "simple" and "complex" MACCs.

[1] Where options are considered mutually exclusive, only the highest abatement option is considered.

Some travel demand management measures identified, which were directed primarily to other benefits (such as public transport provision) and for which air emission reductions are only an ancillary benefit, have not been considered in the final report. These appeared excessively costly considered in the context of emission reductions only and were not genuinely comparable to other actions specifically designed to reduce emissions.

The GMR and Sydney MACC charts for each pollutant are shown at the end of the Executive Summary, and described in more detail together with the Wollongong MACCs in Section 7 of this report.

In reviewing the MACC results, SKM found that while the optimal mix of initiatives differs for each pollutant, there is a significant degree of overlap in initiatives. That is, this analysis shows a number of initiatives that will have multiple benefits.

There are many significant results that can be drawn from the MACC modelling as shown in the MACC charts. Some key results are as follows:

GMR

- NO_X reduction is dominated by two initiatives aimed at reducing emissions from coal fired power stations being Dry Low NO_X (DLN) and Selective Catalytic Reduction (SCR). These initiatives can effectively be considered mutually exclusive – with the option chosen for implementation depending on the total level of abatement required (DLN for lower levels up to around 15% abatement, and SCR for levels between around 15% and 30%).
- PM_{10} reduction is dominated by the effect of buffer zones of future open cut coal mines being equated to emissions reduction. The measure would apply to an estimated future 10 coal mines that will likely be established to meet energy requirements up to 2030. This measure was assessed and considered by the study because no other opportunities were identified within the project scope for significant reduction of particulate emissions from coal mines over and above the existing management practices employed by the industry. It is noted that existing open cut mines already have buffer zones in place to mitigate the impact of particulates and the costs associated with the measure are intended to provide a guide as to the investment in land and property required to mitigate adverse impact by providing buffer zones to separate future mine developments and sensitive receivers.
- Options exist to reduce both NO_X and PM_{10} by the indicative 25% target identified for this study, though initiatives identified will only reduce VOC by 18%.

Sydney

- The profile of abatement options in the Sydney region is similar to the GMR, however with no coal power stations or open cut coal mines in the Sydney region, the largest NO_X and PM_{10} measures applicable to the GMR are not available within the Sydney region.

- NO_X emission reductions in the Sydney region need to focus on motor vehicle emissions and specifically the introduction of emission standards for motor vehicles e.g. Euro 5/6 standards for passenger cars and light commercial vehicles.
- Introduction of Californian Air Resources Board (CARB, 2008) emission standards for VOC sources, in particular surface coatings and consumer products, has the potential to reduce significant quantities of VOC emissions.
- Increased regulation of wood heaters in line with proposed national standards has the potential to reduce the greatest amounts of PM_{10} in the Sydney region.
- Reduction of NO_X by greater than 25% is possible, but reductions of only 10% of PM_{10} and 18% of VOC were identified.

Wollongong

- Aside from the Port Kembla Steelworks, which were not considered by the study as a more generic approach was taken, emissions reduction of NO_X, VOC and PM_{10} in Wollongong will be achieved by similar initiatives to those identified for Sydney.
- As per the Sydney region, NO_X abatement is dominated by Euro 5/6 standards for vehicles, PM_{10} abatement by low emission standards for wood heaters, and VOC abatement by CARB standards and small engine (boat and lawnmower) emission standards.
- Lower proportional abatement potential in the Wollongong region was identified, amounting to 8% of NOx, 4% of PM10, and 17% of VOC. To achieve even moderate reductions in the Wollongong region requires virtually all applicable initiatives to be implemented.

Optimised Mix of Initiatives

Besides the individual MACCs for each substance, SKM used Linear Programming to solve the multi substance optimisation method and model, and used this to analyse the optimum mix of initiatives to meet a notional 25% reduction in NO_X and VOCs and 10 – 30 % for PM_{10}. Because some initiatives reduce more than one substance, and in some instances even increase emissions of one substance while reducing another, determining the optimum mix can be complex, and is not as simple as taking the lowest cost measures from each of the three individual MACCs.

SKM's optimisation approach relies on a linear programming mathematical method, seeking to solve a function that minimises the total cost of all abatement, while achieving three constraints requiring the abatement of each of the three substances to at least equal the target amount. The method uses an iterative approach to arrive at an optimum least cost solution.

The table to follow shows the mix of initiatives implemented to achieve certain levels of abatement in all three substances in the GMR, Sydney and Wollongong regions[2]. Initiatives not available or applicable to some regions are shaded grey, while others indicate the percentage of full implementation of each initiative to meet the overall abatement level required.

Note that the full 25% target abatement is not achievable for all substances, with the actual level of abatement varying by substance and region.

A mix of relatively few initiatives is required to achieve abatement levels up to around 15%. Above that, the majority of cost effective initiatives identified are required. From a policy perspective it is noteworthy that an abatement initiative selected as a cost effective measure to meet a given target may no longer be cost effective when the abatement target is altered. The “end point” must be known when considering the mix of policy options, and gradually rolling out initiatives in order moving up the abatement curve may not result in the optimal mix at higher abatement levels.

Where mutually exclusive options exist (refer to Section 5.2.3) SKM has selected the option that would provide the least cost abatement across the largest range of abatement.

[2] Where possible, noting the full target abatement cannot be achieved for all substances in all regions – this is discussed in more detail in Section 7.5

Summary of LP Optimised Order of Initiatives

	% of full implementation required to meet abatement target	Greater Metropolitan Region				Sydney Region				Wollongong Region			
	Initiative	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement
1	Coal Fired Power Station NOx Control - Low NOx Burners	9%	75%										
2	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2												
3	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 plus USEPA Tier 2 ---> Tier 4					13%	9%	3%		22%	17%	4%	
4	Summer-time Petrol Volatility (62 kPA to 60 kPA)	5%	0%		4%	4%	0%		4%	3%	0%		4%
5	Truck and Bus Diesel Retrofit					0%		0%		0%		0%	
15	Recommission and Electrify Enfield-Port Botany Freight Line	1%	0%	0%	0%	1%	0%	0%	0%				
17	Port Botany Shore-Side Power	2%	0%	0%	0%	3%	1%	0%	0%				
18	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)					0%	2%	1%		1%	4%	1%	
19	Petrol Refinery Vapour Recovery and Leak Detection and Repair	0%			1%	0%			1%				
20	CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols	37%			15%	34%			15%	33%			16%
21	CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)	2%			31%	2%			30%	3%			33%
22	Wood Heaters - Reduce the Moisture Content of Firewood												
23	National Standards for Wood Heaters (3 g/kg)												
24	National Standards for Wood Heaters (1 g/kg)	1%		8%		1%		66%		2%		59%	
25	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	12%	-0%	1%	22%	10%	-1%	10%	20%	12%	-1%	10%	25%
26	CARB 2008 Regulation for Surface Coatings - Smash Repairing	3%			2%	3%			2%	3%			2%
27	Euro 5/6 Emission Standards for New Passenger Vehicles	21%	20%	1%	13%	21%	58%	5%	14%	19%	55%	3%	12%
29	Emission Limits for Industry (NOx and PM10)	2%	4%	2%		2%	12%	14%		4%	25%	22%	
30	Open Cut Coal Mining Buffer Zone Initiative	2%		88%									
31	Coal Fired Power Station - Selective Catalytic Reduction (SCR)												
32	Gas Engine Electricity Generation - SCR					4%	16%						
33	Cement Industry NOx Control					0%	2%						
34	Metal Plating and Coating Works: CARB, 2008 AIM Regulation	0%			4%	0%			5%	0%			7%
35	Printing VOC Emissions Control	1%			7%	1%			9%				
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Total Cost ($ Billion) & abatement % achieved	**$ 1.45**	**25%**	**25%**	**18%**	**$ 1.24**	**25%**	**10%**	**18%**	**$ 0.06**	**8%**	**4%**	**17%**
	Abatement tonnes		**91,899**	**28,358**	**30,806**		**24,994**	**2,571**	**24,112**		**1,189**	**158**	**1,114**

No contribution	0-4% contribution	5-14% contribution	15-29% contribution	> 30% contribution

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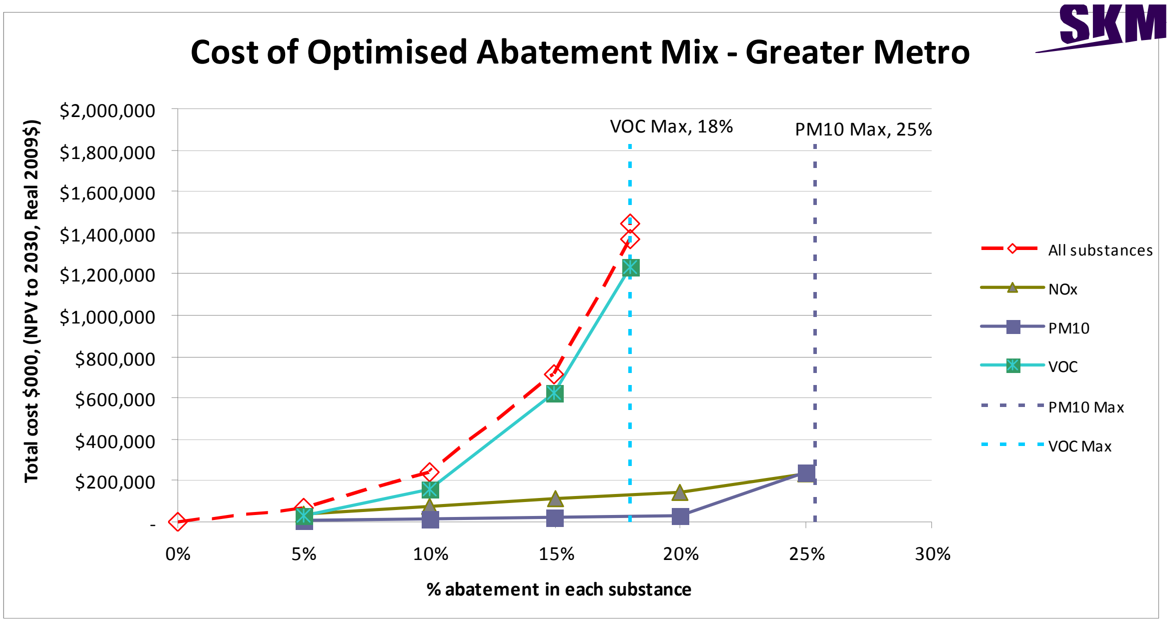
The list of initiatives in approximate priority order, from visual inspection of the optimum mix table above, is shown in the table below.

Priority	GMR
High	▪ Shift Transport Mode to Cycling * ▪ SmartWay Program * ▪ Coal Fired Power Station NOx Control - Low NOx Burners ▪ Petrol Refinery Vapour Recovery and Leak Detection and Repair ▪ CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM) ▪ Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing ▪ Open Cut Coal Mining Buffer Zone Initiative ▪ Metal Plating and Coating Works: CARB, 2008 AIM Regulation ▪ Printing VOC Emissions Control ▪ Euro 5/6 Emission Standards for New Passenger Vehicles
Medium	▪ Summer-time Petrol Volatility (62 kPA to 60 kPA)
Low	▪ Tier 2 -> Tier 4Locomotives: Selective Catalytic Reduction and Diesel Particulate Filter
	Measures requiring higher priority for Sydney region (in addition to those identified above)
High	▪ Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 ▪ Retrofit Tier 2 Locomotives with Selective Catalytic Reduction (SCR) and Diesel Particulate Filter (DPF) ▪ Truck and Bus Diesel Retrofit ▪ Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction) ▪ Wood Heaters - Reduce the Moisture Content of Firewood ▪ National Standards for Wood Heaters (3 g/kg) ▪ National Standards for Wood Heaters (1 g/kg) ▪ Emission Limits for Industry (NOx and PM10) ▪ Gas Engine Electricity Generation — SCR ▪ Cement Industry NOx Control
	Measures requiring higher priority for Wollongong region (in addition to those identified above)
High	▪ Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 ▪ Truck and Bus Diesel Retrofit ▪ Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction) ▪ Wood Heaters - Reduce the Moisture Content of Firewood ▪ National Standards for Wood Heaters (3 g/kg) ▪ Euro 5/6 Emission Standards for New Passenger Vehicles

Note * the Cycling and SmartWay initiatives were assessed as having negative economic cost (net benefit).

The chart below shows the results of SKM's optimisation analysis for the GMR region. Note that maximum achievable VOC abatement was 18%, so the full solution of 25% reduction in NO_X and VOCs and 10 – 30 % for PM_{10} could not be found. For clarity, the options with net benefits have been excluded from the cost analysis, as they can be implemented as "no regrets" options and their strongly negative costs distort the impact of other initiatives. As they exhibit relatively small abatement (between 0.1% - 0.3%) compared to total identified abatements, their omission does not materially alter the results.



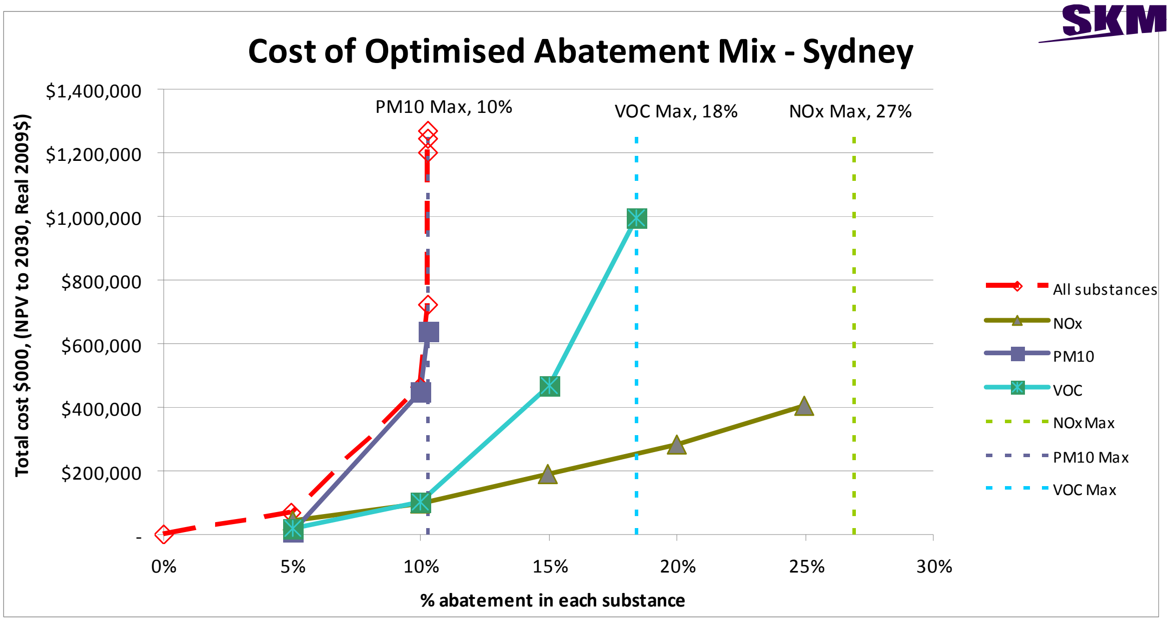
Nominal multi abatement target	0%	5%	10%	15%	20%	25%	30%
Actual abatement achieved							
NOx	0%	5%	10%	15%	20%	25%	30%
PM10	0%	5%	10%	15%	20%	25%	25%
VOC	0%	5%	10%	15%	18%	18%	18%
Net Present Cost ($B)	$0.00	$0.07	$0.24	$0.72	$1.37	$1.45	$1.83

	Achieved Target		<5% Deviation		>5% Deviation

The chart shows that VOC is the primary driver of costs, with the cost of achieving comparable concurrent percentage abatement in other substances only minimally more expensive than VOC alone. If NO_X and PM_{10} are considered independently, the costs are low and could even result in overall economic savings. As the chart and table show, concurrent abatement of all substances to 25% cannot be achieved, as identified initiatives for VOC are insufficient to achieve 25% abatement.

Abatement up to around 15% of all three substances can be achieved at relatively low net present cost (over 20 years), of around $717 million, with a sharp increase in costs for abatement above 15%. The total net present cost of the optimised suite of abatement initiatives for the GMR, to achieve reductions in NO_X, VOCs and PM_{10} of 25%, 18% and 25% respectively, would be $1.45 billion. Greater abatement percentages for NO_X and PM_{10} can be achieved at lower cost, indicating a differentiated target for VOC of around 15% could be an economically attractive policy option. SKM has not assessed the economic benefits of lower VOC emissions, and does not consider it has sufficient information to recommend targets based on costs alone, but the cost curve above provides input to such analysis and policy considerations.

The chart showing the cost of abatement for the Sydney region is presented below.



Nominal multi abatement target	0%	5%	10%	15%	20%	25%	30%
Actual abatement achieved							
NOx	0%	5%	18%	21%	21%	25%	27%
PM10	0%	5%	10%	10%	10%	10%	10%
VOC	0%	5%	10%	15%	18%	18%	18%
Net Present Cost ($B)	$0.00	$0.07	$0.47	$0.72	$1.20	$1.24	$1.27

	Achieved Target		Exceeded Target		≤5% Deviation		>5% Deviation

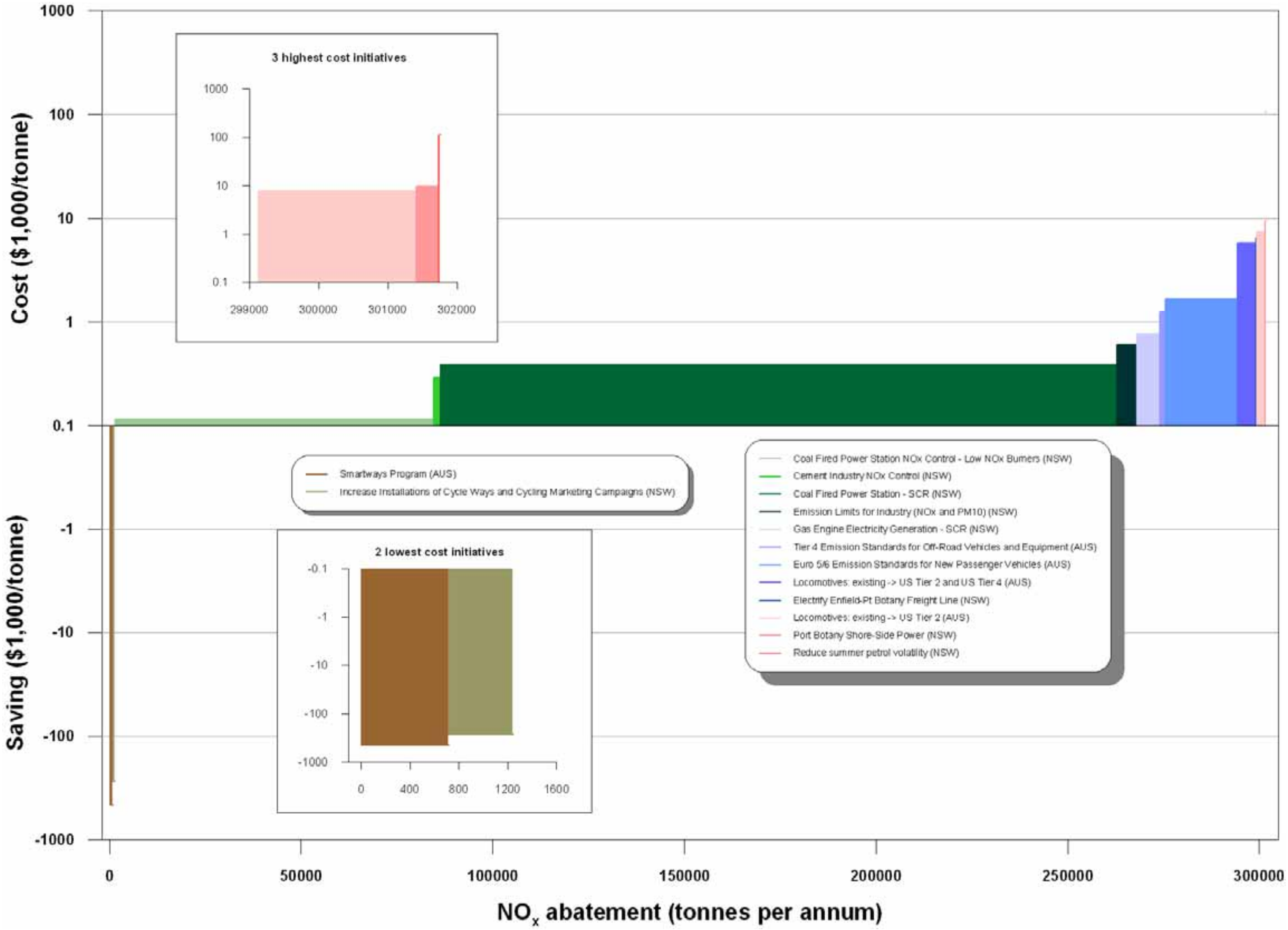
The chart shows that the cost of achieving concurrent percentage abatement up until 10% for all three substances is only minimally more expensive than PM_{10} alone. For further abatement between 10% and 20%, abatement of VOC is the primary driver of cost (holding PM_{10} abatement constant at 10%). As the chart and table show, concurrent abatement of all substances to 25% cannot be achieved, as identified initiatives for PM_{10} and VOC are insufficient to achieve 25% abatement.

The maximum abatement potential identified is 27% for NO_X, 18% for VOC, and 10% for PM_{10}, which could be achieved at a total net present cost of $1.27 billion, with a sharp increase in costs at around 10% "multi abatement" due to PM_{10} measures having been exhausted and the more expensive VOC measures being implemented. The nominal 25% abatement target point is 25% for

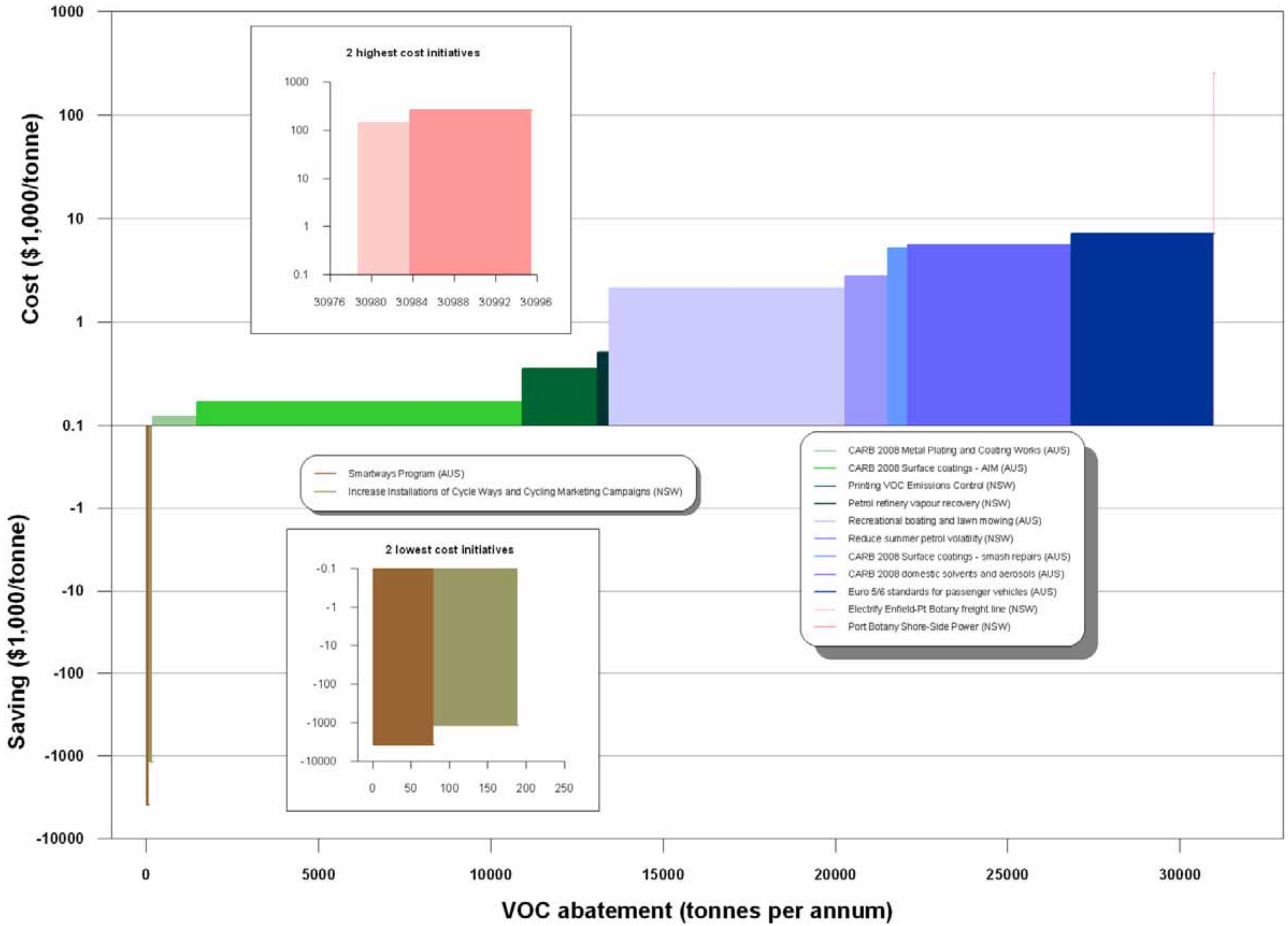
NO_X, 18% for VOC, and 10% for PM_{10}, which could be achieved at a total net present cost of \$1.24 billion. The 10% abatement of all three pollutants could be achieved at a net present cost of around \$465 million. Some differentiation of targets for the three substances could achieve close to the maximum potential abatement at reduced cost.

Again SKM has not assessed the economic benefits of lower VOC emissions, and does not consider it has sufficient information to recommend targets based on costs alone, but the cost curve above provides input to such analysis and policy considerations.

GMR NO_X MACC Chart



GMR VOC MACC Chart



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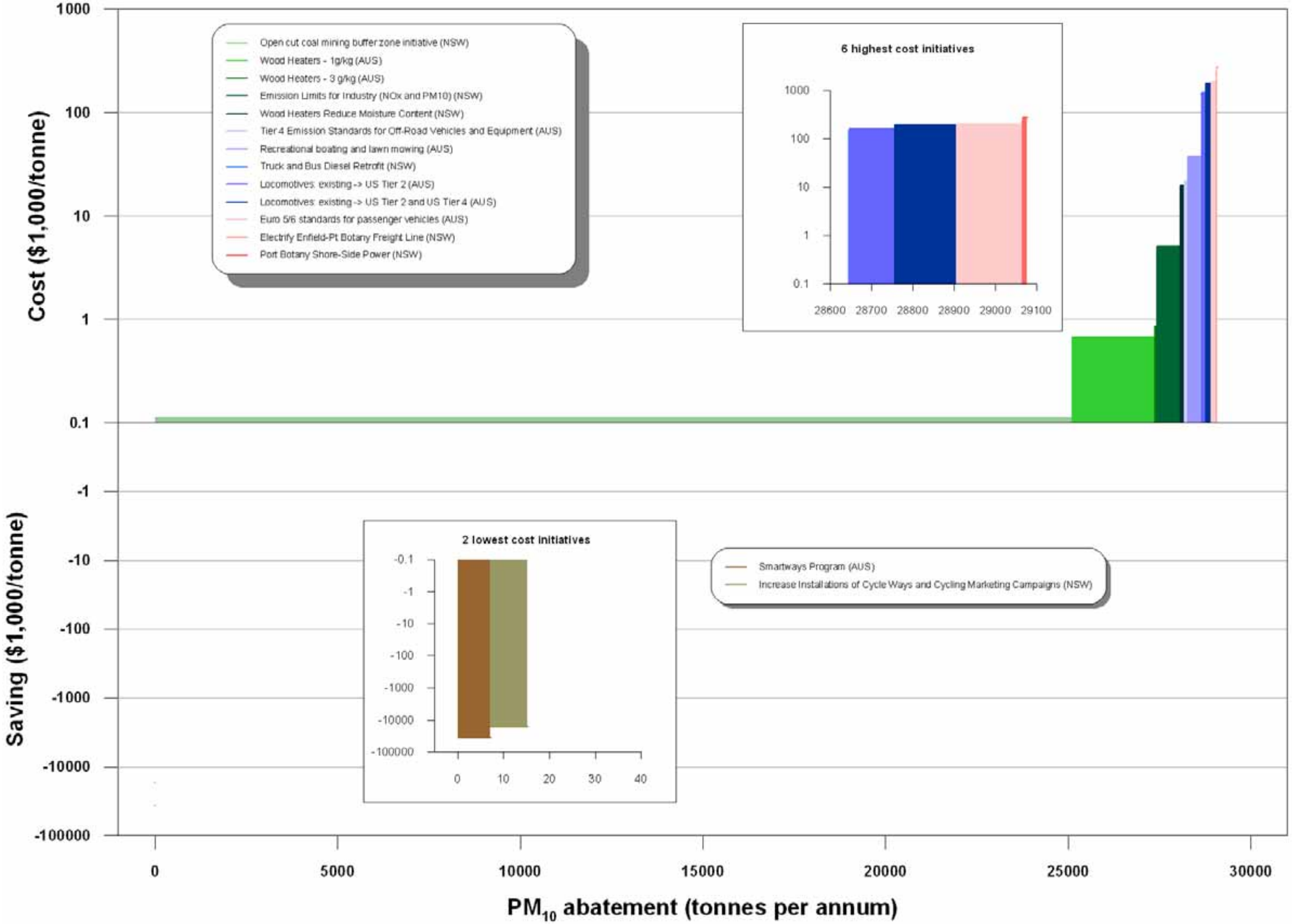
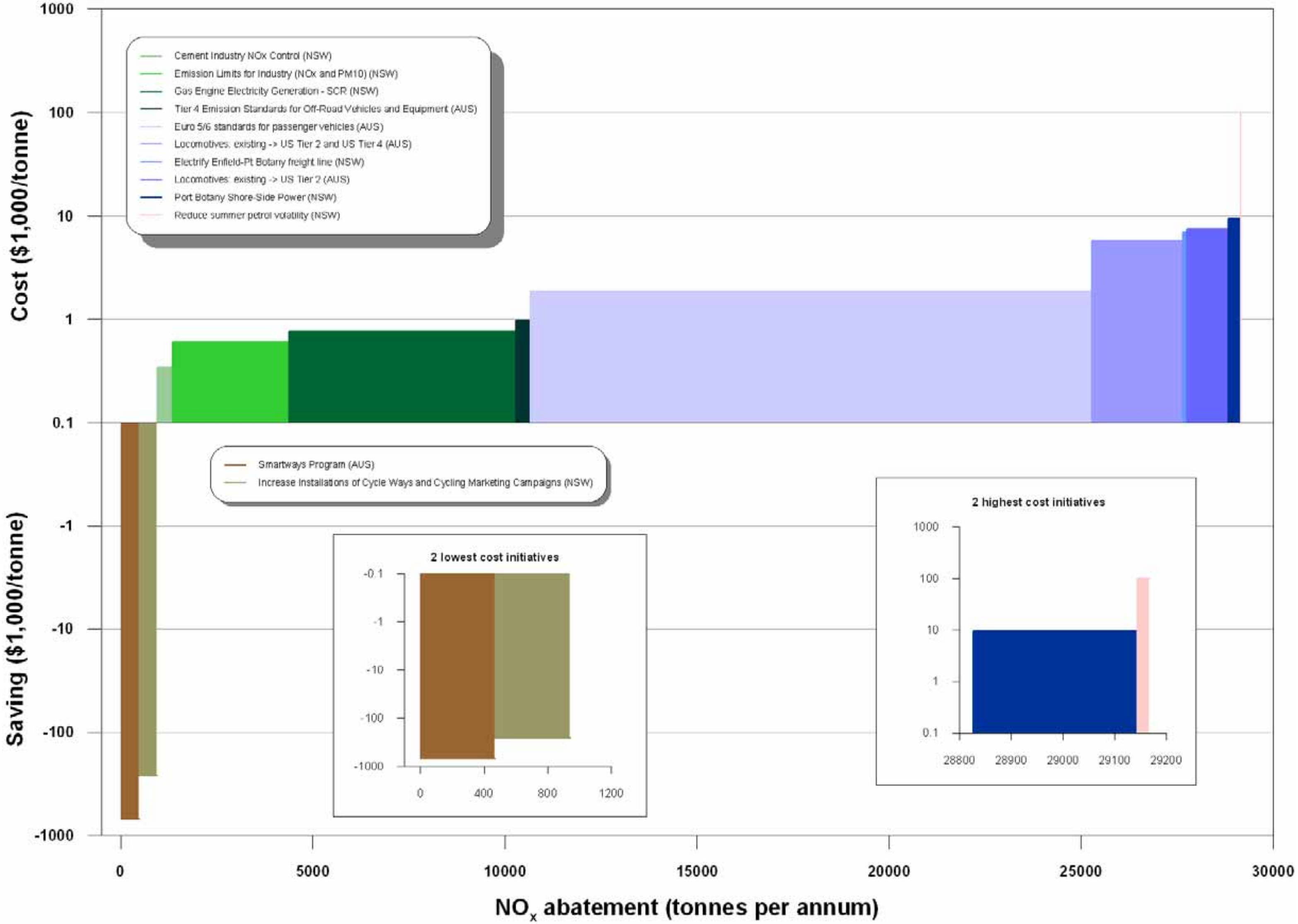
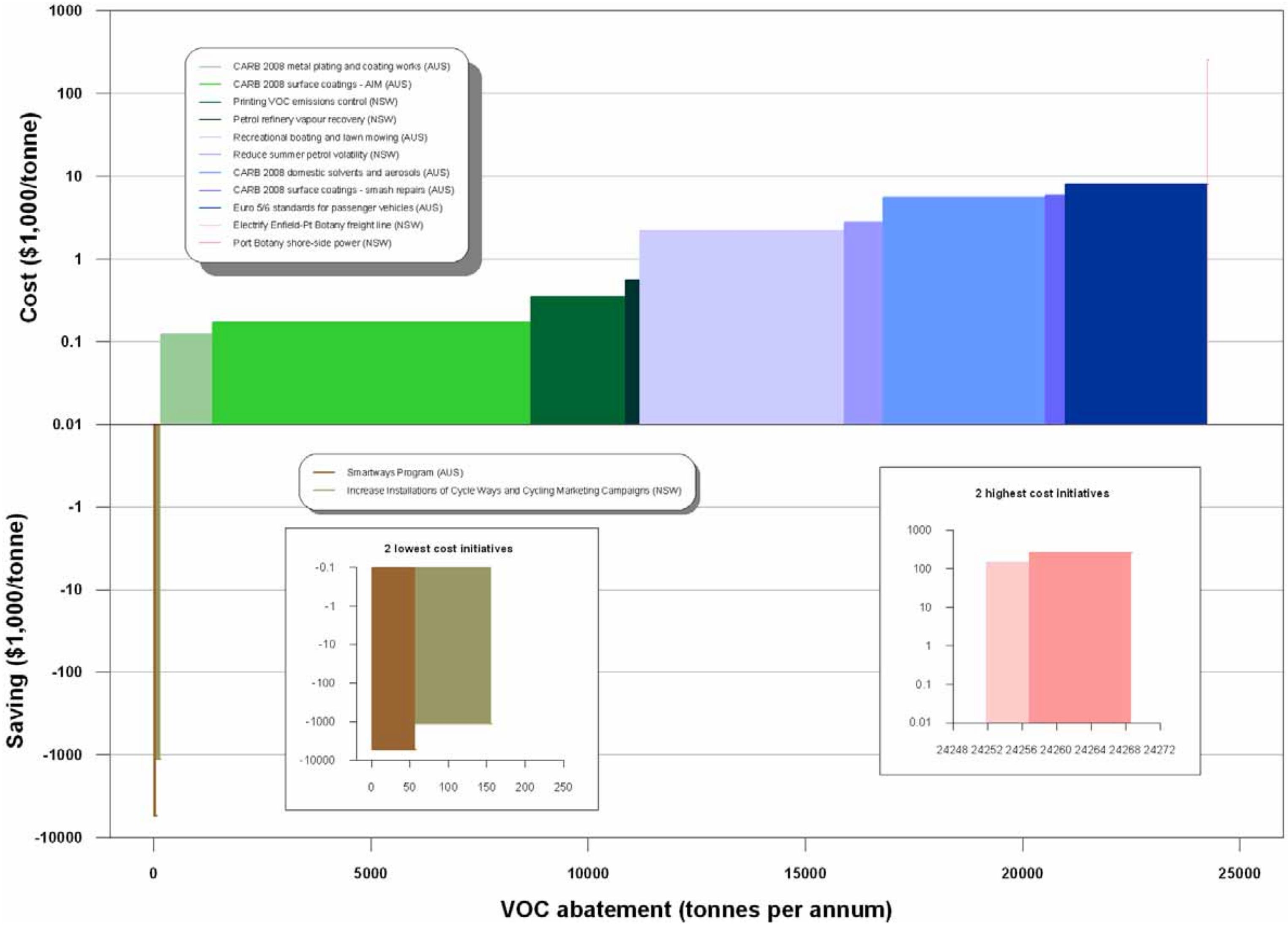
GMR PM_{10} MACC Chart



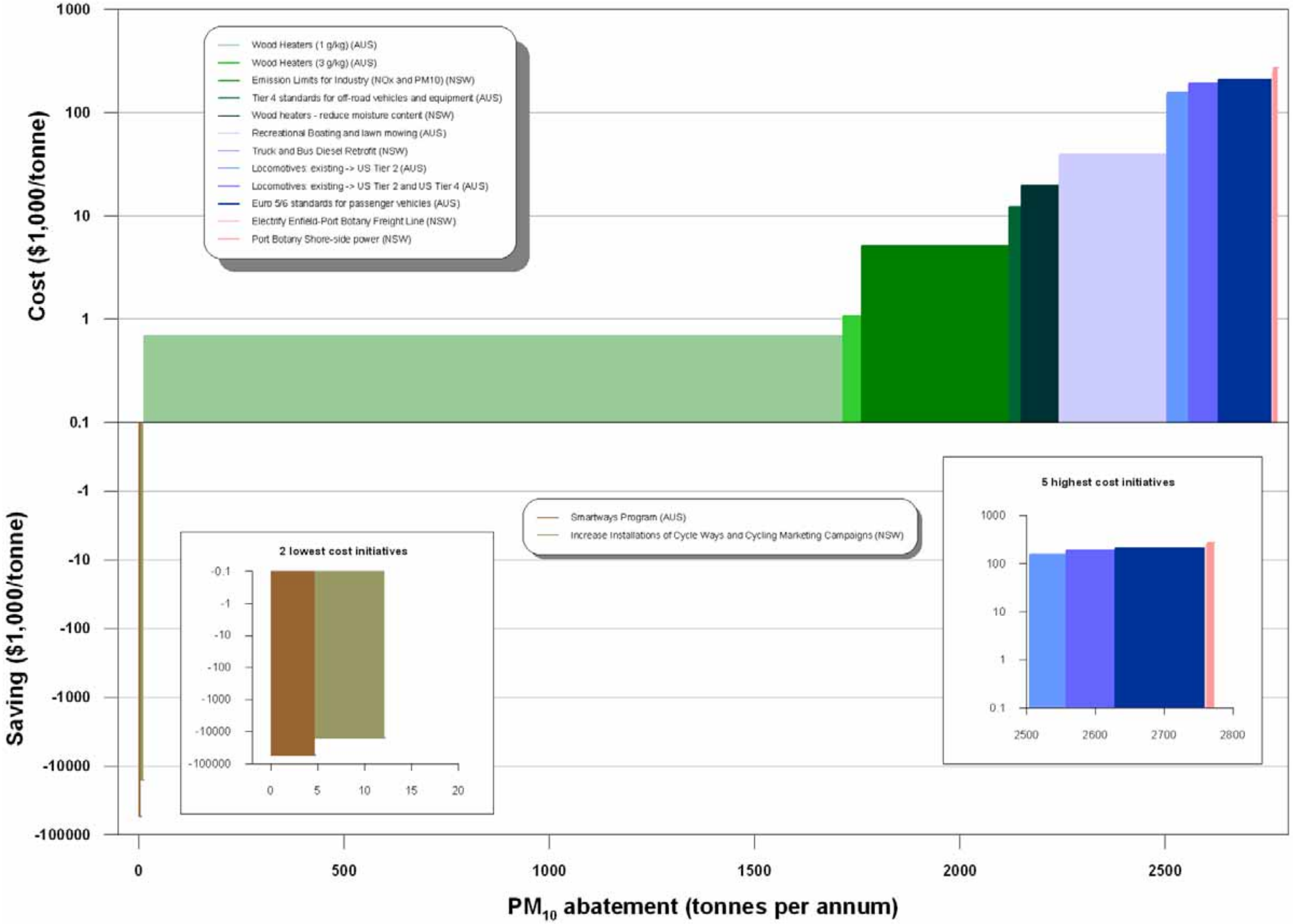
Sydney NO_X MACC Chart



Sydney VOC MACC Chart



Sydney PM_{10} MACC Chart



SINCLAIR KNIGHT MERZ

1. Introduction

1.1. General Introduction

The *National Environment Protection Measure (Ambient Air Quality)* (Air NEPM, NEPC, 1998) set air quality goals in 1998, to be achieved by 2008. The NSW State Plan commits NSW to achieving the air quality goals initially set by the Air NEPM. The Department of Environment, Climate Change and Water (DECCW) reported that only two of the six criteria air pollutants included in the Air NEPM remain significant issues in NSW, namely, photochemical smog (as ozone, O_3) and fine particulate matter (as PM_{10}, that is, particles less than 10 micrometres in diameter) (DECC, 2007).

Ozone, the main constituent in photochemical smog, forms in the presence of sunlight, via a series of complex reactions between oxides of nitrogen (NO_X) and volatile organic compounds (VOCs). Modelling of the Greater Metropolitan Region (GMR) by DECCW has identified that a 25% reduction in 2003 anthropogenic emissions of NO_X (~ 23,000 tonne per annum, tpa) and VOCs (~ 33,000 tpa) in the Sydney region is required in order to meet the NEPM ozone standards.

For the purpose of this project the DECCW has identified 25 % reduction as the goals for NO_X' and VOCs and 10 – 30 % for PM_{10}, of 2003 emissions across the GMR, as well as Sydney and Wollongong sub-regions noting that airsheds are coupled with one another and each airshed may, in some way, contribute to adverse air quality impacts in other airsheds particularly with respect to NO_X and VOCs. The study focuses on the Sydney and Wollongong sub-regions because of recorded exceedences of national air quality goals in those areas.

With this objective, Sinclair Knight Merz (SKM) was commissioned to identify and analyse the effectiveness of a range of emission abatement initiatives and develop a series of marginal abatement-cost curves (MACCs) to assist in assessing their practicability.

This report outlines:

- The method that has been used to develop the MACCs for measures to reduce anthropogenic NO_X, VOCs and PM_{10} emissions in the GMR;
- A list of identified emissions abatement initiatives;
- Assessment of each initiative to determine important costing information and emissions abatement likely to be achieved by each initiative;
- Cost curves for NO_X, VOCs and PM_{10}; and
- Linear optimisation of the curves to consider the multi-pollutant framework of emissions abatement.

As agreed with DECCW biogenic emission sources were excluded from the project.

1.2. Project Terms of Reference (ToR) Objectives

The DECCW ToR objectives of the project were to:

- Identify existing, proposed and potential actions for Sydney, Wollongong and the Greater Metropolitan Region to reduce ozone precursor pollutants (oxides of nitrogen and volatile organic compounds) and fine particles, and assess the magnitude of potential emission reductions (tonnes) and the cost of abatement (dollars per tonne) for each action;
- Develop a clear methodology using a multi pollutant framework to identify the least cost pathways for achieving specified reductions in ozone (and its precursors NO_X and VOCs) and particulates; and
- Apply this methodology to generate a set of cost-abatement curves that rank actions according to their emission reduction potential and cost-effectiveness and clearly show programs that will minimise the costs of achieving target reductions in the pollutants of interest.

The cost-abatement curves will inform DECCW's decision-making and priority-setting on proposed and potential programs to protect human health and meet national air quality goals.

1.3. Overview of Methodology

The methodology involved sequential and complementary steps, as follows:

- The construction of a reference case for abatement of NO_X ,VOCs and PM_{10} in the GMR, based on the emissions projections developed for the NSW Air Emissions Inventory 2003 (DECC, 2007a, 2007b, 2007c, 2007d, 2007e) (refer to **Section 2**);
- The identification of priority emission sources with reference to NSW Air Emissions Inventory 2003, (refer to **Section 3**) ranked by total mass of NO_X, VOCs and PM_{10} emissions;
- The identification of abatement options, costs and the magnitude of emission reductions for single and multiple pollutants, available from relevant actions, to deliver agreed reduction goals, e.g. reduction in anthropogenic emissions in Sydney region of NO_X ,VOCs and associated reduction in PM_{10} based on a Princeton Wedges approach (Socolow *et al.* 2004);
- The development of the cost abatement curve model that provides spreadsheets which graphically present incremental and total abatement cost schedules for each pollutant (refer to **Section 4**); and
- The construction of marginal abatement cost curves using the multi-pollutant framework that account for interdependencies between pollutants and across sectors (refer to **Section 5**). The measures were identified by a review of integrated pollution management programs and

models developed by international agencies (such as Pechan and Associates, 2005, refer to **Appendix A,** Reference C, Item 5).

The GMR study region, which includes Sydney, Wollongong, Newcastle and Non-urban regions, is shown on **Figure 1-1**.

- **Figure 1-1 GMR Study Area**

2. Development of the Reference Case

2.1. Overview

The reference case represents emissions for the GMR (i.e. Sydney, Newcastle, Wollongong and Non Urban sub regions), projected to 2031, under the assumption that prior trends in emissions profiles and drivers continue as they have previously, and adjusted for existing or highly likely policies or industry projects. In this sense, the reference case shows future emissions profiles excluding any abatement efforts beyond those reasonably expected through business as usual. The reference case is based on the emissions projections which were developed for the NSW Air Emissions Inventory (DECC, 2007a, 2007b, 2007c, 2007d, 2007e) and which forecast emissions across five anthropogenic sectors including:

- Industrial;
- Commercial;
- Domestic-Commercial;
- On-Road Mobile; and
- Non-Road Mobile.

The NSW air emissions projections are linked to source-specific assumptions about the key drivers of change in emissions growth, such as energy consumption growth, population growth, vehicle kilometres travelled growth and mandated vehicle emission and fuel standards (for further information see relevant sections on projection factors in DECC, 2007a, 2007b, 2007c, 2007d, 2007e).

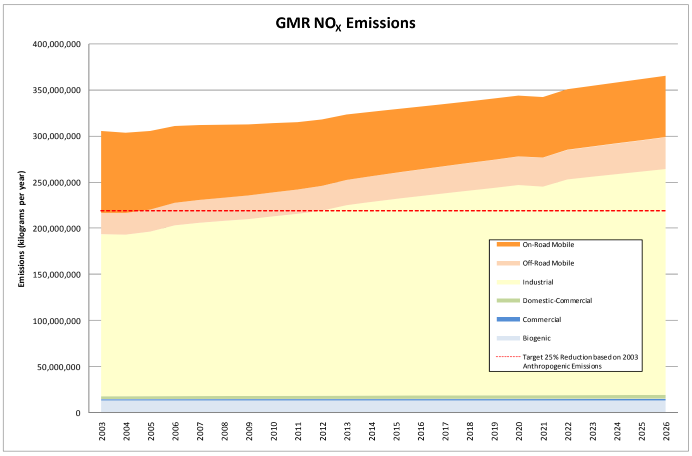
Graphical representation of the reference case emissions by sector for the GMR and the Sydney, Newcastle, Wollongong and Non Urban sub regions are shown in **Figure 2-1** to **Figure 2-5**. As per the ToR emission projections are to 2026, with emission reduction goals nominated for 2016 and 2026. It is noted, however, that the reference case and MACC modelling extends to 2031 which encompasses the full extent of emission projections provided by the DECCW inventory.

A breakdown of emissions by pollutant, sector and major contributing activity for the GMR and each region is displayed graphically in **Appendix B**.

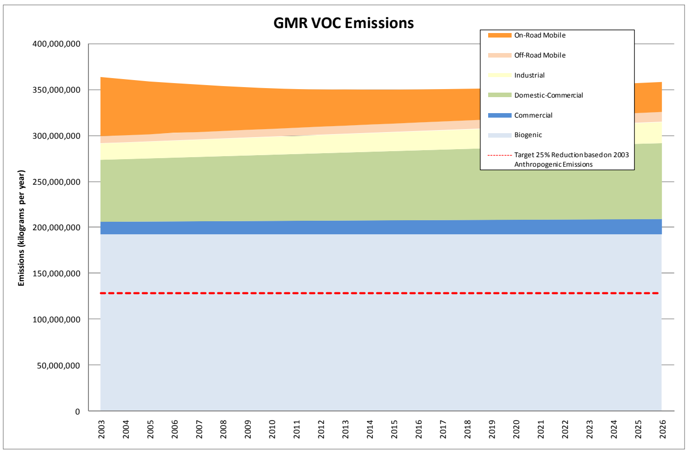
Assumptions underlying emissions projections for relevant industry sectors and activities are as prescribed by DECCW (DECC, 2007a, 2007c, 2007e) and are summarised in **Appendix C**.

- **Figure 2-1 Greater Metropolitan Region Emissions Projections to 2026, Business As Usual**

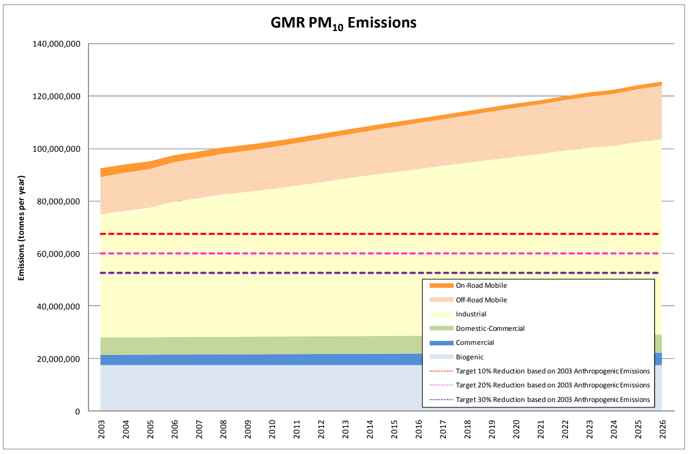
Source: DECC, personal communication, 2009



Annual NOx Emissions kg per year	
2003	305,398,370
2016	331,545,046
2026	365,103,710
Target 25% on 2003 Anthropogenic Emissions	**73,013,544**



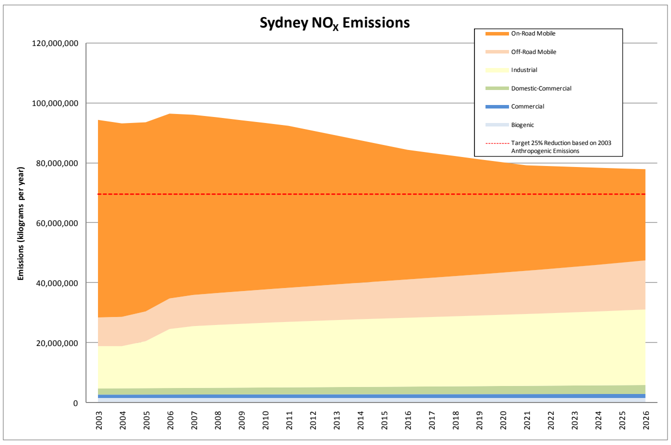
Annual VOCs Emissions kg per year	
2003	363,665,791
2016	349,758,743
2026	358,137,214
Target 25% on 2003 Anthropogenic Emissions	**42,767,973**



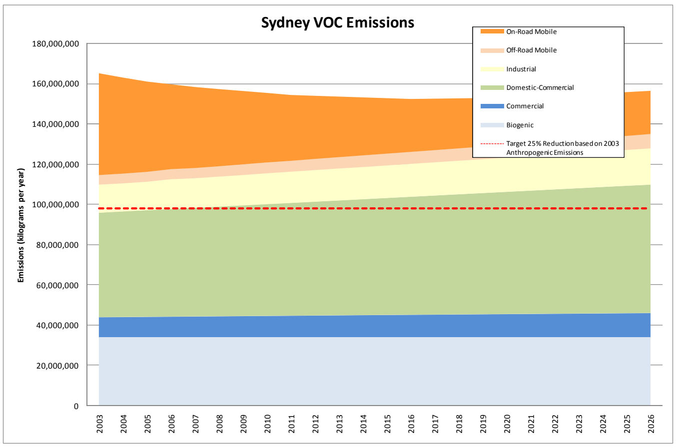
Annual PM10 Emissions kg per year	
2003	92,566,876
2016	111,448,256
2026	125,475,229
Target 10% on 2003 Anthropogenic Emissions	**7,512,798**
Target 20% on 2003 Anthropogenic Emissions	**15,025,596**
Target 30% on 2003 Anthropogenic Emissions	**22,538,394**

■ Figure 2-2 Sydney Sub Region Emissions Projections to 2026, Business As Usual

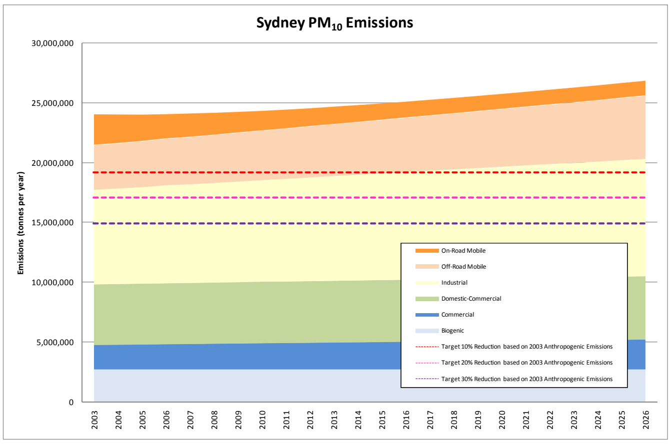
Source: DECC, personal communication, 2009



Annual NOx Emissions kg per year	
2003	94,349,057
2016	84,345,458
2026	77,910,220
Target 25% Reduction on 2003 Anthropogenic Emissions	**23, 587,264**



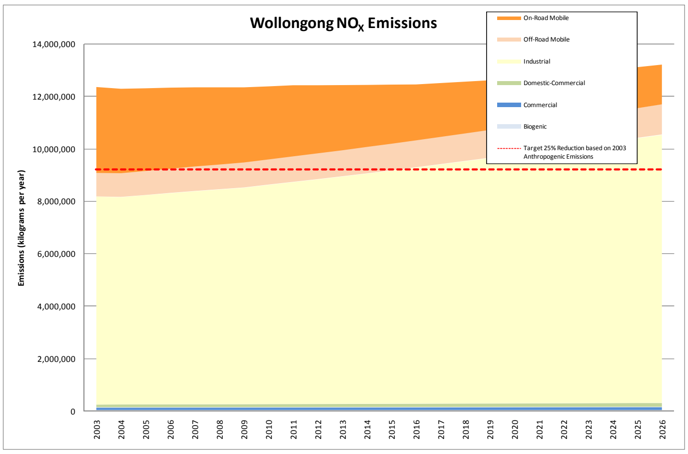
Annual VOC Emissions kg per year	
2003	164,886,157
2016	152,240,482
2026	156,237,986
Target 25% Reduction on 2003 Anthropogenic Emissions	**32,724,377**



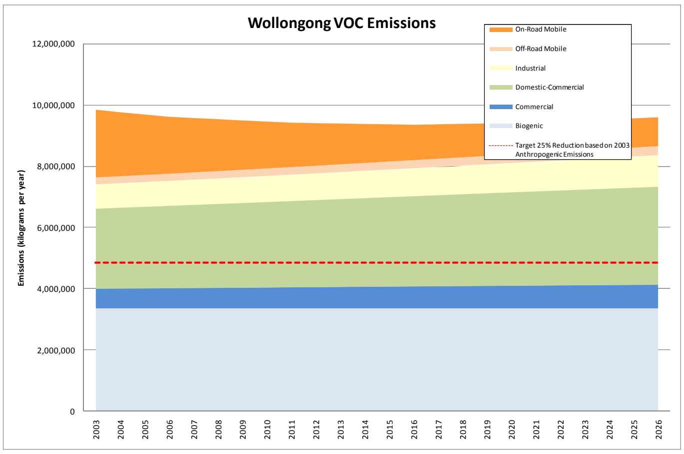
Annual PM10 Emissions kg per year	
2003	24,010,830
2016	25,056,875
2026	26,815,231
Target 10% Reduction on 2003 Anthropogenic Emissions	**2,131,073**
Target 20% Reduction on 2003 Anthropogenic Emissions	**4,262,146**
Target 30% on 2003 Anthropogenic Emissions	**6,393,219**

■ **Figure 2-3 Wollongong Sub Region Emissions Projections to 2026, Business As Usual**

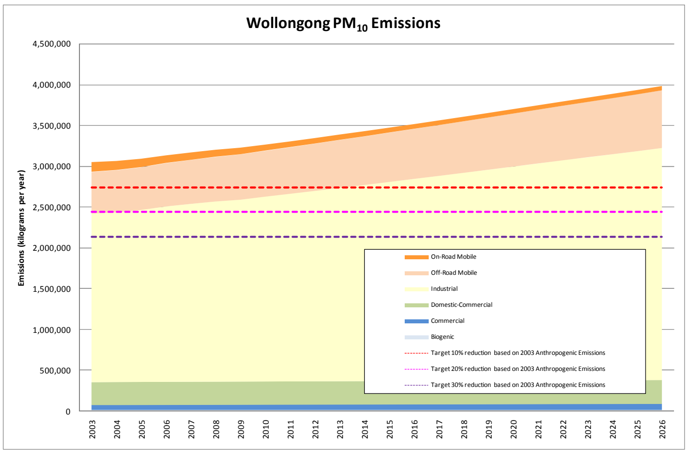
Source: DECC, personal communication, 2009



Annual NOx Emissions kg per year	
2003	12,345,758
2016	12,442,798
2026	13,195,841
Target 25% Reduction on 2003 Anthropogenic Emissions	**3,073,431**



Annual VOCs Emissions kg per year	
2003	9,833,556
2016	9,348,121
2026	9,590,716
Target 25% Reduction on 2003 Anthropogenic Emissions	**1,615,544**

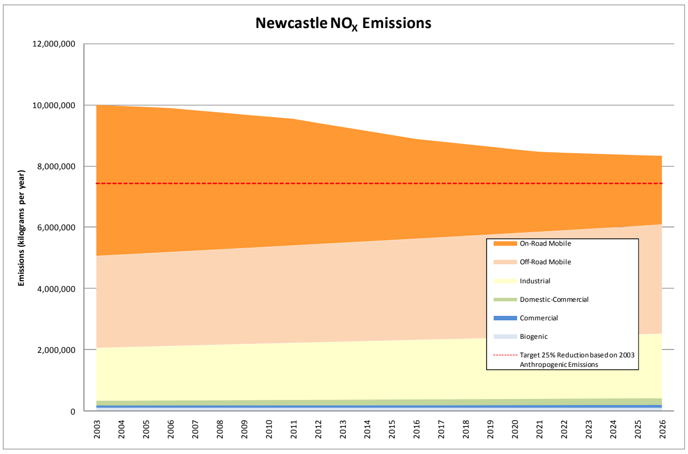


Annual PM10 Emissions kg per year	
2003	3,049,348
2016	3,516,527
2026	3,984,256
Target 10% on 2003 Anthropogenic Emissions	**303,356**
Target 20% on 2003 Anthropogenic Emissions	**606,712**
Target 30% on 2003 Anthropogenic Emissions	**910,068**

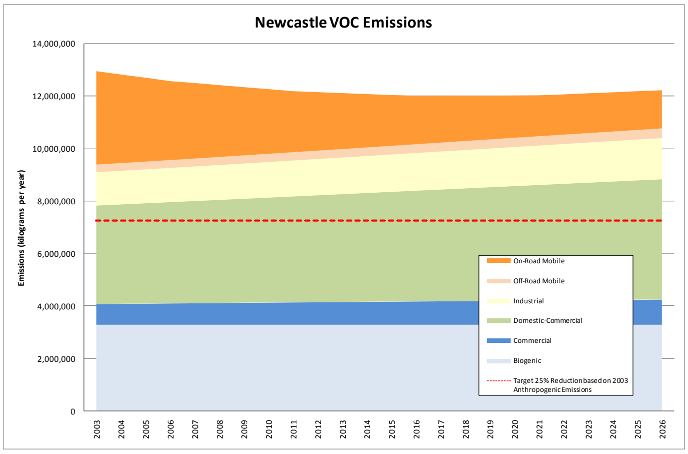
SKM

Figure 2-4 Newcastle Sub Region Emissions Projections to 2026, Business As Usual

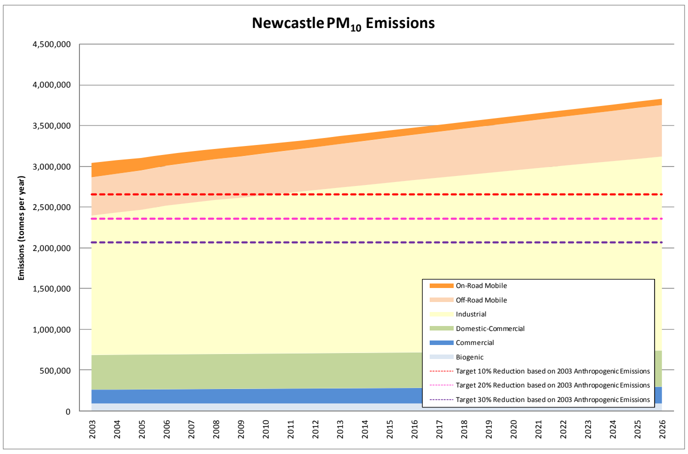
Source: DECC, personal communication, 2009



Annual NOx Emissions kg per year	
2003	10,004,332
2016	8,884,760
2026	8,333,884
Target 25% on 2003 Anthropogenic Emissions	**2,473,548**



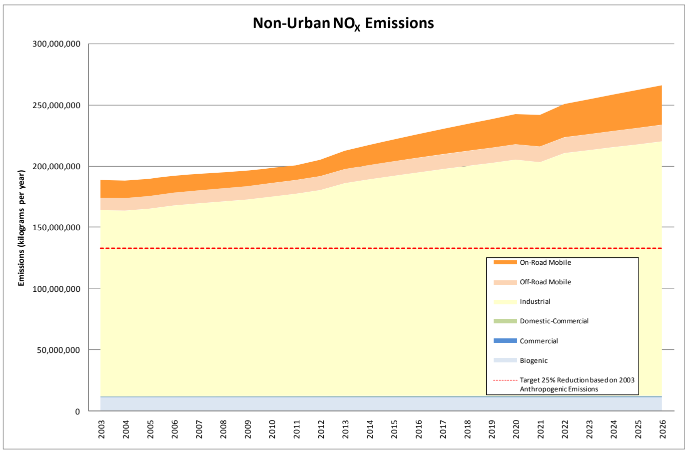
Annual VOCs Emissions kg per year	
2003	12,952,030
2016	12,010,265
2026	12,229,752
Target 25% on 2003 Anthropogenic Emissions	**2,416,494**



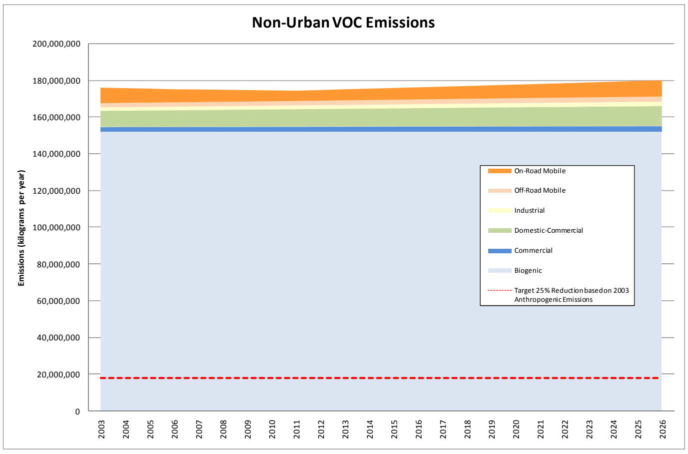
Annual PM10 Emissions kg per year	
2003	3,040,312
2016	3,472,635
2026	3,828,620
Target 10% on 2003 Anthropogenic Emissions	**294,702**
Target 20% on 2003 Anthropogenic Emissions	**589,404**
Target 30% on 2003 Anthropogenic Emissions	**884,106**

▪ Figure 2-5 Non-Urban Sub Region Emissions Projections to 2026, Business As Usual

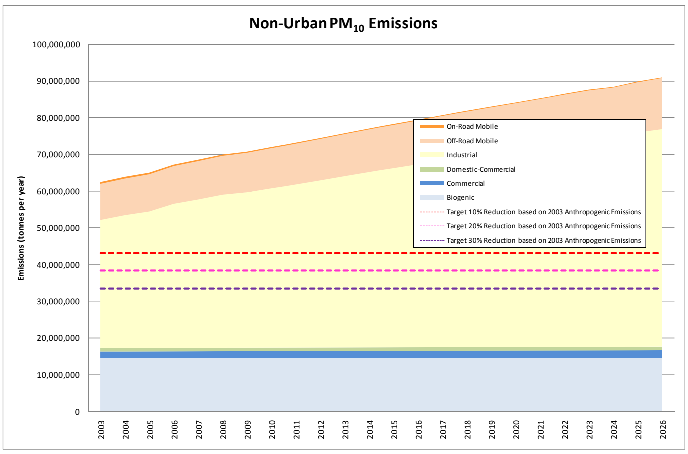
Source: DECC, personal communication, 2009



Annual NOx Emissions kg per year	
2003	188,706,202
2016	225,880,238
2026	265,672,909
Target 25% on 2003 Anthropogenic Emissions	**44,102,034**



Annual VOCs Emissions kg per year	
2003	175,994,048
2016	176,159,874
2026	180,078,760
Target 25% on 2003 Anthropogenic Emissions	**6,011,397**



Annual PM10 Emissions kg per year	
2003	62,466,386
2016	79,402,218
2026	90,847,122
Target 10% on 2003 Anthropogenic Emissions	**4,783,667**
Target 20% on 2003 Anthropogenic Emissions	**9,567,334**
Target 30% on 2003 Anthropogenic Emissions	**14,351,000**

3. Prioritising Emission Sources

3.1. Overview

This section of the report sets out the approach used to identify priority emission sources of NO_X and VOCs and PM_{10} for further investigation within the study.

