Technical Paper
TP01: Trends in Motor Vehicles and their Emissions

Advisory Committee on Tunnel Air Quality
Author: NSW Environment Protection Authority

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Key Points

- Australian new vehicle emission standards are set out in the Australian Design Rules (ADR) and have been progressively and significantly improved over the last 40 years.

- The National Fuel Quality Standards have progressively required cleaner fuels to complement the ADRs and enable use of improved emission control technology. Proposed reforms to the Standards are underway, focusing on petrol, because Australia’s petrol is not as high quality as petrol in other Organisation for Economic Cooperation and Development (OECD) countries.

- Emissions from the in-service vehicle fleet (i.e. the vehicles driven in NSW) have significantly reduced as a consequence of the more stringent emission standards and cleaner fuel.

- Vehicle kilometres travelled (VKT) are increasing steadily, with passenger vehicle VKT increasing in line with population growth at around one per cent annually, while freight vehicle VKT is growing in line with economic growth at two to three per cent annually.

- In spite of the increase in VKT, the strong reduction in vehicle emission rates has resulted in significant reductions in total fleet emissions, and these reductions are projected to continue over the next 10–20 years.

- Heavy duty diesel vehicles and in particular rigid trucks, are disproportionately high contributors to exhaust particulate matter emissions.

- As the newer vehicles in the fleet have significantly reduced emissions due to the tighter ADRs, the older vehicles in the fleet built to less stringent standards make a significant and disproportionately high contribution to the total fleet emissions.

- Fleet composition in terms of both vehicle type and age classes are important factors determining the level of emissions from any specific road corridor.
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1. National Vehicle Emission Standards

New on-road motor vehicle emission standards are set by the Australian Government via the ADRs. The first ADR governing vehicle emissions was set in 1972 with ADR26, which set a limit for the exhaust concentration of carbon monoxide (CO) at idle. This was followed by ADR27 in 1974 which introduced standards based on mass of emissions per kilometre (g/km) measured under a transient drive cycle designed to represent urban driving conditions. The first emission standard for diesel vehicles was set in 1976 under ADR30/00 with the adoption of United Nations Economic Commission for Europe Regulation 24/00 which set limits for exhaust opacity (smoke) under steady state loaded conditions.

The emission standards for light and heavy duty vehicles have been progressively tightened over time based variously on United States (US) and European Union (EU) standards. The current Australian light duty vehicle emission standards are approximately 20–30 times lower than the original drive cycle-based standards in force in 1976, while current heavy duty diesel standards are four times lower for NOx and more than 10 times lower for PM than those first introduced in 1995. In addition to the reduction in emission limits, the required durability of emission controls has been significantly extended.

The history of Australian standards for petrol passenger cars, diesel passenger cars and heavy duty diesel engines is summarised in Table 1, Table 2 and Table 3. Charts displaying the ADRs are included in Appendix A. Current emission standards in Australia are Euro 5 standards for new passenger cars and Euro V for new heavy duty vehicles.

The Australian Government’s Ministerial Forum on Vehicle Emissions is currently considering adoption of the Euro 6 standards for light vehicles and Euro VI standards for heavy vehicles in 2020, lagging Europe by 5–7 years. Euro 6 standards extend the limit on particle number introduced for light duty diesel vehicles with Euro 5 to include those vehicles fitted with petrol direct injection engines. This is expected to require new petrol direct injection vehicles to be fitted with an exhaust particle filter. Euro VI limits for heavy diesel vehicles are expected to result in very large reductions in emissions of NOx, and Euro VI introduces a particle number limit which will drive particle emissions lower.

Beginning in 2017, the EU’s emissions type-approval procedure for light vehicles includes a new real-driving emissions (RDE) test conducted using on-board portable emissions measurement systems (PEMS), to ensure vehicles conform to the required standards under normal on-road driving conditions. The RDE requirements will be fully implemented by January 2021 and will ensure the benefits of reduced NOx limits are not lost through test defeat devices.

