# FCAI Response to Better fuel for cleaner air Draft regulation impact statement

Federal Chamber of Automotive Industries
Level 1, 59 Wentworth Avenue
KINGSTON ACT 2604
Phone: +61 2 6229 8217
Facsimile: +61 2 6248 7673

Contacts:
Mr James Hurnall, Technical Director
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## KEY MESSAGES

**The widespread availability of EN standard fuels is a key enabler for globally consistent vehicle emissions standards and proposed Australian $CO_2$ targets. As such, Australian fuel standards and availability must be first defined before vehicle emission standards and $CO_2$ targets can be properly contemplated.**

**Overview:**

- The FCAI welcomes the establishment of the Ministerial Forum on Vehicle Emissions as vehicle pollutant emission standards, $CO_2$ emissions and fuel quality standards are interrelated and must be considered as a single system to deliver the environmental and health benefits from reductions in light vehicle $CO_2$ emissions and vehicle pollutant emissions.
- The Australian automotive industry is committed to continuing to make a strong contribution to national efforts to reduce the impact of global climate change and improve air quality and supports the introduction of a $CO_2$ standard (relevant to the Australian market) and the introduction of the Euro 6 pollutant emission standards.
- Australia is a small market comprising only 1.5% of global production. To offer vehicles with world-class pollutant emission standards, Australia must harmonise fuel standards and pollutant emission with leading overseas markets.
- $CO_2$ standards or targets need to be considered together with fuel quality standards and pollutant emission standards as they are all interrelated. This same position is held by many governments, research organisations and the global automotive industry.
- The anticipated environmental and health benefits of adopting Euro 6 pollutant emission standards for light vehicles will not be realised until such time as petrol meeting the European standard EN228 (i.e. 95 RON, 10 ppm sulphur, 35% v/v max aromatics, etc.) and diesel meeting European standard EN590 (as well as other applicable fuel standards, e.g. biodiesel and ethanol blends) is widely available in Australia.
- Consideration of the introduction timing of Euro 6 and $CO_2$ targets for new vehicles cannot be undertaken until a detailed consideration of changes to Australian fuel quality standards has been completed. Of central concern is how the Government is planning to transition to the European fuel standards (EN228 for Petrol and EN590 for Diesel) to support the introduction of both Euro 6 and $CO_2$ targets.
- The timeframe for the required fuel to be available to the market will then determine the timeline for the introduction of regulatory $CO_2$ standards and Euro 6 and then the timeline for introduction of new vehicle models with the next stage of engine and emission systems technology. Moving ahead with new emission regulations without resolving fuel quality questions could increase the cost of new vehicles and adversely affect the operability of new emission technologies without delivering the anticipated environmental and health benefits.

**Fuel Standards:**

- Vehicles are designed and developed to meet $CO_2$ standards and pollutant emission standards with an expectation of appropriate/compatible market fuel quality. Vehicles provided to the Australian market are based on global platforms (with some climatic and other minor variations), with engine technology developed for other markets.

- The automotive industry welcomes the discussion on improving the quality of Australian market fuels.
- The FCAI strongly supports Option B: Revisions to the fuel standards to harmonise with European standards (i.e. EN228 for petrol and EN590 for diesel. Regular unleaded petrol (91 RON) would be phased out.
- Option C, harmonising with the European fuel standards, but keeping 91 RON petrol will still deliver pollutant emission reductions and allow for the introduction of Euro 6 pollutant emission standards. However, keeping 91 RON petrol in the marketplace will result in a higher light vehicle $CO_2$ standard, with a lower $CO_2$ abatement, than under Option B.
- Option F, keeping 91 RON petrol and aligning only sulphur with the European standards will result in a higher light vehicle $CO_2$ standard, with a lower $CO_2$ abatement, than would be achievable under Option B. Additionally, light vehicles will only be able to meet the initial stage of Euro 6.
- Complementary measures are required to encourage greater uptake of higher quality petrol meeting EN228 (i.e. 95 RON, 10 ppm sulphur, 35% v/v max aromatics, etc.) by consumers during a transition away from current ULP (i.e. 91 RON, 150 ppm sulphur). This will have the effect of unlocking additional environmental and health benefits from the existing light vehicle national carparc.
- It should also be noted that many governments (including the EU, USA, Japan, China and India) have recognised that the availability of the required market fuel (e.g. EN228 for petrol and EN590 for diesel) is a pre-requisite to mandating Euro 6 (or equivalent) vehicle pollution emission standard.

**Cost Benefit Analysis**

- The cost-benefit analysis undertaken only considered Euro 5 level emissions. Therefore, the analysis does not estimate the opportunity cost of not reducing vehicle emissions and improving air quality and the relative impact on health budgets.
- As part of making the final decision, the government must undertake a cost benefit analysis that takes into account the costs and benefits of the $CO_2$ standard, and level/timing of introduction of Euro 6 that can be achieved with the proposed fuel standard.

**Conclusion**

- Petrol meeting EN228 (i.e. 95 RON, 10 ppm sulphur, 35% v/v max aromatics, etc.) and diesel meeting EN590 must be available in time for implementation of both a $CO_2$ standard and Euro 6 pollutant emission standards.
- The infographic below provides an overview of the major government actions that need to be undertaken between 2017 and 2022 to provide for the start of an accelerated $CO_2$ reduction and implementation Euro 6 for new models.

- Please note this timing was based on completion of the vehicle emissions forum activities in 2017. The delay in finalizing the vehicle emissions package may require a corresponding delay in introduction of accelerated reduction in $CO_2$ and earliest date for introduction of Euro 6.

# Actions for vehicle emission standards

Current – 2022

| | Current | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|
| Fuel Standard | Discussion paper released | Finalise policy for fuel standard required for $CO_2$ and Euro 6 | Fuel Quality Standards Act and new fuel standard | | Start $CO_2$ target and complementary measures | | Fuel harmonised with EN standards widely available<br>Start accelerated $CO_2$ reduction<br>Begin Euro 6 (new models) |
| $CO_2$ Targets | Draft RIS released | Finalise $CO_2$ Targets<br>Update international standard (UN-R101) | Develop Act, administration system and complementary measures | Implement and test admin system<br>Update ADR 81 to include UN-R101 | 2 year lead time for implementation of new ADR 81 | Target monitoring | |
| Euro 6 | Draft RIS proposes to introduce Euro 6 along with WLTP and RDE | Update international standard (UN-R83) | | Update ADR 79 to include UN-R83 | 2 year lead time for implementation of new ADR 79 | | |

GLOSSARY

**Fuel Standard**
Australia needs to harmonise with European fuel standards; e.g. EN228 petrol standard which specifies 95RON, 10 ppm sulphur and other fuel parameters.

**RIS**
Regulation Impact Statement.

**Euro 6**
Pollution emission limits for light vehicles which the Australian government is considering introducing.

**ADR 81**
Australian Design Rule 81 which adopts UN-R101 and is the Australian regulatory standard to define how a vehicle is tested to measure its $CO_2$ emissions.

**ADR 79**
Australian Design Rule 79 which adopts UN-R83 and is the Australian regulatory standard which defines the pollutant emission limits for light vehicles and the test procedures to measure the pollutant emissions on a defined laboratory drive cycle.

**UN-R101**
United Nations Regulation 101 which defines how vehicles are tested to measure their $CO_2$ emissions on a defined laboratory drive cycle.

**UN-R83**
United Nations Regulation 83 which defines the pollutant emission limits for light vehicles and the test procedures to measure the pollutant emissions on a defined laboratory drive cycle.

**WLTP**
Worldwide harmonised Light Vehicle Test Procedure which is the new laboratory based drive cycle which is used to measure light vehicles $CO_2$ and pollutant emissions.

**RDE**
Real Driving Emissions test which is an European on-road test to measure light vehicles $CO_2$ and pollutant emissions.

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## 1.0 INTRODUCTION

The FCAI welcomes the opportunity to respond to the Federal Government's "Better fuel for cleaner air" draft regulation impact statement[1]. The Federal Chamber of Automotive Industries (FCAI) is the peak industry organisation representing the manufacturers and importers of passenger vehicles, light commercial vehicles and motorcycles in Australia.

The Australian automotive industry is committed to continuing to make a strong contribution to national efforts to reduce the impact of global climate change and to improve air quality.

Throughout the Ministerial Forum on Vehicle Emissions process, the FCAI has strongly supported a comprehensive approach to addressing motor vehicle emissions that includes fuel quality standards, introduction of Euro 6 along with the introduction of a realistic, achievable and market relevant $CO_2$ standard. $CO_2$ standards or targets need to be considered together with pollutant emission standards and fuel quality standards as they are all interrelated. This same position is held by many governments, research organisations and the global automotive industry.