The data analysis to follow is based on a review of the NSW Air Emissions Inventory (DECC, 2007a, 2007b, 2007c, 2007d, 2007e). The data has been analysed to identify the relative contribution of NO_X, VOCs, ozone forming potential and PM_{10} by sector and activity.

A breakdown of emissions by pollutant, sector and major contributing activity for the GMR and each region is displayed graphically in **Appendix A**.

3.2. Ozone Precursor Sources (NO_X and VOCs)

The ozone precursors, NOx and VOCs (including carbon monoxide) play quite different roles in its formation. At its simplest, for a parcel of air, the concentration of VOCs determines the rate at which ozone is produced while the concentration of NO_X determines the upper limit to the concentration of ozone that is able to be formed. It is possible that this NO_X-controlled limit will not be reached with the available concentrations of VOCs since sunset may intervene and the air parcel is dispersed before the following sunrise. When the need to reduce levels of ozone was first recognised, most of the widely available controls related to restricting VOC emissions. Thus, both in Australia and internationally, policies to restrict VOC emissions were used to slow the formation of ozone to ensure that the NO_X limit was never reached.

However, in the situation where there are elevated levels of ozone over a few successive hot days with light synoptic winds ("multiday events") there may be sufficient time to allow the NO_X limit for ozone to be reached even with very strict controls on VOCs. Put simply, ozone formation recommences on each subsequent day building on the levels already produced until a major synoptic event, such as a southerly change, clears the airshed. Similarly, VOC control is less effective when four-hour goals for ozone are considered, since these are always lower than the one-hour goal. In these circumstances, NO_X control becomes more important.

Furthermore, not only does the amount of VOC emitted change the potential amount of ozone formed but the very nature of the VOC molecule itself has a very significant bearing. This is because the role of VOCs in the ozone-forming process is through the formation of free radicals: the more stable the free radical the greater its ozone forming potential. At its simplest, large complex molecules have higher ozone forming potential than small simple molecules. Of particular importance in the GMR, given the proximity of substantial national parks, is the fact that a number of emissions from trees and vegetation (biogenic emissions) have relatively high ozone forming potentials. Additionally, biogenic emission rise disproportionately with rising ambient temperature, an important consideration given likely temperature rises under greenhouse-gas-induced climate change in the GMR.

Hence, DECCW studies report that the relative contribution of VOCs sources ranked by ozone-forming potential differs significantly compared with the traditional and simpler method of ranking sources by the total mass of their emissions (DECC, 2008):

...biogenic sources of VOCs are likely to be the most significant contributors to ozone formation in the GMR and Sydney region during January, when atmospheric conditions are highly conducive to photochemical smog formation. This may mean that there is limited scope in achieving national ambient air quality standards for ozone by purely relying on anthropogenic VOCs reductions. The results show that prioritising sources of photochemical smog precursors using annual air emissions inventory data and without adjusting VOCs species using incremental reactivity may provide misleading results (DECC, 2008:ii)

The different roles of the ozone precursors mean that the geographic location and the time of day of emissions can have significant influences on the resulting levels of ozone produced by the same quantum of emission. Thus, for example, a kilogram of toluene emitted near the CBD at 6 am under many circumstances will be likely to produce more ozone that a kilogram emitted near the edge of the GMR close to sunset. This is because the 6am emission is likely to be exposed to sunlight and forming ozone for more than 12 hours before it is blown out of the airshed while the second emission has much more limited time to form ozone.

Meteorological conditions also have important influences on the distribution of ozone in the GMR. On days of elevated ozone levels, afternoon sea breezes typically blow ozone resulting from emissions in the east of the region toward the west or, sometimes, down the coast to Wollongong. Complex interactions in the west of the GMR can see ozone stored aloft overnight to be mixed back to the ground the following day.

Thus, in summary, the levels of ozone experienced in the GMR are affected by numerous interrelated factors:

- Sources of NO_X and VOCs play different roles in ozone formation and are unevenly distributed and vary throughout the day.
- Meteorological processes involved in ozone formation are complex and also vary throughout the day and across the geographical area.
- The amount of ozone formed depends upon the type and amount of VOCs emitted and the relative amount of NO_X in the atmosphere.

It should be noted that this study only considers the mass emission of anthropogenic VOCs and the potential abatement provided by a range of measures. There is no consideration of the location of VOC precursor emissions sources within the GMR, the reactivity of different VOCs nor the influence of meteorological conditions in ozone formations.

3.3. Discussion of MIR and NMIR

As outlined in **Appendix A** and **Table 3-1** to follow, a breakdown of emissions by sector and activities is provided for each pollutant e.g. NO_X and VOCs as well as a break down for ozone generation potential. This considers the relative importance of NO_X and VOCs by source and activity in the ozone formation process.

For VOCs, maximum incremental reactivity (MIR) values are used in calculating the amount of ozone formed by each substance. These are defined as the incremental reactivities of each substance under conditions where ozone formation has the maximum sensitivity to VOCs inputs and reflects those conditions where VOCs controls are most effective for reducing ground-level ozone.

For NOx, maximum incremental reactivity (NMIR) values are used in calculating the amount of ozone formed by each substance. These are defined as the incremental reactivities of each substance under conditions where ozone formation has the maximum sensitivity to NOx inputs and reflects those conditions where NOx controls are most effective for reducing ground-level ozone.

Since the optimum conditions are different for both, the MIR and NMIR analysis, results are not additive (as noted in DECC 2008) and therefore cannot be combined correctly into one metric. Further investigation would be required to assess the importance of the MIR and NMIR on the reduction in ozone formation potential offered by the emission abatement measures considered by this study.

3.4. PM10 Sources

Unlike NO_X and VOCs as relevant to ozone forming potential, PM_{10} can be considered in isolation from other pollutants (although it is acknowledged that reductions in emissions from major sources of NO_X and VOCs in many cases consequently will result in associated reductions in PM_{10}).

3.5. Ranking of Emission Sources

Table 3-1 provides a ranking of emission sources by sector and activity for the GMR and the sub-regions being Sydney, Wollongong, Newcastle and Non-Urban. With respect to ozone forming potential, NO_X and VOCs, the assessment considers January emission profiles only, as representative of main emission sources during the period of the year when photochemical smog is an issue. A key finding with respect to VOC emissions is that actions should be targeted at reducing emissions from sectors and activities that present the greatest ozone forming potential in summer, rather than focussing on mass emissions of VOC sources.

The following key observations are made:

- Across the GMR, with the exception of Wollongong, biogenic VOC emissions dominate the ozone forming potential sources. It is assumed that none of the VOC emission reduction actions identified by this study will affect biogenic emissions;
- In Sydney, on-road mobile and then domestic-commercial VOC emissions follow biogenics as the next most dominant sectors in terms of ozone forming potential; and
- In Wollongong, and Newcastle to a lesser extent, industrial VOC emissions are dominant precursors for ozone formation;
- Oxides of nitrogen emissions in the Sydney region are dominated by on-road mobile sources which are also important in the Wollongong region. However, in the Wollongong region, NO_X emission are dominant in the industrial sector (mostly at Port Kembla Steelworks) and are significant in Newcastle as well;
- Within non-urban areas, ozone formation is dominated (98 %) by biogenic and bushfire emission; and
- With respect to particulates, a range of industrial activities generally dominates across the GMR and sub-regions, with domestic-commercial sources also important in Sydney.

■ Table 3-1 Summary of Emission Ranking Excluding Biogenic (GMR, Sydney, Wollongong, Newcastle, Non-urban) – sources listed in descending order

Pollutant	GMR	Sydney	Wollongong	Newcastle	Non-urban
O_3 Potential	On-road mobile Domestic-Commercial ■ Solvents/Aerosols ■ Surface coatings Industrial ■ Iron and Steel	On-road mobile Domestic-Commercial ■ Solvents/Aerosols ■ Surface coatings ■ Lawn mowing	Industrial ■ Iron and Steel On-road mobile Domestic-Commercial ■ Surface coatings ■ Solvents/Aerosols ■ Lawn mowing	On-road mobile Industrial ■ Al. production Domestic-Commercial ■ Surface coatings ■ Solvents/Aerosols ■ Lawn mowing	Domestic-Commercial ■ Rec. boating ■ Surface coatings ■ Solvents/Aerosols On-road mobile Industrial
VOCs	On-road mobile Domestic-Commercial ■ Solvents/Aerosols ■ Surface coatings ■ Solid fuel combustion Commercial ■ Auto. Fuel Retail	On-road mobile Domestic-Commercial ■ Solvents/Aerosols ■ Surface coatings ■ Solid fuel combustion Commercial ■ Auto. Fuel Retail	On-road mobile Domestic-Commercial ■ Solvents/Aerosols ■ Surface coatings ■ Solid fuel combustion Industrial ■ Iron and Steel	On-road mobile Domestic-Commercial ■ Solvents/Aerosols ■ Surface coatings ■ Solid fuel combustion ■ Auto. Fuel Retail ■ Smash Repair Industrial	On-road mobile Domestic-Commercial ■ Solvents/Aerosols ■ Surface coatings ■ Solid fuel combustion Commercial ■ Auto. Fuel Retail Non-road mobile
NO_X	Industrial ■ Elec. Generation On-road mobile Industrial ■ Iron and Steel Off-road mobile ■ Ind. Vehicles	On-road mobile Non-road mobile ■ Planes/Railway Industrial ■ Petrol Refining ■ Elec. Generation	Industrial ■ Iron and Steel On-road mobile Non-road mobile ■ Commercial Ships ■ Ind. Vehicles	On-road mobile Non-road mobile ■ Commercial Ships Industrial ■ Ag. Fertilisers ■ Aluminium Non-road mobile ■ Railways ■ Ind. Vehicles	Industrial ■ Elec. Generation On-road mobile Non-road mobile Industrial ■ Cement/Lime ■ Coal Mining

Pollutant	GMR	Sydney	Wollongong	Newcastle	Non-urban
PM_{10}	Industrial ▪ Coal Mining Non-road mobile ▪ Ind. Vehicles Domestic-Commercial ▪ Solid Fuel Burning Industrial ▪ Elec. Generation	Domestic-Commercial ▪ Solid Fuel Burning Non-road mobile ▪ Ind. Vehicles Industrial ▪ Crushing/Grinding ▪ Other land based extraction On-road mobile	Industrial ▪ Iron and Steel Non-road mobile ▪ Ind. Vehicles Domestic-Commercial ▪ Solid Fuel Burning Industrial ▪ Coal Loading/Mining	Industrial ▪ Coal Mining Domestic-Commercial ▪ Solid Fuel Burning Non-road mobile • Ind. Vehicles Industrial ▪ Am. Nitrate Prod.	Industrial ▪ Coal mining Non-road mobile ▪ Ind. Vehicles Industrial ▪ Elec. Generation ▪ Other Land Extract.

4. Principles Underpinning Abatement Selection

4.1. Overview

The methodology is designed to account for the interdependencies of a multiple pollutant environment, where targeted actions may impact on all pollutants of interest as well as within and across economic sectors.

4.2. Identification and Costing of Abatement Options

Abatement options were identified initially by a review of cost abatement studies provided to SKM by DECCW. A summary of abatement actions already identified by DECCW are listed in **Appendix D**. It should be noted that investigations undertaken as part of this study refined the initiatives identified by DECCW.

Additional options have been identified by senior SKM project team members with expertise in specific emission sources and technologies, following the previous analysis described in **Section 3**.

4.2.1. General Principles

General principles to be considered when identifying abatement options are outlined in **Table 4-1**.

- **Table 4-1 Criteria for Choosing Abatement Options**

Criterion	Measure
Environmental Impact	Initiatives should aim to achieve an outcome in terms of emission reductions in Sydney and the Wollongong regions in the medium (2016) or long term (2026). These reductions will be measurable in terms of the NSW Air Emissions Inventory. Reductions in carbon monoxide, carbon dioxide and toxics were not considered. A general threshold may be regarded as a minimum reduction of 23,000 tonnes per annum (t pa) for NOx, 33,000 tpa for VOCs and reductions in PM_{10} of 10 – 30 % of 2003 anthropogenic emissions in the GMR.
Technical Feasibility	Any technology driven initiatives will be based on assumptions about technological feasibility and the degree of uptake of the technology.
Economic Impact	Initiatives which have a positive or neutral return to the NSW economy will be favoured. Note that avoided health costs were not considered in this assessment.
Social Impact	Initiatives which are likely to either increase social disadvantage or require substantial structural adjustment will be less favoured – these impacts will be flagged.

A list of candidate initiatives was costed, to determine the true cost of each abatement option relative to the reference case. This was achieved by estimating the lifetime financial cost of each initiative out to 2031, including any research and development costs, costs of implementation and commercialisation, and operating and monitoring costs. Avoided health costs were not considered.

4.2.2. Method and Criteria for Options Identification

The following approach was used in identifying abatement options:

- Review of applicability of abatement options identified from existing studies (refer to **Appendix D**);
- Review of overseas air pollutant abatement options; and
- Workshop involving project team emissions and technology consultants to brainstorm new abatement options across the sectors and activities identified in **Section 3**.

In general, abatement actions were prioritised in sectors and for activities which dominate the emissions inventories, e.g. on road mobile as relevant to ozone formation in the Sydney region. Without this focus and identification of significant abatement options in these sectors, significant reductions in total emissions will not be achieved.

The focus on significant emission sources however, did not lose sight of the fact that options may be implemented more easily within sectors and for activities that are only minor contributors to total emissions.

The abatement actions which represent lowest cost to achieve maximum abatement are ranked more highly than higher cost actions, notwithstanding these may achieve higher levels of abatement. The MACCs generally show actions in ascending order of cost per tonne, with emission abatement accumulating until the target is reached or available actions are exhausted.

Some travel demand management measures identified, which were directed primarily to other benefits (such as public transport provision) and for which air emission reductions are only an ancillary benefit, have not been considered in the final report. These appeared excessively costly considered in the context of emission reductions only and were not genuinely comparable to other actions specifically designed to reduce emissions.

5. Marginal Cost Abatement Curves for a Multi-Pollutant Framework

5.1. Overview

The construction of marginal cost-abatement curves involved application of the model, which combines the emissions reduction potential of each initiative and associated costs to yield the abatement-cost curve for the GMR and the Sydney and Wollongong sub-regions. The core modelling approach included:

- The use of a Princeton wedges style approach to developing a suite of options to reduce emissions of each pollutant, quantify the size and cost of each abatement initiative, and collate these into the three MACCs; and
- Multi-pollutant optimisation.

5.2. Developing MACCs for Each Pollutant

The first stage of the modelling methodology used an approach derived from Princeton Wedges to develop three MACCs.

5.2.1. Reference Case

The approach SKM developed started by characterising each emission source in the reference case in terms of an emissions inventory disaggregated by region and activity. SKM has constructed the reference case to 2031 by analysing existing emissions inventories and projections supplied by DECCW.

5.2.2. Characterisation of Abatement Initiatives

Abatement initiative templates were prepared, in order to collect inputs to the MACC model on a consistent and well defined basis. For each initiative, the template clearly identifies:

- Which activities(s) of emissions the initiative will affect;
- Whether the initiative will have a percentage impact on an existing activity, or a one-off quantity (e.g. changes to a large point source, or even addition of a sink);
- Multiple impacts recognising that actions may complement each other, be alternatives to each other, or otherwise impact on each other's effectiveness (such as decreasing one source and increasing another for substitution initiatives);
- The quantified impact on those source factors (as a %, fixed amount), that include separately each of the 3 pollutants being considered for the study;

- The penetration that is expected, or proportion of maximum available uptake that is expected to be achievable in practice;
- The time over which the initiative will be implemented (assuming a linear ramp-up per the Princeton Wedges model from start date to maximum penetration and impact over a specified number of years)[3];
- The net marginal economic cost of implementing that initiative. This includes:
  - One-off program and set up costs (such as establishing vehicle monitoring facilities);
  - Capital cost of implementation (marginal from "business as usual");
    - Capital cost lifetime, and whether there are "follow on waves" of capital expenditure (such as the higher cost of low-emission vehicles with a 10 year life);
  - Ongoing annual operating and maintenance costs and cost savings (marginal from "business as usual");
    - *Note – the intent is to separate capital and operating costs, such that assumptions and calculations underpinning ultimate "$ / tonne" figures are transparent and can be re-calculated using different assumptions such as discount rates.*
  - Fuel costs and cost savings (marginal from "business as usual");
  - Other *direct* benefits or costs (for example, avoided waste or toxic waste disposal costs from changes to an existing process, increased or decreased filter cleaning costs)[4];
  - The party to whom each cost or benefit accrues (government or end-user)[5];
  - All costs real A$ 2009 based on long term average exchange rates;

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[3] Note that there is a marginal ongoing incremental abatement relative to the reference case if there is growth in the reference case after the end of the implementation period. For example, a vehicle emission control measure might take 10 years to implement, and the model assumes the percentage impact ramps up linearly over that period. Beyond that, there are small incremental impacts if activity emissions continue to grow in the reference case, as the model assumes all emissions including new growth are abated by the same %.

[4] SKM has not attempted to characterise *indirect* benefits or costs, such as reduced accident and injury rates from a switch to public transport, or public health benefits from reduced VOC pollutant levels. SKM did not seek to characterise or analyse second order economic impacts, such as price-elasticity effects, or economic restructuring impacts that may arise as a result of additional pollution control costs imposed on emitters. SKM has not attempted to estimate or quantify costs or benefits that are non-monetary or difficult to quantify (e.g. reduced congestion, or value of loss of utility from not being able to tow a boat due to changing to a smaller car).

[5] Note this is highly dependent on assumptions as to how a given policy outcome is achieved, and which policy implementation options are used. For example, licensing and regulation approaches can push costs onto emitters, whereas incentive programs will involve higher costs for Government. Assumptions will be noted. In some instances there will be a transfer of costs between the private and government sectors, for example where increased pollution charges are introduced, or public transport fares further subsidised. SKM has represented costs in these instances as either positive or negative to the respective sectors, but calculated the economic cost based on the net cost (that is, government + private sector net cost or benefit).

- Exchange rates are based on long term (20 year) averages, to avoid distortions associated with short term fluctuations. Cost estimates with a base in years prior to 2009 are inflated to 2009 using CPI data for the base currency, then converted to AUD at the long term average exchange rate;

- Description of measure, basis of estimates, other relevant information (e.g. technology risks, why certain technologies were rejected etc).

The information from these templates was then collated in the "input" section of the overall MACC model.

5.2.3. Modelling of MACCs for Each Substance

The MACC model calculates the total cost and impact on each pollutant, and derives separate MACC curves for each of the three pollutants being studied. The model calculates the abatement on a regional basis, so that the impact at a regional level can be studied as well as total GMR level abatement. The costs and impacts for each initiative are collated in the MACC model, along with the reference case describing the activities and emissions intensities contributing to base case emissions for each pollutant.

Discounted cash flow analysis is used to determine the Net Present Cost (NPC) of each initiative, taking into account all capital, operating and other costs identified, and the timing of those costs. Note this can produce some apparently "unexpected" results[6], but has been assessed by SKM as being the most robust method to compare different initiatives on a common basis.

[6] For example, some technologies may not yet be commercial, and won't be expected to be implemented for 10 years. The economic cost of that measure will be lower because all the capital and operating costs will be discounted by 10 years, compared to a similar measure with identical impacts and costs that can be implemented today. This introduces some complexity in comparing the "$ / tonne" for similar measures, but does characterise accurately the overall economic cost, and recognises the economic benefit of deferring expenditure. Interim targets and MACCs will show the benefits of those technologies that are available in the short term, compared to "blue sky" initiatives that may be available in the longer term with apparently lower costs. In consultation with DECCW, SKM has implemented an option within the MACC model that allows either a "common" base year for economic discounting, or individual base years for each initiative that starts discounting from the start year for that initiative (effectively giving a levelised cost, rather than present day economic cost).

The model produced two MACCs for each pollutant:

- A "simple" MACC that ignores interactions between the various identified initiatives; and
- A "complex" MACC that models the interactions between initiatives.

The "complex MACC" model allows for interactions between initiatives to be modelled. For example, multiple initiatives may affect the same activity, such as improved emissions controls for vehicles in concert with travel demand management or mode shift. The impact of these initiatives considered together will be less than the simple sum of individual impacts, as the "first" initiative will reduce the emissions available to the "second" initiative to abate. The model achieves this by maintaining a "moving snapshot" of the reference case taking into account the impact of each initiative in turn.

The benefit of the first "simple MACC" is that it can inform decisions about treatment of complementary or mutually exclusive measures, by allowing assessment of the merits of each initiative independent of other initiatives. Where two or more measures interact and are complementary, the order in which they are considered will affect the apparent cost on a $/tonne basis (the cost will not change, but interactions will increase or decrease the modelled impact). SKM have ordered initiatives in an increasing "raw $/tonne" basis, but did considered other criteria in assessing the calculation order for the complex MACC, such as whether there were any higher abatement options that were only marginally more expensive than another initiative and in which case reordering these initiatives would be considered warranted.

The model does not address all possible practical interactions between initiatives, and hence the analysis has some limitations. For example, where one initiative is dependent on implementation of another, the model will not automatically "force" the dependency relationship in the complex MACC calculation order, nor in the LP model optimised abatement mix. It is also possible that the LP optimised mix could effectively order some initiatives differently to the complex MACC sort order, resulting in modest errors in abatement potential for those initiatives. To overcome these issues, the model does include the ability to manually adjust the complex MACC calculation order (by over-riding the default calculation order). An iterative approach that re-orders the complex MACC calculation order based on the results of the LP Optimisation, and taking account of dependency relationships between initiatives, can largely overcome these model limitations, but requires a degree of manual intervention.

SKM previously has developed approaches to dealing with various types of interactions between different initiatives. These are:

- ***Complementary**:* Where measures reinforce each other, SKM generally has found they can be considered separately without special treatment. In some cases, where the costs or implementation are considered to be highly mutually-dependent, SKM has found the most practical outcome is to combine the measures to ensure the dependency effectively is captured and modelled[7].
- ***Parasitic***: Where two or more measures have the effect of reducing the effectiveness of other measures (for example reduced vehicle emissions will reduce the effectiveness of public transport substitution and vice versa), the complex MACC model automatically models this, by taking into account the interactions between individual initiatives. In this instance, the main issue is the order in which the initiatives are considered (the first will show the "full" impact, whereas the 2nd, 3rd etc will show a reduced impact). SKM's model employs a two step process:
  1) Model each initiative individually (i.e. as if it was the only initiative). This gives the "raw" cost and abatement potential. From this analysis, and in consultation with DECCW, SKM determined an order in which the options were considered. This normally would be from least cost to highest cost, but alternatives are possible (e.g. starting from the "demand" end of a supply chain).
  2) The full model with full inter-dependencies is then run, reflecting the order and priorities of initiatives selected in step 1.
- ***Mutually exclusive**:* Some measures are mutually exclusive (e.g. retirement of older vehicles, and improved emissions standard for older vehicles). In this instance, only 1 measure from each "set" of mutually exclusive options was considered, and this was selected from the same step 1 as above[8]. In analysis of energy efficiency, SKM undertook for Planning NSW (the Demand Management and Planning Project DMPP) SKM developed a innovative methodology for selecting the best of mutually exclusive options:
  - Below an agreed "cheap" price point, the option with the greatest potential abatement is selected (i.e. if there are multiple low-cost alternatives, choose the biggest impact).
  - Above this price point, choose the option with least cost (i.e. when the cost increases to the point where we become "price sensitive", select the lowest per unit cost).

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[7] The MACC model does not consider dependencies between initiatives, for instance where one measure is required to be implemented before another is possible. While this is a potential shortcoming of the analysis, in practice SKM considers with the suite of initiatives identified it does not have a material impact on results. By manually adjusting the Complex MACC calculation order, and adding additional constraints to the LP Optimisation model it would be possible to take such dependencies into account.

[8] While the least cost option is generally preferable, SKM has identified instances where a higher cost option can produce an overall optimum result. E.g. if a higher cost option has significantly higher abatement, it may substitute for a separate initiative with a lower cost per tonne of abatement in the optimum mix.

Where costs vary significantly between sites or sectors (e.g. large and small industry), SKM considered "splitting" the initiative. SKM's MACC methodology treats each initiative as having a single cost, so where a range exists that is material, it is sometimes prudent to split the measure into groups that are more uniform.

Practical considerations that arose include mutually exclusive options – one with low cost and low potential, the other relatively high cost but large potential. If the different in abatement potential means the second option is able to displace another option higher up the MACC with an even higher cost, the second option may well be preferable.

From the suite of initiatives identified, SKM has found only 3 sets of mutually exclusive options. These sets, and the initiative chosen for inclusion in the final optimised results are shown in the table below. All initiatives are included in the "Simple MACC" results, in order to show the relative cost and abatement of each initiative, which was used as a basis for selecting the preferred option from each set.

- **Table 5-1 Sets of Mutually Exclusive Initiatives**

Set	Mutually exclusive initiatives	Preferred option and why
1,31	▪ 1. Coal Fired Power Station NOx Control - Low NOx Burners ▪ 31. Coal Fired Power Station - Selective Catalytic Reduction (SCR)	#1. Provides almost enough abatement for 25% of GMR at lower cost per tonne than #31. For higher levels of total abatement, #31 may be part of optimum mix, and should be considered as a viable alternative.
2,3	▪ 2. Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 ▪ 3. Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 + Tier 2---> Tier 4: Retrofit Tier 2 with Selective Catalytic Reduction (SCR) and Diesel Particulate Filter (DPF)	#3. Provides significantly increased abatement, at lower cost per tonne. Requires Initiative #2 to be implemented first.
22,23,24	▪ 22. Wood Heaters - Reduce the Moisture Content of Firewood ▪ 23. National Standards for Wood Heaters (3 g/kg) ▪ 24. National Standards for Wood Heaters (1 g/kg)	#24, as this gives significantly increased abatement of PM_{10} for which sufficient options to meet the desired 25% target are not available.

Following this ordering of initiatives, and selection of mutually exclusive options, a "complex MACC" can be calculated to show the long run marginal economic cost of each initiative and the modelled abatement impact, taking into account interactions with other initiatives.

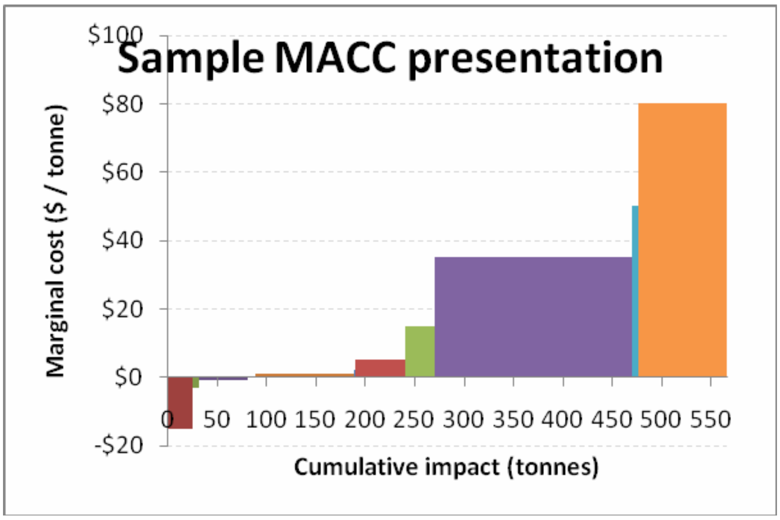
Decisions and assumptions regarding choice of mutually exclusive options, ordering of options etc have been documented and stated above, so they can be revisited for subsequent analysis if required. For example, if future abatement targets become more stringent, it may be desirable to consider "program switching" so that an option that previously was dismissed as being too expensive can be re-introduced to capture larger abatement potential.

5.2.4. Presentation of the MACC

The costs of implementing each initiative cannot be allocated specifically to one pollutant or another (unless a measure affects only one substance). Therefore, each of the three MACCs have been presented as if that is the only substance being considered. The overall optimisation across all three substances was conducted in a subsequent optimisation stage.

Each MACC is presented both as a table and a chart:

- The primary information for each initiative is the cost ($/tonne) and abatement potential (annual tonnes abated in 2030) for that pollutant.
- The chart shows each initiative stacked in ascending cost order, as shown below:



Note that the three MACCs for each individual substance might include "negative abatement" (ie an increase in substance emissions) because of interractions between the three substances. In a single-substance MACC one would normally exclude any initiatives that would increase emissions of that substance. In a multi-substance MACC study, an initiative may abate one substance while *increasing* emissions of another substance. SKM has developed an approach that allows "negative abatement" to be captured and considered in each MACC, such that it can be accurately considered in the final multi-substance optimisation stage.

5.3. Multi Substance Optimisation

The second stage of SKM's methodology relates to the optimisation of the mix of initiatives in a multi-substance environment which is characterised by abatement options that can be both complementary or substitutes.

The optimisation process used the three Simple MACC curves developed to reduce emissions from NO_X, PM_{10} and VOCs. The Simple MACCs were chosen following inspection of the range of initiatives identified for this study, which were such that there were no material interactions between the initiatives, and hence the Complex MACC curves were not required.

As stated in the Introduction (refer to **Section 1**), photochemical modelling of the GMR by DECCW has identified that a 25% reduction in 2003 anthropogenic emissions of NO_X (~ 23,000 tonne p.a.) and VOCs (~ 33,000 tonne p.a.) in the Sydney region is required in order to meet NEPM standards. Cost abatement curve modelling by SKM has considered:

- The least cost (economically efficient) mix to achieve this outcome (25% reduction in each pollutant[9]), and
- A limited number of other abatement target scenarios (including lower uniform and differentiated targets for each pollutant) to identify the overall cost trend relative to abatement targets.

With respect to PM_{10}, it is recognised that there is no safe level of exposure to particulates and for this project it was been agreed with DECCW to review reduction initiatives in the order of 10% - 30%.

Optimisation of the multi-substance outcomes is complex, and SKM has developed an approach it believes provides a practical and straightforward approach to developing an optimal mix of initiatives.

[9] Where sufficient abatement options have been identified. Where less than 25% abatement has been identified, the maximum abatement amount has been used.

5.3.1. Linear Programming Optimisation

Excel Solver was used to derive a mix of abatement initiatives that minimises the total cost subject to constraints of each substance being reduced by the required amount. Each abatement option included in the overall MACCs[10] "i" will be converted into a 4 variable matrix, using the variables:

- $C_i = Total\ cost$
- $\varphi_i^1 = Abatement\ pollutant\ 1$
- $\varphi_i^2 = Abatement\ pollutant\ 2$
- $\varphi_i^3 = Abatement\ pollutant\ 3$

In the above, C and φ for each initiative represent the total or maximum cost and abatement identified for that option if implemented fully (given assumptions about the proportion of take-up or penetration that can be expected realistically).

Each initiative is assumed to be homogeneous – that is the cost and abatement achieved for different industries or sizes of firm are reasonably similar. Where there is a material difference for a particular technology, that initiative is split into several initiatives, each reasonably homogeneous. SKM did not attempt to define a matrix of initiative characteristics (e.g. C_{ij} and φ_{ij} for different sectors or levels "j", although this analysis could be considered for subsequent analysis and targeting of policy response.

The objective function – to minimise the *Total cost* – is calculated by solving an activity vector "x" that describes the proportion of each initiative implemented (constrained between 0 and 1.0), and is multiplied by the C and $\varphi^{1\text{-}3}$ vectors to give the total cost and impact on each pollutant.

SKM modelled a base-case assuming uniform 25% reduction for NO_X and VOCs and 10 – 30 % for PM_{10} with the final reduction targets to be determined based on the total abatement available from identified initiatives, and any "price points" identified within the MACC modelling.

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[10] Mutually exclusive or complementary initiatives were screened during the MACC compilation phase of the project, as described in section 5.2.3, rather than during the linear optimisation phase. The "Simple MACCs" that ignore interaction between initiatives were used as the input to the optimisation process.

6. Abatement Initiatives

6.1. Overview

This section of the report provides an overview of the abatement initiatives identified for this project and includes relevant information used to determine costs of abatement, total abatement potential for each of the initiatives.

6.2. Development of an Abatement Initiative Template

In order to assimilate data for each abatement initiative in a way that allows relevant emissions and cost data to be directly uploaded to the MACC model, an abatement initiative template was developed in consultation with DECCW. The layout of the template is shown in **Figure 6-1.** Key template inputs include:

- Unique ID – numbered sequentially 1 – 100, these identify each abatement initiative within the MACC model;
- Initiative Name – a short name for each initiative;
- Brief Description – describes the initiative in the context of emission sources impacted and references to information assessed for the initiative;
- Timing – includes inputs for start year, years to fully implement, equipment life, practical achievable take-up;
- Physical measure - which identifies the practical type and number of individual actions required to fully implement the initiative (for example, 366 locomotives to be retrofitted);
- Technical Impacts (1 / 2) – provides look ups for emission sources, inputs for the proportion of the source affected and reductions amounts as either percentages or absolute values;
- Cost Impacts – information for program set up, implementation (capital), operating, maintenance, fuel, compliance and any other direct costs / savings;
- Data Rating – (high, medium, low) for emission reduction and cost estimates; and
- Further Comments – This contains information and references used to assess the emissions abatement potential and costs for the initiate including any assumptions.

The program set-up costs, which in general are a very small fraction of total costs for each measure, were estimated based the expected response of government and the private sector to consult with affected stakeholders and to develop and implement policy and regulation associated with the measures. Within the template, emissions reductions and costs are prescribed as (+) values and emissions increases or savings are indicated with (-) values.

Figure 6-1 Emission Abatement Initiative Template

NSW DECC Multi-pollutant MACC project
Abatement initiative input template
V16 - 4/12/2009

Department of Environment & Climate Change NSW

Abatement Initiative				Assumptions	Basis and comments
Unique ID	1				
Initiative Name	Coal Fired Power Station NOx Control - Low NOx Burners				
Brief Description	Dry Low NOx Burner Technology is available for coal fired power stations in NSW and is currently being implemented at one NSW power station.				

Timing				Assumptions	Basis and comments
Start year	2012				
Years to fully implement	3				Costs and impacts will ramp up over this time
Life of capital equipment (yrs)	30				Capital will need to be replaced after this period
Physical measure	12060	Units:	MW		Total NSW installed coal fired electricity capacity
Practical achievable takeup	100%				Realistic % takeup given commercial / technical "realitie
Mutually exclusive initiatives	None				Other initiatives that need to be considered "mutually e

Technical impacts	NOx	PM10	VOC	Assumptions	Basis and comments
Impact 1	This is the primary impact of the initiative				
Emissions source	Electricity Generation - Generation of electrical power from coal				Industrial
Applicable Regions	Exclude	Exclude	Exclude	Non Urban	
Applicable emissions from this source and selected regions (for info only - 2008 emissions)					Not used in this template
Region	NOx	PM10	VOC		Provided to give guidance re costs and impacts
Sydney	-	-	-		Impact will be calculated in MACC model
Newcastle	-	-	-		
Wollongong	-	-	-		
Non Urban	151,839	5,028	729		
Total selected regions	151,839	5,028	729		
Total abatement from Impact 1	60,736	-	-		
Impact units (% or absolute tonnes)	%	Rating: High			Is this impact amount a % or fixed amount (tonnes)
Proportion of source affected	100%				Measure may only be applicable to certain types of equi
Impact % (+ = reduction)	40%	0%	0%		The impact the initiative would have (per installation / if
Do not enter absolute	0	0	0		The impact the initiative would have (per installation / if
Impact 2	This is the secondary impact (if any) of the initiative - eg increase in public transport from decrease in private transport				
Emissions source					#N/A
Applicable emissions from Impact 2 source and selected regions (for info only - 2008 emissions)					Not used in this template
Region	NOx	PM10	VOC		Provided to give guidance re costs and impacts
Sydney	-	-	-		Impact will be calculated in MACC model
Newcastle	-	-	-		
Wollongong	-	-	-		
Non Urban	-	-	-		
Total selected regions	-	-	-		
Total abatement from Impact 2	-	-	-		
Impact units (% or absolute tonnes)	%	Rating: -			Is this impact amount a % or fixed amount (tonnes)
Proportion of source affected	100%				Measure may only be applicable to certain types of equi
Impact % (+ = reduction)					The impact the initiative would have (per installation / if
Do not enter absolute	0	0	0		The impact the initiative would have (per installation / if

Cost impacts ($000 2009)	Government	Private	Currency	Assumptions	Basis and comments
Capital and one-off	Marginal cost from "business as usual". (+ = additional cost; - = cost saving)				
Program / set up	200	100	AUD	One-off	Note - thousands of dollars
		Cost base year:	2009		
Implementation		215,355	AUD	$17857 per MW @ 12060 MW total	
		Cost base year:	2009		
Ongoing / operating costs	Annual marginal cost from "business as usual". (+ = additional cost; - = cost saving)				
Operating	-	-	AUD		Note - thousands of dollars
Maintenance	-	-	2009		Note - thousands of dollars
Fuel	-	-			Note - thousands of dollars
Compliance / monitoring	5,985	- 5,985		Rating	Note - thousands of dollars
Other direct costs / savings	-	-		Medium	Note - thousands of dollars
		Rating: Medium			

Further Comments — Comments, notes, references, limitations, sensitivities, further information required, uncertainty etc

Limitations: extrapolated costs from one NSW coal power station to all NSW coal fired generators, considered to be a reasonable estimate. O&M costs are unknown but not likely to be significant in the context of capital cost and existing O&M costs. The technology proposed is estimated to reduce NOx emission concentrations and loads by 30 - 50 % with a total capital cost of $50M for a 4 x 700 MW plant. A reduction in NOx conc. of this order would bring concentrations down to approximately 500 mg/Nm3 which is the Group 6 CAPER Limit. The cost equates to A$12,500,000 per 700 MW unit or $1,7857 per MW. It is considered that similar technology could be applied at each of the other coal fired power stations in NSW, and this abatement measure is applied at all sites. Total costs are derived based on the installed capacity of coal fired electricity in NSW which is 12060 MW, so total cost is $215,355,420. The savings in LBL fees have been calculated using the DECC's online LBL calculator and fees saved by the electricity industry are $5,984,464 per annum. In economic terms this is a cost to govt.

In order to keep the MACC computations at a manageable level it was necessary for some emissions sources, which sit behind the abatement initiative template and which are unlikely to be affected by abatement initiatives, to be grouped together. The grouping of emission sources is set out in **Appendix E**.

With respect to the emissions reductions (or increases) shown in the abatement initiative templates (refer to **Figure 6-1**), these are the reductions applied to the 2008 base year emissions quoted in the templates. The actual emission reductions are calculated by the MACC model over the life of the abatement initiatives considered.

6.3. Abatement Initiatives

A workshop including SKM project team members identified a range of abatement initiatives, within the priority emissions areas set out in **Table 3-1**, and with reference to successful international programs identified in literature. These were considered in conjunction with information provided by DECCW (refer to **Appendix D**) and a list of abatement initiatives was developed. A total of 35 abatement initiatives have been investigated in detail and are included in the MACC model. This report contains the results of MACC modelling for 26 of the 36 initiatives.

A summary of the GMR initiatives, including pollutants impacted, is included in **Appendix F**.

The purpose of ranking of abatement initiatives (✓, ✓✓, ✓✓✓, x) is to show the main pollutants impacted by the initiative, as well as secondary impacts that may occur.

Abatement initiatives were developed for the GMR as well as the Sydney and Wollongong airshed sub-regions. In the first instance abatement initiatives (emission reductions and costs) were identified for the entire GMR. For initiatives that occur in the Sydney and/or Wollongong airshed sub-regions, the sub-region implementation costs have been factored down in proportion to the GMR either based on population statistics for each of the sub-regions or the proportion of abatement source emissions in each sub-region compared to the GMR.

SKM

Table 6-1 MACC Model Abatement Initiatives

Initiative	No.	Pollutants		
		PM_{10}	NOx	VOCs
On-road Mobile – Technology Initiatives				
▪ Reduce summer petrol volatility	4			✓✓✓
▪ Truck and bus diesel retrofit	5	✓		
▪ Euro 5/6 emission standards for new vehicles	27	✓✓	✓✓✓	
▪ SmartWay Program	28	✓✓	✓✓	✓✓
On-road Mobile – Travel Demand Initiatives				
▪ Increased cycleways	11	✓	✓✓✓	✓✓
Non-road Mobile				
▪ Locomotives: existing Tier 0 -> US Tier 2	2	✓	✓✓✓	
▪ Locomotives: US Tier 0 -> US Tier 4	3	✓✓	✓✓✓	
▪ Recommission and electrify Enfield-Port Botany rail line	15	✓	✓✓	
▪ Port Botany shore side power	17	✓	✓✓✓	
▪ US Tier 4 Standards for non-road vehicles (ind/comm/const)	18	✓✓	✓✓✓	
▪ Small engines: (2 stroke to 4 stroke) – boats and mowers	25	✓	X	✓✓✓
Industrial				
▪ Coal fired power station DLN control (Group 6 CAPER)	1		✓✓✓	
▪ Refinery Vapour Recovery and Leak Detection and Repair	19			✓✓✓
▪ Emission Limits for Industry (NOx and PM10)	29	✓✓	✓✓✓	
▪ Open cut coal mines – buffer zone initiative	30	✓✓✓		
▪ Coal fired power station SCR	31		✓✓✓	
▪ Gas engine electricity SCR	32		✓✓✓	
▪ Cement industry NOx control	33		✓	
▪ CARB, 2008 Metal plating and coating works	34			✓✓✓
▪ Printing VOC emission control	35			✓✓✓
Domestic-Commercial				
▪ CARB, 2008 Regulation consumer solvents and aerosols	20			✓✓✓
▪ Wood heaters – reduce moisture content of wood	22	✓✓		
▪ National Standards for Wood Heaters (3 g/kg)	23	✓✓		
▪ National Standards for Wood Heaters (1 g/kg)	24	✓✓		
Commercial				
▪ CARB, 2008 Regulation for surface coatings	21			✓✓✓
▪ CARB 2008 Regulation for smash repairing	26			✓✓✓

Key: ✓✓✓ Strong abatement
✓✓ Moderate abatement
✓ Low abatement
X Emission increase

A subset of these GMR abatement initiatives was also developed for Sydney and Wollongong and, together with the GMR abatement initiatives, summary templates are provided in **Appendix F,** which include detailed inputs for each abatement action such as reference information, emission reduction estimates, costs and detailed assumptions.

Additionally ratings, from high to low, for the confidence in estimation of costs and emission reductions, which are dependent on the respective data sources and assumptions, are provided.

6.4. Consideration of CO in Identifying Abatement Initiatives

Carbon monoxide (CO) acts in the role of a volatile organic compound (VOC) in the formation of ozone (O_3). However, its O_3 forming potential is substantially less than most other significant VOCs. This is off-set, to some extent, by its mass emissions being much larger than these VOCs.

It was initially intended to treat carbon monoxide as if it were a VOC and simply include it in this category of the analysis. However, subsequent quantification showed that its much larger mass of emissions outweighed any changes in the VOCs brought about by any particular strategy. CO was therefore excluded from specific consideration.

Only one strategy was identified as targeting CO emissions as its major focus. This was the addition of oxygenates (such as ethanol or methyl tetrabutyl ether [MTBE]) to fuel. The phased addition of 10% ethanol in fuel is already required in NSW; higher levels may pose issues for some models of vehicle currently part of the fleet. Thus, consideration of this strategy was not pursued.

A large number of the strategies considered will lead to reductions of carbon monoxide as well as VOCs. To some extent VOCs act as an adequate surrogate for CO for this purpose. If a more detailed study were needed then an appropriate discounting factor would need to be developed for carbon monoxide to allow for its lower ozone forming potential *vis-a-vis* VOCs.

6.5. Abatement Initiative Key Data

Table 6-2 sets out a summary of key data for each abatement initiative that is used in the MACC modelling.

Table 6-2 Abatement Initiative Key Data

		Time + take-up			Regions				Abatement Impact					Cost	
#	Name of Measure	Start	Ramp-up yr	Practical Takeup	Sydney	Newcastle	Wollongong	Non Urban	Activity affected by measure	% of Activity affected	NOx	PM10	VOC	Setup + Capital ($M)M	Operating (Ann.) ($M)M
1	Coal Fired Power Station NOx Control - Low NOx Burners	2012	3	100%	.	.	.	X	Electricity Generation - Generation of electrical power from coal	100%	40%	-	-	$216	$0
2	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2	2011	10	100%	X	X	X	X	Railways	100%	42%	68%	-	$382	$0
3	Diesel Locomotive USEPA Tier 0 ---> Tier 2 plus Tier 2 ---> Tier 4. That is retrofitting Tier 2 locomotives with Selective Catalytic Reduction (SCR) and Diesel Particulate Filters (DPF)	2015	10	100%	X	X	X	X	Railways	100%	90%	92%	-	$651	$0
4	Summer-time Petrol Volatility (62 kPA to 60 kPA)	2010	1	100%	X	X	X	X	Initiatives across multiple activities	100%	32 t	-	1236 t	$1	$7
5	Truck and Bus Diesel Retrofit	2011	4	100%	X	X	X	X	Exhaust Emissions Heavy Duty Commercial - Diesel	100%	-	1%	-	$6	$0
11	Shift Transport Mode to Cycling – including new cycleways and cycle marketing campaign	2010	10	2%	X	X	X	.	Exhaust Emissions Passenger Cars – Petrol	50%	100%	100%	100%	$343	-$335
									Exhaust Emissions Heavy Duty Commercial - Diesel	50%	100%	100%	100%		
15	Recommission and Electrify Enfield-Port Botany Freight Line	2016	2	100%	X	.	.	.	Railways	100%	106 t	3 t	5 t	$29	-$2
17	Port Botany Shore-Side Power	2012	20	50%	X	.	.	.	Commercial Ships	40%	90%	90%	90%	$36	$4
18	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)	2014	17	100%	X	X	X	X	Initiatives across multiple activities	0%	1502 t	85 t	-	$42	$0
19	Petrol Refinery Vapour Recovery and Leak Detection and Repair	2008	25	100%	X	.	.	.	Petroleum refining	90%	-	-	10%	$1	$0

		Time + take-up			Regions				Abatement Impact					Cost	
#	Name of Measure	Start	Ramp-up yr	Practical Takeup	Sydney	Newcastle	Wollongong	Non Urban	Activity affected by measure	% of Activity affected	NOx	PM10	VOC	Setup + Capital ($M)M	Operating (Ann.) ($M)M
20	CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols	2010	1	100%	X	X	X	X	Domestic/Commercial Solvents/Aerosols	100%	-	-	14%	$1	$49
21	CARB 2008 Regulation for Surface Coatings - Architectural Industrial Maintenance (AIM)	2010	1	100%	X	X	X	X	Surface Coatings	100%	-	-	41%	$27	$0
22	Wood Heaters - Reduce the Moisture Content of Firewood	2012	1	100%	X	X	X	X	Solid Fuel Burning (Domestic)	100%	-	1%	-	$0	$7
23	National Standards for Wood Heaters (3 g/kg)	2012	19	2%	X	X	X	X	Solid Fuel Burning (Domestic)	100%	-	51%	-	$1	$0
24	National Standards for Wood Heaters (1 g/kg)	2012	19	100%	X	X	X	X	Solid Fuel Burning (Domestic)	100%	-	36%	-	$35	$0
25	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	2012	15	100%	X	X	X	X	Recreational Boating	80%	-75%	93%	91%	$337	-$6
									Lawn Mowing	100%	-84%	55%	55%		
26	CARB 2008 Regulation for Surface Coatings - Smash Repairing	2010	20	100%	X	X	X	X	Smash Repairing	100%	-	-	8%	$10	$7
27	Euro 5/6 Emission Standards for New Passenger Vehicles	2014	17	100%	X	X	X	X	Exhaust Emissions Passenger Cars – Petrol	100%	40%	19%	30%	$695	$0
									Exhaust Emissions Light Duty Commercial - Petrol	100%	10%	27%	44%		
28	SmartWay Program- aimed at improving truck aerodynamics and fuel efficiency	2012	1	100%	X	X	X	X	Exhaust Emissions Heavy Duty Commercial - Diesel	100%	4%	4%	4%	$1,568	-$863
29	Emission Limits for Industry (NOx and PM10)	2010	20	100%	X	X	X	X	Dummy for initiatives across multiple activities	0%	5290 t	626 t	-	$74	$0
30	Open Cut Coal Mining Buffer Zone Initiative	2010	21	100%	.	.	.	X	Coal mining	100%	-	52%	-	$57	$0
31	Coal Fired Power Station - Selective Catalytic Reduction (SCR)	2012	3	100%	.	.	.	X	Electricity Generation from coal	100%	85%	-	-	$965	$43
32	Gas Engine Electricity Generation - SCR	2012	3	100%	X	.	.	.	Electricity Generation from gas	92%	90%	-	-	$50	$3

		Time + take-up			Regions				Abatement Impact					Cost	
#	Name of Measure	Start	Ramp-up yr	Practical Takeup	Sydney	Newcastle	Wollongong	Non Urban	Activity affected by measure	% of Activity affected	NOx	PM10	VOC	Setup + Capital ($M)M	Operating (Ann.) ($M)M
33	Cement Industry NOx Control	2012	3	100%	X	.	.	X	Cement or lime production	95%	25%	-	-	$4	$1
34	Metal Plating and Coating Works: CARB, 2008 AIM Regulation	2010	1	100%	X	X	X	.	Metal plating or coating works	100%	-	-	41%	$3	$0
35	Printing VOC Emissions Control	2010	1	100%	X	X	X	X	Initiatives across multiple activities	0%	-	-	2172 t	$14	$0

Notes:

"Start year" is the earliest the initiative is expected to be able to achieve a large scale, commercial rollout.

"Ramp-up yrs" is the number of years expected for the measure to be fully implemented (and achieving its full projected impact) – with costs and impacts ramping linearly according to a "Princeton Wedges" style approach over this ramp-up period.

"Practical takeup" is the proportion of affected activity that can practically be expected to implement the measure, due to technical, cost or market barriers and preferences.

"% of activity affected" is the proportion of the emissions under the affected activity that could be impacted by this measure. For example, if only 30% of vehicles were of a type that are suitable for a certain type of emission control technology.

Costs are split into "one off" (capital and setup) and annual ongoing (operating, maintenance, compliance etc).

7. MACC Model Results

This section contains details of the inputs, assumptions and results of the MACC modelling. Included are base assumptions for MACC modelling and separate regional MACC results.

7.1. MACC Model Assumptions

The key assumptions used in the MACC modelling are:

Assumption	Value	Comments
Exchange rates - AUD - USD - EUR - JPY	 1 0.71 0.59 83	Based on 20-year long term averages
Discount Rate	7%	
Discounting treatment	Common 2009 base	For all initiatives (economic cost)
Capital costs re-occur?	Yes	After equipment life in years

SKM has identified two alternatives for discounting treatment, as discussed in Section 5.2.3:

- ***Common base year*** – cash flows for all initiatives are discounted from a common base year (2009). This accurately reflects the economic cost of the timing of different measures, but deferred or long implementation time initiatives will appear to be "cheaper" than equivalent initiatives that are implemented immediately.
- ***Individual base year*** – cash flows for each initiative are discounted from the implementation start year for that particular initiative. This has the benefit of producing comparable "levelised cost per tonne" for measures with different implementation times, but does not reflect the true economic cost.

For the MACCs and costs presented in this report, SKM has chosen the common base year. This decision was taken to reflect the true economic cost of the various options. SKM also notes there is little difference in the start time for the identified initiatives (2009 – 2016), so this will not be a significant issue compared to greenhouse MACC where initiatives such as carbon sequestration or new generation technology can be assumed to start up to 25 years into the future and hence appear significantly cheaper than their present day levelised cost. The MACC model includes a switch that can select either discounting approach should DECCW wish to review the sensitivity of results to this assumption. SKM has found using the individual discounting assumption adds around 20% to the apparent cost of all initiatives, though this impact is not uniform and affects some measures (with deferred start or long ramp times) more.

7.2. GMR – Final Marginal Abatement Cost Curves

With the results from the table above sorted and split by substance, the three MACC curves for each substance are as shown in the tables and charts below. Negative costs (i.e. savings) and abatement (i.e. emissions increases) are highlighted in red. The tables and charts below show the results of the Simple MACCs, representing the best information on the impact that is likely to be achieved in practice.

