EXECUTIVE SUMMARY

Introduction

Coffey Geosciences Pty Ltd (Coffey) was commissioned by Environment Australia to develop six scenarios for possible new fuel specifications for Australia, designed to reduce emissions of greenhouse gases and air pollutants from Australian transport. The study was undertaken by a Review Team, led by Coffey, included significant contributions from the following specialists:

- Dr Frank Carnovale (air emissions specialist)
- Mr Peter Barnes (oil refinery technology specialist),
- Mr Michael Mowle (stakeholder liaison)
- Ecologica (project support),
- Tasman Asia Pacific (economic modelling) and
- Parson Australia (vehicle technology).

The development of the scenarios for new fuel specifications included extensive consultation with stakeholders, including the major stakeholders in the oil and motor vehicle industry. The impacts of the new specifications on air pollutants and greenhouse emissions were assessed, along with the impacts on Australian refineries, vehicle manufacturers, consumers and the economy wide effects of changing fuel specifications for petrol and diesel.

As the study addresses the relationship between fuel quality and emission of greenhouse gases and air pollutants, background information was also collated on the existing policies for motor vehicle emission control technologies, and studies undertaken relating fuel quality to emissions.

Motor Vehicle Emissions – Policy Context

Regulatory issues related to motor vehicle emissions include those addressing ambient air quality and those addressing motor vehicle emission standards. An understanding of the regulatory environment associated with these issues is important in assessing the relationship between motor vehicle emissions and air quality in Australia.

In 1997, the National Environment Protection Council (NEPC) issued a draft National Environment Protection Measure (NEPM) for Ambient Air Quality in Australia, including national standards and goals for the six most common air pollutants: carbon monoxide, nitrogen dioxide (NO_2), photochemical oxidant (as ozone), sulphur dioxide, lead and particulate matter (as particulate matter less than ten microns, PM_{10}). The air pollutants which most commonly exceed goals and standards in Australia are PM_{10}, photochemical smog (ozone) and, to a lesser extent, NO_2. Motor vehicles are a major source of these pollutants (or their precursors) in major Australian cities. Particulates from diesel exhaust are especially a concern. In Australia, PM_{10} typically contains a high proportion of particles in the $PM_{2.5}$ fraction, which presents health and environmental concerns. Diesel particulates typically comprises 80% to 90% $PM_{2.5}$ and they contain some toxic and carcinogenic compounds.

The National Greenhouse Gas Inventory (NGGIC, 1996), indicated that Australia's net emissions of greenhouse gases increased at a compound rate of 0.57% per year during the period 1990 to 1994. The transport sector contributed 11.7% of the total net emissions (CO_2 equivalents) in 1994, having grown at an average rate of 1.7% per year since 1990.

In Australia, the Commonwealth Government and the National Road Transport Commission (NRTC) indicated the Government's total commitment to harmonisation of vehicle emission standards with International Standards (that is, those of the United Nations Economic Commission for Europe (UNECE), which are technically equivalent to the standards adopted in the European Union - i.e. the 'Euro' standards). The Commonwealth Government's *'Environmental Strategy for the Motor Vehicle Industry'* indicates intent to achieve 'full' harmonisation by 2006.

The commitment for Australia to harmonise with international motor vehicle emission standards, together with the medium and long term objective of reducing total emissions from motor vehicles, presents a requirement for Australian motor vehicle emission standards to be tightened.

A package of new vehicle emission ADRs became law under the *Motor Vehicle Standards Act 1999* in December 1999, which included the staged introduction of European standards, namely, Euro 2 and Euro 3 emission standards.

The main regulatory mechanism for control of motor vehicle emissions in Australia is embedded in the Australian Design Rules (ADRs).

The Australian Design Rules (ADRs) contain mandatory standards for motor vehicle safety and emissions under the Commonwealth's Motor Vehicle Standards Act, 1989. They are applied to all vehicles when first supplied to the market, prior to their first registration in Australia. Exhaust and evaporative emissions from new petrol fuelled passenger cars and light commercial vehicles (up to 2.7 tonnes) are currently regulated by ADR 37/01, which includes a chassis dynamometer-based air emissions test procedure. This control standard is based upon the standards that applied in the US for the 1981 and 1982 model years, and was phased-in in Australia during 1997/98.

Comparison with International Standards

The mechanisms for development and implementation of emission standards in different countries vary, making it difficult to draw precise comparisons. For indicative purposes, the Australian emission standard for passenger cars and light commercial vehicles (ADR 37/01) are tabulated in Table 1, along with the principal limits applying and proposed for petrol motor cars in the USA and Europe.

Table 1 Comparison of Emission Standards for Petrol Cars in Australia, the United States and Europe

Pollutant	ADR37/01	US Tier 1	US Tier 2	Euro 1	Euro 2	Euro 3	Euro 4
	1997/99	1994/96	2004/06	1992/93	1996/97	2000/01	2005/06
Exh HC g/km	0.26	0.25*	0.08*			0.20	0.1
Exh NO_X g/km	0.63	0.25	0.124			0.15	0.08
HC+NO_X g/km				0.97	0.5		
Exh CO g/km	2.1	2.1	1.06	2.72	2.2	2.3	1
PM g/km		0.37	0.05				
Evap HC g/test	2	2	2	2	2	2	2

Notes: ADR 37.01 = US 1981 * = Non methane hydrocarbons
Exh = Tailpipe exhaust Evap = Evaporatives
HC = Hydrocarbons NO_X = Oxides of nitrogen PM = Particulate matter
Evaporative test procedures in Euro 3, 4 are more stringent. US Tier 2 is more stringent again.
Test procedural differences and durability requirements mean that direct comparisons of the standards are not necessary valid.

Emission limits for the diesel engines used in heavy duty vehicles are set by ADR 70/00 in Australia. It provides manufacturers with the option of complying with one of three sets of emission standards, being those current in 1995/1996 in Europe (Euro 1), the USA (the 1991 standard) and Japan (the 1993/1994 standard). This ADR is based upon engine dynamometer testing procedures, which are different in each jurisdiction. For indicative purposes, the emission standards for heavy duty vehicles in Australia (ADR 70/00), together with the current and proposed emission standards in Europe, USA and Japan are shown in Table 2.

Table 2 Comparison of Emission Standards for Heavy-duty Diesel Vehicle Engines in Australia, Europe, the United States and Japan

Pollutant	ADR70/00	Euro 2	Euro 3	Euro 4	Euro 5	US	Japan
	1997/99	1995	2000	2005	2008	1998	2004
CO g/k W/hr	4.5	4.0	2.1	1.5	1.5	15.5	2.22
HC g/k W/hr	1.1	1.1	0.66	0.46	0.46	1.3	0.87
NO_x g/k W/hr	8.0	7.0	5.0	3.5	2.0	4.0	3.38
PM g/k W/hr	0.36	0.15	0.1	0.03	0.02	0.1	0.18

Notes: Test procedural differences mean that direct comparisons of standards are not necessary valid
ADR 70/00 = Euro 1 or US 94 or Japan 94. The ADR is shown here as the Euro 1 limits

Motor Vehicle Emission Control Technologies

In order for the motor vehicle emission standards described above to be achievable, motor vehicle emission control technologies must be available and economically viable. Some of these emission control technologies require fuel of a particular quality to enable them to be effective. For example, several diesel engine emission control technologies require the diesel fuel to have a very low sulphur content for the emission control mechanism to be effective.

A variety of technologies exist to control vehicle emissions and/or to reduce fuel consumption.

