Australian Government

Better fuel for cleaner air

Draft regulation impact statement

Ministerial Forum on Vehicle Emissions

January 2018

Better fuel for cleaner air

Draft regulation impact statement

January 2018

Department of the Environment and Energy

This publication is available at

http://www.environment.gov.au/fuel-quality-standards-review

The Department of the Environment and Energy acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.

Contents

List of abbreviations and select glossary

the Act	*Fuel Quality Standards Act 2000 (Cth)*
ADRs	Australian Design Rules
BaU	business as usual
BCR	benefit-cost ratio
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CBA	cost-benefit analysis
CEA	cost-effectiveness analysis
cpl	cents per litre
CO	carbon monoxide—a toxic gas emitted from an engine
CO_2	carbon dioxide—a greenhouse gas emitted from an engine
cSt or mm^2/s	centistokes, or millimetres squared per second—unit of kinematic viscosity
the Department	Department of the Environment and Energy
DIPE	diisopropyl ether, also 2-[(propan-2-yl)oxy]propane
DVPE	dry vapour pressure equivalent
ETBE	ethyl tertiary-butyl ether (ETBE) (2-ethoxy-2-methylpropane)
EU	European Union
Euro 5/V	Current emissions standards for new light vehicles and heavy vehicles in Australia, based on the European standards
Euro 6/VI	Proposed new emissions standards for light vehicles and heavy vehicles
FAME	fatty acid methyl ester
FCAI	Federal Chamber of Automotive Industries
ferrocene	an organometallic fuel additive (bis(η^5-cyclopentadienyl)iron)
fuel standards	Fuel Standard (Petrol) Determination 2001, Fuel Standard (Automotive Diesel) Determination 2001, Fuel Standard (Autogas) Determination 2003, Fuel Standard (Biodiesel) Determination 2003, Fuel Standard (Ethanol E85) Determination 2012
GHG	greenhouse gases
GHG emissions	emissions of carbon dioxide or other greenhouse gases
g/L	grams per litre—unit of density

GTBE	glycerol tertiary butyl ether (3-*tert*-butoxy-1,2-propanediol)
Hart Report	Hart Energy (2014), *International fuel quality standards and their implications for Australian standards*
high-octane petrol	petrol with a research octane number of 95 or higher
kPa	kilopascal—unit of pressure
KOH	potassium hydroxide
LPG	liquefied petroleum gas, autogas
m/m	mass by mass, mass fraction, unit of concentration
mg/L or g/m^3	milligrams per litre, grams per cubic metre, units of density
mg/kg	milligrams per kilogram, equivalent to parts per million
ML	megalitre, one million litres, unit of volume
MMT	an organometallic fuel additive, methylcyclopentadienyl manganese tricarbonyl
molar	moles per litre—a unit of concentration
MON	motor octane number
MTBE	methyl tertiary butyl ether (2-methoxy-2-methylpropane)
NMA	N-methylaniline— a nitrogen containing aromatic compound, a fuel additive
NO_2	nitrogen dioxide—a gas emitted from an engine
NO_x	nitrogen oxides—gases emitted from an engine
noxious emissions	emissions of carbon monoxide, volatile organic compounds, nitrogen oxides, particulate matter and sulfur oxides
NPV	net present value
OECD	Organisation for Economic Cooperation and Development
PAH	polycyclic aromatic hydrocarbons
PM	particulate matter—very small particles emitted by an engine
$PM_{2.5}$	particulate matter, smaller than 2.5μm
PM_{10}	particulate matter, smaller than 10μm
ppm	parts per million, equivalent to milligrams per kilogram
PULP	premium unleaded petrol (95 RON or 98 RON)
RIS	regulation impact statement
RON	research octane number—a measure of petrol's octane value
RULP	regular unleaded petrol, more commonly referred to as ULP

TBA	tertiary butyl alcohol, also 2-methylpropan-2-ol
ULP	unleaded petrol (regular, 91 RON)
ultralow sulfur	petrol with a maximum 10 ppm sulfur content
USA	United States of America
VOCs	volatile organic compounds—compounds emitted from an engine
vol	volume
v/v	volume by volume, equivalent to volume %, volume fraction, unit of concentration
µm	micrometre (one-millionth of a metre)—a unit of length

Executive summary

The quality of Australian fuel affects the quantity and type of emissions from our vehicles. It directly and indirectly influences the quality of the air we breathe and the amount of greenhouse gas in our environment. Improving Australia's fuel standards would enable vehicles and their emission control systems to operate effectively and facilitate the adoption of better engine and emission control technologies. To reduce the impacts of noxious vehicle emissions, Australia has historically adopted increasingly stringent European vehicle emissions standards.

This early assessment regulation impact statement (draft RIS) will form the basis of consultation with stakeholders about possible changes to legislative instruments made under the *Fuel Quality Standards Act 2000* (Cth) (the Act). These instruments include the fuel quality standards for petrol, diesel, autogas (LPG), biodiesel and ethanol (E85); information standards for ethanol in petrol and E85; the *Fuel Quality Standards Regulations 2001* (Cth); and the guidelines for the *Register of Prohibited Fuel Additives*. In addition, a new fuel quality standard is proposed for a B20 diesel-biodiesel blend. Changes are proposed to many parameters in the five fuel standards, most notably, to levels of sulfur, aromatics and possibly octane in petrol, as well as polycyclic aromatic hydrocarbons (PAHs) and cetane in diesel.

The current set of legislative instruments, including the fuel quality standards, are due to sunset (cease to have effect) in 2019.

Proposed reforms focus on petrol because Australia's petrol is not as high quality as petrol in other OECD countries. Improvements in petrol quality are expected to provide the greatest health and environmental benefits for Australians. The petrol parameters that most affect vehicle operability and emissions, and which are out of step with European standards, are:

- sulfur, which has a regulated maximum limit of 150 parts per million (ppm) for regular unleaded petrol and 50 ppm for premium unleaded petrol in Australia. The maximum limit is 10 ppm in Europe
- minimum octane number, which is research octane number (RON) rating of 91 in Australia. The minimum octane number in Europe is 95 RON
- aromatic content, which has a maximum limit of 45 per cent in Australia. The European fuel standards specification is 35 per cent.

Other petrol parameters examined in this draft RIS include oxygenates, including ethanol, and olefins. Some options also involve changes to the other fuel standards, namely diesel, autogas (LPG), ethanol E85 and biodiesel.

This draft RIS has been developed with options for improving the currently regulated Australian fuel quality for petrol, diesel, autogas (LPG), ethanol E85 and biodiesel, with a primary focus on sulfur and aromatic levels in petrol.

The draft RIS canvasses three policy options (identified as options B and C in earlier consultations, and F as proposed by the refining industry) for updating the fuel standards. The status quo is identified as Option A. Two options (identified as D and E in earlier consultations), will not be progressed based on stakeholder feedback.

- Option B. Revisions to the fuel standards to harmonise with European standards. Regular unleaded petrol (91 RON) would be phased out. Changes to broaden the scope of the diesel standard.
- Option C. Revisions to the fuel standards to harmonise with European standards as per Option B, with the exception that 91 RON petrol is retained but with a lower sulfur level of 10 ppm. Changes to broaden the scope of the diesel standard.
- Option F. Revision to the petrol standard to reduce sulfur to 10 ppm, consistent with European standards. No change to other parameters.

Independent consultants Marsden Jacob Associates undertook a cost-benefit analysis on these policy reform options. Each option was considered against three different implementation dates: 2022, 2025 and 2027. The analysis was predicated on the assumption that all currently operating Australian refineries remain open. The analysis found:

- Option B has a negative net present value (NPV), ranging from –$718 million (2022) to –$607 million (2027), meaning that if it is implemented it is unlikely to deliver a net benefit to the community compared with the base case of no changes to fuel standards.
- Option C has a positive NPV, ranging from $641 million (in 2022) to $319 million (2027) and, if implemented, will return $1.18 to $1.24 for every $1 of cost.
- Option F has a positive NPV, ranging from $628 million (2022) to $317 million (2027).

The cost benefit analysis in the draft Regulation Impact Statement focuses on changes to sulfur, aromatics and octane in petrol and changes to cetane and PAHs in diesel, as these changes are expected to deliver the highest benefits. A range of unquantified, but related, policy options have also been considered (see Section 5.6.3.3). The cost with these unquantified policy option are considered relatively minor and have not been included in the cost benefit analysis.

Table ES 1 summarises the results of the analysis and Table ES 2 summarises the proposed impact of the options on fuel prices on motorists.

Table ES 1. Cost-benefit summary of options B, C and F ($millions)

Results	Option B			Option C			Option F		
	2022	2025	2027	2022	2025	2027	2022	2025	2027
Costs	–$5,533.2	–$4,132.0	–$3,341.2	–$2,720.1	–$2,113.8	–$1,764.3	–$2,183.4	–$1,698	–$1,417.7
Benefits / avoided costs	$4,815.0	$3,480.5	$2,734.2	$3,361.0	$2,550.4	$2,083.6	$2,811.3	$2,126.6	$1,734.7
Net present value	–$718.11	–$651.4	–$607.0	$640.9	$436.6	$319.3	$627.9	$428.7	$317.0
Benefit-cost ratio	0.87	0.84	0.82	1.24	1.21	1.18	1.29	1.25	1.22

Table ES 2. Summary of fuel price impact, options B, C and F (cents per litre)

Price impact (2022-2030)				
Price component	Option B	Option C 91 RON	Option C 95 and 98 RON	Option F
Reduce sulfur to 10 ppm	0.6–1.0	0.6–1.0	0.6–1.0	0.6–1.0
Reduce aromatics to 35%, phase out 91 RON	2.3	–	–	–
Reduce aromatics to 35%	–	–	0.3	–
Capital cost of Australian refinery upgrades*	1.0	1.0	1.0	1.0
Total	**3.9-4.3**	**1.6–2.0**	**1.9-2.3**	**1.6–2.0**

* Cost recovery for infrastructure upgrades to produce better quality fuel at Australian refineries. This cost is expected to dissipate after the first five to ten years of policy implementation. Costs are estimated at one to two refinery operating cycles (five to ten years), eight years used in the price impact calculation.

As outlined above, two of the options—Option C, which harmonises with European standards, and Option F, which only entails reducing sulfur in petrol—provide positive net present values (NPVs) and benefit-cost ratios (BCRs) greater than 1.0, regardless of the implementation date.

Potential non-market benefits of options relative to the base case that have not been valued in the analysis include:

- some of the long-term health benefits associated with reducing tailpipe noxious emissions, particularly some cancers associated with ultrafine particulate emissions (<PM_1)
- productivity benefits of reduced illness and hospitalisation
- health benefits associated with reducing evaporative emissions from vehicles (such as when refilling at petrol stations)
- possible benefits of reducing sulfur on fuel consumption and vehicle operability
- possible benefits of reducing aromatics on fuel consumption and vehicle operability.

It is likely that if these benefits could be quantified the NPVs of options B, C and F would all be greater than those currently presented in this report. It is also possible that if these benefits could be quantified the ranking of the options might change.

An assessment of the policy options against the policy assessment criteria used in this document is presented in Table ES 3. Implementation of the policy reforms would require capital and operating cost investment by Australia's petroleum refining industry, fuel supply and energy security implications must also be considered in developing fuel quality standards.

This draft RIS will form the basis of consultation with stakeholders about possible changes to legislative instruments made under the Act. The most significant of the proposed amendments relate to changes to the petrol standards. The options presented in the draft RIS do not represent a government decision nor formal government policy. Stakeholder views will be sought on issues including:

- whether the costs and benefits have been adequately captured and assessed
- how and when the policy options could be implemented
- whether the options are likely to achieve the assessed and desired health, environmental and technological outcomes.

Table ES 3. Summary of the extent to which the policy options meet the policy assessment criteria*

Policy assessment criteria	B 10 ppm sulfur 95 RON 35% aromatics (Euro)	C 10 ppm sulfur 91 RON retained 35% aromatics (Euro)	F 10 ppm sulfur 91 RON retained 45% aromatics
1. Achieve appreciable health and environmental outcomes†	Yes $1.7 billion to $2.9 billion avoided health impacts Net decrease in GHG emissions: $12 million to $46 million	Partial $1.9 billion to $3.1 billion avoided health impacts Net increase in GHG emissions: $40 million to $67 million	Partial $1.6 billion to $2.7 billion avoided health impacts Net increase in GHG emissions: $40 million to $67 million
2. Ensure the most effective operation of engines	Yes Aligns with European standards	Yes Aligns with European standards	Partial Operability issues associated with aromatics
3. Facilitate adoption of better engine and emission control technology	Yes Aligns with European standards	Yes Aligns with European standards	Partial Low sulfur improves emissions
4. Achieve harmonisation with European standards, as appropriate	Yes Aligns with European standards	Yes Aligns with European standards	No Only change to sulfur, no other parameters
5. Minimise regulatory burden	No Regulatory burden $969 million	Partial Regulatory burden $500 million	Yes Regulatory burden $425 million
6. Maximise net national benefits	No NPV –$718 million to –$607 million	Yes NPV $319 million to $641 million	Partial NPV $317 million to $628 million
7. Overall	Net cost Very good health and operability outcomes, highest cost	Net benefit Very good health and operability outcomes, high cost	Net benefit Good health and operability outcomes, lower cost

* Note that the ranges relate to whether implementation begins in 2022 or 2027
† Based on the avoided health cost estimates presented in Table 6 of this draft RIS.

1. Introduction

1.1. Ministerial Forum on Vehicle Emissions

In October 2015, the Australian Government established the Ministerial Forum on Vehicle Emissions to coordinate a whole-of-government approach to reducing motor vehicle emissions that harm our health and contribute to greenhouse gas emissions.

As part of this work, the Ministerial Forum is considering three measures:

- Euro 6/VI vehicle emissions standards to reduce noxious emissions
- fuel efficiency standards to reduce carbon dioxide emissions
- fuel quality standards and instruments to reduce noxious and greenhouse gas emissions.

> Noxious vehicle emissions (those that are harmful to our health) include carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM) and sulfur dioxide (SO_2).

This early assessment regulation impact statement (draft RIS) addresses the fuel quality standards and instruments aspect of the Ministerial Forum's program. This work is the responsibility of the Department of the Environment and Energy (the Department).

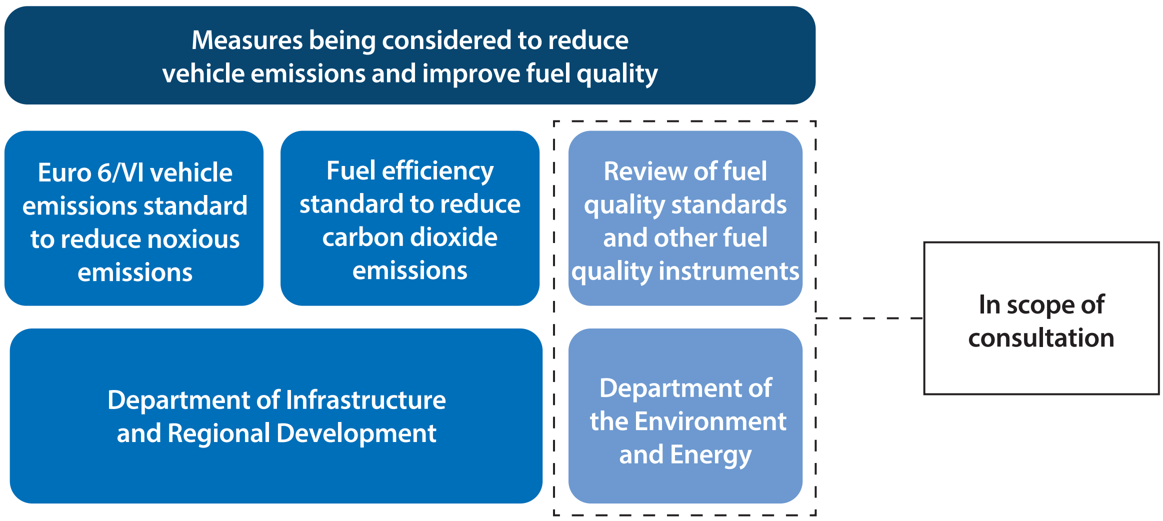
The Euro 6/VI and fuel efficiency measures are the responsibility of the Department of Infrastructure and Regional Development and are subject to their own regulation impact assessment processes*. This draft RIS has been prepared to align with and complement those measures (Figure 1).

Figure 2 shows the three measures being considered as a package to reduce vehicle emissions and improve fuel quality in Australia.

* Draft RISs for these measures have been prepared and released for public comment—see Department of Infrastructure and Regional Development (2016), *Improving the efficiency of new light vehicles and Vehicle emissions standards for cleaner air: draft regulation impact statement*, accessed 20 June 2017, infrastructure.gov.au/roads/environment/forum/index.aspx

Figure 1. The Ministerial Forum's proposed fuel, noxious emissions and fuel efficiency measures

Figure 2. Australian Government measures to reduce motor vehicle emissions



1.2. Review of fuel quality standards and instruments

1.2.1. Legislative framework

The fuel standards and related legislative instruments are made under the *Fuel Quality Standards Act 2000* (the Act). The Australian Government introduced the Act to provide a national framework for fuel quality and information standards across Australia. The objects of the Act reflect the important role that fuel quality plays in managing vehicle emissions and improving engine technology. The objects of the Act are to:

(a) regulate the quality of fuel supplied in Australia in order to:

- (i) reduce the level of pollutants and emissions arising from the use of fuel that may cause environmental and health problems; and
- (ii) facilitate the adoption of better engine technology and emission control technology; and
- (iii) allow the more effective operation of engines; and

(b) ensure that, where appropriate, information about fuel is provided when the fuel is supplied[1].

Harmonisation of Australian vehicle emissions standards with international standards was a noted secondary objective at the time the Act was introduced[2].

An independent statutory review of the Act in 2016 concluded that it has met its objectives, leading to reduced pollution, improved health outcomes and a reduction in greenhouse gas emissions. The Government committed to retaining and amending the Act to ensure that the significant environmental and health outcomes arising from the use of high-quality fuel continue to benefit the Australian public. A review of all of the legislative instruments made under the Act (see Table 1), which are due to sunset in October 2019, formed part of this commitment. This draft RIS provides an opportunity for consultation on all aspects of the legislative instruments, including technical specifications.

Table 1. Legislative instruments made under the Act

Legislative instrument	Web location
Fuel Quality Standards Regulations 2001	legislation.gov.au/Details/F2016C00131
Fuel Standard (Petrol) Determination 2001	legislation.gov.au/Details/F2008C00344
Fuel Standard (Automotive Diesel) Determination 2001	legislation.gov.au/Details/F2009C00145
Fuel Standard (Biodiesel) Determination 2003	legislation.gov.au/Details/F2009C00146
Fuel Standard (Autogas) Determination 2003	legislation.gov.au/Details/F2014C01226
Fuel Standard (Ethanol E85) Determination 2012	legislation.gov.au/Details/F2012L01770
Fuel Quality Information Standard (Ethanol) Determination 2003	legislation.gov.au/Details/F2006C00551
Fuel Quality Information Standard (Ethanol E85) Determination 2012	legislation.gov.au/Details/F2012L01771
Fuel Quality Standards (Register of Prohibited Fuel Additives) Guidelines 2003	legislation.gov.au/Details/F2007B01063
Fuel Standard (B20 Diesel Biodiesel Blend) Determination (Proposed)	To be considered
Guidelines for more stringent fuel standards	None proposed

1.2.2. Better fuel for cleaner air discussion paper

As part of the work of the Ministerial Forum, the Australian Government released the *Better fuel for cleaner air discussion paper*[3] on 20 December 2016, to explore and consult on a range of policy options to improve Australia's fuel quality.

The consultation period on the discussion paper ended on 10 March 2017. Over 70 submissions were received from government and non-government stakeholders, including health and environmental groups, the fuel industry, the vehicle and aviation industries, industry associations and members of the public (Figure 3).

The *Better fuel for cleaner air discussion paper* and the 64 (non-confidential) submissions received can be found on the Department's website at: environment.gov.au/protection/fuel-quality/better-fuel-cleaner-air-discussion-paper-2016.

The Department has completed a detailed analysis of submissions and carried out further stakeholder consultation. This draft RIS builds on this work to describe the current operation of fuel standards regulation in Australia, identify existing and emerging risks and opportunities, and explore issues associated with the implementation of each option. In particular, it includes a cost-benefit analysis of the three major policy reform options for the fuel standards. The options presented do not represent a government decision nor formal government policy.

1.2.3. Policy assessment criteria

To best achieve the objectives of the Act and align with the Government's best practice regulation guidelines, the Department considered six assessment criteria in the development of the policy options. These assessment criteria are outlined in Figure 4.

Figure 3. Stakeholder groups that provided a submission to the *Better fuel for cleaner air discussion paper*

Figure 4. Policy assessment criteria for the draft RIS

Policy assessment criteria

1. Achieve appreciable health and environmental outcomes
2. Ensure the most effective operation of engines
3. Facilitate adoption of better engine and emission control technologies
4. Achieve harmonisation with European standards, as appropriate
5. Minimise regulatory burden
6. Maximise net national benefits

The draft RIS identifies the options that best meet these criteria. It includes a detailed analysis of the costs and benefits for individuals, non-government organisations and businesses—including motorists and fuel suppliers. An analysis of potential impacts on regional Australia is also provided. As implementation of the policy reforms would require capital and operating cost investment by Australia's petroleum refining industry, fuel supply and energy security are also considered.

Feedback received on this draft RIS will be incorporated into a revised draft RIS, which will propose a preferred option based on consideration of the policy assessment criteria. The cost-benefit analysis in Chapter 5 provides quantitative estimates for assessment criteria 1, 5 and 6. However, the final decision by the Government will also consider issues qualitatively.

1.3. The regulation impact statement process

In accordance with the *Australian Government guide to regulation* [4], this draft RIS addresses the following questions:

1. What is the policy problem? (Chapter 2)
2. Why is government action needed? (Chapter 3)
3. What policy options are being considered? (Chapter 4)
4. What is the likely net benefit of each option? (Chapter 5)
5. Who will be consulted and how will they be consulted? (Chapter 6)

Stakeholder views will be sought on the following aspects of the draft RIS:

- the costs and benefits included in this draft RIS
- how and when the policy options could be implemented
- whether the options are likely to achieve the proposed and desired health, environmental and technological outcomes.

Stakeholder input will contribute to the final set of regulatory options for further analysis in a revised draft RIS for consideration by the Government. The revised draft RIS will also address the remaining questions in the *Australian Government guide to regulation*:

6. What is the best option of those considered?
7. How will the chosen option be implemented and evaluated?

The revised draft RIS will inform the Australian Government's decision on what, if any, changes should be made to the legislative instruments, including the fuel standards, under the Act.

1.4. Your feedback

Comments on this draft RIS are requested by 8 March 2018. They should be submitted electronically in Microsoft word .doc or .docx format to: fuel.policy@environment.gov.au.

Please ensure your comments are attached as a separate document when submitting your response by email.

Alternatively, your comments can be mailed to:

Fuel Policy Section
Department of the Environment and Energy
GPO Box 787
CANBERRA ACT 2601

Unless marked as confidential, all submissions will be treated as public documents and posted on the Department's website (www.environment.gov.au). The Department will not post any personal details (such as the names of individuals or email addresses) on the Department's website.

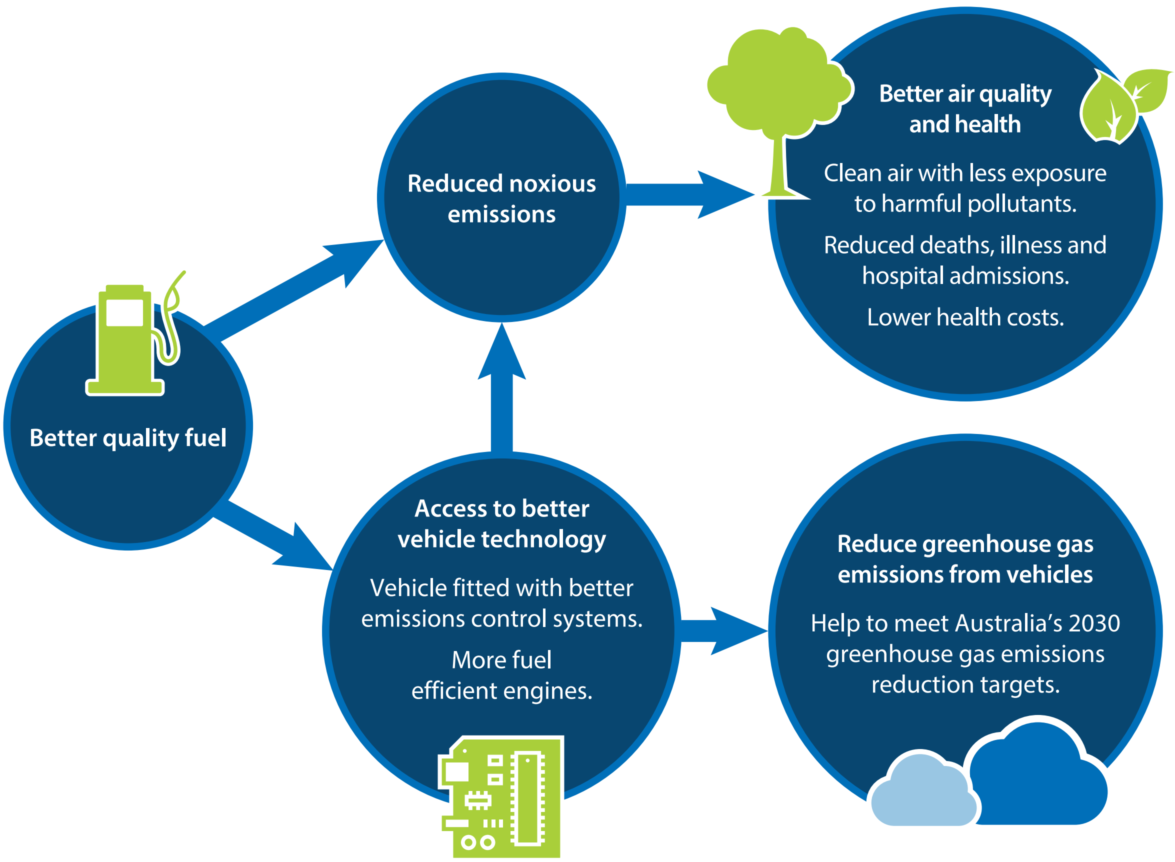
2. What is the policy problem?

Fuel quality influences the type and range of vehicles supplied to the Australian consumer and the operability of new and in-service vehicles. Harmonisation of Australia's fuel standards with European fuel standards, regarded as best practice international fuel standards, would ensure that vehicle emission control systems operate effectively—minimising the release of noxious and greenhouse gas emissions—and enable access to more advanced vehicle technologies with better emission control systems and more fuel-efficient engines. Through its effect on vehicle range and operability, the quality of Australian fuel affects the quantity and type of emissions from our vehicles, and directly and indirectly influences the quality of the air we breathe and the amount of greenhouse gas in our environment (Figure 5).

This chapter identifies the fuel parameters* of concern and discusses four main policy problems:

1. Australian fuel quality harms our health and environment
2. Australian fuel quality affects engine operability and restricts access to some advanced vehicle technologies
3. Australian standards could be better aligned with best practice international fuel quality standards
4. Fuels are supplied in Australia which are not regulated by the Act.

