NSW EPA

Diesel emissions and their management in NSW

Background paper for EPA diesel emissions workshop
13 June 2014

www.epa.nsw.gov.au

Photo credits:

Page 5 – Parratech Environmental Control
Page 7 – Exhaust Control Industries

Published by:
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ISBN 978 1 74359 659 3
EPA 2014/0426
June 2014

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Foreword

The NSW Environment Protection Authority's vision is for a 'healthy environment, healthy community, healthy business'. Central to this vision are clean air and improved air quality management at the local, state and national level.

The EPA uses policy and regulatory measures to improve NSW's performance against national standards for air pollutants known to be harmful to human health. Its chief focus is on fine particle and ozone pollution, as NSW experiences exceedences of the national standards for these pollutants.

Fine particle pollution is of greatest concern because it is associated with mortality and high health costs for the community. In addition, the World Health Organization's International Agency for Research on Cancer has classified diesel exhaust as a human carcinogen. While concentrations are higher closer to sources, fine particles can disperse widely due to their very small size.

Diesel exhaust emissions are a major source of fine particle pollution. People in urban and regional NSW can be exposed to diesel emissions on a daily basis, from trucks and other diesel vehicles on the roads and from diesel engines operating in a variety of off-road settings, for example on rail and at ports, construction sites and mines.

Truck and vehicle emissions are managed through national standards for fuels and new vehicles, together with state-based regulation and programs that target the existing vehicle fleet. Meanwhile, the EPA is reducing diesel exhaust emissions from the non-road diesel fleet through initiatives with industry and councils, while also pursuing introduction of national emissions standards for non-road diesel engines.

To develop effective actions to address diesel emissions, the EPA applies the principles set out in *Managing particles and improving air quality in NSW* (EPA 2013b). These are:

- Strengthen and act on evidence
- Use innovative and effective tools
- Develop least cost pathways to improve air quality and maximise net benefits
- Engage and inform the community
- Collaborate on cleaner air at all levels of government – local, NSW and national.

This paper aims to provide information about diesel emissions in NSW – their sources and impacts and control strategies currently in place – as background for discussion with the community and industry on improving diesel control strategies.

Barry Buffier
Chair and CEO
NSW Environment Protection Authority

Impacts and costs of diesel emissions

Health impacts of fine particles and diesel exhaust

Diesel exhaust consists mostly of fine particles, as well as containing ozone-forming nitrogen oxides and toxins. Fine particles are a priority for EPA action due to their adverse impacts on health, particularly for the elderly, children and those with existing health conditions.

Numerous scientific studies have linked particle exposure to a variety of lung and heart problems, including premature death in people with heart or lung disease; non-fatal heart attacks; irregular heartbeat; aggravated asthma; decreased lung function; and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing (US EPA 2009).

People with heart or lung diseases, children and older adults are the most likely to be affected by particle exposure. However, even healthy individuals may experience temporary symptoms from exposure to elevated particle levels. Long-term exposure (over years) and short-term exposure (over hours or days) have both been linked to health problems. While there is no safe level of exposure, the risk decreases with lower levels of exposure (WHO 2006).

The World Health Organization's International Agency for Research on Cancer has classified diesel exhaust as a human carcinogen, based on evidence that exposure increases the risk of lung cancer (WHO IARC 2012). The IARC experts commented that their findings demonstrated the need to reduce exposure to diesel as a matter of protecting not only occupational health, but general population health as well. They particularly emphasised the need for action in countries that had not yet adopted regulatory standards for diesel equipment, given the long lead times to transform engine fleets.

Further evidence of the health impacts of different types of particle emissions, including those from diesel sources, is being obtained through a study commissioned by the EPA and NSW Health and conducted by the Centre for Air Quality and Health Research and Evaluation (CAR). The project will review international evidence about the health impacts of various sources, types and levels of particle pollution, focusing on those sources to which the population in NSW and the Hunter Valley may be exposed. These include coal-related activities and other industry, wood heaters, on- and off-road diesel and other transport, and hazard reduction burning.

Health costs of particles

Although air quality in NSW is relatively good by international standards and has been steadily improving over time (DECCW 2010), it still imposes major costs on NSW communities.