Of particular interest in this study are those technologies:

(a) that are now being developed for commercial application in order to concurrently achieve major emission and fuel consumption reductions, and

(b) which, in combination with other technologies may be dependent on fuel quality for effective function and durability.

The main, available and emerging technologies for petrol engines are tabulated below with an indication of their dependence on fuel quality.

Table 3 Fuel-Sensitive Technologies for Spark-Ignition Engines

Technology	Availability		Sensitivity to Fuel Quality	Key Fuel Parameter and Threshold
	Now	Emerging		
Computerised engine management	⊗		**Low**	
Knock sensors	⊗		**Low**	
Exhaust gas oxygen (EGO) sensors	⊗		**Low**	
Exhaust gas recirculation	⊗		**Low**	
Multi-point fuel injection	⊗		**Low**	
Sequential fuel injection	⊗		**Low**	
Variable valve timing / lift (VVT)		⊗	**Low**	
Lean burn		⊗	**High**	**Sulfur < 30 ppm**
Stratified charge, petrol direct injection		⊗	**High**	**Sulfur < 30 ppm**
Advanced catalyst formulations		⊗	**High**	**Sulfur < 50 ppm**
On board diagnostics		⊗	**Medium**	**Sulfur < 150 ppm**

Note: Availability "Now" is defined as a technology that is standard or optional equipment on a wide range of vehicle models. All "Now" technologies are under continuing development and refinement. "Emerging" means limited commercial availability or proven technology likely to be commercially available in the near future.

Most of the 'Now' technologies listed in Table 3 are already widely adopted on vehicles supplied in Australia. The exception is sequential fuel injection, which is relatively new in world production and comes at some additional cost and complexity. This technology may be expected to achieve some penetration into the Australian market over the next several years on larger, higher performance models, particularly as more stringent emission standards are implemented.

The 'Emerging Technologies' listed above are under rapid development by the vehicle manufacturing industries and their suppliers.

The lean burn and gasoline direct injection technologies provide fuel efficiency benefits, and suitable advanced catalyst formulations are rapidly being developed that allow their compliance with stringent emission standards. It therefore seems likely these technologies will become 'mainstream' in Europe, Japan and North America within several years.

However, the additional complexity of the technologies and their implied additional costs, together with concerns for sulfur poisoning of advanced catalyst formulations, would likely slow their adoption in Australia until encouraged by emissions and fuel quality requirements equivalent to Euro 4 and beyond.

Available and emerging emission control technologies for diesel engines along with an indication of their sensitivity to fuel quality are summarised in Table 4.

Table 4 Fuel-Sensitive Technologies for Diesel Engines

Technology	Availability		Sensitivity Fuel Quality	Key Fuel Parameter and Threshold
	Now	Emerging		
Computerised fuel and engine management	⊗		Low	
Direct fuel injection	⊗		Low	
Common Rail High Pressure Injection	⊗		Low	
2-way catalyst	⊗		High	Sulfur < 30 ppm
De-NO_x catalyst		⊗	High	Sulfur < 5 to 10 ppm
Continuously regenerating particulate trap		⊗	High	Sulfur < 30 ppm
Particulate filtration		⊗	Low	
On board diagnostics		⊗	Medium	Sulfur <150 ppm

The presence of sulfur in diesel fuel has potential to degrade the performance of virtually all the technologies available to control tailpipe emissions. However, some technologies are more sensitive than others to sulfur levels. In particular, NO_x trapping and reduction systems are degraded by even low sulfur levels. In response, the draft of the World Wide Fuel Charter, developed by the motor vehicle industry, calls for sulfur free (less than 5 to 10 ppm sulfur) petrol and diesel for areas with advanced requirements for emission control to enable sophisticated NO_x technologies.

In summary, if Australia is to move to Euro 3 and Euro 4 emission standards, the exhaust treatment technologies necessary for compliance with these standards will require fuels with a sulfur content of not more than 50 ppm and possibly lower

Fuel Quality Studies and Legislative Environment

A combination of Commonwealth and State Government policies and legislation forms the legislative environment for fuel quality specifications in Australia.

The Commonwealth Government's '*A New Tax System*' legislation was passed by Parliament in June 1999. The legislation includes several commitments which will impact on future vehicle emissions and fuel standards, under the '*Measures for a Better Environment*' element of the '*Tax Package Agreement*'.

Recent Commonwealth Government policy statements have made reference to fuel quality and vehicle emission standards. The Prime Minister's statement on climate change in November 1997, '*Safeguarding the Future: Australia's Response to Climate Change*', includes several commitments of relevance to this study. The National Greenhouse Strategy, including the Environmental Strategy for the motor vehicle industry, includes policy initiatives related to the phasing out of leaded petrol. State Government policy initiatives have also made reference to fuel quality standards, particularly in New South Wales, Victoria and Western Australia.

In order to provide additional information on the relationship between fuel quality and motor vehicle emissions, this study included the collation of relevant information from recent fuel quality studies undertaken in Australia and overseas. These studies have examined the relationship between fuel quality parameters and motor vehicle emissions.

Recent studies undertaken in Australia which provide information on the relationship between fuel quality and motor vehicle emissions include:

- A report by the Australian Academy of Technological Sciences and Engineering (AATSE), '*Independent Inquiry into Urban Air Pollution in Australia*', which identified a number of specific links between fuel characteristics and vehicle emissions;
- A recently completed review of the Australian emission standards (ADR 37/01 and ADR 70/00), which has highlighted issues with respect to fuel characteristics; and
- The fuel quality recommendations included in the report by the Motor Vehicle Environment Committee (MVEC), '*Review of Motor Vehicle Emission Standards*'.

A number of overseas studies have been undertaken on fuel specifications. The recent Auto/Oil Quality Improvement Research Program (AQIRP) in the United States (US) showed a clear relationship between fuel specifications and emissions in petrol fuelled vehicles. A similar study in Europe, the European Auto-Oil Program (EPEFE) carried out by the European Motor Industry (represented by ACEA) and the European Oil Industry (represented by EUROPIA) identified the effect of changing specific fuel characteristics on emissions from diesel and petrol vehicles.

As a result, in US and in the European Union, fuel compositional changes have been driven by vehicle emission requirements and by engine emission control technologies. More recent emission control standards have been coupled with mandated quality and compositional requirements for market petrol and diesel fuel.

Stakeholder Liaison

The above sections outline the relationship between fuel quality parameters, motor vehicle technology and the emissions from motor vehicles. Background is also provided to the Australian government policy setting, and the existing international regulations for motor vehicle emissions and fuel quality. The objective of this study was to build on this information and undertake a comprehensive review of possible new fuel specifications for Australia, designed to reduce emissions of greenhouse gases and air pollutants from Australian road transport.

In order to assess the potential impacts of new fuel quality specifications on Australian refineries, vehicle manufactures and consumers, and taking into account the objectives of the regulators, it was necessary to obtain a high level of cooperation from the stakeholders.

During April and May 1999, the Review Team consulted with a broad range of stakeholders including many within government, the automotive industry and the petroleum industry, to solicit views on future fuel quality scenario development.

Key stakeholders were identified through interaction between the Study Steering Committee (comprising representatives from Environment Australia, Australian Greenhouse Office, the Department of Industry Science and Resources and the Department of Transport and Regional Services) and the Review Team and was expanded during the course of the consultation process. A list of stakeholders is presented as an appendix to Chapter 4.