Modern vehicles are very complex with a range of sophisticated mechanical and electrical components and electronic modules that are integrated to deliver the performance, safety and emissions expected by customers and government. To continue to deliver reduced $CO_2$ emissions and corresponding expected air quality benefits (i.e. reduction in pollutant emissions) with the introduction of advanced vehicle emission standards, market fuel of the relevant standard (i.e. consistent with the EN fuel standards) must be available. If market fuel of the necessary standard is not utilised, higher exhaust emissions (both $CO_2$ and pollutants) will be generated during a vehicle's operation with lower than expected environmental and health benefits.

The FCAI welcomes the establishment of the Ministerial Forum on Vehicle Emissions as vehicle pollutant emission standards, $CO_2$ emissions and fuel quality standards are interrelated and must be considered as a single system to deliver the environmental and health benefits from reductions in light vehicle $CO_2$ emissions and vehicle pollutant emissions.

In 2017 the FCAI responded to the three papers released by the Ministerial Forum on Vehicle Emissions in December 2016;

- Draft Regulatory Impact Statement on Vehicle Emissions Standards for Cleaner Air;
- Draft Regulatory Impact Statement on Improving the Efficiency of New Light Vehicles;
- Discussion Paper on fuel quality standards: Better Fuel for Cleaner Air.

The FCAI's position on fuel quality standards is outlined in our response to the 2016 Discussion Paper has not changed,[2] i.e. "the widespread availability of EN standard fuels is a key enabler for globally consistent vehicle emissions standards and proposed Australian $CO_2$ targets. As such, Australian fuel standards and availability must be first defined before vehicle emission standards and $CO_2$ targets can be properly contemplated."

This position is based on the engine and emission system technology anticipated to be delivered to world markets in future years to deliver reduced $CO_2$ emissions (or improved fuel consumption) and also meet the Euro 6 (or equivalent) pollutant emission levels.

[1] Australian Government, Department of the Environment and Energy, (DEE) "Better fuel for cleaner air", Draft regulation impact statement, January 2018

[2] FCAI Response to Better fuel for cleaner air Discussion Paper, 10 March 2017

## 2.0 ANALYSIS OF OPTIONS

### 2.1 Introduction

Vehicles are designed and developed to meet air pollutant emission standards and/or $CO_2$ targets with an expectation of compatible fuel quality in a particular market. While the Government has mandated Euro 5 (through ADR 79/03 and ADR 79/04), the Government has not mandated the associated European fuel quality standard (EN228[3] for Petrol and EN590[4] for Diesel).

The successful introduction of the next step in light vehicle pollutant emission standards, Euro 6, and also the introduction of a $CO_2$ standard (relevant to Australian market conditions), is dependent on Australia's adoption of European fuel quality standards EN228 (i.e. 95 RON, 10 ppm sulphur, 35% v/v max aromatics, etc) for petrol and EN590 for diesel.

If Australia does not adopt EN228 for the petrol standard and EN590 for the diesel standard, vehicles will be unable to fully comply with Euro 6 in-service requirements (see Section 4.0 and Appendix C for a summary of the Euro 6 emission standards) and will be unable to deliver the anticipated fuel efficiency improvements. It also risks the possibility of future vehicle models shifting Australia's vehicle fleet towards lower grade offerings than other advanced markets. This potentially degrades Australia's progress towards more technologically advanced and efficient vehicles.

To continue to deliver reduced $CO_2$ emissions (and a reduction in fuel consumption) and corresponding expected air quality benefits (i.e. reduction in pollutant emissions) with the introduction of advanced vehicle emission standards, market fuel of the relevant standard (i.e. consistent with the certification fuel standard) must be employed. If market fuel of the necessary standard is not utilised, higher exhausts emissions (both $CO_2$ and pollutants) will be generated during a vehicle's operation with lower than expected improvements to air quality and health outcomes.

Keeping 91 RON petrol in the marketplace will have a fuel consumption penalty as light vehicle engines will need to be able to operate on both 95 RON (the certification fuel standard) and 91 RON. This will then result in a higher light vehicle $CO_2$standard, with a lower $CO_2$ abatement, than would be achievable than if 95 RON was the base grade market fuel.

The benefits from improved fuel quality and the need for fuel standards to be compatible to the vehicle emission standards has been recognized by many countries around the world. Consequently, fuel meeting EN standards (albeit with some minor local variations) are available in many countries that have introduced $CO_2$ targets and Euro 6 level pollutant emission standards.

Improving the quality of Australian market fuel will allow for reduced $CO_2$ and pollutant emissions from the entire motor vehicle fleet, not just new motor vehicles.

### 2.2 Options Proposed

The Better fuel for cleaner air draft regulation impact statement (RIS)[5] identifies three policy options:

- Option B. Revisions to the fuel standards to harmonise with European standards. Regular unleaded petrol (91 RON) would be phased out. Changes to broaden the scope of the diesel standard.

[3] EN228 is the European gasoline (petrol) fuel quality standard and specifies a range of fuel parameters including RON and maximum sulphur levels. Throughout this response the FCAI refers to RON and sulphur as these are the main parameters that affect fuel consumption and pollution emissions (see ABMARC report in Appendix D), however, there are other fuel parameters (e.g. aromatics) that also impact indirectly on vehicle emissions and operability and need to be considered.
[4] EN 590 is the European diesel fuel quality standard and specifies a range of fuel parameters.
[5] DEE, op. cit., pp. 19-24

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

The FCAI strongly supports Option B: Revisions to the fuel standards to harmonise with European standards (i.e. EN228 for petrol and EN590 for diesel). Regular unleaded petrol (91 RON) would be phased out.

The following is an analysis of the ability of the light vehicle industry to deliver the government's objectives of reduced $CO_2$ emissions from the introduction of a $CO_2$ target and reduced pollutant emissions with the introduction of Euro 6 standards under each of the three options put forward in the draft RIS.

## 2.3 Option B

*Revisions to the fuel standards to harmonise with European standards. Regular unleaded petrol (91 RON) would be phased out. Changes to broaden the scope of the diesel standard.*

In our response to the discussion paper, the FCAI strongly supported Policy Alternative B*: Revisions to the fuel standards to align with the recommendations of the Hart Report and to harmonise with European standards.*

Our position has not changed and the FCAI continues to strongly support Option B: Revisions to the fuel standards to harmonise with European standards (i.e. EN228 for petrol and EN590 for diesel. Regular unleaded petrol (91 RON) would be phased out.

This is the only option (of the three options proposed in the draft RIS) that will allow FCAI member brands to deliver advanced market engine and emission systems to deliver the government's expected improvements in fuel consumption (i.e. $CO_2$ reduction) and full Euro 6 level (i.e. Euro 6d with RDE) emission standards.

The introduction timing of higher fuel standards is critical to the implementation timing of both a $CO_2$ standard and Euro 6. Any delay in the change to fuel quality, will also lead to a delay in the ability for the industry to meet a $CO_2$ target and implement the various levels of Euro 6.

Section 3.0 (following) provides an explanation of the need for improved fuel quality (an extract from the submission to the Better fuel for cleaner air Discussion paper). Subsequently, the FCAI provided additional information on the importance of fuel parameters (in particular octane, sulphur and aromatics) on vehicle operation and technology to the Department of Environment and Energy in May 2017 (copy included in Appendix D).

**Any reduced level (i.e. lower than the EN standards) of fuel standards will lead to increased pollutant emissions and higher $CO_2$ emissions (or fuel consumption) than would be achieved with EN standard fuels available in Australia.**

## 2.4 Option C.

*Revisions to the fuel standards to harmonise with the European standards as per Option B, with the exception that 91 RON petrol is retained but with a lower sulfur level of 10 ppm. Changes to broaden the scope of the diesel standard.*

Option C will deliver changes to the fuel quality standards to enable in-service compliance with the Euro 6 pollutant emission standards for light vehicles (e.g. 10 ppm sulphur, 35% aromatics).

However, keeping 91 RON petrol in the marketplace will have a fuel consumption penalty as light vehicle engines will need to be able to operate on both 95 RON (the certification fuel standard) and 91 RON petrol. This will then result in a higher light vehicle $CO_2$ standard, with a lower $CO_2$ abatement, than would be achievable under Option B.

The Technical Background in the World Wide Fuel Charter (WWFC) states that a minimum 95 RON petrol as the market fuel will "enable manufacturers to optimise powertrain hardware and calibrations for thermal efficiency and $CO_2$ reductions."[6] The technology changes introduced for higher octane fuel to improve fuel consumption includes higher engine compression ratio, direct injection systems and higher boost pressures for turbocharging.[7]

A study undertaken by JAMA (Japanese Automobile Manufacturers Association) in 2013 found a fuel consumption improvement of between 1 and 5% for **in-service** vehicles using 95 RON petrol (compared with using 90 RON).[8] Other international experience by FCAI member brands supports this position.

