



Australian Government

Better fuel for cleaner air

Regulation impact statement

Department of the Environment and Energy

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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.

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List of abbreviations and select glossary

ABS	Australian Bureau of Statistics
the Act	<i>Fuel Quality Standards Act 2000</i> (Cth)
ADRs	Australian Design Rules
AIP	Australian Institute of Petroleum
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
COPERT	the European Environment Agency’s road transport emissions model
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
ETAE	ethyl tertiary-amyl ether
ETBE	ethyl tertiary-butyl ether (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- <i>tert</i> -butoxy-1,2-propanediol)
Hart Report	Hart Energy (2014), <i>International fuel quality standards and their implications for Australian standards</i>
high-octane petrol	petrol with a research octane number of 95 or higher
IPP	import parity price
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
MOVES	the United States Environment Protection Agency's Motor Vehicle Emission Simulator
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
OBPR	Office of Best Practice Regulation

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
pool average	the average amount of aromatics in all batches of petrol of that grade manufactured in Australia or imported by a supplier in each six months starting on 1 January
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
SO ₂	sulfur dioxide—a gas emitted from an engine
TAME	tertiary amyl-methyl ether
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
UN	United Nations
USA	United States of America
US EPA	United States Environment Protection Agency
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, impacting 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 enable better engine and emission control technologies to be brought to Australia. To reduce the impacts of noxious vehicle emissions, Australia has historically adopted increasingly stringent European vehicle emission standards.

Australia's fuel parameters are specified in standards for each type of fuel, made as legislative instruments under the *Fuel Quality Standards Act 2000* (Cth) (the Act). These parameters set the physical properties and chemical substances necessary for the fuel to be used in engines. The petrol parameters that most affect vehicle operability and emissions—and on which Australia is out of step with European fuel standards and fuel standards in other Organisation for Economic Co-operation and Development countries—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.
 - Sulfur is currently permitted at the level of 150 parts per million (ppm) in regular unleaded petrol and 50 ppm in premium unleaded petrol.
 - Actual levels of sulfur tend to be significantly lower than these maximum limits. The Australian Institute of Petroleum (AIP) reported average sulfur levels in petrol to be around 60 ppm for regular unleaded and 27 ppm for premium unleaded over the three years 2014–2016.
- **Octane.** Petrol's research octane number (RON) is a measure of petrol's resistance to ignition under compression in a spark-ignition engine. The use of lower octane petrol than that recommended by vehicle manufacturers, or in fuel-efficient high-compression engines, can cause engine 'knocking' and damage. Older vehicles designed for, and which 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.
 - Currently, regular unleaded petrol in Australia must be minimum 91 RON and premium unleaded must be minimum 95 RON. Some suppliers also provide a high-octane 98 RON premium unleaded petrol.
- **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 and other carcinogenic emissions from vehicles. Lowering aromatics would improve engine operability, reduce noxious exhaust emissions, and improve health outcomes.
 - Australian petrol may contain a maximum 45 per cent aromatics by volume, and 42 per cent pool average by volume.
 - Actual aromatic levels tend to be significantly lower than these limits. The AIP reported pool averages of 25 per cent for 91 RON regular unleaded, 30 per cent for 95 RON premium unleaded and 37 per cent for 98 RON premium unleaded over 2014–2016.

Three reform options for consultation

An early assessment regulation impact statement (draft RIS) provided the basis for consultation about possible changes to legislative instruments—including Australia’s fuel standards—under 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 *Fuel Quality Standards (Register of Prohibited Fuel Additives) Guidelines 2003*. In addition, a new fuel quality standard was proposed for a B20 diesel-biodiesel blend. The current set of legislative instruments, including the fuel quality standards, are due to sunset (cease to have effect) in 2019.

The draft RIS presented three reform options for consultation; Options B and C were identified through earlier consultation, and Option F was put forward by the refining industry. The options focussed on improvements to petrol to enable the latest vehicle technology and provide the greatest health and environmental benefits for Australians. In particular, the options proposed changes to three key petrol parameters:

- reducing the level of sulfur to 10 ppm (proposed in all three options)
- reducing aromatics to 35 per cent maximum in all grades (proposed in Options B and C)
- phasing out regular unleaded 91 RON petrol (proposed in Option B only).

A range of other parameter and policy changes were proposed under Options B and C, including changes to the scope of the diesel standard and to levels of cetane and polycyclic aromatic hydrocarbons (PAH) in diesel. Compared to the costs and benefits associated with the proposed changes to the petrol standard, these other changes were minor or administrative in nature and were not the subject of detailed consultation at this stage.

Independent economists Marsden Jacob Associates undertook a cost-benefit analysis on the three reform options. Each option was considered against three different implementation dates: 2022, 2025 and 2027. The analysis estimated:

- Option B would have a negative net present value (NPV), ranging from –\$718 million (2022) to –\$607 million (2027), meaning it would not deliver an overall benefit to the community compared with the base case of no changes to fuel standards.
- Option C would have 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 would have a positive NPV, ranging from \$628 million (2022) to \$317 million (2027) and if implemented, will return \$1.22 to \$1.29 for every \$1 of cost.

For various reasons, not all potential benefits of each option could be quantified with appropriate certainty, meaning those benefits could not be directly or fully reflected in the economic analysis. For example, the link between ultra-fine particle exposure and health outcomes, while demonstrated, has not been reliably quantified and therefore savings were unable to be determined. As another example, uncertainties about the extent to which better quality fuel could reduce manufacturer costs (to ensure new models run reliably), meant potential reductions in vehicle purchase price could not be quantified.

The three options are described in detail in Sections 2–5. Two additional options (Option D and Option E) were included in the *Better fuels for cleaner air discussion paper*, published for consultation on the Department’s website in December 2016. Due to the high costs these options would impose on refineries and motorists—highlighted in submissions received in response to the discussion paper—the options were excluded from further consideration in the draft RIS.

Stakeholder views on the proposed options

Fifty-five submissions were received from the petroleum and alternative fuel industries, automotive and aviation industries, industry associations, motoring consumer groups, health and environmental groups and members of the public.

Option B (reduce sulfur, reduce aromatics, phase out regular unleaded 91 RON petrol) was the most strongly supported option, despite being an overall cost to the community. The automotive industry and health groups were the main supporters of Option B, for the reason that it would enable the latest engine technologies, establish the strongest alignment with European standards and deliver maximum health and environmental benefits. Because Option B was determined to be a net cost to the economy, it was not a focus of further assessment.

Option F (reduce sulfur only) with interim industry reporting, proposed by the AIP, was the second most favoured option. It was supported by AIP, its member refineries and the Motor Trades Association of Australia because it would maximise refinery viability while still delivering health and vehicle technology benefits.

Option C (reduce sulfur, reduce aromatics, retain regular unleaded 91 RON petrol) was supported by a smaller number of submissions as a cost-effective way to achieve strong health and environmental outcomes.

Consultation established the following positions on the three petrol parameters:

- Reduced **sulfur**—was supported by all but one stakeholder. In particular, reduced sulfur was supported by both the refining and automotive industries. Both industries acknowledged the significant health benefits this would achieve and that lower sulfur is key to enabling correct operation of advanced engines and emissions systems.
- Phase-out of regular unleaded (**low octane**) petrol—though supported by the automotive industry, is not cost-effective and would result in a net cost to the community, thus was the subject of limited consultation.
- Reduced **aromatic** limit—was supported by the automotive industry as necessary for meeting tighter emissions standards, but not by the refining industry. AIP stated that due to a lack of a suitable octane-enhancing additive for Australian petrol, it is not feasible to reduce aromatics while maintaining octane, thus requiring lower levels of aromatics would jeopardise refinery viability. No resolution was reached on this matter, however the refining industry:
 - indicated the current level of pool average aromatics in Australian petrol is consistently less than the current regulated limit.
 - committed to reporting aromatic data publicly from 2021.

Further consultation on proposals to reform other fuel standards was supported by stakeholders.

The best option for improving Australia's fuel

The best option combines the most suitable elements of Options C and F. The option is to:

- Reduce sulfur in petrol to 10 ppm from 1 July 2027.
- Retain regular unleaded petrol.
- Reduce the pool average of aromatics in petrol from 42 per cent to 35 per cent, effective 1 January 2022.
- Review the aromatics limit in petrol by 2022 to set a reduced limit by 2027 or establish an alternative solution. The scope of the review will be developed in consultation with industry and reporting will be appropriately staged.
- Consult further with industry on the remaining parameters in the fuel standards covered by the RIS, to finalise these prior to 1 October 2019.

This option provides a suitable approach for aligning with European standards in a way that is most appropriate for Australia. The approach delivers substantial benefits for health and vehicle maintenance, while providing time for further detailed assessment and a decision on the appropriate limit for aromatics in Australian fuel.

This option is estimated to deliver the following benefits and costs:

- \$1.7 billion avoided health and vehicle maintenance costs (2027–2040).
 - Benefits would increase to \$2.1 billion if a reduction in the limit of aromatics to 35 per cent was also decided as a result of the aromatics review.
- In 2027 there will be a small increase of 0.9 cents per litre; increasing to 1.0 cents per litre in 2030; and will then decline after that as lower sulfur fuel becomes the benchmark in the region.
- The small increase in petrol price due to the improved fuel standards is expected to be offset by the significant health benefits, better vehicle operability and improved fuel efficiency for those that purchase the advanced vehicle technology in Euro 6 vehicles. The average fuel efficiency improvement between an average Euro 5 and an average Euro 6d vehicle is around 13 per cent which could provide a \$75 annual saving to motorists.

These estimates reflect the cost benefit analysis for Option F and Option C in the draft RIS.

Regulatory burden of the best option

The regulatory burden of the best option was assessed as \$346 million, as estimated for Option F in the draft RIS. This represents the lowest regulatory burden of all reform options proposed.

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 emission 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 (SO₂).

This regulation impact statement (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 vehicle emissions and the fuel efficiency measures are the responsibility of the Department of Infrastructure, Regional Development and Cities and are subject to their own regulation impact assessment processes*. This RIS has been prepared to align with and complement those measures (Figure 1).

Figure 1 shows the interactions between the measures being considered by the Ministerial Forum. Figure 2 shows the measures under consideration to reduce motor vehicle emissions.

