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Department of Climate Change, Energy, the Environment and Water

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Improving Australia's fuel and vehicle emissions standards—Final impact analysis

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Acknowledgement of Country

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Executive summary

Noxious emissions produced by road vehicles through the combustion of fuel are a major contributor to air pollution in Australia. Noxious emissions from vehicles are a particularly harmful source of pollution as people generally have a higher level of exposure to these than other sources of noxious emissions.[1] This can result in significant health impacts, including reduced lung function, ischemic heart disease, stroke, respiratory illnesses and cancer.[2] Health experts agree that there is no safe level of exposure to particulates and that any reduction in particle concentrations would improve population health outcomes and reduce health costs for individuals and the Australian Government.

Noxious emissions produced by road vehicles contributed to as many as 1,715 deaths in Australia in 2015, or 42% more than the road toll that year.[3] In that same year, air pollution-related health impacts of transportation emissions cost our economy approximately $9.2 billion.[4]

To limit the health impacts of noxious emissions from light road motor vehicles, Australia has mandated the international Euro 5 noxious emissions standards (Euro 5 standards) for newly approved models first manufactured from 1 November 2013, and for all light road motor vehicles manufactured from 1 November 2016. Euro 5 standards continue to mandate limits on noxious emissions from new light road motor vehicles entering the Australian fleet. However, many other countries have introduced increasingly stringent vehicle emissions standards. More stringent Euro 6 (or equivalent) emissions standards (Euro 6 standards) for light vehicles have been adopted in the United States, Canada, the European Union, the United Kingdom, Japan, China, Korea and India. These countries, which account for over 80% of global new vehicle sales and supply most passenger vehicles sold in Australia, also require manufacturers to meet fuel efficiency standards. This means that the latest vehicle models meeting Euro 6 standards are likely to be cleaner and more fuel efficient than equivalent Euro 5 models currently available in Australia.

The global regulation of aromatic hydrocarbons (aromatics) in petrol has implications for the vehicle market in Australia. Aromatics are a natural part of crude oil and are an important element in petrol blending because they improve the highly valued octane rating (octane) of fuels.[a] However, at high levels, aromatics in petrol can impact vehicle operability and human health. Approximately 85% of the global light duty vehicle fleet is in countries using petrol with a maximum aromatics content of 35% (lower aromatics petrol), whereas Australia's aromatics limit is currently 45%, with a 35% maximum annual pool average (by volume) across all grades of petrol.

The Euro 6d phase of the Euro 6 standards, which was progressively implemented in the EU from 2017 to 2020, introduced further changes to improve the integrity of the vehicle emissions testing regime. A key change is the replacement of the current drive cycle testing regime with the new Worldwide harmonised Light vehicle Test Procedure (WLTP) along with the introduction of an on-road Real Driving Emissions (RDE) test. Vehicles that meet Euro 6d standards[b] (Euro 6d vehicles) are designed for lower aromatics petrol and sold to markets with lower aromatics petrol. As a result, vehicle importers are hesitant to introduce Euro 6d vehicles to countries with higher aromatics, such as Australia, where there is a higher potential for engine operability issues.

Without Government intervention to improve both noxious emissions and fuel quality, there is a high probability Australia will be excluded from the global market for cleaner light vehicles in years to come, with resultant impacts on health costs and the community. Market pressures alone will not improve noxious emissions levels or fuel quality standards. This is because the link between fuel

[a] The octane rating is a standard measure of a fuel's ability to withstand compression in an internal combustion engine without detonating. Most cars in Australia require 91 RON or 95 RON petrol in Australia – only about 0.6% of new vehicles sold annually require 98 RON.

[b] See page 8 for an explanation for the Euro 6 phases. In summary, Euro 6d is the standard that the Government is considering for introduction in Australia.

quality, noxious emissions and health is not widely publicised and is often not clear to consumers. As a result, the true costs of noxious emissions are not factored into the price of fuel or vehicles. Further, the health impacts of noxious emissions from vehicles are not borne by vehicle manufacturers, fuel suppliers or consumers alone, but are shared by the community collectively. If Australian regulation does not keep pace with international standards prevalent across the global vehicle market, Australia risks foregoing the benefits of technology available in other countries.

This impact analysis considers options to achieve Government objectives of reducing emissions and improving health outcomes, by:

- improving **noxious emissions standards** to reduce the impacts of noxious emissions from road vehicles on the Australian community
- making changes to **fuel quality standards** to reduce allowable levels of aromatics in petrol sold in Australia and enable the functionality of those vehicles
- ensuring Australia has access to the **latest vehicle technology** by aligning Australian fuel and vehicle standards with international best practice and enabling the importation of light vehicles that produce lower levels of noxious emissions.

In summary, the options considered in this impact analysis are:

- Package 1: Mandate Euro 6d from 2027–2028 and introduce a 35% aromatics limit across all grades of petrol from 2027.
- Package 2: Mandate Euro 6d from 2025–2028 and introduce a 35% aromatics limit in 95 RON petrol from 2025. (**preferred**)
- Package 3: Mandate Euro 6d from 2027–2028 and introduce a 35% aromatics limit for 95 RON petrol from 2025.

These options were informed by feedback received from industry and community stakeholders in response to:

- Draft Regulation Impact Statement 'Light Vehicle Emission Standards for Cleaner Air', released for comment by the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA) from October 2020 to February 2021; and
- the draft Regulation Impact Statement 'Better Fuel for Cleaner Vehicles' released for comment by the Department of Climate Change, Energy, the Environment and Water from November to December 2022.

All of these proposed packages would increase harmonisation of Australia's fuel quality standards with international standards and would allow vehicle importers to provide Euro 6d vehicles without additional testing or modification. Through reducing the community's exposure to noxious emissions, the packages will reduce health costs. They will also increase the fuel efficiency of Australia's fleet, reducing greenhouse gas emissions.

The preferred option – Package 2 – offers the greatest net present value of $4.508 billion from 2025 to 2040. This option would enable implementation of Euro 6d through the availability of lower aromatics 95 RON petrol, at the lowest cost to consumers and the fuel sector. Better air quality would reduce pressure on the public health system by reducing the incidence of disease attributable to air pollution.

Costs to consumers in each option was a key consideration. The preferred option to improve fuel quality would result in a small ongoing price increase to only the 95 RON grade of petrol, estimated at around 0.9 cents per litre in 2025. There would be no price impacts for 91 RON or 98 RON (which account for 88% of petrol use combined) and no price impact for diesel. The motorists most vulnerable to cost-of-living pressures, such as those using existing vehicles with 91 RON or diesel, would not be impacted. Other options considered as part of this impact analysis, including no change to existing standards, would either be too costly to implement (both in terms of Government

costs and costs to consumers) or would not enable the implementation of Euro 6d noxious emissions standards across the all new light passenger and commercial vehicles supplied to Australia.

Aligning Australia's diesel standards with the European diesel standard was also considered. The analysis showed that no changes to diesel quality are required to enable the introduction of Euro 6d standards and changing diesel quality in Australia would provide a negative net present value. For this reason, no changes are recommended to the diesel standard.

1. What problem is the Government trying to solve?

1.1 Noxious emissions from road vehicles cause illness and premature death

Noxious emissions produced by road vehicles are a major contributor to air pollution in Australia that can cause negative human health effects including respiratory disease, cancer and dementia.[5] It is estimated that noxious emissions produced by road vehicles contributed to as many as 1,715 deaths in Australia in 2015, or 42% more than the road toll that year.[6]

Exposure to pollutants is particularly harmful to children, elderly people, pregnant people and people with pre-existing health conditions. Living close to major roads and highways increases the risk of early death and has been linked to a higher incidence of dementia in the elderly.[7] High levels of benzene, a known carcinogen, have been discovered near major roads, particularly when traffic is congested.[8]

The two main air pollutants of greatest concern to health experts are fine particles commonly referred to as $PM_{2.5}$ and ground-level ozone.[c] Noxious emissions produced by road vehicles are a significant contributor to both, particularly in major cities.

Scientific evidence links long-term exposure to $PM_{2.5}$ with ischemic heart disease, cerebrovascular disease (ischemic stroke and haemorrhagic stroke), lung cancer, chronic obstructive pulmonary disease (COPD), and lower respiratory infections, particularly pneumonia. There is also mounting evidence that $PM_{2.5}$ exposure can contribute to the incidence of Type 2 diabetes.[9] A study into the public risk of exposure to air pollutants from 2013 found that long-term population exposure to $PM_{2.5}$ alone was attributable to 9% of all deaths from ischemic heart disease in Australia's four largest cities.[10]

Health experts agree that there is no safe level of exposure to particulates and that any reduction in particle concentrations would improve population health outcomes.[11] In June 2012, the International Agency for Research on Cancer in the World Health Organisation declared that diesel exhaust is a 'known carcinogen' and particulate emissions produced by diesel engines are particularly harmful.[12]

Ozone is a secondary pollutant formed from chemical reactions of oxides of nitrogen (NO_x) emissions with volatile organic compounds (VOCs), such as hydrocarbons (HCs), in hot and sunny weather conditions. Short-term health effects attributed to ozone include irritation of the eyes and airways, exacerbation of asthma symptoms in susceptible people, increased susceptibility to infection and acute respiratory symptoms such as coughing. Long-term exposure is associated with COPD.[13] As with particulates, there is no safe threshold for exposure to ozone and individuals can experience adverse health effects even when exposed to very low concentrations.[14]

While Australia generally has good air quality by global standards, many areas of Australia experience periods of poor air quality. Some pollutants, particularly ground-level ozone and particulate matter (PM), occasionally exceed the air quality standards agreed by governments, especially in urban areas with high volumes of traffic.[d] Since 2006, the air quality index in most major urban regions of Australia has improved on average.[e] However, of these regions, the air quality index in the Sydney, Illawarra, Lower Hunter, Melbourne and South East Queensland regions have all deteriorated since 2011.[15]

[c] Airborne particulate matter measuring less than 2.5 micrometres in aerodynamic diameter.

[d] Ozone and PM are included in the National Environment Protection (Ambient Air Quality) Measure standards set by National Environment Protection Council under the *National Environment Protection Council Act 1994* and complementary state and territory legislation.

[e] Sydney, Illawarra, Lower Hunter, Melbourne, South East Queensland, Adelaide and Perth.

Our growing population is contributing to higher levels of ambient air pollution in Australian cities. Almost 71% of Australians now live in a major city, with another 18% living in inner regional areas.[16] Increased urbanisation is also a factor. In 2017, 17.7 million Australians lived in a major city, compared to 14.6 million in 2007. This is projected to increase to over 21 million by 2027.[17] Due to higher traffic and population density, over 90% of health costs attributable to noxious emissions from light vehicles are borne by Australians living in capital cities.[18]

An ageing population that is more susceptible to the health impacts of air pollutants is exacerbating this problem. The proportion of the Australian population aged over 65 is expected to more than double over the next 40 years.[19] This may lead to, as seen in Japan, an increase in the mortality rate attributed to air pollution despite reductions in ambient air pollution.[20]

While our average level of exposure to $PM_{2.5}$ is declining, in part due to reductions in exhaust emissions from new road vehicles, our exposure to ozone is increasing. Furthermore, although our average level of exposure to ozone is lower than many other developed countries, our exposure to ozone is increasing at a faster rate than many other developed countries, most of which have adopted more stringent noxious emissions standards.[21]

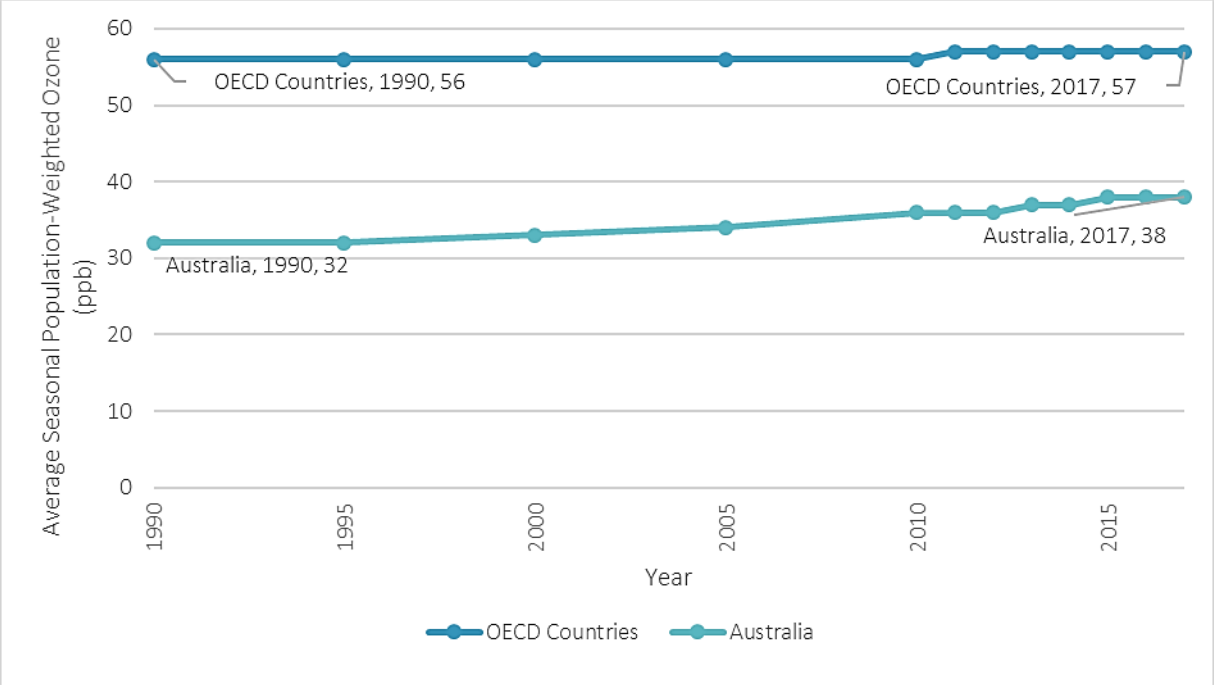

Figure 1: Average seasonal population weighted exposure to ozone in Australia and OECD countries

1.2 Contribution of road vehicles to air pollution in Australia

The most comprehensive data available on road vehicle emissions in Australia, from New South Wales, shows that road vehicles account for over 55% of total NO_x emissions, 43% of carbon monoxide (CO) emissions, 13% of VOC emissions and 13% of $PM_{2.5}$ emissions in the Sydney region.[22]

Data from New South Wales (Figure 2) also shows that total NO_x emissions from light duty diesel vehicles have increased as a result of a significant increase in the proportion of diesel vehicles in the light duty fleet and consequent increase in vehicle kilometres travelled.[23]

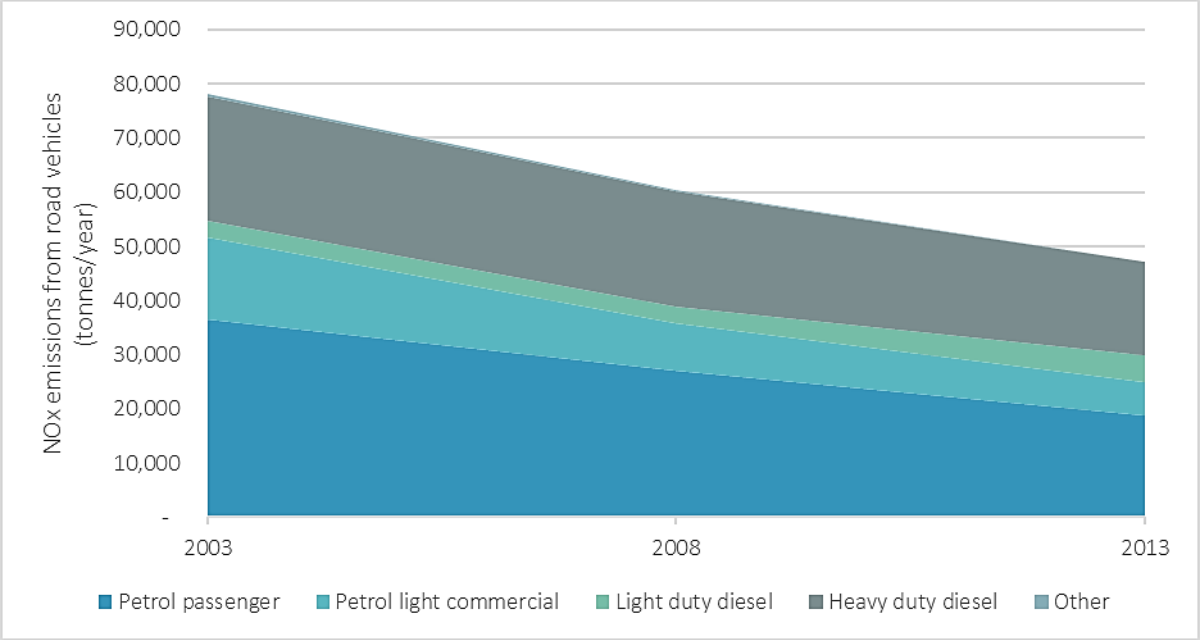

Figure 2: Changes in NO_x emissions from road vehicles by vehicle type in the NSW metropolitan region[24]

Light passenger vehicles (cars and sport utility vehicles) account for 74% of vehicles on the road.[f] They also account for 70% of kilometres travelled and 57% of fuel consumed by road vehicles in Australia. Our increasing demand for transport services is exposing more Australians to ambient air pollution. Between 2014 and 2019, the light vehicle fleet in Australia grew by 10%, making vehicles a growing source of air pollution.[25]

Light vehicle use is steadily increasing, with total light vehicle travel predicted to grow by 66% between 2016 and 2040.[26] This growth in vehicle use may start to outweigh the reductions in noxious emissions from newer vehicles replacing older vehicles meeting less stringent standards.

While road vehicles are not the only source of particulate emissions, exhaust emissions, particularly from diesel vehicles, can contribute up to 30% of the overall particulate load in urban areas.[27] Particulate levels tend to be highest near busy roads and dense urban areas. Data from New South Wales shows that diesel vehicles are the main source of exhaust particulate emissions from light vehicles.[28]

[f] Consistent with the UN regulations, the Australian Design Rules (national minimum standards for vehicles supplied to Australia) for light vehicle emissions apply to passenger (M category) or goods carrying (N category) vehicles with a gross vehicle mass up to 3.5 tonnes.

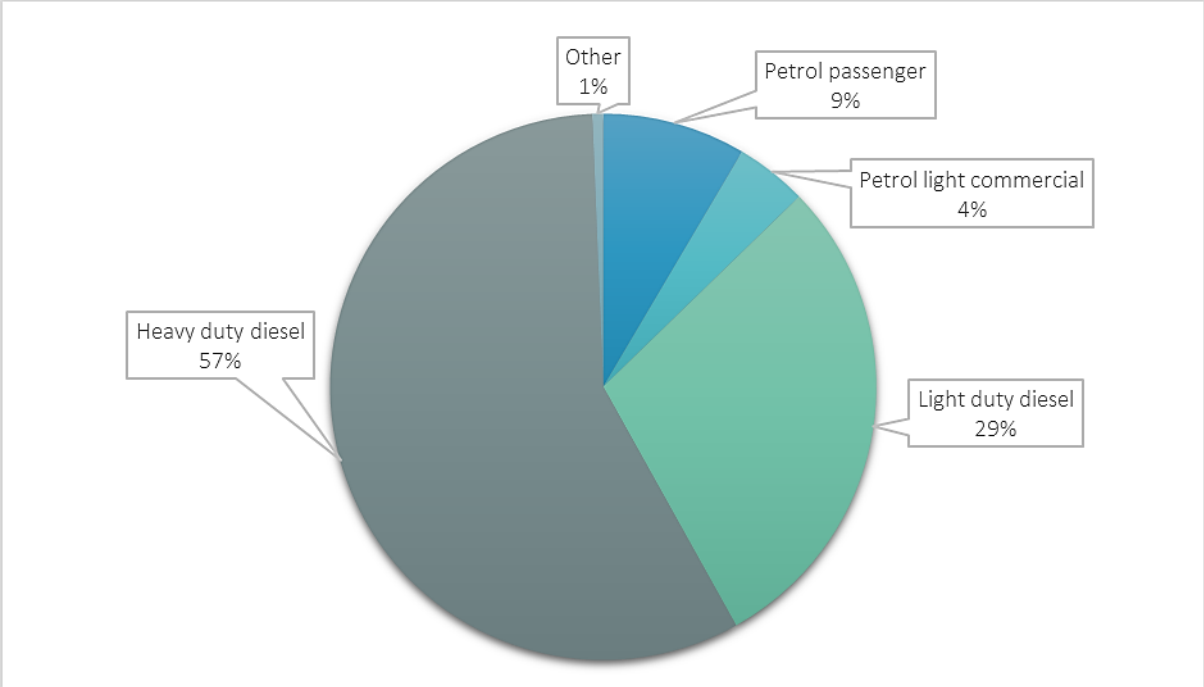

Figure 3: $PM_{2.5}$ exhaust emissions from road vehicles in the NSW greater metropolitan region[29]

Diesel engines, which emit higher levels of NO_x and particulate emissions than petrol vehicles (and are permitted to do so under current standards), now dominate the light commercial segment of the light vehicle market in Australia. Over 93% of new light commercial vehicles that entered the Australian fleet in 2019 were diesel vehicles, compared with only 41% in 2005.[30] Between 2014 and 2019, the number of diesel light commercial vehicles grew by over 50%.[31]

There has also been a sizeable increase in the uptake of light petrol vehicles fitted with gasoline direct injection (GDI) fuelling systems in Australia and globally over the past five years and this growth is expected to continue.[32] GDI engines improve light vehicle fuel efficiency but tend to emit more hazardous fine particles than traditional petrol engines.[33]

As noted above, while Australia generally has very clean air, there is still work to do to make sure that it remains this way as our population and vehicle fleet grows. Battery electric and hydrogen fuel cell electric vehicles, which produce no tailpipe emissions, will become increasingly common on Australian roads as they achieve price and total cost of ownership parity with petrol and diesel vehicles.[g] The Bureau of Infrastructure and Transport Research Economics (BITRE) estimates that under current policy settings, 8% of all new light vehicle sales will be electrified (i.e. battery electric or plug-in hybrid) by 2025 and 27% by 2030.[34]

While the wider adoption of zero emissions vehicles will help reduce noxious emissions, BITRE also estimates that petrol and diesel vehicles will account for most new light vehicle sales until 2035 and most light vehicles on the road until 2050. Limiting the impact of exposure to noxious emissions from petrol and diesel vehicles on human health will be a priority for the Government for some time to come.

[g] Future Government intervention may reduce the overall demand for petrol and diesel for light vehicles in Australia, in particular Government intervention to increase the adoption of low or no emissions vehicles such as through the National Electric Vehicle Strategy. To avoid complexity and misattribution of impacts, this analysis has been undertaken at a point in time using current regulatory and policy settings, without speculating on possible future settings.

1.3 Light vehicles are a major source of greenhouse gas (GHG) emissions

Road vehicles emit a range of GHG emissions that contribute to climate change. The principal GHG emitted is carbon dioxide (CO_2). Combusting fuels in motor vehicles can also produce small amounts of nitrous oxide and methane. The National Greenhouse Gas Inventory data shows that the transport sector accounted for 18.1% of Australia's emissions in 2021.[35]

This makes the sector the third highest emitter in Australia after stationary energy (20.4%) and electricity (32.9%). The proportional contribution of the transport sector has increased by 64% between 1990 and 2018, the largest percentage increase of any sector.

Increasing fuel efficiency is essential to reducing GHG emissions from vehicles. The average fuel efficiency of Australia's vehicle fleet has not been improving at the same rate as other developed markets such as the European Union (EU) and the United States (US).[36] It is essential to introduce measures that can help bring more fuel-efficient vehicles into Australia.

Even with a high uptake of electric vehicles in 2030, more than 80% of the fleet is projected to still use internal combustion engines due to the slow turnover of the fleet. Improving fuel quality and implementing Euro 6d standards will indirectly improve fuel efficiency of vehicles powered by internal combustion engines, as Euro 6d engines are generally more fuel efficient than equivalent engines designed to meet Euro 5.

As the Euro 6d standards do not directly address GHG emissions, the Australian Government is undertaking a separate impact analysis and consultation process to design a preferred fuel efficiency standard for light vehicles. While a fuel efficiency standard, when adopted, will affect the fuel use assumptions in this analysis, these impacts has not been considered in this analysis, as no decisions have been taken on the final design of a fuel efficiency standard. The impact analysis for the proposed fuel efficiency standard, will however, account for any changes to noxious emissions and fuel quality standards agreed at the time of that analysis.

Biofuels provide another opportunity to reduce GHG emissions in the transport sector. Bioenergy Australia estimates that ethanol blends of up to 10% in all grades of petrol in Australia can reduce total GHG emissions by up to 2.6 million tonnes CO_2 equivalent per year.[37]

1.4 Australia's current standards are impeding the supply of cleaner vehicles

1.4.1 How would more stringent noxious emissions standards improve the supply of cleaner vehicles?

To reduce health impacts, noxious emissions from light passenger and commercial vehicles in Australia are currently regulated through Australian Design Rules (ADRs) made under the *Road Vehicle Standards Act 2018* (RVSA). The ADRs are the national standards, which set minimum standards for safety, emissions and anti-theft features that vehicles must meet before they can be provided to the Australian market. These standards apply equally to new road vehicles in Australia, whether they are manufactured locally or imported from overseas.

Australia currently mandates the international Euro 5 noxious emissions standards (Euro 5 standards) for all light road motor vehicles manufactured from 1 November 2016. While Euro 5 standards have and continue to reduce noxious emissions from new light road motor vehicles entering the Australian fleet, many other countries have introduced increasingly stringent vehicle emissions standards. More stringent Euro 6 emissions standards (Euro 6 standards) for light vehicles commenced in the EU from September 2014. Equivalent standards have also been adopted in major vehicle markets in North America and Asia.

The differences between Euro 6 and Euro 5

The key changes under Euro 6 standards when compared to Euro 5 standards are:

- a 55% reduction in the emission limits for oxides of nitrogen for light diesel vehicles
- a particle number limit to reduce fine particle emissions from direct injection petrol vehicles
- tighter thresholds for on-board diagnostic systems that monitor the performance of emissions control systems.

To allow time new vehicle technologies required to meet these standards to develop and mature, the Euro 6 standards were implemented in the European Union over a number of phases. The first mandatory phase of Euro 6, known as 'Euro 6b' was implemented from 2014 to 2016. It adopted stricter emission limits, but based on the same test procedures adopted in Euro 5.

The second mandatory phase of the Euro 6 standards known as 'Euro 6d', which was progressively implemented in the EU from 2017 to 2020, introduced further changes to improve the integrity of the vehicle emissions testing regime. A key change is the replacement of the current drive cycle testing regime with the new Worldwide harmonised Light vehicle Test Procedure (WLTP) along with the introduction of an on-road Real Driving Emissions (RDE) test.