Figure 5. Fuel quality impacts on vehicle emissions



* Fuel parameters specify the limits on the fuel's physical properties and the concentration of chemical substances in fuel.

2.1. Fuel parameters

The fuel quality standards specify limits on each fuel's parameters. These parameters are the physical properties and chemical substances necessary for the fuels use in particular engines. The petrol parameters that most affect vehicle operability and emissions—and on which Australia is out of step with European fuel standards—are:

- Sulfur. Sulfur contaminates vehicles' catalytic converters (catalysts), limiting their ability to convert noxious emissions into less harmful substances. Due to the effect of sulfur on emission control systems, high-sulfur fuels also restrict access to some new engine and emission control technologies that need lower sulfur fuel to operate effectively.
- Octane number. Petrol's octane number, usually represented by its research octane number (RON) and motor octane number (MON), is a measure of petrol's resistance to ignition under compression in a spark-ignition engine. The use of lower octane petrol (such as 91 RON) than that recommended by vehicle manufacturers, or in fuel-efficient high-compression engines, can cause engine 'knocking' and damage. Older vehicles that are designed for, and use, low octane petrol are also generally less fuel efficient than similar vehicles designed to use higher octane petrol. Consequently, they cost motorists more and release more noxious emissions and greenhouse gases per kilometre travelled.
- Aromatic content. A high content of aromatic substances (benzene and its derivatives) in petrol can form combustion chamber deposits in engines and increase particulate matter (PM) and other carcinogenic emissions from vehicles. Lowering aromatics would improve engine operability, reduce noxious exhaust emissions, and improve health outcomes.

Australia's regulated limit for sulfur is 150 ppm (parts per million, or mg/kg) for regular unleaded petrol, 50 ppm for premium unleaded petrol, and 45 per cent (by volume) for aromatics. These regulated limits are less stringent than those of Australia's major trading partners.

Other petrol parameters examined in this draft RIS include oxygenates (ethers and alcohols, including ethanol) and olefins. The reform options focus on the petrol standard because improvements in petrol quality are expected to provide the greatest health and environmental benefits for Australians. However, all options involve changes to parameters in the other fuel standards: diesel, autogas (LPG), ethanol E85, and biodiesel.

In diesel, parameters that most affect vehicle operability and emissions—and on which Australia is out of step with European fuel standards—are:

- Cetane. Higher cetane values generally increase performance and reduce emissions.
- Density. Density that is too low can reduce fuel efficiency. Density that is too high can increase PM emissions.
- Polycyclic aromatic hydrocarbons (PAHs). These can cause engine operability problems and increase noxious emissions. Many PAHs are known carcinogens.

In other respects, Australian diesel already meets international standards—for example, the regulated maximum sulfur limit in the diesel standard is 10 ppm—although it is important to note that the standard currently only applies to automotive diesel and not off-road uses.

Some commonly used fuel additives can also adversely affect vehicle operability, emissions and human health. The parameters and additives are outlined in Appendix A.

2.2. The quality of our fuel harms our health and environment

The combustion of fuel releases a range of substances into the air that harm human health and damage the environment. These substances include particulate matter, benzene and nitrogen oxides, which are known to cause cancer, heart and lung disease, leading to premature death, and greenhouse gases, which contribute to climate change. Burning fuel can also facilitate the creation of secondary pollutants, such as ozone, which causes smog and is a respiratory irritant.

2.2.1. Health impacts

As Australia is a highly urbanised country[*], a large proportion of the population is exposed to vehicle exhaust emissions while driving, walking, and using public places[5]. More Australians will be exposed to vehicle emissions as our population grows and urban density increases.

The effects of exposure to vehicle emissions include reduced lung function, ischemic heart disease, stroke, respiratory illnesses and lung cancer[6]. Bladder cancer[7] and breast cancer[15] are also linked to vehicle emissions. Children are susceptible to a range of additional effects, including low birth weight[8], long-term effects on lung function[9], childhood leukaemia[10, 11], and childhood brain tumours[12]. Living in proximity to highways has also been linked to a higher incidence of dementia in the elderly[13].

A 2013 study into the public risk of exposure to air pollutants found that nine per cent of all deaths due to ischemic heart disease in Australia's four largest cities were attributable to long-term population exposure to particulate matter alone[14]. Air pollutants can also have a significant impact on the cardio-respiratory system, causing or worsening a range of illnesses such as asthma, chronic obstructive pulmonary disease and bronchitis[15, 16, 17]. Individuals with pre-existing respiratory conditions, such as asthma and allergies, are especially vulnerable to air pollutants, causing absences from work and school, and occasionally premature death[18]. Motor vehicles make a significant contribution to this pollutant load. Numerous studies have concluded that reducing noxious emissions from motor vehicles would provide substantial health and economic benefits, particularly in urban areas[19, 20, 21, 22, 23].

Air pollution is a major contributor to illness and premature death among Australians. In 2011, data indicated it caused the premature death of 2549 Australians[24]—more than the national road toll from accidents—at an estimated economic cost of up to $11 billion[25].

Noxious emissions from vehicles are one of the major causes of air pollution, particularly in the more densely populated urban areas, where they contribute up to 70 per cent of emissions of nitrogen oxides (NOx) and carbon monoxide (CO), 28 per cent of volatile organic compounds (VOC) emissions and 30 per cent of fine emissions of particulate matter (PM)[26, 27]. Analysis has indicated health impacts from vehicle emissions cost the Australian economy approximately $3.9 billion[28]. Existing emissions standards are expected to decrease emissions of some pollutants.

The use of diesel for off-road purposes is not currently regulated. However, non-road diesel engines and equipment, are used in a wide variety of private and commercial applications such as construction, agriculture, power generation, rail transport and mining, and are also a significant source of noxious emissions. Occupational exposure to non-road diesel emissions is associated with increased lung cancer risk[29]. A 2010 study estimated that non-road diesel engines emit around 13,500 t of PM_{10} each year, which is of a similar magnitude to emissions from on-road vehicles[30]. The study concluded that reducing emissions from the non-road sector would contribute to reducing particulate and ozone pollution, and associated health risks, in Australian cities and regional areas.

---

* Almost 90 per cent of Australians lived in urban areas in 2015. Trading Economics (2014). Urban population (% of total) in Australia. Available at tradingeconomics.com/australia/urban-population-percent-of-total-wb-data.html

To reduce the impacts of noxious vehicle emissions, Australia has historically adopted increasingly stringent 'Euro' vehicle emissions standards. As a result, while there has been an increase in total fuel consumed—as the Australian fleet is growing at a faster rate than efficiency improvements—some noxious emissions have decreased (for example NO_x, as shown in Figure 6).

However, without action, some vehicle emissions are expected to continue increasing (for example PM emissions in light vehicles, as shown in Figure 7[31]). Despite the projected short-term reduction in some emissions, health costs are expected to remain a concern because of the ongoing increase in population density and ageing, as well as the realisation of health impacts caused by earlier exposure to noxious emissions.

Figure 6. Change in NOx emissions, 2007–2016

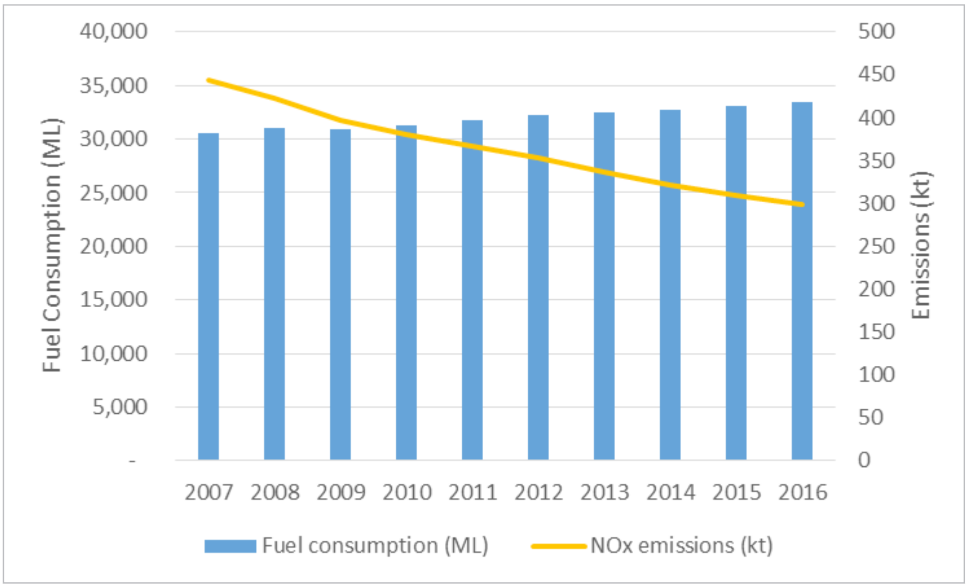
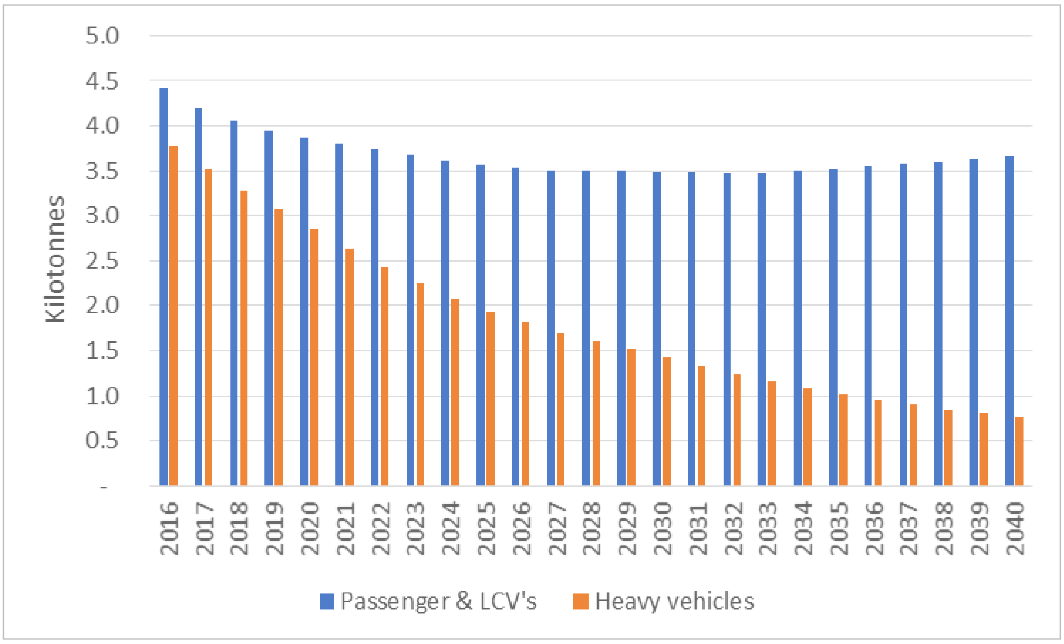


Figure 7. Projected PM_{10} emissions from motor vehicles by category of vehicle, 2016–2040



Vehicle manufacturers advise that Australia's fuel quality must be harmonised with best practice international (European) fuel standards to optimise emission control system effectiveness and realise health benefits[32].

In the case of the older in-service vehicle fleet, which may have less effective emissions control systems, improvements in fuel quality, particularly reductions in petrol sulfur and aromatics content, would also directly reduce the emission of cancer-causing substances such as hydrocarbons and particulate matter. In the majority of the current light vehicle fleet, that employs port fuel injection technologies, estimated to be 80 per cent of vehicles in 2016[33], running lower aromatic content fuels would be expected to reduce the risk of combustion chamber and injector deposits and reduce particulate emissions, which is considered to be beneficial to human health.

The health impacts of common vehicle emission pollutants are summarised in Table 2.

Table 2. Summary of the health impacts of vehicle emission pollutants of concern

Pollutant	Description
carbon monoxide (CO)	Carbon monoxide is a colourless, odourless and tasteless gas that is poisonous to humans. In high concentrations and long exposures, CO interferes with the blood's capacity to carry oxygen. Exposure, even at lower levels, can have adverse effects on individuals with cardiovascular disease.
volatile organic compounds (VOCs)	Many, but not all, VOCs are formed from the combustion of aromatics, or olefins. Benzene, formed from the combustion of aromatics, and 1, 3-butadiene are known carcinogens. VOCs can be inhaled. General effects of exposure to VOCs include cancer; damage to the liver, kidneys and central nervous system; irritation of the eyes, nose and throat; headaches; loss of coordination; and nausea.
nitrogen dioxide (NO_2) and nitrogen oxides (NO_x)	Nitrogen dioxide in the atmosphere may irritate respiratory systems, worsen 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 ozone.
ozone (O_3)	Health effects attributed to ozone include irritation of the 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. Some members of the population are sensitive even at very low concentrations[34].
fine particles (also called particulate matter (PM))	Small particles with a diameter of less than 10µm (PM_{10}) are a particular health concern because they are easily inhaled and retained in the lungs. Studies in the USA and elsewhere consistently show a strong relationship between particulate matter and a range of respiratory and cardiovascular illnesses and cancer. Particles smaller than 2.5µm ($PM_{2.5}$) and ultrafine (less than 0.1µm in diameter) are of greatest concern because they penetrate deep into the lungs and have significant health effects at concentrations below current standards[35]. The current consensus is that there is no safe level of exposure to particulates and that any reduction would improve population health outcomes[36, 37]. The dangers of diesel exhaust are such that cities including Paris, Madrid, Athens and Mexico City are planning to ban diesel vehicles from their city centres by 2025.
sulfur oxides (SOx)	Exposure to sulfur oxides can cause eye and throat irritation, and exacerbate cardiovascular diseases and asthma symptoms. Sulfur oxides are also a precursor to acid rain.

2.2.2. Greenhouse gas emissions

Australia has committed to a new global climate change agreement, the Paris Agreement. Under this agreement, Australia intends to reduce its greenhouse gas emissions by 26–28 per cent below 2005 levels by 2030. In announcing this target, the Australian Government committed to consulting on and implementing initiatives that deliver low-cost emissions reductions, including measures to improve the efficiency of road vehicles.

The proposed introduction of fuel efficiency standards is the responsibility of the Department of Infrastructure and Regional Development and is outside the scope of this draft RIS. While fuel efficiency standards reduce fuel consumption, and lead to the reduction of greenhouse gas emissions, it should be noted that production of higher quality fuel could increase greenhouse gas emissions from refineries. Fuel quality can play a role in facilitating the introduction and market penetration of some technologies used in fuel-efficient vehicles.

2.3. Australia's fuel quality affects engine operability and restricts access to some advanced vehicle technologies

Recognising the role that fuel quality plays as an enabler of advanced technology, the Act's objectives include allowing the more effective operation of engines and facilitating the adoption of better engine and emission control technology.

Australia's current fuel standards were designed to ensure that Australia's fuel was of an appropriate quality to support the move to Euro 2 and Euro 3 emissions standards in 2003 and 2005 respectively. Australia has tightened emissions standards since that time, and presently all light vehicles (up to 3.5 t gross vehicle mass) manufactured from November 2016 must comply with the Euro 5 emissions standards[39], which are mandated through Australian Design Rule (ADR) 79/04. All heavy vehicles (over 3.5 t gross vehicle mass) manufactured from January 2011 must comply with ADR 80/03. At present, the quality of Australia's petrol does not meet the minimum fuel requirements considered necessary to comply with the currently regulated Euro 5 vehicle emissions standards.

The Department of Infrastructure and Regional Development proposes to adopt the Euro 6/VI emissions standards. These standards are more stringent than Euro 5/V with regard to nitrogen oxides, particulate matter limits and on-board diagnostic thresholds (see Appendix C), as well as emissions-testing arrangements. To meet these standards, Euro 6/VI vehicles are designed with advanced fuel efficiency and emissions control systems. Vehicle manufacturers advise that the health and environmental benefits of adopting these standards will not be realised until fuel meeting European standards is widely available in Australia[40]. For example, the Federal Chamber of Automotive Industries advises that adopting the European standard EN 228 limit on aromatics (35 per cent v/v max) is necessary to meet Euro 6c and Euro 6d[*] particulate number limits for gasoline direct injection (GDI) engines, and that the majority of light vehicles introduced into Australia between now and 2030 will have this type of engine[32]. The need to reduce aromatics to 35 per cent so that vehicles can meet Euro 6 emissions standards has been supported by independent automotive technical experts ABMARC.

Independent analysis undertaken for the Department identified that the risk in maintaining the current 45 per cent aromatics limit is that Euro 6c, and in particular Euro 6d (due to the significantly lower particle number limit) petrol cars that are fitted with particulate filters may have a higher rate of in-service problems in Australia compared to Europe. Principally, these problems are expected to be:

- blocked particulate filters due to increased particle production
- higher than normal fuel consumption and possibly reduced drivability or throttle response due to increased deposits fouling fuel injectors[41].

Some advanced vehicle technologies, including advanced emissions control systems and certain fuel-efficient engine technologies, require high-quality fuel to work effectively. If Australia's fuel standards do not harmonise with European fuel standards, Australia may forgo the benefits of some vehicle technologies that are available, or more widely used, in other countries. The ability to take advantage of future advances in vehicle technology may be similarly limited.

* Euro 6 emissions standards are graded with increasingly stringent requirements from 6b through to 6d. The Department of Infrastructure and Regional Development's *Vehicle emissions standards for cleaner air draft regulation impact statement* is based on the Euro 6d emissions standard, as this stage will have the greatest health benefits for the community.

Vehicle manufacturers claim that the use of Australia's current fuel in more efficient and high-performing Euro 6 vehicles is likely to cause a range of problems, including higher emissions than certified for, in-service issues such as malfunction indicator lights activating, and damaged brand reputation. While the Australian Institute of Petroleum does not agree that Euro 6 vehicles require 10 ppm sulfur petrol to operate effectively[42], some vehicle manufacturers advise that they are unwilling to introduce the latest model Euro 6 vehicles to the Australian market unless fuel quality is improved[43].

In addition to producing higher pollutant emissions, the Federal Chamber of Automotive Industries claims that fuel with greater than 10 ppm sulfur will cause increased wear and degradation of engine and emission systems components, including:

- higher in-field emissions due to reduced catalyst efficiency
- risk of on-board diagnostics (OBD) system malfunction indicator lamp illumination—vehicles needing repair
- early (before the regulated 160,000 km life) replacement of catalytic converters
- gasoline particulate filter blockage requiring more frequent regeneration cycles, and fuel consumption and CO_2 emission increases
- increased oil consumption
- piston and cylinder bore seizures[44].

Increased wear and tear could result in additional maintenance and/or fuel costs for Australian motorists.

ABMARC assessed that when there are unique market conditions (environmental, vehicle use or fuels), vehicle manufacturers will be very reluctant to introduce their cars and technologies if they have not assessed the durability of those cars under those unique market conditions. ABMARC attributed this reluctance to the risk that vehicle manufacturers may expose themselves to high warranty costs and reduced customer satisfaction[45].

Better access to advanced vehicle technologies could facilitate Australia's ability to continue to reduce health and transport costs through improvements in fuel efficiency.

In 2014, the Department commissioned the Hart Report to compare Australian fuel standards with those in other countries, and to examine points of difference. The Hart Report suggests harmonisation of sulfur levels in petrol with those in the European Union, Japan and South Korea to enable advanced emission controls technology to be incorporated in the vehicles supplied to the Australian market [46].The report found that there are a number of other parameters in Australian petrol, diesel, biodiesel and ethanol E85 that may require changes to avoid engine and emission system control damage and improve engine operability, including aromatics, PAHs and phosphorus in biodiesel.

2.4. Australian standards could be better aligned with best practice international fuel standards

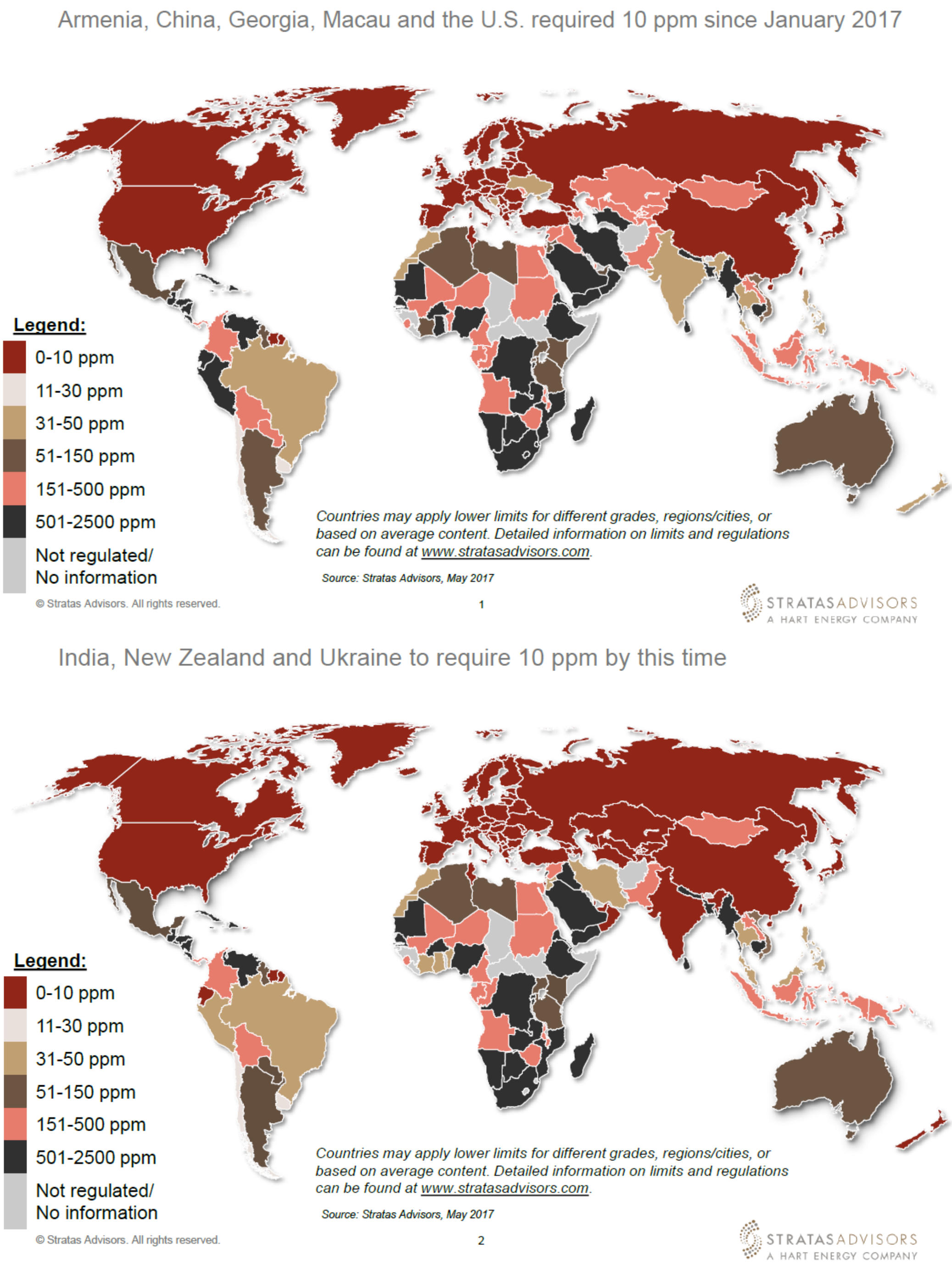
Australia's fuel quality does not align with that of our major trading partners, particularly for petrol.

2.4.1. Australia's current fuel quality

As shown in Figure 8, the majority of Australia's trading partners have reduced permitted sulfur limits in petrol to 10 ppm, or are planning to over the next four years. Sulfur in petrol in the European Union (EU), China and the USA is limited to 10 ppm.

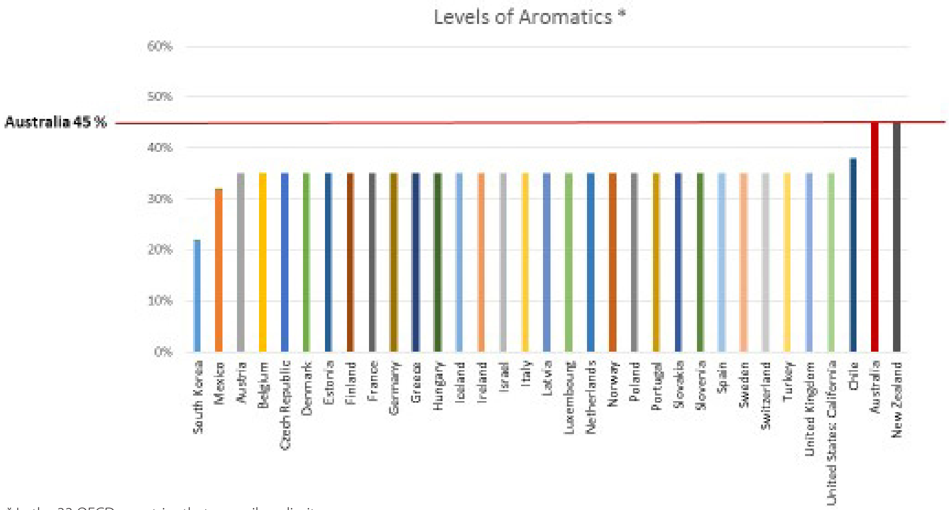
Since the release of the *Better fuel for cleaner air discussion paper* in December 2016, Australia has slipped four places to rank 70th in the 2017 'Top 100' world ranking of petrol quality (based on regulated sulfur content[47]) and is the lowest ranked of the 35 OECD member countries. A regulated petrol aromatic limit of 45 per cent also ranks Australia 82nd of 96 countries that regulate this parameter and ranked equal lowest, with New Zealand, in the OECD[48] (Figure 9).

Figure 8. Maximum global sulfur limits on gasoline, 2017 (top) and 2020 (bottom)



Source: © Copyright Stratas Advisors, May 2017

Figure 9. Maximum global aromatics limits in petrol (2017)[49]



* In the 33 OECD countries that prescribe a limit

2.4.2. Harmonisation would minimise vehicle emissions and price premiums for consumers

The adoption of international standards can reduce duplication of regulatory approvals, reduce delays, increase competition and improve business competitiveness in Australia.

The Australian Government has a long-term policy of harmonising national standards for road vehicles (the ADRs), with international regulations adopted by the United Nations (UN), taking Australian conditions into account where possible. Harmonisation with UN regulations facilitates trade and ensures that improvements in vehicle safety and environmental performance are provided to the Australian market at the lowest possible cost. Where a product has been approved under a trusted international standard, the Australian Government's policy is that it should not impose any additional requirements for approval in Australia, unless it can be demonstrated that there is a good reason to do so[50].

Australia is fully reliant on imports of light vehicles as a result of the cessation of domestic vehicle manufacturing. Globalisation of the motor vehicle industry, the relatively small size of the vehicle market in Australia (1.5 per cent of the global production of vehicles[51]) and the higher costs involved make the development of unique Australian standards undesirable from both a government and a manufacturing perspective. In its submission to the *Better fuel for cleaner air discussion paper*, General Motors Holden noted that harmonisation of design rules and regulations with global markets similar to Australia is typically encouraged to mitigate unnecessary development and implementation cost burdens.