The stakeholder consultation process commenced with the circulation of a letter to the stakeholders, informing them that a series of scenarios were to be developed to represent the range of likely changes in fuel quality over the next ten years. Comment was sought from the stakeholders regarding the key issues to be considered in the fuel quality scenarios.

Written responses were received from 28 stakeholders. A Coffey representative also attended meetings with 30 of the major stakeholders, including state government agencies, petroleum companies and motor vehicle manufacturers. The stakeholder consultation process continued throughout 1999, with the stakeholders providing comment on the draft scenarios, particularly in relation to the incorporation of the Prime Minister's commitments under the *'Measures for a Better Environment'* element of the *'Tax Package Agreement'* (discussed further in Section 5.1).

The main issues identified by the stakeholders for consideration in the development of the scenarios included:

- **Air quality and the Ambient Air National Environment Protection Measure**. More stringent new vehicles emission standards were seen as an essential strategy to combat projected growth in vehicle kilometres travelled (VKT) and assist with achieving and maintaining compliance with the ambient air quality standards specified in the NEPM;
- **Greenhouse commitments**. Stakeholders considered that improvements in vehicle fuel efficiency are important in achieving the greenhouse gas emission targets set in the Kyoto protocol;

- **Emissions standards harmonisation**;
- **The government's commitment to a 15% reduction in the national average fuel consumption (NAFC)** for passenger cars, four wheel drives and light commercial vehicles over business as usual (as stated in the '*Environmental Strategy for the Motor Vehicle Industry*');
- **The increasing demand for high octane petrol following the introduction of more stringent emissions standards**. Government agencies were concerned that this would put pressure on refiners to increase benzene, aromatics and olefins in order to achieve higher pool octane. Refiners were concerned that limits on these compounds would substantially increase the investment required to make higher octane petrol. The use of octane enhancement additives was also raised as issue with potential impacts on the environment and fuel efficiency performance. The increase in greenhouse gas emissions from refineries through production of higher octane petrol was also seen as an important issue for consideration in the development of fuel quality scenarios;
- **The possibility of supplying dual grade 'city/country' diesel**, with low sulphur diesel supplied in the major city areas and higher sulphur diesel supplied in the country areas for an interim period; and
- **Incentives for green fuels and vehicles**.

Development of Scenarios for Fuel Quality

The stakeholder liaison process summarised above, together with consideration of the information relating to the interaction between motor vehicle technology, fuel quality and motor vehicle emissions lead, to the formulation of six potential future fuel quality specification scenarios.

During April and May 1999, the Review Team consulted with a broad range of stakeholders including many within government, the automotive industry and the petroleum industry, to solicit views on future fuel quality scenario development.

During this same period, MVEC finalised its '*Review of Motor Vehicle Emission Standards, Recommendations to NRTC and NEPC'*, which was circulated to the Review Team on 26 May. MVEC anticipates that necessary Government decisions will be made to allow amendments to the ADRs before the end of 1999.

On 28 May 1999, the Government and the Democrats reached agreement on a range of issues within the Government's taxation proposals, *'A New Tax System (ANTS)'*. This *'Tax Package Agreement'* involves a number of amendments to ANTS that will have impact on future vehicle emissions and fuel standards.

MVEC has subsequently revised its recommendations to NRTC and NEPC, and circulated a paper *'Revised Emissions and Fuel Standards Package'* to the Review Team. This paper presents a revision of MVEC's 'Preferred Option' to incorporate the Prime Minister's commitments under the *'Measures for a Better Environment'* element of the *'Tax Package Agreement'*. The ANTS legislation, incorporating the *'Tax Package Agreement',* was passed by the Parliament in late June 1999.

A package of new vehicle emission standards became law under the *Motor Vehicle Standards Act 1999* in December 1999, which included the staged introduction of Euro 2 and Euro 3 emission standards.

Environment Australia directed the Review Team to take account of the Government's *'Measures for a Better Environment'* and MVEC's *'Revised Emissions and Fuel Standards Package',* in developing scenarios for evaluation in this Review.

The scenarios developed by the Review Team reflect the bulk of views put to the Review Team by Stakeholders. These scenarios take account of –

- MVEC's *'Revised Emissions and Fuel Standards Package'.*
- Other relevant provisions of the Government's *'Measures for a Better Environment'.*
- Concerns expressed by Environment Australia with respect to future cooperative arrangements or rationalisation within the refining industry.

During the study, the Review Team examined the scope for increased co-operative efforts between pairs of refineries on Australia's eastern seaboard:

a) In Queensland: BP Bulwer Island and Caltex Lytton;

b) In NSW: Caltex Kurnell and Shell Clyde; and

c) In Victoria: Mobil Altona and Shell Geelong.

Senior managers from each of the above oil companies indicated that rationalisation had been considered and rejected for various economic, technical or political reasons.

The six selected scenarios for fuel quality specifications are summarised below and in Table 5.

- Scenario 1 – 'Base Case' representing business as usual;
- Scenario 2 – 'MVEC/MBE (Explicit) Option'. Includes consideration of the fuel parameters and timelines explicitly set out it in the MVEC/MBE package, that is, the sulphur content of diesel fuel, and Euro 3 sulphur levels introduced in 2005;
- Scenario 3 – 'Best Endeavours – MVEC/MBE (Implicit) Option. Also includes the introduction of Euro 3 petrol in 2005, Euro 4 petrol in 2008 and Euro 4 diesel in 2006. For petrol, parameters other than sulphur concentration, Reid vapour pressure and RON are set on a refinery best endeavours basis;
- Scenario 4 – 'Mandatory – MVEC/MBE (Implicit) Option. As for Scenario 3, but with all the Euro parameters to be mandatory and not on a best endeavours basis;
- Scenario 5 – 'Euro 4 transport fuels by 2006'. As for Scenario 4, but all parameters for petrol and diesel set to Euro 4 specifications from 2006, and 98 RON fuel use assumed for new vehicles produced from 2008;
- Scenario 6 – 'Most stringent case'. As for Scenario 5, but with a requirement for 30ppm sulphur in petrol and diesel from 2008.

Table 5 Adopted Fuel Scenarios in Summary

Scenario	Description	2002	2005	2006	2008
1	Base case	Business as usual: 2 c/L PULP/ULP differential from 2002; LP out in 2002; RVP reduced as per State agreements. Sulfur levels in on road diesel: 500ppm urban / 2000 ppm country in WA from 1/1/00; 500 ppm urban in Brisbane from 1/7/00, country Qld 2000. Other members: 1000 ppm av urban / 2000 ppm av country with +500ppm limits, from 1/1/00.Off road diesel sulfur levels: no change from present position.			
2	MVEC/MBE (Explicit) Option	Gasoline: 500 ppm sulphur (S) On road diesel: best endeavours to achieve metro diesel 500 ppm ahead of 1/12/02; 500 ppm for all on road from 1/12/02. Off road diesel; no change	Gasoline: 150 ppm S 95 RON for all new vehicles. On road diesel: excise reductions on 50 ppm S: 1 c/L in 2003; 2 c/L in 2004/5 Off road diesel; no change from present	On road diesel: 50 ppm S Off road diesel: 50 ppm S	
3	Best Endeavours MVEC/MBE (Implicit) Option	Gasoline - 500 ppm sulphur On road diesel - 500 ppm sulphur Off road diesel; no change from present	As for Scenario 2 but also: Gasoline: Euro 3 with specific requirements for RVP, benzene, S, aromatics and olefins. Specifications for parameters other than S based on refinery best endeavours. 95 RON for all new vehicles	On road diesel with specific requirement for 50 ppm sulphur. Specifications for parameters other than S based on best cost/benefit breakpoints for each refinery. Off road diesel: 50 ppm S.	Euro 4 petrol specifications other than sulphur based on best cost/benefit breakpoint for each refinery.
4	Mandatory MVEC/MBE (Implicit) Option	As for Scenario 3	As for Scenario 3 but set specifications for all parameters to be mandatory	As for Scenario 3 but set specifications for all parameters to be mandatory	Euro 4 petrol specifications mandated.
5	Euro 4 Transport Fuels by 2005	As for Scenario 3	As for Scenario 3	As for Scenario 3 but also: Gasoline: Euro 4	98 RON for all new vehicles
6	Most stringent	As for Scenario 3	Gasoline: Euro 4 complete RVP=60 kPa All diesel: Euro 4 complete		98 RON for all new vehicles. Gasoline: 30 ppm S All diesel: 30 ppm S

The following sections summarise the assessment of the impacts of the fuel quality scenarios outlined above on:

- the projected emissions from motor vehicle;
- costs to the Australian oil refining industry; and
- the Australian economy.