Europe has not formally proposed stricter future standards. The US has recently brought in Tier 3 standards for light duty vehicles which by 2025 will be around 80 per cent more stringent for NOx and non-methane hydrocarbons (NMHC) than Euro 6, while possibly less stringent for PM.

### Table 1: Petrol passenger car emission standards (g/km)

<table>
<thead>
<tr>
<th>ADR</th>
<th>Standard Date(1)</th>
<th>CO</th>
<th>HC/ NMHC(2)</th>
<th>HC+NOx</th>
<th>NOx</th>
<th>Particulate Mass</th>
<th>PN(3)</th>
<th>Test cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADR27A</td>
<td>July 1976</td>
<td>24.2</td>
<td>2.1/–</td>
<td>–</td>
<td>1.90</td>
<td>–</td>
<td>–</td>
<td>US FTP 72</td>
</tr>
<tr>
<td>ADR37/00</td>
<td>US’75 Feb 1986</td>
<td>9.3</td>
<td>0.93/–</td>
<td>–</td>
<td>1.93</td>
<td>–</td>
<td>–</td>
<td>US FTP 75</td>
</tr>
<tr>
<td>ADR37/01</td>
<td>US’90 Jan 1999</td>
<td>2.1</td>
<td>0.26/–</td>
<td>–</td>
<td>0.63</td>
<td>–</td>
<td>–</td>
<td>US FTP 75</td>
</tr>
<tr>
<td>ADR79/00</td>
<td>Euro 2 Jan 2004</td>
<td>2.2</td>
<td>–/–</td>
<td>0.50</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>ECE + EUDC</td>
</tr>
<tr>
<td>ADR79/01</td>
<td>Euro 3 Jan 2006</td>
<td>2.3</td>
<td>0.20/–</td>
<td>–</td>
<td>0.15</td>
<td>–</td>
<td>–</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/02</td>
<td>Euro 4 July 2010</td>
<td>1.0</td>
<td>0.10/–</td>
<td>–</td>
<td>0.08</td>
<td>–</td>
<td>–</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/03</td>
<td>Euro 5 Nov 2013(5)</td>
<td>1.0</td>
<td>0.10/0.068</td>
<td>–</td>
<td>0.06</td>
<td>0.0045(6)</td>
<td>–</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/04</td>
<td>Euro 5 Nov 2016</td>
<td>1.0</td>
<td>0.10/0.068</td>
<td>–</td>
<td>0.06</td>
<td>0.0045(6)</td>
<td>–</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/05</td>
<td>Euro 6 Proposed 2020</td>
<td>1.0</td>
<td>0.10/0.068</td>
<td>–</td>
<td>0.06</td>
<td>0.0045(6)</td>
<td>6x1011(6)</td>
<td>WLTP</td>
</tr>
</tbody>
</table>

1. Standard applies to all vehicles built after this date, generally applies to new models one year earlier
2. Non-methane hydrocarbons
3. PN (particle number) per km
4. ADR27A was the first introduction of g/km limits for CO, hydrocarbons (HC) and NOx
5. Applies to new models only
6. PM and PN standards apply to petrol direct injection engines only.

Table 2: Diesel passenger car emission standards (g/km)