A 2005 study into the health impacts of air pollution in Sydney – *Air Pollution Economics: Health costs in the Greater Sydney Metropolitan Region* – estimated that particle pollution costs the NSW economy between $1 billion and $8.4 billion annually, with an average cost of $4.7 billion or $893 per person per year (DEC 2005). Transport emissions alone have been calculated to have health costs of $2.7 billion per year in Australia (BTRE 2005).

There are significant health and economic gains to be made from reducing exposure to particle and diesel pollution. The United States has found national air programs, especially for diesel emissions, deliver major economic benefits. In 2011, the US Office of Management and Budget highlighted that air pollution regulations produced the great majority of total benefits from all federal regulation, with the highest benefits

from regulations on particles, including the non-road diesel engine rule (US OMB 2011). This rule mandated new exhaust emission standards for non-road diesel engines used in industries such as construction, agriculture and mining.

In NSW, the EPA commissioned the development of a methodology to improve valuation of the health impacts of changes in particle emissions, including diesel emissions (PAEHolmes 2013b). Based on this methodology, a spreadsheet tool has also been developed to estimate health costs from changes in particle emissions associated with new land-use and transport development proposals (PAEHolmes 2013a).

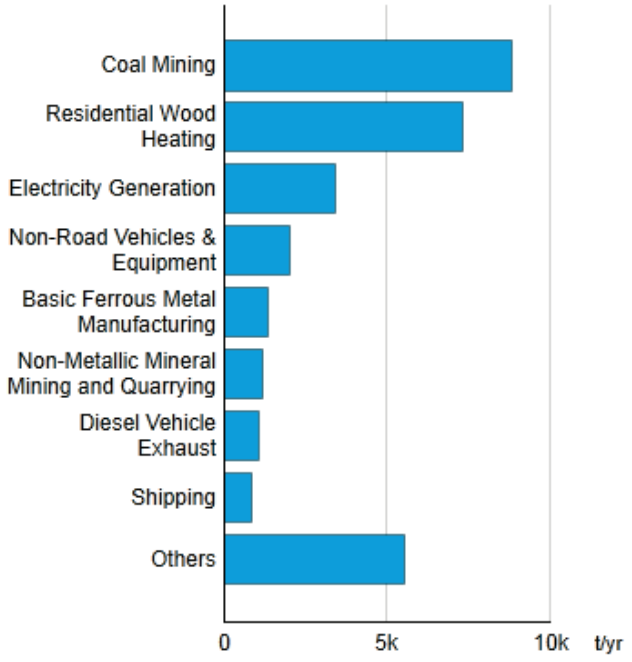
Diesel emission sources in NSW

NSW air emissions inventory

The EPA maintains the NSW Air Emissions Inventory, the most comprehensive study of air emissions in Australia and an important tool for calculating emission levels for different pollutants and identifying major emission sources. Information from the most recent inventory, for calendar year 2008, is available on the EPA website at www.epa.nsw.gov.au/air/airinventory.htm (EPA 2012).

The inventory covers the Sydney, Newcastle and Wollongong and surrounding regions, known collectively as the Greater Metropolitan Region (GMR) and is updated every five years.

Figure 1: $PM_{2.5}$ emissions in the GMR from human-made sources (2008)

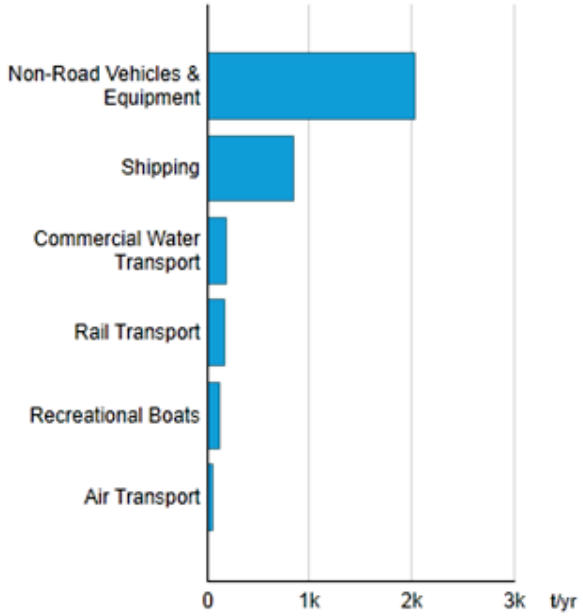


Diesel exhaust sources in the GMR include trucks and buses, marine vessels, locomotives, non-road diesel machines, such as cranes, bulldozers and tractors, and stationary engines used to generate power or pump water.

