Advisory Committee on Tunnel Air Quality comment on Australian Government Vehicle Emissions Discussion Paper

Summary

Strengthening vehicle (air) emission and fuel quality standards will provide health and economic benefits to populations exposed to motor vehicle exhaust emissions.

The continued growth in the size and density of urban areas adjacent to road transport corridors has potential to increase population exposure to air pollution.

Modelling these tighter standards has identified the following air quality benefits:

- Moving from Euro V to Euro VI for heavy vehicles reduces PM emissions from motor vehicle exhaust
- Moving from Euro 5 to Euro 6 for light vehicles, and from Euro V to Euro VI for heavy vehicles, both reduce NOx emissions
- Improving petrol quality by reducing sulfur levels improves the performance of the exhaust gas aftertreatment systems and hence reduces hydrocarbon and NOx emissions, key contributors to ground level ozone and smog
- Improved petrol quality also enables fuel efficient technology

Light vehicle fuel efficiency standards provide a net benefit to the motorists, and are the lowest cost abatement method for greenhouse gas emissions

The particle number limits in Euro 6/VI will ensure reductions in ultra-fine particle emissions

Standards equivalent to Euro 6/VI have been implemented in most other OECD countries and are technically achievable.

Implementing Euro 6/VI will directly address community and stakeholder concerns raised through the planning process for major motorway and tunnel projects.

Reducing health costs associated with emissions, particularly $PM_{2.5}$, can provide significant economic benefits at low cost.

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Introduction

The NSW Government established an Advisory Committee on Tunnel Air Quality to provide a 'whole-of-government' understanding of the scientific and engineering issues informing road tunnel ventilation design and operation based on NSW, national and international experience.

The Committee is chaired by Prof Mary O'Kane, NSW Chief Scientist & Engineer and includes senior executives across key agencies involved in development and regulation of motorway tunnels including NSW Ministry of Health, NSW Environment Protection Authority, Office of Environment and Heritage, Department of Planning and Environment, Roads and Maritime Services and Sydney Motorways Corporation. The Committee also includes an independent technical expert on tunnel air quality issues to advise the Committee on current and emerging issues.

As part of the ongoing advice provided to the NSW government, the Committee has prepared the following analysis, including modelling of air quality implications of strengthening emissions and fuel quality standards.

Background

Motor vehicles are a major source of human generated air pollution in Sydney

In the Sydney region motor vehicles account for 62% of oxides of nitrogen (NO_x) emissions, 24% of hydrocarbon emissions as VOCs and 14% of emissions of fine particles as $PM_{2.5}$[1]; given as a percentage of anthropogenic emissions. NO_x and hydrocarbon emissions contribute to the formation of ground level ozone (smog).

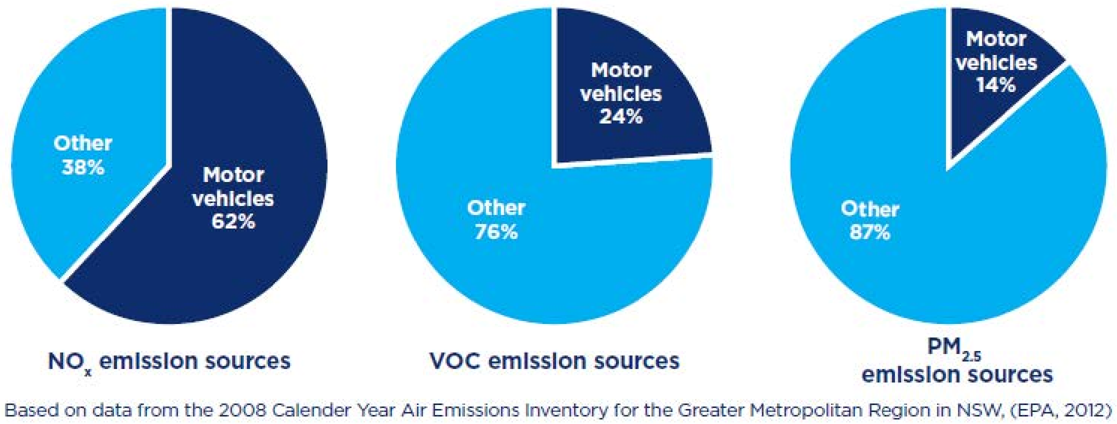

Figure 1 - Contribution of motor vehicle emissions to anthropogenic emissions in Sydney 2008

Implementing Euro 6/VI will directly address community and stakeholder concerns raised through the planning process for major motorway and tunnel projects.

Issues relating to community exposure to motor vehicle emissions are one of the most significant and frequently raised concerns in the planning process for major motorway and tunnel projects. Demonstrating long term reductions in total vehicle emissions due to the benefits accruing from fleet penetration of new emission standards is central to addressing these concerns. Implementing Euro 6/VI extends the period of emission reductions despite continuing VKT growth.

[1] EPA (2012). 2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in NSW. Retrieved from http://www.environment.nsw.gov.au/air/airinventory2008.htm

Health considerations

Reducing motor vehicle emissions will provide various public health benefits.