<table>
<thead>
<tr>
<th>ADR</th>
<th>Standard</th>
<th>Date(1)</th>
<th>CO</th>
<th>HC/ NMHC(2)</th>
<th>HC+NOₓ</th>
<th>NOₓ</th>
<th>Particulate Mass</th>
<th>PN(3)</th>
<th>Test cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADR70/00</td>
<td>Euro 1</td>
<td>Jan 1996</td>
<td>2.72</td>
<td>–</td>
<td>0.97</td>
<td>–</td>
<td>0.14</td>
<td>–</td>
<td>ECE + EUDC</td>
</tr>
<tr>
<td>ADR79/00</td>
<td>Euro 2</td>
<td>Jan 2003</td>
<td>1.0</td>
<td>–</td>
<td>0.70/0.90(4)</td>
<td>–</td>
<td>0.08/0.10(4)</td>
<td>–</td>
<td>ECE + EUDC</td>
</tr>
<tr>
<td>ADR79/01</td>
<td>Euro 4</td>
<td>Jan 2007</td>
<td>0.50</td>
<td>–</td>
<td>0.30</td>
<td>0.25</td>
<td>0.025</td>
<td>–</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/02</td>
<td>Euro 4</td>
<td>Jan 2010(5)</td>
<td>0.50</td>
<td>–</td>
<td>0.30</td>
<td>0.25</td>
<td>0.025</td>
<td>–</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/03</td>
<td>Euro 5</td>
<td>Nov 2013(6)</td>
<td>0.50</td>
<td>–</td>
<td>0.23</td>
<td>0.18</td>
<td>0.0045</td>
<td>–</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/04</td>
<td>Euro 5</td>
<td>Nov 2016</td>
<td>0.50</td>
<td>–</td>
<td>0.23</td>
<td>0.18</td>
<td>0.0045</td>
<td>6x10¹¹</td>
<td>NEDC</td>
</tr>
<tr>
<td>ADR79/05</td>
<td>Euro 6</td>
<td>Proposed 2020</td>
<td>0.50</td>
<td>–</td>
<td>0.17</td>
<td>0.08</td>
<td>0.0045</td>
<td>6x10¹¹</td>
<td>WLTP</td>
</tr>
</tbody>
</table>

1. Standard applies to all vehicles built after this date, generally applies to new models one year earlier.
2. Non-methane hydrocarbons
3. PN (particle number) per km
4. First limit applies to indirect injection engines, second applies to direct injection engines.
5. Same standard as ADR79/01 (Euro 4) but extends to more vehicle classes.
6. Applies to new models only, applies to all vehicles from ADR79/04.

Table 3: Heavy duty vehicle diesel emission standards (g/kWh)

<table>
<thead>
<tr>
<th>ADR</th>
<th>Standard</th>
<th>Date(1)</th>
<th>CO</th>
<th>HC/ NMHC(2)</th>
<th>NOₓ</th>
<th>Particulate Mass</th>
<th>PN(3)</th>
<th>Test cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADR70/00</td>
<td>Euro I</td>
<td>Jan 1996</td>
<td>4.5</td>
<td>1.1/~</td>
<td>8.0</td>
<td>0.36</td>
<td>–</td>
<td>ECE-R49</td>
</tr>
<tr>
<td>ADR80/00</td>
<td>Euro III</td>
<td>Jan 2003</td>
<td>2.1/5.45(4)</td>
<td>0.66/0.78</td>
<td>5.0/5.0</td>
<td>0.10/0.16</td>
<td>–</td>
<td>ESC/ETC</td>
</tr>
<tr>
<td>ADR80/02</td>
<td>Euro IV</td>
<td>Jan 2008</td>
<td>1.5/4.0</td>
<td>0.46/0.55</td>
<td>3.5/3.5</td>
<td>0.02/0.03</td>
<td>–</td>
<td>ESC/ETC</td>
</tr>
<tr>
<td>ADR80/03</td>
<td>Euro V</td>
<td>Jan 2011</td>
<td>1.5/4.0</td>
<td>0.46/0.55</td>
<td>2.0/2.0</td>
<td>0.02/0.03</td>
<td>–</td>
<td>ESC/ETC</td>
</tr>
<tr>
<td>ADR80/04</td>
<td>Euro VI</td>
<td>Proposed 2020</td>
<td>1.5/4.0</td>
<td>0.13/0.16</td>
<td>0.4/0.46</td>
<td>0.01/0.01</td>
<td>8x10¹⁷/ 6x10¹¹</td>
<td>WHSC/ WHTC</td>
</tr>
</tbody>
</table>

1. Standard applies to all vehicles built after this date, generally applies to new models one year earlier.
2. Non-methane hydrocarbons
3. PN (particle number) per kWh
4. First limit applies to ESC test cycle, second to the ETC cycle.
2. National Fuel Standards

Complementing the progressive tightening of the vehicle emission standards, the national fuel standards have also been revised to reduce vehicle emissions in several ways:

- Specifications which support the implementation of new emission control technology (e.g. elimination of lead in petrol and reductions of sulfur levels in fuel to enable the use of exhaust catalysts)
- Specifications to directly reduce engine-out (i.e. before exhaust catalyst) emissions (e.g. reductions in benzene concentrations in petrol)
- Reduction of petrol volatility to reduce evaporative fuel emissions.