Impact of the Fuel Quality Scenarios on Motor Vehicle Emissions

Vehicle emissions estimates for each of the six project scenarios were derived from a consideration of current/future emission standards, fleet composition and fuel quality effects. For each scenario the suite of pollutants inventoried consisted of common air pollutants and a number of air toxics as follows:

- Total Hydrocarbons (HC);
- Carbon monoxide (CO);
- Oxides of nitrogen (NO_x);
- Sulfur dioxide (SO_2);
- Particulate matter, smaller than 10 micron and 2.5 micron respectively (PM_{10} and $PM_{2.5}$);
- Lead;
- Acetaldehyde;
- Benzene;
- 1,3-Butadiene;
- Formaldehyde;
- Polyaromatic hydrocarbons (PAH).

Projected inventories were developed for each of these pollutants for each scenario for the years 2000, 2005, 2010 and 2020.

The Australian motor vehicle fleet was characterised in terms of vehicle activity levels, expressed as Vehicle Kilometres Travelled (VKT). This approach is adopted to account for differences in usage between vehicle categories and vehicle vintages.

The motor vehicle fleet has been assessed in terms of the following vehicle categories:

- passenger vehicles;
- light commercial vehicles;
- rigid trucks;
- articulated trucks;
- buses;
- motor cycles.

The changing make up of the fleet was assessed taking account of the existing age structure and the trends in vehicle usage.

Specific properties of fuels are known to have an effect on vehicle emissions. The fuel properties considered as part of this review were:

Petrol	**Diesel**
Sulfur content	Sulfur content
Vapour pressure	Polyaromatic content
Benzene/Aromatic content	Distillation point
Mid-range and tail-end volatility	Cetane number
Olefin content	Density
Oxygenates	
Lead content	

Table 6 presents the assessment of motor vehicle emissions for 2000.

TABLE 6 SCENARIO 1 – SUMMARY OF FLEET EMISSIONS, 2000 (t/yr)

2000 Parameter (t/yr)	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Hobart	Darwin	Total
HC	71600	69500	37100	33200	22900	6610	4180	1910	247000
NO_x	57100	56900	28700	24200	17200	4800	3500	1420	194000
CO	506000	544000	255000	242000	185000	55300	34300	8990	1830000
PM_{10}	2710	2720	1390	1060	710	196	164	76.4	9030
SO_2	2250	1940	1950	580	245	153	116	42.4	7280
Pb	95.8	95.8	50.2	58.2	35.7	8.3	7	1.89	353
Acetaldehyde	1270	1760	979	733	430	110	110	49.1	5450
Benzene	2280	2410	1080	1040	855	221	149	52.2	8090
1,3-Butadiene	255	249	127	121	86.7	25.2	16.3	5.23	886
Formaldehyde	995	1250	681	553	341	90.3	79.5	32.4	4020
PAH (Semi-Volatile)	98.2	138	76.9	57	33.2	8.47	8.55	3.88	424
PAH as %wt of PM_{10}	1.98	2.82	1.59	0.99	0.52	0.13	0.17	0.1	8.29
Total PAH	100	141	78.5	58	33.7	8.59	8.72	3.99	432
Toluene	3820	3720	1980	1850	1280	371	234	92.3	13300
Xylenes (o,m,p)	3300	3230	1730	1610	1110	323	201	82.2	11600
$PM_{2.5}$	2440	2450	1250	958	639	177	148	68.8	8130

HC = Hydrocarbons; NO_x = Oxides of nitrogen; Pb = Lead; PM_{10} = Particulates < 10 m

VOC = Volatile organic compounds; CO = Carbon monoxide; SO_2 = Sulfur dioxide; $PM_{2.5}$ = Particulates < 2.5 m

PAH = Poly-aromatic hydrocarbons

Predicted emissions were similar for Scenarios 3, 4, 5 and 6 illustrating that the key influence on emissions would be improvements in motor vehicle technology. Table 7 presents the predicted emissions for 2010 under the conditions modelled for Scenario 4. This includes adoption of Euro 3 and Euro 4 vehicle emission standards and implementation of fuel quality changes required to support the technologies needed to deliver the performance called for under those standards.

TABLE 7 SCENARIO 4 – SUMMARY OF FLEET EMISSIONS, 2010 (t/yr)

2000 Parameter (t/yr)	Sydney	Melbourne	Brisbane	Perth	Adelaide	Canberra	Hobart	Darwin	Total
HC	59300	52000	32400	28500	16700	5390	2960	1690	199000
NO_x	36100	37400	20700	18800	10400	2940	2170	899	129000
CO	299000	265000	156000	167000	90400	28200	15100	4830	1030000
PM_{10}	2060	2050	1190	913	548	171	120	63.6	7110
SO_2	331	322	182	149	20.8	27.9	18.8	9.73	1060
Pb	6.45	5.73	3.23	2.87	1.89	0.59	0.34	0.16	21.3
Acetaldehyde	1040	1260	854	674	304	85.6	74.5	43.1	4330
Benzene	1200	977	609	600	340	112	56.1	26.3	3920
1,3-Butadiene	138	115	71.4	67.6	38.4	13.2	6.6	2.94	453
Formaldehyde	690	779	524	423	199	59.1	45.9	25.9	2750
PAH (Semi-Volatile)	81.7	100	67.8	53.4	23.9	6.7	5.92	3.44	343
PAH as %wt of PM_{10}	2.02	2.88	1.82	1.16	0.56	0.15	0.17	0.12	8.88
Total PAH	83.7	103	69.7	54.5	24.5	6.85	6.09	3.56	352
Toluene	2370	1990	1280	1180	666	223	113	62.1	7890
Xylenes (o,m,p)	2030	1700	1100	1030	573	191	95.7	54.3	6770
$PM_{2.5}$	1860	1840	1070	822	493	154	108	57.3	6400

HC = Hydrocarbons; NO_x = Oxides of nitrogen; Pb = Lead; PM_{10} = Particulates < 10 m

VOC = Volatile organic compounds; CO = Carbon monoxide; SO_2 = Sulfur dioxide; $PM_{2.5}$ = Particulates < 2.5 m

PAH = Poly-aromatic hydrocarbons

Greenhouse Emissions

National emissions of greenhouse gases were assessed for vehicles. In addition, the changes to greenhouse emissions from refineries were assessed with respect to the base case (Scenario 1). The greenhouse emissions for transport and petroleum refining for the period 1990 to 1997 reported by the National Greenhouse Gas Inventory Committee are summarised in Table 8.