Exposure to motor vehicle pollution is linked to several adverse health outcomes – ranging from irritation of the airways and lost workdays to early mortality. The Health Effects Institute (HEI) synthesised the research on traffic-related air pollution exposure and health outcomes in 2010 (HEI, 2010), and concluded that exposure to traffic-related air pollution exacerbates asthma. The evidence linking exposure to traffic-related air pollution to several other health outcomes was weaker, but was suggestive of a causal relationship. These outcomes were the onset of childhood asthma, non-asthma respiratory symptoms, impaired lung function, total and cardiovascular mortality, and cardiovascular morbidity. The HEI report identified that the area in the first 300 to 500 metres from a major road was the most highly affected by traffic emissions[2]. This is consistent with the findings of a 2016 review[3] by the Centre for Air Quality and Health Research and Evaluation commissioned by the NSW EPA and NSW Health, which found that:

- Living in close proximity to major roadways is associated with adverse health outcomes that are likely to be partially attributable to exposure to on-road vehicle PM emissions.
- Exposure of the NSW population to all PM (regardless of source) should be minimised by reducing ambient PM levels to as low as possible.

In urban areas such as Sydney, Newcastle and Wollongong, there are likely to be significant health benefits from reducing motor vehicle emissions given the proximity of much of the population to high traffic density.

The continued growth in the size and density of urban areas adjacent to road transport corridors has potential to increase population exposure to air pollution.

Outdoor air pollution is a known human carcinogen

The International Agency for Research on Cancer (IARC) has classified outdoor air pollution as carcinogenic to humans (IARC Group 1). Motor vehicle emissions are a major source of outdoor air pollution in NSW urban areas.

Diesel engine exhaust is a known human carcinogen

The International Agency for Research on Cancer (IARC) has classified diesel engine exhaust as carcinogenic to humans (IARC Group 1).

There is very good evidence that exposure to $PM_{2.5}$ causes cardiovascular disease, respiratory disease and mortality.

The mortality effects of long-term exposure to human-made $PM_{2.5}$ in Sydney in 2008 (annual average of 6.3 $\mu g/m^3$) is estimated to be equivalent to 522 deaths at typical ages[4].

Associations have also been observed between $PM_{2.5}$ exposure and reproductive and development effects such as low birth weight.

[2] HEI (2010). Traffic-related air pollution: a critical review of the literature on emissions, exposure, and health effects – Special Report 17. Health Effects Institute Panel on the Health Effects of Traffic-Related Air Pollution, Boston. Retrieved from http://pubs.healtheffects.org/view.php?id=334

[3] Centre for Air Quality and Health Research and Evaluation (2016),
A review of the health impacts of emission sources, types and levels of particulate matter air pollution in ambient air in NSW, Retrieved from http://www.car-cre.org.au/images/content/Health%20impacts%20of%20PM%20report_final%20for%20web.pdf

[4] University Centre for Rural Health North Coast (2013) Summary for Policy Makers of the Health Risk Assessment on Air Pollution in Australia, Prepared for National Environment Protection Council, Retrieved from http://www.environment.gov.au/system/files/pages/dfe7ed5d-1eaf-4ff2-bfe7-dbb7ebaf21a9/files/summary-policy-makers-hra-air-pollution-australia.pdf

Although the ambient levels of particulate matter in urban NSW are low by world standards, current levels of particulate matter in NSW will have adverse impacts on health, particularly in vulnerable people such as individuals with chronic respiratory and cardiovascular diseases, the elderly, and children. Reductions in particulate matter air pollution in NSW are likely to result in health benefits, particularly for these most vulnerable groups.

There is no evidence of a threshold level of ambient $PM_{2.5}$ below which further reductions in concentration will not provide additional health benefits.[5]

National Air Quality Standards

To achieve national standards, continued emission reductions in $PM_{2.5}$ emissions will be required from all sources, including motor vehicles

In December 2015 national environment ministers adopted new health based air quality standards for particulate matter including long-term health based standards for $PM_{2.5}$.[6] This is identified in the National Clean Air Agreement and is reflected in amendments to the *National Environment Protection (Ambient Air Quality) Measure* made in February 2016.

Any tightening of ambient NO_2 and ozone standards will focus attention on further reducing emissions from motor vehicles given their relative significance

The distinct reduction in ambient NO_2 measured in Sydney from the 1990s to 2009, and anticipated to be due in large part to vehicle emission reduction measures, appears to have tailed off in recent years. The review of health based standards for ozone and nitrogen dioxide (NO_2) is continuing and expected to be finalised in 2017.

Vehicle Emission Standards

Emissions from the in-service vehicle fleet have significantly reduced as a consequence of more stringent emission standards and cleaner fuel.

Since 1972, Australian Design Rules have directed the progressive tightening of motor vehicle emission standards, in concert with national fuel standards. This has resulted in significant and sustained reductions in vehicle exhaust emissions.

Vehicle kilometres travelled (VKT) are increasing steadily, with passenger vehicle VKT increasing in line with population growth at around 1% annually, while freight vehicle VKT is growing in line with economic growth at 2–3% annually.

In spite of the increase in VKT, the strong reduction in vehicle emission rates has resulted in significant reductions in the total fleet emissions[7], and these reductions are projected to continue over the next 10–20 years. However, it is important to note that non-exhaust PM is not subject to standards or mitigation measures, and is increasing in line with increasing VKT. Post 2030, total PM emissions from vehicles is likely to grow if no further measures are implemented.