It is important to note, that this improvement is relevant to vehicles that have been designed to operate on 95 RON as well as the base grade market fuel (91 RON in the case of Australia).

Since 2004 with Euro 3 (introduced as ADR 79/00 from January 2002 for new model diesel vehicles) all light petrol engine vehicles have been certified on 95 RON 10 ppm sulphur petrol. As the average age of passenger cars is 9.8 years[9] (light commercials are slightly higher at 10.5 years), more than 50% of the existing light vehicle fleet has been certified to operate on 95 RON fuel. By 2022[10] more than 90% of petrol engine light vehicles will have been certified on 95 RON petrol and will be able to deliver a fuel consumption improvement by operating on 95 RON petrol.

Which in-service vehicles will deliver a fuel consumption benefit (and the level of fuel consumption improvement) from operating on 95 RON, compared with 91 RON, will vary by model, vehicle operation and condition.

A JAMA 2013 study (reported by ACFA) showed the fuel efficiency for **new vehicles** will improve by between 2 and 8% by upgrading to 95 RON. This will vary depending on the engine technology with up to 8% improvement for supercharged engines, and between 2 and 4% for conventional engines (due to compression ratio increase, ignition time optimisation and transmission shift optimisation).[11]

International experience of FCAI member brands has shown that utilising many of these technologies within a cost competitive environment, a fuel consumption improvement of up to 5% can be achieved by designing and optimising the vehicle to operate on 95 RON fuel. For example, if a downsized engine is used to deliver the same power output and coupled with an advanced transmission to deliver the required vehicle performance, the vehicle can also be reduced in overall mass.

## 2.5 Option F.

*Revision to the petrol standard to reduce sulfur to 10ppm, consistent with European standards. No change to other parameters.*

Option F has been proposed by the oil refining industry. While the FCAI welcomes the oil refining industry's proposal to reduce the sulfur limit to 10 ppm, consistent with European standards, this option will not introduce any change to any other fuel parameter.

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[6] World Wide Fuel Charter, 5th Edition (p. 17)
[7] Riccardo, March 2016, The Influence of Fuel Octane on Fuel Consumption (p. 9)
[8] JAMA report in Asian Clean Fuels Association Newsletter "JAMA: towards upgrading regular gasoline to 95 RON, June 2014.
[9] ABS 93090DO001_2016 Motor Vehicle Census, Australia, 31 Jan 2016
[10] The FCAI's estimated earliest date of introduction of higher fuel standards, Euro 6 and accelerated $CO_2$ rate of reduction
[11] JAMA report in Asian Clean Fuels Association Newsletter "JAMA: towards upgrading regular gasoline to 95 RON, June 2014.

Keeping 91 RON petrol in the marketplace will have a fuel consumption penalty as light vehicle engines will need to be able to operate on both 95 RON (the certification fuel standard) and 91 RON petrol. This will then result in a higher light vehicle $CO_2$ standard, with a lower $CO_2$ abatement, than would be achievable under Option B.

Aligning only sulphur with the EN standards, will result in light vehicles only being able to meet the initial stage of Euro 6, i.e. Euro 6b. Many light vehicle brands are already supplying models with gasoline direct injection (GDI) engines to Europe and/or intend to introduce GDI engines with gasoline particulate filter (GPF) to comply with Euro 6c (and subsequently Euro 6d) in Europe. A GPF is required to meet the in-service particulate matter (PM) and particulate number (PN) requirements and ODB thresholds during operation under Euro 6c (and Euro 6d).

Petrol with high (above 10 ppm) sulphur and high (above 35%) levels of aromatics generates negative impact on injector deposit and it causes an increase of PM/PN. Therefore, petrol with a maximum 10ppm sulphur and 35% v/v aromatics is required to guarantee the emission control performance of PN in real world applications and to meet the in-service test and performance requirements of Euro 6d (i.e. RDE).

Without EN 228 standard petrol (95 RON, 10 ppm sulphur, 35% aromatics) as the base grade market fuel, brands may introduce shorter service intervals and specify operation on 95 RON to compensate for higher sulphur levels. These strategies are necessary to ensure effective operation of the vehicle; however, they will increase cost of ownership.

### 2.6 Summary

The FCAI continues to strongly support Option B: Revisions to the fuel standards to harmonise with European standards (i.e. EN228 for petrol and EN590 for diesel. Regular unleaded petrol (91 RON) would be phased out.

Importantly, the introduction of improved fuel quality standards will deliver environmental and health benefits from both new vehicles (meeting Euro 6 level pollution emission standards) and a substantial proportion of the 16.8 million in-service light vehicle fleet and deliver the greatest $CO_2$ abatement.

Consideration of the introduction timing of Euro 6 and $CO_2$ targets for new vehicles cannot be undertaken until the consideration of changes to Australian fuel quality standards have been completed.

The timeframe for the required fuel to be available to the market will then determine the timeline for the introduction of regulatory $CO_2$ standards and Euro 6 and then the timeline for introduction of new vehicle models with the next stage of engine and emission systems technology. Moving ahead with new emission regulations without resolving fuel quality questions could increase the cost of new vehicles and adversely affect the operability of new emission technologies without delivering the anticipated environmental and health benefits.

## 3.0 OVERVIEW OF IMPORTANT FUEL QUALITY STANDARDS

Section 3.0 provides an overview of important fuel quality parameters that need to be harmonised with the European fuel standards to allow vehicle brands to introduce the latest engine and emission system technology.

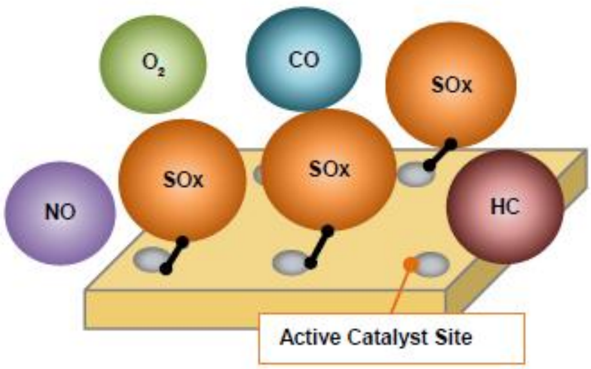
Sections 3.1, 3.2 and 3.3. are extracted from the FCAI response to the Better fuel for cleaner air discussion paper and is reproduced here for ease of reference.

Section 3.4, Aromatics and Particulate Matter (PM), outlines information recently supplied to the FCAI by the Japan Automobile Manufacturers Association (JAMA).

### 3.1: Fuel Quality Standards: New Vehicles

Individual fuel parameters cannot be considered in isolation. For example, higher octane allows the use of higher compression engines leading to greater fuel efficiency (i.e. less fuel used) and lower $CO_2$ and pollutant emissions ($NO_x$, $SO_x$, PM, CO and UHC). Similarly, lower sulphur in the fuel means less $SO_x$ is formed and captured on the catalyst (see figure 4.1 below), which in turn means less often regeneration[12] of the emission after-treatment systems (catalyst and particulate filter), which in turn leads to less fuel used.

**Figure 3.1 Impact of Pollutants on Catalyst[13]**




- The higher sulfur content of 91 RON ULP leads to higher levels of sulfur oxides ($SO_x$) in the exhaust gas.
- $SO_x$ inhibits catalytic converter performance by bonding with the catalyst sites, reducing the reactions between other pollutants.
- 91 RON ULP leads to increased CO, UHC and $NO_x$ emissions compared with 95 RON PULP due to its higher sulfur content.

The Australian transport fuel standards (especially for petrol) are lower than other markets that have introduced or intend to introduce, advanced pollutant emission standards equivalent to Euro 6, including the EU, Japan, the USA, India and China.

A report prepared for the Australian Government in 2014 by Hart Energy, *International Fuel Quality Standards and Their Implications for Australian Standards*[14], demonstrates where Australian fuel

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[12] Regeneration of emission after-treatment systems uses fuel to increase the exhaust gas temperature

[13] ABMARC, 2016, Technical Report: Engine and Emission System Technology, Spark Ignition Petrol Euro 5 & Beyond, Light Duty Vehicle, August 2016

[14] Hart Energy Research and Consulting, October2014, *International Fuel Quality Standards and Their Implications for Australian Standards, Final Report*

quality standards are behind international levels and provides a series of recommendations where Australian fuel quality specifications need to be reviewed and upgraded in line with international standards.

