Vehicle Standard (Australian Design Rule 80/00 — Emission Control for Heavy Vehicles) 2005

Explanatory Statement

Appendix A

Regulation Impact Statement (ADR80/00)

The attached regulation impact statement was prepared by the Department of Transport and Regional Services to evaluate the impact of the introduction of ADR80/00. It also addresses a range of other emission standards.

The Office of Regulation Review has approved the attached RIS as satisfying the Australian Government's requirements for regulation impact statements as set out in the Government's publication *A Guide to Regulation.*

REGULATION IMPACT STATEMENT

New Australian Design Rules for Control of Vehicle Emissions

December 1999

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LIST OF ATTACHMENTS

ABBREVIATIONS

AANEPM	Ambient Air National Environment Protection Measure
ADR	Australian Design Rule
AIP	Australian Institute of Petroleum
APEC	Asia Pacific Economic Cooperation
CO	Carbon Monoxide
ECE	Economic Commission for Europe
EEC	European Economic Commission
EU	European Union
Euro 1	Version of the UNECE standards which applied from 1992 in the European Union
Euro 2	Version of the UNECE standards which applied from 1996 in the European Union
Euro 3	Version of the UNECE standards which will apply from 2000 in the European Union
Euro 4	Version of the UNECE standards which will apply from 2005 in the European Union
FCAI	Federal Chamber of Automotive Industries
FORS	Federal Office of Road Safety
FTP	Federal Test Procedure
LCV	Light Commercial Vehicle
LPG	Liquefied Petroleum Gas
MOU	Memorandum of Understanding
MVEC	Motor Vehicle Environment Committee
NEPC	National Environment Protection Council
NMHVC	Non methane hydrocarbons
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
NRTC	National Road Transport Commission
NSW EPA	New South Wales Environment Protection Authority
NG	Natural Gas
O_3	Ozone
PM	Particulates
PM_{10}	Particulate matter with a diameter of less than 10 μm
PULP	Premium unleaded petrol
RON	Research Octane Number
TELG	Transport Emissions Liaison Group
Tier 1	Current USEPA Tier1 light duty vehicle emission standards
TTMRA	Trans Tasman Mutual Recognition Arrangement
ULP	Unleaded Petrol
UN ECE	United Nations Economic Commission for Europe
US EPA	United States Environment Protection Agency
US94	US heavy duty emission standards introduced in 1994
US98	US heavy duty emission standards introduced in 1998

PREFACE

This Regulation Impact Statement is presented in two parts.

Part A is an analysis of new vehicle emission and fuel standards outlined in the *Measures for a Better Environment* section of the Commonwealth Government's Tax Package Agreement announced by the Prime Minister of Australia on 28 May 1999.

PART B is an analysis of work undertaken by the National Motor Vehicle Environment Committee on the review of Australia's motor vehicle emissions standards. The detailed analysis in PART B was undertaken prior to the Prime Minister's announcement of the Tax Package Agreement.

PART A

COMMONWEALTH GOVERNMENT'S PACKAGE ON NEW VEHICLE STANDARDS AND FUEL

PART A COMMONWEALTH GOVERNMENT'S NEW VEHICLE STANDARDS AND FUEL PACKAGE

1. INTRODUCTION

The Prime Minister announced details of amendments to "A New Tax System" on 28 May 1999, including a range of environmental proposals under the heading '*Measures for a Better Environment*'. There are three main elements of this Package which deal with new vehicle standards and transport fuel quality, *viz*:

- Staged introduction of *Euro 2* and *Euro 3* standards for petrol vehicles;
- Staged introduction of *Euro 2, Euro 3* and *Euro 4* standards for diesel vehicles; and
- The introduction of a clean diesel policy which will provide a mix of incentives and legislation to ensure that ultra low sulfur diesel is available within the timeframe for the proposed new vehicle standards.

Note: for the remainder of this PART A, the above package is referred to as the "Commonwealth Package".

2. STATEMENT OF THE PROBLEM

Motor vehicle pollution in Australia is an ongoing problem particularly in our densely urbanised cities. Vehicles are estimated to contribute up to 70% of total urban air pollution (NSW EPA, 1999). Emissions from vehicles therefore have significant effects on the quality of life for urban residents, particularly those susceptible to air pollution. High levels of air pollutants have been shown to result in a wide range of adverse health and visual impacts on society. Increasing levels of pollution can have significant environmental and economic consequences. Health effects associated with air pollution include respiratory effects, ranging in severity from coughs, chest congestion, asthma, to chronic illness and possible premature death in susceptible people. Other effects of air pollutants include damage to vegetation, buildings and materials, and reduction in visibility.

Reducing the contribution of motor vehicle emissions to air pollution is expected to have a positive impact on human health and the environment

3. OBJECTIVES

The objective of this vehicle standards package, and its diesel fuel elements, is to reduce the adverse effects of motor vehicle emissions on urban air quality and human health. The Commonwealth Government also has an objective, outlined in the Prime Minister's Statement, *Safeguarding the Future* (Prime Minister, 1997), to harmonise Australia's vehicle emission standards with international standards by 2006. A more detailed examination of the rationale for tighter vehicle standards and better fuel quality is contained in PART B. The new Commonwealth Package is consistent with this objective, and permits the acceleration of its achievement (compared to Option 2B (Modified) specified in section 7.3 of PART B). By 2006, Australian new diesel vehicle emission standards will be harmonised with the *Euro 4* standard and new petrol vehicles will be harmonised with the *Euro 3* standard. As the *Euro 4* standard will apply in Europe for all vehicles in 2005, Australia will be fully aligned with the diesel standards and be one step behind with petrol standards.

4. DESCRIPTION OF COMMONWEALTH PACKAGE

The Commonwealth Package involves the adoption of:

Diesel Vehicles[1],

- *Euro 2* in 2002/03 for all new diesel vehicles;
- *Euro 3* in 2002/03 for all new medium and heavy duty diesel vehicles;
- *Euro 4* in 2006/07 for all new diesel vehicles;

Petrol Vehicles[1]

- *Euro 2* in 2003/04 for all new petrol vehicles; and
- *Euro 3* in 2005/06 for all new petrol vehicles.

Table 1 highlights the key emissions differences of the *Euro 2*, *Euro 3* and *Euro 4* standards for passenger cars.

Table 1 Comparison of Passenger Car (Petrol) Emission Standards

Current & Future Standards	Date of Implementation	Limits on Emissions			
		CO (*g/km*)	HC [exhaust] (*g/km*)	NOx (*g/km*)	HC [evaporative] (*g/test*)
ADR37/01 (1)	1997-9	2.1	0.26	0.63	2
UN ECE			(Combined HC and NOx)		
Euro 2 (2)	1996	2.2	0.5		2
Euro 3 (2)	2000	2.3 (3)	0.2	0.15	2
Euro 4 (4)	2005	1.0	0.1	0.08	2

(1) The Australian standard (ADR37/01) requires the emission limits to be met for a period of 5yrs/80,000km and the test method is the same as that used in the US standard.
(2) The *Euro 2* and *Euro 3* standards require the emission limits to be met for a period of 5yrs/80,000km
(3) CO Limit for *Euro 3* is nominally higher, but *Euro 2* test excludes the first forty seconds of testing from sampling, thus making the CO limit much harder to meet
(4) The *Euro 4* standards require the emission limits to be met for a period of 5yrs/100,000km

In addition to the tighter emission limits, the *Euro 3* test, which omits the 40 second "no sampling" period at the beginning of the *Euro 2* test cycle, is a more demanding test for CO and HC emissions. *Euro 3* also has a much more stringent evaporative emissions test, compared to *Euro 2*. The *Euro 4* test is as stringent as the *Euro 3* test.

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1 The year terminology of 200X/0Y refers to the application of the new standards to new models in 200X, and the application to all models produced on or after 200Y.

Table 2 highlights the key emissions differences of the *Euro 2*, *Euro 3* and *Euro 4* standards for diesel vehicles greater than 3.5 tonnes GVM.

Table 2 Comparison of 'Heavy Duty' (Diesel) Vehicle Emission Standards

Current and Future Standard	**Date of Implementation**	**Limits on Emission Limits (g/kWh)**			
		CO	HC	NOx	PM
ADR70/00	1979	4.5	1.1	8.0	0.36
Euro 2	1996-1998	4.0	1.1	7.0	0.15 (1)
Euro 3	2000				
ESC Limit		2.1	0.66	5.0	0.10 (3)
ETC Limit		5.45	0.78 (2)	5.0	0.16 (4)
Euro 4	*2005*				
ESC Limit		1.5	0.46	3.5	0.02
ETC Limit		4.0	0.55(2)	3.5	0.03

(1) Original *Euro 2* limit for PM was 0.25, which was reduced to 0.15 in 1998.
(2) Non-methane hydrocarbons
(3) Smaller engines are subject to more relaxed PM limits of 0.13 (ESC)
(4) Smaller engines are subject to more relaxed PM limits of 0.21 (ETC).

The earlier introduction of tighter diesel vehicle standards is facilitated by the acceleration of the availability of low (500ppm) and ultra low (50ppm) sulfur diesel fuel announced in the Commonwealth Package. This includes:

- Voluntary introduction of 500ppm sulfur diesel in urban areas in 2000;
- 500ppm sulfur diesel as minimum standard for road transport fuel from end 2002;
- Differential pricing from 2003 and 2004 to support early introduction of 50ppm sulfur diesel; and
- Mandatory fuel standard of 50ppm sulfur diesel in 2006.

5. IMPACT ANALYSIS

5.1 Impact on Affected Parties

Vehicle manufacturers, and the road transport and bus industries, are supportive of the adoption of tighter emission standards, provided that suitable fuel is available, and they are phased in over a reasonable time. Vehicle manufacturers have requested a minimum of 2 years notice from gazettal to comply, which would allow introduction from 2002.

The *Euro 2* and *Euro 3* vehicle elements of this Package are similar, with some variation in the timing of adoption, to Option 2B (Modified) recommended in PART B. The significant differences being the acceleration of *Euro 3* for medium duty vehicles, and the adoption of *Euro 4* standards for all diesel vehicles. As such, whilst the magnitude of the impacts are likely to be greater for the industries which supply and use diesel vehicles, the nature of the impacts on key stakeholders will be similar to that outlined in Section 5.1 of PART B.

In relation to diesel vehicles, there are no local manufacturing implications, as these engines are not produced in Australia. All diesel engines/vehicles are imported from Japan, USA and Europe. Consistent with the argument in Section 4.2.1 in Part B, it is appropriate to accept the US heavy duty standards as alternatives to the UN ECE standards. In addition, as there are no emission standards in the UN ECE for heavy duty petrol engines, it is proposed to fill this gap by adopting the US emissions standards for heavy duty engines. It should be noted that there are very few of these vehicles in the Australian fleet. Parent companies are currently working towards *Euro 4* or *US 04* compliance, with *Euro 4* applying in Europe from 2005, and *US 04* being brought forward to late 2002 in the US. Companies that produce engines that comply with *Euro 4* will be able to supply these engines to a range of international markets (which are increasingly adopting ECE standards), as well as the Australian market. The one year lag from European adoption of *Euro 4* in 2005 reflects the practicality of introducing vehicle support and maintenance infrastructure.

In relation to harmonisation of petrol vehicles with *Euro 4* in 2006, there are significant local manufacturing implications, with 30% of passenger vehicles produced in Australia. It is internationally recognised that the technological demands on manufacturers in achieving compliance with Euro 4 will be very demanding. In many cases the likely technological solutions are still in the experimental stage. For these reasons it is unlikely that the local vehicle industry will be able to develop or adopt appropriate technological solutions into local vehicle production within a year of adopting Euro 4 in Europe (2005).

The Federal Chamber of Automotive Industries supports the adoption of tighter emission standards in the period 2002 to 2007. However, it proposes longer lead times for *Euro 2* and *Euro 3,* and a further evaluation of the costs and benefits of *Euro 4* before a decision is made as to its implementation. The Australian Bus and Coach Association, the Australian Trucking Association, and Transport Agencies have supported the Commonwealth Package.

The Commonwealth Package will require a major financial commitment from the Australian petroleum industry, and the AIP has not publicly responded to the Package. However some refineries (BP and Caltex) have indicated that they will be voluntarily providing 500ppm sulfur diesel in urban markets within the next few years. BP has also made a public commitment to provide 50ppm sulfur diesel, provided there are appropriate incentives.

5.2 Impact on Emissions

The Tables at Attachment A summarise the key features and emission limits of the current emission ADRs compared with *Euro 2*, *Euro 3* and *Euro 4* standards. The most significant reductions in the introduction of *Euro 3* and *Euro 4* standards are in the PM and NOx limits, and tighter evaporative HC standards for petrol vehicles. The percentage reductions for petrol vehicles are outlined in the table below.

Table 3 Percentage Reductions in Diesel Vehicle Emission Limits (rounded to the nearest 5%)

Standards	Cars % reduction		4WDs and Light Commercial Vehicles % reduction		Heavy Duty Vehicles % reduction	
	NOx	**PM**	**NOx**	**PM**	**NOx**	**PM**
From Euro 2 (1) to Euro 3	30	40	30-35 (2)	40	30	35
From Euro 3 to Euro 4	50	50	50	50	30	80

(1) For *Euro 2* standards there is a combined regulated limit for HC+NOx, EU assume a ratio of 55:45 (HC:NOx)
(2) Range reflects differing reductions depending on the mass of the vehicle

These vehicle emission reductions will provide a significant contribution to the achievement of the Ambient Air Quality National Environment Protection Measure standards in urban areas. The significant reductions in the sulfur content of diesel fuel will enhance the reductions in total particulate emissions, and will lead to emissions reductions from the total fleet, not just the vehicles meeting the new standards.

5.3 Costs and Benefits

The main costs associated with introducing the new standards relate to incorporating advanced technology and hardware in new vehicles, demonstrating compliance with the new standards and reformulation of existing fuels to meet the demands of the new technologies.

For the *Euro 2* and *Euro 3* elements of the Package, the costs and benefits over 20 years are comparable to those estimated for Option 2B (Modified) recommended in PART B. Option 2B (Modified) is estimated to provide a net benefit of over $800million (see section 5.5.2 of PART B). The main differences are the variation in timing of the introduction of *Euro 2* and *Euro 3* for petrol vehicles and the application of *Euro 3* for medium diesel vehicles in 2002 rather than 2006. It is expected that over a 20 year period, the total costs of the new standards and the low sulfur content diesel fuel, would be higher than the $1,957 million for Option 2B (Modified) in PART B, and total quantified benefits would be higher than the $2,762 for Option 2B (Modified) in PART B.

As can be seen from Table 2, *Euro 4* delivers significant reductions in NOx and PM emissions over *Euro 3*. The introduction of low sulfur diesel fuel standards will not only enable new vehicles to meet the new emission limits, but will also have a significant impact on emissions across the whole vehicle fleet. It is reasonable to conclude that the significant reductions in NOx and PM emissions from *Euro 4* and the associated fuel changes would lead to a significant reduction in health costs, as NOx and PM are the major vehicle related factors contributing to adverse health effects.

At this stage there is insufficient information available on the costs associated with the introduction of *Euro 4* standards for diesel vehicles in 2006/07 and the introduction of ultra low (50ppm) sulfur diesel, which would enable an estimate of the net benefits (ie benefits less costs) to be made. Nevertheless, in recognising the significant reductions in PM emissions which will result from the introduction of *Euro 4* emission standards for diesel vehicles, and from the introduction of ultra low sulfur diesel which will be used in all vehicles (new and in-service), it is expected that the Commonwealth Package would result in a net benefit greater than the $804 million estimated for Option 2B (Modified) recommended in PART B.

6. CONSULTATION

The Commonwealth Package was developed at the highest level of Government. The National Road Transport Commission has advised key stakeholders of the details of the Package, and as stated in Section 5.1, it is supported by the Australian Trucking Association, the Australian Bus and Coach Association and transport agencies. The Federal Chamber of Automotive Industries, whilst supporting the introduction of tighter emissions standards in the period 2003 to 2007, proposes longer lead times for *Euro 2* and *Euro 3* and a further evaluation of *Euro 4*, prior to a decision on its implementation.

7. CONCLUSION AND RECOMMENDED PACKAGE

7.1 Summary of Key Issues

The diesel vehicle elements of Option 2B (Modified) recommended in PART B were qualified because of concerns that low sulfur diesel would not be available in sufficient quantity to allow an earlier introduction date for tighter emission standards. Many medium diesel vehicles will be catalyst equipped to meet *Euro 3* and all diesel vehicles are predicted to need catalysts, or other after-treatment technology, for *Euro 4* standards. Fuel quality is more critical for these vehicles than for heavy duty vehicles which use electronic engine management systems, rather than catalysts, to achieve lower emission. The clean fuel policy outlined in the Commonwealth Package allows the introduction dates for diesel vehicles to be accelerated.

The principal difference between the vehicle emissions standards outlined in the Package and Option 2B (Modified) recommended in PART B of the RIS are as follows:

- *Euro 2* for petrol vehicles from 2003/04 rather than 2002/04;
- *Euro 3* for medium commercial vehicles (3.5 to 12 tonne) from 2002/03 rather than 2006/07;
- *Euro 3* for petrol vehicles from 2005/06 rather than 2006/07; and
- *Euro 4* for all diesel vehicles from 2006/07 (*Euro 4* was not included in the MVEC study).

A more detailed explanation of the differences between the Commonwealth Package and Option 2B (Modified) recommended in PART B are outlined in Attachment B.

This Package has significant benefits over Option 2B (Modified) analysed in PART B due to the acceleration of *Euro 3* and *Euro 4* standards for diesel vehicles, accompanied by the introduction of progressive and significant reductions in the sulfur content of diesel fuel. The increase in costs to meet *Euro 4* diesel standards and tighter diesel fuel standards, while not quantified at this stage, are expected to be offset by the health benefits, and produce a greater net benefit than that for Option 2B (Modified) recommended in PART B. A date has not been set for the adoption of *Euro 4* standards for petrol vehicles. As the adoption of Euro 4 for these vehicles will pose significant technological demand for local manufacturers, it is unlikely that Euro 4 compliant vehicles could be produced within a year of adoption of Euro 4 in Europe.

The Package[2] is supported for the following reasons:

- Early and staged implementation shows commitment to the Environmental Strategy for the Motor Vehicle Industry embodied in the Prime Minister's Statement on Climate Change *Safeguarding the Future;*
- The staged (*Euro 2* then *Euro 3*) approach for light petrol vehicles delivers significant emissions and health benefits, albeit at a lesser level than an early adoption of *Euro 3* across the board. However, attempting to apply *Euro 3* standards across the board in 2002/3 would cause severe disruption and high costs to the local vehicle manufacturing and service industry, many vehicle importers and the local fuel refining industry;
- Later adoption of *Euro 3* for petrol vehicles provides the vehicle industry sufficient lead time to meet the requirements of *Euro 3,* including the upgrading of emission test facilities necessary for local manufacturers, and the provision of a service network for the on-board diagnostic systems required in *Euro 3*;
- For petrol vehicle manufacturers, the Package is achievable at minimum cost, given the technology will be readily available and well proven by the time the standards are adopted in Australia (for the majority of vehicles, *Euro 2* and *Euro 3* would apply in Australia some 5-6 years after application in Europe);
- Early adoption of *Euro 2* for light diesel and *Euro 3* for medium and heavy duty diesel vehicles, followed by *Euro 4* four years later, will deliver significant reductions in NOx and PM emissions, which are two of the pollutants of most health concern;
- Allows latest US EPA heavy duty standards as alternatives, without compromising emission benefits;
- While the *Euro 4* standards will impose significant technological challenges, diesel buses and trucks (or at least their engines) are all imported, and the overseas suppliers will be working to deliver vehicles to this standard;
- Allows compliance with later versions of the nominated standards;
- Includes LPG and NG fuelled vehicles within the scope of the standards;
- The introduction of the clean diesel policy will ensure that low sulfur diesel is available within the timeframe for the new standards; and
- Later adoption of *Euro 3* and *Euro 4* will allow time for MVEC to review fuel requirements for petrol and other (non sulfur) aspects of diesel, in light of the Fuel Quality Review (due in 2000), so that the fuel can be delivered by 2005/6.

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[2] Package includes complimentary elements of the Preferred Option in PART B, which were not addressed in the Commonwealth Package

7.2 Description of Recommended Package

Vehicle Emission Standards

Details of the new vehicle emission standards[3] are outlined in Table 4.

Fuel Requirements

The fuel elements of the Commonwealth Package are outlined below.

From 2000

- Voluntary reduction of the sulfur content of diesel fuel to 500ppm in urban areas.

From end 2002

- Sulfur standard for road transport diesel set at 500ppm.

From 2005

- Changes to fuel parameters required for Euro 3, based on the outcomes of the Fuel Quality Review and discussions with stakeholders.

From 2006

- Sulfur standard for road transport diesel set at 50ppm.

[3] Table 4 includes the complimentary elements of the Preferred Option in PART B, which were not specifically addressed in the Commonwealth Package. These elements include smoke requirements, application of standards to alternative fuels (LPG and NG) and inclusion of US EPA standards as equivalents for heavy duty vehicles.

Table 4 Summary Table of New Australian Design Rules for Vehicle Emissions

ADR Categories			Equivalent ECE Category	Applicable New ADR (1),(2),(3),(4)	2002/3 (Diesel Vehicles) (5)	2003/4 (Petrol Vehicles)	2005/6 (Petrol Vehicles)	2006/7 (Diesel Vehicles)
Description	GVM (t)	Category						
Passenger Vehicles								
Cars	Not Applicable	MA	M1	Light Duty	*Euro 2*	*Euro 2 (6)*	*Euro 3* (6)	*Euro 4*
Forward Control	Not Applicable	MB	M1	Light Duty	*Euro 2*	*Euro 2 (6)*	*Euro 3 (6)*	*Euro 4*
Off-road	Not Applicable	MC	M1	Light Duty	*Euro 2*	*Euro 2 (6)*	*Euro 3 (6)*	*Euro 4*
Buses								
Light	≤ 5	MD	M2 ≤ 3.5	Light Duty	*Euro 2*	*Euro 2 (6)*	*Euro 3 (6)*	*Euro 4*
			> 3.5 ≤ 5	Heavy Duty	*Euro 3 or US 98 (6)*	*US 96 (7)*	*US 98 (7)*	*Euro 4 (6)*
Heavy	> 5	ME	M3	Heavy Duty	*Euro 3 or US 98 (6)*	*US 96 (7)*	*US 98 (7)*	*Euro 4* or *US 2004 (6)*
Goods Vehicles (Trucks)								
Light	≤ 3.5	NA	N1	Light Duty	*Euro 2*	*Euro 2 (6)*	*Euro 3 (6)*	*Euro 4*
Medium	> 3.5 ≤ 12	NB	N2	Heavy Duty	*Euro 3 or US 98 (6)*	*US 96 (7)*	*US 98 (7)*	*Euro 4* or *US 2004 (6)*
Heavy	> 12	NC	N3	Heavy Duty	*Euro 3 or US 98 (6)*	*US 96 (7)*	*US 98 (7)*	*Euro 4* or *US 2004 (6)*

Notes (1) – (7) to Table are on the next page.

Notes to Table 4

(1) The introduction of *Euro 2* standards for light duty petrol and light duty diesel vehicles will be via a new ADR 79/00 *Emission Control for Light Vehicles*, which adopts the technical requirements of ECE R83/04.

(2) The introduction of *Euro 3* standards for light duty petrol vehicles, and *Euro 4* standards for light duty diesel vehicles, will be via a new ADR 79/01 *Emission Control for Light Vehicles*, which adopts the technical requirements of European Council Directive 98/69/EC. Directive 98/69/EC embodies the *Euro 3* and *Euro 4* requirements for light duty petrol and diesel vehicles, however the ADR will only mandate the *Euro 3* (pre 2005) provisions of 98/69/EC for petrol vehicles, but will allow petrol vehicles optional compliance with *Euro 4* standards.

(3) The introduction of *Euro 3* and *Euro 4* standards for medium-heavy duty diesel vehicles (all buses and trucks above 3.5tonnes GVM) will be via a new ADR 80/00 *Emission Control for Heavy Vehicles,* and ADR 80/01 *Emission Control for Heavy Vehicles,* respectively. These ADRs adopt the technical requirements of the proposed European Council Directive [Common Position (EC) No 35/1999 of 22 April 1999] amending European Council Directive 88/77/EEC, which was endorsed by the European Parliament on 16 November 1999.

(4) These new ADRs (ADRs79/00, 79/01, 80/00, 80/01) will replace the existing ADR37/01 and ADR70/00. The "/00" & "/01" versions represent the 2002-4 and 2005-7 groupings of the new requirements, respectively.

(5) A new smoke ADR (ADR30/01) will also apply to all categories of diesel vehicles. The smoke standard will apply from 2002/3 and will adopt UN ECE R24/03 and allow the US 94 smoke standards as an alternative. This new ADR will replace ADR30/00.

(6) Nominated standards also apply to vehicles fuelled with LPG or NG.

(7) UN ECE & EU do not have standards for medium-heavy petrol engines, hence US EPA is adopted in lieu.

8. IMPLEMENTATION AND REVIEW

8.1 Vehicle Standards

The ADRs are national standards under the Motor Vehicle Standards Act 1989 and are therefore subject to complete review on a 10 year cycle.

The Memorandum of Understanding (MOU) between the National Road Transport Commission (NRTC) and the National Environment Protection Council (NEPC) sets out the consultative arrangements governing the development of ADRs for vehicle emission and noise. Under the MOU, the Motor Vehicle Environment Committee (MVEC) has been given the responsibility of managing the work program developed under the MOU, and this review of the emission standards is the highest priority item on the current work plan.

Under the legislation establishing the NEPC, any new emissions ADRs are to be jointly developed and agreed by the NRTC and NEPC, with formal endorsement being the responsibility of the Ministers of the Australian Transport Council. In addition, as the proposed new emission ADRs will be endorsed as standards under the Trans Tasman Mutual Recognition Arrangement, the approval of the Council of Australian Governments is also required.

The new ADRs will be given force in law in Australia by making them National Standards (ADRs) under the *Motor Vehicle Standards Act 1989*. They will be implemented under the type approval arrangements for new vehicles administered by the Federal Office of Road Safety. A manufacturer will be required to ensure that vehicles supplied to the market comply with the vehicle emission requirements of this Package of ADRs. Penalties are incurred for non-compliance with the Motor Vehicle Standards Act.

The 2002/03 elements of the Package need to be gazetted by the end of 1999 to allow sufficient lead time for manufacturers to submit certification documentation. Later elements of the Package may be gazetted at a later time.

8.2 Fuel

The adoption of tighter diesel emission standards will require a reduction in the sulfur content of diesel fuel, initially to 500ppm, and then to 50ppm for the introduction of *Euro 4* in 2006. The adoption of *Euro 3* for petrol vehicles in 2005 will require changes to fuel parameters, based on the outcomes of the Fuel Quality Review and discussions with stakeholders. There is currently no mechanism for setting national fuel standards. This has been recognised by the National Environment Protection Council (NEPC) and MVEC. The Commonwealth states that a mandatory 50ppm sulfur diesel standard may be introduced through a National Environment Protection Measure, equivalent legislative device or by use of the definition in the diesel fuel credit scheme.

8.3 Other

There are a number of other issues which still need to be addressed by the Motor Vehicle Environment Committee. These include the reduction in petrol volatility and an analysis of *Euro 4* standards for petrol vehicles with a view to determining the costs and benefits of introducing these standards in the future.

ATTACHMENT A - COMPARATIVE ASSESSMENT OF CURRENT AND PROPOSED STANDARDS

Light Duty Vehicles

Comparison of Current Standards with *Euro 2*, *Euro 3* and *Euro 4* Requirements

The attached Tables summarise the differences in emission limits, test procedures and other requirements of the *Euro 2, Euro 3* and *Euro 4* standards, with the current ADR provisions for "light duty vehicles".

Currently the relevant ADRs dealing with emissions from light duty vehicles (includes cars, 4WDs and light commercials) are:

- **ADR37/01** (petrol engined vehicles ≤ 2.7 tonnes gross vehicle mass [GVM])
- **ADR36/00** (petrol engined vehicles > 2.7 t GVM, includes some vehicles treated by UN ECE system as light duty *ie ≤3.5*t)
- **ADR70/00** (all diesel engined vehicles).

Table 1 - Emissions Requirements for Cars

Standard & Date of Application	Absolute Emission Limits (g/km)					Emissions Test		Other Requirements
	Cars < 2.5t [4]					Exhaust	Evaporative	
	CO	HC	NOx	PM[5]	Evap			
ADR37/01 (1997-9)	2.1	0.26	0.63	NA	2	US EPA Federal Test Procedure (FTP) from 1975	US EPA 2 hr "SHED"[6] Test from 1975	80,000km durability requirement.
Euro 2 [7] (1996)	2.2	0.28	0.22	0.08	2	Comparative testing on FTP & Euro cycles indicates mixed results on CO, E2 tougher on HC for most vehicles, and E2 much tougher on NOx for locally produced US based engines.	Equivalent to ADR37/01	80,000km durability requirement.
Euro 3 (2000)	2.3	0.2	0.15	0.05	2	E3 test more stringent than E2 as sampling starts from ignition (40s delay in E2). Comparative testing on E2 and E3 cycles indicates it makes CO and HC emission limits harder to meet, variable impact on NOx. ACEA[8] claim E3 leads to effective reduction in CO, HC and NOx emission limits of 30%, 40% & 40% respectively.	Significantly more stringent test with canister loading and conducted over 24 hrs. ACEA estimates equate to an 80% increase in stringency on the E2 limits.	80,000km durability requirement. OBD[9] requirement (initially for petrol vehicles only, phased in for diesels over 2003-2006) Separate -7^{o}C emissions test for HC & CO emissions (from 2002)
Euro 4 *(2005)*	1.0	0.1	0.08	0.025	2	Test cycle as for *Euro 3*	Test as for *Euro 3*	As for *Euro 3* except 100,000km durability requirement

4 More relaxed limits apply for vehicles greater than 2.5t and less than 3.5t, see separate table.

5 Diesel vehicles only

6 Sealed Housing Evaporative Determination.

7 For *Euro 2* there is a combined limit for HC+NOx, split figures assume a ratio of 55:45 (HC:NOx)

8 European Automobile Manufacturers Association (ACEA)

9 On Board Diagnostics.

Table 2 – Emissions Requirements for 4WDs and Light Commercial Vehicles (LCVs)

Standard	Emission Limits (g/km - unless otherwise specified)
	Cars > 2.5t & LCVs - up to max 3.5t (Euro & ADR70/00) 4WDs and LCVs ≤ 2.7t (ADR37/01) 4WDs & LCVs > 2.7t (ADR36/00)

	CO	HC + NOx	HC	NOx	PM	Evap
ADR37/01	6.2	NA	0.5	1.4	NA	2
ADR36/00	1% by vol	NA	180ppm	NA	NA	NA
*ADR70/00**	58-110g/test**	19-28g/test**	NA	NA	NA	2
*Euro 2***						
Petrol	2.2 or 4.0 or 5.0	0.5 or 0.6 or 0.7	NA	NA	NA	2
Diesel	1.0 or 1.25 or 1.5	0.7 or 1.0 or 1.2	NA	NA	0.08 or 0.12 or 0.17	NA
*Euro 3***						
Petrol	2.3 or 4.17 or 5.2	NA	0.2 or 0.25 or 0.29	0.15 or 0.18 or 0.21	NA	2
Diesel	0.64 or 0.8 or 0.95	0.56 or 0.72 or 0.86	NA	0.5 or 0.65 or 0.78	0.05 or 0.07 or 0.1	NA
Euro 4						
Petrol	1.0 or 1.81 or 2.27	NA	0.1 or 0.13 or 0.16	0.08 or 0.1 or 0.11	NA	2
Diesel	0.5 or 0.63 or 0.74	0.3 or 0.39 or 0.46	NA	0.25 or 0.33 or 0.39	0.025 or 0.04 or 0.06	NA

* Diesel vehicles only, *Euro 1* requirements.

** Limits depend on the mass of the vehicle.

*** For *Euro 1* and *Euro 2* there is a combined regulated limit for HC+NOx, EU assume a ratio of 55:45 (HC: NOx)

Heavy Duty Vehicles

Comparison of Current Standards with Euro 2, Euro 3 and Euro 4 Requirements

The attached Table summarises the differences in emission limits, test procedures and other requirements of the *Euro 2*, *Euro 3* and *Euro 4* standards, with the current ADR provisions for "heavy duty vehicles". The comparability of the US EPA's heavy duty standards is also covered.

Currently the relevant ADRs dealing with emissions from heavy duty vehicles (includes trucks and buses) are:

- **ADR36/00** (petrol engined vehicles > 2.7 tonnes gross vehicle mass [GVM])
- **ADR70/00** (all diesel engined vehicles).

Table 3 – Emission Requirements for Heavy Duty Vehicles

Standard & Date of Application	Absolute Emission Limits (g/kWh) (unless otherwise specified)				Emissions Test	Other Comments
	CO	HC	NOx	PM		
ADR36/00 (petrol) (1979) *ADR70/00 (diesel)*[10] (1995-6)	1% by vol 4.5	180ppm 1.1	NA 8.0	NA 0.36	9 mode steady state engine dynamometer test 13 mode steady state engine dynamometer test	ADR36 reflects 1974 US EPA standards for heavy duty petrol engines. US EPA 91 diesel limits at least as stringent as *Euro 1,* although US uses transient test, so not directly comparable
Euro 2 (1996-1998)	4.0	1.1	7.0	0.15[11]	13 mode steady state engine dynamometer test	ECE/EU has no standards for heavy duty petrol engines (>3.5t). US EPA 94 diesel limits at least as stringent as *Euro 2,* but derived from US transient test so not directly comparable.
Euro 3 (2000) *ESC Limit* *ETC Limit*	 2.1 5.45	 0.66 0.78[12]	 5.0 5.0	 0.10[13] 0.16[14]	Manufacturers have choice of 2 new test cycles: Euro Stationary Cycle (ESC); or Euro Transient Cycle (ETC)	US EPA 98 diesel limits similar to *Euro 3* but derived from US transient test, so not directly comparable. US expected to adopt Euro Stationary Cycle as additional requirement to the transient test sometime in 1999.
Euro 4 *(2005)* *ESC Limit* *ETC Limit*	 1.5 4.0	 0.46 0.55[15]	 3.5 3.5	 0.02 0.03	Manufacturers have to meet both test cycles: Euro Stationary Cycle (ESC); and Euro Transient Cycle (ETC)	

10 ADR70/00 allows compliance with ECE/EU standards, US EPA and Japanese Standards, the ECE (*Euro 1*) limits are used here as the basis for comparison.

11 Original *Euro 2* limit for PM was 0.25, which was reduced to 0.15 in 1998.

12 non-methane hydrocarbons

13 smaller engines are subject to more relaxed PM limits of 0.13 (ESC)

14 Smaller engines are subject to more relaxed PM limits of 0.21 (ETC).

15 non-methane hydrocarbons

ATTACHMENT B - COMPARATIVE TIMETABLE UNDER OPTION “2B (MODIFIED) RECOMMENDED IN PART B” & THE “COMMONWEALTH” PACKAGE

The attached tables summarise the differences between the referred Option and the Commonwealth Package. The first table outlines the differences in the adoption of emissions standards and the second table difference in fuels.

Comparative Timetable For Adoption Of *Euro 2*, *Euro 3* and *Euro 4* Emission Standards Under "Option 2B (Modified) Recommended in Part B" and The "Commonwealth Package"

Vehicle Type	Option 2B (Modified) (PART B)	Commonwealth Package (PART A)
Light Passenger Vehicles (Cars & 4WDs)	• Euro2 from 2002 for all new models, and for all models from 2004. These apply to all fuels (petrol, diesel, LPG and natural gas). • Euro 3 from 2006 for new models and from 2007 for all models.	• Euro 2 from 2003 for new petrol models and 2004 for all models. • Euro 2 from 2002 for new diesel models and from 2003 for all models. *Changes – (1) Intro of Euro 2 for new model petrol vehicles delayed by 1 year (from 2002 to 2003); (2) Euro 2 for all diesel models brought forward by 1 year (from 2004 to 2003)* • Euro 3 from 2005 for new petrol models and from 2006 for all models *Changes – Intro of Euro 3 brought forward by a year for both new and existing models (from 2006 to 2005 and 2007 to 2006)*. • Euro 4 from 2006 for new diesel models and from 2007 for all models. *Changes – Option 2B (Modified) did not consider Euro 4*
Heavy Buses and Trucks (buses above 5 tonne GVM and trucks above 12 tonne GVM)	• Euro 3 from 2002 for new petrol and diesel models and from 2003 for all models.	• Euro 3 from 2002 for all new diesel vehicles and from 2003 for all models *No changes* • Euro 4 from 2006 for new diesel models and from 2007 for all diesel models. *Changes – Option 2B (Modified) did not consider Euro 4*
Light – Medium Trucks and Light Buses (buses below 5 tonne GVM, light trucks below 3.5 tonne GVM, medium trucks 3.5-12 tonne GVM)	• Euro 2 from 2002 for new models and from 2003 for all models. • Euro 3 from 2005 for new models and from 2006 for all models.	• Euro 2 from 2002 for new light diesel models and from 2003 for all models. *No change* • Euro 2 from 2003 for new petrol models and from 2004 for all models. *Change - Intro of Euro 2 for new model petrol vehicles delayed by 1 year (from 2002 to 2003);* • Euro 3 from 2002 for new medium diesel models and from 2003 for all models. *Changes – Intro of Euro 3 brought forward by three for medium diesels (ie from 2005 to 2002 and 2006 to 2003)* • Euro 4 from 2006 for new diesel models and from 2007 for all diesel models *Changes - Option 2B (Modified) did not consider Euro 4*

Comparative Timetable for Adoption of Tighter Fuel Standards under "Option 2B (Modified) Recommended in Part B" and the "Commonwealth Package"

	Option 2B (Modified) (PART B)	Commonwealth Package (PART A)
Fuels	• From 2002, reduction of sulphur content of diesel to 500ppm, initially in major urban areas. • From 2005, Euro 3 fuel parameters based on outcomes of Fuel Quality Review and discussions with stakeholders.	• By end 2002, 500ppm sulphur content of diesel supplied to whole Australian market. Phase in initially in urban areas. *Change – brings forward date for delivery of 500ppm diesel* • Diesel standard set at 500ppm sulphur by end 2002. • From 1 January 2003 an increase in diesel excise of 1 cent /litre for fuel above 50ppm. • From 1 January 2004 an increase in the diesel excise of 2 cents/litre for fuel above 50 ppm. *Change - Option 2B (Modified) does not deal with excise issues or other incentives* • From 2006, mandatory diesel fuel standard of maximum 50 ppm sulphur content. *Change –Option 2B (Modified) not specific on fuels beyond 500ppm diesel from 2002*

PART B

ASSESSMENT OF MVEC REVIEW
OF
NEW ADRs FOR THE CONTROL
OF
VEHICLE EMISSIONS

PART B ASSESSMENT OF MVEC REVIEW OF NEW ADRS FOR THE CONTROL OF VEHICLE EMISSIONS

1. INTRODUCTION

Motor vehicles are the single largest contributor to urban air pollution in Australia's major cities. Over the past 20 years, controls on the emissions from new vehicles through the Australian Design Rules (ADRs) have been progressively tightened. Over the last 10 years in particular, there have been improvements in a number of air quality measures, and it is generally accepted that the increasing proportion of these "cleaner" vehicles has played a major part in these improvements. Nevertheless, relatively high concentrations of pollutants are experienced on occasions in our larger cities, with exceedences of ozone goals occurring every year in some of our larger cities.

As part of his November 1997 statement on climate change, *Safeguarding the Future: Australia's Response to Climate Change*, the Prime Minister released the Environmental Strategy for the Motor Vehicle Industry. A key element of the strategy is a commitment to "harmonised noxious emission standards with international standards by 2006". This Environmental Strategy has since been embodied in the 1998 National Greenhouse Strategy (part 5.10), with the Motor Vehicle Environment Committee (MVEC) being identified as the key body responsible for progressing the implementation of the strategy.

The Australian Design Rules (ADRs) set the standards that each vehicle model is required to comply with, prior to their supply to the market. The ADRs set standards for both safety and emissions, with four ADRs setting limits on exhaust and/or evaporative emissions. The relevant ADRs are ADR37/01 and ADR36/00 for petrol engined vehicles, and ADR30/00 and ADR70/00 for diesel engined vehicles.

These ADRs have been reviewed to consider:

- whether the current ADRs will deliver reductions in total emissions from the vehicle fleet at a level sufficient to ensure that improvements in urban air quality in our major cities continues over the medium to long term; and
- The most cost-effective strategies for introducing changes to the standards (if changes are warranted).

In undertaking the review, consideration has been given to ensure standards do not impose excessive requirements on business, that they are cost effective and take account of community, social, economic, environmental, health and safety concerns. The review also takes account of the provisions of the Trans-Tasman Mutual Recognition Arrangement (TTMRA) which promotes the harmonisation of Australian and New Zealand standards with the internationally recognised United Nations Economic Commission for Europe (UN ECE) Regulations.

2. STATEMENT OF THE PROBLEM

Motor vehicle pollution in Australia is an ongoing problem particularly in our densely urbanised cities. Vehicles are estimated to contribute up to 70% of total urban air pollution (NSW EPA, 1999). Emissions from vehicles therefore have significant effects on the quality of life for urban residents, particularly those susceptible to air pollution. High levels of air pollutants have been shown to result in a wide range of adverse health and visual impacts on society. Increasing levels of pollution can have significant environmental and economic consequences. Health effects associated with air pollution include respiratory effects, ranging in severity from coughs, chest congestion, asthma, to chronic illness and possible premature death in susceptible people. Other effects of air pollutants include damage to vegetation, buildings and materials, and reduction in visibility.

Reducing the contribution of motor vehicle emissions to air pollution is expected to have a positive impact on human health.

2.1 HEALTH AND OTHER ENVIRONMENTAL EFFECTS OF URBAN AIR POLLUTION

Air pollutants cause adverse effects if they are present in air at sufficient concentrations and for a sufficient length of time.

Atmospheric pollutants can cause a range of effects on human health and the environment, with the severity of effects often related to the duration of exposure and concentration of the pollutant. These include nuisance effects (eg decreased visibility, odour); acute toxic effects (eg eye irritation, increased susceptibility to infection, reduced respiratory / pulmonary function); chronic health effects (eg mutagenic and carcinogenic actions); and environmental effects (eg material soiling, vegetation damage, corrosion).

Ambient air quality standards are set at levels to protect more susceptible members of society, and significant breaches of these standards represent undesirable impacts on community health. The most common pollutants discharged to the air are oxides of nitrogen (NO_x), carbon monoxide (CO), hydrocarbons (HC), sulfur dioxide (SO_2), and airborne particles (total suspended particles and particulate matter with a diameter of less than 10 µm) including lead. These pollutants are largely produced by the combustion of fossil fuels. Another significant pollutant in major urban areas is ozone (O_3), which is a secondary pollutant formed in sunlight by chemical reactions between oxides of nitrogen and reactive hydrocarbons. The health effects of those pollutants with a strong linkage to motor vehicles are briefly discussed below (Grant *et al*, 1993; Sivak, 1993; NEPC, 1997; NSW EPA, 1996b; Vic EPA, 1994).

Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless and tasteless gas that, in high concentrations, is poisonous to humans. In sufficiently high concentrations and long exposures, CO interferes with the blood's capacity to carry oxygen. Exposure at lower levels can have adverse effects on individuals with cardiovascular disease.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a pungent acid gas. In the atmosphere it may irritate respiratory systems, exacerbate asthma in susceptible individuals, increase susceptibility to cardiovascular disease symptoms and respiratory infections, and reduce lung function. As a precursor to photochemical smog, it also contributes to effects associated with these substances.

Ozone (O_3)
Ozone is a gas with strong oxidising properties. Health effects attributed to ozone include irritation of eyes and airways, exacerbation of asthma symptoms in susceptible people, increased susceptibility to infection, and acute respiratory symptoms such as coughing. Ozone also has adverse effects on vegetation and other materials.

Particulates (PM)
Particulates contribute to reductions in visual amenity of urban air, soiling of buildings, and can have significant impacts on human health. Respirable particles, those with a diameter of less than 10 μm (PM_{10}), are a particular health concern because they are easily inhaled and retained in the lung. Almost all of the particles in diesel exhaust are less than 1 μm in diameter (Concawe, 1998), and diesel particulates also adsorb unburnt hydrocarbons and other potentially carcinogenic organic compounds such as polycyclic aromatic hydrocarbons. The International Agency for Research on Cancer has concluded that diesel exhaust is a probable human carcinogen (California Air Resources Board 1994), and the California Air Resources board has proposed that diesel exhaust be classified as a toxic air contaminant (California Air Resources Board 1998).

Although the mechanisms are not clear, epidemiological studies in the US and elsewhere consistently show a relationship between particulates and a range of respiratory, cardiovascular and cancer related morbidity and mortality (Concawe, 1996; Ballantyne, 1995; NEPC, 1997). The NEPC reports that the research indicates that all particles, irrespective of their origin, are linked with health effects (NEPC, 1997). The US EPA concludes that the elements of particulates most consistently associated with health are fine particulates, respirable particles and sulfate (US EPA 1996, cited in NEPC, 1997). Diesel engines are sources of both fine particles and sulfate.