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[5] National Environment Protection Council (2014) *Draft Variation to the National Environment protection (Ambient Air Quality) Measure: Impact Statement*, Retrieved from http://www.environment.gov.au/system/files/pages/dfe7ed5d-1eaf-4ff2-bfe7-dbb7ebaf21a9/files/aaq-nepm-draft-variation-impact-statement.pdf

[6] AGREED STATEMENT 15 December 2015 Meeting of Environment Ministers http://www.environment.gov.au/system/files/pages/4f59b654-53aa-43df-b9d1-b21f9caa500c/files/mem-meeting4-statement.pdf

[7] See for example the *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in NSW*, available at http://www.epa.nsw.gov.au/air/airinventory2008.htm

Australia's exhaust emission standards for light vehicles (Euro 5) and heavy vehicles (Euro V) are less stringent than comparable OECD countries.

Euro 6 emission standards for light vehicles have been mandatory in Europe since September 2014. Standards equivalent to Euro 6 are also in force in North America and Japan.

Euro VI emission standards for heavy vehicles have been mandatory in Europe since 2012. Standards equivalent to Euro VI were implemented in North America in 2010 and Japan in 2009.

Adopting Euro 6/VI would reduce annual motor vehicle PM emissions by 28% in 2036.

Heavy duty diesel vehicles, and in particular rigid trucks, are disproportionate contributors to exhaust particulate matter emissions. The impact of adopting Euro 6/VI emission standards on total on-road vehicle fleet $PM_{2.5}$ exhaust emissions is shown in Figure 2. This compares the baseline case with the two combinations of measures – change to sulfur content of petrol (50 or 10ppm) and tighter standards (with or without Euro 6/Euro VI). The $PM_{2.5}$ reduction relative to the baseline is estimated to be 87 tonnes in 2036, or 28% and is entirely due to the adoption of Euro VI for heavy duty diesel vehicles. The PM emission of light vehicle classes is not estimated to change by adopting Euro 6.

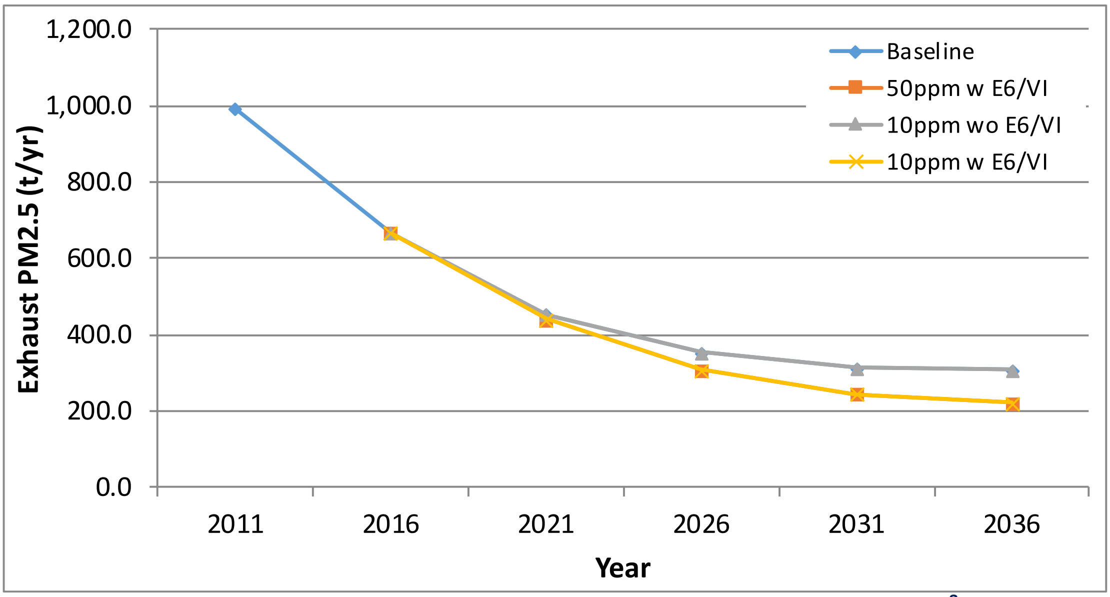

Figure 2 - Impact of emission and fuel standards on exhaust $PM_{2.5}$[8]

Early adoption of emissions standard for heavy vehicles would promote early uptake of less-polluting vehicles.

[8] Analysis by NSW EPA, based on Air Emissions Inventory model (Euro 6/VI impacts) and MOVES 2014 (sulfur content in petrol). Details below under 'Forecasting Methodology and Assumptions'

Adopting Euro 6/VI and 10ppm sulfur petrol would reduce annual motor vehicle NOx emissions by 61% in 2036; this is mainly due to tighter emission standards for diesel vehicles.

The benefit of adopting Euro 6/VI emission standards and 10ppm sulfur petrol to total on-road vehicle fleet NO_x emissions is shown in **Figure 3**. The NO_x reduction, relative to the baseline, is estimated at 15,600 tonnes in 2036, or 61%. This can be broken down as follows:

- over half of this reduction (8,660 tonnes) is from adopting Euro VI for heavy duty diesels (see Figure 4)
- 6,000 tonnes is from adopting Euro 6 for light duty diesel vehicles (see Figure 5)
- the remaining 970 tonnes is from adopting 10 ppm sulfur petrol due to improved efficiency of exhaust gas aftertreatment systems.