The first recommendation for gasoline (petrol) in the Hart Energy Report[15] is:

> *For gasoline, Hart Energy Research & Consulting suggest alignment for two parameter (sulfur and aromatics) including …. ;*
>
> - *Sulfur: Align with the EU, Japan and South Korea by reducing the limit for the current 150 ppm for all grades and 50 ppm for premium-grade gasoline (PULP) to 10 ppm for all grades to enable advanced emission controls that are being produced and driven in markets such as Australia today;*
> - *Aromatics: Align with the EU by reducing the limit from the current cap of 45 vol% (42% pool average over 6 months) to 35 vol% max to help further reduce NOx, benzene and PM emissions in Australia;*

The lack of appropriate market fuel quality restricts the introduction of some engine variants by some brands and it also inhibits the performance of the latest generation of engines (i.e. Euro 6 compliant), particularly due to higher sulphur concentration in petrol. This is highlighted by Hart Energy:[16]

> *Sulfur impacts engine life and it can lead to corrosion and wear of the engine systems. … the EU reduced sulfur content in fuels .. among the following sectors:*
>
> - *Automotive sector; vehicles' ability to conform with vehicle emission standards – e.g. NOx technologies – enables them to upgrade vehicles with new emissions capturing systems."*

Throughout 2016, many vehicle brands presented to the Vehicle Emissions Forum governmental working group providing details on the need for 10 ppm sulphur petrol for correct operation of Euro 6 level engines and emissions systems. In addition to producing higher pollutant emissions, fuel with greater than 10 ppm sulphur will cause increased wear and degradation of engine and emission systems components including:

- Higher in field emissions due to reduced catalyst efficiency
- Risk of OBD system MIL lamp illumination - vehicles needing repair
- Early (prior to regulated 160,000km life) replacement of catalytic converter.
- Gasoline particulate filter blockage requiring more frequent regeneration cycles and fuel consumption/$CO_2$ emission increases.
- Increased oil consumption.
- Piston and cylinder bore seizures.

In our response to the Vehicle Emissions Discussion Paper, the FCAI provided a range of documentation from the global automotive industry, regulators and research organisations that all demonstrate the need to consider fuel standards with vehicle pollutant emission standards, and in particular the need for ultralow (i.e. 10 ppm max) sulfur levels.[17] For completeness these references are included in Appendix B.

To attempt to determine if Euro 6 compliant vehicles would be able to operate on current Australian market fuel, the Australian Government commissioned IHS Advisory Services to undertake a study of

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[15] Hart Energy, *Ibid*; p.2
[16] Hart Energy, *Ibid*; p. 14
[17] FCAI Response to Vehicle Emissions Discussion Paper, 8 April 2016

existing published research. One of the key learnings from IHS Advisory Services' research[18], was "It is clear that "Sulfur is a catalyst poison". IHS also found that all countries that have, or plan to introduce advanced emission standards are also moving to 10 ppm sulphur. IHS also found that there is no compelling available evidence that Euro 6 level vehicles would not be able to operate for the 160,000 km regulated durability period on fuel with up to 30 ppm sulphur. However, **the emission output would be higher than the Euro 6 levels:**[19]

- *You can use 30ppm to 50ppm fuel in cars calibrated for Euro-6, but the emissions output of those vehicles will not likely meet Euro-6 levels*
- *Vehicles designed to meet Euro-6 must have gasoline of 10 ppm or less to provide the desired emissions levels required by the Euro-6 requirements.*

The interaction of $CO_2$ targets, pollutant emission standards and fuel quality standards is a complex issue. Recognising the benefit from an understanding of the operation of engine and emission system technology, in 2016, the FCAI commissioned a Melbourne based firm, ABMARC, to prepare a technical report to explain how a spark ignition petrol engine works with a focus on designs for light duty vehicles and the technologies required to meet future emission standards (contained in Appendix E).[20]

In the Executive Summary, ABMARC summarises the need for 10 ppm sulphur to meet Euro 6;

- *The Euro 6 emissions standards, currently in force in Europe, introduces limits on particulate matter, forcing the use of particulate filters for engines which use direct injection as a means of reducing $CO_2$. As a result, particulate filters are required in the exhaust after treatment system of DI engine vehicles. Although these trap around 90% of the mass of particulates produced by a petrol engine, they must be periodically regenerated to burn off the carbon based soot inside the filter and reduce the resistance to exhaust gas flow, otherwise engine power and fuel economy would suffer.*
- *TWC (three-way catalyst) pollutant conversion efficiency is degraded by incorrect air: fuel ratio, excessive temperature and deactivation by sulfur compounds. Advanced engine management systems controlling technologies such as Multi Port Fuel Injection (MPFI) and Direct Injection (DI) fuel systems combined with variable valve and ignition timing improve combustion, hence the exhaust air/fuel ratio and temperature can be maintained within satisfactory limits for optimum Three Way Catalytic Converter pollutant conversion. However, these developments in engine technology have no impact on the production of sulfur compounds within the engine. To mitigate this detrimental impact on pollutant conversion by the TWC, reduction of sulfur compounds can only be achieved by limiting the concentration of sulfur in the fuel.*
- *In Europe, the USA and Japan the emissions regulations have been aligned with fuels standards as regulators treat fuel quality and emissions standards as a system in order to maximise real world emissions reductions. From 2017, Europe, the USA and Japan will all require petrol to have a maximum sulfur content of 10 ppm. In Australia, fuel standards are not currently aligned with emissions standards.*

In summary, high sulphur petrol will lead to increased fuel consumption from the engine needing to run rich more often to increase the exhaust gas temperature to de-sulphurise the catalyst. More frequent de-sulphurisation cycles will also reduce the service life of the catalyst leading to the need for more frequent replacement. Both these events result in increased emissions and increased costs for consumers.

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[18] IHS Advisory Services, *Fuel Quality Standards and Emission Standards in Australia: Fuel Sulfur Impacts on Euro 6 Compliance*. November 2106 – Final Report, p.44

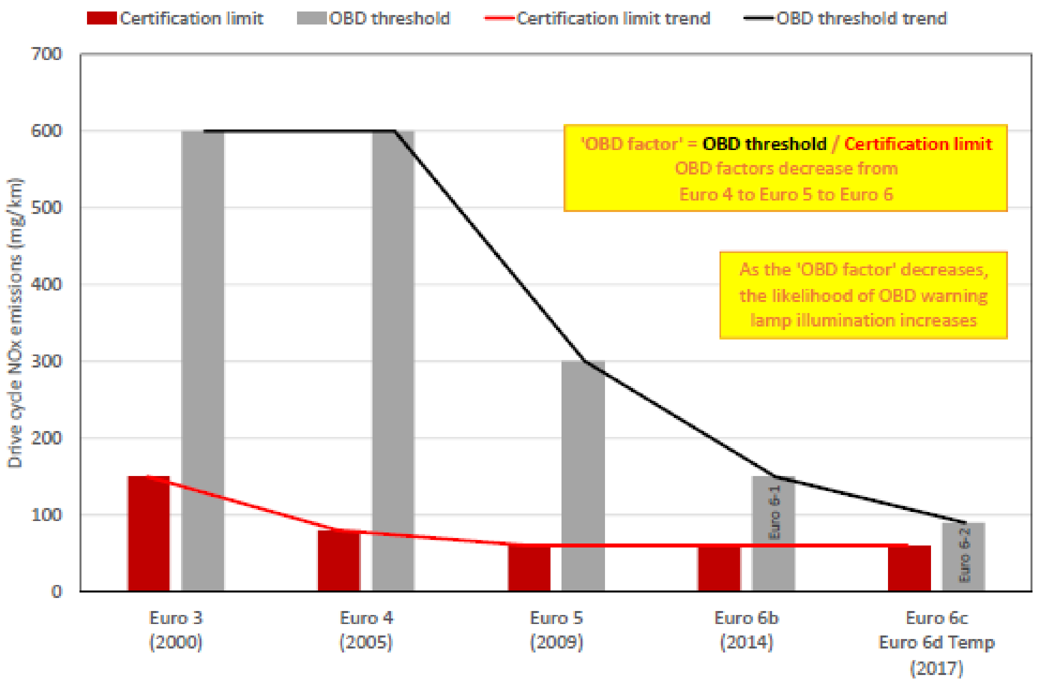
[19] IHS Advisory Services, *ibid*, p. 42

[20] ABMARC, 2016, Technical Report: Engine and Emission System Technology, Spark Ignition Petrol Euro 5 & Beyond, Light Duty Vehicle, August 2016

Euro 6 also introduces OBD threshold limits and in-use performance requirements (IUPR) which tighten from Euro 5 to Euro 6b and then again with Euro 6c and 6d. Euro 6 also includes an in-service conformity requirement of 160,000 km or 5 years. This means that vehicles need to operate to closer tolerances throughout their service life up to a period of 160,000 km or 5 years which makes the need for wide availability of the correct grade of market fuel more critical.