Visible Smoke
While visible exhaust smoke is not considered a direct health hazard, it contributes to haze and can be offensive to motorists and pedestrians because of the odour and physical irritation of airways. While there are no specific air quality goals for smoke, State regulatory authorities report that smoke is a major source of complaints from the general public.

2.2 CURRENT AIR QUALITY IN AUSTRALIA

Air pollution is an undesirable by product or waste from the use of energy in a broad range of industrial, commercial and domestic activities that underpin our modern industrial society and support the Australian lifestyle. In urban areas air pollution is produced largely by motor vehicles, domestic and commercial heating and cooking, and industrial activities.

Topography and geography, as well as meteorology, are important factors in determining the dispersion of pollutants. Most large Australian cities are located near the coast with elevated terrain in the hinterland and are subject to a daily cycle of onshore and offshore air flows, resulting in recirculation of pollutants on days of poor air dispersion. The region across which air pollutants can be transported and recirculated defined by the combination of topography and meteorology is often referred to as an airshed. Studies have now been conducted on the emissions, meteorology and photochemistry of all the large capital city airsheds in Australia, and the meteorological conditions associated with high ozone concentrations have been identified (NEPC, 1997).

The National State of the Environment Report (SoE, 1996) stated that the air quality in the cities and towns of Australia is generally acceptable, and quite good by international standards. Nevertheless, relatively high concentrations of pollutants are experienced on occasions in our larger cities. Consequently management of air pollution in urban areas is focused on dealing with those occasions when poor dispersion allows ambient concentrations to rise significantly (NEPC, 1997).

Australia is one of the most highly urbanised countries in the world, and atmospheric pollution in our cities is a significant issue for the community. Surveys of community attitudes have demonstrated that environmental issues are of major concern to the public, with air pollution a key concern. In NSW surveys, urban air pollution was cited most often (by 45-55% of respondents) as the most important environmental issue requiring action to be taken (NRMA, 1996a; NSW EPA, 1994; Clean Air 2000, 1997). Another survey conducted at the Federal level gave similar results, with respondents indicating that the Commonwealth Government's top priority should be "helping to control air and water pollution" (ANOP, 1993).

The pollutants of current concern in urban airsheds are nitrogen dioxide (NO_2), ozone (O_3), fine particles (PM_{10}), air toxics, and, to a lesser extent, carbon monoxide (CO).

Until recently, air quality goals established by the National Health and Medical Resources Council have been used to assess air quality in all jurisdictions. The Ambient Air Quality National Environment Protection Measure (AANEPM), which was made in 1998, has established a nationally uniform set of ambient air quality standards (see Table 1).

Table 1 National Ambient Air Quality Standards

Pollutant	Averaging Period	Maximum Concentration	Goal within 10 years (Max allowable exceedences)
Carbon monoxide	8 hours	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	None
Photochemical oxidant (as ozone)	1 hour	0.10ppm	1 day a year
	4 hours	0.08ppm	1 day a year
Sulfur dioxide	1 hour 1 day 1 year	0.20ppm 0.08ppm 0.02ppm	1 day a year 1 day a year none
Lead	1 year	0.05 $\mu g/m^3$	none
Particles as PM_{10}	1 day	50 $\mu g/m^3$	5 days a year

Source: NEPC, 1998

The pollutants identified in the table above which are significantly affected by vehicle emissions are CO, NO_2, O_3, PM_{10} and lead. Lead was formerly of concern in urban areas, but the implementation of effective management strategies has resulted in a sustained decline in ambient lead levels. The current status and trends for the remaining four pollutants are discussed below.

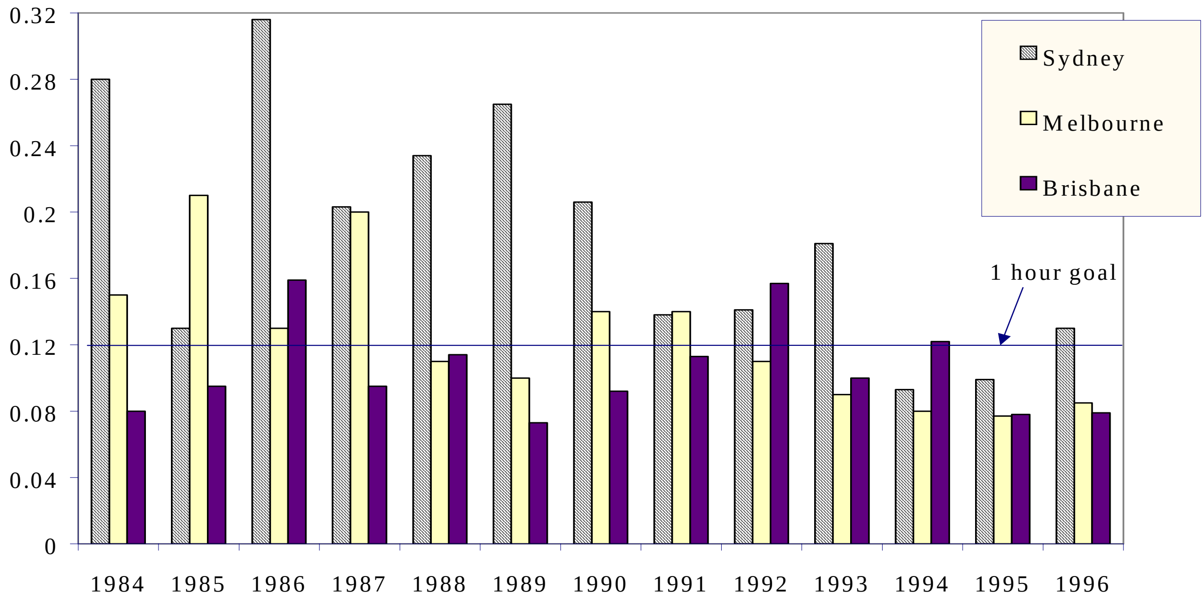
Carbon Monoxide (CO)

Exceedences of CO goals still occur in Australia's larger cities, but the number of exceedences has reduced considerably over the past 10 years. Most exceedences are recorded occur in Sydney and Adelaide, but it is considered that the siting of the monitoring stations near areas of high traffic flows in those cities does not reflect exposure levels for the general population (NEPC, 1997). The general consensus of environmental protection agencies is that the current CO levels are not of concern, and will continue to decrease (SoE, 1996).

Nitrogen Dioxide (NO_2)
The number of breaches of the current NO_2 goal have been low in recent years, with only Sydney and Adelaide having any exceedences in the past 10 years. However, the formation of nitrogen dioxide in the atmosphere (from nitric oxide in vehicle exhaust) is strongly affected by seasonal weather conditions, leading a number of reports to conclude that there are no clear trends in the levels of nitrogen dioxide (NSW EPA, 1996b, Coffey Partners, 1996). While the number of exceedences are low, analysis of the peak data at the 98 percentile level (a reliable indicator of trends) concludes, for example, that a clear downward trend is not apparent in Melbourne's 1 hour average NO_X or NO_2 data (Coffey Partners, 1996).

Figure 1 indicates the trends for peak results in Sydney, Melbourne and Brisbane.

Figure 1 Nitrogen dioxide peak 1 hour values



Source: NSW EPA, Vic EPA, Qld DOE (1995-6 Melbourne Data subject to confirmation)

The New South Wales Health Department's Health and Research Program (HARP) which examined the health effects of urban air pollution (Hensley, 1996; Morgan *et al*, 1998), estimated that days of high NO_2 levels were associated with: a 7% increase in hospital admissions for cardiovascular disease; a 5% increase in childhood asthma admissions; a 3% increase in adult asthma admissions and a 5% increase in chronic obstructive pulmonary disease admissions.

Ozone (O_3)
Gaseous ozone is measured as an indicator of the level of photochemical smog in the atmosphere. It is a secondary pollutant, which is formed from the reaction of a mixture of hydrocarbons and oxides of nitrogen (principally NO_2) in the presence of sunlight.

The national 0.10ppm standard is exceeded on an annual basis in Melbourne, Sydney Brisbane and Perth. Adelaide also experiences less frequent exceedences of the standard. Until recently, breaches of the standard in most Australian cities have steadily declined, with Sydney, Brisbane and Perth showing some variability in the past few years (Figure 2).

The World Health Organisation has set a stricter goal of 0.08ppm, which is the current goal in Western Australia, and which New South Wales has indicated it intends to meet as a long term objective (NSW EPA, 1996b). Adopting this more stringent goal would indicate a significantly higher number of recorded exceedences, and a worsening upward trend (Figure 3). For example, in Sydney the number of exceedences in 1994, based on 0.12ppm, 0.10ppm and 0.08ppm goals, were 2, 12 and 25 days respectively (NSW EPA, 1996a).

Meteorological conditions have a significant impact on ozone formation. Consequently, large variations in exceedences may simply result from variations in the number of calm sunny days from year to year. Accurate assessment of ozone levels in a large urban airshed is also difficult, because the time taken for ozone formation means that levels may be highest in areas remote from concentrations of traffic, where monitoring stations have traditionally been located. For example, monitoring data from the Sydney airshed (NSW EPA, 1996c) confirmed that prevailing winds and topography were conducive to high levels of ozone formation and accumulation in the western part of the airshed (despite the fact that most primary emissions are produced in the east).

A number of reports suggest peak ozone results give a more reliable indicator of air quality trends than exceedences (Coffey Partners, 1996). On the basis of peak ozone levels in Sydney, current ozone precursors would need to be substantially reduced to achieve the 0.08ppm long term goal (NSW EPA, 1996c). In Melbourne, there is also no clear downward trend for ozone (Coffey Partners, 1996).

By international standards, the maximum 1 hour ozone concentrations recorded in Sydney and Melbourne are comparable with cities such as Toronto, San Diego, Philadelphia and Atlanta, and exceed those in London. Whilst the peak 1 hour ozone concentrations recorded in Australia's two largest cities rank as high by international standards (compared with cities of comparable or larger population), the number of days on which the 0.10ppm 1hr standard is exceeded is relatively low.

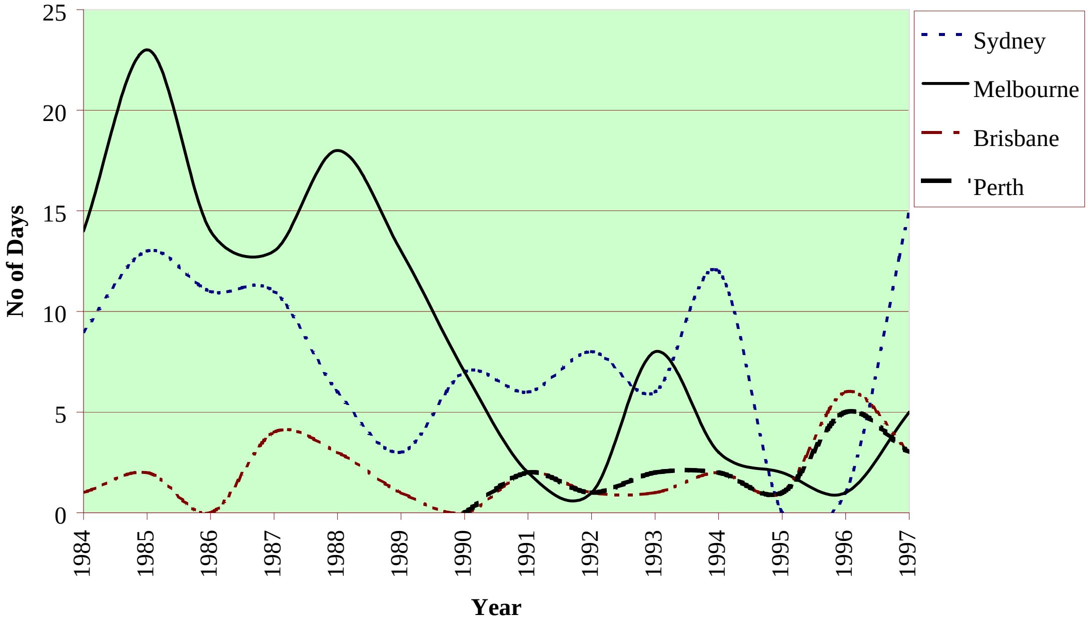
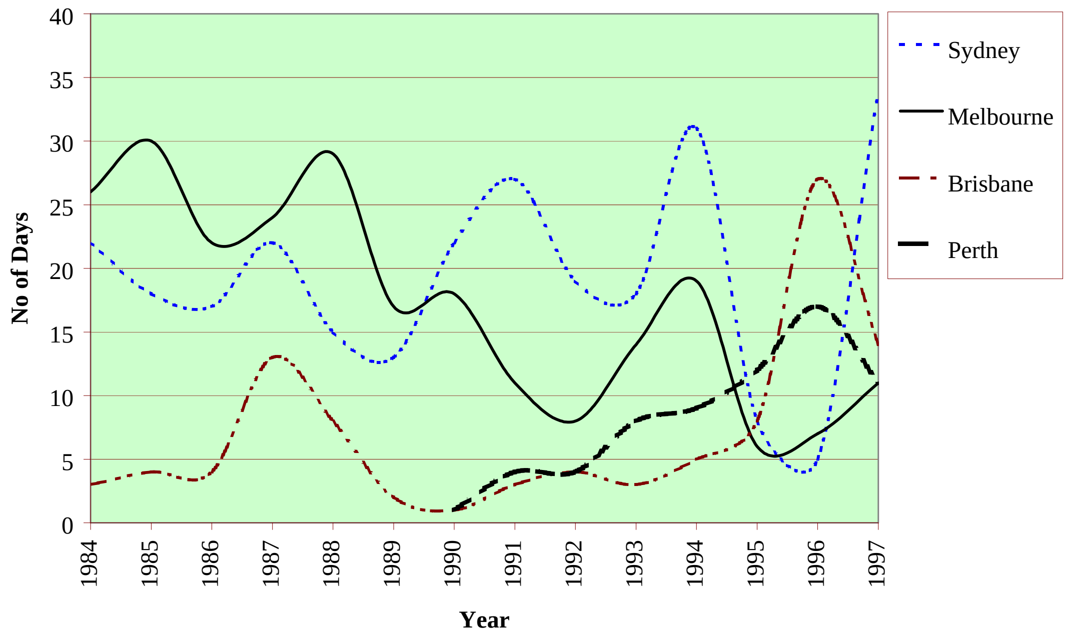


Figure 2 Ozone exceedences, 1 hour 0.10ppm

Source: NSW EPA, Vic EPA, Qld DOE, and WA DEP

Figure 3 Ozone exceedences, 1 hour 0.08ppm



Source: NSW EPA, Vic EPA, Qld DOE, and WA DEP

Particulates

Denison and Chiodo (1996) conclude that "although respirable particle levels in Australia are low, there are still strong associations with adverse health effects", and that "for mortality, at least, there does not appear to be a threshold particle level". Recent research has reported health effects at levels well below current guidelines (Pope *et al* (1995) cited in Denison and Chiodo, 1996). Other reports (NEPC, 1997; NSW EPA, 1998; WA DEP, 1996) also conclude that the research findings point to no discernible threshold below which no adverse health effects occur.

The New South Wales Health Department's Health and Research Program (HARP) which examined the health effects of urban air pollution (Hensley, 1996; Morgan *et al*, 1998), concluded that there are significant links between air pollution and health, particularly heart disease and respiratory problems. Particulate pollution was estimated to contribute to nearly 400 (2%) premature deaths in Sydney each year between 1989 and 1993. The study also estimated that days of high particulate concentrations were associated with: a 3.5% increase in hospital emissions for cardiovascular disease; a 3% increase in chronic obstructive pulmonary disease hospital admissions; and a 3% increase in heart disease admissions in the elderly.

2.3 CONTRIBUTION OF MOTOR VEHICLES TO URBAN AIR POLLUTION

Atmospheric emissions are derived from a wide variety of anthropogenic and natural sources, and have effects both on human health and on the environment. Fossil fuel combustion, particularly by motor vehicles, has been identified as the largest single contributor to the air pollutants specified in Table 2.

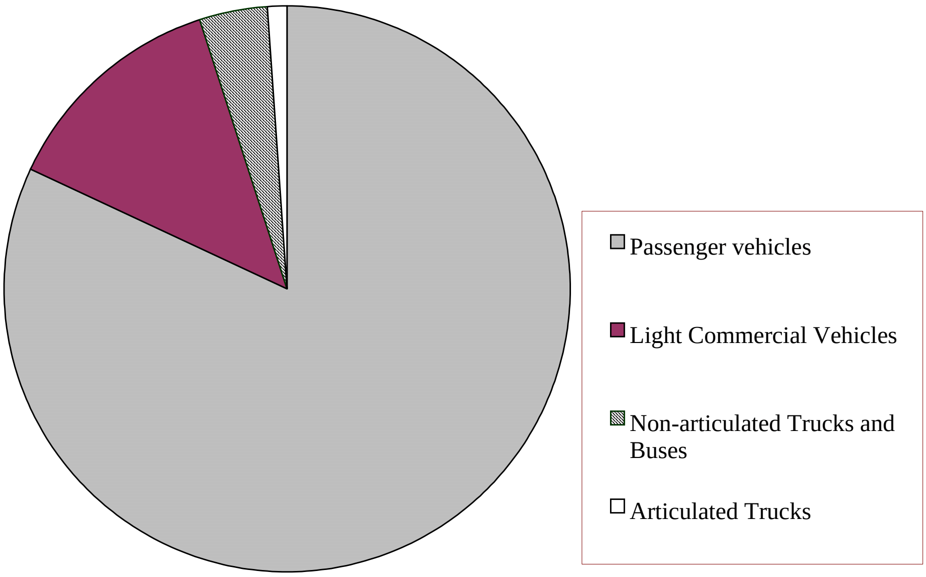
Table 2 Contribution (%) of Motor Vehicles to Air Emissions in Major Australian Cities

Carbon Monoxide (CO)	Hydrocarbons (HC)	Oxides of Nitrogen (NOx)	Particulates (PM)
70-95%	40-50%	70-80%	10-50%

Source: Coffey Partners, 1996

As indicated in Figure 4, while the larger trucks and buses may emit more pollutants per kilometre, cars are the dominant vehicles operating in the urban environment, with light commercial vehicles the next most significant group. The sheer number of cars, as well as their reliance on petrol engines, ensures that they are the major contributors to CO, HC and NOx emissions. Commercial diesel engined vehicles, while fewer in number and kilometres travelled, are nevertheless a significant source of NOx and particulate emissions, and the major vehicle offenders in terms of visible smoke. Trucks are increasingly reliant on diesel as a transport fuel, with the use of petrol by trucks (not including light commercials) falling from 18% in 1984/5 to just 3% in 1994/5 (Apelbaum, 1997).

Figure 4 Kilometres Travelled in Urban Areas, by Vehicle Type



Source: Apelbaum, 1997

Vehicle based HC emissions are a mixture of evaporative and exhaust emissions. The NSW EPA estimates that in summer, approximately 60% of light duty vehicle HC emissions are from evaporation (NSW EPA, 1998).

Data from Sydney, Melbourne and Brisbane indicate that motor vehicles are responsible for around 80% of total NOx emissions, with diesel trucks and buses contributing about 40% of these vehicle emissions (NSW EPA, 1996c; Coffey Partners, 1996; Carnovale *et al*, 1991).

In relation to particulates, a New South Wales study estimates that road transport was responsible for about 30% of particulate emissions, with commercial vehicles being the most significant vehicular emitter (NSW EPA, 1996c). The contribution of Victorian vehicles to anthropogenic particulate emissions were estimated at between 10% (in Winter) and 46% (in Summer). Diesel vehicles are estimated to be responsible for 70-80% of these vehicle PM emissions (Carnovale *et al*, 1991; WA DEP, 1996; NSW EPA, 1998; Q DOE, 1998).

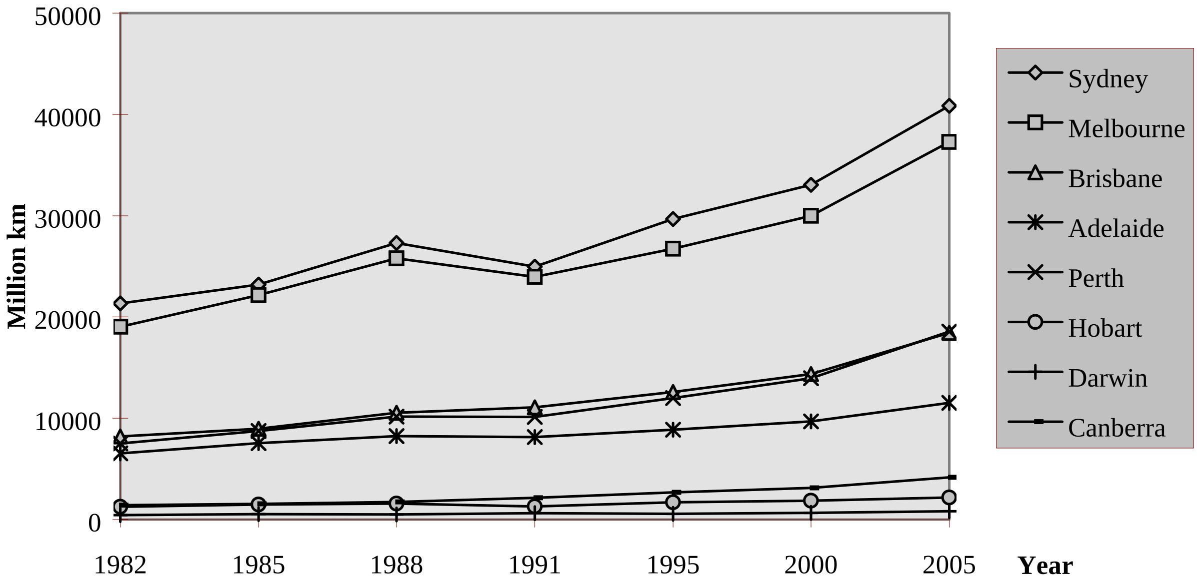
2.4 AIR QUALITY PROJECTIONS

Considerable progress has been made in improving the air quality in our cities by increasing emission controls on vehicles and industry, together with local initiatives such as controlling backyard burning. As a result of these initiatives, urban air quality has improved over the past decade and in some cases, will continue to improve in the short term (Coffey Partners, 1996).

As vehicles complying with ADR 37/00 and ADR37/01 (petrol engined) and ADR 70/00 (diesel engined) make up an increasing proportion of the fleet, the incremental effect of these controls will become less significant and any improvements will occur at a decreasing rate. Unless further action is taken, population growth, urbanisation and increased use of motor vehicles are expected to overtake improvements in the emissions performance of individual vehicles and result in declining air quality in the medium to long term (Ballantyne, 1995).

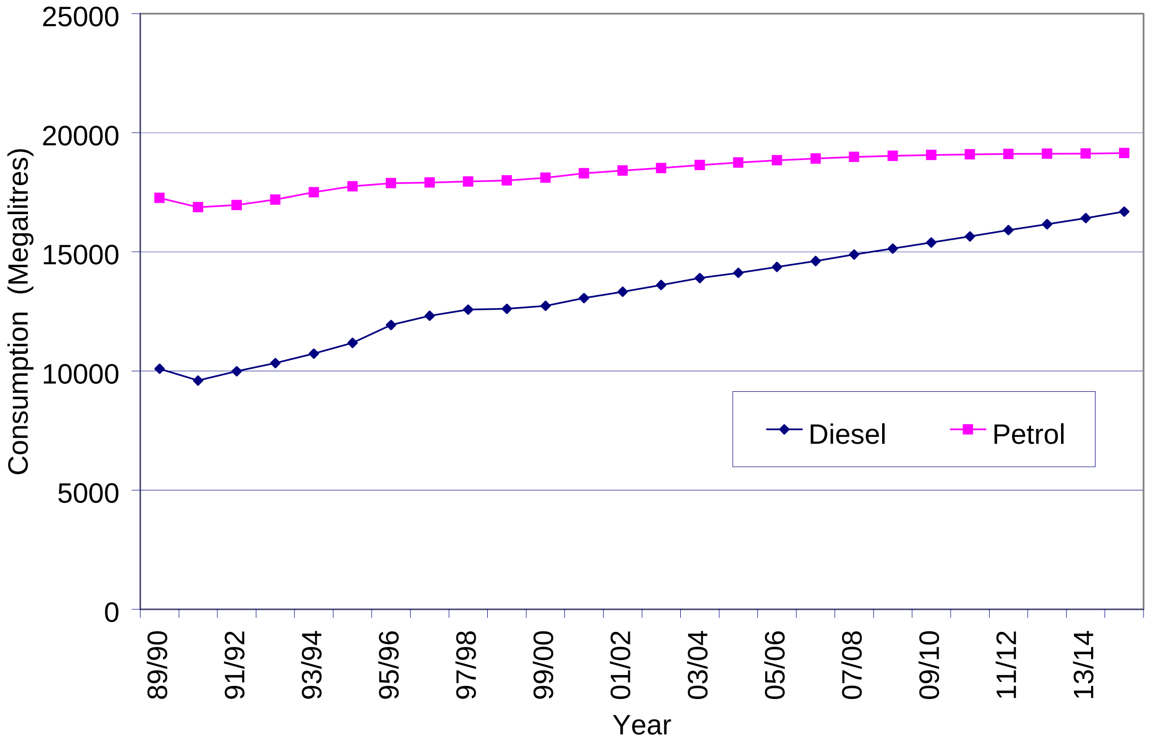
Figures 5 and 6 highlight expected increases in urban travel demand and increasing fuel consumption (particularly diesel fuel). In such an environment, vehicle emissions will increase unless action is taken to reduce emissions per kilometre.

Figure 5 Trends in vehicle kilometres travelled (VKT) in Australian capital cities



Source: Coffey Partners, 1996

Figure 6 Petrol and Automotive Diesel* Consumption (Actual & Predicted)



Source: ABARE, 1999
*diesel excludes bunkers (marine diesel)

A Melbourne airshed study (Carnovale *et al*, 1991) indicates that in the 1990-2000 period vehicle emissions of CO and HC are expected to fall, while NOx emissions are expected to remain fairly stable. The frequency of ozone breaches in Victoria, while comparatively low, are nevertheless considered a cause for concern (Vic EPA, 1993). A similar study of the Perth airshed anticipated increases in NOx emissions in the medium to long term (James, 1994).

A 1991 study of the Melbourne airshed estimates that particulate levels from motor vehicles are likely to increase over the 1990-2000 period by some 17%. Perth air quality studies conclude that PM levels are likely to increase (WA DEP, 1997), with James (1994) estimating that particulate emissions from motor vehicles will increase by some 80% over the period 1991-2011 (although no account was taken of the impact of ADR 70/00).

Recent modelling in South East Queensland, suggests that relative to 1993 levels, CO, HC, NOx and PM emissions will be lower in 2011, but the report concludes that pressures from growth in vehicle use are expected to increase emissions in the long term (Q DOE, 1998).

In the absence of further controls on vehicle emissions and with predicted increases in motor vehicle usage, air quality modelling analyses anticipate that air quality in Sydney, Melbourne, Brisbane and Perth will deteriorate in the medium to long term (NSW EPA, 1996c; RTA, 1994; Carnovale *et al*, 1991; James, 1994). To counteract the effects of increasing total vehicle kilometres, further action is required to curb the potential upward trend in air pollutant exceedences (Coffey Partners, 1996; NRMA, 1996b; Reid, 1997).

2.5 GOVERNMENT INTERVENTION

In congested urban areas, motor vehicle users often fail to take account of the health and environmental costs imposed on the wider community from vehicle emissions when deciding on the purchase or use of their vehicle. To date there has also been little incentive for Australian vehicle designers and manufacturers to take account of these external social and health costs as, unlike many safety features, emissions performance of vehicles are not an important marketable feature of motor vehicles. For example, confidential certification data held by the FORS demonstrates that many manufacturers (including importers) produce vehicles tailored to the Australian market, which meet only minimum passenger and commercial vehicle emissions standards rather than the more stringent international UN ECE standards.

Governments throughout the world, including Australia, have taken action to reduce vehicle emissions rather than relying solely on price signals. Evidence presented earlier in this RIS suggests that this significant problem will be ongoing and further government action is warranted to combat the problem."

Mandatory vehicle emission standards were first introduced in Australia in 1972 in recognition of the significant impact vehicle emissions can have on the health of people living in urban areas. These have been progressively tightened in an effort to improve urban air quality. Application of emission standards as a design requirement under the Australian Design Rules (ADRs) recognises the clear 'market failure' in dealing with motor vehicle drivers who impose adverse effects without bearing the costs. The ADRs are national standards under the *Motor Vehicle Standards Act, 1989*.

3. OBJECTIVES

An objective of government health and environment policy is to reduce the adverse effects of motor vehicle emissions on urban air quality and human health. The government also has an objective to harmonise Australian vehicle emission standards with international standards by 2006. Australian Design Rules are reviewed to ensure they are relevant, cost effective and do not provide a barrier to the importation of safe vehicles and components.

The Government's objective is outlined in the Prime Minister's Statement, *Safeguarding the Future,* (Prime Minister, 1997) as "seeking realistic, cost effective reductions in key sectors where emissions are high or growing strongly while also fairly spreading the burden of action across the economy". Vehicle based measures outlined in the statement aim to reduce air pollution and improve the health of our cities, as well as reducing greenhouse gas emissions. The statement specifically states the government objective that Australia would "harmonise noxious emission standards with international standards by 2006".

4. OPTIONS

This section outlines the potential options for reducing motor vehicle emissions including the 'do nothing' option. As the focus of the review was on the effectiveness of the current ADRs in delivering reductions in total emissions from the motor vehicle fleet at a level sufficient to ensure improvements in urban air quality, the majority of the discussion is on introducing new standards, Option 2. It is recognised, however, that there are a range of complementary strategies for addressing vehicle emissions which could be used as an adjunct to new vehicle standards.

The current standard setting limits on exhaust (CO, HC and NOx) and evaporative HC emissions from light duty petrol engined vehicles is ADR 37/01. This standard was phased in over 1997-9 and requires all new vehicles to comply with US 1993 emission limits. ADR36/00 sets limits on exhaust emissions of CO and HC from heavy duty petrol engined vehicles. This standard took effect in July 1988 and is based on US 1974 emission limits.

The two standards setting limits on exhaust emissions from all diesel engined vehicles are ADR30/00, which sets limits on visible smoke, and ADR70/00, which sets limits on emissions of CO, HC NOx and PM. ADR70/00 was introduced in 1995-6 and provides manufacturers the option of complying with one of three sets of standards. These are ECE Regulations 83/01 and 49/02 (equivalent EEC Directives 91/542 and 91/441, referred to as *Euro 1*), US EPA 1991 or 1994, and Japanese 1993/4. ADR30/00 was introduced in 1976 and sets limits on visible smoke consistent with European and US standards of the early 1970's.

4.1 DO NOTHING (OPTION 1)

As indicated in Section 2, motor vehicles are the largest single source of emissions which degrade air quality in major urban areas. Air quality improvement mechanisms therefore necessarily involve control and reduction of emissions from motor vehicles. As the bulk of the Australian vehicle fleet, petrol vehicles have conventionally been the primary focus of improvements to vehicle emission standards, while diesel vehicles have, until the introduction of ADR70/00 in 1995, received little attention. Other air quality management strategies such as the reduction of the lead content in petrol and increased regulatory controls on industrial and domestic activities have also contributed to improved air quality. Air quality projections indicate that the improvements in air quality detailed in Section 2 will be sustained in the short term, particularly as new vehicles meeting ADR37/01 and ADR70/00 penetrate the fleet and older vehicles are retired.

Maintenance of the emission ADRs in their current form would not be acceptable for a number of reasons:

- Despite improvements, exceedences of some standards, particularly Ozone still occur every year in Australia's larger cities;
- Motor vehicles are a major source of hydrocarbons and oxides of nitrogen (the precursors for photochemical smog) and particulates;
- Significant health impacts from emissions, particularly NOx and PM_{10}. Health studies suggest that current levels of air quality are having significant health effects with a strong correlation between high NO_2 and PM levels and hospital admissions for asthma and heart disease, and no safe level being determined for exposure to particulates;
- The commitment to harmonisation with international standards by 2006;
- Increases in urban population and overall vehicle travel are expected to negate the benefits from these ADRs, leading to a worsening of the air quality related to motor vehicle emissions in our major urban areas early next century. Melbourne and Sydney

are the two most densely populated cities in Australia in 1997 and collectively represented almost 40% of Australia's total population (ABS, 1999). In order to meet NEPC's ambient air quality standards (AANEPM), air quality management is being actively progressed by both of these jurisdictions. However, given their high population densities, it is likely that even with the implementation of a rigorous suite of air quality management strategies, Sydney and Melbourne will still exceed the allowable limits on some occasions. Exceedences of goals also occur to a lesser extent in Brisbane, Perth, and urban development in these cities and adjacent regions is occurring rapidly; and

- There is a high level of community concern over air quality and an expectation that steps will be taken to improve the situation.

It is unlikely that market forces alone would deliver significant reductions in vehicle emissions in the Australian fleet. Some local manufacturers are improving standards voluntarily in order to meet export standards; however, the export 'versions' of these vehicles are not necessarily supplied to the Australian market. The Federal Chamber of Automotive Industries (FCAI) has stated that vehicles can be, and are, tailored to the Australian market. These vehicles often meet the minimum standards only. Some imported vehicles (mainly European) manufactured to tighter emissions standards, are being provided to the Australian market. However, as European vehicles only represent about 6% of the Australian market, this will have little impact on total emissions. For commercial vehicles a mixture of minimum and tighter standard vehicles are supplied eg in the heavy duty sector a mix of US91, US94 and US98 standard engines are supplied (*US91* is the minimum requirement).

Despite the uncertainty inherent in air quality modelling and air quality projections, to 'do nothing', in light of available evidence, conflicts with one of the guiding principles of Ecologically Sustainable Development, that is, 'where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation' (Commonwealth of Australia, 1992). This precautionary approach is also taken by the European Parliament in dealing with air pollution problems (European Commission, 1997).

4.2 INTRODUCE NEW STANDARD(S) (OPTION 2)

Air quality improvements to date demonstrate that the implementation of more stringent new motor vehicle emission standards (largely in the absence of any other significant vehicle based measures) is a highly effective air quality management strategy (NSW EPA, 1998; Vic EPA, 1997; QDOE, 1998). The Industry Commission stated in its Automotive Industry Report (1997) that regulations such as emission standards continue to have an important role to play in addressing environmental problems, as there are substantial problems with using market mechanisms to address all the environmental impacts of vehicle use. These include the technical difficulties in measuring the cost of emissions, allocating those to certain vehicles and relating measurements to trip length and regional impact.

In assessing the need to increase the stringency of the current emissions standards, it needs to be recognised that vehicle related air pollution is essentially a problem associated with Australia's larger urban areas.

Key factors to consider in the adoption of new standards are:

- Which standards should be considered;
- The relative stringency of the candidate standards;
- The timing of the introduction of new standards;
- The impact of fuel parameters on in-service compliance with new standards; and
- The costs and benefits of adopting particular standards.

The first four factors are considered in this Section 4, with the last (costs and benefits) being considered in Section 5.

4.2.1 Which Standards

The preparation of a unique Australian standard is neither desirable nor necessary. The emission ADRs have always been based on overseas standards and these have delivered air quality improvements, even though the test cycles used in these standards may not be particularly representative of Australian urban driving conditions. The globalisation of the motor vehicle industry also makes the development of unique Australian standards undesirable from a manufacturer's perspective. Thus the only realistic option is for the new/revised ADR to adopt an appropriate overseas standard.

Australia's petrol vehicle emission standards have traditionally been based on the US EPA standards, while the diesel standards allow a range of standards. In the interests of facilitating trade in motor vehicles, the Australian Government strongly supports the international harmonisation of vehicle standards (Prime Minister, 1997; Sharp, 1996), and this view is also supported by the vehicle industry (FCAI, 1999a). The Inquiry into Urban Air Pollution in Australia (AATSE, 1997) concludes that harmonisation with UN ECE makes sense on the grounds of emissions reduction, trade facilitation and industry viability.

Under the World Trade Organisation (WTO) rules to which Australia is a signatory, only the Regulations developed by the UN ECE meet the definition of an "international" standard in the vehicle standards field (as opposed to national standards such as the Japanese or US). The UN ECE standards are therefore preferred for adoption in the Australian Design Rules, and the Australian Government is moving to harmonise all the ADRs with the ECE Regulations as far as is possible. The Japanese Government has also made a commitment to harmonisation with ECE vehicle standards by acceding to the UN ECE 1958 Agreement in November 1998. Many Japanese companies have an international focus in exporting to APEC economies and Europe. Most other Asian countries, and indeed the majority of countries in the world, are moving towards adopting ECE Regulations on emissions standards (FCAI, 1996). The US and ECE are also moving towards harmonisation, with some alignment of test cycles occurring in the US99 and *Euro 3* heavy duty standards (DieselNET, 1999).

Note: For brevity, the remainder of this document frequently refers to *"Euro 1", "Euro 2", "Euro 3"* and "*Euro 4",* standards. These are the common terminology used to describe the progressively more stringent versions of the UN ECE standards which apply from 1992, 1996, 2000 and 2005 respectively. Reference is also made to "*Tier 1"* and *"US94"* and *"US98",* which are the current US EPA Tier 1 light duty vehicle emission standards, and the US EPA heavy duty emission standards introduced in 1994 and 1998 respectively.

4.2.1.1 Petrol Vehicle Compliance with ECE Standards

Australia's petrol vehicle emission standards have for many years been based on US EPA requirements, and thus all vehicles manufactured in Australia and those imported (regardless of origin – see Table 3) have to demonstrate compliance with the US EPA emissions tests in ADR37/01 or ADR36/00.

Table 3 Australian Passenger Vehicle Market Share* by Country of Manufacture and Total Sales, 1997**

Australia	Japan	Korea	Germany	Spain	Sweden	Total No. of Cars Sold (rounded)
39%	37%	15%	4%	4%	1%	540,000

* % are rounded

** the country of manufacture is a FORS estimate, based on FCAI sales data for 1997.

A shift to adoption of UN ECE standards in these ADRs would mean that some manufacturers would have to undertake different emission test protocols. This, in itself, is not likely to cause any significant difficulties, as most manufacturers are familiar with the ECE test procedures, and have the facilities to undertake the tests (at least at the *Euro 2* level). Facilities for Australian based car manufacturers would have to be upgraded for compliance testing to *Euro 3*.

The FCAI have stated that the adoption of UN ECE for petrol vehicles may also have implications for fuel octane demand, which are discussed in Section 4.2.4.

4.2.1.2 Diesel Vehicle Compliance with ECE Standards

Gaseous and Particulate emissions

Under Australia's diesel vehicle emission standards (ADR70/00) vehicles can be certified to a range of standards (UN ECE, US and Japan). All diesel vehicles, (or at least their engines) in Australia are imported, with most coming from Japan, with the exception of the heavier vehicle range, most of which are imported from the US and Europe (see Table 4).

Table 4 Australian Commercial Vehicle (Petrol and Diesel*) Market Share and Total Sales, 1997

Vehicle Weight Category	Proportion by Nationality of Manufacturer (%)					Total No of Vehicles [rounded]
	Japanese	European	American	Australian	Korean	
GVM < 3.5 t	75	8	4	10	3	165,700
3.5 t ≤ GVM < 7.5 t	95	4	1	0	0	6,100
7.5 t ≤ GVM< 15.0 t	84	11	4	0	0	4,800
GVM ≥ 15.0 t	10	17	73	0	0	5,600

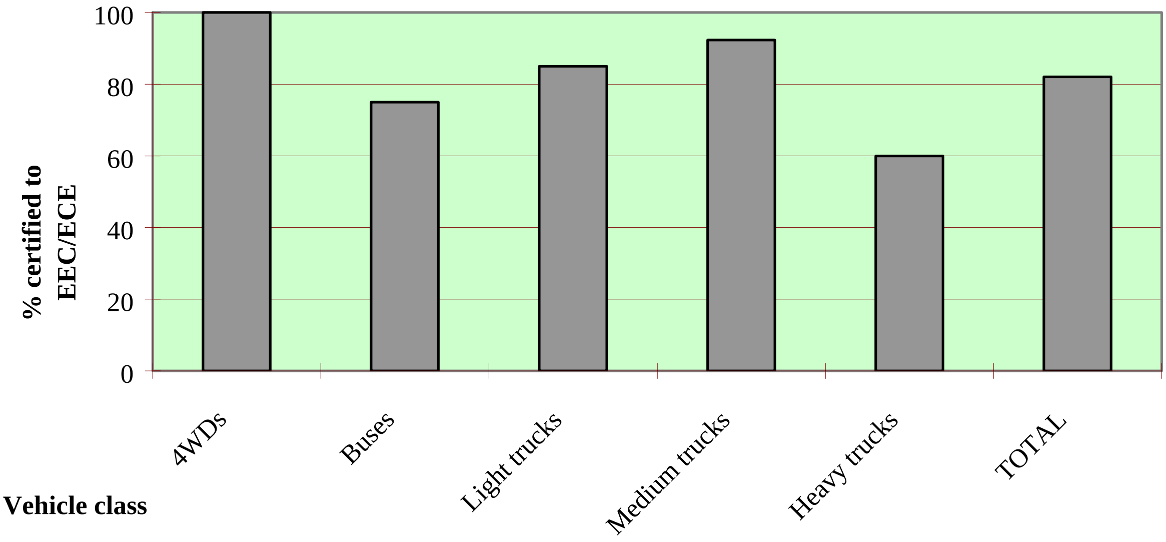
* Commercial vehicles are a mixture of petrol and diesel engined vehicles, with ABS data indicating that around 20% of light commercial vehicles (<3.5 t), 75% of rigid trucks and 100% of articulated vehicles are diesel fuelled (ABS, 1996).

Source: FCAI, 1998

For European based suppliers, harmonisation with UN ECE emission standards should pose no inconvenience since the EEC (European) directives are already technically equivalent.

Over 80% of Japanese vehicles or engines are already certified to ECE/EEC standards under the current ADR 70/00 (Figure 7). For the minority of Japanese vehicles that are currently certified under Japanese standards and do not comfortably meet ECE standards, the main impacts of compliance with ECE standards would be the re-engineering of some vehicles and some rationalisation of models.

Figure 7 Proportion of Japanese manufactured vehicles/ engines certified to EEC/ECE Standards under ADR 70/00



Source: FORS, 1996

As indicated in Table 4, a substantial proportion of heavy duty vehicles are sourced from the USA. For US based suppliers, the FCAI has stated that a revised ADR which only permitted compliance with ECE standards [ie. omitted the US EPA heavy duty standards as an alternative], would have commercial implications associated with additional certification costs. Unlike many of the Japanese vehicles, US sourced vehicles are certified to domestic US EPA standards. There are US engines going to the European market but these are not considered suitable by the industry for the demands of the Australian road freight industry (ACVEN Diesel Emissions WG, 1996). Furthermore, compliance with UN ECE standards is unlikely to improve emissions performance because it appears (albeit on limited data) that the *US94* heavy duty standards are at least as stringent as the equivalent ECE standards (*Euro 2*).

Smoke Emissions

In improving diesel vehicle emission standards, the question is raised as to whether there is still a need for a separate smoke standard (as encompassed in ADR 30/00) or whether the particulate standards alone ensure adequate control of visible smoke. Currently ADR 30/00 details a test method for visible smoke and allows the US EPA provisions and ECE R24 as alternatives.

It has been suggested that compliance with particulate standards of the stringency of US 1991 type standards (currently an option in ADR70/00) should effectively eliminate visible smoke emissions (OECD, 1993); so the question arises as to whether a smoke standard is required at all for vehicles complying with such standards. Nevertheless, the US, Europe and Japan still maintain separate limits for visible smoke in their emission regulations, and thus manufacturers undertake opacity testing as a matter of course to obtain compliance. This maintenance of a smoke test would not add to compliance costs for the Australian market. There is also an argument that for State regulatory authorities to have an effective basis for controlling smoke from in-service vehicles, it is preferable if those vehicles have passed a smoke emission requirement as part of their initial certification test.

4.2.2 Stringency of Standards

Emissions standards are complex, incorporating tests for both exhaust and evaporative[16] emission tests, durability requirements, different emission limits for different classes of vehicles, and sometimes variable applicability dates within the standard. Table 5 summarises the key features of the current ADRs (36/00, 37/01 and 70/00) compared with the *Euro 2* and *Euro 3* standards. More details on the emission limits and test provisions are outlined in the tables at Attachment A.

[16] Evaporative emission tests do not apply to diesel engined vehicles.