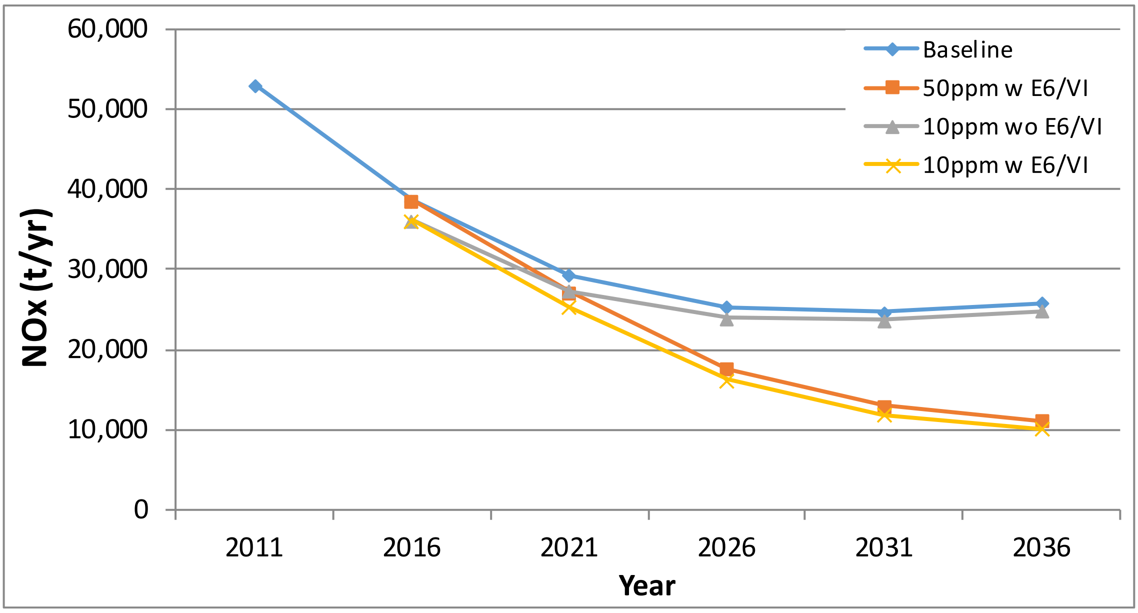

Figure 3 - Impact of all measures – emission and fuel standards – on NOx emissions