In addition to the impact fuel borne sulphur has on the emission of regulated pollutants for petrol engines described in the ABMARC report, sulphur also affects On-Board Diagnostic (OBD) system performance. An on-board diagnostic system that monitors in-use emissions performance is required under all modern emissions legislations, including Euro 6. Figure 4.2 shows the progressive reduction in the NOx OBD thresholds since Euro 3 and the requirement to detect in-field emissions system degradation with much lower margins at Euro 6. High sulphur fuel usage reduces the effective margin and increases the likelihood malfunction indicator lamp (MIL) illumination and vehicles needing repair, particularly at higher mileage.

**Figure 3.2 OBD threshold Limit Increases from Euro 3 to Euro 6c/d**




The FCAI remains of the view that a maximum of 10 ppm sulphur is required for successful operation of Euro 6 compliant vehicles throughout their 160,000 km regulated durability requirement.

## 3.2 Fuel Quality Standard: In-service Vehicles

In their review of the Fuel Quality Standards Act, Marsden Jacobs and Pacific Environment,[21] undertook an air quality assessment and health risk assessment. When considering improving fuel quality standards to facilitate the introduction and operation of better engine and emission control equipment Marsden Jacobs and Pacific Environment concluded (p.55):

> *With respect to the objectives of reducing emissions and improving health outcomes there has been:*

[21] Marsden Jacobs and Pacific Environment, Review of the Fuel Quality Standards Act 2000; Final Report, May 2016

- *a quantifiable reduction in the mass of (assessed) pollutants arising from the use of regulated fuel, with the exception of O3 formation, in both Melbourne and Sydney;*
- *generally an improvement in health outcomes, with some exceptions associated with exposure to O3;*
- *indirectly,a reduction in the level of greenhouse gas emissions arising from the use of regulated fuel.*

It is difficult to quantify the health benefits from current in-service vehicles operating on a higher quality fuel (e.g. 95 RON 10 ppm sulphur). However, there is substantial evidence that demonstrates there will be reduced pollutant emissions from existing vehicles through operation on higher quality fuel. The report prepared by for the Department of Environment by Hart Energy in 2014[22] acknowledged the following studies in the EU, Japan and the US:

- EU study that concluded (ultra-low) 10 ppm sulfur gasoline presents the possibility of reducing NOx emissions by 21% and non-methane hydrocarbons (NMHC) emissions by 13% compared to low (i.e. above 10 and below 50/100 ppm) sulfur fuels.
- Japanese tests showed that increasing sulfur content from 1 ppm to 50 ppm resulted in NOx emissions increase of 25 to 35 times.
- US research comparing 33 ppm sulfur and 3 ppm sulfur, the NOx was reduced by 40%. This research was also included in the response by the US Manufactures of Emission Controls Association (MECA)[23] in response to Australian Government's 2016 Vehicle Emissions Discussion Paper.

Each of these studies provided a different estimation of the reduction in pollutant emissions from the use of lower sulphur fuel. This can be due to the different test parameters such as other fuel parameters or different drive cycles as the EU, Japan and US each have a different emission standard and emission test protocol. However, all demonstrate there is a reduction in pollutant emissions from higher quality fuel.

There is also potential for improvements to the existing fleet with use of 95 RON fuel as the base grade market fuel. There are a number of vehicles already in-service with engines designed to operate on 95 RON petrol as this is the certification fuel for the current Euro 5 emission standard. The World Wide Fuel Charter estimates that use of 95 RON fuel in vehicles designed for that fuel will improve fuel consumption by up to 3%.[24]

### 3.4 Aromatics and Particulate Matter (PM)

The FCAI supports adopting the EN 228 limit on aromatics of 35% v/v as this is critical to meeting the particulate matter (PM) and particulate number (PN) limits in Euro 6 (see Appendix C for the Euro 6 limits) for gasoline direct injection (GDI) engines.

Aromatics content can increase engine combustion chamber deposits with a resulting increase in particulate matter tailpipe emissions. The WWFC summarises results of US AQIRP and the European EPEE studies[25] that showed lowering aromatic levels significantly reduces toxic benzene emissions.

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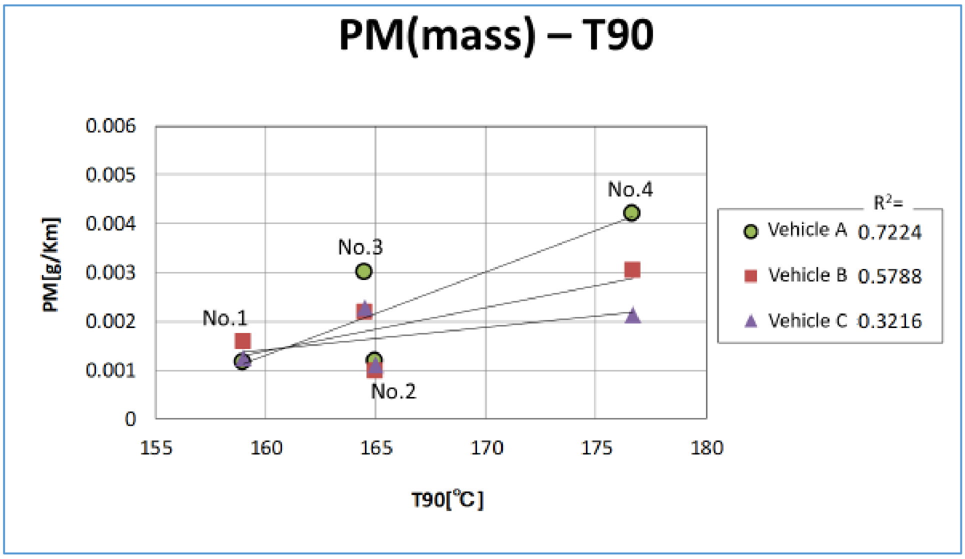
[22] Hart Energy, International Fuel Quality Standards and Their Implications for Australian Standards – Final Report, Oct 2014
[23] MECA, Written Comments on the Manufacturers of Emission Controls Association on the Australian Government's Vehicle Emissions Discussion Paper, April 2016
[24] World Wide Fuel Charter (WWFC), 5th Edition, p. 17
[25] WWFC, *Op. Cit.,* pp.28-29

The European EPEE program demonstrated a linear relationship between $CO_2$ emissions and aromatic content. The reduction of aromatics from 50 to 20% was found to decrease $CO_2$ emissions by 5%.

The JAMA recently provided information on testing of three different vehicles on four different specification 95RON petrol where each fuel had a different total and type of aromatics. A full copy of the data provided by JAMA and an explanation of the graphs is provided in Appendix F.

The JAMA test data shows that the total and type of aromatics drive the PM and PN emissions from gasoline (petrol) engines. Figure 3.3 (below) clearly shows each of the three test vehicles had an increase in PM emissions for fuels with higher levels of aromatics.

**Figure 3.3 JAMA Test – PM emissions**



## 4.0 FUEL QUALITY STANDARDS FOR EURO 6

The successful implementation of the Euro 6[26] level vehicle pollutant emission standards, is dependent on suitable fuel quality standards:

- Petrol: matching the European standard, EN228, that includes 95 RON, 10 ppm sulphur as well as other parameters.[27] 95 RON petrol is currently available in the market, as Premium Unleaded Petrol (PULP). The Australian standard currently allows up to 50 ppm sulphur and also allows higher aromatics and olefins than EN228.
- Diesel: matching the European standard, EN 590. 10 ppm sulphur diesel is the current diesel standard and all diesel market fuel (both locally refined and imported) must meet this standard.

The full anticipated environmental benefits of encouraging the purchase and supply of petrol engine vehicles that meet Euro 6 will not be realised until such time as petrol meeting the European standard, EN228 (i.e. 95 RON, 10 ppm sulphur, 35% v/v max aromatics, etc.) is widely available in the Australian market.

There are three different Euro 6 emission levels with increasingly stringent emission standards.

The following tables (Table 4.1 and 4.2) summarise the fuel parameters that need to be changed from the current Australian fuel standards for the correct operation of a vehicle emissions system to meet the increasingly stringent Euro 6 emission levels.