TABLE 8 TRANSPORT AND REFINERY GREENHOUSE EMISSIONS 1990 to 1997

	Australian Greenhouse Gas Emission (Gg)						
Year	CO	CO_2	N_2O	NO_x	CO	NMVOC	SO_2
	Transport Emissions						
1990	52766	25.2	5.0	371.3	4901.6	620.1	
1991	51749	23.7	5.7	350.2	4342.9	567.7	
1992	52615	21.9	6.9	328.4	3840.0	523.4	
1993	43805	21.5	7.8	329.8	3667.9	506.2	
1994	55168	20.7	8.7	316.3	3241.2	477.6	
1995	56907	20.5	9.6	316.4	3103.4	464.6	
1996	58500	19.6	10.3	304.9	2822.2	435.0	36.8
1997	59886	20.7	11.1	363.2	2471.7	417.9	38.6
	Petroleum Refining Emissions						
1990	5769	0.1	0.1	33.6	4.5	0.1	
1991	5991	0.1	0.1	34.5	4.7	0.1	
1992	5980	0.1	0.1	34.1	4.6	0.1	
1993	6318	0.1	0.1	36.1	4.9	0.1	
1994	6291	0.1	0.1	35.4	4.8	0.1	
1995	6825	0.1	0.1	37.5	5.2	0.1	
1996	7107	0.12	0.06	37.8	5.1	0.09	27.8
1997	6392	0.10	0.05	41.8	5.5	0.08	27.8

An assessment of national greenhouse gas emissions was made based on the modelled fuel consumption for the period 2000 to 2020, as shown in Table 9.

TABLE 9 GREENHOUSE GAS EMISSIONS (CO_2 EQUIVALENT)

Year	Scenario 1 (Gg)	Scenarios 2,3 & 4 (Gg)	Scenarios 5 & 6 (Gg)
1990	54800	54800	54800
2000	67400	67400	67400
2005	73000	72500	72500
2010	78400	76400	76300
2020	85900	81100	80600

An increase in greenhouse emissions from road transport of 27% is predicted under Scenario 1 over the period 2000 to 2010. Over the same period an increase of 20% is predicted for the other scenarios. This improvement is due to the assumption that the National Average Fuel Consumption (NAFC) target of 15% improvement over business as usual would be achieved. A small improvement in greenhouse emissions for Scenarios 5 and 6 compared with Scenarios 2, 3 and 4 is allowed for the improvement in fuel consumption, which would be associated with use of high octane (98 RON) fuel. The results illustrate that fuel quality has little impact on greenhouse emissions from the transport fleet and that much better prospects for improvement in greenhouse emissions will come from vehicle technology improvements.

Table 10 presents an assessment of the increase in greenhouse emissions as a result of the changes to refinery operation that are required to deliver improved fuel quality. The assessment is based on information regarding energy requirements and hydrogen production needs compared with the base case (Scenario 1).

The emissions estimates are consistent with extrapolation of greenhouse gas estimates for the period 1990 to 1997 produced by the National Greenhouse Gas Inventory.

TABLE 10 REFINERY GREENHOUSE EMISSIONS INCREASES (Gg CO_2 Equivalent)

Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
2000	0	0	0	0	0	0
2005	0	200	200	700	700	2100
2010	0	1100	1600	2100	2100	2100
2020	0	1600	1600	2100	2100	2100

Note: The greenhouse emissions for 2010 and 2020 for Scenarios 5 and 6 do not take account of production of a high proportion of 98RON petrol, as the refineries have indicated that this is not practicable.

The assessment of incremental refinery emissions shows significant greenhouse emissions associated with the production of improved fuel quality.

The key findings of the motor vehicle emissions analysis are:

- Substantial reduction in air pollutant emissions are predicted over the next ten years for hydrocarbons, carbon monoxide, oxides of nitrogen, particulate matter and air toxics including benzene,

- In general, emissions are relatively insensitive to changes in fuel quality. Improvements in the emission rates of future vehicle fleets will be due primarily to advances in pollution control technology. This is illustrated by the results of the emissions modelling, which show a relatively small difference in total emissions for Scenarios 3 to 6. The major impact of cleaner fuels is to enable new pollution control technologies to be implemented.

- Emissions of some pollutants tend to vary in proportion to the amount of the pollutant in the fuel.. These include sulfur and lead. Such substances in fuel may undergo little or no transformation during the combustion process before being emitted. Fuel quality, therefore, tends to have a more direct effect on emissions for these substances.

- Evaporative hydrocarbon emissions are expected to contribute an increasing proportion of total hydrocarbon emissions over the period studied, and are estimated to account for the majority of annual emissions by 2010 (under Scenario 4 conditions). This is because stricter limits on evaporative emissions are not part of the new exhaust emission standards to be introduced. It is important to note, however, that the modelling of evaporative emissions undertaken in this study has some uncertainties, particularly with regard to the magnitude of running and resting losses for Australian vehicles.

- Emissions of benzene show significant variation between the Scenarios, which is an indication of the fuel benzene level specified for each Scenario. The exhaust component of benzene is estimated to account for the majority of emissions over the period studied, although the evaporative component will gradually become more important. As for total hydrocarbons, the reason for this change is that stricter limits on evaporative emissions are not part of the new exhaust emission standards to be introduced, meaning that future evaporative emissions of benzene will depend upon fuel benzene levels.

- The Business As Usual travel activity estimates adopted for this study show significant increases in Vehicle Kilometres Travelled over the period studied. For most of the pollutants considered, however, total emissions are expected to decrease for all Scenarios modelled. Exceptions to this are Scenario 1 (base case) emissions of particulate matter, polycyclic aromatics and acetaldehyde, which are primarily diesel related. Emissions of these substances are estimated to stabilise or increase after 2010 under Scenario 1 conditions. This is a reflection of increasing diesel vehicle usage expected for future years.

- Particulate matter emissions are estimated to significantly reduce under Scenarios 2 to 6 compared with the base case. The extent of the reduction is similar for these Scenarios, which is an indication that the main influence of cleaner fuels is to allow the introduction of vehicles with improved emissions performance. Petrol vehicles are expected to contribute the majority of particulate emissions by 2010, which reflects the fact that particulate emission rates of these vehicles are not explicitly controlled as part of new emission standards.

- The sensitivity of emissions to aromatics/olefins content in petrol and sulfur content/cetane number in diesel, was investigated. For petrol vehicles, the results indicate that benzene is sensitive to the level of aromatics, whereas other pollutants are relatively insensitive. Changes to olefin content did not impact significantly on emissions. For diesel vehicles, reduction of sulfur levels in diesel fuel from current levels to EURO levels is expected to reduce particulate matter emissions. Emissions were found to be relatively insensitive to cetane number.

- Fuel quality has little impact of greenhouse emissions from the transport fleet and the best prospects for improvement in greenhouse emissions will come from vehicle technology advancements that allow improvements in fuel economy.

- Greenhouse gas emissions for the Australian transport fleet are projected to substantially exceed the target of an 8% increase from 1990 to 2010 agreed for Australiaunder the Kyoto Protocol.

Impact of the Fuel Quality Scenarios on the Australian Refining Industry

There are eight major oil refineries in Australia:

- Caltex: Lytton Island, Queensland and Kurnell, New South Wales;
- BP: Bulwer Island, Queensland and Kwinana, Western Australia;
- Mobil: Altona, Victoria and Port Stanvac, South Australia; and
- Shell: Clyde, New South Wales and Geelong, Victoria.