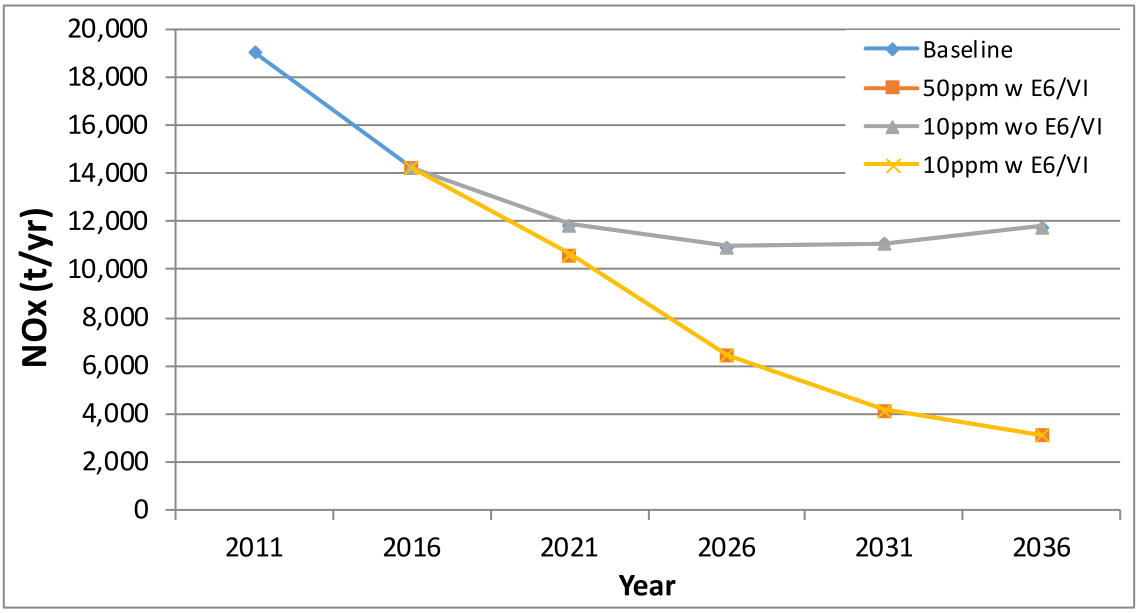

Figure 4 – Impact of Euro VI on NO_x emissions from heavy duty diesel vehicles

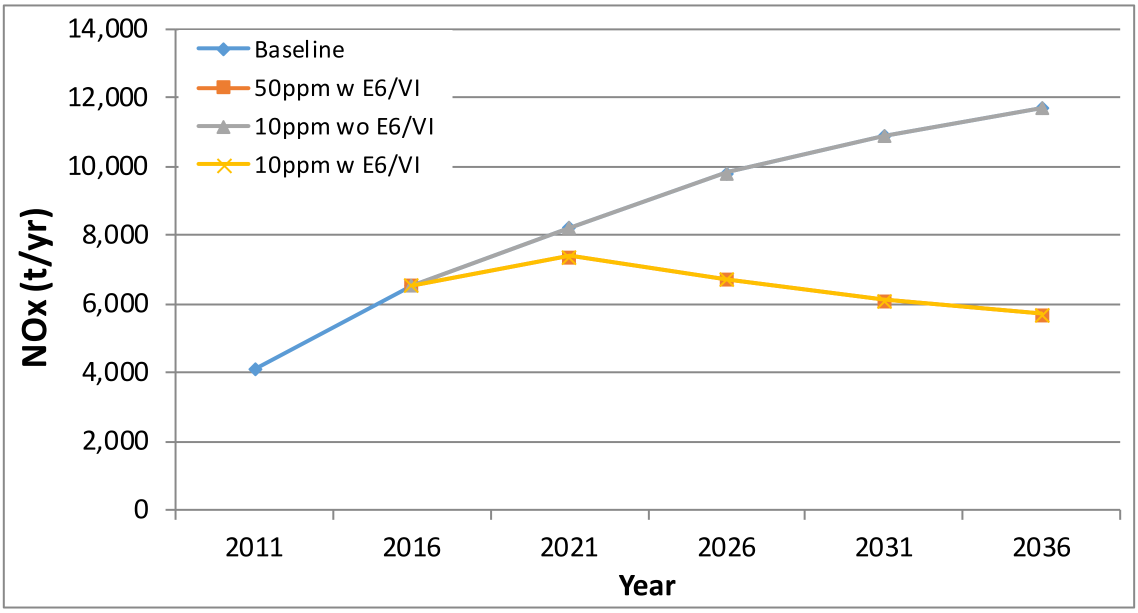

Figure 5 – Impact of Euro 6 on NO_x emissions from light duty diesel vehicles

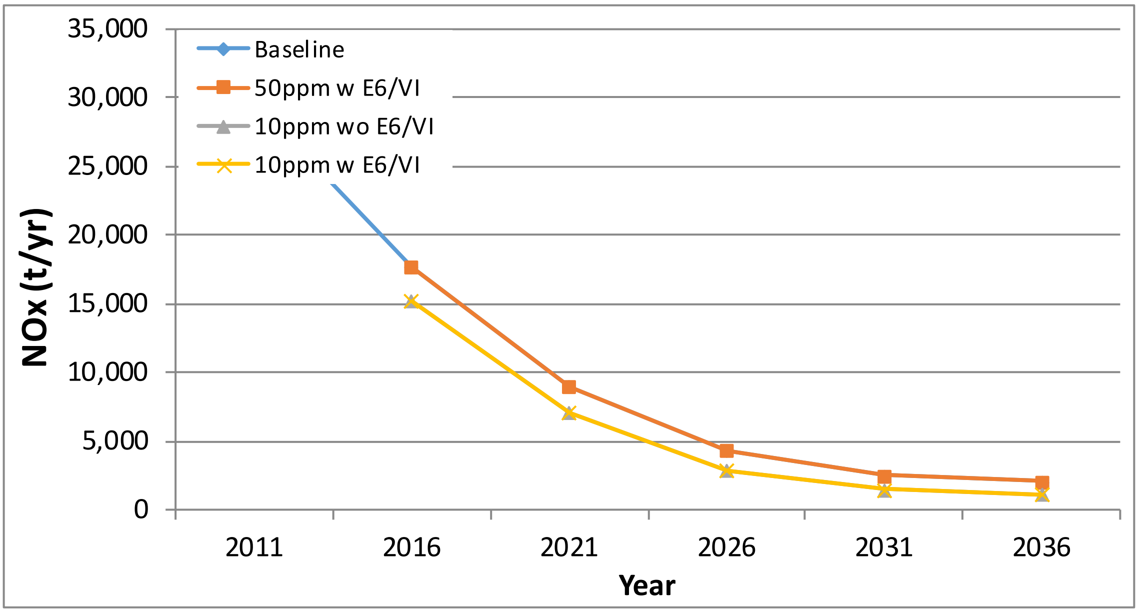

Figure 6 – Impact of 10ppm sulfur petrol on NO_x emissions from petrol vehicles

Reducing sulfur content from 50ppm to 10ppm is estimated to result in a 47% reduction in NO_x from petrol vehicles in 2036 (Figure 6). If the adoption of 10ppm sulfur petrol was fully implemented in 2016, NOx from petrol vehicles is estimated to reduce by 2,500 tonnes, or 14% reduction (Figure 6).

The particle number limits in Euro 6/VI will ensure reductions in ultra-fine particle emissions

Motor vehicle exhaust is an important source of ultra-fine particles in urban settings[9]. There is increasing, though as yet limited, epidemiological evidence on the association between short-term exposures to ultrafine particles and cardiorespiratory health, as well as the health of the central nervous system[10]. Because of their very small size and corresponding low weight, traditional mass based particle limits are not effective at driving reductions in ultra-fine particle emissions.

Vehicle fuel efficiency (carbon dioxide) standards

The majority of the global vehicle market is governed by minimum fuel efficiency standards which do not apply in Australia

The Australian Government discussion paper notes that around 80% of global light vehicle markets have vehicle fuel efficiency standards, including the United States, European Union, Canada, Mexico, South Korea, Japan, China and India. Various studies have identified a significant potential net economic benefit from these kinds of standards in the Australian context[11,12].