In July 2022, the European Union adopted a new phase of Euro 6 known as 'Euro 6e', which will adopt stricter requirements for the on-road 'RDE' test. These requirements will be adopted in the first United Nations (UN) Regulation for Real Driving Emissions.[h]

Euro 6 or similar standards have been adopted in the US, Canada, the EU, the United Kingdom (UK), Japan, China, Korea and India. These countries account for over 80% of global new vehicle sales and supply most passenger vehicles sold in Australia.

As other advanced economies are requiring vehicles to be fitted with technologies that can meet increasingly stringent standards for noxious emissions, fuel efficiency and safety together, the latest vehicle models meeting Euro 6 or equivalent standards are likely to be cleaner and more fuel efficient than equivalent Euro 5 models, which account for most new vehicles currently sold in Australia.

This raises the question of whether, and when, Australia should adopt more stringent noxious emissions standards. This is not only to achieve a reduction in transport-related air pollution but to ensure that the Australian vehicle market is able to access the latest technology available in other advanced economies to reduce GHG emissions from transport, improve Australia's energy security and improve the safety of road transport in Australia.

As a signatory to the UN 1958 Agreement on harmonized vehicle regulations, the Government has committed to adopting the UN vehicle regulations where possible.[i] Harmonisation with UN vehicle regulations facilitates international trade and reduces administrative compliance costs incurred by vehicle manufacturers by enabling the mutual recognition of type approvals, while allowing for a high level of safety and environmental performance. UN Regulation 154, which entered into force in January 2021, adopts the laboratory test requirements of the Euro 6d standard adopted by the EU.[j]

[h] UN Regulation No. [XXX] on uniform provisions concerning the approval of light duty passenger and commercial vehicles with regards to real driving emissions (RDE), ECE/TRANS/WP.29/2023/77.

[i] Full name of the UN 1958 Agreement – Agreement concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations (Revision 3).

[j] Uniform provisions concerning the approval of light duty passenger and commercial vehicles with regards to criteria emissions, emissions of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range (WLTP), ECE/TRANS/WP.29/2020/77 (as amended by ECE/TRANS/WP.29/2020/92).

An additional UN Regulation adopting equivalent on-road testing requirements is due to be considered at the June 2023 session of the World Forum for the Harmonization of Vehicle Regulations (WP.29).[k]

Over 82 million new vehicles were sold globally in 2021 and approximately 14.4 million of these were in right-hand drive markets such as Australia.[38] Around 1 million new light vehicles are sold in Australia each year across approximately 60 light vehicle brands and over 400 models. This makes Australia one of the most open and competitive car markets in the world.

The globalisation of the motor vehicle industry and the relatively small size of the vehicle market in Australia (1.2% of global new vehicle sales) makes the development of unique Australian standards, and the manufacturing of cars designed specifically for our market, undesirable. This is not just from a regulatory perspective but because, as outlined below, it has the potential to affect consumer choice. This is particularly relevant now there is no longer any significant domestic light vehicle manufacturing in Australia.

To meet increasingly stringent standards for noxious emissions and fuel efficiency globally, manufacturers are developing vehicles and engine technologies fitted with turbocharged petrol engines with advanced GDI fuelling systems, catalytic converters, particle filters and electrified powertrains.

As global vehicle manufacturers focus on developing vehicles for larger markets demanding compliance with increasingly stringent standards, there is a significant risk that the range of vehicles available in Australia will diminish over time, as existing models are replaced by newer models that may not be viable to offer in Australia while its current fuel quality and noxious emissions standards remain in force.

Manufacturers advise our current fuel quality and noxious emissions standards will make it difficult to convince their global parent companies that next-generation engine technologies, such as plug-in hybrids or vehicles fitted with intelligent transport systems, will be commercially viable offerings for the Australian market.[39]

If Australia is not able to access new vehicle technologies developed for larger vehicle markets with stricter standards, this may reduce Australia's capacity to reduce GHG emissions and meet its emissions reduction targets for 2030 and beyond. As safety and emissions technologies are increasingly packaged, this may also impact on Australia's ability to reduce road trauma.

1.4.2 Impact on stakeholders

Changes to noxious emissions standards and fuel quality standards would have impacts on a diverse mix of stakeholders. These include:

- automotive industry representatives, including vehicle manufacturers, importers and component suppliers
- Australia's two domestic refineries
- fuel retailers, distributors, wholesalers and associated businesses
- community organisations with an interest in reducing emissions for environmental and/or health reasons
- consumer and business representative groups
- motoring clubs and their peak body representatives at state and national level
- state and territory governments.

The Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA) and the Department of Climate Change, Energy, the Environment and Water (DCCEEW)

[k] UN Regulation No. [XXX] on uniform provisions concerning the approval of light duty passenger and commercial vehicles with regards to real driving emissions (RDE), ECE/TRANS/WP.29/2023/77.

developed the options assessed in this impact analysis through consultation with key stakeholders using tailored questions, literature reviews and commissioned studies (see section 7 for further details).

1.5 Australia's aromatics content in petrol does not align with international best practice

Australia's current fuel quality standards present a barrier to the implementation of Euro 6d standards. In particular, the permitted amounts of aromatic hydrocarbons (aromatics) are much higher in Australia than in other parts of the developed world (Table 1). Aromatics (principally benzene, toluene, ethylbenzene, and xylene) are a natural part of crude oil and are an important element in petrol blending because they are a key source to improve the highly valued octane rating (octane) of fuels.[l] However, when combusted in an engine, aromatics in petrol generate particulate matter. At high levels, this can impact vehicle operability and human health. For instance, benzene is classified as a group one carcinogen by the International Agency for Research on Cancer (IARC).

Current aromatics levels could also lead to adverse impacts on the operation of advanced vehicle emissions control systems, resulting in increased noxious and GHG emissions and vehicle operability issues. Australia's current aromatics limit allows a 45% maximum aromatics content and a 35% maximum pooled average in petrol (see Table 1).[m]

[l] The octane rating is a standard measure of a fuel's ability to withstand compression in an internal combustion engine without detonating. Most cars in Australia require 91 RON or 95 RON petrol in Australia – only about 0.6% of new vehicles sold annually require 98 RON.

[m] This is the average amount of aromatics in all batches of petrol across all grades manufactured in Australia, or imported, by a supplier in each 12 months starting on 1 January.

Table 1: Aromatics specifications in Australia and comparable countries

	Australia[n]	South Korea[o]	Japan[p]	EU[q]	US[r]
Aromatics (max)	35% pool average with a max of 45%	22%	Not specified (Real world average around 25%)[s]	35%	35% California Not specified in US standards (The US Renewable fuel mandates ethanol blending, which lowers aromatics)

Fuel quality and vehicle emissions control systems

Exhaust emissions controls

Vehicle emissions control technologies are components of a vehicle's exhaust system designed to limit noxious emissions released into the environment. Globally, emissions regulations and fuel standards have evolved in tandem because fuel quality and emissions control technologies function as a system to reduce emissions. Improved fuel quality has allowed the development of new technologies that take advantage of the cleaner fuel. Also, as emissions control systems have improved, better fuel quality is required because some components of fuel can interfere with emissions control systems.

Engine technology for emissions reduction – catalytic converters

Light duty petrol cars use 'three way catalytic converters' to convert pollutant gases formed during combustion into less harmful compounds. A catalytic converter can reduce emissions of carbon monoxide, unburnt hydrocarbons and nitrogen oxides. Sulfur in fuel can reduce the efficiency of a catalyst, leading to increased emissions of these pollutants. Prolonged use of high-sulfur fuel can reduce the life of a catalyst. Sulfur can interfere with the on-board diagnostic system of catalysts, leading to a false indication that the catalyst is malfunctioning.

Petrol particulate filters (PPFs) in Euro 6d vehicles

Most vehicles designed to meet the latest Euro 6d standards come equipped with a PPF to meet strict particle emissions limits. A PPF is a device within a vehicle's exhaust system that reduces exhaust emissions by trapping fine particles. This prevents their release into the atmosphere. When exhaust gases make their way through the PPFs, the honeycomb filter traps excess nitrous oxide, carbon monoxide and hydrocarbon particulates. Due to the high temperature of the filter, these are all burned off, giving off water, nitrogen and carbon dioxide in the process. PPFs are highly efficient, capturing more than 90% of airborne particulates. Very few vehicles currently sold in Australia are fitted with a PPF. This is mainly due to Australia's current standards not requiring the use of PPFs, and vehicle importer concerns around Australia's high-sulfur petrol clogging these filters. There are also concerns around the impacts of high levels of aromatics in petrol.[40]

[n] Australia, Fuel Quality Standards Act 2000: Fuel Standard (Petrol) Determination, Fuel Standard (Automotive Diesel) Determination.
[o] South Korea, Clean Air Conservation Act: 2010.
[p] Japan, TransportPolicy.net webpage: Japan: Fuels: Diesel and Gasoline | Transport Policy.
[q] European Union, Directive 98/70/EC as amended, EN 228:2012.
[r] USA, Petrol: Title 40 Part 1090 Subpart C - Code of Federal Regulations (ecfr.io); USA, Diesel - 40 CFR § 1090.305 ULSD standards - Code of Federal Regulations (ecfr.io).
[s] Hart, International Fuel Quality Standards and Their Implications for Australian Standards (Final Report), 2014.

Australia's sulfur limit in petrol will align with international best practice at 10 parts per million (ppm) from 15 December 2024 and so consideration of sulfur levels in petrol is out scope for this analysis.

1.5.1 Why are aromatics a problem for the latest petrol vehicles?

Closer alignment of Australia's petrol quality standards[t] with best-practice international standards would ensure that the latest vehicle emissions control systems operate effectively. It would also provide access to more advanced vehicle technologies with better emissions control systems and more fuel-efficient engines.

The automotive industry, through the Federal Chamber of Automotive Industries (FCAI), has advised that an aromatics limit of 35% for petrol is necessary for vehicles to meet Euro 6d standards for GDI engines.[u] FCAI has advised that most light petrol vehicles introduced into Australia between now and 2030 will have this type of engine.

FCAI has suggested that petrol with high aromatics levels can cause issues for these vehicles. These issues include higher emissions than certified, in-service issues such as false positives from malfunctioning indicator lights, and potential operability issues that could damage brand reputation. The petroleum industry has cited that insufficient evidence exists to show Euro 6d vehicles require maximum 35% aromatics petrol (lower aromatics petrol) to operate effectively. However, some vehicle importers have advised that they are unwilling to introduce the latest model Euro 6d vehicles to the Australian market unless aromatics content is reduced.

Most vehicle importers currently sell models that meet Australia's existing Euro 5 standards. Some importers offer vehicles in Australia that meet Euro 6b standards, which are less stringent than Euro 6d standards. Vehicle importers prioritise Euro 6d models for other markets. These vehicles often include newer, more efficient engines and PPFs.

DCCEEW identified a small number of high-performance models available within the Australian market that use PPFs and effectively meet Euro 6d standards. These vehicles require 95 RON or 98 RON petrol. For instance, media reports suggest some vehicles from Audi, Peugeot-Citroen, BMW, Mini, Mercedes and some Volkswagen Group vehicles sold in Australia meet Euro 6d standards.[41]

There is little conclusive evidence on the issue of the maximum threshold of aromatics for these vehicles. Most countries have operated with a 35% limit for some time, and there has been minimal testing of Euro 6d engine operability on Australian market petrol. DCCEEW commissioned a literature review in 2021 on the impact of higher aromatics petrol on Euro 6d engines. The analysis suggests that if Australia maintains the current 45% aromatics limit, Euro 6d petrol cars fitted with PPFs may experience a higher rate of in-service problems compared to Europe. These potential problems include:

- blocked PPFs due to increased production of particulate matter
- higher than normal fuel consumption
- possibly reduced drivability or throttle response due to increased deposits fouling fuel injectors.[42]

The analysis was unable to quantify the probability of these outcomes as it is dependent on the level of aromatics in fuel used in the vehicle over time.

[t] Diesel is dealt with separately below.

[u] Gasoline direct injection engines are engines where fuel is injected into the combustion chamber. This is distinct from manifold fuel injection systems, which inject fuel into the intake manifold. As a result, these engines are generally more efficient.

1.5.2 International aromatics limits in petrol

Research undertaken for this impact analysis suggests that approximately 85% of the global light duty vehicle fleet is in countries with lower aromatics petrol (see Figure 4 and Figure 5).[43] Of the 195 countries and 28 territories with vehicle markets, 174 have petrol specifications in place. Of these, 134 have either an aromatics limit in place or available market information on their maximum aromatics content. 87 (64.9%) have set a 35% aromatics limit or have market content of 35% aromatics or lower. Top petrol car markets including the US, China, Japan, Brazil, Russia, Germany, Mexico, Canada, India and the UK, have set a 35% aromatics limit or have market content of 35% aromatics or lower. Figure 4 shows aromatics content in petrol globally.[44]

The global regulation of aromatics has implications for the vehicle market in Australia. Euro 6d vehicles are designed and tested for lower aromatics petrol and sold to markets with lower aromatics content in petrol. As a result, vehicle importers are hesitant to introduce Euro 6d vehicles to countries with higher aromatics, such as Australia, where there is a higher potential for engine operability issues.

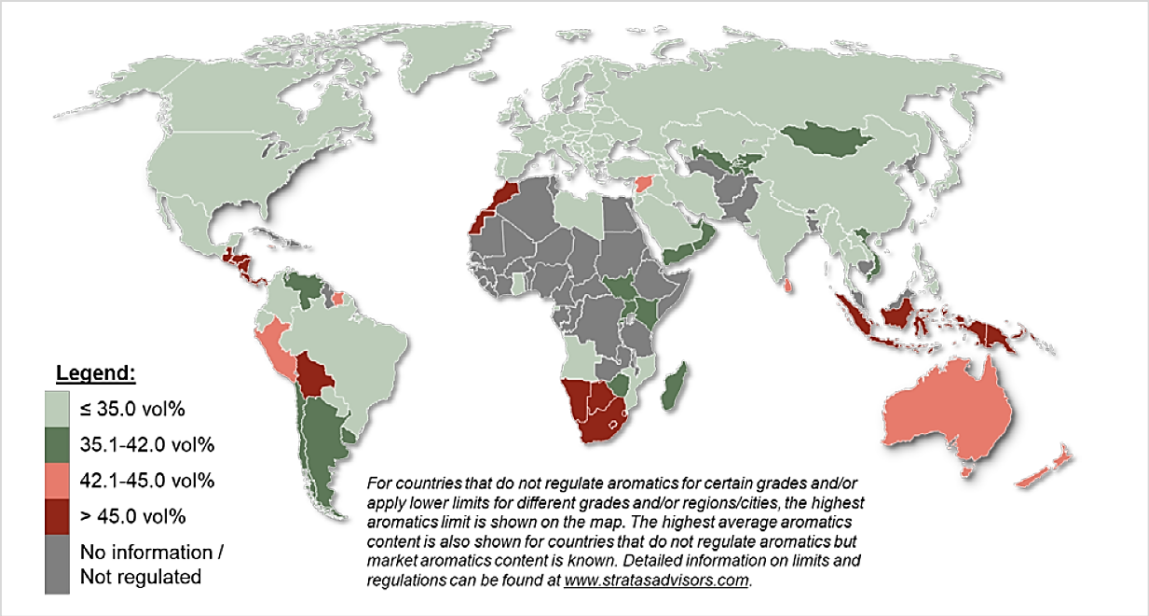

Figure 4: Maximum aromatics content in petrol per country – 2021

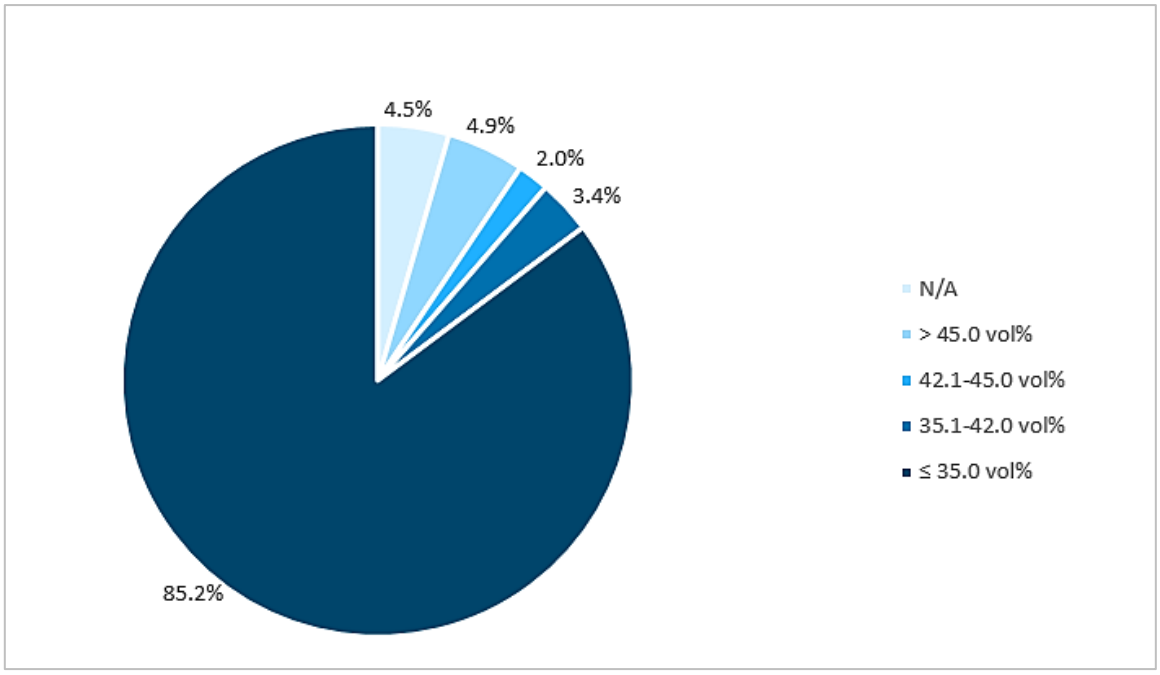

Figure 5: Maximum aromatics content for the global light duty vehicle fleet

In Australia, petrol is marketed by various grades of 'RON', or Research Octane Number:

- regular (unleaded) octane fuels (91 RON)
- mid-grade premium octane fuels (95 RON)
- high-grade premium octane fuels (98 RON)
- E10 is regular unleaded petrol blended with up to 10% ethanol.

Table 2 provides average values for key petrol quality parameters. The data comes from fuel samples taken at service stations around Australia in 2021–22. It shows that Australia's real-world petrol quality is significantly better than the regulated minimum standards. However, our real-world quality still fails to meet international best practice on maximum limits of aromatics.

Table 2: Australian fuel quality sampling data 2021–22 [v]

Grade	91 RON	95 RON	98 RON	E10
Average aromatics (%)	26.2	32.6	37.0	23.9
Maximum aromatics (%)	44.3	42.0	44.6	40.6

1.5.3 Diesel

The regulation of diesel parameters varies from country to country, making it difficult to identify a single 'international standard' (see Table 3). Australian diesel standards do not align with EU standards with respect to three diesel parameters that affect vehicle operability and noxious emissions.

- **Cetane** is a chemical compound found naturally in diesel, and it ignites easily under pressure. Because of its high flammability, it serves as the industry-standard measure for evaluating fuel combustion quality.
- **Polycyclic aromatic hydrocarbons (PAH)** are a class of chemicals that occur naturally in coal, crude oil and fuel. PAH are organic compounds that typically contain from two to eight

[v] Unpublished data from the National Measurement Institute.

aromatic rings. They form during the incomplete combustion of organic compounds and are released and dispersed whenever natural biomass is burned (including, but not limited to, diesel fuel). In Australia, diesel fuel must not contain more than 11% PAH (by mass).

- **Density** is measured as the weight of fuel (in kg) per m3 at 15°C. Denser fuel has higher energy content. Density that is too low can reduce fuel efficiency and impact engine operability. Density that is too high can increase PM emissions.

Australian automotive diesel already meets international best practice in many key parameters, such as sulfur limits. Australia has had a 10 ppm sulfur limit on diesel since 2009.

Table 3: Key diesel specifications in Australia and comparable countries

	Australia[w]	South Korea[x]	Japan[y]	EU[z]	US[aa]
PAH (max) by mass	11%	5%	Not specified	8%	Not specified
Sulfur (max)	10 ppm	10 ppm	10 ppm	10 ppm	15 ppm
Derived or actual cetane number (min)[bb]	Not specified for mineral diesel	52	45/50 (depends on grade)	51	40
Cetane index (min)	46	Not specified	45/50 (depends on grade)	Not specified	40 (or max aromatics content of 35%)
Density (kg/m^3)	820–850	815–835	860 max	820–845	Not specified

Monitoring undertaken in 2021–22 by the Government showed that cetane and PAH levels in Australian diesel on average met European standards (Table 4). The data is derived from fuel samples taken from service stations around Australia.

Table 4: Australian diesel quality sampling data 2021–22[cc]

Average Cetane Index	51.9	Minimum Cetane Index	46.2
Average PAH	3.0%	Maximum PAH	6.9%

Diesel quality was not reported as an issue for implementing Euro VI emissions standards for heavy vehicles, such as large trucks and buses. The Government has decided to phase in Euro VI standards over 12 months starting from 1 November 2024.[45] Heavy vehicle manufacturers and operators did not consider any further changes to diesel fuel quality were necessary to enable the introduction of Euro VI and were sensitive to any increase in price. They also acknowledged that our current diesel quality does not impact diesel vehicle operability.

[w] Australia, Fuel Quality Standards Act 2000: Fuel Standard (Petrol) Determination, Fuel Standard (Automotive Diesel) Determination.
[x] South Korea, Clean Air Conservation Act: 2010.
[y] Japan, TransportPolicy.net webpage: Japan: Fuels: Diesel and Gasoline | Transport Policy.
[z] European Union, Directive 98/70/EC as amended, EN 228:2012.
[aa] USA, Petrol: Title 40 Part 1090 Subpart C - Code of Federal Regulations (ecfr.io); USA, Diesel - 40 CFR § 1090.305 ULSD standards.
[bb] Derived Cetane Number and Cetane index represent different methods to determine cetane of a fuel. Derived Cetane Number is measured using a test engine, whereas the cetane index is calculated based on the properties of the diesel.
[cc] Unpublished data from the National Measurement Institute.

The analysis assessed whether any changes to diesel quality were necessary to enable improved noxious emissions standards for light vehicles. There are around 70 diesel light vehicle models sold in Australia that meet Euro 6 (including Euro 6d) standards.[46] These include models from Ford, Volkswagen, Audi, Land Rover and Mercedes. Vehicle importers have not indicated any known issues with operation of these vehicles using diesel that meets Australian specifications.

1.6 Fuel security and fuel quality

Maintaining Australia's fuel security is an essential consideration in Australian fuel policy. Any changes to Australian fuel quality should not compromise our fuel security.

In 2019, liquid fuels made up 52% of Australia's final energy consumption and included petrol, diesel, jet fuel and biofuels.[47] Growth in liquid fuel demand in Australia is much higher than that of countries with similar economies. Prior to the COVID-19 pandemic, Australia's demand for liquid fuels grew by an average of 1.8% per year over a 10-year period to 2018–19, outstripping population growth. Over the same period, diesel demand grew by 5.0% per year.[48]

Australia's two domestic refineries supply around a quarter of Australia's liquid fuels. Maintaining a domestic refining capability is valuable for Australia, allowing us to increase our resilience to supply chain shocks. Modelling has suggested, based on assumptions from 2018–19, that in the event of an extreme supply chain shock with no imports, by using domestic crude the two remaining refineries could supply essential users of diesel for 465 days and essential users of petrol indefinitely.[49] Without a continued domestic fuel industry, Australia's fuel security would be significantly diminished and Australia could run the risk of protracted fuel shortages, with flow-on effects across the economy.

Therefore, to maintain Australia's fuel security, Australian refineries need to be able to meet the fuel quality standards while maintaining the continuing viability of their operations. At the same time, global sources of supply should not be overly constrained for importers.

Government support for refineries to produce better fuels

Changes to fuel quality standards can be technically complex, expensive and take years to design and build. The Government has implemented the Refinery Upgrades Program (RUP) to support infrastructure upgrades to produce improved quality petrol at the two remaining domestic refineries. The objective of the program is to assure the domestic production and supply of better-quality fuel while maintaining refining capability in Australia. Phase 1 of the RUP provides up to $125 million per refinery, which is capped at a 50% co-contribution towards project costs, to allow the production of petrol with 10 ppm sulfur in 2024. A Phase 2 of the RUP is under Government consideration and depends on the outcomes of the final impact analysis. Phase 2 would provide a further $26 million per refinery for infrastructure upgrades needed to produce fuel of a quality that enables the implementation of Euro 6d standards.

2. Why is Government action needed?

2.1 Existing policies will not remain effective

Since the 1970s, the Government has taken steps to reduce noxious emissions from light vehicles by adopting international noxious emissions standards. These have been progressively strengthened in response to:

- vehicle technology advances and availability of suitable fuels
- increasing international concern over air pollution problems, as greater scientific knowledge has highlighted their impact on human health
- increases in the size of and make up of vehicle fleets as well as vehicle usage patterns, particularly in urban areas.

BITRE estimates that since 1990, light vehicle noxious emissions standards have reduced Carbon Monoxide (CO) and Hydrocarbon (HC) emissions by over 85%, Oxides of nitrogen (NO_x) emissions by almost 50% and Particulate Matter (PM) emissions by approximately 45%. These improvements have occurred despite the fact there are almost twice as many vehicles on the road and total vehicle kilometres travelled have increased by over 60% over the same period.

However, the impact of existing standards will diminish in the 2020s. This is because there will be more vehicles on the road and more kilometres travelled, which will offset the benefit of new vehicles replacing older models, without the introduction of a more stringent standard.

Projections by BITRE (Figure 6) show that, without adopting more stringent standards, NO_x emissions from light vehicles will remain relatively stable over the next 10 years.