* 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/vehicles/environment/forum/index.aspx

Figure 1: Interactions between the fuel quality, noxious emissions and fuel efficiency measures being considered by the Ministerial Forum on Vehicle Emissions

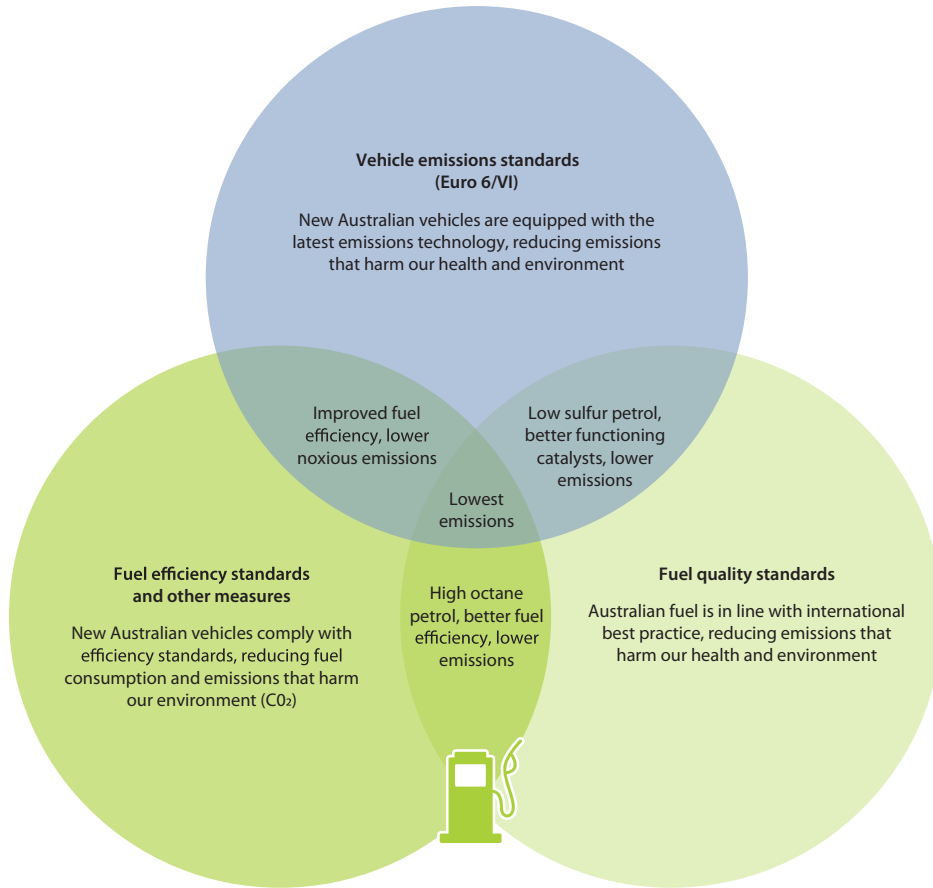
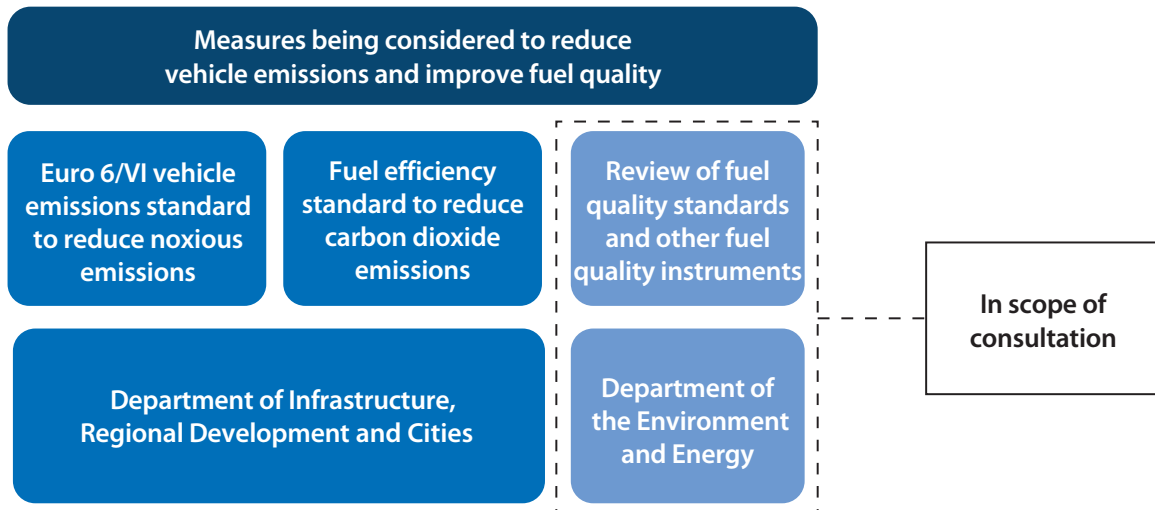


Figure 2: Australian Government measures under consideration to reduce motor vehicle emissions



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. 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:

1. regulate the quality of fuel supplied in Australia in order to:
 - (a) reduce the level of pollutants and emissions arising from the use of fuel that may cause environmental and health problems; and
 - (b) facilitate the adoption of better engine technology and emission control technology;
2. allow the more effective operation of engines; and
3. ensure that, where appropriate, information about fuel is provided when the fuel is supplied¹.

Harmonisation of Australian vehicle emission standards with international standards was a noted secondary objective at the time the Act was introduced².

An independent statutory review of the Act in 2016 concluded that the regulation of the quality of fuel supplied in Australia had led to a quantifiable reduction in the level of pollutants and emissions arising from the use of fuel. The report also made a number of recommendations for the Government's consideration. 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 the recommendations.

Table 1: Legislative instruments made under the Act

Legislative instrument	Web location
Fuel Quality Standards Regulations 2001	legislation.gov.au/Details/F2017C00651
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
<i>Fuel Quality Standards (Register of Prohibited Fuel Additives) Guidelines 2003</i>	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 and draft RIS

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.

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.

Building on feedback received in response to the discussion paper, the *Better fuel for cleaner air* draft regulation impact statement was released for public consultation in January 2018. Over 50 submissions were received from a range of stakeholders as illustrated in Figure 3. All (non-confidential) submissions received will be made available on the Department's website at: <http://www.environment.gov.au/protection/fuel-quality/standards/review>.

Figure 3: Stakeholder groups that provided a submission to the *Better fuel for cleaner air* draft regulation impact statement



The Department has completed a detailed analysis of submissions and carried out further stakeholder consultation. This 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 4: Policy assessment criteria for this RIS

<p>Policy assessment criteria</p> <ol style="list-style-type: none">1. Achieve appreciable health and environmental outcomes2. Ensure the most effective operation of engines3. Facilitate adoption of better engine and emission control technologies4. Achieve harmonisation with European standards, as appropriate5. Minimise regulatory burden6. Maximise net national benefits
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This RIS identifies the options that best meet the policy assessment 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.

This RIS proposes a preferred option based on consideration of the policy assessment criteria and the feedback received through the consultation processes. 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 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)
6. What is the best option of those considered? (Chapter 7)
7. How will the chosen option be implemented and evaluated? (Chapter 8)

Stakeholder views were particularly sought on the following aspects:

- the costs and benefits included in this 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.
8. Stakeholder input contributed to the final set of regulatory options proposed for consideration by the Government. This 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.

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 quality standards with European standards, regarded as international best practice 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 primary 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: The benefits of better quality fuel



* 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 used in particular engines. The petrol parameters that most affect vehicle operability and emissions—and with 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 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. The regulated limit for aromatics is 45 per cent (by volume). These regulated limits are less stringent than those of Australia's major trading partners.

Other petrol parameters examined in this 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 increased greenhouse gas emissions, 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 places⁵. 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 cancer⁶. Bladder cancer⁷ and breast cancer¹⁵ are also linked to vehicle emissions. Children are susceptible to a range of additional effects, including low birth weight⁸, long-term effects on lung function⁹, childhood leukaemia^{10, 11}, and childhood brain tumours¹². Living in proximity to highways has also been linked to a higher incidence of dementia in the elderly¹³.

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 alone¹⁴. 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 death¹⁸. 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 Australians²⁴—more than the national road toll from accidents—at an estimated economic cost of up to \$11 billion²⁵.

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 NO_x and CO, 28 per cent of VOC emissions and 30 per cent of fine emissions of PM^{26, 27}. Analysis has indicated health impacts from vehicle emissions cost the Australian economy approximately \$3.9 billion²⁸. Existing emission 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 risk²⁹. A 2010 study estimated that non-road diesel engines emit around 13,500 t of PM₁₀ each year, which is of a similar magnitude to emissions from on-road vehicles³⁰.

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 (per cent 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 emission 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 7³¹). 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 NO_x emissions, 2007–2016

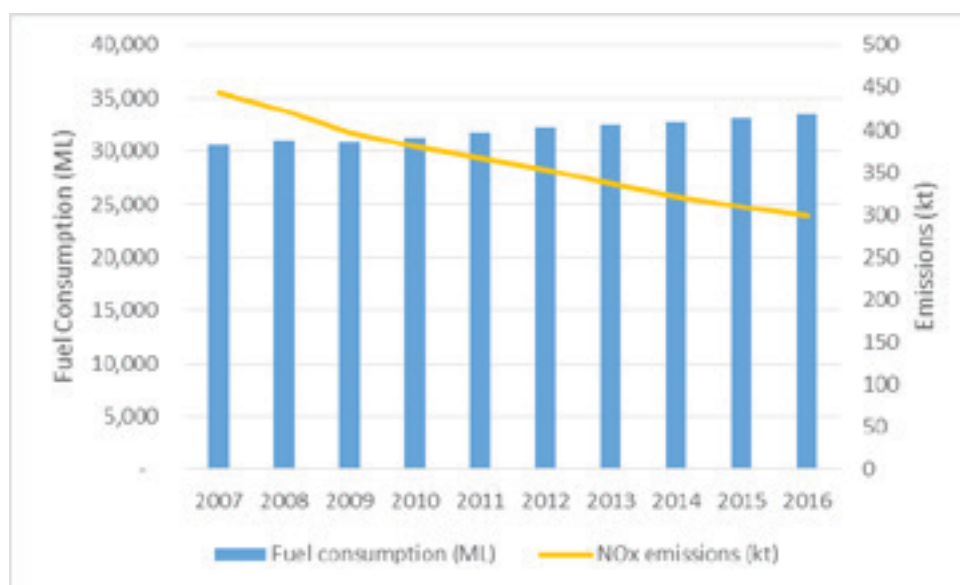
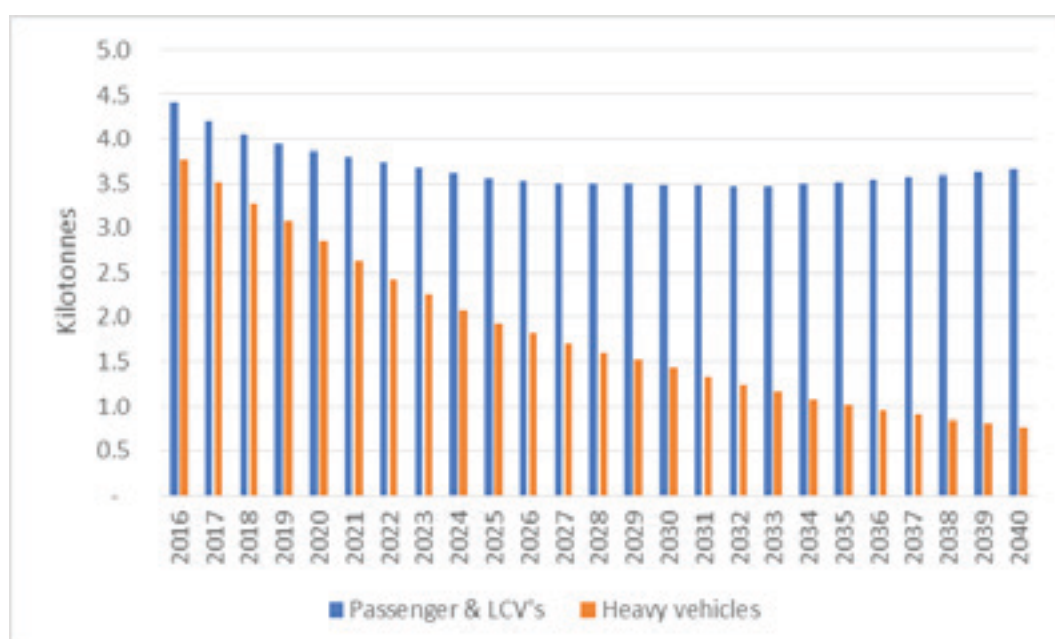


Figure 7: Projected PM₁₀ emissions from motor vehicles by category of vehicle, 2016–2040



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 benefits³².