Table 5 - Comparison of UN ECE (*Euro 2* & *Euro 3*) standards with Current ADRs

Vehicle Type	Key Features of the ECE Standards vs Current ADRs (1)	
	Euro 2	***Euro 3***
Petrol		
Light Duty (≤ 2.7 tonnes)	• No change in limits for CO & HC, 65% reduction in NOx limits (2) • Evap test same (2hrs) • Durability requirement same (80k)	• Tougher emissions test, including cold start sampling • No change in limits for CO & HC, 75% reduction in NOx limits (3) • Evap test much tougher (24hrs) • Durability requirement same (80k) • On board diagnostics (OBD) • Separate -7 ^{o}C test for CO & HC
Heavy Duty (>2.7 tonnes)	• More stringent emission requirements all round • Limits on NOx (none at the moment) • ECE does not cover petrol engines over 3.5 tonnes (4)	• Much more stringent emission requirements all round • Limits on NOx (none at the moment) • Apart from emission limits, other requirements as for light duty above • ECE does not cover petrol engines over 3.5 tonnes (5)
Diesel		
Light Duty (≤ 3.5 tonnes)	• LCVs and 4WDs subject to more stringent emission test and limits • LCVs and 4WDs meet PM limit (none at the moment)	• LCVs and 4WDs subject to much more stringent emission test and limits • LCVs and 4WDs meet PM limit (none at the moment) • Apart from emission limits, other requirements as for light duty above, except no evap test and OBD requirements phased in over longer period
Heavy Duty (>3.5 tonnes)	• 15% reduction in NOx limits • 60% reduction in PM limits	• Changes to test procedures • 40% reduction in NOx limits • 70% reduction in PM limits

(1) % reductions rounded to nearest 5%
(2) But comparative testing on FTP and ECE indicates ECE Euro 2 test tougher on HC for most vehicles and tougher on NOx for locally produced US based engines.
(3) But comparative testing on FTP and ECE indicates ECE *Euro 3* test much tougher on CO, HC and NOx for most vehicles
(4) Propose to address this shortcoming by adoption of US Heavy duty standards for petrol engines.
(5) Propose to address this shortcoming by adoption of US Heavy duty standards for petrol engines.

As well as comparing the relative stringency of the UN ECE standards with the current ADRs, the stringency of alternative standards was also considered.

The US EPA emission standards have set the pace for international emission standards over the past 20 odd years. However, during the 1990's the UN ECE standards have been significantly strengthened to the point where it is generally accepted that the current UN ECE standards and the current US standards are "equivalent", as far as can be established, given that that the emissions tests used in the standards are different. Table 6 compares the US and UN ECE standards for petrol engined cars.

Table 6 Comparison of Passenger Car (Petrol) Emission Standards

Current & Future Standards	**Date of Implementation**	**Limits on Emissions**			
		CO (*g/km)*	**HC [exhaust] (*g/km)***	**NOx (*g/km)***	**HC [evaporative] (*g/test)***
ADR37/01 (1)	1997-9	2.1	0.26	0.63	2
UN ECE			(Combined HC and NOx)		
Euro 2 (2)	1996	2.2	0.5		2
Euro 3 (2)	2000	2.3 (3)	0.2	0.15	2
Euro 4 (4)	2005	1.0	0.1	0.08	2
US EPA					
Tier 1 (5)	1994-6	2.1	0.25 [0.15] (6)	0.25	(7)
Tier 2	2004	1.0	0.08 (8)	0.12	

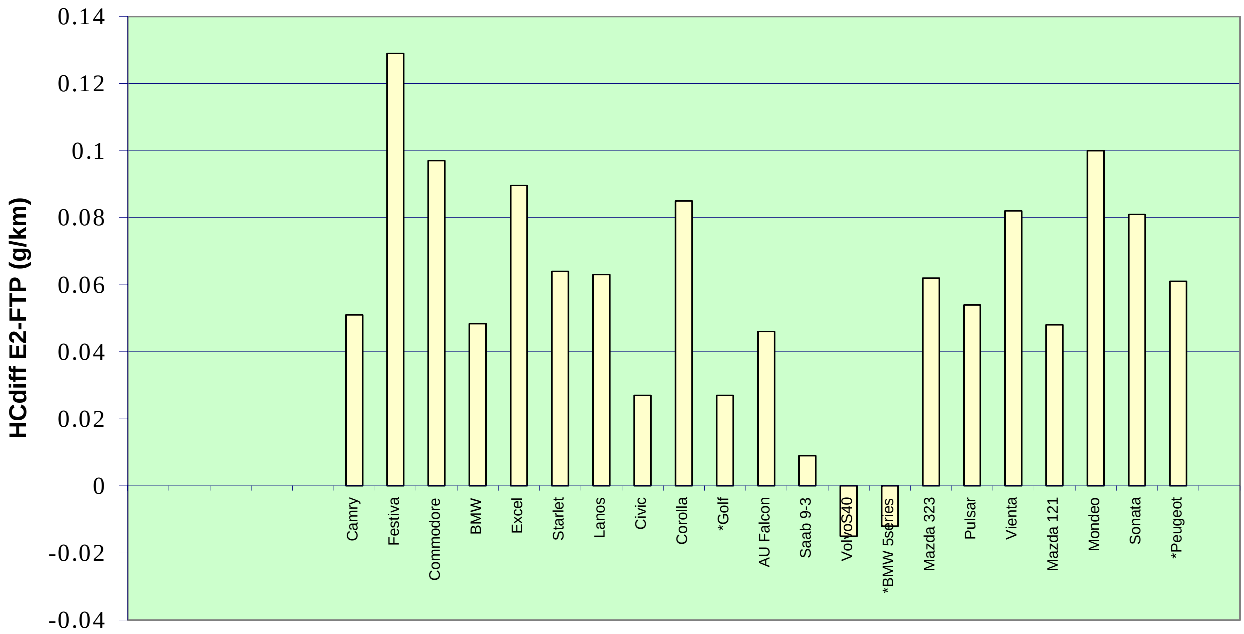
(1) The Australian standard (ADR37/01) requires the emission limits to be met for a period of 5yrs/80,000km and the test method is the same as that used in the US standard.
(4) The *Euro 2* and *Euro 3* standards require the emission limits to be met for a period of 5yrs/80,000km
(5) Limit for *Euro 3* is nominally higher, but Euro 2 test excludes the first forty seconds of testing from sampling, thus making the CO limit much harder to meet
(4) The *Euro 4* standards require the emission limits to be met for a period of 5yrs/100,000km
(5) Ti*er 1* requires the emission limits to be met for a period of 5yrs/80,000km and sets more relaxed limits to be met up until 10yr/160,000km.
(6) *Tier 1* requires total hydrocarbons ≤0.25g/km, with the non-methane hydrocarbons (NMHC) content being ≤0.15g/km.
(7) Complex evaporative emission requirements are being progressively introduced in the US between 1996-99.
(8) Limit relates to non-methane hydrocarbons. (NSW EPA estimates NMHC ≈ 80% of total HC)

The Federal Office of Road Safety is undertaking a comparative emissions test program using current model passenger vehicles from the Australian fleet to investigate the relationships between the different standards. The key findings based on the results to date are:

- On average, current vehicles (built to meet ADR37/01) have emission rates well under the nominated ADR37/01 limit (average 30-40% of the regulated limit). While, on average, these vehicles are also under the *Euro 2* emission limits for CO and the combined HC+NOx limit, they are considerably closer to the limits (average 50% of the CO and 80% of the HC+NOx limits). When the NOx limits are considered separately (ie as ½ of the combined HC+NOx limit), the vehicles exceed the NOx limits by 20% on average. These averages for HC+NOx and NOx exclude the two high volume local models which fail the *Euro 2* NOx limits by a wide margin. These results indicates that further engine/catalyst development would be required for a number of these vehicles to enable them to meet *Euro 2* HC+NOx limits, and also for the manufacturers to be confident that the 80,000km durability requirements will be met for all 3 gases.

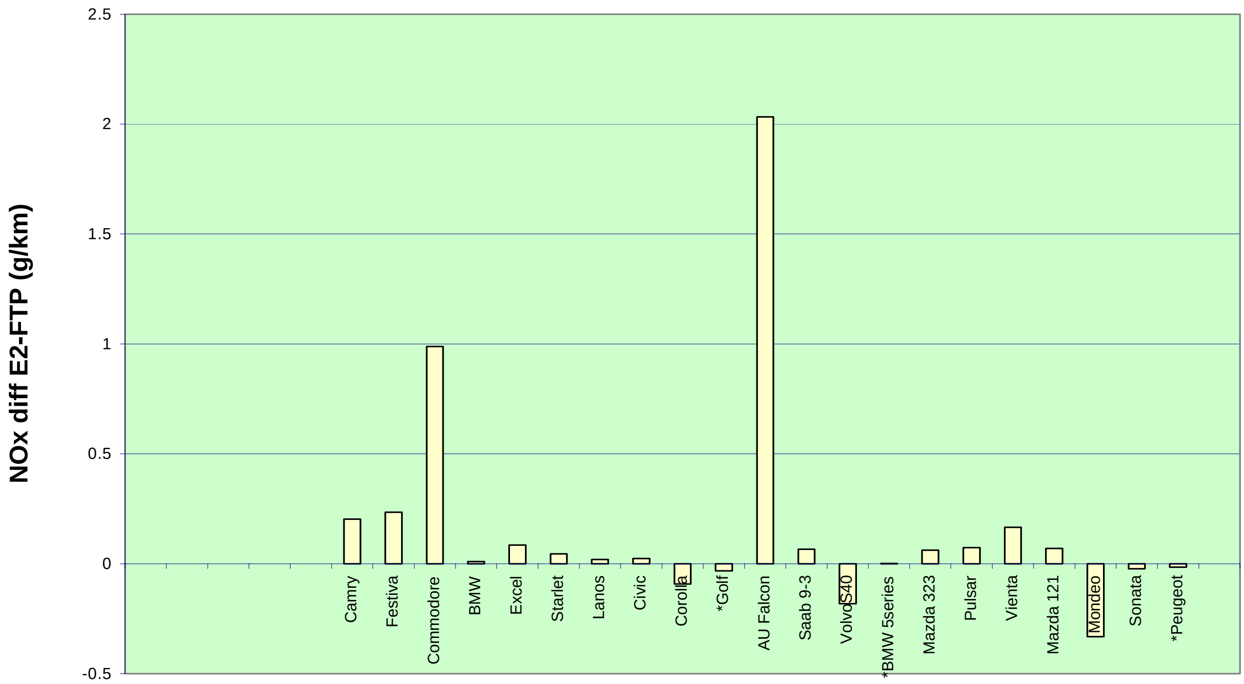
- The *Euro 2* is more demanding on HC for most vehicles (Figure 8).
- The *Euro 2* exhaust emissions test is significantly more demanding on NOx for locally built vehicles using US derived engines (Figure 9).
- The *Euro 3* exhaust emissions test is more demanding on HC and CO emissions (Figures 10 & 11).

Figure 8 **Difference[17] in HC emissions between ADR37/01 Emissions test (US FTP) and the UN ECE test (*Euro 2*) (g/km)**



[17] Positive result indicates *Euro 2* test more demanding than ADR37/01

Figure 9 Difference in NOx Emissions between ADR37/01 Emissions Test (US FTP and the UN ECE Test (*Euro 2*)



A shift to adoption of UN ECE standards in these ADRs would mean that some manufacturers would have to undertake different emission test protocols. This, in itself, is not likely to cause any significant difficulties, as most manufacturers are familiar with the ECE test procedures, and have the facilities to undertake the tests for *Euro 2*. For *Euro 3*, however, the local vehicle manufacturers would have to upgrade emissions testing facilities including variable volume 'sheds' for 24 hour evaporative testing and more sensitive emission analysers.

The FORS emissions test program also compared the performance of vehicles on the *Euro 2* and *Euro 3* versions of the UN ECE exhaust emissions test. Preliminary data indicate that the *Euro 3* test, which omits the 40 second "no sampling" period at the beginning of the *Euro 2* test cycle, is a more demanding test for almost all the tested vehicles on CO and HC emissions (see Figures 10 and 11[18]), and in a number of vehicles, it was also tougher for NOx emissions.

[18] Positive number indicates that *Euro 3* test is more demanding.

Figure 10 **Difference** in CO emissions between *Euro 2* and *Euro 3* versions of the UN ECE Emissions Test g/km

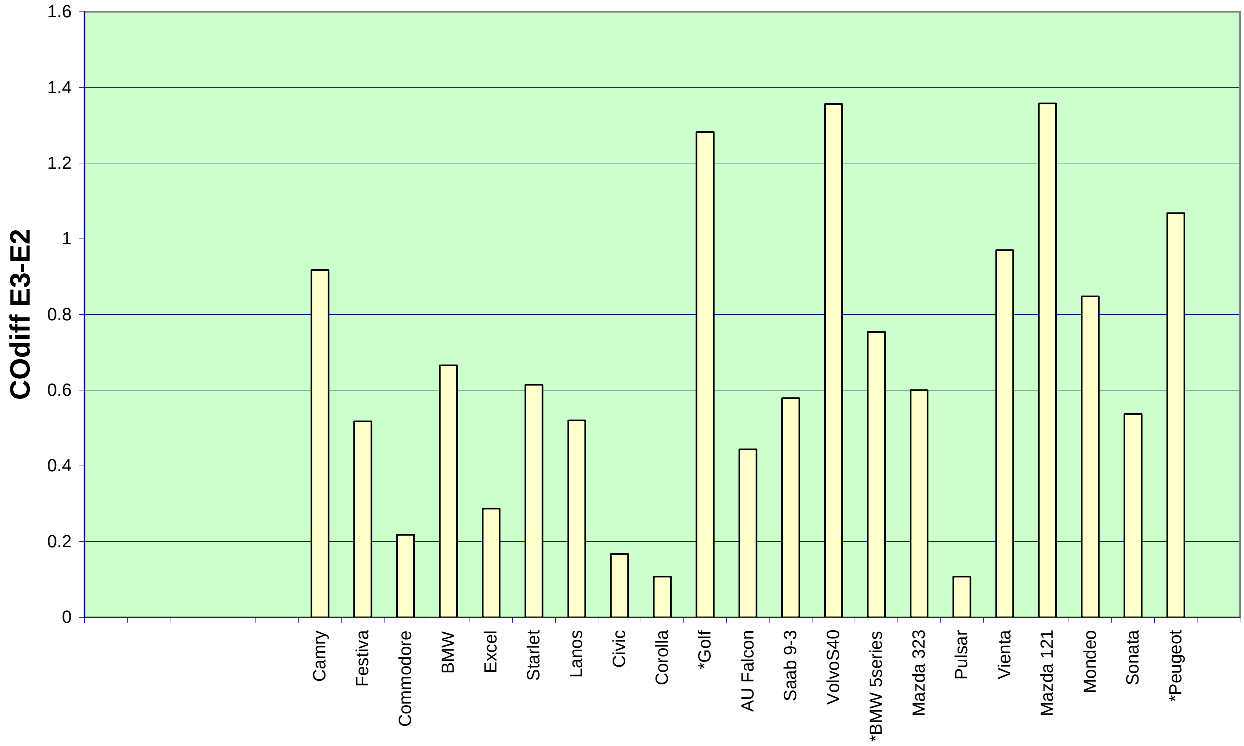
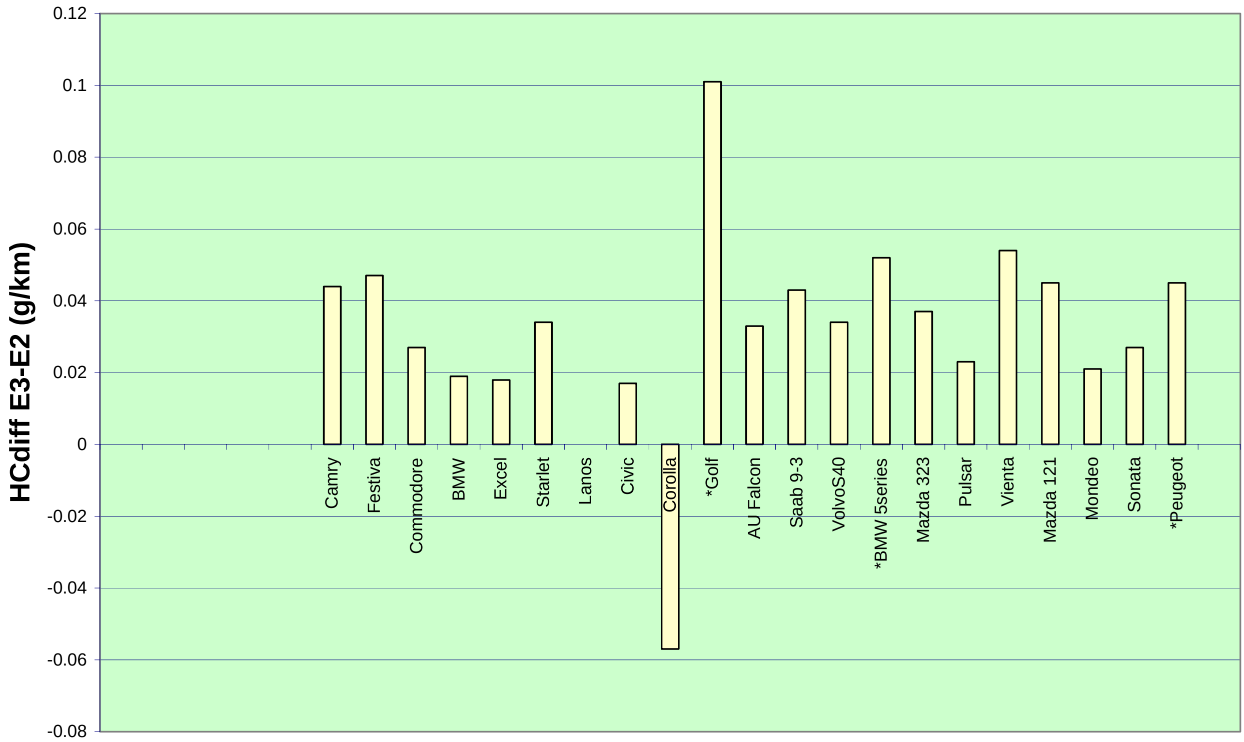


Figure 11 **Difference** in HC emissions between *Euro 2* and *Euro 3* versions of the UN ECE Emissions Test g/km



For diesel vehicles, the ECE, US and Japanese standards all set limits on HC, CO, NO_X, particulates and visible smoke. Limits set by these standards are not consistent, and comparisons between the US, ECE and Japanese standards are difficult, due to differing units of measurement, test methods, and/or vehicle category definitions.

Some measure of comparative stringency can be gained by focussing on "heavy" vehicles (as defined in the relevant standards). For heavy vehicles, current (1996) standards are reasonably consistent on control of NOx emissions, but the Japanese standard is considerably less stringent (by a factor of 6) on particulates (see Table 7). By 2000, the NOx limits will have been tightened across the board. In 2000, the particulate limits will have also been tightened in all three standards, but the Japanese standard will still significantly more lenient (although by a factor of about 2).

Table 7 Comparison of 'Heavy Vehicle' Standards on NO_X and PM Limits

Standard *	Gross Vehicle Mass / Engine Category	Oxides of Nitrogen [g/kWh]			Particulates [g/kWh]		
		ADR70/00	1996	2000	ADR70/00	1996	2000
ECE 49/02 (*Euro 1*,*2*,*3*)	> 85 kW	8.0	7.0	5.0	0.36	0.15	0.10
US EPA (91,94,98)	> 3.9 tonnes	6.7	6.7	5.4	0.33	0.13	0.13
Japan (94,94,97-2000)	> 2.5 tonnes	7.8	6.8	4.5	0.96	0.96	0.25

* For the purposes of this table, a 1:1 relationship has been assumed for all three standards for both NOx and particulates. While caution must be exercised in comparing results from different test methods, the OECD reports that conversion factors for US transient test and the ECE 13-mode test for NOx are 1:1. For particulates the relationship is not so straightforward, however, a Norwegian analysis suggests that a 1:1 correlation is acceptable for values of 0.4-1.0 g/kWh. No correlations were available for the Japanese standard, but it also uses a 13 mode test for "heavy" vehicles (OECD, 1993).

4.2.3 Timing

The timing of introduction for any new ADR needs to consider:

- Current and proposed international standards suitable for adoption;
- The degree of lead time necessary for vehicle manufacturers to supply vehicles to the market which meet the new standards; and,
- Where necessary, for petroleum producers to supply the fuel to ensure satisfactory in-service emissions performance from the vehicles meeting the new standards.

In deciding on which standards to adopt, consideration should also be given as to how much the ADRs should lag behind UN ECE standards. The Prime Minister's statement, *Safeguarding the Future* (Prime Minister 1997), committed the Federal Government to harmonisation with international standards by 2006. By 2006, *Euro 3* emission standards will have been mandated for six years, with *Euro 2* standards having been in place for an additional four years (introduced in 1996). The European Union will also mandate *Euro 4* standards in 2005.

In terms of lead times, the current practice with ADRs is to aim for a minimum lead time of 2 years for manufacturers whenever possible. The Federal Chamber of Automotive Industries (FCAI) has stated that costs for compliance would be reduced if the timing of new standards were timed to coincide with major model changes, which on average were expected in

2002/3. This could be accommodated by requiring new models to comply by the agreed date, and allowing existing models to remain on the market for a year or more after that date. Subsequent advice from the FCAI indicates that major model changes for two locally manufactured passenger vehicle models are now scheduled a year or two later than 2002. However, the remaining local manufacturers and importers are able to accommodate a 2002/3 timeframe. It is feasible that the adoption of new standards would be phased in to allow manufacturers a transition period between phasing out existing models and introducing new models. This has been standard practice in the past, with a 1 year phase in period allowed for ADR70/00 and a two year phase in period for ADR37/01.

Although there are no local manufacturing implications for new diesel engine standards, (as they are all imported) some lead time is required for local suppliers to source suitable engines, and in some cases make modifications to enable the assembled vehicles to operate successfully under Australian climatic conditions. To comply with the *Euro 2* limits in ECE 49/02, it is expected that smaller truck models will require catalysts whilst heavy trucks generally will not (FCAI, 1996). For heavy duty diesel vehicles, industry advice is that European and US supplies can readily supply engines to the market which meet *Euro 3* or equivalent US standards in 2002. As indicated earlier, companies from these source countries dominate this sector of the heavy duty truck and bus market. Japanese diesel vehicles may not be able to readily comply with *Euro 3* by 2002.

Meeting the request for a two year lead time means that any new ADR would not take effect before 2002. With 2002 as the start date, there are a number of options which could be considered, including:

1. Adopt the version of the UN ECE standard which is in place now (*Euro 2*) in 2002; or
2. Adopt the version of the standard which will be in place by 2000 *(Euro 3)* perhaps with a later application date; or
3. A combination of both 1 and 2.

If alternative certification under US standards was recommended for heavy duty vehicles, then the *US94* standards would be the "equivalent " standards to the primary (*Euro 2*) standard. It is recognised that the US introduced even more stringent standards in 1998, but if the *Euro 2* standard is to be adopted, it would be unreasonable to <u>require</u> US suppliers to certify to *US98*, as this would force US suppliers to meet a standard significantly more stringent than the primary ECE standard. However, it would be appropriate to allow certification to *US98* as an alternative to the *US94*. If the *Euro 3* standards were adopted, then compliance with the *US98* standards would be appropriate.

Although the European Union will be mandating *Euro 4* in 2005, this review did not analyse the impact of *Euro 4* as the European Union are still determining the fuel and technological requirements for *Euro 4*. Hence it is difficult to assess the impact of *Euro 4* at this time.

The Australian Institute of Petroleum (AIP) has also stated that the petroleum industry would want 4-5 years lead time to install the necessary capital equipment to provide low sulfur diesel fuel across the market [see fuel discussion in Section 4.2.4].

4.2.4 Role of Fuel Parameters

If emissions standards are to be met in practice, then the relationships between fuel properties and exhaust emissions need to be recognised. Specifically, there is a need to consider the relative impacts of fuel parameters on emissions and the capacity of vehicles to meet the emission limits imposed by a new ADR in the in-service environment. There are different issues associated with petrol and diesel.

A comprehensive Fuel Quality Review has been commissioned by Environment Australia to examine the impacts of changing a broad range of fuel parameters to meet a number of environmental objectives. The results of the Review are expected to be available in early 2000.

The international vehicle manufacturers have also developed a World Wide Fuel Charter (ACEA/AAMA/JAMA/EMA, 1998) which details the manufacturers' preferred fuel standards for vehicles meeting specified emission standards applicable in those markets.

This review focused on the limited number of fuel parameters which are considered to have a direct impact on in-service compliance with the *Euro 2* and US EPA 94 (heavy duty diesel only) standards. These included petrol volatility, octane rating and the sulfur content of diesel. The fuel parameters for *Euro 3* will be considered by the Fuel Quality Review.

4.2.4.1 Petrol

Three grades of commercial petrol are marketed in Australia. Leaded petrol with a minimum research octane number (RON) of 96 currently accounts for approximately 30% of the total petrol market, and demand is steadily falling as the number of pre-1986 vehicles on the road declines. Two unleaded grades are also available; regular unleaded (ULP), with a RON of 91-93, and "premium" unleaded (PULP), with a RON of 95. Regular ULP comprises the majority of the ULP market; PULP accounts for approximately 3% of the total petrol market. This review is only concerned with the unleaded petrol grades.

The parameters of petrol which are important to consider in the context of this review of emission standards, are the octane rating and volatility. A summary of selected parameters of test and commercial fuels in Australia, Europe and the USA is contained in Table 8.

Table 8 Comparison of Selected Parameters of Test and Commercial Petrol Fuels in Australia, Europe and the USA (based on "standard" grade of unleaded petrol)

Fuel Properties	Australia			Europe		USA	
	ADR37 ULP Test Fuel	Commercial ULP		ECE R83 Test Fuel	Commercial ULP Specifications	FTP Test Fuel	Commercial ULP (averages)
		Average	Range				
Research Octane Number (RON)	91-93	91.6	90.5-96.4	95 (min)	95 (min) *	93 (min)	92.2
Volatility (RVP)	60-63.4	72.7 (Nov-Feb)	60-83 (N-F)	56-64	60 ** (summer)	63.4	variable
Benzene (% vol)	-	2.7	0-5	-	5 (1**)	-	1.6
Sulfur (% mass)	0.05 (max)	0.017	0-0.06	0.04 (max)	0.05 (0.015**)	0.1 (max)	0.035
Aromatics (% vol)	35 (max)	30	11.4-47	45 (max)	42 (max) **	35 (max)	?
Olefins (% vol)	10 (max)	10	5.5-20.7	20 (max)	18 (max) **	10 (max)	?

* Some European countries have commercial grades of ULP with lower octane ratings (90-92 RON)

** These limits to apply from 2000.

Sources:

Australian Commercial ULP figures from Australian Product Characteristics Summary 1997 – Unleaded Petrol – AIP

US Market figures for min/max from ASTM D-4814 and Motor Vehicle Emission regulations and fuel specifications – 1992 update, Concawe publication.

US Average figures from Motor Gasolines, Winter 1991-1992 & Summer 1992 NIPER publication.

EEC Market figures for min/max from Motor Vehicle Emission regulations and fuel specifications – 1997 update, Concawe publication

Petrol Volatility

Petrol volatility is an indication of how fast a fuel evaporates. The fuel that evaporates from the fuel tank and system of vehicles can be discharged into the air. The discharged fuel vapours are known as evaporative emissions, and contribute to the development of photochemical smog. A number of vehicle technologies are used to limit the discharge of the fuel vapours, the principal technique being the use of a carbon canister.

As indicated in Table 8, the volatility of commercial grades of ULP in Australia are considerably higher than that of the test fuel on which the vehicle is certified under ADR37/01. Recent research conducted in Australia (FORS, 1996) indicated that many vehicles are not meeting evaporative emission standards once they are in-service. Further investigation in the Petrol Volatility Report (FORS/EA, 1997) confirmed the linkage between fuel volatility and evaporative emissions, and demonstrated that reductions in fuel volatility can significantly reduce evaporative emissions from vehicles. This later research also demonstrated that replacement of carbon canisters on vehicles can also reduce evaporative emissions, but the longevity of this benefit was uncertain.

It needs to be recognised that the issue of fuel volatility affects the in-service compliance of vehicles with the evaporative emission standards in ADR37/01 and earlier versions of the standard, so it is not an issue associated with the adoption of new standards, *per se.* Evaporative emission standards are likely to continue to be exceeded in-service with current and future standards, unless fuel volatility is reduced.

Octane Rating

Octane is a measure of the ability of a fuel to resist detonation (engine knock), with a higher number indicating greater resistance. In essence if the octane demand of a vehicle engine exceeds that of the fuel it is using, the vehicle will not be operating at optimum efficiency.

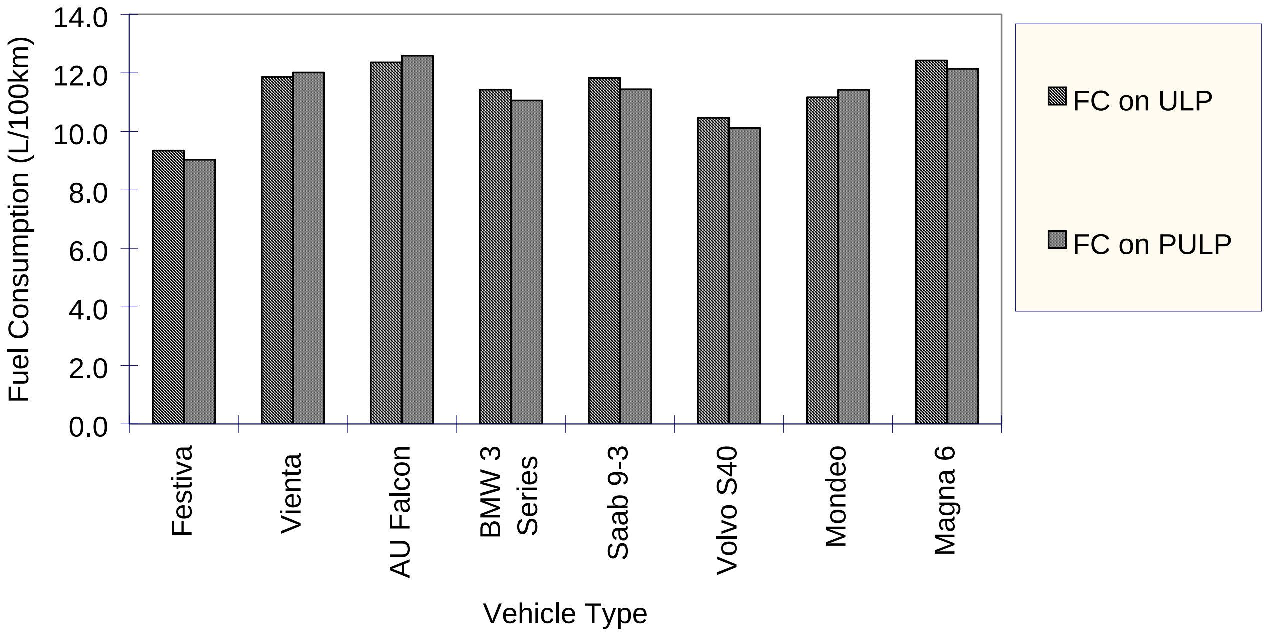
As indicated in Table 8, the average octane rating of Australian ULP is around 91 RON, in line with the ADR37/01 test fuel. In contrast, the *Euro 2* standards specify a test fuel of minimum 95 RON, with most (but not all) regular ULP in Europe also being 95 RON. Some countries in Europe have ULP with octane ratings similar to that of Australian ULP.

The FCAI have argued that if the revision of ADR 37/01 results in the adoption of the UN ECE standard, all new models certified to the new standard will need 95 RON fuel to operate efficiently (FCAI, 1999b). There was no evidence available to the review to demonstrate that a vehicle certified to UN ECE R83 (*Euro 2*) on 95 RON test fuel would have worse emissions when that vehicle is operated on a commercial fuel of less than 95 RON. This view is supported by the draft Report commissioned by Environment Australia to investigate measures for reducing vehicle consumption (ACIL, 1999) which states that no change would be required to petrol for the adoption of *Euro 2.* However, as it is likely that high compression engines will be used to comply with *Euro 3*, 95 RON may then be required for many *Euro 3* vehicles. The Federal Government is seeking to expand the supply of high octane (95 RON) petrol, as it considers it will encourage the vehicle industry to supply later technology engines which deliver improved fuel economy on 95 RON fuel (ESMVI, 1997).

Clearly there are imported vehicles on the Australian market now which are designed and tested to *Euro 2* specifications and which run satisfactorily on ULP but it is not clear whether this operation compromises their performance, fuel consumption or emission levels. Advice from one manufacturer stated that engine recalibration for driveability on 91 RON ULP, while still meeting the *Euro 2* standards on 95RON, will sacrifice optimum emissions performance, fuel consumption and engine power (Toyota, 1999).

Preliminary results from the comparative emissions test program being managed by FORS, indicate that, based on a small sample of 8 vehicles, emission rates and fuel consumption for most vehicles under the *Euro 2* test were not much different when the vehicles were tested on regular unleaded petrol (ULP - 91RON) and high octane petrol (PULP – 95RON). Emissions differences were particularly small in the 4 European vehicles which met the *Euro 2* emission limits and are presumably designed to meet the UN ECE cycle. One locally produced vehicle with very high NOx levels did show a marked difference in NOx emissions when operated on the 2 fuels. The fuel consumption results are summarised in Figure 12.

Figure 12 Fuel Consumption under UN ECE *Euro 2* Test Conducted on ULP and PULP



The vehicle industry in many countries is being required to concurrently meet both emissions and fuel consumption objectives. The review was not presented with any evidence to establish that adoption of *Euro 2* and *Euro 3* emission standards will compromise efforts to meet the Government's greenhouse gas reduction objectives for the vehicle sector.

4.2.4.2 Diesel

In terms of the key NOx and PM emissions, diesel fuel properties appear to have little bearing on NOx emissions, but some properties have significant effects on PM emissions.

Fuel Sulfur

Sulfur in diesel has been identified as a parameter closely linked to particulate emissions. PM emissions are a combination of carbon particles [the largest portion], hydrocarbons [measured as the soluble organic fraction] and sulfate particles (Bagley *et al*, 1996). The contribution of diesel fuel sulfur content to exhaust particulate emissions has been well established (McCarthy *et al*, 1992; Bertoli *et al*, 1993, OECD, 1993), with a general linear relationship between fuel sulfur levels and regulated emissions (EPEFE, 1995). Lower sulfur content in the fuel directly reduces sulfate particulate emissions and emissions of sulfur dioxide, which is converted to sulfate particulates in the atmosphere (Bagley *et al*, 1996; Den Ouden *et al*, 1994; Opris *et al* 1993 - see Table 9).

Table 9 Summary of effects of sulfur content on NO_X, PM, SO_4 and HC emissions

Fuel Property Action	Heavy Duty Vehicles		
	Effect on NO_X	Effect on Total PM *	Effect on SO_4 Proportion of PM
Reduce Sulfur (0.29∏0.01wt%) @ 25% load	no significant effect	⇓ 17%	⇓ 98%
Reduce Sulfur (0.29∏0.01wt%) @ 75% load	no significant effect	⇓ 24%	⇓ 96%

* PM from diesel engined vehicles is comprised of carbon [C], a soluble organic fraction [SOF] and sulfate [SO_4].

Source: Opris *et al*, 1993

Testing indicates that the relative impact on PM emissions from reductions in the sulfur content of the fuel can vary. Factors that contribute to this variation include vehicle/engine type, the emissions test cycle, the vehicle/engine technology used to meet emission standards and the level of reduction in the sulfur content of the fuel.

The FCAI has indicated that many light duty diesel vehicles [<3.5 tonnes GVM] will require oxidation catalysts to comply with *Euro 2* type standards. This would also apply to *Euro 3* type standards. In addition the FCAI has stated that compliance with *Euro 2* standards will not be possible unless the sulfur content of commercial diesel fuel is reduced to a maximum of 0.05% (FCAI, 1999b). In light of this, the impact of sulfur content on catalyst operation also needs to be examined, particularly as light duty vehicles do most of their work in urban areas.

Oxidation catalysts lower HC, CO and PM emissions, but have no impact on NOx emissions. They have little impact on the carbonaceous component of PM emissions, but typically remove around 30% of total PM emissions through oxidation of a large proportion of the soluble organic fraction (Accurex, 1993). The sulfur content of the fuel is widely reported to have an impact on the effective operation of oxidation catalysts used on some diesel engined vehicles (OECD, 1993; Accurex, 1993; California Air Resources Board, 1994; Manufacturers of Emission Controls Association, 1996; ACEA/EC/Europia, 1995).

The conversion of sulfur in the catalyst reduces the availability of active sites on the catalyst surface. The catalyst does not appear to suffer permanent damage, and will largely recover after a period of operation on low sulfur fuel and exposure to high operating temperatures (Webster, 1997).

There is also considerable research to demonstrate that a high sulfur content in the fuel can also lead to the formation of sulfates in the converter which are then emitted as additional PM (California Air Resources Board, 1994; Hosoya and Shimoda, 1996; Ketcher and Horrocks, 1990; Ketcher and Morris, 1991; Brown, 1997).

To enable compliance with tighter PM emission standards for diesel vehicles, tighter limits on the maximum sulfur content of commercial diesel fuel have been, or are being, introduced in many countries around the world (see Table 10). Even though the sulfate proportion of the total PM emission is relatively small (around 10%), it has become more significant as the PM emission standards (which are all based on the total mass of the PM), have become more stringent. So while substantial reductions in PM emissions can be obtained without reducing sulfur levels down to the 0.05% mark, compliance with *Euro 2* type standards is not possible at higher levels, because of the relatively greater proportion of sulfates in the total mass of PM emission. Even lower sulfur limits 0.035% and 0.005% have been set in parallel with *Euro 3* and *Euro 4* standards.

Table 10 Current and Future Regulated Maximum Sulfur Limits on Diesel Fuel in Various Countries

Country/ Region	Situation at the end of 1997	Future Situation	
	Maximum Sulfur Limit	Maximum Sulfur Limit	Proposed Year of Introduction
EU	0.05%	0.035% 0.005%	2000 2005
US	0.05%	U	U
Canada	0.05%	U	U
Japan	0.05%	U	U
Hong Kong	0.05%	0.035%	2000
Singapore	0.05%	U	U
Thailand	0.2%	0.05%	1999
Australia	0.5%*	U	U

"U" means unknown;
* Sulfur content is not regulated by law in Australia, however 0.5% is the limit in the Australian Standard AS 3570, Automotive Diesel Fuel, which the industry meets on a voluntary basis.
Source: Concawe (1995), European Commission (1996b), Drummond (1997)

The lowering of the diesel fuel sulfur content to 0.05% in the US was timed to occur in conjunction with the *US94* emission standards. Similarly, the 0.05% limit in the EU was aligned with the introduction of the *Euro 2* emission standards (Concawe, 1995). In both the EU and US, all the research and development work, and subsequent certification testing of vehicles to the current standards, is conducted with low (0.05%) sulfur test fuels, in the expectation that the commercial fuel supplied will also have a low sulfur content. Apart from contributing to effective operation of catalysts and reducing PM emissions, the European move to an even lower maximum sulfur content of 0.035% by 2000 and 0.005% by 2005, is to enable tighter emission standards to be met by the use of next generation "de-NOx" catalysts, which are very sensitive to sulfur (Drummond, 1997; Council of the EU, 1998)

The average sulfur content of Australian diesel is currently 0.13% with a range of 0.0-0.5% (AIP, 1999). This average is very much dependent on the crude oil feedstock and refinery configuration.

Other Diesel Fuel Properties
Research on fuel property effects indicates that reduced fuel density, reduced polyaromatic content, increased cetane number and decreased back-end distillation temperature have beneficial but fairly weak effects in reducing emissions relative to improved engine design (EPEFE, 1995; McCarthy *et al*, 1992). Reduced fuel density is the only one of these parameters producing a significant reduction in particulates but only for light duty vehicles.

4.2.4.3 Fuels Issues Summary

In considering the findings of EPEFE (1995) and other work, the conclusions regarding the relative and absolute impacts of fuel parameters on emissions are as follows:

- Both fuel parameters and engine technologies are important determinants of emission levels;
- Relationships between fuel properties, engine technologies and emissions are complex, and, in the case of diesel fuel, changing one fuel property may have different effects on emissions from light and heavy duty vehicles;

- The fuel requirements for in-service delivery of *Euro 3* standards are likely to be more stringent than that for *Euro 2*;
- In the case of petrol:
  - reducing commercial fuel volatility would improve in-service compliance with evaporative emission standards;
  - There is no objective data to support an increase in octane rating of commercial fuel to ensure *Euro 2* standards are met in practice, but an increase in octane may be necessary for *Euro 3*;
- In the case of diesel:
  - Reducing the sulfur content, and lowering fuel density, appear to be the only measures which have a significant impact on PM emissions;
  - Fuel properties appear to have no significant impact on NOx emissions;
  - Reducing fuel sulfur content is the only change to fuel properties that can be made largely independently of other properties, and delivers significant reductions in particulate emissions. High sulfur levels also impair effective catalyst operation, but do not appear to cause permanent damage to catalysts. Current limits on maximum sulfur content in Australian diesel fuels are set at levels ten times those of the US and Europe; and
  - *Euro 2* diesel vehicles using catalysts are unlikely to meet the standards in practice unless the sulfur content is reduced to 0.05%.

4.3 TIGHTER CONTROLS ON IN-SERVICE EMISSION STANDARDS (OPTION 3)

It is recognised that achieving reductions in total emissions requires a mix of strategies including motor vehicle standards and in-service programs. For example the New South Wales, Victorian and Queensland air quality strategies recommend action on new vehicles, and in service measures (NSW EPA, 1998; QDOE, 1998; Vic EPA, 1997).

The National In-service Emissions Study (NISE Study – FORS, 1996) into in-service emissions from passenger cars demonstrated that considerable exhaust emission benefits could be obtained from regular tuning and maintenance. For cars built to ADR37/00 standards, the average reductions in emissions from tuning ranged from 9% for NOx, 21% for HC and 24% for CO. State and Territory Governments operate a range of in-service vehicle emission programs, which vary widely in their nature and level of enforcement. To date only the NSW Government has made a commitment to a regular inspection and maintenance program based on emissions testing.

The NISE Study also indicated that evaporative emissions from vehicles are on average well above the limits mandated in ADR37. The subsequent Petrol Volatility Project (FORS/EA, 1997) examined this in more detail and concluded that, from a vehicle perspective, considerable reductions in evaporative emissions could be obtained by replacing carbon canisters, although this benefit is dependent on the durability of the canisters. A program of canister replacement would be difficult to administer, and is only likely to work on a mandatory basis.

Currently, the only in-service controls on diesel vehicles are for visible smoke. There appears to be considerable technical and cost impediments to wider in-service controls on diesel vehicles. The current in-service diesel emissions studies being managed by the NEPC aim to provide some information on the emissions performance of the Australian diesel vehicle fleet, the potential benefits of maintenance, and the feasibility of establishing workable, objective in-service emission tests for diesel vehicles. Results are not expected to be available from these studies until late 1999.

The Industry Commission stated in its Automotive Industry Report (1997) that a mandatory in-service inspection scheme would be resource intensive, and if the Commonwealth Government was to administer such a scheme, it might require legislative changes as this policy area is State and Territory Government responsibility.

Clearly strategies to ensure good in-service maintenance of the vehicle fleet can deliver significant emissions benefits. However, given the costs involved to administer, this option has not been pursued further.

4.4 WIDER USE OF ALTERNATIVE FUELS (OPTION 4)

There is a limited capacity to run more of the fleet which currently use petrol and diesel fuel on alternative fuels. The most significant options are liquefied petroleum gas (LPG) and natural gas (NG).

LPG is already widely used in urban areas, particularly by high mileage vehicles such as taxis, and its application to date is mainly in petrol engined vehicles. Recent testing on modern petrol engined vehicles, and equivalent vehicles running on LPG, concluded that the LPG fuelled vehicles do not offer significant environmental benefits over the petrol engined vehicles (FORS, 1997). Recent work in the UK and Europe indicates however, that heavy duty vehicles designed to run on LPG can have a very good emissions performance compared to diesel (Le Cornu and Day, 1998). The scope of LPG substitution is also claimed to be limited by its supply, with replacement of 7-8% of petrol use representing the maximum substitution (BTCE, 1994), however the current view is that LPG reserves in Australia are very substantial (Commonwealth of Australia, 1996; Le Cornu and Day, 1998).

NG has very limited use at the moment, and its greatest potential would appear to be as a diesel substitute in commercial vehicles operating out of a common refuelling point. The use of NG is becoming more common in urban bus fleets (in Perth, Adelaide, Sydney and Brisbane for example). As a substitute for diesel fuel, it offers significant benefits in reductions of PM emissions over diesel engines, but unless engine settings and emissions controls are adequate, NOx emissions from NG fuelled vehicles may be higher (BTCE, 1994). The very limited nature of the NG vehicle refuelling network is a major barrier to wider adoption. The bulkiness of NG fuel tanks and high capital cost for conversions can also limit its appeal to transport operators.

There are currently no emission standards in Australia for vehicles powered by LPG or NG. In principle, all vehicles within the scope of the ADRs should be required to meet the same emission standards, regardless of the fuel they are designed to operate on.

ECE Regulations 83/03 and 49/02 are currently undergoing amendments to incorporate emission standards for vehicles powered by NG and LPG. The limits are identical to those for equivalent vehicles running on petrol or diesel fuel. Given that these ECE Regulations will be referenced in any revised emissions ADRs it would seem appropriate to also adopt the requirements for NG and LPG engines. If the *US94* standard was adopted as an alternative, then its requirements for NG and LPG engines should also be adopted.

The inclusion of standards for LPG and NG vehicles would require changes to the scope of the ADRs, as they are presently written as petrol or diesel vehicle emission standards only.