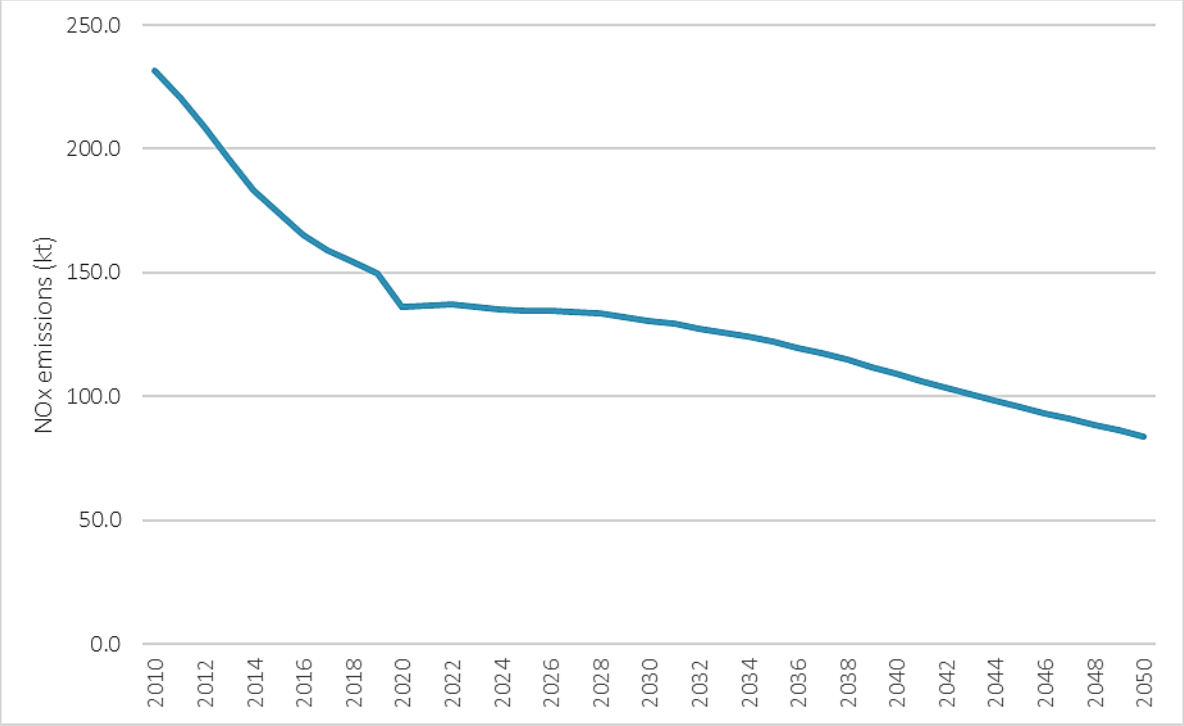

Figure 6: Projected impact of Euro 5 standards on NO_x emissions from the light vehicle fleet (2010–2050)

BITRE projections (Figure 7) also show that under current existing standards, fine particulate emissions from light vehicles will also remain relatively stable until the mid-2030s.

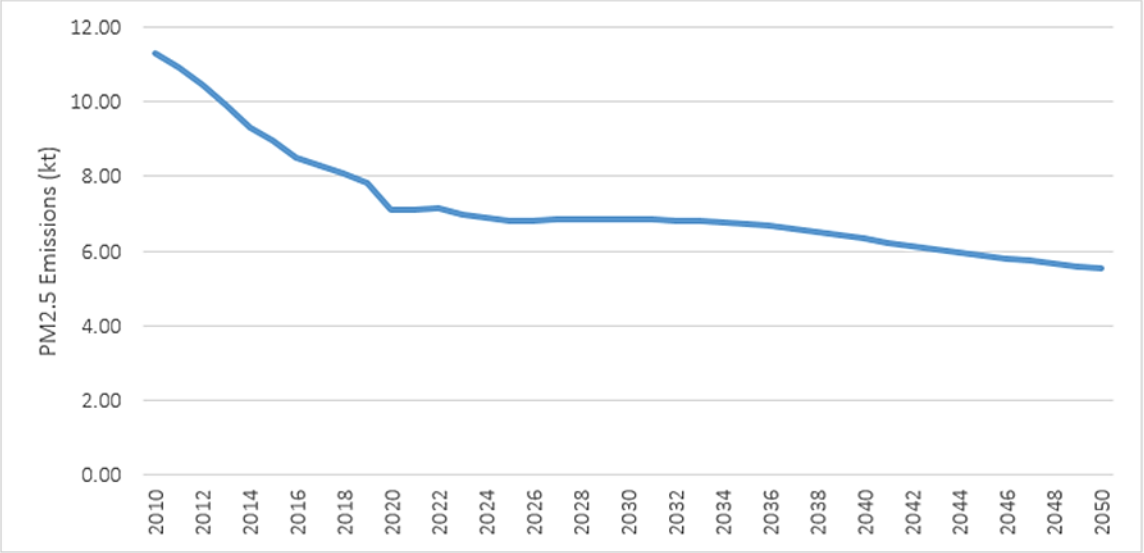

Figure 7: Projected impact of Euro 5 standards on $PM_{2.5}$ emissions from the light vehicle fleet (2010–2050)

2.2 Market pressures alone will not improve noxious emissions or fuel quality

Externalities arise when the economic activity of one organisation (or person) generates a positive or negative impact for another without a market price associated with the impact. In this instance, the costs of health and environmental impacts caused by the release of noxious emissions are not factored into the price of fuel or vehicles.

As a result, the health impacts of noxious emissions from vehicles are not borne by vehicle manufacturers, fuel suppliers or consumers alone, but are shared by the community collectively. When purchasing a vehicle or fuel, motorists are more likely to consider factors that impact on them directly, such as performance, price, comfort and safety. Because of this, without Government intervention, manufacturers have no clear market incentive to supply vehicles with the latest emissions control technology and fuel suppliers have no clear incentive to supply cleaner fuels.

The link between fuel quality, noxious emissions and health impacts is not widely publicised and is often not clear to consumers. Other than octane levels, the quality of fuel is not usually advertised by retailers or considered by fuel purchasers. Beyond the vehicle suppliers indicating to motorists the necessary fuel grade for their vehicle (for example, through a sticker on the fuel tank flap), this analysis assumes that consumer awareness of the impact of fuel grades is low. 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. This issue is a priority for joint action by governments, businesses and the community.[50]

In the absence of a clear market signal from consumers or the Government to supply cleaner fuels and vehicles with advanced emissions control systems, some manufacturers will continue to supply vehicles meeting less stringent standards if it is cost effective to do so, especially if newer technology requires cleaner fuels that are not readily available. For example, the Second National In-Service Emissions Study found that many vehicles sold in Australia between 1986 and 2007 only met the minimum legal requirements at that time despite more advanced technologies being widely available overseas.[51] If one manufacturer does this to remain competitive in Australia, this will put commercial pressure on other manufacturers to cut costs to remain competitive by supplying older technology.

Without Government intervention, noxious emissions will continue to increase, as will the associated health and environmental cost burden. Government action to improve fuel quality and

reduce noxious emissions would improve air quality and provide greater certainty that Australians will be protected from noxious emissions.

Australia has fuel standards for each type of fuel, made as legislative instruments under *the Fuel Quality Standards Act 2000* (Cth). The Government can improve the quality of Australian fuel by amending the fuel standards. Similarly, Australia also has noxious emissions standards, made as legislative instruments under the *Road Vehicle Standards Act 2018*. The Government can improve noxious emissions standards by adopting more stringent Australian Design Rules.

2.3 Improvements to Australia's fuel can unlock the benefits of Euro 6d

Australia is a vehicle technology taker, and technology development is driven by the regulatory environment of the major markets of Europe, the US and China. These markets all use lower aromatics petrol and require noxious emissions standards and fleet fuel efficiency standards to be met. Scientific evidence is scarce about the exact impact of Australian fuel that contains higher aromatics. In the absence of evidence, increased harmonisation of Australia's fuel quality standards with international standards would allow vehicle importers to provide Euro 6d vehicles without additional testing or modification to ensure these vehicles are fit for purpose on Australian market fuels. This would ensure Australia can access the latest vehicle technology, while reducing the risk of vehicle operability issues for consumers.

If Australian regulation does not keep pace with international standards prevalent across the global vehicle market, Australia risks foregoing the benefits of technology available in other countries. During previous stakeholder consultations, light vehicle manufacturers advised their latest models, fitted with the latest safety and fuel-saving technologies, are packaged with engines designed to meet the Euro 6d or equivalent standards required in the larger European, North American and Asian vehicle markets.

As Australia is a smaller vehicle market, it risks having access to fewer models fitted with these technologies if its noxious emissions and fuel quality standards are not updated. This is because it will be harder to compete with older, cheaper models and it will cost too much to develop and add new safety technologies to older models specifically for the Australian market. This would reduce the availability of new vehicle safety and emissions technologies in the Australian light vehicle fleet.

3. What policy options are under consideration?

3.1 The objectives of Government action

The objectives of Government action are to:

- ensure the most appropriate measures to reduce the impacts of noxious emissions from road vehicles on the Australian community are in place
- ensure Australia has access to the latest vehicle technology, through closer alignment with international fuel and vehicle standards
- provide the greatest net benefit to the Australian community.

The decision rule for this analysis is that the recommended option should be the option with the highest net benefit in line with the *Australian Government Guide to Policy Impact Analysis*.[52] Where intervention involves the use of regulation, the Agreement on Technical Barriers to Trade encourages Australia to adopt international standards where they are available or imminent.

A core objective of the Road Vehicle Standards Act (RVSA), which regulates the first supply of road vehicles to Australia, is also to set nationally consistent performance-based standards that road vehicles must comply with before being provided in Australia and provide consumers with a choice of road vehicles that meet the safety and environmental expectations of the community.

As a contracting party to the UN 1958 Agreement, the Government has also committed to harmonise Australia's vehicle standards wherever possible with international standards adopted by the UN World Forum for the Harmonization of Vehicle Regulations (WP.29). The options considered to improve fuel quality and reduce noxious emissions from light vehicles align with these objectives.

This analysis considers the options for noxious emissions standards, the options to improve fuel quality standards and then combines the analysis into the most relevant packages of options. This is because moving to Euro 6d standards cannot be undertaken without moving to improved fuel quality standards. Options under consideration are summarised below.

3.1.1 Noxious emissions options

Table 5 summarises the noxious emissions options considered and their viability. Options were considered viable if the proposed measure would significantly increase the proportion of vehicles meeting Euro 6d standards beyond the proportion expected under current policy settings.

Table 5: Noxious emissions standards options

Option Name	Business as usual	Option A Implement fleet purchasing policies	Option B Implement a voluntary standard	Option C Mandate Euro 6d standards from 2027-28	Option D Mandate Euro 6d standards from 2025-28
Description	Maintain Euro 5 noxious emissions standards	Maintain Euro 5 noxious emissions standards but seek to influence vehicle purchasing decisions by adopting minimum noxious emissions performance requirements in the Australian Government fleet.	Maintain Euro 5 noxious emissions standards but encourage vehicle manufacturers, through peak industry groups, to enter into an agreement with the Australian Government to meet increased minimum noxious emissions performance requirements.	Mandate Euro 6d from 2027–28 (original approach considered in consultation RIS to align with the introduction of improved fuel quality standards, if adopted from 2027).	Mandate Euro 6d from 2025–28 (an alternative approach proposed to align with the introduction of improved fuel quality standards, if adopted from 2025).
Viable	N/A	No	No	Yes	Yes

3.1.2 Fuel quality options

Table 6 provides a summary of the fuel quality options considered and their viability. Petrol options were considered viable if they would enable the introduction of Euro 6d standards and were technically feasible. The diesel option (Option 4) was considered viable as it presents the costs and benefits of changing the diesel standard. No changes to the diesel standard are required to enable the introduction of Euro 6d standards.

Table 6: Viability of fuel quality standards options

Option Number	Business as usual	Option 1 (petrol)	Option 2 (petrol)	Option 3 (petrol)	Option 4 (diesel)
Implementation date	N/A	2024	2025	2027	2024
Description	Continuation of current policy settings	35% maximum aromatics for 91 RON, 35% grade average for 95 RON. No change to 98 RON	35% maximum aromatics content for 95 RON No change to other grades	35% maximum aromatics content across all grades of petrol	Align key diesel specifications with the EU standard
Viable	N/A	No	Yes	Yes	Yes (although not required for the implementation of Euro 6d standards).

Why we are including the diesel option (Option 4)

Some stakeholders suggested the Government should align Australia's diesel standard with the European standards. DCCEEW developed Option 4 to assess the cost of aligning Australia's diesel standard with the EU standard, and whether changes were required to enable the operation of Euro 6d light diesel vehicles, or Euro VI heavy vehicles.

A change to the diesel standard is considered technically viable, but the analysis did not find any evidence to suggest that diesel quality was a barrier for enabling more stringent noxious emissions standards for either light or heavy vehicles. Detailed analysis of the costs and benefits of the changes are included in this document.

3.1.3 Combined Options

Table 7 provides a summary of the noxious emissions standard options against the fuel quality standard options, noting which this analysis considers viable, which are not viable, and a summary of the NPV costs and benefits for those that are viable. Packages implementing Euro 6d and improved fuel quality standards together were considered viable if Euro 6d standards commenced on or after the proposed introduction of lower sulfur and aromatics in petrol. As no changes to the diesel standards are required to introduce Euro 6d standards, the diesel option (Option 4) was not included in the viable packages.

Table 7: Viable packages of noxious emissions standards and fuel quality standards options

Option: Noxious Emissions Standards vs Fuel Quality Standards	*Business as usual: Noxious Emissions*	Option A: Implement fleet purchasing policies	Option B: Implement a voluntary standard	Option C: Mandate Euro 6d standards from 2027-28	Option D: Mandate Euro 6d standards from 2025-28
Business as usual: Fuel Quality	N/A (default options) NPV $0	Not viable	Not viable	Not viable	Not viable

Option: Noxious Emissions Standards vs Fuel Quality Standards	*Business as usual: Noxious Emissions*	Option A: Implement fleet purchasing policies	Option B: Implement a voluntary standard	Option C: Mandate Euro 6d standards from 2027-28	Option D: Mandate Euro 6d standards from 2025-28
Option 1: 35% maximum aromatics for 91 RON, 35% grade average for 95 RON *No change to 98 RON*	Negative NPV	Not viable	Not viable.	Not viable	Not viable
Option 2: 35% maximum aromatics content for 95 RON *No change to other grades*	Negative NPV	Not viable	Not viable	Yes Package 3. NPV $3,717.8 million	Yes Package 2 NPV $4,508.4 million
Option 3: 35% maximum aromatics content across all grades of petrol	Negative NPV	Not viable	Not viable	Yes Package 1 NPV $2,493.5 million	Not viable
Option 4: Align key diesel specifications with the EU standard	Negative NPV	Not viable	Not viable	Viable (if adopted with Fuel Quality Option 2 or 3), but not required	Viable, (if adopted with Fuel Quality Option 2), but not required

For options not considered viable, the costs and benefits have not been quantified in this analysis. These packages were informed by feedback received from industry and community stakeholders in response to:

- The draft Regulation Impact Statement 'Light Vehicle Emission Standards for Cleaner Air', released for comment by the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA) from October 2020 to February 2021[dd]; and
- the draft Regulation Impact Statement 'Better Fuel for Cleaner Vehicles' released for comment by the Department of Climate Change, Energy, the Environment and Water from November to December 2022.[ee]

Our analysis suggests that **Package 2** is preferred, with the highest net benefits to the community. We now present our analysis across each of the options across noxious emissions standards and fuel quality standards, and how we have constructed our proposed packages.

3.2 Noxious emissions standards – overview of options considered

The options considered to reduce noxious emissions from new light road vehicles are:

- **Business as usual**: Allow the existing Euro 5 noxious emissions standards and market forces to provide a solution.

[dd] See https://www.infrastructure.gov.au/sites/default/files/migrated/vehicles/environment/forum/files/light-vehicle-emission-standards-for-cleaner-air.pdf
[ee] See https://consult.dcceew.gov.au/better-fuel-for-cleaner-vehicles

- **Option A**: Fleet purchasing policies (not considered viable): Maintain Euro 5 noxious emissions standards but seek to influence vehicle purchasing decisions by adopting minimum noxious emissions performance requirements in the Australian Government fleet.
- **Option B**: Voluntary standards (not considered viable): Maintain Euro 5 noxious emissions standards but encourage vehicle manufacturers, through peak industry groups, to enter into an agreement with the Australian Government to meet increased minimum noxious emissions performance requirements.
- **Options C and D**: Increased mandatory standards – mandate Euro 6d standards for light vehicles under the RVSA.

Following stakeholder feedback on the draft regulation impact statement (RIS) *Light Vehicle Emission Standards for Cleaner Air* released for public consultation in 2020–2021, two possible approaches have been evaluated for this impact analysis.

- Option C – Mandate Euro 6d standards from 2027–28 (original approach considered in the *Light Vehicle Emission Standards for Cleaner Air* draft RIS to align with the introduction of improved fuel quality standards, if adopted from 2027).[ff]
- Option D – Mandate Euro 6d standards from 2025–28 (an alternative approach proposed to align with the introduction of improved fuel quality standards, if adopted from 2025).[gg]

Options A and B were not considered viable, as they would not provide sufficient commercial incentive for all manufacturers to replace their Euro 5-compliant vehicle models with Euro 6d-compliant vehicle models. See section 3.5 below, or the *Light Vehicle Emission Standards for Cleaner Air* RIS for more information[hh].

3.2.1 Business as usual

The Government requires all impact analyses to include an analysis of a business-as-usual (BAU) option to act as a benchmark. The cost benefit analysis (CBA) for any remaining options are then calculated relative to this, so what would have happened under existing policy settings is not attributed to any proposed intervention.

Under a BAU option, the Government would not intervene further and instead rely on the existing Euro 5 standards and market forces to control noxious emissions from light vehicles.

Existing noxious emissions standards, which were phased in from 2013 to 2016, have delivered air quality benefits over the last decade. However, as noted in the previous section, existing standards will stop delivering reductions in NO_x and PM emissions in the coming years. The number of vehicles on the road and kilometres travelled is increasing, and without more stringent standards this will offset the benefit of new vehicles replacing older models.

A growing proportion of vehicles entering the Australian market may meet Euro 6 standards by virtue of their adoption in overseas markets. However, this would occur at a much lower rate than under a mandated standard, as commercial pressures will encourage manufacturers to minimise their production costs.

[ff] For newly approved models first supplied to Australia from 2027. Models approved and supplied to Australia for the first time prior to 2027 would be required to comply from 2028, if that model is still being produced and supplied to Australia in 2028.

[gg] For newly approved models first supplied to Australia from 2025. Models approved and supplied to Australia for the first time prior to 2025 would be required to comply from 2028, if that model is still being produced and supplied to Australia in 2028.

[hh] In *Light Vehicle Emission Standards for Cleaner Air* Options A and B were referred to as Options 2 and 3. For ease of readability, in this document we have re-labeled the options to avoid confusion with the options presented as part of our analysis of fuel quality standards.

There are no additional benefits or costs associated with this option as there are no proposed changes to existing policy settings. The best possible outcome under this option would be that the health impacts and number of premature deaths resulting from traffic-related pollution remain relatively constant in line with the number of vehicle kilometres travelled over the next decade.

3.3 Noxious emissions standards – Viable options considered

3.3.1 Options C and D: Increased mandatory standards

Under these options, the Government would mandate improved noxious emissions performance for new light vehicles, by determining new ADRs adopting Euro 6d requirements under the RVSA. The only difference between Option C and Option D is commencement timing (as above). Consequently, we consider these options together.

Under the ADRs, vehicles are approved on a model (or vehicle type) basis known as vehicle type approval. The Government approves the design of a vehicle type based on test and other information supplied by the manufacturer. Compliance of vehicles built under that approval is ensured by the regular audit of the manufacturer's test facilities and production processes. The ADRs apply equally to new imported vehicles and new vehicles manufactured in Australia.

Vehicle standards for noxious emissions both in Australia and internationally are a cost-effective measure to reduce urban air pollution from the road transport sector. The NSW Environmental Protection Authority found that NO_x emissions produced by light petrol passenger vehicles per kilometre travelled were 71% lower in 2013 than in 2003, thanks to the introduction of the Euro 3, 4 and 5 noxious emissions standards. NO_x emissions from light diesel vehicles in 2013 were 36% lower per kilometre than in 2003, and particulate emissions were 89% lower per kilometre.[53] DITRDCA's analysis of the 2016–17 'Real Driving Emissions' (RDE) testing study conducted by the Australian Automobile Association (Figure 8) also suggests that NO_x emissions from Euro 6 diesel passenger vehicles are substantially lower than Euro 4 and Euro 5 diesel passenger vehicles.[54]

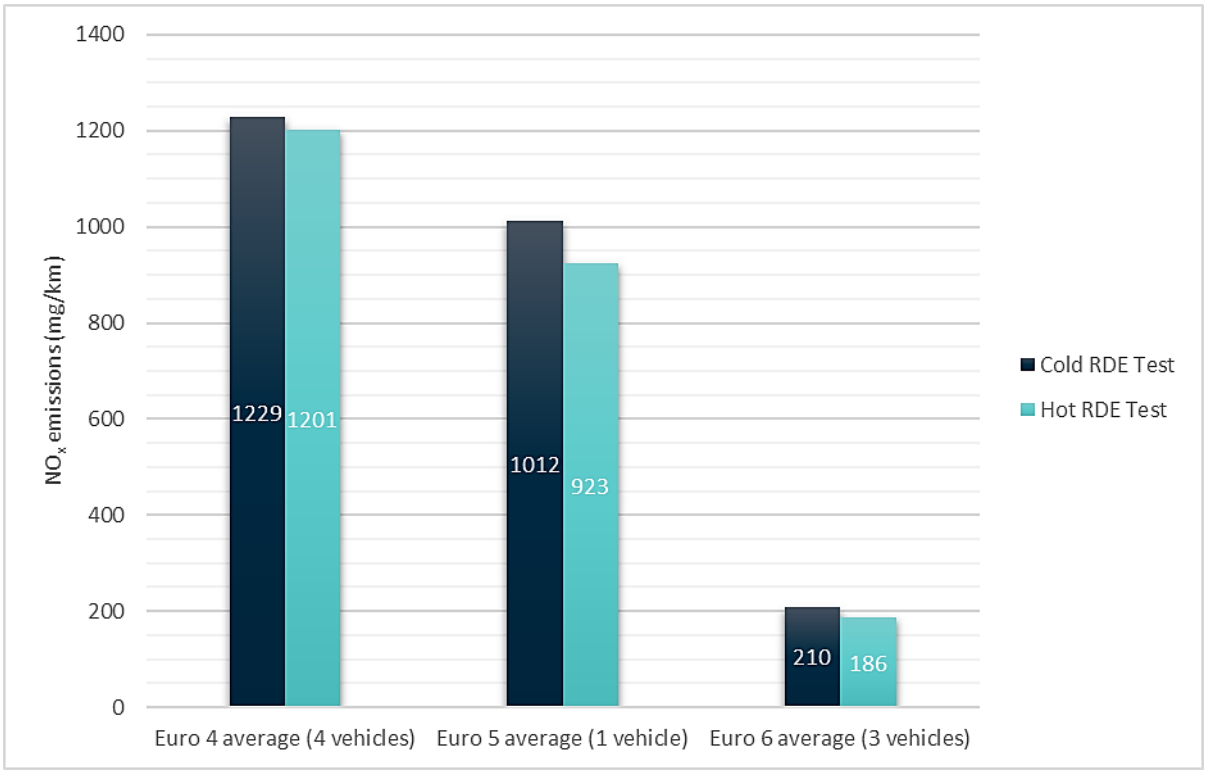

Figure 8: On-road NO_x emissions from diesel passenger vehicles
(tested to the European 'Real Driving Emissions' (RDE) test by the Australian Automobile Association)

Similarly, DITRDCA's analysis also found that particulate emissions from Euro 5 and Euro 6 diesel passenger vehicles (Figure 9) are also substantially lower than Euro 4 diesel passenger vehicles.

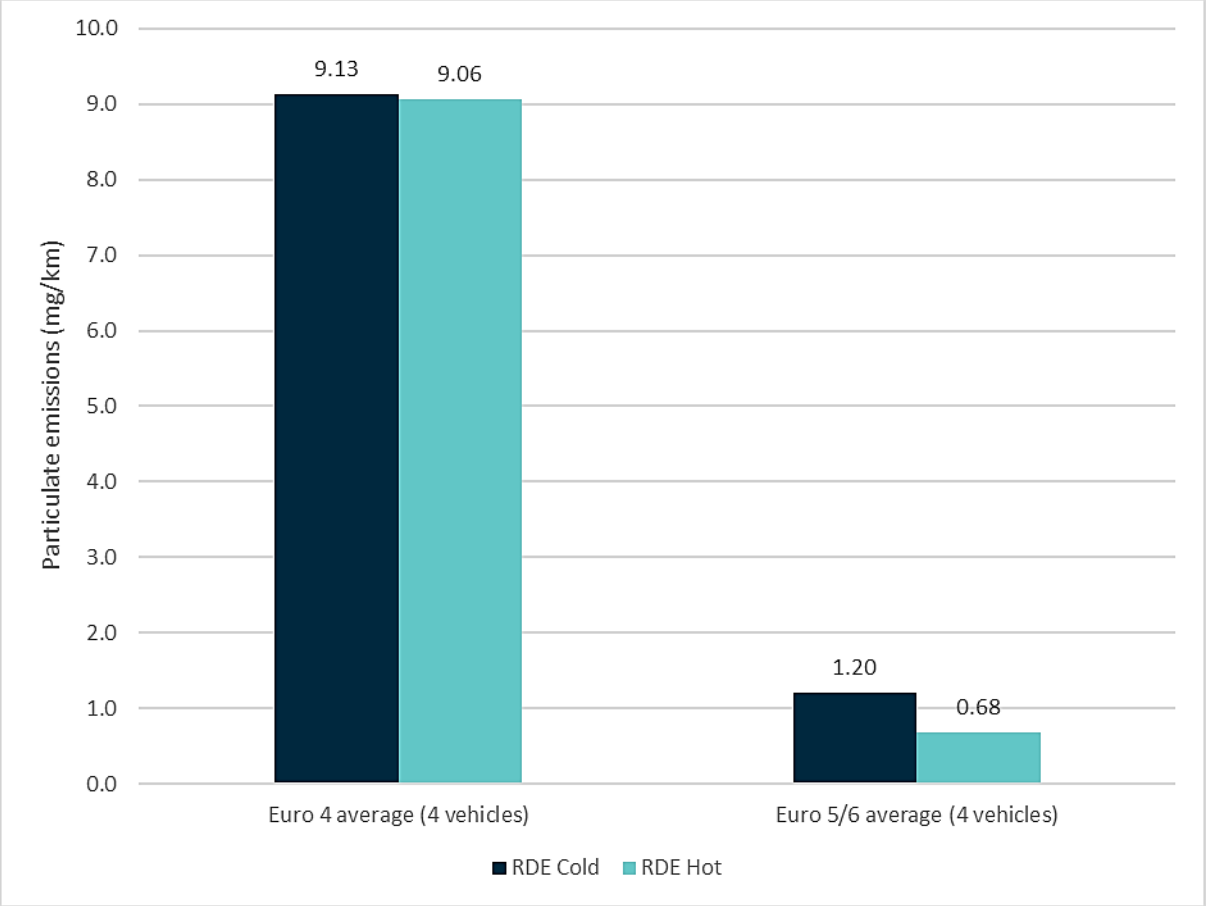

Figure 9: On-road particulate emissions from diesel passenger vehicles
(tested to the European 'Real Driving Emissions' (RDE) test by the Australian Automobile Association)

The adoption of Euro 6 standards would deliver the following key benefits for new vehicles entering the light vehicle fleet:

- for light diesel vehicles, a 55% reduction in the emissions limits for NOx
- for petrol vehicles with direct injection fuelling systems, the introduction of a limit on the number of particles to control fine particle emissions
- more stringent requirements for on-board diagnostic systems that monitor the emissions control systems, including a reduction in the thresholds at which a malfunction warning is detected and an increased frequency of monitoring (in-use performance ratio).