Refinery technology and operation are tailored to average crude type and product slate. Therefore, refineries differ significantly in both size and process plant detail, and thus have different capabilities and constraints in regard to changing the quality of fuel produced. The age of the plant and the prevailing environmental standards also often influence a refinery's current performance potential.

In order to assess the impacts of the fuel quality scenarios on the Australian oil industry, linear program modelling was undertaken by specialist engineers of Australian refineries. The modelling undertaken included new plant and alternative feedstocks for several of the proposed fuel quality scenarios. The results are therefore specific to the location of the refinery and the fuel quality scenario being addressed.

Most of the oil companies participating in this review used their existing operating refinery linear programming (LP) models to validate sophisticated spreadsheet models. Compared with LP-models, these spreadsheet models are easier to modify to reflect the addition of new process plants (with new product yields, qualities and energy demands) and new fuel specifications. The latest spreadsheet models also include advanced optimiser routines.

The modelling of options towards a 'minimum cost' response to fuel quality changes is subject to assumptions / perceptions about the external business environment, internal constraints, relative operating and capital costs of competing technologies and corporate financial goals. Therefore, a wide range of equally valid 'minimum cost solutions' is to be expected from the modelling process. Increases in operating costs, as well as capital costs, need to be considered.

Cost estimates were evaluated relative to Scenario 1, which includes all costs to reduce petrol Reid Vapour Pressure (RVP) to a level which satisfies current tighter Australian volatility specifications. The cost of Scenario 1 is taken notionally as nil. The central costing estimates presented in this section are the cost increases (relative to the base case) of producing fuel to meet Euro 4 specifications for fuel quality, as defined by Scenario 4.

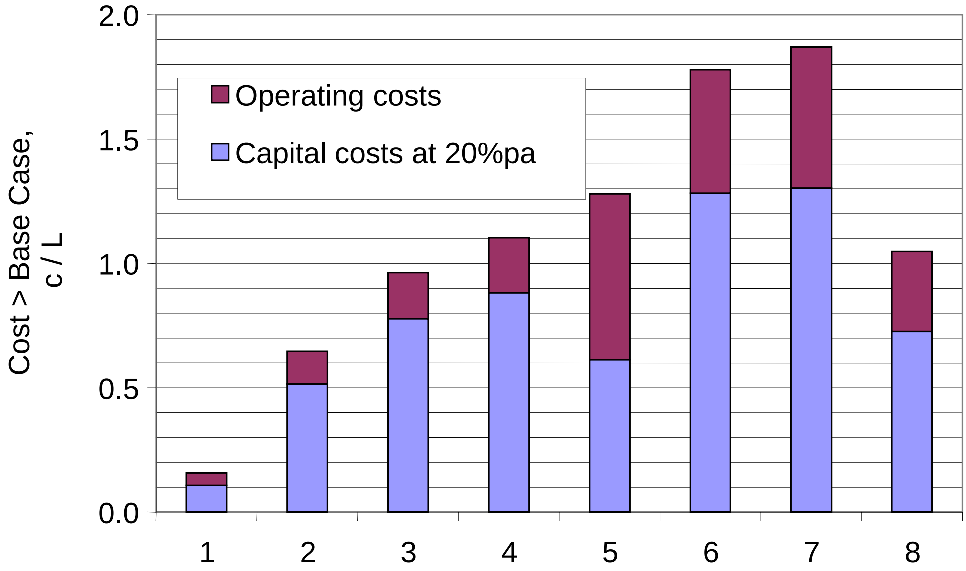
The oil refinery representatives found it was too complex and impractical (with the resources available) to develop cost estimates for Scenarios 2, 3, 5 and 6 to the same level of detail as Scenario 4. Rather, additional data was indicated as overlays on Scenario 4, where this was seen as being relevant.

The costing variations for Scenarios 2, 3, 5, 6 related only to petrol as all scenarios called for the same diesel quality as Scenario 4 (with the exception of 30 ppm sulfur in diesel for Scenario 6).

Summary of the Results of Modelling of the Production of Euro 4 Fuel

The data supplied by Australian oil refineries indicates that the production of Euro 4 diesel and petrol (including 50 ppm sulfur for both fuels) would require Australian oil refineries to invest a total additional **$1320 Million (M)** above what is already planned. At one refinery, a substantial proportion of the work required to achieve Euro 4 diesel and petrol is already committed in existing programs. Excluding this refiner, capital investment per refinery averages $185M. Operating expenditure would increase by a total of $136 million/year for the production of Euro 4 fuels, an average of $17 million/year per refinery.

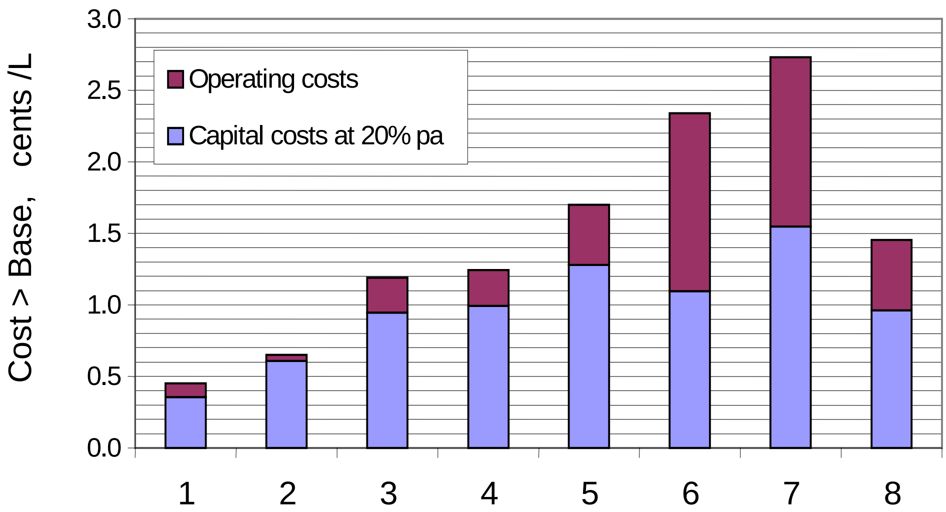
Figure 1
Estimated Cost of Production of Euro 4 Petrol



1 to 6 = Australian Refineries (excluding Bulwer),
7 = Clyde Refinery, 8 = Weighted Average

The bar charts in Figures 1 and 2 show the capital and operating costs for each Australian refinery, expressed in cents per litre, with refinery names suppressed at oil company request. Costs assessed for the Shell Clyde refinery are identified, as Shell has indicated that the future of the Clyde Refinery is uncertain beyond 2006. A range of costs is evident, depending on existing configuration and size for each of the seven refineries represented.