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 2016³³), 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 primary 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 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, exacerbated 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 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 scientific 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 particulate matter from 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 ³⁸ .
sulfur oxides (SO _x)	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 the 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.

Improved quality fuel plays a role in facilitating the introduction and market penetration of some technologies used in more fuel-efficient vehicles. This fuel efficiency gain can contribute to offsetting the minor increase in greenhouse gas emissions from refineries that will result from an increase in energy to produce improved petrol quality.

The consideration of fuel efficiency standards is the responsibility of the Department of Infrastructure, Regional Development and Cities and is outside the scope of this RIS.

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 Australia's fuel was of an appropriate quality to support the move to Euro 2 and Euro 3 emission standards in 2003 and 2005 respectively. Australia has tightened emission standards since that time, and presently all light vehicles (up to 3.5t gross vehicle mass) manufactured from November 2016 must comply with the Euro 5 emission standards³⁹, 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 emission standards.

The Department of Infrastructure, Regional Development and Cities proposes to adopt the Euro 6/VI emission 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 emission 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 Australia⁴⁰. For example, the Federal Chamber of Automotive Industries (FCAI) 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 engine³². Independent automotive technical experts ABMARC broadly found that higher than 35 per cent aromatics in petrol present a risk to advanced engine and emissions system (Euro 6) operation, however they could not draw a conclusion on an appropriate aromatic limit based on the evidence available.

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

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 injectors⁴¹.

Some advanced vehicle technologies, including advanced emission control systems and certain fuel-efficient engine technologies, require higher-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.

Vehicle manufacturers have submitted 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 AIP does not agree that Euro 6 vehicles require 10 ppm sulfur petrol to operate effectively⁴², some vehicle manufacturers advise that they are unwilling to introduce the latest model Euro 6 vehicles to the Australian market unless fuel quality is improved⁴³.

In addition to producing higher pollutant emissions, the FCAI submits that fuel with greater than 10 ppm sulfur will also cause increased wear and degradation of engine and emission systems components, including:

- 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 CO₂ emission increases
- increased oil consumption
- piston and cylinder bore seizures⁴⁴.

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

Independent technical expert consultancy ABMARC has 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 attributes this reluctance to the risk that vehicle manufacturers may expose themselves to high warranty costs and reduced customer satisfaction⁴⁵.

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 market⁴⁶. 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

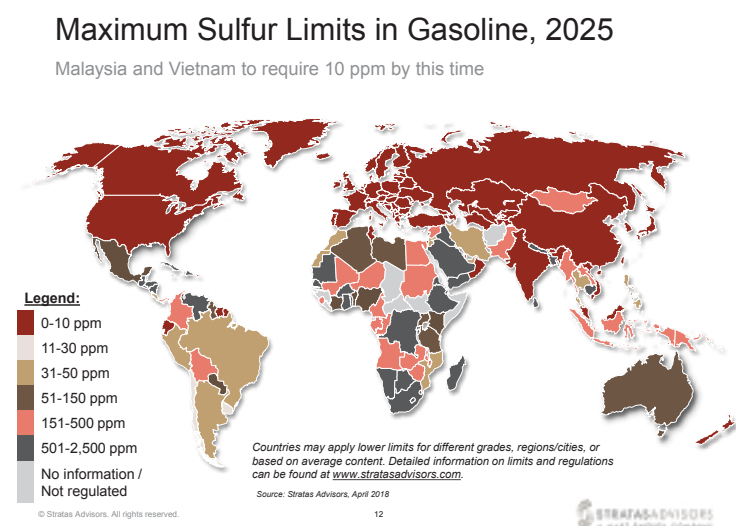
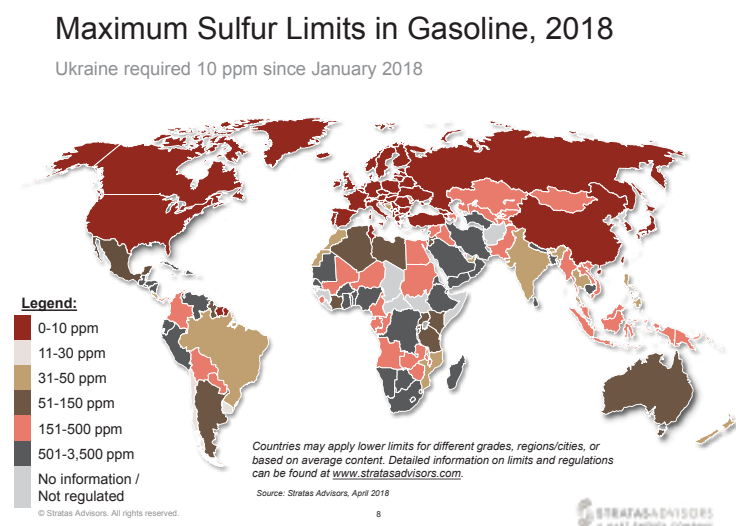
Australia's fuel quality does not align with that of our major trading partners, particularly for petrol.

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 by 2025. Sulfur in petrol in the European Union (EU), China and the USA is already limited to 10 ppm.

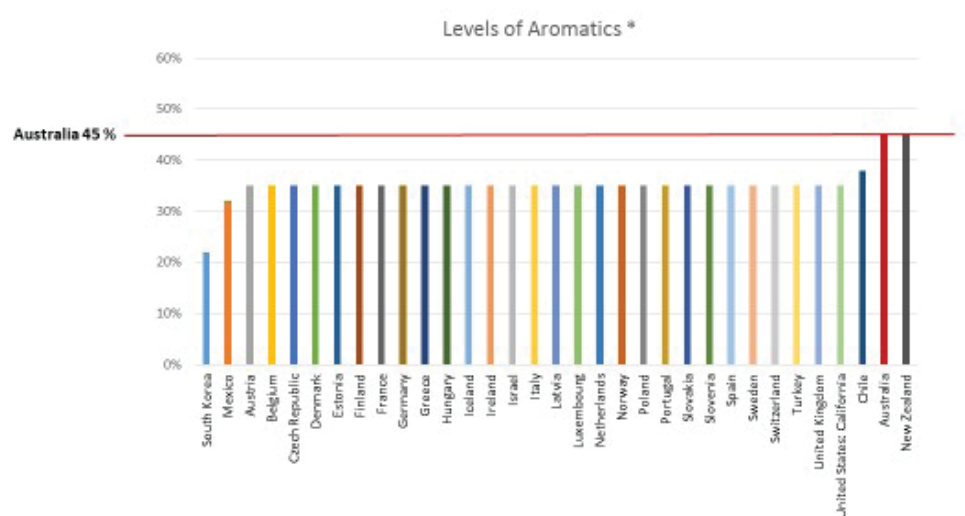
Since the release of the *Better fuel for cleaner air* draft RIS in January 2018, Australia has slipped three places to rank 73rd in the 2018 'Top 100' world ranking of petrol quality (based on regulated sulfur content⁴⁷) and is the lowest ranked of the 36 OECD member countries (Figure 8). A regulated 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 OECD⁴⁸ (Figure 9).

Figure 8: Maximum global sulfur limits on gasoline, 2018 (top) and 2025 (bottom)



Source: © Stratas Advisors, July 2018

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 so⁵⁰.

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 vehicles⁵¹) 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 emission 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 emission 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 FCAI, which advised that to offer vehicles with world-class pollutant emission 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 current 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 2016⁵², 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 five 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 four to six years). Detailed planning of upgrades takes place several years in advance.

Australia's petroleum refineries supply around 40–50 per cent of Australia's total liquid fuel needs and more than 60 per cent of our petrol⁵³. 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 AIP have made an in-principle offer to supply 10 ppm sulfur petrol by 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.

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 impact⁴. 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 lower quality fuel, which has greater health and environmental externality than higher-quality fuel.

The human health and environmental impacts from exposure to noxious 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 community⁵⁴.

Without government intervention, noxious air pollution 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 vehicle 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.

Similar 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 standards 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 (where appropriate).

4. What policy options were considered?

This chapter explores the policy reform options considered in this RIS. These revised and refined policy options were developed following detailed analysis of stakeholder submissions on the *Better fuel for cleaner air discussion paper*, draft RIS and further direct 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 AIP advised that, due to the costs associated with implementation, this option would likely close the domestic 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 risks⁵⁶.
- 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 AIP, the New South Wales Government, and Doctors for the Environment Australia. The AIP 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 implementing the necessary capital works. Their view was supported by independent fuel industry experts⁵⁷.
- Inclusion of Fuel Standard Option F. The AIP, representing domestic refinery operators, proposed an additional option of 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 informed the policy options of this RIS are included in Chapter 6, Chapter 7 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’ refers to the fuel standards (determinations), information standards and guidelines.

Table 3: Summary of proposed major policy amendments

Legislative instrument	Description	Section	
Fuel standards	<p>Fuel Standard (Petrol) Determination 2001</p> <p>Fuel Standard (Automotive Diesel) Determination 2001</p> <p>Fuel Standard (Autogas) Determination 2003</p> <p>Fuel Standard (Ethanol E85) Determination 2012</p> <p>Fuel Standard (B20 Diesel Biodiesel Blend) Determination (new)</p>	<p>A range of options for changes to fuel parameters in each of the fuel standards:</p> <p>–Option A—Australia’s fuel standards remain in effect in their current form (business as usual). Petrol and diesel standards are retained.</p> <p>–Option B—Fuel standards are revised to align with the recommendations of the Hart Report and to harmonise with European standards⁴⁶. 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.</p> <p>–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.</p> <p>–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).</p>	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 <i>Fuel Quality Information Standard (Ethanol) Determination 2003</i>	4.3
Guidelines	<i>Register of Prohibited Fuel Additives</i>	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 proposed amendments to the fuel quality standards. Four policy options were considered. These are summarised below and outlined in more detail in Table 4 and Appendix B.

4.2.1. Option A—no change to the fuel quality standards

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

4.2.2. Option B—harmonise with the European Union

Fuel quality standards are revised to align with the recommendations of the Hart Report⁴⁶ 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 one 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.

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

Table 4: Significant parameter changes for each fuel under the proposed options

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	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)	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
F Reduction of sulfur to 10 ppm in all petrol by 2027	RON 91 95 MON 81 85 Sulfur 10 10	Pool average for aromatics 35% in 2022 In ethanol, sulfur 30 ppm and inorganic chloride 32 ppm	Minor amendments See Appendix B	Minor amendments See Appendix B	N/A Sulfur 10 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.