In 2015, the National Transport Commission (NTC) estimated new passenger vehicles sold in Australia had an average emissions intensity of 177 grams of CO_2 per kilometre. This compares with an average of 124 grams of CO_2 per kilometre for new vehicles sold in the EU; a difference of 43 per cent[13].

Fuel efficiency (carbon dioxide) standards would change the composition of the Australian light vehicle fleet and may improve air quality

Regulatory analysis of light vehicle fuel efficiency standards in the United States found that standards would significantly reduce some pollutants (particulates, oxides of nitrogen and sulfur dioxide) and increase others (carbon monoxide). For example, the US EPA estimated that the 2017-2025 Light-Duty Vehicle Corporate Average Fuel Economy Standards would deliver air quality related health benefits of around $3.1 billion. The European Commission found that fuel efficiency standards would have no significant direct impact on air pollutants. However, this regulatory analysis assumed that air quality standards are independent of fuel consumption.

Light vehicle fuel efficiency standards provide a net benefit to the motorists, and are the lowest cost abatement method for greenhouse gas emissions

Modelling of fuel efficiency standards shows an initial price increase for motorists, rapidly offset by fuel savings. A 105 g CO_2/km target would increase the average cost of a new car in 2025 by about $1,500, but fuel savings of $830 in the first year and $8,500 across the vehicle life would leave motorists better off.

A standard would also prevent emissions, and save Australia $580 for each tonne of CO_2 avoided. A study by ClimateWorks[11] found that light vehicle fuel efficiency standards provided the lowest cost opportunity to reduce emissions across the economy, and could deliver reductions of 4 Mt CO_2e in 2020 and 8.7 Mt CO_2e in 2024, equivalent to taking 2.2 million cars off the road in 2024.

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[9] HEI (2013). Understanding the health effects of Ambient Ultrafine Particles. Health Effects Institute Panel on Ultrafine Particles, Boston. Retrieved from http://pubs.healtheffects.org/getfile.php?u=893

[10] WHO Regional Office for Europe (2013). Review of evidence on health aspects of air pollution – REVIHAAP Project Technical Report. WHO Regional Office for Europe. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf

[11] Climate Works, 2014, *Improving Australia's Light Vehicle Fuel Efficiency*.

[12] Commonwealth Government, 2010, *CO_2 Emissions Standards for Light Vehicles: Supporting Technical Document for Quantitative Analysis & Standards Design*.

[13] National Transport Commission, 2016, *Carbon Dioxide Emissions Intensity for New Australian Light Vehicles 2015: Information Paper March 2016*

Fuel quality standards

Achieving the very low emission levels required by modern petrol vehicle emission standards requires the three way catalyst (TWS) to operate at very high emission reduction efficiency, of better than 98%[14]. Sulfur in petrol reduces the effectiveness by catalyst by binding to, and thus deactivating precious metal catalyst sites in the TWC, leaving less sites available to reduce the target pollutants. Unlike lead, sulfur does not act as a poison per se, in that it does not permanently destroy the catalyst activity, but inhibits the efficiency. Sulfur inhibition of TWC has been shown to be largely reversible when lower sulfur fuel is used and the vehicle is operated under conditions that result in catalyst temperatures above around 500°C and/or rich operating conditions[15,16]. US EPA studies have shown catalyst desulfurisation to be achieved under test cycles that reflect real world higher load driving, such as the US06 or motorway driving[17,18]

Adopting Euro 6/VI and 10ppm sulfur petrol would reduce annual motor vehicle hydrocarbon emissions by 31% in 2036; this is almost entirely from adopting 10ppm sulfur petrol.

The impact of adopting Euro 6/VI emission standards and 10ppm sulfur on total on-road petrol vehicle fleet exhaust hydrocarbon (HC) emissions is shown in Figure 7. The HC reduction relative to the baseline, from adopting both Euro 6/VI and 10ppm petrol sulfur standards, is estimated to be 1,250 tonnes in 2036, or 31%. The reduction is almost entirely from petrol vehicles, with around 10% of the reduction estimated to result from adoption of Euro 6, and the remaining 90% from the adoption of 10ppm sulfur petrol. In 2016 the adoption of 10ppm sulfur petrol is estimated to result in a 1,500 tonne, or 20% reduction in HC from petrol vehicles.