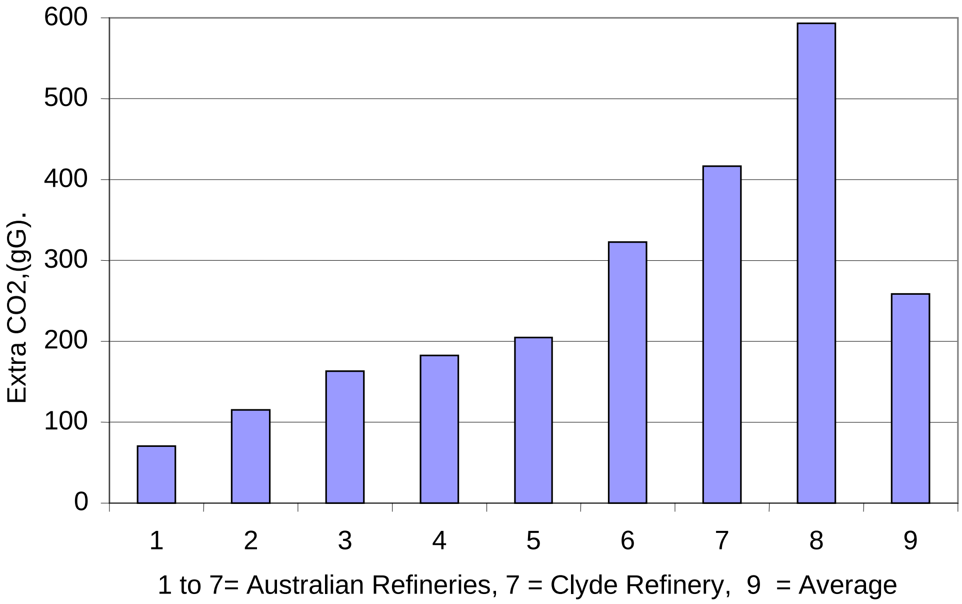
Figure 2
Estimated Cost of Production of Euro 4 Diesel



1 to 6 = Australian Refineries (excluding Bulwer), 7 = Clyde Refinery
8 = Weighted average

The production of Euro 4 fuels will increase energy consumption in refineries, and therefore increase greenhouse gas emissions. The increased energy consumption will result from direct fuel burning in process furnaces, carbon rejection to make hydrogen and by remote electricity generation. It is estimated that total greenhouse gas emissions from the eight refineries will increase by 2.1 million tonne pa CO_2 equivalent. The estimated increase in greenhouse gas emissions from the eight refineries is illustrated in Figure 3.

Figure 3
Estimated Additional Greenhouse Gas Emissions for the Production of Euro 4 Fuels (Relative to Euro 2 Fuels)



The costs of greenhouse gas emissions may well include carbon trading permits. Refineries will generally not be able to fit the additional emissions into any allocation based on historical emissions and will have to buy additional permits to cover the cost of fuel quality improvements. **As the timing and detail of introduction of carbon trading is unclear, possible costs associated with permits for increases in greenhouse gas emissions are not included in the assessment of refining costs**.

As discussed above, in developing the refinery costs, Scenario 4 was treated as a central scenario and savings or additional costs associated with Scenarios 2, 3, 5 and 6 were estimated by comparison with Scenario 4. This approach was followed as was not feasible for the refineries to develop separate costing for each of the scenarios considered. A cost comparison against the baseline (Scenario 1) is presented below.

Table 11 Summary of Average Fuel Cost Increases

Scenario	Increase in operating costs per refinery	Increase in capital cost per refinery (2008 cf. base)	Increase in petrol cost by 2008 to 2020 (c/L)	Increase in diesel cost (c/L)
2	$7M pa	$85M	0.5 to 0.8	1.5
3	$7M pa	$167M	0.9 to 1.2	1.5
4	$17M pa	$185M	1.1 to 2.1	1.5
5	$79M pa	$260M	1.4 to 5.3	1.5
6	$79M pa	$260M	1.4 to 5.3	1.6 to 1.7

Notes:

1. The above c/L sums are the oil refining company's incremental **costs** (not prices). The actual price increases at the bowser may be impacted by imports of overseas surplus petrol and diesel.

2. Scenario-5 costs are virtually the same as Scenario-6 costs, since both have the same tighter specifications on olefins and the introduction of 98 RON PULP. They differ only marginally in timing, and in the reduction of sulfur in petrol from 50 ppm to 30 ppm.

3. For Scenarios 5 and 6, (relative to Scenario-4), the average increase in capital and operating costs are:

   a) for olefins, about $25 M for capital costs and $3M pa for operating costs, resulting in a cost increase of 0.3 c/L from 2008, plus

   b) for 98 RON PULP, about $50M for capital costs and $60M pa increased operating costs, resulting in a further cost increase of 2.9 c/L by 2020;

   Therefore, the total increased cost for Scenario 6 in 2020 is approximately 5.3 c/L.

4. Due to the range of viable operating and plant change options available, and also due to the multiple interactions and synergies between nearly all refinery plant investments, it is impossible to precisely identify, isolate and quantify costs pertaining to just one particular fuel quality change (eg. aromatics or olefins). The numbers in the table above are estimates only.

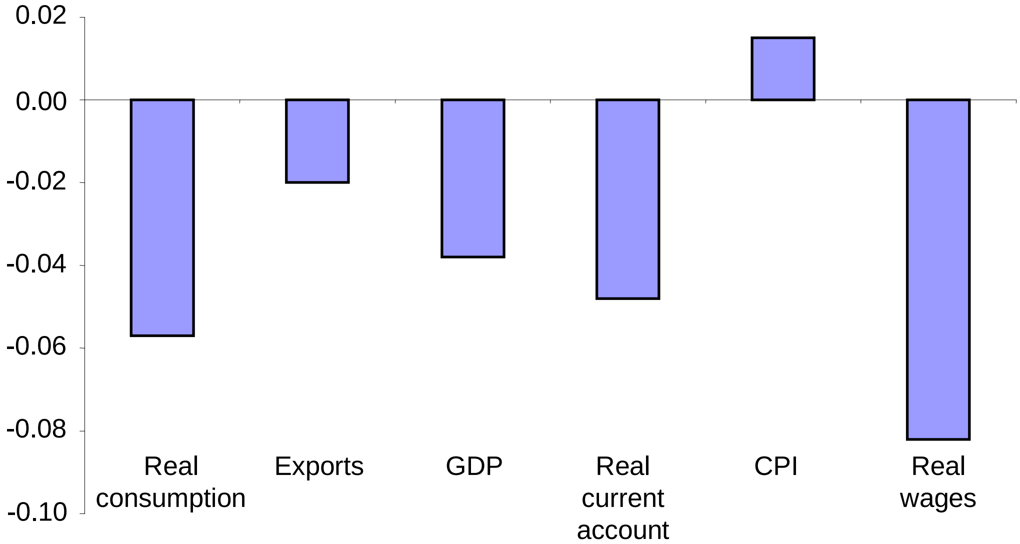
5. Costs are relative to Scenario 1. The cost of Scenario 1 was taken as zero, as the refinery models were developed on the basis that operations and projects required for 'business as usual' are already in place.

Impacts of the Fuel Quality Scenarios on the Australian Economy

The impacts on the Australian economy of the predicted increase in the costs of production of improved fuel quality were assessed using an economic model. The State Model used for this purpose is a computer model of the Australian economy which has been extensively used to examine policy issues. The version of the State Model used for this analysis has a 1994-5 database with 105 industries. The simulation undertaken was illustrative of the effects of higher costs. The benefits of improved fuel quality, such as health benefits which would flow from improved air quality, are not modelled in the simulation as these were not assessed in the study.

Higher fuel standards would refine refining costs leading to higher fuel prices for industry and consumers. But the initial effects of higher fuel prices provide only a partial picture of the impacts higher fuel prices would have on the economy. Because higher fuel costs raise industry costs, their imposition would initially decrease the competitiveness of industry leading to decreased sales, decreased exports and decreased employment. There would also be further changes in the economy as it adjusts to the reduced market opportunities brought about by the increase in fuel prices. These impacts are illustrated by the modelled impacts of a one percent increase in the cost of production as shown in Figure 4.