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 farmers⁵⁸. 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 RON⁵⁹ 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* and draft RIS. 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 the scope of the diesel standard is expanded to include diesel used for non-road purposes, for example in stationary engines such as generators, off-road vehicles (such as 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.

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

If scope were to be extended, 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 *Better fuel for cleaner air discussion paper* and draft RIS, 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. The proposed definition is:

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 Australian Government Department of 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 AIP 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 AIP has also offered to implement an interim step for sulfur and aromatics to safeguard current market fuel quality. From 2021, this would be industry based voluntary reporting 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 per cent pool average (45 per cent 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 per cent pool average (45 per cent cap).

* 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.

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.

4.3. Proposed amendments to fuel quality information standards

The then Minister for the Environment and Energy (the Minister) 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 *Register of Prohibited Fuel Additives*. 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 noted that consideration should be given to establishing a *Register of Prohibited Fuel Additives* and that the following types of fuel additives could be considered for inclusion:

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 lead⁶³ 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 NO_x emissions and ash formation and can adversely affect vehicle emission systems.
3. Polychlorinated n-alkanes (chlorinated paraffins) are harmful, bioaccumulative and toxic compounds.

The FCAI supports the inclusion of tetraethyl lead, MMT, ferrocene, NMA and polychlorinated n-alkanes on the *Register of Prohibited Fuel Additives*. The FCAI also notes that MMT was a prohibited additive under the *Worldwide Fuel Charter*, because of the damage it causes to engines and sensors. The AIP recommends further testing of the operability impacts of NMA-blended petrol and supports the inclusion of NMA on the list of prohibited substances. The AIP 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. Prior to an additive being included on the register, a comprehensive legislative process would need to be implemented. The *Fuel Quality Standards Act 2000* requires the Minister to first publish a notice of the intention to establish or amend the register, and invite interested parties to make a submission on the proposal. As part of the decision making process, the Minister is required to consult the Fuel Standards Consultative Committee and take any recommendations from the Committee, as well as all submissions received, into account. If, after taking into account all of this information, the Minister decides to list an additive on the register, the decision must be published and all parties that made a submission notified of the decision.

* 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 5)—and identifies differential impacts on different stakeholder groups, including consumers and regional Australia.

The main findings of the analysis are:

- 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 RIS.
- 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 minor fuel price impact will be 0.9 cents per litre (cpl) in 2027, rising to 1.0 cpl in 2030 and will then decline.
 - 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. It is expected that industry will absorb the capital costs.
 - 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 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 minor fuel price impact will be 0.9 cents per litre (cpl) in 2027, rising to 1.0 cpl in 2030 and will then decline.
 - 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 and it is expected that industry will absorb the capital costs. 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.

* 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 seven 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) and if implemented, will return \$1.22 to \$1.29 for every \$1 of cost.
- 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 CBA⁶⁴ 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)

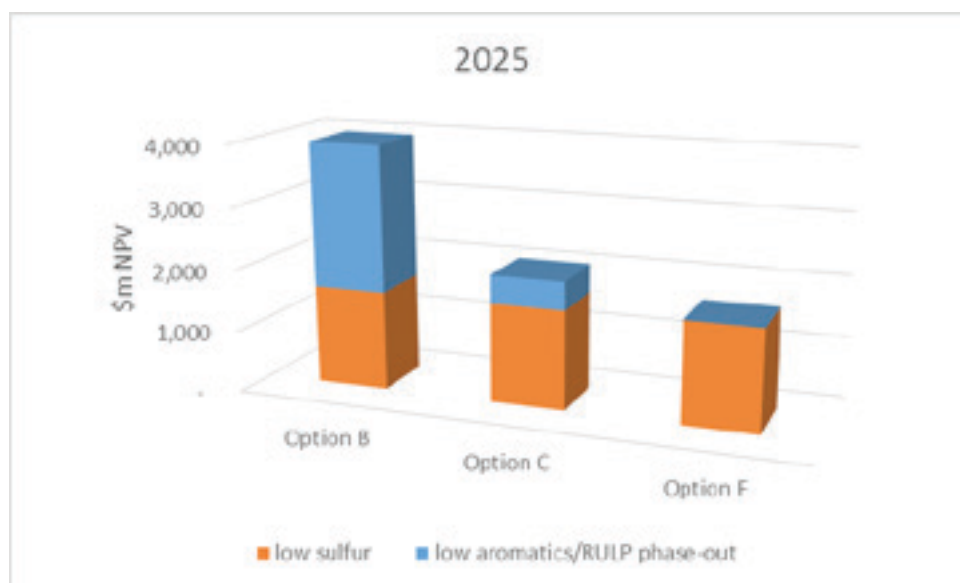


Table 6: CBA results summary for Options B, C and F
Implementation date 2022

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

Implementation date 2025

Present value of costs and benefits relative to BaU (\$ million)				
	Option B	Option C	Option F	Option F
Costs				
Refinery capital costs	-\$642.1	-\$642.1	-\$609.7	-\$609.7
Refinery operating costs	-\$2,078.2	-\$1,087.3	-\$777.8	-\$777.8
Fuel price impact—imported fuel (91 RON phase-out)	-\$914.7	\$0.0	\$0.0	\$0.0
Fuel price impacts—imported fuel (revised fuel standards)	-\$330.4	-\$326.1	-\$254.6	-\$254.6
Fuel price impacts—wholesale and retail margins (foreign companies)	-\$77.9	\$0.0	\$0.0	\$0.0
Fuel demand impacts (increased fuel prices)	-\$19.3	-\$2.2	-\$1.6	-\$1.6
Increased GHG emissions (refinery upgrades)	-\$62.9	-\$49.8	-\$49.8	-\$49.8
Industry compliance (revised standards)	-\$5.3	-\$5.3	-\$3.6	-\$3.6
Company tax impact (demand changes, foreign entities)	-\$2.3	-\$1.1	-\$0.8	-\$0.8
Government administration costs	\$1.1	\$0.0	\$0.0	\$0.0
Total costs	-\$4,132.0	-\$2,113.8	-\$1,698.0	-\$1,698.0
Benefits / avoided costs				
Avoided health impacts	\$2,142.4	\$2,322.0	\$2,014.0	\$2,014.0
Reduced fuel consumption (phase-out of 91 RON)	\$995.1	\$0.0	\$0.0	\$0.0
Reduced GHG emissions (phase-out of 91 RON)	\$85.1	\$0.0	\$0.0	\$0.0
Reduced particle filter failure (lower aromatics)	\$115.8	\$115.8	\$0.0	\$0.0
Reduced catalyst failure (ultra-low sulfur)	\$112.6	\$112.6	\$112.6	\$112.6
Impacts of price changes on retailer producer surplus	\$29.5	\$0.0	\$0.0	\$0.0
Total benefits / avoided costs	\$3,480.5	\$2,550.4	\$2,126.6	\$2,126.6
NPV	-\$651.4	\$436.6	\$428.7	\$428.7
BCR	0.84	1.21	1.25	1.25

Implementation date 2027

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

The estimated pass through price impact for the improved fuel standards has been revised from the draft RIS. The revised estimate reflects the implementation date of 2027 and the absorption of the capital costs by industry. This means that the revised estimates of price impacts to motorists does not include the additional 1.0 cpl that was attributed to capital cost, and the revised estimates are subsequently reduced by 1.0 cpl and become 0.9 cpl increase in 2027, rising to 1.0 cpl in 2030 and will then decline after that as lower sulfur fuel becomes the benchmark in the region.

* Australian Institute of Petroleum. 2017 dollars.

† As described in Marsden Jacob 2017.

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.

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.

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*

Fuel Parameter	Cost of producing fuel (operating)			Cost of importing fuel			Price impact on motorists			Relevant option
	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

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.

Under business as usual, health 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.

* Ranges indicate change in costs/prices over time.

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.

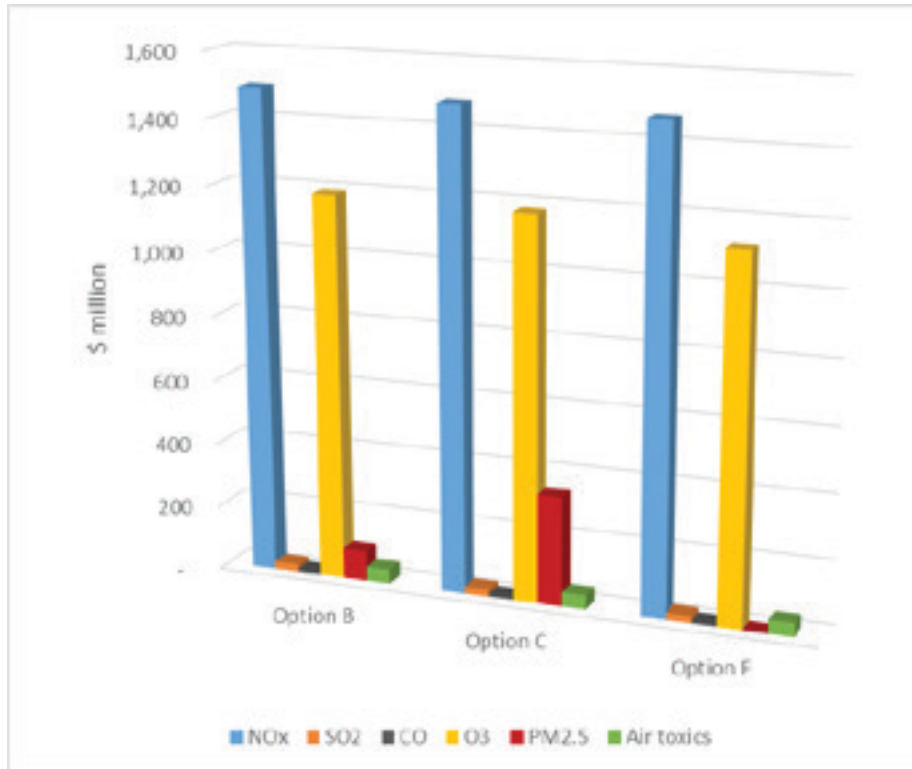
Reducing the regulated limit of sulfur in petrol under options B, C and F is expected to lead to significant reductions in NO_x, VOC and CO emissions from motor vehicles. The reduction in NO_x emissions is estimated to be approximately 22 per cent in 2022, increasing to about 29 per cent by 2030, with 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 NO_x emissions, are the major pollutants contributing to ozone formation.

The health benefits of Option C are estimated to be higher than those for Options B and F. This is due to reduced particulate emissions as a result of lower aromatics in petrol under Option C compared to Options B and F. 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*.