International vehicle manufacturers are designing vehicles to meet the more stringent fuel efficiency and emissions standards adopted by our trading partners. These vehicles are designed to perform optimally on higher quality fuel than is currently available in Australia, particularly in relation to petrol sulfur, aromatic and octane levels. Harmonisation of Australia's fuel quality with the quality of fuel that these vehicles are designed to operate on will maximise vehicle emissions control system operability and fuel efficiency outcomes, and will limit vehicle operability issues (for example, to vehicle catalysts).

Harmonisation with European fuel standards was strongly supported by the Federal Chamber of Automotive Industries, which advised that to offer vehicles with world-class pollutant emissions standards, Australia must harmonise fuel standards with leading overseas markets.

2.5. Fuels are supplied in Australia which are not regulated by the Act

2.5.1. 98 RON petrol

The Australian petrol standard includes minimum octane parameters for 91 RON and 95 RON petrol, but not 98 RON petrol, although that fuel is commonly available on service station forecourts. Sales of 98 RON petrol increased by 60 per cent from 2010 to 2016[52], faster than that of other fuels.

There is currently no 98 RON standard in Australia. Consequently, 98 RON petrol is legally held to the 95 RON standard, providing no recourse under the Act for 98 RON labelled petrol that actually has an octane number between 95 and 98.

2.5.2. Diesel for non-road purposes

The scope of the diesel standard is limited to fuel that is considered 'automotive diesel'. This standard does not apply to diesel supplied and labelled for other uses, such as for use in generators, graders, tractors, trains or industry.

In their submissions to the *Better fuel for cleaner air discussion paper*, the New South Wales and Victorian governments called for the diesel standard to be expanded to non-road (non-automotive) uses to reduce emissions of particulate matter and nitrogen oxides. The application of the fuel standards to the supply of fuel regardless of its use, with only minimal exceptions, would be beneficial to engine operability generally and would improve environmental and health outcomes. Non-road engines operate near humans and therefore should use fuels that comply with a standard that meets community expectations.

Extending the scope of the standard could mean that those who use non-road diesel would be able to seek recourse under the Act if non-compliant diesel were supplied to them.

2.5.3. B20 diesel

B20 fuel is a diesel blend with more than 5 per cent, but less than or equal to 20 per cent, biodiesel. It is used by mining operators and truck fleets. Given that there is no provision under the Act for B20 diesel, fuel suppliers that wish to sell this fuel in Australia are required to apply for an exemption under section 13 of the Act. The application and its assessment require a significant amount of administrative work on the part of the applicant and the Department. A new fuel standard for a B20 diesel-biodiesel blend has been proposed by a number of stakeholder groups as a way to reduce the administrative burden on industry. Currently, all B20 manufacturers must apply for separate approvals.

2.5.4. Renewable and synthetic diesel

The automotive diesel standard does not explicitly define and include renewable and synthetic diesel. This creates confusion in industry as to whether the diesel standard applies to these novel fuels. Where suppliers do not think these fuels are covered by the diesel standard, they may be selling non-compliant fuel for use in diesel engines.

2.6. Australia's refining industry has an important role in Australia's fuel supply and energy security

Australia's petroleum refineries produce a range of products that are used by most Australians on a daily basis. Australia has four major oil refineries, including two in Victoria (Altona, Melbourne – owned by Mobil, and Geelong – owned by Viva), one in Queensland (Lytton, Brisbane – owned by Caltex), and one in Western Australia (Kwinana – owned by BP). In addition to supplying products including petrol, diesel and gas, the refineries employ around 1500 direct staff, several hundred contractors and support associated businesses. Contractor numbers can double for major upgrade and maintenance programs (undertaken every 4-6 years). Detailed planning of upgrades takes place several years in advance.

Australia's petroleum refineries supply 47 per cent of Australia's total liquid fuel needs and 65 per cent of our petrol[53]. The total domestic petrol production for motor vehicles in 2015-16 such as regular, premium and E10 petrol was 11,641 million litres compared with imports of 6,638 million litres. The refineries produce 95 RON and 98 RON petrol with lower sulfur and aromatics concentration than the regulated limit permits and these are available to Australian motorists. However, petrol in Australia is not currently required to meet the European fuel standards of a maximum of 10 ppm sulfur and 35 per cent aromatic content. Imported petrol is generally better quality than that manufactured in Australia; however, it also may not meet European fuel standards.

Australia's refineries are ageing and would require significant capital investment, and increased operating costs, to produce better quality petrol. While refiners prefer that fuel quality standards are not amended, the members of the Australian Institute of Petroleum have made an in-principle offer to supply 10 ppm sulfur petrol by July 2027, stating that this would ensure the best chance of ongoing oil refining viability in Australia, minimise the price impact on consumers and maximise the robustness of Australia's liquid fuel security. This option is analysed in this draft RIS.

3. Why is government action needed?

3.1. Improving fuel quality could address health and environmental externalities

Externalities arise when the economic activity of one organisation (or people) generates a positive or negative impact for another without there being a market price associated with the impact[4]. In this instance, the cost of health and environmental impacts caused by the release of vehicle emissions are not factored into the price of fuel. People using lower quality fuel in their vehicles, which are likely to release more harmful emissions, do not pay more for their fuel and are not necessarily impacted directly by the choices they make.

The link between fuel quality, vehicle emissions and health impacts is not widely publicised and may not be clear to many consumers, further limiting their ability to make informed decisions about the type of fuel they purchase and the type of car they drive. Without government intervention, consumers will continue to purchase cheaper, lower quality fuel, which has greater health and environmental externality than higher-quality fuel.

The human health impacts from exposure to noxious emissions and impacts from greenhouse gas emissions are a cost to society which is largely beyond the control of communities and individual businesses. The links between exposure to noxious vehicle emissions and human and environmental health make this issue a priority for joint action by governments, businesses and the community[54].

Without government intervention, noxious air pollution and greenhouse gas emissions will continue to increase, as will the associated health and environmental cost burden. Government action to improve fuel quality would provide a pathway to improved air quality and greater certainty that Australians will be protected from harmful emissions.

3.2. Harmonisation with international fuel standards could increase vehicle choice and provide operability benefits

As Australia comprises a small fraction of the international vehicle market, further harmonisation of Australia's fuel quality standards with international standards would minimise the risk of creating a 'boutique' Australian vehicle specification requirement and attracting additional price premiums.

Similarly to the issues noted above in relation to health externalities, Australian consumers are not necessarily aware of the vehicle choice and operability benefits of harmonisation with international standards. Therefore, there is insufficient demand in the Australian market to harmonise fuel standards. In the absence of this demand signal, government intervention is needed to harmonise with international fuel quality and enable Australians to realise the vehicle choice and operability benefits that harmonisation would bring.

Government intervention would also ensure that fuel standards are applied equally to imported and domestically produced petroleum fuels and are compatible with relevant internationally accepted standards.

4. What policy options are being considered?

This chapter explores the policy reform options considered in this draft RIS. These revised and refined policy options have been developed following detailed analysis of stakeholder submissions on the *Better fuel for cleaner air discussion paper* and further consultation with industry, consumer and health advocates, and government stakeholders. The major changes to the scope of the policies (compared to those in the discussion paper) are as follows.

- Removal of Fuel Standard Option D. Option D proposed aligning fuel standards with the Worldwide Fuel Charter[55]. While Option D provides the greatest health and environmental benefits and was supported by many stakeholders, the cost-benefit analysis revealed that it is unlikely that it will deliver a net benefit to the community (see Chapter 5). The Australian Institute of Petroleum advised that, due to the costs associated with implementation, this option would likely close the refining industry and that fuel complying with the specifications proposed would be very difficult and expensive to source in the Asian region, increasing the price to consumers. This view was supported by independent fuel industry experts, which considered the implementation of this option may introduce fuel security risks[56].
- Removal of Fuel Standard Option E. Option E, which involved a staged introduction of world standards beginning in 2020 was not favoured by any stakeholders, including the Australian Institute of Petroleum, the New South Wales Government, and Doctors for the Environment Australia. The Australian Institute of Petroleum advised that the cost for most refineries would be the same as for other options and that implementation of any reform option in 2020 is not feasible due to the lead times necessary for planning and implementation of the necessary capital works. Their view was supported by independent fuel industry experts[57].
- Inclusion of Fuel Standard Option F. The Australian Institute of Petroleum, representing domestic refinery operators, proposed an additional option reducing sulfur to a maximum of 10 ppm in all petrol grades by 2027 with no changes to any other fuel parameters.
- Consideration of a standard for 98 RON and use of octane enhancers (option B and C).
- Consideration of the expansion of the Fuel Standard (Automotive Diesel) Determination 2001 (options B and C) to include the use of diesel fuel in non-road diesel engines (such as tractors, generators and trains). In their submissions to the *Better fuel for cleaner air discussion paper*, the New South Wales and Victorian governments called for the diesel standard to be expanded to non-road (non-automotive) uses to reduce emissions of particulate matter and nitrogen oxides.
- Possible definition of renewable and synthetic diesel (options B and C).
- Possible changes to parameter limits and test methods (options B and C) resulting from stakeholder feedback on the discussion paper about the need to harmonise with European standards to optimise vehicle operability (see Appendix B for details).

The final scope of the proposed reforms is outlined in Section 4.1.

Further detail on stakeholder views that have informed the policy options of this draft RIS are included in Chapter 6 and Appendix E.

4.1. Scope of the proposed reforms

A summary of the proposed policy reforms relating to each legislative instrument is presented in Table 3. The remainder of this chapter describes in detail the proposed changes to each of the legislative instruments. Legislative instruments includes fuel standards (determinations), information standards and guidelines.

Table 3. Summary of major policy amendments

Legislative instrument		Description	Section
Fuel standards	Fuel Standard (Petrol) Determination 2001 Fuel Standard (Automotive Diesel) Determination 2001 Fuel Standard (Autogas) Determination 2003 Fuel Standard (Ethanol E85) Determination 2012 Fuel Standard (B20 Diesel Biodiesel Blend) Determination (new)	A range of options for changes to fuel parameters in each of the fuel standards: –Option A—Australia's fuel standards remain in effect in their current form (business as usual). Petrol and diesel standards are retained. –Option B—Fuel standards are revised to align with the recommendations of the Hart Report[55] and to harmonise with European standards. 91 RON petrol is not retained. Possible standard for 98 RON petrol. Possible changes to the scope of the Fuel Standard (Automotive Diesel) Determination 2001: a possible definition of renewable and synthetic diesel, and a new standard for B20 diesel-biodiesel blend. –Option C—As per Option B, fuel standards are revised to align with the recommendations of the Hart Report and to harmonise with European standards and regular unleaded petrol (91 RON) is retained. Possible standard for 98 RON petrol. Possible changes to the scope of the Fuel Standard (Automotive Diesel) Determination 2001: a possible definition of renewable and synthetic diesel and a new standard for B20 diesel-biodiesel blend. –Option F—Petrol standard is revised to reduce sulfur to 10 ppm in all grades of petrol by 2027. 91 RON is retained and all other parameters for all fuel types remain in their current form (business as usual).	4.2
Information standards	Fuel Quality Information Standard (Ethanol E85) Determination 2012	Section 4(1)(b) and section 6(a)(ii) amended to promote consistency with the Fuel Quality Information Standard (Ethanol) Determination 2003	4.3
Guidelines	*Register of Prohibited Fuel Additives*	Further evaluation of organometallic compounds (including tetraethyl lead, methycyclopentadienyl manganese tricarbonyl (MMT), ferrocene), N-methylaniline (NMA), and polychlorinated n-alkanes (chlorinated paraffins).	4.4

4.2. Proposed amendments to fuel quality standards

This section outlines the main features of the amendments to the fuel quality standards. There are four policy options, which are summarised below and outlined in more detail in Table 4 and Appendix B.

4.2.1. Option A—no change to the fuel standards

Option A represents the business as usual or no-change scenario.

4.2.2. Option B—harmonise with the European Union

Fuel standards are revised to align with the recommendations of the Hart Report[55] and to harmonise with European standards, subject to Australia's unique environmental conditions. The main changes proposed under Option B include changes to each of the fuel standards—petrol, diesel, autogas, ethanol E85 and biodiesel—as well as a new standard for a B20 diesel-biodiesel blend.

For petrol, there is consideration of the possible inclusion of an additional octane limit for 98 RON petrol, as well as the potential use of ethanol to provide greater flexibility to meet a minimum 95 RON / 85 MON specification. For diesel, there is also consideration of an expanded scope of the standard to include non-road vehicles and to include a definition of renewable and synthetic diesel.

4.2.2.1. 98 RON petrol

A standard for 98 RON petrol specifying the minimum RON could be considered. This could provide an assurance that petrol meets the 98 RON octane limit if a fuel labelled as such is being supplied. While the *Worldwide Fuel Charter* specifies 88 MON for 98 RON petrol, Options B and C propose that 98 RON petrol should have a minimum 85 MON, which is the same as that specified for 95 RON petrol.

4.2.2.2. Octane-enhancing additives in petrol

Certain chemical additives can be used to increase octane in petrol. Such additives are typically alcohols, ethers or organometallic compounds (see section 4.4.2). Some have been limited in the petrol standard because they pose environmental risks. These currently include MTBE, diisopropyl ether (DIPE) and tertiary butyl alcohol (TBA), each of which is limited to 1 per cent or less by volume. MTBE, while used widely across the European Union (EU) and elsewhere overseas, is limited in Australian petrol because of its potential to contaminate surface water and groundwater, and because it can be detected by taste and odour at extremely low levels.

Table 4. Significant parameter changes for each fuel under the options in this discussion paper

Option	Petrol		Diesel	Autogas	Biodiesel	Ethanol E85	Biodiesel B20
A No changes to the fuel standards	No change RON 91 95 MON 81 85 Sulfur (ppm) 150 50	Aromatics 45% In ethanol, sulfur 30 ppm and inorganic chloride 32 ppm	No change Derived cetane number 51 (diesel containing biodiesel) Polycyclic aromatic hydrocarbons 11%	No change	No change	No change Sulfur 70 ppm RON 100 MON 87	No change
B Revisions based on Hart Report and/or to harmonise with the EU	RON* 95 98 MON 85 85 Sulfur (ppm) 10 10 *phase out ULP (91 RON)	Aromatics 35% In ethanol, sulfur 10 ppm and inorganic chloride 1 ppm See Appendix B	Derived cetane number 51 (for all diesel, including diesel not containing biodiesel) Polycyclic aromatic hydrocarbons 8% Consideration of: expanded scope to include non-road uses possible definition of renewable diesel See Appendix B	Minor amendments See Appendix B	Minor amendments. See Appendix B	Sulfur 10 ppm RON 104 MON 88 See Appendix B	New standard See Appendix B
C Revisions retaining low-octane petrol	RON 91 95 98 MON 81 85 85 Sulfur (ppm) 10 10 10 * retain ULP (91 RON)	As per Option B	As per Option B	As per Option B	As per Option B	As per Option B	As per Option B
F Reduction of sulfur to 10 ppm in all petrol by 2027	RON 91 95 MON 81 85 Sulfur 10 10	Aromatics 45% In ethanol, sulfur 30 ppm and inorganic chloride 32 ppm	No change Derived cetane number 51 (diesel containing biodiesel) Polycyclic aromatic hydrocarbons 11%	No change	No change	No change Sulfur 70 ppm RON 100 MON 87	No change

Note: All proposed changes to the legislative instruments, including the fuel standards, are fully set out in Appendix B.

Stakeholder views are sought on related ethers, such as ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME) and ethyl tertiary amyl ether (ETAE)—whether their properties are similar enough to MTBE to require a new limit of 1 per cent in the petrol standard, or whether they can be adequately managed and their use encouraged as safe sources of octane.

Potential for ethanol-blended petrol

Ethanol is a high-octane petrol additive with 108 RON. Petrol blended with up to 10 per cent ethanol is specified in the petrol standard and is commonly marketed as E10 or 94 RON petrol.

Ethanol can provide an effective alternative to octane enhancers currently used by refiners and importers in Australia and overseas, such as MTBE or NMA. A number of stakeholders, including the Australian Biofuels Association, supported greater use of ethanol in Australian fuels to reduce greenhouse gas emissions, create employment in regional Australia and potentially provide new markets for Australian farmers[58]. Independent consultants to the Department also confirmed that ethanol, subject to sufficient quantities being available, is an example of how lower aromatics targets or increased octane to a minimum of 95 RON[59] could be achieved.

Blendstocks for oxygenated blending* could make it simpler and cheaper to maintain octane in refining processes. As E10 petrol currently averages about 94.7 RON and 84.2 MON, the production cost of 95 RON petrol containing ethanol (95 RON E10) may not be significantly greater than that of current E10 petrol. In the USA, nearly all fuel ethanol is blended with a blendstock for oxygenated blending, in order to produce E10 petrol, which comprises about 95 per cent of all US petrol.

Some stakeholder views on the benefits of extending the use of ethanol in higher grade petrol are consistent with policy statements in both New South Wales and Queensland[60, 61], which cite the policy objectives of stimulating investment in regional industries and jobs while meeting environmental and future fuel challenges.

While ethanol is an effective octane enhancer, a consumer resistance to ethanol-blended fuels was noted in some stakeholder submissions to the *Better fuel for cleaner air discussion paper*. It is also noted that some petrol-fuelled machinery cannot use ethanol-blended fuels and therefore retailer forecourts would most likely seek to retain a non-ethanol-blended petrol option for the consumer.

4.2.2.3. Extend the scope of the Fuel Standard (Automotive Diesel) Determination 2001

To ensure engine operability and minimise emissions it is proposed to consider the expansion of the scope of the diesel standard to include diesel used for non-road purposes, for example in stationary engines such as generators, off-road vehicles (tractors) and trains. Extending the standard in this way could mean that those who use non-road diesel would be able to seek recourse under the Act if non-compliant diesel were supplied to them. An amended scope would continue to exclude marine bunker fuel (the International Maritime Organisation has specified a reduction to 5000 ppm from 35,000 ppm sulfur from 2020) and military fuels. The proposal will be subject to more detailed consultation.

Some stakeholders, including the New South Wales Government and the Australian Institute of Petroleum, noted that it is likely that the majority of diesel fuel supplied for non-road uses is already compliant with the automotive diesel standard. Other stakeholders have indicated that they may use diesel that is not consistent with the standard.

If the expansion was pursued, one of the fuel types in the definition of 'fuel' in regulation 3(2) of the Fuel Quality Standards Regulations 2001 would need to be amended from 'automotive diesel' to 'diesel'.

---

* Blendstocks for oxygenated blending are designed to be blended with an oxygenate such as ethanol to make petrol that meets the petrol standard. Blended petrol would only be required to meet the petrol standard after it is blended with ethanol, and not before blending.

4.2.2.4. Include a definition of renewable and synthetic diesel

The diesel standard currently applies to any automotive diesel, whether derived from crude oil or synthesised from other feedstocks. In several submissions responding to the discussion paper, stakeholders asked the Government to include a definition of renewable diesel in the diesel standard to recognise the development of the industry and confirm that renewable diesel, along with other synthetic diesel, is subject to the diesel standard. Proposed definitions are:

Renewable diesel is liquid fuel that is manufactured by chemically altering (through thermal fractionation and hydrofinishing) vegetable oils, animal fats, biomass, biosolids, organic waste, plastic waste or waste rubber, such as tyres. It does not include diesel made from any fossil fuel.

Synthetic diesel is paraffinic diesel manufactured by chemically altering any feedstock.

Diesel means automotive diesel, renewable diesel, synthetic diesel or any combination of these.

Stakeholders also raised the preferential excise treatment given to biodiesel in the *Excise Tariff Act 1921*. Renewable diesel, while chemically different, can be made from the same renewable feedstocks as biodiesel, but it no longer qualifies for the same reduced excise as it once did under the previous Cleaner Fuels Grant Scheme. Excise issues are matters for the Treasury and are out of the scope of this consultation.

4.2.2.5. A new fuel standard (B20)

Following consideration of the proposal of a new fuel standard for a B20 diesel-biodiesel blend, a number of stakeholder groups viewed it as a way to reduce administrative burden on industry by eliminating the need to apply to the Department for a section 13 approval. Development of a B20 standard may reduce regulatory burden, provide greater certainty for the biodiesel industry, and improve consumer confidence in the quality of this fuel. The technical parameters that could be considered for B20 are listed in Appendix B.

4.2.3. Option C—harmonise with the European Union, retain 91 RON

Option C is the same as Option B except that 91 RON petrol is retained.

4.2.4. Option F—a maximum of 10 ppm sulfur in petrol by 2027

Under Option F, the petrol standard is revised to reduce sulfur to 10 ppm in unleaded petrol by 2027. The members of the Australian Institute of Petroleum have made an in-principle offer to supply 10 ppm sulfur petrol by July 2027. All other parameters for all fuel types remain in their current form (business as usual), and 91 RON petrol is retained.

The Australian Institute of Petroleum has also offered to implement an interim step for sulfur and aromatics to safeguard current market fuel quality. From 2021, this would be a reported, not regulated, procedure that is proposed to capture information on both domestically produced and imported fuels*. It is proposed to be based on the following parameters and limits, reported annually:

- For 91 RON, the sulfur limit will be 70 ppm pool average (150 ppm cap) and for aromatics the limit will be 35% pool average (45% cap).
- For 95 RON and 98 RON, the sulfur limit will be 35 ppm pool average (50 ppm cap) and the aromatics limit will be 42% pool average (45% cap).

If an interim reporting requirement was to be implemented, it could provide assurance to Australian motorists that current sulfur limits are lower on average than the maximum regulated limits.

---

* It is proposed that other producers and importers would report to the Department of the Environment and Energy. All consolidated annual reports would be made public

4.3. Proposed amendments to fuel quality information standards

The Minister for the Environment and Energy (the Minister) has made two fuel quality information standards under section 22A of the Act: the Fuel Quality Information Standard (Ethanol) Determination 2003, for which no changes are proposed, and the Fuel Quality Information Standard (Ethanol E85) Determination 2012.

4.3.1. Fuel Quality Information Standard (Ethanol) Determination 2003

The Fuel Quality Information Standard (Ethanol) Determination 2003 provides that the petrol pump from which ethanol is supplied must display one of the following:

(a) the words 'Contains up to x% ethanol', where x is no less than the percentage of ethanol in the ethanol blend

(b) the words 'Contains y% ethanol', where y is the percentage of ethanol in the ethanol blend.

No changes to this determination are proposed.

4.3.2. Fuel Quality Information Standard (Ethanol E85) Determination 2012

The Fuel Quality Information Standard (Ethanol E85) Determination 2012 provides that the petrol pump from which ethanol E85 is supplied must clearly display one of the following:

(a) the words 'Contains 70–85% ethanol', and 'Not Petrol or Diesel'

(b) the words 'Contains x% ethanol', where x is a number between 70 and 85, and 'Not Petrol or Diesel'.

Some submissions to the 2016 review of the Act expressed concern about a technical issue relating to the current wording of the 2012 information standard for ethanol E85. The submissions noted that this standard is inconsistent with the 2003 information standard and does not make it clear whether the stated range includes fuels that are either 70 per cent or 85 per cent ethanol.

To address these concerns and to provide greater clarity, the Department proposes a minor amendment to section 4(1)(b) and section 6(a)(ii) of the Fuel Quality Information Standard for Ethanol (E85) to read: 'x% ethanol, where x is a number more than 70 but less than or equal to 85'. The words used on a bowser would not change.

4.4. Proposed amendments to the Register of Prohibited Fuel Additives Guidelines

4.4.1. Review of the Fuel Quality Standards (Register of Prohibited Fuel Additives) Guidelines 2003

The *Fuel Quality Standards (Register of Prohibited Fuel Additives) Guidelines 2003* set out the matters that the Minister must consider before entering a fuel additive on or removing a fuel additive from the Fuel Quality Standards Register. The guidelines are intended to ensure that a consistent, objective process is followed in deciding whether a fuel additive should be prohibited. The guidelines also provide a process for interested parties to make submissions on the proposed listing or delisting of any fuel additives. Stakeholders did not comment on the guidelines. Minor amendments to the guidelines are proposed to clarify that some fuel additives could be prohibited when used in certain circumstances. For example, if lead were on the register, then it would need to be clear that this did not prevent the use of lead in aviation gasoline, if that were the intention.

4.4.2. Register of Prohibited Fuel Additives

Additives can increase the octane rating of petrol, or act as corrosion inhibitors or lubricants, or otherwise facilitate the use of higher compression engines to achieve greater engine efficiency and a reduction in emissions. Types of additives include metal deactivators, corrosion inhibitors, oxygenates and antioxidants. While some additives can be beneficial, there are some that are harmful and are therefore regulated or banned in some countries. In Australia, the Act prohibits the supply or importation of fuel additives on the *Register of Prohibited Fuel Additives*. To date, no fuel additives or classes of fuel additives have been entered on the register.

The 2016 discussion paper considered the following types of fuel additives:

1. Organometallic compounds. These are organic compounds that have bonds to metal atoms. Organometallic additives can increase a petrol's octane rating, but metal compounds in exhaust emissions can be dangerous when inhaled, can contribute to the formation of ash- forming particulate matter, and can be abrasive to engines. Metallic additives have been explicitly excluded from fuels by leading vehicle manufacturers[62, *]. Organometallic additives include the following compounds.
    (a) Tetraethyl lead[63] is already prohibited in petrol (a limit of 0.005 g/L is effectively a ban on the addition of lead). Any ban on lead would need to be implemented so that it does not preclude the use of lead in aviation gasoline. In June 2017, the Australian Government advised that lead will be phased out in racing fuels over two years from 1 July 2017, with no more leaded racing fuel to be supplied from 1 July 2019. Leaded racing fuels have previously been permitted under approvals given under section 13 of the Act since its commencement.
    (b) Methylcyclopentadienyl manganese tricarbonyl (MMT), available as a high-octane petrol fuel additive and an anti-valve seat recession additive, is an ash-forming compound that can adversely affect vehicle emission systems.
    (c) Ferrocene, used as a fuel additive, is an ash-forming compound that can adversely affect vehicle emission systems and increase fuel consumption.
2. N-methylaniline (NMA), a high-octane additive that increases NOx emissions and ash formation and can adversely affect vehicle emission systems.
3. Polychlorinated n-alkanes (chlorinated paraffins) are harmful bioaccumulative toxic compounds.

The Federal Chamber of Automotive Industries supports the inclusion of tetraethyl lead, MMT, ferrocene, NMA and polychlorinated n-alkanes on the *Register of Prohibited Fuel Additives*. The Federal Chamber of Automotive Industries also notes that MMT was a prohibited additive under the *Worldwide Fuel Charter*, because of the damage it causes to engines and sensors. The Australian Institute of Petroleum recommends further testing of the operability impacts of NMA-blended petrol and supports the inclusion of NMA on the list of prohibited substances. The Australian Institute of Petroleum also recommends further consultation with original equipment manufacturers and additive suppliers to determine an approach to the use of MMT.

Some stakeholders indicated that listing of additives on the register could have cost, competitiveness and/ or viability implications for their businesses. The listing of fuel additives on the *Register of Prohibited Fuel Additives* would require further evaluation and consultation, including public consultation, conducted within legislative processes.

* No intentional addition of metal-based additives is allowed.

5. What are the likely net benefits of each option?

The Department engaged independent advisors Marsden Jacob Associates to undertake a range of economic analyses to determine the net benefits and regulatory burden associated with policy options A, B, C, D* and F. The incremental benefits and costs of options B, C, and F were assessed relative to the business as usual (BaU) case (Option A). Implementation dates ranging from 2022 to 2027 were considered in the analysis for options B, C and F.