The changes in emissions limits from Euro 5 to Euro 6 are detailed in Table 8 and Table 9.

Table 8: Euro 5 and Euro 6 light passenger vehicle emissions limits

Pollutant	Euro 5		Euro 6	
	Petrol/LPG	Diesel	Petrol/LPG	Diesel
Oxides of nitrogen	60 mg/km	180 mg/km	60 mg/km	80 mg/km
Particulate matter	4.5 mg/km (for direct injection)	4.5 mg/km	4.5 mg/km (for direct injection)	4.5 mg/km
Particle number limit	No limit	$6x10^{11}$/km	$6x10^{11}$/km (for direct injection)	$6x10^{11}$/km

Table 9: Euro 5 and Euro 6 light commercial vehicle emissions limits

Pollutant	Euro 5		Euro 6	
	Petrol/LPG	Diesel	Petrol/LPG	Diesel
Oxides of nitrogen	82 mg/km	280 mg/km	82 mg/km	125 mg/km
Particulate matter	4.5 mg/km (for direct injection)	4.5 mg/km	4.5 mg/km (for direct injection)	4.5 mg/km
Particle number limit	No limit	$6x10^{11}$/km	$6x10^{11}$/km (for direct injection)	$6x10^{11}$/km

Although the changes to the 'headline' Euro 6 emissions limits for petrol vehicles appear minor, the introduction of the limit on number of particles will require a significant change to most petrol vehicles. This is because most new petrol vehicles now have direct injection fuelling systems to reduce fuel consumption and CO_2 emissions, but also produce more ultrafine particles, which can penetrate more deeply into the lungs and bloodstream. This limit will effectively require all new direct injection petrol vehicles to fit a petrol particulate filter to minimise the community's exposure to these emissions, which is estimated to increase new vehicle production costs by $450.

In addition to the stricter emissions limits discussed above, the Euro 6 requirements adopted in the EU from 2017 onwards (known as Euro 6d standards), also adopt improved emissions tests that are more representative of real-world driving for all vehicles to help ensure vehicles meet the regulated limits on the road, as well as the official lab test. These new tests are:

- A new laboratory test (known as the Worldwide harmonised Light vehicles Test Procedure or WLTP) that is more representative of real-world driving to determine compliance with emissions requirements. The WLTP test requirements of Euro 6d were transposed into UN Regulation 154, which entered into force in January 2021.
- A new on-road test, known as the Real Driving Emissions or RDE test to improve the correlation between laboratory-tested and on-road emissions levels.

Both tests aim to address deficiencies highlighted by the 'dieselgate' scandal in 2015, where the Volkswagen Group was alleged to have fitted software to some of its diesel engines, which changed the way a vehicle's emissions control system operated when it was being tested to pass more stringent emissions standards.[55] These new tests have been in place for some time in jurisdictions that have adopted Euro 6d standards.

A similar test to the Euro 6d RDE test is being adopted by Australian Automobile Association, as part of the 'Real World Testing of Vehicle Efficiency' program funded by the Australian Government to improve consumer information on the real-world fuel consumption and emissions of vehicles. The RDE test mandated by Euro 6d standards would complement this program by setting a maximum limit for NO_x and particulate emissions for all new vehicles in an on-road setting.

3.3.2 Proposed alternative standards

Traditionally, the ADRs for light vehicle emissions have only recognised equivalent UN Regulations as an alternative standard. However, to reduce the regulatory burden and increase the range of vehicles manufacturers could offer without compromising the policy objectives of the proposed standards, the *Light Vehicle Emission Standards for Cleaner Air* draft RIS sought feedback on whether Australia should recognise any other national or regional emissions standards as alternatives.

To be recognised as an equivalent alternative standard, DITRDCA considered that any other national or regional standard for noxious emissions would need to adopt comparable test procedures and emissions limits to Euro 6d requirements and a durability requirement of no less than 160,000 km based on the Euro 6d requirements and the expected operational life of vehicles supplied to Australia. Based on these criteria, it is proposed that any new ADRs adopting the Euro 6d

requirements, as adopted in the UN vehicle regulations, also accept vehicles meeting the EU Regulation 2017/1151 and the US Tier 3 standards for light duty vehicles, as they specify similar emissions limits and durability requirements for the European and US markets. Accepting these standards in addition to the UN Regulation would reduce the need for additional testing specifically for the Australian market and make it easier for manufacturers to align their sales practices in Europe and US with Australia.

Although the emissions limits and test requirements of the Japanese 2018 standard were similar to Euro 6d standards, the Japanese standard was not considered equivalent in stringency to Euro 6d standards as it only required vehicles to meet the relevant emissions requirement for 80,000 km (as opposed to the 160,000 km required by Euro 6d standards). Further data on the emissions of vehicles manufactured to comply with the Japanese standard that have been in service for 160,000 km would be required before the Japanese standard could considered further as an equivalent alternative standard.

3.3.3 Proposed timeframes

Any proposed timeframe for the introduction of Euro 6d standards would need to strike a balance between the earliest possible introduction, which would maximise health benefits, and a delayed introduction, which allows vehicle manufacturers sufficient time to develop and source products designed to meet new emissions standards.

Consequently, in this analysis we have considered two sub-options based on the date of introduction of Euro 6d standards.

- Option C – Mandate Euro 6d from 2027–28[ii]
- Option D – Mandate Euro 6d from 2025–28.[jj]

In effect, the key difference between these options is that Option D would have Euro 6d standards introduced two years prior to Option C. Option C allows vehicle manufacturers greater time to implement Euro 6d standards, but delays health benefits, whilst Option D brings forward health benefits but there would be less implementation time (and thus, greater costs) for vehicle manufacturers. Quantification of the benefits and costs of these options appears at section 4.7 respectively. These implementation timeframes align with the different options to improve fuel quality standards discussed below. That is:

- Noxious Emissions Standards Option C (Mandate Euro 6d from 2027) aligns with Fuel Quality Option 3 (95 RON: 35% maximum aromatics limit across all grades – which could be implemented from 2027).
- Noxious Emissions Standards Option D (Mandate Euro 6d from 2025) aligns with Fuel Quality Option 2 (95 RON: 35% maximum aromatics – which could be implemented from 2025).

3.3.4 Other regulatory options for noxious emissions not considered further in this analysis

3.3.4.1 Adopt Euro 6e

In July 2022, the EU adopted a new stage of Euro 6 standards, known as Euro 6e, which will be phased in for new light vehicles supplied to the EU over four years from September 2023. Euro 6e standards reduce the emissions levels permitted in the RDE test and allows the RDE test to be

[ii] For newly approved models first supplied to Australia from 2027. Models approved and supplied to Australia for the first time prior to 2027 would be required to comply from 2028, if that model is still being produced and supplied to Australia in 2028.

[jj] For newly approved models first supplied to Australia from 2025. Models approved and supplied to Australia for the first time prior to 2025 would be required to comply from 2028, if that model is still being produced and supplied to Australia in 2028.

performed in a wider range of temperature conditions. Euro 6e standards also adopt changes to the way fuel consumption and emissions are calculated for plug-in hybrid vehicles to account for a higher proportion of use of the internal combustion engine fitted to these vehicles.

Subject to agreement by contracting parties to the UN 1958 Agreement at the June 2020 session of the World Forum for the Harmonization of Vehicle Regulations, it is anticipated these Euro 6e requirements will be transposed into two new UN Regulations (a new UN Regulation for Real Driving Emissions and a new series of UN Regulation 83).

As Euro 6e standards have only been adopted very recently in Europe and did not exist at the time the *Light Vehicle Emission Standards for Cleaner Air* draft RIS was released for consultation in 2020–2021, this impact analysis has not evaluated the costs and benefits of Euro 6e standards. As Euro 6e standards will be phased in over a number of years in the EU, and will be phased in over three sub-phases to enable manufacturers to develop the technology required, it would not be viable to adopt Euro 6e standards in Australia until at least 2027.

As Euro 6d standards can be implemented as soon as improved fuel quality standards are in place, and further analysis would be required to quantify the costs and benefits of adopting Euro 6e standards, Australia would risk foregoing some of the health benefits of adopting Euro 6d standards, if a policy decision on adopting Euro 6d standards was to be delayed to also evaluate the costs and benefits of adopting Euro 6e standards.

As Euro 6d or equivalent standards have been in force in the EU and other major vehicle markets for a number of years, global vehicle manufacturers supplying vehicles to Australia have a clear understanding of the technology required to meet Euro 6d standards. For this reason, this impact analysis continues to propose adopting Euro 6d standards when improved fuel quality standards commence.

3.3.4.2 Adopt Euro 6d standards from an earlier date for diesel vehicles

As diesel fuel sold in Australia is considered sufficiently compatible with Euro 6d vehicles, many submissions to the *Light Vehicle Emission Standards for Cleaner Air* draft RIS from non-industry stakeholders proposed an earlier introduction of Euro 6d standards for diesel vehicles, to enable health benefits from cleaner diesel vehicles to be realised before the improved fuel quality standards to reduce sulfur in petrol were due to commence (1 July 2027 at the time of this consultation).

In May 2021, the Government announced the Refinery Upgrades Program, which would enable the legislated reduction in sulfur limits for petrol to be brought forward from 2027 to 2024. Following this decision, DITRDCA concluded it would be more appropriate to consider an earlier introduction of Euro 6d standards for both petrol and diesel vehicles, as this would remove the main barrier to an earlier introduction of Euro 6d standards.

A separate introduction for diesel vehicles, if adopted, would be inconsistent with the approach adopted in other vehicle markets with equivalent standards which have adopted stricter standards for petrol and diesel vehicles together. An earlier introduction for diesel vehicles would also disproportionately affect manufacturers of light commercial vehicles, as over 90% of light commercial vehicles sold in Australia have diesel engines and the incremental cost of the additional technology required for light commercial vehicles to meet Euro 6d standards is generally higher than for petrol or diesel passenger vehicles. Since the ‘dieselgate’ scandal in 2015, many global vehicle manufacturers have phased out the sale of passenger vehicle models with diesel engines.

For these reasons, an earlier introduction of Euro 6d standards for diesel vehicles was not considered viable and has not been evaluated in this impact analysis.

3.3.4.3 Adopt an earlier stage of Euro 6 standards as an interim step

During consultation on the *Light Vehicle Emission Standards for Cleaner Air* draft RIS in 2020–2021, DITRDCA sought comment on whether the first mandatory stage of Euro 6 standards adopted in the EU in 2014 (known as Euro 6b) should be adopted as an interim step to allow more time for the technology to develop and mature in Australia and enable some health benefits to be realised before improved fuel quality standards commenced (1 July 2027 at the time of this consultation).

Adopting Euro 6b as an interim step was not supported by any of the stakeholders who provided feedback on the draft RIS, including the vehicle manufacturers. As the Euro 6b standard, if adopted, would still use the current laboratory test (known as the New European Drive Cycle or NEDC), which has been phased out in EU and UN vehicle regulations, adopting Euro 6b would not achieve the objective of improved harmonisation with international vehicle standards. Manufacturers would also incur additional administrative compliance costs under this approach, as they would need to perform two sets of testing – to Euro 6b requirements in the interim and again to Euro 6d requirements a few years later once it became mandatory.

Following the Government's decision to bring forward the reduction in sulfur limits for petrol from 2027 to 2024, DITRDCA concluded it would be more appropriate to consider an earlier introduction of Euro 6d standards, as this would remove the main barrier to an earlier introduction of Euro 6d standards. As Euro 6d or equivalent standards have been in force in the EU and other major vehicle markets since 2017, global vehicle manufacturers supplying vehicles to Australia will have a clear understanding of the technology required to meet Euro 6d standards. For these reasons, adopting Euro 6b as an interim step has not been evaluated further in this impact analysis.

3.4 Noxious emissions standards – Options not considered viable in this analysis

3.4.1 Option A: Fleet purchasing policies

DITRDCA considered whether the adoption of cleaner vehicles could be accelerated if the Government adopted a policy to only purchase or lease light vehicles meeting Euro 6d emissions systems for its light vehicle fleet. This would create an additional incentive for manufacturers to fit these systems to models to be suitable for Government requirements. Advantages of targeted fleet purchasing are:

- ex-fleet vehicles are often sold after two to three years, giving the public the opportunity to buy a near new vehicle at a large discount
- fleet vehicles are on average driven twice as far annually as household vehicles, thus maximising the use of any technology benefits.[56]

In 2022, the Government committed to having 75% of new passenger vehicle orders being low or zero emissions vehicles by 2030, to achieve carbon dioxide emissions reductions. As this would significantly reduce the number of internal combustion powered vehicles in the Australian Government fleet, DITRDCA determined mandating Euro 6d standards for the remaining petrol or diesel vehicles in the Government fleet was unlikely to significantly increase the number of Euro 6d petrol or diesel vehicles on the road, as the Government fleet as a whole accounts for less than 0.3% of new vehicle sales.

The main cost of adopting this option would be developing a new fleet purchasing policy. There would also be some opportunity costs in foregoing a Euro 5 vehicle that may otherwise be more suitable for operational requirements. As this option was considered unlikely to achieve a higher level of compliance with Euro 6d or equivalent standards than existing policy settings, it was not considered viable, and no further analysis of this option was undertaken as part of this impact analysis.

3.4.2 Option B: Voluntary standards

DITRDCA considered whether a voluntary standard could be adopted through an agreement by industry to fit emissions control systems meeting Euro 6d standards for new light vehicles. Under this approach, Euro 5 standards would remain the minimum mandatory standard.

Voluntary standards usually involve a high degree of industry participation, as well as a greater responsiveness to change when needed. For a voluntary standard to succeed, the relationship between business, government and consumer representatives should be collaborative so that all parties have ownership of, and commitment to, the arrangements.

Because of its voluntary nature, a voluntary standard would only be effective if it were in the commercial interest of light vehicle manufacturers and/or their customers to comply. If there is no commercial incentive to supply light vehicles meeting more stringent noxious emissions standards, because it is not cost effective to do so or there is limited consumer demand for such technologies, manufacturers are less likely to comply with a voluntary standard.

As noted earlier, the health impacts of noxious emissions from vehicles are not borne by vehicle manufacturers, or consumers, but are shared by the community collectively. As motorists are more likely to consider factors that impact on them directly, such as performance, price, comfort and safety, this would still mean manufacturers would lack a clear market incentive to supply vehicles with the latest noxious emissions technology even if a voluntary standard was adopted.

It is therefore concluded that a more stringent voluntary standard would be unlikely to achieve a higher level of compliance with Euro 6d or equivalent standards, as the only incentive for a manufacturer to comply would be reputational.

Voluntary standards are also harder to enforce. Unlike a mandatory standard, where a manufacturer must demonstrate that a vehicle complies with a standard before it can be supplied, non-compliance with a voluntary standard would only be detected after a vehicle has been supplied through independent testing and reporting by governments and/or third-party experts.

In its consideration of the case for Euro 5 and Euro 6 noxious emission standards for light vehicles, the European Commission (EC) found that 'self-regulation would imply a significant departure from an approach that is well established all over the world and has proven its effectiveness in the past'. The EC noted that to measure compliance under a voluntary approach, governments and manufacturers would need to establish processes which would essentially duplicate those that already operate for mandatory standards, thus increasing costs and complexity.[57] This would diminish any compliance cost savings from a voluntary standard, in lieu of a mandatory standard.

As manufacturers would have little or no additional incentive to comply with a voluntary standard other than possible reputational risk, and governments would incur a high cost to monitor, detect and respond to breaches, this option was not considered a viable option to reduce noxious emissions from light vehicles. As a voluntary standard was unlikely to achieve a higher level of compliance with Euro 6d or equivalent standards than existing policy settings, no further analysis of this option was undertaken as part of this impact analysis.

3.5 Fuel quality standards – Overview of options considered

The options considered to improve fuel quality standards are:

- **Business as usual**: Continuation of the current policy settings.
- **Option 1 (not considered viable)**: From 2024, specify the maximum level of aromatics in 91 RON as 35% and the maximum grade average for the 95 RON grade as 35%. No change to 98 RON petrol.

- **Option 2 (considered viable)**: From 2025 specify the maximum level of aromatics content as 35% for 95 RON. No change to other grades.
- **Option 3 (considered viable)**: From 2027 specify the maximum level of aromatics content as 35% across all grades of petrol.
- **Option 4 (considered viable, but unnecessary)**: Align key diesel specifications with the EU standard

3.5.1 Business as usual

The BAU option is the baseline in the assessment. The benefits and impacts of the options presented can be quantified and compared against these existing conditions. The aromatics limit of the BAU option remains at a 35% maximum pooled average across all grades of petrol with a 45% maximum for each grade. This reflects the aromatics limits from January 2022. The diesel standard remains unchanged.

This option has several issues. Most countries that implement Euro 6d or equivalent standards for light vehicles limit aromatics to less than 35%.[kk] Implementing Euro 6d standards in Australia might create vehicle operability and warranty issues or car importers might not provide their most advanced engine technology. It also would not reduce the noxious emissions from vehicles. The BAU option was not considered viable and has not been considered further in this analysis.

3.6 Fuel quality standards: Options considered viable

3.6.1 Option 2: 95 RON: 35% maximum aromatics

This option incorporates a 35% aromatics limit for 95 RON, and a maximum pooled average of 35% aromatics across all grades. Both 91 RON and 98 RON would be limited to a maximum of 45% aromatics. This option was assessed for implementation by 2025.

Option 2 would enable the introduction of Euro 6d standards and allow all new vehicles that can run on 91 RON or 95 RON to meet noxious emissions standards. This would account for around 99% of new vehicles in the Australian fleet. DCCEEW chose to cost this option as a lower cost alternative to reducing aromatics across all grades.

3.6.2 Option 3: 35% maximum aromatics limit across all grades

This option requires a maximum limit of 35% aromatics for all three grades of unleaded petrol from 2027. To achieve this, infrastructure modifications would be required at the refineries and throughout the distribution and retail supply chain to enable the use of ethanol in all 98 RON petrol to reduce aromatics. The time required to undertake infrastructure updates means it would not be feasible to implement this option before 2027.

A hard limit of 35% aromatics in 98 RON would only be possible for refiners and importers with the use of an octane enhancer and infrastructure upgrades. DCCEEW costed Option 3 using the addition of up to 10% ethanol as the implementation pathway. This option would align Australian petrol with best practice across all grades.

DCCEEW considered a similar option, with a reduction in the maximum aromatics content across all grades to below 45% but above 35%. Initial analysis and consultation suggested that the cost would be similar to Option 3 but would not provide the necessary aromatics reduction for the automotive industry to introduce Euro 6d vehicles. On this basis, DCCEEW decided not to continue to a cost benefit analysis on that option.

[kk] Canada has Euro 6d equivalent standards but does not regulate aromatics. However, actual average aromatics levels in Canadian petrol are 23.9%.

3.6.3 Option 4: Diesel

This option would align one or all parameters considered with EU standards for diesel fuel. It would not introduce changes to petrol quality standards. It includes changes to:

- the polycyclic aromatic hydrocarbon (PAH) level (reduction from 11% to 8%)
- derived cetane number (DCN) (implementing a 51 DCN for all diesel) [II]
- density at 15°C (reduction in the range from 820–850 kg/m^3 to 820–845 kg/m^3).

DCCEEW developed this option to assess the cost of aligning Australia's diesel standard with the EU standard. DCCEEW also analysed whether these changes are required to enable the efficient operation of Euro 6d light diesel vehicles or Euro VI heavy vehicles.

3.7 Fuel quality standards: Options not considered viable

3.7.1 Option 1: 91 RON: 35% maximum aromatics, 95 RON: 35% grade average

This option closely aligns to the existing fuel quality standards, except for:

- an improvement for 91 RON petrol, proposed to have a maximum of 35% aromatics
- an improvement for 95 RON petrol, proposed to have a 35% maximum grade average and 45% maximum aromatics.

This option was proposed by the petroleum industry. Most vehicles in Australia currently run on 91 RON, however an increasing number of new vehicles require the use of petrol with minimum 95 RON. Through the analysis, it became clear that this option would not enable the implementation of Euro 6d standards as it would not sufficiently reduce the aromatics content in 95 RON. The FCAI was not able to confirm whether models made for the Australian market would meet Euro 6d standards using 91 RON. From the available information, it appears many Euro 6d vehicles would require 95 RON, and for those vehicles, no 35% maximum aromatics petrol would be available to them.

Further analysis of this option has not been included in this impact analysis as it was considered unlikely to enable the implementation of Euro 6d standards any more than existing policy settings. The full costs and benefits for this option can be found in the *Better fuels for cleaner vehicles: draft regulation impact statement*.[58]

3.7.1.1 Unviable pathways to reduce aromatics in 98 RON – Methyl tertiary butyl ether (MTBE)

DCCEEW ruled out the use of MTBE during analysis of the preliminary options. MTBE is a volatile organic chemical used as an octane enhancer in some countries, including the EU and in Asia. The benefits of MTBE are that it is cheap to produce and by increasing octane, it improves fuel combustion and reduces noxious emissions.

Some ethers, such as MTBE, are limited in Australian petrol. Even in small concentrations, MTBE is a groundwater contamination risk due to its taste, odour, persistence and mobility in water. Since January 2004, the volume of MTBE has been limited in all grades of petrol supplied in Australia to less than 1%. Although Australian refineries do not use MTBE, fuel from international refineries may contain trace levels of MTBE.

Western Australia implements a 0.1% MTBE limit and other states limited its use prior to 2004.[59] If the Government were to decide to increase the limit, it is likely other states would follow Western Australia and re-introduce MTBE limits in state legislation. DCCEEW does not consider MTBE to be a viable option for Australian petrol.

[II] Derived Cetane Number is a specific test to measure the cetane of diesel. Cetane serves as the industry-standard measure for evaluating combustion quality.

3.7.1.2 Unviable pathways to reduce aromatics in 98 RON – N-methylaniline (NMA)

NMA is a derivative of aniline and includes a benzene ring and an amino group. It is an efficient octane enhancer, particularly for petrol with low octane. 96 RON can be achieved from 90 RON base petrol with the addition of 3% NMA.[60]

DCCEEW consulted on whether NMA could be a feasible octane enhancer. Based on feedback from a range of stakeholders on the vehicle operability impact and consumer aversion, DCCEEW decided NMA should not be considered further.

3.8 Combined noxious emissions and fuel quality standards – package options

As the timing for the introduction of Euro 6d is dependent on the introduction of improved fuel quality standards for petrol, three joint scenarios were evaluated for the purposes of this impact analysis. Only Options 2 and 3 for fuel quality would allow for the introduction of Euro 6d standards, and so no packages with Option 1 for fuel quality were analysed in conjunction with Euro 6d standards.[mm]

Package 1 – Noxious Emissions Standards Option C (mandate from 2027–28) and Fuel Quality Option 3[nn] (35% aromatics across all grades from 2027)

This involves a 35% aromatics limit for all grades of petrol from 2027. As the implementation date for Fuel Quality Option 3 is 2027, only Noxious Emissions Option C could be implemented, as the fuel quality in 2025 would not be of a sufficient quality to enable the introduction of Euro 6d standards.

Package 2 – Noxious Emissions Standards Option D (mandate from 2025–28) and Fuel Quality Option 2 (35% aromatics limit for 95 RON petrol from 2025)[oo]

As Fuel Quality Option 2 has an earlier implementation date, this would allow Euro 6d standards to be implemented sooner than 2027.

As manufacturers require at least two years notice to make any substantive changes to planned new model releases and up to three years longer to plan, reengineer and update existing models, the earliest timeframe considered viable in this impact analysis was 2025 for new models and 2028 for existing models.

Package 3 – Noxious Emissions Standards Option C (mandate from 2027–28) and Fuel Quality Option 2 (35% aromatics limit for 95 RON petrol from 2025)[pp]

This option was also assessed for the sake of completeness, as the Government could implement fuel quality standards in 2025 and delay the phased implementation of Euro 6d standards until 2027.

[mm] The quality of diesel fuel in Australia is not a barrier to implement Euro 6d standards and therefore Option 4 was not considered in any of these combined options.

[nn] For newly approved models first supplied to Australia from 2027. Models approved and supplied to Australia for the first time prior to 2027 would be required to comply from 2028, if that model is still being produced and supplied to Australia in 2028.

[oo] For newly approved models first supplied to Australia from 2025. Models approved and supplied to Australia for the first time prior to 2025 would be required to comply from 2028, if that model is still being produced and supplied to Australia in 2028.

[pp] For newly approved models first supplied to Australia from 2027. Models approved and supplied to Australia for the first time prior to 2027 would be required to comply from 2028, if that model is still being produced and supplied to Australia in 2028.

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

4.1 Impact categories

Table 10: Impact categories used in this analysis

Impact Category	Explanation	Extent quantified
	Noxious Emissions	
Avoided health costs	Health costs avoided through reduced exposure to noxious emissions.	Fully
Avoided fuel costs	Reduced fuel costs for consumers due to increases in the fuel efficiency of Euro 6d vehicles.	Fully
Avoided greenhouse gas costs	Reduced GHG emissions due to increase in the fuel efficiency of the fleet.	Fully
Additional capital costs	Additional costs of Euro 6d models of vehicles.	Fully
Avoided development costs	Possible development costs for manufacturer to add new safety features (engineered for Euro 6d vehicles overseas) to Euro 5 vehicles, that could be avoided, if Euro 6d is mandated.	Not quantified (insufficient data)
Administrative costs	Possible additional administrative costs for manufacturers to demonstrate Euro 6d compliance, if Euro 6e compliance is required to obtain a UN type approval.	Not quantified (insufficient data)
	Fuel Quality	
Refinery capital costs	Infrastructure investments at Australia's domestic refineries to produce lower aromatic petrol, such as increased tank storage.	Fully
Refinery operating costs	Changes to the operation of Australia's domestic refineries to produce lower aromatics petrol.	Fully
Imported fuel price increase	Increased price of imported fuels due to the more stringent quality specifications.	Fully
Fuel demand impacts (loss of consumer surplus)	Increased price of petrol is assumed to decrease demand, reducing the consumer surplus.	Fully
Increased GHG emissions at refinery	Increased emissions as a result of producing lower aromatics petrol.	Fully
Ethanol supply chain costs for terminal operators and distributors	Additional supply chain infrastructure required to store, handle and mix ethanol-blended petrol.	Fully
Ethanol supply chain capital costs for retailers	Additional capital costs from including ethanol in the 98 RON grade, including tank upgrades.	Fully
Ethanol supply chain operational costs for retailers	Additional operational costs from including ethanol in the 98 RON grade, including tank flushing and turnovers.	Fully

4.2 Noxious emissions standards

4.2.1 Cost benefit analysis

For the 2020 *Light Vehicle Emission Standards for Cleaner Air* draft RIS, the then Department of Infrastructure, Transport, Regional Development and Communications undertook a detailed CBA of implementing Euro 6d standards from 2027 for new model light vehicles and from 2028 for all new

light vehicles (Option C in this impact analysis). This approach was proposed at the time to align with introduction of improved fuel quality standards from 1 July 2027, as announced by the Government in February 2019.