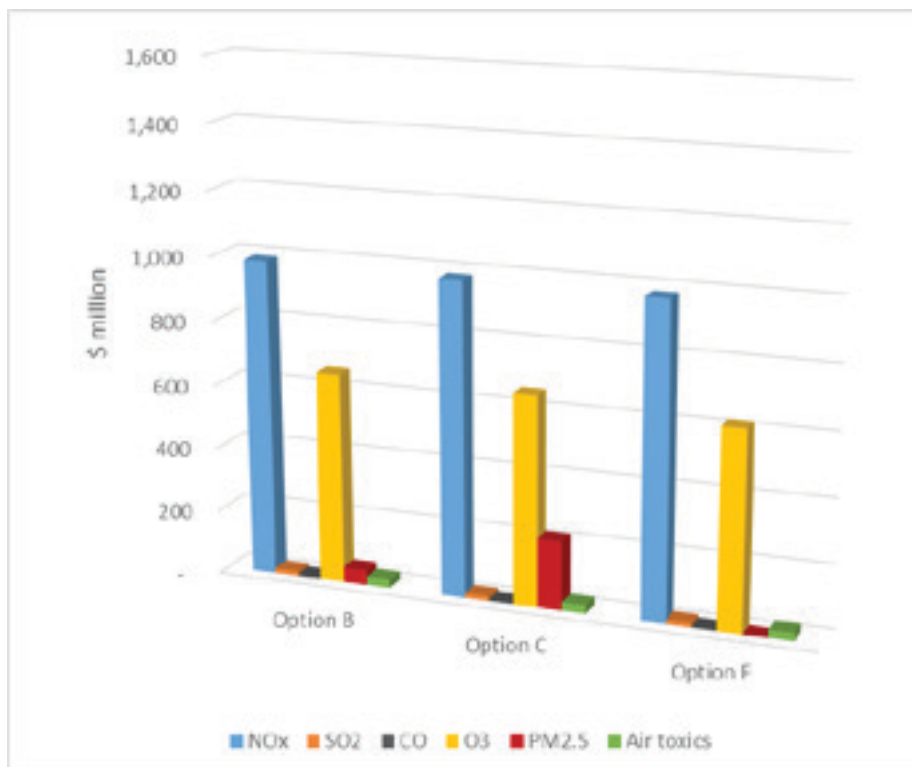
* The pool average aromatics level under Option C is estimated to be about 26 per cent, compared with 28 per cent under BaU (Option A).

Figure 11: Breakdown of avoided health costs, by pollutant, 2020–2040, at NPV (with implementation date 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.

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.

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.

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). As noted above, the slightly higher estimated health benefits for Option C are due to reduced particulate emissions as a result of lower aromatics under Option C compared to Options B and F.

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 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	1,598,132	4,444,456

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	-\$599.9
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	-\$747.8
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 data from the Australian Bureau of Statistics (ABS) (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 ABS 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 appropriate to regional areas and 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 emission standards for cleaner air* and *Improving the efficiency of new light vehicles*—being undertaken by the Department of Infrastructure, Regional Development and Cities.

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 emission 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 emission 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 emission 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 emission 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 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 (one to four per cent) and do not alter the relative rankings of the options. The values provided in the table are for a 2027 commencement and consider the years 2025 to 2034—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	\$444	\$159	\$123
Total	\$ 0	\$851	\$427	\$346

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 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 AIP (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 (three 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 due to a lack of specific data 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 (<PM₁)
- 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 the RIS were not included in the CBA, primarily because the costs associated with them were considered relatively minor.

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.

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 <i>Register of Prohibited Fuel Additives</i>	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.

Although an increase in greenhouse gas emissions was estimated under Options C and F due to the higher energy requirements at refineries to produce low sulfur fuel, improved fuel quality plays a role in facilitating the introduction and market penetration of some technologies used in more fuel efficient vehicles. The contribution of these emissions reductions to offsetting the increase in refinery emissions will continue to grow as new, fuel efficient vehicles enter the fleet and replace older, higher emissions vehicles.

Under Option B, phase-out of regular unleaded petrol would reduce greenhouse gas emissions from both new and, to a lesser extent, existing vehicles, resulting in a greater decrease in greenhouse gas emissions.

Bringing forward the implementation date 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 Decrease in GHG emissions: \$12 million to \$46 million	Partial \$1.9 billion to \$3.1 billion avoided health impacts Increase in GHG emissions: \$40 million to \$67 million	Partial \$1.6 billion to \$2.7 billion avoided health impacts 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	Partial Only change to sulfur, no other parameters
5. Minimise regulatory burden	No Regulatory burden \$851 million	Partial Regulatory burden \$427 million	Yes Regulatory burden \$346 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 RIS.

‡ The additional energy production may be offset by the uptake of more fuel efficient vehicles over time.

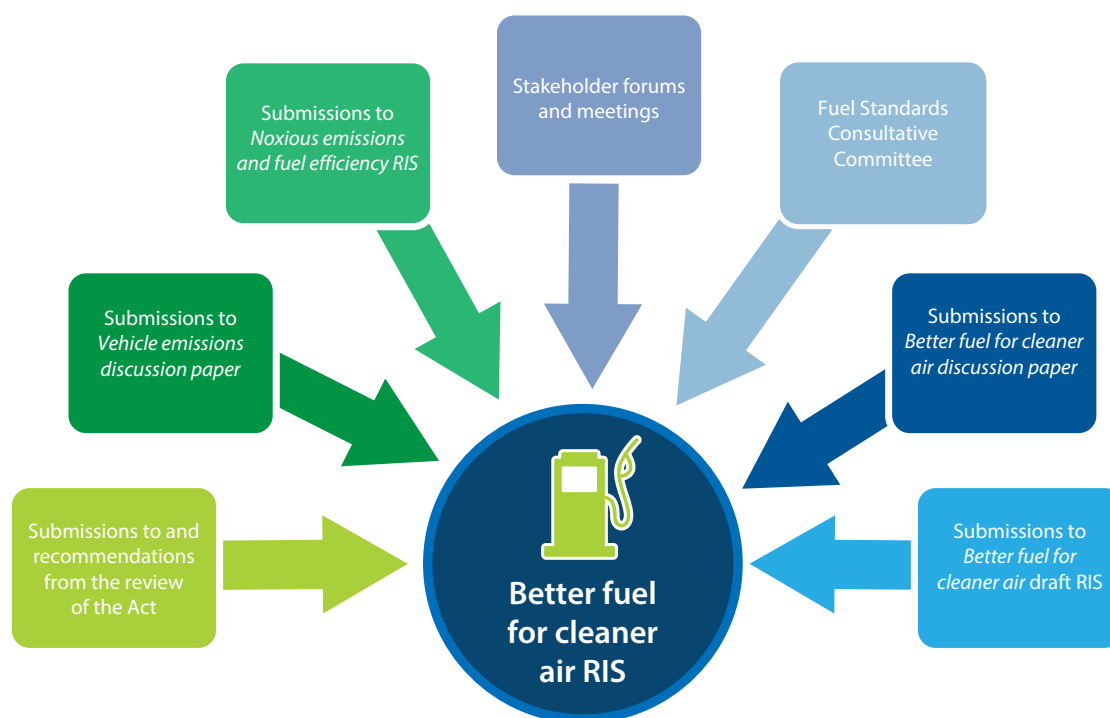
6. Consultation

This chapter provides an overview of the consultation process and stakeholder views that have shaped the policy options in the RIS.

The feedback received has served as a valuable resource to inform the development of this RIS. Non-confidential submissions to the Discussion Paper and draft RIS will be made available on the Department's fuel quality webpage at environment.gov.au/protection/fuel-quality.

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

Figure 12: Consultation processes for this RIS



6.1. Review of the Fuel Quality Standards Act

Two rounds of stakeholder consultation (an issues paper in 2015 and a draft report in 2016) were held during the review of the *Fuel Quality Standards Act 2000*. In responding to the review, many stakeholders provided their perspectives on potential changes to the fuel standards, which are legislative instruments under the Act. This consultation provided the foundation for options proposed in the draft RIS. Key views from stakeholders included:

- The FCAI and a range of other stakeholders argued 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 FCAI stated that meeting Euro 6 emission standards will require maximum sulfur limits to be set at 10 ppm.

- The AIP 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 emission standards.
- The Australian Automobile Association (AAA) stated 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

6.2. Vehicle emissions discussion paper

The Ministerial Forum on Vehicle Emissions released the *Vehicle emissions discussion paper* in February 2016. This discussion paper sought views on possible amendments to the fuel standards as part of a broader suite of measures to reduce vehicle emissions in Australia. Eighty submissions were received from a range of stakeholders, including vehicle manufacturers, fuel suppliers, transport operators, and consumer, health and environmental groups. Vehicle manufacturers, petroleum refiners and motoring consumer groups expressed similar views to those they had 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/vehicles/environment/forum/index.aspx

6.3. Noxious emissions RIS and fuel efficiency RIS

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

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

A number of stakeholders, including motor vehicle and component manufacturers, and health advocates, indicated a preference for the proposed reforms to be considered with respect to the amendments to the fuel standards.

6.4. Stakeholder forums

The Ministerial Forum on Vehicle Emissions held three face-to-face meetings with major stakeholders to hear their views, facilitate discussion and identify opportunities.

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

6.5. Fuel Standards Consultative Committee

The *Fuel Quality Standards Act 2000* established the Fuel Standards Consultative Committee (the Committee) to provide advice on setting fuel quality standards and amendments to 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 advice provided to the Government is comprehensive and considers a broad range of views.

As required under section 24A(1) of the Act, the Committee is consulted on the fuel standards and their technical parameters.

In early 2017, the Department of the Environment and Energy sought views from the Committee on the policy options for the draft RIS, and on the proposed scope and methodologies for the cost-benefit analysis. The Committee will continue to provide advice to the Minister on future amendments to the fuel quality standards.

6.6. Better fuel for cleaner air discussion paper

Taking into account feedback received from stakeholders on the review of the *Fuel Quality Standards Act 2000*, the *Vehicle emissions discussion paper*, the *Vehicle emissions for cleaner air* RIS, the *Improving the efficiency of new light vehicles* RIS, and stakeholder meetings and forums, the Department of the Environment and Energy 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 key stakeholders did not differ from those stated in earlier rounds of consultation, except that the AIP and member refineries proposed an alternative option (Option F).

The discussion paper and submissions are available at environment.gov.au/protection/fuel-quality

6.7. Better fuel for cleaner air draft RIS

The Department of the Environment and Energy released the *Better fuel for cleaner air* draft regulation impact statement in January 2018. Consultation closed on 8 March 2018.

Stakeholder feedback provided through the preceding consultation processes influenced the design of each policy option proposed in the draft RIS. The intention of the options proposed was to minimise negative impacts on the regulated community while maximising benefits to human health and the environment.

Several stakeholders who responded formally to the discussion paper also provided submissions on the draft RIS, including the AIP, the AAA, the FCAI, and peak health and environmental advocacy groups. One-on-one meetings with key stakeholders were also held during the consultation period to hear their views.

The *Better fuel for cleaner air* draft RIS is available at environment.gov.au/protection/fuel-quality. A summary of stakeholder views is outlined at Appendix E.

Chapter 7 describes what was learned from consultation on the draft RIS.

7. The best option

7.1. Consultation outcomes

Fifty-five submissions were received in response to the draft RIS from the petroleum and alternative fuel industries, automotive and aviation industries, industry associations, motoring consumer groups, health and environmental groups and members of the public.