The economic analysis comprised four major elements: cost-benefit analysis (CBA); cost-effectiveness analysis (CEA); distributional impact assessment; and regulatory burden measurement. This analysis addresses policy assessment criteria five and six—minimise regulatory burden and maximise the net national benefits (see Figure 4)—and identifies differential impacts on different stakeholder groups, including consumers and regional Australia.

The main findings of the analysis are:

- Two of the options—Option C, which harmonises with European standards, and Option F, which only entails reducing sulfur in petrol—provide positive net present values (NPVs)† and benefit-cost ratios (BCRs) greater than 1.0, regardless of the implementation date‡.
- Option C has an NPV ranging from $641 million (2022) to $319 million (2027).
- Option F has an NPV ranging from $628 million (2022) to $317 million (2027).
- Under Option C:
  - The broader community is the major beneficiary, with health costs reduced by about $371 million in 2022, increasing to $392 million in 2030 and $418 million in 2040
  - The price increase is estimated at up to 1.0 cents per litre (cpl) for 91 RON petrol and up to 1.3 cpl for 95 RON and 98 RON petrol, with additional costs associated with upgrading infrastructure in Australia equivalent to approximately 1.0 cpl across all grades of petrol after the introduction of improved fuel quality standards.
  - Any increases to fuel prices are similar in metropolitan and regional areas
  - Capital and operating costs increase for refineries. Only some of these cost increases can be passed on to motorists, because Australian fuel prices are notionally set by the import parity price (IPP) of fuel
  - The appropriate market fuel (low sulfur, lower aromatics) is available to support the introduction of vehicles with the latest emission technology (Euro 6) into Australia and maintain the operability of the in-service fleet
  - The retention of 91 RON petrol may slow the uptake of more fuel-efficient, high-compression engine technology, as vehicle manufacturers will continue to supply vehicles capable of using 91 RON petrol.

---

* As noted in Chapter 4, while Option D was assessed as part of the economic analysis by Marsden Jacob, it has not been considered further in this draft RIS.

† NPV is the present value (PV) of economic benefits delivered by the option, less the PV of economic costs incurred. A positive NPV indicates that the benefits outweigh the costs.

‡ The BCR is calculated by dividing the present value of benefits by the present value of costs. A BCR value greater than 1 indicates that the benefits outweigh the costs.

- Under Option F:
  - The broader community is the major beneficiary, with health costs reduced by about $323 million in 2022, increasing to about $340 million in 2030 and $362 million in 2040
  - The price impact is low compared to other options—estimated at up to 1.0 cpl for all grades of petrol, with additional costs associated with upgrading infrastructure in Australia equivalent to approximately 1.0 cpl across all grades of petrol after the introduction of improved fuel quality standards
  - Any increases to fuel prices are similar in metropolitan and regional areas
  - Capital and operating costs for refineries (between $1.16 billion* and $1.79† billion in present value terms) are lower than under Option C (between $1.45 billion and $2.23 billion), and substantially lower than under Option B (between $2.24 billion and $3.57 billion). As with Option C, only some of these cost increases can be passed on to motorists. Lower costs for refineries increase the prospect of retaining domestic refining capacity
  - The retention of high aromatics in petrol will result in higher particulate emissions than options B and C and may also result in higher fuel consumption in some vehicle types relative to options B and C
  - As with Option C, the retention of 91 RON petrol may slow the uptake of more fuel-efficient high-compression engine technology.
- A number of likely benefits could not be quantified in the analysis. If these benefits could be quantified, the NPVs of options B, C and F would probably be greater than presented in this draft RIS.

* 2027 implementation
† 2022 implementation

5.1. Cost-benefit analysis

The CBA assessed the economic costs and benefits of each of the reform options compared to the business as usual case. The results of the CBA are presented as NPVs and BCRs for each of the options. Costs and benefits were assessed for a 24-year timeframe, 2017 to 2040, with implementation dates ranging from 2022 to 2027. A real discount rate* of 7 per cent† was applied to future costs and benefits. All values are expressed in 2016 dollars.

This analysis has assumed that refineries will remain open and continue to be viable. If refinery operators choose to close, the results of the analysis are likely to be different from those detailed below.

5.1.1. CBA results overview

The main results of the CBA are as follows:

- Option B has a negative NPV, ranging from –$718 million (2022) to –$607 million (2027), meaning that if it is implemented it is unlikely to deliver a net benefit to the community compared with the base case of no changes to fuel standards.
- Option C has a positive NPV, ranging from $641 million (in 2022) to $319 million (2027). If implemented, this option will deliver a return of $1.18 to $1.24 for every $1 of cost.
- Option F has a positive NPV, ranging from $628 million (2022) to $317 million (2027).
- The modest outcome for Option B relative to options C and F reflects significantly greater fuel cost increases linked to a shift in consumption from 91 RON petrol to 95 RON or 98 RON petrol. This cost increase is only partly offset by reductions in fuel consumption and greenhouse gas emissions linked to fuel-efficiency gains.
- Similar outcomes for options C and F reflect lower costs of producing fuel under Option F compared to Option C, but greater health benefits under Option C compared to Option F.

NPV and BCR results are summarised in Table 5. Costs and benefits for a selection of implementation dates are presented in Table 6. Detailed results from the CBA[64] are presented in Appendix D.

Table 5. NPV 2017–2040 ($million) and BCR for implementation in 2022, 2025, 2027

Present value of costs and benefits relative to BaU (Option A)				
Implementation date	Quantity	2022	2025	2027
Option B	NPV	–$718	–$651	–$607
	BCR	0.87	0.84	0.82
Option C	NPV	$641	$437	$319
	BCR	1.24	1.21	1.18
Option F	NPV	$628	$429	$317
	BCR	1.29	1.25	1.22

* The rate that converts future values into present values. The discount rate is in effect an 'exchange rate' between value today and value in the future. The Office of Best Practice Regulation (OBPR) suggests the calculation of net present value at an annual real discount rate of 7 per cent.

† A discount rate of 7 per cent is specified by the OBPR in its cost-benefit analysis guidance note, February 2016 pmc.gov.au/resource-centre/regulation/cost-benefit-analysis-guidance-note

5.1.2. Major factors influencing CBA results

5.1.2.1. Refinery capital and operating costs

An increase in the cost of producing and importing fuel is the main factor driving costs under each of the reform options, and differences in fuel costs between the options is the key factor explaining the relative performance of the options (see Figure 10).

Figure 10. Additional costs of producing and importing fuel under each option, expressed as $million (2025 implementation date)

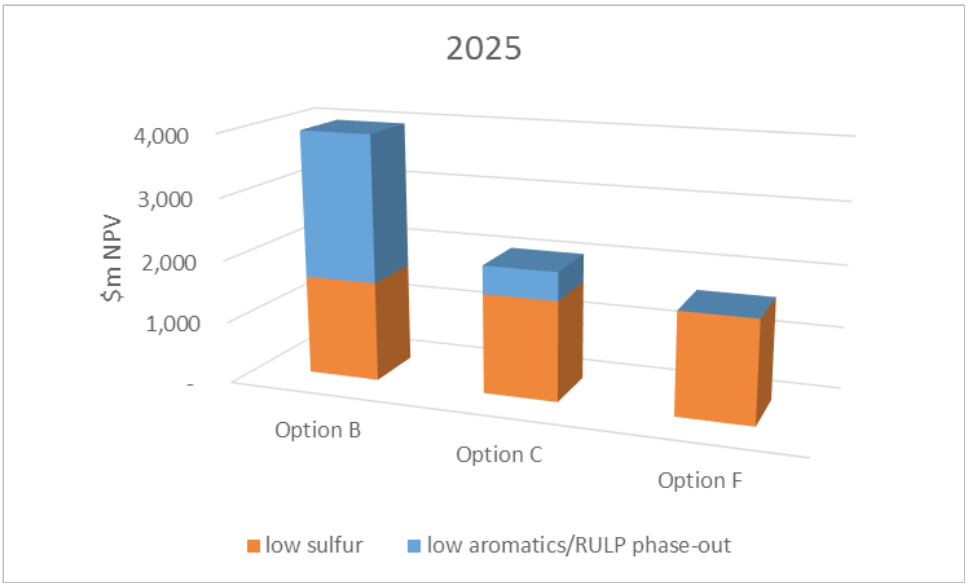


Table 6. CBA results summary for Options B, C and F
Implementation date 2022

	Present value of costs and benefits relative to BaU ($ million)		
	Option B	Option C	Option F
Costs			
Refinery capital costs	–$786.5	–$786.5	–$746.9
Refinery operating costs	–$2,785.5	–$1,444.8	–$1,042.5
Fuel price impacts—imported fuel (91 RON phase-out)	–$1,246.3	$0.0	$0.0
Fuel price impacts—imported fuel (revised fuel standards)	–$420.8	–$411.2	–$319.5
Fuel price impacts—wholesale and retail margins (foreign companies)	–$168.5	$0.0	$0.0
Fuel demand impacts (increased fuel prices)	–$33.0	–$3.1	–$2.3
Increased GHG emissions (refinery upgrades)	–$84.2	–$66.7	–$66.7
Industry compliance (revised standards)	–$6.3	–$6.3	–$4.3
Company tax impact (demand changes, foreign entities)	-$3.4	-$1.5	-$1.2
Government administration costs	$1.4	$0.0	$0.0
Total costs	**–$5,533.2**	**–$2,720.1**	**–$2,183.4**
Benefits / avoided costs			
Avoided health impacts	$2,850.4	$3,070.1	$2,664.3
Reduced fuel consumption (phase-out of 91 RON)	$1,468.0	$0.0	$0.0
Reduced GHG emissions (phase-out of 91 RON)	$129.7	$0.0	$0.0
Reduced particle filter failure (lower aromatics)	$143.9	$143.9	$0.0
Reduced catalyst failure (ultralow sulfur)	$147.0	$147.0	$147.0
Impacts of price changes on retailer producer surplus	$75.9	$0.0	$0.0
Total benefits / avoided costs	**$4,815.0**	**$3,361.0**	**$2,811.3**
NPV 2017–2040	**–$718.1**	**$640.9**	**$627.9**
BCR	**0.87**	**1.24**	**1.29**

Implementation date 2025

	Present value of costs and benefits relative to BaU ($ million)		
Costs	Option B	Option C	Option F
Refinery capital costs	–$642.1	–$642.1	–$609.7
Refinery operating costs	–$2,078.2	–$1,087.3	–$777.8
Fuel price impact—imported fuel (91 RON phase-out)	–$914.7	$0.0	$0.0
Fuel price impacts—imported fuel (revised fuel standards)	–$330.4	–$326.1	–$254.6
Fuel price impacts—wholesale and retail margins (foreign companies)	–$77.9	$0.0	$0.0
Fuel demand impacts (increased fuel prices)	–$19.3	–$2.2	–$1.6
Increased GHG emissions (refinery upgrades)	–$62.9	–$49.8	–$49.8
Industry compliance (revised standards)	–$5.3	–$5.3	–$3.6
Company tax impact (demand changes, foreign entities)	-$2.3	-$1.1	-$0.8
Government administration costs	$1.1	$0.0	$0.0
Total costs	–$4,132.0	–$2,113.8	–$1,698.0
Benefits / avoided costs			
Avoided health impacts	$2,142.4	$2,322.0	$2,014.0
Reduced fuel consumption (phase-out of 91 RON)	$995.1	$0.0	$0.0
Reduced GHG emissions (phase-out of 91 RON)	$85.1	$0.0	$0.0
Reduced particle filter failure (lower aromatics)	$115.8	$115.8	$0.0
Reduced catalyst failure (ultra-low sulfur)	$112.6	$112.6	$112.6
Impacts of price changes on retailer producer surplus	$29.5	$0.0	$0.0
Total benefits / avoided costs	**$3480.5**	**$2,550.4**	**$2,126.6**
NPV	**–$651.4**	**$436.6**	**$428.7**
BCR	**0.84**	**1.21**	**1.25**

Implementation date 2027

	Present value of costs and benefits relative to BaU ($ million)		
	Option B	Option C	Option F
Costs			
Refinery capital costs	–$560.8	–$560.8	–$532.5
Refinery operating costs	–$1,680.5	–$886.3	–$629.0
Fuel price impacts—imported fuel (91 RON phase-out)	–$728.2	$0.0	$0.0
Fuel price impacts—imported fuel (revised fuel standards)	–$271.6	–$269.7	–$210.9
Fuel price impacts—wholesale and retail margins (foreign companies)	–$30.6	$0.0	$0.0
Fuel demand impacts (increased fuel prices)	–$13.2	–$1.7	–$1.2
Increased GHG emissions (refinery upgrades)	–$50.8	–$40.3	–$40.3
Industry compliance (revised standards)	–$4.7	–$4.7	–$3.2
Company tax impact (demand changes, foreign entities)	-$1.8	-$0.9	-$0.7
Government administration costs	$0.9	$0.0	$0.0
Total costs	–$3,341.2	–$1,764.3	–$1,417.7
Benefits / avoided costs			
Avoided health impacts	$1,735.3	$1,894.0	$1,642.2
Reduced fuel consumption (phase-out of 91 RON)	$741.7	$0.0	$0.0
Reduced GHG emissions (phase-out of 91 RON)	$62.3	$0.0	$0.0
Reduced particle filter failure (lower aromatics)	$97.1	$97.1	$0.0
Reduced catalyst failure (ultra-low sulfur)	$92.5	$92.5	$92.5
Impacts of price changes on retailer producer surplus	$5.3	$0.0	$0.0
Total benefits / avoided costs	**$2,734.2**	**$2,083.6**	**$1,734.7**
NPV	**–$607.0**	**$319.3**	**$317.0**
BCR	**0.82**	**1.18**	**1.22**

Costs associated with producing low-sulfur fuel

All reform options require capital investment by the refineries to produce low-sulfur fuel. The capital cost for this is estimated to be a total of $979 million* across the four refineries.

As well as capital investment, the production of low-sulfur fuels requires additional operating costs in the form of energy and chemicals (such as hydrogen). These additional operating costs are estimated to be about $132 million per year, which equates to approximately 1.1 cpl.

Costs associated with producing low-aromatics fuel

All the reform options, except for Option F, require capital investment to reduce the quantity of aromatics in fuel from a limit of 45 per cent to a revised maximum limit of 35 per cent. The reduction in aromatics would require a capital investment at all of the refineries, which is estimated to cost $52 million†.

Lowering aromatics in petrol is anticipated to add to the operating cost of producing of 95 RON and 98 RON petrol. No additional cost is expected for production of 91 RON petrol because it already generally meets the proposed 35 per cent aromatics limit. Under Option C (which does not entail a phase-out of 91 RON petrol), the cost is estimated to be approximately $46 million per annum in 2022, equivalent to about 1.3 cpl. This increases over time to about $73 million in 2040 as the production of 95 RON and 98 RON petrol increases. As Option B includes the phase out of 91 RON petrol, the total cost of changing the specification for aromatics is higher and is estimated at about $221 million per annum, equivalent to about 1.9 cpl.

5.1.2.2. Fuel price impacts of imported fuel

There is expected to be a minimal impact on fuel prices, which were carefully examined in considering options for improving fuel quality in Australia. These are summarised in Table 7. The analysis assumes that Australian refineries will continue to operate under the base case and the reform options.

While Australian refineries produce a significant proportion of Australia's fuel requirement, Australia is a net importer of fuel. Estimated import parity price (IPP) increases for imported fuel under the reform options are outlined below.

Price impacts of low-sulfur fuel

A move to low-sulfur petrol under options B, C or F is estimated to result in petrol price increases of approximately 0.6 cpl in 2022, 0.9 cpl by 2027 and 1.0 cpl on implementation, relative to the business as usual case (Option A). The increase in price over time reflects an expected change in the demand–supply balance for low-sulfur fuel in international markets.

Price impacts of low–aromatics fuel and phase-out of 91 RON fuel

The move to low-aromatics petrol under Option C is estimated to lead to an increase in the IPP of 95 RON and 98 RON petrol of approximately 0.3 cpl. There is unlikely to be any additional cost for the IPP of 91 RON petrol, since imported 91 RON petrol already meets the 35 per cent aromatics limit.

---

* Australian Institute of Petroleum. 2017 dollars.

† As described in Marsden Jacob 2017

The increase in the IPP price from phasing out 91 RON and using 95 RON or 98 RON petrol under Option B is likely to be more substantial, amounting to an additional 2.3 cpl.

Overall, the expected cost increases to motorists resulting from low-sulfur, low-aromatics petrol would be the same as those discussed for imported fuel.

5.1.2.3. Health impacts

The major benefit stemming from fuel quality changes under options B, C and F is improvements to health and environmental outcomes for the Australian community.

Under business as usual, annual health costs in Australian cities associated with air pollution from motor vehicle emissions are estimated to be approximately $3.9 billion per annum in 2020, changing only slightly over the period of the analysis. Costs include:

- premature deaths from respiratory and cardiovascular illnesses and lung cancer, associated with long-term exposure to air pollution
- premature deaths from respiratory and cardiovascular illnesses, associated with acute exposure to air pollution
- hospital admissions
- emergency department admissions (especially due to asthma attacks)
- reduced quality of life associated with illnesses.

Table 7. Overview of additional costs of producing and importing fuel, relative to BaU, and price impacts on motorists (cpl) following improvements to fuel quality standards[*]

	Cost of producing fuel (operating)			Cost of importing fuel			Price impact on motorists			Relevant option
Fuel parameter	**91 RON**	**95/98 RON**	**Diesel**	**91 RON**	**95/98 RON**	**Diesel**	**91 RON**	**95/98 RON**	**Diesel**	
Sulfur 10 ppm	1.1	1.1	–	0.6–1.0	0.6–1.0	–	0.6–1.0	0.6–1.0	–	B, C, F
Aromatics 35% / 91 RON phase-out	–	1.9	–	–	2.3	–	–	2.3	–	B
Aromatics 35%	–	1.3	–	–	0.3	–	–	0.3	–	C
PAHs 8%	–	–	–	–	–	–	–	–	–	B, C
Cetane (derived cetane number = 51)	–	–	–	–	–	–	–	–	–	B, C
Australian refinery upgrade—capital costs										
Fuel parameter	**91 RON**	**95/98 RON**	**Diesel**	**91 RON**	**95/98 RON**	**Diesel**	**91 RON**	**95/98 RON**	**Diesel**	
Capital cost[†]	1.0	1.0	–	N/A	N/A	N/A	1.0	1.0	–	B, C, F

* Ranges indicate change in costs/prices over time.

† Cost recovery for infrastructure upgrades to produce better quality fuel at Australian refineries. This cost is expected to dissipate five to ten years after policy implementation. Costs are estimated at one to two refinery operating cycles (five to ten years), eight years used in the price impact calculation.

Under business as usual, heath costs remain constant over the period of the analysis, despite significant reductions in emissions of the main pollutants over that time. This is because:

- the numbers of people being exposed to the pollution increase over time as populations and population densities in our cities increase
- some of the health impacts of pollution are associated with long-term exposure to pollution, and changes in air quality can take time to take effect.

Implementing options B, C or F would result in reductions to health impacts and associated costs relative to business as usual. Estimates of annual health costs under each of the options are shown below in Figure 11, and represent the span of implementation dates from 2022–2027.

Figure 11 provides a breakdown of total avoided health costs under each of the options over the period 2020–2040. Reducing sulfur is the major factor driving avoided health impacts under options B, C and F, being responsible in options B and C for 97 and 89 per cent respectively of avoided health costs, and 100 per cent of avoided health costs in Option F.

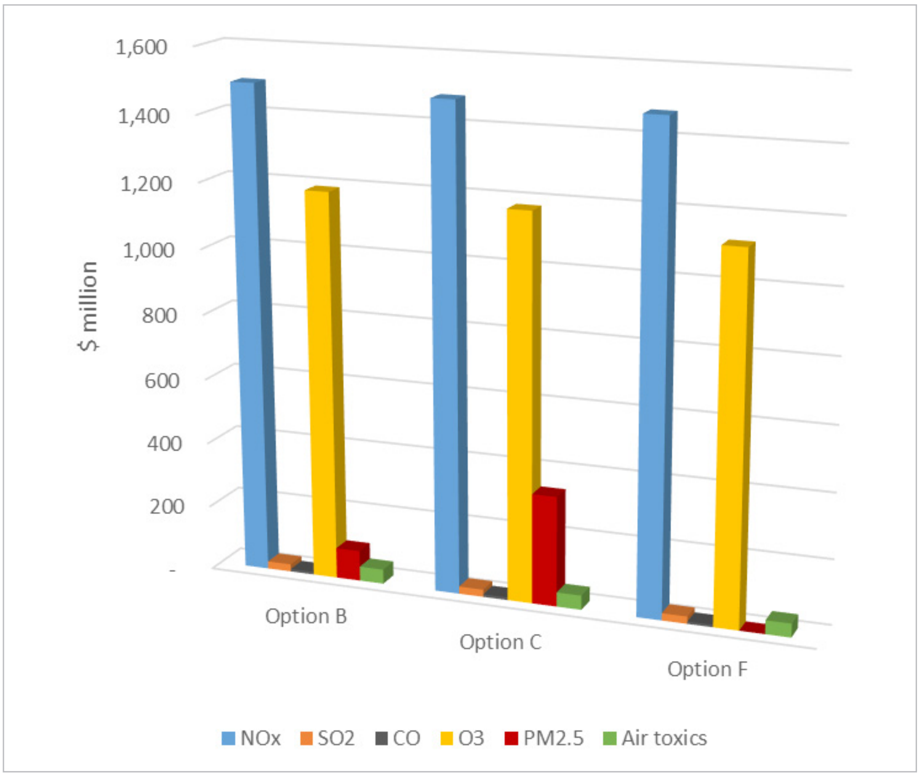
Reducing the regulated limit of sulfur in petrol under options B, C and F is expected to lead to significant reductions in NOx, VOC and CO emissions from motor vehicles. The reduction in NOx emissions is estimated to be approximately 22 per cent in 2022, increasing to about 29 per cent by 2030, with all reductions in emissions coming from petrol vehicles. The greater reduction over time reflects a number of factors including a greater proportion of Euro 5 and Euro 6 compliant vehicles in the fleet, with emissions from these vehicles being more sensitive to fuel sulfur and ageing of catalysts over time. VOC emissions are projected to decrease by approximately 18 per cent in 2022 and 15 per cent in 2030. VOC emissions, along with NOx emissions, are the major pollutants contributing to ozone formation.

Reducing the regulated limit of aromatics is expected to lead to a small reduction in $PM_{2.5}$ emissions under Option C, but no reduction in $PM_{2.5}$ emissions under Options B or F. Under Option C, the projected reduction in $PM_{2.5}$ emissions is about 1.7 per cent in 2022, increasing to 2.0 per cent in 2030*.

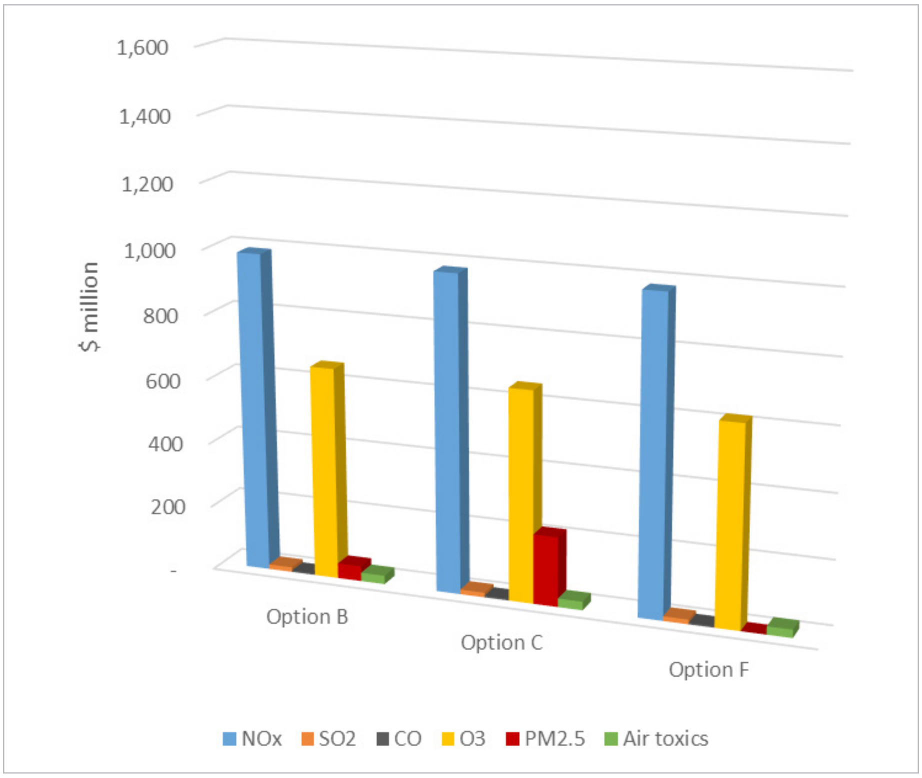
* The pool average aromatics level under Option C is estimated to be about 26 per cent, compared with 28 per cent under BaU (Option A).

Figure 11. Breakdown of avoided health costs, by pollutant, 2020–2040, at NPV (with implementation dates of 2022 and 2027)

2022



2027



5.1.3. CBA sensitivity analysis

This CBA, as with all such analyses, is necessarily based on a series of assumptions, meaning there is a degree of uncertainty around the results. Sensitivity testing was undertaken to clarify which assumptions can materially change the results, including on the following inputs:

- discount rates
- implementation timing
- changes to key costs and benefits that result in 'high', 'central', and 'low' scenarios from a combination of changes to:
  - fuel price impact of changes to the various fuel specifications
  - the social cost of carbon
  - the economic costs of health impacts
  - fuel consumption reductions achieved through switching to 95 or 98 RON petrol.
- an alternative approach to calculating health impacts
- whether the levels of sulfur and aromatics in petrol are at the regulated limits.

Summarised NPV results from the sensitivity analysis are outlined in Table 8. The values under different implementation dates are shown and, where relevant, the central case is indicated.

Table 8. Results of sensitivity analysis, $million NPV*

	Option B		Option C		Option F	
Implementation timing						
2022	–718		641		628	
2025	–651		437		429	
2027	–607		319		317	
Discount rates	**2022**	**2027**	**2022**	**2027**	**2022**	**2027**
3%	–444	-731	1,409	821	1,375	811
7% (central)	–718	-607	641	319	628	317
10%	–768	-504	324	138	320	139
Key cost benefit assumptions	**2022**	**2027**	**2022**	**2027**	**2022**	**2027**
Low benefit/ high cost values	–2294	–1525	–627	–497	–407	–334
Central values (central)	–718	–607	641	319	628	317
High benefit/ low cost values	716	–218	1,723	993	1,554	894
Health impacts estimation approach	**2022**	**2027**	**2022**	**2027**	**2022**	**2027**
Impact pathways approach (central)	–718	–607	641	319	628	317
Damage cost assessment approach†	–683	–454	521	390	591	439
BaU (Option A) set at regulated limits	**2022**	**2027**	**2022**	**2027**	**2022**	**2027**
Regulated sulfur (91 RON-150 ppm, 95 RON-50 ppm)	2702	1379	4061	2306	4048	2305
Regulated aromatics (42% pool average)	738	156	2,097	1,083	628	317

* Low and high ranges of values reflect differences in timing.
† The damage cost approach applies a dollar value per tonne of pollutant

Under sensitivity testing, Option C retains the highest NPV under nearly all scenarios. Options C and F have positive NPVs under most scenarios. One exception is when the low benefit / high cost scenario is applied. Option B has negative NPVs under nearly all scenarios except when the high benefit / low cost scenario is applied.