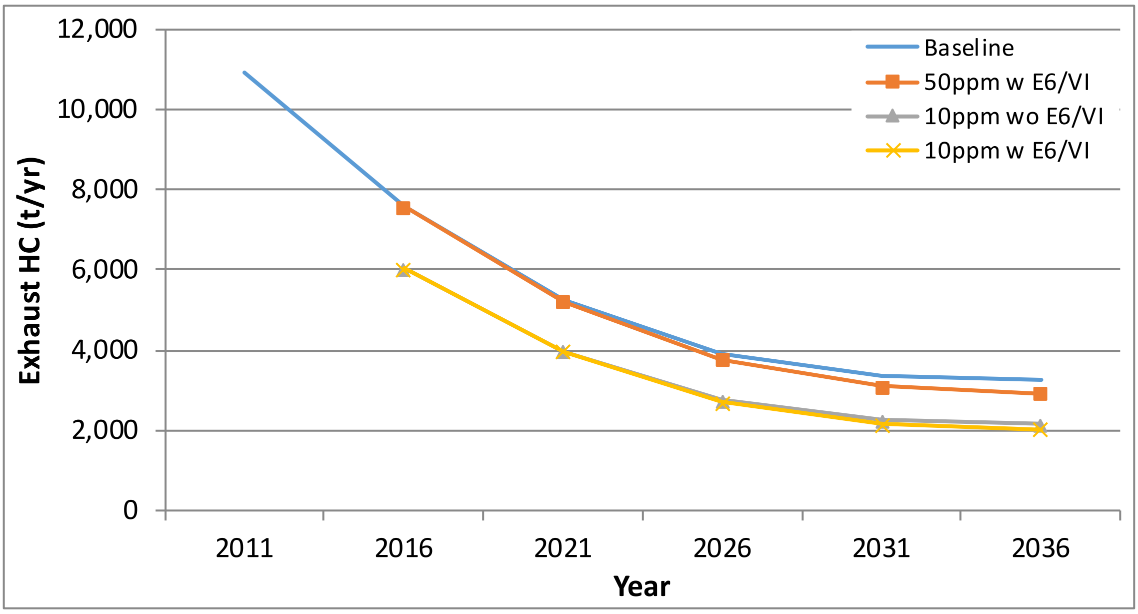

Figure 7 - Impact of emission and fuel standards on HC emissions from petrol vehicles

[14] Worldwide Fuel Charter, fifth edition, September 2015, http://www.acea.be/publications/article/worldwide-fuel-charter
[15] ACEA data of the sulfur effect on advanced emission control technologies, Association of European Automobile manufacturers, July 2000.
[16] The impact of gasoline fuel sulfur on catalytic emission control systems, Manufacturers of Emission Controls Association, June 2013, www.meca.org
[17] The effects of Gasoline Sulfur Level on Emissions from Tier 2 Vehicle in the In-Use Fleet, US EPA EPA-420-D-13-003 April 2013
[18] Regulatory Impact Analysis – Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements

Reducing average petrol sulfur levels from 50 ppm to 10 ppm could reduce NSW GMR petrol vehicle NO_x emissions by 47% in 2036.

Cleaner fuels regulated through fuel quality standards are effective in reducing noxious exhaust pollutants, both directly and by enabling operation of cleaner vehicle technology. Improvements in fuel quality deliver reduced emissions from the existing in-service fleet and allow the full emission benefits of new vehicle emission regulations to be achieved.

Sulfur content of fuel is regulated to control noxious vehicle emissions and protect engine operation. The current standard for petrol sets the maximum sulfur limit at 150 ppm for regular petrol (91 RON) and 50 ppm for premium petrol (95+ RON). Most OECD countries have adopted fuel standards that limit sulfur content in petrol to 10 ppm. The minimum standard for petrol in the EU is 95 RON with sulfur limited to 10ppm from the introduction of Euro 5. Most European light vehicle manufacturers specify the use of 95 RON fuel for vehicles sold in Australia.

Lowering fuel sulfur levels enables improved fuel consumption. In Europe, reducing sulfur in petrol to 10ppm has enabled use of more fuel efficient lean burn direct injection petrol engines that improve fuel economy. Fuel economy improvements of up to 15% can be gained by enabling NO_x control through use of low sulfur fuels. Improved fuel quality could support the introduction of vehicle fuel efficiency standards to manage greenhouse gas emissions growth in Australia's transport sector as discussed in the previous section.
The impact of sulfur levels in petrol has been estimated using the US EPA MOVES2014 model[19]. The MOVES2014 sulfur model was updated in February 2016 and is based on emission test data for a significant number of vehicles. The MOVES2014 model estimates the change in emissions for a reduction of petrol sulfur from 50 ppm to 10ppm as shown in Table 1 for cold start and hot running emissions. The current NSW volume weighted average petrol sulfur levels are assumed to be similar to 2008-2010, for which data held by the EPA indicated sulfur to be around 50ppm. Reducing sulphur levels in petrol to 10ppm in 2016 could reduce NO_x emissions from vehicles across the Greater Metropolitan Region (GMR) by 47% by 2036.

Table 1 - Emissions impact for sulfur reduction from 50 ppm to 10 ppm

ADR[1]	**US Equiv.**	**NO_x**		**HC**		**CO**	
		Cold	Hot	Cold	Hot	Cold	Hot
37/00	Tier 0	-7.4%	-3.3%	-0.4%	-21.8%	2.9%	-26.4%
37/01	Tier 0	-7.4%	-3.3%	-0.4%	-21.8%	2.9%	-26.4%
79/00	Tier 1/LEV	-4.4%	-30.0%	-4.0%	-29.1%	-0.8%	-14.4%
79/01	LEV	-5.6%	-57.5%	-7.6%	-48.8%	-2.4%	-22.0%
79/02	ULEV	-5.6%	-57.5%	-7.6%	-48.8%	-2.4%	-22.0%
79/03/04	Tier 2	-5.6%	-57.5%	-7.6%	-48.8%	-2.4%	-22.0%
79/05	Tier 2	-5.6%	-57.5%	-7.6%	-48.8%	-2.4%	-22.0%

Notes: 1 – ADR refers to Australian Design Rules, the rules referred to are those which implement emissions standards

Supply of low sulfur petrol depends on global markets, as NSW imports all fuel

The 2015 Energy White Paper identifies declining production of crude oil along the east coast, and a trend for decreasing refinery capacity together with refinery closures. Reliability would instead by maintained through imports, combined with existing Australian stockholdings and at-sea tanker arrangements[20]. NSW no longer has an operating refinery, with both Kurnell and Clyde closing in the last five years.