A detailed summary of submissions is provided at Appendix E. Additionally, forty-four submissions provided as public documents will be made available on the Department's website at: environment.gov.au/protection/fuel-quality. Eleven submissions were provided in confidence and are not published.

7.1.1. All options received some stakeholder support

Half of the submissions received stated a preferred policy option.

Option B was supported by approximately 60 per cent of submissions which expressed a preference, mainly from the automotive industry and health groups. Supporters chose Option B because it would deliver maximum health and environmental benefits, access to the latest engine technologies and the strongest alignment with European standards. While it would deliver maximum benefits, Option B also required the highest costs and was modelled overall as a net cost to the economy. For this reason, Option B was not a focus of this assessment and is not preferred.

Option F, proposed by the AIP, was the second most favoured alternative. It was supported by the AIP, its refinery members and the Motor Trades Association of Australia. Supporters chose Option F because it would ensure the best prospects of refinery viability while still delivering health and vehicle technology benefits.

Support for Option C was expressed in six submissions, either outright or in equal preference to either Option B or Option F. Supporters of Option C noted it would be a cost effective way to achieve strong health and environmental outcomes. Compared to Option F, Option C would deliver higher benefits to the community, albeit at a higher cost to refineries to reduce aromatics in petrol.

The major costs and benefits of the options presented in this RIS result from proposed changes to three petrol parameters; reducing sulfur, reducing aromatics and phasing out lower-octane regular unleaded petrol. The formulation of the three reform options and consultation centred on possible changes to these parameters.

The Department met with a broad range of stakeholders during the draft RIS consultation period and following receipt of submissions. In particular, the Department convened a number of face-to-face meetings with the AIP and the FCAI to discuss technical aspects of the proposals for the three petrol parameters.

7.1.2. Sulfur

The proposal to reduce sulfur to 10 ppm was supported almost unanimously—only one submission (confidential) expressed a preference to maintain current levels of sulfur in petrol. The automotive industry stated reducing petrol sulfur levels to 10 ppm is critical to achieve emissions standards and enable correct operation of advanced engines and emissions control systems. Refineries accept this, but reiterated the financial impacts and indicated that reducing sulfur levels only, not aromatics in addition, is the only scenario they believe provides the best prospects for all refineries to remain viable. Both the automotive and refinery industries are broadly aligned on a 2027 implementation date.

7.1.3. Octane

The proposal to phase out regular unleaded (91 RON) petrol under Option B was supported in many submissions because it would achieve a more significant reduction in greenhouse gas emissions. In addition, the FCAI supported phasing out regular unleaded petrol because it represented a higher degree of harmonisation of Australian and European petrol. Neither the AIP nor the Australian Automobile Association supported phasing out regular unleaded petrol, noting the cost this would impose on refiners, motorists and the community. Ultimately the costs of phasing out regular unleaded petrol outweigh the technology, health and environmental benefits that could be achieved, leading the Department to consider the retention of regular unleaded petrol as an element of the best option.

7.1.4. Aromatics

The proposal to reduce the aromatics limit in petrol from 45 per cent to 35 per cent (in Options B and C) emerged in consultation as the key point of difference between the refinery and automotive industries. The automotive industry stated a limit of 35 per cent is critical for one type of high-efficiency engine technology (gasoline direct injection) to meet Euro 6c and Euro 6d particulate number emission limits. The industry also reiterated its general concern that higher levels of aromatics can increase engine combustion chamber deposits with a resulting increase in particulate emissions. On the other hand, the AIP questioned the draft RIS estimate of the capital cost to refineries to reduce aromatics, stating it may underestimate the true costs depending on the refinery solution to reduce aromatics. AIP also stated it would not be feasible to blend high octane (98 RON) petrol containing less than 35 per cent aromatics without octane enhancing additives. Additionally, AIP expressed the view there was insufficient evidence vehicles require a lower aromatic limit.

Following receipt of submissions, the Department held several face-to-face meetings with AIP and FCAI to seek an acceptable outcome for aromatics, including a joint technical meeting with the automotive industry and domestic refiners to discuss aromatics in detail. Through these meetings, refiners and automotive companies agreed heavy aromatics (containing nine or more carbon atoms) are the main contributors to engine operability issues and emissions. It was also noted that reducing the overall level of aromatics in petrol may not directly control the level of problematic heavy aromatics. Both industries maintain they face substantial risks if their stated position on aromatics is not appropriately considered. No definitive evidence for an appropriate reduced limit of aromatics—balancing engine operability and emissions outcomes with refinery viability—was identified during consultation. While the two groups did not reach consensus on a feasible approach for aromatics within the consultation timeframe, they agreed to work collaboratively to develop a suitable way forward.

To support consultation and consideration of aromatics, the Department obtained independent technical advice from ABMARC on the impact of aromatics on vehicle operation, particularly risks to Euro 6 vehicles using petrol with more than 35 per cent aromatics. The advice (ABMARC 2018) considered relevant stakeholder information, literature and international experiences. ABMARC broadly found higher than 35 per cent aromatics present a risk to advanced engine and emissions system (Euro 6) operation, but stated that lowering aromatics generally may not guarantee reduced particulate (particulate mass and particle number) emissions. It identified more detailed aromatics parameters, such as the proportion of heavy aromatics, volatility and distillation characteristics have a more direct influence on particulate emissions. ABMARC could not draw a conclusion on an appropriate aromatic limit based on the evidence available.

A number of technical issues about the impact of aromatics on vehicles and vehicle emissions, and challenges to refineries to produce low aromatic, low sulfur, high octane petrol were identified by stakeholders during consultation. Understanding the options available to address these issues is required before the best approach for aromatics in Australian petrol can be identified. The issues are:

- How feasible it is for Australian petrol importers and producers to meet a reduced aromatics limit without the use of octane-enhancing additives.
- Whether, and under what conditions, non-aromatic octane-enhancing additives could be allowed or should be promoted for use in Australian petrol.
- How Australian climatic conditions and seasonal variations affect particulate emissions. For example:
 - Particulate emissions tend to be highest under cold running conditions, more frequent in climates such as Europe than in Australia.
 - Australian petrol typically has lower aromatic content in winter due to the addition of butane and other volatile components.
 - Australia experiences a broad range of climates during its winter and summer, and petrol composition is understood to vary to meet the requirements of regional climates.
- What role detergents play in reducing and reversing the formation of combustion chamber deposits, and the subsequent impact on particle emissions.
- How other engine technologies—for example, engines which combine port fuel injection and gasoline direct injection—are affected by aromatics.
- How on-board diagnostic limit thresholds—which define how readily a vehicle will indicate a malfunction to its driver—could be set to enable durable vehicle operation with higher than 35 per cent aromatics, without activating unnecessary malfunction warnings.

In addition to an aromatics limit, the Australian petrol standard sets an allowable pool average for petrol, currently 42 per cent. In its submission, AIP identified the measured pool average of petrol is lower than 35 per cent, a position supported by confidential information provided on behalf of the four refineries.

7.1.5. Other points raised in submissions

AIP stated the draft RIS incorrectly assumed no refinery closures under any reform option (on the basis all relevant costs are taken into account in the cost benefit analysis). In support of its view, AIP stated a number of costs and constraints which it believed to be underestimated or lacking from consideration. In response, the Department highlights that modelling on all refineries remaining open provides for an assessment of the full investment costs.

The petroleum and automotive industries cautioned against referring to the options as ‘harmonising’ with other countries’ standards. They noted Australia’s ban on Methyl Tertiary Butyl Ether (widely used in Europe and Asia to achieve octane without increasing aromatics) and the possible retention of 91 RON petrol (phased out in Europe) are fundamental differences.

7.2. What is the best option from those considered?

The best option is based on Option E, including a review mechanism to potentially achieve Option C. It sets a balanced path for improving Australia’s petrol and commits to ongoing consultation with industry and other stakeholders to revise the other fuel standards, parameters and associated instruments. The option is to:

- Reduce sulfur in petrol to 10 ppm from 1 July 2027.
- Retain regular unleaded petrol.
- Reduce the pool average of aromatics in petrol from 42 per cent to 35 per cent, effective 1 January 2022.
- Review the maximum aromatics limit in petrol by 2022 to set a reduced limit by 2027 or establish an alternative solution. The scope of the review will be developed in consultation with industry and reporting will be appropriately staged.
- Consult further with industry on the remaining parameters in the fuel standards covered by the RIS to finalise them prior to 1 October 2019. The instruments are:
 - Fuel Quality Standards Regulations 2001
 - Fuel Standard (Automotive Diesel) Determination 2001
 - Fuel Standard (Biodiesel) Determination 2003
 - Fuel Standard (Autogas) Determination 2003
 - Fuel Standard (Ethanol E85) Determination 2012
 - Fuel Standard (B20 Biodiesel Blend) Determination (proposed)
 - Fuel Quality Information Standard (Ethanol) Determination 2003
 - Fuel Quality Information Standard (Ethanol E85) Determination 2012
 - *Fuel Quality Standards (Register of Prohibited Fuel Additives) Guidelines 2003.*

7.2.1. Benefits and costs of the best option

The recommended option provides for a suitable approach towards aligning with European standards, while allowing time for further detailed assessment of an appropriate limit for aromatics in Australian fuel. It enables greater fuel choice and minimises fuel costs to motorists. Fuel price impacts are estimated to be 0.9 cents per litre in 2027, increasing to 1.0 cents per litre in 2030 and will then decline after that as low sulfur fuel becomes the benchmark in the region. This is well within the range of day-to-day price fluctuations which can be up to 13 cents per litre.

Euro 6 passenger vehicles are often fitted with other advanced engine and emission technologies that provide for a fuel efficiency gain (compared with average Euro 5 vehicles). Low sulfur petrol will enable the uptake of some of these technologies and therefore indirectly contribute to a fuel efficiency benefit. The expected fuel efficiency improvement between an average Euro 5 and an average Euro 6d vehicle is around 13 per cent which could provide a \$75 annual saving to motorists.

Emission reductions from improved fuel efficiency will contribute to offsetting the increase in greenhouse gas emissions in refineries (from increased energy demand). These emission reductions will continue to grow as more fuel efficient vehicles enter the fleet and replace older, higher emissions vehicles.

The potential petrol price impact associated with setting an aromatics limit beyond 2022 will depend on the approach, to be informed by the outcome of the aromatics review that will conclude by 2022. The projected price increase, based on a blending solution to achieve a limit of 35 per cent aromatics, is estimated to be 0.3 cents per litre.

The best option will achieve significant and positive health and environmental outcomes. The option balances the benefits of reducing sulfur with maintaining refinery viability. It provides for a net benefit outcome achieved by the benefits of Option F, coupled with a plan for action to review aromatics, with a view to reduction as appropriate to Australian conditions. This would avoid \$1.7 billion in health and vehicle maintenance costs by 2040. Total benefits would increase to \$2.1 billion by 2040 if a further reduction in aromatics was realised. The total benefits include annual avoided health costs of \$340 million per year (for reducing sulfur) to \$392 million per year (for reducing sulfur and the aromatic limit) by 2030.