Generally, Australian fuel specifications have been aligned to European fuel standards. This has been applied to match the requirements of vehicle technology designed to the EU emission standards that Australia has adopted.

Key fuel specifications are detailed in Table 4 for petrol and Table 5 for diesel.²

Table 4: Key petrol fuel standard specifications

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard</th>
<th>Fuel Grade</th>
<th>Implementation Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>≤500 ppm</td>
<td>Unleaded petrol</td>
<td>1 Jan 2002</td>
</tr>
<tr>
<td></td>
<td>≤150 ppm</td>
<td>Premium unleaded petrol</td>
<td>1 Jan 2002</td>
</tr>
<tr>
<td></td>
<td>≤150 ppm</td>
<td>All</td>
<td>1 Jan 2005</td>
</tr>
<tr>
<td></td>
<td>≤50 ppm</td>
<td>Premium unleaded petrol</td>
<td>1 Jan 2008</td>
</tr>
<tr>
<td>Benzene</td>
<td>≤1% by vol.</td>
<td>All</td>
<td>1 Jan 2006</td>
</tr>
<tr>
<td>Lead</td>
<td>≤0.005 g/L</td>
<td>All</td>
<td>1 Jan 2002</td>
</tr>
<tr>
<td>Olefins(1)</td>
<td>18% pool av. over 6 months; 20% cap</td>
<td>All</td>
<td>1 Jan 2004</td>
</tr>
<tr>
<td></td>
<td>≤18% by vol.</td>
<td>All</td>
<td>1 Jan 2005</td>
</tr>
<tr>
<td>Aromatics(2)</td>
<td>45% pool av over 6 months; 48% cap</td>
<td>All</td>
<td>1 Jan 2002</td>
</tr>
<tr>
<td></td>
<td>42% pool av over 6 months; 45% cap</td>
<td>All</td>
<td>1 Jan 2005</td>
</tr>
<tr>
<td>Reid Vapour Pressure(2)</td>
<td>62 kPa from Nov to March</td>
<td>All</td>
<td>1 Nov 2004³</td>
</tr>
</tbody>
</table>

1. Pool average over all batches in any six month period, cap applies to any single batch
2. Vapour pressure limit is NSW regulation
3. Low volatility fuel was introduced by a memorandum of understanding in 1998 but was not regulated in NSW until 2004.

Table 5: Key diesel fuel specifications

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard</th>
<th>Implementation Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>≤500 ppm</td>
<td>31 Dec 2002</td>
</tr>
<tr>
<td></td>
<td>≤50 ppm</td>
<td>1 Jan 2006</td>
</tr>
<tr>
<td></td>
<td>≤10 ppm</td>
<td>1 Jan 2009</td>
</tr>
<tr>
<td>Cetane Index</td>
<td>≥46</td>
<td>1 Jan 2002</td>
</tr>
<tr>
<td>Density</td>
<td>820-860 kg/m³</td>
<td>1 Jan 2002</td>
</tr>
<tr>
<td></td>
<td>820-850 kg/m³</td>
<td>1 Jan 2006</td>
</tr>
<tr>
<td>Distillation T95</td>
<td>370°C</td>
<td>1 Jan 2002</td>
</tr>
<tr>
<td></td>
<td>360°C</td>
<td>1 Jan 2006</td>
</tr>
<tr>
<td>Polyaromatic Hydrocarbons</td>
<td>11% by mass</td>
<td>1 Jan 2006</td>
</tr>
</tbody>
</table>

In December 2016, the Ministerial Forum on Vehicle Emissions released a discussion paper on improving fuel quality standards and invited public comment until March 2017. The discussion paper highlighted two fuel parameters of particular concern: sulfur and octane in petrol. Sulfur reduces the efficiency of vehicle catalytic converters, so reduced petrol sulfur levels will significantly reduce emissions. Higher octane fuels can be used in high compression petrol engines which are more fuel efficient and produce less greenhouse gas emissions.