The inventory shows that on-road diesel vehicles and non-road sources together account for 14% of human-made fine particle emissions in the GMR. On-road diesel exhaust (from heavy and light duty vehicles) make up 4% (1.11 kilotonnes a year) and other diesel engines, including non-road equipment, shipping and other sources, account for 10% (2.04 kilotonnes a year) (Figure 1).

Non-road vehicles and equipment make up the fourth largest human source of fine particle emissions and the largest unregulated source in the GMR.

Figure 2: $PM_{2.5}$ emissions in the GMR from non-road diesel sources (2008)



While on-road vehicles consume more diesel fuel in total than non-road sources, they have lower total particle emissions because their new vehicles are regulated to meet emission standards. Principal non-road diesel emission sources in the GMR are non-road vehicles and equipment, shipping and other water transport and rail locomotives (Figure 2).

Diesel equipment used at industrial premises contributes 73% of all non-road diesel emissions in the GMR. Coal mining diesel equipment is estimated to contribute 86% of these fine particle emissions in the GMR and 95% in the Hunter.

Other major industrial activities contributing to non-road diesel emissions in the GMR are metalliferous mines, quarries, landfill or waste operations, ports, and construction and infrastructure projects.

Particle characterisation

The relationship between emissions and the air people breathe is complex. Meteorology, topography and atmospheric reactions drive the dispersion, transportation and transformation of emissions. In addition to the emissions inventory, studies of the composition of particles where levels are of concern are also used to understand the sources that are affecting human health.

Particle composition studies have been undertaken for Sydney and the Upper Hunter (Hibberd et al 2013) and a further particle composition study is underway in the Lower Hunter. Sampling commenced in March 2014 for the Lower Hunter Particle Characterisation Study to determine the composition and major sources, including diesel sources, which contribute to $PM_{2.5}$ concentrations in the vicinity of Newcastle Port (OEH 2014).

Following an independent review of particle emissions data for the Hunter rail corridor (Ryan & Wand 2014), the EPA has commissioned further analysis. This follows research begun in 2012 when the EPA required the Australian Rail Track Corporation (ARTC) to investigate particle emissions in the corridor and whether loaded coal trains produced more particulate matter than other trains.

Framework for managing diesel emissions in Australia and NSW

Instruments and agencies at national and state level set the framework for managing diesel emissions, from on-road and non-road vehicles and equipment and from new and existing fleets of vehicles and equipment.

Management of on-road diesel emissions

At the national level, the Commonwealth Government is responsible for policy and standards relating to on-road diesel vehicle emissions under the *Motor Vehicles Standards Act 1989* and *Fuel Quality Standards Act 2000*. Australian policy, strongly supported by NSW, has been to harmonise Australian vehicle emissions standards with progressively more stringent European Union standards for diesel and petrol vehicles.

States and territory governments manage emissions from their operating vehicle fleets. The *National Environment Protection (Diesel Vehicle Emissions) Measure 2001* (NEPC 2001) requires all jurisdictions to submit annual reports on implementation and assessment of activities to reduce diesel vehicle emissions from operating fleets.

The NSW EPA and NSW Roads and Maritime Services (RMS) have implemented a range of programs to reduce diesel emissions in NSW. These include:

- The EPA's smoky vehicle enforcement program targets highly polluting vehicles, with a recently developed mobile app assisting community members to report smoky vehicles (EPA 2013c).
- The diesel retrofit program for older polluting vehicles retrofitted over 500 vehicles between 2005 and 2011 (RMS 2013). RMS has also run a ports diesel program, retrofitting over 80 trucks servicing Port Botany and Port Kembla, and continues to operate the M5 enforcement and compliance program, targeting smoky trucks using the M5 East tunnel.

Management of non-road diesel emissions

While Australia has national emissions standards for on-road diesel vehicles, no regulations specifically apply to emissions from non-road diesel sources in Australia or NSW (except underground coal mines).