For completeness, that analysis showed that Option 3 had a higher net benefit compared to Options 1 and 2 (which were not considered viable). That is 'there were significant benefits for the Australian community to be gained from improving air quality by mandating Euro 6d for new light vehicles. These benefits would not otherwise be realised either through a business as usual approach or through various other non-regulatory options.' That analysis showed that the introduction of Euro 6d standards (from 2027) would result in avoided health costs of $6,385 million and increased capital costs to manufacturers of $1,103 million over the period to 2050. The net benefits over this same period were estimated to be $5,282 million with a benefit-cost ratio (BCR) of 5.79.[qq] Note that to ensure comparability of options across noxious emissions standards and fuel quality standards, the period of analysis has been altered to 2040 across all options. Thus, the benefits and costs for noxious emissions standards in *Light Vehicle Emission Standards for Cleaner Air* (and reproduced here) differ from the benefits and costs of Option C as reported below. However, the benefits and costs of Options C and D exceed those of doing nothing or Options A and B regardless of whether the period of analysis is out to 2040 or 2050.

As several stakeholder submissions supported an earlier introduction of Euro 6d standards and the Government's subsequent decision to bring forward the reduction in sulfur limits for petrol to the end of 2024, and to assist with the evaluation of the costs and benefits of reducing aromatics in petrol by 2025, this impact analysis has also evaluated the costs and benefits of implementing Euro 6d standards from 2025 for new model light vehicles and from 2028 for all new light vehicles (as Option D). This was considered to be the earliest viable timeframe for the introduction of these new standards.

As the adoption of new standards in legislation would provide certainty on when compliance is required, some manufacturers are likely to align the introduction of improved engines and emissions control systems with new model releases. As some new models are likely to be released in the year prior to the commencement date for newly approved models (2024 for Option C, 2026 for Option C), it is likely some new models released in that year, that would not otherwise be made to comply in the absence of the new standard, will be supplied with the new technology at the time of release. As a result, additional costs and benefits (beyond those under BAU) for some models are assumed to commence in 2024 if Option C is adopted and from 2026 if Option D is adopted.

Costs included in this analysis were additional capital costs to fit the emissions control systems required to meet Euro 6d standards borne by vehicle manufacturers and/or their customers. These include an allowance for administrative compliance costs incurred by manufacturers to demonstrate that their vehicles meet the proposed vehicle standards.

Benefits quantified in this analysis were avoided health costs borne by the community through reduced exposure to noxious emissions from vehicles and avoided fuel costs and GHG emissions through an increased availability of more fuel-efficient engines packaged with Euro 6 emissions control systems. These benefits were calculated by estimating the expected change in fuel consumption and emissions of light vehicles if the proposed standards were adopted relative to the change expected under existing policy settings.

There are also likely to be other significant benefits to all stakeholders from keeping pace with international vehicle standards, as this will reduce technical and commercial barriers to the supply of the latest light vehicle models fitted with the latest safety technologies as standard, particularly when connected and automated vehicle technologies become more common. However, as there is no methodology to estimate these benefits reliably, they cannot be quantified and have been

[qq] See Light-vehicle-emission-standards-for-cleaner-air.pdf (infrastructure.gov.au), page 33.

excluded from the CBA. This means the estimated benefits in the CBA are likely to be slightly conservative.

For the purposes of this analysis, BITRE has assumed an average vehicle life of 17 years. Results showed that by 2040, using a discount rate of 7% (as required by the *Australian Government Guide to Policy Impact Analysis*) and a 2022 base year (i.e. 2023 as the first year that discount rates are applied).[61]

- Option C would result in a net benefit of $4,059 million and a BCR of 3.88
- Option D would result in a net benefit of $4,849 million and a BCR of 4.27.

Table 11 provides a summary of the benefits quantified in this analysis.

Table 11: Costs and benefits of implementing Euro 6d standards

(2026–2040 for Option C, 2024–2040 for Option D, 7% discount rate and 2022 base year)

Option	Option C (2027–28)	Option D (2025–28)
Total Costs ($m)	1,046.9	1,483.6
Total Benefits ($m)	5,105.6	6,332.4
Net Benefit ($m)	4,058.7	4,848.8
BCR	3.88	4.27

The quantified benefits of Options C and D far outweigh the costs and would result in significant net benefits to the community. **Appendix A** provides further details about the CBA.

4.2.1 What were the main assumptions?

The analysis assumed that emissions reduction technology fitted to vehicles purchased during most years of the evaluation period would continue to generate benefits beyond the end of the evaluation period in 2040.

Since the benefits from this technology are fairly constant over the lives of the vehicles, an approximation to residual evaluation was obtained by prorating the cost of the technology over the lives of the vehicles, then only counting costs attributed to years before 2040.

The average vehicle life (median survival time) was assumed to be 17 years. For vehicles purchased during the later years of the evaluation period, the cost of the emissions reduction technology was annualised over 17 years.

Additional capital cost estimates for the vehicle emissions control technologies were informed by industry submissions received in response to the 2020 Light Vehicle Emission Standards for Cleaner Air draft RIS and previous consultations. It was anticipated that most manufacturers will have to fit selective catalytic reduction systems to their diesel vehicles, and particulate filters to most petrol vehicles, to achieve the very low levels of emissions required by the standards proposed in Options C and D. The introduction of Euro 6d standards is expected to increase vehicle production costs by $450 to $1,000, noting that closer alignment with international standards would also reduce development costs for adding new safety and fuel-saving technologies to vehicles sold in Australia, as these are developed together as a package for other larger vehicle markets.

In January 2023, the UN Working Party on Pollution and Energy (GRPE) agreed to adopt a UN Regulation for RDE and a new series of UN Regulation 83 based on the Euro 6e requirements. As many manufacturers use the UN type approval process to comply with ADR requirements, and there will be no UN Regulation specifically adopting the Euro 6d RDE requirements, manufacturers may incur additional compliance costs to obtain a UN type approval accepted by Australia (by meeting

Euro 6e) or submitting additional information to DITRDCA to demonstrate compliance to Euro 6d RDE requirements. As data is not readily available from vehicle manufacturers to quantify how this would affect compliance costs in practice, these costs have not been quantified in this analysis. The European Commission has also not quantified the costs of meeting Euro 6e standards over Euro 6d standards, as it expects the emissions control systems fitted by manufacturers to comply with Euro 6d standards will be sufficient to meet the stricter on-road test requirements adopted in Euro 6e.[62]

Avoided health costs were calculated by quantifying the emissions of pollutants and estimating the emissions saved relative to the base case and establishing a value for an average health cost based on analysis by Marsden Jacob Associates in 2018.[63]

Expected changes in fuel use and greenhouse gas emissions were informed by analysis by ABMARC in 2017, which found that Euro 6 vehicles were 3% more fuel efficient than equivalent Euro 5 vehicles. The economic benefits of avoided GHG emissions were based on the median value used in the current Australian Transport Assessment and Planning Guidelines ($60/tonne).[64] These guidelines are currently used by the Australian Government and state and territory governments to evaluate the economic costs and benefits of transport infrastructure projects.

In August 2022, the Government announced it would also consider adopting a fuel efficiency standard as part of the National Electric Vehicle Strategy, to increase the supply of more affordable and fuel-efficient low and zero emission vehicles and reduce greenhouse emissions from the light vehicle sector. To avoid complexity and misattribution of impacts, this analysis has been undertaken at a point in time using current regulatory and policy settings and does not speculate on how or when a fuel efficiency standard may be implemented during this period.

4.2.3 Benefits

The BITRE analysis found there would be a direct benefit to the health and wellbeing of the Australian community through reductions in air pollution and through reduced fuel consumption and GHG emissions if either option to mandate Euro 6d standards was adopted. Better air quality would reduce pressure on the public health system by reducing the incidence of disease attributable to air pollution, particularly in communities with more vehicle traffic. This would reduce public healthcare costs borne by all taxpayers in both urban and regional communities. Table 12 provides a summary of the benefits quantified in this analysis.

Table 12: Summary of benefits of implementing Euro 6d standards

(2026 to 2040 for Option C, 2024 to 2040 for Option D, 7% discount rate and 2022 base year)

Benefits (by 2040)	Affected stakeholders	Option C (2027)	Option D (2025)
Avoided health costs ($m)	Community	3,751.5	4,585.5
Avoided fuel costs ($m)	Motorists	1,160.7	1,494.7
Avoided greenhouse gas emissions ($m)	Community	193.4	252.7

4.2.4 Costs

To meet Euro 6d or equivalent standards, light vehicle manufacturers currently producing Euro 5 vehicles for the Australian market would need to fit additional emissions control systems to vehicle models they wish to continue manufacturing for the Australian market. Alternatively, a manufacturer may choose to replace these models with a new model or a model sold overseas that meets these standards.

Some or all of these costs, including those borne by manufacturers overseas, could be passed on to motorists purchasing new vehicles through higher vehicle prices or changes in specifications. The extent to which this may happen is likely to be influenced by a highly competitive vehicle market in Australia. DITRDCA notes the adoption of previous iterations of noxious emissions standards in Australia does not appear to have had any direct impact on retail vehicle prices.

There are also likely to be some costs incurred by the Government to develop, implement and enforce the new standards. These costs are assumed to be absorbed within existing departmental resources.

Table 13: Summary of costs to implement Euro 6d standards

(2026 to 2040 for Option C, 2024 to 2040 for Option D, 7% discount rate and 2022 base year)

Cost (by 2040)	Stakeholder affected	Option C (2027)	Option D (2025)
Additional Capital Costs ($m)	Manufacturers and New Car Buyers	1,046.9	1,483.6

4.2.4 Regulatory burden

The Australian Government has established a deregulation policy that aims to improve productivity growth and enhance competitiveness across the Australian economy. DITRDCA is a key regulator and continuous improvement is at the core of this portfolio's regulatory vision. The portfolio is vigorously pursuing best practice regulatory reforms, with a focus on achieving efficiencies through harmonising international and domestic regulatory requirements where possible. This will make sure that the standards for Australia's transport systems remain fit for purpose while reducing unnecessary regulatory burden.

The *Australian Government Guide to Policy Impact Analysis* requires that all new regulatory options are costed in accordance with the Government's *Regulatory burden measurement framework: guidance note*.[65] The RBM is a different measure to the full CBA, as it does not capture the benefits of avoided health costs for the wider community. The average annual regulatory costs for Options C and D were established by calculating the average undiscounted costs (non-prorated) over the first ten years of proposed implementation date for each option (i.e. 2027–2036 inclusive for Option C and 2025–2034 inclusive for Option D).

DITRDCA analysis found that the average annual regulatory cost associated with Option C is $255.6 million (Table 14), and $263.3 million for Option D (Table 15). To the extent that market forces allow, the costs to business in the table below may be passed on to consumers.

It is proposed that any additional regulatory burden arising from the adoption of Option C or D would be fully offset over time through the ongoing regulatory program for increased harmonisation of the ADRs with international standards and removal of Australian-specific content from the ADRs.

Table 14: Regulatory burden estimate for Option C: Adopt Euro 6d from 2027

Average annual regulatory costs (from business as usual)				
Change in costs ($m)	Business	Community organisations	Individuals	Total change in costs
Total, by sector	255.6	-	-	255.6

Table 15: Regulatory burden estimate for Option D: Adopt Euro 6d from 2025

Average annual regulatory costs (from business as usual)				
Change in costs ($m)	Business	Community organisations	Individuals	Total change in costs
Total, by sector	263.3	-	-	263.3

4.3 Improved fuel quality standards

In 2021, DCCEEW engaged independent advisors GHD and ACIL Allen to undertake an economic analysis. GHD and ACIL Allen worked with key industry stakeholders to determine the net benefits and regulatory burden of the policy options. The analysis:

- assessed the incremental benefits and costs of the options relative to the BAU case
- considered implementation dates ranging from 2024 (Options 1, 2 and 4) to 2027, (Option 3) out to 2040[rr]
- costed three options for changes to petrol quality (Option 1 to 3) and one option for diesel (Option 4)
- had a start year of 2022 (i.e. 2023 is the first year that discount rates are applied).

The CBA for fuel quality standards did not consider the benefits associated with the implementation of Euro 6d standards.

A further description of the results and methodology is at **Appendix B**.

Table 16: Net present value (NPV) of costs and benefits of petrol options to 2040

(Costs and benefits of Option 3 have been presented across petrol grades)

		Option 2	Option 3		
	Fuel quality parameter	95 RON, 35% max aromatics	91 RON, 35% max aromatics	95 RON, 35% max aromatics	98 RON, 35% max aromatics
	Year regulation commences	2025	2027	2027	2027
		$m	$m	$m	$m
Costs (to 2040)	Refinery capital costs	63.3	0	55.3	55.3
	Refinery operating costs (domestic)	37.9	10.4	30.1	192
	Imported fuel price increase	233.5	15.3	261.8	157.6
	Fuel demand impacts (loss of consumer surplus)	11	0.8	11.8	8.5
	Increased GHG emissions at refinery	15.2	5.9	11.1	71.1
	Ethanol supply chain capital costs for terminal operators and distributers	-	-	-	56.9
	Ethanol supply chain operational costs for terminal operators and distributers	-	-	-	7.2
	Ethanol supply chain capital costs for retailers	-	-	-	437.7
	Ethanol supply chain operational costs for retailers	-	-	-	273.1
	Total costs	**360.8**	**32.4**	**370.1**	**1,259.4**
Benefits	**Avoided health costs**	**17.8**	**0**	**29.9**	**66.9**

[rr] Due to stakeholder feedback from the draft RIS, DCCEEW readjusted the start date to 2025 for Option 2 in this impact analysis.

NPV at 7%	Benefits minus costs	−343.0	−32.4	−340.2	−1,192.5
BCR		0.049	0	0.081	0.053

4.3.1 Option 2

Option 2 (95 RON: 35% maximum aromatics limit) has a negative net present value (NPV) of −$343.0 million. If a 35% aromatics limit is implemented for 95 RON in 2025, it is unlikely to deliver a positive net benefit without the implementation of Euro 6d standards. The CBA estimated each refinery would require $35 million in total capital expenses required to meet this standard.[ss] Under this option, each refinery could be eligible for grants of $26 million under Phase 2 of the Refinery Upgrades Program. The net effect is a present value of capital costs for both refineries of $17.4 million.

The net present benefit of total avoided health costs for Option 2 is $17.8 million. This assumes that under a 35% aromatics limit for 95 RON, there would be a 1.6% reduction in particulate emissions.

This option would enable implementation of Euro 6d standards for more than 99% of the vehicle fleet through the availability of lower aromatics 95 RON. The NPV associated with implementation of Euro 6d standards from 2025 to 2040 is around $4.8 billion. The NPV of implementing this fuel quality option with Euro 6d standards is available below in section 4.7.

4.3.2 Option 3

Option 3 could be implemented for all petrol grades in 2027 at the earliest and would enable implementation of Euro 6d standards from 2027 but has a total negative NPV of −$1,565.1 million. This option would limit aromatics in all grades of petrol to 35%. This option is unlikely to deliver a net benefit to the community without the implementation of Euro 6d standards. BITRE's CBA estimated the NPV associated with implementing Euro 6d standards from 2027 to 2040 is $3.0 billion to 2040. The NPV of implementing this fuel quality option with Euro 6d standards is available below in section 4.7.

Changes to 95 RON under this scenario have a negative NPV of −$340.2 million.

98 RON has the highest negative NPV at −$1,192.5 million. This is because lowering the aromatics content in 98 RON requires the use of an octane enhancer. The octane enhancer chosen for this study was ethanol as it has the lowest engine, health and environmental impacts. The use of ethanol requires modifications to many Australian fuel terminals, distribution equipment and retailer infrastructure to accommodate the ethanol-blended 98 RON. It would also require construction of additional ethanol production capacity in Australia (out of scope for the analysis). For further information on the supply chain costs in Option 3, see **Appendix B**.

The net present benefit of total avoided health costs under Option 3 for 95 RON and 98 RON between 2027 and 2040 is $96.8 million. This assumes a 7.4% reduction in particulate emissions from a 35% aromatics limit for 98 RON, and the same reduction in particulate emissions for 95 RON as in Option 2.

[ss] Some petroleum sector submissions to the *Better fuel for cleaner vehicles: draft regulation impact statement* in late 2022 indicate costs for the upgrades could be considerably greater due to changed market conditions. For the purposes of the CBA, we have maintained the $35 million assumption, but acknowledge that this could be an under estimation.

4.3.3 Option 4 (Diesel)

Table 17: Net present value of costs and benefits of diesel options to 2040 (Option 4)

	Fuel quality parameter	All	PAH	DCN, CI	Density
	Year regulation commences	2024	2024	2024	2024
		$m	$m	$m	$m
Costs (to 2040)	Refinery capital costs (net of government assistance)	5.8	0.0	5.8	0.0
	Refinery operating costs (domestic)	436.0	6.8	82.1	347.1
	Imported fuel price increase	134.5	0.0	134.5	0.0
	Fuel demand impacts (loss of consumer surplus)	6.1	0.0	6.1	0.0
	Total costs	582.4	6.8	228.5	347.1
Benefits	Total benefits or avoided costs	25.1	0	0	25.1
NPV at 7%		−557.4	−6.8	−228.5	−322.0
BCR		0.043	0.000	0.000	0.072

Option 4 relates to the diesel fuel quality parameters, and involves aligning the PAH limit, minimum DCN and maximum density with EU standards. It has a negative NPV for all three parameter changes, ranging from −$6.8 million for PAH, to −$322.0 million for density, totalling −$557.4 million.

DCCEEW's analysis and consultation did not find any evidence to suggest that diesel quality was a barrier for enabling more stringent noxious emissions standards. It identified that there are already many Euro 6d/VI vehicles sold on the Australian market and no known reports of operability issues. In addition, DCN, density, and PAH standards vary considerably globally.

Meeting the lower PAH limit is not an issue for imported diesel and would not likely involve a price increase. However, the CBA identified that a small number of Australian refined batches currently exceed a PAH limit of 8%. Producing diesel with maximum 8% PAH at refineries would cost around $1 million. This would incur, on average, operational expenses of 0.019 cents per litre (cpl). Nearly all Australian diesel already has PAH content below 8%. There are therefore no benefits associated with lowering the limit, as the impact on real world diesel quality would be negligible.

Achieving a 51 DCN minimum would require the use of cetane enhancer. Adding cetane enhancer to achieve DCN of at least 51 would require capital expenditure of $3 million for each refinery. It would also incur a 0.227 cpl increase in cost to produce diesel domestically, and a 0.087 cpl increase to the price of imported diesel.

To comply with the density maximum of 845 kg/m3, the 'crude diet' at Australian refineries would need to change, so the choice of crude oil Australian refineries could use would be limited.tt This would incur 0.962 cpl for domestic refined diesel. Meeting the density standard is not an issue for imported diesel and would not involve a price increase.

The net present benefit of total avoided health costs under Option 4 for diesel is $25.1 million. This assumes a 0.5% reduction in particulate emissions resulting from a maximum density of 845 kg/m^3. Changes to the other diesel specifications under Option 4 do not result in health benefits.

[tt] Crude diet is the mix of different crude grades that the refinery is running.

4.4 Consumer price impact of the fuel quality standards options

Changes to the fuel quality standards will likely have a small impact on the fuel price. DCCEEW carefully examined price impacts when considering options for improving fuel quality in Australia.

Wholesale fuel prices in Australia are set based on the import parity price (IPP). The IPP closely reflects the actual cost of importing fuel into Australia, as it is based on the international price of refined fuel plus freight and other import costs. The IPP and taxes (fuel excise and the wholesale GST) are the major elements of wholesale prices in Australia. They account for over 95% of wholesale prices, with the other elements being wholesale costs and margins.

Table 18 outlines the estimated IPP increases for fuel under the reform options.

Table 18: Import price parity increase for each option

	Option 2	Option 3			Option 4
	95 RON	91 RON	95 RON	98 RON	Diesel
Import price parity increase (cpl)	0.9[uu]	0.03	0.9[vv]	1.3	0.087

In Option 2 for petrol, and Option 4 for diesel, the price impact to consumers is the same as the IPP increase in Table 18. DCCEEW's modelling assumes that the $775 million of additional supply chain costs of adding ethanol to 98 RON in Option 3 will be passed through to the consumers. The fuel excise rate for ethanol (Option 3) is lower than for petrol so motorists would pay a lower fuel excise due to the inclusion of 10% ethanol in the grade. This would partly offset the increased cost to motorists. The model also assumes that the price increase as a result of ethanol use is only passed through 98 RON. As 98 RON consumption reduces in our forecasts, the price increase from a BAU scenario also increases. This is because there is less product to spread the cost through.

Option 2 would only see a price increase in 95 RON petrol, and the other grades would remain unchanged. In contrast, Option 3 would increase petrol prices for all grades.

All price forecasts come with a large degree of uncertainty, as they are dependent on the future global market conditions. The increase for Options 2 and 4 will be unnoticeable to motorists due to the large fluctuations in the price of petrol and diesel. They are also insignificant when comparing to BAU price fluctuations in the market.

Since the release of the *Better fuels for cleaner* vehicles draft RIS, DCCEEW commissioned Stratas Advisors to update the IPP premium assumptions for lower aromatics 95 RON. The price premium has been forecast to be 0.9 cpl in 2024, increasing to 1.9 cpl by 2040, based on late 2022 market conditions.[66] For further explanation of the methodology, see **Appendix B**.

[uu] The IPP increase for 95 RON in Option 2 is modelled to be 0.9 cpl in 2025 increasing to 1.9 cpl by 2040.
[vv] The IPP increase for 95 RON in Option 3 is modelled to be 0.9 cpl in 2027 increasing to 1.9 cpl by 2040.

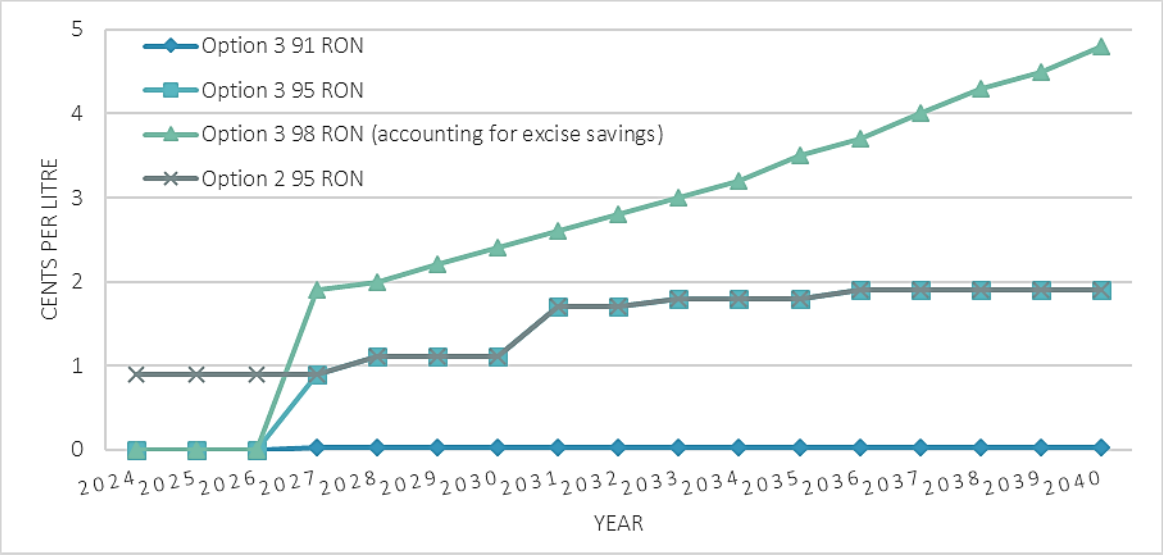

Figure 10: Real price petrol increase for motorists under various petrol options (cpl increase by year)

4.5 Regulatory burden

DCCEEW has prepared an estimate of the regulatory burden of the proposed reform options on the private sector (businesses, community organisations and individuals) and government-owned corporations in line with the Government's Regulatory burden measurement framework: guidance note.[67]

Table 19 provides a summary of the regulatory burden for the reform options. The analysis did not include a number of administrative costs due to uncertainties regarding implementation. For example, the analysis did not have sufficient information on potential administrative costs for retailers under Option 2.

Administrative compliance costs may include, but are not limited to:

- retailers requiring changes to signage
- retailers changing procedures and undertaking additional processes related to the change in fuel quality, such as tank flushing.

DCCEEW assumes there would be no change in the testing regime and no additional reporting costs.

Substantive compliance costs for domestic refiners and the supply chain include:

- additional compliance costs for refineries due to the need for infrastructure to meet the new standards
- increased costs for refineries and the supply chain from the introduction of ethanol into petrol for Option 3, due to the need for additional equipment for storage and ethanol blending
- increased running costs and staff for all options
- increased carbon emissions.

All options would lead to an increase in the price of fuels and hence, increased substantive compliance costs to motorists. The increase in price ranges from 0.09 cpl for 95 RON, to up to 4.84 cpl for 98 RON under Option 3. Under Option 4, the model found the price of diesel could increase by 0.087 cpl.

Table 19: Regulatory burden estimate summary ($m/year)

Average annual regulatory costs to 2040 ($m/year)	Option 2		Option 3		Option 4
	95 RON	91 RON	95 RON	98 RON	Diesel
Refining Sector	2.5	1.0	6.1	26.1	49.2
Supply chain	0	0	0	136.2	0
Consumers	34.8	3.1	46.9	71.7	19.1

4.6 Unquantified benefits

Not all potential benefits of implementing the options are directly or fully reflected in market prices. It is 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. For the CBA, DCCEEW did not consider benefits where there was a lack of data to assign a quantified economic value to the benefits.

Due to data uncertainties and a lack of available evidence, the CBA could not quantify benefits from health benefits. DCCEEW was also unable to quantify the GHG reduction of including ethanol in the 98 RON grade for Option 3 due to uncertainties over life cycle emissions. However, Bioenergy Australia estimates that ethanol use at up to 10% in all grades of petrol in Australia can reduce total GHG emissions by up to 2.6 million tonnes CO_2 equivalent per year.[68]

Other potential non-market health benefits of options relative to the BAU case that have not been assessed 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
- productivity benefits of reduced illness and hospitalisation
- health benefits associated with reducing evaporative emissions from vehicles (such as when refilling at petrol stations).

