Air pollution – where does it come from?

Air Emissions Inventory for the Greater Metropolitan Region in NSW

Why do we need an air emissions inventory?

Air pollution comes from many sources, so we need to know the contribution each one makes in order to develop the best approaches for improving air quality. The last air emissions inventory for NSW was completed in 1996 and although that data has served us well until now, emissions have changed, making it necessary for a new inventory.

The major task of developing the new inventory commenced in 2004 and took nearly three years to complete. The results are now available and being used to shape the way we improve air quality in NSW.

What is the air emissions inventory?

The air emissions inventory is a detailed listing of pollutants discharged into the atmosphere by each source type during a given time period and at a specific location. The study area covers 57,330 km^2, which includes the greater Sydney, Newcastle and Wollongong regions, known collectively as the Greater Metropolitan Region (GMR). Figure 1 shows the GMR, Sydney, Newcastle and Wollongong regions. Approximately 76% of the NSW population resides in the GMR.

Figure 1 Definition of GMR, Sydney, Newcastle and Wollongong Regions

The inventory includes emissions from biogenic (i.e. natural) and anthropogenic (i.e. human) derived sources as outlined below:

- Biogenic (e.g. bushfires, trees and windborne dust)
- Commercial businesses (e.g. quarries, service stations and smash repairers)
- Domestic activities (e.g. house painting, lawn mowing and wood heaters)
- Industrial premises (e.g. oil refineries, power stations and steelworks)
- Off-road mobile (e.g. aircraft, railways and recreational boats)
- On-road mobile (e.g. buses, cars and trucks).

The inventory includes over 90 air pollutants. They are:

- criteria pollutants (i.e. carbon monoxide (CO), lead, oxides of nitrogen (NO_x), PM_{10}, $PM_{2.5}$, sulfur dioxide (SO_2) and volatile organic compounds (VOCs))
- metal air toxics (e.g. antimony, arsenic, beryllium, chromium and nickel)
- organic air toxics (e.g. benzene, formaldehyde, polycyclic aromatic hydrocarbons (PAHs), toluene and xylenes).

Air emissions data can be presented either for the GMR, Sydney, Newcastle or Wollongong regions, or each of the 66 local government areas (LGAs) within the GMR. Emissions vary by month, weekday/weekend day and hour of the day, and can be presented on an annual, monthly, daily or hourly basis.

Department of Environment & Climate Change NSW

How was the air emissions inventory completed?

The air emissions inventory project was largely funded by the NSW Environmental Trust, with additional funding provided by the Department of Environment and Climate Change NSW (DECC) and the Commonwealth Department of the Environment and Water Resources in line with State and Commonwealth agreements under the National Pollutant Inventory (NPI) National Environment Protection Measure (NEPM).

After six months preparatory work and project planning, the inventory project formally commenced in July 2004. The inventory project has been a significant air quality study that has taken nearly three years to complete.

DECC has been responsible for overall project management and three contractors have provided DECC with expertise in emission estimation methodology design, database design, activity data collection, emissions estimation and quality assurance/quality control. Over ten engineers and scientists have been responsible for completing the project.

How have air emissions been estimated?

Activity data has been obtained from industry groups, government departments and other service providers. A number of surveys have also been conducted to obtain activity data.

Air emissions have been estimated by combining activity data with emission factors. Where available, source emission test data has been used in preference to emission factors for industrial and commercial sources.

The emissions have been assigned to map coordinates for industrial and commercial point sources, or each 1-km by 1-km grid cell for biogenic, domestic-commercial, off-road mobile and on-road mobile area sources. Emissions are then calculated for months, weekdays/weekend days and hours using factors derived from the activity data. Figure 2 shows the grid coordinate system.

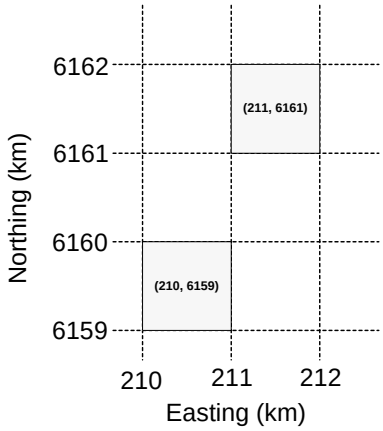

Figure 2 Grid Coordinate System

Emission estimation techniques for all source types have been based on either published Australian (i.e. NPI) or overseas methodologies (e.g. California Air Resources Board (CARB) or United States Environmental Protection Agency (USEPA)).