7.2.1. GMR Simple MACC Tables and Charts

NO_X

Rank	Initiative Name	NOX $000/tonne	NOX t pa	Cumul. Tonnes	% abatement
-	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 48.046	- 303	-	0%
1	SmartWay Program	($ 456.170)	712	712	0%
2	Shift Transport Mode to Cycling	($ 270.983)	531	1,243	0%
3	Coal Fired Power Station NOx Control - Low NOx Burners	$ 0.115	83,075	84,318	23%
4	Cement Industry NOx Control	$ 0.286	1,810	86,128	23%
5	Coal Fired Power Station - Selective Catalytic Reduction (SCR)	$ 0.386	176,535	262,663	71%
6	Emission Limits for Industry (NOx and PM10)	$ 0.605	5,290	267,953	73%
7	Gas Engine Electricity Generation - SCR	$ 0.756	5,911	273,864	75%
8	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Const	$ 1.235	1,502	275,366	75%
9	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 1.670	18,727	294,093	80%
10	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 + Retrofit Tier 2 Locomotives with Selective Ca	$ 5.783	4,927	299,020	81%
11	Recommission and Electrify Enfield-Port Botany Freight Line	$ 6.522	106	299,126	81%
12	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2	$ 7.525	2,280	301,406	82%
13	Port Botany Shore-Side Power	$ 9.477	317	301,723	82%
14	Summer-time Petrol Volatility (62 kPA to 60 kPA)	$ 107.185	32	301,755	82%

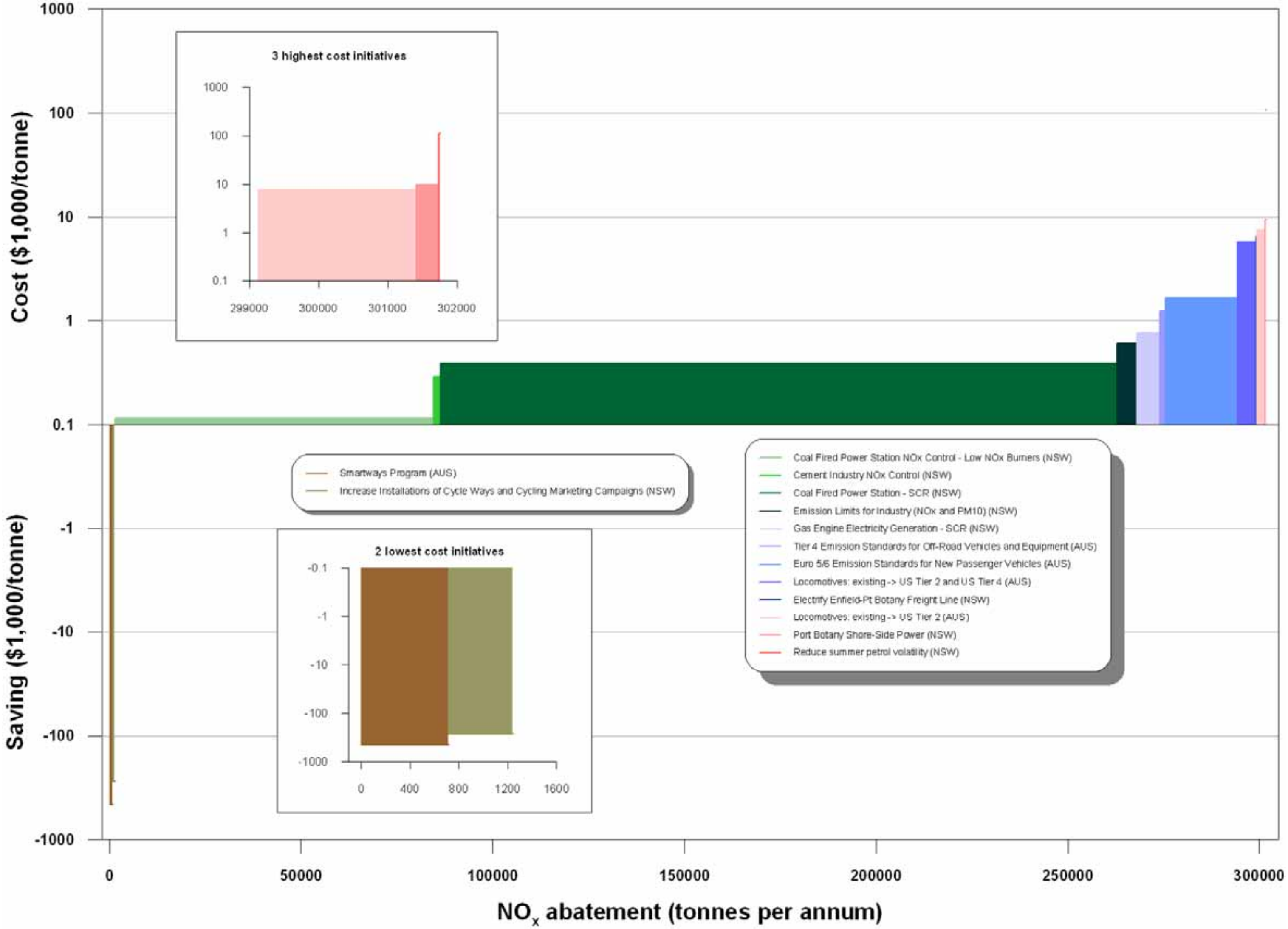
VOC

Rank	Initiative Name	VOC $000/tonne	VOC t pa	Cumul. Tonnes	% abatement
1	SmartWay Program	($ 3,992)	79	79	0%
2	Shift Transport Mode to Cycling	($ 1,185)	110	189	0%
3	Metal Plating and Coating Works: CARB, 2008 AIM Regulation	$ 0	1,269	1,459	1%
4	CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)	$ 0	9,450	10,909	6%
5	Printing VOC Emissions Control	$ 0	2,172	13,081	8%
6	Petrol Refinery Vapour Recovery and Leak Detection and Repair	$ 1	335	13,415	8%
7	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 2	6,853	20,268	12%
8	Summer-time Petrol Volatility (62 kPA to 60 kPA)	$ 3	1,236	21,504	13%
9	CARB 2008 Regulation for Surface Coatings - Smash Repairing	$ 5	592	22,097	13%
10	CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols	$ 6	4,737	26,834	16%
11	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 7	4,145	30,979	18%
12	Recommission and Electrify Enfield-Port Botany Freight Line	$ 138	5	30,984	18%
13	Port Botany Shore-Side Power	$ 255	12	30,995	18%

PM_{10}

Rank	Initiative Name	PM10 $000/tonne	PM10 t pa	Cumul. Tonnes	% abatement
1	SmartWay Program	($ 36,264)	7	7	0%
2	Shift Transport Mode to Cycling	($ 16,904)	8	15	0%
3	Open Cut Coal Mining Buffer Zone Initiative	$ 0	25,085	25,100	22%
4	National Standards for Wood Heaters (1 g/kg)	$ 1	2,262	27,362	24%
5	National Standards for Wood Heaters (3 g/kg)	$ 1	60	27,422	24%
6	Emission Limits for Industry (NOx and PM10)	$ 5	626	28,048	25%
7	Wood Heaters - Reduce the Moisture Content of Firewood	$ 20	123	28,171	25%
8	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Const	$ 22	85	28,256	25%
9	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 38	387	28,643	25%
10	Truck and Bus Diesel Retrofit	$ 148	2	28,645	25%
11	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2	$ 156	110	28,755	25%
12	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 + Retrofit Tier 2 Locomotives with Selective Ca	$ 191	150	28,905	25%
13	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 197	158	29,063	26%
14	Recommission and Electrify Enfield-Port Botany Freight Line	$ 230	3	29,066	26%
15	Port Botany Shore-Side Power	$ 274	11	29,077	26%

GMR NO_X Simple MACC Chart



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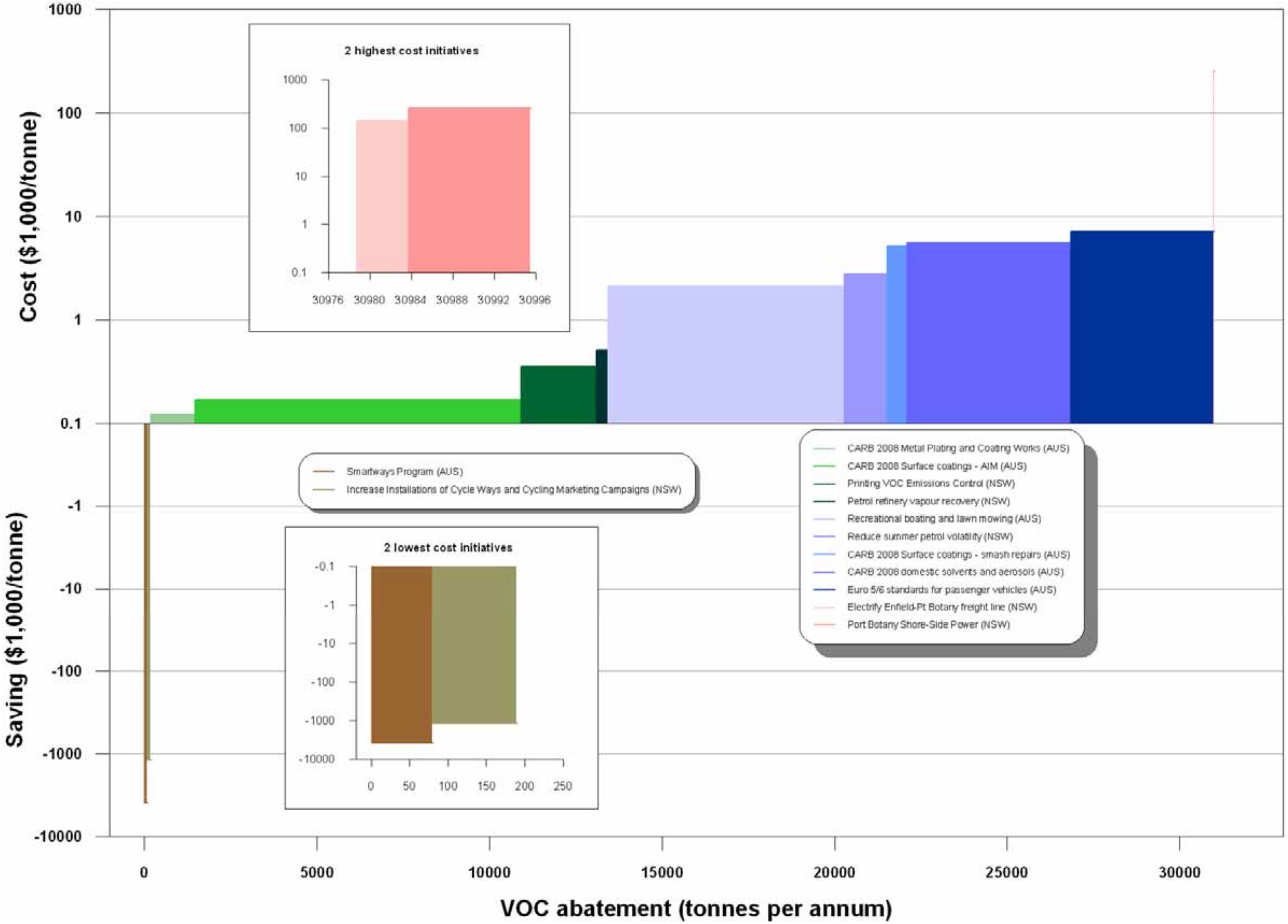
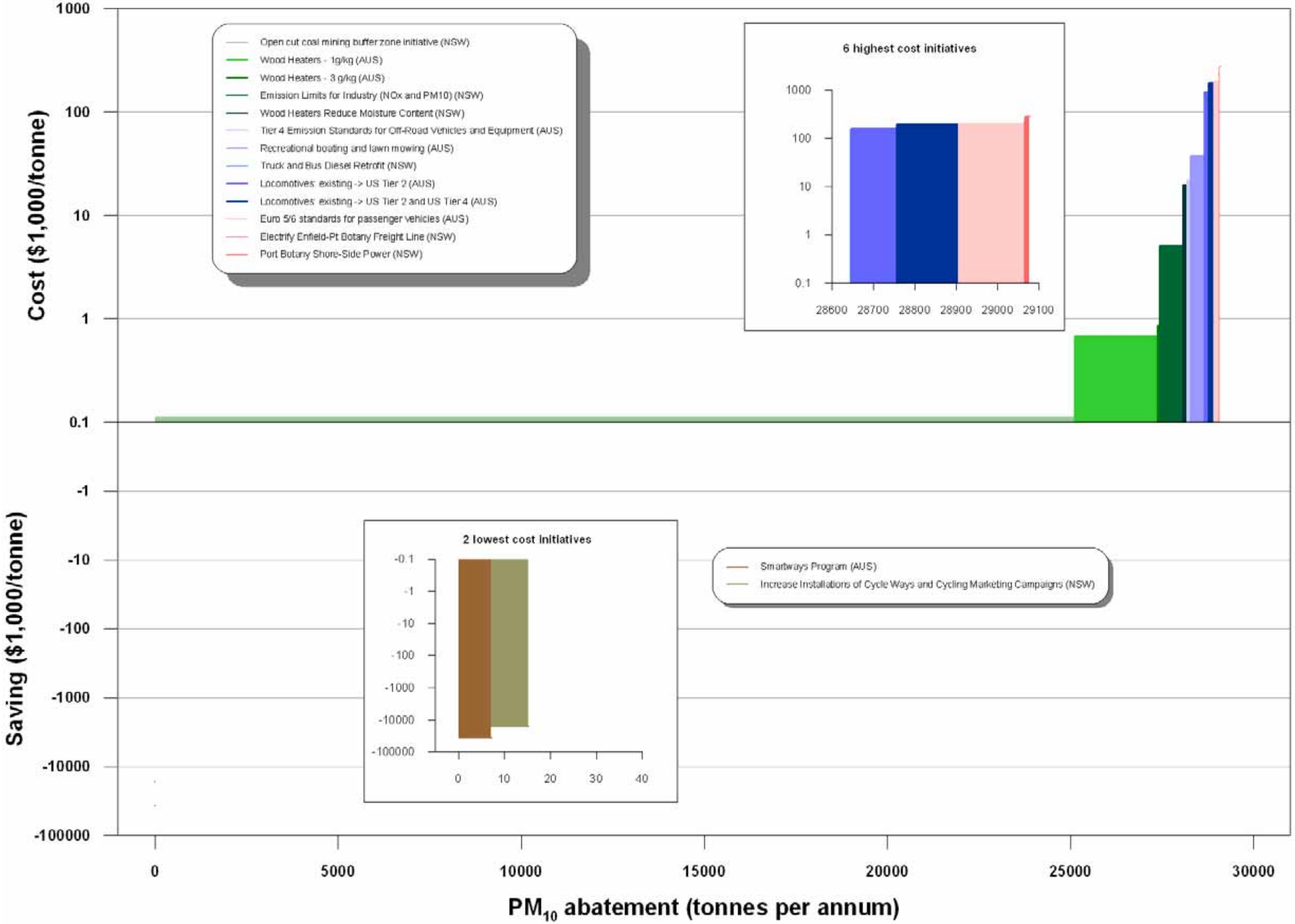
GMR VOC Simple MACC Chart



GMR PM_{10} Simple MACC Chart



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7.2.2. Sydney Simple MACC Tables and Charts

The following Sydney MACCs have been produced using the same approach as for the GMR, using initiatives applicable to the sub-region, and, where appropriate, region specific data. Negative costs (i.e. savings) and abatement (i.e. emissions increases) are highlighted in red.

NO_X

Rank	Initiative Name	NOX $000/tonne	NOX t pa	Cumul. Tonnes	% abatement
-	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 48.806	- 210	-	0%
1	SmartWay Program	($ 691.864)	468	468	0%
2	Shift Transport Mode to Cycling	($ 263.446)	472	941	1%
3	Cement Industry NOx Control	$ 0.343	396	1,337	1%
4	Emission Limits for Industry (NOx and PM10)	$ 0.605	3,024	4,361	4%
5	Gas Engine Electricity Generation - SCR	$ 0.756	5,911	10,272	10%
6	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)	$ 0.976	386	10,658	11%
7	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 1.881	14,603	25,261	25%
8	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 + Retrofit Tier 2 Locomotives with Selective Catalytic Reductio	$ 5.786	2,364	27,625	28%
9	Recommission and Electrify Enfield-Port Botany Freight Line	$ 6.919	106	27,731	28%
10	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2	$ 7.528	1,094	28,825	29%
11	Port Botany Shore-Side Power	$ 9.477	317	29,142	29%
12	Summer-time Petrol Volatility (62 kPA to 60 kPA)	$ 98.887	25	29,167	29%

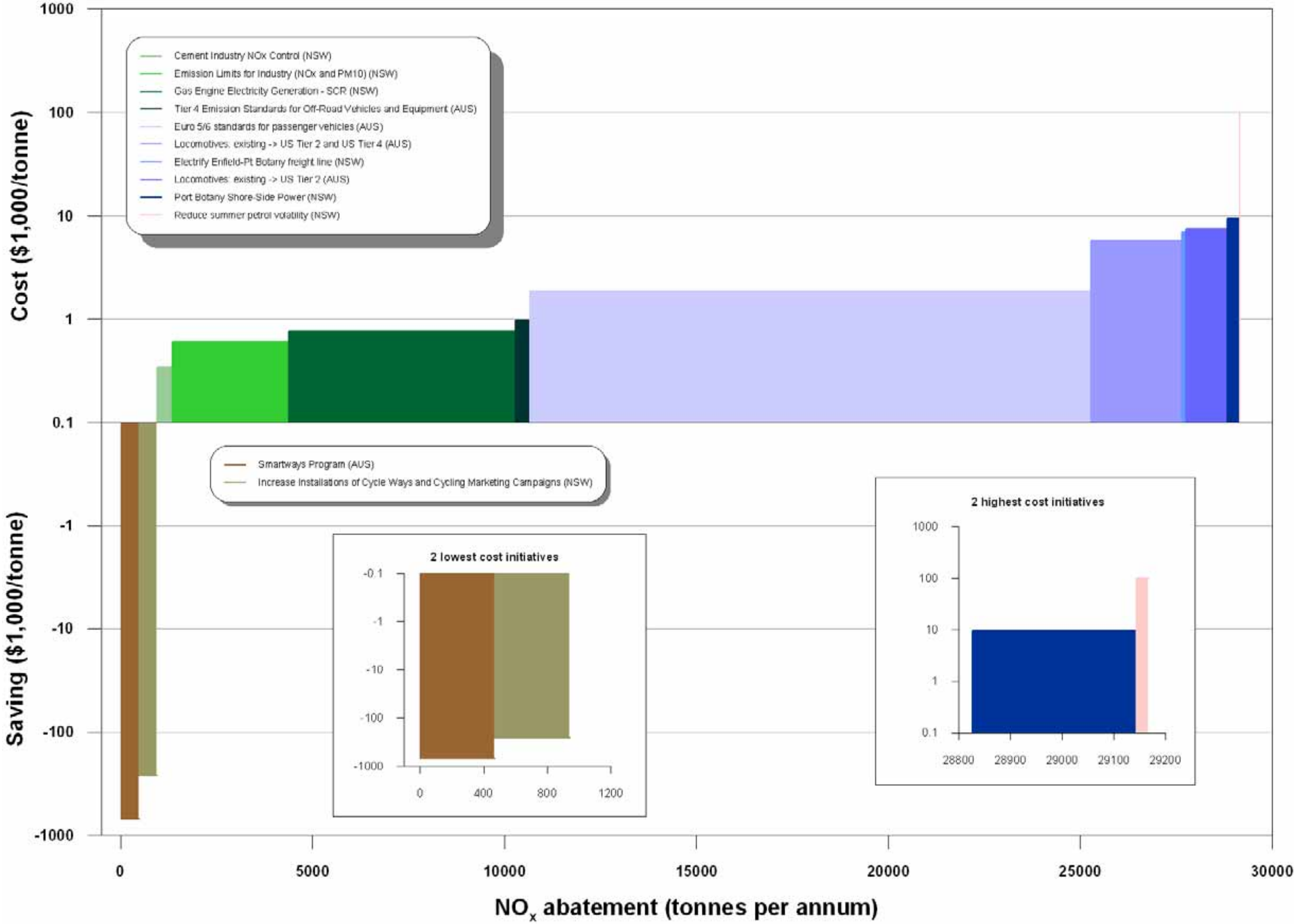
VOC

Rank	Initiative Name	VOC $000/tonne	VOC t pa	Cumul. Tonnes	% abatement
1	SmartWay Program	($ 5,536)	57	57	0%
2	Shift Transport Mode to Cycling	($ 1,140)	99	156	0%
3	Metal Plating and Coating Works: CARB, 2008 AIM Regulation	$ 0	1,189	1,345	1%
4	CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)	$ 0	7,333	8,678	7%
5	Printing VOC Emissions Control	$ 0	2,172	10,850	8%
6	Petrol Refinery Vapour Recovery and Leak Detection and Repair	$ 1	335	11,185	9%
7	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 2	4,704	15,889	12%
8	Summer-time Petrol Volatility (62 kPA to 60 kPA)	$ 3	892	16,781	13%
9	CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols	$ 6	3,734	20,515	16%
10	CARB 2008 Regulation for Surface Coatings - Smash Repairing	$ 6	465	20,980	16%
11	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 8	3,272	24,252	19%
12	Recommission and Electrify Enfield-Port Botany Freight Line	$ 147	5	24,257	19%
13	Port Botany Shore-Side Power	$ 255	12	24,269	19%

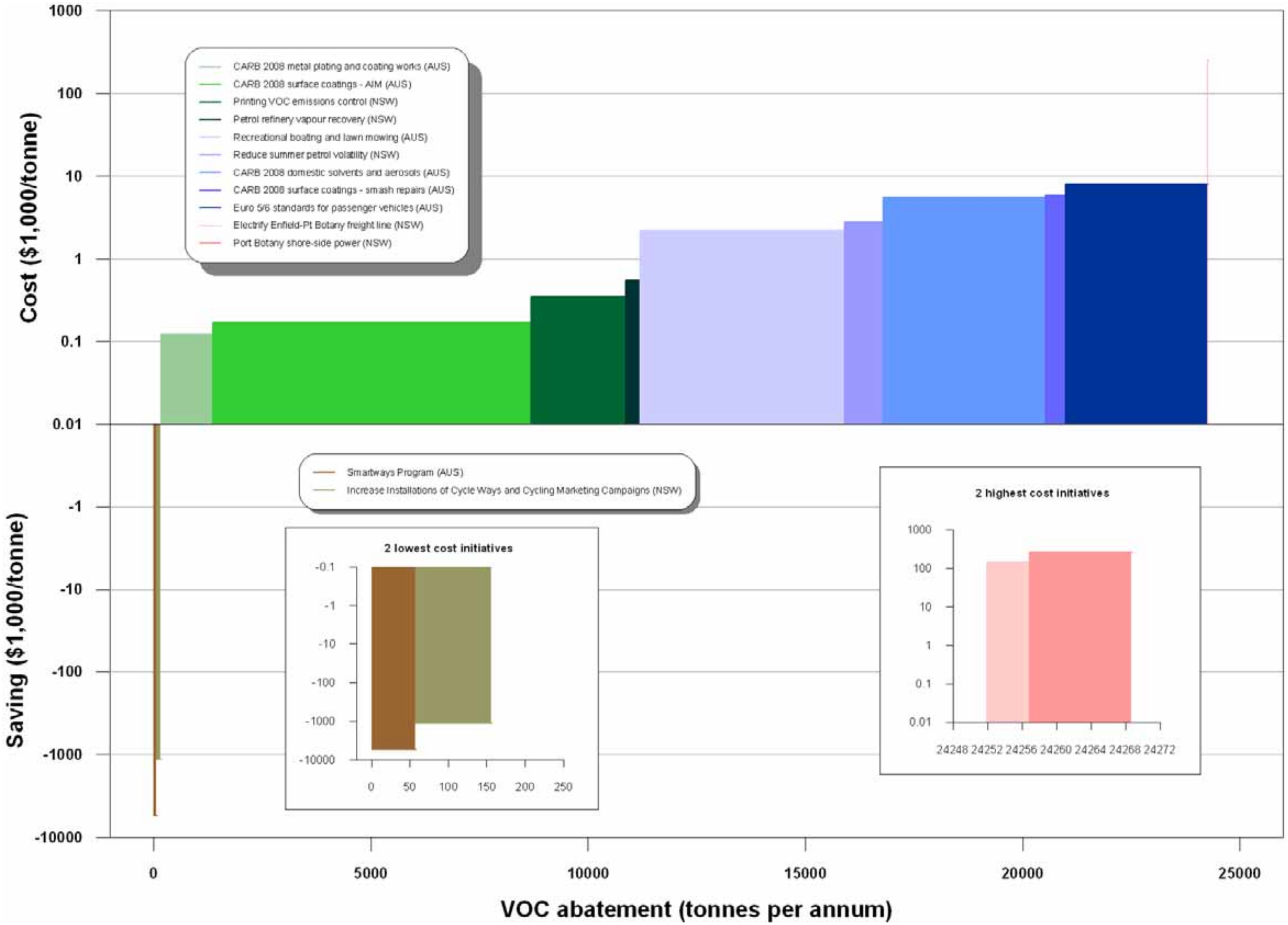
PM_{10}

Rank	Initiative Name	PM10 $000/tonne	PM10 t pa	Cumul. Tonnes	% abatement
1	SmartWay Program	($ 54,266)	5	5	0%
2	Shift Transport Mode to Cycling	($ 16,146)	7	12	0%
3	National Standards for Wood Heaters (1 g/kg)	$ 1	1,701	1,713	7%
4	National Standards for Wood Heaters (3 g/kg)	$ 1	45	1,759	7%
5	Emission Limits for Industry (NOx and PM10)	$ 5	359	2,118	9%
6	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)	$ 12	31	2,149	9%
7	Wood Heaters - Reduce the Moisture Content of Firewood	$ 20	93	2,241	9%
8	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 39	261	2,503	10%
9	Truck and Bus Diesel Retrofit	$ 151	1	2,504	10%
10	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2	$ 156	53	2,557	10%
11	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 + Retrofit Tier 2 Locomotives with Selective Catalytic Reductio	$ 191	72	2,629	11%
12	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 209	131	2,760	11%
13	Recommission and Electrify Enfield-Port Botany Freight Line	$ 244	3	2,763	11%
14	Port Botany Shore-Side Power	$ 274	11	2,774	11%

Sydney NO_X Simple MACC Chart

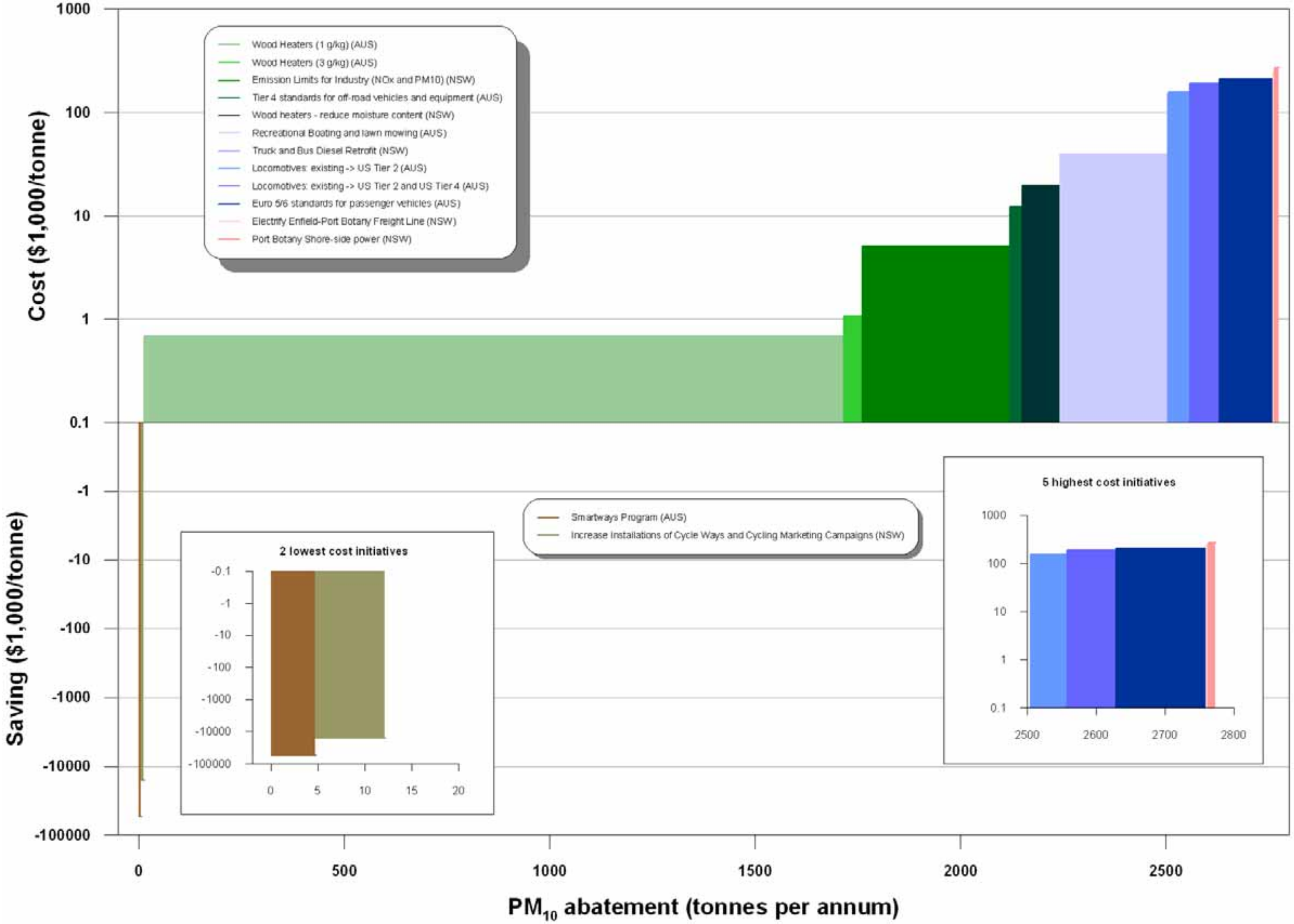


Sydney VOC Simple MACC Chart



SINCLAIR KNIGHT MERZ

Sydney PM_{10} Simple MACC Chart



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7.2.3. Wollongong Simple MACC Tables and Charts

The following Wollongong MACCs have been produced using the same approach as for the GMR, using initiatives applicable to the sub-region, and, where appropriate, region specific data. Negative costs (i.e. savings) and abatement (i.e. emissions increases) are highlighted in red.

NO_X

Rank	Initiative Name	NOX $000/tonne	NOX t pa	Cumul. Tonnes	% abatement
-	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 47.909	- 12	-	0%
1	SmartWay Program	($ 10,620.977)	31	31	0%
2	Shift Transport Mode to Cycling	($ 226.178)	24	54	0%
3	Emission Limits for Industry (NOx and PM10)	$ 0.605	293	347	2%
4	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)	$ 1.031	49	396	3%
5	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 1.854	655	1,051	7%
6	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 + Retrofit Tier 2 Locomotives with Selective Catalytic Reductio	$ 5.838	203	1,255	9%
7	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2	$ 7.584	94	1,349	9%
8	Summer-time Petrol Volatility (62 kPA to 60 kPA)	$ 74.698	1	1,350	9%

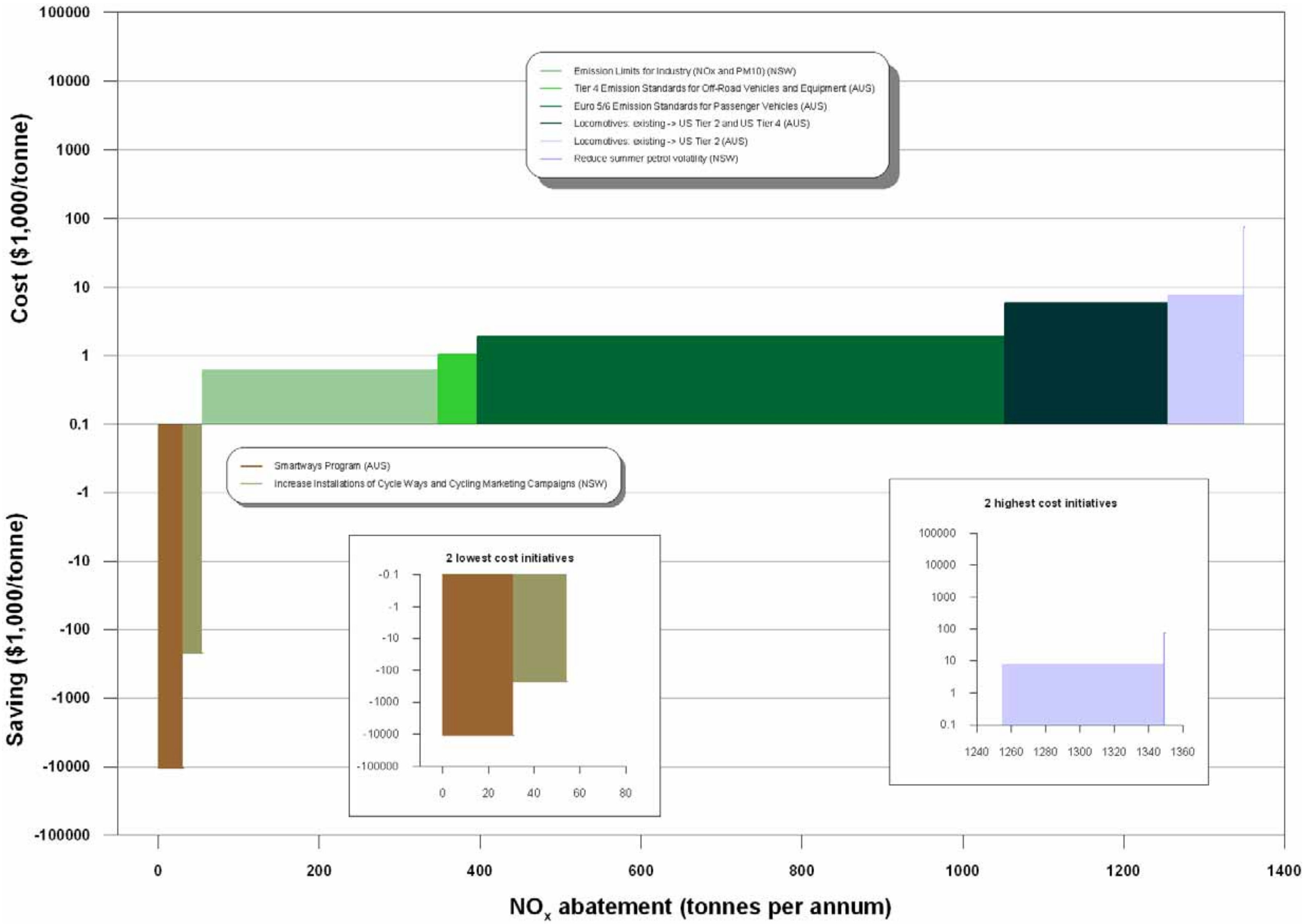
VOC

Rank	Initiative Name	VOC $000/tonne	VOC t pa	Cumul. Tonnes	% abatement
1	SmartWay Program	($ 91,748)	3	3	0%
2	Shift Transport Mode to Cycling	($ 1,085)	4	8	0%
3	Metal Plating and Coating Works: CARB, 2008 AIM Regulation	$ 0	80	88	1%
4	CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)	$ 0	369	457	7%
5	Summer-time Petrol Volatility (62 kPA to 60 kPA)	$ 2	46	503	8%
6	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 2	281	784	12%
7	CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols	$ 6	179	964	15%
8	CARB 2008 Regulation for Surface Coatings - Smash Repairing	$ 6	23	987	15%
9	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 9	135	1,122	17%

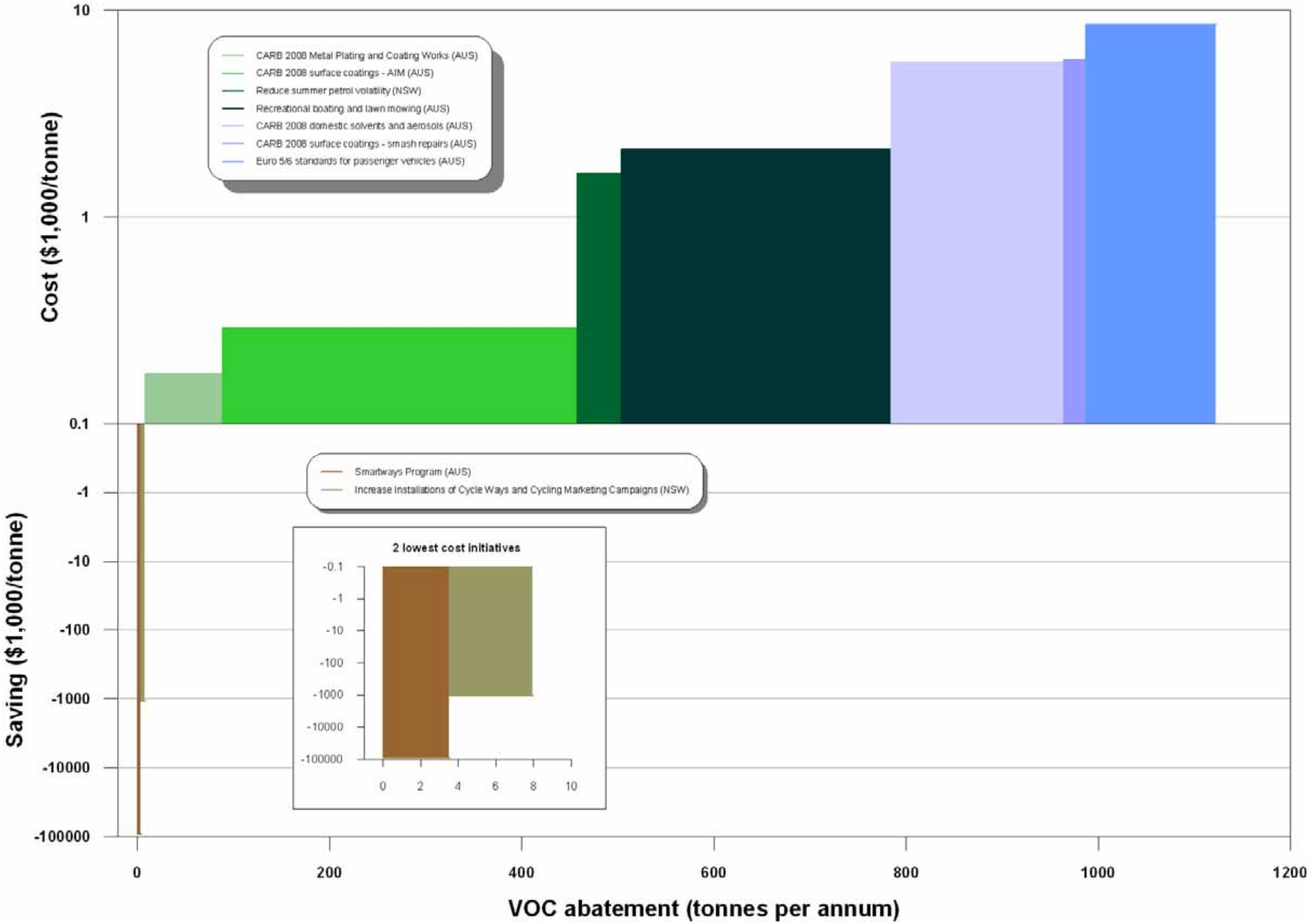
PM_{10}

Rank	Initiative Name	PM10 $000/tonne	PM10 t pa	Cumul. Tonnes	% abatement
1	SmartWay Program	($ 833,360)	0	0	0%
2	Shift Transport Mode to Cycling	($ 15,679)	0	1	0%
3	National Standards for Wood Heaters (1 g/kg)	$ 1	94	94	2%
4	National Standards for Wood Heaters (3 g/kg)	$ 2	2	97	2%
5	Emission Limits for Industry (NOx and PM10)	$ 5	35	132	3%
6	Wood Heaters - Reduce the Moisture Content of Firewood	$ 20	5	137	3%
7	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)	$ 25	2	139	3%
8	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	$ 38	16	155	4%
9	Truck and Bus Diesel Retrofit	$ 139	0	155	4%
10	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2	$ 157	5	160	4%
11	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 + Retrofit Tier 2 Locomotives with Selective Catalytic Reductio	$ 192	6	166	4%
12	Euro 5/6 Emission Standards for New Passenger Vehicles	$ 238	5	171	4%

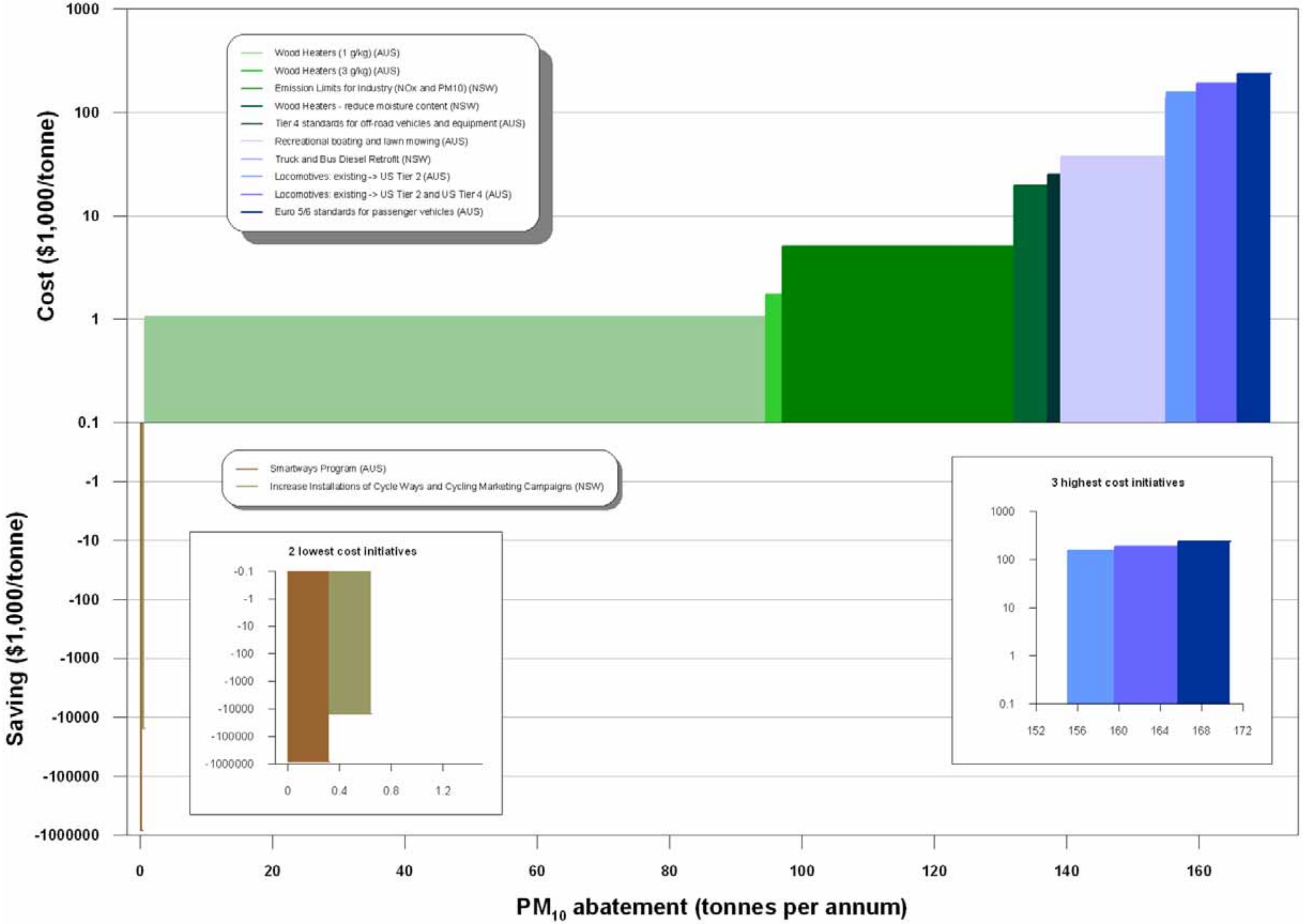
Wollongong NO_X Simple MACC Chart



Wollongong VOC Simple MACC Chart



Wollongong PM_{10} Simple MACC Chart



7.3. General Discussion of MACC Results

It can be seen that the charts of MACC results are presented on a log-linear scale. This is as a consequence of the large variation in abatement costs ($000/tonne) and is needed to enable all results to be viewed in the one set of graphed results. Negative costs are also presented on a log scale for clarity, and this needs to be understood in interpreting the graphs.

In all cases MACC results should be assessed in the context of the assumptions used to estimate emissions abatement and costs as set out in the abatement initiative summary tables in **Appendix F**.

When considering the cost of abatement, the single pollutant MACCs are calculated with 100% of costs allocated to each individual MACC, as it is not feasible to allocate costs to different pollutants. This can make costs ($000/tonne) look disproportionately high for pollutants which are not the main target of the abatement initiative.

Table 6-1 shows the primary and secondary pollutants impacted by each abatement initiative. In Section 7.5 abatement initiatives are assessed in a multi-pollutant framework.

The MACC results presented are for the Simple MACCs calculated by the SKM model, that ignores multiple initiatives operating on the same source. For the set of initiatives identified by SKM for this study, there are few instances where there are multiple initiatives operating on the same source, and, as the abatement percentages for these cases are relatively low, the "complex MACC" effect is correspondingly low. For the GMR region the difference in abatement identified differs by 6.5% for NO_X, 3.7% for PM_{10}, and 0.1% for VOC. These differences are not considered material in the context of the uncertainty and estimation precision for this study, however, SKM has determined that the Simple MACC results provide the most realistic outputs and have been used as the basis of reported results and further optimisation. Similarly, the calculation order for the Complex MACC will have limited impacts, and is also not considered to be a material factor in the results, although in theory with a different set of initiatives the calculation order could be an issue.

Specifically the MACC model is not intended to address all possible limitations and complexities associated with multiple initiatives, such as interactions between initiatives (the "Complex MACC" effect), dependencies and mutually exclusive options. These can generally be modelled with reasonable accuracy, but may require some manual intervention to achieve the most accurate modelled results. These manual interventions are:

- **Complex MACC calculation order**. The calculation order for the complex MACC will affect the calculated abatement of multiple initiatives affecting the same source. The way the model operates, the first initiative calculated in a group will show the full impact of that initiative (i.e. the same as the Simple MACC abatement impact), while the second and subsequent initiatives will show proportionally reduced abatement impacts. The model calculates an initial sort order based on the least cost per tonne of “normalised abatement”[11] across the three substances. Where the LP Optimisation determines a different priority order for these initiatives, or other factors such as dependencies between initiatives (e.g. “A” must be implemented before “B” can be implemented) mean a different Complex MACC calculation order is more accurate, the model allows the users to manually enter a preferred calculation order. The calculation order should be reviewed prior to finalising results to ensure it is consistent with the LP Optimisation and practical considerations that are not able to be considered by the MACC model.

- **Dependencies between initiatives**. The model is not able to account for dependencies between implementation of initiatives (e.g. “A” must be implemented before “B” can be implemented). This means that (a) the Complex MACC calculation order could rank the “B” initiative ahead of “A” and (b) the LP Optimisation could likewise include “B” in an optimised mix but not “A” (or a higher level of “B” than “A”). The first issue can be addressed using a manual sort order for the Complex MACC, while the second cannot currently be accurately modelled in the optimisation model. If this issue is found to be a material problem, an alternative is to restructure the initiatives (e.g. into “A alone” and “A and then B”, capturing the full cost of both initiatives in the second combined option) and then make these two initiatives mutually exclusive.
- **Mutually exclusive options**. With mutually exclusive options, implementation of only one of a set of initiatives is feasible. The model ignores this restriction in the calculation of the Simple and Complex MACCs. While this will not affect the results of other initiatives in the Simple MACC, it could affect other initiatives operating on the same source in the Complex MACC. The solution to this issue is to review the Complex MACC calculation order, and ensure the preferred initiatives are calculated first by entering a manual calculation order, or by disabling the “non preferred” initiatives in the inputs sheet (by switching “Include?” to “No”). The LP Optimisation model allows for up to 4 sets of mutually exclusive initiatives to be considered, with the preferred initiative in each set chosen manually. A switch to “Include” or “Ignore” restrictions on mutually exclusive initiatives allows the Optimisation model to be run initially ignoring the mutually exclusive options, and the results used to inform a decision as to which option will provide the greatest benefit to the overall optimal set of initiatives. The model can then be re-run with the model set to “Include” restrictions on mutually exclusive

[11] The normalised abatement takes into account the total GMR inventory of each of the three substances considered in the study, and calculates a notional “equivalent” tonne for all three substances. This effectively gives an equal weighting to the same percentage abatement of all three substances. In practice it is not feasible to produce a simple equivalent for ozone or smog creation potential, and this index was intended to provide a simple basis for an initial calculation order only.

options, to give the final optimised solution. In some instances it may be necessary to revisit the MACC calculations to confirm the Complex MACC sort order places the preferred options first.

The actual cost for each abatement initiative was calculated for the initiative being applied to the whole GMR. For the Sydney and Wollongong sub-regions the costs have been factored down in proportion to the GMR either based on population statistics for each of the sub-regions or the proportion of abatement source emissions in each sub-region compared to the GMR.

There are two initiatives that show large cost savings[12] per tonne of emissions abated but relatively minor reductions in emissions. These initiatives are:

- SmartWay Programs; and
- Shift to cycling.

In all other cases abatement initiatives result in cost increases.

Increases in NO_X emissions (negative emissions abatement) result from one initiative for VOC reduction being Small engines (2 strokes to 4 stroke) – recreational boating and lawn mowing. While comparatively large VOC emissions reductions result from this measure (refer to VOC MACC charts), it will also result in increases in NO_X, however, comparatively small compared total NO_X abatement offered by all measures.

[12] Energy savings from use of energy efficiency devices integral to the implementation of SmartWay outweigh the costs of diesel retrofit. Changing from car to bicycle for 5% of trips again produces savings on car and public transport use that outweigh the program costs.

7.4. Significant Findings

There are many significant results that can be drawn from the MACC modelling as shown in the MACC charts. Some key results are as follows:

GMR

- NO_X reduction is dominated by two mutually exclusive initiatives aimed at reducing emissions from coal fired power stations being Dry Low NO_X (DLN) and Selective Catalytic Reduction (SCR). The DLN initiative is cheaper (on a $/tonne) basis, and SKM has chosen this initiative for inclusion in the optimised results, although the SCR option gives larger abatement (at higher $/tonne cost, but still below other initiatives required to get to 25% overall abatement, and hence could be part of an optimised mix at higher overall abatement levels); and
- PM_{10} reduction is dominated by the effect of buffer zones associated with open cut coal mines being equated to emissions reduction. This measure would apply to an estimated future 10 coal mines that will likely be established to meet energy requirements up to 2030. The future mines were considered by the study because no other options for significant reduction of particulate emissions from coal mines were identified over and above the existing management practices employed by the industry. It is noted that existing open cut mines already have buffer zones in place to mitigate the impact of particulates and the costs associated with the measure are intended to provide a guide as to the investment in land and property required to mitigate adverse impact by providing buffer zones to separate future mine developments and sensitive receivers.

Sydney

- The profile of abatement options in the Sydney region is similar to the GMR, however with no coal power stations or mines in the Sydney region, the largest NO_X and PM_{10} measures applicable to the GMR are not available within the Sydney region.
- NO_X emission reductions in the Sydney region need to focus on motor vehicle emissions. The introduction of emission standards for motor vehicles e.g. Euro 5/6 standards for passenger cars, result in significant reductions over time;
- The consideration of selective catalytic reduction (SCR) for gas engine electricity generation (not gas turbine) in the Sydney region also has the potential to reduce significant NO_X emissions;
- Introduction of Californian Air Resources Board (CARB, 2008) emission standards for VOC sources, in particular surface coatings and consumer products also has the potential to reduce significant quantities of VOC emissions. It is however, recommended that further work be done to identify the existing VOC content of coatings and aerosols as many may already comply with CARB, 2008 and this is not reflected in the reference case emissions; and

- Increased regulation of wood heaters in line with proposed national standards has the potential to reduce the largest amounts of PM_{10} in the Sydney region. The standards would, however, need to be applied to existing wood heaters (i.e. replacement) as well as new ones.

Wollongong

- With respect to NO_X emissions the Port Kembla Steelworks is the largest emitter in the region and it is noted that there is no consideration of NO_X control for this source as part of this study and a more generic approach to emissions sources has been adopted for the purpose of this report.
- Aside from the steelworks emissions reduction of NO_X, VOC and PM_{10} in Wollongong will be achieved by similar initiatives to those identified for Sydney. As per the Sydney region, NO_X abatement is dominated by Euro 5/6 standards for vehicles, PM_{10} abatement by low emission standards for wood heaters, and VOC abatement by CARB standards and small engine (boat and lawnmower) emission standards.

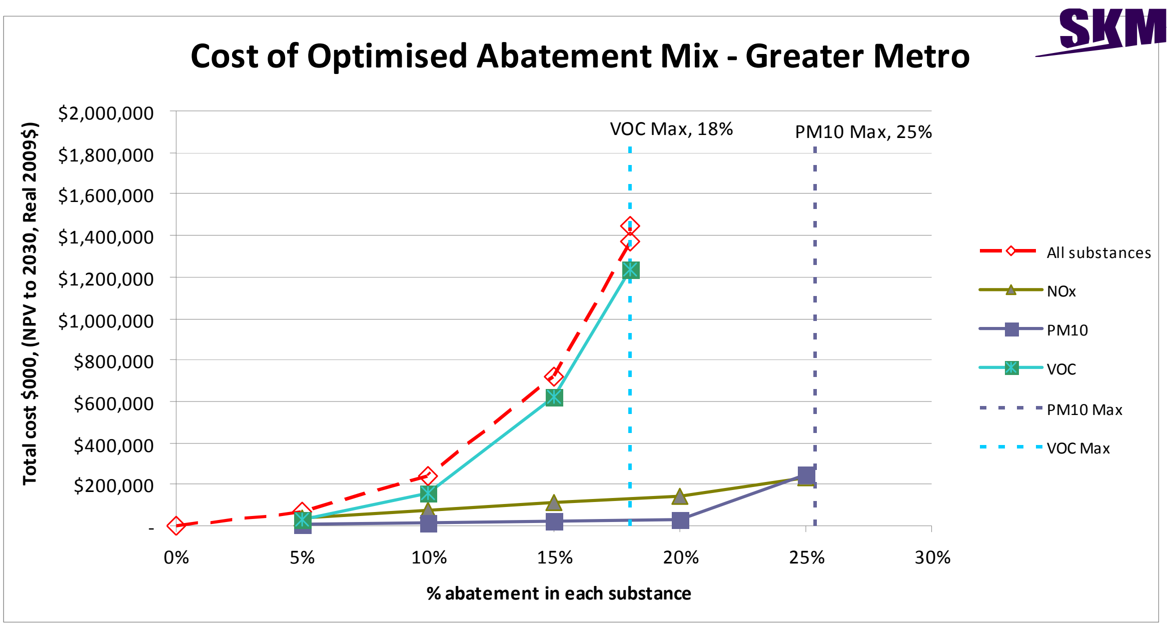
7.5. Optimised Multi-pollutant Suite of Initiatives

SKM has used linear programming to optimise the results of the three separate Simple MACC curves to derive an overall optimised suite of initiatives to deliver abatement for all three substances at least cost. "Optimised" is defined as the lowest overall cost of meeting the defined abatement targets for each of the three substances.

7.5.1. GMR Optimisation Results

Figure 7-1 shows the results of SKM's optimisation analysis for the GMR region. Note that maximum achievable VOC abatement was 18%, so the full solution of 25% reduction for NO_X and VOCs and 10 – 30 % for PM_{10} in all three substances could not be found.

- **Figure 7-1 Cost of Optimised Abatement Mix (GMR)**



The graph of the optimised abatement mix presents the cumulative cost of abatement action on the y-axis (in thousands of dollars) and the percentage emission abatement of each substance on the x-axis. For a desired percentage of emissions reduced, the y-axis indicates the net present cost to achieve the emission reductions. The cumulative cost on the y-axis adds all savings and costs to give the total cost to achieve the emission reductions. Note that the impacts of smaller measures are difficult to discern in a cumulative graph.

The individual measures that are included to achieve the desired abatement are shown in **Table 7-1** below.

Table 7-1 Cost of Optimised Abatement Mix for Individual Initiatives (GMR)

	% of full implementation for each measure to achieve optimised abatement target																					
	All substances							NOx					PM10					VOC				
Initiative Name	0%	5%	10%	15%	20%	25%	30%	5%	10%	15%	20%	25%	5%	10%	15%	20%	25%	5%	10%	15%	20%	25%
Coal Power Station Low NOx Burners		22%	44%	46%	66%	83%	96%	22%	44%	66%	88%	100%		0%	0%	0%			0%			
Diesel Loco Tier 2																						
Retrofit Locos with SCR & DPF							100%															
Summer Petrol Volatility				100%	100%	100%	100%													100%	100%	100%
Truck and Bus Diesel Retrofit							100%															
Shift to Cycling																						
Electrify Enfield-Pt Botany Freight Line					100%	100%	100%														100%	100%
Port Botany Shore-Side Power					100%	100%	100%														100%	100%
Equipment							100%										100%					
Petrol Refinery Vapour Recovery			100%	100%	100%	100%	100%												100%	100%	100%	100%
CARB 2008 Domestic Solvents and Aerosols					100%	100%	100%														100%	100%
CARB 2008 Surface Coatings - AIM		77%	100%	100%	100%	100%	100%											77%	100%	100%	100%	100%
Wood Heaters Reduce Moisture Content																						
Wood Heaters (3 g/kg)																						
Wood Heaters (1 g/kg)						100%	100%										100%					
Recreational Boating and Lawn Mowing			57%	100%	100%	100%	100%										78%		57%	100%	100%	100%
CARB 2008 Surface Coatings - Smash Repairs				100%	100%	100%	100%													100%	100%	100%
Euro 5/6 Standards for Passenger Vehicles				91%	100%	100%	100%													91%	100%	100%
SmartWays Program																						
Emission Limits for Industry (NOx and PM10)						72%	100%					100%					100%					
Open Cut Coal Mining Buffer Zone Initiative		23%	44%	66%	88%	100%	100%	0%					23%	45%	68%	90%	100%					
Coal Power Station - SCR																						
Gas Engine Electricity Generation - SCR												29%										
Cement Industry NOx Control												100%										
CARB 2008 Metal Plating and Coating Works		100%	100%	100%	100%	100%	100%	0%						0%	0%	0%		100%	100%	100%	100%	100%
Printing VOC Emissions Control			100%	100%	100%	100%	100%												100%	100%	100%	100%
Abatement achieved (% in 2030)																						
NOx	0%	5%	10%	15%	20%	25%	30%	5%	10%	15%	20%	25%	0%	0%	0%	0%	2%	0%	0%	5%	5%	5%
PM10	0%	5%	10%	15%	20%	25%	25%	0%	0%	0%	0%	1%	5%	10%	15%	20%	25%	0%	0%	0%	0%	0%
VOC	0%	5%	10%	15%	18%	18%	18%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	5%	10%	15%	18%	18%

Note from the percentage abatement achieved section at the bottom of the table that the target abatement for each substance was not always achieved. Those abatement achieved figures shown in orange indicate "close" to the target (within 5%), while those in red indicate well below the target (more than 5% below). Figures in bright green indicate abatement above the required target for that substance.

The mix of measures to achieve the overall optimum (nominal 25%) target, and contribution of each measure to total costs and abatement for each substances is shown in **Table 7-2**.

Table 7-2 Mix of Abatement Initiatives to Achieve Optimum Target (GMR)

Initiative #	Include?	% of full implement'n	Initiative Name	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement
1	Yes	83%	Coal Power Station Low NOx Burners	9%	75%	-	-
2	Yes	0%	Diesel Loco Tier 2	-	-	-	-
3	Yes	0%	Retrofit Locos with SCR & DPF	-	-	-	-
4	Yes	100%	Summer Petrol Volatility	5%	0%	-	4%
5	Yes	0%	Truck and Bus Diesel Retrofit	-	-	-	-
11	No	0%	Shift to Cycling	-	-	-	-
15	Yes	100%	Electrify Enfield-Pt Botany Freight Line	1%	0%	0%	0%
17	Yes	100%	Port Botany Shore-Side Power	2%	0%	0%	0%
18	Yes	0%	Tier 4 Standards for Off-Road Vehicles and Equipment	-	-	-	-
19	Yes	100%	Petrol Refinery Vapour Recovery	0%	-	-	1%
20	Yes	100%	CARB 2008 Domestic Solvents and Aerosols	37%	-	-	15%
21	Yes	100%	CARB 2008 Surface Coatings - AIM	2%	-	-	31%
22	Yes	0%	Wood Heaters Reduce Moisture Content	-	-	-	-
23	Yes	0%	Wood Heaters (3 g/kg)	-	-	-	-
24	Yes	100%	Wood Heaters (1 g/kg)	1%	-	8%	-
25	Yes	100%	Recreational Boating and Lawn Mowing	12%	-0%	1%	22%
26	Yes	100%	CARB 2008 Surface Coatings - Smash Repairs	3%	-	-	2%
27	Yes	100%	Euro 5/6 Standards for Passenger Vehicles	21%	20%	1%	13%
28	No	0%	SmartWays Program	-	-	-	-
29	Yes	72%	Emission Limits for Industry (NOx and PM10)	2%	4%	2%	-
30	Yes	100%	Open Cut Coal Mining Buffer Zone Initiative	2%	-	88%	-
31	Yes	0%	Coal Power Station - SCR	-	-	-	-
32	Yes	0%	Gas Engine Electricity Generation - SCR	-	-	-	-
33	Yes	0%	Cement Industry NOx Control	-	-	-	-
34	Yes	100%	CARB 2008 Metal Plating and Coating Works	0%	-	-	4%
35	Yes	100%	Printing VOC Emissions Control	1%	-	-	7%
			Total	**100%**	**100%**	**100%**	**100%**
			Total Cost ($ Billion) & abatement % achieved	**$ 1.45**	**25%**	**25%**	**18%**
			Abatement tonnes		91,899	28,358	30,806

Key: For "Include" column, Green shows initiatives selected for inclusion in the LP Optimisation, with Red (and greyed name) showing those excluded. The colour in the "% of full implementation" column is an indicator of the extent that each initiative has been implemented, on a gradual scale from Green (100%, ie fully implemented) through Orange to Red (0%, ie not required to be implemented).

Table 7-3 shows the proportion of each initiative implemented for an optimum mix to achieve a 15% uniform abatement target. This figure was chosen as it appears to represent the knee point of the cost curve, and will thus show the mix of options that can achieve abatement at the lowest cost.

Table 7-3 Mix of Abatement Initiatives to Achieve 15 % Target (GMR)

Initiative #	Include?	% of full implement'n	Initiative Name	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement
1	Yes	46%	Coal Power Station Low NOx Burners	11%	70%	-	-
2	Yes	0%	Diesel Loco Tier 2	-	-	-	-
3	Yes	0%	Retrofit Locos with SCR & DPF	-	-	-	-
4	Yes	100%	Summer Petrol Volatility	11%	0%	-	5%
5	Yes	0%	Truck and Bus Diesel Retrofit	-	-	-	-
11	No	0%	Shift to Cycling	-	-	-	-
15	Yes	0%	Electrify Enfield-Pt Botany Freight Line	-	-	-	-
17	Yes	0%	Port Botany Shore-Side Power	-	-	-	-
18	Yes	0%	Tier 4 Standards for Off-Road Vehicles and Equipment	-	-	-	-
19	Yes	100%	Petrol Refinery Vapour Recovery	0%	-	-	1%
20	Yes	0%	CARB 2008 Domestic Solvents and Aerosols	-	-	-	-
21	Yes	100%	CARB 2008 Surface Coatings - AIM	4%	-	-	37%
22	Yes	0%	Wood Heaters Reduce Moisture Content	-	-	-	-
23	Yes	0%	Wood Heaters (3 g/kg)	-	-	-	-
24	Yes	0%	Wood Heaters (1 g/kg)	-	-	-	-
25	Yes	100%	Recreational Boating and Lawn Mowing	25%	-1%	2%	27%
26	Yes	100%	CARB 2008 Surface Coatings - Smash Repairs	5%	-	-	2%
27	Yes	91%	Euro 5/6 Standards for Passenger Vehicles	39%	31%	1%	15%
28	No	0%	SmartWays Program	-	-	-	-
29	Yes	0%	Emission Limits for Industry (NOx and PM10)	-	-	-	-
30	Yes	66%	Open Cut Coal Mining Buffer Zone Initiative	3%	-	97%	-
31	Yes	0%	Coal Power Station - SCR	-	-	-	-
32	Yes	0%	Gas Engine Electricity Generation - SCR	-	-	-	-
33	Yes	0%	Cement Industry NOx Control	-	-	-	-
34	Yes	100%	CARB 2008 Metal Plating and Coating Works	0%	-	-	5%
35	Yes	100%	Printing VOC Emissions Control	2%	-	-	8%
			Total	**100%**	**100%**	**100%**	**100%**
			Total Cost ($ Billion) & abatement % achieved	**$ 0.72**	**15%**	**15%**	**15%**
			Abatement tonnes		55,140	17,015	25,666

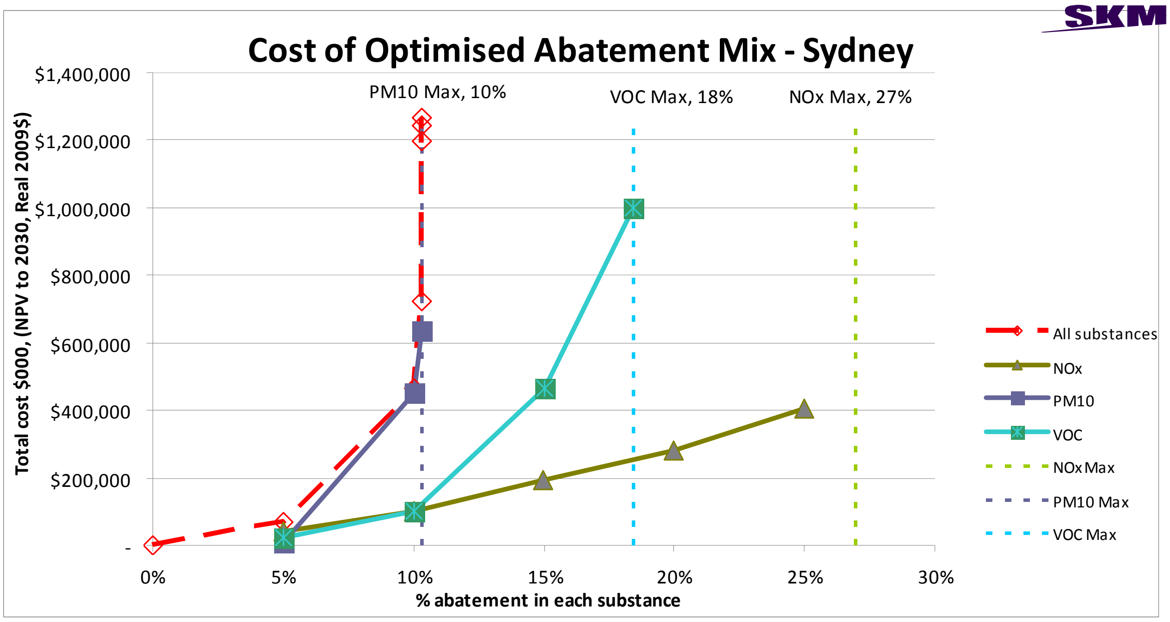
Key: For "Include" column, Green shows initiatives selected for inclusion in the LP Optimisation, with Red (and greyed name) showing those excluded. The colour in the "% of full implementation" column is an indicator of the extent that each initiative has been implemented, on a gradual scale from Green (100%, ie fully implemented) through Orange to Red (0%, ie not required to be implemented).