5.2. Cost-effectiveness analysis

A cost-effectiveness analysis (CEA) generally examines the unit cost of achieving a given benefit, with the benefits quantified in non-monetary terms. CEA is a useful alternative means of assessing and ranking options, especially if benefits are difficult to quantify in monetary terms or if monetary valuation of benefits is contested. For the CEA in this study we focused on the primary objective of fuel quality standards as the basis of the CEA: avoided health impacts, specifically avoided premature deaths. Under Option A, average annual premature deaths due to air pollution from motor vehicles are estimated to be 781. Under options B, C and F, avoided premature deaths range from an average of 72 each year (Option F) to 82 each year (Option C).

The CEA considered the unit cost of avoided premature deaths from changes in the fuel quality standards. Table 9 presents results of the CEA using two methods:

- Under the first method, future costs are discounted but future avoided deaths are not.
- Under the second method, referred to as 'levelised cost' basis, both future costs and future avoided deaths are discounted on an equal basis.

The two methods reflect different judgements about the value placed on future life compared to life now. Either way, the results can be thought of as the cost of saving a life.

Under both methods, Option F is the most cost-effective, followed quite closely by Option C, then Option B.

Table 9. Cost-effectiveness analysis results (based on avoided premature deaths)

	Total premature deaths (2022-2040)	Average deaths/year (2022-2040)	Avoided premature deaths (2022-2040)	Avoided premature deaths/year	$/avoided death	
					(non discounted)	(discounted)
Option A	14,833	781				
Option B	13,361	703	1,471	77	3,760,355	10,549,225
Option C	13,273	699	1,559	82	1,744,284	4,885,017
Option F	13,467	709	1,366	72		

5.3. Distributional impact analysis

Distributional impact assessment has been undertaken because neither the financial nor the economic analysis provides direct information on the distribution of costs and benefits. The distributional impact assessment draws on information from the CBA modelling to assess the impacts of the proposed options on different stakeholder groups.

5.3.1. Stakeholder group impacts

The distributional analysis focuses on several stakeholder groups:

- motorists
- community
- environment
- government
- petroleum industry.

Results of the distributional analysis are presented in Table 10, and represent the span of implementation dates from 2022–2027.

Table 10. Distributional impacts of options on stakeholder groups (NPV 2017 $millions)

2022

Distribution of costs and benefits relative to BaU			
	Option B	Option C	Option F
Motorists	–$2042.9	–$1718.1	–$1660.3
Community	$2850.4	$3,070.1	$2664.3
Environment	$45.5	-$66.7	-$66.7
Government	$288.6	$126.9	$108.6
Petroleum industry	–$1859.7	–$771.2	–$417.9
NPV	–$718.1	$640.9	$627.9

2027

Distribution of costs and benefits relative to BaU			
	Option B	Option C	Option F
Motorists	–$1254.8	–$1067.1	–$1035.1
Community	$1735.3	$1894.0	$1642.2
Environment	$11.5	-$40.3	-$40.3
Government	$158.8	$74.5	$62.8
Petroleum industry	–$1257.9	–$541.8	–$312.7
NPV	–$607.0	$319.3	$317.0

While it is recognised that fuel prices are higher in regional areas than metropolitan areas, the proposed reforms do not appear to have an impact on distribution costs to regional areas or on the competition between petrol stations in regional areas. Therefore the results in Table 10 apply equally to regional and metropolitan areas. While regional fuel cost increases will be comparable to those in metropolitan areas, the impacts on regional Australia may differ. Impacts on regional Australia are discussed separately below.

The results of the distributional analysis are:

- Motorists would bear a proportion of the costs associated with implementing the options and the broader community would be the major beneficiary of implementing any of the options due to reduced health impacts.
- The petroleum industry would bear substantial net costs, with increased margins for wholesalers being more than offset by the cost to refineries of meeting the revised standards. If Australian refineries are to remain competitive with fuel importers, it is unlikely that the full amount of these costs would be passed on to motorists, since the cost to the refineries of meeting the revised standards is likely to exceed the cost impact of revised standards on imported fuel, notionally reflected in the IPP.

5.3.2. Impacts on regional Australia

The distributional analysis considered the impacts the proposed reforms would have on regional Australia and regional customers.

The analysis considered whether the reforms would result in residents living in regional areas being disadvantaged, compared to those living in urban areas. The finding was inconclusive. BITRE analysis shows that regional households spend on average six per cent more on motor vehicle fuel per week compared with capital city households. There are several factors that contribute to this higher weekly spend, including higher fuel prices in regional areas, higher vehicle kilometres travelled and more fuel intensive vehicles. Data suggests that households in regional areas drive nine per cent further each week than households in capital cities (44.5 km a week compared to 40.9 km a week)[65], however, the most recent available ABS data (2011) suggests that households in capital cities spend more per week on transport* ($194.44) than households in regional areas ($190.10). The higher capital city transport expenditure may reflect that fact that driving in cities is less fuel efficient than in regional areas due to greater traffic congestion. The same ABS data also indicates that regional households spend a greater proportion of their weekly incomes on transport (17.2 per cent), than capital city households (14.8 per cent), probably reflecting lower average weekly incomes in regional areas. As findings are based on averages and so apply at a macro level, they may not necessarily be accurate for small communities or individuals.

The analysis also considered the regional distribution of health benefits. It is noted that the majority of health benefits will accrue in metropolitan and neighbouring areas. This geographic focus of the health benefits is because air pollution is most significantly impacted by motor vehicles in metropolitan and neighbouring areas.

The Australian Bureau of Statistics estimates that 71 per cent of the population resides in major cities and another 18 per cent in inner regional areas, meaning that around 89 per cent of the Australian population would potentially benefit directly from improved air quality. An improvement in air quality in metropolitan areas would either reduce total healthcare costs or allow resources to be diverted to alternative programs. In this manner, the improvement of air quality in metropolitan areas would benefit all Australians, even those living in remote locations. Accordingly, access to higher quality fuel, and therefore cost-saving technologies, is as appropriate to regional areas as it is to cities.

---

* Transport is defined as including, but not limited to public transport costs.

5.4. Alignment with other studies

As outlined in Chapter 1, the Department's review of fuel quality standards is being undertaken at the same time as two related reviews—*Vehicles emissions standards for cleaner air and Improving the efficiency of new light vehicles*—which are being undertaken by the Department of Infrastructure and Regional Development.

Like the review of fuel quality standards, both of these reviews consider measures that have the potential to reduce vehicle emissions and/or fuel consumption in vehicles in Australia.

As far as possible, analysis for this review was undertaken in a way that ensures consistency with the other reviews, including using the same base case assumptions where relevant. These assumptions include:

- Current and projected fuel consumption by light and heavy vehicles, and the split of fuel types, are essentially the same for all three studies.
- Current emissions standards (ADR 79/04 and ADR 80/03, equivalent to Euro 5/V) are assumed to be in place for light and heavy vehicles respectively for all three studies.
- Emission factors relating to fuel quality parameters, such as sulfur, that were applied in the United States Environmental Protection Agency (US EPA) MOVES model for the Vehicle emissions standards for cleaner air study, are also used in the COPERT Australia emissions modelling that is used in this study as the basis for the impact pathway method of assessing health impacts. The fuel quality emissions factors applied in the US EPA MOVES model are more up to date than those used in the COPERT Australia model. In other respects, however, the COPERT Australia model, which is specifically designed for Australian conditions, is more appropriate to use as the basis for estimating emissions in Australia.
  - The same base case emissions data modelled through the US EPA MOVES model for the Vehicle emissions standards for cleaner air study are used as the basis for estimating emission reductions in this study for the damage cost health impacts method.

This study assesses the costs and benefits of changes to fuel quality standards in isolation from changes to noxious emissions standards and fuel efficiency standards. If the three studies are read together, adjustments will need to be made, particularly relating to the assessed health impacts and fuel consumption benefits of the various reforms. The baseline used to model emission and fuel consumption reductions, linked to the introduction of revised fuel quality parameters, will need to be realigned. The realignment will have to account for emission reduction and fuel consumption reductions achieved through the introduction of revised fuel quality parameters in combination with introducing revised noxious emissions standards and fuel efficiency standards.

5.5. Regulatory burden measurement

An estimate of the regulatory burden of the proposed reform options on the private sector (businesses, community organisations and individuals) and those of government-owned corporations has been prepared in line with the Australian Government's *Regulatory burden measurement framework: guidance note*[66].

The regulatory burden values are provided as a simple average of changes in costs to the private sector over the first 10-year period, starting two years before the reform date, in 2016 values. They have been disaggregated by cost type:

- Administrative compliance costs—costs that are primarily driven by the need to demonstrate compliance with the reform such as annual reporting. They include signage and tank changeover at service stations. Some of these costs may be borne by consumers.
- Substantive compliance costs—costs that are directly attributable to reform and are outside the usual business costs. They may include the capital costs of plant upgrades as well as operational costs from process changes or additional staff training.

- Delay costs—costs relating to the time taken to prepare applications (application delay) and the time taken for approval (approval delay). Estimating the cost savings relating to removing delays requires a strong understanding of the realistically achievable timeframes, the likely delays that could be avoided, and the value (potential cost) of any avoidable delay.

The regulatory burden analysis aligns with the 'most likely' outcome analysis of industry impacts and so does not include costs that are only identified under the 'best' or 'worst' case outcomes.

Regulatory burden costs and offsets were identified for two key groups—the refining sector; and customers (both businesses and individuals) buying petrol, typically at a petrol station.

The regulatory burden estimates for the reform options are summarised in Table 11. The lowest regulatory burden is for Option F, followed by Option C.

The regulatory burden changes slightly depending on the timing of implementation of the reforms. These changes are due to factors such as the modelled change in total fuel demand, which alters over time. However, the changes in burden are relatively minor (1 per cent to 4 per cent) and do not alter the relative rankings of the options. The values provided in the table are for a 2025 commencement and consider the years 2023 to 2032—however, they are indicative of regulatory burden values for any commencement date between 2022 and 2027.

Table 11. Regulatory burden estimate summary

Change in costs	Option A ($million/year)	Option B ($million/year)	Option C ($million/year)	Option F ($million/year)
Refining sector	$ 0	$407	$265	$223
Customers	$ 0	$562	$234	$202
Total	**$ 0**	**$969**	**$500**	**$425**

5.6. Methods and assumptions

5.6.1. Sources

The analysis has drawn on a number of information sources. In addition to literature reviews relating to major costs and benefits assessed in the analysis, the project team drew on inputs from the following key sources:

- Specialist consultant inputs. Three consultants were engaged for the project to undertake specialist analysis:
  - FuelTrac, and Hale and Twomey were engaged to assess the impacts of proposed options on refinery viability and fuel prices
  - Pacific Environment Limited was engaged to undertake noxious emissions modelling of the proposed options. Results of the modelling were in turn used to assess avoided health costs under each of the options
- Discussions with key stakeholder groups.

5.6.2. Assumptions

Where necessary, the CBA made assumptions based on the best available evidence collected from a wide range of published sources, expert advice, and stakeholder feedback. Two key assumptions are discussed below.

5.6.2.1. Sulfur and aromatics levels used in the analysis

As noted earlier in this draft RIS, the average concentration of sulfur in petrol is substantially lower than the regulated limits of 150 ppm in 91 RON, and 50 ppm in 95 or 98 RON. To provide a more accurate estimate of the costs and benefits under Option A, for comparison against the reform options, the CBA adopted the average sulfur levels in petrol provided by the Australian Institute of Petroleum (Table 12). These figures are based on the measured concentrations of fuel batches sold into fuel markets in Australian capital cities over a three year period 2014-2016. Based on this data, estimates of the average sulfur in Australia were based on projected proportions of 91 RON and 95/98 RON petrol in future years. These projections provide weighted average sulfur content in petrol of 46.3 in 2020 and 43.6 in 2030.

Table 12. Average sulfur concentrations in petrol used as basis for Option A (ppm)

	91 RON	95/98 RON	All petrol
2014	54	26	45
2015	63	28	52
2016	61	26	49
3 year average	59.3	26.7	48.6

Under options B, C and F, the regulated limit of sulfur is assumed to reduce to 10 ppm, with a pool average (average of all petrol produced) of 5 ppm.

Similarly, the average concentration of aromatics in petrol is significantly lower than the regulated limit of 45 per cent (pool average 42 per cent). Available data from fuel sampling undertaken by the Department indicates that the pool average aromatics level in petrol is probably around 27.3 per cent at present, with 91 RON petrol having an average of about 24 per cent and 95 RON petrol having an average of about 29 per cent and 98 RON petrol having an average of about 36 per cent. Based on projected future consumption of 91, 95 and 98 RON petrol, the pool average under BaU is projected to be 27.6 per cent in 2020 and 28.5 per cent in 2030.

Under Option C, with a regulated limit of 35 per cent, the pool average aromatics level is estimated to reduce to 25.9 per cent in 2020 and 26.4 per cent in 2030. Under Option B, with all petrol being 95 or 98 RON, the pool average will be higher.

5.6.3. Limitations

5.6.3.1. Data uncertainties

Assessed costs and benefits of options are dependent on the data assumptions that underpin key cost and benefit variables. Although considerable background analysis (including stakeholder consultation) has gone into assigning suitable values to the variables, in practice there are still uncertainties around the estimated values for a number of variables.

Therefore, where data assumptions have the potential to significantly affect outcomes of the analysis, we have tested the effect of changing these assumptions through sensitivity analysis. Sensitivity analysis has been conducted by using scenarios that involve changes to a number of key assumptions and applying the changes across all options to test the impact of changes on the net benefit or cost of the options.

Results of the CBA were also tested through sensitivity analyses of alternative discount rates (3 per cent and 10 per cent), different implementation timeframes, and alternative methods of assessing avoided health impacts.

5.6.3.2. Unquantified benefits

Not all potential benefits of implementing options are directly or fully reflected in market prices. It is therefore difficult to quantify those benefits in dollar values or estimate their worth in a way that provides a true reflection of their economic value. In other cases, the full impacts of implementing a policy alternative can be difficult to quantify.

Potential non-market benefits of options relative to the base case that have not been valued in this analysis include:

- some of the long-term health benefits associated with reducing tailpipe noxious emissions, particularly in relation to some cancers associated with ultrafine particulate emissions ($<PM_1$)
- productivity benefits of reduced illness and hospitalisation
- health benefits associated with reducing evaporative emissions from vehicles (such as when refilling at petrol stations)
- possible additional benefits of reducing sulfur on fuel consumption and vehicle operability
- possible additional benefits of reducing aromatics on fuel consumption and vehicle operability.

It is likely that if these benefits could be quantified the NPVs of options B, C and F would all be greater than currently presented in this report. It is also possible that if these benefits could be quantified the ranking of the options might change.

5.6.3.3. Unquantified policy options

The scope of the CBA was limited to assessment of net benefits and regulatory burdens associated with implementation of changes to sulfur, aromatics and octane in petrol and changes to cetane and PAHs in diesel in reform options B, C, and F*. Other changes proposed in this draft were not included in the CBA, primarily because the costs associated with them were considered relatively minor. If feedback from this draft RIS reveals that the unquantified proposals have substantial costs, the CBA would need to be revised before Government considered proceeding with the inclusion of those additional proposals.

The inclusions and exclusions from quantification in the CBA and regulatory burden estimate are presented in Table 13.

* Option D was also assessed as part of the CBA by Marsden Jacob, but is not considered further in this draft RIS

Table 13. Scope of CBA and regulatory burden measurement

	Option	B	C	F
INCLUDED IN CBA	RIS section			
Cost of low-sulfur petrol	5.1.2.2	✓	✓	✓
Cost of low-aromatic petrol	5.1.2.2	✓	✓	
Cost impact of phasing out 91 RON petrol	5.1.2.2	✓		
Cost of low-PAH and higher cetane diesel	5.1.2.3	✓	✓	
NOT COSTED IN CBA	RIS Section			
Consideration of an octane limit for 98 RON petrol	4.2.2.1	✓	✓	
Consideration of expanded scope of the automotive diesel to non-road uses	4.2.2.3	✓	✓	
Possible amendments to test methods in fuel standards	Appendix B	✓	✓	
Possible alignment of other fuel parameters with European standards	Appendix B	✓	✓	
Possible definition of renewable and synthetic diesel	4.2.2.4	✓	✓	
A new standard for B20 diesel-biodiesel blend	4.2.2.5	✓	✓	
Consideration of amendments to the fuel quality information standards	4.3	✓	✓	✓
Further evaluation and consideration of listing some fuel additives on the ***Register of Prohibited Fuel Additives***	4.4			

5.7. General conclusions

Of the options considered, implementation of Option C is likely to produce the greatest community net value. Option C is also a relatively cost-effective approach to reducing health impacts associated with the use of motor vehicle fuels. In terms of avoided health costs, Option C is likely to provide the best outcomes. Through the retention of 91 RON petrol, this option also retains current fuel choice, which some stakeholders advocated on the basis that continued availability of low-octane petrol might limit any price increases.

Option F has the lowest implementation costs for Australian refineries. This option also provides the most cost-effective approach to avoiding premature deaths associated with the use of motor vehicle fuels; however, health benefits under this option are lower due to the retention of a higher aromatics concentration in petrol. This option would only harmonise the petrol sulfur parameter with European standards.

While there are a number of benefits associated with Option B, the costs associated with the phase-out of 91 RON petrol outweigh the benefits, and it would have a net cost to the community.

Bringing forward implementation of either Option C or Option F could significantly increase the net benefits; however, this could increase the costs of implementation.

An assessment of the policy options against the policy assessment criteria outlined in Chapter 1 is presented in Table 14.

Table 14. Summary of the extent to which the policy options meet the policy assessment criteria*

Policy assessment criteria	B 10 ppm sulfur 95 RON 35% aromatics (Euro)	C 10 ppm sulfur 91 RON retained 35% aromatics (Euro)	F 10 ppm sulfur 91 RON retained 45% aromatics
1. Achieve appreciable health and environmental outcomes†	Yes $1.7 billion to $2.9 billion avoided health impacts Net decrease in GHG emissions: $12 million to $46 million	Partial $1.9 billion to $3.1 billion avoided health impacts Net increase in GHG emissions: $40 million to $67 million	Partial $1.6 billion to $2.7 billion avoided health impacts Net increase in GHG emissions: $40 million to $67 million
2. Ensure the most effective operation of engines	Yes Aligns with European standards	Yes Aligns with European standards	Partial Operability issues associated with aromatics
3. Facilitate adoption of better engine and emission control technology	Yes Aligns with European standards	Yes Aligns with European standards	Partial Low sulfur improves emissions
4. Achieve harmonisation with European standards, as appropriate	Yes Aligns with European standards	Yes Aligns with European standards	No Only change to sulfur, no other parameters
5. Minimise regulatory burden	No Regulatory burden $969 million	Partial Regulatory burden $500 million	Yes Regulatory burden $425 million
6. Maximise net national benefits	No NPV –$718 million to –$607 million	Yes NPV $319 million to $641 million	Partial NPV $317 million to $628 million
7. Overall	Net cost Very good health and operability outcomes, highest cost	Net benefit Very good health and operability outcomes, high cost	Net benefit Good health and operability outcomes, lower cost

* Note that the ranges relate to whether implementation begins in 2022 or 2027.

† Based on the avoided health cost estimates presented in Table 6 of this draft RIS.

6. Consultation

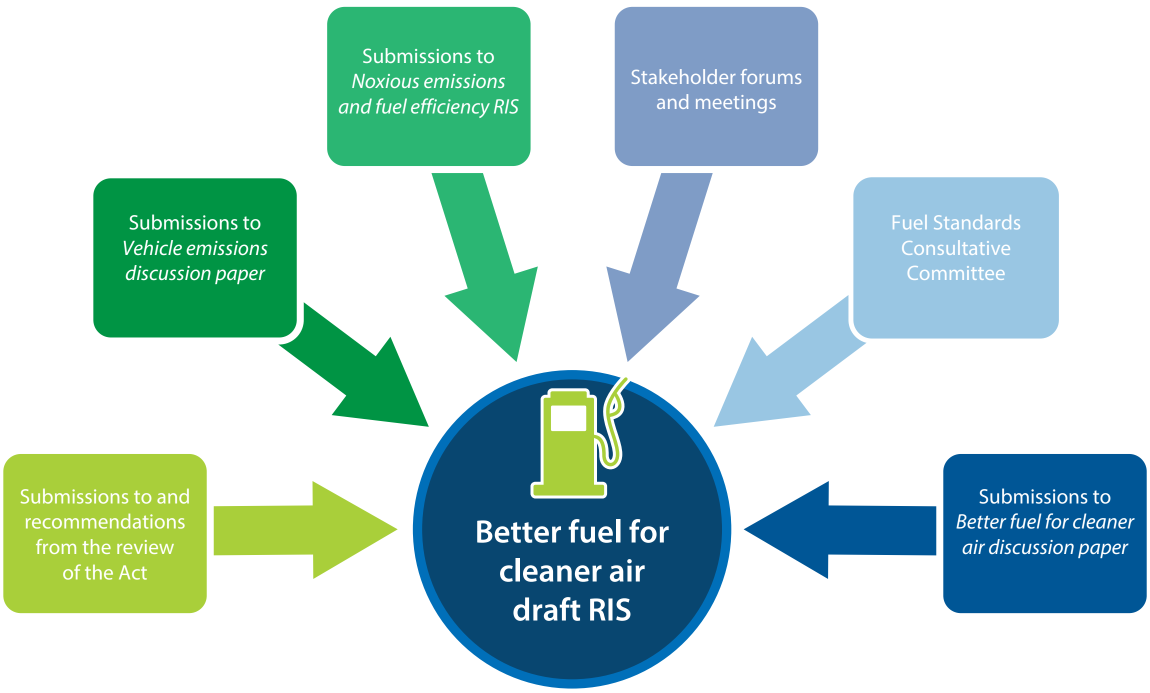
This chapter provides an overview of the consultation process and stakeholder views that have shaped the policy options in this draft RIS. Section 6.2 outlines future opportunities for stakeholders to provide input into this regulatory review of the legislative instruments under the Act.

This draft RIS has incorporated suggestions and addressed many concerns raised in stakeholder forums and submissions. Submissions are available on the Department's fuel quality webpage at environment.gov.au/protection/fuel-quality. The Department will update that site to keep stakeholders informed about the progress of the legislative instruments review program.

6.1. Results of consultation to date

This draft RIS has been informed by a range of consultation processes. The processes are outlined in Figure 12 and described in further detail below.

Figure 12. Consultation processes for this draft RIS



6.1.1. Review of the Fuel Quality Standards Act

Two rounds of stakeholder consultation (an issues paper in 2015 and a draft report in 2016) were undertaken during the review of the Act. In responding to the review, many stakeholders provided their perspectives on potential changes to the fuel standards, which are legislative instruments under the Act. It is important to note those processes because they informed and, to a large extent, provided the foundation for the changes proposed in options B, C and D. Views on fuel standards through these consultation processes included the following:

- The Federal Chamber of Automotive Industries and a range of other stakeholders argued that Australia should continue to align with international vehicle emissions and fuel standards, which are largely set in Europe and, to some extent, the USA.
- The Federal Chamber of Automotive Industries stated that meeting Euro 6 emissions standards will require maximum sulfur limits to be set at 10 ppm.
- The Australian Institute of Petroleum stated that it is not necessary for Australia to move from current standards for sulfur in unleaded petrol and premium unleaded petrol in order to achieve Euro 6 emissions standards.
- The Australian Automobile Association stated that the costs of motoring and the operability of vehicles are important factors in considering improving fuel standards.

The final report on the review of the Act, and submissions made to the review, are available at environment.gov.au/protection/fuel-quality/legislation/review-2015

6.1.2. Vehicle emissions discussion paper

In February 2016, the Ministerial Forum released the V*ehicle emissions discussion paper* seeking stakeholder views on possible measures to reduce vehicle emissions in Australia. Potential amendments to the fuel standards formed part of the proposed suite of measures. Eighty submissions were received from interested stakeholders, including vehicle manufacturers, fuel suppliers, transport operators, and consumer, health and environmental groups. Vehicle manufacturers, petroleum refiners and motoring consumer groups expressed views similar to those provided in response to the review of the Act. Health and environment stakeholders also pointed to the health impacts of noxious emissions and highlighted the need to improve health outcomes.

The *Vehicle emissions discussion paper* and stakeholder submissions are available at infrastructure.gov.au/roads/environment/index.aspx

6.1.3. Noxious emissions and fuel efficiency RIS

As part of the work of the Ministerial Forum, the Australian Government Department of Infrastructure and Regional Development released two related draft regulation impact statements in 2016: *Vehicle emissions for cleaner air and Improving the efficiency of new light vehicles*.

A number of stakeholders, including motor vehicle and component manufacturers and health advocates, noted that, due to the nature of the changes, they preferred the proposed reforms should be considered as a package and at the same time as amendments to the fuel standards.

These draft regulation impact statements are on the Department of Infrastructure and Regional Development website at infrastructure.gov.au/roads/environment/forum/. Stakeholder submissions are available at infrastructure.gov.au/roads/environment/forum/submissions-ris.aspx

6.1.4. Stakeholder forums

The Ministerial Forum held three face-to-face meetings with major stakeholders in Canberra to hear their views, facilitate discussion and identify opportunities for delivering beneficial outcomes. The forums, hosted by the Minister for the Environment and Energy and the Minister for Urban Infrastructure, were attended by a wide range of stakeholders.

Representatives from the Department of the Environment and Energy and the Department of Infrastructure and Regional Development also met with key stakeholders throughout the policy development process.

6.1.5. Fuel Standards Consultative Committee

The Act established the Fuel Standards Consultative Committee (the Committee) to provide advice on the setting of fuel quality standards and the *Register of Prohibited Fuel Additives*, among other matters. The Committee includes representatives from the Commonwealth, state and territory governments, fuel producers, the automotive industry, consumer groups and environmental groups. This membership ensures that the advice provided to the Government is comprehensive and reflects the broad range of stakeholder views.

As required under section 24A (1) of the Act, the Committee was consulted in the setting of the current fuel standards and their technical parameters, and as they have been amended.

In early 2017, the Department provided the Committee with an overview of the policy options explored in this draft RIS and the proposed scope and method of the cost-benefit analysis. Many Committee members, in their organisational capacities, provided submissions in response to the *Better fuel for cleaner air discussion paper*. The Committee will provide advice to the Minister on what changes, if any, should be made to the fuel quality standards.

6.1.6. Better fuel for cleaner air discussion paper

Taking into account feedback received from stakeholders on the review of the Act, the *Vehicle emissions discussion paper* and related RISs, and stakeholder meetings and forums, the Department released the *Better fuel for cleaner air discussion paper* in late 2016.

Many stakeholders who had provided submissions to the Vehicle emissions discussion paper and the review of the Act subsequently provided submissions on the Better fuel for cleaner air discussion paper. The positions of the key stakeholders did not differ from those stated in earlier rounds of consultation, except that the Australian Institute of Petroleum and member refineries proposed an alternative option (Option F), to supply 10 ppm sulfur to the Australian market by 2027.