A draft regulation impact statement proposing improvements to fuel standards under the Fuel Quality Standards Act 2000 was released in January 2018. These changes are designed to bring key properties of Australia’s fuel quality into line with international standards.

3. In-service Fleet Performance

The effectiveness of the tighter emission standards on the in-service petrol passenger vehicle fleet is demonstrated with data from the Commonwealth’s Second National In-Service Emission Study (NISE2) (DEWHA, 2009).

The average hydrocarbon (HC) emissions for the four ADR classes tested in the NISE2 project are shown in Figure 1. The data shown is for the 20 km Australian Combined Urban Emission Drive Cycle\(^3\) (CUEDC) for both a start from cold and a start with a fully hot engine. The emission rates are seen to have decreased by an order of magnitude from the ADR37/00 cars of the 1990s to the latest vehicles tested in this project, 2006–07 ADR79/01 (Euro 3) vehicles.

The corresponding NO\(_x\) emissions are shown in Figure 2 and are also seen to have decreased by an order of magnitude from ADR 37/00 to ADR79/01.

The Sydney Particle Characterisation Study showed that PM\(_{2.5}\) emissions from vehicles have fallen by around 40 per cent over the last 15 years, despite increases in vehicle use (ANSTO, 2016).

European real world in-service test data on Euro 5 and 6 petrol vehicles has demonstrated that these standards have been effective in driving significant emission reductions.

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\(^3\) The Combined Urban Emissions Drive Cycle is a ‘real-world’ vehicle test cycle developed from monitoring of thousands of kilometres of actual vehicle operation across Australian capital cities.
VKT are estimated by Transport for NSW’s Transport Performance and Analytics (TPA). The TPA estimates VKT using sophisticated strategic transport models calibrated with pooled data from the annual NSW Household Travel Survey (HTS) for passenger transport and commercial transport surveys for freight transport (BTS, 2011, TDC, 2010). TPA estimates are generally in agreement with other VKT sources such as the Australian Bureau of Statistics Survey of Motor Vehicle Use (SMVU).

The TPA modelled growth in VKT for passenger vehicles and freight vehicles for the NSW greater metropolitan region (GMR) are shown in Figure 3. The vehicle classes represented by the dashed lines refer to the right hand axis. The total fleet annual VKT growth rate is around one per cent per year. Passenger vehicles dominate the VKT and grow at population growth of also around one per cent per year, while VKT growth rates for both rigid and articulated trucks are in line with economic growth at around two to three per cent per year.

Figure 3: Average weekday VKT growth 2003–2036
5. Motor Vehicle NSW GMR Emission Inventory Projections

The NSW Environment Protection Authority (EPA) motor vehicle emission inventory model is used to project the entire fleet emissions for the NSW GMR to future years as shown in Figure 4 (EPA, 2012). VKT growth and congestion are estimated from the TPA data above, and the model includes fleet turnover and the resultant adoption of new technology.

The projections depicted with the solid lines in Figures 4 and 5 exclude proposed adoption of Euro 6/VI for light/heavy vehicles. The dashed lines demonstrate the impact of adoption of Euro6/VI and a 10 ppm sulfur limit for petrol.

The projections do not account for any uptake of hybrid or electric vehicles. In 2016, new registrations of electric and hybrid vehicles comprised 0.1 per cent and 1.2 per cent respectively of new light vehicles. As new petrol and diesel vehicles have very low emissions, and the contribution of older vehicles dominates fleet emissions, a large uptake of electric vehicles would be required to have significant impact on the fleet emissions.