Inspection of the above data shows that abatement in the GMR of around 15% on all three substances can be achieved at relatively low cost, with the sharp increase at 15%. Greater abatement percentages for NOx and PM_{10} can be achieved at low cost, indicating a revised 15% target for VOC could be more economically feasible. SKM has not assessed the economic benefits of lower VOC emissions, and does not consider it has sufficient information to recommend targets based on costs alone, but that the cost curve above provides sound input to such analysis and policy considerations.

7.5.2. Sydney Region Optimisation Results

Figure 7-2 shows the results of SKM's optimisation analysis for the Sydney region. Note that maximum achievable VOC abatement was 18%, and PM_{10}, 10%, so the full solution of 25% reduction for NO_X and VOCs and 10 – 30 % for PM_{10} in all three substances could not be found.

▪ **Figure 7-2 Cost of Optimised Abatement Mix (Sydney)**



The individual measures included to achieve the desired abatement are shown in **Table 7-4**.

▪ **Table 7-4 Cost of Optimised Abatement Mix for Individual Initiatives (Sydney)**

	% of full implementation for each measure to achieve optimised abatement target																					
	All substances							NOx					PM10					VOC				
Initiative Name	0%	5%	10%	15%	20%	25%	30%	5%	10%	15%	20%	25%	5%	10%	15%	20%	25%	5%	10%	15%	20%	25%
Coal Power Station Low NOx Burners																						
Diesel Loco Tier 2																						
Retrofit Locos with SCR & DPF			11%	100%	100%	100%	100%					29%		11%	100%	100%	100%					
Summer Petrol Volatility				67%	100%	100%	100%													100%	100%	100%
Truck and Bus Diesel Retrofit				100%	100%	100%	100%								100%	100%	100%					
Shift to Cycling																						
Electrify Enfield-Pt Botany Freight Line				100%	100%	100%	100%								100%	100%	100%				100%	100%
Port Botany Shore-Side Power				100%	100%	100%	100%								100%	100%	100%				100%	100%
Tier 4 Standards for Off-Road Vehicles & Equipment		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%					
Petrol Refinery Vapour Recovery				100%	100%	100%	100%												100%	100%	100%	100%
CARB 2008 Domestic Solvents and Aerosols					100%	100%	100%														100%	100%
CARB 2008 Surface Coatings - AIM		73%	53%	100%	100%	100%	100%											73%	100%	100%	100%	100%
Wood Heaters Reduce Moisture Content																						
Wood Heaters (3 g/kg)																						
Wood Heaters (1 g/kg)		50%	100%	100%	100%	100%	100%						73%	100%	100%	100%	100%	0%				
Recreational Boating and Lawn Mowing			100%	100%	100%	100%	100%							100%	100%	100%	100%		44%	100%	100%	100%
CARB 2008 Surface Coatings - Smash Repairs					100%	100%	100%													100%	100%	100%
Euro 5/6 Standards for Passenger Vehicles			100%	100%	100%	100%	100%		2%	36%	70%	100%		100%	100%	100%	100%			77%	100%	100%
SmartWays Program																						
Emission Limits for Industry (NOx and PM10)		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%					
Open Cut Coal Mining Buffer Zone Initiative																						
Coal Power Station - SCR																						
Gas Engine Electricity Generation - SCR		20%				67%	100%	20%	100%	100%	100%	100%										
Cement Industry NOx Control		100%				100%	100%	100%	100%	100%	100%	100%						0%	23%			
CARB 2008 Metal Plating and Coating Works		100%	100%	100%	100%	100%	100%						0%					100%	100%	100%	100%	100%
Printing VOC Emissions Control				100%	100%	100%	100%												100%	100%	100%	100%
Abatement achieved (% in 2030)																						
NOx	0%	5%	18%	21%	21%	25%	27%	5%	10%	15%	20%	25%	0%	18%	21%	21%	21%	0%	0%	11%	15%	15%
PM10	0%	5%	10%	10%	10%	10%	10%	2%	2%	2%	2%	2%	5%	10%	10%	10%	10%	0%	0%	1%	2%	2%
VOC	0%	5%	10%	15%	18%	18%	18%	0%	0%	1%	2%	3%	0%	6%	6%	6%	6%	5%	10%	15%	18%	18%

Key: For "Include" column, Green shows initiatives selected for inclusion in the LP Optimisation, with Red (and greyed name) showing those excluded. The colour in the "% of full implementation" column is an indicator of the extent that each initiative has been implemented, on a gradual scale from Green (100%, ie fully implemented) through Orange to Red (0%, ie not required to be implemented).

The mix of measures to achieve the overall optimum (nominal 25% target, noting that only around 10% PM_{10} and 18% VOC abatement is possible), and contribution of each measure to total costs and abatement for each substances is shown in **Table 7-5**.

Table 7-5 Mix of Abatement Initiatives to Achieve Optimum Target (Sydney)

Initiative #	Include?	% of full implement'n	Initiative Name	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement
1	No	0%	Coal Power Station Low NOx Burners	-	-	-	-
2	Yes	0%	Diesel Loco Tier 2	-	-	-	-
3	Yes	100%	Retrofit Locos with SCR & DPF	13%	9%	3%	-
4	Yes	100%	Summer Petrol Volatility	4%	0%	-	4%
5	Yes	100%	Truck and Bus Diesel Retrofit	0%	-	0%	-
11	No	0%	Shift to Cycling	-	-	-	-
15	Yes	100%	Electrify Enfield-Pt Botany Freight Line	1%	0%	0%	0%
17	Yes	100%	Port Botany Shore-Side Power	3%	1%	0%	0%
18	Yes	100%	Tier 4 Standards for Off-Road Vehicles and Equipment	0%	2%	1%	-
19	Yes	100%	Petrol Refinery Vapour Recovery	0%	-	-	1%
20	Yes	100%	CARB 2008 Domestic Solvents and Aerosols	34%	-	-	15%
21	Yes	100%	CARB 2008 Surface Coatings - AIM	2%	-	-	30%
22	Yes	0%	Wood Heaters Reduce Moisture Content	-	-	-	-
23	Yes	0%	Wood Heaters (3 g/kg)	-	-	-	-
24	Yes	100%	Wood Heaters (1 g/kg)	1%	-	66%	-
25	Yes	100%	Recreational Boating and Lawn Mowing	10%	-1%	10%	20%
26	Yes	100%	CARB 2008 Surface Coatings - Smash Repairs	3%	-	-	2%
27	Yes	100%	Euro 5/6 Standards for Passenger Vehicles	21%	58%	5%	14%
28	No	0%	SmartWays Program	-	-	-	-
29	Yes	100%	Emission Limits for Industry (NOx and PM10)	2%	12%	14%	-
30	No	0%	Open Cut Coal Mining Buffer Zone Initiative	-	-	-	-
31	No	0%	Coal Power Station - SCR	-	-	-	-
32	Yes	67%	Gas Engine Electricity Generation - SCR	4%	16%	-	-
33	Yes	100%	Cement Industry NOx Control	0%	2%	-	-
34	Yes	100%	CARB 2008 Metal Plating and Coating Works	0%	-	-	5%
35	Yes	100%	Printing VOC Emissions Control	1%	-	-	9%
			Total	**100%**	**100%**	**100%**	**100%**
			Total Cost ($ Billion) & abatement % achieved	**$ 1.24**	**25%**	**10%**	**18%**
			Abatement tonnes		24,994	2,571	24,112

Table 7-6 shows the proportion of each initiative implemented for an optimum mix to achieve a 25% NOx, and a 10% PM_{10} and VOC abatement target, with these figures chosen as they appear to represent the knee point of the cost curve, and will thus show the mix of options that can achieve the bulk of cost effective abatement at the lowest cost.

- **Table 7-6 Mix of Abatement Initiatives to Achieve Knee Point Target (Sydney)**

Initiative #	Include?	% of full implement'n	Initiative Name	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement
1	No	0%	Coal Power Station Low NOx Burners	-	-	-	-
2	Yes	0%	Diesel Loco Tier 2	-	-	-	-
3	Yes	37%	Retrofit Locos with SCR & DPF	10%	3%	1%	-
4	Yes	0%	Summer Petrol Volatility	-	-	-	-
5	Yes	0%	Truck and Bus Diesel Retrofit	-	-	-	-
11	No	0%	Shift to Cycling	-	-	-	-
15	Yes	0%	Electrify Enfield-Pt Botany Freight Line	-	-	-	-
17	Yes	0%	Port Botany Shore-Side Power	-	-	-	-
18	Yes	100%	Tier 4 Standards for Off-Road Vehicles and Equipment	1%	2%	1%	-
19	Yes	0%	Petrol Refinery Vapour Recovery	-	-	-	-
20	Yes	0%	CARB 2008 Domestic Solvents and Aerosols	-	-	-	-
21	Yes	58%	CARB 2008 Surface Coatings - AIM	3%	-	-	33%
22	Yes	0%	Wood Heaters Reduce Moisture Content	-	-	-	-
23	Yes	0%	Wood Heaters (3 g/kg)	-	-	-	-
24	Yes	100%	Wood Heaters (1 g/kg)	2%	-	68%	-
25	Yes	93%	Recreational Boating and Lawn Mowing	21%	-1%	10%	33%
26	Yes	0%	CARB 2008 Surface Coatings - Smash Repairs	-	-	-	-
27	Yes	100%	Euro 5/6 Standards for Passenger Vehicles	47%	58%	5%	25%
28	No	0%	SmartWays Program	-	-	-	-
29	Yes	100%	Emission Limits for Industry (NOx and PM10)	4%	12%	14%	-
30	No	0%	Open Cut Coal Mining Buffer Zone Initiative	-	-	-	-
31	No	0%	Coal Power Station - SCR	-	-	-	-
32	Yes	100%	Gas Engine Electricity Generation - SCR	12%	24%	-	-
33	Yes	100%	Cement Industry NOx Control	0%	2%	-	-
34	Yes	100%	CARB 2008 Metal Plating and Coating Works	1%	-	-	9%
35	Yes	0%	Printing VOC Emissions Control	-	-	-	-
			Total	**100%**	**100%**	**100%**	**100%**
			Total Cost ($ Billion) & abatement % achieved	**$ 0.57**	**25%**	**10%**	**10%**
			Abatement tonnes		24,994	2,492	13,080

As can be seen from the analysis above, this second set of differentiated targets achieves almost the same amount of total abatement for NOx and PM_{10}, but nearly halves the VOC abatement achieved to 10%, with an overall total cost less than half the previous figure (of $1.24 billion) to $0.57 billion. This implies that further analysis is required to understand the regional air quality targets, and whether differentiated targets for the different substances and regions are appropriate. If so, then it appears that significant cost savings are available.

8. Conclusion

In response to the NSW Government's State Plan, which commits the state to achieving air quality goals set in 1998 by the *National Environment Protection Measure (Ambient Air Quality)* the Department of Environment, Climate Change and Water (DECCW) recognises that a reduction in anthropogenic emissions of volatile organic compounds (VOC) and oxides of nitrogen (NO_X) by 25% from 2003 levels must be achieved to meet this commitment.

This report identifies and analyses a range of emission abatement initiatives across the Greater Metropolitan Region and sub-regions of NSW. SKM developed a Marginal Abatement Cost Curve (MACC) model to assist in assessing the practicability of each identified initiative from a number of perspectives including economic, environmental and social impacts as well as technical feasibility. The study includes direct benefits to the company or person undertaking the action, such as lower fuels costs, but excludes broader social benefits such as avoided health costs.

The MACC modelling exercise has yielded abatement cost curves that provide a range of measures, impacts and costs that can be considered as policy options to reduce ozone and particulates in the NSW GMR.

The curves identify potential sets of strategies that could be applied to achieve target emission reductions at the least estimated cost, and are intended to provide a guide to potential actions for further investigation. The cost and emission abatement estimates for actions on which the curves are based are indicative and not always readily compared across actions, given that they are drawn from a range of studies and jurisdictions. Further full analysis of potential actions is required to determine the actual costs and emission abatement potential of the actions identified, as well as other benefits that may contribute to a program's value. For example, the air toxics reductions associated with actions to reduce VOC emissions represent a significant health benefit but are not included in the current analysis.

Separate pollutant MACCs were developed for the GMR, Sydney and Wollongong. A total of 35 abatement initiatives were developed for the GMR with 26 of these assessed in this report. A smaller subset of the GMR abatement initiatives applicable in the Sydney and Wollongong regions were also assessed. The following table represents the % reduction in regional emissions that could be abated through the full implementation of all initiatives:

Maximum Identified Reductions of 2003 Emissions			
Region	**NO_X**	**PM_{10}**	**VOC**
GMR	58 %	25 %	18 %
Sydney	27 %	10 %	18 %
Wollongong	8 %	4 %	17 %

There are many significant results that can be drawn from the MACC modelling as shown in the MACC charts. Some key results are as follows:

GMR

- NO_X reduction is dominated by two initiatives aimed at reducing emissions from coal fired power stations being Dry Low NO_X (DLN) and Selective Catalytic Reduction (SCR). These initiatives can effectively be considered mutually exclusive – with the option chosen for implementation depending on the total level of abatement required (DLN for lower levels up to around 15% abatement, and SCR for levels between around 15% and 30%); and
- PM_{10} reduction is dominated by buffer zones associated with future open cut coal mines being equated to emissions reduction.

Sydney

- The profile of abatement options in the Sydney region is similar to the GMR, however with no coal power stations or mines in the Sydney region, the largest NO_X and PM_{10} measures applicable to the GMR are not available within the Sydney region;
- NO_X emission reductions in the Sydney region need to focus on motor vehicle emissions and the introduction of emission standards for motor vehicles e.g. Euro 5/6 standards for passenger cars;
- Other actions important for NO_X control in Sydney include industry NO_X control and controls on gas engine electricity generation and national standards for non-road engines;
- Introduction of Californian Air Resources Board (CARB, 2008) emission standards for VOC sources, in particular surface coatings and consumer products also has the potential to reduce significant quantities of VOC emissions;
- Controls on printers and vapour recovery, national standards for small engines and lowering limits for petrol volatility in summer also show significant potential for VOC emission reductions;
- Increased regulation of wood heaters in line with proposed national standards has the potential to reduce moderate amounts of PM_{10} in the Sydney region; and
- Other important actions for reducing particles in Sydney include emission limits for industry and tighter standards for non-road diesel engines, small engine standards and diesel retrofit. Actions that are more costly but would still be needed to achieve substantial particle reductions include locomotive standards and retrofit; electrification of the Enfield-Port Botany freight line and port-side power for Port Botany to reduce emissions from ship's generators.

Wollongong

- Aside from the Port Kembla Steelworks, which was not considered by the study, emission reductions of NO_X, VOC and PM_{10} in Wollongong will be achieved by similar initiatives to those identified for Sydney.
- As per the Sydney region, NO_X abatement is dominated by Euro 5/6 standards for vehicles, PM_{10} abatement by low emission standards for wood heater, and VOC abatement by CARB standards for industrial emissions and small engine (boat and lawnmower) emission standards.

Table 8-1 shows the mix of initiatives implemented to achieve certain levels of abatement in all three substances in the GMR, Sydney and Wollongong regions. Initiatives not available or applicable to some regions are shaded grey, while others indicate the percentage of full implementation of each initiative to meet the overall abatement level required.

It can be seen there is a mix of relatively few initiatives required to meet target abatement levels up to around 15%, while above that the majority of cost effective initiatives identified are required. It is noteworthy that an abatement initiative selected as a cost effective measure to meet a given target may no longer be cost effective when the abatement target if altered. From a policy perspective this implies the “end point” must be known when considering the mix of policy options, and that gradually rolling out initiatives in order moving up the abatement curve may not result in the optimal mix at higher abatement levels.

Table 8-1 Summary of LP Optimised Order of Initiatives

	% of full implementation required to meet abatement target	Greater Metropolitan Region				Sydney Region				Wollongong Region			
	Initiative	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement	% of total cost	% of total NOx abatement	% of total PM10 abatement	% of total VOC abatement
1	Coal Fired Power Station NOx Control - Low NOx Burners	9%	75%										
2	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2												
3	Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 plus USEPA Tier 2 ---> Tier 4					13%	9%	3%		22%	17%	4%	
4	Summer-time Petrol Volatility (62 kPA to 60 kPA)	5%	0%		4%	4%	0%		4%	3%	0%		4%
5	Truck and Bus Diesel Retrofit					0%		0%		0%		0%	
15	Recommission and Electrify Enfield-Port Botany Freight Line	1%	0%	0%	0%	1%	0%	0%	0%				
17	Port Botany Shore-Side Power	2%	0%	0%	0%	3%	1%	0%	0%				
18	Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)					0%	2%	1%		1%	4%	1%	
19	Petrol Refinery Vapour Recovery and Leak Detection and Repair	0%			1%	0%			1%				
20	CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols	37%			15%	34%			15%	33%			16%
21	CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)	2%			31%	2%			30%	3%			33%
22	Wood Heaters - Reduce the Moisture Content of Firewood												
23	National Standards for Wood Heaters (3 g/kg)												
24	National Standards for Wood Heaters (1 g/kg)	1%		8%		1%		66%		2%		59%	
25	Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing	12%	-0%	1%	22%	10%	-1%	10%	20%	12%	-1%	10%	25%
26	CARB 2008 Regulation for Surface Coatings - Smash Repairing	3%			2%	3%			2%	3%			2%
27	Euro 5/6 Emission Standards for New Passenger Vehicles	21%	20%	1%	13%	21%	58%	5%	14%	19%	55%	3%	12%
29	Emission Limits for Industry (NOx and PM10)	2%	4%	2%		2%	12%	14%		4%	25%	22%	
30	Open Cut Coal Mining Buffer Zone Initiative	2%		88%									
31	Coal Fired Power Station - Selective Catalytic Reduction (SCR)												
32	Gas Engine Electricity Generation - SCR					4%	16%						
33	Cement Industry NOx Control					0%	2%						
34	Metal Plating and Coating Works: CARB, 2008 AIM Regulation	0%			4%	0%			5%	0%			7%
35	Printing VOC Emissions Control	1%			7%	1%			9%				
	Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Total Cost ($ Billion) & abatement % achieved	$ 1.45	25%	25%	18%	$ 1.24	25%	10%	18%	$ 0.06	8%	4%	17%
	Abatement tonnes		91,899	28,358	30,806		24,994	2,571	24,112		1,189	158	1,114

The list of initiatives in approximate priority order, from visual inspection of the optimum mix table above, is shown in **Table 8-2**.

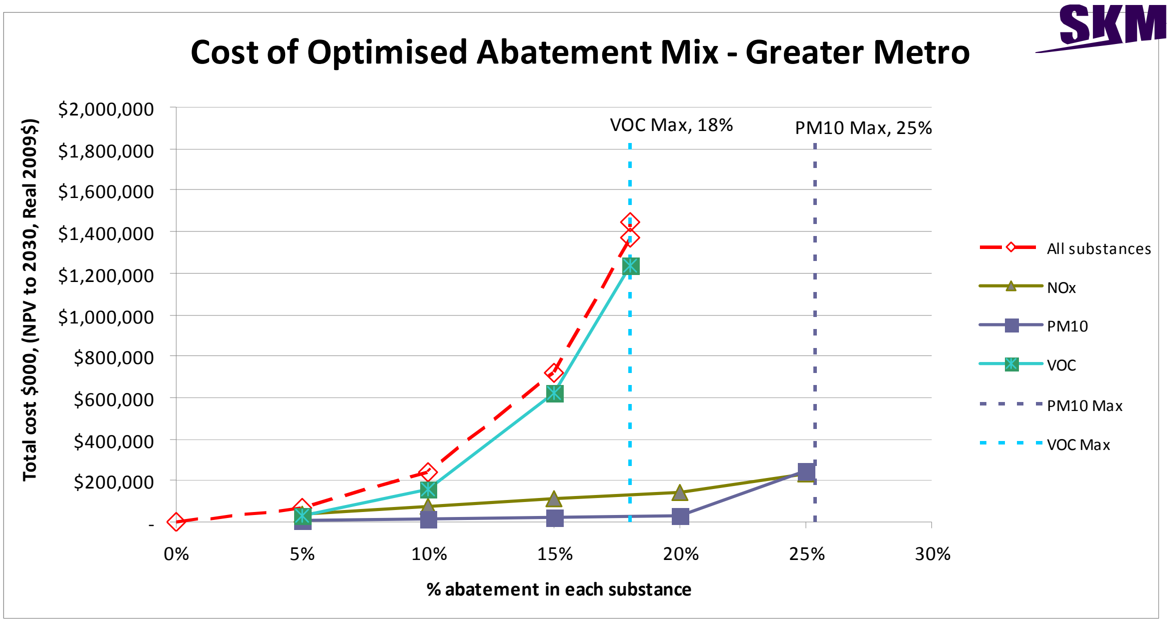
Table 8-2 Priority Abatement Initiatives

Priority	GMR
High	▪ Shift Transport Mode to Cycling * ▪ SmartWay Program * ▪ Coal Fired Power Station NOx Control - Low NOx Burners ▪ Petrol Refinery Vapour Recovery and Leak Detection and Repair ▪ CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM) ▪ Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing ▪ Open Cut Coal Mining Buffer Zone Initiative ▪ Metal Plating and Coating Works: CARB, 2008 AIM Regulation ▪ Printing VOC Emissions Control ▪ Euro 5/6 Emission Standards for New Passenger Vehicles
Medium	▪ Summer-time Petrol Volatility (62 kPA to 60 kPA)
Low	▪ Tier 2 -> Tier 4Locomotives: Selective Catalytic Reduction and Diesel Particulate Filter
	Measures requiring higher priority for Sydney region (in addition to those identified above)
High	▪ Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 ▪ Retrofit Tier 2 Locomotives with Selective Catalytic Reduction (SCR) and Diesel Particulate Filter (DPF) ▪ Truck and Bus Diesel Retrofit ▪ Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction) ▪ Wood Heaters - Reduce the Moisture Content of Firewood ▪ National Standards for Wood Heaters (3 g/kg) ▪ National Standards for Wood Heaters (1 g/kg) ▪ Emission Limits for Industry (NOx and PM10) ▪ Gas Engine Electricity Generation — SCR ▪ Cement Industry NOx Control
	Measures requiring higher priority for Wollongong region (in addition to those identified above)
High	▪ Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 ▪ Truck and Bus Diesel Retrofit ▪ Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction) ▪ Wood Heaters - Reduce the Moisture Content of Firewood ▪ National Standards for Wood Heaters (3 g/kg) ▪ Euro 5/6 Emission Standards for New Passenger Vehicles

Note * the Cycling and SmartWay initiatives were assessed as having negative economic cost (net benefit).

Figure 8-1 shows the results of SKM's optimisation analysis for the GMR region. Note that maximum achievable VOC abatement was 18%, so the full solution of 25% reduction in NO_X and VOCs and 10 – 30 % for PM_{10} could not be found. For clarity the net benefit options have been excluded from these charts, as they generally exhibit relatively small abatement (between 0.1% - 0.3%) and hence do not materially alter the results.

▪ **Figure 8-1 Cost of Optimised Abatement Mix (GMR)**



Nominal multi abatement target	0%	5%	10%	15%	20%	25%	30%
Actual abatement achieved							
NOx	0%	5%	10%	15%	20%	25%	30%
PM10	0%	5%	10%	15%	20%	25%	25%
VOC	0%	5%	10%	15%	18%	18%	18%
Net Present Cost ($B)	$0.00	$0.07	$0.24	$0.72	$1.37	$1.45	$1.83

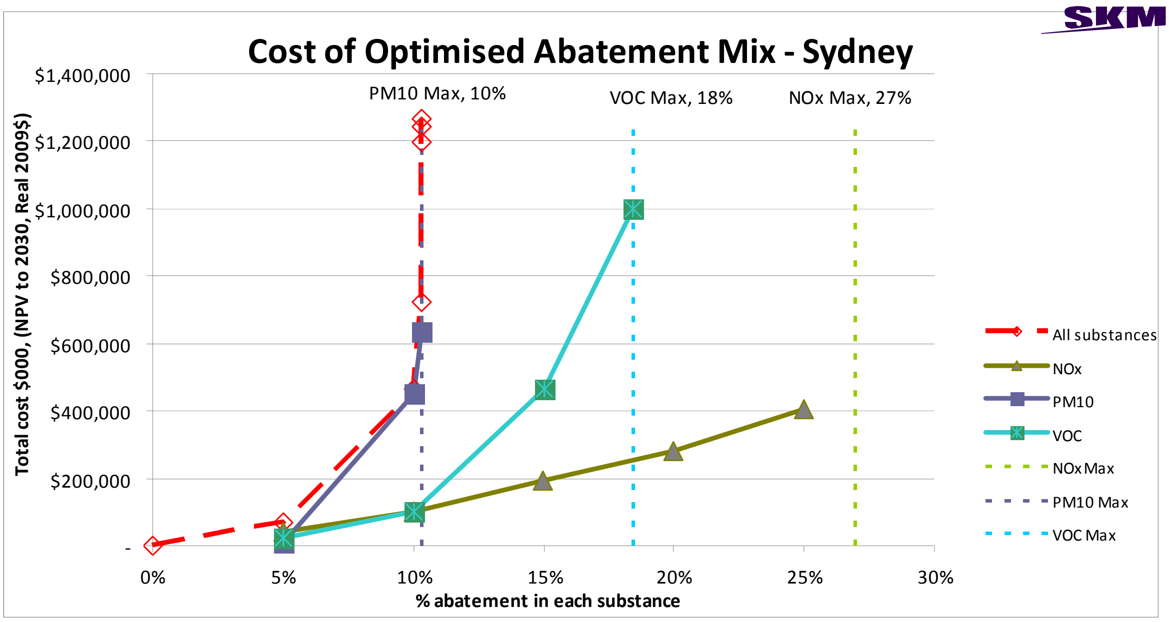
(green)	Achieved Target	(yellow)	<5% Deviation	(red)	>5% Deviation

The chart shows that VOC is the primary driver of costs, with the cost of achieving comparable concurrent percentage abatement in other substances only minimally more expensive than VOC alone. If NO_X and PM_{10} are considered independently, the costs are low and could even result in overall economic savings. As the chart and table show, concurrent abatement of all substances to 25% cannot be achieved, as identified initiatives for VOC are insufficient to achieve 25% abatement.

Abatement up to around 15% of all three substances can be achieved at relatively low net present cost, of around $717 million, with a sharp increase for abatement above 15%. The total net present cost of the optimised suite of abatement initiatives for the GMR, to achieve reductions in NO_X, VOCs and PM_{10} of 25%, 18% and 25% respectively, would be $1.45 billion. Greater abatement percentages for NO_X and PM_{10} can be achieved at lower cost, indicating a differentiated target for VOC of around 15% could be an economically attractive policy option. SKM has not assessed the economic benefits of lower VOC emissions, and does not consider it has sufficient information to recommend targets based on costs alone, but the cost curve above provides input to such analysis and policy considerations.

The chart showing the cost of abatement for the Sydney region is presented in **Figure 8-2** below.

- **Figure 8-2 Cost of Optimised Abatement Mix (Sydney)**



Nominal multi abatement target	0%	5%	10%	15%	20%	25%	30%
Actual abatement achieved							
NOx	0%	5%	18%	21%	21%	25%	27%
PM10	0%	5%	10%	10%	10%	10%	10%
VOC	0%	5%	10%	15%	18%	18%	18%
Net Present Cost ($B)	$0.00	$0.07	$0.47	$0.72	$1.20	$1.24	$1.27

	Achieved Target		Exceeded Target		≤5% Deviation		>5% Deviation

The chart shows that the cost of achieving concurrent percentage abatement up until 10% for all three substances is only minimally more expensive than PM_{10} alone. For further abatement between 10% and 20%, abatement of VOC is the primary driver of cost (holding PM_{10} abatement constant at 10%). As the chart and table show, concurrent abatement of all substances to 25% cannot be achieved, as identified initiatives for PM_{10} and VOC are insufficient to achieve 25% abatement.

The maximum abatement potential identified is 27% for NO_X, 18% for VOC, and 10% for PM_{10}, which could be achieved at a total net present cost of $1.27 billion, with a sharp increase in costs at around 10% “multi abatement” due to PM_{10} measures having been exhausted and the more expensive VOC measures being implemented. The nominal 25% abatement target point is 25% for NO_X, 18% for VOC, and 10% for PM_{10}, which could be achieved at a total net present cost of $1.24 billion. The 10% abatement of all three pollutants could be achieved at a net present cost of around $465 million, though the least cost mix gives 18% abatement of NO_X. Some differentiation of targets for the three substances could achieve close to the maximum potential abatement at reduced cost.

Again SKM has not assessed the economic benefits of lower VOC emissions, and does not consider it has sufficient information to recommend targets based on costs alone, but the cost curve above provides input to such analysis and policy considerations.

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Appendix A Literature Review

The following literature review discusses relevant scientific, strategic and policy related documents reviewed to inform the methodology of this study and includes:

- Comments on major sources of emissions
- Comments on integrated pollution management programs and models developed by international agencies to simultaneously regulate multiple pollutants and achieve joint abatement
- Summarise costed measures from confidential papers provided by DECCW

A	**NSW Emissions Information**
1.	DECC, 2007, *Air Emissions Inventory for the Greater Metropolitan Region in NSW*, Department of Environment and Climate Change (DECC) NSW, Sydney, NSW 2000, Australia http://www.environment.nsw.gov.au/air/airinventory.htm **Relevance:** The inventory is documented as a set of technical reports (TRs), providing the main and most recent inventory reference for NSW emissions (see below). TR1 and TR2 are recreated in this section, with the remainder listed for reference.
	Technical Report 1 Criteria Pollutant Emissions for all Sectors: Results **Summary:** TR1 present an overall summary of sectors grouped by source types: commercial, domestic-commercial, industrial, off-road mobile and on-road mobile). TR1 provides map and grid references for GMR, Sydney, Newcastle and Wollongong. Excludes emissions from coal fired power stations in western coal fields, central coast, upper Hunter Reductions in emissions from large sources of NOx & VOCs will also reduce PM 25% reduction in NO_X & VOC emissions, based on total Sydney and Wollongong emissions requires reduction in : NO_X = 2.6×10^7 kg/yr T_VOCs = 3.4×10^7 kg/yr Largest emission sources by sector and the percentages of total emissions of the respective substances in Sydney and Wollongong are as follows: NOX: On-road mobile (65%), Industrial (21%), Off-road mobile (10%) PM10: Industrial (37%), Domestic -commercial (20%), Off-Road Mobile (16%) PM2.5: Domestic – Commercial (29%), Industrial (28%), On-Road Mobile (14%) T_VOCs: Domestic – Commercial (31%), On-Road Mobile (30%), Industrial 8%, (Biogenic emissions, 21%) Largest emission sources (kg/year) and the percentages of total anthropogenic emissions of the respective substances in Sydney and Wollongong are as follows: Sydney: NO_X: - Exhaust emissions passenger petrol cars (3.8×10^7, 41.2%), - Heavy duty diesel commercial vehicles (1.7×10^7, 18.2%), - Light duty commercial petrol vehicles (4.5×10^6, 4.9%) T_VOCs: - Exhaust emissions passenger petrol cars (2.6×10^7, 19.9%) - Aerosols and solvents (2.1×10^7, 15.8%), surface coating (1.3×10^7, 10.0%),

Evaporative emissions petrol ($1.2x10^7$, 9.0%)

PM10:

- Solid fuel combustion ($4.6x10^6$, 21.8%),
- Industrial off-road vehicles and equipment ($2.8x10^6$, 13.1%)
- Crushing, grinding and separating works ($2.1x10^6$, 9.6%)

Wollongong:

NOX:

- Primary iron and steel ($7.8x10^6$, 63.6%)
- Exhaust emissions passenger petrol cars ($1.7x10^6$, 14.2%)
- Heavy duty diesel commercial vehicles ($1.1x10^6$, 8.7%)

T_VOCs:

- Exhaust emissions passenger petrol cars ($1.1x10^6$, 17.6%)
- Aerosols and solvents ($9.9x10^5$, 15.3%)
- Surface coating ($6.6x10^5$, 10.2%)

PM10:

- Primary iron and steel ($1.6x10^6$, 53.3%)
- Industrial off-road vehicles and equipment ($5.4x10^5$, 14.9%)
- Solid fuel combustion ($2.6x10^5$, 8.4%)

Ten largest sources by emissions product (NOX * VOC) are as follows:

Region	Source Group	Source Type	NO_X*T_VOCs
Sydney	On Road Mobile	Exhaust Emissions - Petrol Passenger Cars Exhaust Emissions - Diesel Heavy Duty Commercial Exhaust Emissions - Petrol Light Duty Commercial Exhaust Emissions - Other Vehicles Exhaust Emissions - Diesel Light Duty Vehicles	$1x10^{15}$ $4x10^{13}$ $2x10^{13}$ $9x10^{12}$ $4x10^{12}$
	Domestic - Commercial	Solid Fuel Burning (Domestic) Lawn Mowing (Domestic) Lawn Mowing (Public Open Space) Gaseous Fuel Burning	$2x10^{12}$ $5x10^{11}$ $2x10^{11}$ $1x10^{11}$
	Commercial	Hospitals (except Psychiatric)	$4x10^{10}$
Wollongong	On Road Mobile	Exhaust Emissions - Petrol Passenger Cars Exhaust Emissions - Diesel Heavy Duty Commercial Exhaust Emissions - Petrol Light Duty Commercial Exhaust Emissions - Other Vehicles	$2x10^{12}$ $2x10^{11}$ $3x10^{10}$ $2x10^{10}$
	Domestic - Commercial	Solid Fuel Burning (Domestic)	$1x10^{10}$
	On Road Mobile	Exhaust Emissions - Diesel Light Duty Vehicles	$6x10^9$
	Domestic - Commercial	Lawn Mowing (Domestic) Lawn Mowing (Public Open Space)	$2x10^9$ $4x10^8$
	Commercial	Hospitals (except Psychiatric)	$4x10^8$
	Domestic - Commercial	Gaseous Fuel Burning	$3x10^8$

Selected on-road emissions sources in Sydney and Wollongong (by high NOX * VOC)

Emission Source	NO_X kg/yr	T_VOCs kg/yr	PM_{10} kg/yr
Sydney			
Petrol passenger car exhaust	$3.8x10^7$	$3.4x10^4$	$8.7x10^5$
Heavy duty diesel commercial vehicles	$1.7x10^7$	$2.6x10^6$	$7.0x10^5$
Petrol light duty commercial vehicles	$4.5x10^6$	$5.0x10^4$	$4.6x10^6$
Wollongong			
Petrol passenger car exhaust	$1.7x10^6$	$1.1x10^5$	$3.4x10^4$

Heavy duty diesel commercial vehicles	$1.1x10^6$	$1.5x10^5$	$4.2x10^4$
Petrol light duty commercial vehicles	$1.1x10^5$	$2.1x10^5$	$3.5x10^3$

Selected industrial (petro-chem) emissions sources in Sydney (by high NOX * VOC):

Emission Source	NO_X kg/yr	T_VOCs kg/yr	PM_{10} kg/yr
Petroleum refining	$3x10^6$	$3x10^6$	$3x10^5$
Petrochemical production	$1x10^6$	$5x10^5$	$5x10^4$
Chemical storage (petroleum)	$9x10^5$	$3x10^5$	$7x10^4$
Plastics	$4x10^4$	$9x10^3$	$2x10^6$
Glass production	$2x10^6$	$4x10^4$	$9x10^4$

Technical Report 2 Anthropogenic Ozone Precursors and Particle Emissions in the Greater Metropolitan and Sydney Regions: Results

Relevance:

This report focuses on sources of NOx and VOCs and particles. Breakdown is for GMR & Sydney. No breakdown of stats for Wollongong region. (Emissions quantities and source information is also reported in the TRs for main source categories, TR4 to TR8, which provide break down for Wollongong).

Numerical values represent an index of combined impact of dependant source groups and source types (TR2:24).

Summary:

Numerical indices:

Sydney NOx priority sources:

petrol cars (41.2)

heavy diesel (18.2)

petrol light commercial (5.9)

Sydney VOCs priority sources:

petrol cars (19.9)

aerosols & solvents (18.4)

surface coating (11.7)

Sydney 1992 vs. 2003 changes in VOCs emissions:
NOx:

↑ 4% industrial, ↑ 209% off-road, ↓34% dom-com, ↓ 18% on-road

Δ ~1.22 to ~ 0.91 times > 1992 reflects
(1) inclusion of commercial boats, off-road industrial & commercial vehicles;
(2) decrease in on-road mobile emissions (TR2:vi) VOCs:

↓35% on-road, ↓24% off-road, ↓17% industrial, ↓12% dom-com

Δ ~0.82 – 0.77 times > 1992 reflects
(1) decrease in on-road mobile emissions (TR2:vi)

	Technical Report 3 Biogenic Emissions Module: Results
	Technical Report 4 Commercial Emissions Module: Results
	Technical Report 5 Domestic-Commercial Emissions Module: Results
	Technical Report 6 Industrial Emissions Module: Results
	Technical Report 7 Off-Road Mobile Emissions Module: Results
	Technical Report 8 On-Road Mobile Emissions Module: Results
	Technical Report 9 Emissions Data Management System (EDMS v1.0): User's Manual
	Technical Report 10 Emissions to Area Report Analysis: Excel Workbook Instructions and Excel workbook

SKM

B	Cost Abatement Curve Models
2.	Next Energy, 2004, *Cost Curve for NSW Greenhouse Gas Abatement*, prepared for the NSW Greenhouse Office by Next Energy Pty Ltd, Sydney, Australia **Relevance**: This report provides background & key findings of GHG CAC study, including summary of ~25 abatement measures – description; assumptions; market uncertainty; policy uncertainty; normalisation to NSW, 10 yr horizon and business as usual; and implementation & timing issues. The report found that while for some measures, there are already policies in place to facilitate implementation, most require significant additional policy & program development. Automobile usage reduction abatement measure relevant to NOx VOC PM reduction. Biodiesel and ethanol measures may also be relevant. **Summary:** *Background* – existing NSW policies & initiatives to reduce GHG (NGGAS, BASIX, Land clearing, Electricity price & service regulation, Education) - little work previously to integrate potential individual abatement measures and to adapt specifically for NSW - study does not investigate policy tools to implement measures *Key Findings* Array of measures to abate to year 2014+ = ~33.3% of current NSW GHG emissions, fit well to current & new policies Small set of abatement measures = large reduction potential and low or negative cost (Increased energy efficiency, reduced land clearing, increased plantation based sequestration & industrial cogeneration). Energy efficiency offers negative costs (= $ savings) Geosequestration at coal power plant = 'careful analytical attention' advised due to: - high long term abatement potential, however, technical uncertainty, more economic if developed in conjunction with new plant, no suitable storage site yet in NSW, uncertain if technology & available within 10 years, 'relevance to near term generation decisions within NSW' i.e. study considers 10 years 2004 to 2014, thus 2014 = end of term. Most abatement measures have significant lead times and therefore require 'near-term start of implementation to achieve full potential within the 10 year time frame considered by study. Cost and performance uncertainties in all measures, especially: large scale Geosequestration, commercial – industrial energy efficiency, automobile usage and purchasing patterns, reduced land clearing. Most measures, including low cost and negative cost measures require significant additional NSW policy and program development. *Methodology* to identify, quantify and compare abatement measures available to NSW: Identification – in consultation with NSW government, broad array of measures identified for consideration. Only the most speculative, small scale measures removed from consideration. Investigation of key opportunities – at least one public document per measure reviewed for estimate of likely cost and quantification of potential emission abatement. Normalisation – to allow comparison of measures, costs and quantities estimated for NSW within a 10 year time frame. Review of assumptions and uncertainties – qualitative assessment for each measure. *Abatement Measures Relevant to DECCW NOC VOCs CACs* *Higher Efficiency Automobiles*: *Primary References -* - *Green Vehicle Guide* www.greenvehicleguide.gov.au. Commonwealth Department of Transport and Regional Services and the Australian Greenhouse Office. Next Energy report states that this publicly available document provides information on environmental performance for a full range of automobiles available in Australia. To find details, the green vehicle guide online green vehicle guide calculator must be used, rather than a document. - *Study on Factors Impacting on Australia's National Average Fuel Consumption Levels to 2010*, Report to AGO, June 1999. Next Energy report states that This publicly available document was produced for the Australian Greenhouse Office to help establish a target for negotiations with automobile manufacturers regarding fuel efficiency targets to be achieved by 2010.

	Brief description of abatement measure This measure involves improving the average fuel economy of the automobile fleet by 10%. *Normalisation to NSW* - The total Australian automobile GHG emissions reported in the National Greenhouse Gas Inventory were prorated to NSW based on relative population. *Normalisation to ten year horizon* - The estimate is based on 10% savings from 2002 emissions levels. No normalisation was made, although total automobile usage and GHG emissions are expected to rise over the horizon. Accordingly, the estimate used can be viewed as conservative. *Normalisation for 'Business as Usual'* The fuel economy of the automobile fleet continues to improve. However, there continues to be a significant range of consumption levels between automobiles in each class, and no normalisation was made. *Implementation and timing issues* - As the average automobile age is under ten years in NSW, implementation within the 10 year timeframe should be achievable. *<u>Automobile Usage Reduction:</u>* *Primary References* - *Greenhouse Gas Abatement Program Award Announcement, Australian Greenhouse Office.* This document summarises the National Travel Behaviour Change Program (NTBCP), which was awarded GGAP funding of $6.5 million. The NTBCP is a joint program involving governments of the ACT, Queensland, South Australia and Victoria. - *The Greenhouse Abatement Potential of Travel Behaviour Change Initiatives.* Report by Transport SA, in conjunction with Transport WA for the National Greenhouse Strategy Measure 5.3 Taskforce. This publicly available document was produced for the National Greenhouse Strategy. *Brief description of abatement measure.* This measure involves replacing some car usage by modes such as walking, cycling, public transport and ride sharing. The NTBCP anticipates that the program will result in a **reduction of more than 3 billion vehicle kilometres travelled** and over one million tonnes of greenhouse gas emissions in the Kyoto period. *Normalisation to NSW*- The NTBCP estimate is given in terms of total abatement and number of participating households. For the cost curve, this value was pro rataed to NSW based on an assumed number of households, specifically, **25% of households** in NSW. *<u>Biofuels – Biodiesel and Ethanol for Transport Fuel</u>* *Primary References* - *Appropriateness of a 350 Million Litre Biofuels Target* Report to the Australian Government Department of Industry Tourism and Resources, CSIRO, ABARE, BTRE, December 2003. This publicly available document was produced to examine the economic, environmental, and regional impacts and industry viability of maintaining a Commonwealth Government objective to increase production of biofuels to at least 350 ML by 2010. *Brief description of abatement measure.* Currently about 60 ML p.a. of transport biofuels are produced in Australia, substituting for petroleum products. Production is projected to increase to 115 ML by 2010. **This abatement measure assumes that production is further increased to 350 ML by 2010.** The additional biofuel production would come primarily from ethanol derived from energy crops (i.e. sugar and cereal grains). *Critical assumptions in source of primary analysis* *Technical uncertainty:* Production of biodiesel and ethanol from renewable sources is well demonstrated. New technology is under development that may deliver cost and performance improvements, but only demonstrated technology is included in the estimate.
3.	McKinsey and Company, 2008, *An Australian Cost Curve for Greenhouse Gas Reduction*, report prepared for Australian Department of Climate Change **Relevance:** This publicly available report evaluates GHG emission reduction strategies for the reduction-potential to 2020 and 2030 and their associated costs. Cost presented as average annual cost per household. Method and format relevant. Appendix A – How to read an abatement cost curve – Exhibit A may assist in writing of DECCW NOx VOCs CAC Methodology Paper

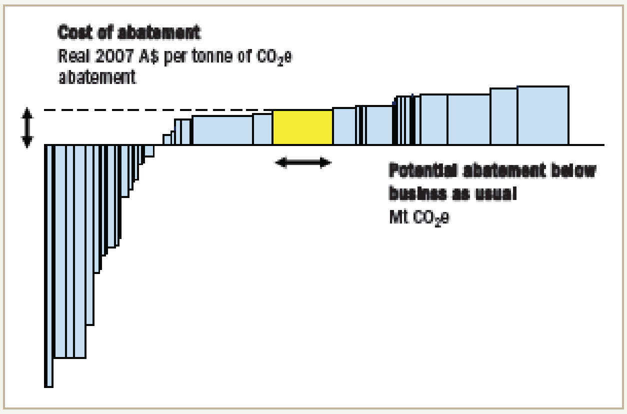
APPENDIX A—HOW TO READ AN ABATEMENT COST CURVE

Exhibit A

Two dimensions

Each bar represents one opportunity to reduce greeenhouse gas emissions, or a group of closely related opportunities (eg, 'residential lighting efficiency')

- Width–amount of CO_2e that could potentially be reduced per year by implementing this opportunity
- Height–average cost of avoiding one tonne CO_2e with this opportunity, relative to the activities that would otherwise occur in the business-as-usual case.



Negative and positive costs

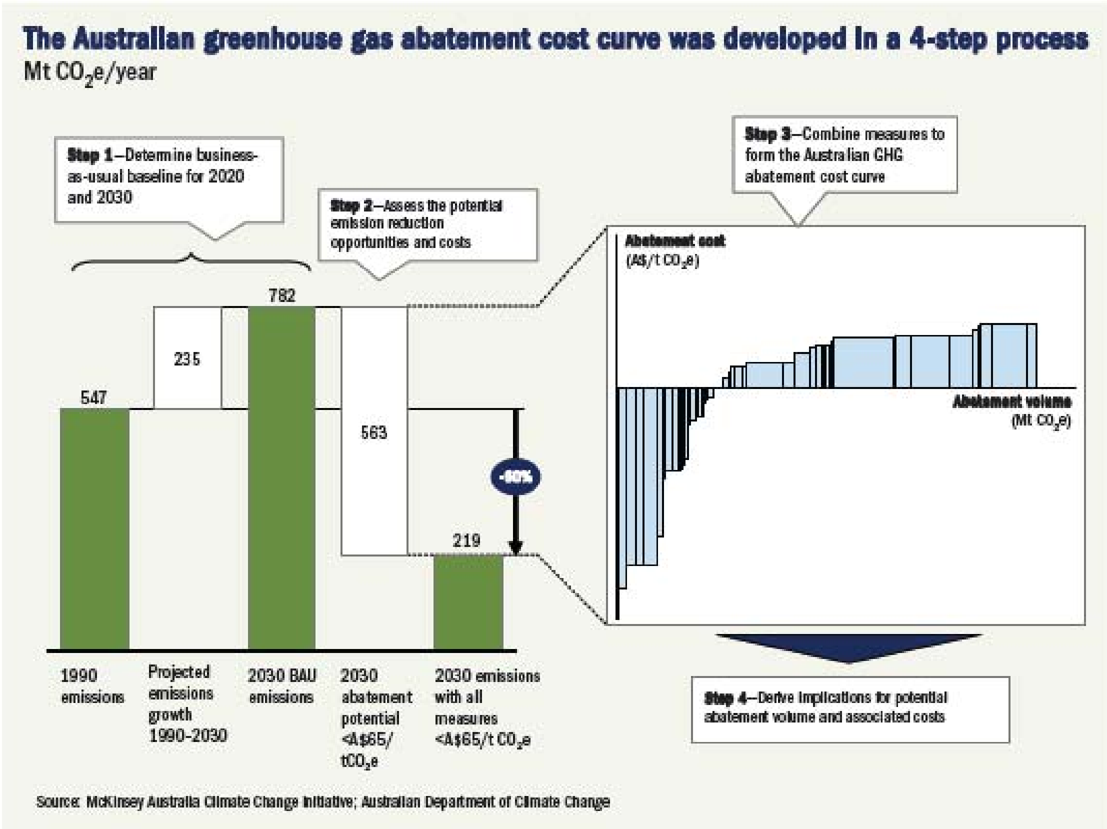
- Negative costs (those below the horizontal axis) indicate a net financial benefit to the economy over the lifecycle of the abatement opporunity
- Positive costs (above the axis) imply that capturing the opportunity would incur incremental lifecycle costs compared to the business-as-usual or 'do nothing' case

Source: McKinsey & Company

Summary:

Modelling Approach**:** cost abatement potential of > 100 abatement measures across 6 industry groups analysed using 4-step process (Exhibit 1).

Exhibit 1



McKinsey and Company 2008 *An Australian Cost Curve for Greenhouse Gas Reduction McKinsey Australian Climate Change Initiative* http://www.gbca.org.au/resources/publications/an-australian-cost-curve-for-greenhouse-gas-reduction/1475.htm) Accessed September 2008.

Relevance:

Publicly available pdf of slides from conference presentation. Graphics may assist in drafting DECCW NOX VOCs Methodology Paper and Software Training Support Materials

C	Sources of Cost Abatement Data
4.	Transportation Research Board, 2002, *The Congestion Mitigation and Air Quality Improvement (CMAQ) Program, Assessing 10 years Experience*, US National Research Council, http//:onlinepubs.trb.onlinepubs/sr/sr246.pdf **Relevance:** This publicly available document reports on a review of 10yrs of CMAQ programs, specifically: An estimate of the efficiency or cost-effectiveness of projects funded under the program, including their cost per ton of pollution reduction ($year 2000) and per unit of congestion reduced; and A comparison of the cost-effectiveness of emission reductions achieved by CMAQ-funded strategies with that of other pollution reduction measures. In the absence of Australian/NSW based costings for various transport emissions reduction strategies, US values may be applicable to present study E.g. see below

330 THE CMAQ PROGRAM: Assessing 10 Years of Experience

Incremental Cost-Effectiveness of Alternative-Fueled Transit Buses

Technology	Lifetime Emission Benefits (tons) NO$_x$	Lifetime Emission Benefits (tons) PM	Incremental Cost (2000 $)	Cost per Ton, NO$_x$ (2000 $)	Cost per Ton, PM (2000 $)
1991–1998 diesel	0.545	0.267	196	360	734
Methanol	6.051	Negligible	128,534	21,242	N.A.
CNG	6.580	0.231	88,570–143,796	8,334–13,488	383,420–622,494
Hybrid-electric	4.198	0.242	35,428–172,972	8,439–41,203	146,397–714,760

Source: Schimek, Reducing Emissions from Transit Buses (2001).

Summary of findings

(TRB:2002:155) It was not possible to undertake a credible scientific quantitative evaluation of the cost-effectiveness of the CMAQ program at the national level. The CMAQ program is modestly funded and accounts for a small portion of any region's transportation budget. Thus, evaluation of the effectiveness of the CMAQ program even at the local level was difficult because the effects of most CMAQ projects were small compared with those of other sources of variation in emissions and air quality. In addition, methods for measuring the effects of many CMAQ-funded projects on emissions and air quality were limited. The available models were not suited to estimating the emissions effects of small projects or linking these effects with air quality.

The limited evidence available suggested that, when compared on the sole criterion of emissions reduced per dollar spent, approaches aimed directly at emission reductions (e.g., new-vehicle emission and fuel standards, well-structured inspection and maintenance programs, and vehicle scrappage programs) were generally been more successful than most CMAQ strategies relying on changes in travel behaviour.

5.	Pechan and Associates, 2005, *AirControlNET Version 4.1 Documentation Report*, prepared by Pechan and Associates Inc for the United States Environment Protection Agency, Report No. 05.09.009/9010.463, available at http://www.epa.gov/air/ozonepollution/SIPToolkit/documents/DocumentationReport.pdf **Relevance**: **Extensive list of control measures and costs US$ / tonne pollutant for comprehensive range of individual emission sources** AirControlNET software and documentation may assist development of NSW DECCW NOX VOCs software. This publicly available document describes the AirControlNET control strategy and costing analysis tool developed by E.H. Pechan & Associates for the U.S. EPA to assist in conducting regulatory impact analyses of air pollution regulations and policies. AirControlNET is a relational database system in which control technologies are linked to sources within EPA emissions inventories. It contains a database of control measures and cost information for reducing the emissions of criteria pollutants (e.g., NOx, SO2, VOC, PM10, PM2.5, NH3) as well as CO and Hg from point (utility and non-utility), area, nonroad, and mobile sources as provided in EPA's National Emission Inventory (NEI) format. As such, AirControlNET is linked to and dependent upon EPA emission inventories as a source of emissions data. The control measure data files in AirControlNET include the control efficiency to calculate emission reductions for that source and cost data (annual and capital) to calculate the total costs of applying the control measure The functions within AirControlNET include: 1) Control Scenarios Module (CSM) that allows you to select specific control measures from the database by pollutant, source, and geographic area to create an emissions reduction scenario with computed emissions reductions and associated costs. You can then export this scenario into spreadsheet format for further analysis or into an input script for air quality modelling within REMSAD-ST (Pechan and ENVIRON, 2001 and 2002). 2) Least-Cost Module (LCM) that allows you to obtain an emissions reduction scenario by source and geographic area consisting of the set of control measures that achieves a stated pollutant-specific emission reduction target (in tons or percentage) with the least amount of total annual costs. 3) Script Builder Module (SBM) that allows you to develop “control factor files” based on percent reductions by pollutant, source, and geographic area to create an emissions reduction scenario for input into the REMSAD-ST air quality model. The document describes the use of AirControlNET through its interface, which facilitates the viewing, analysis, and exporting of the information contained within the database. Documentation of the control measure files and the development of the AirControlNET database are provided in companion volumes at web site Specific control measure information, including costing methods and control effectiveness calculations, is detailed in AirControlNET Volume III: Control Measure Documentation for AirControlNET. Information concerning the development and history of AirControlNET can be found in the AirControlNET Volume II: Development Report (Pechan, 2005a). **NOTE: Since Pechan and Associates is a compendium of information, there is no necessary consistency in the methods used to derive data.**
6	NSW EPA, 2001, *NOX and Fine Particle Reduction Options from Non-Licensed Sources*, MMA report to the NSW EPA, September 2001. Copy requested from DECCW.
7.	NSW EPA, 1997, *Regulatory Impact Assessment of the Proposed Clean Air (Plant and Equipment) Regulation*, NSW EPA, June 1997 **Relevance**: The RIA coincided with the introduction of load based licensing, designed to introduce an economic incentive for pollution reduction Method – identified and where possible quantified costs & benefits of regulatory options ‘Damages valuation estimates’ for urban Australian conditions were estimated by adopting the median value of the European vs. US conditions; i.e. health & other costs per tonne of pollutant Table A.1 1996$ (NSW EPA, 1997:98)
8	US EPA, 1997, *Regulatory Impact Analysis for Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule,* prepared by Innovative Strategies and Economics Group, office of Air Quality Planning and Standards, Us, Environment Protection Agency, Research Triangle Park,

	N,C. Review in response to evidence that health and social effects particulate matter and ozone occur at ambient levels below the NAAQS. Methodology inputs and assumptions – potential costs, economic impacts and health benefits of reducing PM & O3 & improving visibility. **Relevance:** research likely provided data bases for later AirControlNET
9.	Petrol cap replacement programs
10	Exchange rates Australia – Reserve Bank of Australia – to assist in converting foreign currency costs to A$
11	Australian CPI – to assist in projecting estimated future costs of measurers
12	US CPI – to assist in projecting estimated costs of US measures

D	Multi Pollutant Management Models
13	US Napolitano, S, LaCount, M. and Risley, D. 2009, *A Multi-Pollutant Strategy – An integrated approach could prove move effective for controlling emissions*, Public Utilities Fortnightly, January 2009. (Napolitano *et al.* US EPA Clean Air Markets Division). http://www.epa.gov/airmarkets/resource/docs/multipstrategy.pdf **Summary**: Publicly available document outlines failure of a series of multi-pollutant bills introduced to US Congress. Thus, 'the void of a US multi-pollutant emissions reduction program for the power sector remains unfilled' (page 38). However, more commonalities than differences between proposals, suggests minor issues will be resolved and multi-pollutant reduction framework forthcoming. More recent inclusion of costing of health benefits seems to have strengthened the economics and science of the case for emissions reduction. Summarises $ costs and benefits of the series of US Congress bills and EPA regulatory policy proposals to introduce multi-pollutant integrated frameworks for reducing SO2, NOX, Hg, CO2 emissions. Coal fired power stations major source. Clean Air Power Initiative (CAPI) – 1995 stakeholder process SO2, NOx, Hg 'first concerted effort', to reduce over 15 yr planning horizon, driven by prospect of increased Clean Air Act (CAA) regulations on power sector and corresponding transition towards more competitive power markets, 6 cap and trade scenarios (SO2 27-41%, NOx 54-67% <2000 levels by 2010 forecast costs range US$3.8-6.5 billion. Process wound down in absence of regulatory driver. EPA 1999 – hypothetical option to extend cap & trade for SO2 (50-65%), NOx (50% non-ozone season reduction) and include CO2 (7% <1990 levels) and Hg maximum achievable control technology (65-90% reduction MACT) Drivers (1) 1997 NAAQS revisions and forthcoming PM2.5 standard, regional state haze implementation plants (SIPs) (2) 1997 Kyoto Protocol adoption and (3) Hg problem evidence – 1999 appellate court decision remanded 1997 NAAQS for O3 & PM, process wound down. Congress 1999 S172 Acid Deposition and Ozone Control, bill proposed 50% cut in SO2, 60% NOx cut. EPA 2000 cost analysis quantified (annual monetised) human health benefits ~ US$75 billion, visibility benefits, US$1.5 billion vs. compliance cost $6 billion by 2010. Reduction costs $1,200 /tonne NOx & $ 830 /tonne SO2 2002 Clear Skies (CS) Bill – Drivers – increased sense of urgency 40% population exposed to AQ> NAAQS. Forecast health benefit US$138 billion by 2020 vs. cost $8 billion. Bill failed. Disagreements over failure to include CO2 (as several competing bills did), also issues with Hg cap and trade and provisions that streamlined existing CAA. 2005 Senator Jeffords CPA Bill - EPA costing to cut power sector emissions 76% SO2 < Y=Title IV levels, 11% NOx beyond Clear Skies, no mercury trading, CO2 cap and 16% on 2000 levels by 2020, benefits of US$258 billion vs. estimated annual costs $62 billion in 2020. 2003 EPA CAIR/CAMR/CAVR – 3 regulations forming multi-pollutant framework regulatory rather than legislative (did not alter CAA vs. CS did), CAIR- 28 eastern states, cap power sector emissions & cut SO2 (73%) & NOx (61%) on 2003 levels to achieve PM2.5 & O3 NAAQS (vs. CS national), CAMR to cut Hg 70%, CAVR to cut emissions affecting visibility in national parks, Costed health benefit $171 billion to 2020 vs. $7 billion cost @ costs / tonne SO2 $860 (2010) - $1700 (2020) and NOx $1600 (2010) and $2000 (2020).