DCCEEW assumes the unquantified benefits are immaterial to the outcome of the analysis. The health benefits that have been quantified are minor. This is because the fuel quality policy options have limited impact on the real-world pool average aromatics content of petrol, with a 1.6% reduction in aromatics content of 95 RON for Option 2, and a 7.4% reduction in aromatics content for Option 3. DCCEEW assumes the same logic applies for the unquantified health benefits and would not have a determinative impact on the comparative NPVs of the various options.

For a full description of these unquantified benefits, see **Appendix B**.

4.7 Costs and benefits of fuel quality and noxious emissions standards

The costs included in the combined packages were:

- increased vehicle production costs borne by vehicle manufacturers to meet Euro 6d standards
- refinery capital costs
- increased operating costs for refineries
- imported fuel price increases for fuel importers
- fuel demand impacts (loss of consumer surplus)
- increased GHG emissions at refineries

- ethanol supply chain capital costs for terminal operators and distributors (if aromatics is reduced in 98 RON, as proposed in Fuel Quality Option 3)
- ethanol supply chain operational costs for terminal operators and distributors (if Fuel Quality Option 3 adopted)
- ethanol supply chain capital costs for retailers (if Fuel Quality Option 3 adopted)
- ethanol supply chain operational costs for retailers (if Fuel Quality Option 3 adopted).

The start year for this analysis is 2022, i.e. 2023 is the first year that discount rates are applied.

See Table 20 above for further details on these costs.

Table 20: Combined costs of implementing Packages 1–3

Cost (by 2040) ($ millions)	Stakeholder affected	Package 1 Noxious Emissions Option C and Fuel Quality Option 3	Package 2 Noxious Emissions Option D and Fuel Quality Option 2	Package 3 Noxious Emissions Option C and Fuel Quality Option 2
Additional capital costs	Manufacturers and new car buyers	1,046.9	1,483.6	1,046.9
Refinery capital costs	Local refineries	110.6	63.3	63.3
Refinery operating costs (domestic)	Local refineries	232.5	37.9	37.9
Imported fuel price increase	Fuel importers	434.7	233.5	233.5
Fuel demand impacts (loss of consumer surplus)	Motorists	21.2	11.0	11.0
Increased GHG emissions at refinery	Community	88.1	15.2	15.2
Ethanol supply chain capital costs (terminals and distribution)	Fuel terminal operators and distributors	56.9		
Ethanol supply chain operational costs (terminals and distribution)	Fuel terminal operators and distributors	7.2		
Ethanol supply chain capital costs (retailers)	Fuel retailers	437.7		
Ethanol supply chain operational costs (retailers)	Fuel retailers	273.1		
Total cost		**2,708.9**	**1,844.5**	**1,407.8**

Table 21: Combined benefits of implementing Packages 1– 3

Benefits (by 2040) ($ million)	Affected stakeholders	Package 1 Noxious Emissions Option C and Fuel Quality Option 3	Package 2 Noxious Emissions Option D and Fuel Quality Option 2	Package 3 Noxious Emissions Option C and Fuel Quality Option 2
Avoided health costs from mandating Euro 6d for new vehicles ($m)	Community	3,751.5	4,585.5	3,751.5
Avoided fuel costs from mandating Euro 6d for new vehicles ($m)	Motorists	1,160.7	1,494.7	1,160.7
Avoided GHG emissions from mandating Euro 6d for new vehicles	Community	193.4	252.7	193.4
Avoided health impacts from improved fuel quality[ww] ($m)	Community	96.8	20.0	20.0
Total benefits ($m)		**5,202.4**	**6,352.9**	**5,125.6**

Table 22: Total combined costs and benefits

Option	Package 1 Noxious Emissions Option C and Fuel Quality Option 3	Package 2 Noxious Emissions Option D and Fuel Quality Option 2	Package 3 Noxious Emissions Option C and Fuel Quality Option 2
Total Costs ($m)	2,708.9	1,844.50	1,407.8
Total Benefits ($m)	5,202.4	6,352.9	5,125.6
Net Present Value ($m)	2,493.5	4,508.4	3,717.8
Benefit/Cost Ratio	1.92	3.44	3.64

4.7.1 Shared assumptions in the noxious emissions and fuel quality standards CBAs

Wherever possible, assumptions for the noxious emissions standards and fuel quality standards CBAs were aligned. This includes:

- the current noxious emissions standards for light vehicles (ADR 79/04) are part of the BAU in both analyses
- assumptions on the social cost of carbon are aligned at $60/tonne[69]
- the value of all health costs are the same
- the base year for both models is the same (2022).

There are minor differences in the projections for petrol consumption between the two models, with the noxious emissions modelling assuming around 6% more petrol consumption out to 2040 than the fuel quality model.[xx] This can be attributed mainly to minor differences in assumptions regarding the EV uptake out to 2040. Preliminary analysis of aligning the fuel consumption projections for the two models would have only a 1–2% impact on the NPVs of the packages and no difference to the BCRs. Therefore, this difference in assumption would not make a material impact on the preferred options or the preferred package. For a full list of assumptions please see Table 30.

[ww] Attributable to existing vehicles supplied prior to the proposed Euro 6d mandate.

[xx] The aggregate difference in petrol consumption between 2020–2040 between the noxious emissions and fuel quality standards modelling is around 21.000ML which amounts to 6% of the total consumption.

5. Consultation

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

5.1 Euro 6d noxious emissions standards

The preparation of this impact analysis considered feedback received from several consultation processes.

From 27 October 2020 to 26 February 2021, the then Department of Infrastructure, Transport Regional Development and Communications released a draft RIS *Light Vehicle Emission Standards for Cleaner Air*, which evaluated the costs and benefits of mandating Euro 6d standards for light vehicles. This draft RIS was informed by feedback received during consultation in 2016–17 and subsequent discussions with stakeholders.

More stringent noxious emissions standards for light vehicles has also been discussed at DITRDCA's peak vehicle standards consultative forums, the Strategic Vehicle Safety and Environment Group (SVSEG) and the Technical Liaison Group (TLG). SVSEG and TLG include senior representatives of governments (Australian and state/territory), the manufacturing and operational arms of the industry, including organisations such FCAI and consumer and road user organisations, such as the Australian Automobile Association.

5.2 Responses to the draft RIS Light Vehicle Emission Standards for Cleaner Air

The *Light Vehicle Emission Standards for Cleaner Air* draft RIS was released for public consultation to elicit views from all interested parties on its key proposals. Feedback was specifically sought on the estimated benefits and costs of the proposals and implementation timing.

Eighteen submissions were received from a range of stakeholders, including from:

- vehicle manufacturers
- motoring organisations
- state and territory governments
- consumer and business representative groups
- environment and health groups
- component suppliers
- fuel industry organisations
- individuals and community groups.

Overall, the submissions supported Government action to improve air quality by reducing noxious emissions from road vehicles.

5.2.1 Comments received in response to the draft RIS

Submissions received from health, environment, community and motoring groups, and state and territory governments supported an earlier introduction of Euro 6d standards, particularly for diesel vehicles, as well as improved fuel quality standards.

Stakeholders representing light vehicle manufacturers supported the adoption of Euro 6d standards in principle when appropriate fuel quality standards have been implemented for both petrol and diesel. They did not support an earlier introduction for diesel vehicles or the adoption of Euro 6b as an interim step.

5.2.2 How we have responded to the comments received on the draft RIS

In light of the feedback received during this consultation, the Government's decision to bring forward the introduction of lower sulfur petrol to the end of 2024, and to assist the Government's consideration of further improvements to reduce aromatics in petrol from 2025, DITRDCA has also modelled the costs and benefits of adopting Euro 6d standards from 2025–28. The assumptions used in the modelling for this option (Option D) and the 2027 option (Option C) were also updated to account for the effects of the COVID-19 pandemic on traffic growth.

The costs and benefits of an earlier introduction date for diesel vehicles, as proposed in some submissions has not been evaluated, as this approach would be inconsistent with the approach adopted in other vehicle markets with equivalent standards and would have a disproportionate impact on light commercial vehicles. However, Option C considers the costs and benefits of an earlier (2025) introduction for both petrol and diesel vehicles.

5.3 Improved fuel quality standards

DCCEEW undertook two rounds of consultation, one in late 2021 while the CBA was being developed and another in late 2022, on the outcomes of the CBA through the *Better Fuel for Cleaner Vehicles* draft RIS.

5.3.1 Initial CBA consultation

At the outset of the analysis, DCCEEW identified nine key stakeholder groups to consult:

- domestic refiners
- fuel importers
- fuel supply chain sector
- automotive industry
- fuel additive suppliers
- renewable fuel industry
- consumer representatives
- health and environment interest groups
- state and Commonwealth government agencies.

DCCEEW identified these stakeholder groups due to their specialised knowledge of the issues and potential impacts on their business or area of interest. The stakeholders represented a range of views including full coverage of the liquid fuel sector (see **Appendix B** for a full list of stakeholders consulted).

5.3.2 Regular consultation

DCCEEW met with 22 stakeholders over a period of two months in late 2021. Following the meetings, DCCEEW provided questions tailored to each specific stakeholder to allow for a considered response. DCCEEW also reached out to non-government organisations specialising in health and environment issues, however these groups were unable to meet.

Following this round of stakeholder engagement, DCCEEW finalised the options for analysis. DCCEEW then undertook focussed consultation with specific stakeholders to further explore issues raised through the first round of consultation. DCCEEW's consultants engaged with importers and domestic refiners to develop the cost impacts used in the CBA. Table 23 outlines the outcomes from these consultations.

Table 23: Outcomes from consultation

Issue	Stakeholder feedback summary
Interaction with planned reduction in sulfur	• Reducing sulfur in petrol will reduce the octane rating, making it more costly to achieve 35% aromatics in petrol
Reducing aromatics to 35%	• Reducing aromatics will decrease octane in petrol, requiring addition of an octane enhancer or alkylate to provide petrol with the appropriate RON • Importers noted they could source 95 RON petrol with reduced aromatics at an increased cost of supply • Vehicle industry requires a maximum limit of 35% aromatics in fuel before introducing vehicles that meet Euro 6d standards
Ethanol blending	• Ethanol is the one viable octane enhancer to make 98 RON petrol with 35% aromatics • Use of ethanol would have additional infrastructure costs for the supply chain, refiners and importers • Some concern from fuel suppliers and retailers regarding consumer acceptance of ethanol in fuel • Biofuels industry supported ethanol as an octane enhancer
Additives and octane enhancers	• Some importers noted ethers (especially MTBE) are used internationally to increase octane in lower aromatic fuels, but are limited to trace elements in the petrol standard, and also some states in Australia • No stakeholder supported the use of NMA as an octane enhancer
Issues related to increasing the DCN to 51	• Supplying diesel with DCN greater than 51 would be feasible, with increased cost of supply
Maximum PAH level of 8%	• Supplying diesel with PAH of less than 8% would be feasible with increased cost of supply
Maximum density of 845 kg/m^3	• Refiners would incur high costs to supply diesel with a maximum density of 845 kg/m^3 • Fuel importers would be able to source diesel with a maximum density of 845 kg/m^3 with increased cost of supply

5.3.3 Consultation on the *Better fuel for cleaner vehicles* draft RIS

In November 2022, DCCEEW publicly released the *Better fuel for cleaner* vehicles draft RIS, seeking comments and further information from relevant industry stakeholders on the options put forward in the CBA.

DCCEEW received 28 submissions, most representing either the petroleum sector (refineries, suppliers and distributors), the vehicle/automotive industry or community health stakeholder groups.

- In general, submissions from the petroleum sector expressed a preference for Option 1, with a common view that it would not hinder application of Euro 6d standards. As noted, subsequent departmental analysis has indicated Option 1 would not enable the introduction of Euro 6d standards.
- Respondents also expressed broad in-principle support for Option 2 as technically feasible and offering policy certainty for the application of Euro 6d standards. Some noted that the 2024 implementation timeframe for Option 2 was not feasible, and the earliest possible implementation time for Option 2 was 2025. Some petroleum stakeholders also stated that infrastructure upgrades would cost more than the indicative costings of the CBA.

    - In addition, submissions from the petroleum sector indicated the prohibitive nature of the technical difficulties relating to Option 3, specifically regarding the production and distribution of 98 RON within the 35% aromatics limit.
- Health groups generally supported Option 3. However, some of these respondents acknowledged Option 2 as the only technically feasible option, at least in the short term, to enable the introduction of Euro 6d standards.
- For vehicle importers, Option 3 was the preferred option in general. They maintained that Option 3 was the option that would enable all vehicles to meet Euro 6d standards without any increased risk of operability issues, and put forward some hesitance at implementing Euro 6d standards with the implementation of either Options 1 or 2.
    - DCCEEW and DITRDCA are continuing to work with the vehicle sector to work through these concerns and consider potential for Euro 6d standards to be implemented in a way that accommodates for Option 2.

From across all stakeholder groups, there was very limited support for any of the changes to diesel put forward in Option 4. Many submissions noted diesel fuel already meets Euro 6d requirements and noted there was therefore no need to change the Australian automotive diesel standard.

6. What is the best option from those considered?

6.1 Best combined option considered

The decision rule for this analysis is that the recommended option should be the option with the highest net benefit in line with the *Australian Government Guide to Policy Impact Analysis*.[70]

When considering the best option for Euro 6d standards and improved fuel quality standards, it is important to consider the best combined option. This is because improving fuel quality standards is a precondition for implementing Euro 6d standards. Implementing Euro 6d standards without improving fuel quality standards comes with a much higher risk of vehicle operability problems (compared to irregular use), and so would not be recommended. For fuel quality, all options for improvements have a negative NPV when taken in isolation and would not be recommended if these changes were not required to enable the implementation of Euro 6d standards.

Therefore, this impact assessment considered three possible approaches to implement improved fuel quality and Euro 6d standards to reduce noxious emissions from road vehicles entering the Australian vehicle fleet.

There is a strong case for mandatory standards to improve fuel quality and reduce noxious emissions from road vehicles. The costs of air pollution from road vehicles are not borne directly by the vehicle manufacturers or by owners but are shared by the community. As such, the problem will not be addressed effectively by market forces alone, as there is no commercial reason to do so. Noxious emissions standards are internationally recognised as a very effective measure to reduce urban air pollution and have delivered improvements in urban air quality despite growth in vehicle use. Without Government action to further reduce these emissions, the health impacts and number of premature deaths resulting from traffic-related pollution caused by noxious emissions from road vehicles are expected to increase over the next decade.

Improved fuel quality standards will enable Australia to implement Euro 6d standards for light vehicles, bringing Australia's national vehicle standards into closer alignment with international standards adopted by major vehicle markets. This would increase consumer choice and improve Australians' access to the latest safety and fuel-saving technology by reducing any technical or commercial barriers to the introduction of vehicles meeting Euro 6d or equivalent standards.

Our analysis found that there were significant benefits for the Australian community to be gained from improving air quality by mandating Euro 6d standards for new light vehicles. These benefits would not otherwise be realised either through a BAU approach or through various other non-regulatory options (Noxious Emissions Options A and B).

- If Package 1 (35% limit on aromatics for all grades of petrol from 2027 to enable the adoption of Euro 6d standards for newly approved models manufactured from 1 July 2027 and for all new light vehicles manufactured from 1 July 2028) was adopted, it would result in avoided health, fuel and GHG costs of $5,202 million. These savings outweigh any increased costs of $2,709 million over the period to 2040. The net present value over this period was estimated to be $2,493 million, with a BCR of 1.92.
- If Package 2 (35% limit on aromatics for 95 RON petrol from 2025 to enable Euro 6d standards for newly approved models manufactured from 1 July 2025 and for all new light vehicles manufactured from 1 July 2028) was adopted, it would result in avoided health, fuel and GHG costs of $6,353 million by 2040. These savings outweigh any increased costs of $1,844 million over the period to 2040. The net present value over this period was estimated to be $4,508 million, with a BCR of 3.44.
- Package 3 (35% aromatics limit for 95 RON petrol from 2025 and the adoption of Euro 6d standards for newly approved models manufactured from 1 July 2027 and for all new light vehicles manufactured from 1 July 2028) it would result in avoided health, fuel and GHG costs

of $5,216 million by 2040. These savings outweigh any increased costs of $1,408 million over the period to 2040. The net present value over this period was estimated to be $3,718 million, with a BCR of 3.64.

The *Australian Government Guide to Policy Impact Analysis* advises the recommended option should be the option with the highest net benefit.[71] On this basis, the preferred option is to adopt Package 2 from 2025. The preferred package would adopt a 35% limit on aromatics for 95 RON petrol in 2025 and phase in Euro 6d standards for light vehicles from 2025 to 2028. The proposed implementation timeframe was decided after consideration of stakeholder views, including the need for refineries to undertake infrastructure upgrades to improve the quality of petrol they produce, which could be achieved at earliest in 2025, and allowing manufacturers sufficient time to develop and source products designed to meet these new noxious emissions and fuel quality standards.

Vehicle importers' main concern with this package was meeting the regulatory limits of Euro 6d standards for the less than 1% of vehicles that require 98 RON. For these vehicles, they will still be running on petrol with slightly higher than 35% aromatics. Consistent with the Government's longstanding approach to ADRs adopting international vehicle standards (including the ADR adopting Euro VI for heavy vehicles), the proposed ADRs to adopt Euro 6d will not require manufacturers to meet in-service conformity testing requirements. The forthcoming UN Regulation adopting the RDE test will also allow for test fuel (with lower aromatics than Australian market fuel) to be used to demonstrate compliance. The approach will include an evaluation in 2030 to assess whether there are any vehicle operability issues associated with the use of higher aromatics 98 RON for Euro 6d vehicles.

This impact analysis does not recommend changes to the diesel standard. Australia's diesel quality does not impact the introduction of Euro 6d standards, and so changes to diesel quality have been assessed based on the NPV they provide. Introducing a DCN for all diesel, reducing the PAH limit, and reducing the density maximum all provide negative NPVs. The combined changes provide an NPV of −$557.4 million from 2024 to 2040. In addition, the road transport sector is particularly sensitive to price increases in diesel, due to the large amount required to transport goods around Australia. While price increases for the changes are minor, any price increases would disproportionately impact road freight sector users. For instance, each articulated truck on average travelled 78.3 thousand kilometres in 2020, compared to 11.1 thousand kilometres for private vehicles.[72]

6.2 Regulatory burden of the preferred package

The estimation of regulatory burden provides the average yearly costs to stakeholders that results from changes to regulation. The analysis estimated the regulatory burden of the preferred package, Package 2, to be $300.6 million per annum. This includes $263.3 million for implementing Option D for Euro 6d standards, and $37.3 million for implementing Option 2 for fuel quality standards improvements.

7. Implementation and evaluation of the preferred option

7.1 Euro 6d noxious emissions standards for light vehicles

If the Australian Government chooses to implement the preferred package and mandate new noxious emissions standards based on the Euro 6d requirements adopted in many other countries, this could be done by adopting new national vehicle standards (ADRs) under the Road Vehicle Standards Act (RVSA).

Section 12 of the RVSA allows the responsible Minister to make new ADRs or amend existing ADRs to make road vehicles safe to use; control the emission of gas, particles or noise from road vehicles; secure road vehicles against theft; provide for security marking of road vehicles; or promote the saving of energy.

The Government has a long-term policy to harmonise ADRs with international regulations adopted by the UN. The UN regulations for noxious emissions are traditionally based on the 'Euro' standards adopted by the EU.

Historically, the Euro standards adopted by the EU for light vehicles, have been transposed into a new series of UN Regulation 83. However, to accommodate the needs of other Contracting Parties to the UN 1958 Agreement, the UN World Forum's Working Party on Pollution and Energy (GRPE) has agreed that the Euro 6d requirements adopted in the EU will be transposed into three separate UN regulations. These are:

- a new UN Regulation 154, which adopts the Euro 6d Type 1 (tailpipe emissions), Type 4 (evaporative emissions), Type 5 (durability) and on-board diagnostic requirements of Euro 6d as its 'Level 1A' approval requirements
- a new UN Regulation adopting on-road emissions testing requirements based on the Euro 6e and Japanese RDE requirements
- a new '08' series of amendments to UN Regulation 83 adopting:
    - the Level 1A requirements of UN Regulation 154 (by reference)
    - the requirements of the proposed UN Regulation for RDE (by reference)
    - the residual requirements of Euro 6d, which include the Type 2 (idle emissions), Type 3 (crankcase emissions) and Type 6 (low temperature emissions) tests for petrol vehicles.

A new UN Regulation for RDE and a new '08' series of amendments to UN Regulation 83 were agreed at the 87th session of GRPE held on 11 to 13 January 2023 and will be considered for formal adoption at the June 2023 session of the World Forum for the Harmonization of Vehicle Regulations. If agreed, these new UN Regulations will formally enter into force in January 2024.

As Australia is a contracting party to the UN Regulation for International Whole Vehicle Type Approval, which now adopts UN Regulation 154 as a requirement, it is proposed to adopt Euro 6d standards in Australia by adopting an ADR structure aligned with the structure adopted in the UN Regulations. This would involve adopting three new ADRs under section 12 of the RVSA.

- A new ADR adopting the Euro 6d WLTP test requirements in UN Regulation 154.
- A new ADR adopting the UN Regulation for RDE (subject to agreement at the World Forum in June 2023). As the requirements of this UN Regulation go beyond those required in the Euro 6d requirements adopted by the EU in 2017, it is also proposed to accept vehicles meeting Euro 6d requirements specified in EU Regulation 2017/1151.
- An ADR adopting the residual Euro 6d requirements (idle, crankcase and low temperature emissions tests for petrol vehicles).

It will be important to determine new ADRs as soon as possible following a policy decision to provide certainty to manufacturers and maximise their ability to undertake necessary business planning to comply with the new ADRs by the time they are due commence. To enable this to occur, DITRDCA

will draft the text of proposed ADRs in consultation with government and industry stakeholders represented on its Technical Liaison Group once a policy decision has been announced and the relevant UN Vehicle Regulations have been adopted by WP.29.

As the WLTP test requirements adopted in Euro 6d include new requirements for measuring and reporting fuel consumption and CO_2 emissions, which are not directly comparable with figures derived from the current laboratory test, it is also proposed that the ADR for fuel consumption labelling (ADR 81/02) be reviewed to consider how fuel consumption, CO_2 emissions, energy consumption and battery range data should be reported and presented to consumers for vehicles that comply with the WLTP test requirements.

The ADRs adopting Euro 6d standards will be reviewed as resources permit, when the relevant international vehicle regulations are reviewed and updated. This will help ensure they continue to achieve the objectives of the RVSA.

To ensure the RVSA continues to achieve its objectives, ADRs are typically reviewed as resources permit and international vehicle standards are updated.

7.2 Improved fuel quality standards

If the Government implements the preferred package and reduces the aromatics content in 95 RON petrol, this could be done by amending the Fuel Quality Standards (Petrol) Determination 2019 (petrol standard). Once a policy decision has been made on the preferred option, the Minister for Climate Change and Energy will amend the petrol determination as soon as possible to provide certainty to industry and consumers.

7.3 Implementation timeline

The below table sets out the implementation milestones for the best option.

Table 24: Implementation timeline

Date	*Milestone*
July 2023	Legislating adopting new and amended ADRs and amending the petrol standard to introduce a more stringent aromatics limit for 95 RON from 2025.
December 2025	Reduced aromatics limit for 95 RON comes into force.
December 2025	Compliance with Euro 6d noxious emissions standards mandatory for all newly approved light vehicle models.
July 2028	Compliance with Euro 6d noxious emissions standards mandatory for all new light vehicles.
2030	Implementation evaluation of policy package.

7.4 Implementation impacts

None of the changes to Australian fuel standards being considered will require motorists to change the fuel they use in their existing vehicles. Changes to standards will only impact the fuel required for new vehicles if Euro 6d standards commence.

The preferred option of reducing the aromatics limit in 95 RON enables the implementation of Euro 6d standards at the lowest cost. This will require changes to the fuel and vehicle sectors for new vehicle purchasers. This section sets out implementation impacts of the preferred option.

7.4.1 Changes for motorists

Motorists generally associate higher RON with better quality petrol. Creating a lower aromatics 95 RON petrol will challenge this perception. 95 RON could become the recommended grade of petrol for most new Euro 6d vehicles.

During consultation, the Australian Automobile Association raised the issue of misfuelling due to confusion that 95 RON becomes the preferred grade of petrol for new Euro 6d vehicles. DCCEEW investigated this issue and expects the change would impact motorists gradually, as it would only affect those purchasing new vehicles. Approximately 5% of the fleet turns over every year, and so it would take many years before the majority of the fleet requires 95 RON petrol.[yy] Many motorists that purchase new European vehicles are already advised by the importer or automotive dealership to use 95 RON in their vehicles.

DCCEEW also found no evidence to suggest that the occasional or accidental use of 98 RON would impact on a Euro 6d-compliant vehicle operating (i.e. starting and running). Further, as there are already a small number of Euro 6d vehicles that are sold in Australia, the risk of operability issues with these vehicles is already being tested. The risk to operability of vehicles that run on 98 RON appears to be low. Analysis by DCCEEW suggests that sustained use of higher aromatics 98 RON may lead to a need for more frequent servicing and reduced life of the petrol particulate filter. There is no evidence of this occurring in Australia to date.

Premium sports cars from brands such as Ferrari, Lamborghini, Porsche and other luxury marques often recommend or require the use of 98 RON in Australia. These vehicles tend to be high-performance cars with highly tuned engines specifically designed to run on high octane fuels. Data from previous years suggests that around 0.6% of annual vehicle sales were models that are required to use 98 RON.[zz]

DCCEEW acknowledges that with the implementation of Euro 6d standards, future new vehicles sold that require 98 RON may need more regular service intervals due to the potential for higher levels of aromatics in 98 RON. However, existing vehicles will be able to continue to use 98 RON without any impacts. DCCEEW's testing showed 98 RON had an average aromatics content of 37.0% for 2021–22.[73] While slightly higher than the European limit, this is considerably lower than Australia's legislated maximum. With the trend to electrification occurring at a faster rate in the premium vehicle markets, the proportion of vehicles requiring 98 RON may gradually decline in the future from the already very small number of vehicles in Australia that require this fuel. It is therefore DCCEEW's view that the additional $1.2 billion in costs to introduce a 35% maximum aromatics limit to 98 RON does not provide a net benefit to the community.

The Government will work with industry to educate consumers on any changes

The Government will provide consumers with information about the new fuel standards prior to their implementation. DCCEEW has budgeted around $350,000 in the 2024–25 financial year to provide information on the introduction of the new fuel quality standards. The Government will consult with industry prior to the campaign to ensure a coordinated approach.

[yy] Based on ABS and vehicle sales (VFACTS) data.

[zz] Based on Departmental calculations using data from the Green Vehicle Guide and VFACTS.