A study to gather information and scope possible actions for non-road diesels in Australia found that significant health benefits, ranging from $2.5 to $4.7 billion by 2030, could potentially be achieved by actions to reduce PM_{10} and nitrogen oxide emissions (Environ 2010).

NSW is working with the Commonwealth and other jurisdictions to develop national measures to reduce diesel emissions, including emission standards for non-road diesel engines. In a statement on 29 April 2014, Australian environment ministers signalled they would work towards finalising a National Clean Air Agreement by June 2016 (Hunt 2014). NSW will continue to support the development and adoption of non-road engine standards as part of the national agreement.

The NSW EPA has identified a need to act independently on non-road diesel emissions in light of the lack of national standards, growth in emissions from this sector, increasing evidence of adverse health impacts from diesel, and the availability of standards and proven technologies to reduce diesel emissions.

Regulated emission limits for non-road diesel sources have been in force in the United States (US EPA 2014) and European Union (European Commission 2013) since the mid-to-late 1990s and were more recently introduced in Canada, Russia, Switzerland, Turkey, Japan, China, India, South Korea, Singapore and Brazil (Ecopoint Inc. 2013). Overseas approaches to managing non-road diesel emissions are outlined in Appendix I.

The EPA has developed non-regulatory measures to manage diesel emissions, through the Clean Machine Program, described below. It is also developing new management approaches drawing on its regulatory powers. The *Protection of the Environment Operations Act 1997*, Protection of the Environment Operations (Clean Air) Regulation 2010 and environment protection licensing of industry provide a framework for the EPA to manage air emissions from licensed premises, including diesel emissions.

EPA non-road diesel initiatives

Diesel emissions from coal mines

The EPA is undertaking a project targeting coal mines as the principal industrial source contributing to non-road diesel emissions in the GMR. Similar to the Dust Stop program for NSW coal mines, this project involves reviewing and applying best practice measures to manage diesel emissions from equipment used in coal mines. The EPA has surveyed all 64 licensed coal mines in NSW to obtain detailed information about the composition and use of their diesel fleet, their maintenance and engine replacement schedules, fleet projections and fuel use.

Locomotives

As with non-road engines, no regulations apply to limit exhaust emissions from diesel locomotives in Australia or NSW. The Australasian Railway Association (ARA), through its Rail Industry Safety and Standards Board and associated Freight Rail Operators Environmental Policy Group, is in the process of developing environmental standards for freight locomotives.

The EPA commissioned and has released the report of a study into reducing locomotive emissions in NSW and Australia (Environ 2013). The report showed that around 81% of existing Australian locomotives do not meet any US emissions standard. In addition, it found that the average age of a diesel locomotive in Australia is 35 years, compared to eight years in the US. In NSW the locomotive fleet is older than the Australian fleet as a whole and also has a higher rate of fuel use.

Evaluation of studies to date of particle emissions from rail in the Hunter has drawn attention to diesel emissions from locomotives as a significant contributor to particle levels. The EPA has requested further analysis of data to assess the impact of diesel locomotives.

Ports and shipping

There are currently few controls on emissions from port operations. Ships are generally powered by large diesel engines operating on low-quality fuel with relatively high sulfur content. A December 2011 report commissioned for the EPA showed that the majority of port emissions are from shipping (80% of particle emissions or 892 tonnes per year) (PAEHolmes 2011).

Clean Machine Program

From 2011 to the present, the EPA has operated the Clean Machine Program to reduce exhaust emissions from diesel equipment used, for example, in ports and on construction sites (EPA 20013a). Under the program, the EPA partners with councils and businesses to encourage:

- best practice for managing diesel emissions from worksite operations, such as limiting equipment idling times and minimising impacts near sensitive populations, for example, those around schools, hospitals and aged care homes
- purchase of better emission standard engines
- retrofitting of exhaust treatment to existing engines – Subsidies of 50–90% are provided for the retrofit of diesel particle filters to machines such as cranes, gantries, bulldozers, loaders, and graders. The program targets high-use, high-polluting equipment in populated areas.