Figure 4 shows two lines for PM$_{2.5}$. The light blue line shows exhaust emissions of PM$_{2.5}$ and shows strong decreases with the penetration of new technology into the fleet as a direct response to the large reductions in emissions limits in the ADRs. Exhaust PM is mostly less than 1.0 µm in diameter) (PM$_1$), and represents more than 99 per cent of the number of PM$_1$ particles emitted and more than 85–90 per cent of the mass of PM$_1$ particles emitted. Adoption of Euro 6 standards for light vehicles and Euro VI for heavy vehicles would significantly reduce the projected PM$_{1.5}$ exhaust emissions.

The dark blue line is the total PM$_{2.5}$ which includes non-exhaust sources of tyre, brake and road wear added to the exhaust emissions. Non-exhaust particles comprise larger size fractions than exhaust PM, with only 34 per cent of total PM as PM$_{2.5}$, of which seven per cent is PM$_1$.

As there is no current abatement technology or legislated standards for the non-exhaust sources of PM, emissions from this source grow as a direct function of VKT. Hence the total PM$_{2.5}$ reaches a minimum around 2026 and then starts to grow.

The PM$_{2.5}$ data on the blue lines is plotted against the left hand axis. VKT data represented by the red line is plotted against the right hand axis. Note: VKT is in millions of kilometres per year (million km/year).

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Figure 5: Projected NSW GMR NO$_x$ and VOC motor vehicle emissions (EPA, 2017)

Note: The NO$_x$ data is represented by the red lines and are plotted against the right hand axis. VOC data are represented by the blue line and are plotted against the left hand axis.

Figure 5 shows the projected emissions of NO$_x$ and VOC emissions with new vehicle standards. NO$_x$ emissions can be seen to strongly decline into the future as a result of the new low emission vehicles entering the fleet. The dashed red line shows that the adoption of Euro 6/VI standards for light/heavy diesel vehicles and adoption of 10 ppm sulfur petrol would significantly reduce NO$_x$ emissions.

Although motor vehicle emissions are projected to decline, health evidence indicates that particulate matter is a non-threshold pollutant and O$_3$ (formed from hydrocarbons and oxides of nitrogen) is also likely to be a non-threshold air pollutant. Hence, ongoing emission reductions will continue to deliver positive public health benefits (WHO 2013, Bell & Dominici 2008).

The data trends shown in Figures 4 and 5 as an aggregation across the GMR may not reflect changes in any one location or road corridor which may have significantly different VKT growth rates and traffic mixes. For instance, rigid trucks tend to be replaced at a much slower rate than articulated trucks. The emission contribution by vehicle type is presented in the next section.

5.1 Emission contribution by vehicle type

The NSW EPA motor vehicle emissions inventory estimates the contribution by vehicle type to the total 2008 NSW GMR motor vehicle emissions. This is shown in Figure 6, Figure 7 and Figure 8 for PM$_{10}$, VOC and NO$_x$ respectively. The vehicle type abbreviations used are given in Table 6.

Table 6: Vehicle type abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Vehicle Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ART</td>
<td>Articulated trucks and heavy truck-trailer combinations</td>
</tr>
<tr>
<td>BUS</td>
<td>Heavy diesel public transport buses</td>
</tr>
<tr>
<td>DLCV</td>
<td>Diesel light commercial vehicles (utes and vans)</td>
</tr>
<tr>
<td>DPV</td>
<td>Diesel passenger vehicles (cars and SUV/4WD)</td>
</tr>
<tr>
<td>HDD</td>
<td>Heavy-duty diesels (rigid trucks, articulated trucks, heavy buses)</td>
</tr>
<tr>
<td>HDCP</td>
<td>Heavy-duty commercial petrol (&gt;3,500 kg)</td>
</tr>
<tr>
<td>LDD</td>
<td>Light-duty diesels &lt;3,500 kg (light commercial vehicles and cars and SUV/4WD)</td>
</tr>
<tr>
<td>MC</td>
<td>Motor cycles</td>
</tr>
<tr>
<td>MC+HDCP</td>
<td>Motor cycles and heavy-duty commercial petrol</td>
</tr>
<tr>
<td>PLCV</td>
<td>Petrol light commercial vehicles (utes and vans)</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Vehicle Type</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>PPV</td>
<td>Petrol passenger vehicles (cars and SUV/4WD)</td>
</tr>
<tr>
<td>RIG</td>
<td>Rigid trucks (&gt;3.5t to ~25t)</td>
</tr>
</tbody>
</table>