	Lesson 1: Multi-pollutant strategy beneficial overall , "parochial" regulatory vs. legislative issues resolvable Lesson 2: Coal-fired generation can achieve significant reductions and still compete effectively, given its relatively low operating costs compared to generation from other fossil fuels, nuclear and renewables. Lesson 3: With respect to reducing PM2.5, a ton of SO2 emissions reduced from electric power generation has over seven times the benefit of a ton of NOx emissions reduced. Average health benefit associated with each ton of SO2 reduced is nearly $12,000 per ton. Lesson 4: Substantial Hg co-benefits result from SO2 and NOx control Lesson 5:Benefits of cap & trade as regulatory tool: (a) certainty – industry response evident (b) reduced cost cf. command & control regulation (c) innovation – $ reward for efficient pollution reduction technology (d) broad distribution of large emission reductions, > emission = > reduction Conclusion – Difference between the series of past proposals are minimal compared to commonalities. Great potential for benefit of multi-pollutant strategy, targets, cap & trade.
14	USEPA, 2004, *The Integrated Environmental Strategies Handbook – A Resource Guide for Air Quality Planning*, United States Environment Protection Agency, Office of Atmospheric Programs, Washington, DC. **Relevance**: Relevant to current study method. USEPA initiated the Integrated Environmental Strategies (IES) program in June 1998 to help developing countries evaluate the public health, economic, and environmental benefits of integrated planning, to address both global greenhouse gas emissions and local environmental concerns. This publicly available handbook describes the IES Program approach which enables local researchers to quantify the co-benefits that could be derived from implementing policy, technology, and infrastructure measures to reduce air pollutants and GHG emissions. 'Quantifying the effects of air emissions brings research into the public decision making process and provides a solid foundation upon which to build environmental and public health improvements'. Case studies of individual countries available http://www.epa.gov/ies/documents/index.htm **Summary**: IES program's multi-disciplinary approach brings together specialist in economics, environmental policy, air quality management and public health to control local air pollutant & GHGs. Program steps: (1) Scope project & build team (outcome = project plan identifying all project activities, (2) Develop energy/ emissions scenarios (establish base-year emissions inventory, then develop series of energy/ emissions scenarios of future energy demand, economic growth, population growth, control measures and resulting emissions (e.g. 10 to 20 years), (3) Calculate /forecast future atmospheric concentrations, quantify public health benefits, perform economic valuation of health benefits, rank measure & share results, implement measures (4) Quantify public health effects (identify set of health endpoints e.g. incidence of respiratory symptoms, hospital admissions, adopt concentration-response functions describing increased emission concentrations and resulting health effects, **(5)** economic valuation of health benefits (estimate monitory values of avoided mortality and morbidity incidences resulting from each scenario (6) Rank measures by cost and benefits and share results (7) implement measures Data sets required (relevance to current study – demographic data, fuel use, technologies, forecasts of future consumption/ fuel use/, emission factors, costing information
15	Austria RAINS and GAINS models developed by the International Institute for Applied Systems Analysis (IIASA), co-funded by the LIFE programme of the European Union, as part of the European Consortium for Modelling of Air Pollution and Climate Strategies (EC4MACS) www.iiasa.ac.at/rains/gains-online.html **Relevance**: Publicly available software with a detailed description of the RAINS model, on-line access to certain model parts as well as all input data to the model can be found on the Internet (http://www.iiasa.ac.at/rains). RAINS = regional air pollution information and simulation. RAINS = framework for the analysis of emission reduction strategies, focusing at acidification, eutrophication and tropospheric ozone. RAINS comprises modules for emission generation (with databases on current and future economic activities, energy consumption levels, animal livestock numbers, fuel characteristics, etc.), for emission control options and costs, for atmospheric dispersion of pollutants and for environmental sensitivities (i.e., databases on critical loads). In order to create a consistent and comprehensive picture of the options for simultaneously addressing the three environmental problems (acidification, eutrophication and tropospheric ozone), the model considers emissions of sulphur dioxide (SO2), nitrogen oxides (NOx), ammonia (NH3) and the volatile organic compounds (VOC) (Kilmont *et al*. 2000:1)

	Amman, M, Cofala, J. Heyes, C., Kilmont, Z., Mechler, R., Posch, M. and Schoepp, W., 2004, *The RAINS Model. Documentation of the model approach prepared for the RAINS peer review 2004*, RAINS Review 2004, IIASA, February 2004. **Relevance:** Publicly available document provides comprehensive detailed assumptions and approach to modelling emissions, projections of emission generating activities, control technology potentials and costs, health impacts of particulate matter and ground level ozone. NOx module Cofala, J. and Syri, S., *Nitrogen oxides emissions, abatement technologies and related costs for Europe in the RAINS model database*, IIASA, Laxenburg, Austria **Relevance:** This publicly available paper describes the module of RAINS that deals with potential and costs for controlling NOx. Simulates environmental impacts of alternative emission control strategies (i.e. a set of assumptions, for a particular year, about the application of specific control measures to certain fractions of the emission sources in the various economic sectors). Good theory on options for reducing NOx (p 21 Chapter 6) – i.e. (1) changes in the energy system, by energy conservation or fuel substitution, leading to lower consumption of fuels; (2) combustion modification (air staged low NOx burners, LNBs; flue gas recirculation LNB; fuel staged LNB; reductions on NOx due to LNB = ~50%) (3) treatment of flue/exhaust gases (SCR selective catalytic reduction, SNCR - selective non-catalytic reduction) Table 6-1 page 24 stationary sources control technologies and % removal efficiencies NOx, Table 6-2 page 32 – mobile source control technologies and % removal NOx/VOCs Section 6.3.2 theory on diesel engines & inherent conflict between effective NOx control techniques and particulate emissions Chapter 7 Costings - investment annualised over the lifetime (e.g. aggregate expenditure until start up of installation e.g. deliver of installation, construction, civil works, ducting, engineering and costing, license fees, land requirement, capital) Operating costs Unit reduction costs (per PJ, per ton of pollutant removed) Marginal reduction cost – extra cost per additional measure Chapter 8 - Data Sources and Parameter values Chapter 10 – Control Strategies and Cost Curves, Table 10-5 stationary NOx sources VOCs Module : Kilmont, Z., Amman, M. and Cofala, J. Estimated costs for controlling emissions of volatile organic compounds from stationary sources in Europe, IIASA, 2000. This paper provides documentation of the RAINS module that describes emissions, control potential and control costs of volatile organic compounds (VOC) from stationary sources. Section 2 introduces the sectoral structure of the VOC emission module for stationary and mobile sources; after this a brief characteristic of the various control measures applicable to the individual emission sources is provided. Section 4 reviews the methodology for cost calculation for stationary sources (Kilmont *et al.* 2000:1). GAINS = RAINS + GHGs The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)-Model, framework for the analysis of co-benefits reduction strategies from air pollution and greenhouse gas sources. Considers emissions of CO2, CH4, NOx, N2O, TSP, PM10, PM2.5, PM1, SO_2 and VOCs. Some versions also NH3, CO, F-gases Modelling software online, 6 screen options displaying: Economic Activity Pathways – emission source activities (energy production, passenger & freight transport, industrial and agricultural activities, solvent use, etc) Emission control strategies – evolution of emissions and control over given time horizon Emission scenarios – computed for a selected emission scenario (combination of energy pathway & emissions control strategy), emission factors, results display & input values)

Emission Control Costs – displays for selected emissions scenario

Impacts – presents ecosystem sensitivities & human health impacts

Data Management – provides an interactive interface where owner-specific data can be modified, updated, exported & downloaded

Model can be operated in 2 modes

(1) scenario analysis – following the pathways of emissions from sources to impacts, providing estimates of regional costs & environmental benefits of alternative emission control strategies

(2) optimisation mode – identifies cost-optimal allocations of emission reductions in order to achieve specific deposition levels, concentration targets, or GHG emissions ceilings, as well as calculating emissions and control costs for those strategies.

E Other References

16 ATC, 2008, *Vehicle Fuel Efficiency- Potential measures to encourage the uptake of more fuel efficient, low carbon emission vehicles*, Public Discussion Paper, Prepared by Australian Transport Council (ATC) and Environment Protection and Heritage Council (EPHC) Vehicle Fuel Efficiency Working Group With support from The Australian Government, September 2008

http://www.environment.gov.au/settlements/transport/publications/pubs/vfe-paper.pdf

Relevance: This publicly available document presents for public comment a range of potential measures which were considered by the ATC/Environment Protection and Heritage Council (EPHC) Working Group to offer the capacity to improve the fuel efficiency of the road vehicle fleet. Following consideration of the public comment, the Working Group prepared a final report for consideration by Ministers at COAG. The measures presented in the paper do not represent the position of any Government and were presented for evaluation and discussion purposes. Nevertheless, COAG by establishing this Working Group indicated a desire to consider measures to deliver 'world's best practice' in vehicle fuel efficiency, to address the problem of increased CO2 emissions from transport.

Report includes profile of Australian vehicle fleet; source ABS Motor Vehicle Census, 2007. E.g. relevant data may be the following:

Table 1: Average annual growth of registered vehicle numbers (2003–2007) (ATC, 2008:8)

Vehicle Class	Average annual growth (%)
Passenger Vehicles	2.3
Campervans	3.1
Light Commercial Vehicles	3.9
Rigid Trucks	3.1
Articulated Trucks	3.7
Buses	2.5
Motorcycles	7.9
Overall Fleet	2.9

Source: ABS Motor Vehicle Census 2007

Summary of Comments on fuel costs

(ATC, 2008:19-20) Demand for road transport is considered to be relatively inelastic (-0.1 to -0.2) with respect to fuel prices in the short term. Even though the cost of fuel is an important contribution to overall transport costs, it tends to be overshadowed by the total generalised cost of motoring, i.e. the combination of other operating costs (such as depreciation and maintenance) and original vehicle purchase costs and access charges, as well as the value that travellers place on travel time and convenience relative to other travel modes. (Original Source: *Greenhouse Gas Emissions From Australian Transport: Base Case Projections To 2020*, Bureau of Transport and Regional Economics, 2005)

National average fuel consumption target (ATC, 2008:22): - A voluntary national average fuel consumption (NAFC) target for new passenger cars was negotiated between the Australian Government and the Federal Chamber of Automotive Industries (FCAI). The target established in 2003 was 6.8 L/100km for

	petrol passenger cars by 2010. If delivered, this would represent an estimated 18% improvement in the fuel consumption of new vehicles between 2002 and 2010 – a rate of improvement similar to the EU and Japanese targets, but starting from a higher absolute level. See also : Table 6: Estimated Fuel Savings from a Range of Vehicle and Engine Technologies and Design Measures, ATC, 2008:27) ATC, 2008:28 - A report prepared for the UK Department for Transport and broadly supported by the UK Government) concluded that continued improvements in conventional engines, reducing weight, mild hybrids and other near market technologies offer the prospect of "developing very significantly lower carbon vehicles over the longer term (Original source: E4tech (2007) A review of the UK innovation system for low carbon road transport technologies A report for the Department for Transport at http://www.dft.gov.uk/pgr/scienceresearch/technology/lctis/e4techlcpdf .) ATC, 2008:28 The estimated costs for these technologies vary widely, and the net cost (technology cost less fuel savings over the life of the vehicle) is highly dependent on the price of fuel. One 2007 OECD estimate suggests that a realistic combination of technologies delivering a 25–30% improvement in fuel efficiency of a petrol engine vehicle would cost US$2000–2600 per vehicle in technology costs, but only $190 in net cost terms (at 2007 oil prices, and based on first 90,000 km of vehicle's life).40 The King Review concluded that the payback period for technologies delivering a 30% fuel consumption improvement would be 3–5 years for most UK drivers.(King review: EC (2007) Results of the review of the Community Strategy to reduce CO2 emissions from passenger cars and light commercial vehicles, COM(2007) 19 at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0019:FIN:EN:PDF) ATC, 2008:28 A recent US paper also estimated that improvements in conventional engines and transmissions could be deployed in high volumes in the near term and deliver around 30% reduction in fuel consumption in the US light vehicle fleet, at cost increases of US$1500–$3500 per vehicle. The paper also concluded that the improvements in fuel consumption would deliver fuel savings to offset the increase in vehicle costs within a few years, depending on the particular technology and the price of fuel. ATC, 2008:31- If liquefied natural gas (LNG) engine technology and refuelling infra-structure could be developed, then its lower cost compared to traditional diesel could provide a net economic advantage to fleet operators ATC, 2008:31 - Hydrogen has potential to be an emission-free fuel with a number of trials of hydrogen fuel cell vehicles occurring around the world. Significant technical challenges need to be overcome before it would be commercially feasible, including the development of affordable and efficient drivetrains and carbon neutral methods of producing and distributing the hydrogen fuel. There is broad agreement that hydrogen as a transport fuel is only likely to be an option in the long term, if at all.
	DCC, 2007, *Transport Sector Greenhouse Gas Emissions Projections*, Department of Climate Change, Australian Government. October 2007 **Relevance:** This publicly available document reports on GHG emissions projections for the Australian transport sector for 2005-2020. Relevance to DECCW study (1) methodology, macro economic data (population, transport activity data and economic growth projections) may be relevant, (2) GHG emission reduction measures may over lap/ influence NOx VOCs reduction measures **Summary:** The report presents historical trends in emissions (Section 1.2), key drivers of transport emissions projections (Section 1.3), method for developing transport sector projections (Section 1.4), projection results (Chapter 2), detailed analysis of on-road and off-road sub sectors (Chapters 3 &4), and sensitivity of projections to key variables such as changes in oil prices and improvements in fuel efficiency under different future scenarios (Chapter 5). Section 1.3 Key Drivers: economic and demographic indicators (GDP, international oil prices, consumption, income, population forecasts) Note page 5- assumes strong economic growth vehicle technology (fuel efficiency, design standard) future travel behaviour GHG abatement measures introduced by government Appendix A Measures A.1 Environmental Strategy for the Motor Vehicle Industry The Prime Minister announced the Environmental Strategy for the Motor Vehicle Industry (ESMVI) in 1997. The initiatives outlined under ESMVI include mandatory fuel labelling, a fuel consumption guide,

SKM

	voluntary fuel consumption targets and new motor vehicle emission standards. Voluntary fuel consumption targets - The voluntary fuel consumption target is the only initiative that directly impacts greenhouse gas emissions. A National Average Fuel Consumption (NAFC) for new passenger motor vehicles was agreed between the Commonwealth and the automotive industry and aimed to improve fuel efficiencies by approximately 15 per cent beyond business as usual by 2010. A voluntary target for fuel efficiency of new passenger vehicles of 6.8 L/100k by 2010 was agreed, which represents an 18% improvement over the 2002 fuel efficiency of new cars. This also represented an 8% improvement over the 2010 'business-as-usual' case and this improvement was assumed to also apply to the 2015 and 2020 targets. Further negotiations have taken place with the industry to develop a target for light commercial vehicles12 (LCVs) and a similar voluntary reduction target of 18% below the 2000 level has been agreed. The effect of the fuel efficiency target is to gradually reduce the fleet fuel consumption rate over time and is dependent on the number and types of new vehicles purchased annually <u>A.2 Biofuels</u> <u>A.3 Alternative Fuels Conversion Program</u> The compressed natural gas infrastructure program (CNGIP) aims to establish a network of publicly accessible compressed natural gas refuelling stations, funded by a $7.6 million programme. Abatement from this programme is covered by the estimate for the Alternative Fuel Conversion Programme (AFCP) described below. The alternative fuels conversion programme provides a subsidy of **50 per cent of the cost** of converting or substituting original engines (petrol or diesel) to alternative fuel engines such as liquefied petroleum gas or compressed natural gas. The measure applies to vehicles over 3.5 tonnes gross mass, which excludes passenger cars and light commercial vehicles. The program is now in its final phase with the emphasis changed to providing support for key **commercial fleet operators** to trial selected alternatively fuelled or hybrid vehicles. The aim of this phase of the program is to assess the commercial viability of these engine systems in heavy vehicles and demonstrate their feasibility to the wider transport industry. The program generally funds up to 50% of trial costs and requires a minimum 5% emissions reduction to be demonstrated. The annual abatement is estimated to be 0.01 Mt CO_2-e.

B Macro assumptions

Table B.1 Population assumptions (000' persons)

ACG and BTRE

	ACG	BTRE
2006	20566	20603
2007	20801	20836
2008	21049	21079
2009	21304	21314
2010	21557	21552
2011	21809	21782
2012	22060	22003
2013	22310	22216
2014	22558	22430
2015	22807	22646
2016	23081	22853
2017	23343	23062
2018	23609	23261
2019	23879	23462
2020	24152	23664

ACG population series is based on ABS Population Projections Cat 3222.0, Access Economics Business Outlook June 2006

BTRE population series based on ABS (mid –range series B) long-term projections.

Source: ACG 2007, BTRE 2007.

Table B.2 Oil price assumptions

US$ per barrel (2004 prices)

	Best [a]	*High* [b]	*Low* [c]
2006	60.17	60.17	60.17
2007	58.20	59.00	57.80
2008	59.00	62.27	57.63
2009	55.95	62.41	51.15
2010	55.00	66.68	47.21
2011	54.00	71.14	43.33
2012	52.88	74.97	39.70
2013	50.83	76.67	36.90
2014	49.80	78.83	35.24
2015	49.67	80.65	33.82
2016	49.80	83.17	33.47
2017	50.21	84.37	33.17
2018	50.83	86.40	33.21
2019	51.35	88.18	33.10
2020	51.77	90.24	33.11

[a] Based on US EIA 'base' scenario.

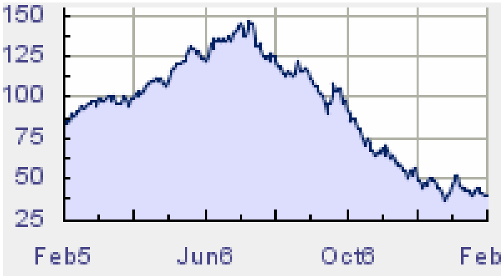
[b] Based on US EIA 'High' scenario.

[c] Based on US EIA 'Low' scenario.

Source: BTRE 2007.

Note oil price in last 12 months

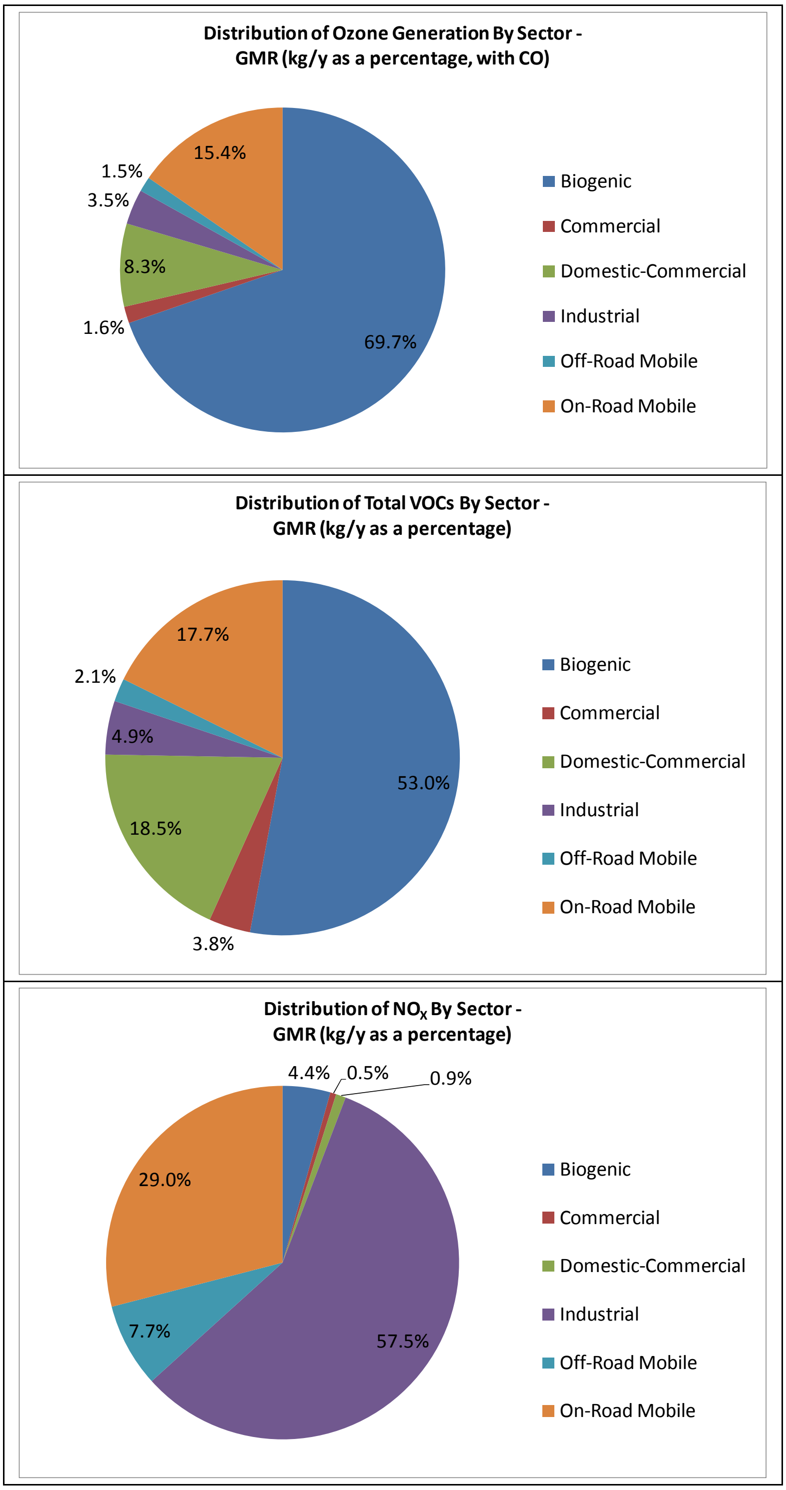
http://www.oil-price.net/

	
	Study on Factors Impacting on Australia's National Average Fuel Consumption (NAFC) Levels to 2010 (extract on http://hartnet.net/Cheaper%20Petrol.htm **Relevance:** Impediments to improving NAFC identified to be (1) low fuel prices (2) resultant low priority of fuel efficiency for consumers
	QLD GHG MACC – NOUS SKM NOUS SKM, 2008, *An Enhanced Queensland Marginal Abatement Cost Curve*, prepared by NOUS Group and SKM for Queensland Environment Protection Agency, Office of Climate Change **Relevance**: **High** - Consultants report prepared by members of NSW DECCW NOx VOCs CAC team. Relevant methodology and report format to transfer to current project.

Appendix B Emissions and Source Contributions

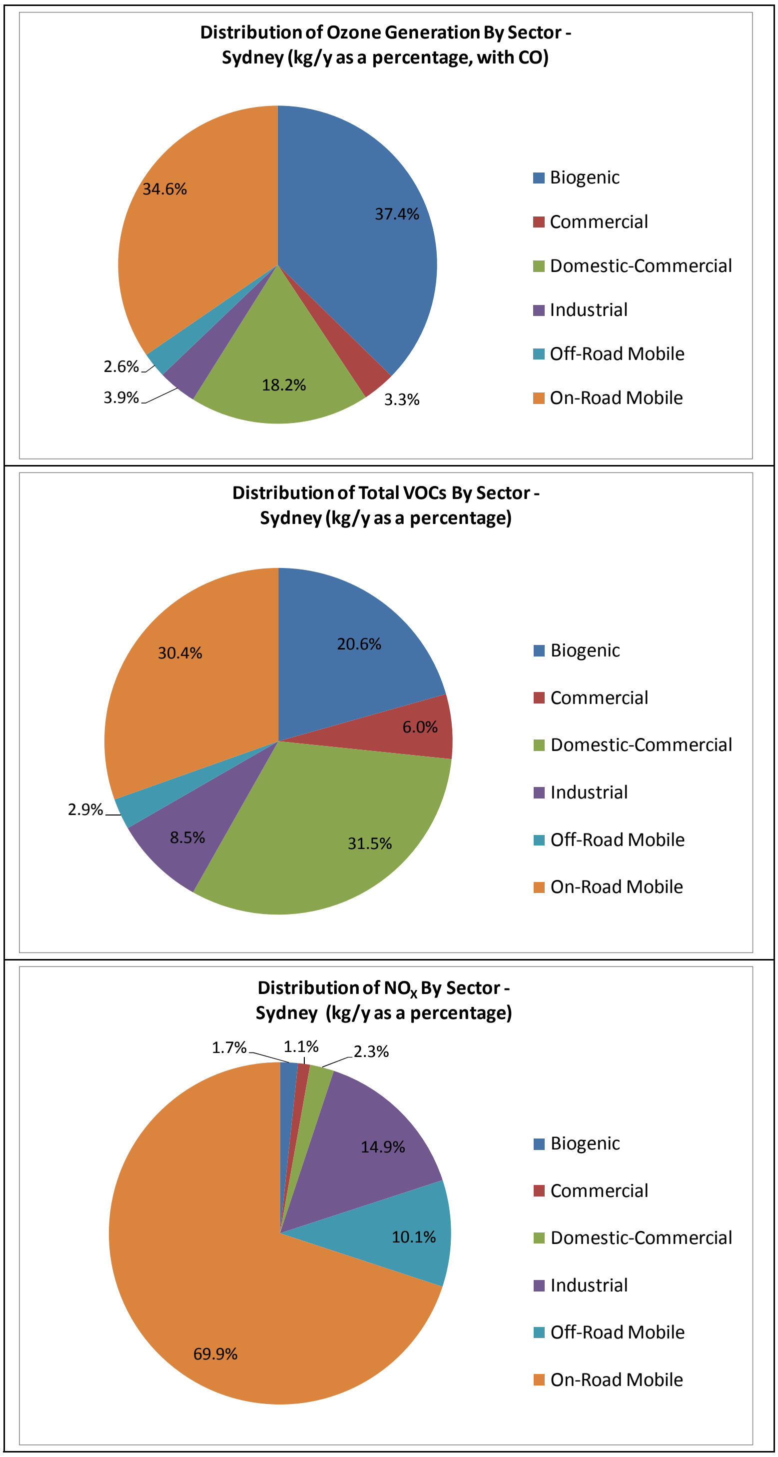
▪ **Figure B-1 Source Contribution by Sector, GMR 2003 – Ozone Forming Potential vs. Total Mass of Precursor Pollutant Emissions**

Source: DECC, 2008; DECC, 2007f



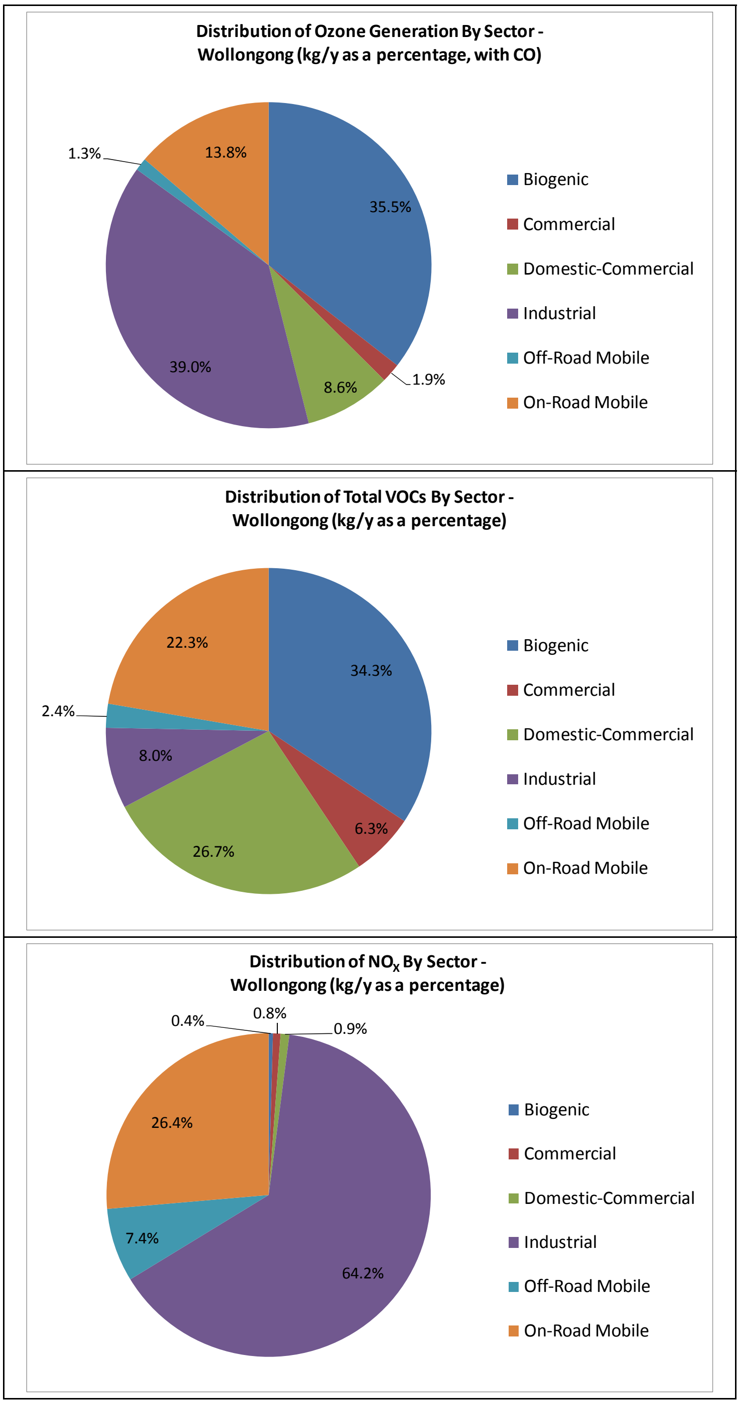
- **FigureB-2 Source Contribution by Sector, Sydney Sub Region 2003 – Ozone Forming Potential vs. Total Mass of Precursor Pollutant Emissions**

Source: DECC, 2008; DECC, 2007f



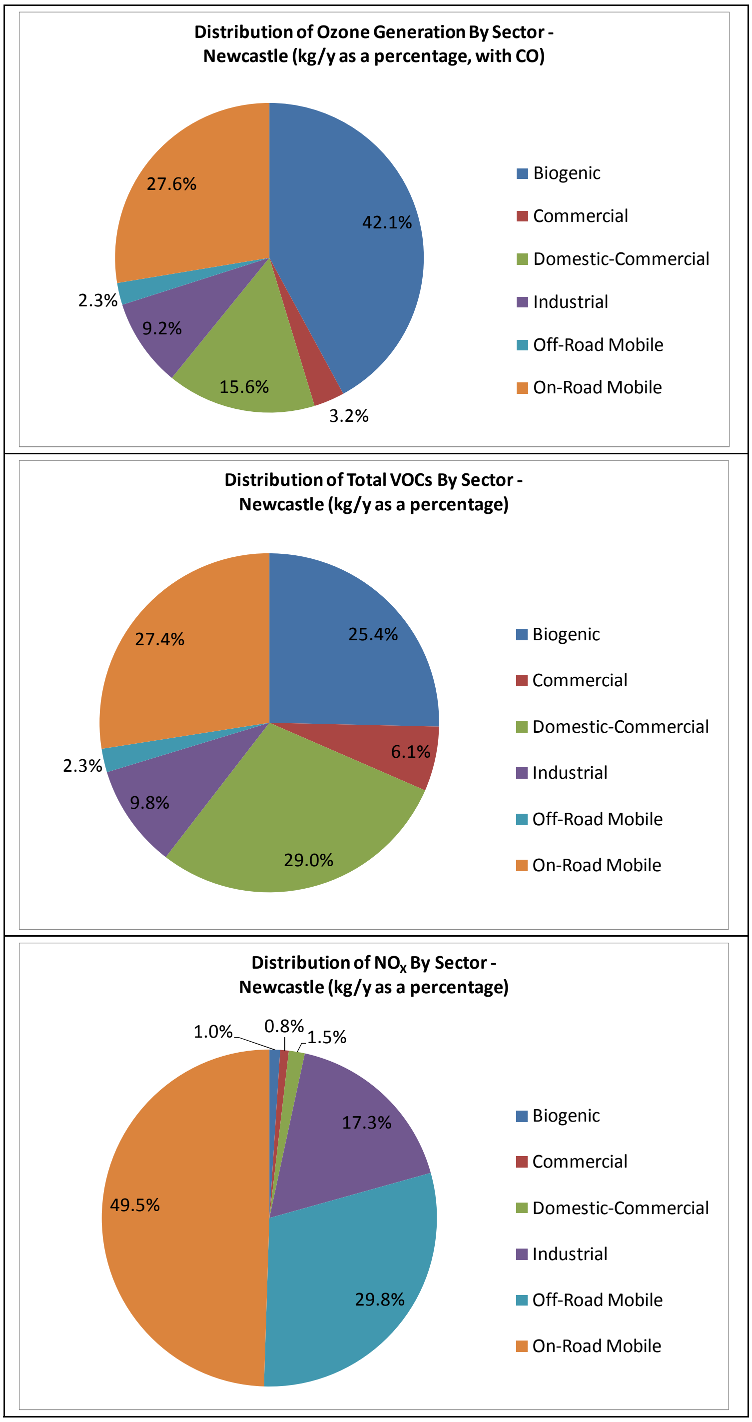
■ **Figure B-3 Source Contribution by Sector, Wollongong Sub Region 2003 – Ozone Forming Potential vs. Total Mass of Precursor Pollutant Emissions**

Source: DECC, 2008; DECC, 2007f



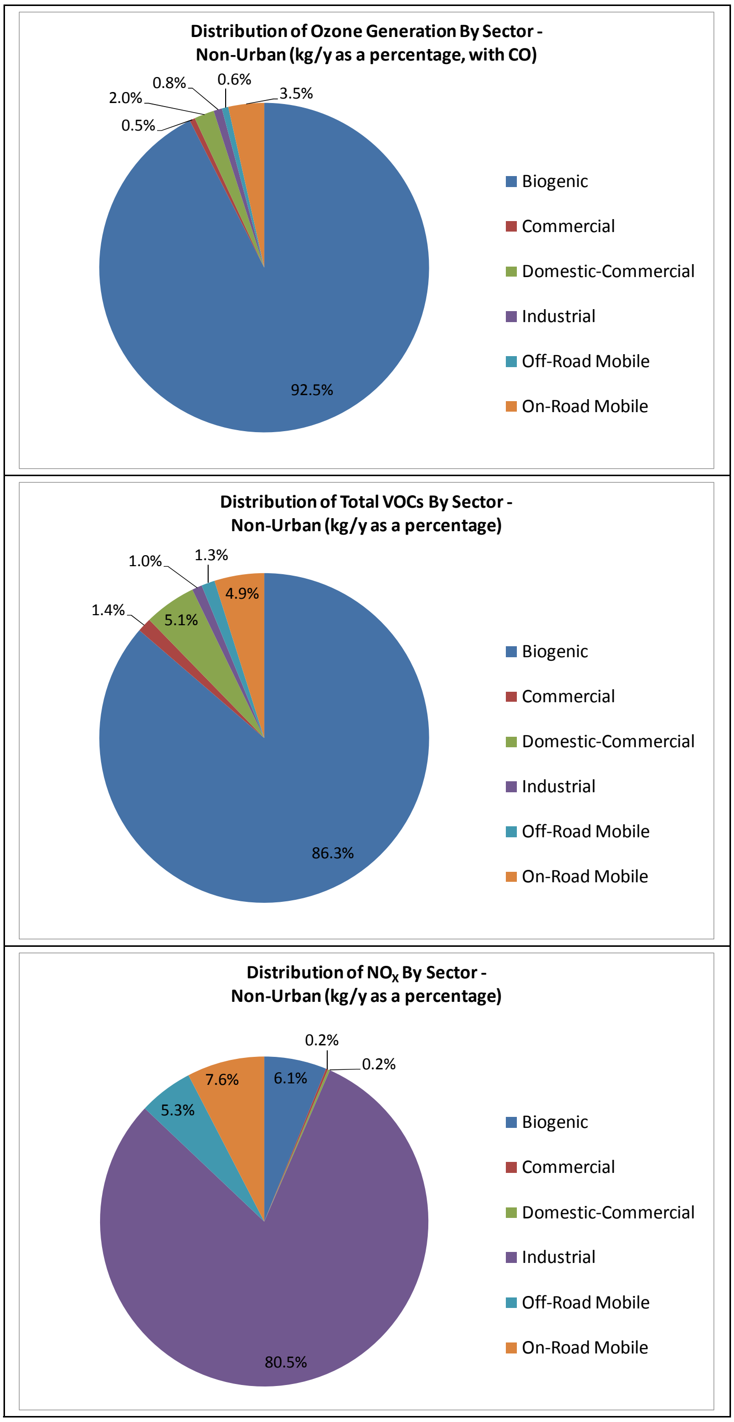
- **Figure B-4 Source Contribution by Sector, Newcastle Sub Region 2003 – Ozone Forming Potential vs. Total Mass of Precursor Pollutant Emissions**

Source: DECC, 2008; DECC, 2007f



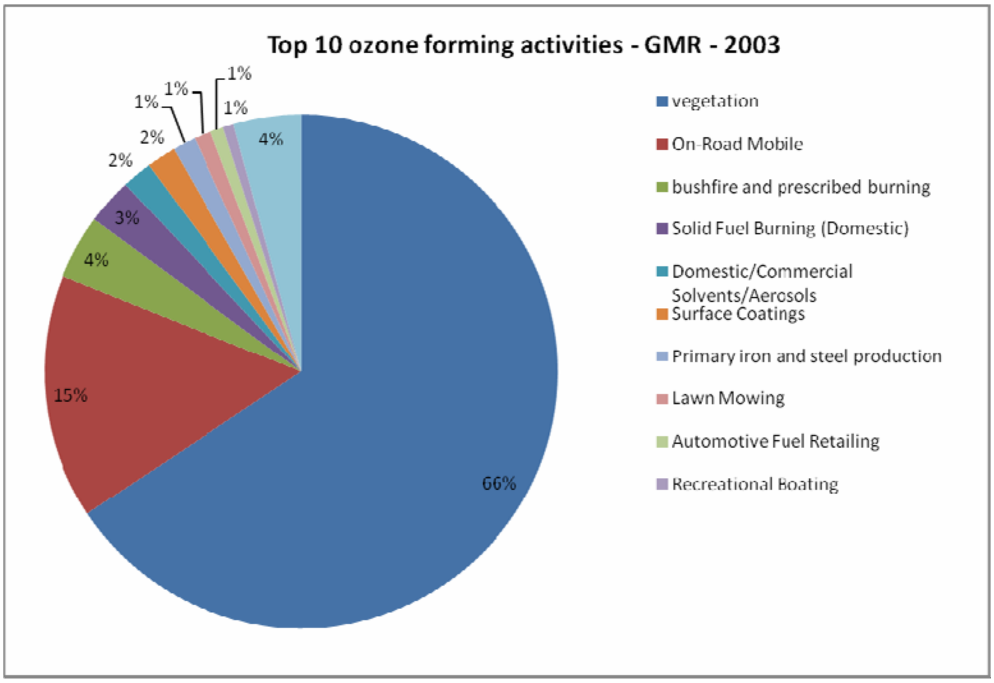
- **Figure B-5 Source Contribution by Sector, Non-Urban Sub Region 2003 – Ozone Forming Potential vs. Total Mass of Precursor Pollutant Emissions**

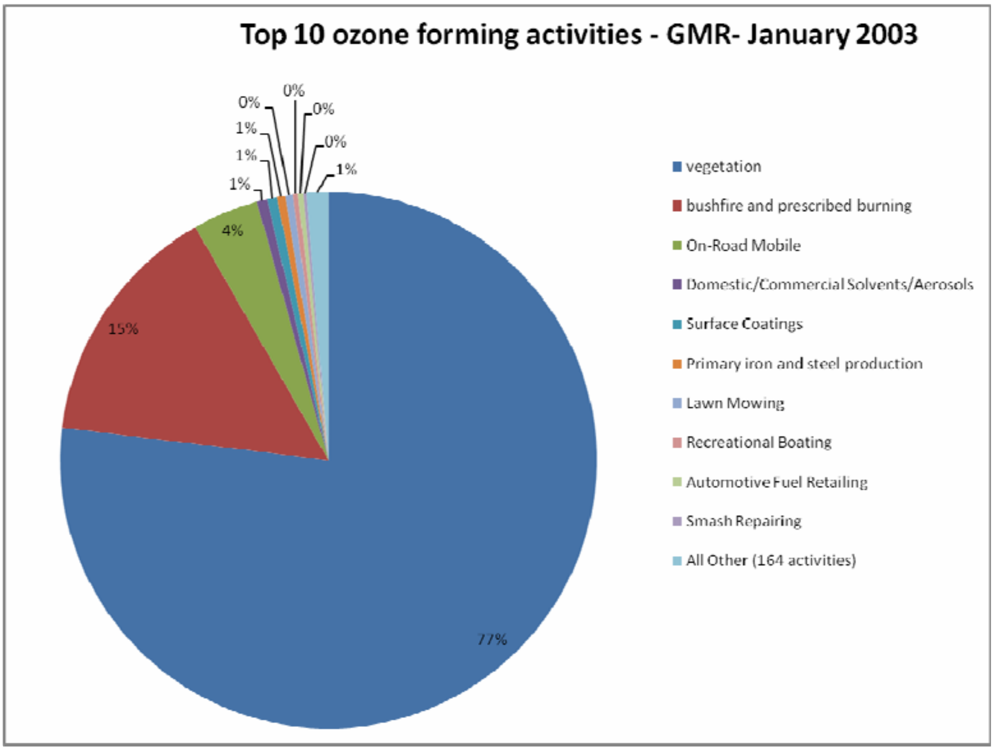
Source: DECC, 2008; DECC, 2007f



- **Figure B-6 Source Contribution of Activities by Ozone Forming Potential (kg Ozone) GMR 2003**

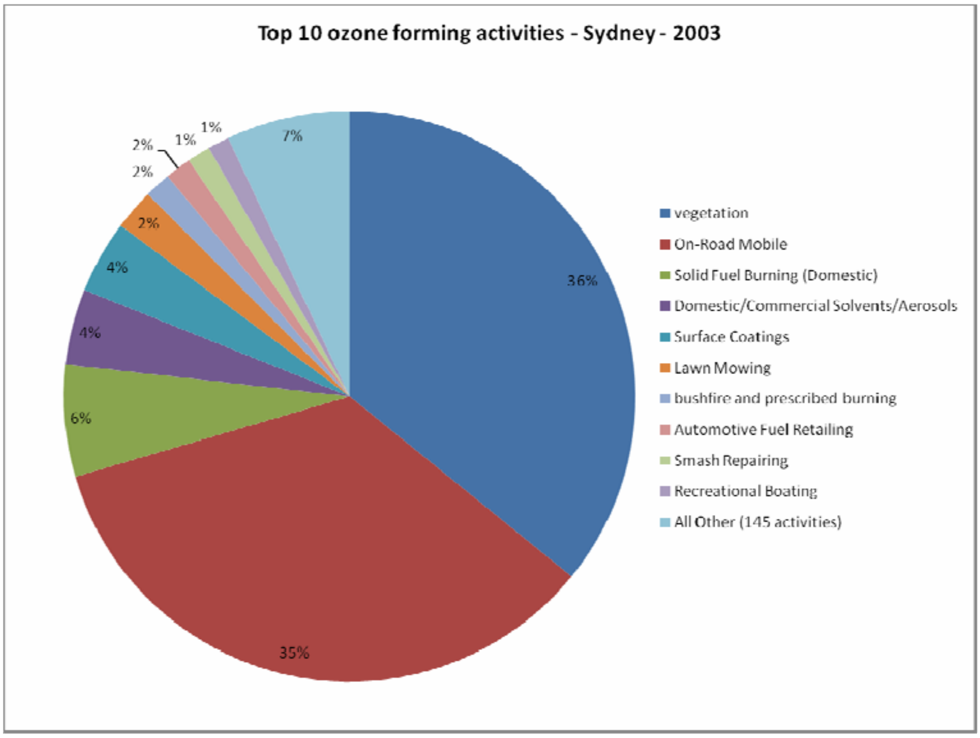
Source: DECC, personal communication, 2009

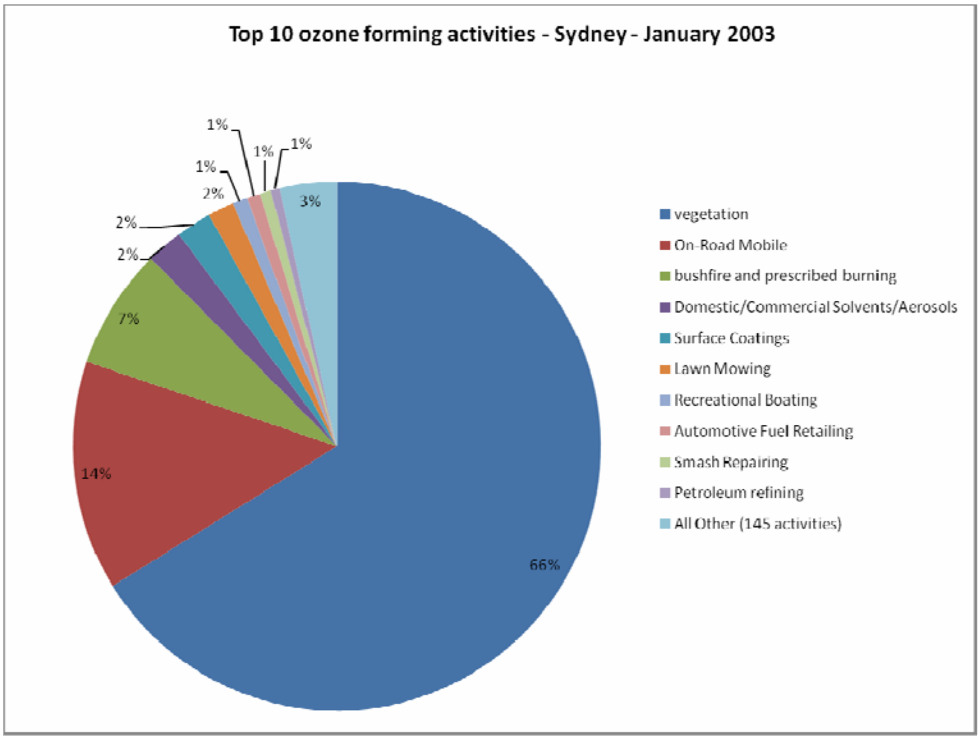




▪ **Figure B-7 Source Contribution of Activities by Ozone Forming Potential (kg Ozone) Sydney 2003**

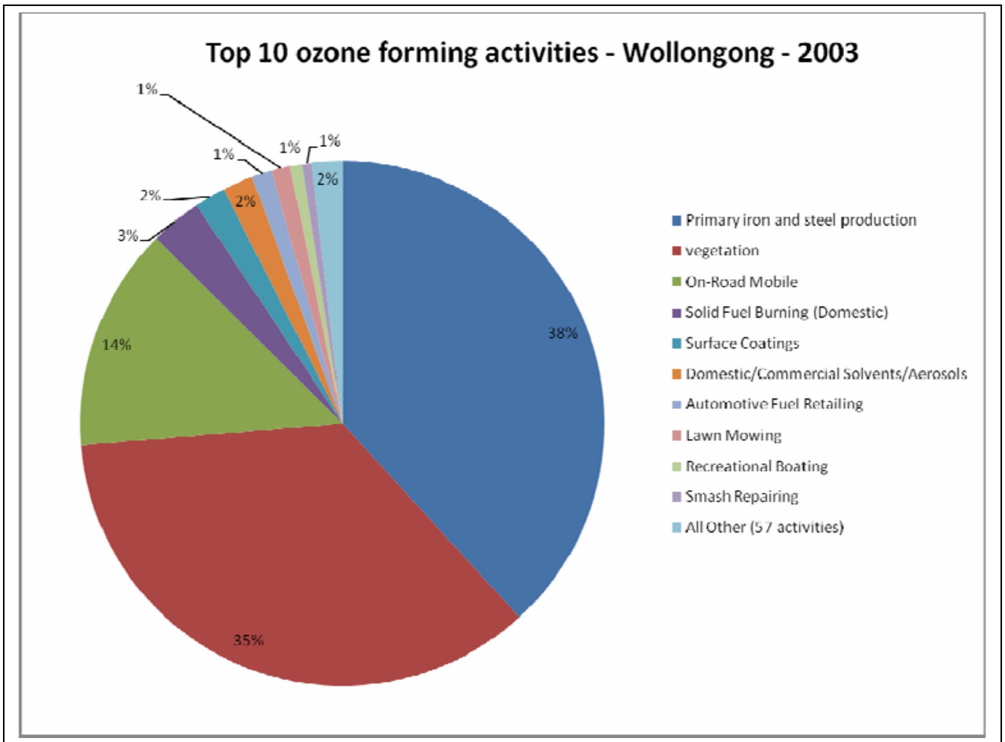
Source: DECC, personal communication, 2009

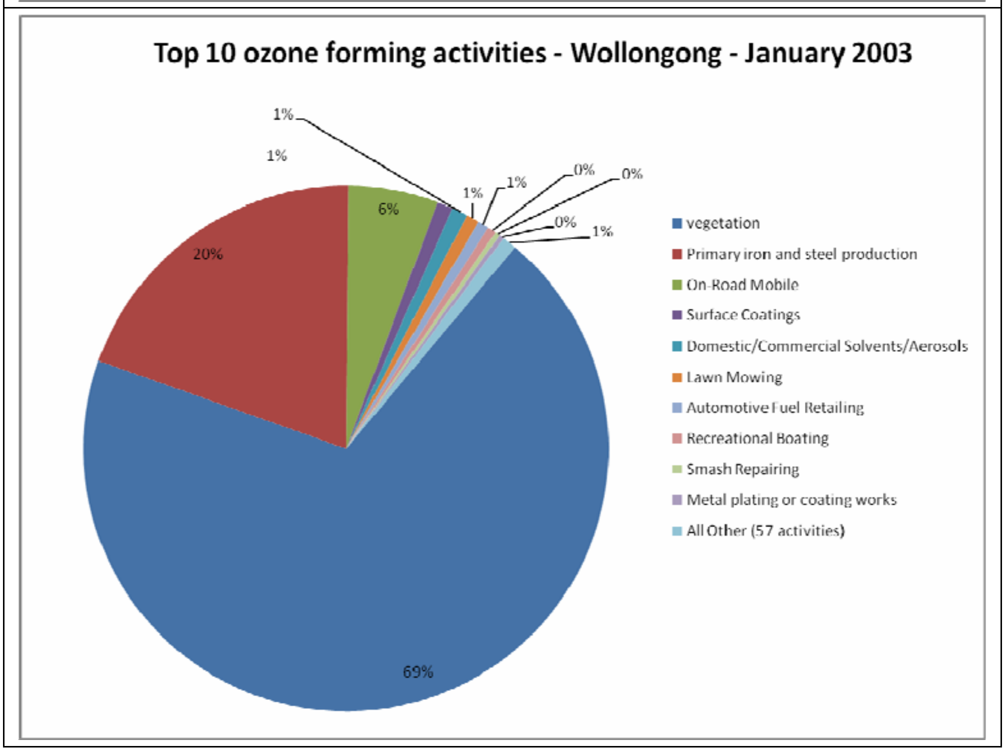




- **Figure B-8 Source Contribution of Activities by Ozone Forming Potential (kg Ozone) Wollongong 2003**

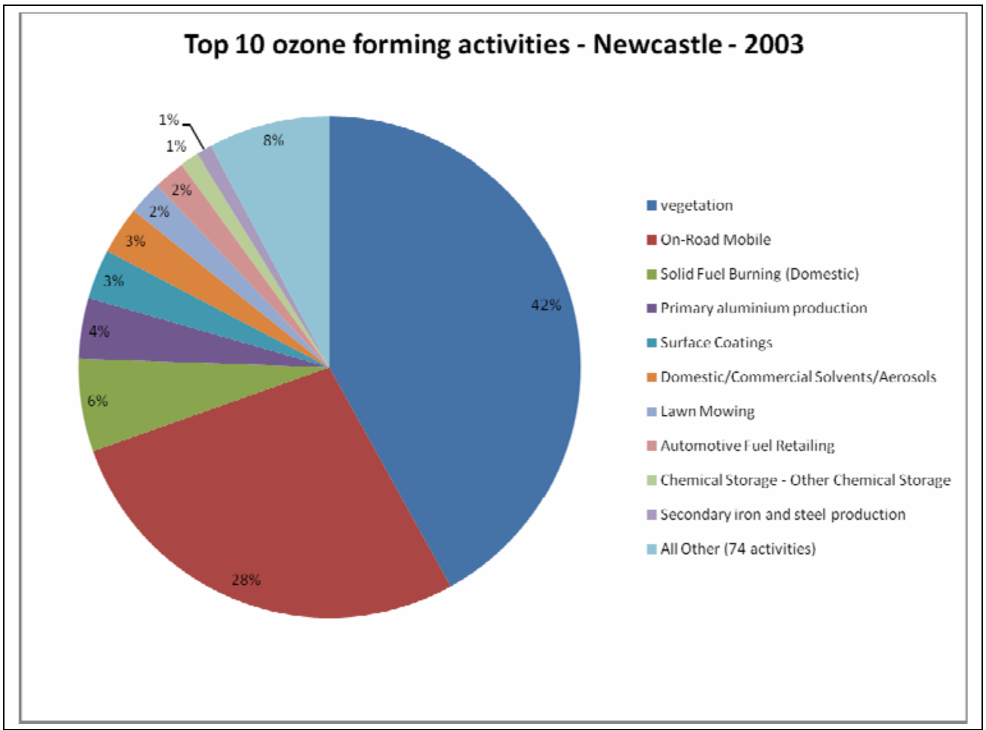
Source: DECC, personal communication, 2009

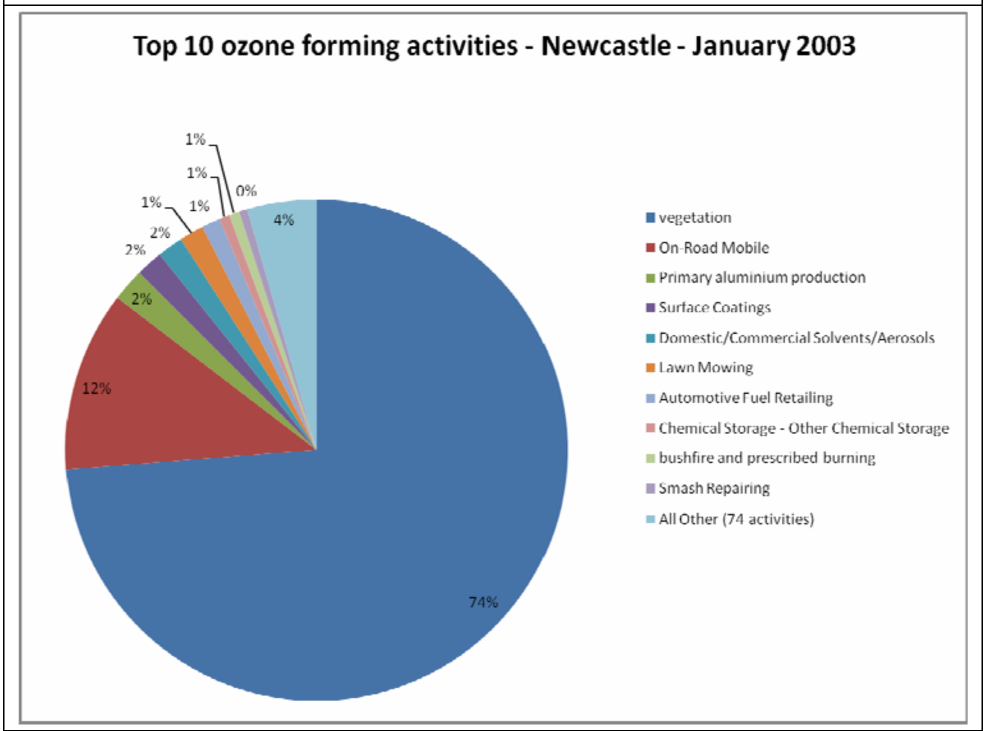




▪ **Figure B-9 Source Contribution of Activities by Ozone Forming Potential (kg Ozone) Newcastle 2003**

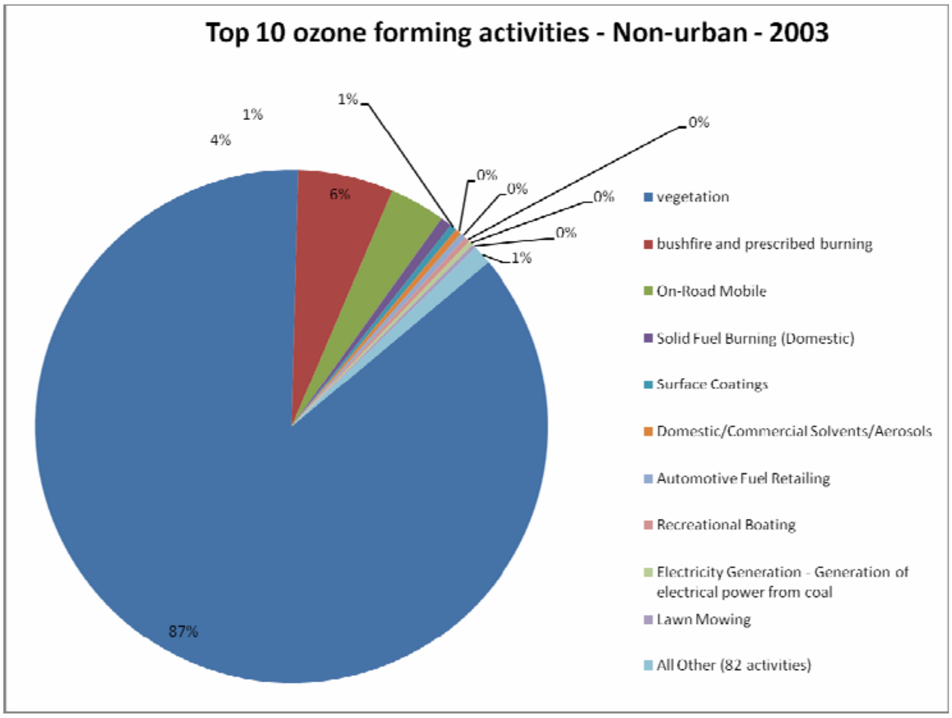
Source: DECC, personal communication, 2009





■ **Figure B-10 Source Contribution of Activities by Ozone Forming Potential (kg Ozone) Non-Urban 2003**