The Government could require consistent labelling requirements to assist consumers

Under the Fuel Quality Standards Act the Minister has the power to create fuel quality information standards. DCCEEW will consider the appropriateness of creating a new information standard for petrol that is compatible with Euro 6d vehicles. An information standard requiring labelling of 95 RON with maximum 35% aromatics as 'Euro 6d-compliant' could reduce consumer confusion and the risk of misfuelling. To complement this measure, other grades of petrol could require labels stating they are 'unsuitable for use in Euro 6d vehicles'. DCCEEW would co-develop details of the standard with industry and consumer groups. Introducing a new information standard would incur additional regulatory burden for petroleum retailers, comprising the costs in additional labelling of fuel bowsers at service stations.

Information about fuel is available on the Green Vehicle Guide website

The Government's Green Vehicle Guide provides information to consumers on the environmental performance of light vehicles sold in Australia, such as whether a vehicle is Euro 6-compliant. This includes information to consumers regarding the appropriate grades of petrol for specific vehicles. As part of the information materials, DCCEEW will draw consumers' attention to this feature. This will also be a useful tool for motorists who are uncertain of the refuelling requirements for their vehicles.

7.4.2 Changes for vehicle importers

If the Government introduces improved fuel quality and Euro 6d standards, 95 RON could become the recommended grade of petrol for Euro 6d vehicles. Vehicle importers may be concerned about the risk of higher aromatics content in petrol impacting the life of petrol particulate filters. This may result in importers advising customers against operating Euro 6d vehicles regularly on 98 RON. This would require changing the recommended fuel filling information supplied on new vehicles.

Vehicles in Japan, South Korea and the US can run on 91 RON (or an equivalent anti-knock index). These markets have noxious emissions standards equivalent, although not identical, to Europe. Aromatics content of 91 RON is almost always below 35%, even without a regulated limit. It is therefore possible that vehicle importers from these markets may allow the use of 91 RON petrol in their Euro 6d vehicles.

7.4.3 Changes for service stations

Around 55% of Australian fuel retailers provided 95 RON in 2021. We expect that with the specification changes to 95 RON and potential implementation of Euro 6d standards, gradual growth in demand for 95 RON petrol would likely result in a greater number of fuel retailers stocking the product. DCCEEW does not expect that availability of 95 RON will need Government intervention.

With changes to fuel quality, service stations may need to undergo a tank flushing procedure. If the Government creates new information standards, service stations will be required to implement additional labels on pumps.

7.4.4 Changes for refineries

Domestic refineries will need to upgrade their infrastructure to produce lower aromatics 95 RON petrol. It is important that these upgrades can be completed without compromising Australia's fuel security by affecting the viability of Australia's remaining refineries.

The Government is providing assistance to Australia's refineries to improve fuel quality

Funding for refinery infrastructure upgrades may be available through a proposed Phase 2 of the Refinery Upgrades Program (RUP). This existing program could provide up to $26 million for each of the Australian refiners to produce lower aromatics petrol, providing an offset to the additional regulatory compliance cost for the petroleum industry. If the Government chooses to proceed with the preferred option, DCCEEW will work towards establishing Phase 2 of the RUP.

7.4.5 Changes for fuel importers

Imported 95 RON regularly meets a 35% aromatics limit. To ensure that all product meets the standard, importers may have to secure new supply agreements with overseas refineries.

Most markets in the Asia Pacific already have a 35% aromatics limit on their petrol. The product often includes oxygenates such as methyl tertiary butyl ether (MTBE) and ethyl tertiary butyl ether (ETBE). Australian legislation limits these oxygenates to trace amounts in petrol supplied in Australia. As a result, there will be fewer sources of supply for MTBE/ETBE-free, lower aromatics 95 RON. The CBA commissioned by the Government assumed that because of the reduction in supply options for importers, there would likely be a 0.9 cpl price premium for the product in 2024, increasing to around 1.9 cpl by 2040.[74] However, there may also be more competition and greater volumes of 95 RON sold, putting downward pressure on local prices.

7.4.6 Assessing compliance with improved fuel quality standards

If the Government chooses to improve fuel quality and implement Euro 6d standards, DCCEEW will need to monitor compliance with the improved fuel quality standards. Information about Australia's real world fuel quality will also be important for vehicle importers in ensuring they have the confidence to bring in Euro 6d vehicles.

The Government will provide more data on fuel quality

DCCEEW's fuel quality compliance program is expanding in the lead up to the 2024–25 implementation of fuel quality standard improvements. This will provide the Government with more data on the real-world quality of Australia's fuel, and will assess the level of industry compliance when the improved standards come into force.

Through the Fuel Quality Standards Act's annual report, DCCEEW will publish detailed data on the results of the expanded compliance program. This will provide industry with up-to-date information on Australia's actual fuel quality standards. Australia's fuel quality usually far exceeds the regulated minimum standards. This could provide industry with the certainty to import a greater number of Euro 6d vehicles without additional regulatory burden on the petroleum industry.

7.4.7 Shifts in petrol demand by grade

If the Government reduces aromatics content in 95 RON and implements Euro 6d standards, this is likely to impact the demand of petrol by grade. DCCEEW expects that demand will transition away from 91 RON and towards 95 RON. As only around 5% of the Australian fleet turns over annually, the transition will be gradual. The analysis has not quantified the costs or benefits of this transition because:

- vehicle importers have been unable to provide information on whether they could provide 91 RON vehicles that meet Euro 6d standards to the Australian market. Hence, the proportion of new vehicles that run on 91 RON versus 95 RON is difficult to estimate.
- most of the existing Australian fleet can use 91 RON. However, many motorists choose to fuel their vehicles with 95 RON and 98 RON. This will still be possible for any existing vehicles within the fleet. There may also be more competition and greater volumes of 95 RON sold, putting downward pressure on price. With these counteracting factors it is difficult to quantify the impact on demand for petrol by grade.

7.5 Implementation risks

The below risk matrix highlights possible risks and mitigation strategies for the implementation of the preferred package of policies.

ID	Risk Description	Business Impact	Risk Owner	Controls	Likelihood	Consequence	Risk Rating	Risk acceptable
1	Refineries unable to produce lower aromatics 95 RON petrol at the time the lower limit comes into force	Australian refineries will be unable to produce petrol that meets Australia's standards and will be dependent on imports. Potential economic impacts on Australia's refineries.	DCCEEW	Liaising closely with the Australian refineries to ensure the start date for the lower aromatics limit is achievable.	**Unlikely**	**Substantial**	**Medium**	Yes
2	Operability issues for vehicles that run on 98 RON	Some high-performance Euro 6d vehicles that require 98 RON may have operability issues from continued use of higher aromatics petrol.	DCCEEW and DITRDCA	The 2030 evaluation will consider the vehicle operability impacts of higher aromatics 98 RON.	**Unlikely**	Substantial	Medium	Yes
3	Poor compliance with the improved standards	Petrol is being supplied that does not meet the more stringent aromatics specifications.	DCCEEW	Increased fuel sampling out to 2024–25 with the potential for increased sampling for 2025–26 and beyond.	**Unlikely**	Moderate	Low	Yes
4	Consumer confusion regarding the appropriate petrol to use	This may increase the instances of misfuelling. This would only have a detrimental impact on Euro 6d vehicles.	DCCEEW	Information campaign before the implementation of improved fuel quality standards. DCCEEW will explore the potential for new labelling requirements.	Unlikely	Moderate	Low	Yes

7.6 Evaluation of fuel quality and noxious emissions package

Following the introduction of improved fuel standards, DCCEEW will periodically evaluate its ongoing operation. This will include consideration of whether the new standards are meeting the objectives of the Fuel Quality Standards Act and are enabling Euro 6d vehicles to be supplied in Australia.

DCCEEW and DITRDCA are proposing a review in 2030, after the full implementation of Euro 6d standards, to assess implementation of the new fuel quality and noxious emissions standards and consider whether any further changes are needed to improve air quality and reduce greenhouse gas emissions from light vehicles. The focus of the review will be on:

- are petrol standards impacting Euro 6d vehicle operability?
- are diesel parameters a barrier to future diesel vehicle operability?
- have the costs and benefits to supply a lower aromatics 98 RON petrol changed?
- how have emissions from new vehicles supplied to Australia changed since the new standards have been implemented?
- how will these improvements affect health costs attributable to noxious vehicle emissions over the period to 2040 and beyond?
- should Australia consider adopting further changes to noxious emissions and fuel quality standards in line with other advanced economies?

Under the preferred package considered, the Euro 6d requirements for existing vehicle models are intended to commence on 1 July 2028. This is intended to enable manufacturers to undertake more complex engineering work to add new technology to existing models, particularly for vehicle models requiring 98 RON petrol. The review proposed in 2030 will help determine whether our fuel quality is impacting these 98 RON vehicles and whether any changes to settings may be appropriate.

It is proposed this review considers data from a range of existing sources including, but not limited to:

- air emissions inventories maintained by DCCEEW and state/territory governments
- emissions data from the Australian Automobile Association's real-world testing program funded by the Australian Government
- new research by government and non-government organisations in Australia and overseas.

Appendix A – Further information on cost benefit analysis for Euro 6d

The key indicators of the economic viability of a proposed option are its net benefits and benefit-cost ratio (BCR). A positive net benefit means that the returns on the option will outweigh the resources outlaid. The BCR is a measure of the efficiency of the option. If the net benefits are positive, the BCR will be greater than one. A higher BCR means that, for a given cost, the benefits are paid back a number of times over.

- The benefits included were from the health costs avoided relative to business as usual.
- The costs included were the estimated costs likely to be incurred by manufacturers to fit more advanced emissions control systems.

Two regulatory scenarios have been modelled in this analysis.

The first scenario modelled considered the costs and benefits of adopting new Australian Design Rules mandating Euro 6d standards from 1 July 2027 for newly approved light vehicle models (M and N category vehicles with a gross vehicle mass up to 3.5 tonnes) and all light vehicles manufactured from 1 July 2028, to align with a 35% limit on aromatics across all grades of petrol from 2027. Table 25 provides the modelling results for this scenario.

The second scenario modelled considered the costs and benefits of adopting new Australian Design Rules mandating Euro 6d standards from 1 July 2025 for newly approved light vehicle models (M and N category vehicles with a gross vehicle mass up to 3.5 tonnes) and all light vehicles manufactured from 1 July 2028, in conjunction with a 35% limit on aromatics for 95 RON petrol from 2025. Table 26 provides the modelling results for this scenario.

Table 25: Cost benefit analysis for the 2027 implementation of Euro 6d standards in Australia

Net present value, 2022 Australian dollars ($m), 2026–2040

Year	Capital costs	Avoided health costs	Avoided fuel costs	Avoided GHG emissions	Net benefit
2026	16.8	0.5	0.4	0.1	−15.9
2027	119.8	17.6	9.9	1.8	−90.4
2028	186.6	59.8	29.4	5.4	−92.1
2029	151.8	112.0	50.8	9.2	20.2
2030	125.9	163.7	69.5	12.4	119.7
2031	103.9	212.1	83.8	14.7	206.6
2032	85.8	255.1	94.2	16.3	279.8
2033	69.6	292.8	101.3	17.3	341.8
2034	55.4	324.8	105.5	17.7	392.6
2035	43.3	351.1	107.3	17.8	432.9
2036	32.8	371.7	107.0	17.5	463.4
2037	23.9	386.8	105.4	17.0	485.2
2038	16.5	396.8	102.5	16.3	499.2
2039	10.1	402.4	98.9	15.5	506.7
2040	4.7	404.3	94.7	14.6	509.0
Total	1,046.9	3,751.5	1,160.7	193.4	4,058.7

Estimated costs:	$1,046.9m
Estimated benefits:	$5,105.6m
Net benefit:	$4,058.7m
Benefit/Cost Ratio:	3.88

Table 26: Cost benefit analysis for the 2025 implementation of Euro 6d standards in Australia

Net present value, 2022 Australian dollars ($m), 2026–2040

Year	Capital costs	Avoided health costs	Avoided fuel costs	Avoided GHG emissions	Net benefit
2024	42.4	1.0	1.7	0.3	−39.3
2025	166.5	11.7	11.5	2.2	−141.1
2026	189.9	39.3	28.1	5.3	−117.0
2027	174.5	81.9	46.2	8.6	−37.7
2028	186.6	132.5	65.1	11.9	22.8
2029	151.8	183.9	83.5	15.1	130.7
2030	125.9	233.3	99.0	17.6	224.0
2031	103.9	278.8	110.1	19.3	304.3
2032	85.8	318.7	117.7	20.3	370.9
2033	69.6	353.0	122.2	20.8	426.4
2034	55.4	381.3	123.8	20.8	470.5
2035	43.3	403.8	123.4	20.4	504.3
2036	32.8	420.5	121.1	19.8	528.6
2037	23.9	431.7	117.6	18.9	544.3
2038	16.5	437.7	113.1	18.0	552.3
2039	10.1	439.3	108.0	16.9	554.1
2040	4.7	437.3	102.5	15.8	550.8
Total	1,483.6	4,585.5	1,494.7	252.2	4,848.8

Estimated costs:	$1,483.6m
Estimated benefits:	$6,332.4m
Net benefit:	$4,848.8m
Benefit/Cost Ratio:	4.27

Assumptions

The analysis assumed that the emissions reduction technology on vehicles purchased during most years of the evaluation period would continue to generate benefits beyond the end of the evaluation period in 2040.

Since the benefits from this technology are fairly constant over the lives of the vehicles, an approximation to residual evaluation was obtained by prorating the cost of the technology over the lives of the vehicles, then only counting costs attributed to years before 2040.

The average vehicle life (median survival time) was assumed to be 17 years. For vehicles purchased during the evaluation period, the cost of the emissions reducing technology was annualised over 17 years.

A standard discount rate of 7% was used, as required by the Office of Impact Analysis (OIA). Sensitivity testing conducted on discount rates of 3% and 11%, as required by OIA, showed that, even with a higher discount rate of 11%, the BCR would remain well above one.

The analysis assumed an increase in the proportion of new vehicle models employing GDI technology, with GDI light vehicles possibly approaching half of new petrol vehicle sales before 2025. It also assumed that oil prices would remain relatively close to current levels over the medium term and then gradually rise over the ensuing decades. Electric vehicle uptake was also anticipated to increase as predicted in the BITRE Research Report 151 'Electric Vehicle Uptake – Modelling a Global Phenomenon'.[75]

Costs of introducing Euro 6 standards for new light vehicles in Australia were assessed based on increased capital costs associated with fitting new emissions reduction technologies. The cost estimates for these technologies were informed by industry submissions to previous consultation papers along with a range of studies.

The total estimated cost of meeting Euro 6 standards was likely slightly conservative as it did not include additional maintenance costs. It is anticipated that there would be some increase in the maintenance costs for light diesel vehicles, notably in relation to the exhaust after-treatment system. Over the long term, as the technology becomes more mature, maintenance costs would likely reduce.

Further, possible changes in fuel costs and GHG emissions from meeting Euro 6 standards were also included. The fuel economy of Euro 6-compliant light vehicles depends on the emissions abatement technology used and duty cycles, that is how the engine is going to be used and its operating temperature profile. A sensible assumption would be that, in a competitive environment, engine/vehicle manufacturers would make every effort to minimise fuel consumption to the lowest possible levels subject to compliance with the Euro 6 standards. In addition to the findings of a 2017 study by ABMARC, this also suggests Euro 6 engines are more likely to be fitted with fuel-saving technologies. As vehicle manufacturers were concurrently required to meet more stringent fuel efficiency standards in other markets, it was anticipated fuel consumption and CO_2 emissions of new vehicles supplied to Australia would be 3% lower than under existing policy settings.[76]

The benefits of introducing Euro 6 standards were assessed based on avoided health costs. The first step was to estimate the tonnes of emissions saved under Euro 6 standards relative to business as usual. The second step was to establish a value for an average health cost ($ per tonne of emissions) from the latest available data. The final step was to calculate the total health benefits (i.e. health costs avoided) by multiplying tonnes of emissions saved by unit values for health costs. The unit values for the health costs were derived from work undertaken by independent consultants Marsden Jacob Associates for the then Department of the Environment and Energy's RIS *Better fuel for cleaner air*.

The economic benefits of avoided greenhouse gas emissions were based on the median value used in the current Australian Transport Assessment and Planning Guidelines ($60/tonne).[77] These guidelines are currently used by the Australian Government and state and territory governments to evaluate the economic costs and benefit of transport infrastructure projects.

Sensitivity testing

As the second option modelled (Euro 6d from 2025) had the highest net benefit, further sensitivity tests were applied to this option to account for inevitable uncertainties with some of the assumptions used.

Sensitivity tests were undertaken on assumptions around:

- discount rates
- potential fuel efficiency benefits (included in core scenario, excluded in sensitivity test)
- possible additional reagent costs for diesel vehicles, and possible additional fuel cost impacts, if the introduction of Euro 6d standards led to an increase in the number of petrol vehicles requiring higher octane grades of petrol
- analysis period (2040 vs 2050).

The results are summarised in Table 27.

Table 27: Sensitivity test results for Euro 6d for light vehicles from 2025

Sensitivity test	Benefit-cost ratio	Net benefits ($m)
Core scenario	4.27	3,958.1
Low discount rate (3%)	5.25	7,636.8
High discount rate (11%)	3.50	2,110.0
'Worst case' scenario Adoption of Euro 6d requires: - a higher proportion of vehicles to use higher octane grades of petrol - increased reagent costs for diesel vehicles.	1.49	1,297.7
If incidental fuel efficiency and greenhouse gas benefits are excluded	3.09	2,530.8
Extension of analysis period to 2050	4.97	6,974.2

Appendix B – Further information on the cost benefit analysis for improved fuel quality standards

Costs associated with using ethanol as an octane enhancer for 98 RON

Costs for refineries and terminals

To create 98 RON with a 35% aromatics limit, the refineries can likely produce a reformulated blendstock for oxygenate blending (petrol blendstock). This would have an approximate RON of 95.5 and a reduced Reid vapour pressure (RVP), such that the ethanol-blended petrol has a RON of 98 and an RVP which meets the current specification. E10 has a lower energy content than regular unleaded petrol, so using E10 98 RON will reduce fuel economy by a small percentage.

Ethanol cannot be added to petrol at the refineries and is instead added at fuel terminals. This is because ethanol absorbs water which promotes corrosion in the finished petrol systems. It is best mixed into the petrol as close to the delivery point as possible. This option requires more infrastructure costs outside the refineries. This includes investment in ethanol storage and blending infrastructure at fuel terminals around Australia, and upgrades to 98 RON tanks and dispensing systems at retailers.

Australian fuel terminals would need more tanks and upgraded fire suppression equipment. The industry consultations show a wide range of costs, with an average of around $2 million per terminal. This equates to a total terminal capital expenditure of $72 million across all sites. The analysis projected annual operational expenditure to be 1.5% of capital expenditure, which equates to around $1.1 million per year.

Ethanol supply chain costs

Introducing ethanol into a new petrol grade for 98 RON will impose costs on retailers due to the following changes:

- new underground storage tanks or re-lining of existing tanks, as some tanks are incompatible with ethanol—noting this does not impact all sites
- introducing ethanol-blended petrol into a tank that previously did not hold it involves a complex change-over and quality-verification process
- higher costs for maintenance and inspections required on bowsers and tanks that have ethanol-blended fuels
- rebranding with new decals, signage and software to notify consumers that 98 RON has changed to E10 98 RON.

For petrol retailers, ethanol-petrol blends can cause corrosion in old underground steel storage tanks. Storage of E10 in older fiberglass tanks can cause failure of the resin if it concentrates in the bottom of the tank when there is free water present.

It will be challenging for the fuel supply chain to accommodate the use of ethanol in 98 RON by 2027. Introducing ethanol blends to all retail sites will take several years (approximately 7,000 sites) and there are limited resources to complete necessary facility upgrades.

The use of ethanol as an octane enhancer to produce 98 RON with a maximum of 35% aromatics would allow importers to import and certify Euro 6d vehicles that use either grade of premium unleaded petrol. However, if 98 RON containing ethanol is suitable for Euro 6d vehicles, and there is also a 95 RON without ethanol that is suitable for Euro 6d vehicles, some consumers may move away from 98 RON to avoid the use of petrol containing ethanol.

In Australia, fuel-grade ethanol is made as a biofuel from feedstocks that are byproducts of human food production, such as molasses, wheat starch and sorghum. According to a 2021 Bioenergy Australia report, the current installed production capacity is 436 ML/year from three facilities. One ethanol plant is

currently shut down (in 2021), reducing the domestic ethanol capacity to approximately 360 ML/year.[78] The pre-existing ethanol capacity would be needed to meet the NSW and QLD ethanol mandates.

The amount of ethanol required to make all 98 RON sold in Australia in 2021 contain 10% ethanol is around 310 ML/year. The development of Australia's ethanol industry, while important, is out of scope for this impact analysis.

Benefits from reduced health costs

Under BAU, annual health costs in Australian cities associated with motor vehicle emissions were approximately $3.9 billion in 2024. This equates to around 1.6% of total health spending in Australia. These costs include:

- premature deaths from respiratory and cardiovascular illnesses and lung cancer which are 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 the BAU option, health costs remain constant over the period of analysis despite significant reductions in emissions of the main pollutants over that time. This is because:

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

The CBA calculated health impacts using the damage cost approach. This approach estimates the avoided health costs through improving fuel quality standards. These damage costs assume an average impact on an average population affected by changes in air quality. Results are presented as a cost per tonne of emissions per geographic location. These costs are influenced by:

- deaths and illnesses caused by pollutant exposure
- the number of people exposed
- the value placed on human life and health
- the range of added costs and damages.

The BAU assumed the 2024 introduction of the 10 ppm sulfur limit, which has already been legislated. The focus of the CBA was limited to the reduction of aromatic content in Australian petrol and changes to diesel.

Implementing Option 1 would result in no net benefits. This is because the vast majority of regular unleaded petrol currently sold has an aromatics level below the proposed 35% aromatics limit, so any changes would be negligible.

The net present benefit of total avoided health costs for Option 2 between 2025 and 2040 is $17.8 million. The estimation assumes that under a 35% aromatics limit for 95 RON, there would be a 1.6% reduction in particulate emissions. This result does not consider the benefits of Option 2 enabling Euro 6d standards.

The net present benefit of total avoided health costs under Option 3 for 95 RON and 98 RON between 2027 and 2040 is $96.8 million. This assumes a 7.4% reduction in particulate emissions from a 35% aromatics limit for 98 RON, and the same reduction in particulate emissions for 95 RON as in Option 2.

There is evidence that suggests that blending 91 RON petrol with up to 10% ethanol may result in a 19–33% reduction of particulate emissions.[79] This may also translate to 98 RON, however the positive contribution to air quality and human health from blending ethanol with 98 RON was not quantified due to the lack of available evidence. The health benefits of $96.8 million for Option 3 is likely underestimated as the air quality benefits from including ethanol in 98 RON were not completely quantified.

The net present benefits of avoided health costs under Option 4 for diesel is $25.1 million. This assumes a 0.5% reduction in particulate emissions resulting from a maximum density of 845 kg/m^3. No health benefits were linked with changes to the other diesel specifications under Option 4.

Unquantified benefits

Not all potential benefits of implementing the policy options are directly or fully reflected in market prices. It is difficult to quantify those benefits in dollar values or estimate their worth in a way that provides a true reflection of their economic value. For the CBA, DCCEEW did not consider certain benefits where there was a lack of data to assign a monetary value to the benefits.

Unquantified health benefits

Adding ethanol to any petrol grade generally results in a reduction of noxious emissions and an increase in emissions of acetaldehyde and formaldehyde. The extent of emissions reductions attributed to ethanol varies greatly between studies. DCCEEW did not find literature or evidence specifically relating to E10 98 RON. As a result, the analysis does not include a reduction of particulate emissions from including 10% ethanol in 98 RON.

Other potential non-market health benefits of options relative to the BAU case that have not been assessed 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
- productivity benefits of reduced illness and hospitalisation
- health benefits associated with reducing evaporative emissions from vehicles (such as when refilling at petrol stations).

CBA sensitivity analysis

The CBA is based on a series of assumptions, meaning there is a degree of uncertainty around the results. Sensitivity testing can clarify which assumptions can materially change the results, including on discount rates and the number of refineries.

Discount rates

The OIA requires the calculation of NPVs at an annual real discount rate of 7%. The sensitivity analysis also calculated the NPV with real discount rates of 3% and 10%. The analysis indicates the discount rate does not change whether the NPV of the options is positive or negative. This is mainly due to the proportional changes in costs and benefits over time moving together in all options assessed in this study.

Table 28: Discount rate sensitivity analysis

Option	Grade	Timing	NPV, 3% discount rate, $m	BCR, 3% discount rate	NPV, 7% discount rate, $m	BCR, 10% discount rate	NPV, 10% discount rate, $m	BCR, 10% discount rate
Option 2	95 RON	2025–2040	−477.6	0.05	−343.0	0.05	−275.1	0.05
Option 3	91 RON	2027–2040	−47.0	0.00	−32.4	0.00	−25.0	0.00
	95 RON	2027–2040	−334.1	0.06	−340.2	0.08	−189.7	0.05

Option	Grade	Timing	NPV, 3% discount rate, $m	BCR, 3% discount rate	NPV, 7% discount rate, $m	BCR, 10% discount rate	NPV, 10% discount rate, $m	BCR, 10% discount rate
	98 RON	2027–2040	−1,662.8	0.07	−1,192.5	0.05	−1,035.2	0.06
Option 4	Diesel all	2024–2040	−750.5	0.04	−557.4	0.04	−457.6	0.04
	PAH	2024–2040	−9.1	0.00	−6.8	0.00	−5.7	0.00
	DCN, CI	2024–2040	−313.7	0.00	−228.5	0.00	−185.3	0.00
	Density	2024–2040	−427.7	0.07	−322.0	0.07	−266.6	0.07

Ongoing operation of Australian refineries

Under the Fuel Security Services Payment and the Refinery Upgrades Program, Australian refineries have committed to continue operation until 2027, with the option of extending to 2030. After this time, there is significant uncertainty around the operation of Australian refineries to 2040. The sensitivity analysis considers the implication of the refinery operations under two alternative BAU cases. The BAU case used in the CBA assumes two refineries would continue to operate to 2030 and one would operate to 2040. The alternative BAU cases are:

- BAU2: The existing two refineries continue to operate to 2040.
- BAU3: The existing two refineries continue to operate to 2030 and both would end their operations in 2031.

The impact of refineries on the estimated net benefits of fuel quality standards is small. This is mostly due to their small share of supply in the domestic market. Table 29 summarises the results of different BAU cases.

The estimated net costs are lower when the existing two refineries cease to operate under BAU3. This is because they avoid paying the amortised capital expenditure required to upgrade their facilities and there will be no need for imported alkylate to improve the fuel quality specifications.

No sensitivity analysis was undertaken for a 2027 refinery closure as part of this analysis due to the option for the Fuel Security Services Payment to extend to 2030.