While it has a higher net present value than Option F, Option C in its entirety is not preferred. If, along with a reduction in sulfur, aromatics were also limited to 35 per cent, it is technically uncertain how Australian refineries and fuel importers would achieve the octane required in premium petrol, particularly 98 RON.

The best option better aligns key parameters—sulfur and aromatics—in Australian petrol to values in use worldwide to support the latest engine and emissions control technologies. Regulation of new fuel parameters from 2027 would not stop improved fuel being supplied earlier where it makes sense for businesses to do so.

The best option does not propose Australia's fuel parameters be fully aligned with those of Europe or any other jurisdiction. Fuel parameters often vary between countries depending on particular circumstances. For example, and as noted above, petrol octane ratings are achieved in Europe by the addition of MTBE and in the US by the addition of ethanol, neither of which have widespread support for use in Australia. As another example, our hotter climate requires Australian petrol to have different volatility and Reid vapour pressure parameters to Europe, which experiences cooler summers and much colder winters.

7.2.1.1 Sulfur

Implementation of 10 ppm sulfur by 2027 is preferred over 2022 and 2025. The later date achieves significant health and environmental benefits while maximising the viability of domestic refineries which represent significant infrastructure. Refineries require relatively long lead times (six to seven years) to plan and implement major capital projects, such as would be required to reconfigure existing domestic refineries to produce petrol with less than 10 ppm sulfur. Implementation from 2027 represents the best option for the viability of domestic refineries. For these reasons, implementation of 10 ppm sulfur in 2027 is identified as the best option from a system-wide perspective.

7.2.1.2 Octane

As noted above, the costs of phasing out regular unleaded petrol outweigh the technology, health and environmental benefits this would deliver. For this reason, phase out of regular unleaded petrol was dismissed as an element of the best option.

7.2.1.3 Aromatics

Given the uncertainties regarding aromatics identified during consultation, it is reasonable to defer a decision about reducing the maximum level of aromatics below the current 45 per cent. This will allow time for a review of aromatics in petrol, in particular how changes to aromatics would impact vehicle operation and refinery viability. In turn, the outcomes of a review would be used to inform a decision about a suitable reduced limit for aromatics in Australian petrol, or an appropriate alternative approach.

The scope of this review will be settled with relevant industry stakeholders and not be limited, constrained or defined by the initial questions identified by the Department (detailed in section 7.1.4).

7.2.1.4 Other fuel standards, parameters and associated instruments

The draft RIS included a range of minor policy reform options to other fuel standards, parameters and associated legislation, detailed in Section 4. Further consultation on these proposals is required before a decision on changes can be made.

7.2.3. Regulatory burden of the best option

The regulatory burden of the best option was assessed as \$346 million, as estimated for Option F in the draft RIS. This represents the lowest regulatory burden of all reform options proposed.

Two components of the best option which differed from Option F and had the potential for a regulatory burden impact were:

- Voluntary annual reporting of aromatics information by fuel suppliers, commencing 2019.
- Reducing the pool average of aromatics in the petrol standard from 42 per cent to 35 per cent, effective 1 January 2022.

The AIP indicated it would voluntarily commence reporting aromatic data from its member refineries in 2019. The data to be reported are routinely collected by fuel suppliers, and there would be no penalty for non-participation in a reporting arrangement. Data reported through the arrangement would be used to inform the review of aromatics in Australian petrol. The burden of this reporting was assessed to be less than \$1500 per year, and thus is not significant enough to require revision of the formal regulatory burden assessment completed for Option F. Existing annual reporting requirements are specified under section 67 of the *Fuel Quality Standards Act 2000*.

Reducing the pool average of aromatics to 35 per cent from 1 January 2022 is proposed as an appropriate step toward a potential reduction in the maximum limit of aromatics, to be informed by the outcome of the review. Implementing this measure was determined to have negligible impact on fuel suppliers, who demonstrated during consultation the actual pool average of aromatics is currently lower than 35 per cent. The mechanism of an aromatics pool average and cap is already regulated under the *Fuel Quality Standards Act 2000*.

8. How will the chosen option be implemented?

The Department of the Environment and Energy will manage implementation of the chosen option through four workstreams.

8.1. Four workstreams

8.1.1. Stream one—reduction of sulfur in Australia’s petrol

A new petrol standard which sets the maximum limit for sulfur in Australian petrol at 10 ppm with effect from 1 July 2027 will be in place before 1 October 2019.

The Minister for the Environment has the authority to make or change fuel standards under the Act. Before making or changing a standard the Minister must consult with the Fuel Standards Consultative Committee. When the new fuel standard is tabled, it is subject to a disallowance period of 15 sitting days.

8.1.2. Stream two—reduced pool average and review of aromatics in Australia’s petrol

The pool average of aromatics in Australian petrol will be reduced to 35 per cent (from 42 per cent) with effect from 1 January 2022. In addition, aromatics in Australian petrol will be reviewed in the context of setting a revised maximum limit or suitable alternative by 1 January 2022, with effect from 1 July 2027.

This timing is effectively as soon as possible for the Department to conduct the aromatics review. If, through the review or any other channel, a suitable solution can be found prior to 2022, the Department will seek to implement that solution in the petrol standard as soon as practicable.

The work will be led by the Department in four stages.

- First will be to reduce the aromatic pool average in petrol from 42 per cent to 35 per cent. This will be subject to a determination by the Minister for the Environment under the Act and ordinary legislative review processes. The new standard will be in place before 1 October 2019 with effect from 1 January 2022.
- Second will be a review of the case for reducing aromatics to 35 per cent maximum, led by the Department in consultation with industry. The review will inform a policy decision by the Minister for the Environment by 2022. Review reporting will be staged and include the following processes:
 - Voluntary, annual reporting of petrol aromatic data by refineries and independent fuel suppliers to the Department commencing in 2019 (reporting 2018 data).
 - The Department will assess the need for and feasibility of reducing aromatics to 35 per cent maximum, and alternative approaches. The scope of the assessment will be established in consultation with the petroleum and automotive industries, and the assessment finalised in consultation with those industries.

- Third will be a policy decision by the Minister for the Environment on an appropriate aromatic limit for Australian petrol, informed by the outcome of the review.
- Fourth will be to amend the petrol standard by 1 January 2022, in line with the Minister’s policy decision on an aromatics limit. The standard will be amended by the Minister under the Act, including consultation and following the legislative process outlined above. The new limit would come into effect the same time as 10 ppm sulfur (1 July 2027) providing five years for Australian petrol suppliers to prepare for meeting the limit.

8.1.3 Stream three—updating the remaining fuel standards identified in the draft RIS

The Department will continue to consult with industry on the remaining parameters in the fuel standards to finalise them prior to 1 October 2019. The legislative instruments comprise four existing (non-petrol) fuel standards, regulations, guidelines and two information standards. Potential revisions to these instruments, consulted publicly through the draft RIS, include proposed changes to a number of parameters and policy approaches, detailed in Appendix A and Appendix B.

New and updated fuel standards, fuel quality information standards and guidelines will be made by the Minister for the Environment under authority of the Act. The Minister will consult with the Fuel Standards Consultative Committee before making or changing fuel standards and fuel quality information standards. New or updated fuel quality regulations will be made by the Governor-General under authority of the Act. When tabled, all instruments will be subject to disallowance for a period of 15 sitting days.

8.1.4. Stream four—compliance

The Department will update its fuel quality monitoring, compliance and enforcement procedures, and implement an improved fuel quality compliance framework.

8.2. What the chosen option will achieve

Successful implementation of the measures set out in the chosen option will:

- Improve Australia’s petrol quality by reducing sulfur to worldwide minimum levels and reviewing the aromatic limit with a view to reducing it in line with Australian needs and international best practice.
- Set achievable, balanced improvements in the quality of Australia’s fuel to ensure the ongoing viability of refineries in Australia.
 - Under the proposed option, the refining and petroleum industry will have eight years (2019–2027) to prepare for supplying petrol with a sulfur limit of 10 ppm, three years (2019–2021) to adjust to providing petrol with an aromatics pool average level of 35 per cent, and five years (2022–2027) to prepare for a further revised aromatics limit in petrol.
- Introduce revised and updated regulations, information standards, guidelines and fuel standards for all fuels, including a new standard for blended diesel (B20).
 - This will ensure Australia’s fuel continues to support vehicle operation, the adoption of better engine and emissions control technology, and reduce pollutants and emissions harmful to health and the environment arising from fuel use.
- Contribute to the supply of reliable quality, fit-for-purpose fuel to enable the operation of more efficient, lower emissions, high-technology vehicles.

8.3. Risks to success

A risk to success is the potential for unresolved issues at the conclusion of the aromatics review. If this is the case, the existing parameters—limit of 45 per cent, pool average of 35 per cent (effective 2022)—will remain in place. This approach ensures the achievable reduction of the pool average is locked in for the future, when demand for high octane, typically higher-aromatics fuels will increase.

Unforeseen issues affecting vehicle operability and emissions present another risk. The Department will identify, assess and manage such issues if they arise through its monitoring, compliance and enforcement framework. Management responses may include working with industry to address minor problems, or revising relevant standards or framework legislation. These responses can be put into action whenever required, and would be done in consultation with industry and in line with administrative processes established under the *Fuel Quality Standards Act 2000*.

8.4. How the policy will be evaluated

The measure of success of the policy will be the renewal of Australia's fuel standards and the introduction of advanced vehicle emission control technologies.

The policy will be evaluated through the existing administrative processes and reporting required under the *Fuel Quality Standards Act 2000*. This includes monitoring, compliance and enforcement processes which operate continually for standards in force. In addition to regulatory processes managed by the Department, evaluation will be supplemented by industry's voluntary interim reporting of sulfur and aromatics levels. Stakeholders will remain informed through participation in the aromatics review and the Fuel Standards Consultative Committee.

The *Fuel Quality Standards Act 2000* is due for its next review from 2021.

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	<ul style="list-style-type: none"> • 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 emission 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 emission 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 73rd in the world for sulfur limits. 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)	<ul style="list-style-type: none"> • 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 emission 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 emission 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)	<ul style="list-style-type: none"> 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) ⁶	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Can clog vehicle catalytic converter systems and increase vehicle exhaust emissions.
9	Petrol additive	Organometallic compound: tetraethyl lead	<ul style="list-style-type: none"> 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).