The base year of the inventory represents activities that took place in the 2003 calendar year and emission projection factors have been developed for every year from 2004 to 2031 using the methodologies published by USEPA, which is shown below in Equation 1 and the following data:

- Final energy usage growth data published by Australian Bureau of Agriculture and Resource Economics (ABARE)
- Free standing dwelling growth data published by Australian Bureau of Statistics (ABS) and Transport and Population Data Centre (TPDC)
- Population growth data published by ABS and TPDC
- Primary energy usage growth data published by ABARE
- Total dwelling growth data published by ABS and TPDC
- Vehicle kilometres travelled growth data published by TPDC.

Equation 1 $$E_{i,j,n} = E_{i,j,2003} \times PF_{j,n}$$

where:

$E_{i,j,n}$	=	Emission of substance i from source type j for year n	tonnes/year
$E_{i,j,2003}$	=	Emission of substance i from source type j for the base year 2003	tonnes/year
$PF_{j,n}$	=	Emission projection factor for source type j for year n	

Where is the air emissions data stored?

The air emissions inventory data is stored in a database, which includes several features such as:

- air pollution modelling using models developed by California Institute of Technology (CIT), CSIRO and USEPA
- emissions charting by air pollutant, source, LGA and region
- emissions data visualisation using geographical information systems (GIS)
- emissions forecasting up to the year 2031
- emissions modelling to test out policy scenarios
- environmental reporting by air pollutant, source, LGA and region
- source and pollutant prioritisation using CARB facility prioritisation guidelines
- VOC prioritisation based on photochemical smog forming potential using the CARB maximum incremental reactivity (MIR) methodology.

Figure 3 presents the role of the air emissions inventory within the air quality management cycle.

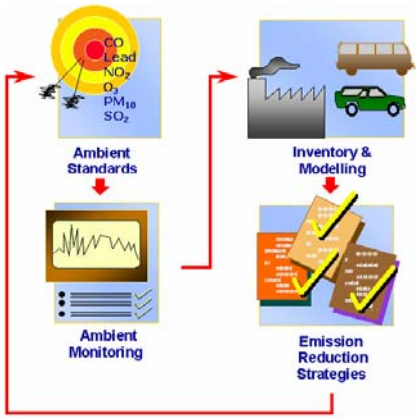

Figure 3 Air Emissions Inventory within the Air Quality Management Cycle

What are the priority air pollutants?

Air quality in the GMR has been steadily improving since the 1980s. In 1998, ambient air quality standards and goals for six criteria pollutants (i.e. CO, lead, NO_2, O_3, PM_{10} and SO_2) were set in the Ambient Air Quality NEPM. Ambient concentrations of CO, lead, NO_2 and SO_2 are all consistently below their respective national standards. However, some exceedences of national standards occur for O_3 and periodically for PM_{10}. Emissions of NO_x, PM_{10}, $PM_{2.5}$ and VOCs are the air pollutants of primary concern in the GMR and Sydney region. Figure 4 illustrates air pollution sources, their transport and transformation and parts of the environment that are impacted by air pollution.

NO_x and VOCs (or photochemical smog precursors), in the presence of sunlight, undergo a series of complex reactions, which are responsible for photochemical smog formation. Ground-level ozone is an indicator of photochemical smog, which is characterised by a white atmospheric haze during the warmer months of the year.

PM_{10} and $PM_{2.5}$ (or particles with an aerodynamic equivalent diameter less than 10 microns and 2.5 microns respectively) are responsible for fine particulate matter pollution. Fine particulate matter pollution is characterised by a brown atmospheric haze during the cooler months of the year.