Table 29: Impact of different BAU cases with a 7% discount rate

Option	Grade	Timing	BAU 1 NPV, $m	BAU 1 BCR	BAU 2 NPV, $m	BAU 2 BCR	BAU 3 NPV, $m	BAU 3 BCR
Option 2	95 RON	2024–2040	−343.0	0.049	−343.5	0.05	−348.7	0.05
Option 3	91 RON	2027–2040	−32.4	0.00	−37.2	0.00	−27.6	0.00
	95 RON	2027–2040	−340.2	0.08	−259.4	0.1	−252.4	0.1
	98 RON	2027–2040	−1,192.5	0.053	−1,314.7	0.05	−1,129.3	0.06
Option 4	Diesel all	2024–2040	−557.4	0.04	−678.9	0.04	−435.8	0.05
	PAH	2024–2040	−6.8	0.00	−8.8	0.00	−4.9	0.00
	DCN, CI	2024–2040	−228.5	0.00	−247.3	0.00	−209.8	0.00
	Density	2024–2040	−322.0	0.07	−422.8	0.06	−221.2	0.10

Distributional impact analysis

Besides the overall BCR, decision makers also consider the distributional impacts of a regulatory change on affected parties. As analysed in the CBA, the proposed standards have different impacts on the affected parties. The main affected groups are:

- refineries
- motorists
- environment
- community
- government
- petroleum supply chain.

Similar to Marsden Jacob's study in 2018, Figures 11–13 list the potential impacts of the options, both positive and negative, on these stakeholder groups.[80] A key point to note about the distributional analysis is that it not only includes costs and benefits but also transfers. Transfers are financial transactions between two or more stakeholder groups that are not of themselves an economic cost or benefit. Key transfers in this analysis include Government support to the refineries. The analysis includes consideration of a transfer between the Government and motorists through the reduction in fuel excise in Option 3.

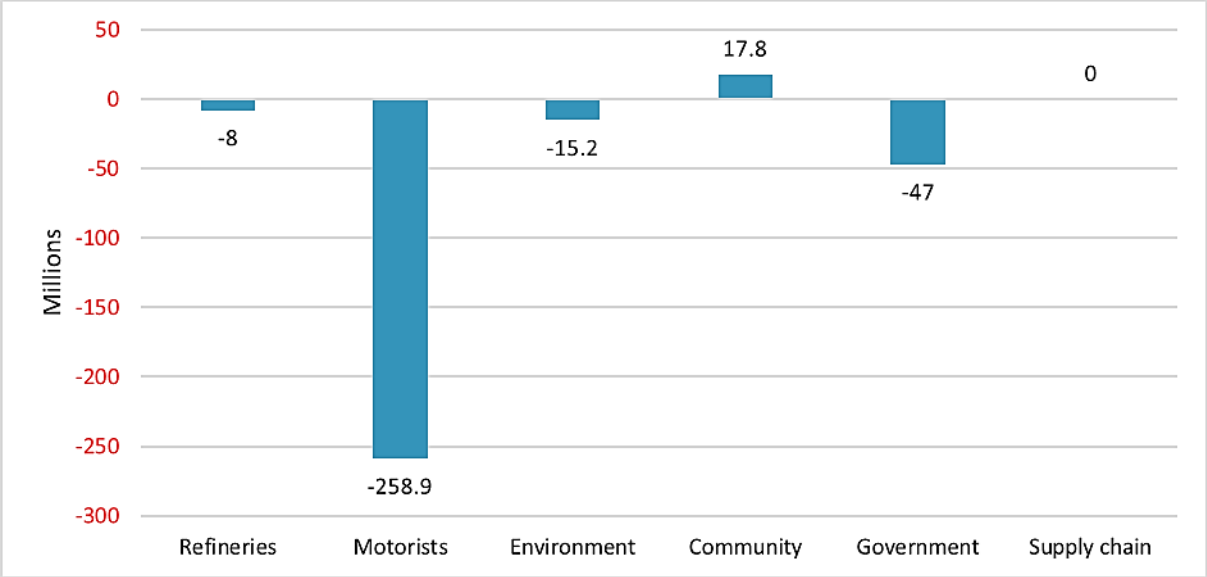

Figure 11: Option 2 – 95 RON distributional analysis total cost and benefits (NPV) to 2040

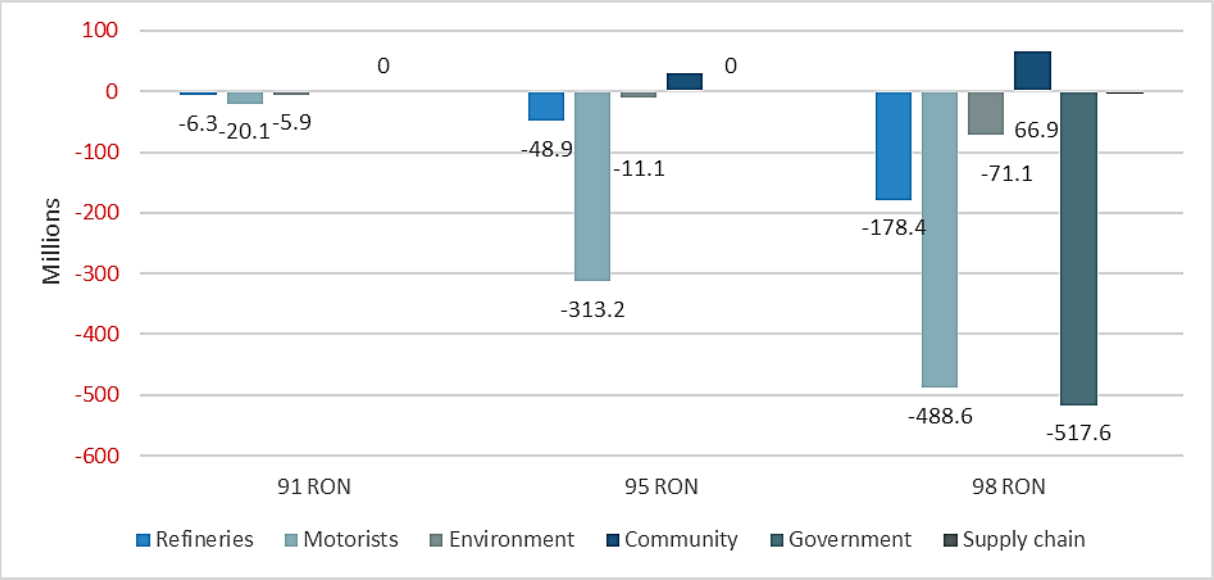

Figure 12: Option 3 – 91/95/98 RON distributional analysis total costs and benefits (NPV) to 2040

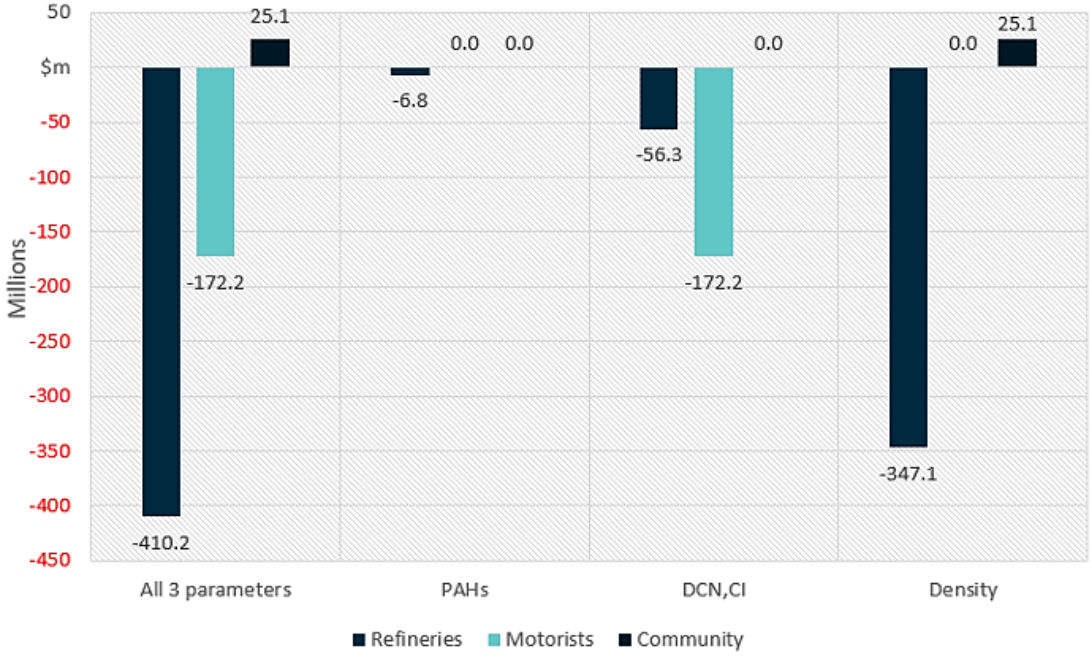

Figure 13: Option 4 – diesel quality distributional analysis total cost and benefits (NPV) to 2040

Sources

The analysis has drawn on a number of information sources. As these reports were procured for use internal to Government only, they will not be made publicly available but will be made available to the Office of Impact Analysis for their review.

Specialist consultant inputs

DCCEEW commissioned three studies in 2021, and one in 2022, as part of the review of fuel quality standards.

1. Hale & Twomey, *Fuel quality standard investigations*.[81]

A desktop research report on options for reform to Australia's fuel quality standards. This work was utilised by GHD and ACIL Allen in their preparation of a CBA report.

2. Stratas Advisors, *Impacts of aromatics in gasoline on Euro 6 vehicle operability*.[82]

A desktop study on the impacts of higher aromatics levels on Euro 6d engines. This work canvassed international experience and academic literature. The report was utilised by GHD and ACIL Allen in their preparation of a CBA report.

3. GHD and ACIL Allen*, Fuel quality standards implementation: cost benefit analysis*.[83]

GHD and ACIL Allen undertook the CBA which underlies the information presented in this impact analysis.

4. Stratas Advisors, *Availability and Price Assessment of Petrol Grades Meeting Australian Specifications,* 2022, unpublished.

In late 2022 Stratas Advisors undertook a modelling exercise examining the availability and price premium of 35% aromatics, MTBE- and ethanol-free 95 RON on the international market, based on 2022 market conditions. The modelling was based on Stratas Advisors research on the availability of the requisite capability to produce alkylate and the associated price premium with including more alkylate in the finished petrol.

Discussions with key stakeholder groups

DCCEEW worked with industry in formulating the assumptions for the study. Please see section 5.3 for further information on the consultations.

Fuel demand forecasts

The fuel demand forecasts are consistent with the forecasts used for BITRE's 2021 CBA modelling on Euro 6d (this modelling has not been published), however with minor differences due to different EV sales projections.

Fuel price forecasts

Two sources of long-run crude oil price projections are available from the US Energy Information Administration and the Organisation of Economic Co-operation and Development (OECD)/International Energy Agency (IEA). The analysis has opted to use OECD/IEA's World Energy Outlook 2021 Stated Policies Scenario oil prices.[84] They project the price of oil will be US$82 per barrel of crude oil in '2020 prices' by 2040. The analysis uses an exchange rate of A$0.73/US$ to convert into Australian dollars.

The analysis assumes that the historical price differentials between different grades of petrol and the price differentials between the terminal gate prices and retail prices would remain and continue reflecting their quality differences, transport, and other costs and margins.

The analysis calculates retail fuel price components of 91 RON, 95 RON, 98 RON and diesel prices based on the projected nominal prices. All grades of petrol and diesel pay the same excise duty rates. Petrol and diesel prices moved in line with each other historically (generally following movements in the price of crude oil).

As fuel prices in Australia are largely driven by international fuel prices, fuel price increases experienced by motorists under the different options will largely reflect the estimated changes to prices of imported fuel.

Appendix C – Assumptions for noxious emissions and fuel quality standards analysis

Noxious emissions

The analysis assumed that the emissions reduction technology on vehicles purchased during most years of the evaluation period would continue to generate benefits beyond the end of the evaluation period in 2040.

Since the benefits from this technology are fairly constant over the lives of the vehicles, an approximation to residual evaluation was obtained by prorating the cost of the technology over the lives of the vehicles, then only counting costs attributed to years before 2040.

The average vehicle life (median survival time) was assumed to be 17 years. For vehicles purchased during the evaluation period, the cost of the emissions reducing technology was annualised over 17 years.

A standard discount rate of 7% was used, as required by the OIA. Sensitivity testing conducted on discount rates of 3% and 11%, as required by OIA, showed that, even with a higher discount rate of 11%, the BCR would remain well above one.

The analysis assumed an increase in the proportion of new vehicle models employing GDI technology, with GDI light vehicles possibly approaching half of new petrol vehicle sales before 2025. It also assumed that oil prices would remain relatively close to current levels over the medium term and then gradually rise over the ensuing decades. Electric vehicle uptake was also anticipated to increase as predicted in the BITRE Research Report 151 'Electric Vehicle Uptake – Modelling a Global Phenomenon'.85

Costs of introducing Euro 6 for new light vehicles in Australia were assessed based on increased capital costs associated with fitting new emissions reduction technologies. The cost estimates for these technologies were informed by industry submissions to previous consultation papers along with a range of studies.

The total estimated cost of meeting Euro 6 was likely slightly conservative as it did not include additional maintenance costs. It is anticipated that there would be some increase in the maintenance costs for light diesel vehicles, notably in relation to the exhaust after-treatment system. Over the long term, as the technology becomes more mature, maintenance costs would likely reduce.

Further, possible changes in fuel costs and greenhouse gas emissions from meeting Euro 6 were also included. The fuel economy of Euro 6-compliant light vehicles depends on the emissions abatement technology used and duty cycles, that is, how the engine is going to be used and its operating temperature profile. A sensible assumption would be that, in a competitive environment, engine/vehicle manufacturers would make every effort to minimise fuel consumption to the lowest possible levels subject to compliance with the Euro 6 standards. Based on this, and the findings of a 2017 study by ABMARC also suggests Euro 6 engines are more likely to be fitted with fuel-saving technologies, as vehicle manufacturers were concurrently required to meet more stringent fuel efficiency standards in other markets, it was anticipated fuel consumption and CO_2 emissions of new vehicles supplied to Australia would be 3% lower than under existing policy settings.[86]

The benefits of introducing Euro 6 were assessed based on avoided health costs. The first step was to estimate the tonnes of emissions saved under Euro 6 relative to business as usual. The second step was to establish a value for an average health cost ($ per tonne of emissions) from the latest available data. The final step was to calculate the total health benefits (i.e. health costs avoided) by multiplying tonnes of emissions saved by unit values for health costs. The unit values for the health costs were derived from work undertaken by independent consultants Marsden Jacob Associates for the then Department of the Environment and Energy's RIS *Better fuel for cleaner air*.

The economic benefits of avoided greenhouse gas emissions were based on the median value used in the current Australian Transport Assessment and Planning Guidelines ($60/tonne).[87] These guidelines are currently used by the Australian Government and state and territory governments to evaluate the economic costs and benefit of transport infrastructure projects.

Fuel quality

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. Table 30 outlines the key factors that determine the benefits of each option, and the values used for them. These key factors include:

- supply of raw materials:
    - additional refinery blendstock – required to improve the octane number whilst reducing the level of aromatics. This would impact on refinery operational expenditure.
    - blendstock price premium – as blendstock is a product from an overseas refinery that is imported and costs more than the same volume of crude oil.
    - change in refinery crude slate required to adjust the diesel specification.
- production of finished fuels:
    - additional refinery capital costs – capital expenditure associated with modifications to existing refinery equipment and installation of new infrastructure.
    - Government support with capital costs – through RUP Phase 2, each refinery is eligible for up to $26 million in grants towards infrastructure improvements to enable the implementation of Euro 6d standards in Australia. This is only available in the event the improved fuel standards are implemented in 2024.
    - additional refinery operating costs – operational expenditure associated with changed refinery operations, for example, purchase of additional feedstock and increased fuel consumption.
- addition of ethanol (where applicable), which has the following impacts:
    - capital expenditure on additional fuel terminals – changes such as increased storage and mixing facilities for options that require ethanol to be added to the petrol.
    - retail distribution capital expenditure – retailers will incur extra costs to supply grades of fuel containing ethanol. This requires some retailers to upgrade or modify their underground storage tanks and pipework. There will be other associated costs with site features such as tank changeover, certification and signage.
    - additional ethanol production operating costs – the price premium of ethanol over 98 RON is not known and is not included in the CBA.
- current proportion of fuel that does not already meet the changed specification for each option
- per cent impact of each option on noxious emissions, and the associated urban and rural emissions unit health costs
- human life extension benefits (avoided health and human costs) due to lower noxious emissions
- change in GHG emissions in refining and road transport, and the associated real GHG emissions price, taken to be $60/tonne CO_2 based on the median value used in the current Australian Transport Assessment and Planning Guideline).[88]

Refinery production costs

The actual reduction in aromatics required under Option 2 to meet a 35% limit (down from 45%) is likely to be minor. Data indicates the current levels of aromatics in petrol are already substantially below current limits and mostly meet the revised limit.

For Option 2, the reduction in aromatics in 95 RON would require an estimated capital investment of around $70 million across the two Australian refineries, mainly related to alkylate storage facilities. Under

Option 3 for 98 RON, refineries will need capital investment and incur operating costs to meet the proposed new standard. There will be significant supply chain capital and operating costs.

Lowering aromatics in petrol is also anticipated to add to the operating cost of producing 95 RON and 98 RON petrol. The estimated refinery capital and operational expenditure related to various options are outlined in Figure 14.

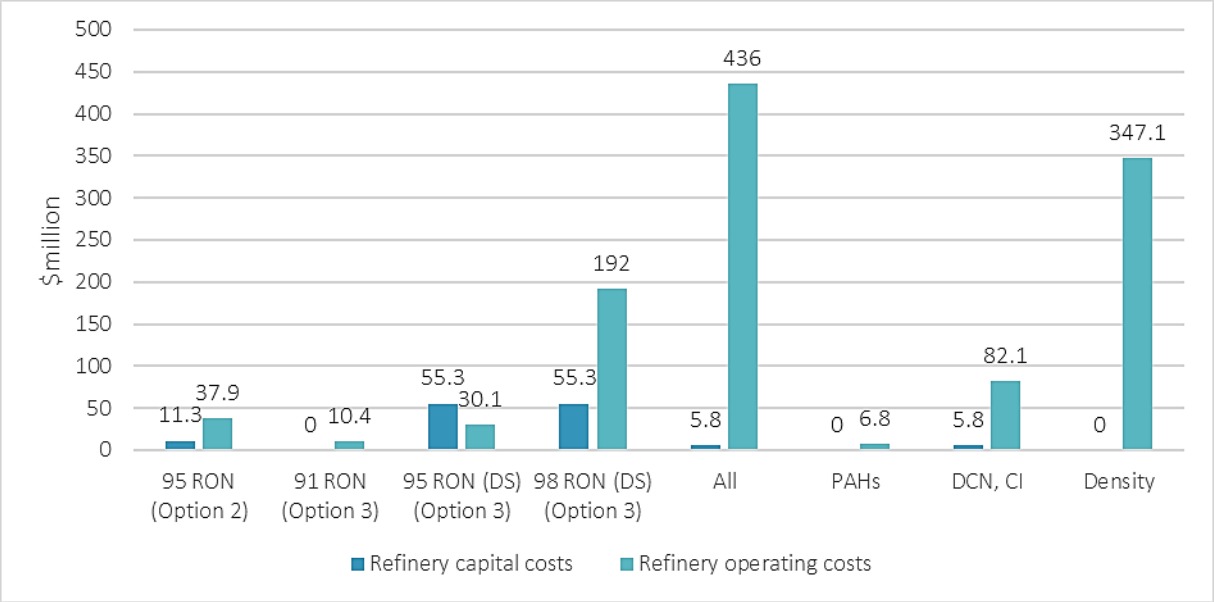

Figure 14: Estimated refinery expenditure for each option

Impact of desulfurisation on aromatics

From 15 December 2024, all petrol supplied in Australia must meet a maximum limit of 10 ppm sulfur. The desulfurisation process reduces octane in petrol. To bring petrol back up to the required octane levels, more aromatics content is needed. The CBA assumes a 2% increase in aromatics content post-desulfurisation. This assumption was then used to create estimations of post-desulfurisation aromatics content in the BaU scenario.

Complete list of assumptions for the noxious emissions and fuel quality analyses

Table 30 sets out all the assumptions for both the fuel quality and noxious emissions analyses.

*Table **30**: Key assumptions*

Item	Variables	Relevant options	Units	Value $
Costs				
Capital Costs	New/improved emissions systems for petrol vehicles	Noxious emissions Options C/D	$/vehicle	450
	New/improved emissions systems for diesel vehicles	Noxious emissions Options C/D	$/vehicle	1,000
Capital costs	Infrastructure to meet 35% max aromatics	Option 3: 91 RON	$m	0
	Infrastructure to meet 35% max aromatics	Option 2: 95 RON and Option 3: 95 RON	$m	70
	Infrastructure to meet 35% max aromatics	Option 3: 98 RON for refineries	$m	70
	Infrastructure to meet 35% max aromatics	Option 3: 98 RON supply chain terminals	$m	72

Item	Variables	Relevant options	Units	Value $
	Infrastructure to meet 35% max aromatics	Option 3: 98 RON supply chain retailers	$m	554
	Infrastructure to meet 35% max aromatics	Option 3: 98 RON total capital expenditure	$m	696
Capital costs	No infrastructure required to meet <8% PAH in diesel	Option 4: Diesel PAH	$m	0
Capital costs	Infrastructure required to meet >51 DCN in diesel	Option 4: Diesel DCN	$m	6
Capital costs	Infrastructure required to meet ≤845 kg/m^3 density in diesel	Option 4: Diesel density	$m	0
Capital costs	Three diesel parameters	Option 4: Total capital expenditure	$m	6
Refinery operating cost impact on fuel prices	Operational expenses required to meet 35% max aromatics	Option 3: 91 RON	cpl	0.08
Refinery operating cost impact on fuel prices	Operational expenses required to meet 35% max aromatics	Option 2: 95 RON and Option 3: 95 RON	cpl	1.10
Refinery operating cost impact on fuel prices	Operational expenses required to meet 35% max aromatics	Option 3: 98 RON	cpl	3.60
Refinery operating cost impact on fuel prices	Operational expenses required to meet <8% PAH in diesel	Option 4: Diesel PAH	cpl	0.019
Refinery operating cost impact on fuel prices	Operational expenses required to meet >51 DCN in diesel	Option 4: Diesel DCN	cpl	0.227
Refinery operating cost impact on fuel prices	Operational expenses required to meet ≤845 kg/m^3 density in diesel	Option 4: Diesel density	cpl	0.962
Imported fuel price impacts	Expenses required to meet 35% max aromatics	Option 3: 91 RON	cpl	0.03
Imported fuel price impacts	Expenses required to meet 35% max aromatics	Option 2: 95 RON and Option 3: 95 RON	cpl	0.90[aaa]
Imported fuel price impacts	Expenses required to meet 35% max aromatics	Option 3: 98 RON	cpl	1.30
Imported fuel price impacts	Expenses required to meet <8% PAH in diesel	Option 4: Diesel PAH	cpl	0.00
Imported fuel price impacts	Expenses required to meet >51 DCN in diesel	Option 4: Diesel DCN	cpl	0.087
Imported fuel price impacts	Expenses required to meet ≤845 kg/m^3 density in diesel	Option 4: Diesel density	cpl	0.00
Benefits				
Noxious emissions	$PM_{2.5}$ and PM_{10} reductions	Option 1: 91 RON and Option 3: 91 RON	%	0.00%
Noxious emissions	$PM_{2.5}$ and PM_{10} reductions	Option 2: 95 RON and Option 3: 95 RON	%	−1.60%
Noxious emissions	$PM_{2.5}$ and PM_{10} reductions	Option 3: 98 RON	%	−7.40%

[aaa] In 2025, increasing to 1.9 cpl by 2040.

Item	Variables	Relevant options	Units	Value $
Noxious emissions	$PM_{2.5}$ and PM_{10} reductions	Option 4: Diesel PAH	%	0.00%
Noxious emissions	$PM_{2.5}$ and PM_{10} reductions	Option 4: Diesel DCN	%	0.00%
Noxious emissions	$PM_{2.5}$ and PM_{10} reductions	Option 4: Diesel density	%	−0.50%
Avoided health costs	$PM_{2.5}$	46. All	$/t, $2021 prices	584,971
Avoided health costs	PM_{10}	47. All	$/t, $2021 prices	109,695
Avoided health costs	NOx	48. All	$/t, $2021 prices	6,256
Avoided GHG emissions	CO_2	49. All	$/t, $2021 prices	60

Glossary

91 RON	unleaded petrol which has a RON of at least 91
95 RON	premium unleaded petrol which has a RON of at least 95
98 RON	premium unleaded petrol which has a RON of at least 98
ADR	Australian Design Rules
aromatics	Aromatic hydrocarbons
BAU	business as usual
BCR	benefit-cost ratio
BITRE	Bureau of Infrastructure and Transport Research Economics
CBA	cost benefit analysis
CO	carbon monoxide
CO_2	carbon dioxide
cpl	(Australian) cents per litre
DCN	derived cetane number
DCEEW	Department of Climate Change, Energy, the Environment and Water
DITRDCA	Department of Infrastructure, Transport, Regional Development, Communications and the Arts
draft RIS	draft regulation impact statement
E10 98 RON	premium unleaded petrol which has a RON of at least 98, and which contains up to 10% ethanol
EN 228	European Committee for Standardisation (CEN) Automotive fuels – Unleaded Petrol – Requirements and Test Methods
EN 590	German Institute for Standardization (DIN) Automotive fuels – Diesel – Requirements and Test Methods
ETBE	ethyl tertiary butyl ether (an octane enhancer)
Euro 6d	Euro 6d vehicle noxious emissions standards
Euro 6d vehicles	vehicles that are capable of meeting Euro 6d noxious emissions standards
EV	electric vehicle
FCAI	Federal Chamber of Automotive Industries
GDI	gasoline direct injection (engine)
GHG	greenhouse gas
HC	hydrocarbons
IPP	import parity price
lower aromatics petrol	petrol with a maximum aromatics content of 35%

MTBE	methyl tertiary butyl ether (octane enhancer)
NMA	N-methyl aniline (octane enhancer)
NO_x	oxides of nitrogen (a noxious emission)
NPV	net present value
octane	octane rating
OIA	Office of Impact Analysis
PAH	polycyclic aromatic hydrocarbons
PM	particulate matter (a noxious emission)
$PM_{2.5}$	ultrafine particulate matter (a noxious emission)
PPF	petrol particulate filter
ppm	parts per million by weight
RON	Research Octane Number
RVP	Reid vapour pressure
RVSA	*Road Vehicle Standards Act 2018*
VOC	volatile organic compounds

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