**Table 4.1: Petrol**

| Emission Level[1] | Change from previous emission (Euro) level | Fuel parameter(s) that need to be changed from current Aust fuel standard to EN 228 |
|---|---|---|
| **UN R83/07**<br>**(Euro 6b)** | PN introduced (for DI engines[9])<br>Large reduction in OBD[4] thresholds for NOx, NMHC & PM<br>IUPR[5] introduced | Reduced sulphur required for correct emissions systems function (e.g. meet OBD thresholds). |
| **UN R83/07**<br>**(Euro 6c)** | Large reduction in PN (for DI engines[9])<br>Further reductions in OBD[4] thresholds for; NOx & PM | 10 ppm sulphur required for correct emissions systems function<br>35% aromatics (max) required to meet PN limit |
| **Euro 6d:**<br>**not yet in UN R83** | WLTP[6] (more stringent lab test) introduced<br>RDE[7] (on-road test) introduced | WLTP[6] test fuel is 95 RON 10 ppm sulphur<br>Need EN 228 petrol (including 95 RON, 10 ppm sulphur and 35% aromatics) for RDE compliance |

[26] Australian Government, *Vehicle emission standards for cleaner air*, Draft Regulation Impact Statement, Ministerial Forum on Vehicle Emissions, December 2016

[27] Note: the certification fuel standard for Euro 6 (UN R83/07) includes 95 RON, 10 ppm sulphur and max aromatics of 35% v/v for E5 and 32% for E10.

**Table 4.2: Diesel**

| Emission Level[1] | Change from previous emission (Euro) level | Fuel parameter(s) that need to be changed from current Aust fuel standard to EN 590 |
|---|---|---|
| **UN R83/07**<br>**(Euro 6b)** | NOx limit reduced<br>Large reduction in THC + NOx limit<br>Large reduction in OBD[4] thresholds for CO, NMHV, NOx & PM<br>IUPR introduced | Max 8% PAH required to meet particulate number and for correct emission systems function. |
| **UN R83/07**<br>**(Euro 6c)** | Further reductions in OBD thresholds for NOx & PM<br>IUPR increased | Max 8% PAH required to meet particulate number and for correct emission systems function. |
| **Euro 6d:**<br>**not yet in UN R83** | WLTP[6] (more stringent lab test) introduced<br>RDE[7] (on-road test) introduced | Max 8% PAH required to meet particulate number and for correct emission systems function to meet both new WLTP an RDE tests. |

Notes to Tables 2.1 and 2.2:

1. Emission level as per UN R83/07 (and European Commission Regulation (EU) 2016/247 of 10 March 2016)
   a. UN R83/07 currently only covers Euro 6b and 6c.
   b. There is a 3-year delay between introduction of Euro 6b to the introduction of Euro 6c.
   c. Work is underway to include WLTP and RDE into UN R83 (to introduce Euro 6d).
      i. This is scheduled to be completed in 2019 and is likely to be a new series of UN R83, i.e. R83/08.
      ii. Following the usual 3-year introduction timing, the earliest date for R83/08 (i.e. Euro 6d) would then be 2022/23 for new approvals and 2025/26 all approvals.

2. Emissions regulated under UN R83 are:
   a. Petrol engines:
      i. THC (total mass of hydrocarbons), NMHC (non-methane hydrocarbons), NOx (oxides of nitrogen), CO (carbon monoxide) and PM (particulate matter) all measured in mg/km.
      ii. PN (particulate number) measured in Nb/km.
   b. Diesel engines:
      i. NOx (oxides of nitrogen), HC+NOx (total mass of hydrocarbons and nitrogen oxides), CO (carbon monoxide) and PM (particulate matter) all measured in mg/km.
      ii. PN (particulate number) measured in Nb/km.

3. The regulation laboratory tests (currently NEDC) has the following tests:
   a. Type I Test (exhaust emissions including particulates): on chassis dynamometer at 20-30$^{o}$C.
   b. Type II Test (idle CO): measure CO on chassis dynamometer at idle.
   c. Type III Test (Crankcase emissions): Measure on chassis dynamometer at idle and steady speeds.
   d. Type IV Test (Evaporative emissions): Measure fumes from fuel tank in sealed room.
   e. Type VI Test (160,000 km durability): Run 160,000 km and then measure emissions. Durability affected by level of sulphur in fuel.

4. OBD (On-Board Diagnostics): diagnoses when the emissions control system in on longer operating effectively.

5. IUPR (In-Use Performance Ratio monitoring): how often a specific monitor is operating relative to vehicle operation.

6. WLTP (worldwide light vehicle test procedure): a laboratory test procedure to replace the current (in UN R83 and ADR 79/04) NEDC test cycle.
   a. WLTP is up to 20% more stringent than the NEDC cycle.
   b. Work is underway at WP.29 to introduce WLTP into UN R83. The first stages are to be completed in mid to late 2019.

7. RDE (real driving emissions): a European on-road test to regulate light vehicle pollutant emissions (NOX and PN).
   a. RDE not yet in included in UN R83; under consideration at WP29.
   b. Amendments will be required to meet road rules in countries that are signatories to the 1958 Agreement.
   c. Ability to meet RDE pollutant emission standards impacted by level of sulphur in market fuel.
   d. RDE designed to be conducted with market fuel.

8. RDE Conformance Factors (CF);
   a. Temporary CF: introduced into the EU as part of Euro 6d-temp from 1 Sep 2017 for new approvals and 1 Sep 2019 for all registrations (for M and N1<1305 kg reference mass):
      i. NOx limit x 2.1 (incl. measurement tolerance).
      ii. PN limit x 1.5 (1.0 + 0.5 measurement tolerance).
   b. Final CF: planned to be introduced into the EU as part of Euro 6d from 2020 for new approvals and 2021 for all registrations (for M and N1<1305 kg reference mass):
      i. NOx and PN limit x 1.5 (1.0 + 0.5 measurement tolerance). Measurement tolerance of 0.5 subject to regular reviews and possible adjustment.

9. DI: Direct Injection engine; where fuel-air mixture is directly injected into combustion chamber.
   a. Improved fuel consumption and consequently DI engines are used to meet $CO_2$ targets.
   b. However, DI engines increases particulate formation compared to other types of fueling systems (e.g. multi-point fuel injection).

## 5.0 COST BENEFIT ANALYSIS

The Ministerial Forum on Vehicle Emissions is considering the introduction of both a $CO_2$ standard and Euro 6 pollutant emission standards for light vehicles. Therefore, the cost benefit analysis needs to consider the implications of achieving these objectives with changes to the fuel quality standard.

The cost-benefit analysis undertaken in the fuel standards draft RIS considers no change to the two other policy aspects being considered, i.e. introduction of a $CO_2$ standard and introduction of Euro 6 pollutant emission standards. Therefore, the analysis does not estimate the opportunity cost of not reducing vehicle emissions and improving air quality and the relative impact on health budgets. Also, the cost-benefit analysis is not based on the three options achieving equivalent outcomes.

As part of making the final decision, the government should undertake a cost benefit analysis that takes into account the costs and benefits of the $CO_2$ standard, and level/timing of introduction of Euro 6 that can be achieved with the proposed fuel standard.

The Australian petroleum industry already benchmarks the price of Australian 91 RON petrol against the Singaporean market price of 95 RON. It stands to reason that continuing to use this benchmark could provide refineries with a level of compensation for any extra costs associated with phasing out 91 RON. Alternatively, if it is judged that there is a significant amount of processing needed to bring a 95 RON fuel up to a new Australian standard (e.g. aligning with EN 228 with 10 ppm sulphur and 35% aromatics), the Singaporean market 97 RON price could be considered as the benchmark.

### 5.1 Option B

The cost benefit analysis needs to consider Option B as part of introduction for Euro 6 and a $CO_2$ standard rather than only analysing the current situation, i.e. Euro 5 level pollutant emission standards and no $CO_2$ standard.

In addition to ensuring the correct in-service operation of Euro 6 level engine and emission system technology, Option B will deliver benefits to existing fleet. As outlined in our response to the Fuel Standards Discussion Paper, (and replicated in Section 3.0 above) introducing fuel standards that are harmonised with the European Standards (i.e. Option B) will deliver substantial benefits to the in-service fleet in terms of both improved fuel consumption and reduced pollutant emissions.[28] The benefits include:

- Reduction in NOx and NMHC emissions.
- Reduction in particulate matter.
- Reduced CO2 emissions.
- Improved fuel consumption.

### 5.2 Option C

Option C will deliver changes to the fuel quality standards (e.g. 10 ppm sulphur, 35% aromatics) that will enable in-service compliance with the Euro 6 pollutant emission standards for light vehicles. Therefore, the cost benefit analysis needs to include that Option C fuel standards will still deliver pollutant emission reductions for both the in-service fleet and for new vehicles with the introduction of Euro 6 pollutant emission standards (i.e. reduction in NOx, NMHC and particulate matter emissions).