Figure 4: Macro economic impact of a one per cent increase in the ex-refinery price of fuel (percentage change)



The impact of higher fuel prices would be to reduce the competitiveness of the economy leading to reduced output and increases in CPI. A higher costs structure reduces exports. As the competitiveness of the economy declines, wages adjust downwards in real terms to maintain employment levels. This drives down labour income, which is a major contributor to decreased consumption. With real consumption and exports falling, it is not surprising that GDP falls also.

Table 12 sets out the modelled macro economic impact of increased fuel production cost on the Australian economy for Scenario 2 to 6 as compared with business as usual (Scenario 1).

Table 12: Macro economic impact increased cost of fuel production (percentage change)

		Percentage Change					
Scenario	*Percentage increase in ex-refinery price*	*Real Consumption*	*Exports*	*GDP*	*Real current account*	*CPI*	*Real wages*
2	3.6	-0.20	-0.07	-0.14	-0.17	0.06	-0.30
3	4.5	-0.26	-0.09	-0.17	-0.22	0.07	-0.37
4	4.9	-0.28	-0.10	-0.19	-0.23	0.08	-0.45
5	5.5	-0.31	-0.11	-0.21	-0.26	0.08	-0.45
6	5.8	-0.33	-0.12	-0.22	-0.28	0.09	-0.48

Table 13 presents the modelled impact on national output for Scenarios 2 to 6.

Table 13: Impact on national output of increased cost of fuel production ($million, 1994–95 prices)

Scenario	*Percentage increase in ex-refinery price*	*Initial reduction in output*	*Flow on effects*	*Total reduction in output*
2	3.6	373	278	651
3	4.5	467	347	814
4	4.9	508	378	886
5	5.5	571	424	994
6	5.8	602	447	1049

The detrimental effects on national output of higher fuel prices can be seen when the total effect on national output of the decline in productivity is compared with the initial effect of the productivity decline. The flow on effects of higher fuel prices are relatively strong as they fall disproportionately on some of Australia's more efficient export industries. As these industries are amongst Australia's most efficient industries, a decline in the output of these industries reduces economic efficiency adding to the initial effect of the decline in productivity.

Table 14 presents the modelled impact on selected industries.

Table 14: Impact on the output of selected industries to increased fuel production costs (percentage change)

		Scenario				
	Model	*Scenario 2*	*Scenario3*	*Scenario 4*	*Scenario 5*	*Scenario 6*
Percentage increase in fuel production cost	1.00	3.6	4.5	4.9	5.5	5.8
Sheep	-0.02	-0.06	-0.07	-0.08	-0.09	-0.10
Grains	-0.01	-0.03	-0.04	-0.04	-0.04	-0.05
Beef cattle	-0.02	-0.07	-0.08	-0.09	-0.10	-0.11
Coal, oil & gas	0.04	0.13	0.16	0.18	0.20	0.21
Iron ore	-0.05	-0.19	-0.23	-0.26	-0.29	-0.30
Petroleum & Coal Products	-0.09	-0.33	-0.42	-0.45	-0.51	-0.54
Non-ferrous metal ores	-0.16	-0.59	-0.73	-0.80	-0.90	-0.95
Other food products	-0.02	-0.06	-0.07	-0.08	-0.09	-0.09
Basic non-ferrous metals & products	-0.10	-0.35	-0.44	-0.48	-0.54	-0.57

A simple simulation was undertaken to illustrate the effects of the costs of achieving higher fuel standards on the Australian economy. If higher fuel standards were to raise refining costs and these cost increases were passed on to industry and consumers, then it would be expected that these effects would reduce national output. This does not mean that higher fuel standards would necessarily be detrimental to the economy overall. This is because any benefits of higher fuel standards would need to be factored into the analysis before the net effects of higher fuel standards could be assessed.

The results presented here must be considered preliminary. They do not differentiate between petrol and diesel fuel rises. Nevertheless, the broad conclusion from the analysis, that higher fuel prices driven by the new fuel specifications would have a negative impact on the economy, will most likely stand if further refinements to the simulation were undertaken.

Further work could be undertaken to examine the economic implications of improving fuel standards in Australia. This could involve:

- Examination of the effects of higher standards for diesel and petroleum;
- More in depth specification and modelling of the cost implications for refineries of the higher fuel standards; and
- Incorporation of the benefits of higher fuel standards into the analysis.

If these refinements were undertaken a comprehensive analysis could be undertaken of the net benefits to the Australian economy of introducing higher fuel standards in Australia.

Conclusions

The main conclusions developed from the fuel quality review are:

- Adoption of vehicle emission standards equivalent to Euro 3 for petrol vehicles in 2005/06 and Euro 4 for diesel vehicles from 2006/7 will occur in Australia. These standards are more stringent than those currently used in Australia and represent substantial reductions to the allowable emissions standards for new vehicles. Improved fuel quality will be required to support the technologies employed to deliver these improved emissions standards. In particular, reduction of sulfur levels in petrol to a maximum of 150ppm will be required by 2005 and a reduction in sulfur levels in diesel to a maximum of 50ppm will be required by 2006.
- A range of six scenarios was considered, varying from "business as usual" to adoption of Euro 4 standards for petrol and diesel and for each scenario the pollutant emissions from the vehicle fleet and from the refineries were assessed for the period 2000 to 2020. The impacts on cost of production of fuel quality changes were assessed by the refining organisations.
- Substantial reductions to air emissions from the transport fleet are predicted for the pollutants modelled under all scenarios reflecting the above changes.
- Fuel quality improvements in themselves are not predicted to result in substantial reductions to air emissions except in the case of benzene emissions. The main air emissions benefits from improved fuel quality stem from enabling of improved motor vehicle emissions control and engine technology.
- Fuel quality has a significant direct effect upon the level of benzene emissions, through the contribution of influences on evaporative and engine emissions.
- Fuel quality changes within the ranges considered have little impact on greenhouse emissions from the transport fleet. Greenhouse emissions are predicted to increase from the 2000 level between 20% and 27% for the range of scenarios considered. These increases would result in Australian transport emissions exceeding the 1990 emissions by between 39% and 43% by the year 2010. This is substantially in excess of the Australian target of an 8% increase in greenhouse emissions, agreed under the Kyoto Protocol.
- Production costs of the order of 1 to 2 cents per litre would be required to meet the refinery capital and operating costs needed to deliver Euro 4 standard petrol to the Australian public with the corresponding cost for diesel in the vicinity of 1.5 cents per litre. These costs correspond to approximately 2 percent of the current retail price of fuel.
- The increase in fuel price equal to the modelled cost increase for production of Euro 4 fuels would result in a reduction of 0.19 percent in gross domestic product

and 0.08 percent increase in consumer price index. This assessment does not include an allowance for increased vehicle costs associated with improved emissions performance and does not address the economic benefits associated with reduced air emissions.

- If higher fuel standards were to raise refining costs and these cost increases were passed on to industry and consumers, then it would be expected that these effects would reduce national output. This does not mean that higher fuel standards would necessarily be detrimental to the economy overall. This is because any benefits of higher fuel standards would need to be factored into the analysis before the net effects of higher fuel standards could be assessed.

Limitations

The emissions predictions are considered to provide a reasonable basis for assessment of transport emissions to 2010 for the nominated scenarios. The projections contain uncertainties in relation to the application of emissions sensitivity factors from international experience (predominantly Europe and United States) to Australian conditions. Predictions of emissions to 2020 must be considered speculative as new vehicle technologies such as fuel cell engines and hybrid vehicles may change the nature of the motor vehicle fleet within that time frame.