A summary of stakeholder views is outlined at Appendix E. The discussion paper and stakeholder submissions are available at environment.gov.au/protection/fuel-quality

6.2. Current consultation

Submissions received in response to this draft RIS will guide the need for further consultation with major stakeholders on the main elements of the proposed policy options before the final policy decision. Key stakeholders include motorists and consumer groups, the Australian Institute of Petroleum and fuel suppliers, the Australian Automobile Association, the Federal Chamber of Automotive Industries, peak health advocacy groups, and state and territory governments. It is suggested that the interests of individuals and community organisations will be represented through discussions with these groups, and the results of previous public consultation will be re-examined for relevance.

Of particular focus will be the most significant amendments to the petrol standards contained in options B, C and F, as they apply to each stakeholder. This includes the proposed changes to sulfur, aromatics and octane levels.

Stakeholders' views on the results of the economic analysis and their feedback on the following aspects of the draft RIS will inform the following:

- whether it adequately captures and assesses the main costs and benefits
- how and when the policy options could be implemented
- whether the options are likely to achieve the proposed and desired health, environmental and technological outcomes.

Feedback will be incorporated into a revised draft RIS for consideration by the Government in 2018. The main elements of the policy options as costed in this draft RIS (contained in options B, C and F) will be considered as a package with the Department of Infrastructure and Regional Development's *Vehicle emissions standards for cleaner air and Improving the efficiency of new light vehicles* early assessment RISs. The remaining elements of the policy options*, along with the less significant amendments to existing standards, will be considered subsequently as an additional package. Views on those remaining elements are also sought during this consultation process.

* such as amendments to the information standards, new standards or significant changes in scope (such as for automotive diesel) and matters related to the register of prohibitive additives (refer to Table 13)

Appendix A. Fuel parameters of interest

Table A1. Summary of key fuel parameters and their issues

	Fuel type	Parameter	Issues (environmental, health, operability, harmonisation)
1	Petrol	Sulfur	• A natural component of crude oil that needs to be removed during the refining process • Poisons vehicle catalysts, in both old and new vehicles, limiting the ability of vehicle emissions systems to remove noxious and toxic substances from exhaust emissions and comply with emissions standards • Australia's high-sulfur petrol is an impediment to vehicle manufacturers importing vehicles with advanced technology (based on performance and emissions) • Need for increased regeneration frequency of poisoned catalysts results in higher fuel consumption, greenhouse gas emissions, noxious emissions and costs for consumers • Can block gasoline particulate filters used in some advanced technology vehicles • Can form sulfur dioxide and secondary particulate sulfates, which harm our health • The certification fuel for Euro 5/V and Euro 6/VI emissions standards specify 10 ppm petrol. As a result Australian Euro 5 and Euro 6 vehicles using higher sulfur fuels in service may produce higher emission levels on road • Australian petrol is ranked 70th in the world. Australian petrol quality based on sulfur does not align with European fuel quality standards, which are recognised as world's best practice
2	Petrol	Octane* (usually RON and/or MON)	• A measure of petrol's capacity to withstand compression before igniting. High-octane fuels are more efficient and have benefits in high-performance vehicles • Low-octane petrol (regular unleaded petrol, 91 RON) can cause engine 'knocking' and damage fuel-efficient high-compression engines • As 91 RON is the dominant petrol type consumed in Australia, the majority of vehicles imported to Australia are not optimised to run on high-octane petrol (e.g. 95 RON, 98 RON). This reduces fuel efficiency (up to six per cent), could increase consumer fuel costs, and results in the release of more noxious emissions and greenhouse gases per kilometre travelled than from vehicles optimised for high-octane petrol • Vehicles that are designed to operate on high-octane petrol (e.g. 95 RON, 98 RON) can be five per cent more energy efficient, and perhaps eight per cent if turbocharged, meaning similar reductions in greenhouse and noxious emissions • The removal of sulfur during the refining process decreases petrol's octane rating. Other means need to be found to increase octane to maintain high performance • The certification fuel for Euro 5 and Euro 6 emissions standards is minimum 95 RON petrol (also maximum 10 ppm sulfur and 35 per cent aromatics). Australian Euro 5 and Euro 6 vehicles using low-octane fuels in service might not meet vehicle emissions standards • The Australian petrol standard includes minimum octane limits for 91 RON and 95 RON petrol, but not 98 RON petrol • Australia's best-performing variants of top-selling vehicles use about three per cent more fuel than the equivalent model sold in the UK†

* Research octane number (RON) and motor octane number (MON) are two different measures of petrol's octane rating. The octane rating, or octane number, measures the extent to which a fuel can resist ignition under compression in a spark-ignition engine. Fuel with a higher octane number can be used in more efficient high-compression engines.

† Department of Infrastructure and Regional Development (2016). *Improving the efficiency of new light vehicles: draft regulation impact statement*, Canberra.

	Fuel type	Parameter	Issues (environmental, health, operability, harmonisation)
3	Petrol	Aromatic hydrocarbons (aromatics)	• Natural components of crude oil that contribute to petrol's octane rating • Can cause combustion chamber deposits in vehicle engines and increase tailpipe emissions • Some aromatics, including benzene, are carcinogenic and can increase carcinogenic emissions through incomplete combustion • Increase emissions of particulate matter (PM), which may be carcinogenic
4	Petrol	Ethers (including MTBE, DIPE, ETBE, FAME, GTBE)*	• Chemical compounds added to petrol, with high octane and good energy density • Some ethers, such as MTBE, are limited in Australian petrol. Even in small concentrations, MTBE is a groundwater contamination risk from leaking petrol storage tank discharge due to its taste, odour, persistence and mobility in water
5	Petrol	Ethanol	• A chemical compound added to petrol, with high octane (around 108 RON) • Typically blended with 91 RON petrol to produce 'E10' petrol, sometimes marketed as 94 RON petrol • Petrol blended with ethanol is currently less expensive than 91 RON fuel but has lower energy density. E10 fuel has an energy density about three per cent less than petrol, so it needs to be at least three per cent cheaper to be cost-effective for consumers • Can be a more sustainable petrol component, depending on the feedstock used to produce it • Some consumer aversion to ethanol-blended petrol due to perceived engine operability and fuelling frequency concerns
6	Petrol	Olefins	• Natural components of crude oil that can increase octane rating • Contribute to engine operability problems including combustion chamber deposits, which increase tailpipe emissions • Include 1,3-butadiene, a known human carcinogen • Contribute to formation of ozone
7	Petrol	Inorganic chloride	• Component of ethanol introduced during manufacture that can cause engine corrosion • Can be a natural component of ethanol feedstock but is more typically a by-product created during production • Limit needs to be updated to match the E85 limit to avoid engine corrosion and ensure consistency across standards
8	Petrol	Phosphorus	• Can clog vehicle catalytic converter systems and increase vehicle exhaust emissions
9	Petrol additive	Organometallic compound: tetraethyl lead	• Effectively banned, but still added to racing fuel and aviation gasoline to boost octane • Large body of evidence for adverse health effects and mental impairment • Contaminates catalytic converters, limiting their ability to process noxious emissions

* Methyl tertiary butyl ether (MTBE), diisopropyl ether (DIPE), ethyl tert-butyl ether (ETBE), fatty acid methyl ester (FAME), glycerol tertiary butyl ether (GTBE).

	Fuel type	Parameter	Issues (environmental, health, operability, harmonisation)
10	Petrol additive	Organometallic compound: MMT (methylcyclo-pentadienyl manganese tricarbonyl)	• Used as an octane enhancer • Vehicle manufacturers object to its use because it increases ash formation, which can adversely affect vehicle emission systems
11	Petrol additive	Organometallic compound: ferrocene	• Used as an octane enhancer • Decreases the insulation resistance of spark plugs, which can damage catalysts • Increases fuel consumption and emissions
12	Petrol additive	N-methylaniline (NMA)	• Used as an octane enhancer • Vehicle manufacturers object to its use because it increases ash formation, which can adversely affect vehicle emission systems • Toxic, and increases NOx emissions
13	Petrol additive	Chlorinated paraffins	• Toxic, persistent and bioaccumulative • Used in some aftermarket additives to improve performance and lubrication • May contribute to corrosion of engines over time
14	Diesel	Cetane, as measured by cetane index and derived cetane number	• A measure of the combustion speed of diesel. Higher cetane values are generally preferred to increase performance and reduce emissions, though specifics depend on types of vehicles and emissions • Australian diesel standard specifies a cetane index (46) that harmonises with European standards, but has not yet specified a derived cetane number for diesel not containing biodiesel (51 is required to harmonise with European standards) • Australian refiners have been given exemptions under section 13 of the Act to not meet this parameter of the diesel standard for some diesel types. As a result Australian diesel vehicles may produce higher emission levels on road
15	Diesel	Density	• Density that is too low can reduce fuel efficiency, but density that is too high can increase emissions, especially of PM
16	Diesel	Polycyclic aromatic hydrocarbons (PAHs)	• Natural components of crude oil • Cause engine operability problems including poor auto-ignition quality, increased thermal cracking, peak flame temperatures and delayed combustion processes • Many PAHs are known human carcinogens • Increase noxious tailpipe emissions of PM, NO_x, formaldehyde and acetaldehyde

Appendix B. Proposed parameter limits

This appendix details the possible suite of parameter limits for the proposed fuel standards.

The tables compare the limits for each fuel parameter under each option with Option A, which reflects the current parameter limits. Where a parameter is different from the current limit, it is shaded either pale or dark green, depending on whether the change is minor or major respectively.

Major changes are either significant numerical changes or new parameters. For example, under Option B in the petrol standard, significant numerical changes are being made to the aromatics, octane, inorganic chloride, sulfate and water parameters.

Minor revisions are those where the name of an existing parameter has changed slightly, where the unit of measurement has changed, or where the number of significant figures has increased. For example, in the petrol standard the benzene limit is currently 1 per cent. Under Options B and C a limit of 1.00 per cent is proposed, and this is shaded pale green, denoting what is anticipated to be a minor revision. In the petrol standard, under Option B, minor revisions are also proposed for the limits for ethanol, existent washed gum, lead, olefins, phosphorus and copper.

The tables also provide the source of each proposed change, shown as a footnoted reference. For example, most of the changes in Option B align with either the relevant EU fuel standard or recommendations in the Hart Report.

Test methods are also proposed for each parameter. Where these differ from those in the current standards, they have similarly been shaded.

Changes in units have been made to align with the respective test methods.

These changes are predicated on the principle of harmonisation with European standards and, with the exception of the parameters* associated with main elements of the proposed policy options, are not intended to result in demonstrable cost impacts.

Key to parameter tables

(pale green)	Minor revisions: change of name, unit or number of significant figures
(dark green)	Major change: change of specification, limit or test method, or new specification

In the tables,

- '% v/v' means 'per cent volume by volume' and is equivalent to 'volume %', 'vol %' and '% vol'
- '% m/m' means 'per cent mass by mass' and is equal to 'mass %', '% mass' and 'weight %'
- 'mg/kg' is the same as 'ppm'.

* which have been costed (refer to Table 13)

Table B1. Proposed parameters for petrol compared to the EU standard, including test methods, for each policy option

Petrol parameter	Option A (Business as usual)	Option B (Revisions to align with Hart Report [a] and/or EU [b])	Option C (Revisions as for Option B, except 91 RON petrol is retained)	Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027)	EU petrol standard (EN 228:2012)	Test method
Aromatics	45% v/v 42% v/v pool average over 6 months	35.0% v/v [b]	35.0% v/v [b]	45% v/v 42% v/v pool average over 6 months	35.0% v/v	Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D1319) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85
Benzene	1% v/v	1.00% v/v [b]	1.00% v/v [b]	1% v/v	1.00% v/v	Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D5580) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85
Copper corrosion	Class 1 (3 h at 50°C)	Class 1 (3 h at 50°C) [b]	Class 1 (3 h at 50°C) [b]	Class 1 (3 h at 50°C)	Class 1 (3 h at 50°C)	ASTM D130
Diisopropyl ether (DIPE)	1% v/v	1% v/v [a]	1% v/v [a]	1% v/v	ASTM D4815	
Distillation—maximum final boiling point	210°C	210°C [b]	210°C [b]	210°C	210°C	Replace 'Not specified' with ASTM D86
Ethanol	10% v/v	10.0% v/v [b]	10.0% v/v [b]	10% v/v	10.0% v/v	ASTM D5501
Existent gum (washed)	50 mg/L	5 mg/100 mL [b]	5 mg/100 mL [b]	50 mg/L	5 mg/100 mL	ASTM D381
Induction period (oxidation stability)	360 minutes	360 minutes [b]	360 minutes [b]	360 minutes	360 minutes	ASTM D525
Lead	0.005 g/L	5 mg/L [b]	5 mg/L [b]	0.005 g/L	0.005 g/L	ASTM D3237
Motor octane number (MON)	91 RON petrol: 81.0	91 RON petrol is discontinued [b]	91 RON petrol: 81.0	91 RON petrol: 81.0	85.0 c	ASTM D2700

Petrol parameter	Option A (Business as usual)	Option B (Revisions to align with Hart Report [a] and/or EU [b])	Option C (Revisions as for Option B, except 91 RON petrol is retained)	Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027)	EU petrol standard (EN 228:2012)	Test method
	95 RON petrol: 85.0	95 RON petrol (with or without ethanol d): 85.0 [b]	95 RON petrol (with or without ethanol d): 85.0 [b]	95 RON petrol: 85.0		
	98 RON petrol	98 RON petrol (with or without ethanol d): 85.0 f	98 RON petrol (with or without ethanol d): 85.0 f			
Methyl tertiary butyl ether (MTBE)	1% v/v	1% v/v [a]	1% v/v [a]	1% v/v	22.0% v/v total ethers	ASTM D4815
Olefins	18% v/v	18.0% v/v [b]	18.0% v/v [b]	18% v/v	18.0% v/v	Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D1319) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85
Oxygen—for petrol without ethanol	2.7% m/m	2.7% m/m [b]	2.7% m/m [b]	2.7% m/m	2.7% m/m	ASTM D4815
Oxygen—for petrol with ethanol	3.9% m/m	3.9% m/m [a]	3.9% m/m [a]	3.9% m/m	3.7% m/m	ASTM D4815
Phosphorus	0.0013 g/L	1.3 mg/L Add 'Compounds containing phosphorus shall not be added' [b]	1.3 mg/L Add 'Compounds containing phosphorus shall not be added' [b]	0.0013 g/L	Compounds containing phosphorus shall not be added	ASTM D3231

Petrol parameter	Option A (Business as usual)	Option B (Revisions to align with Hart Report [a] and/or EU [b])	Option C (Revisions as for Option B, except 91 RON petrol is retained)	Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027)	EU petrol standard (EN 228:2012)	Test method
Research octane number (RON)	91 RON petrol: 91.0	91 RON petrol is discontinued [b]	91 RON petrol: 91.0 [a]	91 RON petrol: 91.0	95.0	ASTM D2699
	95 RON petrol: 95.0	95 RON petrol (with or without ethanol e): 95.0 [b]	95 RON petrol (with or without ethanol e): 95.0 [b]	95 RON petrol: 95.0		
		98 RON petrol (with or without ethanol e): 98.0 [f]	98 RON petrol (with or without ethanol e): 98.0 [f]			
Sulfur	91 RON petrol: 150 mg/kg	91 RON petrol is discontinued [b]	91 RON petrol: 10.0 mg/kg [a]	91 RON petrol: On commencement 150 mg/kg		10.0 mg/kg
	95 RON petrol: 50 mg/kg	95 RON petrol: 10.0 mg/kg [b]	95 RON petrol: 10.0 mg/kg [b]	95 RON petrol: On commencement 50 mg/kg From 1 July 2027 10.0 mg/kg		
		98 RON petrol: 10.0 mg/kg [f]	98 RON petrol: 10.0 mg/kg [f]			
Tertiary butyl alcohol (TBA)	0.5% v/v	0.5% v/v a	0.5% v/v a	0.5% v/v		ASTM D4815

a Hart Energy (2014). International fuel quality standards and their implications for Australian standards, report prepared for the Department of the Environment and Energy. Accessed 20 June 2017, environment.gov.au/protection/publications/international-fuel-quality-standards

b European petrol standard as described in National Standards Authority of Ireland (2012), I.S. EN 228:2012 Automotive fuels—unleaded petrol—requirements and test methods, Dublin. Purchased 7 June 2016, infostore.saiglobal.com/en-au/Standards/I-S-EN-228-2012-1600459/

c EU member states may decide to continue to permit the marketing of gasoline with a minimum MON of 81 and a minimum RON of 91

d Petrol blendstocks with less than 85.0/88.0 MON can be used as long as the final blended fuel meets the octane limit

e Petrol blendstocks with less than 95.0/98.0 RON can be used as long as the final blended fuel meets the octane limit

f European Automobile Manufacturers Association, Alliance of Automobile Manufacturers, Truck and Engine Manufacturers Association & Japan Automobile Manufacturers Association (2013). Category 5 Unleaded Gasoline. Worldwide Fuel Charter, 5th edition. Accessed 20 June 2017, acea.be/uploads/publications/Worldwide_Fuel_Charter_5ed_2013.pdf

Table B2. Proposed parameters for ethanol in petrol compared to the EU standard, including test methods, for each policy option

Ethanol parameter	Option A (Business as usual)	Option B (Revisions to align with Hart Report a and/or EU [b])	Option C (Options B and C are identical except for 91 RON petrol)	Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027)	EU ethanol standard (EN 15376:2014)	Test method
Acidity	0.007% m/m	0.007% m/m [b]	0.007% m/m [b]	0.007% m/m	0.007% m/m	ASTM D1613
Appearance	Clear and bright Visibly free of suspended or precipitated contaminants	Clear and bright Visibly free of suspended or precipitated contaminants [c]	Clear and bright Visibly free of suspended or precipitated contaminants [c]	Clear and bright Visibly free of suspended or precipitated contaminants	Clear and colourless	ASTM D4806
Copper	0.1 mg/kg	0.100 mg/kg [b]	0.100 mg/kg [b]	0.1 mg/kg	0.100 mg/kg	ASTM D1688A
Denaturant	Must contain denaturant, which must be ULP or PULP 1–1.5% v/v	Must contain denaturant, which must be ULP or PULP 1–1.5% v/v [c]	Must contain denaturant, which must be ULP or PULP 1–1.5% v/v [c]	Must contain denaturant, which must be ULP or PULP 1–1.5% v/v	Permitted	Industry views are sought on developing a suitable test method in the absence of a standard method
Ethanol content	95.6% v/v	95.6% v/v [c]	95.6% v/v [c]	95.6% v/v	98.7% m/m (ethanol and higher saturated alcohols content)	ASTM D5501
Inorganic chloride	32 mg/L	1 mg/kg [d]	1 mg/kg [d]	32 mg/L	1.5 mg/kg	Replace ASTM D512C with ASTM D7328
Methanol	0.5 % v/v	0.5 % v/v [c]	0.5 % v/v [c]	0.5 % v/v	1.0% m/m	ASTM D5501
pHe	6.5–9.0	6.5–9.0 [c]	6.5–9.0 [c]	6.5–9.0		ASTM D6423
Solvent washed gum	5.0 mg/100 mL	5.0 mg/100 mL [c]	5.0 mg/100 mL [c]	5.0 mg/100 mL	10 mg/100 mL	ASTM D381
Sulfate	4 mg/kg	3.0 mg/kg [b]	3.0 mg/kg [b]	4 mg/kg	3.0 mg/kg	Replace ASTM D4806 Annex 1 with D7328
Sulfur	30 mg/kg	10.0 mg/kg [b]	10.0 mg/kg [b]	30 mg/kg	10.0 mg/kg	ASTM D5453
Water	1.0% v/v	0.300% v/v [b]	0.300% v/v [b]	1.0% v/v	0.300% m/m	ASTM E203

a Hart Energy (2014). International fuel quality standards and their implications for Australian standards, report prepared for the Department of the Environment and Energy. Accessed 20 June 2017, environment.gov.au/protection/publications/international-fuel-quality-standards

b European ethanol standard as described in National Standards Authority of Ireland (2014), I.S. EN 15376:2014 Automotive fuels—ethanol as a blending component for petrol—requirements and test methods, Dublin. Purchased 8 May 2017, https://infostore.saiglobal.com/en-au/Standards/I-S-EN-15376-2014-1769743/

c No change proposed

d This value matches the current ethanol E85 inorganic chloride limit

Table B3. Proposed parameters for diesel compared to the EU standard, including test methods, for each policy option

Diesel parameter	**Option A** (Business as usual)	**Option B** (Revisions to align with Hart Report a and/or EU b)	**Option C** (Options B and C are identical except for 91 RON petrol)	**EU diesel standard (EN 590:2013)**	**Test method**
Ash	0.01% m/m	0.010% m/m [b]	0.010% m/m [b]	0.010% m/m	ASTM D482
Biodiesel (FAME) content	5.0% v/v	5.0% v/v [a]	5.0% v/v [a]	7.0% v/v	EN 14078
Carbon residue	0.2 mass % (10% distillation residue)	0.15 mass % [a]	0.15 mass % [a]	0.30% m/m	ASTM D4530
Cetane index	46	46.0 [b]	46.0 [b]	46.0	ASTM D4737 Procedure A
Colour	2	2 [a]	2 [a]		ASTM D1500
Conductivity at ambient temperature for all diesel held by a terminal or refinery for sale or distribution	50 pS/m at ambient temperature	50 pS/m at ambient temperature [a]	50 pS/m at ambient temperature [a]		ASTM D2624
Copper corrosion	Class 1 (3 h at 50°C)	Class 1 (3 h at 50°C) [b] Class 1 (3 h at 50°C) [b]	Class 1 (3 h at 50°C)	ASTM D130	
Density	820–850 kg/m3	820.0–845.0 kg/m3 at 15°C [b]	820.0–845.0 kg/m3 at 15°C [b]	820.0–845.0 kg/m3 at 15°C	ASTM D1298
Derived cetane number	51 (containing biodiesel)	51.0 [b]	51.0 [b]	51.0	ASTM D6890
Distillation—T95	360°C	360°C [b]	360°C [b]	360°C	ASTM D86
Flash point	61.5°C	61.5°C [a]	61.5°C [a]	55.0°C	ASTM D93
Filter blocking tendency	2.0	2.0 [a]	2.0 [a]		IP 387
Kinematic viscosity at 40°C	2.0–4.5 cSt	2.000–4.500 mm2/s [b]	2.000–4.500 mm2/s [b]	2.000–4.500 mm2/s	ASTM D445
Lubricity	0.460 mm	460 µm [b]	460 µm [b]	0.460 mm	IP 450
Oxidation stability	25 mg/L	2.5 mg/100 mL [b]	2.5 mg/100 mL [b]	25 g/m3	ASTM D2274
Polycyclic aromatic hydrocarbons (PAH)	11% m/m	8.0% m/m [b]	8.0% m/m [b]	8.0% m/m	IP 391
Sulfur	10 mg/kg	10.0 mg/kg [b]	10.0 mg/kg [b]	10.0 mg/kg	ASTM D5453
Water and sediment	0.05 vol%	0.05% v/v [a]	0.05% v/v [a]		ASTM D2709
Water—for diesel containing biodiesel	200 mg/kg	200 mg/kg [b]	200 mg/kg [b]	200 mg/kg	ASTM D6304

a Hart Energy (2014). International fuel quality standards and their implications for Australian standards, report prepared for the Department of the Environment and Energy. Accessed 20 June 2017, environment.gov.au/protection/publications/international-fuel-quality-standards

b European diesel standard as described in National Standards Authority of Ireland (2014), I.S. EN 590:2013 Automotive fuels—diesel—requirements and test methods, Dublin. Purchased 7 June 2016, infostore.saiglobal.com/en-au/Standards/I-S-EN-590-2013-1679974/

Table B4. Proposed parameters for autogas (LPG) compared to the EU standard, including test methods, for each policy option

Autogas (LPG) parameter	Option A (Business as usual)	Option B (Revisions to align with Hart Report a and/or EU b)	Option C (Options B and C are identical except for 91 RON petrol)	EU autogas standard (EN 589:2008)	Test method
Copper corrosion (1 h at 40°C)	Class 1	Class 1 [b]	Class 1 [b]	Class 1	EN ISO 6251
Dienes	0.3% molar	0.3% molar [a]	0.3% molar [a]	0.5% molar	ISO 7941
Hydrogen sulphide	Negative	Negative [b]	Negative [b]	Negative	EN ISO 8819
Motor octane number (MON)	90.5	90.5 [a]	90.5 [a]	89.0	ISO 7941 / EN 589 Annex B
Odour	Detectable in air at 20% of lower flammability limit	Detectable in air at 20% of lower flammability limit [a]	Detectable in air at 20% of lower flammability limit [a]	Unpleasant and distinctive at 20% of lower flammability limit	EN 589:2008 Annex A
Residue on evaporation	60 mg/kg	60 mg/kg [b]	60 mg/kg [b]	60 mg/kg	Replace JLPGS-S-03 with EN 15471 to increase precision
Sulfur (after stenching)	50 mg/kg	50 mg/kg [b]	50 mg/kg [b]	50 mg/kg	ASTM D6667
Vapour pressure (gauge) at 40°C	800–1530 kPa	800–1530 kPa [a]	800–1530 kPa [a]	1500 kPa	ISO 8973
Volatile residues (C5 and higher)	2.0% molar	2.0% molar [a]	2.0% molar [a]		Replace ISO 7941 with ASTM D1263-14e1 to increase precision
Water	No free water at 0°C	No free water at 0°C [b]	No free water at 0°C [b]	None	Replace EN 589:2004 with EN 15469

a Hart Energy (2014). *International fuel quality standards and their implications for Australian standards*, report prepared for the Department of the Environment and Energy. Accessed 20 June 2017, environment.gov.au/protection/publications/international-fuel-quality-standards

b European LPG standard as described in National Standards Authority of Ireland (2012), I.S. *EN 589:2008 Automotive fuels—LPG—requirements and test methods*, Dublin. Purchased 16 May 2016, infostore.saiglobal.com/en-au/Standards/I-S-EN-589-2008-1140721/

Table B5. Proposed parameters for biodiesel compared to the EU standard, including test methods, for each policy option