The Federal Government currently exempts both LPG and NG from fuel excise as a means of encouraging the development of both as alternative fuels. However, there is no policy to specifically encourage their use over other fuels, but rather to allow them to compete in the transport energy market on their own merits. The Government is not able to mandate the use of specific fuels, as it would be contrary to competition principles. As indicated above, the alternative fuels network has a limited capacity to supply the fleet, and thus the use of alternative fuels, in itself, can not deliver significant reductions in total emissions from the vehicle fleet.

4.5 LIMITING VEHICLE TRAVEL (OPTION 5)

In order to address transport related urban air pollution, there is a ultimately a need to deal with the underlying issue of increasing vehicle travel, particularly as the emission reductions achievable from technological improvements to vehicles and fuels become progressively smaller. Mechanisms to limit vehicle use include fiscal policies (to reflect true costs of transport), transport planning and traffic management (Auto-Oil, 1995). While these mechanisms will have an important place in stabilising and reducing transport air emissions, they are beyond the scope of this review.

4.6 TAXATION STRATEGIES (OPTION 6)

The European Commission (1991) and others (Royal Commission on Environmental Pollution, 1994; Finemore, 1997) have encouraged Governments to adjust the sales tax and/or registration regimes to encourage both the scrapping of older vehicles and the purchase of newer vehicles which meet emissions standards ahead of the regulatory requirements.

An incentive based approach could be used to directly influence consumer demand for low emissions vehicles and indirectly, producer/supplier decision making. This could be achieved by lowering the purchase price of these vehicles and imposing an emissions tax on high emission vehicles. The purchase price for low emission vehicles may be lowered:

- Indirectly, through taxation and/or tariff exemptions or concessions; or
- More directly, through a rebate or subsidy to the consumer under the tax system via a direct subsidy program.

It is likely that these avenues impose a high cost on Government (from loss of revenue) for a relatively small impact on total emissions from the fleet.

Early retirement schemes for passenger vehicles are in place in some countries, and are being examined in Australia, but it is not clear whether such schemes deliver clear environmental benefits.

The taxing of emissions through a taxation regime that would allow consumers to choose between vehicles based on emissions performance, would provide a clear message to the consumer about the environmental costs associated with emissions. Low emitting vehicles would impose a lower tax, and hence be more attractive. However, taxes on emissions should be levied on the volume of pollutants from each motor vehicle. Hence, consumers should be taxed according to their level of usage and not only the design characteristics of the vehicle.

The Industry Commission stated in its Automotive Industry Report (1997) concluded that although the technology exists for measuring emissions instantaneously by analysing exhaust gases as the vehicle passes a monitoring point, there are technical limitations with this method. The level of emission varies significantly depending on the way the vehicle is being driven. Hence this type of monitoring provides an unreliable indication of the emissions performance of the vehicle.

4.7 COMPARATIVE ASSESSMENT

The focus of this review is on the effectiveness of the current new vehicle emission standards in contributing to improvements in air quality, and whether changes to those standards are warranted to ensure continuing improvements in urban air quality in Australia. This approach has been addressed in Option 2, and the following impact analysis in Section 5 examines a number of potential approaches under Option 2 in more detail.

It is widely recognised, both in Australia (eg NSW EPA 1998; QDOE 1998; Vic EPA 1997) and overseas (eg EPEFE 1995) that controlling air pollution will require a mix of strategies, and the options identified in this report are frequently identified as some of the desirable measures. However, in all cases, tighter new vehicle standards are seen as the critical measure which underpins the suite of vehicle based strategies. As an example, the South East Queensland Regional Air Quality Strategy (QDOE, 1998) states that "the most comprehensive and effective measure to reduce motor vehicle emissions is the adoption of new, tighter Australian Design Rules for motor vehicle emissions." As stated earlier, the Industry Commission concluded that regulations such as emission standards continue to have an important role to play in addressing environmental problems, as there are substantial problems using market mechanisms to address impacts of vehicle use (Industry Commission, 1997).

New vehicle standards are considered an essential element of any strategy to address the contribution of vehicle emissions to air pollution. The other options identified above are considered *complementary*, rather than *alternative*, strategies to the introduction of new vehicle emission standards. For this reason, this Regulatory Impact Statement does not attempt to compare the relative benefits of the other options with Option 2 (except to use Option 1 as a "base case" in assessing the relative merits of the 3 "sub-options" assessed under Option 2). This is not to say that these other options do not have merit, but it is outside the scope of this report to consider them in more detail.

5. IMPACT ANALYSIS/COSTS AND BENEFITS

The only realistic option to deliver significant reductions in motor vehicle emissions, and meet the Government's objectives as outlined in the Prime Minister's Statement on Climate Change, is to revise the current emission standards (Option 2).

The impact on emissions of adopting UN ECE standards, and the relative costs and benefits of those standards have been assessed as far as practicable, noting that projections are based on limited data, and costing of items such as health effects is, at best, a very difficult exercise.

Separate analyses have been undertaken on the compliance of petrol and diesel engined vehicles with UN ECE *Euro 2* and *Euro 3* standards. Three options have been considered:

Option 2A: Adopt *Euro 2* [19] in 2002;
Option 2B: Adopt *Euro 2* in 2002, followed by *Euro 3* in 2005; and
Option 2C: Adopt *Euro 3* in 2002.

The detail of each option is outlined in Attachment B.

Whilst the principal elements of each option are the adoption of *Euro 2* or *Euro 3* standards, each option also includes:

- US heavy duty vehicle standards adopted as an alternative for heavy duty vehicles (petrol and diesel above 3.5 tonnes);
- Smoke standards in ECE 24/03 applied to diesels, with the appropriate US smoke standards accepted as an alternative for heavy duty vehicles over 3.5 tonnes;
- Emission standards applied to all vehicles operating on all fuels nominated – currently petrol, diesel, LPG and NG; and
- Later versions of the nominated standards accepted, provided they are demonstrated to be no less stringent than the version specified in the ADR.

These additional aspects are not specifically addressed in the cost benefit or cost effective analyses, as they are unlikely to have any significant impact on the conclusions.

5.1 IDENTIFICATION OF AFFECTED PARTIES

The main parties affected by the introduction of new standards are the vehicle manufacturers/importers, and the fuel industry who will incur costs and the general public who will benefit from reduced health costs and other related benefits associated with air pollution. The costs incurred by the vehicle and fuel industries are discussed in detail in sections 5.3.1 and 5.3.2. The health benefits are outlined in section 5.4.1. The impact on vehicle manufacturers, the fuel industry and consumers is also outlined in the summary of each option in Section 7.

Apart from the detailed impact analysis elsewhere (as indicated above) the impacts of introducing internationally harmonised vehicle standards at the *Euro 2* and *Euro 3* level are summarised below.

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[19] As reflected in the UN ECE Regulations 83 and 49.

Vehicle Manufacturers and Importers
The adoption of international standards will facilitate trade in vehicles as vehicles manufactured for world markets will be readily acceptable in Australia and those in Australia will be acceptable to a greater number of overseas markets. In addition, as it is proposed that later standards be accepted as alternatives, there will be no delays, or additional costs, in accepting vehicles complying with more stringent international standards. Harmonising with international standards provides for ready acceptance of certificates of conformance issued by international regulatory authorities. This lessens the regulatory burden on manufacturers by dispensing with the need for expensive testing programs. This will also streamline certification procedures.

Local car manufacturers will have to undertake certification test protocols which are compatible with international requirements. For *Euro 3* standards local car manufacturers will incur a cost to upgrade emission testing facilities.

Manufacturers and importers will incur investment costs to adopt the technology to meet more stringent standards and an increase in production costs.

Fuel Industry
The oil companies will incur some costs in desulfurisation capacities to reduce diesel sulfur content for *Euro 2*. For *Euro 3*, there will be significant investment costs to change additional fuel parameters (The Fuel Quality Review will assess such costs). The cost to the fuel industry may be reduced if the demand for low sulfur fuels was phased in (eg by initially requiring low sulfur diesel fuel in urban areas).

Component Manufacturers
Component manufacturers will be affected in much the same way as vehicle manufacturers and importers. A move to harmonisation with international standards means that products manufactured for world markets will be readily acceptable in Australia, and that local manufacturers will be able to produce products that are acceptable in both the local and overseas markets. There will be no delays in incorporating components and systems complying with later (more stringent) international standards.

Small Business
<u>The automotive service industry</u>
The adoption of *Euro 2* standards will have a minimal impact on the automotive service industry. The adoption of *Euro 3* standards incorporates on board diagnostics, which will require training of staff in servicing such equipment and the provision of the tools to service the equipment.

<u>Vehicle retailers</u>
It is expected that there will be minimal impact on vehicle retailers.

<u>Fuel Retailers</u>
Some of the small fuel retailers, particularly in rural and remote areas have limited or no storage and dispensing facilities for PULP. This could potentially cause some difficulties if PULP is the standard fuel (this is not expected until *Euro 3* introduction). However, it is anticipated that the storage and dispensing facilities used for leaded petrol may be replaced with PULP when leaded petrol is no longer provided to the market.

<u>Businesses with high vehicle input costs</u>
Section 5.3.1 indicates new standards will lead to increased production costs, however, the FCAI indicates that the majority of those production costs are likely to be absorbed by the vehicle manufacturer, particularly for passenger vehicles. The Bus Industry Confederation

indicates that whilst there is currently a cost difference between the *Euro 1*and *Euro 2* engine, it is envisaged that the cost difference will fall to zero during 1999 as the *Euro 2* engines will be produced in higher numbers. The cost of *Euro 3* engines will also decline as volumes increase (BIC, 1999).

Submissions to the review also indicate that some companies choose to provide latest standard vehicles to the market and have not suffered in market share.

Consumers
One of the primary impacts for consumer is improved air quality and hence reduction in health costs. In addition. harmonisation with international standards will allow consumers to have access to safer, less polluting vehicles sooner than would otherwise be the case.

It is unclear as to whether new emission standards would increase the retail costs of those vehicles currently not produced to *Euro 2* standards. Industry advice is that due to the competitive nature and price sensitivity, particularly of the passenger car market, increases in production costs may be substantially or totally absorbed by the manufacturers. Despite this, the cost benefit analysis includes estimates of costs for all vehicles under the three option. If there are increases in retail prices these will borne equally by urban and rural residents, even though the urban residents will receive the benefits of reduced emissions, air quality and hence a reduction in health costs. However, anticipated lower government outlays on health will indirectly benefit consumers in rural areas.

In relation to fuel costs, the petroleum industry will incur additional capital investment and maintenance costs for desulfurisation technology for the production of low sulfur diesel. It is unclear what proportion of these costs would be passed on to the consumer.

Regulatory Authorities
Harmonisation and the acceptance of later, more stringent international standards will allow FORS to accept certification information from other authorities which is based on the same set of regulations, thus reducing administrative load. There will be no impact on State and Territory registration authorities

Regions – Industry Viability
All sectors in both the vehicle and refining industries will be competing under the same circumstances. While some companies may be in a better position than others to meet tighter vehicle standards and fuel specifications, all parties (domestic and overseas) will be asked to meet the same standards. In the refining industry in particular, there are suggestions (Caltex, 1999a) that further rationalisation of refineries in Australia may be necessary. However, this is a commercial decision for the individual companies concerned and the tighter standards proposed in this review, are not, in themselves, likely to affect the stability of any particular operation. Such rationalisation would occur in absence of this review.

Emission standards apply the same solution to different levels of atmospheric pollution in different locations. Hence, any general tightening of emission standards impinges on vehicle users in all areas for different gains in terms of reduced local pollution (Industry Commission 1997). For this reason residents of non-urban areas may argue that it is not appropriate for emission standards to be based on the level of local pollution of one particular city, where local pollution may be relatively high. However, it is simply not financially feasible in Australia's small market for vehicle manufacturers to supply vehicles in Australia to a range of standards based on regional air quality needs. It would also be virtually impossible for regulatory authorities to prevent the use and resale of "non-urban" standard vehicles in urban areas. In addition, as global rationalisation of vehicle models increases, the development of a single global emission standard becomes more likely. Vehicles made for export have to meet international standards in order to be sold in the greatest number of markets.

5.2 IMPACT ON EMISSIONS

In order to assess the impact on total emissions over the medium term, some cost effectiveness and cost benefit analyses have been undertaken. The following results are derived from the cost effectiveness study undertaken by the University of Melbourne and an indicative cost benefit analysis undertaken by the New South Wales Environment Protection Authority (NSW EPA). The full text of these reports is at Attachment C and Attachment D respectively. The University of Melbourne modelling covered passenger cars only, while the cost benefit work undertaken by the NSW EPA covered all vehicles except light commercial vehicles (LCVs). Table 11 indicates the predicted reductions in emissions from the 3 options outlined at the beginning of this Section 5. The wide range in projected emissions is due, in part, to differing assumptions in the modelling (particularly the deterioration rates applied) and also arises because the two models use different timelines (2015; 2021).

Table 11 Percentage Reductions in Emissions from Cars and Heavy Duty Vehicles (>3.5 tonnes GVM) (Current standards used as the base, rounded to the nearest 5%)

	Option 2A ***Euro 2* in 2002** **%**	***Option 2B*** ***Euro 2 in 2002 and Euro 3 in 2005*** ***%***	**Option 2C** ***Euro 3* in 2002** **%**
NOx	15-50	60	30-80
HC	0-5	25-45	25-55
CO	+20-20	25-50	50-70
PM10	5	15	17

Sources: University of Melbourne 1999 (Attachment C) and NSW EPA (Attachment D)

The table indicates that the introduction (in 2002) of the UN ECE *Euro 2* standards reduces total fleet emissions of NOx and PM, but has little impact on HC emissions, and may lead to increased CO emissions (because of the omission of cold start sampling in the *Euro 2* test cycle). The introduction of *Euro 3* standards would lead to further reductions in all emissions.

As LCVs were not covered by the other analyses, the Bureau of Transport Economics (BTE) modelled changes in NOx and PM emissions from diesel LCVs, using data supplied by FORS. The modelling indicates that in the absence of any new standards to replace ADR70/00, emissions of NOx (particularly), and PM would increase over the 2000-2015 period (see Figures 13-14). This analysis indicates that *Euro 2* would deliver significant reductions in both NOx and PM emissions from diesel LCVs, with *Euro 3* increasing the magnitude of the benefit. Early introduction of *Euro 3* appears to offer only a small additional reduction in emissions in 2015 over the staged approach (option 2B). Because of the limitations in data on diesel vehicles on the Australian market (particularly prior to 1995,when ADR70/00 was introduced) Figures 13-14 should be considered as indicative of likely trends only.

Figure 13 Estimates of NOx Emissions from LCVs under "No Change" (ADR70/00) and 3 New Standard Options

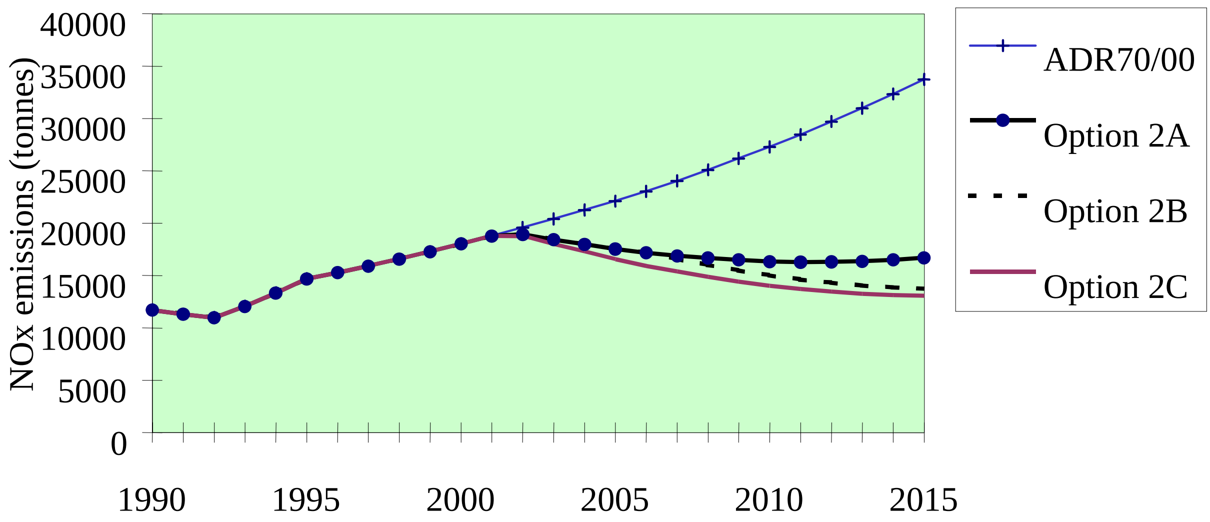
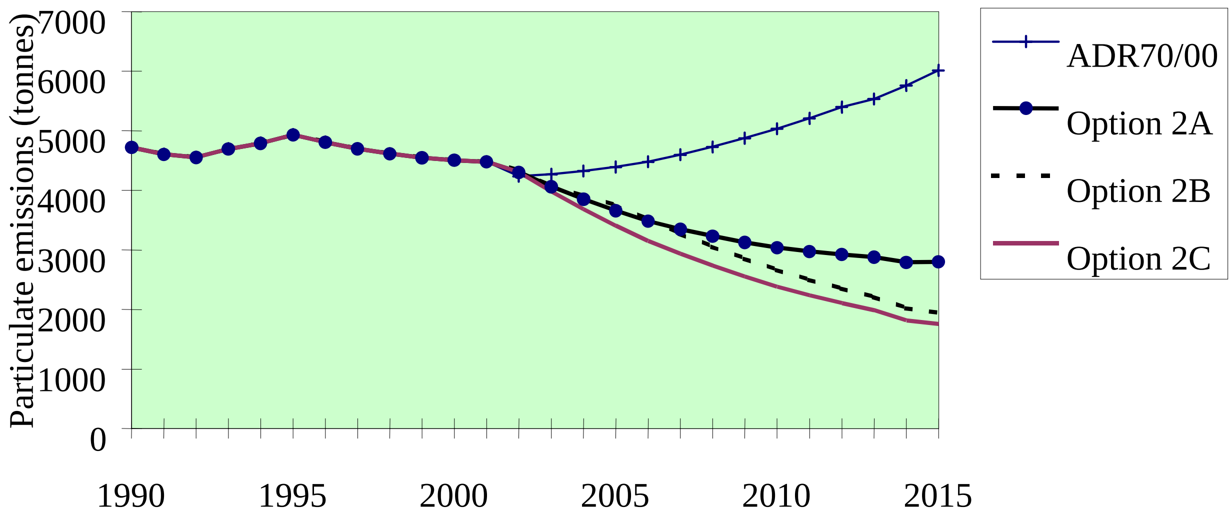


Figure 14 Estimates of PM Emissions from LCVs under "No Change" (ADR70/00) and 3 New Standard Options



5.3 COSTS

Estimates of vehicle and fuel costs have been drawn from a number of sources including the FCAI, the University of Melbourne study, NSW EPA analysis and overseas reports.

5.3.1 Vehicle Costs

Estimates have been made for the anticipated increase in retail costs as a consequence of adopting technology and hardware to move from the current standards to *Euro 2* and *Euro 3* standards. These are outlined in Table 12 below.

Table 12. Estimated Increase in Retail Cost

Vehicle Category	Estimated Increase in Retail Costs ($A)		
	Current to *Euro 2**	***Euro 2* to *Euro 3***	**Current to *Euro 3***
Petrol			
Small	520	350 - 600	1130
Medium	510	390 - 520	1020
Large	630	500 – 610	1210
Diesel			
Light Commercials		250 - 580	
Heavy Duty	2,000 – 3,000**	910 – 4,450	

* NSW EPA has estimated that only 25% of vehicles will need to be modified to comply with *Euro 2*

** Advice from the Bus Industry Confederation, is that during the course of 1999, the cost difference between *Euro 1 and Euro 2* engines will fall to zero.

Sources: University of Melbourne 1999 (Attachment C), European Commission (1996a), FCAI 1996, Bus Industry Confederation (BIC, 1999) and modelling undertaken by the NSW EPA (Attachment D)

These costs should be viewed as indicative only, and will vary considerably depending on the source of the vehicle. It should also be noted that only a proportion of new vehicles might need new technology to meet the standards. For example, a manufacturer of an imported European vehicle will have already met the design and development costs of *Euro 2* in supplying the vehicle to the European market, and thus there are no additional investment costs associated with supplying that vehicle to the Australian market. Similarly as Japanese and Korean, and to some extent, Australian based companies, increasingly develop vehicles for overseas markets where the UN ECE standards apply, there will be no additional investment costs associated with supplying that vehicle to Australia.

These costs are likely to be overestimates as the cost of technologies become cheaper as the components become well proven, and are produced in increased volumes. This is particularly the case for Option 2A to adopt *Euro 2* in 2002, as the necessary technology will have been on the international market for over 6 years. This will also apply to Option 2B, where *Euro 3* is introduced in 2005, as *Euro 3* will have been introduced in the European market in 2000.

In the heavy duty sector it should be noted that even now only *Euro 2* and *US94* specification engines are available for some vehicles, as the market for some *Euro 1* and *US91* standard engines falls below economic levels for the parent companies. By the end of this decade, it is likely that the availability of other than *Euro 2* and *US94* or *US98* engines will be even less. Thus although the later standard engines will cost more than those complying with the standards in the current ADR70/00, these cost increases will be largely the result of changes to standards in Europe and the US, not the introduction of tighter standards in Australia. Advice from the Bus Industry Confederation is that during the course of 1999, the cost difference between *Euro 1 and Euro 2* engines will fall to zero.

It is estimated that the total cost to the domestic passenger vehicle industry to upgrade emissions testing facilities for testing and certification to the *Euro 3* standards is approximately $4.5 million (Attachment D). These laboratory upgrade costs are assumed to be incurred for adopting *Euro 3* standards but not for *Euro 2*.

Adopting ECE standards for cars would involve additional certification costs, particularly for local vehicle manufacturers. Those imported vehicles already with EU/ECE compliance are assumed to incur no additional compliance costs. Industry estimates of certification costs to meet *Euro 2* are approximately $40 million per model. The NSW EPA analysis (Attachment D) suggests that the two local companies most affected by *Euro 2* compliance will be Ford and Holden. For these two key industry players the costs are taken to be $80 million (ie 2 models at $40 million each).

Certification costs would be incurred by all companies in adopting *Euro 3* standards. The cost for *Euro 3* compliance is considerably higher than for *Euro 2,* as it is a significantly more demanding standard than *Euro 2* - in terms of both the test procedures for exhaust and evaporative emissions, the new –7^{o}C test and the lower absolute NOx emission limits (refer discussion of results from comparative emissions test program in section 4.2.2). The FCAI have indicated that there are major design implications for compliance with *Euro 3* which are not applicable to *Euro 2*. In order to comply with the standards all manufacturers will have to:

- Significantly upgrade catalyst specifications, with the likelihood of the need for “light off” and close coupled catalysts. Apart from the additional hardware costs of these items, fitting larger and multiple catalysts closer to the engine will, in many cases, lead to changes to the car floorpan and other significant structural changes to engine mountings, cross members etc. Such changes will also affect compliance with the safety ADRs which set standards for occupant protection (ADR69/00 and ADR73/00) and recertification to these ADRs is likely to be required;
- Upgrade evaporative emission control systems to meet the more demanding evaporative emissions test;
- Install on board diagnostics (OBD) systems compliant with the *Euro 3* specifications (there is no requirement for OBD systems in the *Euro 2* standards); and
- Develop new service systems and support infrastructure for servicing and maintenance of OBD systems.

The FCAI indicated at the Transport and Emissions Liaison Group Meeting on 19 April 1999, that due to the competitive nature of the passenger vehicle industry, it is likely that the costs of compliance with any revised standards would be absorbed by industry rather than passed onto the consumer as an increase in vehicle price. Estimated costs have been included in the cost benefit analysis at Attachment D.

For commercial diesel vehicles, the adoption of *Euro 2* standards is likely to incur costs associated with vehicle modifications such as the fitting of catalytic converters (for light commercial vehicles), as well as costs associated with certification itself. The FCAI claims there would be an additional hardware cost associated with fitting of catalysts to meet *Euro 2* standards of some $1,000 - $1,300 per vehicle.

For US vehicles, the US heavy duty diesel engine manufacturers advise that there would be significant additional costs if US certified engines were required to be re-certified to comply with ECE Regulations. These costs include engine development and optimisation for the ECE test cycle. On this basis it has been proposed that for heavy duty vehicles, US EPA 94 and US EPA 98 standards be accepted as alternatives to the UN ECE *Euro 2* and *Euro 3* heavy duty diesel regulations. Progress is being made to harmonise the US EPA and UN ECE test cycles for certification purposes, and it is anticipated that in the future these standards will be fully harmonised (DieselNET, 1999).

For Japanese and Korean vehicles, implementation of the *Euro 2* and *Euro 3* standards may require further engine development work and the use of catalysts in many light and medium duty vehicles. Heavy duty vehicles are unlikely to require the use of catalysts in order to meet the *Euro 2* standard but may be necessary for *Euro 3* (Romvari, 1999). Some models may also be withdrawn from the market, as it will not be cost effective to bring them into compliance with *Euro 2.*

5.3.2 Fuel Costs

In assessing the options for new standards, there are different fuel implications for *Euro 2* and *Euro 3*. The key parameters are:

- The octane rating of petrol;
- The sulfur content of diesel fuel; and
- The sulfur content of petrol.

These are discussed below.

Fuel requirements for *Euro 3* will be clarified at the conclusion, early in 2000, of the Fuel Quality Review being undertaken by Environment Australia. The Fuel Quality Review will examine the impacts, including costs, of changing a broad range of fuel parameters to meet a number of environmental objectives.

Octane Rating of Petrol
No costings associated with possible increases in the minimum octane rating of petrol have been done at this stage, because the need for high octane (95 RON) petrol to ensure in-service compliance with *Euro 2* standards has not been convincingly established. It is generally accepted that high octane (95 RON) petrol will be required for the engines that manufacturers are likely to use to enable compliance with the *Euro 3* standards.

However, if high octane fuel was required for vehicles meeting *Euro 2* standards, the increase in demand will be gradual as the proportion of *Euro 2* standard vehicles increases. The petroleum industry will not be required to produce high octane fuel for all vehicles “overnight”, thus allowing for refineries to plan investments to meet the growing demand. The differential in maximum retail prices between regular ULP (average 91 RON) and “premium” ULP (average 96 RON) as of July 1998 was 3c/L (ACCC, 1998), but the differential in the market can be over 10c/L. These differences are unlikely to be indicative of the costs of producing 95 RON petrol in quantities larger than the current PULP production (around 4%).

Sulfur Content of Diesel
Additional costs are associated with the introduction of more stringent limits on diesel fuel sulfur content. Sulfur limits for *Euro 2* and *Euro 3* are 0.05% and 0.035%, respectively.

Removal of sulfur is a well understood procedure, which requires capital investment in desulfurisation technology and ongoing operational costs. Unlike most other parameters, fuel sulfur can be reduced without significantly affecting the other fuel properties, or the availability of fuel from a barrel of crude oil. Previous advice provided by the AIP with respect to the initial introduction of ADR 70/00, indicated that installation of diesel fuel desulfurisation capacities at all eight Australian refineries would cost in the order of $700 million (FORS, 1993), with varying cost impacts on each refinery, depending on the level of technology in place in particular refineries (ACVEN Diesel Emissions Working Group, 1996).

Based on overseas experience (eg Candido *et al,* 1997), the then Department of Primary Industries and Energy (DPIE) (Harrison, 1998) estimated that the cost of a desulfurisation unit alone to produce diesel at a 0.05% level (down from a 0.5% level) is around $30m, while noting that, because of the integrated nature of refineries, it is unlikely that investment in desulfurisation capacity will be done in isolation, and concurrent expenditure in other parts of the refinery may occur to meet other fuel requirements. DPIE also commented that the impact on each Australian refinery will be different, and the costs may be higher or lower than indicated.

Estimates for reducing the sulfur content to 0.05% in Canada were estimated at an average of $15 million per refinery [capital costs] and $1.8 million [operational costs], leading to a unit cost increase of approximately 1.3 c/L (CCME, 1996).

The AIP has indicated that even changes to sulfur alone would impose significant costs on the Australian refining industry, which is currently operating on low profitability levels.

One way of easing the early demand for commercial diesel with sulfur content of 0.05% would be to supply two grades of diesel fuel - low sulfur diesel in urban areas, and high sulfur in rural/regional areas. This would reduce the extent (and thus cost) of desulfurisation capacity required across the Australian refineries. It could also be used as an interim strategy in moving to 0.05% sulfur across the market, while meeting urban air quality objectives. BP Amoco and Caltex have publicly stated their commitment to voluntarily providing 0.05% sulfur diesel in urban markets (BP and Caterpillar, 1999; Caltex 1999b).

The Australian petroleum industry believes that having two grades of diesel may present difficulties in handling and distribution (ACVEN Diesel Emissions WG, 1996), and that effective administration of such a system may incur additional costs for Government.

The European Union estimates of fuel reformulation costs for meeting the *Euro 3* standards are $0.0035/L for diesel. However, consideration must be given to the existing sulfur levels in fuel in Australia and Europe. Australian diesel fuel has, on average, around 0.13% sulfur. In Europe, diesel is already at 0.05% and will be reduced to 0.035% (*Euro 3*) and 0.005% (*Euro 4*). In addition, Australian refineries are generally small and relatively old in comparison to world standards, therefore fuel reformulation costs may be higher. Alternatively, reformulation costs would be lower if over the period new refining facilities were constructed for Australia, or the market share of imported fuels increased. For the purposes of the cost benefit analysis, the NSW EPA has assumed that there are no costs for fuel reformulation for adoption of *Euro 2,* and that for *Euro 3,* costs for petrol are the same as Europe ($0.0035/L) and for diesel, double those estimated for European conditions (ie $0.0070/L). For Option 2B this is a total cost of $1,199 million over 20 years and for Option 2C, $1,287 million over 20 years.

Reducing the sulfur content of fuel is important for achieving the anticipated reductions in particulate matter emissions. Improving the quality of fuel by reducing sulfur content improves the operation and efficiency of the catalytic equipment to reduce particulate and other emissions. Without fuel reformulation, the performance of new emission technology would be sub-optimal, but still generate reductions as compared with current emission standards.

Sulfur Content of Petrol

Consistently low sulfur levels are necessary to ensure proper functioning of the OBD systems required by the *Euro 3* standards. Based on the European commercial fuel specifications, the maximum acceptable sulfur level for *Euro 3* vehicles is 150ppm. Currently, the average sulfur levels in Australian petrol are at that level, but there is a very wide range (0 - 6,000 ppm) (AIP, 1999). High sulfur levels will result in a number of defaults being detected by the on board diagnostics and system errors will occur. This would increase the number of occasions that consumers would need to return their vehicles for service, in a situation where service technicians may be unable to rectify the apparent problem. Industry advice indicates that presently OBD systems are disabled on *Euro 3* capable vehicles entering the Australian market.

5.3.3 Costs of Early Compliance with *Euro 3*

Section 5.3.1 identified that passenger vehicle manufacturers will incur significant costs in the design, development and hardware provision for *Euro 3* compliance. These costs can be minimised if there is adequate time to factor these processes into model planning cycles, which tend to be a long term (4-5 year) process.

The early (2002-3) introduction of *Euro 3* for passenger cars would present major planning, technical and financial difficulties for the local vehicle industry, in particular. While the impact would be less significant on imported Japanese and Korean passenger cars, 4WDs and light commercials, it may severely reduce the model choice, at least in the short term, as only a proportion of these models are exported to Europe. European model cars imported into Australia will most likely meet *Euro 3* from 2000, but they only represent about 6% of the market.

To put it in perspective, the vehicles produced by the local manufacturers represent some 30% of the market. The top ten selling models in Australia represent some 45% of the market share, five of which are locally manufactured. These five models represent 60% of the market share of the top ten selling models. The passenger motor vehicle market can be divided into four segments, small cars, medium cars, upper medium and luxury segments. The largest segment in Australia is the upper medium cars (35%). This segment is dominated by the locally produced Holden Commodore, Ford Falcon, Toyota Camry V6 and Mitsubishi Magna. This segment has faced minimal import competition (Industry Commission, 1997).

The FCAI (FCAI, 1999c) have indicated that all of the local manufacturers would be unable to fully comply with Euro 3 by 2002. The reasons given fall into 4 main categories as follows:

1. Insufficient time for the extensive engine and vehicle development required;
2. Insufficient time to upgrade and commission emission test facilities to support engine development and certification;
3. Insufficient time to develop the expertise and network for development and maintenance of OBD systems; and
4. Lack of guaranteed supply of suitable fuel.

Items 1, 2 and 3 are largely an issue for the four local manufacturers (Ford, Holden, Mitsubishi, Toyota), but will also affect model options for Japanese and Korean importers. The fuel issue (Item 4) will affect all models, local and imported.

In relation to Item 1, advice from local manufacturers is that attempting to compress the significant research and development required for *Euro 3,* into a very short time frame which takes no account of current investment and forward business plans, would severely affect their viability. One manufacturer indicated that meeting *Euro 3* in 2002-3 would require a total reallocation of resources in an attempt to meet the requirements, thus severely curtailing other product research and development which is necessary to ensure the ongoing competitiveness of these vehicles in the market.

If local engine development over a short time frame was not possible, an alternative for local manufacturers is to cease production of engines in Australia and source engines from their parent companies overseas. This approach not only affects the engine manufacturing and component production industries in terms of viability and unemployment, it is often no less complex than local development.

Whether the engine is locally developed or imported, the requirements for *Euro 3* are likely to lead to changes to vehicle floorpans. Floorpan changes affect the structure of the vehicle which would most likely impact on its compliance with certain safety Australian Design Rules (ADR69/00, ADR73/00) relating to impact protection. In addition to the engine costs, industry would also incur costs in structural and mechanical redesign including, (but not limited to) alternations to the engine bay which would require additional sheet metal work, moving engine mounts, fitting of larger catalytic converters and heat shields. Consideration would also need to be given to the impact of any redistribution of the weight of the engine to the steering and suspension. These modifications would require further research and development, testing and certification. Thus, depending on the extent of redevelopment to accommodate the engine, this option can be as complex as local engine development.

In addition to the modifications to accommodate the engine, manufacturers need to consider the relative performance of an imported engine. As mentioned earlier, the Australian vehicles dominate the upper medium segment of the market where there is minimal import competition. One of the reasons consumers' state for purchasing these vehicle is the torque pattern of the engine. European engines are typically smaller and have less torque than those in the locally produced upper medium vehicles. The installation of the smaller engine in a heavier Australian vehicle may have a detrimental impact on the performance and fuel consumption of the vehicle, which could further erode the market share of local producers.

In relation to Item 2, to develop and test a local engine for *Euro 3* compliance, local manufacturers would need to upgrade testing facilities which includes purchasing, setting up and testing new equipment and building an evaporative test cell. Advice from industry indicates that this process would take approximately 15 months. This time is broken up into the following components:

- Emission sampling and analysis equipment for *Euro 3* purchased as a 'turnkey' unit. Such units take 9 months to produce from date of the order;
- 1-2 months for shipping of the unit to Australia;
- 1 month to install the unit; and
- 3 months for quality assurance testing and training of staff to operate the unit effectively.

Training of staff and quality assurance is also a significant cost and time component, given that the *Euro 3* emission test contains procedures not included in previous emission standards such as sub-zero emissions sampling, canister loading and the use of variable volume evaporative emissions enclosures.

The new standard of test facilities would be required to support engine development. If the new equipment was ordered in (say) January 2000, it would not be operational until April 2001. If *Euro 3* was introduced in 2002, this would only leave 8 months to work through the process of manufacturing, testing and redesign of a prototype engine, prior to certification and mass production. It is not practical for this process to be undertaken in such a short time frame. Advice from industry indicates that engine development typically takes 4 years, and, from an emissions perspective, *Euro 3* is the most significant change in Australia since the introduction of the first catalyst equipped vehicles in 1986.

In relation to Item 3, the introduction of on board diagnostics for *Euro 3* passenger vehicles requires both engine development and calibration and the development of service systems and support infrastructure. Local manufacturers are of the view that the introduction of *Euro 3* in 2002 would not provide sufficient time for the development and installation of dealership support infrastructure and systems, or for the training of staff.

In relation to Item 4, the discussion in 5.3.2 indicated that keeping fuel parameters within certain specifications is critical for *Euro 3* compliance and proper vehicle operation. While at least one oil refiner has made a commitment to the provision of 'cleaner fuels', the majority will not make any investment decisions on the production on '*Euro 3*' fuel until the outcomes of the Fuel Quality Review are available. The Fuel Quality Review will significantly aid the understanding of the refining industries' ability to manufacture 'cleaner' fuels and the associated cost penalties. The outcomes of the Fuel Quality Review will include a recommendation of the minimum requirements for a '*Euro 3'* fuel, and until government makes a final decision in response to those recommendations (expected to be late 2000), individual oil refineries will hold off on major investment decisions. The length of the refinery investment cycle from design to implementation can range from a few months for minor process changes to up to 4 years for major hardware commissioning.

As the new vehicle fleet (less than 1 year old) typically accounts for around 5 per cent of the market, the initial demand for '*Euro 3*' fuel would be small and steadily increase in line with the volume of *Euro 3* vehicles. If Australian refineries were unable to produce suitable fuel by 2002, it could be imported, to ensure that *Euro 3* vehicles operate effectively. However, the economics of producing and/or distributing small quantities of fuel would present a disincentive for local refiners and importers. A significant difference in retail prices between a *Euro 3* fuel and ordinary unleaded is undesirable, as it is likely to tempt owners of *Euro 3* vehicles to misfuel with unleaded petrol, with resultant OBD problems and probable decreases in the performance and fuel consumption of the vehicle. In addition, given that there are currently three grades of petrol on the market, many service stations would simply not have the storage capacity to handle another grade of petrol.

In conclusion, the available evidence suggests that the four local manufacturers would either be unable to produce *Euro 3* compliant vehicles by 2002, or would suffer serious financial penalties in attempting to do so.

5.3.4 Total Costs

The estimated "upfront" costs to Australia of adopting *Euro 2* and *Euro 3* standards are shown in the table below. The costs of adopting *Euro 2* are significantly lower as it is assumed that there would be no additional fuel reformulation costs or laboratory testing upgrades. Major fuel reformulation costs would apply in adopting *Euro 3* hence the higher cost. The time lag between the adoption of new standards and implementation may have a significant effect on the real cost of the standard. Technology, hardware and fuel reformulation costs are ongoing, whilst laboratory upgrade and certification cost are once only.

Table 13 Total costs of Euro standards (A$/1999) for first year

Standard	***Euro 2***	***Euro 3***
Technology and Hardware	$88 million	$107 million
Fuel reformulation	$0	$161 million
Laboratory upgrade	$0	$4.5 million
Certification costs	$80 million	$80 million
Total costs (year 1)	**$168 million**	**$352 million**

5.4 BENEFITS

5.4.1 Reduction in Health Costs

Vehicle emissions are linked to a wide range of adverse health impacts including respiratory disease and heart disease. The vehicle related pollutants with the most significant links to health are photochemical smog (measured as ozone), NO_2 and particulates.

While the findings of various researchers outlined below indicate considerable variance in estimates of health impacts, the general conclusion is that the social and economic cost of the health impacts of air pollution is considerable. Air pollution costs have been estimated at around 0.2% of GDP (BTCE 1994). With Australia's GDP at $444.6 billion in 1996-97 (ABS 1998) this equates to around $889 million pa. The Bureau of Transport and Communication Economics surveyed the international literature to broadly assess the total national costs of air pollution in other countries. Although each study used a wide range of techniques and assumptions, the estimates are in the same order of magnitude, ranging from 0.15% to 1.04% of GDP.

The Inter-State Commission made an attempt to estimate the costs of vehicle emissions in Australia in 1990 based on a similar study undertaken in the US. Using data on the rates of emissions and damage costs the Inter-State Commission estimated the annual cost of emission to be $786 m (Inter-State Commission, 1990).

The National Road Transport Commission (Segal 1995) undertook a review of health costs associated with vehicle emissions. The report concludes that health costs to Australia are "likely to fall within the range of $20 to $100 million with $50 million suggested as reasonable midpoint". The analysis is based on an arbitrary estimation of 0.1% of cancers and 0.1% of respiratory illnesses attributable to road vehicle emissions. The study produces a very low estimate of health costs because it only examines two health end-points, (cancers and respiratory disease) and does not include the impact of particulates. The report concludes that more understanding is needed on the impact of vehicle emissions on health.

Simpson and London (1995) estimated that the economic cost of current air pollution in the Brisbane City Council area is in the range $254 million and $462 million per year. Mortality effects from particulate pollution account for around 90% ($230 million to $415 million) while morbidity effects account for the remainder. Ozone impacts were estimated to account for $2.5 million in costs per year.

The impact statement released by National Environment Protection Council on air quality (NEPC, 1997) reports that health costs from ozone are estimated to be in the range of $95-$285million per annum, which compares with just $14million per annum estimated by Segal (1995).

According to the ESD Working Group on Transport (1991), the estimated health cost of emissions from heavy duty diesel engined vehicles is in excess of $150 million per annum, or $142 million if the particulate impact estimated at that time is excluded ($A 1995). Since that time, more information has become available regarding the impact of particulates on health (Ballantyne, 1995).

5.4.2 Other Benefits

Harmonisation, Trade Facilitation and Administrative Efficiency

The adoption of UN ECE standards at the *Euro 2* and *Euro 3* level is consistent with the Principles and Guidelines for National Standard Setting and Regulatory Action by Ministerial Councils and Standards Setting Bodies laid down by the Council of Australian Governments (COAG). The COAG principles state that wherever possible, regulatory measures or standards should be compatible with relevant international or internationally accepted standards or practices in order to minimise impediments to trade. Industry and Government are expected to achieve improvements in trade facilitation and administrative efficiency from adopting *Euro 2* and *Euro 3* standards. If Australian manufacturers do not aspire to international standards in an increasing global market, they will limit their ability to export to a range of open world markets. (Industry Commission 1997)

Improved trade facilitation and administrative efficiency are expected to flow from further harmonisation with the UN ECE international regulations, due to increased use of UN ECE approvals for certification by FORS. The time savings occur in the preparation and scrutiny of compliance documentation by manufacturers and regulatory authorities respectively. Quantifying these savings is difficult due to other FORS initiatives in the area of electronic lodgement of compliance data, a system which is expected to be fully on stream in 1999.

Tourism

The Inquiry into Urban Air Pollution (AATSE, 1997) also points to improved air quality in Australia's large cities as not only having health benefits for the local community, but also wider benefits. Clean urban air is beneficial to a city's tourism potential, and its capacity to attract international business and major sporting and cultural events. The inquiry indicates that if just 5% of international visitors were deterred from coming to Australia because of polluted cities, then the resultant drop in tourism income would be approximately $700m per year.

Durability and Fuel Economy

Manufacturers have stated that the engines designed to the higher standards have increased durability and improved fuel economy. While these benefits for vehicle owners may not be due to compliance with tighter emission standards *per se*, they reflect the benefits of the additional design effort undertaken by vehicle and engine manufacturers.

5.5 ANALYSIS OF COSTS AND BENEFITS

As indicated in section 5.2, two independent analyses were undertaken to assess the cost and benefits associated with the introduction of *Euro 2* and for *Euro 3* emission standards. The cost benefit analysis examined costs and health benefits for passenger vehicles and heavy duty diesels, as well as costs (but not benefits) for light commercial vehicles. The cost effectiveness study did not attempt to estimate benefits, and only covered petrol engined cars. The key conclusions from these analyses are summarised below. Full details of the analyses are at Attachments C and D.

5.5.1 Cost Effectiveness Analysis

The cost effectiveness analysis conducted by the University of Melbourne estimated the reduction in total emissions from the car fleet projected to 2015, and then applied cost estimates of *Euro 2* and *Euro 3* compliance, to determine the relative cost effectiveness of *Euro 2* and *Euro 3* standards. The cost per tonne of emission reductions derived from the analysis are summarised in Table 14. It is important to recognise that this analysis is narrower than the cost benefit analysis, in that it deals with passenger cars only and does not attempt to estimate benefits. The full text of the analysis is at Attachment C.

Table 14 Estimates of the Cost per Mass of Emission reduced for Passenger Cars

Emission Type	Cost ($m - range) per ktonne by Option (rounded)		
	Option 2A *Euro 2* **in 2002**	**Option 2B** *Euro 2* **in 2002,** *Euro 3* **in 2006**	**Option 2 C** *Euro 3* **in 2002**
HC	1900-2700*	40-60	35-55
NOx	8-11	12-18	12-19
HC+NOx	8-11	9-14	9-14

* Euro 2 delivers only a small reduction on HC. If all the costs of control are attributed to HC alone, the cost per mass of HC reduced is extremely high.

The key findings of the cost effectiveness study are as follows:

- *Euro 2* alone should improve NOx emissions for cars, but will have virtually no impact on HC emissions and may lead to increases in CO emissions;
- A combination of *Euro 2* followed by *Euro 3* will lead to more significant reductions in all emissions from cars compared to *Euro 2* alone;
- Early application of *Euro 3* will further increase the reductions in all emissions from cars;
- The cost effectiveness of various options depends on the emissions reduction objectives.
  - : If the ratio of HC and NOx is not important (*Euro 2* sets a combined limit) then *Euro 2* alone (Option 2A) is the most cost effective;
  - : If only NOx control is needed, then a staged approach (Option 2B) is the most cost effective; and
  - : If reductions in both HC and NOx from cars are desired, then the staged approach of *Euro 2* followed by *Euro 3* (Option 2B), and the direct move to *Euro 3* in 2002 (Option 2C), are equally cost effective.