Source: DECC, personal communication, 2009



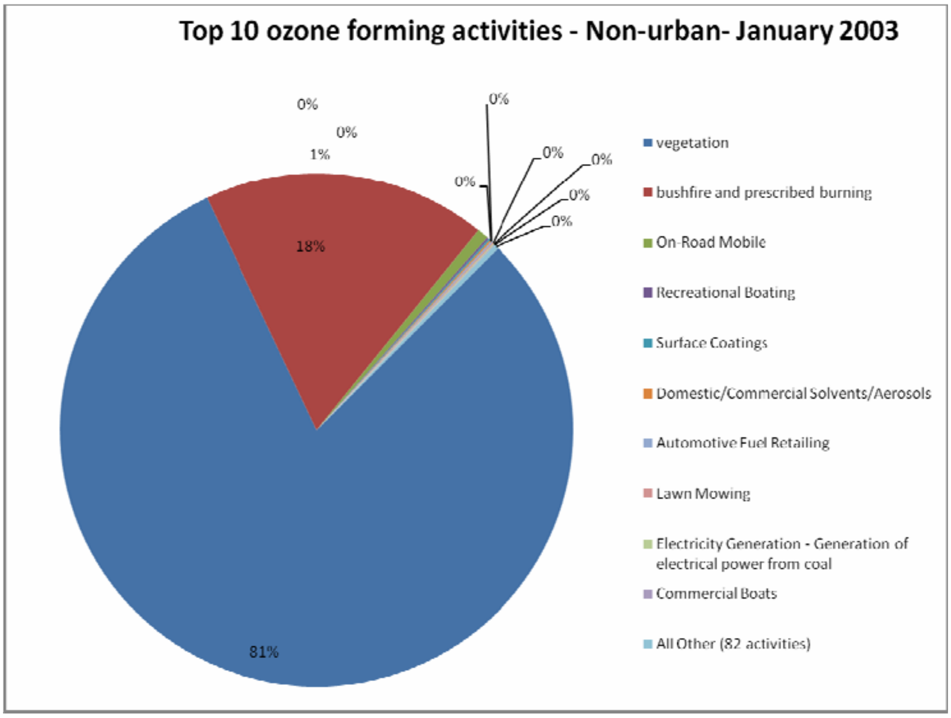
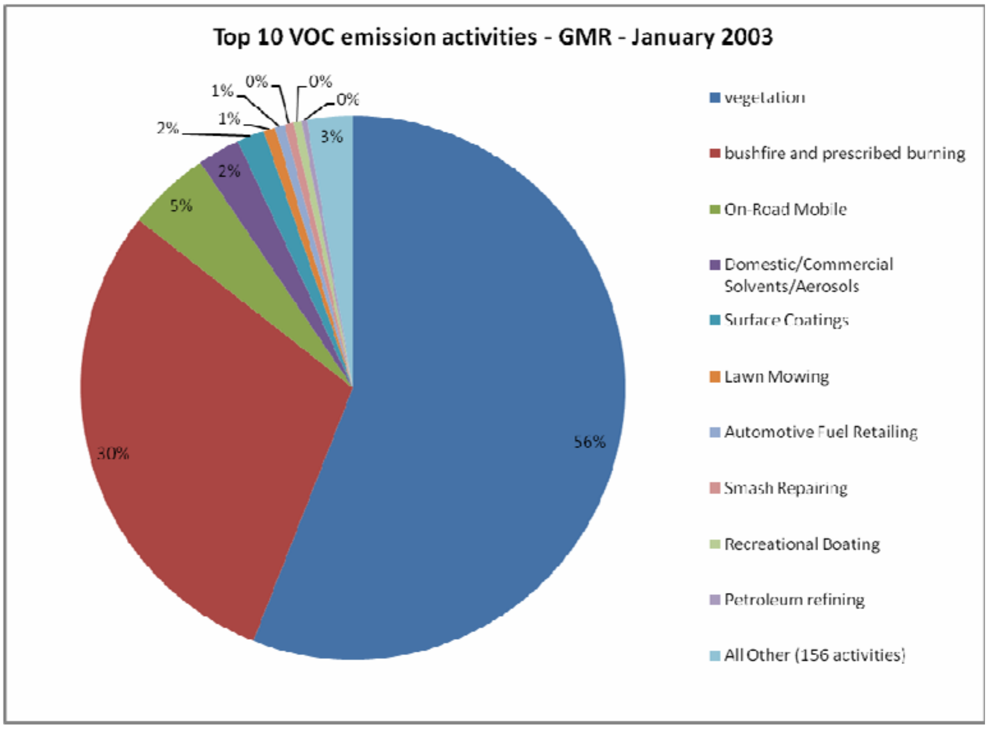
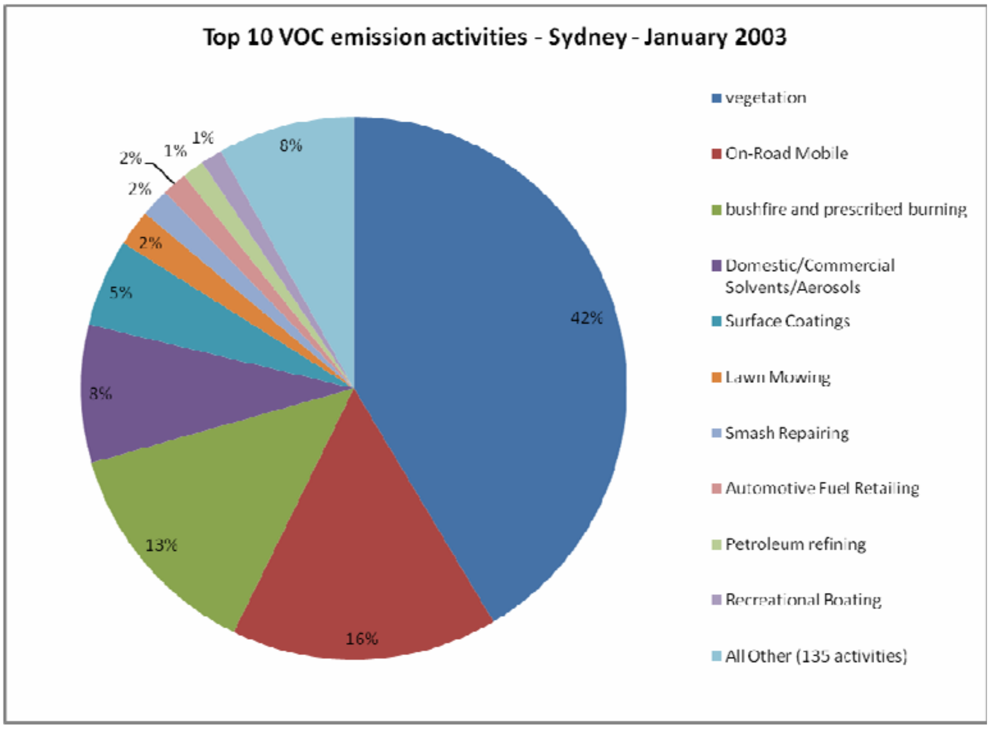
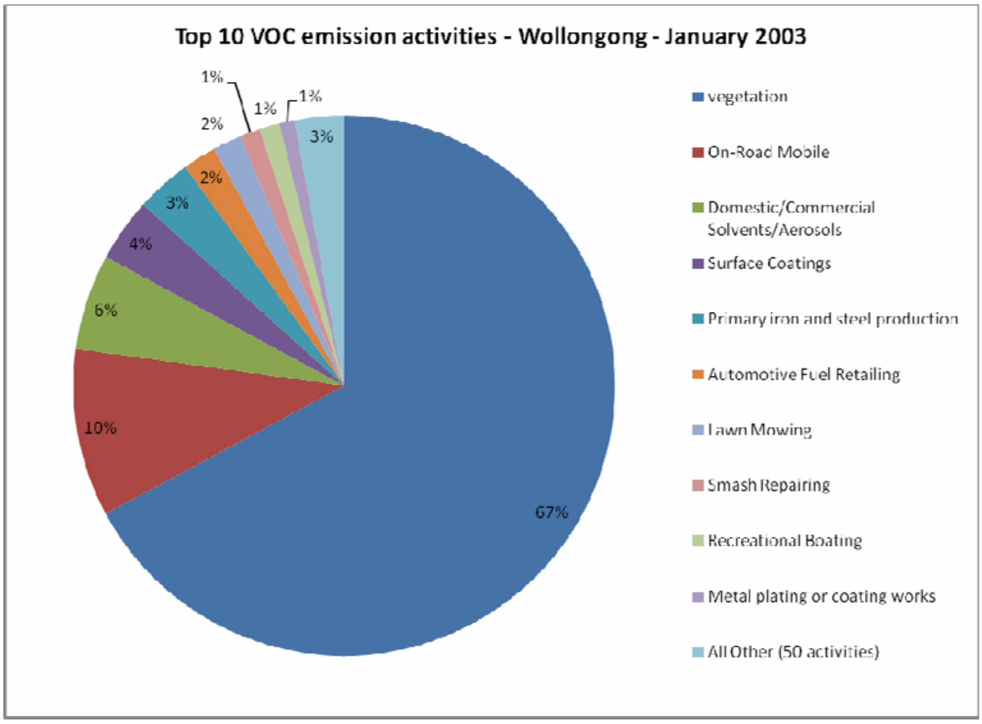


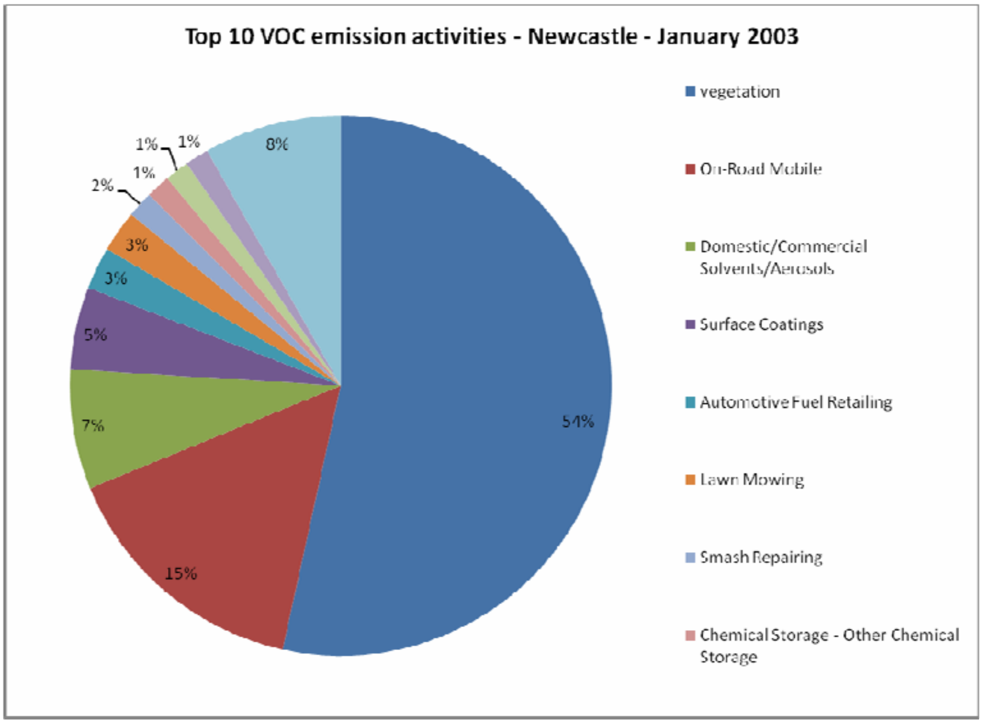
Figure B-11 Source Contribution of VOC Emissions by Activity – January 2003 (kg per year as percentage)

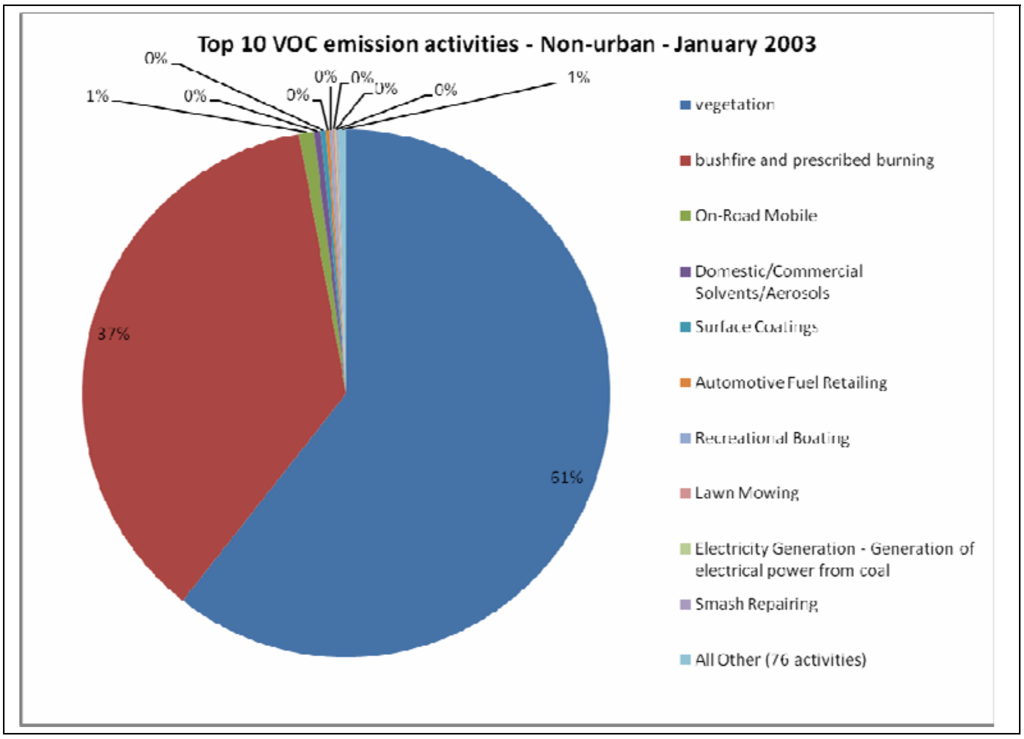
Source: DECC 2007f






Top 10 VOC emission activities - Wollongong - January 2003
vegetation
On-Road Mobile
Domestic/Commercial Solvents/Aerosols
Surface Coatings
Primary iron and steel production
Automotive Fuel Retailing
Lawn Mowing
Smash Repairing
Recreational Boating
Metal plating or coating works
All Other (50 activities)
67%
10%
6%
4%
3%
2%
2%
1%
1%
1%
3%

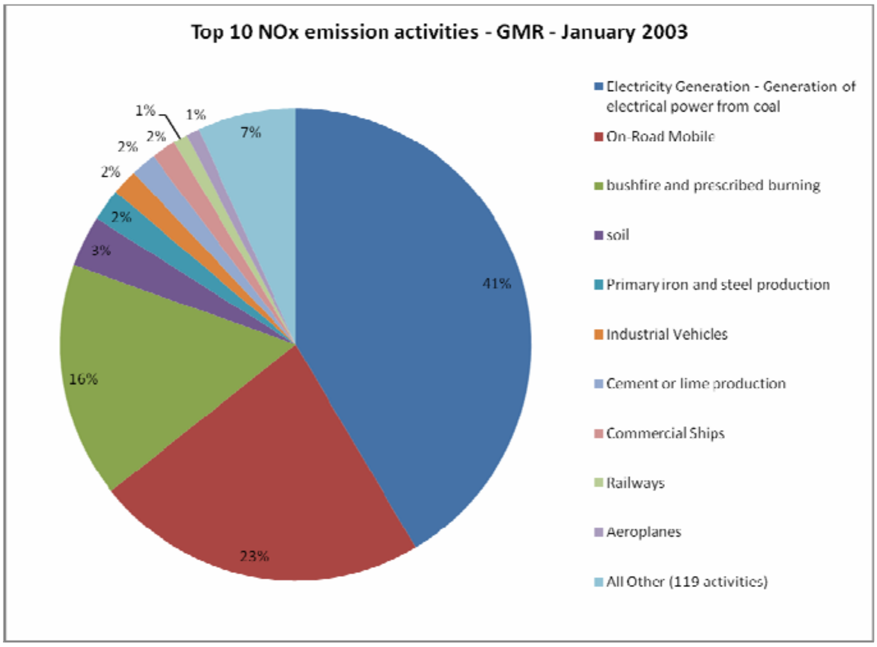

Top 10 VOC emission activities - Newcastle - January 2003
vegetation
On-Road Mobile
Domestic/Commercial Solvents/Aerosols
Surface Coatings
Automotive Fuel Retailing
Lawn Mowing
Smash Repairing
Chemical Storage - Other Chemical Storage
54%
15%
7%
5%
3%
3%
2%
1%
1%
1%
8%

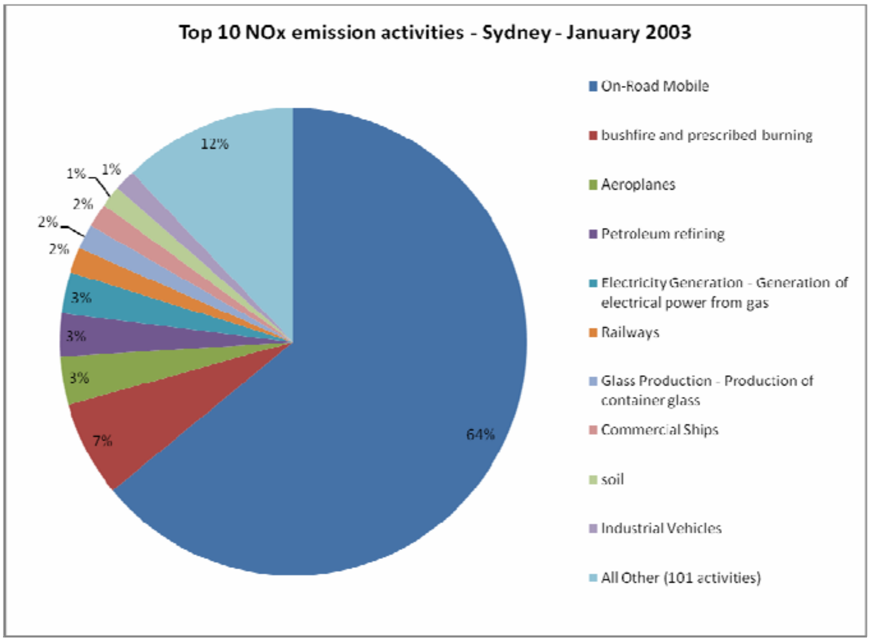


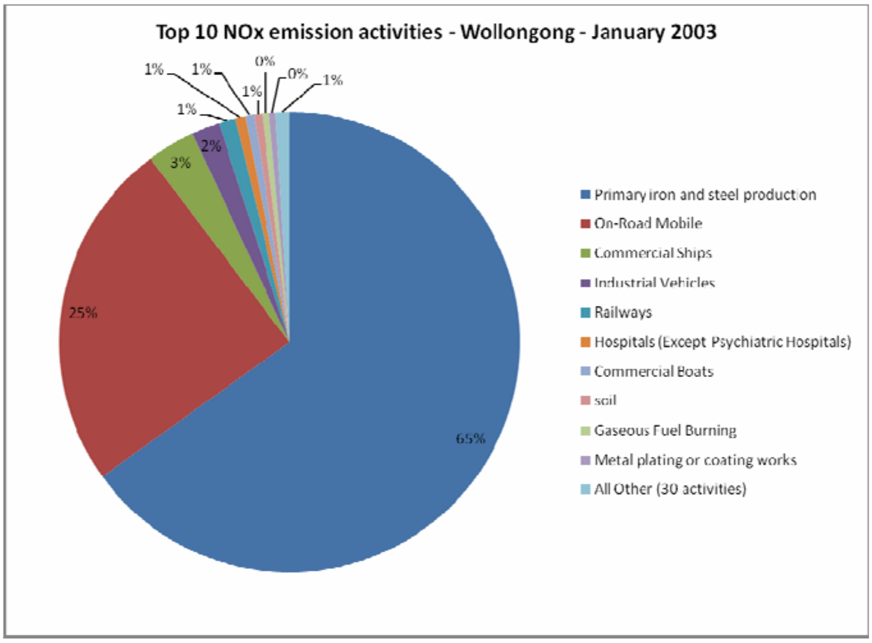
Top 10 VOC emission activities - Non-urban - January 2003
0%
1%
0%
0%
0%
0%
0%
0%
1%
37%
61%
vegetation
bushfire and prescribed burning
On-Road Mobile
Domestic/Commercial Solvents/Aerosols
Surface Coatings
Automotive Fuel Retailing
Recreational Boating
Lawn Mowing
Electricity Generation - Generation of electrical power from coal
Smash Repairing
All Other (76 activities)

▪ **Figure B-12 Source Contribution of NO_X Emissions by Activity – January 2003 (kg per year as percentage)**

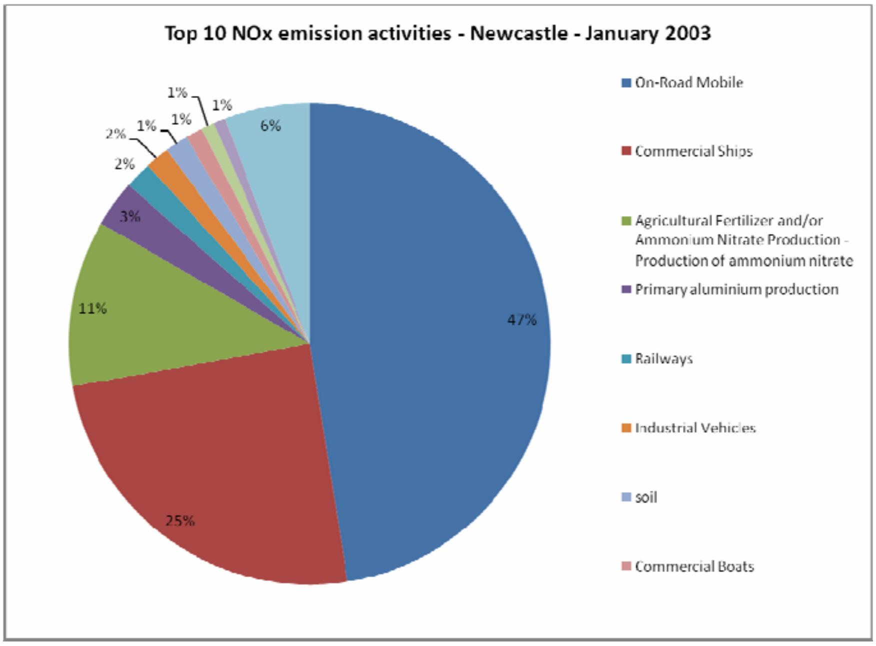
Source: DECC 2007f



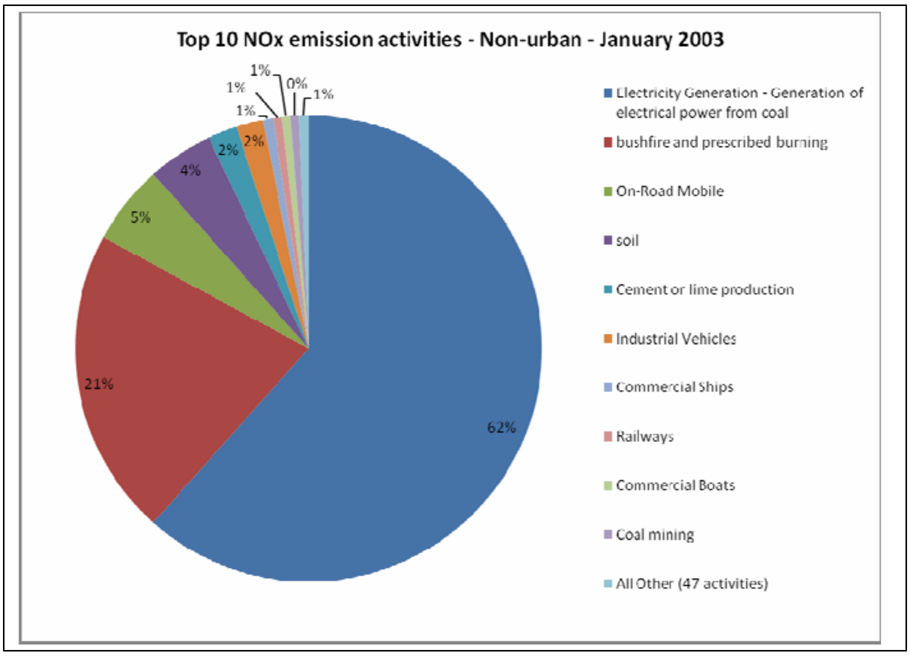




Top 10 NOx emission activities - Wollongong - January 2003
1%
1%
0%
0%
1%
1%
1%
2%
3%
25%
65%
Primary iron and steel production
On-Road Mobile
Commercial Ships
Industrial Vehicles
Railways
Hospitals (Except Psychiatric Hospitals)
Commercial Boats
soil
Gaseous Fuel Burning
Metal plating or coating works
All Other (30 activities)

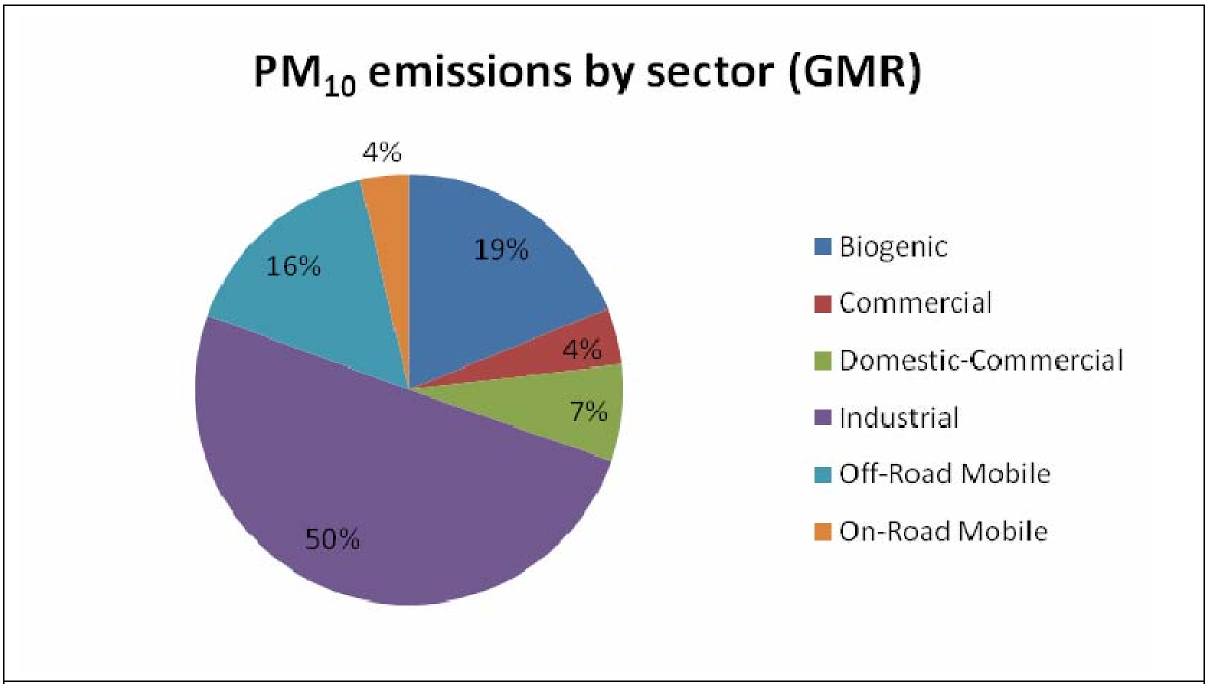


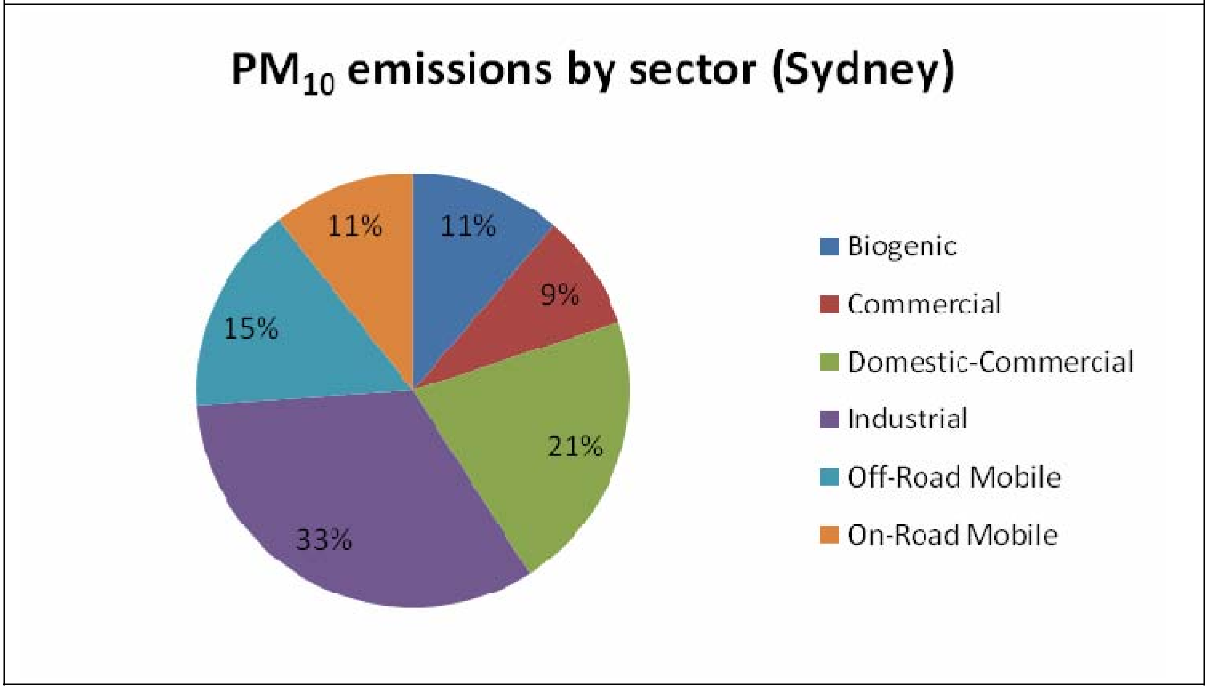
Top 10 NOx emission activities - Newcastle - January 2003
1%
1%
2%
1%
1%
2%
3%
6%
11%
47%
25%
On-Road Mobile
Commercial Ships
Agricultural Fertilizer and/or Ammonium Nitrate Production - Production of ammonium nitrate
Primary aluminium production
Railways
Industrial Vehicles
soil
Commercial Boats

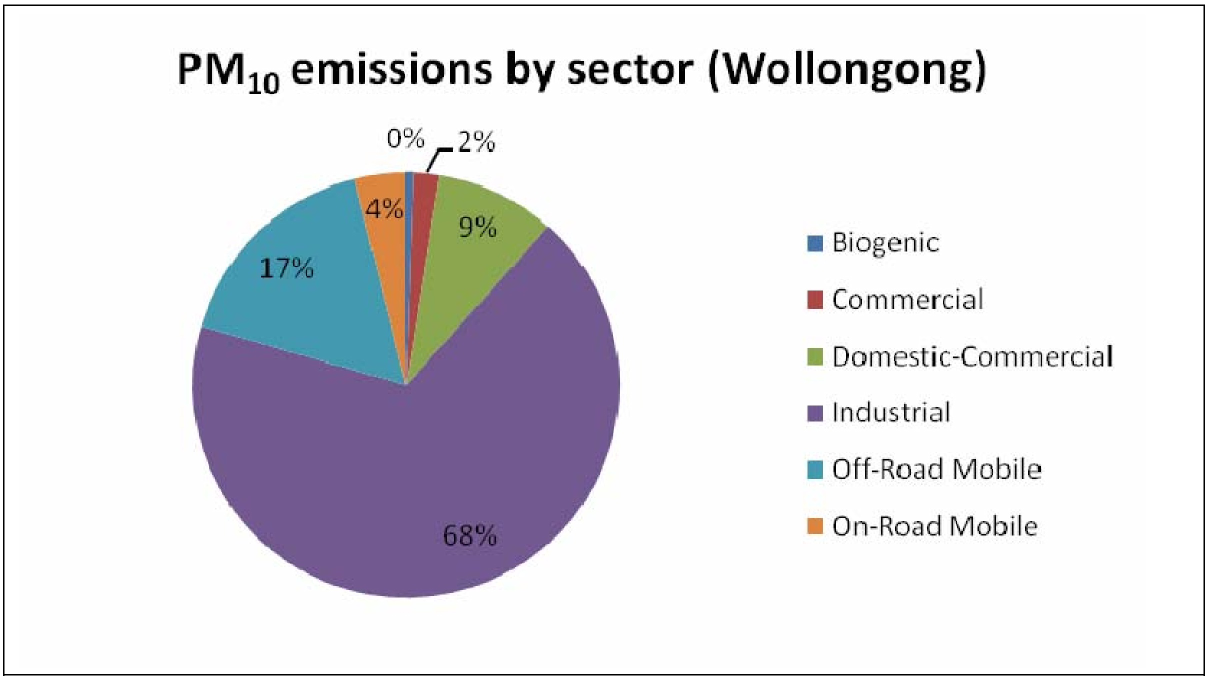

Top 10 NOx emission activities - Non-urban - January 2003
62%
21%
5%
4%
2%
2%
1%
1%
1%
0%
1%
Electricity Generation - Generation of electrical power from coal
bushfire and prescribed burning
On-Road Mobile
soil
Cement or lime production
Industrial Vehicles
Commercial Ships
Railways
Commercial Boats
Coal mining
All Other (47 activities)

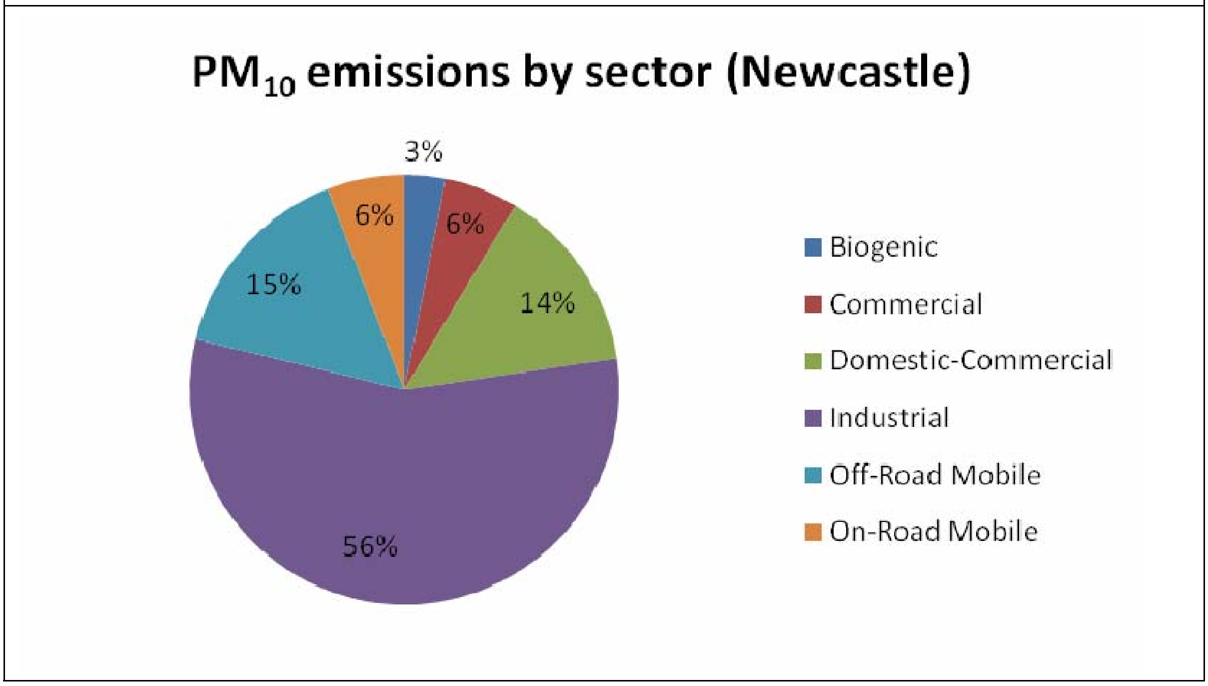
- **Figure B-13 Source Contribution of PM_{10} Emissions by Sector (kg per year as percentage)**

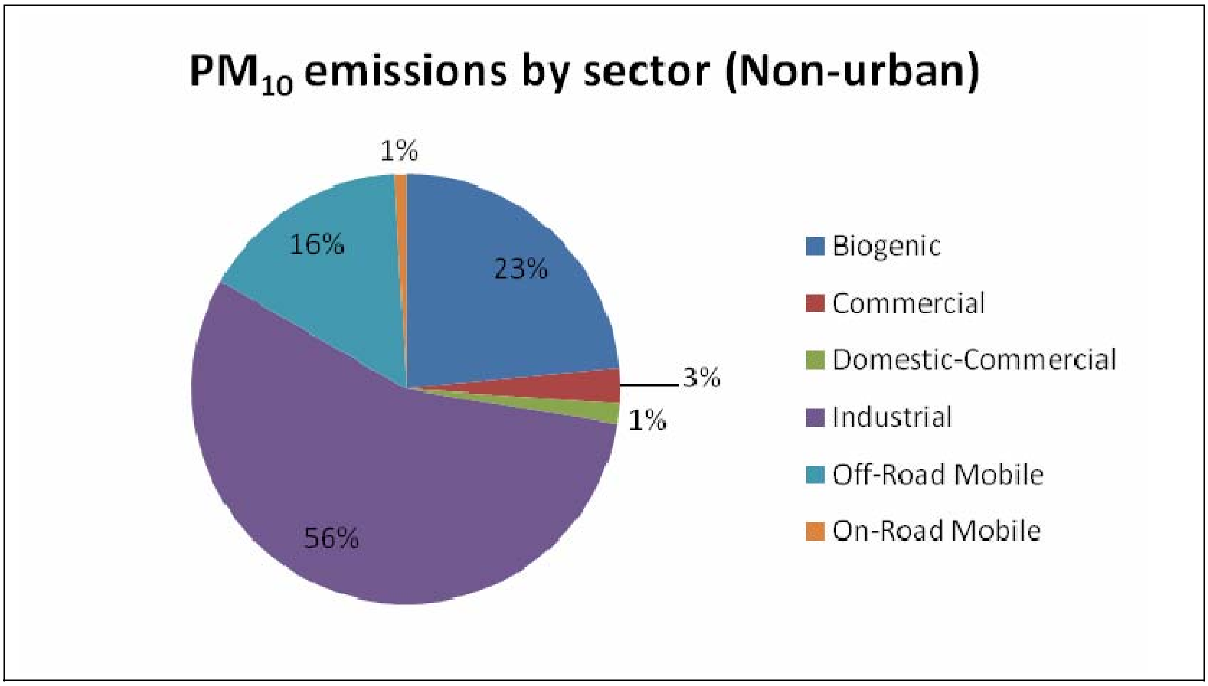
Source: DECC 2007f






PM10 emissions by sector (Wollongong)
0%
2%
4%
9%
17%
68%
Biogenic
Commercial
Domestic-Commercial
Industrial
Off-Road Mobile
On-Road Mobile

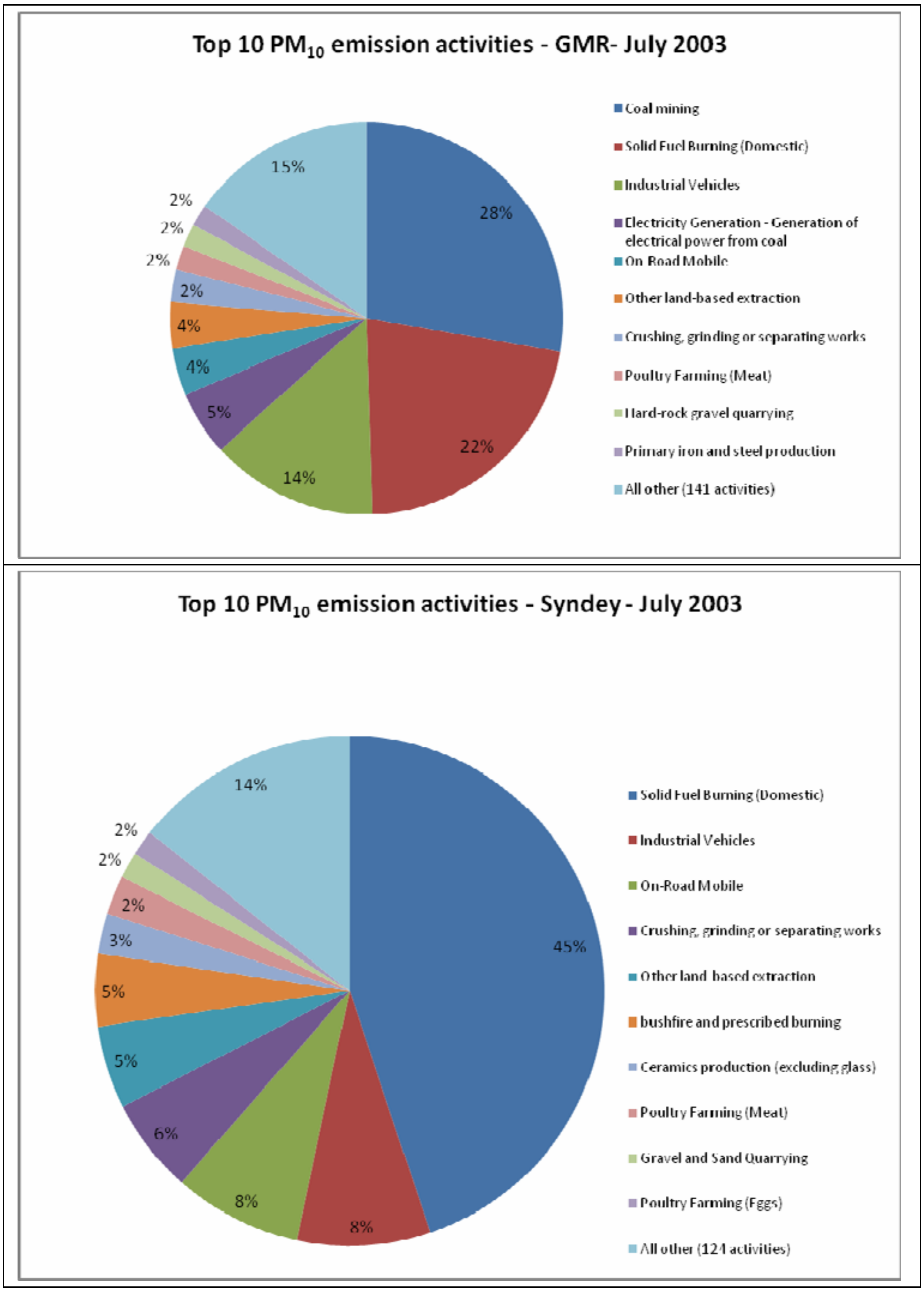

PM10 emissions by sector (Newcastle)
3%
6%
6%
15%
14%
56%
Biogenic
Commercial
Domestic-Commercial
Industrial
Off-Road Mobile
On-Road Mobile

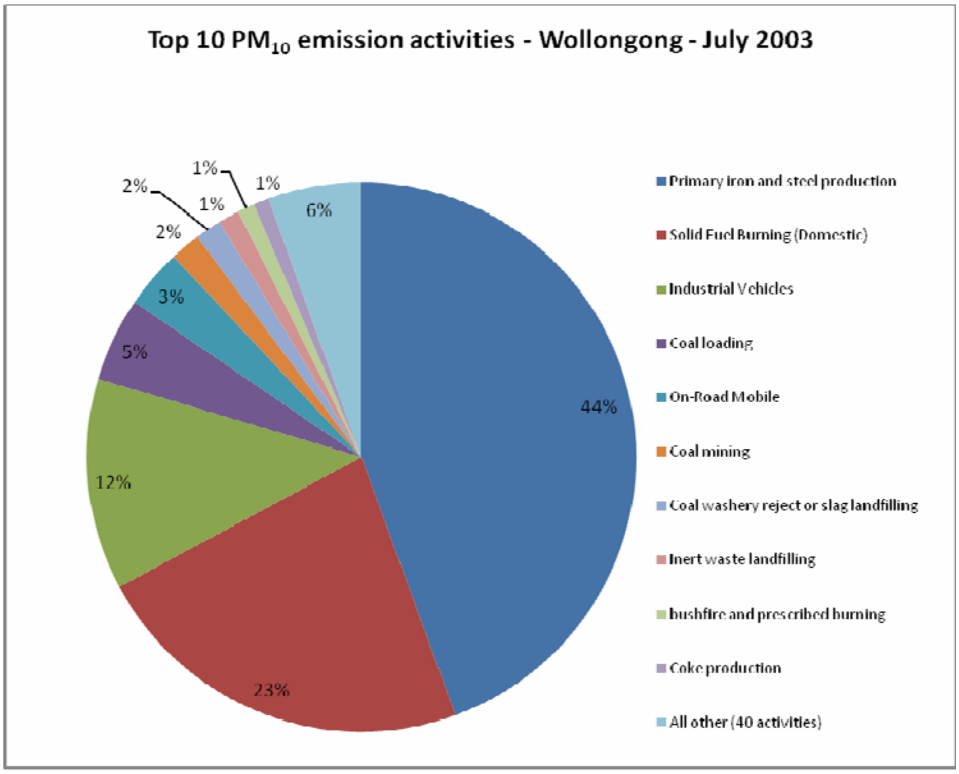

PM10 emissions by sector (Non-urban)
1%
16%
23%
3%
1%
56%
Biogenic
Commercial
Domestic-Commercial
Industrial
Off-Road Mobile
On-Road Mobile

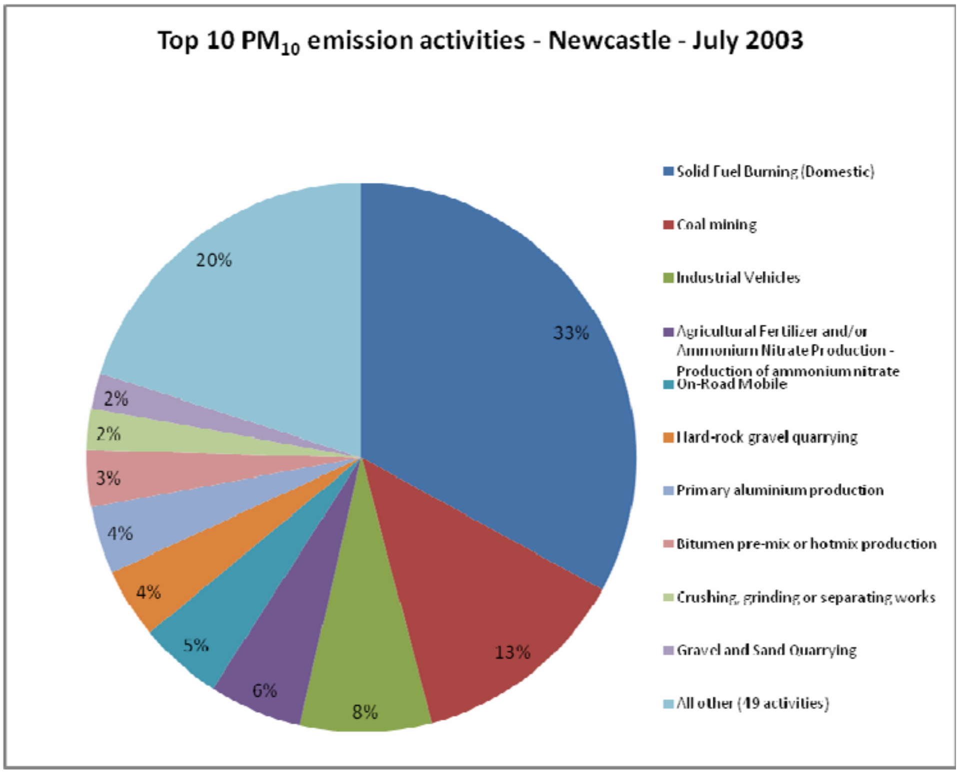
■

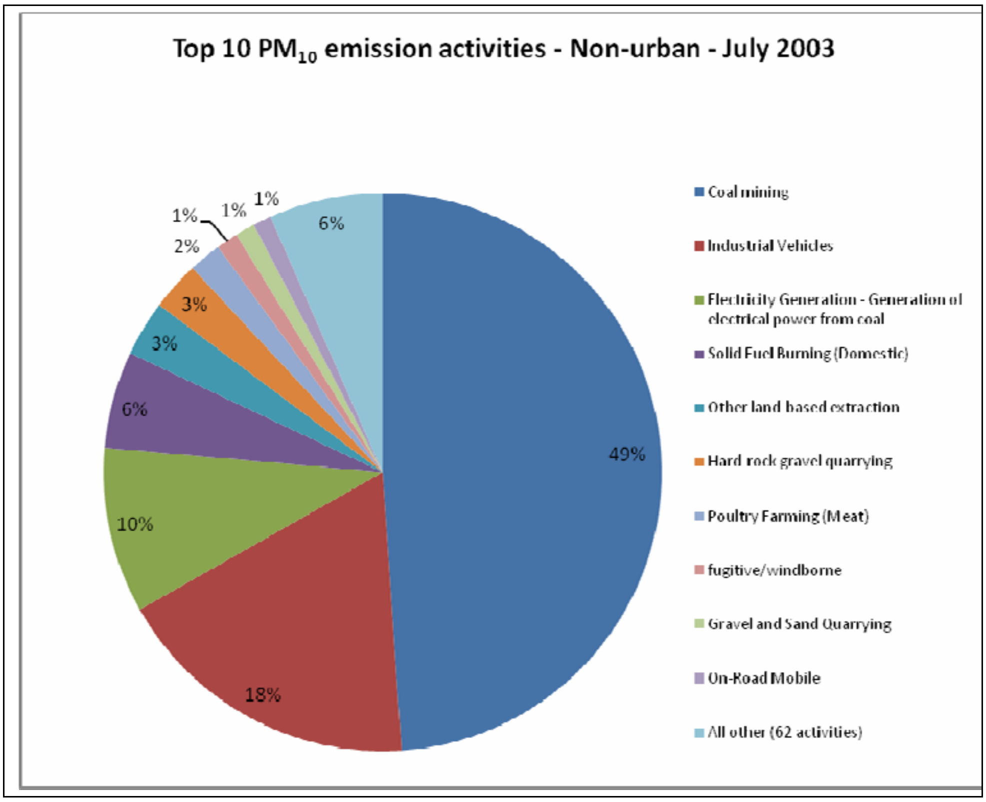
Figure B-14 Source Contribution of PM_{10} Emissions by Activity July 2003 (kg per year as percentage)

Source: DECC 2007f



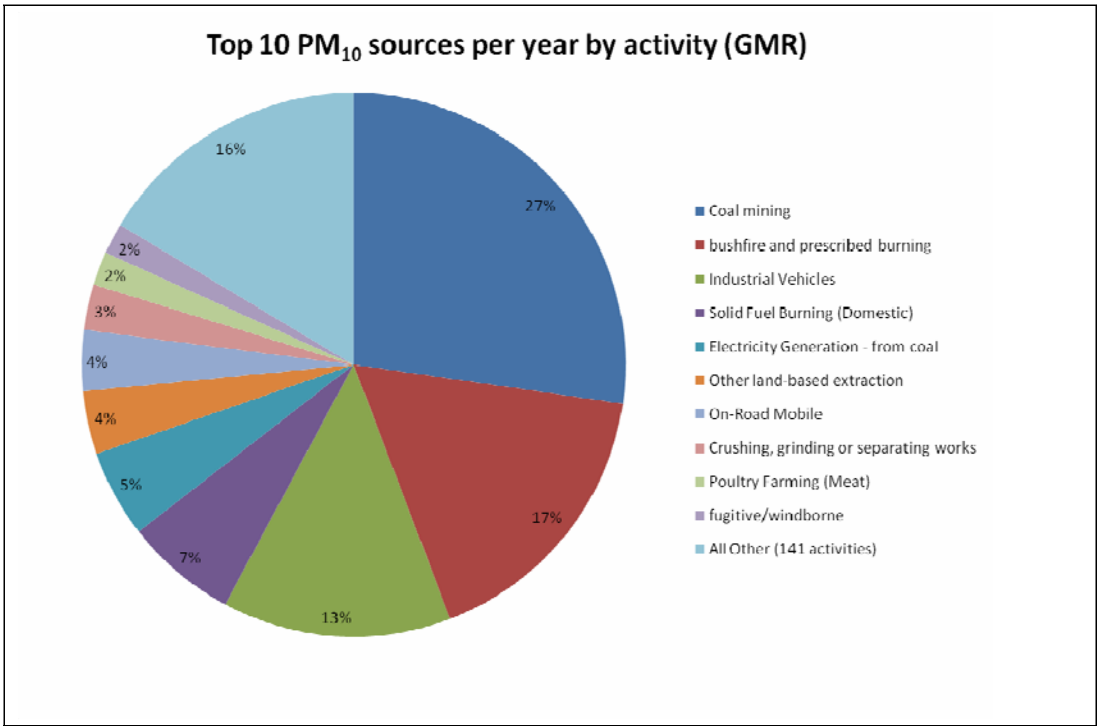

Top 10 PM_{10} emission activities - Wollongong - July 2003
44%
23%
12%
5%
3%
2%
2%
1%
1%
1%
6%
Primary iron and steel production
Solid Fuel Burning (Domestic)
Industrial Vehicles
Coal loading
On-Road Mobile
Coal mining
Coal washery reject or slag landfilling
Inert waste landfilling
bushfire and prescribed burning
Coke production
All other (40 activities)

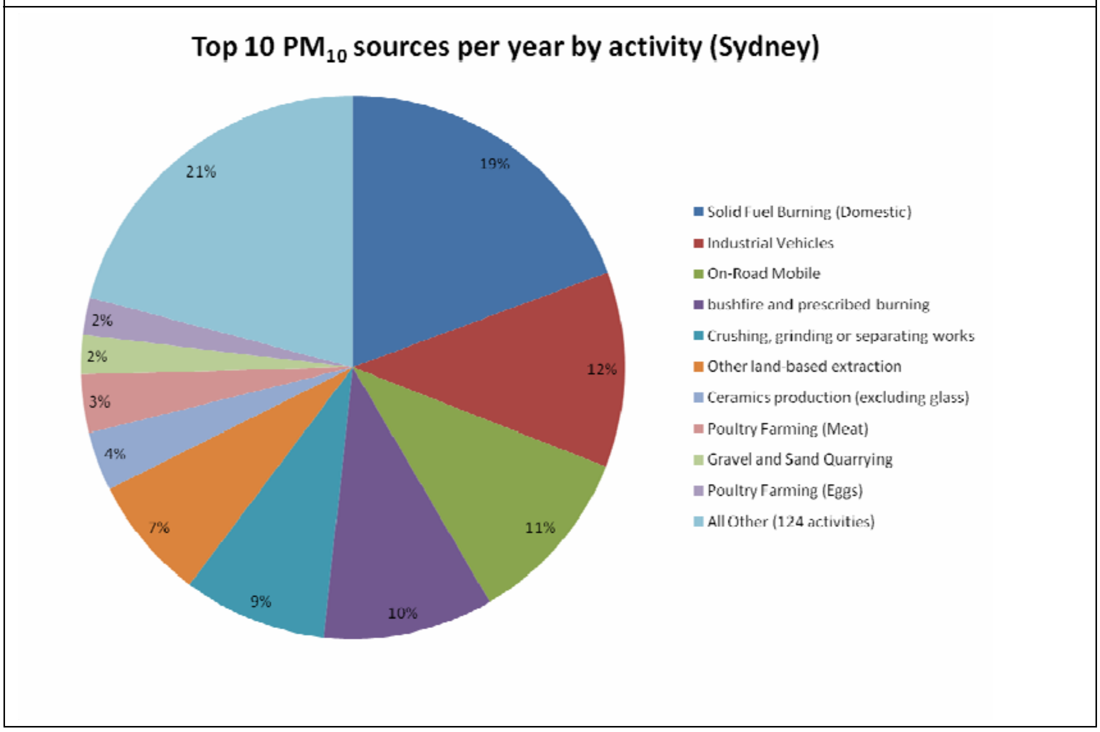

Top 10 PM_{10} emission activities - Newcastle - July 2003
33%
13%
8%
6%
5%
4%
4%
3%
2%
2%
20%
Solid Fuel Burning (Domestic)
Coal mining
Industrial Vehicles
Agricultural Fertilizer and/or Ammonium Nitrate Production - Production of ammonium nitrate
On-Road Mobile
Hard-rock gravel quarrying
Primary aluminium production
Bitumen pre-mix or hotmix production
Crushing, grinding or separating works
Gravel and Sand Quarrying
All other (49 activities)

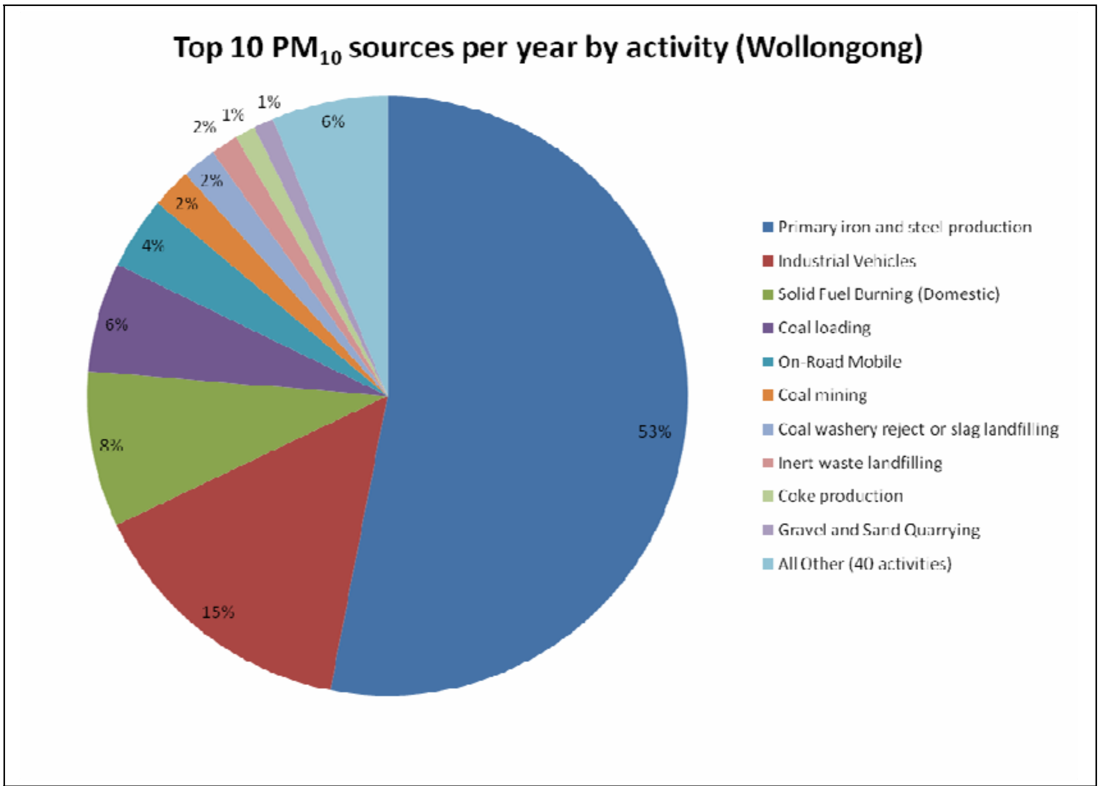

Top 10 PM10 emission activities - Non-urban - July 2003
49%
18%
10%
6%
3%
3%
2%
1%
1%
1%
6%
Coal mining
Industrial Vehicles
Electricity Generation - Generation of electrical power from coal
Solid Fuel Burning (Domestic)
Other land based extraction
Hard rock gravel quarrying
Poultry Farming (Meat)
fugitive/windborne
Gravel and Sand Quarrying
On-Road Mobile
All other (62 activities)

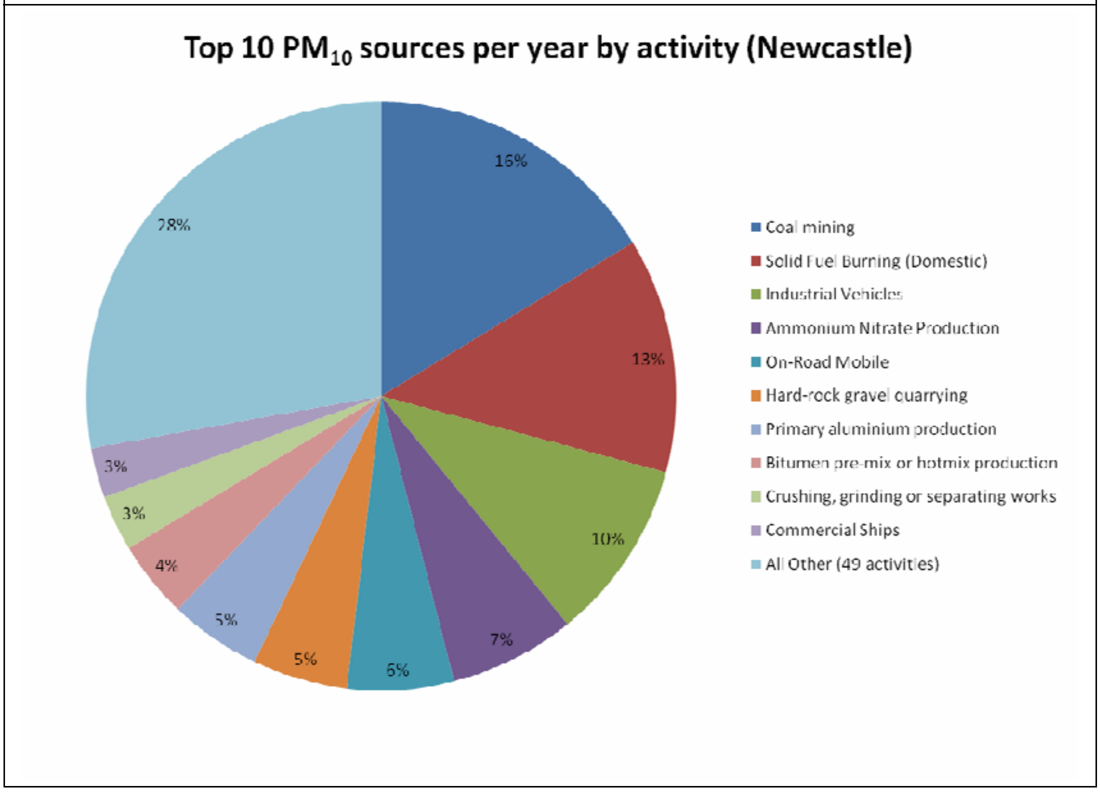
▪ **Figure B-15 Ten Largest Anthropogenic Activity Sources of PM_{10} Emissions**

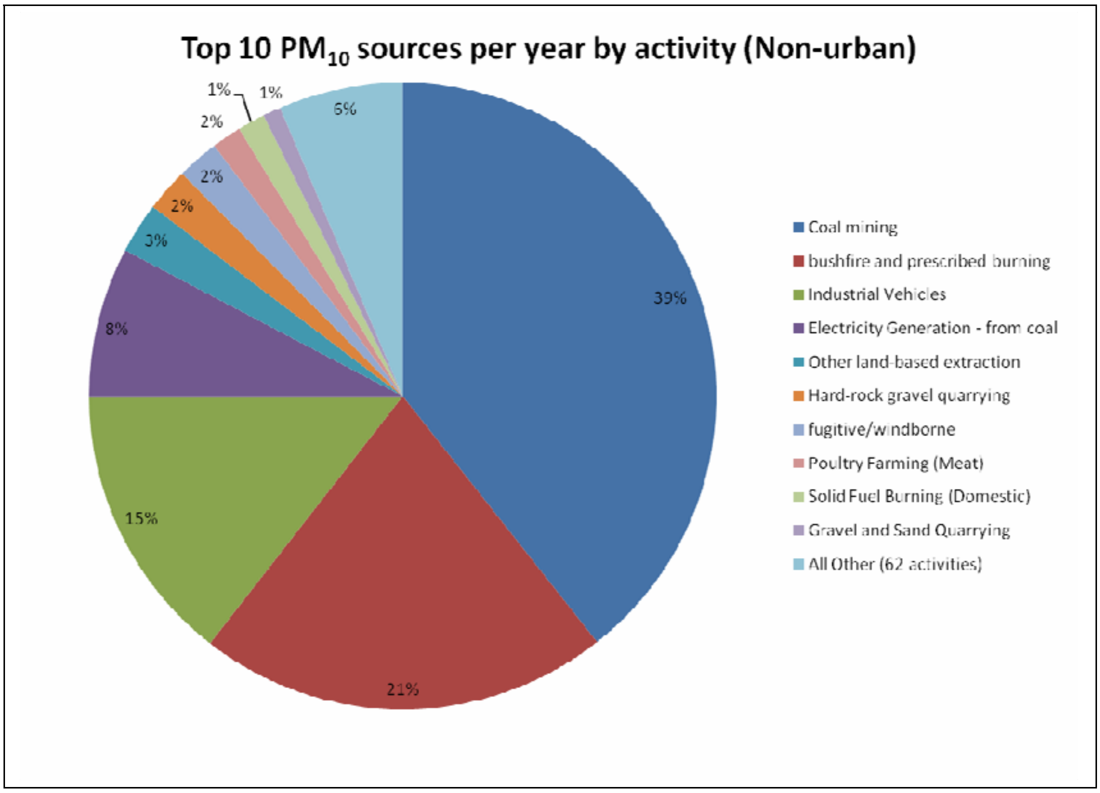
Source: DECC 2007f






Top 10 PM10 sources per year by activity (Wollongong)
53%
15%
8%
6%
4%
2%
2%
2%
1%
1%
6%
Primary iron and steel production
Industrial Vehicles
Solid Fuel Burning (Domestic)
Coal loading
On-Road Mobile
Coal mining
Coal washery reject or slag landfilling
Inert waste landfilling
Coke production
Gravel and Sand Quarrying
All Other (40 activities)


Top 10 PM10 sources per year by activity (Newcastle)
16%
13%
10%
7%
6%
5%
5%
4%
3%
3%
28%
Coal mining
Solid Fuel Burning (Domestic)
Industrial Vehicles
Ammonium Nitrate Production
On-Road Mobile
Hard-rock gravel quarrying
Primary aluminium production
Bitumen pre-mix or hotmix production
Crushing, grinding or separating works
Commercial Ships
All Other (49 activities)



Top 10 PM_{10} sources per year by activity (Non-urban)
39%
21%
15%
8%
3%
2%
2%
2%
1%
1%
6%
Coal mining
bushfire and prescribed burning
Industrial Vehicles
Electricity Generation - from coal
Other land-based extraction
Hard-rock gravel quarrying
fugitive/windborne
Poultry Farming (Meat)
Solid Fuel Burning (Domestic)
Gravel and Sand Quarrying
All Other (62 activities)

Appendix C Reference Case Assumptions

Source: DECC, 2007a, 2007c, 2007e

Source Type	Assumptions
On-Road Mobile Emissions	■ As shown by a drive cycle comparative study undertaken by Ford Australia, a progressive tightening in testing stringency presumably will achieve future reductions in in-service emissions, regardless of emission limits.
	■ In service conformity checking measures incorporated in the original EURO III will not be effectively implemented under Australian conditions, thus durability will remain unchecked. The EURO III in-service conformity requirement has no bearing on changing NOx emission deterioration behaviour.
	■ Emission levels of CO, VOCs and NO_x for a new car are initially 50% of the relevant emission limits under EURO II and III standards.
	■ The trend of steady improvement in CO emission deterioration performance is assumed to continue through EURO II and EURO III.
	■ The decreasing trend in VOC emission deterioration rate is about to plateau and emission deterioration though EURO II and III will not change dramatically.
	■ The level of NOx emission deterioration in EURO II stays the same as the pre-EURO level, and under EURO III a small improvement is assumed.
	■ Most current petrol light duty commercial vehicles emission levels are very high – close to uncontrolled level passenger cars. A significant reduction is therefore expected after EURO II comes into force: ■ For NOx, under EURO II new vehicle emission level is about 90% of the emission limit while keeping deterioration unchanged. ■ Under Euro III, new vehicle level will be 50% the emission limit, and deterioration will be half of that of EURO II. ■ For CO and VOC under EURO II and III, the same assumptions as for NOx are used.
	■ For heavy duty commercial vehicles emission deterioration is assumed to be insignificant and thus not accounted for.