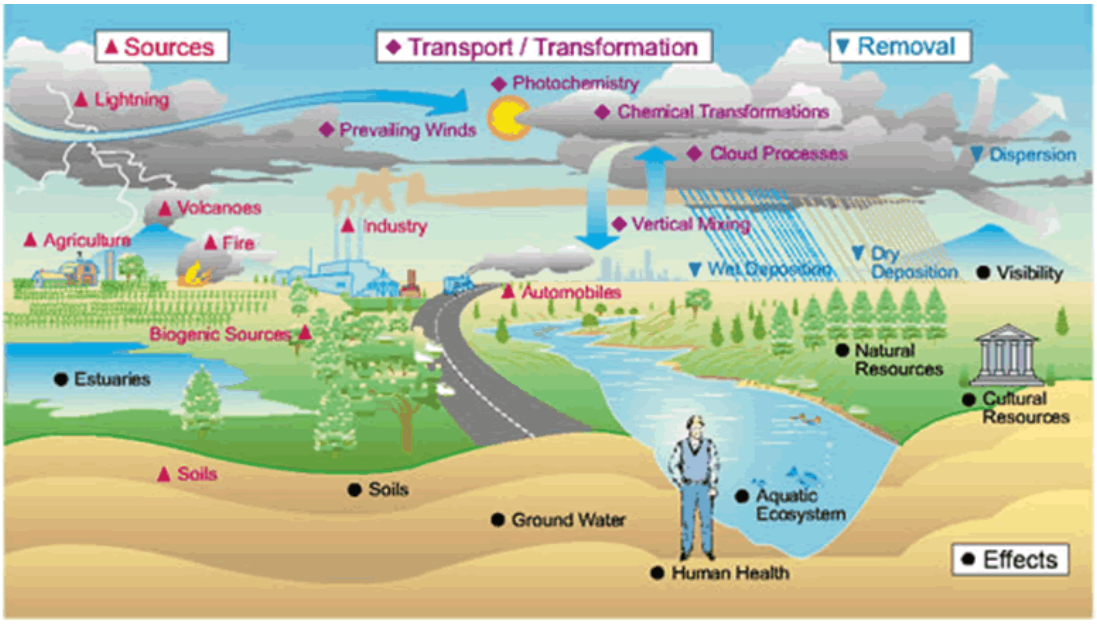

Figure 4 Sources of Air Pollution and their Impact on the Environment

What are the major anthropogenic sources in the GMR?

Table 1 presents annual anthropogenic emissions of criteria pollutants in the GMR.

Table 1 Annual Anthropogenic Emissions of Criteria Pollutants in the GMR

Substance	Anthropogenic Source Type					Anthropogenic Total
	Commercial	Domestic-Commercial	Industrial	Off-Road Mobile	On-Road Mobile	
	tonnes/year					
CO	1,801	90,516	603,133	32,144	559,047	1,286,641
Lead	0.194	0.153	11.964	54.917	13.701	80.929
NO_x	2,648	1,791	175,537	23,470	88,609	292,054
PM_{10}	4,032	6,651	46,530	14,566	3,349	75,128
$PM_{2.5}$	1,270	6,428	13,127	6,486	3,188	30,499
SO_2	71.005	143	295,819	4,170	1,660	301,863
VOCs	13,844	67,303	17,786	7,640	64,493	171,067

- CO – Industrial, on-road mobile and domestic-commercial sources make-up ~97.4%
- Lead – Off-road mobile, on-road mobile and industrial sources make-up ~99.6%
- NO_x – Industrial, on-road mobile and off-road mobile sources make-up ~98.4%
- PM_{10} – Industrial, off-road mobile and domestic-commercial sources make-up ~90.2%
- $PM_{2.5}$ – Industrial, off-road mobile, domestic-commercial and on-road mobile sources make-up ~95.8%
- SO_2 – Industrial sources make-up ~98%
- VOCs – Domestic-commercial, on-road mobile, industrial and commercial sources make-up ~95.5%.

Figures 5 to 8 show major source contributions to annual anthropogenic emissions of NO_x, PM_{10}, $PM_{2.5}$ and VOCs in the GMR.