5.5.2 Cost Benefit Analysis

The cost benefit analysis evaluated the impact of adopting European emission standards (*Euro 2* and *Euro 3*) by assessing the marginal costs and benefits of moving to a higher standard. The analysis attempted, where possible, to quantify in dollar terms the improved health and environmental benefits of tighter emission standards in comparison with industry costs. The detail of this analysis is at Attachment D.

The primary costs from adopting UN ECE standards are the cost of new technology and hardware, fuel reformulation and vehicle compliance. The additional retail cost of upgrading vehicles with new equipment was estimated for both petrol and diesel vehicles and applied to the number of vehicles produced within Australia.

The link between air pollutants and human health was examined using dose response relationships. The health cost avoided per tonne of pollutant was then calculated for four major pollutants. These were PM, CO, HC and NO_2. The results are considered to under-estimate the health benefits, as the impacts of ozone and air toxics (such as benzene), and the personal and social costs of air pollution, were not valued. The estimated benefits from each of the 3 options are contained in Table 15.

The analysis estimates that for Options 2A, 2B and 2C, the positive net benefits would be:

- Option 2A (*Euro 2* in 2002) - $119 million
- Option 2B (*Euro 2* in 2003 and *Euro 3* in 2005) - $618 million
- Option 2C (*Euro 3* in 2002) - $1,359 million

Thus all options are estimated to provide net benefits with significantly higher benefits from the options which include the adoption of *Euro 3* standards.

Table 15. Net Benefits of UN ECE Standards ($ million 1999)

	Option 2A *Euro 2* in 2002	**Option 2B *Euro 2* in 2002, *Euro 3* in 2005**	**Option 2C *Euro 3* in 2002**
Costs*			
Technology and hardware	662	831	803
Fuel reformulation	-	1,199	1,287
Laboratory upgrades	-	3	4
Certification	70	65	70
Total costs	**732**	**2,098**	**2,164**
Benefits* (Health costs avoided from):			
Hyrdocarbons	80	701	892
Nitrogen dioxide	409	1,150	1,409
Carbon monoxide	38	262	341
Particulates	324	793	882
Personal and social costs avoided, investment opportunities, visual amenity, export potential, infrastructure damage avoided and reduced greenhouse emissions	Not quantified	Not quantified	Not quantified
Total benefits	**851**	**2,716**	**3,523**
Net Quantified Benefits	**119 m**	**618m**	**1,359 m**

(* All figures in Present Values discounted at 7% over 20 years)
Note: figures may not add due to rounding

As indicated in the timing discussion in section 4.2.3, heavy duty trucks and bus manufacturers are likely to be able to meet *Euro 3* standards by 2002. In an effort to assess the impacts of early adoption of *Euro 3* for these vehicles in 2002, the NSW EPA undertook further analysis of a modified version of the staged option (Option 2B) to include the adoption of *Euro 3* for heavy duty vehicles from 2002. This analysis indicated an increased net benefit of $804m, compared to the net benefit of $618m for Option 2B.

A range of other benefits, including enhanced investment opportunities, visual amenity, export potential and tourism were examined but not quantified. Reducing vehicle emissions may also provide benefits through infrastructure damage costs avoided and reduced greenhouse emissions.

These results are sensitive to assumptions in the timing and magnitude of fuel reformulation, technology and hardware costs. It has been conservatively estimated that industry costs would decline slowly over the period of the analysis, whereas typically, the costs of technology decline rapidly due to innovation and economies of scale.

Sensitivity testing was conducted in relation to the major uncertainties in the analysis (see Attachment D). Overall, the sensitivity testing demonstrated that significant changes in cost and benefit estimates for the major variables does not affect the relative net benefit of each option.

The costs associated with adopting stronger emission standards would be initially borne by the car manufacturing industry and oil refinery producers in upgrading plant and equipment to comply with the new standards. However, these costs are dynamic in the sense that a new standard may force manufacturers and producers to become more innovative as they seek to minimise costs and adopt best practice technology. Some costs would be passed on to consumers by way of higher fuel and vehicle prices. However, competition would limit the extent such costs could be passed on, particularly for passenger car manufacturers.

The benefits from avoided health costs would flow primarily to those with pre-existing health conditions such as asthma or bronchitis. Reduced health costs would also ease the burden on public health system through reduced hospital admissions and attendances and treatment costs. In addition, families would benefit through lower levels of sickness and less restricted activity days.

6. CONSULTATION

6.1 CONSULTATION PROCESS

Public Comment

In October 1998, MVEC issued a comprehensive discussion paper on the Review of Australia's Vehicle Emissions Standards for 3 months public comment. The paper considered the case for revising Australia's vehicle emission standards, taking account of:

- The status of current air quality;
- Air quality trends;
- The adequacy of existing standards;
- The options for adopting new standards;
- The timing of the implementation of new standards;
- Fuel quality; and
- Other strategies to reduce vehicle emissions.

Printed versions of the Review paper were provided to approximately 220 organisations using existing mailing lists and responses to an advertisement placed in the 10 October 1999 edition of the Weekend Australian. Mailing lists included organisations from the vehicle, fuel and transport industries, motoring organisations, environment groups, academia and government agencies. The review paper was also placed on the Department of Transport and Regional Services web site. Accompanying the Review Paper was a Public Comment Response Sheet, which encouraged comments from the public and asked a number of specific questions on the introduction of tighter emissions standards and fuel parameters.

Transport and Emissions Liaison Group

Following its initial consideration of the public comment, the Motor Vehicle Environment Committee provided a discussion paper on an expanded range of options to the Transport Emissions Liaison Group (TELG). TELG includes representatives from the vehicle, fuel and transport industries, motoring organisations and government agencies. A TELG meeting was held in Melbourne on 19 April 1999 to discuss the options and for TELG members to provide comments to MVEC. TELG members were also invited to make any further comments in writing to MVEC.

Meetings with Individual Stakeholders

Representatives from MVEC also had a number of meetings with the FCAI, AIP and individual vehicle manufacturers and fuel refining companies on a confidential basis, to further explore the impacts on individual companies on the different options on introducing tighter standards.

6.2 SUMMARY OF COMMENTS

Public Submissions

Approximately 50 submissions were received. Respondents were asked the following specific questions on the Review "4 Questions" Response Sheet:

- Do you agree/disagree with the paper's argument for tighter standards for vehicle emissions and fuel parameters?
- Do you agree/disagree with the proposal to
  - Adopt *Euro 2* standards?
  - Apply *Euro 2* standards from 2002/3?
  - Lower fuel volatility and reduce diesel sulfur content?
- Would you support the adoption of *Euro 3* standards?
- If you support the adoption of *Euro 3* standards should they be in lieu of *Euro 2* in 2002/3 or follow adoption of *Euro 2* (say 5 years later)?

From the submissions it was clearly evident that a number of issues were non-contentious. These included:

- Accepting the US 94 heavy duty standards as alternatives to the ECE standards;
- Allowing compliance with later versions of the nominated standards; and
- Including LPG and NG fuelled vehicles within the scope of the standards.

With regard to the remaining recommendations, respondents expressed a range of views. In relation to the four specific questions asked, the public comments are summarised below (note that each submission was counted as one response even though it may have been from a body representing a number of organisations).

Of the submissions that responded to the questions:

- 98% supported the need for tighter emission standards and fuel parameters;
- 95% supported the need for lower fuel volatility and to reduce diesel sulfur content;
- 79% supported the proposal to adopt *Euro 2* standards (the majority of stakeholders disagreeing were environmental organisations who wanted more stringent standards);
- 71% supported the proposal to apply *Euro 2* standards from 2002/3 (the majority of these being vehicle industry, motoring and government organisations);
- 64% supported the adoption of *Euro 3* standards (majority of support from government, environment and motoring organisations) 22% were unable to decide without further cost benefit analysis; and
- Of the 29 submissions that supported the adoption of *Euro 3*, 14 supported its adoption in lieu of *Euro 2* in 2002/3, while12 supported its adoption in some time after *Euro 2*.

A summary of the public comments is at <u>Attachment E</u>.

Main Stakeholder Views from the Public Submissions

The FCAI (FCAI 1999a) proposes that *Euro 2* becomes effective from 2003 for new models, and 2005 for existing models subject to:

- ensuring that suitable fuel qualities are widely available at a competitive price by that time;
- assuring a minimum of 2 years lead time from rule gazettal for new models;
- *US94* and 1998 Japan standards be allowable alternative standards for heavy duty diesel vehicles;
- EEC certificates be accepted for compliance, as the test procedure is the same as UN ECE; and
- Certification on PULP (95 RON) be allowable.

FCAI supports the adoption of *Euro 3* standards after an appropriate lead-time. *Euro 3* requires sufficient lead-time to develop supporting infrastructure for both OBD systems service and provision of a high quality fuel supply to the market place.

The Road Transport Forum (RTF) is of the view that *Euro 2* (with USEPA 94 as an acceptable alternative for heavy vehicles) should be adopted from 2002/3 with *Euro 3* standards being considered in the context of a staged approach five years later, inclusive of industry incentives to upgrade or renew equipment.

The Bus Industry Confederation (BIC) advocated the adoption of *Euro 2* standards from 2002/3. It also acknowledged that from the year 2000 *Euro 3* engines would be the industry norm. BIC recognises that the in-service emissions performance of *Euro 3* engines will be contingent on the capacity of the refineries to supply low sulfur content fuel (0.05% or lower). BIC is concerned that the adoption of *Euro 3*, five years after *Euro 2,* departs from the Prime Minister's statement to harmonise with international standards by 2006. Harmonisation implies adoption of *Euro 4* in 2006. This would require substantial investment by the oil refineries in order to supply fuel with a sulfur content that meets *Euro 4* standards.

The European Automobile Manufacturers Association (ACEA) supports the adoption of *Euro 3* standards by 2002/3. As these standards will be widely applied in Europe in 2001, the technical solutions will be available for Australian manufacturers shortly after this date. The costs should not be an obstacle due to the fact that the standards would provide a harmonised framework for the development and industrialisation of the technology.

The Australian Institute of Petroleum state that there is no current justification for *Euro 3* and that scientific work needs to be done to clarify *Euro 3* before a decision is made to adopt *Euro 2* in order to avoid short term non-optimal investment.

Transport and Emissions Liaison Group Meeting

The Transport and Emissions Liaison Group meeting was held on 19 April 1999 and was well attended. Key stakeholders were represented, including the FCAI and AIP. While the meeting did not reach a consensus on the way forward or express a preference on the options presented, some points were clear.

- There was a general acceptance of the move to tighter standards;
- There was a general recognition, of the imperatives for better air quality, and cleaner vehicles and fuel;
- Links with the Fuel Quality Review and the Petroleum Products Action Agenda were noted;
- The passenger car fleet also has to meet fuel consumption objectives by 2010;
- Significant sections of the passenger vehicle industry claim not to be ready or able to meet *Euro 3* in 2002; and
- The oil industry was not considering any changes until after the Fuel Quality Review was completed, and was seeking a long term strategy from Government.

7. CONCLUSION AND RECOMMENDED OPTION

7.1 SUMMARY OF KEY ISSUES

Australia is one of the most highly urbanised countries in the world, and atmospheric pollution in our cities has been identified as a significant community issue. Relatively high concentrations of pollutants are experienced on occasions in our larger cities, with the standards in the National Environment Protection Measure for ozone and particles being exceeded in many capital cities. It is well recognised that concentrations of pollutants cause a range of effects on human health, even concentrations below air quality standards (the World Health Organisation has recently stated that there is no safe threshold for particulates).

Vehicles are the largest single contributor to urban air pollution, and without further controls on vehicle emissions, expected increases in vehicle use will mitigate against the penetration of ADR37/01 and ADR70/00 standard vehicles, leading to predictions of worsening air quality in the long term. The need to introduce tighter emission and fuel standards was overwhelmingly supported in the public comment.

The introduction of UN ECE emission standards for petrol and diesel vehicles would be an effective strategy for reducing CO, HC, NOx and PM emissions, and is consistent with Commonwealth Government and vehicle industry objectives of harmonising with international standards. There are sound economic arguments for also including the US emissions standards for <u>heavy duty vehicles</u> as an alternative to the UN ECE requirements, without compromising emissions objectives. There are no equivalent arguments for US EPA standards for <u>light duty vehicles</u>.

Introducing the *Euro 2* standard from 2002 (Option 2A), would deliver significant emission HC and NOx benefits, particularly in light-medium duty vehicles, and should not pose any significant technological difficulties for manufacturers. The analysis by the University of Melbourne, concludes that if the objective is to reduce emissions of the combination of HC and NOx (without concern for the balance between the two), then Option 2A is the most cost effective option for <u>passenger cars</u> (although this analysis does not cost the implications for the fuels industry). The cost benefit analysis concludes that while *Euro 2* alone Option 2A delivers net benefits, these are much smaller than those for *Euro 3* (Option 2B or 2C). Lowering the sulfur content of diesel fuel to 0.05% would appear to be the only change to fuel required to ensure on road compliance with *Euro 2* emission limits.

Euro 3 is a more stringent standard with significantly tighter emission limits, tougher exhaust and evaporative emissions tests, and the introduction of on board diagnostics. It would be difficult for the local vehicle industry, in particular, to meet *Euro 3* in 2002 (Option 2C), and it would also be likely to have a significant impact on imported Japanese and Korean vehicles, both passenger cars and light-medium duty commercials. However, advice from industry indicates that compliance with *Euro 3* standards is readily achievable in 2002 for the heavy duty truck and bus sector. European model cars imported into Australia will most likely meet *Euro 3* from 2000, but they only represent about 6% of the market. The European manufacturers importing vehicles into Australia have made investment decisions and plans based on the supply of vehicles to the European market at the *Euro 3* standard.

As mentioned, the adoption of Option 2C would have a number of significant ramifications for local vehicle manufacturers, Japanese and Korean manufacturers of passenger cars and light-medium duty commercial vehicles. Moving from the current standards to *Euro 3* standards in 2002 would significantly increase production costs. Manufacturers have indicated that they are unlikely to pass these costs to consumers in the form of an increase in retail prices, due to the competitiveness of the industry. Consumers around the world are demanding an increase in value-for-money and in Australia it is generally agreed that passenger vehicles have become less affordable in real terms. Emissions control equipment does not add to the value of the vehicle from a consumers perspective. As such the cost of the equipment is often borne by the manufacturer, rather than impacting on the retail price of the end product. This will impact on the manufacturers investment decisions, many of which are already 'locked' into forward plans. *Euro 3* adds considerably to variable and investment cost which threatens the business equation for locally manufactured vehicles.

Local manufacturers state that Euro 3 for 2002/3 is completely unattainable, even if *Euro 3* fuels were the base market fuels, given the amount of research and development that would be required. Sourcing engines from overseas is problematical given the differences in floor plans of the Australian vehicles.

In addition, on board diagnostics systems service and support infrastructure would not be available by 2002. Without adequate support, a high level of customer complaints could be expected on OBD false alarm warnings. OBD systems are also very sensitive to fuel specification and variations.

The changes in fuel parameters needed for on road delivery of *Euro 3* standards may be significant, and cannot adequately be determined until the completion of the Fuel Quality Review, being managed by Environment Australia. It is most unlikely that the Australian refining industry could deliver, for example, the quality of fuel that the vehicle industry desires for *Euro 3* vehicles by 2002. To produce such fuel requires a significant investment over a period of time.

The analysis by the University of Melbourne concludes that if the objective is to reduce emissions of both HC and NOx, then the introduction of *Euro 3* in 2002 is a cost effective option for passenger cars (although this analysis does not cost the implications for the fuels industry). The cost benefit analysis concludes that moving directly to *Euro 3* in 2002 delivers the greatest net benefit of all three options.

A staged approach of adopting *Euro 2* now, and *Euro 3* some years later (Option 2B), would allow manufacturers sufficient lead time to re-design models and investigate new engine options for both passenger cars and commercial vehicles. It would also provide sufficient lead time to discuss fuel parameters for *Euro 3* with the vehicle and fuel industry, in light of the Fuel Quality Review findings, which will not be complete until early 2000. The cost benefit analysis indicates that the net benefit of the staged approach of adopting *Euro 2* in 2002/3 and *Euro 3* in 2005/6 delivers significantly greater net benefit than *Euro 2* alone, but not as much as the early adoption of *Euro 3* (Option 2C). The analysis by the University of Melbourne concludes that if the objective is to reduce emissions of both HC and NOx, then this staged approach is the most cost effective option for passenger cars (although as indicated earlier, this analysis does not cost the implications for the fuels industry). The Further NSW EPA analysis concluded that modifying Option 2B to require the adoption of *Euro 3* for heavy duty trucks and buses in 2002 would increase the net benefit significantly.

Based on the NSW EPA analysis Option 2C provides the greatest net benefit. However the significant cost and logistical burden of early compliance with *Euro 3* under this option, falls heavily on the local vehicle manufacturing industry. The available evidence suggests that the four local manufacturers would either be unable to produce Euro 3 compliant vehicles by 2002, or would suffer serious financial and marketing penalties in attempting to do so. There is also considerable uncertainty as to whether Australia will be able to supply sufficient quantities of low sulphur fuel for Euro 3 passenger vehicles (local and imported) in 2002-3. A fuller assessment of this risk will not be known until the completion of the Fuel Quality Review in 2000. Advice from the local vehicle manufacturing and fuel industries indicates that the early introduction of Euro 3 in 2002 (Option 2C) is neither realistic in terms of both time nor cost given the significant investment required in research, development and hardware.

Option 2B with the modification that heavy duty trucks and buses adopt Euro 3 from 2002, is considered the most appropriate option. Option 2B (Modified) delivers significant environmental benefits and begins the path towards harmonisation, without causing major disruption to the vehicle manufacturing and fuel industries or adversely affecting their financial viability. Thus Option 2B (Modified) is the most consistent with the Government’s objective which is outlined in the Prime Minister’s Statement, *Safeguarding the Future*, (Prime Minister, 1997) as “seeking realistic, cost effective reductions in key sectors where emissions are high or growing strongly while also fairly spreading the burden of action across our economy”.

A summary assessment of each of the three options is at Table 16.

Table 16 Summary Analysis of Options

Option[20]	Impact On			Likely benefit/comment
	Vehicle Industry	Fuel Industry	Consumers/Public	
Option 2A, *Euro 2* in 2002	• Lowest cost option • Minimal impact for imported cars (*Euro 2* in place since 1996) • Minimal impact on US &Euro Diesel suppliers, *Euro 2*/*US94* already "standard" • Greater impact for some local car manufacturers • Estimated vehicle costs $660m (over 20 year period) • Increase in petrol vehicle costs $520- $630 • Increase in diesel vehicle costs $2,000 - $3,000	• Only fuel change required is 0.05% sulfur in diesel • Estimated costs of desulfurisation capacities at all eight refineries $350-500 million	• estimated benefits from avoided health costs $851m (over 20 year period) • criticism that this measure reflects out of date standards and on its own not sufficient • minimal impact on retail car prices (costs likely to be absorbed)	• estimated net benefit of $119 million (over 20 year period) • lowest cost option • emission benefits mostly in locally manufactured cars and light-medium duty diesels
Option 2B, *Euro 2* in 2002, *Euro 3* in 2005	• *Euro 3* test more stringent than *Euro 2*, requires on board diagnostics, tougher evaporative emission test • *Euro 3* significantly tighter NOx and PM limits • Heavy Duty manufacturers have a choice of two new test cycles, which have more stringent emission limits than *Euro 2* • Provides industry with 5 years to comply with *Euro 3* • Minimal impact for imported vehicles (*Euro 3* in place in 2000) • More significant impacts for local manufacturers • Minimal impact for US and Euro diesel engine importers (*Euro 3* and US 98 in place in 2000) • Higher technology and hardware costs than Option 2A ($831m over 20 year period, or $807m if *Euro 3* adopted by heavy duty trucks an buses in 2002) • Increase in petrol vehicle retail cost from	• For *Euro 2* in 2002 only fuel change required is 0.05% sulfur in diesel • Current fuel will not meet *Euro 3* requirements, estimated fuel reformulation costs $1,199 million or $1,084 million if *Euro 3* adopted by heavy duty trucks and buses in 2002 (over 20 year period) • Adequate lead time to negotiate changes in fuel parameters for *Euro 3* (Results of Fuel Quality Review available in 2000)	• Estimated benefits from avoided health costs $2,716million or $2,762 million if *Euro 3* adopted by heavy duty trucks and buses in 2002 (over 20 year period) • Delayed adoption of *Euro 2* and *Euro 3* increases the likelihood that costs will be absorbed	• higher cost option than Option 2A, but greater estimated net benefits of $618 million or $804 million if *Euro 3* adopted by heavy duty trucks and buses in 2002 (over 20 year period) • significant emission benefits across all sectors of the fleet

20 This is a simplified description of the options. For a detailed description see Attachment B.

	Euro 2 to *Euro 3 $350 - $600* • Costs to local car industry to significantly upgrade emissions testing facilities (estimate $4.5M)			
Option 3, *Euro 3* in 2002	• Cost as for *Euro 3* in option 2B except lead times significantly reduced • Estimated total technology and hardware costs $800m over 20 year period • Increase in petrol vehicle retail costs to *Euro 3* $1,130 - $1,210 • Significant impacts for most non-European importers and local manufacturers, very limited lead time to meet significantly more stringent standards and upgrade facilities • Minimal impact for US and European heavy duty diesel engine suppliers – costs minimal as *Euro 3/US98* will be 'standard' • Major impact on imported Japanese diesel vehicles, many export engines will not comply • Costs to local car industry to significantly upgrade emissions testing facilities (estimate $4.5M)	• Current fuel will not meet *Euro 3* requirements. • Insufficient information available at this stage to determine what changes in fuel parameters are necessary to deliver full emission benefits. Results of Fuel Quality Review not available until 2000 • Very limited lead time to negotiate and implement changes to fuel parameters. • Estimate of fuel costs for *Euro 3* $1,594 (over a 20 year period).	• Estimated benefits from avoided health costs $3,523 m (over a 20 year period)	• Highest cost option, but greatest estimated net benefit of $1,052 m (over a 20 year period) • Significant emissions benefits across the fleet, but major disruption to local manufacturers and many importers

7.2 RATIONALE FOR PREFERRED OPTION

The staged approach reflected in Option 2B (Modified) is considered, on balance to be the most effective strategy. The analysis indicated that this approach delivered significant environmental benefits while enabling the vehicle and fuel industries to reorient their marketing strategies and to plan longer term investments. Option 2B (Modified) is therefore recommended. The modifications, which reflect consultation with industry groups, are:

- Additional one year phase in period for passenger cars. Effective dates 2002 for new models, 2004 for all models;
- Extension of *Euro 3* compliance date by one year to 2006 for passenger cars; and
- Heavy duty buses and trucks to comply with *Euro 3* by 2002/3.

This modified option is preferred for the following reasons:

- Early and staged implementation shows commitment to the Environmental Strategy for the Motor Vehicle Industry embodied in the Prime Minister's Statement on Climate Change *Safeguarding the Future;*
- Achievable at minimum cost, given the technology will be readily available and well proven (this means that for the vast majority of vehicles, *Euro 2* and *Euro 3* would apply in Australia some 5-6 years after application in Europe);
- The staged (*Euro 2* then *Euro 3*) approach delivers significant emissions and health benefits, albeit at a lesser level than an early adoption of *Euro 3* across the board. However, attempting to apply *Euro 3* standards across the board in 2002/3 would cause severe disruption and high costs to the local vehicle manufacturing and service industry, many vehicle importers and the local fuel refining industry;
- Adoption of *Euro 2* will deliver early and significant reductions in NOx and PM emissions, which are two of the pollutants of most health concern;
- Allows latest US EPA heavy duty standards as alternatives, without compromising emission benefits;
- Later adoption of *Euro 3* provides the vehicle industry sufficient lead time to meet the requirements of *Euro 3,* including the upgrading of emission test facilities necessary for local manufacturers, and the provision of a service network for the on-board diagnostic systems required in *Euro 3*;
- Heavy duty diesel buses and trucks (or at least their engines) are all imported and predominantly supplied by European and US manufacturers which will already comply with *Euro 3* or *US 98* standards;
- "Locks in" next step to *Euro 3* across the fleet, which delivers significant additional benefits;
- Amends ADR37/01 as soon as possible to include UN ECE R83 (*Euro 2* and *Euro 3* levels) as an alternative standard, thus enabling manufacturers to supply vehicles meeting more stringent standards (than currently required) to the Australian market;
- Allows compliance with later versions of the nominated standards;
- Includes LPG and NG fuelled vehicles within the scope of the standards;
- Only fuel change required by 2002 is the reduction of diesel sulfur levels to 500ppm, and this could be phased in initially as a requirement for major urban centres only, to ease the volume demand on refineries. For some years there has been a widespread expectation that 500ppm sulfur would be a minimum requirement for delivering *Euro 2* emission standards and could reasonably be seen as a "base case" scenario; and
- Later adoption of *Euro 3* will allow fuel requirements for petrol and diesel to be assessed in light of the Fuel Quality Review (due in 2000) and delivered by 2005.

7.3 DESCRIPTION OF PREFERRED OPTION

The details of the Preferred Option are as follows:

Vehicles

From 2000

(1) Amend ADR37/01 as soon as possible to incorporate UN ECE R83/03 (*Euro 2* and *Euro 3* levels) as an alternative standard

From 2002

(2) Introduce 3 new ADRs, one for "light duty" vehicles, one for "heavy duty" vehicles and one for smoke emissions, which align with the UN ECE emission regulations as follows[21]:
   - The light duty vehicle emissions ADR will adopt UN ECE R83/03 (Euro 2 level);
   - The heavy duty vehicle emissions ADR will adopt:
     - for diesel, NG and LPG vehicles, UN ECE R49/02 (*Euro 2* level) including Supplements 1 and 2, except for vehicle categories ME and NC, for which the *Euro 3* standards will apply;
     - for petrol vehicles, the US 1996 standards for heavy duty petrol engines; and
   - The smoke emissions ADR will adopt UN ECE R24/03.

(3) Require the new heavy duty and smoke emissions ADRs to accept the following standards as alternatives to the principal UN ECE standards in (2):
   - The heavy duty ADR - the US 1994 Heavy Duty Emission Standards (US EPA 1999 for vehicle categories ME and NC); and
   - The smoke emissions ADR - the US 1994 Heavy Duty Smoke Standards

(4) Require the 3 new ADRs to allow compliance with later versions of the nominated standards, provided they are demonstrated to be no less stringent than the version specified in the ADR.

(5) Adopt the emission standards in the above nominated ECE and US standards which apply to vehicles operating on all of the fuels nominated in the standards (currently petrol, diesel, LPG and NG).

(6) Introduce the above new ADRs to take effect from 2002 for new models and 2003 for all models, except as outlined in Table 17 below.

From 2005

(7) Revise[22]:
   - the new light duty vehicle ADR to adopt UN ECE R83/04 (Euro 3 level); and
   - the new heavy duty ADR to adopt:
     - for diesel, NG and LPG vehicles, the replacement version of UN ECE R49, (at the Euro3 level) for all vehicle categories;
     - For petrol vehicles, the US 1998 standards for heavy duty petrol engines.

(8) Revise the new heavy duty ADRs to accept the US 1998 Heavy Duty Emission Standards as an alternative to the principal UN ECE standards in (2)

(9) Introduce the revised new ADRs to take effect from 2005 for new models and 2006 for all models, except as outlined in Table 17 below

Fuel

From 2002

(1) Reduction of the sulfur content of diesel fuel to 500ppm, initially in major urban areas.

From 2005

(2) Changes to fuel parameters required for Euro 3, based on the outcomes of the Fuel Quality Review and discussions with stakeholders.

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[21] To determine which vehicle categories fall within each of the ADRs refer to the Applicability Table on the next page.

[22] Smoke standards remain the same.

Table 17 Detailed description of new ADRs and associated implementation dates under the Preferred Option.

ADR Categories			Equivalent ECE Category	Applicable New ADR[23],[24]	Euro 2 Introduction	Euro 3 Introduction
Description	GVM (t)	Designation				
Passenger Vehicles						
Cars	Not Applicable	MA	M1	Light Duty	*Euro 2 – 2002/04*	*Euro 3 – 2006/07*
Forward Control	Not Applicable	MB	M1	Light Duty	*Euro 2 – 2002/04*	*Euro 3 – 2006/07*
Off-road	Not Applicable	MC	M1	Light Duty	*Euro 2 – 2002/04*	*Euro 3 – 2006/07*
Buses						
Light	≤ 5	MD	M2 ≤ 3.5	Light Duty	*Euro 2 – 2002/03*	*Euro 3 – 2005/06*
			> 3.5 ≤ 5	Heavy Duty	*Euro 2* (diesel, NG, LPG) & *US 96* (petrol) – 2002/03	*Euro 3* (diesel, NG, LPG) *US 98* (petrol) – *2005/06*
Heavy	> 5	ME	M3	Heavy Duty		*Euro 3 or US 98 – 2002/03*
Goods Vehicles (Trucks)						
Light	≤ 3.5	NA	N1	Light Duty	*Euro 2 – 2002/03*	*Euro 3 – 2005/06*
Medium	> 3.5 ≤ 12	NB	N2	Heavy Duty	*Euro 2 or US 94 (diesel,* NG, LPG*) & US 96 (petrol) – 2002/03*	*Euro 3 or US 98 (diesel,* NG, LPG*) & US 98 (petrol) – 2005/06*
Heavy	> 12	NC	N3	Heavy Duty		*Euro 3 or US 98 – 2002/03*

[23] The introduction of *Euro 2* and *Euro 3* standards will be via two new ADRs, one for light duty vehicles (adopting ECE R83) and one for heavy duty vehicles (adopting ECE R49 & US HDV standards). These new ADRs will replace ADR37/01 and ADR70/00.

[24] A new smoke standard will also apply to all categories of diesel vehicles. The smoke standard will apply from 2002/3 and will adopt UN ECE R24/03 and allow the US 94 smoke standards as an alternative. This new ADR will replace ADR30/00.

8. IMPLEMENTATION AND REVIEW

8.1 Vehicle Standards

The ADRs are national standards under the Motor Vehicle Standards Act 1989 and are therefore subject to complete review on a 10 year cycle.

The Memorandum of Understanding (MOU) between the National Road Transport Commission (NRTC) and the National Environment Protection Council (NEPC) sets out the consultative arrangements governing the development of ADRs for vehicle emission and noise. Under the MOU, the Motor Vehicle Environment Committee (MVEC) has been given the responsibility of managing the work program developed under the MOU, and this review of the emission standards is the highest priority item on the current work plan.

Under the legislation establishing the NEPC, any new emissions ADRs are to be jointly developed and agreed by the NRTC and NEPC, with formal endorsement being the responsibility of the Ministers of the Australian Transport Council. In addition, as the proposed new emission ADRs will be endorsed as standards under the Trans Tasman Mutual Recognition Arrangement, the approval of the Council of Australian Governments is also required.

The new ADRs will be given force in law in Australia by making them National Standards (ADRs) under the *Motor Vehicle Standards Act 1989*. They will be implemented under the type approval arrangements for new vehicles administered by the Federal Office of Road Safety. A manufacturer will be required to ensure that vehicles supplied to the market comply with the vehicle emission requirements of this package of ADRs. Penalties are incurred for non-compliance with the Motor Vehicle Standards Act.

The Preferred Option, if gazetted by the end of 1999, would provide sufficient lead time for manufacturers to submit certification documentation.

8.2 Fuel

The adoption of *Euro 2* standards in 2002 will require a reduction in the sulfur content of diesel fuel to 500ppm, initially in the major urban areas. The adoption of *Euro 3* in 2006 will require changes to fuel parameters, based on the outcomes of the Fuel Quality Review and discussions with stakeholders.

There is currently no mechanism for setting national fuel standards. This has been recognised by the National Environment Protection Council (NEPC) and MVEC. MVEC will need to discuss the most effective way to deliver the desired fuel with the petroleum industry. Implementation methods could include a National Environment Protection Measure or a memorandum of understanding between the petroleum industry and the Government.

8.3 Other

The review of the emissions standards raised a number of other issues which need to be addressed by the Motor Vehicle Environment Committee. These include the reduction in petrol volatility and an analysis of *Euro 4* standards with a view to determining the costs and benefits of introducing these standards in the future.

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ATTACHMENT A - COMPARATIVE ASSESSMENT OF CURRENT AND PROPOSED STANDARDS

LIGHT DUTY VEHICLES

Comparison of Current Standards with *Euro 2* and *Euro 3* Requirements

The attached Tables summarise the differences in emission limits, test procedures and other requirements of the *Euro 2* and *Euro 3* standards, with the current ADR provisions for "light duty vehicles".

Currently the relevant ADRs dealing with emissions from light duty vehicles (includes cars, 4WDs and light commercials) are:

- **ADR37/01** (petrol engined vehicles ≤ 2.7 tonnes gross vehicle mass [GVM])
- **ADR36/00** (petrol engined vehicles > 2.7 t GVM, includes some vehicles treated by UN ECE system as light duty *ie ≤3.5*t)
- **ADR70/00** (all diesel engined vehicles).

TABLE A1 - EMISSIONS REQUIREMENTS FOR CARS

Standard & Date of Application at Source	Absolute Emission Limits (g/km)					Emissions Test		Other Requirements
	Cars < 2.5t [25]					Exhaust	Evaporative	
	CO	HC	NOx	PM[26]	Evap			
ADR37/01 (1997-9)	2.1	0.26	0.63	NA	2	US EPA Federal Test Procedure (FTP) from 1975	US EPA 2 hr "SHED"[27] Test from 1975	80,000km durability requirement.
Euro 2 [28] (1996)	2.2	0.28	0.22	0.08	2	Comparative testing on FTP & Euro cycles indicates mixed results on CO, E2 tougher on HC for most vehicles, and E2 much tougher on NOx for locally produced US based engines.	Equivalent to ADR37/01	80,000km durability requirement.
Euro 3 (2000)	2.3	0.2	0.15	0.05	2	E3 test more stringent than E2 as sampling starts from ignition (40s delay in E2). Comparative testing on E2 and E3 cycles indicates it makes CO and HC emission limits harder to meet, variable impact on NOx. ACEA[29] claim E3 leads to effective reduction in CO, HC and NOx emission limits of 30%, 40% & 40% respectively.	Significantly more stringent test with canister loading and conducted over 24 hrs. ACEA estimates equate to an 80% increase in stringency on the E2 limits.	80,000km durability requirement. OBD[30] requirement (initially for petrol vehicles only, phased in for diesels over 2003-2006) Separate -7^{o}C emissions test for HC & CO emissions (from 2002)

25 More relaxed limits apply for vehicles greater than 2.5t and less than 3.5t, see separate table.

26 Diesel vehicles only

27 Sealed Housing Evaporative Determination.

28 For *Euro 2* there is a combined limit for HC+NOx, split figures assume a ratio of 55:45 (HC:NOx)

29 European Automobile Manufacturers Association (ACEA)

30 On Board Diagnostics.

Table A2 - Emissions Requirements for 4WDs and Light Commercial Vehicles (LCVs)

Standard	**Emission Limits** **(g/km - unless otherwise specified)**
	Cars > 2.5t & LCVs - up to max 3.5t (Euro & ADR70/00) **4WDs and LCVs ≤ 2.7t (ADR37/01)** **4WDs & LCVs > 2.7t (ADR36/00)**

	CO	HC + NOx	HC	NOx	PM	Evap
ADR37/01 *ADR36/00* *ADR70/00**	6.2 1% by vol 58-110g/test**	NA NA 19-28g/test**	0.5 180ppm NA	1.4 NA NA	NA NA NA	2 NA 2
*Euro 2*** Petrol Diesel	 2.2 or 4.0 or 5.0 1.0 or 1.25 or 1.5	 0.5 or 0.6 or 0.7 0.7 or 1.0 or 1.2	 NA NA	 NA NA	 NA 0.08 or 0.12 or 0.17	 2 NA
*Euro 3*** Petrol Diesel	 2.3 or 4.17 or 5.2 0.64 or 0.8 or 0.95	 NA 0.56 or 0.72 or 0.86	 0.2 or 0.25 or 0.29 NA	 0.15 or 0.18 or 0.21 0.5 or 0.65 or 0.78	 NA 0.05 or 0.07 or 0.1	 2 NA

* Diesel vehicles only, *Euro 1* requirements.

** Limits depend on the mass of the vehicle.

*** For *Euro 1* and *Euro 2* there is a combined regulated limit for HC+NOx, EU assume a ratio of 55:45 (HC: NOx)

Key conclusion on Petrol Engined 4WDs and LCVs

While the above picture is complex, *Euro 2* provides significant improvements over current standards for 4WDs and LCVs because:

- All vehicles ≤ 3.5 t GVM subject to same emissions test as cars (currently vehicles > 2.7 t are only required to be tested under ADR36/00, which is a much simpler test than ADR37/01)
- E2 Emission limits (particularly NOx) are tighter than ADR37/01 and ADR70/00, even the most lenient ones
- E2 sets limits on NOx for those vehicles currently exempt from any NOx requirement under ADR36/00
- E2 sets limits on PM for those vehicles currently exempt from any PM requirement under ADR70/00

Heavy Duty Vehicles

Comparison of Current Standards with *Euro 2* and *Euro 3* Requirements

The attached Table summarises the differences in emission limits, test procedures and other requirements of the *Euro 2* and *Euro 3* standards, with the current ADR provisions for “heavy duty vehicles”. The comparability of the US EPA’s heavy duty standards is also covered.

Currently the relevant ADRs dealing with emissions from heavy duty vehicles (includes trucks and buses) are:

- **ADR36/00** (petrol engined vehicles > 2.7 tonnes gross vehicle mass [GVM])
- **ADR70/00** (all diesel engined vehicles).

Table A3 – Emission Requirements for Heavy Duty Vehicles

Standard & Date of Application at Source	Absolute Emission Limits (g/kWh) (unless otherwise specified)				Emissions Test	Other Comments
	CO	HC	NOx	PM		
ADR36/00 (petrol) (1979) *ADR70/00 (diesel)*[31] (1995-6)	1% by vol 4.5	180ppm 1.1	NA 8.0	NA 0.36	9 mode steady state engine dynamometer test 13 mode steady state engine dynamometer test	ADR36 reflects 1974 US EPA standards for heavy duty petrol engines. US EPA 91 diesel limits at least as stringent as *Euro 1,* although US uses transient test, so not directly comparable
Euro 2 (1996-1998)	4.0	1.1	7.0	0.15[32]	13 mode steady state engine dynamometer test	ECE/EU has no standards for heavy duty petrol engines (>3.5t). US EPA 94 diesel limits at least as stringent as *Euro 2,* but derived from US transient test so not directly comparable.
Euro 3 (2000) *ESC Limit* *ETC Limit*	 2.1 5.45	 0.66 0.78[33]	 5.0 5.0	 0.10[34] 0.16[35]	Manufacturers have choice of 2 new test cycles[36]: Euro Stationary Cycle (ESC); or Euro Transient Cycle (ETC)	US EPA 98 diesel limits similar to *Euro 3* but derived from US transient test, so not directly comparable. US expected to adopt Euro Stationary Cycle as additional requirement to the transient test sometime in 1999.

31 ADR70/00 allows compliance with ECE/EU standards, US EPA and Japanese Standards, the ECE (*Euro 1*) limits are used here as the basis for comparison.

32 Original *Euro 2* limit for PM was 0.25, which was reduced to 0.15 in 1998.

33 non-methane hydrocarbons

34 smaller engines are subject to more relaxed PM limits of 0.13 (ESC)

35 Smaller engines are subject to more relaxed PM limits of 0.21 (ETC).

36 *Euro 4* will require both tests to be met.

ATTACHMENT B - DESCRIPTION OF OPTIONS

Option 2A - Adopt *Euro 2* in 2002

Vehicles
- Amend ADR37/01 as soon as possible to incorporate UN ECE R83/03 (*Euro 2* and *Euro 3* levels) as an alternative standard
- *Euro 2* by 2002 for new models, 2003 for all models
- *US94* HDV standards accepted as an alternative for HDVs (petrol and diesel above 3.5 tonnes)
- Smoke standards in ECE 24/03 apply to diesels, with *US 94* smoke standards accepted as alternative for HDVs over 3.5 tonnes
- Emissions standards apply to all vehicles operating on all fuels nominated – currently petrol, diesel, LPG and NG
- Acceptance of later versions of the nominated standards, provided they are demonstrated to be no less stringent than the version specified in the ADR

Fuel
- Reduction of the sulfur content of fuel to 0.05%

Option 2B - Adopt *Euro 2* in 2002, followed by *Euro 3* in 2006

Vehicles
- Amend ADR37/01 as soon as possible to incorporate UN ECE R83/03 (*Euro 2* and *Euro 3* levels) as an alternative standard

From 2002
- *Euro 2* by 2002 for new models, 2003 for all models
- *US 94* HDV standards accepted as an alternative for HDVs (petrol and diesel above 3.5 tonnes)
- Smoke standards in *ECE 24/03* apply to diesels, with *US 94* smoke standards accepted as alternative for HDVs over 3.5 tonnes
- Emissions standards apply to all vehicles operating on all fuels nominated – currently petrol, diesel, LPG and NG
- Acceptance of later versions of the nominated standards, provided they are demonstrated to be no less stringent than the version specified in the ADR.

From 2005
- *Euro 3* by 2005 for new models, 2006 for all models
- *US 98* HDV standards accepted as an alternative for HDVs (petrol and diesel above 3.5 tonnes)
- Smoke standards in ECE 24/03 apply to diesels, with *US 98* smoke standards accepted as alternative for HDVs over 3.5 tonnes
- Emissions standards apply to all vehicles operating on all fuels nominated – currently petrol, diesel, LPG and NG
- Acceptance of later versions of the nominated standards, provided they are demonstrated to be no less stringent than the version specified in the ADR.

Fuel

From 2002

- Reduction of the sulfur content of diesel fuel to 0.05%

From 2005

- Changes to fuel parameters based on the outcomes of the Fuel Quality Review and discussions with industry

Option 2C - Adopt Euro 3 in 2002

Vehicles

- Amend ADR37/01 as soon as possible to incorporate UN ECE R83/03 (*Euro 2* and *Euro 3* levels) as an alternative standard
- *Euro 3* by 2002 for new models, 2003 for all models
- *US 98* HDV standards accepted as an alternative for HDVs (petrol and diesel above 3.5 tonnes)
- Smoke standards in ECE 24/03 apply to diesels, with *US 98* smoke standards accepted as alternative for HDVs over 3.5 tonnes
- Emissions standards apply to all vehicles operating on all fuels nominated – currently petrol, diesel, LPG and NG
- Acceptance of later versions of the nominated standards, provided they are demonstrated to be no less stringent than the version specified in the ADR.

Fuel

- Reduction of the sulfur content of diesel fuel at least to 0.05%, possibly lower
- Other changes to fuel parameters may also be required (need to base on the outcomes of the Fuel Quality Review (2000))

ATTACHMENT C

Draft Final Report on the Project to Estimate the Emissions Impacts and Cost Effectiveness of the Adoption of Euro 3 Emission Standards

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For the

Motor Vehicle Environment Committee

March 1999

Draft Final Report on the Project to Estimate the Emissions Impacts and Cost Effectiveness of the Adoption of Euro 3 Emission Standards

Introduction

This report is the delivery of a contract to the Federal Office of Road Safety. Earlier work undertaken by the author had been incorporated in the ACVEN report into the review of ADR-37/01 as part as an SAE submitted report. This earlier work had examined the impact of six scenarios of possible emission standards on the passenger car emission source input into the Melbourne airshed. This work had excluded examination of the European Year 2000 standard commonly known as Euro 3.

This report extends to the earlier work to include Euro 3 projections and cost benefit analysis.

Objectives

The objective of this project is to obtain reliable estimates of the emissions and cost effectiveness of the adoption in Australia of Euro3 Standards relative to Euro2 and US EPA Tier 1 Standards.

Scenarios

The following four scenarios will be embodied in the presentation of emissions projections and the cost effectiveness of the following scenarios:

Introduction of US Tier 1 Emission Standards for All New Passenger Cars from 2002

Introduction of Euro2 Emission Standards for All New Passenger Cars from 2002. It will be seen that this objective evolved into 2 scenarios.

Introduction of Euro2 Emission Standards for All New Passenger Cars from 2002 followed by the Introduction of Euro3 Emission Standards for all New Passenger Cars from 2006

Introduction of Euro3 Emission Standards for All New Passenger Cars from 2002

Emission Standards

The following Table 1 identifies the ADR37/00 & 001 Standards as well as the ECE Euro 2 and Euro 3 Standards. It should be restated that the test procedure for the Euro procedures is different from that for ADR37. In addition it should be noted that there is a variation in the procedure between Euro 2 and Euro 3 in including the first forty seconds of engine operation in Euro 3 which is omitted in Euro 2. The significance of this will have particular consequence to HC and CO emissions and to a lesser extent on NOx and almost no impact on fuel consumption. This is because emissions produced during the starting and warm up period are included in the Euro 3 measurement process, as they have always been included in the ADR37 procedure.