Source Type			Assumptions
			▪ Emission factor for diesel light duty vehicles in the current fleet were developed from National Environment Protection (Diesel Vehicle Emissions) Measure (DNEPM, NEPC, 2007) data. No deterioration is assumed.
			▪ Due to the significant portion of imported diesel vehicles from countries with more stringent standards it is assumed that 50% of vehicles are EURO II compliant in 1997 and 20% are EURO III compliant in 2001. Thus, overall emission performance of heavy diesel fleet will be better than the legal requirement.
			▪ There is no significant impact from changes in emission standards for evaporative emissions.
			▪ EURO IV and V for heavy duty vehicles have not been included in the projection.
Industrial Emissions	NO_x	Electricity Generation (coal)	▪ Projection factors derived from Australian Bureau for Agricultural and Resource Economics (ABARE) projected primary energy consumption of black coal for electricity generation in NSW 2005.
		Primary Iron and Steel Production	▪ Projection factors derived from ABARE projected final energy consumption for aluminium smelting in NSW 2005.
		Cement or Lime Production	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW Department of Planning (DoP), assuming that activity growth is proportional to population growth.
		Petroleum Refining	▪ Projection factors have been based on ABARE projected primary energy consumption by the petroleum refining industry in NSW 2005.
		Electricity Generation (gas)	▪ Projection factors derived from ABARE projected primary energy consumption of natural gas and biogas for electricity generation in NSW 2005.
	VOCs	Petroleum Refining	▪ Projection factors have been based on ABARE projected primary energy consumption by the petroleum refining industry in NSW 2005.
		Metal Plating or Coating Works	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that emissions growth from metal plating or coating works is proportional to population growth.

Source Type			Assumptions
Industrial Emissions	VOCs	Printing	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that emissions growth from printing is proportional to population growth.
		Other Metal Processing	▪ Projection factors derived from ABARE projected primary energy consumption for the manufacturing and construction sector in NSW 2005.
		Electricity Generation (coal)	▪ Projection factors derived from ABARE projected primary energy consumption of black coal for electricity generation in NSW 2005.
		Other Chemical Processing	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that emissions growth from chemical processing is proportional to population growth.
		Primary Iron and Steel Production	▪ Projection factors derived from ABARE projected final energy consumption for aluminium smelting in NSW 2005.
		Hazardous Industry or Group A Waste Generation or Storage	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity growth in the hazardous industrial group A waste generation or storage sector is proportional to population growth.
		Plastics Production	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that emissions growth from plastics production is proportional to population growth.
		Electricity Generation (gas)	▪ Projection factors derived from ABARE projected primary energy consumption of natural gas and biogas for electricity generation in NSW 2005.
		Other Chemical Storage	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity growth for other chemical storage facilities is proportional to population growth.
		Solid Waste Landfilling	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that emissions growth from solid waste land filling is proportional to population growth.

Source Type			Assumptions
Industrial Emissions		Petrochemical Production	▪ Projection factors derived from ABARE projected primary energy consumption by the petroleum refining in NSW 2005.
		Storage of Petroleum and/or Petroleum Products	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity growth for storage of petroleum and petroleum products is proportional to population growth.
	PM_{10}	Coal Mining	▪ Projection factors derived from ABARE projected black coal production growth rates in Australia 2005.
		Electricity Generation (coal)	▪ Projection factors derived from ABARE projected primary energy consumption of black coal for electricity generation in NSW 2005.
		Other Land-based Extraction	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP.
		Crushing, Grinding or Separating Works	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity growth from in crushing or grinding or separating facilities is proportional to population growth.
		Hard-rock Gravel Quarrying	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP.
		Primary Iron and Steel Production	▪ Projection factors derived from ABARE projected final energy consumption for aluminium smelting in NSW 2005.
		Ceramics Production (excluding glass)	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centred NSW DoP, assuming that activity growth from in ceramic production facilities is proportional to population growth.
		Solid Waste Landfilling	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centred NSW DoP, assuming that emissions growth from solid waste land filling is proportional to population growth.
		Concrete Batching	▪ Projection factors have been derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity growth from the

Source Type			Assumptions
			concrete product manufacturing sector is proportional to population growth.
Commercial Emissions	NO_x	Hospitals (except psychiatric Hospitals)	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that growth in the hospital sector is proportional to population growth.
		Unaccounted Fuel Combustion	▪ Projection factors have been derived from ABARE projected total primary energy consumption of natural gas in NSW, 2006. All unaccounted for fuel combustion is assumed to be natural gas.
		Port Operators	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth of the identified port operator is proportional to population growth.
		Glass and Glass Product Manufacturing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the glass and glass product manufacturing sector is proportional to population growth.
		Plaster Product Manufacturing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the plaster manufacturing sector is proportional to population growth.
		Metal Coating and Finishing	▪ Projection factors have been derived from ABARE projected final energy consumption for the manufacturing and construction sector in NSW, Australia Energy Statistics 2006.
		Food Manufacturing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the food manufacturing sector is proportional to population growth.
	VOCs	Automotive Fuel Retailing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP.
		Smash Repairing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the smash repair sector is proportional to population growth.

Source Type			Assumptions
Commercial Emissions		Printing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the printing sector is proportional to population growth.
		Laundries and Dry-Cleaners	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the laundries and dry-cleaning sector is proportional to population growth.
		Chemical Product Manufacturing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the chemical product manufacturing sector is proportional to population growth.
		Food Manufacturing	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the food manufacturing sector is proportional to population growth.
	PM_{10}	Poultry Farming	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that activity data growth in the poultry farming sector is proportional to population growth.
		Hospitals (except psychiatric Hospitals)	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP, assuming that growth in the hospital sector is proportional to population growth.
		Unaccounted Fuel Combustion	▪ Projection factors have been derived from ABARE projected total primary energy consumption of natural gas in NSW, 2006. All unaccounted for fuel combustion is assumed to be natural gas.
		Construction Material Mining	▪ Projections factors were derived based on population projections provided by the Transport and Population Data Centre, NSW DoP.

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Appendix D Initial Identified Abatement Options

Reference *Cost Effectiveness of Action-for-Air-Programs,* (DECCW,2009, personal communication) 5 programs costed - (1) Summer low volatility in petrol (VOCs calculations) (2) Diesel retrofit (PM10 calculations) (3) Vapour recover (VR2) (VOC calculations) (4) Industrial emission limits (old plant upgrade) (PM10, NOx) (5) Cleaner government fleet (PM10 calculations) For full source references, assumptions, inclusions, see Confidential documents provided by DECCW 18 Feb 09 average avoided tonnes p.a. (NOx ~10,600 tpa, VOC ~7,500 tpa, PM10 ~760 tpa) total cost is approx $700 million.				
Measure & Pollutant	**Total avoided (tonne)**	**Total abatement costs ($ millions)**	**Average avoided /year (tonnes)**	**Abatement cost/tonne ($A)**
Petrol Volatility (greatest reduction option 62kPa to 60kPa), VOCS	9,819 (5 yrs)	88.5	1,964	$9,016
Diesel Retrofit, PM10	1,239 (10 yrs)	318	129	$245,922
VR2 (preferred option), VOC	65,700 (13 yrs)	136	5,475	$2,575
Old Plant Upgrade (PM10, NOx) PM10 Low NOx option High NOx option	 12,529 (20 yrs) 139,379 (20 yrs) 72,208 (20 yrs)	 9 28 102	 629 6,969 3,610	 $750 $204 $1,416
Diesel Retrofit 488 STA Buses (PM10)	21 (10 yrs)	4	2.07	193,632

Reference				
MMA 2001, *NOx and Fine Particle Reduction Options from Non-Licensed Sources,* prepared by McLennan Magasanik Associates Pty Ltd, South Melbourne, for NSW Environment Protection Authority, September 2001				
32 Costed Measures. For full assumptions see reference. No attempt made to exclude programs that were mutually exclusive. That is, there was more than one potential program for each emission source and the implementation of one program may preclude subsequent programs (MMAS, 2001:i-ii). Further, the study does not consider the potential synergies or conflicts between programs or the allocation of costs to the reduction of secondary pollutants.				
Table 1 Summary of Control for NOx Emissions				
Source Type	**Sub Source Type**	**Abatement Action**	**Cost ($A/t)**	**Maximum Emission Reduction (t/y)**
Motor Vehicles	**Passenger Vehicles**	**Accelerated Vehicle Retirement**	**$22,000**	**100**
		Inspection & Maintenance (I&M) Programs	$18,000	3,000
		Remote Sensing I&M	$6,000	3,000
		Retrofit Controls	$55,000	18
		Demand Management	$2,800	3,000
		Parking Surcharges	$530	3,000
		Fuel Taxes 20%	$12,500	33,000
		Fuel Taxes 50%	$31,000	8,400
Commercial / Industrial Combustion	Boilers / Furnaces	General Engineering (max $)	$50	2,000
Stationary IC Engines	Rich-Burn Sla (Spark Ignition) (Natural Gas Fuel)	Air Fuel Ratio Adjustment (AF)	$4,200	540
		Ignition Timing Retard (IR)	$4,100	430
		AF + IR	$4,200	
		Prestratisfied Charge (PSC)	$9,300	1,870
		Non-Selective Catalytic Reduction (NSCR)	$900	2,000
		Low-Emission Combustion (L-E)	$200	1,900
	Lean-Burn SI (NG Fuel)	AF	$5,100	430
		IR	$3,700	210
		AF + IR	$4,900	650
		SCR	$9,200	1,900

		Demand Management	$2,800	3,000
		L-E	$1,100	1,900
	Diesel Combustion Engine	IR	$4,100	540
		SCR	$25,000	1,800
	Dual-Fuel Compression Ignition (CI)	IR	$1,900	540
		SCR	$5,700	1,800
		L-E	$8,600	1,600
Marine	Shipping	SCR	$1,000	1,800
		Humid Air Motor	$1,000	1,600
Railways		Electrification	$40,000	4,000
		New & Refurbished Emission Standards	$360	
		Natural Gas Conversion & SCR	$7,500	

Table 2 Summary of Control for PM10 Emissions

Source Type	Sub Source Type	Abatement Action	Cost ($A/t)	Maximum Emission Reduction (t/y)
Domestic Fuel Combustion	Wood heaters	Heater Standards	$1,800	200
		Wood Moisture Standards	$5,200	90
		Education in Proper Use	$3,500	150
		Smoke Monitoring & Enforcement	$3,200	230
		Replacement Heater Subsidies for AS4013 Open Fire (max $)	$3,800	120
		Replacement Heater Subsidies for Gas/ Electricity	$2,900	140
		Replacement Heater Subsidies for AS4013 Conventional (max $)	$6,300	85
		Replacement Heater Subsidies Conventional Gas/ Electricity (max $)	$4,200	130
		Insulation Retrofit to all	$11,200	12
		Insulation Retrofit to selected (max$)	$8,000	10
		Substituting Fire logs	$18,000	use on high pollution days
		Banning resale of inefficient heaters	NA	14

		Banning Open Fireplace	NA	780
Open Burning	Backyard Burning	Increased Education / Enforcement	$1,900	185
Motor Vehicles	Diesel Buses	Retrofit Particle Traps	$1,900	2,000
		Fuel Substitution (to LNG)	$20,000	2,000
	Diesel Trucks	Retrofit Particle Traps	$1,900	900
Mowers	Petrol Operated	2-Stroke to Electric Subsidy	$30,500	2

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Reference Greaves, S., *An Assessment of Strategies for Reducing the Greenhouse Gas and Air Quality Impacts for Road Freight in Sydney, Phase II – Modelling and Mitigation Measures*, prepared for NSW Government Department of Environment and Climate Change, by Dr Stephen Greaves, in association with The Institute of Transport and Logistic Studies, University of Sydney, December 2008 See reference for underlying assumptions. 14 Costed Technologies for Diesel Retrofit ($US) relevant to NOx &/or PM. Sulphur tolerance indicates the quality of diesel fuel required for the particular technology to work properly							
Technology	**Emission Reduction (%)**				**Fuel Penalty (%)**	**Sulphur Tolerance (ppm)**	**Price ($US/?)**
	NOx	**PM10**	**HC**	**CO**			
Base Metal Oxidation		10-30	50	50	0-2	<500	1-2K
Precious Metal Oxidising PM Filter		20-40	90	90	0-2	<15	1-3k
Base Metal Oxidising PM Filter		80	50	50	2-4	<500	6.5-10k
Highly Oxidising Precious Metal PM Filter	0-5	>90	90	90	<15		6.5-10k
Active Lean NOx Catalyst (requires supplementary fuel injection)	20				4-7	<250	6.5-10k
4-Way Catalyst (Active Lean NO_XCat + PM Filter)	20	80	70	70	4-7	<500	8-10k
NOx Absorber (requires engine integration for supplementary fuel injection)	>90	10-30	90	90	-	<15	
Diesel Emulsion	5-30	20-50			0	>500	0.01/gal
Selective Catalytic Reduction (SCR)	60	0-30	50	50	Urea consumption 4% of fuel use	<500	10-20k, urea 0.80/gal
Compact SCR	90	10-30	90	90	Urea consumption 6% of fuel use	<500	10-20k, urea 0.80/gal
Fuel Borne Catalyst (FBC)	<10	<33	<50	<50	-8	<350	0.05-0.06/gal
FBC w/lightly catalyzed oxidation catalyst	<10	30-60	<50	<50	4-6	<350	1-1.5k, 0.05-0.06/gal
FBC w/lightly catalyzed PM filter	<10	85	80	80	2	<50	3.5-4.5k, 0.05-0.06/gal
Cooled-EGR	50				0-5	<500	3.5-4.5k, 0.05-0.06/gal

Appendix E Emission Source Groupings

Module	Source Group Name	Included Activities
Commercial	Food & Beverage	Poultry Farming (Meat)
		Poultry Farming (Eggs)
		Food Manufacturing n.e.c.
		Bread Manufacturing
		Wine Manufacturing
		Spirit Manufacturing
		Cake and Pastry Manufacturing
		Biscuit Manufacturing
		Soft Drink, Cordial and Syrup Manufacturing
		Ice Cream Manufacturing
		Milk and Cream Processing
		Spring and Wire Product Manufacturing
		Fruit and Vegetable Processing
		Confectionery Manufacturing
	Metal & Equipment Manufacturing, Handling, Finishing	Basic Non-Ferrous Metal Manufacturing n.e.c.
		Non-Ferrous Metal Casting
		Steel Pipe and Tube Manufacturing
		Structural Steel Fabricating
		Electric Cable and Wire Manufacturing
		Basic Iron and Steel Manufacturing
		Fabricated Metal Product Manufacturing n.e.c.
		Structural Metal Product Manufacturing n.e.c.
		Lifting and Material Handling Equipment Manufacturing
		Mining and Construction Machinery Manufacturing
		Automotive Component Manufacturing n.e.c.
		Electrical and Equipment Manufacturing n.e.c.
	Chemical/ Petrochemical Manufacture, Wholesale	Chemical Product Manufacturing n.e.c.
		Chemical Wholesaling
		Soap and Other Detergent Manufacturing
		Medicinal and Pharmaceutical Product Manufacturing
		Synthetic Resin Manufacturing
		Plastic Injection Moulded Product Manufacturing
		Ink Manufacturing
		Plastic Product, Rigid Fibre Reinforced, Manufacturing

Module	Source Group Name	Included Activities
		Petroleum Product Wholesaling Plastic Bag and Film Manufacturing
	Other Manufacture	Plaster Product Manufacturing Concrete Slurry Manufacturing Ceramic Product Manufacturing Solid Paperboard Container Manufacturing Furniture Manufacturing n.e.c. Wood Product Manufacturing n.e.c. Aircraft Manufacturing Paper Product Manufacturing n.e.c. Corrugated Paperboard Container Manufacturing Prepared Animal and Bird Feed Manufacturing Wooden Furniture and Upholstered Seat Manufacturing Rubber Product Manufacturing n.e.c. Ceramic Product Manufacturing n.e.c.
	Mining/ Construction	Non-Building Construction n.e.c.
	Other comm.services	Rail Transport Funeral Directors, Crematoria and Cemeteries Gas Supply Industrial Gas Manufacturing
Industrial	Extraction Other processing	Rendering or fat extraction Other metal processing Other chemical processing Composting and related reprocessing or treatment Other agricultural crop processing Milk processing Other livestock processing Used tyre processing or disposal Drum or container reconditioning Wood or timber milling Animal slaughtering Wood preservation Contaminated soil treatment Metal plating or coating works Other activities – printing Other activities - dry cleaning
	Waste/ landfill, recycling	Waste storage, transfer, separating or processing Biomedical waste incineration

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Module	Source Group Name	Included Activities
		Waste oil recovery Coal washery reject or slag landfilling Scrap metal recovery Landfilling in designated areas Inert waste landfilling Solid waste landfilling Sewage Treatment - processing by large plants (> 10000 ML per year) Hazardous, industrial or group A waste generation or storage Sewage Treatment - processing by small plants (< 10000 ML per year) Environmentally sensitive area landfilling Hazardous, industrial, group A or group B waste processing Hazardous, industrial, group A or group B waste disposal
	Handling / Storage	Chemical Storage - Storage of Petroleum and/or Petroleum Products Chemical Storage - Other Chemical Storage Mooring and boat storage Chemical storage Other vessel construction or maintenance
	Other Production	Battery production Pesticides production Secondary non-ferrous production (excluding aluminium) Pharmaceutical or veterinary products production Beer or distilled alcohol production Primary non-ferrous production (excluding aluminium) Soap or detergent production Agricultural Fertilizer and/or Ammonium Nitrate Production - Production of phosphate fertilizer Poultry production Plastics production Explosives or pyrotechnics production Secondary iron and steel production Ceramics production (excluding glass) Paper production using recycled materials
		Paint production Other activities - soft drink manufacturing Other activities - bread manufacturing

Module	Source Group Name	Included Activities
		Other activities - oil and fat manufacturing Other activities - confectionary manufacturing Other activities - cake and pastry manufacturing
	Other Industrial - transport	Aircraft (helicopter) facilities Railway activities Vessel construction or maintenance using dry or floating docks Other activities - services to air transport Freeway or tollway construction

Appendix F Abatement Initiative Templates

F.1 GMR

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F.1.1 On-road Mobile - Technology Initiatives

Abatement Initiative #4: Summer-time Petrol Volatility (62 kPA to 60 kPA)					
Description	This measure is as per DECC, 2009 and involves reducing summer petrol volatility from 62 kPA to 60 kPA				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			High
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	32	-	1,236	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		0	000 AUD		
Implementation (capital)		1,495	000 AUD		
Annual operating / ongoing		6,696	000 AUD		
Assumptions and comments					
There are unique features associated with the cost estimate for reducing petrol volatility and significant factors which could not be incorporated into the study, which limits the accuracy and comparability of the figure derived. In particular: Emission reduction figures do not take into account the increasing use of ethanol 10% ethanol petrol (E10). Ethanol petrol blends between 5 and 10% significantly increase VOC emissions (while providing the benefit of reduced particle emissions). The NSW Biofuels regulation requirement for all unleaded petrol to be blended with E10 means that 90% of ethanol petrol in NSW will be E10. All VOC reductions achieved by tightening petrol volatility limits are delivered during summer when ozone exceedances occur. This means that lowering petrol volatility limits is more effective in managing ozone formation than actions which provide comparable emission reductions spread over the full calendar year. Compliance figures are based on aggregated NSW oil industry estimates of likely future costs (ie reduced revenue streams from selling butane in other markets rather than in petrol) and developed following extensive stakeholder consultation, while costings for other measures are often based on broad overseas measures and adjusted to Australian dollars.					

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Abatement Initiative #5: Truck and Bus Diesel Retrofit

Description	Diesel retrofit for trucks and buses, based on DECC, 2009 data.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Low
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	21,716	591	2,810	
	Abatement (tpa)	-	7	-	
	Abatement from proportion of source affected (%)	0%	1%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		0	000 AUD		
Implementation (capital)		6,000	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

Emissions reduction and cost data provided by DECC, 2009. Source of cost data is RTA Retrofit Stage 4 Program Report. Assumptions are that it is a $6M program over 4 years; 50/50 govt./private split; 133 trucks per million $ of program; $7500 average per truck, each truck retrofitted has 10 years remaining life; 9 kg of PM10 abated per truck per year. The NSW retrofit program is examining incorporation of energy efficiency devices on vehicles (such as improved vehicle aerodynamics, idle-off devices, low roll resistant tyres, or driver training). This "Smartway" style extension of the program is expected to reduce scheme costs, lower fuel use and reduce greenhouse gas emissions. (See measure 28).

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Abatement Initiative #27: Euro 5/6 Emission Standards for New Passenger Vehicles

Description	This measure requires all new passenger and light duty commercial petrol vehicles from 2014 to meet Euro 5/6 standards. NOx and PM10 emissions will reduce with emission factors for new vehicles being NOx = 0.06 g/km and PM10 = 0.005 g/km				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Exhaust Emissions Passenger Cars - Petrol				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	46,252	841	22,379	
	Abatement (tpa)	18,820	161	6,832	
	Abatement from proportion of source affected (%)	41%	19%	31%	
Impact 2		**Pollutants**			**Medium**
AEI Activity:	Exhaust Emissions Light Duty Commercial - Petrol				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	4,160	50	4,261	
	Abatement (tpa)	426	14	1,898	
	Abatement from proportion of source affected (%)	10%	27%	45%	
Implementation costs					**Low**
Program / set-up		1,000	000 AUD		
Implementation (capital)		693,950	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Note: Emission reduction statistics are based on DECC, 2009 on-road mobile emissions modelling. DECC provided yearly "Scenario" and "BAU" emissions from 2014 - 2031 and the annual average emission reductions have been applied to all years. Cost estimates have been derived using a marginal cost of $85 per new Euro5/6 petrol vehicle and $1000 per new Euro5/6 diesel vehicle (Ref: http://www.infrastructure.gov.au/roads/environment/files/FINAL_Draft_RIS_E5_E6_Light_Vehicles_Emissions_Review_20100104.pdf) with the number of new vehicles in the GMR sourced from the 2008 RTA Handbook, with a calculated 1 % of passenger vehicles and 35 % of light commercial vehicles being diesel and the remainder petrol. Costs are extrapolated to 2031 using ABS population projection data.					

Abatement Initiative #28: SmartWay Program

Description	Improved Aerodynamics for whole B-Double vehicle & trailers				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	21,716	591	2,810	
	Abatement (tpa)	869	24	112	
	Abatement from proportion of source affected (%)	4%	4%	4%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		1,000	000 AUD		
Implementation (capital)		1,567,460	000 AUD		
Annual operating / ongoing		(863,169)	000 AUD		
Assumptions and comments					

Note: Program, fuel saving and cost data provided by DECC, 2009. A 4 % in fleet fuel saving has been assumed from the 12 % reduction in fuel saving (10 - 14 % range) per vehicle, noting that approx. 2/3 of the vehicle fleet would have aerodynamic kits fitted already. The 4% reduction in fuel has been assumed to result in 4 % reduction in emissions. DECC, 2009 costs are estimated at $60,000 per truck. RTA statistics indicate that there are 78373 heavy vehicles in NSW, and therefore total costs to retrofit 1/3 of the fleet is $1,567,460,000. The fuel savings are based on 25,416 litres per vehicle per year (DECC, 2009) at $1.30 per litre, a total saving of $863,168,873 per year. The greenhouse gas emission reduction co-benefits of the SmartWay program associated with improved fuel consumption have not been calculated.

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F.1.2 On-road Mobile – Travel Demand Initiatives

Abatement Initiative #11: Shift Transport Mode to Cycling					
Description	Increase Installations of Cycle Ways and Cycling Marketing Campaigns - Install cycle ways in urban areas and multiply the number of trips made on bicycle by 5 by 2020 (currently 1% of all trips in metro Sydney are on bike)				
Regions:	Sydney, Newcastle, Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Exhaust Emissions Passenger Cars - Petrol				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	40,272	760	19,645	
	Abatement (tpa)	403	8	196	
	Abatement from proportion of source affected (%)	100%	100%	100%	
Impact 2		Pollutants			Low
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	16,526	456	2,283	
	Abatement (tpa)	165	5	23	
	Abatement from proportion of source affected (%)	100%	100%	100%	
Implementation costs					Low
Program / set-up		3,010	000 AUD		
Implementation (capital)		339,775	000 AUD		
Annual operating / ongoing		(334,788)	000 AUD		
Assumptions and comments					
Cycling data is from RTA, MOT "Cycling in Sydney - Bicycle ownership and use" (2008). It is assumed that 50% of mode shift to cycling will be from private vehicles while 50% will be from public transport. It is assumed that new bicycles will be purchased by the increasing number of cyclists, averaging $80/cyclist. Cost of cycleways is based on implementation cost of A$7,000,000 for Marrickville which contains approximately 2.2 % of the NSW urban population.					

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F.1.3 Non-road Mobile

Abatement Initiative #2: Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2					
Description	This initiative involves replacing existing NSW rail fleet locomotives (assumed to be USEPA Tier 0) with Tier 2 locomotives.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	3,662	109	157	
	Abatement (tpa)	1,538	74	-	
	Abatement from proportion of source affected (%)	42%	68%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		100	000 AUD		
Implementation (capital)		381,931	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
This initiative can be achieved by an engine system replacement (est. cost A$1M) or replacing the entire locomotive (est. cost A$3M): Source : LGreentree. Tier 0 NOx = 59 g/L, Tier 2 NOx = 34.5 g/L (42% reduction). Tier 0 PM10 = 1.39 g/L, Tier 2 PM10 = 0.47 g/L (66 % reduction) It is estimated that there are 366 locomotives on the NSW rail network (Source: http://locopage.railpage.org.au) that could be retrofitted or would need to be replaced for 100 % uptake of this action. Note: Locomotives able to achieve Tier 2 emission standards eg. Pacific National (PN) 92 class or Queensland Rail (QR) 5000 class are now being introduced to the NSW rail fleet.					

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Abatement Initiative #3: Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 plus USEPA Tier 2 ---> Tier 4

Description	Replace Diesel locos with Tier 2 (As per Initiative #2), then as per CARB reference: Technical Options to Achieve Additional Emission and Risk Reductions from Californian Locomotives and Railyards (Draft, Dec 2008), The NOx reduction technology is Selective Catalytic Reduction (SCR) and particulate reduction technology is diesel particulate filters (DPF). Note this initiative is mutually exclusive with initiative 2 (Tier 0 -> Tier 2) as it includes the impact and cost of that measure in addition to SCR and DPF.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	3,662	109	157	
	Abatement (tpa)	3,324	101	-	
	Abatement from proportion of source affected (%)	91%	93%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		200	000 AUD		
Implementation (capital)		650,896	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
A cost of US $500,000 per loco (366 locos in total) is provided to upgrade Tier 2 equivalent locos (Tier 2 NOx = 34.5 g/L and PM = 0.47 g/L) to Tier 4 (NOx = 5.5 g/L and PM = 0.11 g/L). Costs & abatement include Init #2 (Tier 0 -> Tier 2 replacement) + additional costs & abatement from Tier 2 -> Tier 4: SCR and DPF (converted from USD to AUD).					

Abatement Initiative #15: Recommission and Electrify Enfield-Port Botany Freight Line

Description	Recommission and electrify Enfield-Port Botany freight line for container movements between Port Botany and the Enfield Intermodal Centre (ILC) on the existing reservation. This measure would result in a reduction in NOx, VOCs and PM10 from reducing truck movements delivering containerised freight on the Sydney road network, and also zero emissions from electric locomotives compared to diesel.				
Regions:	Sydney,				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,757	52	76	
	Abatement (tpa)	106	3	5	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		**Pollutants**			**Low**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		100	000 AUD		
Implementation (capital)		29,260	000 AUD		
Annual operating / ongoing		(1,608)	000 AUD		
Assumptions and comments					

Reductions in truck emissions were estimated in the Environmental Assessment (EA) for the Enfield Intermodal Logistics Centre (ILC) - SKM, 2005. Reductions amounts in 2016 annual emissions from trucks were calculated as follows: NOx = 79 tpa, VOCs = 7 tpa, PM10 = 4.3 tpa. Reductions in locomotive emissions from diesel powered trains that would use the line in the absence of electrification are as follows: NOx = 106 tpa, VOCs = 5 tpa, PM10 = 2.5 tpa. It noted that while the Enfield ILC project is proceeding (currently under construction) there is no proposal to electrify the rail line. The costs determined for this this initiative are the costs to electrify the rail line only, as the ILC is under construction. A review of literature (ref: http://www.railcrc.net.au/publications/downloads/R1106-Paper-8-Powering-Rail-Electrification--Emissions-Intensity.pdf) outlined that the cost of electrifying existing rail lines is variable, but a recent 2007 UK study identified costs to be in there range of £550K to £650K per single track kilometre. A capital cost of £600K per km (A$1.3M per km) was applied to this initiative and equates to $23.4M for the 18 km track. It would also be necessary to purchase 4 x electric freight locomotives (assume refurbished 86 class locomotives at $A1M per locomotive - A$4M total). In terms of diesel locomotive operating costs that will be saved compared to electric locomotives this has been determined based on an estimated 105,120 train kilometres per year, and 17 litres of diesel per km for a train pulled by 2 x 44 class locomotives. Assuming A$1 per litre for diesel the annual fuel bill saved is A$1,787,040. Energy operating costs to replace diesel trains with electric trains is estimated at 10 % of the diesel train cost of $178,704.

SKM

Abatement Initiative #17: Port Botany Shore-Side Power

					Rating
Description	This abatement initiative involves installation of shore-side power on the 5 new berths proposed at Port Botany as part of the port expansion project.				
Regions:	Sydney,				
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Commercial Ships				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	1,658	57	62	
	Abatement (tpa)	298	10	11	
	Abatement from proportion of source affected (%)	90%	90%	90%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Medium**
Program / set-up		500	000	AUD	
Implementation (capital)		20,912	000	EUR	
Annual operating / ongoing		2,385	000	EUR	
Assumptions and comments					

Relevant cost information was sourced from the American Association of Port Authorities Draft Use of Shore-Side Power for Ocean Going Vessels White Paper (May 2007). Source: http://www.westcoastcollaborative.org/files/sector-marine/AAPA-ShorePower-050107.pdf. This document provides various examples of shore power within international port. The example chosen for cost information is the Euromax port development in Rotterdam which has a capacity of 2.3 M TEU compared with Port Botany Expansion at 1.6 M TEU. The shore power capital an annual operating cost for Euromax are €28.5M and €3.25M respectively. These costs have been directly applied at Port Botany in the ratio of 1.6/2.3. In terms of estimating the proportion of the source affected it is noted that Port Botany and Port Jackson are both within the Sydney region and 90 % of emissions are from Port Botany. Additionally DECC's AEI includes emissions from ships berthed at port and travelling to and from port within 8 km of the coast. It was estimated that 90 % of emissions occur at berth and that 50 % of Port Botany's berths will be affected by the measures. As such the proportion of the source affected is 40 % (0.9 x 0.9 x 0.5). It was further assumed that 90 % of berthed emissions would be controlled by shore power. No account of costs needed to upgrade ships to use shore power have been included. It has been assumed that over the life of the abatement (2012 - 2031) that 50 % achievable take-up is possible as new ships come on line and SPC can co-ordinate efforts with international shipping operators to use shore power compatible ships at these berths.

SKM

Abatement Initiative #18: Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)					
Description	USEPA Tier 4 emission standards being introduced for new equipment will reduce exhaust emissions of PM10 and NOx in the order of 90%. New diesel engines will have to be fitted with advanced emission after treatment devices, such as particulate filters and NOx reduction catalysts. In the US various provisions of the new regulation become effective from 2008 to 2015; for most engine categories, the Tier 4 standards will be phased-in over the period 2011-2014. This measure is proposed to be introduced in 2014.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	1,502	85	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		600	000	AUD	
Implementation (capital)		29,362	000	USD	
Annual operating / ongoing		0	000	AUD	
Assumptions and comments					
Emissions reduction potential and cost information have been sourced from DieselNet: http://www.dieselnet.com/news/2004/05epa2.php. It should be noted that the quoted 90% emissions reduction will be variable based on the actual make-up of the equipment fleet in the 2003 AEI year, which is understood to resemble the US fleet in the same year. Further in the AEI while diesel powered equipment make up the majority of equipment, there are also petrol, LPG etc items of plant which will be unaffected by this measure, as such the measure assumes 80 % reduction in NOx emissions rather than 90 %. Commercial/construction plant: A 20 % reduction in PM10 is assumed, as this measure will not impact particulate emissions from wheel generated dust etc. In terms of costs DieselNet estimates a 1 -3 % increase on existing equipment costs to meet Tier 4 standards. For commercial plant there is an estimated 44 new plant items coming online between 2014 and 2031 @ US$230K per plant item, the marginal cost increase would be up to US$6900 per item of plant. A total cost of US$303,600 for commercial plant. For construction plant there is an estimated 50 new plant items coming online between 2014 and 2031 @ US$230K per plant item, the marginal cost increase would be up to US$6900 per item of plant. A total cost of US$345,000 for construction plant. The total cost for both commercial and construction plant is $US648,600. Industrial plant: A 1 % reduction in PM10 is assumed, as this measure will not impact particulate emissions from non-exhaust mining emissions. In terms of costs DieselNet estimates a 1 -3 % increase on existing equipment costs to meet Tier 4 standards. For industrial plant there is an estimated 1193 new plant items coming online between 2014 and 2031 @ US$750K per plant item, the marginal cost increase would be up to US$22,500 per item of plant. A total cost of US$26,842,500 for industrial plant. It is important to note that a new DECCW and DEWHA report ‘Identification and Recommendation of Measures to Support the Uptake of Cleaner Nonroad Diesel Engines in Australia’ is now showing emissions and possible emission reductions from this sector are larger than estimated in the NSW 2003 AEI.					

Abatement Initiative #25: Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing

Description	Recreational Boating: Restrict emissions from new outboard marine engines (and personal water craft) sold into the market to the equivalent of CARB "2 star" levels. This will, in effect, see the replacement of all two-stroke carburettor and injection engines with four-stroke (or possibly some two-stroke direct injection) engines. Increased cost will reduce the number of new engines sold and slow the impact of the measure. Lawn Mowing: Restrict emissions from new handheld equipment and lawnmowers to the equivalent of USEPA (and EU) Phase I limits. Note that these limits are different for handheld and non-handheld equipment. This measure does not include lawnmowing in public open spaces which use larger machines.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				**Rating**
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Recreational Boating				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	183	248	3,862	
	Abatement (tpa)	- 110	184	2,811	
	Abatement from proportion of source affected (%)	-75%	93%	91%	
Impact 2		**Pollutants**			**-**
AEI Activity:	Lawn Mowing				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	189	267	5,771	
	Abatement (tpa)	- 158	147	3,174	
	Abatement from proportion of source affected (%)	-84%	55%	55%	
Implementation costs					**Medium**
Program / set-up		500	000 AUD		
Implementation (capital)		336,378	000 AUD		
Annual operating / ongoing		(5,650)	000 AUD		

Assumptions and comments

Recreational Boating: It is assumed that two-stroke engines will be replaced by four-stroke ones of the same horse-power (kW) size: "power creep" is neglected. No allowance has been made for emissions performance deterioration with age. Further, no allowance has been made for owners who are deterred from replacing engines due to the higher cost or who cease this activity as a result of increased cost. The estimated number of engines is somewhat inconsistent with the emissions estimates. Estimates are based on the MMA (2008) report to DEWHA and the DEWR (2007) report. Fuel savings are based on cost of $1.30 per litre with a 30% load factor. Lawn Mowing: There is considerable variation in the price of lawn mowers resulting from differences in power and features offered as much as the emissions performance of the engine. Some two-stroke models tested as high VOC emitters are more expensive than similar mowers using lower emission four-stroke technology. However, since these models are, in effect, being phased out by the industry itself, the capital cost estimates here are based on the cost differential between a complying and a non-complying four-stroke mower. Prices vary widely amongst suppliers and hence have larger uncertainties associated with them. Removal of cheaper non-complying models from the market may see the price of others increase when this competitive pressure is lost. Emission reductions are based on actual emissions data from DTA (2008). In the absence of PM10 test data and taking account of the similarity in percentage reductions for PM10 and VOCs for outboard engines, PM10 reduction here is assumed to be the same as the VOC reduction. Lawnmowers are assumed to be replaced by one of similar power (even if such models may not be available). Sales and other related data are from DEWR (2007). Fuel savings are based on $1.30 per litre. Maintenance costs are expected to be similar.

F.1.4 Industrial

Abatement Initiative #1: Coal Fired Power Station NOx Control - Low NOx Burners					
Description	Dry Low NOx Burner Technology is available for coal fired power stations in NSW and is currently being implemented at one NSW power station.				
Regions:	Non Urban				Rating
Impact 1		Pollutants			High
AEI Activity:	Electricity Generation - Generation of electrical power from coal				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	151,839	5,028	729	
	Abatement (tpa)	60,736	-	-	
	Abatement from proportion of source affected (%)	40%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		300	000 AUD		
Implementation (capital)		215,355	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Limitations: extrapolated costs from one NSW coal power station to all NSW coal fired generators, considered to be a reasonable estimate. O&M costs are unknown but not likely to be significant in the context of capital cost and existing O&M costs. The technology proposed is estimated to reduce NOx emission concentrations and loads by 30 - 50 % with a total capital cost of $50M for a 4 x 700 MW plant. A reduction in NOx conc. of this order would bring concentrations down to approximately 500 mg/Nm3 which is the Group 6 CAPER Limit. The cost equates to A$12,500,000 per 700 MW unit or $1,7857 per MW. It is considered that similar technology could be applied at each of the other coal fired power stations in NSW, and this abatement measure is applied at all sites. Total costs are derived based on the installed capacity of coal fired electricity in NSW which is 12060 MW, so total cost is $215,355,420. The savings in LBL fees have been calculated using the DECC's online LBL calculator and fees saved by the electricity industry are $5,984,464 per annum. In economic terms this is a transfer payment to govt.					

SKM

Abatement Initiative #19: Petrol Refinery Vapour Recovery and Leak Detection and Repair

Description	Petrol Refineries can address the issue of VOC emissions through changes to equipment including vapour recovery units to recover VOCs that escape during tanker loading. Further leak detection and repair programs (LDAR) which include inspecting and maintaining pipes, valves and other equipment can minimise the risk of escaping VOCs. It is expected that refineries in the GMR have such programs in place they are not reflected in the 2003 AEI, hence it is considered appropriate to include them as an abatement initiative.				
Regions:	Sydney,				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Petroleum refining				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	2,831	269	3,212	
	Abatement (tpa)	-	-	289	
	Abatement from proportion of source affected (%)	0%	0%	10%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		1,000	000	AUD	
Implementation (capital)		0	000	AUD	
Annual operating / ongoing		174	000	USD	
Assumptions and comments					
Note: A review of 2003 EPL data identified that one GMR refinery made up 90 % of total VOC emissions from all petroleum refining activities in Sydney. A review of NPI data for this refinery showed that 66 % of annual VOC emissions between 2005 and 2008 had been reduced. As the abatement initiatives have been designed for abatement starting no earlier than 2008, this initiative has been assumed to start in 2008. Initial cost estimates from CARB (http://www.arb.ca.gov/pm/pmmeasures/ceffect/reports/baaqmd_8-18_report.pdf) indicate US$320-$1600 per ton per annual required to run the LDAR programs. An estimate of US$500 per tonne per year has be used. It should be noted that in discussions with one GMR refinery, it was indicated that the large VOC reduction between 2005 and 2008 has occurred to a large degree as a result of improvement measurement and estimation of emissions rather than being directly associated with emission reduction projects. For this study it has been assumed that 15 % of the 66 % reduction in VOCs is attributed to emission reduction projects eg. LDAR.					

SKM

Abatement Initiative #29: Emission Limits for Industry (NOx and PM10)

Description	This initiative assesses emissions reductions and costs associated with industrial plant upgrades for Group 1 and 2 industries regulated by the POEO (Clean) Air Regulation 2002 (amended in 2005) to meet Group 5 NOx and PM10 emission limits.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Low
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	5,290	626	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		0	000 AUD		
Implementation (capital)		74,000	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Assumptions on emissions reduction and cost are based on DECC, 2008. The AEI as included in the initiative template includes "dummy" emission source input to include industrial emission reductions and associated costs for this measure. With respect to NOx emissions the average of the 'high" and "low" costs have been used.					

Abatement Initiative #30: Open Cut Coal Mining Buffer Zone Initiative

Description	Open cut coal mines are a significant source of PM10. There are minimal opportunities to reduced significant quantities of PM10 at the source of emission with most mine sunder pressure from regulators and local communities already employing onsite dust control measures. The most effective means of minimising the PM10 impact of mines on receivers is to ensure adequate separation is provided by source and receivers.				
Regions:	Non Urban				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Coal mining				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,674	30,808	122	
	Abatement (tpa)	-	16,020	-	
	Abatement from proportion of source affected (%)	0%	52%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		0	000	AUD	
Implementation (capital)		57,444	000	AUD	
Annual operating / ongoing		0	000	AUD	

Assumptions and comments

This initiative studies the impact of three recent mine developments in the Hunter Valley. Essentially the results of PM10 (24 hour) modelling have been studied across the various years of mine development to determine the total area inundated by a mine impact of 50 ug/m3 (increment), and the quantity of PM10 emissions that resulted in this impact. The modelling results were then analysed to determined the emission reduction required to reduce incremental impacts to 50 ug/m3 (24 hour) at a target radius of 1km from the centre of mining operations. On average it was determined that a 52 % reduction in PM10 emissions was required to reduce impacts from an average radius distance of 2.2 km to 1 km, that is a reduction in land area of 1203 ha. The NSW Value General in a May, 2009 publication quoted Upper Hunter rural land prices varying from A$900 to A$2400 per hectare, with an average of A$1600 per hectare (Ref: http://www.lands.nsw.gov.au/_media/lands/pdf/valuer_generals/media_releases/Upper_Hunter_13_01_09.pdf). Typically the Hunter Valley mining industry have paid in the order of 3 x land valuation prices as part of land acquisitions, i.e. A$4800 per hectare. Based on this analysis is can be determined that a 52 % reduction in mining PM10 emissions from future mine developments can be costed at A$5,744,400 per mine development. Between 2010 and 2031 coal mining within the GMR is projected to grow by 34 %. Based on an estimated 20 separate open cut coal mining developments operating in the Hunter Valley at present, with an average remaining life on 10 out of 21 years there will need to be approximately 10 new developments between 2010 and 2031 to meet projected increases in demand. This equates to a total cost of A$57,444,000 for a 52 % reduction in PM10 emissions for coal mining.

SKM

Abatement Initiative #31: Coal Fired Power Station - Selective Catalytic Reduction (SCR)

					Rating
Description	Implementation of SCR on NSW coal fired power stations.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Electricity Generation - Generation of electrical power from coal				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	151,839	5,028	729	
	Abatement (tpa)	129,063	-	-	
	Abatement from proportion of source affected (%)	85%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		300	000 AUD		
Implementation (capital)		964,800	000 AUD		
Annual operating / ongoing		43,200	000 AUD		

Assumptions and comments

Data sourced from USEPA, 2001: http://www.epa.gov/nrmrl/pubs/600r01087/600r01087.pdf SCR is considered to reduce 85 to 95 % (use 85 %) of NOx from coal fired power stations. Cost estimates are of the order of US$50-110 per kW (use US$80 per kW), with operating and maintenance costs ranging between US$1.6-3.2M per boiler per year (use US$2.4M) . Applying this data to the 12060 MW of installed capacity from 18 coal fired boilers in NSW power stations and the resulting capital cost is US$964,800,000 with O&M costs of the order of US$43,200,000 per year.

SKM

Abatement Initiative #32: Gas Engine Electricity Generation - SCR

					Rating
Description	This measure considers the application of selective catalytic reduction (SCR) to reciprocating gas engine power stations.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Electricity Generation - Generation of electrical power from gas				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	3,177	55	595	
	Abatement (tpa)	2,630	-	-	
	Abatement from proportion of source affected (%)	90%	0%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Medium**
Program / set-up		300	000 AUD		
Implementation (capital)		50,000	000 AUD		
Annual operating / ongoing		2,760	000 AUD		
Assumptions and comments					

Data sourced from SKM, 2009: Financial Analysis of NOx Controls on Gas Fired reciprocating Engines. Estimated SCR capital cost for 1 MW engines is A$500K. NOx removal efficiency is approximately 90 % and operating and maintenance costs are A$4 per MWh. This data has been applied to the NSW gas engine installed capacity of approximately 100 MW. The resulting capital cost is A$50M and annual operating costs for 80 % capacity factor is A$2.76M.

SKM

Abatement Initiative #33: Cement Industry NOx Control

Description	This measure involves the application of low NOx burners to precalciners and kilns				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Low
AEI Activity:	Cement or lime production				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	6,409	296	89	
	Abatement (tpa)	1,522	-	-	
	Abatement from proportion of source affected (%)	25%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		150	000	AUD	
Implementation (capital)		2,578	000	USD	
Annual operating / ongoing		514	000	USD	
Assumptions and comments					

Data sourced from USEPA, 1994: http://yosemite1.epa.gov/ee/epa/ria.nsf/vwAN/cement.pdf/$file/cement.pdf. Capital cost for Low NOx Burners approximately US$1.27-2.18 million (use US$1.73M). Annualised operating costs range between US$267-423K (use US$345K). NOx reduction is in the range of 20-30% (use 25%). It should be noted that higher reductions may be possible.

Abatement Initiative #34: Metal Plating and Coating Works: CARB, 2008 AIM Regulation

Description	The DECC's 2003 AEI estimates emissions from surface coatings within the Industrial Module using a product consumption based emissions estimation approach from the NPI, 2003 (http://www.npi.gov.au/publications/emission-estimation-technique/fsurfc.html) which uses product usage information provided by the Australian Paint Manufacturers Federation (APMF). The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of surface coating products that would be needed to meet CARB 2008 emission regulations (Ref: http://www.arb.ca.gov/coatings/arch/VOCLimits.htm and http://www.arb.ca.gov/consprod/regact/tscpwg/cpworkshop04_01_09.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Metal plating or coating works				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	76	45	2,604	
	Abatement (tpa)	-	-	1,068	
	Abatement from proportion of source affected (%)	0%	0%	41%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		100	000 AUD		
Implementation (capital)		2,637	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 33% - solvents thinned; 68% - thinners for architectural and decorative paints, enamels and clears; 43 % - industrial paints, enamels and clears; 68 % - industrial thinners; 50 -55 % for timber finishes. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 1.89E+04 to 1.11E+04, that is 7,839 tonnes of VOCs in 2003 abated or 41%. In 2008, the VOC abatement is 7,379 tonnes and in 2010 the reduction is 7,571 tonnes. In terms of costs CARB estimated the cost per ton for a from-scratch AIM regulation based upon its new rule would be US$1.12 per pound, or US$2,240 per ton (US$2,469 per tonne) of VOC reduced. That is a 2010 cost of A$2,636,892.

SKM

Abatement Initiative #35: Printing VOC Emissions Control

Description	This measure considers control of fugitive emissions from printing using after-burner treatment.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Low
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	2,172	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		200	000 AUD		
Implementation (capital)		14,228	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Data sourced from Ramsay, 1996. Incineration (after-burner) VOC control is estimated at 70 % with capital costs of A$4,640 per tonne. There are 3102 tonnes of VOCs emitted from industrial printers in the GMR, mostly in Sydney. Total abatement costs are calculated to be A$10.1M.					

F.1.5 Domestic-Commercial

Abatement Initiative #20: CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols					
Description	The DECC's 2003 AEI estimates emissions from aerosols and solvents within the Domestic-Commercial Module using a population based emissions estimation approach from the USEPA Eastern Research Group, 1996. The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of consumer aerosol products that would be needed to meet CARB 2008 emission regulations (Ref: http: http://www.arb.ca.gov/consprod/regact/tscpwg/proposedreg033009bolded.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		Pollutants			Low
AEI Activity:	Domestic/Commercial Solvents/Aerosols				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	27,479	
	Abatement (tpa)	-	-	3,984	
	Abatement from proportion of source affected (%)	0%	0%	15%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		1,000	000 AUD		
Implementation (capital)		0	000 AUD		
Annual operating / ongoing		48,869	000 AUD		
Assumptions and comments					
The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 24 % - personal care products; 5 % - household products; 23 % - automotive aftermarket products; 26% - adhesives and sealants; 1.5 % - insecticide, fugitive, rodenticide and herbicide products; 6.5% - coatings and related products; 0 % for miscellaneous products. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 2.62 x 10E+4 to 2.24 x 10E+4, that is 3800 tonnes of VOCs in 2003 abated or 14.5 %. In 2008, the VOC abatement is 3984 tonnes. In terms of costs the Aerosol Institute of Australia (AIA) were contacted to assess if any data exists on %VOCs of Australian consumer products. The AIA have provided information on the breakdown of aerosol type by product, however, no information on VOC content was provided. A brief review of the aerosol product breakdown provided by the AIA possibly suggest a different consumer breakdown than the USEPA formula used in the 2003 AEI. With respect to VOC content a review of MSDSs for common products either indicated that products meet relevant US standards eg. CARB or they contained no information. The assumptions made are: A$1M Govt. costs to set up and implement regulations; there are 1,970,583 households in the GMR (pro-rata of 1,879,572 quoted for 2003 AEI), and each household spends A$10 per week on consumer aerosol products, 75 % of which already meet CARB, 2008 regulations. It is estimated that in each product category there is a 20 % price difference between the most expensive brands and the cheapest brands with the expensive brands meeting CARB 2008 (generally as per MSDS review) and the cheaper ones currently not in compliance. Annualising these costs the additional spend for CARB 2008 compliant products in the GMR is A$48,868,872 with these additional costs lasting for 1 year.					

Abatement Initiative #22: Wood Heaters - Reduce the Moisture Content of Firewood

Description	This measure was initially developed by McLennan Magasanik and Associates (MMA, 2001) in a study from the NSW EPA titled: NOx and Fine Particulate Reduction Options from Non-Licensed Sources. Additional information from Todd, 2008: Woodheater Operation and Firewood Parameters - prepared for the Department of Environment, Water, Heritage and the Arts is also referenced.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	481	6,191	12,701	
	Abatement (tpa)	-	121	-	
	Abatement from proportion of source affected (%)	0%	2%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		0	000 AUD		
Implementation (capital)		0	000 AUD		
Annual operating / ongoing		6,675	000 AUD		
Assumptions and comments					
MMA estimated emission reductions of 2.8 % have been reduced by a factor of 0.7 based on additional analysis by Todd, 2008. MMA, 2001 costs (capital and operating) of $5,200 per tonne have been applied.					

SKM

Abatement Initiative #23: National Standards for Wood Heaters (3 g/kg)

Description	This measure is as per the BDA Group, 2006 report: Wood Heater Particle Emissions and operating Efficiency Standards Cost Benefit Analysis prepared for the Department of Environment and Heritage. Assumes a standard of 3 g/kg with only new heaters meeting the new standard, i.e. that is no replacement of existing heaters.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	481	6,191	12,701	
	Abatement (tpa)	-	59	-	
	Abatement from proportion of source affected (%)	0%	51%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		500	000 AUD		
Implementation (capital)		332	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Estimated marginal costs for new wood heater which meets the 3 g/kg and a 60% efficiency standard is $100. There is estimated to be approximately 3000 new wood heaters installed in the GMR over the life of this measure, as determined by projection factors in the inventory.					

SKM

Abatement Initiative #24: National Standards for Wood Heaters (1 g/kg)

Description	This measure is as per the BDA Group, 2006 report: Wood Heater Particle Emissions and operating Efficiency Standards Cost Benefit Analysis prepared for the Department of Environment and Heritage. Assumes a standard of 1 g/kg, with 70% of wood heaters being replaced.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	481	6,191	12,701	
	Abatement (tpa)	-	2,229	-	
	Abatement from proportion of source affected (%)	0%	36%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		500	000 AUD		
Implementation (capital)		34,149	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

The BDA, 2006 report: http://www.environment.gov.au/atmosphere/airquality/publications/woodheater-particle-emissions.html, sets out emissions reduction and cost data for reduced PM10 emission limits of 3g/kg, 2 g/kg, 1.5 g/kg and 1 g/kg compared to the current AS4013 standard of 4 g/kg. While the Sydney airshed is considered as part of the study it is difficult to extract specific data for Sydney. As such information used here relies on a average data for each of the airsheds considered. The data suggests that for the introduction of a 1 g/kg limit in 2007 by 2011 PM10 emissions from wood heathers would have reduced by approximately 9 % and by 2021 the reduction would be 36 %. For the study period considered here (2012 to 2031), the 36 % reduction is assumed. One point to note is that BDA, 2006 suggests that even without the introduction of a new standard PM10 emissions will fall by approximately 30 % as old wood heaters are replaced. This is not reflected in the DECC, AEI where emission forecasts continue to grow using ABS population data. In terms of project costs BDA, 2006 provides an additional cost of $300 per wood heater to meet a new standard of 1 g/kg. Assuming 70 % of wood heater are replaced in the study period and there are 162,613 wood heaters in the GMR in 2012, with no substantial growth in number during the study period, the total costs would be $34,148,730.

SKM

F.1.6 Commercial

Abatement Initiative #21: CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)					
Description	The DECC's 2003 AEI estimates emissions from surface coatings within the Domestic-Commercial Module using a product consumption based emissions estimation approach from the NPI, 2003 (http://www.npi.gov.au/publications/emission-estimation-technique/fsurfc.html) which uses product usage information provided by the Australian Paint Manufacturers Federation (APMF). The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of surface coating products that would be needed to meet CARB 2008 emission regulations (Ref: http://www.arb.ca.gov/coatings/arch/VOCLimits.htm and http://www.arb.ca.gov/consprod/regact/tscpwg/cpworkshop04_01_09.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Surface Coatings				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	17,997	
	Abatement (tpa)	-	-	7,379	
	Abatement from proportion of source affected (%)	0%	0%	41%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		1,000	000 AUD		
Implementation (capital)		18,693	000 USD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 33% - solvents thinned; 68% - thinners for architectural and decorative paints, enamels and clears; 43 % - industrial paints, enamels and clears; 68 % - industrial thinners; 50 -55 % for timber finishes. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 1.89E+04 to 1.11E+04, that is 7,839 tonnes of VOCs in 2003 abated or 41%. In 2008, the VOC abatement is 7,379 tonnes and in 2010 the reduction is 7,571 tonnes. In terms of costs CARB estimated the cost per ton for a from-scratch AIM regulation based upon its new rule would be US$1.12 per pound, or US$2,240 per ton (US$2,469 per tonne) of VOC reduced. That is a 2010 cost of A$18,692,799.					

Abatement Initiative #26: CARB 2008 Regulation for Surface Coatings - Smash Repairing

Description	This measure estimates the VOC emissions reduction achievable by implementing CARB 2008 regulations in smash preparing (automotive refinishing) businesses. Emission reduction estimated are sourced from Environ 2009: VOCs from Surface Coatings - Assessment of the Categorisation, VOC Content and Sales Volume of Coating Products Sold in Australia - a report prepared for the Environment Protection Heritage Council. Capital cost data is sourced from Rare: 2009: Reducing VOC emissions from automotive refinishing in the Sydney Basin.				
Regions:	Sydney, Newcastle, Wollongong, Non Urban				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Smash Repairing				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	5,707	
	Abatement (tpa)	-	-	498	
	Abatement from proportion of source affected (%)	0%	0%	9%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		500	000	AUD	
Implementation (capital)		9,562	000	AUD	
Annual operating / ongoing		5,205	000	USD	
Assumptions and comments					

Environ: 2009 estimates that this measure has the potential to reduce VOC emissions by 440-1668 tonnes per annum for all of Australia (estimated 4500 smash repair shops). The 2003 AEI states that there are 1,258 smash repair businesses in the GMR in 2003. Using the AEI population based projection factors there will be 1,343 in 2010. Based on this data the estimated maximum VOC emission reduction in the GMR is 498 tonnes per annum (8.8 % of total emissions). In terms of capital costs Rare, 2009 estimated A$7.5M for the Sydney Basin, scaled up to A$9.56M for the GMR (based on increased emission in GMR compared to Sydney). In terms of operating costs CARB, 2005 (Ref: http://www.arb.ca.gov/coatings/autorefin/scm/sreport/appendc.pdf) provide an average cost of US$3,400 per smash repairer per annum to implement the measure. This equates to a total cost of US$ 4,566,200 per annum to smash repairers in the GMR.

F.2 Sydney

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F.2.1 On-road Mobile – Technology Initiative

Abatement Initiative #4: Summer-time Petrol Volatility (62 kPA to 60 kPA)					
Description	This measure is as per DECC, 2009 and involves reducing summer petrol volatility from 62 kPA to 60 kPA				
Regions:	Sydney,				Rating
Impact 1		Pollutants			High
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	25	-	892	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		0	000 AUD		
Implementation (capital)		1,068	000 AUD		
Annual operating / ongoing		4,827	000 AUD		
Assumptions and comments					
There are unique features associated with the cost estimate for reducing petrol volatility and significant factors which could not be incorporated into the study, which limits the accuracy and comparability of the figure derived. In particular: Emission reduction figures do not take into account the increasing use of ethanol 10% ethanol petrol (E10). Ethanol petrol blends between 5 and 10% significantly increase VOC emissions (while providing the benefit of reduced particle emissions). The NSW Biofuels regulation requirement for all unleaded petrol to be blended with E10 means that 90% of ethanol petrol in NSW will be E10. All VOC reductions achieved by tightening petrol volatility limits are delivered during summer when ozone exceedances occur. This means that lowering petrol volatility limits is more effective in managing ozone formation than actions which provide comparable emission reductions spread over the full calendar year. Compliance figures are based on aggregated NSW oil industry estimates of likely future costs (ie reduced revenue streams from selling butane in other markets rather than in petrol) and developed following extensive stakeholder consultation, while costings for other measures are often based on broad overseas measures and adjusted to Australian dollars.					