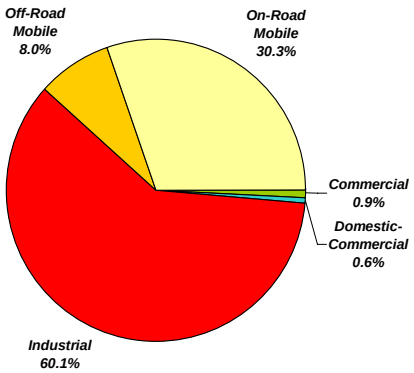

Figure 5 Annual Emissions of NO_x in the GMR

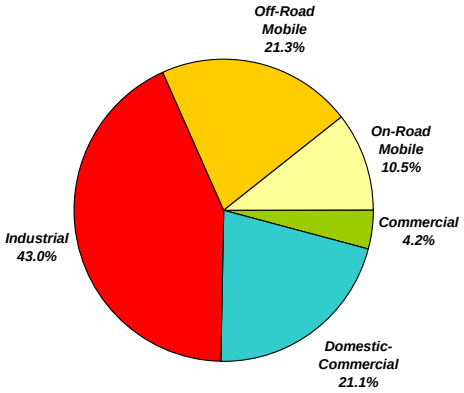

Figure 7 Annual Emissions of $PM_{2.5}$ in the GMR

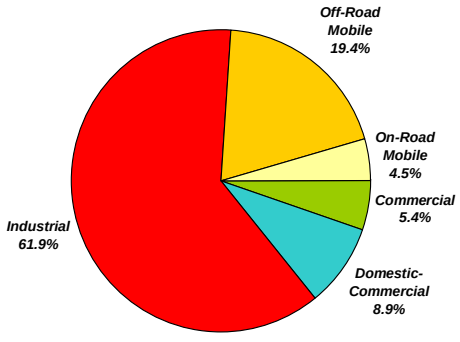

Figure 6 Annual Emissions of PM_{10} in the GMR

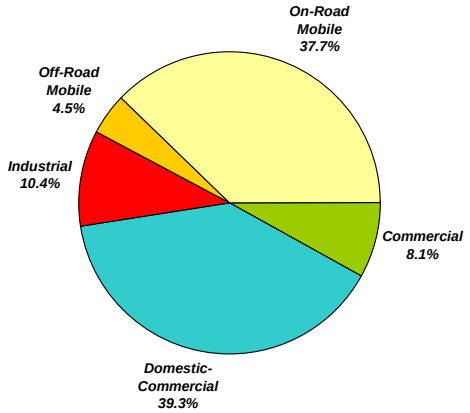

Figure 8 Annual Emissions of VOCs in the GMR

What are the major anthropogenic sources in the Sydney region?

Table 2 presents annual anthropogenic emissions of criteria pollutants in the Sydney region.

Table 2 Annual Anthropogenic Emissions of Criteria Pollutants in the Sydney Region

Substance	Anthropogenic Source Type					Anthropogenic Total
	Commercial	Domestic-Commercial	Industrial	Off-Road Mobile	On-Road Mobile	
	tonnes/year					
CO	1,265	67,221	8,004	20,251	431,270	528,011
Lead	0.189	0.114	4.703	13.325	10.713	29.044
NO_x	1,870	1,356	14,032	9,514	65,996	92,768
PM_{10}	2,143	4,993	7,911	3,707	2,552	21,305
$PM_{2.5}$	723	4,826	3,390	1,761	2,426	13,126
SO_2	48.074	108	10,980	1,374	1,254	13,764
VOCs	9,973	51,929	13,989	4,772	50,171	130,834

- CO – On-road mobile and domestic-commercial sources make-up ~94.4%
- Lead – Off-road mobile, on-road mobile and industrial sources make-up ~99%
- NOx – On-road mobile, industrial and off-road mobile sources make-up ~96.5%
- PM_{10} – Industrial, domestic-commercial, off-road mobile and on-road mobile sources make-up ~89.9%
- $PM_{2.5}$ – Domestic-commercial, industrial, on-road mobile and off-road mobile sources make-up ~94.5%
- SO_2 – Industrial sources make-up ~79.8%
- VOCs – On-road mobile, domestic-commercial, industrial and commercial sources make-up ~96.3%.