Table 1 Regulated and proposed emission standards

	HC g/km	CO g/km	NOx g/km
ADR 37/00	0.91	9.4	1.93
ADR 37/01	0.25	2.11	0.63
Euro 2	0.25*	2.2	0.25*
Euro 3	0.2	2.3	0.15
Euro 4	0.1	1.0	0.08

* Assumed split, HC + NOx = 0.5

Emissions Projections for Melbourne

Conversion Factors

An extensive search of the published literature has been undertaken to identify if there are possible conversion factors that are relevant to the present task. The search has been both library sourced and Internet based. All of the references were found in US and European literature, apart from the recently produced FORS project data. However, there are issues of vehicle type and size mix being different in Europe and the US from Australia. It would be fair to say that with respect to the specific task of conversion factors for ECE/US FTP, the only data that was found in the search was an SAE paper written by Environment Canada, and subsequent investigation revealed that this was based on the ECE15, rather than Euro 2, test cycle that includes the extraurban driving cycle. Other data is available in documents provided by industry and testing agencies using European or Japanese market cars.

By delaying the submission of this report by one week it has been possible to increase the FORS data base from the 5 car test data used in the interim report to that for 19 cars (however only 16 were used). It is this data base that was judged to be the most relevant for the task of these projections because:

- the cars were ones sold into the local market
- the data were obtained on the same equipment at the Ford Emission laboratory used in part of the baseline study (see below)
- the raw data were available for error checking if questionable results were found

In addition to establishing conversion factors for Euro 2 to US procedures on which ADR37 has been based, there has been an endeavour to relate production vehicle performance in Euro 2 specification to Euro 3 performance to determine the effect of the change in test procedure.

The data base used by the author in preparation of the 1997 SAE's submission to ACVEN was based on measurements made to ADR37 on vehicles tested by the various EPAs and from the FORS 600 car study (FORS, 1996). The range of conversion factors from Euro 2 (ECE 94/12) to ADR 37 test method are found in Table 2

Table 2 ECE Euro 2 to ADR 37 conversion factors

	HC	CO	NOx	HC +NOx
JAMA	1.612	1.69	1.28	1.41
FCAI	1.48	1.56	1.05	
ACEA		1.40		1.32
FORS 16 cars	1.632	1.271	1.330	

The data used in the 1997 SAE projections for Euro 2 were those provided by JAMA.

Discussion of Euro 2 to Euro 3 conversion factors

There are five major differences between the Euro 2 and the Euro 3 standards:

- the values of allowable emissions as given in Table 1
- the inclusion of emissions in Euro 3 from engine cold start. (In Euro 2 there is a pre-test 40 second idle which is eliminated in Euro 3)
- a production conformity requirement.
- an OBD (on board diagnostic) requirement.
- more stringent evaporative emission procedure.

The second point not only has a major influence on the emissions quantity, the deliberate exclusion of cold start emissions has an influence on environmental impact.

In the analysis which follows, these excluded emissions are included in the estimation of the air-shed inventory of car emissions in the following way:

Euro 3 is taken as the base Euro case. Euro 2R (R = real) is introduced which:

- factors in the excluded amounts, since they are emitted to the environment, and
- allows for the difference in the values required by the standard as given in Table 1 assuming that HC = NOx for Euro 2 as suggested in the table.

Table 3 Ratios of Alternative test cycles to ADR 37 and Euro 3 to Euro 2

	HC	CO	NOx
Euro 2/ADR 37*	1.639	1.271	1.330
PREVIOUS Eu2 (JAMA)	1.612	1.690	1.280
Euro 3/ADR 37*	2.034	2.071	1.571
AUC/ADR 37*	2.157	2.898	1.668
Euro 3/Euro 2*	1.241	1.629	1.181
Eu3/Eu2 (UK data source)	1.227	1.725	1.227

* from FORS data (Source private communication from Jon Real)

The current 19 car FORS data is summarised in Appendix A. By reducing this data set to 16 cars, all able to comply with ADR 37/01 and Euro 2 as tested the outlier cars were eliminated as described in the Appendix.
It can be seen that the Euro3/Euro2 compares favorably with a UK confidential source of data.
These data are presented graphically in figure 1.

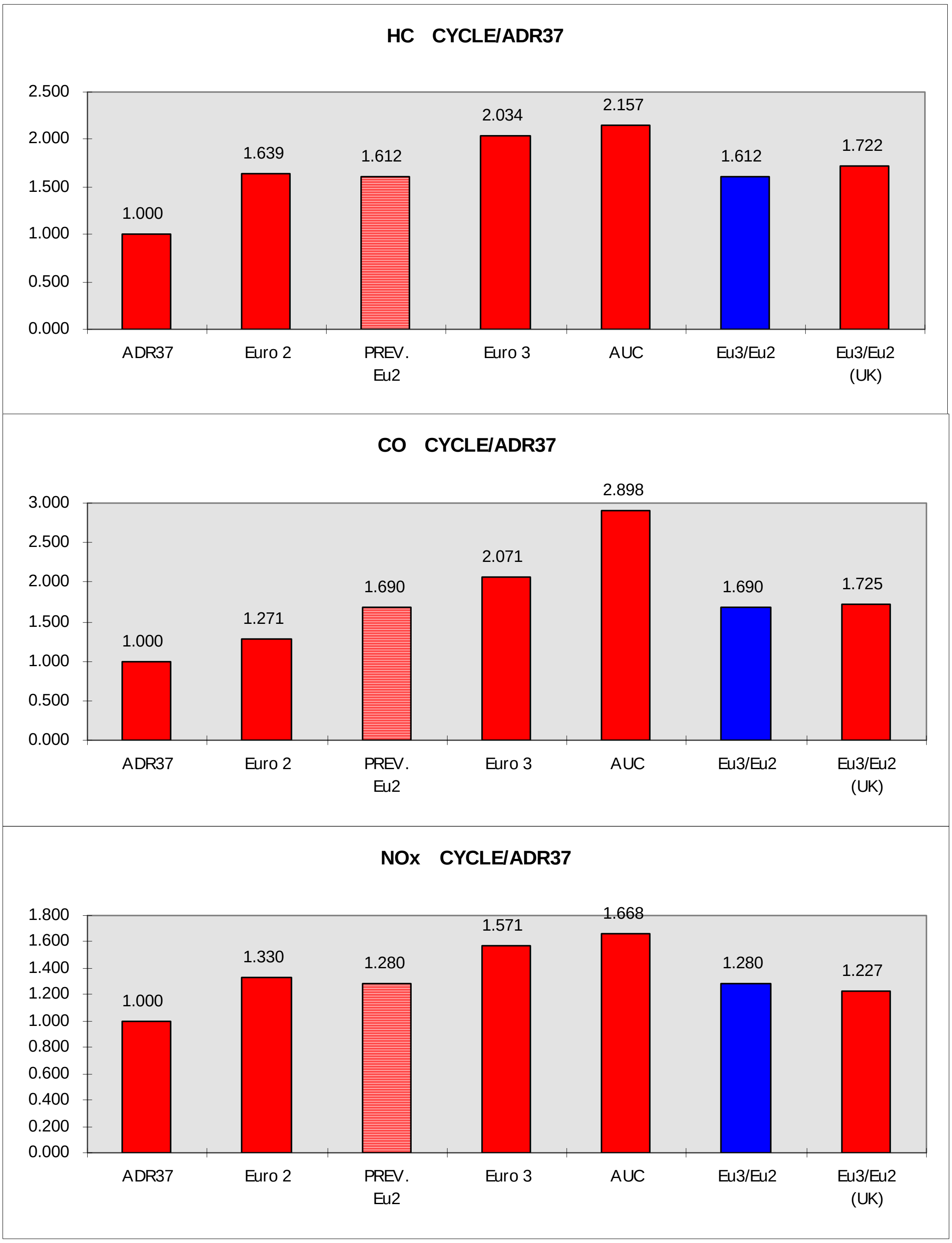

Figure 1 Drive cycle ratios for 16 car data set.

In Service Performance

The simulations carried out here make assumptions about the deterioration slope of the in service vehicles. This can be described as the initial emission rate of the new vehicle and the emissions rate at the 80,000km certification point for the test procedures. Based on the Australian 600 car study data obtained from the FORS report in the submission to ACVEN (SAE report) it was argued by sensitivity analysis that an initial emission rate of 0.5 times the standard and a rate at 0.9 times the standard at 80,000km were conservative values. Only one of the scenarios examined in the sensitivity analysis had a slightly higher emissions rate than this scenario.

It follows that in this work it has been assumed that Euro 2 vehicles would emit according to the 0.5 - 0.9 factors and that Euro 3 vehicles would do slightly better (a 20% reduced deterioration (based on Californian experience)) because of the OBD facilitating repair of emission defective systems. It has been suggested that the deterioration of Euro 2 emissions may be faster than ADR37/00. However, it is the authors view that the industry would continue to be inherently conservative about catalyst loadings and the like, since it would not wish to be caught in a major recall program if there was to be shown a consistent failure of its emission systems. This is evidenced by the fact that in the ADR37/00 vehicles surveyed by FORS in the 600 car study, there were only 4 vehicles that required catalyst replacement.

If however the 0.5 - 0.9 factors are not acceptable further work could be undertaken with different factors.

There is an additional issue that needs to be considered: as mentioned above, the Euro 2 test omits the first forty seconds of engine operation in the exhaust gas analysed. This omitted gas contains high concentrations of HC and CO as the cold engine is started. This omission may be explained as compensation for later hot restarts of the engine in real-world conditions, but not included in the test procedure. From the environmental standpoint, it is the cold start, in the 6 to 10 am period that is most influential in providing photochemical smog precursors. Therefore, this forty seconds should be included in emissions inventory calculations, either entirely or partially (if some proportion of hot starts is to be included). As explained in Appendix A this can be done with only small approximation by correcting the Euro 2 estimated car emission data by a Euro 3/Euro 2 factor for each pollutant. This scenario is called Euro 2R (R= real). In the source projections which follow, the entirely cold start scenario is included for the Euro 3 implementation in 2002.

Projections of Car Emissions in the Melbourne Airshed

The calculation of emissions within a given region or airshed is an established method. It involves for each vehicle in the fleet, calculating its emissions, allowing for deterioration in performance with distance travelled, and estimating: the change in annual distance driven with age; the difference in emission rates from the standard test expected in-service; the probability of the vehicle being scrapped from the fleet during the course of a particular year's operation; and the introduction of new vehicles into the fleet to new owners and to replace those scrapped. The details of the method are presented in Appendix B and this is supported by a graphical representation in figure B.1 of the process which shows the general trends of the variables used in the calculation and their dependence upon year or distance driven by the vehicle.

There are some limitations of this method since they calculate the global input into a given region, in this case the Melbourne statistical district. It is possible that traffic congestion may cause the saturation of vehicle emission inputs into particular regions, thus limiting local emission source into areas which may be significant in the later-in-the-day pollution, for example, the formation of ozone. Also, it is possible that the growth of new suburbs in the city causes an extension of the corridors over which critical parcels of air pass, collecting the emissions that cause the ozone problem. In this simple analysis it is assumed that the city grows in a homogeneous way.

In addition to the uncertainties associated with the nature of the source area and distribution, just described, there are also other uncertainties of similar or greater magnitude, particularly the in-service deterioration performance already mentioned, the variability of vehicle sales according to the state of the economy, and the growth of population, and several other variables. Thus, it is the nature of any projection work that these uncertainties need to be recognised. With further effort sensitivity analysis can be undertaken to quantify the effects of likely variance in these parameters, but that is not part of the work delivered here.

Results

The graphs which follow in figures 2 to 4, for projections of the passenger car source of Melbourne's emissions, allow comparison of ADR37/01 with US Tier 1 implementation in 2002, Euro 2 (and Euro 2R) in 2002, and Euro 2R in 2002 followed by Euro 3 in 2006 and the last scenario, Euro 3 implementation in 2002. All Euro 3 simulations assume that the OBD effect is a 20% reduction in the rate of emission deterioration with age. This only has a small effect on the results by 2015 (of the order of 5 to 7% extra reduction). The results for the projections for year 2015 are summarized in Table 4.

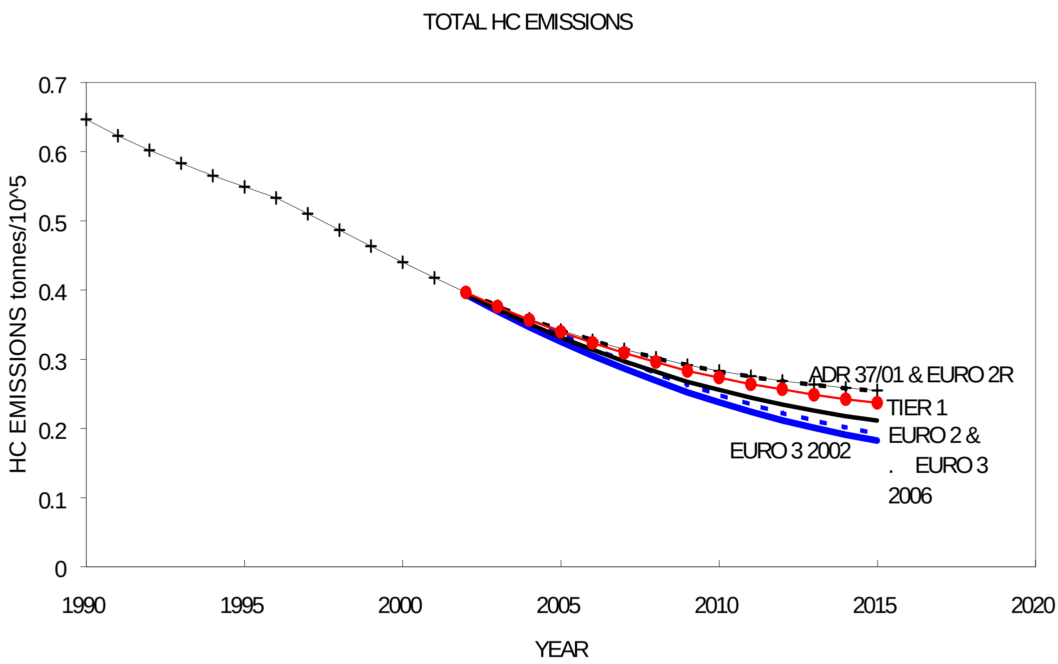

Figure 2 Total (exhaust, evaporative and crankcase)HC projections for the Melbourne airshed.

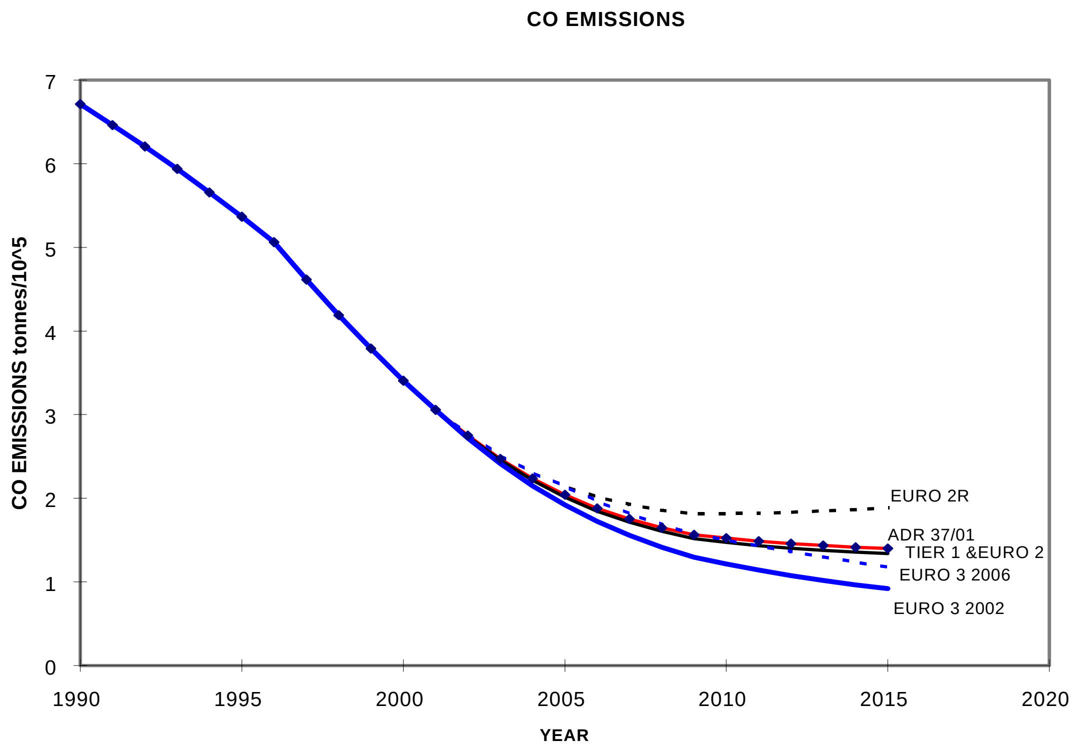

Figure 3 CO projections for the Melbourne airshed

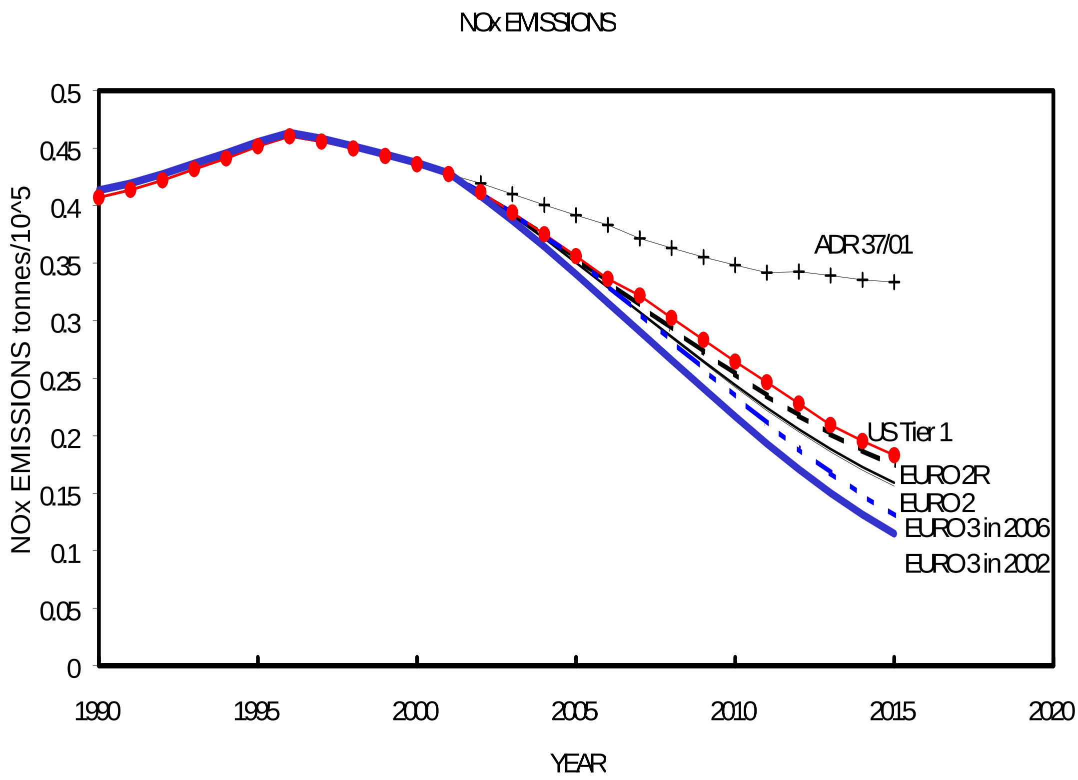

Figure 4 NOx projections for the Melbourne airshed.

Table 4 Projected values for the passenger car input to the airshed under four scenarios for the year 2015

	HC ktonnes	CO ktonnes	NOx ktonnes
ADR 37/01	25.50	1550	33.3
US Tier 1	23.71	1399	18.32
Euro 2 only in 2002	21.13	1389	15.61
Euro 2R (incl. 40 s) only in 2002	25.43	1884	17.43
Euro 2R in 2002 & Euro 3 in 2006	19.25	1176	13.06
Euro 3 in 2002	18.23	919	11.47

Euro 3 Cost Analysis

The cost analysis is performed in Appendix C. At the foot of Table C.2 there is found a relative narrow band of average costs of Euro 3 technology over that of Euro 2. It may be that the findings of the three European documents are interlinked by coming from a common source. However, costs from present development of Euro 3 technology for implementation next year seems to support the other reported values.

It is concluded that, excluding the costs of Euro 3 evaporative emission control requirements, that an average price increment range of $300 to $700 will occur. This is added to the Euro 2 costs previously presented by the FCAI in their submission to ACVEN.

Table 5 Projected costs per new vehicle sold of the emission control options presented in $Aus

	ADR 37/01	US Tier 1	Euro 2	Euro 3	Euro 3 inc Evap
Low	0	500	350	725	775
High	0	650	500	1125	1200

These values have been used to compute the range of emission control costs presented in Table 6.

Summary Conclusions

Reported here is the process for obtaining estimates of the emissions source from petrol fueled passenger cars and derivatives in Melbourne and the costs of the adoption of Euro3 Standards relative to Euro2 and US EPA Tier 1 Standards. The values of cost per mass emission reduction are presented in Table 6.

Table 6 Estimates of the cost per mass of emission reduced

	Scenario	US Tier 1	Euro 2	Euro 2R	Euro 2R/3 2006	Euro 3
m$/ktonne HC	Low	115	28	1893	41	36
	High	149	41	2704	62	55
m$/ktonne NOx	Low	12.4	7.13	7.96	11.69	12.13
	High	16.12	10.19	11.38	17.68	18.57
m$/(ktonne HC+NOx)	Low	11.19	5.7	7.93	9.09	9.08
	High	14.54	8.15	11.33	13.75	13.90

The emission reductions used for the Table 6 calculations are the cumulative emissions change for the period 2002 to 2015. This is a more accurate evaluation than using the emission in year 2015 alone. The incremental vehicle costs are the sum for all the vehicles sold in the period 2002 to 2015 inclusive (2.55 million).

In preparing Table 6 the range of costs from Table 5 and are assumed constant for the period. In the first four rows the costs are attributed to each tonne of the individual (HC or NOx) emissions reduced even though the same investment simultaneously reduced all emissions. As CO emissions are unlikely to be of concern in any Australian city they are excluded from this presentation. In the last two rows it has been assumed that HC and NOx are equally harmful and may be added without weighting factors.

The results show that scenario Euro 2 is likely to be the most cost effective of all the scenarios on a cost benefit basis. However, Euro 2 ignores emissions during the first 40s of engine operation. When corrected for this in Euro 2R scenario the cost for HC control is very high. However, in the combined HC + NOx analysis Euro 2R is more cost effective than either of the Euro 3 analyses.

The Euro 3 scenarios, Euro 2R in 2002 and Euro 3 in 2006, and Euro 3 in 2002, are equally cost effective, but more expensive than Euro 2R alone, particularly as judged by the combined HC + NOx values. If only NOx control is needed then the Euro 2R in 2002 and Euro 3 in 2006 scenario would be preferred.

The reader is reminded that the emission reductions forecast are strongly dependent on the use of US/ECE test conversion factors based on a small amount of data 16 cars from the current 50 car test program. Not only are the conversion factors important but the HC/NOx ratio has been assumed as 1/1 in the Euro 2 analysis, since the ECE regulation (directive) refers to emissions of HC+NOx of 0.5 g/km. The 16 cars tested do not have a 1/1 HC/NOx.

It is recommended that this report might be updated at the completion of the FORS test program and the presentation reworked using a more representative HC/NOx ratio.

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Appendix A

ANALYSIS OF 19 CAR FORS DATA

The in-progress test of 50 representative cars to various test cycles has been analysed at a time when the data for 19 cars was available (Private communication from Jon Real of FORS).

If valid comparison is to be made of the relative environmental impact of cars developed to different emission standards, an ideal experiment would include back-to-back tests of individual car models developed by the manufacturer to be compliant with each standard. It is unlikely that more than a few such models could be sourced from the world market. An alternative, but with some compromise would be to test vehicles that were compliant with both (ADR37/01 and Euro 2). ADR37/01 and Euro 3 comparison is unlikely to be relevant since Euro 3 is a much more stringent standard as specified in the standard's emission numbers and in real technical difficulty in compliance.

To date, only a few of the manufacturer's cars that have been tested in the FORS program have been sanctioned by the manufacturer as Euro 2 compliant, (as current models they are all ADR37/01 compliant with one exception - an ADR37/00 Ford Falcon). To proceed with this analysis, 16 cars have been selected as vehicles which meet both ADR37/01 and Euro 2. There were five cars that also met (marginally in some cases) Euro 3. All of these were imports.

The following tables show the 16 cars emissions rates, and the fraction of the emission standard. It is clear that the fleet average was well under (20 to 40%) the ADR37/01 standard, and at 47 to 70% of the Euro 2 standard,

Table A.1 16 car emissions to ADR 37 test

	HC	CO	NOx
Emissions g/km	0.08	0.81	0.13
Fraction of ADR 37/01 standard	0.30	0.39	0.21

Table A.2 16 car emissions to Euro 2 test

	HC	CO	NOx
Emissions g/km	0.12	1.03	0.17
Fraction of Euro 2 standard*	0.49	0.47	0.70

Assumes HC = NOx for standard

Table A.3 16 car emissions to Euro 3 test

	HC	CO	NOx
Emissions g/km	0.15	1.68	0.21
Fraction of Euro 3 standard	0.77	0.73	1.38

The assumption made in this work that all new cars meet 50% of ADR and Euro 2 standard rates is seen to be true for all emissions except Euro 2 NOx.

Appendix B

EMISSION PROJECTION METHODOLOGY

Mathematical formulation

Whilst there exist several methods for estimating the future demand for transport fuels or exhaust emissions it is usual to project the growth of cities (urban airsheds) or the country as a whole based on the expected population growth and to use vehicle ownership trends to estimate the likely vehicle population.

The growth of the vehicle population has been assumed to be represented by a non-linear relationship with time. This will vary from city to city depending upon vehicle ownership, the geographic location of the city in generating inter city travel by road, economic factors influencing discretionary travel and the availability of alternative transport means and so on. It has been found that for cars and derivatives in Australia this approach produces a simple time series relation.

For three Australian cities studied (Watson 1992), the relation for the population P of vehicles using fuel type j is of the form

$$P_j = (a + b*year)^{0.5}$$

From a projection of the vehicle population growth, vehicle sales can be derived once data are provided on the car scrappage or the survival rate. Thus if the market for vehicle type j in model year i is N_{ij}, then those sold in that year will be:

$$n_{ij} = N_{ij} - N_{(i-1)j} + \underset{all_i}{\underline{SUM}} \{p_{iyj}\}$$

where n_{ij} is number of vehicles of type j sold in model year i

p_{iyj} is the proportion of vehicles made in model year i and scrapped in year y. Typically 25 historical years are included in the analysis for a current year.

The scrappage rates p_{iyj} are found from the Australian Bureau of Statistics Surveys of Motor Vehicle Use over the period 1971-1991. The form of these functions may be found in Appendix A of Watson (1991). The p_{iyj} functions are calculated on a regional basis e.g. the Melbourne Statistical District in this instance, and have been found to change with time as depicted in figure B.1 as the median age of the fleet has extended from 13.5 years in 1976 to 16 years in 1988. This trend is extrapolated into the future.

The equation for the emission of type e, or fuel consumption of the total vehicles of type j (cars or trucks) in year y is, from Watson et al. (1981):

$$F_{je} = \underset{all_i}{\underline{SUM}} \{n_{ij}.s_{iyj}.v_{iyj}.f_{ije}.c_{iyje}\}$$

where s_{iyj} is the proportion of vehicles of model year i not scrapped (i.e. surviving) by year y (= 1- p_{iyj})

v_{iyj} is the km of travel in year y by the vehicles of model year i

f_{ije} is the emission or fuel rate of the model year i

c_{iyje} is the correction factor for the difference between the measurement process according to ADR37 or AS2877 and real world emission or fuel consumption.

The form of the v_{iyj} with the age of the car may be found in Appendix A of Watson (1991), where it is shown that old cars travel less than half the distance per year covered by new ones. A sketch of the form of this relation found in figure B.1.

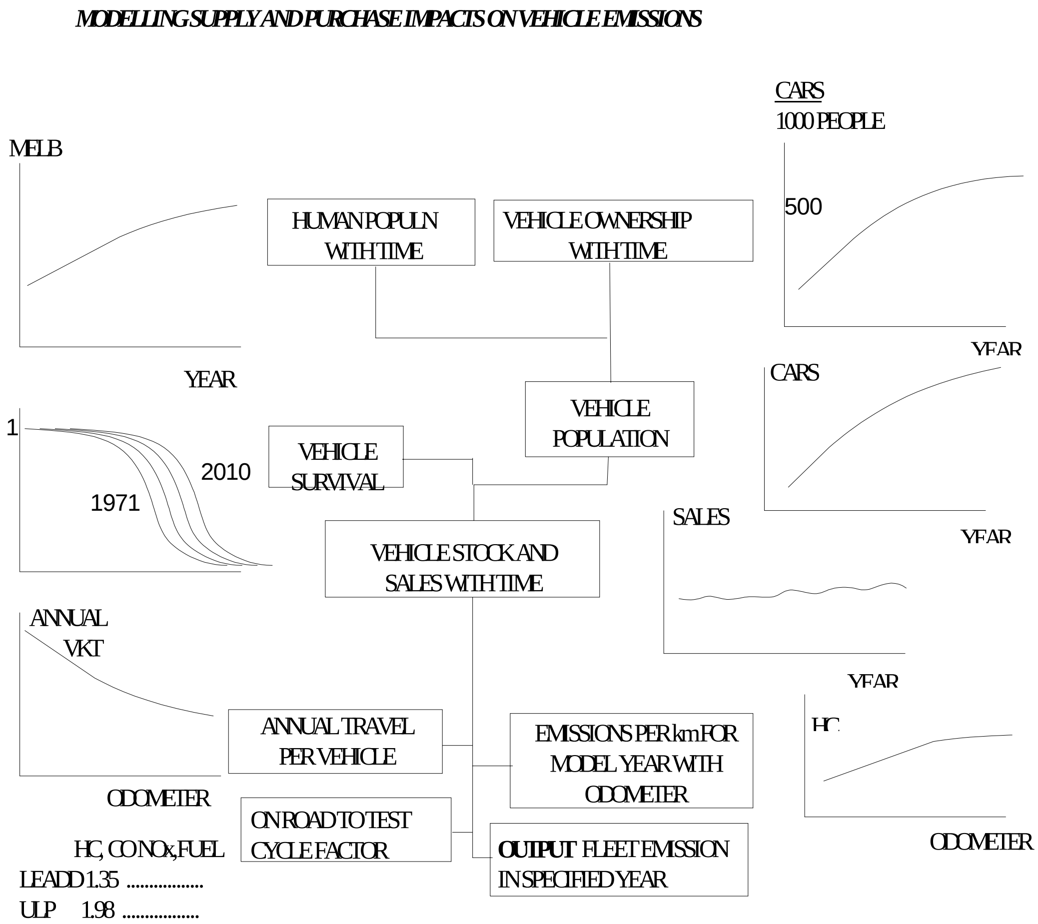

Figure B.1 Forms of the relationships used in the simulations

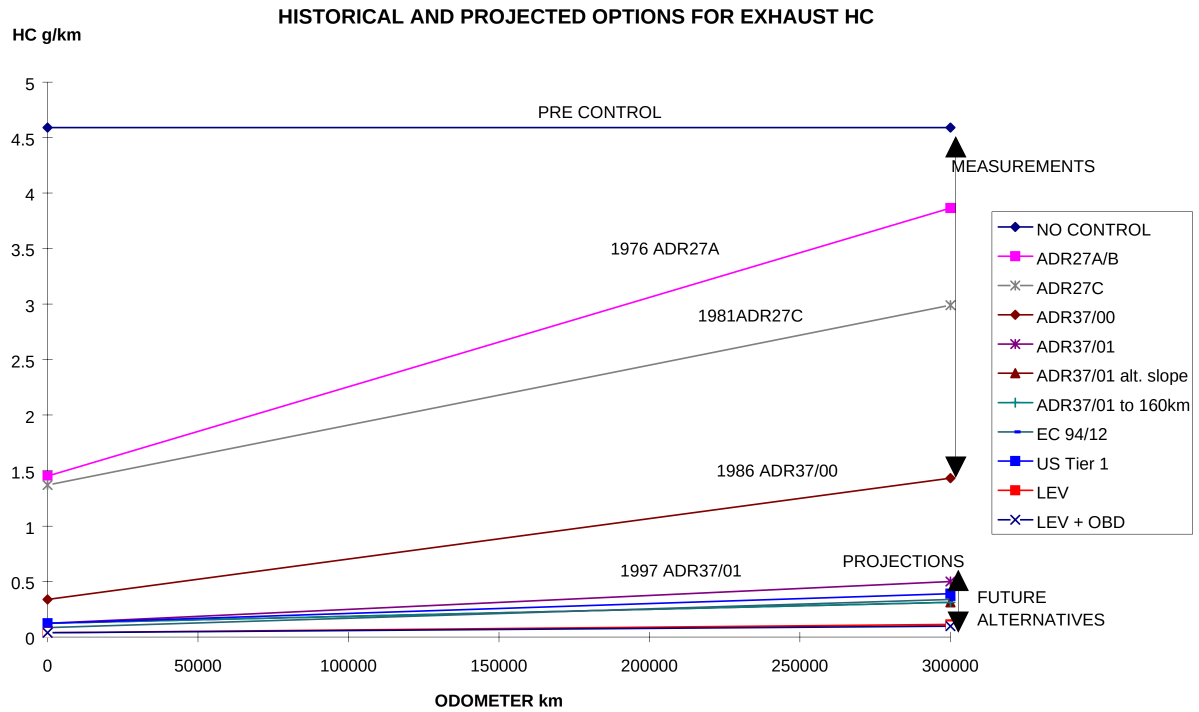

Figure B.2 Per vehicle HC emissions as measured for the historical fleet and predicted for the range of scenarios covered in the SAE Report (Watson, 1997) .

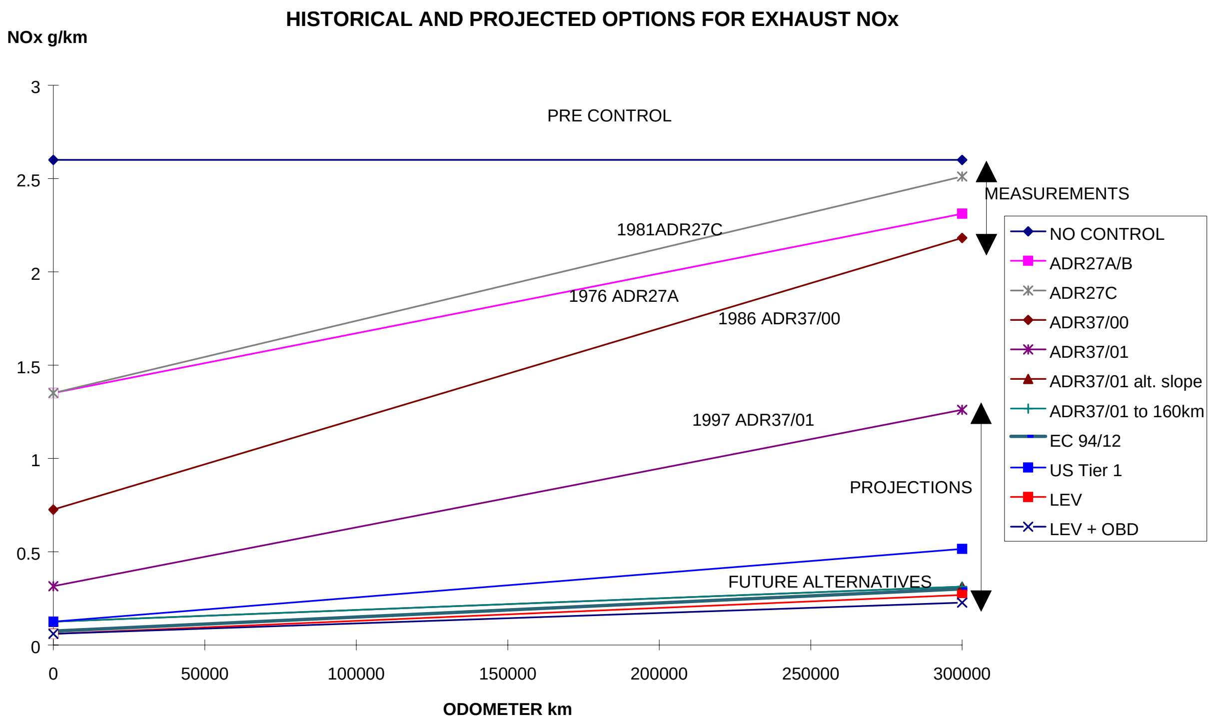

Figure B.3 Per vehicle NOx emissions as measured for the historical fleet and predicted for

Appendix C

EURO 3 COST ANALYSIS

The procedure adopted for determining the cost of moving from Euro 2 to Euro 3 has been to carry out a literature search of the available American and European databases, which reflect the published information in a number of journals and institutions. About 45 papers were extracted from this literature search of which 8 were obtained. However, although potentially there was information on the effect of changing technology none of the cost data presented yielded values that were suitable for the present study in which it would be desirable to reflect the Euro 2 and Euro 3 cost penalty across several vehicle classes.

The data that have been useful have been obtained by other means. Primarily from data supplied by FORS, and the author's personal contacts, in Europe.

Table C.1 Data extracted for large (upper medium) car conversion costs to various levels of emission reduction from a Euro 1 base, converted to $Aus

	Touche - Ross Study (1995)	
	Scenario 2	Scenario 3
Item (N.B. multiples of some needed)	Approx Euro 2	Approx Euro 3
Improved electronic engine control	4	6
Exhaust gas recirculation (EGR)	39	38
Improved and low light-off wash coats	9	19
Greater catalyst loading	9	19
Dual oxygen sensors	54	54
Improved fuel preparation and injection	37	61
Auxiliary air injection	73	73
Air assisted injectors	15	15
Double wall exhaust pipes	9	9
Close coupled catalyst	110	
Heated catalyst		292
Research and development	131	309
Business support (included in above)	23	43
Total	**490**	**896**

The analysis of each of these data sets is presented leads to the tables which follow. It must be stated at the outset that most of these values arespeculative, since a lot of the Euro 3 technology is new and not yet introduced into production. There is also the assumption that the adoption of more mature technology, by later implementation (Euro 2 in 2002 instead of 1996 or Euro 3 in 2002 or 2006 instead of 2000) will not incur cost reductions. This may be counteracted by the transport, small volume issues in Australian implementation. Tariff and import duty considerations are also ignored.

The Touche Ross study was carried out in 1994 and not completed until the end of 1995, before Euro 2 was implemented. Thus it identifies the need for a heated catalyst to meet Euro 3. It is probable that the development of storage and low temperature light-off catalysts will have over taken the heated technology. Nonetheless, many of the items listed in would appear to be relevant in the author's opinion.

Table C.2 Compilation of various sources of European conversion costs leading to values of the Euro 3 to Euro 2 costs in $Aus

Source		Touche Ross Study					
		Scenario 2	Scenario 3		CEC Commn	EPEFE	Priv. Comm
CAR		Approx Euro 2	Aprrox Euro 3	Euro 3-Euro 2	Euro 3 - Euro 2	45-65%	Euro 3 - Euro 2
Small	Industry min	375	759	384			
	Industry max	668	1848	1180			
	Average	526	1131	605	357	423	
	Estd package	368	608	240			
	OBD		147	147			
	Evaporative		59	59			
Medium	Industry min	146	363	217			375
	Industry max	885	1471	586			525
	Average	507	1025	518	402	457	
	Estd package	386	622	236			
	OBD		147	147			
	Evaporative		63	63			
Large	Industry min	300	613	313			
	Industry max	1018	2763	1745			
	Average	633	1212	579	518	609	
	Estd package	490	896	406			
	OBD		173	173			
	Evaporative		69	69			
Weighted	Industry min	299	621	322			375
40/20/40	Industry max	851	2139	1287			525
	Average	565	1142	**577**	**430**	**504**	**450**
	Estd package	420	726	**306**			
	OBD		157	157			
	Evaporative		64	64			

Table C.2 is largely self explanatory. The weighting of small/medium/large cars of 40/20/40 is introduced as a rough representation of the Australian market split. The estimated package costs represent a build up from lists as in Table C.1 (including R&D etc) for the various vehicle size classes, whereas the industry values were their reported estimates, on average about 80% higher than from the parts base. How various overheads were included by industry in their estimates appears to have been a cause of some of the difference.

These data suggest that $450-550 is about the average from the various sources. We note that OBD and evaporative emission components are not included in the estimated package value which is for exhaust emission control alone. Whilst the benefit from OBD are included in the Euro 3 simulations in this report the evaporative emission control benefit is not. The cost of this is seen to be estimated to be more than $50. This leads to the view that an average increase of $500 without evaporative controls is likely. Noting that the weighted average industry minimum is about $300 a variance of +/-$200 seems probable. The industry high values of $1300, probably reflect costs on complex vehicles with smaller volume runs and whilst noticed, is ignored in the range of expected costs of $300 to $700 for Euro 3 over Euro 2.

ATTACHMENT D

Work in progress

Preliminary Economic Analysis of Adopting New Vehicle Emission Standards

Economics and Environmental Reporting Branch

NSW Environment Protection Authority

May 1999

This paper has been provided to the Motor Vehicle Environment Committee (MVEC) and the Federal Office of Road Safety (FORS) to assist in considering the impacts of adopting European emission standards. The paper reports work in progress and presents preliminary results that have not been subject to comprehensive review. Consequently, the results presented should be considered as indicative orders of magnitude rather than as precise estimates of impacts.

Executive Summary

Motor vehicle pollution in Australia is a pervasive problem within the highly urbanised cities of Australia and vehicles are estimated to contribute up to 70% of total air pollution. Australian emission standards for passenger vehicles lag more than a decade behind US standards.

This paper presents the results of work in progress of the costs and benefits of adopting more stringent emission standards for new motor vehicles in Australia. The report provides a framework upon which further work could be undertaken to confirm the conclusions. The results should be taken as providing a guide, not as definitive estimates. This preliminary analysis is therefore considered indicative and may be updated when further information becomes available.

The impact of adopting European emission standards (Euro 2 and Euro 3) are evaluated by assessing the marginal costs and benefits of moving to a higher standard. The analysis attempts to quantify, in dollar terms, the improved health and environmental benefits of tighter emission standards in comparison with industry costs. As there is no direct vehicle manufacturing within NSW the analysis is extrapolated to the national level to identify the total impact. Where quantification has not been possible, impacts are discussed in qualitative terms.

Modelling work by the NSW EPA in the NSW Metropolitan Air Quality Study area (MAQS) estimated the emission reductions in several major pollutants including particulates, carbon monoxide, nitrogen dioxide, hydrocarbons and benzene that are expected if more stringent standards are adopted.

The primary costs from adopting European standards include technology and hardware costs, fuel reformulation costs and compliance costs. The additional cost of upgrading vehicles with new equipment was estimated for both petrol and diesel vehicles and applied to the number of vehicles produced within Australia.

Positive health impacts were found to be the major feature of the identified benefits. The link between air pollutants and human health was examined using dose response relationships. The health cost avoided per tonne of pollutant was then calculated for four major pollutants. These were particulate matter, carbon monoxide, hydrocarbons and nitrogen dioxide. The results under-estimate the health benefits as the impacts of air toxics such as benzene and ozone and the personal and social costs of air pollution were not valued.

Emission reductions for light duty commercial vehicles could not be estimated for the analysis. This has the effect of underestimating the health benefits, as the reduction in pollutants from these vehicles was excluded. However the cost of technology and compliance to meet the new standards was included.

In addition to quantified health benefits, a range of other benefits were discussed but not quantified. These include enhanced investment opportunities, visual amenity and export potential. Reducing vehicle emissions may also provide benefits through infrastructure damage costs avoided and reduced greenhouse emissions.

The economic analysis demonstrates that adopting Euro 3 emission standards for all vehicles in 2002 would generate net benefits in excess of $1 billion to the Australian community.

Adopting Euro 3 standards for heavy duty diesel (trucks) and Euro 2 for petrol vehicles (cars and light commercial) in 2002 progressing to Euro 3 later in 2005 was estimated to provide net benefits of around $800 million.

Phasing in the introduction of Euro 2 in 2002 and then Euro 3 in 2005 for all vehicle types was estimated to produce net benefits of around $600 million but would result in significant forgone benefits comparison to the earlier introduction of Euro 3 in 2002.

Adopting Euro 2 in 2002 would produce net benefits of only $100 million, some ten times smaller than the benefits of adopting Euro 3 from 2002.

Sensitivity testing of the major variables demonstrated that the absolute value of the net benefits of options was sensitive to estimates used. The most sensitive variables in the analysis are fuel reformulation costs and technology and hardware costs. However, costs of fuel reformulation associated with adopting Euro 3, would need to be increased 160% (above the conservative base assumptions) before adopting Euro 3 became less preferable than Euro 2.

The costs of adopting stronger emission standards would be initially borne by vehicle manufacturers and oil refinery producers in upgrading plant and equipment. The benefits from avoided health costs would flow to those with pre-existing health conditions, the public health system and families through lower levels of sickness and less restricted activity days.