Abatement Initiative #5: Truck and Bus Diesel Retrofit

Description	Diesel retrofit for trucks and buses, based on DECC, 2009 data.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	14,444	401	2,035	
	Abatement (tpa)	-	5	-	
	Abatement from proportion of source affected (%)	0%	1%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		0	000 AUD		
Implementation (capital)		4,072	000 AUD		
Annual operating / ongoing		0	000 AUD		

Assumptions and comments

Emissions reduction and cost data provided by DECC, 2009. Source of cost data is RTA Retrofit Stage 4 Program Report. Assumptions are that it is a $6M program over 4 years; 50/50 govt./private split; 133 trucks per million $ of program; $7500 average per truck, each truck retrofitted has 10 years remaining life; 9 kg of PM10 abated per truck per year. The NSW retrofit program is examining incorporation of energy efficiency devices on vehicles (such as improved vehicle aerodynamics, idle-off devices, low roll resistant tyres, or driver training). This "Smartway" style extension of the program is expected to reduce scheme costs, lower fuel use and reduce greenhouse gas emissions. (See measure 28).

SKM

Abatement Initiative #27: Euro 5/6 Emission Standards for New Passenger Vehicles

Description	This measure requires all new passenger and light duty commercial petrol vehicles from 2014 to meet Euro 5/6 standards. NOx and PM10 emissions will reduce with emission factors for new vehicles being NOx = 0.06 g/km and PM10 = 0.005 g/km				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Exhaust Emissions Passenger Cars - Petrol				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	35,807	688	17,558	
	Abatement (tpa)	14,570	132	5,360	
	Abatement from proportion of source affected (%)	41%	19%	31%	
Impact 2		Pollutants			-
AEI Activity:	Exhaust Emissions Light Duty Commercial - Petrol				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	3,224	41	3,332	
	Abatement (tpa)	330	11	1,484	
	Abatement from proportion of source affected (%)	10%	27%	45%	
Implementation costs					Low
Program / set-up		1,000	000 AUD		
Implementation (capital)		590,240	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Note: Emission reduction statistics are based on DECC, 2009 on-road mobile emissions modelling. DECC provided yearly "Scenario" and "BAU" emissions from 2014 - 2031 and the annual average emission reductions have been applied to all years. Cost estimates have been derived using a marginal cost of $85 per new Euro5/6 petrol vehicle and $1000 per new Euro5/6 diesel vehicle (Ref: http://www.infrastructure.gov.au/roads/environment/files/FINAL_Draft_RIS_E5_E6_Light_Vehicles_Emissions_Review_20100104.pdf) with the number of new vehicles in the Sydney region sourced from the 2008 RTA Handbook, with a calculated 1 % of passenger vehicles and 35 % of light commercial vehicles being diesel and the remainder petrol. Costs are extrapolated to 2031 using ABS population projection data.					

SKM

Abatement Initiative #28: SmartWay Program

Description	Improved Aerodynamics for whole B-Double vehicle & trailers				
Regions:	Sydney,				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	14,444	401	2,035	
	Abatement (tpa)	578	16	81	
	Abatement from proportion of source affected (%)	4%	4%	4%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		1,000	000 AUD		
Implementation (capital)		1,567,460	000 AUD		
Annual operating / ongoing		(863,169)	000 AUD		
Assumptions and comments					

Note: Program, fuel saving and cost data provided by DECC, 2009. A 4 % in fleet fuel saving has been assumed from the 12 % reduction in fuel saving (10 - 14 % range) per vehicle, noting that approx. 2/3 of the vehicle fleet would have aerodynamic kits fitted already. The 4% reduction in fuel has been assumed to result in 4 % reduction in emissions. DECC, 2009 costs are estimated at $60,000 per truck. RTA statistics indicate that there are 78373 heavy vehicles in NSW, and therefore total costs to retrofit 1/3 of the fleet is $1,567,460,000. The fuel savings are based on 25,416 litres per vehicle per year (DECC, 2009) at $1.30 per litre, a total saving of $863,168,873 per year. The greenhouse gas emission reduction co-benefits of the SmartWay program associated with improved fuel consumption have not been calculated.

SKM

F.2.2 On-road Mobile – Travel Demand Initiatives

Abatement Initiative #11: Shift Transport Mode to Cycling					
Description	Increase Installations of Cycle Ways and Cycling Marketing Campaigns - Install cycle ways in urban areas and multiply the number of trips made on bicycle by 5 by 2020 (currently 1% of all trips in metro Sydney are on bike)				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Exhaust Emissions Passenger Cars - Petrol				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	35,807	688	17,558	
	Abatement (tpa)	358	7	176	
	Abatement from proportion of source affected (%)	100%	100%	100%	
Impact 2		Pollutants			Low
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	14,444	401	2,035	
	Abatement (tpa)	144	4	20	
	Abatement from proportion of source affected (%)	100%	100%	100%	
Implementation costs					Low
Program / set-up		2,830	000 AUD		
Implementation (capital)		315,360	000 AUD		
Annual operating / ongoing		(310,731)	000 AUD		
Assumptions and comments					
Cycling data is from RTA, MOT "Cycling in Sydney - Bicycle ownership and use" (2008). It is assumed that 50% of mode shift to cycling will be from private vehicles while 50% will be from public transport. It is assumed that new bicycles will be purchased by the increasing number of cyclists, averaging $80/cyclist. Cost of cycleways is based on implementation cost of A$7,000,000 for Marrickville which contains approximately 2.2 % of the NSW urban population.					

SKM

F.2.3 Non-road Mobile

Abatement Initiative #2: Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2					
Description	This initiative involves replacing existing NSW rail fleet locomotives (assumed to be USEPA Tier 0) with Tier 2 locomotives.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,757	52	76	
	Abatement (tpa)	738	36	-	
	Abatement from proportion of source affected (%)	42%	68%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		100	000 AUD		
Implementation (capital)		183,247	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
This initiative can be achieved by an engine system replacement (est. cost A$1M) or replacing the entire locomotive (est. cost A$3M): Source : LGreentree. Tier 0 NOx = 59 g/L, Tier 2 NOx = 34.5 g/L (42% reduction). Tier 0 PM10 = 1.39 g/L, Tier 2 PM10 = 0.47 g/L (66 % reduction) It is estimated that there are 366 locomotives on the NSW rail network (Source: http://locopage.railpage.org.au) that could be retrofitted or would need to be replaced for 100 % uptake of this action. Note: Locomotives able to achieve Tier 2 emission standards eg. Pacific National (PN) 92 class or Queensland Rail (QR) 5000 class are now being introduced to the NSW rail fleet. When applying this abatement initiative to the Sydney region only, the capital costs have been reduced in the ratio (1757/3662) which is the proportion of Sydney locomotive NOx to GMR locomotive NOx.					

SKM

Abatement Initiative #3: Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 plus USEPA Tier 2 ---> Tier 4

Description	Replace Diesel locos with Tier 2 (As per Initiative #2), then as per CARB reference: Technical Options to Achieve Additional Emission and Risk Reductions from Californian Locomotives and Railyards (Draft, Dec 2008), The NOx reduction technology is Selective Catalytic Reduction (SCR) and particulate reduction technology is diesel particulate filters (DPF). Note this initiative is mutually exclusive with initiative 2 (Tier 0 -> Tier 2) as it includes the impact and cost of that measure in addition to SCR and DPF.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,757	52	76	
	Abatement (tpa)	1,595	48	-	
	Abatement from proportion of source affected (%)	91%	93%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		200	000 AUD		
Implementation (capital)		312,295	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

A cost of US $500,000 per loco (366 locos in total) is provided to upgrade Tier 2 equivalent locos (Tier 2 NOx = 34.5 g/L and PM = 0.47 g/L) to Tier 4 (NOx = 5.5 g/L and PM = 0.11 g/L). When applying this abatement initiative to the Sydney region only, the capital costs have been reduced in the ratio (1757/3662) which is the proportion of Sydney locomotive NOx to GMR locomotive NOx. Costs & abatement include Init #2 (Tier 0 -> Tier 2 replacement) + additional costs & abatement from Tier 2 -> Tier 4: SCR and DPF (converted from USD to AUD).

SKM

Abatement Initiative #15: Recommission and Electrify Enfield-Port Botany Freight Line

Description	Recommission and electrify Enfield-Port Botany freight line for container movements between Port Botany and the Enfield Intermodal Centre (ILC) on the existing reservation. This measure would result in a reduction in NOx, VOCs and PM10 from reducing truck movements delivering containerised freight on the Sydney road network, and also zero emissions from electric locomotives compared to diesel.				
Regions:	Sydney,				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,757	52	76	
	Abatement (tpa)	106	3	5	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		**Pollutants**			**Low**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		100	000 AUD		
Implementation (capital)		29,260	000 AUD		
Annual operating / ongoing		(1,608)	000 AUD		

Assumptions and comments

Reductions in truck emissions were estimated in the Environmental Assessment (EA) for the Enfield Intermodal Logistics Centre (ILC) - SKM, 2005. Reductions amounts in 2016 annual emissions from trucks were calculated as follows: NOx = 79 tpa, VOCs = 7 tpa, PM10 = 4.3 tpa. Reductions in locomotive emissions from diesel powered trains that would use the line in the absence of electrification are as follows: NOx = 106 tpa, VOCs = 5 tpa, PM10 = 2.5 tpa. It noted that while the Enfield ILC project is proceeding (currently under construction) there is no proposal to electrify the rail line. The costs determined for this this initiative are the costs to electrify the rail line only, as the ILC is under construction. A review of literature (ref: http://www.railcrc.net.au/publications/downloads/R1106-Paper-8-Powering-Rail-Electrification--Emissions-Intensity.pdf) outlined that the cost of electrifying existing rail lines is variable, but a recent 2007 UK study identified costs to be in there range of £550K to £650K per single track kilometre. A capital cost of £600K per km (A$1.3M per km) was applied to this initiative and equates to $23.4M for the 18 km track. It would also be necessary to purchase 4 x electric freight locomotives (assume refurbished 86 class locomotives at $A1M per locomotive - A$4M total). In terms of diesel locomotive operating costs that will be saved compared to electric locomotives this has been determined based on an estimated 105,120 train kilometres per year, and 17 litres of diesel per km for a train pulled by 2 x 44 class locomotives. Assuming A$1 per litre for diesel the annual fuel bill saved is A$1,787,040. Energy operating costs to replace diesel trains with electric trains is estimated at 10 % of the diesel train cost of $178,704.

SKM

Abatement Initiative #17: Port Botany Shore-Side Power

Description	This abatement initiative involves installation of shore-side power on the 5 new berths proposed at Port Botany as part of the port expansion project.				
Regions:	Sydney,				**Rating**
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Commercial Ships				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	1,658	57	62	
	Abatement (tpa)	298	10	11	
	Abatement from proportion of source affected (%)	90%	90%	90%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Medium**
Program / set-up		500	000	AUD	
Implementation (capital)		20,912	000	EUR	
Annual operating / ongoing		2,385	000	EUR	

Assumptions and comments

Relevant cost information was sourced from the American Association of Port Authorities Draft Use of Shore-Side Power for Ocean Going Vessels White Paper (May 2007). Source: http://www.westcoastcollaborative.org/files/sector-marine/AAPA-ShorePower-050107.pdf. This document provides various examples of shore power within international port. The example chosen for cost information is the Euromax port development in Rotterdam which has a capacity of 2.3 M TEU compared with Port Botany Expansion at 1.6 M TEU. The shore power capital an annual operating cost for Euromax are €28.5M and €3.25M respectively. These costs have been directly applied at Port Botany in the ratio of 1.6/2.3. In terms of estimating the proportion of the source affected it is noted that Port Botany and Port Jackson are both within the Sydney region and 90 % of emissions are from Port Botany. Additionally DECC's AEI includes emissions from ships berthed at port and travelling to and from port within 8 km of the coast. It was estimated that 90 % of emissions occur at berth and that 50 % of Port Botany's berths will be affected by the measures. As such the proportion of the source affected is 40 % (0.9 x 0.9 x 0.5). It was further assumed that 90 % of berthed emissions would be controlled by shore power. No account of costs needed to upgrade ships to use shore power have been included. It has been assumed that over the life of the abatement (2012 - 2031) that 50 % achievable take-up is possible as new ships come on line and SPC can co-ordinate efforts with international shipping operators to use shore power compatible ships at these berths.

SKM

Abatement Initiative #18: Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)					
Description	USEPA Tier 4 emission standards being introduced for new equipment will reduce exhaust emissions of PM10 and NOx in the order of 90%. New diesel engines will have to be fitted with advanced emission aftertreatment devices, such as particulate filters and NOx reduction catalysts. In the US various provisions of the new regulation become effective from 2008 to 2015; for most engine categories, the Tier 4 standards will be phased-in over the period 2011-2014. This measure is proposed to be introduced in 2014.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	386	31	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		200	000	AUD	
Implementation (capital)		5,872	000	USD	
Annual operating / ongoing		0	000	AUD	
Assumptions and comments					

Emissions reduction potential and cost information have been sourced from DieselNet: http://www.dieselnet.com/news/2004/05epa2.php. It should be noted that the quoted 90% emissions reduction will be variable based on the actual make-up of the equipment fleet in the 2003 AEI year, which is understood to resemble the US fleet in the same year. Further in the AEI while diesel powered equipment make up the majority of equipment, there are also petrol, LPG etc items of plant which will be unaffected by this measure, as such the measure assumes 80 % reduction in NOx emissions rather than 90 %. Commercial/construction plant: A 20 % reduction in PM10 is assumed, as this measure will not impact particulate emissions from wheel generated dust etc. In terms of costs DieselNet estimates a 1 -3 % increase on existing equipment costs to meet Tier 4 standards. For commercial plant there is an estimated 44 new plant items coming online between 2014 and 2031 @ US$230K per plant item, the marginal cost increase would be up to US$6900 per item of plant. A total cost of US$303,600 for commercial plant. For construction plant there is an estimated 50 new plant items coming online between 2014 and 2031 @ US$230K per plant item, the marginal cost increase would be up to US$6900 per item of plant. A total cost of US$345,000 for construction plant. The total cost for both commercial and construction plant is $US648,600. Industrial plant: A 1 % reduction in PM10 is assumed, as this measure will not impact particulate emissions from non-exhaust mining emissions. In terms of costs DieselNet estimates a 1 -3 % increase on existing equipment costs to meet Tier 4 standards. For industrial plant there is an estimated 1193 new plant items coming online between 2014 and 2031 @ US$750K per plant item, the marginal cost increase would be up to US$22,500 per item of plant. A total cost of US$26,842,500 for industrial plant. When applying this abatement initiative to the Sydney region only, the capital costs have been reduced to 20 % of GMR costs based on an estimate of the number of plant in the Sydney Region. It is important to note that a new DECCW and DEWHA report 'Identification and Recommendation of Measures to Support the Uptake of Cleaner Nonroad Diesel Engines in Australia' is now showing emissions and possible emission reductions from this sector are larger than estimated in the NSW 2003 AEI.

Abatement Initiative #25: Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing

Description	Recreational Boating: Restrict emissions from new outboard marine engines (and personal water craft) sold into the market to the equivalent of CARB "2 star" levels. This will, in effect, see the replacement of all two-stroke carburettor and injection engines with four-stroke (or possibly some two-stroke direct injection) engines. Increased cost will reduce the number of new engines sold and slow the impact of the measure. Lawn Mowing: Restrict emissions from new handheld equipment and lawnmowers to the equivalent of USEPA (and EU) Phase I limits. Note that these limits are different for handheld and non-handheld equipment. This measure does not include lawnmowing in public open spaces which use larger machines.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Recreational Boating				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	115	155	2,422	
	Abatement (tpa)	- 69	116	1,763	
	Abatement from proportion of source affected (%)	-75%	93%	91%	
Impact 2		Pollutants			-
AEI Activity:	Lawn Mowing				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	142	201	4,341	
	Abatement (tpa)	- 119	110	2,387	
	Abatement from proportion of source affected (%)	-84%	55%	55%	
Implementation costs					Medium
Program / set-up		500	000 AUD		
Implementation (capital)		236,946	000 AUD		
Annual operating / ongoing		(4,250)	000 AUD		

Assumptions and comments

Recreational Boating: It is assumed that two-stroke engines will be replaced by four-stroke ones of the same horse-power (kW) size: "power creep" is neglected. No allowance has been made for emissions performance deterioration with age. Further, no allowance has been made for owners who are deterred from replacing engines due to the higher cost or who cease this activity as a result of increased cost. The estimated number of engines is somewhat inconsistent with the emissions estimates. Estimates are based on the MMA (2008) report to DEWHA and the DEWR (2007) report. Fuel savings are based on cost of $1.30 per litre with a 30% load factor. Lawn Mowing: There is considerable variation in the price of lawn mowers resulting from differences in power and features offered as much as the emissions performance of the engine. Some two-stroke models tested as high VOC emitters are more expensive than similar mowers using lower emission four-stroke technology. However, since these models are, in effect, being phased out by the industry itself, the capital cost estimates here are based on the cost differential between a complying and a non-complying four-stroke mower. Prices vary widely amongst suppliers and hence have larger uncertainties associated with them. Removal of cheaper non-complying models from the market may see the price of others increase when this competitive pressure is lost. Emission reductions are based on actual emissions data from DTA (2008). In the absence of PM10 test data and taking account of the similarity in percentage reductions for PM10 and VOCs for outboard engines, PM10 reduction here is assumed to be the same as the VOC reduction. Lawnmowers are assumed to be replaced by one of similar power (even if such models may not be available). Sales and other related data are from DEWR (2007). Fuel savings are based on $1.30 per litre. Maintenance costs are expected to be similar. Costs: estimated to 75 % of GMR costs based on emissions in Sydney region compared to GMR.

F.2.4 Industrial

Abatement Initiative #19: Petrol Refinery Vapour Recovery and Leak Detection and Repair					
Description	Petrol Refineries can address the issue of VOC emissions through changes to equipment including vapour recovery units to recover VOCs that escape during tanker loading. Further leak detection and repair programs (LDAR) which include inspecting and maintaining pipes, valves and other equipment can minimise the risk of escaping VOCs. It is expected that refineries in the GMR have such programs in place they are not reflected in the 2003 AEI, hence it is considered appropriate to include them as an abatement initiative.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Petroleum refining				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	2,831	269	3,212	
	Abatement (tpa)	-	-	289	
	Abatement from proportion of source affected (%)	0%	0%	10%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		1,000	000 AUD		
Implementation (capital)		0	000 AUD		
Annual operating / ongoing		174	000 USD		
Assumptions and comments					
Note: A review of 2003 EPL data identified that one GMR refinery made up 90 % of total VOC emissions from all petroleum refining activities in Sydney. A review of NPI data for this refinery showed that 66 % of annual VOC emissions between 2005 and 2008 had been reduced. As the abatement initiatives have been designed for abatement starting no earlier than 2008, this initiative has been assumed to start in 2008. Initial cost estimates from CARB (http://www.arb.ca.gov/pm/pmmeasures/ceffect/reports/baaqmd_8-18_report.pdf) indicate US$320-$1600 per ton per annual required to run the LDAR programs. An estimate of US$500 per tonne per year has be used. It should be noted that in discussions with one GMR refinery, it was indicated that the large VOC reduction between 2005 and 2008 has occurred to a large degree as a result of improvement measurement and estimation of emissions rather than being directly associated with emission reduction projects. For this study it has been assumed that 15 % of the 66 % reduction in VOCs is attributed to emission reduction projects eg. LDAR.					

SKM

Abatement Initiative #29: Emission Limits for Industry (NOx and PM10)

Description	This initiative assesses emissions reductions and costs associated with industrial plant upgrades for Group 1 and 2 industries regulated by the POEO (Clean) Air Regulation 2002 (amended in 2005) to meet Group 5 NOx and PM10 emission limits.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	3,024	359	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		0	000 AUD		
Implementation (capital)		42,300	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Assumptions on emissions reduction and cost are based on DECC, 2008. The AEI as included in the initiative template includes "dummy" emission source input to include industrial emission reductions and associated costs for this measure. With respect to NOx emissions the average of the 'high" and "low" costs have been used. Emission reductions and costs have been factored based on the number of industrial emission sources in Sydney.					

SKM

Abatement Initiative #32: Gas Engine Electricity Generation - SCR

					Rating
Description	This measure considers the application of selective catalytic reduction (SCR) to reciprocating gas engine power stations.				
Regions:	Sydney,				
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Electricity Generation - Generation of electrical power from gas				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	3,177	55	595	
	Abatement (tpa)	2,630	-	-	
	Abatement from proportion of source affected (%)	90%	0%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Medium**
Program / set-up		300	000 AUD		
Implementation (capital)		50,000	000 AUD		
Annual operating / ongoing		2,760	000 AUD		
Assumptions and comments					

Data sourced from SKM, 2009: Financial Analysis of NOx Controls on Gas Fired reciprocating Engines. Estimated SCR capital cost for 1 MW engines is A$500K. NOx removal efficiency is approximately 90 % and operating and maintenance costs are A$4 per MWh. This data has been applied to the NSW gas engine installed capacity of approximately 100 MW. The resulting capital cost is A$50M and annual operating costs for 80 % capacity factor is A$2.76M.

Abatement Initiative #33: Cement Industry NOx Control

Description	This measure involves the application of low NOx burners to precalciners and kilns				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Cement or lime production				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,401	75	4	
	Abatement (tpa)	333	-	-	
	Abatement from proportion of source affected (%)	25%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		150	000	AUD	
Implementation (capital)		653	000	USD	
Annual operating / ongoing		130	000	USD	
Assumptions and comments					

Data sourced from USEPA, 1994: http://yosemite1.epa.gov/ee/epa/ria.nsf/vwAN/cement.pdf/$file/cement.pdf. Capital cost for Low NOx Burners approximately US$1.27-2.18 million (use US$1.73M). Annualised operating costs range between US$267-423K (use US$345K). NOx reduction is in the range of 20-30% (use 25%). It should be noted that higher reductions may be possible.

Abatement Initiative #34: Metal Plating and Coating Works: CARB, 2008 AIM Regulation

Description	The DECC's 2003 AEI estimates emissions from surface coatings within the Industrial Module using a product consumption based emissions estimation approach from the NPI, 2003 (http://www.npi.gov.au/publications/emission-estimation-technique/fsurfc.html) which uses product usage information provided by the Australian Paint Manufacturers Federation (APMF). The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of surface coating products that would be needed to meet CARB 2008 emission regulations (Ref: http://www.arb.ca.gov/coatings/arch/VOCLimits.htm and http://www.arb.ca.gov/consprod/regact/tscpwg/cpworkshop04_01_09.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Sydney,				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Metal plating or coating works				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	17	31	2,439	
	Abatement (tpa)	-	-	1,000	
	Abatement from proportion of source affected (%)	0%	0%	41%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		100	000 AUD		
Implementation (capital)		2,470	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 33% - solvents thinned; 68% - thinners for architectural and decorative paints, enamels and clears; 43 % - industrial paints, enamels and clears; 68 % - industrial thinners; 50 -55 % for timber finishes. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 1.89E+04 to 1.11E+04, that is 7,839 tonnes of VOCs in 2003 abated or 41%. In 2008, the VOC abatement is 7,379 tonnes and in 2010 the reduction is 7,571 tonnes. In terms of costs CARB estimated the cost per ton for a from-scratch AIM regulation based upon its new rule would be US$1.12 per pound, or US$2,240 per ton (US$2,469 per tonne) of VOC reduced. That is a 2010 cost of A$2,470,000.

SKM

Abatement Initiative #35: Printing VOC Emissions Control

Description	This measure considers control of fugitive emissions from printing using after-burner treatment.				
Regions:	Sydney,				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	2,172	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		200	000 AUD		
Implementation (capital)		14,228	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

Data sourced from Ramsay, 1996. Incineration (after-burner) VOC control is estimated at 70 % with capital costs of A$4,640 per tonne. There are 3102 tonnes of VOCs emitted from industrial printers in the GMR, mostly in Sydney. Total abatement costs are calculated to be A$10.1M.

F.2.5 Domestic-Commercial

Abatement Initiative #20: CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols					
Description	The DECC's 2003 AEI estimates emissions from aerosols and solvents within the Domestic-Commercial Module using a population based emissions estimation approach from the USEPA Eastern Research Group, 1996. The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of consumer aerosol products that would be needed to meet CARB 2008 emission regulations (Ref: http: http://www.arb.ca.gov/consprod/regact/tscpwg/proposedreg033009bolded.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Domestic/Commercial Solvents/Aerosols				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	21,662	
	Abatement (tpa)	-	-	3,141	
	Abatement from proportion of source affected (%)	0%	0%	15%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		1,000	000 AUD		
Implementation (capital)		0	000 AUD		
Annual operating / ongoing		38,523	000 AUD		
Assumptions and comments					
The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 24 % - personal care products; 5 % - household products; 23 % - automotive aftermarket products; 26% - adhesives and sealants; 1.5 % - insecticide, fugitive, rodenticide and herbicide products; 6.5% - coatings and related products; 0 % for miscellaneous products. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 2.62 x 10E+4 to 2.24 x 10E+4, that is 3800 tonnes of VOCs in 2003 abated or 14.5 %. In 2008, the VOC abatement is 3984 tonnes. In terms of costs the Aerosol Institute of Australia (AIA) were contacted to assess if any data exists on %VOCs of Australian consumer products. The AIA have provided information on the breakdown of aerosol type by product, however, no information on VOC content was provided. A brief review of the aerosol product breakdown provided by the AIA possibly suggest a different consumer breakdown than the USEPA formula used in the 2003 AEI. With respect to VOC content a review of MSDSs for common products either indicated that products meet relevant US standards eg. CARB or they contained no information. The assumptions made are: A$1M Govt. costs to set up and implement regulations; there are 1,970,583 households in the GMR (pro-rata of 1,879,572 quoted for 2003 AEI), and each household spends A$10 per week on consumer aerosol products, 75 % of which already meet CARB, 2008 regulations. It is estimated that in each product category there is a 20 % price difference between the most expensive brands and the cheapest brands with the expensive brands meeting CARB 2008 (generally as per MSDS review) and the cheaper ones currently not in compliance. Annualising these costs the additional spend for CARB 2008 compliant products in the GMR is A$48,868,872 with these additional costs lasting for 1 year. For the Sydney region, costs have been apportioned in the ratio of Sydney domestic/commercial solvent/aerosol emissions to GMR emissions that is (21,662/27,479).					

SKM

Abatement Initiative #22: Wood Heaters - Reduce the Moisture Content of Firewood					
Description	This measure was initially developed by McLennan Magasanik and Associates (MMA, 2001) in a study from the NSW EPA titled: NOx and Fine Particulate Reduction Options from Non-Licensed Sources. Additional information from Todd, 2008: Woodheater Operation and Firewood Parameters - prepared for the Department of Environment, Water, Heritage and the Arts is also referenced.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	362	4,656	9,553	
	Abatement (tpa)	-	91	-	
	Abatement from proportion of source affected (%)	0%	2%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		0	000	AUD	
Implementation (capital)		0	000	AUD	
Annual operating / ongoing		3,911	000	AUD	
Assumptions and comments					
MMA estimated emission reductions of 2.8 % have been reduced by a factor of 0.7 based on additional analysis by Todd, 2008. MMA, 2001 costs (capital and operating) of $5,200 per tonne have been applied. Costs have been factored down by 25 % for the Sydney region.					

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Abatement Initiative #23: National Standards for Wood Heaters (3 g/kg)

Description	This measure is as per the BDA Group, 2006 report: Wood Heater Particle Emissions and operating Efficiency Standards Cost Benefit Analysis prepared for the Department of Environment and Heritage. Assumes a standard of 3 g/kg with only new heaters meeting the new standard, i.e. that is no replacement of existing heaters.				
Regions:	Sydney,				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	362	4,656	9,553	
	Abatement (tpa)	-	45	-	
	Abatement from proportion of source affected (%)	0%	51%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		500	000 AUD		
Implementation (capital)		249	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Estimated marginal costs for new wood heater which meets the 3 g/kg and a 60% efficiency standard is $100. There is estimated to be approximately 3000 new wood heaters installed in the GMR over the life of this measure as determined by projection factors in the inventory. Costs have been factored down by 25 % for Sydney.					

Abatement Initiative #24: National Standards for Wood Heaters (1 g/kg)

Description	This measure is as per the BDA Group, 2006 report: Wood Heater Particle Emissions and operating Efficiency Standards Cost Benefit Analysis prepared for the Department of Environment and Heritage. Assumes a standard of 1 g/kg, with 70% of wood heaters being replaced.				
Regions:	Sydney,				Rating
Impact 1		**Pollutants**			**Low**
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	362	4,656	9,553	
	Abatement (tpa)	-	1,676	-	
	Abatement from proportion of source affected (%)	0%	36%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		500	000 AUD		
Implementation (capital)		25,882	000 AUD		
Annual operating / ongoing		0	000 AUD		

Assumptions and comments

The BDA, 2006 report: http://www.environment.gov.au/atmosphere/airquality/publications/woodheater-particle-emissions.html, sets out emissions reduction and cost data for reduced PM10 emission limits of 3g/kg, 2 g/kg, 1.5 g/kg and 1 g/kg compared to the current AS4013 standard of 4 g/kg. While the Sydney airshed is considered as part of the study it is difficult to extract specific data for Sydney. As such information used here relies on a average data for each of the airsheds considered. The data suggests that for the introduction of a 1 g/kg limit in 2007 by 2011 PM10 emissions from wood heathers would have reduced by approximately 9 % and by 2021 the reduction would be 36 %. For the study period considered here (2012 to 2031), the 36 % reduction is assumed. One point to note is that BDA, 2006 suggests that even without the introduction of a new standard PM10 emissions will fall by approximately 30 % as old wood heaters are replaced. This is not reflected in the DECC, AEI where emission forecasts continue to grow using ABS population data. In terms of project costs BDA, 2006 provides an additional cost of $300 per wood heater to meet a new standard of 1 g/kg. Assuming 70 % of wood heater are replaced in the study period and there are 162,613 wood heaters in the GMR in 2012, with no substantial growth in number during the study period, the total costs would be $34,148,730. Costs have been factored down by 25 % for Sydney.

F.2.6 Commercial

Abatement Initiative #21: CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)					
Description	The DECC's 2003 AEI estimates emissions from surface coatings within the Domestic-Commercial Module using a product consumption based emissions estimation approach from the NPI, 2003 (http://www.npi.gov.au/publications/emission-estimation-technique/fsurfc.html) which uses product usage information provided by the Australian Paint Manufacturers Federation (APMF). The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of surface coating products that would be needed to meet CARB 2008 emission regulations (Ref: http://www.arb.ca.gov/coatings/arch/VOCLimits.htm and http://www.arb.ca.gov/consprod/regact/tscpwg/cpworkshop04_01_09.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Sydney,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Surface Coatings				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	13,965	
	Abatement (tpa)	-	-	5,726	
	Abatement from proportion of source affected (%)	0%	0%	41%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		1,000	000	AUD	
Implementation (capital)		14,505	000	USD	
Annual operating / ongoing		0	000	AUD	
Assumptions and comments					
The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 33% - solvents thinned; 68% - thinners for architectural and decorative paints, enamels and clears; 43 % - industrial paints, enamels and clears; 68 % - industrial thinners; 50 -55 % for timber finishes. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 1.89E+04 to 1.11E+04, that is 7,839 tonnes of VOCs in 2003 abated or 41%. In 2008, the VOC abatement is 7,379 tonnes and in 2010 the reduction is 7,571 tonnes. In terms of costs CARB estimated the cost per ton for a from-scratch AIM regulation based upon its new rule would be US$1.12 per pound, or US$2,240 per ton (US$2,469 per tonne) of VOC reduced. That is a 2010 cost of A$18,692,799. For the Sydney region, costs have been apportioned in the ratio of Sydney surface coating emissions to GMR emissions that is (13,965/17,997).					

Abatement Initiative #26: CARB 2008 Regulation for Surface Coatings - Smash Repairing

Description	This measure estimates the VOC emissions reduction achievable by implementing CARB 2008 regulations in smash preparing (automotive refinishing) businesses. Emission reduction estimated are sourced from Environ 2009: VOCs from Surface Coatings - Assessment of the Categorisation, VOC Content and Sales Volume of Coating Products Sold in Australia - a report prepared for the Environment Protection Heritage Council. Capital cost data is sourced from Rare: 2009: Reducing VOC emissions from automotive refinishing in the Sydney Basin.				
Regions:	Sydney,				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Smash Repairing				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	4,476	
	Abatement (tpa)	-	-	391	
	Abatement from proportion of source affected (%)	0%	0%	9%	
Impact 2		**Pollutants**			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		500	000	AUD	
Implementation (capital)		7,500	000	AUD	
Annual operating / ongoing		4,082	000	USD	
Assumptions and comments					

Environ: 2009 estimates that this measure has the potential to reduce VOC emissions by 440-1668 tonnes per annum for all of Australia (estimated 4500 smash repair shops). The 2003 AEI states that there are 1,258 smash repair businesses in the GMR in 2003. Using the AEI population based projection factors there will be 1,343 in 2010. Based on this data the estimated maximum VOC emission reduction in the GMR is 498 tonnes per annum (8.8 % of total emissions). In terms of capital costs Rare, 2009 estimated A$7.5M for the Sydney Basin. In terms of operating costs CARB, 2005 (Ref: http://www.arb.ca.gov/coatings/autorefin/scm/sreport/appendc.pdf) provide an average cost of US$3,400 per smash repairer per annum to implement the measure. This equates to a total cost of US$ 4,566,200 per annum to smash repairers in the GMR. Costs have been factored for the Sydney region.

F.3 Wollongong

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F.3.1 On-road Mobile - Technology Initiatives

Abatement Initiative #4: Summer-time Petrol Volatility (62 kPA to 60 kPA)					
Description	This measure is as per DECC, 2009 and involves reducing summer petrol volatility from 62 kPA to 60 kPA				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			High
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	1	-	46	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		0	000 AUD		
Implementation (capital)		40	000 AUD		
Annual operating / ongoing		145	000 AUD		
Assumptions and comments					
There are unique features associated with the cost estimate for reducing petrol volatility and significant factors which could not be incorporated into the study, which limits the accuracy and comparability of the figure derived. In particular:• Emission reduction figures do not take into account the increasing use of ethanol 10% ethanol petrol (E10). Ethanol petrol blends between 5 and 10% significantly increase VOC emissions (while providing the benefit of reduced particle emissions). The NSW Biofuels regulation requirement for all unleaded petrol to be blended with E10 means that 90% of ethanol petrol in NSW will be E10. • All VOC reductions achieved by tightening petrol volatility limits are delivered during summer when ozone exceedances occur. This means that lowering petrol volatility limits is more effective in managing ozone formation than actions which provide comparable emission reductions spread over the full calendar year. • Compliance figures are based on aggregated NSW oil industry estimates of likely future costs (ie reduced revenue streams from selling butane in other markets rather than in petrol) and developed following extensive stakeholder consultation, while costings for other measures are often based on broad overseas measures and adjusted to Australian dollars.					

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Abatement Initiative #5: Truck and Bus Diesel Retrofit

Description	Diesel retrofit for trucks and buses, based on DECC, 2009 data.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	923	24	117	
	Abatement (tpa)	-	0	-	
	Abatement from proportion of source affected (%)	0%	1%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		0	000 AUD		
Implementation (capital)		244	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

Emissions reduction and cost data provided by DECC, 2009. Source of cost data is RTA Retrofit Stage 4 Program Report. Assumptions are that it is a $6M program over 4 years; 50/50 govt./private split; 133 trucks per million $ of program; $7500 average per truck, each truck retrofitted has 10 years remaining life; 9 kg of PM10 abated per truck per year. The NSW retrofit program is examining incorporation of energy efficiency devices on vehicles (such as improved vehicle aerodynamics, idle-off devices, low roll resistant tyres, or driver training). This “Smartway” style extension of the program is expected to reduce scheme costs, lower fuel use and reduce greenhouse gas emissions. (See measure 28).

Abatement Initiative #27: Euro 5/6 Emission Standards for New Passenger Vehicles

Description	This measure requires all new passenger and light duty commercial petrol vehicles from 2014 to meet Euro 5/6 standards. NOx and PM10 emissions will reduce with emission factors for new vehicles being NOx = 0.06 g/km and PM10 = 0.005 g/km				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Exhaust Emissions Passenger Cars - Petrol				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,650	28	772	
	Abatement (tpa)	671	5	236	
	Abatement from proportion of source affected (%)	41%	19%	31%	
Impact 2		Pollutants			-
AEI Activity:	Exhaust Emissions Light Duty Commercial - Petrol				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	117	1	122	
	Abatement (tpa)	12	0	54	
	Abatement from proportion of source affected (%)	10%	27%	45%	
Implementation costs					Low
Program / set-up		1,000	000 AUD		
Implementation (capital)		24,656	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Note: Emission reduction statistics are based on DECC, 2009 on-road mobile emissions modelling. DECC provided yearly "Scenario" and "BAU" emissions from 2014 - 2031 and the annual average emission reductions have been applied to all years. Cost estimates have been derived using a marginal cost of $85 per new Euro5/6 petrol vehicle and $1000 per new Euro5/6 diesel vehicle (Ref: http://www.infrastructure.gov.au/roads/environment/files/FINAL_Draft_RIS_E5_E6_Light_Vehicles_Emissions_Review_20100104.pdf) with the number of new vehicles in the Wollongong region sourced from the 2008 RTA Handbook, with a calculated 1 % of passenger vehicles and 35 % of light commercial vehicles being diesel and the remainder petrol. Costs are extrapolated to 2031 using ABS population projection data.					

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Abatement Initiative #28: SmartWay Program

Description	Improved Aerodynamics for whole B-Double vehicle & trailers				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	923	24	117	
	Abatement (tpa)	37	1	5	
	Abatement from proportion of source affected (%)	4%	4%	4%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		1,000	000 AUD		
Implementation (capital)		1,567,460	000 AUD		
Annual operating / ongoing		(863,169)	000 AUD		
Assumptions and comments					

Note: Program, fuel saving and cost data provided by DECC, 2009. A 4 % in fleet fuel saving has been assumed from the 12 % reduction in fuel saving (10 - 14 % range) per vehicle, noting that approx. 2/3 of the vehicle fleet would have aerodynamic kits fitted already. The 4% reduction in fuel has been assumed to result in 4 % reduction in emissions. DECC, 2009 costs are estimated at $60,000 per truck. RTA statistics indicate that there are 78373 heavy vehicles in NSW, and therefore total costs to retrofit 1/3 of the fleet is $1,567,460,000. The fuel savings are based on 25,416 litres per vehicle per year (DECC, 2009) at $1.30 per litre, a total saving of $863,168,873 per year. Costs have not been factored for Wollongong as trucks operate throughout the state. The greenhouse gas emission reduction co-benefits of the SmartWay program associated with improved fuel consumption have not been calculated.

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F.3.2 On-road Mobile – Travel Demand Initiatives

Abatement Initiative #11: Shift Transport Mode to Cycling					
Description	Increase Installations of Cycle Ways and Cycling Marketing Campaigns - Install cycle ways in urban areas and multiply the number of trips made on bicycle by 5 by 2020 (currently 1% of all trips in metro Sydney are on bike)				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Exhaust Emissions Passenger Cars - Petrol				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	1,650	28	772	
	Abatement (tpa)	16	0	8	
	Abatement from proportion of source affected (%)	100%	100%	100%	
Impact 2		Pollutants			Low
AEI Activity:	Exhaust Emissions Heavy Duty Commercial - Diesel				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	923	24	117	
	Abatement (tpa)	9	0	1	
	Abatement from proportion of source affected (%)	100%	100%	100%	
Implementation costs					Low
Program / set-up		560	000 AUD		
Implementation (capital)		13,649	000 AUD		
Annual operating / ongoing		(13,449)	000 AUD		
Assumptions and comments					
Cycling data is from RTA, MOT "Cycling in Sydney - Bicycle ownership and use" (2008). It is assumed that 50% of mode shift to cycling will be from private vehicles while 50% will be from public transport. It is assumed that new bicycles will be purchased by the increasing number of cyclists, averaging $80/cyclist. Cost of cycleways is based on implementation cost of A$7,000,000 for Marrickville which contains approximately 2.2 % of the NSW urban population.					

F.3.3 Non-road Mobile

Abatement Initiative #2: Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2					
Description	This initiative involves replacing existing NSW rail fleet locomotives (assumed to be USEPA Tier 0) with Tier 2 locomotives.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	151	4	6	
	Abatement (tpa)	63	3	-	
	Abatement from proportion of source affected (%)	42%	68%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		100	000 AUD		
Implementation (capital)		15,749	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
This initiative can be achieved by an engine system replacement (est. cost A$1M) or replacing the entire locomotive (est. cost A$3M): Source : LGreentree. Tier 0 NOx = 59 g/L, Tier 2 NOx = 34.5 g/L (42% reduction). Tier 0 PM10 = 1.39 g/L, Tier 2 PM10 = 0.47 g/L (66 % reduction) It is estimated that there are 366 locomotives on the NSW rail network (Source: http://locopage.railpage.org.au) that could be retrofitted or would need to be replaced for 100 % uptake of this action. Note: Locomotives able to achieve Tier 2 emission standards eg. Pacific National (PN) 92 class or Queensland Rail (QR) 5000 class are now being introduced to the NSW rail fleet. When applying this abatement initiative to the Wollongong region only, the capital costs have been reduced in the ratio (151/3662) which is the proportion of Wollongong locomotive NOx to GMR locomotive NOx.					

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Abatement Initiative #3: Diesel Locomotive Replacement USEPA Tier 0 ---> Tier 2 plus USEPA Tier 2 ---> Tier 4

Description	Replace Diesel locos with Tier 2 (As per Initiative #2), then as per CARB reference: Technical Options to Achieve Additional Emission and Risk Reductions from Californian Locomotives and Railyards (Draft, Dec 2008), The NOx reduction technology is Selective Catalytic Reduction (SCR) and particulate reduction technology is diesel particulate filters (DPF). Note this initiative is mutually exclusive with initiative 2 (Tier 0 -> Tier 2) as it includes the impact and cost of that measure in addition to SCR and DPF.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Medium
AEI Activity:	Railways				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	151	4	6	
	Abatement (tpa)	137	4	-	
	Abatement from proportion of source affected (%)	91%	93%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Medium
Program / set-up		200	000 AUD		
Implementation (capital)		26,844	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
A cost of US $500,000 per loco (366 locos in total) is provided to upgrade Tier 2 equivalent locos (Tier 2 NOx = 34.5 g/L and PM = 0.47 g/L) to Tier 4 (NOx = 5.5 g/L and PM = 0.11 g/L). When applying this abatement initiative to the Wollongong region only, the capital costs have been reduced in the ratio (151/3662) which is the proportion of Wollongong locomotive NOx to GMR locomotive NOx. Costs & abatement include Init #2 (Tier 0 -> Tier 2 replacement) + + additional costs & abatement from Tier 2 -> Tier 4: SCR and DPF (converted from USD to AUD).					

SKM

Abatement Initiative #18: Tier 4 Emission Standards for Off-Road Vehicles and Equipment (Industrial) and (Commercial and Construction)

Description	USEPA Tier 4 emission standards being introduced for new equipment will reduce exhaust emissions of PM10 and NOx in the order of 90%. New diesel engines will have to be fitted with advanced emission aftertreatment devices, such as particulate filters and NOx reduction catalysts. In the US various provisions of the new regulation become effective from 2008 to 2015; for most engine categories, the Tier 4 standards will be phased-in over the period 2011-2014. This measure is proposed to be introduced in 2014.				
Regions:	Wollongong,				**Rating**
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	49	2	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		**Pollutants**			-
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Medium**
Program / set-up		200	000 AUD		
Implementation (capital)		587	000 USD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

Emissions reduction potential and cost information have been sourced from DieselNet: http://www.dieselnet.com/news/2004/05epa2.php. It should be noted that the quoted 90% emissions reduction will be variable based on the actual make-up of the equipment fleet in the 2003 AEI year, which is understood to resemble the US fleet in the same year. Further in the AEI while diesel powered equipment make up the majority of equipment, there are also petrol, LPG etc items of plant which will be unaffected by this measure, as such the measure assumes 80 % reduction in NOx emissions rather than 90 %. Commercial/construction plant: A 20 % reduction in PM10 is assumed, as this measure will not impact particulate emissions from wheel generated dust etc. In terms of costs DieselNet estimates a 1 -3 % increase on existing equipment costs to meet Tier 4 standards. For commercial plant there is an estimated 44 new plant items coming online between 2014 and 2031 @ US$230K per plant item, the marginal cost increase would be up to US$6900 per item of plant. A total cost of US$303,600 for commercial plant. For construction plant there is an estimated 50 new plant items coming online between 2014 and 2031 @ US$230K per plant item, the marginal cost increase would be up to US$6900 per item of plant. A total cost of US$345,000 for construction plant. The total cost for both commercial and construction plant is $US648,600. Industrial plant: A 1 % reduction in PM10 is assumed, as this measure will not impact particulate emissions from non-exhaust mining emissions. In terms of costs DieselNet estimates a 1 -3 % increase on existing equipment costs to meet Tier 4 standards. For industrial plant there is an estimated 1193 new plant items coming online between 2014 and 2031 @ US$750K per plant item, the marginal cost increase would be up to US$22,500 per item of plant. A total cost of US$26,842,500 for industrial plant. When applying this abatement initiative to the Wollongong region only, the capital costs have been reduced to 2 % of GMR costs based on an estimate of the number of plant in the Wollongong Region. It is important to note that a new DECCW and DEWHA report ‘Identification and Recommendation of Measures to Support the Uptake of Cleaner Nonroad Diesel Engines in Australia’ is now showing emissions and possible emission reductions from this sector are larger than estimated in the NSW 2003 AEI.

Abatement Initiative #25: Small engines: (2 stroke to 4 stroke) Recreational Boating and Lawn Mowing

Description	Recreational Boating: Restrict emissions from new outboard marine engines (and personal water craft) sold into the market to the equivalent of CARB "2 star" levels. This will, in effect, see the replacement of all two-stroke carburettor and injection engines with four-stroke (or possibly some two-stroke direct injection) engines. Increased cost will reduce the number of new engines sold and slow the impact of the measure. Lawn Mowing: Restrict emissions from new handheld equipment and lawnmowers to the equivalent of USEPA (and EU) Phase I limits. Note that these limits are different for handheld and non-handheld equipment. This measure does not include lawnmowing in public open spaces which use larger machines.				
Regions:	Wollongong,				**Rating**
Impact 1		**Pollutants**			**Medium**
AEI Activity:	Recreational Boating				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	7	10	157	
	Abatement (tpa)	- 4	7	114	
	Abatement from proportion of source affected (%)	-75%	93%	91%	
Impact 2		**Pollutants**			**-**
AEI Activity:	Lawn Mowing				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	8	11	239	
	Abatement (tpa)	- 7	6	132	
	Abatement from proportion of source affected (%)	-84%	55%	55%	
Implementation costs					**Medium**
Program / set-up		500	000	AUD	
Implementation (capital)		13,045	000	AUD	
Annual operating / ongoing		(234)	000	AUD	
Assumptions and comments					

Recreational Boating: It is assumed that two-stroke engines will be replaced by four-stroke ones of the same horse-power (kW) size: "power creep" is neglected. No allowance has been made for emissions performance deterioration with age. Further, no allowance has been made for owners who are deterred from replacing engines due to the higher cost or who cease this activity as a result of increased cost. The estimated number of engines is somewhat inconsistent with the emissions estimates. Estimates are based on the MMA (2008) report to DEWHA and the DEWR (2007) report. Fuel savings are based on cost of $1.30 per litre with a 30% load factor. Lawn Mowing: There is considerable variation in the price of lawn mowers resulting from differences in power and features offered as much as the emissions performance of the engine. Some two-stroke models tested as high VOC emitters are more expensive than similar mowers using lower emission four-stroke technology. However, since these models are, in effect, being phased out by the industry itself, the capital cost estimates here are based on the cost differential between a complying and a non-complying four-stroke mower. Prices vary widely amongst suppliers and hence have larger uncertainties associated with them. Removal of cheaper non-complying models from the market may see the price of others increase when this competitive pressure is lost. Emission reductions are based on actual emissions data from DTA (2008). In the absence of PM10 test data and taking account of the similarity in percentage reductions for PM10 and VOCs for outboard engines, PM10 reduction here is assumed to be the same as the VOC reduction. Lawnmowers are assumed to be replaced by one of similar power (even if such models may not be available). Sales and other related data are from DEWR (2007). Fuel savings are based on $1.30 per litre. Maintenance costs are expected to be similar. Costs: estimated to 4 % of GMR costs based on emissions in Wollongong region compared to GMR.

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F.3.4 Industrial

Abatement Initiative #29: Emission Limits for Industry (NOx and PM10)					
Description	This initiative assesses emissions reductions and costs associated with industrial plant upgrades for Group 1 and 2 industries regulated by the POEO (Clean) Air Regulation 2002 (amended in 2005) to meet Group 5 NOx and PM10 emission limits.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Dummy for initiatives across multiple activities				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	293	35	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		0	000 AUD		
Implementation (capital)		4,094	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
Assumptions on emissions reduction and cost are based on DECC, 2008. The AEI as included in the initiative template includes "dummy" emission source input to include industrial emission reductions and associated costs for this measure. With respect to NOx emissions the average of the 'high" and "low" costs have been used. Emission reductions and costs have been factored based on the number of industrial emission sources in Wollongong.					

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Abatement Initiative #34: Metal Plating and Coating Works: CARB, 2008 AIM Regulation

Description	The DECC's 2003 AEI estimates emissions from surface coatings within the Industrial Module using a product consumption based emissions estimation approach from the NPI, 2003 (http://www.npi.gov.au/publications/emission-estimation-technique/fsurfc.html) which uses product usage information provided by the Australian Paint Manufacturers Federation (APMF). The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of surface coating products that would be needed to meet CARB 2008 emission regulations (Ref: http://www.arb.ca.gov/coatings/arch/VOCLimits.htm and http://www.arb.ca.gov/consprod/regact/tscpwg/cpworkshop04_01_09.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Metal plating or coating works				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	57	11	164	
	Abatement (tpa)	-	-	67	
	Abatement from proportion of source affected (%)	0%	0%	41%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		100	000	AUD	
Implementation (capital)		166	000	AUD	
Annual operating / ongoing		0	000	AUD	
Assumptions and comments					

The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 33% - solvents thinned; 68% - thinners for architectural and decorative paints, enamels and clears; 43 % - industrial paints, enamels and clears; 68 % - industrial thinners; 50 -55 % for timber finishes. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 1.89E+04 to 1.11E+04, that is 7,839 tonnes of VOCs in 2003 abated or 41%. In 2008, the VOC abatement is 7,379 tonnes and in 2010 the reduction is 7,571 tonnes. In terms of costs CARB estimated the cost per ton for a from-scratch AIM regulation based upon its new rule would be US$1.12 per pound, or US$2,240 per ton (US$2,469 per tonne) of VOC reduced. That is a 2010 cost of A$166,000.

F.3.5 Domestic-Commercial

Abatement Initiative #20: CARB 2008 Regulation for Domestic Consumer Solvents and Aerosols					
Description	The DECC's 2003 AEI estimates emissions from aerosols and solvents within the Domestic-Commercial Module using a population based emissions estimation approach from the USEPA Eastern Research Group, 1996. The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of consumer aerosol products that would be needed to meet CARB 2008 emission regulations (Ref: http: http://www.arb.ca.gov/consprod/regact/tscpwg/proposedreg033009bolded.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Wollongong,				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Domestic/Commercial Solvents/Aerosols				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	1,041	
	Abatement (tpa)	-	-	151	
	Abatement from proportion of source affected (%)	0%	0%	15%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		100	000	AUD	
Implementation (capital)		0	000	AUD	
Annual operating / ongoing		1,851	000	AUD	
Assumptions and comments					
The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 24 % - personal care products; 5 % - household products; 23 % - automotive aftermarket products; 26% - adhesives and sealants; 1.5 % - insecticide, fugitive, rodenticide and herbicide products; 6.5% - coatings and related products; 0 % for miscellaneous products. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 2.62 x 10E+4 to 2.24 x 10E+4, that is 3800 tonnes of VOCs in 2003 abated or 14.5 %. In 2008, the VOC abatement is 3984 tonnes. In terms of costs the Aerosol Institute of Australia (AIA) were contacted to assess if any data exists on %VOCs of Australian consumer products. The AIA have provided information on the breakdown of aerosol type by product, however, no information on VOC content was provided. A brief review of the aerosol product breakdown provided by the AIA possibly suggest a different consumer breakdown than the USEPA formula used in the 2003 AEI. With respect to VOC content a review of MSDSs for common products either indicated that products meet relevant US standards eg. CARB or they contained no information. The assumptions made are: A$1M Govt. costs to set up and implement regulations; there are 1,970,583 households in the GMR (pro-rata of 1,879,572 quoted for 2003 AEI), and each household spends A$10 per week on consumer aerosol products, 75 % of which already meet CARB, 2008 regulations. It is estimated that in each product category there is a 20 % price difference between the most expensive brands and the cheapest brands with the expensive brands meeting CARB 2008 (generally as per MSDS review) and the cheaper ones currently not in compliance. Annualising these costs the additional spend for CARB 2008 compliant products in the GMR is A$48,868,872 with these additional costs lasting for 1 year. For the Wollongong region, costs have been apportioned in the ratio of Wollongong domestic/commercial solvent/aerosol emissions to GMR emissions that is (1,041/27,479).					

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Abatement Initiative #22: Wood Heaters - Reduce the Moisture Content of Firewood

Description	This measure was initially developed by McLennan Magasanik and Associates (MMA, 2001) in a study from the NSW EPA titled: NOx and Fine Particulate Reduction Options from Non-Licensed Sources. Additional information from Todd, 2008: Woodheater Operation and Firewood Parameters - prepared for the Department of Environment, Water, Heritage and the Arts is also referenced.				
Regions:	Wollongong,				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	20	257	527	
	Abatement (tpa)	-	5	-	
	Abatement from proportion of source affected (%)	0%	2%	0%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	**PM_{10}**	**VOCs**	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		0	000 AUD		
Implementation (capital)		0	000 AUD		
Annual operating / ongoing		216	000 AUD		
Assumptions and comments					
MMA estimated emission reductions of 2.8 % have been reduced by a factor of 0.7 based on additional analysis by Todd, 2008. MMA, 2001 costs (capital and operating) of $5,200 per tonne have been applied. Costs have been factored down by 96 % for the Wollongong region.					

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Abatement Initiative #23: National Standards for Wood Heaters (3 g/kg)

Description	This measure is as per the BDA Group, 2006 report: Wood Heater Particle Emissions and operating Efficiency Standards Cost Benefit Analysis prepared for the Department of Environment and Heritage. Assumes a standard of 3 g/kg with only new heaters meeting the new standard, i.e. that is no replacement of existing heaters.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	20	257	527	
	Abatement (tpa)	-	2	-	
	Abatement from proportion of source affected (%)	0%	51%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		50	000	AUD	
Implementation (capital)		14	000	AUD	
Annual operating / ongoing		0	000	AUD	
Assumptions and comments					
Estimated marginal costs for new wood heater which meets the 3 g/kg and a 60% efficiency standard is $100. There is estimated to be approximately 3000 new wood heaters installed in the GMR over the life of this measure as determined by projection factors in the inventory. Costs have been factored down by 96 % for Wollongong.					

Abatement Initiative #24: National Standards for Wood Heaters (1 g/kg)

Description	This measure is as per the BDA Group, 2006 report: Wood Heater Particle Emissions and operating Efficiency Standards Cost Benefit Analysis prepared for the Department of Environment and Heritage. Assumes a standard of 1 g/kg, with 70% of wood heaters being replaced.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Solid Fuel Burning (Domestic)				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	20	257	527	
	Abatement (tpa)	-	92	-	
	Abatement from proportion of source affected (%)	0%	36%	0%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		500	000 AUD		
Implementation (capital)		1,417	000 AUD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					

The BDA, 2006 report: http://www.environment.gov.au/atmosphere/airquality/publications/woodheater-particle-emissions.html, sets out emissions reduction and cost data for reduced PM10 emission limits of 3g/kg, 2 g/kg, 1.5 g/kg and 1 g/kg compared to the current AS4013 standard of 4 g/kg. While the Sydney airshed is considered as part of the study it is difficult to extract specific data for Sydney. As such information used here relies on a average data for each of the airsheds considered. The data suggests that for the introduction of a 1 g/kg limit in 2007 by 2011 PM10 emissions from wood heathers would have reduced by approximately 9 % and by 2021 the reduction would be 36 %. For the study period considered here (2012 to 2031), the 36 % reduction is assumed. One point to note is that BDA, 2006 suggests that even without the introduction of a new standard PM10 emissions will fall by approximately 30 % as old wood heaters are replaced. This is not reflected in the DECC, AEI where emission forecasts continue to grow using ABS population data. In terms of project costs BDA, 2006 provides an additional cost of $300 per wood heater to meet a new standard of 1 g/kg. Assuming 70 % of wood heater are replaced in the study period and there are 162,613 wood heaters in the GMR in 2012, with no substantial growth in number during the study period, the total costs would be $34,148,730. Costs have been factored down by 96 % for Wollongong.

F.3.6 Commercial

Abatement Initiative #21: CARB 2008 Regulation for Surface Coatings - Architectural_Industrial_Maintenance (AIM)					
Description	The DECC's 2003 AEI estimates emissions from surface coatings within the Domestic-Commercial Module using a product consumption based emissions estimation approach from the NPI, 2003 (http://www.npi.gov.au/publications/emission-estimation-technique/fsurfc.html) which uses product usage information provided by the Australian Paint Manufacturers Federation (APMF). The emission factors developed for the DECC 2003 AEI have been modified based on % reductions in VOC content of surface coating products that would be needed to meet CARB 2008 emission regulations (Ref: http://www.arb.ca.gov/coatings/arch/VOCLimits.htm and http://www.arb.ca.gov/consprod/regact/tscpwg/cpworkshop04_01_09.pdf). It is assumed that this initiative would be introduced in 2010 which is the final date for compliance for all products in CARB, 2008.				
Regions:	Wollongong,				Rating
Impact 1		Pollutants			Low
AEI Activity:	Surface Coatings				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	703	
	Abatement (tpa)	-	-	288	
	Abatement from proportion of source affected (%)	0%	0%	41%	
Impact 2		Pollutants			-
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					Low
Program / set-up		1,000	000 AUD		
Implementation (capital)		730	000 USD		
Annual operating / ongoing		0	000 AUD		
Assumptions and comments					
The following % reductions in the 2003 AEI emission factor were determined by applying the CARB 2008 regulation: 33% - solvents thinned; 68% - thinners for architectural and decorative paints, enamels and clears; 43 % - industrial paints, enamels and clears; 68 % - industrial thinners; 50 -55 % for timber finishes. Recalculating the total 2003 GMR emissions with the revised emission factors provides an annual tonnage reduction of VOCs from 1.89E+04 to 1.11E+04, that is 7,839 tonnes of VOCs in 2003 abated or 41%. In 2008, the VOC abatement is 7,379 tonnes and in 2010 the reduction is 7,571 tonnes. In terms of costs CARB estimated the cost per ton for a from-scratch AIM regulation based upon its new rule would be US$1.12 per pound, or US$2,240 per ton (US$2,469 per tonne) of VOC reduced. That is a 2010 cost of A$18,692,799. For the Wollongong region, costs have been apportioned in the ratio of Sydney surface coating emissions to GMR emissions that is (703/17,997).					

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Abatement Initiative #26: CARB 2008 Regulation for Surface Coatings - Smash Repairing

Description	This measure estimates the VOC emissions reduction achievable by implementing CARB 2008 regulations in smash preparing (automotive refinishing) businesses. Emission reduction estimated are sourced from Environ 2009: VOCs from Surface Coatings - Assessment of the Categorisation, VOC Content and Sales Volume of Coating Products Sold in Australia - a report prepared for the Environment Protection Heritage Council. Capital cost data is sourced from Rare: 2009: Reducing VOC emissions from automotive refinishing in the Sydney Basin.				
Regions:	Wollongong,				**Rating**
Impact 1		**Pollutants**			**Low**
AEI Activity:	Smash Repairing				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	220	
	Abatement (tpa)	-	-	19	
	Abatement from proportion of source affected (%)	0%	0%	9%	
Impact 2		**Pollutants**			**-**
AEI Activity:	N/A				
		NO_X	PM_{10}	VOCs	
	AEI 2008 Emission (tpa)	-	-	-	
	Abatement (tpa)	-	-	-	
	Abatement from proportion of source affected (%)	0%	0%	0%	
Implementation costs					**Low**
Program / set-up		50	000	AUD	
Implementation (capital)		289	000	AUD	
Annual operating / ongoing		201	000	USD	
Assumptions and comments					

Environ: 2009 estimates that this measure has the potential to reduce VOC emissions by 440-1668 tonnes per annum for all of Australia (estimated 4500 smash repair shops). The 2003 AEI states that there are 1,258 smash repair businesses in the GMR in 2003. Using the AEI population based projection factors there will be 1,343 in 2010. Based on this data the estimated maximum VOC emission reduction in the GMR is 498 tonnes per annum (8.8 % of total emissions). In terms of capital costs Rare, 2009 estimated A$7.5M for the Sydney Basin scaled down to A$289K for Wollongong (based on increased emission in Wollongong compared to Sydney). In terms of operating costs CARB, 2005 (Ref: http://www.arb.ca.gov/coatings/autorefin/scm/sreport/appendc.pdf) provide an average cost of US$3,400 per smash repairer per annum to implement the measure. This equates to a total cost of US$ 4,566,200 per annum to smash repairers in the GMR. Costs have been factored for the Wollongong region.