[19] Fuel Effects on Exhaust Emissions from On-road Vehicles in MOVES2014, final report, US EPA-420-R-16-001, https://www3.epa.gov/otaq/models/moves/documents/420r16001.pdf

[20] Department of Industry and Science , 2015. *2015 Energy White Paper*, retrieved from http://ewp.industry.gov.au/sites/prod.ewp/files/EnergyWhitePaper.pdf

Economic benefits

Health impacts from road transport emissions were $2.7 billion in 2000

Analysis by the Bureau of Transport and Resource Economics estimated annual health costs of $2.7 billion (2000 dollars) due to road transport PM_{10} emissions across Australia. For NSW, costs were estimated at $706 million - $1,682 million [21]. As the population of Sydney increases, the monetised health benefits of reducing air pollution exposure increase.

Reducing health costs associated with emissions, particularly $PM_{2.5}$, can provide significant economic benefits at low cost

Incremental vehicle costs for Euro 6 vehicles were estimated at $0 for petrol vehicles and $355 for diesel vehicles[22]. Costs for Euro VI vehicles were not estimated in the Regulatory Impact Statement, however these vehicles are already being purchased in Australia[23].

In comparison, air pollution has a high cost, particularly in areas of high population density where more people are exposed. Recent studies estimated costs ranging from $110,000-$280,000 $/tonne $PM_{2.5}$ for the five areas with the highest population density[24].

Previous regulatory impact statements for Euro 5/6 and Euro V/VI both supported the tightening of emission standards.

Forecasting Methodology and Assumptions

The emission impact of adopting Euro 6 (for light duty vehicles) and Euro VI (for heavy duty vehicles) and a 10ppm sulfur standard for all petrol is estimated for the NSW GMR. Emissions have been modelled using the NSW Air Emissions Inventory motor vehicle emissions model[25]. Modelling assumes the full implementation of Euro 6c in 2021, which addresses real world driving emissions.

The emission rates for Euro 6/VI vehicles have been assumed to reduce relative to Euro 5/V vehicles as shown in Table **2**2. No change in evaporative HC emissions is assumed.

Table 2 - Assumed changes in Euro 6/VI exhaust emissions relative to Euro 5/V

Vehicle Class	NO_x	PM	HC
Light duty petrol	0%	0%	~-18%
Light duty diesel	-55%	0%	0%
Heavy duty diesel	-80%	-60%	-10%

[21] *Health Impacts of Transport Emissions in Australia: Economic Costs*, BTRE Working Paper 63, Bureau of Transport and Regional Economics, Canberra, ACT www.bitre.gov.au/publications/2005/files/wp_063.pdf

[22] Department of Infrastructure and Transport (2010) *Final Regulation Impact Statement for Review of Euro 5/6 Light Vehicle Emissions Standards*, retrieved from https://infrastructure.gov.au/roads/environment/files/Final_RIS_Euro_5_and_6_Light_Vehicle_Emissions_Review.pdf

[23] Transport and Logistics News (2014), *Australia's first Euro 6 [sic] truck fleet delivered*, retrieved from http://www.tandlnews.com.au/2014/11/18/article/australias-first-euro-6-truck-fleet-delivered/

[24] Aust N, Watkiss P, Boulter P and Bawden K (2013), *Methodology for valuing the health impacts of changes in particle emissions* Retrieved from http://www.epa.nsw.gov.au/resources/air/HealthPartEmiss.pdf

[25] Technical Report 7: On-Road Mobile Emissions, NSW EPA 2012, http://www.epa.nsw.gov.au/air/airinventory2008.htm

Summary and Conclusions

Strengthening vehicle (air) emission, fuel efficiency (carbon dioxide) and fuel quality standards can provide health benefits to populations exposed to motor vehicle exhaust emissions.

The continued growth in the size and density of urban areas adjacent to road transport corridors has potential to increase population exposure to air pollution.

Modelling these tighter standards has identified the following air quality benefits:

- Moving from Euro V to Euro VI for heavy vehicles reduces PM emissions from motor vehicle exhaust
- Moving from Euro 5 to Euro 6 for light vehicles, and from Euro V to Euro VI for heavy vehicles, both reduce NOx emissions
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- Improved petrol quality also enables fuel efficient technology

Standards equivalent to Euro 6/VI have been implemented in most other OECD countries and are technically achievable.

Light vehicle fuel efficiency standards provide a net benefit to the motorists, and are the lowest cost abatement method for greenhouse gas emissions

The particle number limits in Euro 6/VI will ensure reductions in ultra-fine particle emissions

Implementing Euro 6/VI will directly address community and stakeholder concerns raised through the planning process for major motorway and tunnel projects.

Reducing health costs associated with emissions, particularly $PM_{2.5}$, can provide significant economic benefits at low cost.

Vehicle fuel efficiency standards have been implemented in the United States, European Union, Canada, Mexico, South Korea, Japan, China and India, with studies indicating a significant potential net economic benefit from these kinds of standards in the Australian context.