This paper reports the results of a preliminary economic analysis of work in progress. Please forward comments to:

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Preliminary Economic Analysis of Adopting New Vehicle Emission Standards

INTRODUCTION

The purpose of this paper is to provide preliminary estimates of the costs and benefits of adopting more stringent emission standards for new motor vehicles in Australia. The analysis aims to quantify in dollar terms the improved health and environmental benefits of tighter emission standards in comparison with industry costs. Where quantification has not been possible, the issue is discussed in qualitative terms. The report provides a framework upon which further work could be undertaken to confirm the conclusions.

Motor vehicle pollution in Australia is an ongoing problem particularly in the densely urbanised cities of Sydney, Melbourne and Brisbane. Vehicles are estimated to contribute up to 70% of total air pollution. The Metropolitan Air Quality Study (EPA 1997a) estimates that vehicles contribute 80% of oxides of nitrogen (NOx) emissions, 50% of hydrocarbon (HC) emissions (precursors to photochemical smog, measured in terms of its principal constituent, ozone) and 90% of carbon monoxide (CO) emissions.

The impacts of emissions from vehicles has significant effects on air quality and hence our quality of life. High levels of primary and secondary air pollutants have been shown to result in a wide range of adverse health and visual impacts on our society. Increasing levels of pollution can have significant environmental and economic consequences. Health effects associated with air pollution include respiratory effects, ranging in severity from cough, chest congestion, asthma, to chronic illness and possibly death in susceptible people (ACVEN 1997 pii).

Emission standards for Australian vehicles lag more than a decade behind international standards for Europe and the US. The 1997 Industry Commission Inquiry into the Automotive Industry notes that Australia has significantly lower emission standards than other international standards (IC 1997, 276). The Federal Office of Road Safety (FORS) is currently coordinating a review of Australia's emission standards and recommends the introduction of Euro 2 levels for light duty and heavy vehicle standards.

While Euro 2 standards may lead to a possible decrease in emissions for new vehicles in comparison to earlier standards, the increasing number of new vehicles and increased use of existing vehicles will more than offset any new vehicle emissions savings. This issue has been widely recognised by FORS (1996), *"Increases both in car usage and in the total vehicle population will start to outweigh the benefits of tighter standards unless more is done to control emissions."*

The main findings of the NSW State of the Environment Report (NSW EPA 1997) support this conclusion and suggest that "improved vehicle emission controls may not compensate for continuing upward trends in motor vehicle use." The report also notes the continuing problems of photochemical smog and brown haze in metropolitan areas and the developing links between air toxics and human health. Community surveys in 1995 revealed that air quality was the number one environmental concern for 28% of respondents while in 1997 it was the number two concern (24%) (EPA 1997b). Similar findings have been reported by the ABS (1996).

The NSW Air Quality Management Plan (AQMP) (NSW Gov 1998) includes a plan called *Action for Air* that focuses on regional pollution and outlines NSW's proposed approach to achieving the standards for the other NEPM pollutants, particularly ozone, nitrogen dioxide and fine particles. In *Action for Air*, NSW is proposing long term goals that are equivalent to, or more stringent than, the NEPM standards. Consequently, *Action for Air* identifies an extensive range of strategies that will be required to meet the NEPM. One of these actions is to reduce emissions from vehicles through improved emission standards.

CHARACTERISTICS OF THE AUSTRALIAN VEHICLE FLEET

To provide a context for the following analysis it is useful to outline some of the key characteristics of the Australian vehicle fleet.

- The total number of registered vehicles continues to increase steadily, from 8.3 million 1984 to 10.9 million in 1995 (a 24% increase). This represents an annual average increase of around 2.2% per annum (AATSE 1997).
- During the same period passenger vehicles increased by 2 million (30%).
- Australian vehicles are older relative to other countries with similar levels of car ownership and use. Of the total 10.9 million vehicles registered, over 6 million (57%) are 10 years old or more (AATSE 1997).
- Very low turnover and scrappage rates
- Cars 10 to 16 years old create the most pollution (HC and CO).
- New cars account for higher average annual travel but generally have lower average emissions because they are well maintained. However, deterioration of catalyst equipment is a significant problem in older vehicles.
- Emission standards currently specify durability requirements of 80,000 km. This means a vehicle must perform to the emission standard for the first 80,000 km of its life. There are no warranty, recall or testing procedures currently in place to test for durability. The US durability requirement is 100,000 km and is currently considering extending this to 160,000 km for new LEV (2) standards. Since 1994 the US has required on-board diagnostics and since 1992 a federal in-service testing. The Industry Commission notes that in revising emission standards greater attention could be paid to both durability requirements and on-board diagnostics (IC 1997, 277).
- Significantly more could be done to reduce motor vehicle pollution by tuning the existing car population. FORS (1996) estimate that emissions could be reduced by between 7% and 20% below existing levels by tuning the worst 20% of vehicles.

As a result of low turnover rates, the new emission standards may take some time before they take effect on reducing emission levels. However, the longer these standards are delayed, the longer the delay in achieving reduced emissions.

EMISSION STANDARDS

Australian Design Rules for passenger cars (ADR37/01) now being introduced into the Australian market are based on the limits introduced federally in the US in 1981. These US standards were current until 1993. This places Australian standards more than a decade behind the US. The US is implementing an aggressive strategy to significantly reduce vehicle emissions. For passenger cars, Euro 3 is loosely equivalent to the US Low Emission Vehicle (LEV) standards, and Euro 4 is comparable to the Californian Ultra Low Emission Vehicle limits (ULEV).

Table 1 – Comparable standards – passenger cars

Aust	ADR37/01			
Europe		Euro 2 (1996)	Euro 3 (2000)	Euro 4 (2005)
US	1981-1993 Federal standards	Tier 1 (1994)	**Tier 2 (2004, but may be brought forward to 2001) Low Emission Vehicle (LEV - California)**	Ultra Low Emission Vehicle (ULEV - California)

The standards for LEV and ULEV are part of a package where manufacturers are required to meet an average for the total fleet sold per year. It is the manufacturers choice as to what proportion is LEV/ULEV, although there are minimum requirements. These standards are being adopted federally in the US as part of the National LEV program.

For diesel engines, FORS is proposing the European limits as the primary standard and the equivalent US Federal standard as an alternate to allow for heavy duty vehicles which are almost exclusively imported from America. Euro 2 is equivalent to US 94 diesel standards, and these set significantly tighter limits than the existing standards for control of particulates. Euro 3 is equivalent to US 98, and both of these standards set tighter limits for particulates. Euro 4 diesel controls are still under discussion in the European Commission.

Table 2 – Comparable standards – diesel powered vehicles

Aust	ADR70 (1993)			
Europe	Euro 1 (1991)	Euro 2 (1996)	Euro 3 (2000)	Euro 4 (2005)
US	1991 Federal standards	US 94 Federal standards	US 98 federal standards	Not known
Japan	1993 standards			

OPTIONS TO IMPROVE EMISSION STANDARDS

This CBA only considers options related to improving emission standards in new vehicles. It does not evaluate alternative means of reducing pollution by other policy instruments such as taxes, subsidies or investment in public transport. In considering the range of alternatives for emission standards the following options are presented for analysis:

Do nothing (base case)

1. Adopt Euro 2 in 2002/3

2. Adopt Euro 2 in 2002/3 then Euro 3 in 2005/6

3. Adopt Euro 3 in 2002/3

4. Adopt Euro 3 in 2005/6

5. For petrol cars adopt Euro 2 in 2002/3, then Euro 3 in 2005/6
   For heavy duty diesel vehicles adopt Euro 3 in 2002/3

Under the base case (do nothing) the existing Australian Design Rules (ADR 37/01) would continue to apply and air pollution would be likely to worsen. The base case sets the benchmark for comparing the performance of each option in the analysis. Each of the other alternatives is compared to the base case to assess the marginal costs and benefits of moving to a higher emission standard.

Euro 2 provides emission standards that are equivalent to or slightly stricter than current Australian standards. Euro 2 was adopted as the standard in Europe in 1996, with Euro 3 due to commence in the EU in 2000/1 and Euro 4 in 2005/6. Australia has historically lagged behind US and EU emission standards by a significant margin.

Euro 3 provides significantly stronger emission standards than current ADR's. As shown in the following section, Euro 3 is estimated to reduce pollutant emissions from between three and twelve times that of Euro 2 for various pollutants. Euro 3 is also expected to require the use of reformulated fuel with a lower sulphur content, so as to achieve the expected emission reductions.

Each of these options would result in different levels of costs and benefits to industry and the community depending upon the level of pollutants avoided, the timing of their introduction and the technology required to achieve such reductions.

POLLUTION REDUCTIONS UNDER NEW STANDARDS

Modelling work by the NSW EPA has assessed the reductions in some pollutants that come from adopting the various European standards. The assumptions used are based on annual emission reductions in tonnes per year from the assumed baseline averaged between the years 2002 and 2021 for the MAQS region of NSW. The results are summarised in table 3 below.

The modelling demonstrates that adopting Euro 3 produces the highest level of reductions in key pollutants. National estimates can be estimated at about 4.3 times the figures quoted. This national estimate comes from the ratio of national motor vehicles to those in NSW multiplied by ratio of the NSW population to the MAQS population (ie. 636,528/221,294 x (6/4) = 4.3).

Table 3. Reductions in Key Pollutants 1st and 15th year of each program

Pollutant (Tonne per year)		EURO2	EURO3
PM10	1st yr	46	128
	15th yr	299	821
CO	1st yr	1,171	3,778
	15th yr	10,354	115,300
NO_x as NO_2	1st yr	1,382	2,997
	15th yr	11,072	44,913
HC	1st yr	146	1,876
	15th yr	2,183	26,419
Benzene	1st yr	5	59
	15th yr	299	821

Source: NSW EPA

A number of assumptions have been made in the development of the EPA's emission projections (see Table 4). Appendix 3 includes graphs which represent the data used as the basis for the reductions shown in Table 3 above, as well as a comparison of the assumptions with other modelling.

Table 4. Key assumptions in NSW EPA emission projections

Factor	*NSW EPA assumption*
Vehicles[1]	Passenger vehicles and heavy duty diesels
Deterioration rates	• Baseline – new cars emit 50% of allowable emissions at 0km; deterioration calculated from emissions at 80,000km based on laboratory tests of vehicles fitted with 3-way catalysts • Euro 2 – same ratio to emission limits as baseline. • For Euro 3 - all vehicles emit 50% of the allowable emissions at 0km, and 90% of allowable emissions at 80,000km.
% of cars requiring upgrading	24% of new cars require upgrading for both Euro 2 and Euro 3, other new vehicles being imported already meet the standards
Airshed	Sydney-Newcastle-Wollongong
VKT	NSW Dept of Transport travel forecast model
Fuel	Benefits of cleaner fuel not explicitly considered
Cycles	Ratio of US to Euro cycle based on literature survey (similar to Prof Watson)
Real world consideration	Five road categories including congestion
Cost of controls	Based on up-to-date information provided by Parsons engineering (1999)
Evaporative emissions	For Euro 3 a reduction in evaporative emissions by 60% over Euro 2 was included
HC/ NO_x split	50/50

Note 1. Vehicles

It is not possible at the moment to model the impact of regulation on light duty commercial vehicles with a reasonable degree of certainty, given that the impact of fuel and technology is largely unknown. The EPA believes that it has underestimated the emissions of PM_{10} for each scenario and has sought confirmation from the US EPA on its recent research.

COSTS OF ADOPTING EUROPEAN STANDARDS

In cost benefit analysis, only the additional costs and benefits of moving to the new standard are identified and valued. This is known as the *marginal* approach in economics. To develop the estimates of costs and technologies required to meet the proposed standards a consultant {Parsons (1999)} was retained to review the existing literature from local and overseas sources. The key costs in revising current standards are identified below:

- **Technology and hardware costs** – Increased costs of production arising from requirement to invest in new technology to meet revised standards (eg. improved catalytic converters).
- **Fuel reformulation costs** – Cost to industry fuel refiners in making cleaner fuel.
- **Compliance costs** – Cost of auditing/ monitoring the new standards.

Most sources indicate that adopting Euro 3 or higher standards may require fuel reformulation, otherwise vehicles using new technology would not optimise emission performance. However, substantial reductions in emissions would still be realised from new vehicles using current fuel standards. The cost figures sourced from Parsons (1999) assume that fuel specifications and vehicle technology are upgraded simultaneously (note that the benefits from fuel reformulation are not explicitly considered in the modelling).

TECHNOLOGY AND HARDWARE COSTS

The technology and hardware required for adopting Euro 3 standards is evolutionary and generally well established. The type of technology used on individual models will depend on base engine technology and engine size. The broad costs of moving from Euro 2 to Euro 3 are given below.

Table 5 – Estimated retail costs of adopting Euro 3

Petrol vehicles	Additional Retail Cost	Diesel vehicles	Additional Retail Cost
Small	$456	N/A	N/A
Medium	$500	Medium	$739
Large	$614	Large	$982
Light commercial	$325-$579	Light commercial	$325-$579
		Diesel vans to heavy duty vehicles (EU mfrs)	$913 to $2793
		Diesel vans to heavy duty vehicles (UK mfrs)	$1670 to $4450

Source: Parsons 1999

Directly translating the cost estimates from Europe and UK studies may under or over-estimate the real cost to Australian manufacturers. However, these estimates serve to provide a reasonable benchmark from which to assess the additional industry costs. In relative terms the overall UK estimates suggest the cost increases per vehicle range between 7.5% for the smallest diesel vehicle to 0.8% for the largest vehicle. The European commission estimates the cost of compliance will increase costs by 1.5% on average. Vehicles certified to European or US standards would not incur increased costs of compliance, as they would already meet the standard. It is assumed that Japanese and Korean vehicles exported to Australia meet the Euro standards. Based on 1997 sales figures and FORS data on certification, Parsons's estimates the annual number of vehicles sold annually in Australia affected by increased costs due to Euro 3 to be 173,052 or 24% of total sales.

Technological and hardware costs are likely to decrease over time as environmentally friendly products are gaining an increasing market share and demand. In fact, incremental costs are likely to approach zero as economies of scale reduce production costs and the costs of producing outdated and non-compliant emission engines increases. For this analysis it is assumed that technology and hardware costs would fall by 4% pa over the period of the analysis. The average unit costs of technology and hardware required were applied in each option to estimate total costs.

FUEL REFORMULATION COSTS

Reducing the sulphur content of fuel is important for achieving the estimated reduction in particulate matter emissions. Improving the quality of fuel by reducing sulphur content improves the operation and efficiency of the catalytic equipment to reduce particulate and other emissions. Without fuel reformulation, the performance of new emission technology would be sub-optimal, but still generate significant reductions as compared with current emission standards.

The European Union estimates of fuel reformulation costs for meeting the Euro 3 standards are 0.35 c/L (cents per litre) for petrol and 0.35 c/L for diesel (Parsons 1999 – sourced from European Commission Auto-Oil Program 1998, Brussels). However, consideration must be given to the existing sulphur levels in fuel in Australia and Europe. For petrol, Australia is roughly equivalent to Europe with an average sulphur content of around 150 ppm. Australian diesel fuel has around 1500ppm sulphur with 500ppm proposed as a new standard. In Europe, diesel is already at 500ppm and will be reduced to 350ppm (Euro 3) and 50ppm (Euro 4). In addition, Australian refineries are generally small and relatively aged in comparison to world standards, therefore reformulation costs may be higher. Alternatively, reformulation costs would be lower if, over the period, new refining facilities were constructed for Australia, or the market share of imported fuels increased.

On balance, it is estimated in this analysis that the costs of fuel reformulation to quality equivalent to the fuel standards adopted for Euro 3 for petrol are the same as Europe (0.35 c/L) and for diesel production are double those estimated for European conditions (ie 0.7 c/L). These estimates are likely to be generous and include costs to address fuel components other than just sulfur. These are the best estimates available at the current time.

A recent announcement by BP Amoco indicates the company will be producing a new ultra-low sulphur diesel which is estimated to emit 90% less sulphur dioxide and 30% less particulates than standard diesel. The new fuel is part of a $100 million investment in greener fuels that the company plans to sell at no extra cost to consumers. The cost to BP of producing reformulated “greener fuels” is not known, so it is assumed in this analysis that the above costs from Parsons are indicative for Australia.

The above figures were applied to projections of annual average fuel consumption for the Australian fleet (Australian Institute of Petroleum) for petrol and diesel to estimate total fuel reformulation costs. The timing of the introduction of these costs has a significant outcome on the final results. For option 2 and option 5, the cost of reformulation of diesel is assumed to be delayed until 2005. This is based on the assumption from engine manufacturers and importers that heavy-duty diesel engines are still able to perform to the European standards using existing diesel fuel quality.

Total fuel consumption figures were adjusted for imports of fuel, as the cost of reformulation would be borne outside Australia. Diesel imports averaged 6.3% and petrol imports 3.7% over the last three years (Australian Institute of Petroleum).

The introduction of a goods and services tax on fuel consumption may have a marked impact on the demand for fuel. If the excise duty on diesel fuel were removed the price of diesel would decline significantly leading to an increased demand. The Howard “Tax Package” states the cost of diesel would be cut 25 cents per litre (from 43 cents to 18 cents a litre). This needs to be considered in the context of future projections of fuel consumption of petrol and diesel.

CERTIFICATION AND COMPLIANCE COSTS

Parsons (1999) estimate that the total cost to industry to upgrade emissions testing is approximately $4.5 million based on three key automotive emissions testing laboratories being upgraded (at a cost of $1 million each) plus the purchase of three new analysers (at $0.5 million each). Laboratory upgrade costs are assumed to be incurred for adopting Euro 3 standards but not for Euro 2.

Adopting Euro standards would involve additional certification costs particularly to Ford and Holden. Imported vehicles already with EU/ECE compliance are assumed to incur no additional cost. Industry estimates of certification costs to meet Euro 2 and Euro 3 are approximately $40 million per model. For these two key industry players the costs are therefore estimated at $80 million.

TOTAL COSTS

The total costs to Australia in the first year of introduction of the new European standard are shown in the table below. The costs of adopting Euro 2 are significantly lower as it is assumed that there would be no additional fuel reformulation costs or laboratory testing upgrades. Fuel reformulation costs would apply in adopting Euro 3 hence the higher cost. The time lag between the adoption of new standards and implementation may have a significant effect on the real cost of the standard. Technology and hardware costs and fuel reformulation costs are assumed to be ongoing over the whole period of the analysis while laboratory upgrades and certification costs are one-off up front costs.

Table 6. Total costs of Euro standards (A$/1999) for first year of operation

Standard	Euro 2	Euro 3
Technology and Hardware	$88 million	$107 million
Fuel reformulation	$0	$161 million*
Laboratory upgrade	$0	$4.5 million
Certification costs	$80 million	$80 million
Total costs (year 1)	**$168 million**	**$352 million**

*Includes cost for both petrol and diesel fuel reformulation (note in some options that cost of diesel reformulation is delayed)
Source: Parsons 1999

BENEFITS OF EUROPEAN STANDARDS

ESTIMATES OF HEALTH EFFECTS FROM PAST STUDIES

As noted in the introduction, vehicle emissions are linked to a wide range of adverse health effects such as respiratory disease (including asthma) and heart disease. The social and economic cost of these health impacts is considerable. Air pollution costs have been estimated at around 0.2% of GDP (BTCE 1994). With Australia's GDP at $444.6 billion in 1996-97 (ABS 1998) this equates to around $889 million pa. The Bureau of Transport and Communication Economics surveyed the international literature to broadly assess the total national costs of air pollution in other countries. Although each study used a wide range of techniques and assumptions, it is interesting to note that the estimates are in the same order of magnitude, ranging from 0.15% to 1.04% of GDP. In mainland China, the World Bank has estimated that the damage bill due to air and water pollution is a staggering 7.7% of GDP (AFR 1999).

The National Environment Protection Measure (NEPM) for ambient air quality, developed by the National Environment Protection Council (NEPC), sets national standards for six pollutants: carbon monoxide, nitrogen dioxide, photochemical oxidants (as ozone), sulfur dioxide, lead and particles (as PM_{10}). A cost-benefit analysis was undertaken on the NEPM indicated benefits significantly outweighed costs.

The Inter-State Commission made an attempt to estimate the costs of vehicle emissions in Australia in 1990 based on a similar study undertaken in the US. Using data on the rates of emissions and damage costs the Inter-State Commission estimated the annual cost of emission to be $786 m (NRTC 1995).

The National Road Transport Commission (1995) undertook a review of health costs associated with vehicle emissions. The report concludes that health costs to Australia are "likely to fall within the range of $20 to $100 million with $50 million suggested as reasonable midpoint". The analysis is based on a fairly arbitrary estimation of 0.1% of cancers and 0.1% of respiratory illnesses attributable to road vehicle emissions. The study produces a very low estimate of health costs because it only examines two health end-points, cancers and respiratory disease. The report concludes that more understanding is needed on the impact of vehicle emissions on health.

A study by Simpson and London (1995) of Griffith University Queensland estimated that the economic cost of current air pollution in the Brisbane city council area is in the range $254 million and $462 million per year. Of the total health impacts mortality effects from particulate pollution account for around 90% ($230 million to $415 million) while morbidity effects account for the remainder. Ozone impacts were considerably less but estimated to account for $2.5 million in costs per year.

Morrison and Bernauer (1995) identified the external costs of petrol consumption in NSW. They estimated the health impacts due to air pollution from particulates, ozone and lead emissions were $232 million per year for particulates, $49 million per year for ozone and $294 million year for lead. The external cost associated with loss of visual amenity was estimated at $77 million per year. In addition, significant external costs associated with pollutants such as benzene and carbon monoxide were not quantified in the study.

APPROACH TO ESTIMATING HEALTH IMPACTS

Apart from directly quantifiable health and medical treatment costs, the *social* and *personal* costs of illness and disease are very high but cannot be readily quantified in monetary terms. Willingness to pay studies can estimate these costs but this has not been attempted in the analysis. There is often conjecture over the certainty of the relationship between emissions and health effects. However, there is growing evidence in Australian and international research that continuing exposure to air pollutants is having many detrimental health effects on urban populations. Dose response[37] relationships have been demonstrated to be significant for particulate matter, nitrogen dioxide and ozone.

The omission of health costs can seriously affect the results of decision-making processes. The Advisory Committee on Vehicle and Noise (ACVEN) in their review of ADR 37/01 emission controls for light vehicles notes that "*The absence of health costs represents a significant gap in the information required to justify a change to the current new emission standard*" (ACVEN 1997). The results of this paper will help fill this information gap.

The uncertainty of health effects does not necessarily mean the impacts should be ignored or remedial measures delayed. Ecologically sustainable development requires the effective integration of economic and environmental issues in decision-making processes. The precautionary principle is now a key tenant of ecologically sustainable development and embodied into a wide range of environmental law. This principle states that "if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation" (POEO Act 1998).

Determining the benefits of avoided health costs is a difficult exercise given a complex chain of factors that interact to cause air pollution. The BTCE (1994) study outlines a series of steps in the "causal chain". These can be summarised as follows:

Traffic volumes | primary emissions | secondary pollutants |

[37] Dose response relationships are one of the criteria used to assess causality (cause-effect relationship). A strong relationship between the level of exposure to the factor being studied (the "dose") and the outcome being studied (the "response") suggests a true causal relationship exists.

air quality | human exposure | dose response |
health effects | health costs

Adopting the health costs estimated in overseas studies may be problematic as each country has different health standards and costs that may not be applicable to Australia. Another approach is to take the total cost of the health problem within Australia (such as hospital admissions, loss of work days etc) and apply the dose response relationship that is attributable to motor vehicle emissions as estimated by medical studies. This approach accounts for Australian conditions and costs rather than relying on generalised international estimates. International studies play a critical role however, by providing dose response relationships and comparative estimates of costs.

PARTICULATES

Particle pollution was one of the first types of air pollution to be associated with serious health effects. Of particular concern are fine particles, which are those less than 10 µm (PM_{10}). Fine particles can lodge in the lungs and cause irritation and disease. The main health effects of fine particles include:

- increased frequency of asthma attacks
- increased activity restrictions due to adverse lung reactions
- increased potential for severe respiratory distress and heart attacks
- increased mortality due to heart disease and respiratory illnesses.

The dose-response relationships between increases in particles and health impacts including mortality are well established. Overseas studies (Dockery & Pope 1994, Morgan et. al. 1998 and WHO 1994) have consistently shown that each 10 $\mu g/m^3$ increase in the 24 hour average for PM_{10} results in a 1% increase in daily mortality (all causes), a 3.4% increase in respiratory mortality and a 1.4% increase in cardiovascular mortality. There were similar results in the NSW Health and Air Research Programs (HARP) studies (see Morgan et al 1998a), which found an association between increased particle pollution and hospital admissions, and in daily mortality in Sydney. The National Environment Protection Council noted that these studies indicated that fine air particles account for almost 400 premature deaths in Sydney per year (1.8% of total deaths per year) (NEPC 1998, p138).

Notably, the observed health effects of PM_{10} appear to occur independently of the presence of other pollutants such as ozone, nitrogen dioxide and probably sulfur dioxide. WHO (1994) has not set a guideline for fine particles because of the absence of a threshold below which there are no effects, indicating the significant relationship between fine particles and health. This is supported by Morgan's (Morgan et al 1998) conclusion that the linear dose-response relationship between particulates and all-cause mortality showed no evidence of a threshold effect. This analysis assumes that there is no safe minimum level of exposure for the health effects of fine particulates.

The costs of particulate matter to human health are estimated in terms of mortality, morbidity and health treatment costs and described in Appendix 2. A brief discussion on estimating the value of a statistical life is given in Appendix 1.

The total estimated health costs avoided has been estimated to be mortality ($15,128) + morbidity ($2,217) + health treatment ($21,700) from a one-tonne reduction in fine particulate discharges. This represents in total $39,045 per tonne.

The above estimate was applied to the modelled PM_{10} reductions to estimate the health benefits from adopting Euro standards. PM_{10} reductions are projected to reduce by an average of 213 tonnes per year with Euro 2 and 580 tonnes per year with Euro 3 per annum.

Note that the total health costs avoided underestimate the full extent of benefits as chronic effects have not been taken into account. For example, asthma sufferers may require increased use of ventilin on high pollution days, those with other respiratory problems may experience discomfort and loss of energy. These effects have real economic and social effects on the exposed population but the monetary cost has not been valued in this analysis. As an indication of likely costs the US EPA value shortness of breath at $8.13 per day.

NITROGEN DIOXIDE

NO_2 is an oxidising agent and can cause both short and medium term health impacts. It is one of the several oxides of Nitrogen (NO_x) which is largely produced by human activities such as combustion processes. Around 80% of ambient NO_2 comes from motor vehicles. Significant health effects from NO_2 can include:

- reduced lung function leading to increased potential for respiratory infection
- increased frequency of asthma attacks
- increased potential for heart disease and related complications
- a possible link between NO_2 and respiratory related deaths.

Nitrogen dioxide appears to exert its effect on the human organism both directly, leading to an inflammatory reactions in the human lung, and indirectly by the induction of relative impairment of immune defence mechanisms in the lung. Epidemiological studies suggest that young children are especially susceptible to these effects, resulting in the onset of respiratory infections following disturbances in immune defence mechanisms.

Nitrogen dioxide appears to contribute both to morbidity and to mortality, especially those susceptible subgroups such as young children, asthmatics, and in those individuals with chronic inflammatory airway disease (chronic bronchitis and related conditions). The NSW HARP studies found a strong correlation between increases in ambient NO_2 levels and hospital admissions for asthma and heart disease.

Acute exposure to nitrogen dioxide at 0.2 to 0.3 ppm can decrease lung function and increase airway responsiveness in mild asthmatics. Controlled exposure studies have shown varied results. Some epidemiological studies have shown associations between NO_2 concentrations and an increased risk of respiratory illness in children aged 5 to 12 years at annual average NO_2 levels of 0.04-0.08 ppm (75-151 $\mu g/m^3$), while others have not identified such links. Asthmatics and people with existing lung diseases are most susceptible to respiratory effects of NO_2.

The analysis of the health related data for short term exposures indicate that the lowest effect level is around 0.2-0.3 ppm and with the use of an uncertainty factor to ensure adequate protection of the most vulnerable sub groups of the population the guideline range of 0.1-0.15 should be used. Chronic exposure data from epidemiological studies for indoor exposures indicate health effects at levels of 0.04-0.08 ppm., and some studies using ambient nitrogen dioxide concentrations found associations with incidence and duration of respiratory symptoms at in children at 60-140 $\mu g/m^3$ (approx 0.03-0.07 ppm).

A wide range of studies undertaken in the US and Europe has estimated the damage effects of NO_2 on human health. The estimates from 16 separate studies that examined damage costs and avoidance costs range from a low of $3.50 per tonne to $6,000 per tonne. The median estimate of avoided health and damage costs is $1,385 per tonne of NO_2 (NSW EPA 1997c). This estimate has been applied to the modelled reductions in NO_2 that result from adopting the Euro standards.

HYDROCARBONS – AIR TOXICS

Motor vehicles emit a wide range of hydrocarbons which are photochemicaly reactive organic compounds, sometimes referred to as reactive organic compounds (ROC) or non-methane hydrocarbons (NMHC). These compounds play an important role in the formation of ozone. Many of these compounds are also known or probable carcinogens. The impact of ozone is dealt with in the next section and the general impact of hydrocarbons from motor vehicles is addressed below.

Much attention is paid to benzene, which along with other aromatics, such as toluene, xylene and ethyl benzene, are important in the refining process as they increase the octane rating of petrol to that required by modern engines. In contrast to lead, benzene is not added to petrol rather, it is present in the crude oil and is produced via refinery processes (e.g. Reforming) and petrol combustion in engines.

About 80% of the benzene emitted from motor vehicles is in the exhaust gases. Benzene is also produced from the combustion of other aromatics in the fuel. Vehicles produced since 1986 have used catalytic converters to clean up exhaust gases. This also reduces the emissions of benzene by up to 90% of that of a pre-catalyst vehicle.

Ambient benzene levels are the primary exposure for the general population and are directly related to motor vehicle usage (accounting for 76% to 85% of ambient benzene concentrations).

Hydrocarbons contain air toxics, such as 1-3 butadiene and benzene, are of concern because they are known to cause cancer. Benzene ambient air levels as a result of motor vehicle emissions have led to future predictions of cancer rates in large cities. Reductions in hydrocarbon exhaust emissions and evaporative emissions and durability required by Euro 3 should also reduce many air toxics such as benzene.

Motor vehicles are reported (Metropolitan Air Quality Study, NSW EPA 1997a) to emit some 10 tonnes per day of benzene in Sydney. San Francisco has a similar airshed to Sydney, and has previously experienced worse air quality. As a consequence of controls on engines and fuel, levels of benzene in San Francisco have fallen below levels measured in Sydney. Data for 1995 shows the annual average to be 0.95 parts per billion (ppb), compared to Sydney levels of 1.2 ppb annual average for outer Sydney and Central Sydney of 2.5 ppb (Bay Area Air Quality Management District, monitoring data for 1995). San Francisco's benzene levels for 1997 have continued to fall with levels about 0.6 ppb.

Studies from the US and Europe on human health effects of hydrocarbons has estimated the damage costs at between $90 and $10,130 per tonne (NSW EPA 1997c). The median estimate from these studies is $1,440 per tonne and this estimate has been assumed to provide a reasonable indication of the health costs avoided per tonne reduction in hydrocarbons. This estimate has been applied to the modelled reductions in hydrocarbons that result from adopting the Euro standards.

OZONE

Photochemical oxidant is a term used to describe a complex mixture of chemicals produced in the atmosphere by the action of sunlight. It is commonly known as photochemical smog. The principal component of photochemical oxidant is ozone: also present are formaldehyde, other aldehydes, and peroxyacetyl nitrate (PAN). Measurements of photochemical oxidant (and standards relating to it) are usually referenced to ozone.

Ozone is a secondary pollutant ie. it is not emitted directly but is formed in the atmosphere by the reaction of various precursor compounds. These include oxides of nitrogen (NOx) and photochemically reactive organic compounds, commonly referred to as reactive hydrocarbons, or reactive volatile organic compounds (ROCs), non methane hydrocarbons (NMHCs), or just hydrocarbons. Many chemical reactions and intermediate products are involved, and the reactions are driven by energy in the form of ultraviolet light.

There is strong supportive evidence from clinical, epidemiological and controlled exposure studies, of health effect associations at ambient ozone levels normally encountered in Australian cities. Health effects associated exposure to ozone include minor changes in lung function, increased symptoms consistent with airway irritation, leading to increased requirement for additional medication as well as medical and hospital services. There is also evidence of a slight but clearly present increase in mortality, chiefly from cardiovascular causes, especially in the elderly. Exercise enhances the effects of ozone on lung function.

Most evidence of the effects of ozone come from studies and observations in North American and European cities. Recent studies in Sydney assessing various health outcomes including mortality and morbidity confirm the reproducibility of overseas health responses to ozone exposure in Australia. There is no reason why similar responses would not be observed in other Australian cities.

There is consistent evidence to suggest that there are specific subgroups in the population, in particular asthmatics, which are more susceptible to the adverse health effects from ozone exposure, and individual susceptibility is wide. There is also an increasing body of literature which details the interaction of ozone with other pollutants, in particular, the enhancement of the effects of ozone as a result of prior or concurrent exposure to particles, nitrogen dioxide, airborne allergens, and sulfur dioxide, and conversely, for people with asthma, sensitisation to other agents by exposure to ozone.
No threshold exposure level can be identified for ozone. There is a monotonic relationship between increasing ozone concentration and adverse health effects.

WHO has classified the overall effect of exposure to 1 hour ozone concentrations of between 0.05 and 0.10 ppm as 'mild'. In this range, of exposures, eye, nose and throat irritation would probably occur in a sensitive minority, an average FEV_1 (Forced Expiatory Volume - 1 second) decrement in the whole population, and a 10% decrement in FEV_1 in the most sensitive 10%. Other effects include some chest pains and cough, and slight reductions in peak athletic performance.

A 5% - 10% decrement in FEV_1 is considered significant in clinical terms and decrements of 10% and 20% are highly significant, particularly for susceptible subgroups. Under current exposure and regulatory regimes, the maximum probability that a 10 % decrement in FEV_1 is 1.3 %. The concentration at which this maximum probability occurs is 0.082 ppm and the affected population is approximately 6 million. This means the maximum expected cases per year with a 10% decrement in FEV_1 is approximately 78,000.

Current effects of air pollution for various health end points have been estimated by Simpson and London (1995) for the Brisbane City Council and could be extrapolated nationally. For various reasons, these are likely to be underestimates. Not all health points have costing data. For example the maximum expected occurrence of a 10% FEV decrement is close to 1 million cases, and the significance of this, and the effects cannot be estimated. Likewise, no deaths have been ascribed, although the health study indicates a small but clear relationship with ozone. There has been no estimates of the potential effects and long term costs of lung ageing, and none of the other distinct but subtle structural and biochemical changes. The assumed threshold of effects has been 0.08 ppm although the medical data suggests a zero threshold.

One of the key points to consider is the large number of minor symptoms estimated for ozone exposure. These include the combined incidence of one or more of sore throat, cough, headache, chest discomfort, and eye irritation is estimated at between 6 and 20 million incidents per annum. There are clearly very large impacts of irritating symptoms potentially affecting productivity, as well as general well being.

The health impacts of ozone have not been calculated for this analysis since ozone is a secondary pollutant and including the effects may lead to double counting of the impacts.

CARBON MONOXIDE

Carbon Monoxide (CO) is a colourless, odourless, toxic gas produced by the incomplete combustion of organic compounds. The primary health effect of carbon monoxide is to reduce the oxygen carrying capacity of the blood. In ambient concentrations, CO can affect the functions of the brain, lungs, heart and ability to exercise, all of which are sensitive to blood oxygen content. Exposure to high CO levels is also associated with low birth weights in infants. Recent evidence from several countries suggests that fluctuations in CO levels increase the risk of hospital admissions or death due to cardiovascular disease (UKDOH 1998). A rise of $10 mg/m^3$ is associated with increases of about 10% in all-cause mortality and 20% in hospital admissions for cardiovascular diseases. These associations have been estimated in studies from the UK, Canada and US (UKDOH 1998).

Studies from the US and Europe on human health effects of carbon monoxide has estimated the damage costs at between $6 and $45 per tonne (NSW EPA 1997c). The median estimate from these studies is $12 per tonne and this estimate has been assumed to provide a reasonable indication of the health costs avoided per tonne reduction in CO. This estimate has been applied to the modelled reductions in CO that result from adopting the Euro standards.

OTHER BENEFITS AND COSTS NOT QUANTIFIED

INVESTMENT OPPORTUNITIES

Australia is in a strategic location to the Asia pacific region that is predicted to grow immensely over the next 2-3 decades. If Australia is to maintain its competitiveness as a centre for economic activity then keeping the air clean will provide attractive incentives for significant investments. There is global competition between cities not just for hosting the Olympic games but for attracting business investment that is environmentally friendly and brings the potential to create wealth. Many of the service industries such a telecommunications and information technology firms fit these criteria.

For example, when international companies are making a decision on where to locate their corporate headquarters, Sydney or Melbourne could be seen to have the edge over other Asia-Pacific cities on environmental grounds. Australian cities have many advantages over other cities, including political stability, public safety, favourable climates, natural attractions, low population density and public infrastructure.

The correlation between location decisions by corporations and air pollution however, would be second order considerations. The impact of the quality of the environment however, is a real effect and would have some influence on such decisions. American Express located its regional head offices in Sydney in 1993-94 bringing with it a direct investment of $84 million (AATSE 1997). AATSE estimate that the loss of one medium size business would result in the loss of $0.75 million per annum. This estimate however, has not been included in the analysis. Improving air quality in Australian cities can therefore be considered an important element in attracting investment and maintaining a competitive edge.

VISUAL AMENITY

Tourism plays a highly significant role in generating economic activity for Australia's economy. At present tourism generates around $14 billion in export income that equates to about 10.5% of GDP in direct and indirect effects. A large proportion of inbound tourists spend their time in our cities. The relative cleanliness of the environment (including our air) is one of the major reasons Australia is highly regarded as a destination for international visitors (DSARD 1999).

The AATSE (1997) propose that 5% of international visitors might be deterred from visiting polluted cities. This would result in a loss of tourism income of $0.7 billion per annum. AATSE consider this scenario is conservative given that over 70% of inbound tourists choose to visit Australia because of its natural environment and unique flora and fauna.

Morrison and Bernauer (1995) estimate the value of visual disamenity currently associated with motor vehicle usage in Sydney is approximately $77 million per annum.

People's perceptions of air pollution play a critical role in determining visitation to an area. The Sydney 2000 Olympic Games will provide an opportunity to showcase Sydney and Australia as a whole as environmentally responsible. Improving emission standards in new vehicles signals that Australia is committed to improving urban air quality and achieving sound environmental outcomes.

ENHANCED EXPORT POTENTIAL

The value of Australian automotive exports in 1997 was $2.6 billion. This figure represents a six-fold increase since 1984 (DISR 1997). Export growth has averaged 20% per year over the last three years with vehicles making up an increasing proportion of the total (vehicles 50%, components 50%). Exports to Japan and Europe have declined significantly since 1988 with the growth markets being South Korea, NAFTA and ASEAN countries. A range of export programs has seen the Toyota Camry exported to the Middle East, Ford Falcon to South Africa and Mitsubishi Diamante to the USA.

Adopting international standards means Australia is better able to compete on the world car market and export vehicles with similar emission standards. While export programs will depend heavily on price and quality considerations, emission standards will play a small but important role in meeting the regulatory requirements of the destination country and thereby opening up new opportunities.

"As global rationalisation of vehicle models increases a single global standard will effectively develop…...If Australian manufacturers do not aspire to international standards in an increasingly global market, they will limit their ability to export to a range of open world markets" (IC 1997, 284*).*

Similarly, the NRMA in its submission to the Automotive Industry Inquiry notes that *"Australian manufacturers are not encouraged to design vehicles for export, where they would be able to sell their product into any world market."* (IC 1997, 284).

An increasing number of multi-national companies are now designing products with an "environmental" angle. New technologies have the potential to significantly reduce emissions. If it is assumed that adopting more stringent new emission standards will encourage car manufacturers to embrace new technologies sooner, this will increase the potential to increase export earnings from both component engine and vehicle sales.

Japan formally adopted the United Nations/ European Economic Community (UN/ECE) emissions standards system in 1998. Similarly Korea, has announced its intention to adopt UN/ECE standards from 1999. US standards exceed current and future European standards. Exports to countries with Euro 3 standards or higher is shown in the table below.

Table 7. Automotive exports to UN/ECE emission compliant countries

Country	Exports ($m)	Share (%)
NAFTA	708,577,127	26.7
South Korea	373,068,337	14.9
Japan	216,733,905	8.2
Germany	73,017,636	2.76
Unite Kingdom	52,576,562	2
France	20,683,556	0.78

Belgium/Luxembourg	11,765,133	0.44
Rest of Europe	6,714,555	0.25
Italy	2,504,244	0.09
Spain	2,208,020	0.08

Source: State of Automotive Industry, Dept Industry Science and Resources 1997

It should also be noted that Australia may potentially lose existing export markets if emission standards are not equivalent to our trading partners. This cost has not been quantified for the analysis.

INFRASTRUCTURE DAMAGE COSTS AVOIDED

A significant increase in emissions could eventually lead to acid rain thereby damaging buildings, crops and the environment. In Australia this is not a prevalent problem as in parts of the US with localised heavy industries combined with motor vehicle pollution. Improved standards may lead to reduced long-term motor vehicle emissions which means these costs are avoided in the future.

REDUCED GREENHOUSE GAS EMISSIONS

Adopting more stringent emission standards for motor vehicles could assist Australia to meet its commitments under the Kyoto Protocol at lower cost to the economy.

CALCULATION OF OVERALL NET BENEFITS

This section summarises the key assumptions and calculates the net benefits for each option.

As noted in section 6, technology and hardware costs are assumed to decrease by 4% pa over the period of the analysis. This may still over-estimate the actual costs as the cost of new technology in almost all industries has been shown to significantly decrease over time due to economies of scale and innovation. Technology and hardware costs are assumed to be incurred from one year prior to the introduction of the standard in view of the fact manufacturers would be developing prototypes and gearing up for new production technology.

Fuel reformulation costs are based on the average consumption of petrol and diesel estimates from Australia Institute of Petroleum extrapolated to year 2020 and adjusted for imports of petrol (3.7%) and diesel (6.3%). Cost estimates for fuel reformulation derived from Europe are doubled for diesel production in Australia to promote a conservative allowance for the higher sulphur content in Australian diesel fuel. As with technology and hardware costs, fuel costs are assumed to be incurred from one year before the introduction of the new emission standard.

Fuel reformulation costs are assumed to be incurred over the full period of the analysis years from the introduction of the standard. Note also fuel costs are conservatively assumed to remain constant over the 20 year period whereas the additional costs are likely to decline significantly over time (as with hardware and technology costs) due to technological advances and economies of scale. Fuel reformulation is the largest cost component of adopting Euro 3 standards.

Laboratory upgrade and certification costs are one-off costs that are assumed to be incurred one year before the introduction of the standards in order to give industry time to install new testing equipment and commence certification protocols.

The modelled reduction in pollutants shows that the most significant benefits do not occur until a significant number of new vehicles have penetrated the total vehicle fleet. The early years demonstrate very marginal reductions while later years show very significant reductions (see table 3). Euro 3 generates significantly greater reductions than Euro 2 in all levels of pollutants which is reflected in the results.

Applying the broad industry costs associated with each option as outlined in section 6 and the benefits from avoided health costs (section 7) from those pollutants that can be valued gives the following results.

Table 8. Net Benefits of Euro Standards ($NPV million 1999)

OPTION	1	2	3	4	5
	Euro 2 @ 2002	**Euro 2 @ 2002 then Euro 3 @ 2005**	**Euro 3 @ 2002**	**Euro 3 @ 2005**	**Cars-E2 then E3; Trucks – E3@2002**
Costs*					
Technology and hardware	662	831	803	623	807
Fuel reformulation	-	1,199	1,287	1,199	1,084
Laboratory upgrades	-	3	4	3	3
Certification	70	65	70	57	63
Total costs	**732**	**2,098**	**2,164**	**1,882**	**1,957**
Benefits* (Health costs avoided from):					
Hydrocarbons	80	701	892	611	630
Nitrogen dioxide	409	1,150	1,409	963	1,071
Carbon monoxide	38	262	341	227	217
Particulates	324	793	882	621	884
Unquantified benefits: includes personal and social costs avoided, investment opportunities, visual amenity, export potential, infrastructure damage avoided and reduced greenhouse emissions	Not quantified	Not quantified	Not quantified	Not quantified	Not quantified
Total benefits	**851**	**2,716**	**3,523**	**2,423**	**2,762**
Net Benefits	**119 m**	**618 m**	**1,359 m**	**541 m**	**804 m**

(* All figures in Present Values discounted at 7% over 20 years)
Note: figures may not add due to rounding

This analysis demonstrates that adopting Euro 3 standards for all vehicles in 2002 would produce a net gain to the Australian community in excess of $1.3 billion over the next 20 years. This result is largely comprised of the avoided health costs that stem from motor vehicle pollution. The result can be considered conservative, as a wide range of other benefits was not quantified for the analysis. Option 5, adopting Euro 3 for heavy duty vehicles in 2002 and then a phased introduction of Euro 2 in 2002 and Euro 3 in 2005 for passenger and light duty vehicles, would result in a second best option producing net benefits $804 million.