		Issues (environmental, health, operability, harmonisation)	
Fuel type	Parameter		
10	Petrol additive Organometallic compound: MMT (methylcyclopentadienyl manganese tricarbonyl)	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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-methylamine (NMA)	<ul style="list-style-type: none"> 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 NO_x emissions. 	
13	Petrol additive Chlorinated paraffins	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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)	<ul style="list-style-type: none"> 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

-  Minor revisions: change of name, unit or number of significant figures
-  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	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

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
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
	95 RON petrol: 85.0	95 RON petrol (with or without ethanol ^b): 85.0 ^b	95 RON petrol (with or without ethanol ^b): 85.0 ^b	95 RON petrol: 85.0		
	98 RON petrol	98 RON petrol (with or without ethanol ^b): 85.0 ^f	98 RON petrol (with or without ethanol ^b): 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 ^e and/or EU ^g)	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 ^f): 95.0 ^b	95 RON petrol (with or without ethanol ^f): 95.0 ^b	95 RON petrol: 95.0		
Sulfur	91 RON petrol: 150 mg/kg	98 RON petrol (with or without ethanol ^f): 98.0 ^f	98 RON petrol (with or without ethanol ^f): 98.0 ^f	91 RON petrol: On commencement 150 mg/kg		10.0 mg/kg
	95 RON petrol: 50 mg/kg	91 RON petrol: discontinued ^b	91 RON petrol: 10.0 mg/kg ^a	95 RON petrol: On commencement 50 mg/kg		
			95 RON petrol: 10.0 mg/kg ^b	From 1 July 2027 10.0 mg/kg		
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/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-5-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_Sed_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/m ³	820.0–845.0 kg/m ³ at 15°C ^b	820.0–845.0 kg/m ³ at 15°C ^b	820.0–845.0 kg/m ³ 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 mm ² /s ^b	2.000–4.500 mm ² /s ^b	2.000–4.500 mm ² /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/m ³	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 JLPGA-5-03 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	2.0% molar ^a	Replace ISO 7941 with ASTM D2163-14e1 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/m ^{3a}	860–890 kg/m ^{3a}	860–900 kg/m ³	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	3.5–5.00 mm ² /s ^b	3.50–5.00 mm ² /s ^b	3.50–5.00 mm ² /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 LPG standard as described in National Standards Authority of Ireland (2012). *IS EN 589:2008 Automotive fuels—LPG—requirements and test methods*, Dublin. Purchased 16 May 2016. info.store.saiglobal.com/en-au/Standards/I-S-EN-589-2008-1140721/

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
Motor octane number (MON)	87	88.0 ^b	88.0 ^b	88.0	

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
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 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	0.3 mg KOH/g ^a		ASTM D664
Ash	0.010% m/m ^b	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	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	0.30% m/m ^a		ASTM D4530
Copper strip corrosion (3 h at 50°C)	Class 1 ^a	Class 1 ^a	Class 1 ^a		ASTM D130
Density at 15°C	820.0 kg/m ³ –860.0 kg/m ^{3b}	820.0 kg/m ³ –860.0 kg/m ^{3b}	820.0 kg/m ³ –860.0 kg/m ^{3b}	820.0 kg/m ³ –860.0 kg/m ³	ASTM D4052
Derived cetane number	51.0 ^b	51.0 ^b	51.0 ^b	51.0	ASTM D6890
Distillation—T90	360°C ^b	360°C ^b	360°C ^b	360°C	ASTM D1160
Flash point	61.5°C ^a	61.5°C ^a	61.5°C ^a	Above 55.0%	ASTM D93
Kinematic viscosity at 40°C	2.000–4.620 mm ² /s ^b	2.000–4.620 mm ² /s ^b	2.000–4.620 mm ² /s ^b	2.000–4.620 mm ² /s	ASTM D445
Lubricity	460 µm ^a	460 µm ^a	460 µm ^a		IP 450
Oxidation stability	20.0 h ^b	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 ^b	8.0% m/m	EN 12916:2016
Sulfur	10.0 mg/kg ^b	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	200 mg/kg ^c	260 mg/kg	ASTM D6304
Water and sediment	0.05% v/v ^a	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 emission 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	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	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	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	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	\$7473,616	\$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	-\$601,200,319	-\$793,845,118	-\$601,200,319	-\$601,960,098	-\$598,231,147	-\$586,915,111	-\$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	-\$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	-\$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	-\$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	\$166,693,4584	\$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 draft RIS—stakeholder views

Fifty-five submissions were received from a range of stakeholders including the fuel and alternative fuel industry, automotive and aviation industries, industry associations, motoring consumer advocacy groups, non-government organisations with expertise in health care and environmental protection, and members of the public.

A summary of stakeholder views is provided below. Non-confidential stakeholder submissions will be made available at environment.gov.au/protection/fuel-quality

E.1 Views on policy options

Submissions received were based on the policy options provided in the draft RIS. The main themes for discussion are summarised below.

E.1.1 Sulfur content

There was broad support across stakeholders for reducing sulfur levels in petrol to 10 ppm.

The automotive industry, including the FCAI, maintains 10 ppm sulfur levels is crucial for the correct operation of advanced engine and emissions control technology that meet full Euro 6 emission standards. They stated that unless Australia's fuel is aligned with European standards (10 ppm sulfur and other parameters), vehicles cannot comply with Euro 6 in-service requirements. Apart from increasing particulate matter, the FCAI noted that fuel with more than 10 ppm sulfur will increase wear and degradation of engine and emissions systems components, which could result in additional costs for motorists.

Other submissions such as those from the Public Health Association of Australia and the Royal Automobile Club of WA supported lowering sulfur levels to reduce its harmful effect on human health and the environment.

The AIP argues there is insufficient evidence demonstrating that 10 ppm sulfur is necessary to achieve Euro 6 emission standards, or that such reduction will provide substantial operability and environmental benefits. They also reiterated the significant financial pressure refineries will face in achieving this limit, and noted that the average concentration of sulfur present in Australian petrol is already substantially lower than the maximum regulated limits for all grades of petrol.

E.1.2 Aromatics

Views between key stakeholders differed on the proposed reduction of aromatic content in petrol to a 35 per cent maximum.

The FCAI restated its position that aligning Australian fuel with European standards (including 35 per cent aromatics) must be implemented to deliver the anticipated health and environmental benefits in-service from adopting Euro 6 emission standards. It maintained this is critical to meet Euro 6c and 6d particulate number limits for gasoline direct injection engines.

On the other hand, the AIP submits that no clear case supports the position that a 35 per cent aromatics limit will provide significant health and environmental benefits or improve vehicle operability. AIP also called for recognition of the various market risks from lowering aromatics—including limited octane-enhancing alternatives available to refineries—and further stressed that meeting this reduction will cause significant impact to refinery viability and operations.

Aromatics and their impact on particulate matter was discussed in both stakeholders' submissions. There was general acknowledgement on the correlation between high molecular weight hydrocarbons (or 'heavy aromatics') and increased particulate matter, in addition to particulate matter levels being dependent upon the type of aromatics (i.e. light or heavy) in proportion to the total aromatics content. This issue is to be explored in further detail.

The AAA acknowledges the link between aromatics and engine and emissions performance, however highlights the importance of sourcing cost-effective alternatives to maintain octane if aromatics is reduced, especially given Australia's limit on MTBE.

E.1.3 91 RON petrol

The phase-out of 91 RON regular unleaded petrol was supported primarily by supporters of Option B, including Doctors for the Environment Australia and the FCAI. Submissions stated retaining 91 RON petrol would delay modernisation of the Australian fleet, resulting in reduced health and environmental benefits. Some submissions stated that removing 91 RON petrol will prevent engine 'de-rating' whereby engines certified to run on 95 RON petrol are modified to run on a lower grade fuel, which could compromise engine operability and efficiency.

AIP opposes the removal of 91 RON petrol, arguing it will negatively impact consumers and force existing vehicles to run on premium grade petrol, even if such use is not required to benefit the vehicle's performance.

E.1.4 Comments on other fuel parameters and policy elements

Comments from stakeholders were received on introducing new policy elements and proposed changes to a number of other parameters in the fuel standards. These included:

- **Polycyclic aromatic hydrocarbons (PAHs):** FCAI supports a reduced eight per cent maximum limit for PAHs, to achieve Euro 6 particulate number limits and ensure the correct function of Euro 6 emissions systems. Other submissions supported the reduction to lower noxious emissions, noting PAHs' carcinogenic nature. The AIP argues there are negligible environmental and operability benefits from lowering PAHs, and doing so require investments that would threaten refinery viability.
- **Cetane and density:** the FCAI supports proposed changes to these parameters, stating it will assist in delivering improved efficiency and reduced emissions. In contrast, the AIP claims such changes will significantly impact refinery operations for no demonstrated operability or environmental improvement.
- **Ethanol:** Some submissions—including Bioenergy Australia, Doctors for the Environment Australia and Manildra Group—called for greater use of ethanol blends, citing its benefits in boosting octane, reducing tailpipe emissions and increasing investment within the biofuels industries. However, the AIP cited barriers to the uptake of ethanol including limited local supply, sustainability concerns and consumer aversion. They also stated that ethanol blends increase volatile organic carbon emissions, and will cause significant financial impact upon refineries and the broader fuels supply chain.

- **MTBE:** Some submissions supported the addition of MTBE on the *Register of Prohibited Fuel Additives* due to concerns with groundwater contamination. The AIP and the AAA acknowledged these concerns in the context of reducing aromatics, and highlighted the absence of octane-enhancing alternatives given the effective ban on MTBE. Other stakeholders, such as the Asian Clean Fuels Association and the European Oxygenates Association cited engine operability and environmental benefits from using MTBE and suggested appropriate storage and leak detection technologies to eliminate risk of contamination.
- **Fuel additives:** There was general support among submissions to add organometallic compounds (such as MMT), NMA and chlorinated paraffins to the *Register of Prohibited Fuel Additives* due to the negative impact on health, the environment and engine operability.
- **Renewable diesel:** More than 20 submissions supported the inclusion of a definition for renewable diesel. A majority suggested the definition proposed in the draft RIS be expanded to capture ‘other post-consumer wastes’ and to clarify that renewable diesel excludes diesel made from any products or wastes resulting from the primary processing of virgin fossil fuels.
- **Diesel standard scope:** Expanding the scope of the diesel standard to non-road (non-automotive) uses was generally supported by a range of stakeholders—including the AIP, Doctors for the Environment Australia, Bioenergy Australia and the Truck Industry Council.
- **Proposed B20 and 98 RON petrol standards:** Most submissions which commented on establishing a B20 and/or 98 RON petrol standard were generally in favour of doing so. The AIP however, considers a 98 RON petrol standard unnecessary and emphasised support for a minimum 85 MON were it to be regulated.
- **E85 information standard:** The proposed minor changes to the Fuel Quality Information Standard (Ethanol E85) Determination 2012 was generally supported across submissions. The Queensland Renewable Fuels Association rejected a 15 per cent volume margin, arguing E85 should equal 85 per cent ethanol.

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}, PM₁₀, O₃, NO₂, SO₂*, submitted to National Environment Protection Council Service Corporation. Accessed 20 June 2017, www.environment.gov.au/system/files/pages/dfc7ed5d-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 RE, 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 (2018). 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 (2018). *Revised fuel quality standards: economic analysis*, report prepared for the Department of the Environment and Energy.
- 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/nonroaddieslrpt.pdf
- 31 Department of Infrastructure and Regional Development (2016). *Vehicle emission 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, <https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=149923>
- 35 Yue W, Schneider A, Stölzel M, Rückerl R, Cyrus 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: PM₁₀ 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 emission standards*, accessed 20 June 2017, www.infrastructure.gov.au/vehicles/environment/emission/index.aspx
- 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 on the *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, <https://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, <https://www.energy.gov.au/sites/g/files/net3411f/australian-petroleum-statistics-feb2017.pdf>
- 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.
- 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>