However, keeping 91 RON petrol in the marketplace will have a fuel consumption penalty as light vehicle engines will need to be able to operate on both 95 RON (the certification fuel standard) and

[28] FCAI Response to Better fuel for cleaner air Discussion paper. 10 March 2017, p.22

91 RON. This will then result in a higher light vehicle $CO_2$ standard, with a lower $CO_2$ abatement, than would be achievable under Option B. The analysis needs to recognise that keeping 91 RON (ULP) as the base grade market fuel will result in higher fuel consumption, of between 3-5% for the in-service fleet and up to 8% for new vehicles (depending on engine technology) than under Option B (see Section 3.0).

This option also needs to consider that PULP (95 RON) already retails with a significantly higher margin included in its retail price than ULP (91 RON) petrol. An ACCC[29] study noted that RON 95 fuel prices in Australia already wholesales for an average of 4.5 cents per litre on top of the import parity price, while the costs and margins components of the retail price of 95 RON petrol is 16 per cent, compared with 11 per cent for 91 RON. This suggests that 95 RON fuel is already sold at a margin of 5 per cent in excess of 91 RON.

### 5.3 Option F

Option F has been proposed by the Australian Institute of Petroleum (AIP) in their response to the Better fuel for cleaner air Discussion paper.[30]

Option F, keeping 91 RON and aligning only sulphur with the EN standards will then result in a higher light vehicle $CO_2$ standard, with a lower $CO_2$ abatement, than would be achievable under Option B. Additionally, light vehicles will only be able to meet the initial stage of Euro 6, i.e. Euro 6b.

Additional costs to be considered under Option F include:

- Loss of health benefits from not delivering Euro 6 level pollutant emission standards for new vehicles.
- Loss of health benefit from the in-service fleet being able to benefit from improved fuel quality standards.
- Increased fuel consumption (compared to in-service fleet operating on 95 RON under Option B) and consequent lower $CO_2$ abatement.
- Cost to the economy to retain a domestic refining capability.

[29] ACCC, 2013. *Monitoring of the Australian Petroleum Industry*.
[30] AIP, 2017, AIP Submission to Department of Environment and Energy.

# 6.0 OTHER FUEL PARAMETERS

The FCAI supports changing fuel standards and parameters to harmonise with the European standards.

The FCAI supports the recommendations from the Hart Energy 2014 review of the Australian fuel standards;

- Align both sulphur and aromatic limits with EN228.
- Insert a footnote to the phosphorous limit to align with EN228.
- Introduce a sliver corrosion limit.

Following are the FCAI positions on the various parameters for each of the fuel standards:

- Table 6.1 – Petrol
- Table 6.2 – Ethanol
- Table 6.3 - Diesel
- Table 6.4 – Autogas (LPG)
- Table 6.5 – Biodiesel
- Table 6.6 – Ethanol E85
- Table 6.7 – B20 Biodiesel

**Table 6.1: FCAI Position on fuel parameters – Petrol**

| Petrol parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report[a] and/or EU[b]) | Option C (Revisions as for Option B, except 91 RON petrol is retained) | Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027) | EU petrol standard (EN 228:2012) | Test method | FCAI Position |
|---|---|---|---|---|---|---|---|
| Aromatics | 45% v/v<br>42% v/v pool average over 6 months | 35.0% v/v [b] | 35.0% v/v [b] | 45% v/v<br>42% v/v pool average over 6 months | 35.0% v/v | Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D1319) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85 | The FCAI supports reducing the maximum limit on aromatics to be reduced to 35% to align with the EN228 standard.<br>Adopting the EN228 limit on Aromatics (35% v/v max) is critical to meet Euro 6c and Euro 6d Particulate Number (PN) limits for gasoline direct injection (GDI) engines.<br>Aromatic content can increase engine combustion chamber deposits which can increase tailpipe emissions.<br>The WWFC summarises results of US AQIRP and the European EPEE studies[31] that showed lowering aromatic levels significantly reduces toxic benzene emissions.<br>The European EPEE program demonstrated a linear relationship between $CO_2$ emissions and aromatic content. The reduction of aromatics from 50 to 20% was found to decrease $CO_2$ emissions by 5%.<br>Aromatics are good octane components and are high-energy density molecules. Therefore, with a reduction in the aromatic limit to 35%, other options to increase octane need to be considered. |
| Benzene | 1% v/v | 1.00% v/v [b] | 1.00% v/v [b] | 1% v/v | 1.00% v/v | Industry views are sought on ASTM D6839 as a | No objection to proposed change to test method. |

[31] WWFC, *Op. Cit.*, pp.28-29

| Petrol parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report[a] and/or EU[b]) | Option C (Revisions as for Option B, except 91 RON petrol is retained) | Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027) | EU petrol standard (EN 228:2012) | Test method | FCAI Position |
|---|---|---|---|---|---|---|---|
| | | | | | | replacement to the current method (ASTM D5580) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85 | |
| Copper corrosion | Class 1 (3 h at 50°C) | Class 1 (3 h at 50°C) [b] | Class 1 (3 h at 50°C) [b] | Class 1 (3 h at 50°C) | Class 1 (3 h at 50°C) | ASTM D130 | Support current standard |
| Diisopropyl ether (DIPE) | 1% v/v | 1% v/v [a] | 1% v/v [a] | 1% v/v | ASTM D4815 | | EN228 controls with maximum oxygen content.<br>Recommend harmonise with EN 228 to provide flexibility for providing octane. |
| Distillation—maximum final boiling point | 210°C | 210°C [b] | 210°C [b] | 210°C | 210°C | Replace 'Not specified' with ASTM D86 | Recommend align with EN228 that specifies EN ISO 3405 as the test method. No objection to including ASTM D86 as alternative test method. |
| Ethanol | 10% v/v | 10.0% v/v [b] | 10.0% v/v [b] | 10% v/v | 10.0% v/v | ASTM D5501 | Support harmonisation with EN 228. Extensive test program required to consider > 10%. |
| Existent gum (washed) | 50 mg/L | 5 mg/100 mL [b] | 5 mg/100 mL [b] | 50 mg/L | 5 mg/100 mL | ASTM D381 | Support harmonisation with EN 228 with max 5mg/100 mL (max).<br>No objection to change in reporting units.<br>Need to maintain current limit as high levels of existent gum can foul injectors and fuel lines. |

| Petrol parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report[a] and/or EU[b]) | Option C (Revisions as for Option B, except 91 RON petrol is retained) | Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027) | EU petrol standard (EN 228:2012) | Test method | FCAI Position |
|---|---|---|---|---|---|---|---|
| Induction period (oxidation stability) | 360 minutes | 360 minutes [b] | 360 minutes [b] | 360 minutes | 360 minutes | ASTM D525 | Support current standard. |
| Lead | 0.005 g/L | 5 mg/L [b] | 5 mg/L [b] | 0.005 g/L | 0.005 g/L | ASTM D3237 | Support current standard; harmonised with EN 228.<br>No objection to change in reporting units. |
| Motor octane number (MON) | 91 RON petrol: 81.0 | 91 RON petrol is discontinued [b] | 91 RON petrol: 81.0 | 91 RON petrol: 81.0 | 85.0 c | ASTM D2700 | Support current standard only if 91 RON petrol is maintained. |
| | 95 RON petrol: 85.0 | 95 RON petrol (with or without ethanol d): 85.0 [b] | 95 RON petrol (with or without ethanol d): 85.0 [b] | 95 RON petrol: 85.0 | | | Support current standard |
| | 98 RON petrol | 98 RON petrol (with or without ethanol d): 85.0[f] | 98 RON petrol (with or without ethanol d): 85.0[f] | | | | Support current standard |
| Methyl tertiary butyl ether (MTBE) | 1% v/v | 1% v/v [a] | 1% v/v [a] | 1% v/v | 22.0% v/v total ethers | ASTM D4815 | EN228 controls MTBE and other ethers with maximum oxygen content. Recommend harmonise with EN 228 to provide flexibility for providing octane. |
| Olefins | 18% v/v | 18.0% v/v [b] | 18.0% v/v [b] | 18% v/v | 18.0% v/v | Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D1319) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) | Support current standard; harmonised with EN 228.<br>No objection to proposed change to test method. |