Figures 9 to 12 show major source contributions to annual anthropogenic emissions of NO_x, PM_{10}, $PM_{2.5}$ and VOCs in the Sydney region.

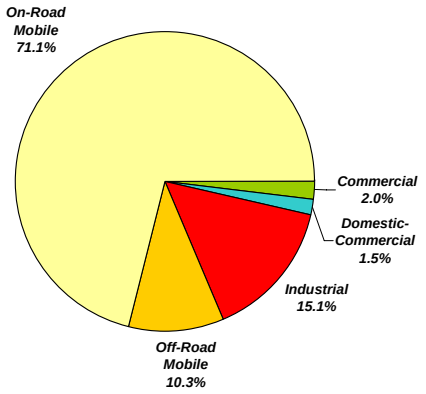

Figure 9 Annual Emissions of NO_x in the Sydney Region

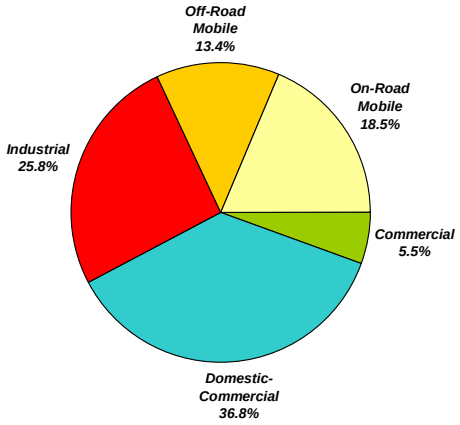

Figure 11 Annual Emissions of $PM_{2.5}$ in the Sydney Region

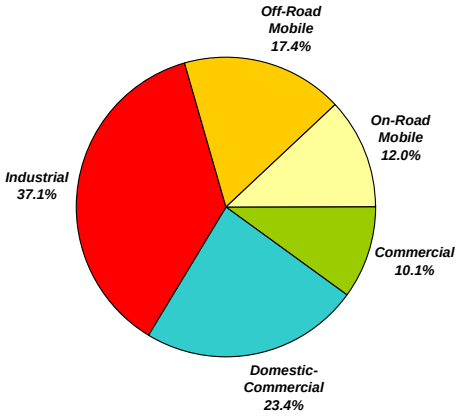

Figure 10 Annual Emissions of PM_{10} in the Sydney Region

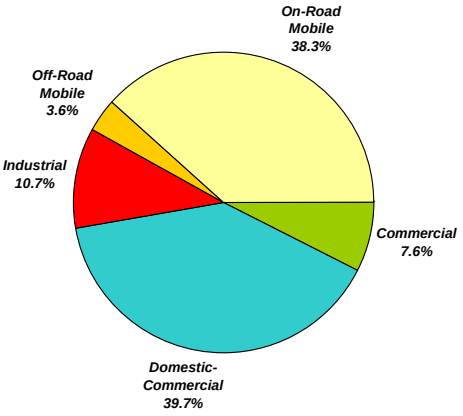

Figure 12 Annual Emissions of VOCs in the Sydney Region

How will the information be used?

In 1998 the NSW Government released 'Action for Air', its 25-year air quality management plan for the GMR. 'Action for Air' focuses on regional air pollution. The strategies in the plan aim to reduce the two pollutants of primary concern:

- photochemical smog (i.e. ground-level ozone)
- fine particle pollution (i.e. PM_{10} and $PM_{2.5}$).

The inventory will be used to refine existing emission reduction strategies and develop new-targeted strategies for all major sectors to further reduce their emissions. These will be included in the next review of 'Action for Air' in 2007.

Where can I obtain additional information?

If you require more detailed information about activity data, emission estimation methodologies, sources and emissions of other air pollutants included in the air emissions inventory you can visit the DECC web site at www.environment.nsw.gov.au/air/ and download the following documents:

- Criteria Pollutant Emissions for all Sectors
- Anthropogenic Ozone Precursors and Particle Emissions in the Greater Metropolitan and Sydney Regions
- Biogenic Emissions Module
- Commercial Emissions Module
- Domestic-Commercial Emissions Module
- Industrial Emissions Module
- Off-Road Mobile Emissions Module
- On-Road Mobile Emissions Module.

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