Since the program began in 2011, the NSW Government has invested three-quarters of a million dollars to support installing particle filters in about 140 machines across Sydney, the Illawarra, the Central Coast, and Upper and Lower Hunter. Over the next 10 years, the EPA estimates the retrofits completed under the program will deliver total reductions of around 36 tonnes of diesel particles and an estimated $8.1 million in health benefits for NSW residents.

Clearing the air about mobile plant emissions

The EPA has commenced a project to reduce emissions from diesel equipment used in major infrastructure projects in the Sydney region, where there is potentially high population exposure. The project involves representatives from government agencies responsible for significant public infrastructure and the construction industry. It aims to include educational and potentially regulatory components. Improvements on major projects are expected to have flow-on effects with better plant and practices spreading throughout the construction industry.

Appendix I: Overseas standards for non-road diesel engine emissions

Sources: Ecopoint 2013; European Commission 2013; Integer Research Ltd 2014; US EPA 2012

Country	Standard	Implementation date	Comment
North America			
US	Tier 1 Tier 2 Tier 3 Tier 4	1996–2000 2000–2008 2004–2008 2008–2015	In 1998, Tier 1 standards were regulated for engines under 37 kW and increasingly more stringent Tier 2 and Tier 3 standards for all engines. Tier 1–3 standards are met through advanced engine design. Tier 4 emission standards were introduced in 2004, requiring emissions of PM and NO_x to be further reduced by about 90%. This involves the use of control technologies, including advanced exhaust gas after-treatment (Ecopoint 2013). The National Clean Diesel Campaign (NCDC) uses strategies and programs to reduce emissions from in-service diesel engines, including in vehicles, vessels, locomotives and non-road equipment. The California Air Resources Board (CARB) complements new vehicle standards with the Regulation for In-use Off-road Diesel-fuelled Fleets.
Canada	Tier 2 Tier 3 Tier 4	2006 2006–2008 2012–2015	Tier 2 and 3 certification values are aligned with US EPA standards but were implemented at later dates. Tier 4 values align with US EPA Tier 4 for engine models 2012 and later.
Europe			
EU	EU Stage I EU Stage II EU Stage IIIA EU Stage IIIB EU Stage IV	1999 2001–2004 2006–2008 2011–2013 2014	The European emission standards for new non-road diesel engines have been structured as progressively more stringent standards from Stage I–IV. The regulations are specified by a 1997 directive with numerous later amendments (Ecopoint 2013).
Russia	GOST R41 96–99 GOST R41 96–2011	2000 2014	Equivalent to EU Stage I Equivalent to EU Stage III

Country	Standard	Implementation date	Comment
Turkey	Stage I (Faz I) Stage II (Faz II) Stage IIIA (Faz IIIA) Stage IIIB (Faz IIIB) Stage IV (Faz IV)	2003 2007 2010 2011–2013 2014	The standards are fully harmonised with the EU non-road standards but implementation dates are different.
Asia			
Japan	Tier 3 Tier 4i/IIIB Tier 4/EU Stage IV	2006–2008 2011–2013 2015–2016	Emission standards apply to engines between 19 and 560 kW and are based on US and EU equivalent standards.
China	Stage I Stage II	2007 2009	Standards are based on the European Stage I–II emission standards for mobile non-road engines but also cover small diesel engines with emission limits consistent with the US Tier 1–2 non-road standards.
India	Bharat (CEV) Stage II Bharat (CEV) Stage III	2007–2008 2011	Emission standards cover construction machinery. Stage II standards are based on the EU Stage I requirements, but also cover smaller engines that were not regulated under the EU Stage I. Stage III standards are based on US Tier 2–3 requirements.
South Korea	Tier 1–2 Tier 3 Tier 4	2004–2005 2009–2013 2015	Tier 1–2 standards apply to mobile non-road diesel engines between 19 and 560 kW such as construction equipment and are based on US regulations. Tier 3 standards are based on US EPA Tier 3 and became effective in 2009 for construction machinery and in 2013 for agricultural equipment. Tier 4 emission limits are based on US EPA Tier 4 final requirements.
Singapore	Stage I	2000	New non-road diesels must comply with EU Stage I, US EPA Tier 1 or Japan Tier 1 standards.
South America			
Brazil	PROCONVE MAR-I	2015–2018	Standards set limits for engines in construction and farming machinery equivalent to US EPA Tier 3 and EU Stage IIIA.

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