Biodiesel parameter	**Option A** (Business as usual)	**Option B** (Revisions to align with Hart Report a and/or EU [b])	**Option C** (Options B and C are identical except for 91 RON petrol)	**EU biodiesel standard (EN 14214:2012)**	**Test method**
Acid value	0.80 mg KOH/g	0.50 mg KOH/g [a, b]	0.50 mg KOH/g [a, b]	0.50 mg KOH/g	
ASTM D664					
Carbon residue–10% distillation residue	0.30% m/m	0.30% m/m a	0.30% m/m a		ASTM D4530
Copper strip corrosion	Class 1 3 h at 50°C	Class 1 3 h at 50°C [b]	Class 1 3 h at 50°C [b]	Class 1 3 h at 50°C	EN ISO 2160 ASTM D130
Density at 15°C	860–890 kg/m^3	860–890 kg/m3 [a]	860–890 kg/m^3 [a]	860–900 kg/m3	ASTM D1298
Derived cetane number	51.0	51.0 [b]	51.0 [b]	51.0	ASTM D613 ASTM D6890
Distillation—T90	360°C	360°C [a]	360°C [a]		ASTM D1160
Ester content	96.5% m/m	96.5% m/m [b]	96.5% m/m [b]	96.5% m/m	EN 14103
Flash point	120.0°C	120.0°C a	120.0°C a	101°C	ASTM D93
Free glycerol	0.020% mass	0.020% m/m [a]	0.020% m/m [a]	0.02% m/m	ASTM D6584
Kinematic viscosity	3.5–5.0 mm^2/s	3.50–5.00 mm2/s [b]	3.50–5.00 mm^2/s [b]	3.50–5.00 mm2/s	ASTM D445
Metals–Group I (Na, K)	5 mg/kg	5.0 mg/kg [b]	5.0 mg/kg [b]	5.0 mg/kg	EN 14538
Metals–Group II (Ca, Mg)	5 mg/kg	5.0 mg/kg [b]	5.0 mg/kg [b]	5.0 mg/kg	EN 14538
Methanol	0.20% m/m	0.20% m/m [b]	0.20% m/m [b]	0.20% m/m	EN 14110
Oxidation stability at 110°C	6 h	8.0 h [b]	8.0 h [b]	8.0 h	EN 15751 EN 14112
Phosphorus	10 mg/kg	4.0 mg/kg [b]	4.0 mg/kg [b]	4.0 mg/kg	EN 14107
Sulfated ash	0.020% mass	0.020% m/m [a]	0.020% m/m [a]	0.02% m/m	ASTM D874
Sulfur	10 mg/kg	10.0 mg/kg [b]	10.0 mg/kg [b]	10.0 mg/kg	ASTM D5453
Total contamination	24 mg/kg	24 mg/kg [b]	24 mg/kg [b]	24 mg/kg	EN 12662:2014
Total glycerol	0.250% mass	0.250% m/m [a]	0.250% m/m [a]	0.25% m/m	ASTM D6584
Water and sediment	0.050% vol	0.050% v/v [a]	0.050% v/v [a]		ASTM D2709

a Hart Energy (2014). International fuel quality standards and their implications for Australian standards, report prepared for the Department of the Environment and Energy. Accessed 20 June 2017, environment.gov.au/protection/publications/international-fuel-quality-standards

b European biodiesel standard as described in National Standards Authority of Ireland (2014), *I.S. EN 14214:2012 Liquid petroleum products—fatty acid methyl esters (FAME) for use in diesel engines and heating applications—requirements and test methods*, Dublin. Purchased 16 May 2016, infostore.saiglobal.com/en-au/Standards/I-S-EN-14214-2012-1592181/

Table B6. Proposed parameters for ethanol E85 compared to the EU standard, including test methods, for each policy option

Ethanol E85 parameter	Option A (Business as usual)	Option B (Revisions to align with Hart Report a and/or EU b)	Option C (Options B and C are identical except for 91 RON petrol)	EU ethanol E85 standard (CEN/TS 15293:2011)	Test method
Acidity (as acetic acid)	0.006% m/m	0.005% m/m [b]	0.005% m/m [b]	0.005% m/m	ASTM D1613
Benzene	0.35% v/v	0.35% v/v [a]	0.35% v/v [a]		Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D5580) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85
Copper	0.10 mg/kg	0.10 mg/kg [b]	0.10 mg/kg [b]	0.10 mg/kg	EN 15837 (as modified in CEN/TS 15293)
Ethanol	70–85% v/v	70–85% v/v [a]	70–85% v/v [a]	70–85% v/v (summer) 50–85% v/v (winter)	Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D5501) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85
Ethers (5 or more C atoms)	1.0% v/v	1.0% v/v [a]	1.0% v/v [a]	11% v/v	Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D4815) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85
Distillation—final boiling point	210°C	210°C [a]	210°C [a]		ASTM D86
Higher alcohols (C3–C8)	2.0% v/v	2.0% v/v [a]	2.0% v/v [a]	6.0% v/v	ASTM D4815 (note 1)
Inorganic chloride	1 mg/kg	1 mg/kg [a]	1 mg/kg [a]	1.2 mg/kg	ASTM D7328
Lead content	5 mg/L	5 mg/L [a]	5 mg/L [a]		ASTM D3237
Methanol	0.5% v/v	0.5% v/v [a]	0.5% v/v [a]	1.0% v/v	ASTM D5501

Ethanol E85 parameter	**Option A** (Business as usual)	**Option B** (Revisions to align with Hart Report a and/or EU b)	**Option C** (Options B and C are identical except for 91 RON petrol)	**EU ethanol E85 standard (CEN/TS 15293:2011)**	**Test method**
Motor octane number (MON)	87	88.0 [b]	88.0 [b]	88.0	
Oxidation stability	360 minutes	360 minutes [b]	360 minutes [b]	360 minutes	ASTM D525
pHe	6.5–9.0	6.5–9.0 [a]	6.5–9.0 [a]		ASTM D6423
Phosphorus	1.3 mg/L	0.15 mg/L [b]	0.15 mg/L [b]	0.15 mg/L	ASTM D3231
Research octane number (RON)	100	104 [b]	104 [b]	104	
Solvent washed gum	5 mg/100 mL	5 mg/100 mL [b]	5 mg/100 mL [b]	5 mg/100 mL	ASTM D381
Sulfate	4.0 mg/kg	4.0 mg/kg [b]	4.0 mg/kg [b]	4.0 mg/kg	ASTM D7319
Sulfur	70 mg/kg	10.0 mg/kg [b]	10.0 mg/kg [b]	10.0 mg/kg	ASTM D5453
Vapour pressure (DVPE)	38–65 kPa at 37.8°C	38–65 kPa at 37.8°C [a]	38–65 kPa at 37.8°C [a]	35.0–60.0 kPa (summer)	ASTM D5191
Water	1.0% m/m	0.0400% m/m [b]	0.0400% m/m [b]	0.0400% m/m	ASTM E1064

a Hart Energy (2014). *International fuel quality standards and their implications for Australian standards*, report prepared for the Department of the Environment and Energy. Accessed 20 June 2017, environment.gov.au/protection/publications/international-fuel-quality-standards

b European ethanol (E85) standard as described in National Standards Authority of Ireland (2011), SR CEN/TS 15293:2011 *Automotive fuels—Ethanol (E85) automotive fuel—requirements and test methods*, Dublin. Purchased 16 May 2016, infostore.saiglobal.com/en-au/Standards/SR-CEN-TS-15293-2011-1461166/

Table B7. Proposed parameters for B20 diesel biodiesel blend compared to the EU standard, including test methods, for each policy option

B20 diesel biodiesel blend parameter	**Option A** (Business as usual—no standard)	**Option B** (Revisions to align with B20 discussion paper a and/or EU b)	**Option C** (Options B and C are identical except for 91 RON petrol)	**EU B20 diesel biodiesel blend standard (EN 16709:2015)**	**Test method**
Acid value		0.3 mg KOH/g [a]	0.3 mg KOH/g [a]		ASTM D664
Ash		0.010% m/m [b]	0.010% m/m [b]	0.010% m/m	ASTM D482
Biodiesel content		5.1% v/v–20.0% v/v [c]	5.1% v/v–20.0% v/v [c]	14.0% v/v–20.0% v/v	EN 14078
Carbon residue 10% distillation residue		0.30% m/m [a]	0.30% m/m [a]		ASTM D4530
Copper strip corrosion (3 h at 50°C)		Class 1 [a]	Class 1 [a]		ASTM D130
Density at 15°C		820.0 kg/m3–860.0 kg/m^3 [b]	820.0 kg/m3–860.0 kg/m^3 [b]	820.0 kg/m3–860.0 kg/m^3	ASTM D4052
Derived cetane number		51.0 [b]	51.0 [b]	51.0	ASTM D6890
Distillation—T90		360°C [b]	360°C [b]	360°C	ASTM D1160
Flash point		61.5°C [a]	61.5°C [a]	Above 55.0%	ASTM D93
Kinematic viscosity at 40°C		2.000–4.620 mm2/s [b]	2.000–4.620 mm2/s [b]	2.000–4.620 mm^2/s	ASTM D445
Lubricity		460 µm [a]	460 µm [a]		IP 450
Oxidation stability		20.0 h [b]	20.0 h [b]	20.0 h	EN 15751
Polycyclic aromatic hydrocarbons (PAH)		8.0% m/m [b]	8.0% m/m [b]	8.0% m/m	EN 12916:2016
Sulfur		10.0 mg/kg [b]	10.0 mg/kg [b]	10.0 mg/kg	ASTM D5453
Water		200 mg/kg [c]	200 mg/kg [c]	260 mg/kg	ASTM D6304
Water and sediment		0.05% v/v [a]	0.05% v/v [a]		ASTM D2709

a Department of Sustainability, Environment, Water, Population and Communities (2012), *Developing a B20 fuel quality standard: a discussion paper for consultation covering the selection, specification and test methods for a B20 fuel quality standard*, Canberra. Accessed 20 June 2017, environment.gov.au/node/13465

b European B20 diesel-biodiesel blend standard as described in National Standards Authority of Ireland (2016), *I.S. EN 16709:2015 Automotive fuels—high FAME diesel fuel (B20 and B30)—requirements and test methods*, Dublin. Purchased 16 May 2016, infostore.saiglobal.com/en-au/Standards/I-S-EN-16709-2015-1827582/

c Amendments following stakeholder feedback to the Department of Sustainability, Environment, Water, Population and Communities (2012), *Developing a B20 fuel quality standard: a discussion paper for consultation covering the selection, specification and test methods for a B20 fuel quality standard*, Canberra. Accessed 20 June 2017, environment.gov.au/node/13465

Appendix C. Euro 5/V and Euro 6/VI emissions standards

Table C1. Euro 5/V and proposed Euro 6/VI emissions standards

Emission standard	Category	Emission limits						OBD thresholds*	
			NO_x (mg/km)	PM (mg/km)	Particle number (numbers/km)	CO (mg/km)	(NMHC)† (mg/km)	NO_x (mg/km)	PM (mg/km)
Euro 5 (ADR 79/04)	Passenger vehicle	Petrol/LPG	60	4.5 (for direct injection)	No limit	1900	250	300	50
		Diesel	180	4.5	6x1011	1900	320	540	50
	Light commercial vehicle	Petrol/LPG	82	4.5 (for direct injection)	No limit	4300	400	410	50
		Diesel	280	4.5	6x1011	2800	400	840	50
Euro 6 (final) (proposed ADR 79/05)	Passenger vehicle	Petrol/LPG	60	4.5 (for direct injection)	6x1011 (for direct injection)	1900	170	90	12
		Diesel	80	4.5	6x1011	1750	290	140	12
	Light commercial vehicle	Petrol/LPG	82	4.5 (for direct injection)	6x1011 (for direct injection)	4300	270	120	12
		Diesel	125	4.5	6x1011	2500	350	220	12
Euro V (ADR 80/03)	Heavy diesel	Stationary cycle	2000 mg/kWh	20 mg/kWh	N/A			7000 (mg/kWh)	100 (mg/kWh)
		Transient cycle	2000 mg/kWh	30 mg/kWh	N/A				
Euro VI (final) (proposed ADR 80/04)	Heavy diesel	Stationary cycle	400 mg/kWh	10 mg/kWh	8x1011/kWh				
		Transient cycle	460 mg/kWh	10 mg/kWh	6x1011/kWh			1200 (mg/kWh)	25 (mg/kWh)

* OBD means on-board diagnostics.
† NMHC means non-methane hydrocarbons.

Appendix D. Detailed cost-benefit analysis results

Table D1. Cost-benefit analysis results Option B, NPV 2017–2040 ($2017) and BCR

2022

Option B	NPV	2017-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Costs												
Refinery capital costs	-$786,544,964	$0	-$1,031,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Refinery operating costs	-$2,785,474,890	$0	$0	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580
Fuel price impacts imported fuel (RULP phase-out)	-$1,246,272,055	$0	$0	-$165,633,621	-$165,633,621	-$165,633,621	-$165,633,621	-$165,633,621	-$165,633,621	-$165,633,621	-$165,633,621	-$165,633,621
Fuel price impacts imported fuel (revised fuel standards)	-$420,841,850	$0	$0	-$42,615,106	-$45,261,106	-$48,076,150	-$50,972,051	-$53,514,968	-$55,827,501	-$57,991,692	-$59,844,965	-$61,511,922
Fuel price impacts wholesale & retail margins (foreign companies)	-$168,510,024	$0	$0	-$347,105,148	$13,353,555	$6,862,903	$328,318	-$3,438,226	-$5,498,278	-$6,522,624	-$5,668,133	-$3,818,822
Fuel demand impacts (increased fuel prices)	-$33,009,733	$0	$0	-$11,971,746	-$5,042,491	-$4,715,626	-$4,682,172	-$4,460,807	-$4,188,171	-$3,983,785	-$3,730,024	-$3,475,637
Increased GHG emissions (refinery upgrades)	-$84,244,919	$0	$0	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233

Option B	NPV	2017-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Industry compliance (revised standards)	-$6,306,756	$0	$0	-$3,117,960	-$3,152,294	-$3,184,565	$0	$0	$0	$0	$0	$0
Company tax impact (demand changes, foreign entities)	-$3,398,744	$0	$0	-$856,475	-$408,403	-$412,678	-$420,938	-$422,402	-$420,615	-$421,972	-$419,910	-$416,329
Government administration costs	$1,419,296	$0	$0	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000
Total costs	**-$5,533,184,640**	**$0**	**-$1,031,000,000**	**-$935,067,868**	**-$569,912,172**	**-$578,927,549**	**-$585,148,276**	**-$591,237,836**	**-$595,335,998**	**-$598,321,506**	**-$599,064,466**	**-$598,624,144**
Benefits/ Avoided Costs												
Avoided health impacts	$2,850,416,715	$0	$0	$333,573,772	$337,549,460	$341,525,148	$345,500,836	$349,476,524	$353,452,212	$357,427,900	$361,403,588	$365,379,276
Reduced fuel consumption (phase out of RULP)	$1,468,048,175	$0	$0	$69,520,168	$91,653,895	$113,561,084	$133,713,041	$153,026,207	$171,814,890	$187,225,637	$201,574,841	$214,949,096
Reduced GHG emissions (phase out of RULP)	$129,746,660	$0	$0	$7,540,536	$9,597,712	$11,494,518	$13,096,774	$14,519,103	$15,806,809	$16,987,534	$18,037,520	$18,969,048
Reduced particle filter failure (lower aromatics)	$143,931,184	$0	$0	$12,832,074	$14,150,921	$15,326,866	$16,333,874	$16,848,253	$17,400,062	$17,924,312	$18,483,748	$19,046,257
Reduced catalyst failure (ultra low sulfur)	$147,017,080	$0	$0	$16,951,534	$17,205,807	$17,463,895	$17,725,853	$17,974,015	$18,207,677	$18,426,169	$18,647,283	$18,871,051
Impacts of price changes on retailer producer surplus	$75,888,093	$0	$0	-$168,426,921	$7,473,616	$3,840,977	$183,750	-$1,924,280	-$3,077,235	-$3,650,533	-$3,172,298	-$2,137,289
Total benefits/ avoided costs	**$4,815,047,907**	**$0**	**$0**	**$271,991,163**	**$477,631,412**	**$503,212,489**	**$526,554,129**	**$549,919,823**	**$573,604,415**	**$594,341,020**	**$614,974,682**	**$635,077,438**
NPV	**-$718,136,733**	**$0**	**-$1,031,000,000**	**-$663,076,705**	**-$92,280,760**	**-$75,715,060**	**-$58,594,147**	**-$41,318,013**	**-$21,731,583**	**-$3,980,487**	**$15,910,217**	**$36,453,294**
BCR	**0.87**	**0.00**	**0.00**	**0.29**	**0.84**	**0.87**	**0.90**	**0.93**	**0.96**	**0.99**	**1.03**	**1.06**

2027

Option B	NPV	2017-2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Costs												
Refinery capital costs	-$560,795,689	$0	-$1,031,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Refinery operating costs	-$1,680,458,998	$0	$0	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580	-$353,263,580
Fuel price impacts imported fuel (RULP phase-out)	-$728,166,611	$0	$0	-$165,633,621	-$165,633,621	-$165,633,621	-$165,633,621	-$163,574,078	-$158,801,238	-$153,974,817	-$149,156,366	-$144,143,467
Fuel price impacts imported fuel (revised fuel standards)	-$271,584,279	$0	$0	-$55,827,501	-$57,991,692	-$59,844,965	-$61,511,922	-$60,463,180	-$59,115,772	-$57,764,749	-$56,441,156	-$55,147,914
Fuel price impacts wholesale & retail margins (foreign companies)	-$30,626,950	$0	$0	-$198,486,200	-$6,522,624	-$5,668,133	-$3,818,822	$2,091,176	$9,684,254	$17,297,706	$24,756,577	$32,044,414
Fuel demand impacts (increased fuel prices)	-$13,155,750	$0	$0	-$6,275,363	-$3,622,703	-$3,370,861	-$3,119,775	-$2,830,921	-$2,520,537	-$2,229,857	-$1,964,664	-$1,716,324
Increased GHG emissions (refinery upgrades)	-$50,824,415	$0	$0	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233	-$10,684,233
Industry compliance (revised standards)	-$4,676,366	$0	$0	-$3,260,072	-$3,277,824	-$3,292,343	$0	$0	$0	$0	$0	$0
Company tax impact (demand changes, foreign entities)	-$1,773,140	$0	$0	-$594,550	-$384,043	-$382,362	-$379,195	-$370,296	-$358,748	-$347,227	-$336,030	-$324,911
Government administration costs	$856,252	$0	$0	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000	$180,000
Total costs	**-$3,341,205,944**	**$0**	**$0**	**-$793,845,118**	**-$601,200,319**	**-$601,960,098**	**-$598,231,147**	**-$588,915,111**	**-$574,879,853**	**-$560,786,757**	**-$546,909,452**	**-$533,056,014**

Option B	NPV	2017-2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Benefits/ Avoided Costs												
Avoided health impacts	$1,735,333,685	$0	$0	$347,708,572	$350,863,740	$354,018,908	$357,174,076	$360,329,244	$363,484,412	$366,639,580	$369,794,748	$372,949,916
Reduced fuel consumption (phase out of RULP)	$741,663,549	$0	$0	$83,031,918	$99,319,137	$114,110,356	$128,728,851	$142,664,964	$155,756,004	$168,250,073	$180,208,812	$191,494,640
Reduced GHG emissions (phase out of RULP)	$62,315,298	$0	$0	$7,638,859	$9,011,518	$10,210,936	$11,360,195	$12,416,255	$13,368,280	$14,240,905	$15,041,951	$15,762,493
Reduced particle filter failure (lower aromatics)	$97,137,138	$0	$0	$17,400,062	$17,924,312	$18,483,748	$19,046,257	$19,534,198	$20,027,620	$20,541,646	$21,061,614	$21,622,983
Reduced catalyst failure (ultra low sulfur)	$92,496,998	$0	$0	$18,207,677	$18,426,169	$18,647,283	$18,871,051	$19,097,503	$19,326,673	$19,558,593	$19,793,296	$20,030,816
Impacts of price changes on retailer producer surplus	$5,259,995	$0	$0	-$87,715,400	-$3,650,533	-$3,172,298	-$2,137,289	$1,170,373	$5,420,010	$9,681,049	$13,855,573	$17,934,375
Total benefits/ avoided costs	**$2,734,206,663**	**$0**	**$0**	**$386,271,688**	**$491,894,344**	**$512,298,933**	**$533,043,140**	**$555,212,538**	**$577,382,999**	**$598,911,846**	**$619,755,995**	**$639,795,222**
NPV	**-$606,999,281**	**$0**	**$0**	**-$407,573,430**	**-$109,305,975**	**-$89,661,165**	**-$65,188,007**	**-$33,702,573**	**$2,503,146**	**$38,125,090**	**$72,846,543**	**$106,739,208**
BCR	**0.82**	**0.00**	**0.00**	**0.49**	**0.82**	**0.85**	**0.89**	**0.94**	**1.00**	**1.07**	**1.13**	**1.20**

For ease of presentation, results are only shown to 2030 and 2035. However the analysis is based on the period to 2040.

Table D2. Cost-benefit analysis results Option C, NPV 2017–2040 ($2017) and BCR

2022

Option C	NPV	2017-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Costs												
Refinery capital costs	-$786,544,964	$0	-$1,031,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Refinery operating costs	-$1,444,751,668	$0	$0	-$178,534,413	-$178,534,413	-$178,534,413	-$178,534,413	-$178,534,413	-$178,534,413	-$178,534,413	-$178,534,413	-$178,534,413
Fuel price impacts imported fuel (RULP phase-out)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel price impacts imported fuel (revised fuel standards)	-$411,186,162	$0	$0	-$39,400,876	-$42,730,001	-$45,855,660	-$48,729,775	-$51,526,412	-$54,201,875	-$56,727,535	-$59,045,640	-$61,208,184
Fuel price impacts wholesale & retail margins (foreign companies)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel demand impacts (increased fuel prices)	-$3,106,073	$0	$0	-$232,974	-$259,311	-$285,350	-$310,904	-$337,416	-$364,441	-$395,692	-$427,559	-$459,963
Increased GHG emissions (refinery upgrades)	-$66,747,853	$0	$0	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194
Industry compliance (revised standards)	-$6,306,756	$0	$0	-$3,117,960	-$3,152,294	-$3,184,565	$0	$0	$0	$0	$0	$0
Company tax impact (demand changes, foreign entities)	-$1,498,277	$0	$0	-$156,035	-$163,296	-$169,965	-$176,029	-$181,772	-$187,143	-$193,944	-$200,358	-$206,444
Government administration costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total costs	**-$2,720,141,753**	**$0**	**-$1,031,000,000**	**-$229,907,452**	**-$233,304,509**	**-$236,495,148**	**-$236,216,315**	**-$239,045,207**	**-$241,753,066**	**-$244,316,778**	**-$246,673,164**	**-$248,874,198**

Option C	NPV	2017-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benefits/ Avoided Costs												
Avoided health impacts	$3,070,068,977	$0	$0	$371,159,983	$373,750,578	$376,341,172	$378,931,766	$381,522,360	$384,112,955	$386,703,549	$389,294,143	$391,884,737
Reduced fuel consumption (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced GHG emissions (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced particle filter failure (lower aromatics)	$143,931,184	$0	$0	$12,832,074	$14,150,921	$15,326,866	$16,333,874	$16,848,253	$17,400,062	$17,924,312	$18,483,748	$19,046,257
Reduced catalyst failure (ultra low sulfur)	$147,017,080	$0	$0	$16,951,534	$17,205,807	$17,463,895	$17,725,853	$17,974,015	$18,207,677	$18,426,169	$18,647,283	$18,871,051
Impacts of price changes on retailer producer surplus	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total benefits/ avoided costs	**$3,361,017,242**	**$0**	**$0**	**$400,943,591**	**$405,107,306**	**$409,131,933**	**$412,991,493**	**$416,344,629**	**$419,720,694**	**$423,054,030**	**$426,425,174**	**$429,802,045**
NPV	**$640,875,489**	**$0**	**-$1,031,000,000**	**$171,036,140**	**$171,802,797**	**$172,636,785**	**$176,775,178**	**$177,299,422**	**$177,967,628**	**$178,737,252**	**$179,752,010**	**$180,927,847**
BCR	**1.24**	**0.00**	**0.00**	**1.74**	**1.74**	**1.73**	**1.75**	**1.74**	**1.74**	**1.73**	**1.73**	**1.73**

2027

Option C	NPV	2017-2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Costs												
Refinery capital costs	-$560,795,689	$0	-$1,031,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Refinery operating costs	-$886,292,277	$0	$0	-$178,534,413	-$178,534,413	-$178,534,413	-$178,534,413	-$179,810,300	-$182,767,074	-$185,757,042	-$188,742,072	-$191,847,563
Fuel price impacts imported fuel (RULP phase-out)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel price impacts imported fuel (revised fuel standards)	-$269,676,351	$0	$0	-$54,201,875	-$56,727,535	-$59,045,640	-$61,208,184	-$60,463,180	-$59,115,772	-$57,764,749	-$56,441,156	-$55,147,914
Fuel price impacts wholesale & retail margins (foreign companies)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel demand impacts (increased fuel prices)	-$1,713,796	$0	$0	-$222,719	-$247,656	-$273,523	-$300,198	-$326,734	-$353,648	-$381,171	-$409,286	-$438,093
Increased GHG emissions (refinery upgrades)	-$40,268,548	$0	$0	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194
Industry compliance (revised standards)	-$4,676,366	$0	$0	-$3,260,072	-$3,277,824	-$3,292,343	$0	$0	$0	$0	$0	$0
Company tax impact (demand changes, foreign entities)	-$852,114	$0	$0	-$148,893	-$156,014	-$162,811	-$169,310	-$175,076	-$180,430	-$185,555	-$190,479	-$195,242
Government administration costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total costs	**-$1,764,275,140**	**$0**	**$0**	**-$244,833,166**	**-$247,408,635**	**-$249,773,923**	**-$248,677,298**	**-$249,240,484**	**-$250,882,119**	**-$252,553,711**	**-$254,248,188**	**-$256,094,006**

Option C	NPV	2017-2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Benefits/ Avoided Costs												
Avoided health impacts	$1,893,960,257	$0	$0	$384,112,955	$386,703,549	$389,294,143	$391,884,737	$394,475,332	$397,065,926	$399,656,520	$402,247,114	$404,837,708
Reduced fuel consumption (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced GHG emissions (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced particle filter failure (lower aromatics)	$97,137,138	$0	$0	$17,400,062	$17,924,312	$18,483,748	$19,046,257	$19,534,198	$20,027,620	$20,541,646	$21,061,614	$21,622,983
Reduced catalyst failure (ultra low sulfur)	$92,496,998	$0	$0	$18,207,677	$18,426,169	$18,647,283	$18,871,051	$19,097,503	$19,326,673	$19,558,593	$19,793,296	$20,030,816
Impacts of price changes on retailer producer surplus	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total benefits/ avoided costs	**$2,083,594,393**	**$0**	**$0**	**$419,720,694**	**$423,054,030**	**$426,425,174**	**$429,802,045**	**$433,107,033**	**$436,420,219**	**$439,756,759**	**$443,102,025**	**$446,491,507**
NPV	**$319,319,253**	**$0**	**$0**	**$174,887,528**	**$175,645,395**	**$176,651,251**	**$181,124,747**	**$183,866,549**	**$185,538,100**	**$187,203,048**	**$188,853,836**	**$190,397,501**
BCR	**1.18**	**0.00**	**0.00**	**1.71**	**1.71**	**1.71**	**1.73**	**1.74**	**1.74**	**1.74**	**1.74**	**1.74**

Table D3. Cost-benefit analysis results Option F, NPV 2017–2040 ($2017) and BCR

2022

Option F	NPV	2017-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Costs												
Refinery capital costs	-$746,874,413	$0	-$979,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Refinery operating costs	-$1,042,539,088	$0	$0	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420
Fuel price impacts imported fuel (RULP phase-out)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel price impacts imported fuel (revised fuel standards)	-$319,507,347	$0	$0	-$30,049,987	-$32,471,964	-$35,035,056	-$37,677,300	-$40,074,008	-$42,306,575	-$44,431,004	-$46,317,447	-$48,056,189
Fuel price impacts wholesale & retail margins (foreign companies)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel demand impacts (increased fuel prices)	-$2,255,171	$0	$0	-$156,938	-$176,748	-$197,634	-$219,488	-$241,568	-$263,961	-$289,707	-$315,858	-$342,527
Increased GHG emissions (refinery upgrades)	-$66,747,853	$0	$0	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194
Industry compliance (revised standards)	-$4,323,737	$0	$0	-$2,138,985	-$2,161,030	-$2,181,750	$0	$0	$0	$0	$0	$0
Company tax impact (demand changes, foreign entities)	-$1,175,788	$0	$0	-$118,151	-$124,319	-$130,438	-$136,447	-$141,929	-$147,014	-$153,372	-$159,335	-$165,010
Government administration costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total costs	**-$2,183,423,395**	**$0**	**-$979,000,000**	**-$173,147,676**	**-$175,617,675**	**-$178,228,492**	**-$178,716,849**	**-$181,141,120**	**-$183,401,165**	**-$185,557,696**	**-$187,476,254**	**-$189,247,340**