SENSITIVITY ANALYSIS

Sensitivity testing was conducted in relation to the major uncertainties in the assessment. Two tests were undertaken:

1. Worst case scenario: 10% increase in costs and 10% decrease in benefits
2. Best case scenario: 10% decrease in costs and 10% increase in benefits

The key parameters tested include:

Variable	Worst case assumptions	Best case assumptions
Fuel reformulation cost estimates	10% increase	10% decrease
Technology and hardware cost estimates	10% increase	10% decrease
Future fuel consumption estimates	10% increase	10% decrease
Certification costs estimates	10% increase	10% decrease
Value of life estimates for mortality impacts from particulates	10% decrease	10% increase
Modelled reductions in pollutant emissions	10% decrease	10% increase

This sensitivity testing produced the following results:

($NPV million 1999)

OPTION	**1**	**2**	**3**	**4**	**5**
	Euro 2 @ 2002	**Euro 2 @ 2002 then Euro 3 @ 2005**	**Euro 3 @ 2002**	**Euro 3 @ 2005**	**Cars-E2 then E3; Trucks – E3@2002**
Worst case scenario	-51	-20	618	-43	263
Base assumptions (most likely result)	*119*	*618*	*1359*	*541*	*804*
Best case scenario	291	1239	2080	1106	1331

Overall, sensitivity testing shows that significant changes in cost and benefit estimates for the major variables does not affect the relative ranking of each option. In absolute terms, options 3 and 5 still demonstrate positive net benefits even under the ‘worst case’ scenario assumptions.

The key cost differential between Euro 2 and Euro 3 is fuel reformulation costs. However, it was also found that, holding other assumptions constant, fuel reformulation costs would need to be increased 160% before adopting Euro 2 yielded higher net benefits than Euro 3 in 2002.

INCIDENCE ANALYSIS

The costs associated with adopting stronger emission standards would be initially borne by the car manufacturing industry and oil refinery producers in upgrading plant and equipment to comply with the new standards. However, these costs are dynamic in the sense that a new standard may force manufacturers and producers to become more innovative as they seek to minimise costs and adopt best practice technology. Some costs would be passed on to consumers by way of higher fuel and vehicle prices. However, import competition would limit the extent such costs could be passed on particularly for car manufacturers.

The benefits from avoided health costs would flow primarily to those with pre-existing health conditions such as asthma or bronchitis. Reduced health costs would also ease the burden on public health system through reduced hospital admissions and attendances and treatment costs. In addition, families would benefit through lower levels of sickness and less restricted activity days.

CONCLUSION

This analysis has examined the costs and benefits of adopting improved emissions standards based on European standards for new motor vehicles. The costs examined include technology and hardware, laboratory upgrades, fuel reformulation and certification costs. These costs assume that the fuel specifications and vehicle technology are upgraded in parallel in order to deliver the estimated pollution reductions.

On the benefit side, health impacts were found to be the major feature of the analysis. The link between air pollutants and human health was examined using dose response relationships. The health cost avoided per tonne of pollutant was then calculated for four major pollutants. These were particulate matter, carbon monoxide, hydrocarbons and nitrogen dioxide. Modelling work undertaken to estimate reductions in the MAQS region (NSW) was extrapolated to provide nation-wide estimates of emission reductions. The results under-estimate the health benefits as the health effects of some pollutants were not valued.

Of the five options presented, it was found that adopting Euro 3 standards in 2002 produced the highest net benefit of almost $1.4 billion to the community over the next twenty years. Euro 3 was also shown to generate larger reductions in key pollutants of CO, NO_2, HC and Benzene. This result is conservative because the personal and social costs of air pollution have not been estimated, nor the health benefits from reductions in benzene and ozone.

Adopting Euro 3 standards for heavy duty diesel (trucks) and Euro 2 for petrol vehicles (cars and light commercial) in 2002 progressing to Euro 3 later in 2005 produces a second best option with estimated net benefits of around $800 million.

Phasing in the introduction of Euro 2 in 2002 and then Euro 3 in 2005 for all vehicle types was estimated to produce net benefits of around $600 million but would result in significant forgone benefits comparison to the earlier introduction of Euro 3 in 2002.

The fourth ranked option, adopting Euro 3 in 2005, was estimated to generate net benefits of $541 million.

Adopting Euro 2 in 2002, without any commitment to the future adoption of Euro 3 standards, was estimated to produce net benefits of $119 million to the Australian community. Therefore the adoption of Euro 3 in 2002 was estimated to generate over eleven times as many benefits as adopting Euro 2 in 2002.

These results were shown to be sensitive to assumptions in the timing and magnitude of fuel reformulation, technology and hardware costs. It was conservatively estimated that technology and hardware costs, associated with vehicle emissions controls decline slowly over the period of the analysis, whereas often, the costs of technology decline rapidly due to innovation and economies of scale. The results also assume that fuel reformulation occurs in parallel with the new standards. If fuel reformulation is delayed, the impact of the modelled reductions in pollutants on the health benefits is likely to be small. This is due to the low level of penetration of new vehicles into the total fleet in the early years.

By adopting a higher standard at the time of a review, manufacturers would be better prepared to face inevitable changes to emission standards. It would also involve less marginal cost than undergoing a review again in a few years time since producers can begin re-designing models and investing in new technology.

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APPENDIX 1

ESTIMATING THE VALUE OF A STATISTICAL LIFE

Some forms of air pollution increase the risk that people will die prematurely. To estimate the benefits of pollution reductions on mortality, it is necessary to use an estimate of the value of life. The US EPA (1997) undertook a major review of mortality valuation estimates (see also Viscusi 1992). The US EPA examined 26 policy-relevant value of life studies, five of which were contingent valuation (CV) studies that directly obtain willingness to pay (WTP) information from people. The remainder of the studies were wage-risk studies which base WTP estimates on the additional compensation paid to workers in riskier jobs. The value of life estimates range from A$0.92 million to A$20.8 million (using exchange rate of AUD$/US$0.65). Using a Weibull (statistical) distribution, the best estimate was taken from each study and produced a mean of A$7.38 million and standard deviation of A$4.9 million. It is interesting to note that all the WTP studies produced an estimate lower than the mean estimate generated by the distribution exercise. The US EPA (1997) present an extensive discussion on the methods used to value health and welfare effects from pollution (see appendix I of US EPA 1997).

A UK study by National Economic Research Associates (1998) recommends the use of WTP approach taking into account life expectancy, income and contextual factors based on how WTP varies with age and health state. The criticisms of the approach – dependence on marginal utility of income and ranking problems - can be accommodated by circumspect use of the approach, using appropriately selected distributional weights. These, however, may be seen as arbitrary. Using the approach and distributional weights suggested in the paper, the value of a statistical life in Australia is estimated to be between $6 million and $9.5 million, depending on type of health impact and age.

This analysis adopts the estimate of $7.38 million as estimated by the US EPA. This is considered a reasonable approximation of the willingness to pay to avoid premature death from air pollution.

APPENDIX 2

HEALTH EFFECTS OF PARTICULATES

Mortality

The 1992 Metropolitan Air Quality Study (NSW EPA 1992) estimated a total particulate load of 100 000 tonnes from all sources in the Sydney, Hunter and Illawarra area. Based on available data it is conservatively assumed for this analysis that approximately 40 000 tonnes of this comprised PM_{10}. The mean ambient PM_{10} loading for the greater Sydney region (incorporating the Sydney, Illawarra and Hunter regions) is approximately 23 ug/m^3 (NSW EPA 1997a). Assuming a linear relationship between changes in total pollutant load and ambient conditions at the margin, a one-tonne reduction in fine particulate loading represents a 0.000575 ug/m^3 reduction in mean ambient fine particulate loading in the Sydney region. It is assumed below that for locations outside the Sydney, Hunter and Illawarra regions, conditions are such that ambient loadings are negligible, and a one tonne reduction in fine particulate loadings has no effect on ambient levels of fine particles.

Based on studies by Schwartz and Dockery (1992 a,b) and Schwartz (1991), a Department of Energy and Minerals study adopts a mortality effect of 0.775 deaths per 100 000 for each 1 ug/m^3 increase in average annual PM_{10}. Ambient fine particulate conditions in the greater Sydney area are lower than United States EPA and Californian guidelines (NSW EPA 1997a). Given this, it would be expected that the majority of health impacts would occur among those most sensitive to air pollution – those with respiratory illnesses such as asthma or bronchitis. The National Health Survey conducted by the Australian Bureau of Statistics (ABS) in 1989-90 estimated that 34.4 out of every 1000 people have bronchitis and 81.5 out of every 1000 people have asthma. Allowing for some overlaps between the groups, approximately 10% of the population could be affected by fine particulate and other air pollution.

With a population of approximately 4.6 million residing in the Sydney, Hunter and Illawarra regions, approximately 460 000 people will be affected by fine particulate pollution. (This estimate is consistent with a Victorian EPA (1997) study which indicates the incidence of asthma in Melbourne at 120 000 per 1 million people). Given an affected population of this size, each 1 ug/m^3 increase in annual average PM_{10} would result in 3.6 statistical deaths annually in the Sydney,
Hunter and Illawarra area. This estimate appears very conservative, given the findings of a recent NSW Health study (Morgan et al 1998) from which an estimate could derived of over 400 premature deaths in Sydney each year associated with fine particulate pollution.

Using the results of US EPA for the statistical value of life ($7.38 million in 1997) and the Schwartz and Dockery mortality rates, the mortality cost of fine particulate pollution is $26.3 million for each 1 ug/m^3 increase in annual average PM_{10}. To estimate the mortality cost per tonne for the existing level of particulate pollution we must multiply the total cost by 23 ug/m^3 (existing mean ambient measure of PM_{10}) and then divide by 40 000 t. This equates to a cost of mortality of $15,128 per tonne of fine particulate discharges. The estimated cost in regions outside of greater Sydney (ie. metropolitan areas including Newcastle and Wollongong) are assumed to be zero for fine particulate pollution from motor vehicles.

Morbidity

Morbidity effects of particulate pollution can be measured in terms of 'restricted activity days' (RADs). Based on US studies, the Department of Energy and Minerals (1993) estimates that fine particulate pollution causes an additional 5690 RADs per 100 000 people for each average annual change in ambient levels of PM_{10} of 1 ug/m^3. Assuming the average daily wage rate is a reasonable proxy for estimating the cost of a RAD, and given the average daily rate of $147.34 (ABS 1998), then this amounts to a cost of $838 364 per 100 000 people for each average annual change in ambient levels of PM_{10} per ug/m^3. Note that this value is believed to understate significantly the actual cost of morbidity because it ignores subjective individual losses and additional stresses placed on families with sickness. Given the effected population described above, this amounts to a morbidity benefit in the greater Sydney region of $2,217 per tonne of avoided fine particulate discharges.

Health Treatment Costs

As noted earlier, international research is demonstrating a growing consistency in the links between PM_{10} and adverse health. The UK Department of Health (1998) have estimated that for each 1 ug/m^3 daily increase there is a 0.326% increase in chronic obstructive airways disease (COAD), a 0.08% increase in respiratory admissions and a 0.07% increase in cardiovascular admissions.

Taking the total health costs of these key diseases and attributing the proportion of the total cost associated with PM_{10} can provide an indicative estimate of the health impacts of PM_{10}. The average treatment cost of these conditions and total number of admissions is given in the table below.

Table 9. Health costs and admissions in NSW

Condition	Average Cost (NSW average)	No. of Admissions (Sydney only)
(COAD)	$17,196	3,540
Bronchitis and Asthma	$5,517	8,942
Other Respiratory	$5,283	26,243
Heart disease	$2,368	17,228

Source: NSW Dept of Health

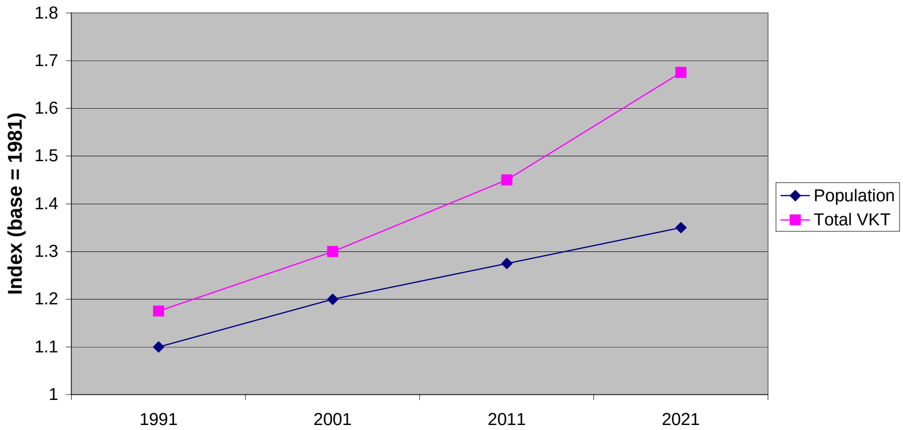
The estimate of total health costs avoided may under-estimate the total cost as areas outside Sydney are excluded and a higher average cost of treatment is more common in Sydney. Further, chronic (ie. ongoing long-term) cost effects of particulate pollution are also excluded from the analysis.

Applying the dose response relationships outlined above, the total health treatment costs of fine particulate pollution is $48.8 million for each 1 ug/m^3 increase in annual average PM_{10}. This translates into a health treatment cost of $21,700 per tonne of PM_{10} of discharged. Again this under-estimates the total health costs, as the analysis does not consider hospital attendance or cases not reported. The analysis also excludes the health costs to people that experience complications of existing health problems due to exposure to $PM_{10.}$ For example, the UK Department of Health (1998) estimate that every 1 ug/m^3 increase in PM_{10} results in a 0.2% increase in bronchodilator use, meaning asthma suffers experience additional costs on high pollution days.

APPENDIX 3
FRAMEWORK FOR ASSESSMENT OF IMPACTS OF OPTIONS FOR NEW ADRS

This appendix outlines the key assumptions that underpin the emissions projections. Figure 1 shows projected growth for the Sydney-Newcastle-Wollongong region. This was developed by the NSW Department of Transport as part of its transport forecast model.

Figure 1 - Projected growth



(Source: NSW EPA 1998)

Figures 2-5 show the projected emissions for the whole vehicle fleet in the Sydney-Newcastle-Wollongong region covered by the Metropolitan Air Quality Study (MAQSR) prepared by the NSW EPA in 1999. These graphs show estimated emissions under four scenarios and represent the data used to calculate the benefits of each scenario:

- Business as usual – projected baseline, incorporating the impacts of ADR37/01
- Euro 2 for all vehicles in 2002/3
- MVEC proposal, labelled here as the ‘hybrid’ option
- Euro 3 for all vehicles in 2002/3

ATTACHMENT E - SUMMARY OF PUBLIC COMMENT

The attached is a summary of the key points raised in each submission received on the MVEC Review of Australia's Vehicle Emissions Standards.

Respondent	Comment
1. School of Chemistry Macquarie University	• Support the adoption of Euro 3 standards in lieu of Euro 2. • Concern that Euro 3 and Euro 4 standards may lead to many vehicle manufacturers importing only PULP vehicles, which has some greenhouse implications. • Sulfur content needs to be reduced to allow use of catalytic converters on diesel vehicles.
2. Australian Automobile Association (AAA)	• No option but to adopt Euro 3 standards under GATT/WTO obligations and APEC. • Adopt Euro 3 in lieu of Euro 2 as manufacturers would not wish to have two (delayed) standards – only phase with the rest of the world.
3. Department of Environmental Protection, WA	• Support the adoption of Euro 3 standards by 2005/6 in lieu of Euro 2. • Recommendations are incompatible with Government policy commitments to implement an Automotive Industry Environmental Strategy. One element of which is "harmonised noxious emissions standards with International standards by 2006". • Global climate change and air toxics issues ignored. No consideration of the role of motor vehicles in the emissions of greenhouse gases (carbon dioxide, methane and nitrous oxide) and of air toxics, in particular benzene, toluene, 1,3-butadiene and polycyclic aromatic hydrocarbons. • Review is deficient in not assessing the costs and benefits of complying with Euro 3. This should be undertaken as soon as possible and published as an addendum to the Review. • Adoption of Euro 2 will not meet the Federal Government commitment of harmonisation with UN ECE standards by 2006. Application of Euro 2 standards to new models in 2002 will be six years after Europe and all models in 2003 would be 7 years after Europe. This would allow for the potential for dumping vehicles meeting lesser performance standards on the Australian market. • Strongly support the proposal to include all petrol vehicles up to 3.5 tonnes in the revised design rule. • The issue of test fuel specification is not included. The quite significant differences between test fuel and commercially available and commonly used fuel should be addressed, with a view to ensuring a test fuel that resembles as closely as possible commonly used fuel.
4. Ferrari	• Strongly support International harmonisation of regulations. • Support the adoption of Euro 3 standards. Would also be useful for low volume operators to adopt an alternative like the USA Tier 1.

Respondent	***Comment***
5. A J Smith	• If any change to the RON is envisaged then a review of the capabilities of Australian Refineries to meet the proposed RON should be conducted. • Need to focus on inspection and maintenance, in particular catalyst deterioration which is one of the contributors to emissions. • Rather than harmonise with Europe, should attack the obvious sources of the problems, ie evaporative emissions and in particular volatility and catalyst deterioration. • MVEC should canvass the option of requiring all light duty city trucks and buses to use gaseous fuels. • MVEC on the basis of the report, has not justified the move to new standards, this is especially so as the air quality data does not support the change. • Until the comparison data between the relevant standards has been produced and evaluated it does no credit to MVEC to present recommendations for passenger cars.
6. Nissan Motor Company	• Agree to the introduction of more stringent emission requirements if such a decision has been made as a result of sufficient study including the consideration of other methods (developing inspection and maintenance system for in-use vehicles, or any political methods for encouraging the scrappage of old vehicles), evaluation of costs and benefits, and if it would be proceeded with enough lead time and appropriate change on fuel properties. • Strongly believe Australia should increase the octane number (harmonise its level to Europe – 95RON) in commercial fuel in order to maintain the vehicle performance which meet the Euro 2 requirement. • Cannot decide the necessity of adopting Euro 3 standards without considering the result of air quality improvement based on the introduction of Euro 2.
7. Denso Manufacturing Australia Pty Ltd	• Suggest that the benefit derived from the replacement of charcoal canisters would be substantially less than projected. The working capacity deterioration of charcoals used in canisters should typically be less than 20% during the vehicle life. • The performance of the charcoal canister can be adversely effected by some other service affects. Vehicle producers are aware of field service deterioration and make some provision for this in deciding the canister requirements. • Although regular replacement of charcoal canisters is an appealing concept, the environmental benefits are not expected to be substantial when applied to later model vehicles.
8. International Trucks Australia Limited	• Support Euro 3 and required fuel quality only if study demonstrated that it was technically and economically viable (given Australia's high sulfur fuel) compared/balanced against a reduction in health costs.

Respondent	Comment
9. Bus Industry Confederation	• Euro 2 engines will be introduced into the Australian market before they are legally required to be introduced. (around 75% of new buses sold in Australia in 1999 will be equipped with Euro 2 engines). From the year 2000, Euro 3 engines will become the industry norm and advocates the mandatory introduction of Euro 3 engine standards in line with the proposed MVEC timetable • Supports the introduction of Euro 2 standards. However, the key parameter that influences whether in-service emissions from Euro 2 engines conform is the sulphur content of the diesel fuel. • Appropriate assistance should be provided to help the refineries met the cost of investing in desulphurisation units – by tax expenditure mechanisms such as accelerated depreciation or extension if the Infrastructure Borrowing's Tax Offset Scheme to include this form of investment. Another possible incentive is to lower excise on low sulphur fuel. • CNG is not the only option for reduced emissions and might not be the best option when greenhouse gas emissions are taken into account. • At present a Euro 2 engine cost from $2,000 to $3,000 more than an Euro 1 engine. During the course of 1999, based on the fact that Euro 2 engines will be produced in higher numbers, it is envisaged that the cost difference between Euro 1 and Euro 2 engines will fall to zero. • Tentative estimates are that Euro 3 engines will cost between $2,500 and $3,500 more than Euro 2 engines. The cost is likely to decline over time as volumes increase through increased market penetration of Euro 3 engines. • Considerable debate regarding the cost of installing necessary desulphurisation facilities at Australian refineries. Refinery estimates put the figure in excess of $1 billion. Based on overseas evidence the costs of installing desulphurisation units was $15 million per refinery in Canada with increased operating costs of around $1.8 million per year. MVEC paper estimates the cost at around $30 million per refinery with increased operating costs of around $2 million per year. Assuming that six of the eight Australian refineries need to upgrade their facilities this would imply an investment cost at around $180 million. • CNG engines are about 20% less fuel efficient than their diesel counterparts. A CNG bus would be approximately 15% more expensive than the equivalent diesel bus, and maintenance costs can be up to 5% higher for CNG buses. There are insufficient outlet to fuel CNG vehicles. • Although the emissions of some gases from diesel buses are higher than from CNG busses, clean diesel engines (Euro 2 engines) also have low emission when operating on low sulphur fuels. With regard to green house emissions, diesel appears to be superior to CNG in terms of carbon dioxide emissions for the same transport task, and when assessed on a life cycle basis.
10. Australian Automotive Aftermarket Association Ltd	• Agree to Euro 2 from 2002/3; do not support Euro 3. • Agree with tighter vehicle emissions, not fuel parameters. • The existing fleet should be tested annually for compliance with their relevant emission ADRs.

Respondent	Comment
11. Queensland Conservation Council	• There is little point in passing new exhaust emission standards for petrol and diesel engines if there is no credible level of in-service testing to ensure those standards are adhered to. • MVEC should revisit the option of following the US EPA's lead. Heavy diesels could readily comply with Euro3/EPA1999 or 2002. Australia could be in line with the US EPA standards by the time EPA 2004 is in place. • Supportive of options linking fuel and registration costs to improvements in emissions. • Supportive of measures to increase the proportion of the vehicle fleet, especially the heavy or freight vehicle component, utilising CNG and LPG. • Australian emission standards should incorporate fuel specifications as is the case in European and US emission standards • Need to accelerate the lowering of diesel fuel sulphur content to .05 or lower urgently. • Document fails to propose full adoption and implementation of EPA98 immediately, implementation of Euro 2 immediately and short term transition to Euro 3 standards as options. • Process of ongoing review of Australia's' standards to keep us in line with international standards is crucial.
12. Department of Transport – Queensland	• Euro 2 emission standards are the logical next step in harmonising Australia standards with the international market. • Fuel with volatility greater than ADR test fuel has been shown to significantly lower the in-service performance of vehicle evaporative control systems. • Review has not provided sufficient information regarding fuel quality on which to confidently support the introduction of Euro 3 standards. • Given the time taken to conduct reviews, reach agreement and allow manufacturers time to comply, it would seem logical to not only review Euro 3 standards but Euro 4 as well. • If review Euro 4 now, it should be possible to introduce Euro 4 in Australia at the same time as overseas, by-passing Euro 3 altogether. This would achieve true international harmonisation of introduction dates as well as standards.
13. Department of Transport WA	• Euro 2 should be adopted immediately. Euro 3 should be adopted as soon as possible ie 2002/3. • The introduction of Euro 2 engines into Australia will provide added leverage to seek the full specifications that these engines require.

Respondent	Comment
14. Australian Institute of Petroleum	• The implementation date for new emission standards should be based on the requirements of future air quality, and the practical investment schedules of both the auto and oil industries. • Review should incorporate the results of airshed modelling out to 2020. • Premature to make decisions on vehicle emission standards which have fuel quality impacts, before the fuel quality impacts have been fully assessed. Formally incorporate the review of Fuel Quality Requirements into the Review as the source of fuel related cost and impact data. • Set the date of introduction of the proposed standards on the basis of demonstrated need in the most critical airshed. Work backwards from that date to set timetables for auto and oil industry activities. • Consider all likely changes to petrol properties, not just RON, and in a timeframe out to 2020. Utilise the review of Fuel Quality Requirements for this purpose. • Implement a test program to determine whether 95 RON is really needed for maintaining the emissions performance of Euro 2 vehicles • Carry out scenario planning, airshed modelling and refinery investment analysis in connection with Euro 3 and Euro 4 before making any decisions on Euro 2, especially on the timing of implementation of Euro 2. • Do not introduce petrol volatility reduction as an alternative to the proper maintenance and performance of a component of existing and future vehicle emission control systems. Petrol volatility reduction should be considered on a stand-alone basis.
15. Caltex Australia Limited	• Agree to adopt Euro 2 standards, however timing should be determined following consultation with stakeholders. Do not support Euro 3 at this time. • It will not be possible to make any recommendations on future fuel quality requirements until after the findings of the Transport Fuels Study are available. • UN ECE standards could pose problems if these standards are designed to solve European air quality problems, which are different to the problems encountered in Australia, either for climatic or geographic reasons. • Need clarification of what is meant by harmonising with UN ECE standards. If it means that Australia would adopt European standards as soon as they are implemented in Europe, this could see Australia industry forced into investments, which yield little local environmental benefits.
16. Royal Automobile Club of Victoria (RACV)	• Supports harmonisation with UN ECE • Supports the reduction of the volatility of petrol provided that the reduced volatility does not have a detrimental effect on the driveability of existing vehicles in certain climate regions and that any associated impacts on petrol prices are minimised. • Commercial grade petrol should have the same octane specification as test fuel. • Introduction of lower sulfur content diesel fuel should be timed to minimise the impact on the local refinery industry in order to ensure that there are minimal impacts on petrol prices. • Do not support Euro 3, as further work is needed to assess the benefits and costs of such a proposal. The initial objective should be to ensure that the adoption of UN ECE Euro 2 delivers the anticipated emission benefits.
17. Col Potts Engineering	• Agree with summary of recommendations 6.2 of report • Projected diesel emissions can only be reached if higher standard diesel fuel is available. • For optimum performance and to minimise emissions, oils should meet engine manufactures specifications

Respondent	Comment
18. Toyota Motor Corporation Australia Ltd	• Supports the thrust of response provided by the FCAI, particularly in regard to the vital importance of fuel quality and pricing on the success of future emissions standards. • Endorse Euro 2 subject to supporting conditions identified by the FCAI.
19. The Royal Automobile Club of Queensland Ltd	• Supports the introduction of Euro 2 standards from 2002/3 and Euro 3 some time thereafter, say five years. • Tightening of emissions standards should be carried out according to a widely published plan in respect of the emission levels, the timings and fuel parameters • Support alignment with UN/ECE standards • Ensure fuel standards move in line with emission standards. Commercial fuels should meet the specifications of the standard test fuel. • Support on-board diagnostic system (that is guaranteed for the life of the vehicle) to warn of the failure of any part of the emission control system.
20. Detroit Diesel-Allison Australia	• Disagree with the adoption of Euro 2 standards, support adoption of alternative US EPA 1994 standards. • Do not support the adoption of Euro 3 standards without full cost and benefit assessment.

21. Federal Chamber of Automotive Industries	• Supports progressive tightening of emission standards and harmonisation with ECE standards. Proposes the Euro 2 standards become effective from 2003 for new models, and 2005 for existing models, subject to:
	  • Ensuring that suitable fuel qualities are widely available at a competitive price
	  • Assuring a minimum of 2 years leadtime from rule gazettal for new models
	  • US94 and Japan 98 standards be allowable alternative standards for heavy duty diesel vehicles
	  • EEC certificates be accepted for compliance, as the test procedure is the same as UN ECE.
	  • Acceptance of certification of vehicles on 95RON test fuel.
	• Support adoption of Euro 3 standards after an appropriate lead time to develop supporting infrastructure for both OBD systems service and provision of a high quality fuel supply to the market. (market place fuel quality to be the same as specified by the emission regulation ie World Fuel Charter, category 3, the same as regulated in Europe).
	• Adoption of Euro 3 following a comprehensive evaluation which demonstrates the need for such a standard
	• Essential to modify fuel specification and improve fuel quality not only in terms of reducing fuel volatility and diesel sulfur content, but also ULP octane increase and ULP reduced sulfur levels.

Respondent	Comment
22. Dr Sue Graham-Taylor, on behalf of the National Environmental Consultative Forum	• Adopt UN ECE vehicle emission regulations as soon as possible. Adopt Euro 3 standards. • Review should also consider the problem of air toxics from motor vehicles and their fuels such as benzene, 1,3-butadiene, acetaldehyde and formaldehyde • Review should elaborate on the health effects of fine particles less than PM 2.5 in the summaries • Review fails to consider carbon dioxide emissions. Improving fuel consumption can reduce such emissions. Should consider tax incentives for low emission vehicles. • Support adopting Euro 3 standards (skip Euro 2) • If emission standards are to be met, fuel parameters need to be considered. • Should not be considering a 0.05% (500 ppm) standard for sulphur in diesel as it will be out of date by the time it is implemented. • Urge the establishment of emission standards for vehicles running on alternative fuels, in particular for LPG and natural gas, due to methane emissions.
23. Department of Transport, WA	• Support adoption of Euro 2, followed by Euro 3, depending on the outcomes of a detailed Australian costs benefit analysis • Develop and implement a policy offering incentives for the adoption of low polluting alternative fuels to encourage new Australian technologies, industries and innovations.
24. Environment Protection Agency, SA	• Adopt Euro 2 for the commercial (diesel fuelled) portion of the fleet. Euro 2 for passenger vehicles is considered premature, insufficient information to determine if Euro 2 is the most cost-effective solution. • Main concern for the adoption of Euro 3 (as well as Euro 2) is the risk that 95 RON fuel may need to be introduced, and the associated risk of introducing more air toxics into urban airsheds. • Request that further analysis be undertaken on the impact on fuel consumption from the introduction of the proposed ECE/US standards – full assessment of the impact of proposed options on greenhouse gas. • Subject to the findings of the national fuel study, the move to reduce lower petrol volatility and lower sulphur content in diesel (to 0.05%) is considered beneficial • Strongly support the need to include a smoke emission requirement in the relevant ADR, as it supports in-service programs. • Concern that the proposed PM mass based emission standards for diesel vehicles may lead to an increase in the number of (very) fine particles. The health impacts should be assessed. • Support that the ADR should apply to all types of (alternative) fuels, and that the mass limit in ADR 37/01 should be increased to 3.5t.
25. Environment Victoria	• As Australia has signed an International treaty that requires us to adopt International standards by 2006, the paper should be largely about the process and timing of adopting the standards. • No point in adopting standards that have already been superseded in Europe and the USA • Would only support adoption of Euro2 and Euro 3 if they were part of a process to reach international standards by 2006. Such a process should involve stakeholder consultation. • Need in service monitoring. • National Environment Consultative Forum should be involved in the process of developing the formal response to the public comments.

Respondent	Comment
26. Clean Air Society of Australia and New Zealand	• Basic agreement with the recommendations of the report, however, recommendations are not sufficiently far reaching. • Report lacked discussion of the role of diesel fine particulate emissions. In service diesel vehicles emit large numbers of particulates in submicron range, Euro standards will not address these emissions as the Euro standards are based on PM10 mass measurements.
27. Cummins	• Agree to the introduction of Euro 2 standards from 2002/3, with the stipulation of US EPA 1994 as an alternative. • Unable to agree to Euro 3 until a cost benefit assessment is undertaken.
28. Robert Bosch (Australia) Pty Ltd	• Agree to the adoption of Euro 2 standards in the quickest possible timeframe. • Euro 3 standards cost and benefits should be further investigated as any change in fuel specifications will have obvious wide-ranging economic benefits
29. Royal Automobile Club of WA (Inc)	• Agree to the adoption of Euro 2 standards from 2002/3. • Would support the adoption of Euro 3 standards provided that it shows a positive net benefit. Consideration needs to be given to the effect on new car prices. If there is an increase it will reduce the number of new cars purchased and prolong the life of older cars.
30. Road Transport Forum	• Changes to vehicle emission and fuel parameters should be done in such a way not to impose significant costs or impediments upon the industry. • Degree of policy symmetry should be established linking vehicle emission standards and fuel parameters with other government policy instruments to provide incentives for industry to purchase new or upgrade equipment to meet government environmental objectives. • Adopt Euro 2 and USEPA94 standards introduced once fuel parameters have been resolved (from 2002/3) with Euro 3 standards then being considered in the context of a staged approach five years later. • Lowering sulphur content is likely to impose an extra fuel cost on industry as a result of extra refining processes. This should be considered when changing fuel parameters. • Standards for alternative fuels such as LPG and CNG should be aligned with UN/ECE and American standards • Introduce positive policy incentives to encourage industry to upgrade engines or purchase new vehicles in order to meet the new standards • Taxation strategies should be an integral part of broader environment and industry policy.

Respondent	Comment

31. Department of Transport and Works, NT	• Support the adoption of Euro 2 , followed by Euro 3 if supported by cost benefit analysis
	• Document does not quantify the net costs for remote and rural areas, which are likely to come from increased fuel and vehicle costs
	    • Vehicle equipment – additional equipment is likely to be required on each vehicle ($300-650 per light vehicle and $1000-1300 per light diesel vehicle.
	    • Impact on fuel prices of the additional refinery capital costs or the possible need for refineries to use more crude oil and increase energy consumption in order to achieve higher quality fuels.
	• Remote and rural areas should be compensated for these increased costs as the tighter emission standards are primarily directed at solving problems associated with urban areas.
	• Decisions about future fuel standards should be delayed until the results of the Fuel Study are available.
	• Paper ignores the financial impact of the phase out of leaded super petrol on the owners of vehicles, which require this petrol. There are significant conversion / modification costs

32. People for Ecologically Sustainable Transport	• Support adoption of Euro 3 in 2002/3.
33. Land Transport Safety Authority, New Zealand	• Support the move towards UN-ECE as part of the move towards global harmonisation. • Would not impose any restrictions on vehicles coming from Australia and built to Euro 2 levels.
34. Pedal Power	• Concerned about the double standards between vehicles powered by petrol and vehicles powered by diesel. Standards for diesel should be the same as those for petrol. • Would like to see particulate emissions reduced.
35. Caterpillar of Australia Ltd	• All Caterpillar engines supplied to Australia meet current US 98 standards. • Support the introduction of Euro 3/EPA 99 standards for the 300+ HP vehicles in 2002/3 and for vehicles with lower HP in 2005/6. • Euro 3 and US 99 test procedures for heavy vehicles are the closest match between US and EU heavy duty standards to date. • Adoption of latest standards will not necessarily increase costs, and will enable full advantage to be taken from progressive improvements in fuel quality. • Have been using engines designed for low sulphur on Australia's high sulfur fuels with no identifiable problems. • However, if Australia continues to use high sulphur fuels there is concern that modern oils (designed for use with low sulfur fuel) will not be able to provide the same level of protection.

Respondent	Comment

36.
Australian Greenhouse Office
	• Supports the introduction of a new ADR for 'light duty' vehicles that adopts UN ECE R83/03 (Euro 2 level).
	• Need to ensure that this is implemented in a manner that will ensure that the following Commonwealth objectives are met:
	  • Harmonising with international UN ECE vehicle emission standards by 2006
	  • Minimising the impact on the NAFC framework and system of targets;
	  • Facilitating the introduction of a model specific labelling scheme as soon as possible ;
	  • Minimising the need for motor vehicle industry to conduct more than one test procedure to meet vehicle emissions and greenhouse/fuel consumption data requirements.
	• The above objectives can be met provided that:
	  • ADR37/01 is not amended to incorporate Euro 2 and Euro3 as alternatives standards as soon a possible (unless the comparative emissions test program being undertaken by FORS shows minimal or no difference in the fuel consumption results achieved using the AS 2877 and UN ECE test procedures); and
	  • There is a single date for the Introduction of the proposed new ADR for all 'light duty' vehicles (rather than the two step introduction arrangement.
	• New passenger cars will achieve different fuel consumption figures when tested using the AS 2877 and UN ECE test procedures. Euro 2 should be implemented in such a way as to minimise the impact to a single discontinuity in the NAFC data set at an identified point in time. This will also be an issue for fuel consumption labelling.
	• The move to UN ECE Regulation 83 will encompass vehicles up to 3.5 tonnes which will facilitate the inclusion of LCVs and 4WDs between 2.7 and 3.5 tonnes in the NAFC framework.
	• Agrees that all vehicles within the scope of the ADRs should be required to meet the same emission standards, regardless of the fuel they are designed to operate on.
	• The test procedure remains an issue for the implementation of model specific labelling unless the comparative emissions test program being undertaken by FORS shows minimal or no difference in the fuel consumption results achieved using the AS 2877 and the UN ECE test procedures.

37. Institute of Automotive Mechanical Engineers	• Support adoption of Euro 2 standards from 2002/3.
38. Department of Infrastructure, Energy and Resource, Tasmania	• Euro 2 standards are the most sensible option available and from 2002/3 will provide sufficient lead –time to allow industry to comply. • Unable to support Euro 3 without detailed cost benefit analysis

Respondent	Comment

39.
VicRoads
	• Support in principle the adoption of Euro 2 standards for new model vehicles from 2002 and all new vehicles from 2003 and to lower the volatility of petrol and the sulphur content of diesel. However, prior to the promulgation of a revised ADR 37/01 based on Euro 2 the fuel octane issue should be clarified.
	• Octane rating of ULP in Australia is 91.6, Euro 2 test fuel minimum 95 RON
	  • There may be a compromise in emissions, such that operation on 91.6 RON leads to increase in emissions, negating the impact of introducing Euro2
	  • There will be a reduction in vehicle performance and increase in fuel consumption
	  • Owners of Euro 2 certified vehicles may be forced to use PULP at an extra cost
	  • If a higher octane fuel is required, then there will be a cost for the petroleum industry
	  • Decisions on the introduction of Euro 3 (and Euro 4) should be deferred until the full costs and benefits of Euro 2 standards has been established and an analysis of the impacts of Euro 3 standards has been undertaken.

40. Total Environment Centre	• Support the adoption of Euro 3 in lieu of Euro 2. Agree with the proposal to lower fuel volatility and reduce diesel sulphur content.
41. ACT Department of Urban Services	• Adoption of Euro 2 a minimum requirement. Support the adoption of Euro 3 in lieu of Euro 2. • Support moves to lower the volatility of petrol and to reduce the sulphur content in diesel fuel. However, the pace of change needs to be such that it can be accommodated by the Australian fuel industry.
42. Environment Australia	• Supports the adoption of internationally harmonised vehicle emission standards based on UN ECE regulations for light and heavy vehicles, and for these standards to include alternative fuel vehicles. • Euro 3 should be considered subject to the outcome of further analysis. • Support acceptance of US EPA 1994 standards as alternatives to the principle standards. Given that vehicles of US origin certified under US EPA procedures dominate the heavy vehicle market in Australia, it appears logical to accept US certification for those vehicles. The concession should not apply to vehicles of other than US origin or to vehicles of US origin that have been certified under UN ECE procedures. The concession should not apply to light vehicles regardless of country of origin.
43. Australian Liquefied Petroleum Gas Association Ltd	• Considerable scope for gaseous fuels to replace diesel fuel for both freight and bus operations. • Significant emission reductions to be achieved from in-service vehicles • Light Duty standards – progressive tightening of emission limits may not be cost effective when there is scope to achieve significant short and medium term fleet wide emission eductions by other complementary means – in-service, alternative fuels • Medium/Heavy Commercial Vehicles – adopt a rapid, phased uptake of Euro 3 standards for all medium and heavy –duty vehicles • Support the adoption of Euro 2 standards for light duty spark-ignition engines. All spark ignition OEM and factory-converted vehicle should be included in the scope of upgraded emission standards, subject to appropriate lead times.

Respondent	Comment
44. Department of Environment and Heritage Qld	• Agree to tighter standards and harmonisation • There should be no technical impediment for Australian manufacturers to comply with Euro 2 and 2002/3 appears reasonable for this purpose • Support Euro 3 in principle, subject to a cost benefit analysis of the incremental change from Euro2. Undecided at to the timing of Euro 3. Nevertheless going straight to Euro3 may be attractive to Australian Manufacturers, as there would only be one change to production lines instead of two.
45. Volvo Truck Australia Pty Ltd	• Support harmonisation with ECE regulations. Definition of harmonisation includes identical system of certification, identical testing methods, uniform sets of standards (limit values) and identical production of conformity routines. • Strongly recommend ECE regulation 49 • Recommend that only the US99 heavy duty standards be accepted as an alternative in Australia.

46. BP Australia Limited	• BP's introduction timetable and proposed fuel quality parameters are aligned with the following recommendation of the review
	  • Introduce all 3 new ADRs to take effect from 2002 for new models, and 2003 for all models
	  • Reduce the sulphur content of commercial diesel fuel to 0.05% and the volatility of petrol by 5-10 kPa to coincide with the introduction of the revised standards.
	• Regulating the introduction of Euro3/4, and complementary fuel quality parameters should be revisited when the implications of introducing Euro2 are better understood.
	• While understanding the benefits of harmonising vehicle emission standards, does not necessarily support the need to harmonise implementation timetables. There is a significant local vehicle and fuel manufacturing sector where the cost may significantly outweigh the benefits of an internationally harmonised implementation timetable. Population, urban exposure levels etc in Australia are significantly different to those in Europe and the USA.
	• Do not yet understand the total lifecycle benefits and costs, especially for regional air quality parameters of moving the unleaded petrol pool from 91 to 95 octane
	• In relation to 0.05% sulphur diesel, there may not be a significant health and environment benefit from moving country and off-road use to a lower level of sulphur.

47. European Automobile Manufacturers Association (ACEA)	• Supports the adoption of Euro 3 standards by 2002/3, which will impose improvements in catalyst formulation, fuel injection systems and their calibrations. It also implies specifications for the environmental properties of both fuels. • As these standards will be applied in 2001 in the EU, the technical solutions would be available for Australian manufactures shortly after this date. The costs should not be an obstacle due to the fact that the standards would provide a harmonised framework for the development and the industrialisation of the technology. • The EU has retained for Euro 3 an important measure, which consists in the introduction of On-Board Diagnostic systems on both gasoline and Diesel vehicles. With these systems, the operation of the components of the emission control device remain under a permanent control during the life of the vehicle.

Respondent	Comment
48. Bob Murphy	• US diesel companies who dominate the heavy truck market in Australia already meet higher standards than those proposed in the MVEC paper. • Caterpillar is already on US EPA 98, Cummins has nearly finished implementing EPA94 and expects to adopt EPA98 in Australia this year, Volvo has named Cummins as its new engine partner so expect to see the new Cummins engine in Volvo trucks in Australia this year; some Detroits are being imported at EPA98 levels, locally supplied Detroits are still complying with EPA91 but they are moving to EPA94 this year. • The requirement to introduce EPA94 would be 9 years behind the US requirement and US engine builders supply more than 70% of Australia's heavy vehicle engines.
49. Armidale Air Quality Group	• If Europe can adopt Euro3 by the year 2000, and Euro 4 by 2005, the onus will be to justify why Australia can't do the same, or at least introduce Euro 3 for diesel engines by 2002 and the Euro 4 diesel standards at the same time as Europe. • Australia should adopt the European standards that will be current at that time – Euro 3. Harmonisation of international emission standards by 2005/6 will surely require the adoption of Euro 4 or its US equivalent. • Most manufacturers will be planning to meet these standards for the vehicles they sell in Europe and the US, so compliance should not be an issue. • If Australia has less stringent emission standards than US or Europe it might become a dumping ground for manufacturers older, more polluting models. • The adoption of Euro 3 in Europe in 2000 presumably means that it has been assessed as cost effective there. Given recent research into adverse effects of air pollution there can be little doubt that Euro 3 would be found to be cost effective in Australia. Move to meet international emission standards as soon as possible will ensure Australia is not at a competitive disadvantage. • To allow industry the longest possible lead-time to adjust, the decision should be taken as soon as possible to adopt Euro 3 by 2002/3, followed by the agreed harmonisation to international standards including Euro 4 by 2005/6. MVEC should also consider what standards should be adopted beyond that timeframe and its lead in investigating what further standards and strategies are to be adopted including alternative fuels and emissions testing or retro-fitting of existing vehicles.
50. Smogbusters Nature Conservation Council of NSW	• MVEC should not make a decision about emission standards until they have investigated the ability of current technologies to meet strict air quality standards at the earliest possible date • MVEC should publish economic simulations, such as how the new standard would exert an influence on jobs in the automotive industry, freight costs, and cost of running private cars. • MVEC should set a target to have all private petrol vehicles 10% more fuel efficient by 2004 and adopt measure to ensure this is achieved. • Petrol vehicles - The European Euro standard is tighter than the US Tier system, as such Australia should not adopt the US Tier system • Euro 3 standards for petrol should be adopted in 2002 and Euro 4 in 2005. • Euro 3 standards for diesel should be adopted in 2004 • Support for CNG infrastructure • Reductions in the level of sulphur in fuel need to occur as a matter of urgency. Technology to reduce PM must be considered in the light of the development of motor vehicles emission standards. • Economic incentives should be adopted to make the attractive purchase of small, fuel efficient cars with low emissions.

Respondent	Comment
51. Australian Automobile Association (AAA) (2)	• Support harmonisation with UN ECE • Support the points raised in the MVEC document • Support the introduction of alternative fuels • Fuels necessary to obtain the best emissions performance and at the same time reduce fuel consumption. may not be readily available from the National refineries and will have a higher cost implication.