Non-exhaust sources of PM$_{10}$ account for more than half of the total motor vehicle PM$_{10}$, of which most (60 per cent) is generated by petrol passenger vehicles due to their dominance in VKT. Heavy duty diesel vehicles are disproportionately high contributors to PM$_{10}$ exhaust emissions at more than 60 per cent, while accounting for only six per cent of VKT. Light duty diesel vehicles are also significant contributors at 23 per cent while accounting for five per cent of VKT.

Evaporative fuel emissions and exhaust emissions are estimated to contribute equally to total motor vehicle VOC emissions. Of the 50 per cent emitted by exhaust, petrol vehicles dominate. Evaporative emissions are only emitted by petrol vehicles and increase when the weather is hotter. Vehicles standards now require some control on vehicle evaporative emissions. NSW limits petrol volatility in summer to manage the increase in evaporative emissions during warmer months.
Heavy duty diesels contribute a disproportionately high 35 per cent of NO\textsubscript{x} emissions, while accounting for only six per cent of the entire fleet’s VKT. Petrol passenger vehicles and petrol light commercial vehicles contribute the majority of the remainder.

The significantly different rates of emissions per vehicle type indicate that the composition of the vehicle fleet on any particular road corridor will be an important factor in the level of emissions in that corridor.

5.2 Emission contribution by age

The contribution to the total daily emissions by age class (ADR compliance) and vehicle type are shown in Figure 9 and Figure 10 for exhaust PM\textsubscript{2.5} and NO\textsubscript{x} respectively for the 2008 calendar year. The stacked bars show the emissions by age class with the oldest vehicles at the bottom and the newest at the top. The per cent figures shown are the total contribution of all ages of each vehicle type to total fleet emissions.
As shown in the previous section, exhaust PM is dominated by heavy duty diesels (RIG, ART, BUS) with a significant contribution from diesel light commercial vehicles (DLCV). For the two largest contributors, DLCV and rigid trucks, together comprising over 60 per cent of total exhaust emissions, around 50 per cent of the emissions are produced by vehicles older than 1996 (ADR70/00 and older certification). These pre-1996 vehicles account for only 15 per cent and 18 per cent of the respective vehicle class VKT, and are thus significantly disproportionate contributors to emissions at around three times the fleet average emission rate (per kilometre).

For articulated trucks, the pre-1996 vehicles contribute 17 per cent of the PM_{2.5} emissions and account for nine per cent of the VKT, and hence are emitting at around twice the fleet average rate.

For NO_{x} the dominant contributors are petrol passenger vehicles and petrol light commercial vehicles. The pre-1999 petrol vehicles (pre-ADR37/01) contribute approximately half of their respective vehicle type emissions, but only account for around 30 per cent of the VKT. The high emission rates of older vehicles in the fleet indicate that the fleet’s age profile and vehicle type composition are both important factors in estimating the level of emissions from any specific road corridor.
6. References


Appendix A: Australian ADR Emission Limits

Figure A1: Petrol light duty carbon monoxide emission limits

Figure A2: Petrol light duty hydrocarbon emission limits

Figure A3: Petrol light duty oxides of nitrogen emission limits

Figure A4: Diesel light duty carbon monoxide emission limits

Figure A5: Diesel light duty combined hydrocarbon and oxides of nitrogen emission limits

Figure A6: Diesel light duty particulate matter emission limits
Carbon Monoxide

Hydrocarbons

Oxides of Nitrogen

Particulate Matter

Figure A7: Diesel heavy duty carbon monoxide emission limits
Figure A8: Diesel heavy duty hydrocarbon emission limits
Figure A9: Diesel heavy duty oxides of nitrogen emission limits
Figure A10: Diesel heavy duty particulate matter emission limits