Option F	NPV	2017-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benefits/ Avoided Costs												
Avoided health impacts	$2,664,316,025	$0	$0	$322,741,436	$324,899,176	$327,056,916	$329,214,655	$331,372,395	$333,530,135	$335,687,875	$337,845,615	$340,003,354
Reduced fuel consumption (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced GHG emissions (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced particle filter failure (lower aromatics)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced catalyst failure (ultra low sulfur)	$147,017,080	$0	$0	$16,951,534	$17,205,807	$17,463,895	$17,725,853	$17,974,015	$18,207,677	$18,426,169	$18,647,283	$18,871,051
Impacts of price changes on retailer producer surplus	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total benefits/ avoided costs	**$2,811,333,106**	**$0**	**$0**	**$339,692,970**	**$342,104,983**	**$344,520,810**	**$346,940,508**	**$349,346,410**	**$351,737,812**	**$354,114,044**	**$356,492,898**	**$358,874,405**
NPV	**$627,909,711**	**$0**	**-$979,000,000**	**$166,545,294**	**$166,487,308**	**$166,292,318**	**$168,223,659**	**$168,205,290**	**$168,336,647**	**$168,556,348**	**$169,016,644**	**$169,627,065**
BCR	**1.29**	**0.00**	**0.00**	**1.96**	**1.95**	**1.93**	**1.94**	**1.93**	**1.92**	**1.91**	**1.90**	**1.90**

2027

Option F	NPV	2017-2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Costs												
Refinery capital costs	-$532,511,134	$0	-$979,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Refinery operating costs	-$628,957,093	$0	$0	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420	-$132,218,420
Fuel price impacts imported fuel (RULP phase-out)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel price impacts imported fuel (revised fuel standards)	-$210,900,471	$0	$0	-$42,306,575	-$44,431,004	-$46,317,447	-$48,056,189	-$47,236,859	-$46,184,197	-$45,128,710	-$44,094,653	-$43,084,308
Fuel price impacts wholesale & retail margins (foreign companies)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel demand impacts (increased fuel prices)	-$1,206,009	$0	$0	-$144,464	-$164,119	-$184,521	-$205,694	-$226,935	-$248,468	-$270,541	-$293,146	-$316,240
Increased GHG emissions (refinery upgrades)	-$40,268,548	$0	$0	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194	-$8,465,194
Industry compliance (revised standards)	-$3,198,165	$0	$0	-$2,230,230	-$2,241,627	-$2,250,949	$0	$0	$0	$0	$0	$0
Company tax impact (demand changes, foreign entities)	-$651,918	$0	$0	-$108,760	-$115,437	-$121,783	-$127,871	-$133,331	-$138,385	-$143,225	-$147,877	-$152,346
Government administration costs	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total costs	**-$1,417,693,339**	**$0**	**$0**	**-$185,473,643**	**-$187,635,802**	**-$189,558,314**	**-$189,073,368**	**-$188,280,740**	**-$187,254,665**	**-$186,226,090**	**-$185,219,292**	**-$184,236,509**

Option F	NPV	2017-2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Benefits/ Avoided Costs												
Avoided health impacts	$1,642,186,639	$0	$0	$333,530,135	$335,687,875	$337,845,615	$340,003,354	$342,161,094	$344,318,834	$346,476,574	$348,634,314	$350,792,053
Reduced fuel consumption (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced GHG emissions (phase out of RULP)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced particle filter failure (lower aromatics)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reduced catalyst failure (ultra low sulfur)	$92,496,998	$0	$0	$18,207,677	$18,426,169	$18,647,283	$18,871,051	$19,097,503	$19,326,673	$19,558,593	$19,793,296	$20,030,816
Impacts of price changes on retailer producer surplus	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total benefits/ avoided costs	**$1,734,683,637**	**$0**	**$0**	**$351,737,812**	**$354,114,044**	**$356,492,898**	**$358,874,405**	**$361,258,597**	**$363,645,507**	**$366,035,167**	**$368,427,610**	**$370,822,869**
NPV	**$316,990,298**	**$0**	**$0**	**$166,264,169**	**$166,478,242**	**$166,934,584**	**$169,801,037**	**$172,977,857**	**$176,390,843**	**$179,809,077**	**$183,208,318**	**$186,586,360**
BCR	**1.22**	**0.00**	**0.00**	**1.90**	**1.89**	**1.88**	**1.90**	**1.92**	**1.94**	**1.97**	**1.99**	**2.01**

Appendix E. Better fuel for cleaner air—stakeholder views

Over 70 submissions were received from six state or territory governments, the fuel and alternative fuel industry, vehicle and aviation industries, industry associations, motoring consumer advocates, non-government organisations with expertise in health care and environmental protection, and members of the public. A summary of stakeholder views that have informed the policy options in this draft RIS is provided below. Stakeholder submissions are available at environment.gov.au/protection/fuel-quality/better-fuel-cleaner-air-discussion-paper-2016-submissions

E.1 Views on policy options

Around half of the submissions indicated a preference for one of the key policy options. These submissions were based on the Discussion Paper and preceded the analysis made available in this draft RIS.

- Option B, or as a second best option, Option D, were preferred by most stakeholders (who noted a preference) because of the health, environment and vehicle operability benefits that would be achieved.
- Option C, was supported as an 'acceptable' or 'possible' option warranting further investigation. Stakeholders who nominated Option C also nominated options B or D as acceptable or as the preferred options.
- Option A, the no-change option, was supported by the Australian Institute of Petroleum and member refineries.
- Option E was not supported by any stakeholder, including the Australian Institute of Petroleum and member refineries. The Australian Institute of Petroleum claimed that the cost to implement Option E would be similar to that of other reform options. The New South Wales Government noted that Option E would provide insufficient reductions in sulfur levels, miss the opportunity to achieve substantial emissions reductions to protect the health of the state's residents and impede efforts to meet the national ambient air quality standard for ozone.
- Option F was proposed by the Australian Institute of Petroleum and member refineries, stating that it would maximise overall outcomes and provide Australia's refineries with the best chance of survival.

E.1.1 Sulfur content

Stakeholder views differ markedly on the concentration of sulfur needed to reduce noxious emissions, meet Euro 5/V and 6/VI standards and improve engine operability.

Vehicle manufacturers, including the Federal Chamber of Automotive Industries, argued that implementation of Euro 6 standards, and future improvements in vehicle emission control and fuel efficiency, are dependent on low sulfur content in petrol and diesel fuels. They noted that vehicles are designed to use fuels meeting specified parameters to meet emissions standards, and that petrol engine light vehicles will not be able to comply with Euro 6 limits in service unless European standards (10 ppm sulfur and other parameters) are widely used.

While the Australian Institute of Petroleum has offered in its Option F to reduce sulfur content to 10 ppm by 2027, it observes that sulfur levels in Australian fuel are already well below the regulated limit*. The Australian Institute of Petroleum states that refinery production of sulfur levels below 50 ppm will require substantial capital and ongoing operating refinery investment, and argues that there is insufficient evidence of environmental benefits, in the Australian context, to establish the case for this investment. In direct contrast to the views of the Federal Chamber of Automotive Industries, the Australian Institute of Petroleum also argues that there is insufficient evidence to demonstrate that such low sulfur levels are necessary to introduce Euro 6 vehicle requirements[51].

As noted above, the majority of stakeholders who nominated a preference indicated support for options B, C or D, which propose a reduction in sulfur to 10 ppm. In supporting a reduction in sulfur concentration, the New South Wales Environment Protection Authority estimated that reducing average petrol sulfur levels from 50 ppm to 10 ppm would deliver immediate emission reductions from the in-service fleet and reduce annual motor vehicle hydrocarbon and nitrogen oxide emissions in the Sydney greater metropolitan region by 31 per cent and 47 per cent, respectively, by 2036. It noted that the reduction would be almost entirely from petrol vehicles, with 10 per cent of the reduction estimated to come from adoption of Euro 6 vehicles and the remaining 90 per cent from the adoption of 10 ppm sulfur petrol† in the in-service fleet.

E.1.2 Aromatics

Many stakeholders support the proposed reduction in aromatic content to 35 per cent due to the health benefits of reduced benzene emissions. The Federal Chamber of Automotive Industries advised that a reduction in aromatics is ‘critical to meet Euro 6c and Euro 6d particulate number limits for gasoline direct injection engines’, noting that the majority of light vehicles introduced into Australia between now and 2030 will have this type of engine. They also note that ‘aromatic content can increase engine combustion chamber deposits, which can increase tailpipe emissions’[41].

The Australian Institute of Petroleum does not support any reduction in aromatics, arguing that ‘the change in the aromatics standards will be costly and difficult to implement and there have been no identified operability or environmental benefits’.

E.1.3 91 RON petrol

A number of submissions commented on the phasing out of 91 RON (regular unleaded) petrol. This draft RIS has found that Option B has a negative NPV, ranging from –$718 million (2022) to –$607 million (2027), meaning that if it is implemented it is unlikely to deliver a net benefit to the community compared with the base case of no changes to fuel standards.

* The Australian Institute of Petroleum reports that the volume-weighted average sulfur concentrations of regular unleaded petrol in Sydney (imported fuel) and Melbourne (locally produced fuel) in 2014–15 were 28 ppm and 60 ppm respectively. Maximum concentrations were 85 ppm and 147 ppm respectively.

† New South Wales Environment Protection Agency (2017). *NSW comment on better fuel for cleaner air discussion paper, submission on the Better fuel for cleaner air discussion paper*. Accessed 20 June 2017, environment.gov.au/submissions/fuel-quality/better-fuel/nsw-gov.pdf

E.1.4 Comments on other fuel parameters

Comments from stakeholders were received on proposed changes to a number of other parameters in the fuel standards and the use of fuel additives. These included:

- Australian Institute of Petroleum member companies believe there would be negligible environmental and operability benefits of reducing the PAH limit as described in Option B. Domestic refineries would likely need to invest in expensive diesel hydrotreater reactors to achieve any substantial reduction in PAH.
- Australian Institute of Petroleum does not consider that there is any compelling evidence (that is, no adverse operability or environmental benefit) to require Australian mineral diesel nor biodiesel blends to meet a cetane limit of 51 minimum as described in Option B. The AIP state there would be significant costs associated with implementing a 51 cetane. In addition, the AIP considers that higher cetane does not facilitate better engine technology.
- arguments supporting the specification of a minimum 85 MON in 98 RON petrol, including from the Australian Institute of Petroleum
- a consumer aversion to ethanol-blended fuels, raised by the Australian Institute of Petroleum
- the Biofuels Association of Australia view that use of ethanol in Australian fuels could reduce greenhouse gas emissions by around 50 per cent, create employment in regional Australia and provide new markets for Australian farmers
- support for the use of MTBE to enhance octane during the petroleum-refining process[51], to harmonise with fuels used in Europe and Asia[*]
- opposition to increasing the use of MTBE as an octane enhancer due to concerns about groundwater contamination from spills and from leaking fuel storage tanks[26 †],
- comments on the adverse effect of fuel additives, including lead, MMT and NMA, on human health and vehicle operability, including from the Federal Chamber of Automotive Industries and, in relation to NMA, from the Australian Institute of Petroleum
- a recommendation from the Australian Institute of Petroleum to consult further on an approach to the use of MMT
- support from suppliers of some fuel and fuel additives for the retention of octane-enhancing compounds, such as NMA and MMT, to enable refiners and providers to meet clean fuels targets
- comments on the benefits of reducing polycyclic aromatic hydrocarbons in diesel fuel, in particular particulate emissions from the older in-service fleet[26]
- recommendations to include a definition of renewable and synthetic diesel in the fuel standards from seven stakeholders, including the biofuels and aviation industries and the Department of Defence
- recommendations by the New South Wales and Victorian governments to expand the scope of the diesel standard to non-road vehicles to reduce harmful emissions, provide clarity on the application of the standard and provide quality assurance for users of non-road diesel vehicles and fuels. Toyota Australia also supported standardising fuel standards across different uses.

---

* Asian Clean Fuels Association (2017). Meeting higher fuel standards requirements for Australia, submission on the Better fuel for cleaner air discussion paper. Accessed 20 June 2017, environment.gov.au/submissions/fuel-quality/better-fuel/acfa.pdf

† For example, in New South Wales more than 800 documented contaminated sites are petrol stations.

Appendix F. References

1 *Fuel Quality Standards Act 2000* (Cth), section 3.

2 The Parliament of the Commonwealth of Australia (2000). Fuel Quality Standards Bill 2000, Revised Explanatory Memorandum, House of Representatives, Commonwealth of Australia, Canberra. Accessed 20 June 2017 at Federal Register of Legislation, www.legislation.gov.au/Details/C2004B00794/Revised%20Explanatory%20Memorandum/Text

3 Department of the Environment and Energy (2016). Better fuel for cleaner air discussion paper, Canberra. Accessed 20 June 2017, www.environment.gov.au/protection/fuel-quality/better-fuel-cleaner-air-discussion-paper-2016

4 Department of the Prime Minister and Cabinet (2014). *The Australian Government guide to regulation*, Canberra.

5 Department of the Environment and Energy (2016). National Pollutant Inventory. Accessed 13 July 2016, *www.npi.gov.au/data/search.html*

6 Straif K, Cohen A, Samet J & International Agency for Research on Cancer (2013). *IARC Scientific Publication No. 161: Air pollution and cancer*. World Health Organization, Geneva. Accessed 20 June 2017, www.iarc.fr/en/publications/books/sp161/AirPollutionandCancer161.pdf

7 International Agency for Research on Cancer (2012). IARC: Diesel engine exhaust carcinogenic, press release 213. Accessed 20 June 2017, www.iarc.fr/en/media-centre/pr/2012/pdfs/pr213_E.pdf

8 Brauer M, Lencar C, Tamburic L, Koehoorn M, Demers P & Karr C (2008). A cohort study of traffic-related air pollution impacts on birth outcomes. *Environmental Health Perspectives 116(5):680–686*.

9 Peters JM, Avol E, Berhane K, Gauderman JW, Gilliland F, Jerrett M, Junzli N, London S, McConnell R, Navidi B, Rappaport E, Thomas D, Lurmann F, Roberts P, Alcorn S, Funk T, Gong H, Linn WS, Cass G & Margolis H (2004). *Epidemiologic investigation to identify chronic effects of ambient air pollutants in Southern California*, prepared for the California Air Resources Board and the California Environmental Protection Agency. Accessed 20 June 2017, www.arb.ca.gov/research/single-project.php?row_id=60245

10 Whitworth KW, Symanski E & Coker AL (2008). Childhood lymphohematopoietic cancer incidence and hazardous air pollutants in southeast Texas, 1995–2004. Environmental Health Perspectives 116:1576–1580.

11 Heck JE, Park AS, Qiu J, Cockburn M & Ritz B (2014). Risk of leukemia in relation to exposure to ambient air toxics in pregnancy and early childhood. *International Journal of Hygiene and Environmental Health* 217:662–668.

12 Peters S, Glass D, Reid A, de Klerk N, Armstrong BK, Kellie S, Ashton LJ, Milne E & Fritschi L (2012). Parental occupational exposure to engine exhausts and childhood brain tumors. *International Journal of Cancer* 132:2975–2979.

13 Chen H, Kwong JC, Copes R, Tu K, Villeneuve PJ, van Donkelaar A, Hystad P, Martin RV, Murray BJ, Jessiman B, Wilton AS, Kopp A & Burnett RT (2017). Living near major roads and the incidence of dementia, Parkinson's disease, and multiple sclerosis: a population-based cohort study. *The Lancet* 389(10070):718–726.

14 Golder Associates (2013). *Exposure assessment and risk characterisation to inform recommendations for updating ambient air quality standards for $PM_{2.5}$, PM_{10}, O_3, NO_2 SO_2*, submitted to National Environment Protection Council Service Corporation. Accessed 20 June 2017, www.environment.gov.au/system/files/pages/dfe7ed5d-1eaf-4ff2-bfe7-dbb7ebaf21a9/files/exposure-assessment-risk-characterisation.pdf

15 Gasana J, Dillikar D, Mendy A, Forno E & Vieira ER (2012). Motor vehicle air pollution and asthma in children: a meta-analysis. *Environmental Research* 117:36–45.

16 Buckeridge DL, Glazier R, Harvey BJ, Escobar M, Amrhein C & Frank J (2002). Effect of motor vehicle emissions on respiratory health in an urban area. *Environmental Health Perspectives* 110(3):293–300.

17 Samoli E, Atkinson RW, Analitis A, Fuller GW, Green DC, Mudway I, Anderson HR & Kelly FJ (2017). Associations of short-term exposure to traffic-related air pollution with cardiovascular and respiratory hospital admissions in London, UK. *Occupational and Environmental Medicine* 73:300–307.

18 Department of Environment and Conservation NSW (2005). Air pollution economics: health costs of air pollution in the greater Sydney metropolitan region, Sydney.

19 New South Wales Environment Protection Agency (2016). *Advisory Committee on Tunnel Air Quality submission on Australian Government vehicle emissions discussion paper*, Department of Infrastructure and Regional Development. Accessed 20 June 2017, http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0010/87589/160610-NSW_Advisory_Committee_on_Tunnel_Air_Quality_amended.pdf.

20 Benbrahim-Tallaa L, Baan RA, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, Guha N, Loomis D & Straif K (2012). International Agency for Research on Cancer Monograph Working Group. Carcinogenicity of diesel-engine and gasoline-engine exhausts and some nitroarenes. *Lancet Oncology* 13:663–664.

21 Zhou Y & Levy JI (2007). Factors influencing the spatial extent of mobile source air pollution impacts: a meta-analysis. *BMC Public Health* 7:89.

22 Hagler GSW, Baldauf RW, Thoma ED, Long TR, Snow RF, Kinsey JS, Oudejans L & Gullett BK (2009). Ultrafine particles near a major roadway in Raleigh, North Carolina: downwind attenuation and correlation with traffic-related pollutants. *Atmospheric Environment* 43:1229–34.

23 Venkatram A, Isakov V, Seila R & Baldauf R (2009). Modeling the impacts of traffic emissions on air toxics concentrations near roadways. *Atmospheric Environment* 43:3191–3199.

24 Australian Institute of Health and Welfare (2017). AIHW analysis of burden of disease database, 2011.

25 Marsden Jacob Associates Pty Ltd (2017). Analysis of AIHW burden of disease data, in *Revised fuel quality standards: economic analysis*, report prepared for the Department of the Environment and Energy.

26 Environment Protection Authority Victoria, Vehicle emissions and air quality website. Accessed 7 July 2017, www.epa.vic.gov.au/your-environment/air/vehicle-emissions-and-air-quality

27 State Government of New South Wales (2017). Submission on the *Better fuel for cleaner air discussion paper*.

28 Marsden Jacob Associates (2017). *Revised fuel quality standards: economic analysis*, report prepared for the Department of the Environment and Energy, Canberra.

29 Hime N, Cowie C & Marks G (2015). *Review of the health impacts of emission sources, types and levels of particulate matter air pollution in ambient air in NSW*, report prepared for NSW Environment Protection Agency and NSW Ministry of Health, Environment Health Branch, Sydney. Accessed 20 June 2017, www.car-cre.org.au/images/content/Health%20impacts%20of%20PM%20report_final%20for%20web.pdf

30 Environ Australia Pty Ltd (2010). Cleaner non-road diesel engine project—identification and recommendation of measures to support the uptake of cleaner non-road diesel engines in Australia, report prepared for NSW Department of Environment, Climate Change and Water. Accessed 7 June 2017, www.epa.nsw.gov.au/resources/air/nonroaddieselrpt.pdf

31 Department of Infrastructure and Regional Development (2016). *Vehicle emissions standards for cleaner air: draft regulation impact statement*, Ministerial Forum on Vehicle Emissions, Canberra.

32 Federal Chamber of Automotive Industries (2017). Submission on the *Better fuel for cleaner air discussion paper*. Accessed 20 June 2017, www.environment.gov.au/submissions/fuel-quality/better-fuel/fcai.pdf

33 ABMARC (2017). Technical advice on fuel parameters and specifications, August, report prepared for the Department of the Environment and Energy.

34 United States Environmental Protection Agency (2006). *Air quality criteria for ozone and related photochemical oxidants*, Washington, DC. Accessed 20 June 2017, cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=149923

35 Yue W, Schneider A, Stölzel M, Rückerl R, Cyrys J, Pan X, Zareba W, Koenig W, Wichmann HE & Peters A (2007). Ambient source-specific particles are associated with prolonged repolarization and increased levels of inflammation in male coronary artery disease patients. *Mutation Research: Fundamental and Molecular Mechanisms of Mutagenesis* 621:50–60.

36 Daniels MJ, Dominici F, Zeger SL & Sarnet JM (2004). The national morbidity, mortality, and air pollution study part III: PM_{10} concentration-response curves and thresholds for the 20 largest US cities. *Research Report (Health Effects Institute)* 94 Pt 3:1–21.

37 Schwartz J, Coull B, Laden F & Ryan L (2008). The effect of dose and timing of dose on the association between airborne particles and survival. *Journal of Environmental Health Perspectives* 116:64–69.

38 Harvey F (2016). Four of world's biggest cities to ban diesel cars from their centres. *The Guardian*, 2 December 2016. Accessed 20 June 2017, www.theguardian.com/environment/2016/dec/02/four-of-worlds-biggest-cities-to-ban-diesel-cars-from-their-centres

39 Department of Infrastructure and Regional Development (2017), *Vehicle emissions standards*, accessed 20 June 2017, www.infrastructure.gov.au/roads/environment/emission/

40 Federal Chamber of Automotive Industries (2017). Submission on the *Better fuel for cleaner air discussion paper*.

41 ABMARC (2017). Technical advice on fuel parameters and specifications, report prepared for the Department of the Environment and Energy.

42 Australian Institute of Petroleum (2017). Submission on the Better fuel for cleaner air discussion paper. Accessed 20 June 2017, www.environment.gov.au/submissions/fuel-quality/better-fuel/aip.pdf

43 Toyota Australia (2017). *Submission to Ministerial Forum on Vehicle Emissions better fuel for cleaner air discussion paper*. Accessed 20 June 2017, www.environment.gov.au/submissions/fuel-quality/better-fuel/toyota-australia.pdf

44 Federal Chamber of Automotive Industries (2017). Submission on the *Better fuel for cleaner air discussion paper.*

45 ABMARC (2017). *Technical advice on fuel parameters and specifications*, report prepared for the Department of the Environment and Energy.

46 Hart Energy (2014). *International fuel quality standards and their implications for Australian standards*, report prepared for the Department of the Environment and Energy. Accessed 20 June 2017, www.environment.gov.au/protection/publications/international-fuel-quality-standards

47 Stratas Advisors (2016). Stratas advisors' rankings confirm movement to lower sulfur content in gasoline. Accessed 20 June 2017, www.stratasadvisors.com/Insights/052516-Sulfur-In-Fuel

48 Stratas Advisors (2017). Data tools—compare specs across countries 2017. Accessed 5 June 2017, https://tools.stratasadvisors.com/Gfs/DetailsByYear (subscription service)

49 Stratas Advisors (2017). Data tools—compare specs across countries. Accessed 5 June 2017, tools.stratasadvisors.com/Gfs/DetailsByYear (subscription service)

50 Australian Government (2015). *International standards and risk assessments*. Available from https://www.cuttingredtape.gov.au/resources/guidance/international-standards-and-risk-assessments

51 Federal Chamber of Automotive Industries (2017). *Submission on the Better fuel for cleaner air discussion paper*.

52 Department of the Environment and Energy (2017). *Australian Petroleum Statistics* 247, February 2017, Canberra. Accessed 20 June 2017, www.environment.gov.au/energy/publications/petroleum-statistics-february-2017

53 Australian Institute of Petroleum (2017). Submission on the *Better fuel for cleaner air discussion paper*. Accessed 20 June 2017, www.environment.gov.au/submissions/fuel-quality/better-fuel/aip.pdf

54 Department of the Environment and Energy (2015). *National Clean Air Agreement*. Available at www.environment.gov.au/protection/air-quality/national-clean-air-agreement

55 European Automobile Manufacturers Association, Alliance of Automobile Manufacturers, Truck and Engine Manufacturers Association & Japan Automobile Manufacturers Association (2013). *Worldwide Fuel Charter*, 5th edition, September 2013.

56 Fueltrac Pty Ltd (2017). *Possible reforms to the fuel quality standards*, report prepared for Marsden Jacob Associates.

57 Hale and Twomey (2017). *Assessing impacts on refining from proposed changes to Australia's fuel specifications*, report prepared for the Department of the Environment and Energy.

58 Biofuels Association of Australia (2017). Submission on the *Better fuel for cleaner air discussion paper.*

59 Fueltrac Pty Ltd (2017). *Assessing impacts on refining from proposed changes to Australia's fuel specifications*, report prepared for the Department of the Environment and Energy.

60 Independent Pricing and Regulatory Tribunal of New South Wales (2015). *Ethanol mandate—options to increase the uptake of ethanol blended petrol,* Sydney. Accessed 8 August 2017, https://www.ipart.nsw.gov.au/files/sharedassets/website/trimholdingbay/final_report_-_ethanol_mandate_-_options_to_increase_the_uptake_of_ethanol_blended_petrol_-_may_2015.pdf

61 Utilities, Science and Innovation Committee (2015). Liquid Fuel Supply (Ethanol and Other Biofuels Mandate) Amendment Bill 2015, Queensland Parliament. Accessed 8 August 2017, http://www.parliament.qld.gov.au/documents/tableOffice/TabledPapers/2015/5515T1680.pdf

62 European Automobile Manufacturers Association, Alliance of Automobile Manufacturers, Truck and Engine Manufacturers Association & Japan Automobile Manufacturers Association (2013). *Worldwide Fuel Charter*, September 2013, 5th edition. Fuel quality recommendations accessed 1 May 2017, www.acea.be/publications/article/worldwide-fuel-charter

63 National Health and Medical Research Council (2015). *NHMRC statement and information: evidence on the effects of lead on human health*. Accessed 20 June 2017, www.nhmrc.gov.au/guidelines-publications/eh58

64 Marsden Jacob Associates (2017) *Revised fuel quality standards: economic analysis*, prepared for the Department of the Environment and Energy, Canberra

65 Bureau of Infrastructure, Transport and Regional Economics (2017), BITRE internal analysis of spatial differences in vehicle kilometres travelled by Australian households, Canberra

66 Department of the Prime Minister and Cabinet (2016). *Regulatory burden measurement framework: guidance note*, February 2015. Available at http://www.dpmc.gov.au/resource-centre/regulation/regulatory-burden-measurement-framework-guidance-note

ENV207.0717