| Petrol parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report[a] and/or EU[b]) | Option C (Revisions as for Option B, except 91 RON petrol is retained) | Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027) | EU petrol standard (EN 228:2012) | Test method | FCAI Position |
|---|---|---|---|---|---|---|---|
| | | | | | | can also be used for a number of methods in petrol and E85 | |
| Oxygen—for petrol without ethanol | 2.7% m/m | 2.7% m/m [b] | 2.7% m/m [b] | 2.7% m/m | 2.7% m/m | ASTM D4815 | Support current standard; harmonised with EN 228 to allow up to 2.7% with up to 5% ethanol. |
| Oxygen—for petrol with ethanol | 3.9% m/m | 3.9% m/m [a] | 3.9% m/m [a] | 3.9% m/m | 3.7% m/m | ASTM D4815 | Support current standard; harmonised with EN 228 to allow up to 3.7% with up to 10% ethanol. |
| Phosphorus | 0.0013 g/L | 1.3 mg/L Add 'Compounds containing phosphorus shall not be added' [b] | 1.3 mg/L Add 'Compounds containing phosphorus shall not be added' [b] | 0.0013 g/L | Compounds containing phosphorus shall not be added | ASTM D3231 | Support current standard of max 1.3 mg/L and support adding "compounds containing phosphorous shall not be added" to harmonise with EN 228. |
| Research octane number (RON) | 91 RON petrol: 91.0 | 91 RON petrol is discontinued [b] | 91 RON petrol: 91.0 [a] | 91 RON petrol: 91.0 | 95.0 | ASTM D2699 | Support phase out of 91 RON petrol in appropriate timeframe as part of harmonisation with EN 228 |
| | 95 RON petrol: 95.0 | 95 RON petrol (with or without ethanol e): 95.0 [b] | 95 RON petrol (with or without ethanol e): 95.0 [b] | 95 RON petrol: 95.0 | | | Support current standard; harmonised with EN 228 |
| | | 98 RON petrol (with or without ethanol e): 98.0 [f] | 98 RON petrol (with or without ethanol e): 98.0 [f] | | | | Support introduction of a 98 RON petrol standard |
| Sulfur | 91 RON petrol: 150 mg/kg | 91 RON petrol is discontinued [b] | 91 RON petrol: 10.0 mg/kg [a] | 91 RON petrol: On commencement 150 mg/kg | | 10.0 mg/kg | Support phase out of 91 RON petrol in appropriate timeframe as part of harmonisation with EN 228. |

| Petrol parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report[a] and/or EU[b]) | Option C (Revisions as for Option B, except 91 RON petrol is retained) | Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027) | EU petrol standard (EN 228:2012) | Test method | FCAI Position |
|---|---|---|---|---|---|---|---|
| | | | | | | | If 91 RON petrol is retained sulphur parameter limit must be 10.0 mg/kg to support introduction of vehicle technology to meet Euro 6 emission standards in-service. |
| | 95 RON petrol: 50 mg/kg | 95 RON petrol: 10.0 mg/kg [b] | 95 RON petrol: 10.0 mg/kg [b] | 95 RON petrol: On commencement 50 mg/kg from 1 July 2027 10.0 mg/kg | | | Sulphur limit must be 10.0 mg/kg to support introduction of vehicle technology to meet Euro 6 emission standards in-service. |
| | | 98 RON petrol: 10.0 mg/kg [f] | 98 RON petrol: 10.0 mg/kg [f] | | | | Sulphur limit must be 10.0 mg/kg to support introduction of vehicle technology to meet Euro 6 emission standards in-service. |
| Tertiary butyl alcohol (TBA) | 0.5% v/v | 0.5% v/v a | 0.5% v/v a | 0.5% v/v | | ASTM D4815 | Support harmonising with EN 228 which allows up to 15% v/v TBA with Oxygen limit not ot exceed 2.7%. EN228 controls with maximum oxygen content. |

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

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

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

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

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

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

**Table 6.2: FCAI Position on fuel parameters - Ethanol**

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

| Ethanol parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report a and/or EU [b]) | Option C (Options B and C are identical except for 91 RON petrol) | Option F (Aligns with Option A, except for reduction of sulfur to 10.0 mg/kg for all grades of petrol in 2027) | EU ethanol standard (EN 15376:2014) | Test method | FCAI Position |
|---|---|---|---|---|---|---|---|
| Sulfate | 4 mg/kg | 3.0 mg/kg [b] | 3.0 mg/kg [b] | 4 mg/kg | 3.0 mg/kg | Replace ASTM D4806 Annex 1 with D7328 | Support current standards |
| Sulfur | 30 mg/kg | 10.0 mg/kg [b] | 10.0 mg/kg [b] | 30 mg/kg | 10.0 mg/kg | ASTM D5453 | Support harmonisation with EN 15376. Sulphur parameter limit must be 10.0 mg/kg to support introduction of vehicle technology to meet Euro 6 emission standards in-service. |
| Water | 1.0% v/v | 0.300% v/v [b] | 0.300% v/v [b] | 1.0% v/v | 0.300% m/m | ASTM E203 | Support harmonisation with EN 15376. |

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

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

c No change proposed

d This value matches the current ethanol E85 inorganic chloride limit

**Table 6.3: FCAI Position on fuel parameters - Diesel**

| Diesel parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report and/or EU [b]) | Option C (Options B and C are identical except for 91 RON petrol) | EU diesel standard (EN 590:2013) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Ash | 0.01% m/m | 0.010% m/m [b] | 0.010% m/m [b] | 0.010% m/m | ASTM D482 | Support current standards; harmonised with EN 590 |
| Biodiesel (FAME) content | 5.0% v/v | 5.0% v/v [a] | 5.0% v/v [a] | 7.0% v/v | EN 14078 | Support current standards. Australian biodiesel standard needs to be aligned with EN standard to support limit of 7%. |
| Carbon residue | 0.2 mass % (10% distillation residue) | 0.15 mass % [a] | 0.15 mass % [a] | 0.30% m/m | ASTM D4530 | Support harmonisation with EN 590 to support Euro 6 for light duty vehicle diesel vehicles. Carbon residue increases tailpipe emissions and deposits. |
| Cetane index | 46 | 46.0 [b] | 46.0 [b] | 46.0 | ASTM D4737 Procedure A | Support harmonisation with EN 590 to support Euro 6 for light duty vehicle diesel vehicles. Higher cetane index provides for improved efficiency and reduced emissions, particularly particulates. |
| Colour | 2 | 2 [a] | 2 [a] | | ASTM D1500 | Support current standards; |
| Conductivity at ambient temperature for all diesel held by a terminal or refinery for sale or distribution | 50 pS/m at ambient temperature | 50 pS/m at ambient temperature [a] | 50 pS/m at ambient temperature [a] | | ASTM D2624 | Support current standards; |
| Copper corrosion | Class 1 (3 h at 50°C) | Class 1 (3 h at 50°C) [b] | Class 1 (3 h at 50°C) | ASTM D130 | | Support current standards; harmonised with EN 590 |
| Density | 820–850 kg/m3 | 820.0–845.0 kg/m3 at 15°C [b] | 820.0–845.0 kg/m3 at 15°C [b] | 820.0–845.0 kg/m3 at 15°C | ASTM D1298 | Support harmonisation with EN 590. Density needs to be controlled for light duty vehicles engine and fuel system controls to deliver improved efficiency and reduced emissions, particularly |

| **Diesel parameter** | **Option A** (Business as usual) | **Option B** (Revisions to align with Hart Report and/or EU [b]) | **Option C** (Options B and C are identical except for 91 RON petrol) | **EU diesel standard (EN 590:2013)** | **Test method** | **FCAI Position** |
|---|---|---|---|---|---|---|
| | | | | | | particulates. |
| Derived cetane number | 51 (containing biodiesel) | 51.0 [b] | 51.0 [b] | 51.0 | ASTM D6890 | Support harmonisation with EN 590 to support Euro 6 for light duty vehicle diesel vehicles.<br>Higher cetane provides for improved efficiency and reduced emissions, particularly particulates |
| Distillation—T95 | 360°C | 360°C [b] | 360°C [b] | 360°C | ASTM D86 | Support current standards; harmonised with EN 590 |
| Flash point | 61.5°C | 61.5°C [a] | 61.5°C [a] | 55.0°C | ASTM D93 | Support harmonizing with EN 590.<br>No objection to maintaining current standard of 61.5°C for safety reasons. |
| Filter blocking tendency | 2.0 | 2.0 [a] | 2.0 [a] | | IP 387 | Support current standards; harmonised with EN 590 |
| Kinematic viscosity at 40°C | 2.0–4.5 cSt | 2.000–4.500 mm2/s [b] | 2.000–4.500 mm2/s [b] | 2.000–4.500 mm2/s | ASTM D445 | Support current standards; harmonised with EN 590.<br>Support changing measurement units to align with EN 590. |
| Lubricity | 0.460 mm | 460 µm [b] | 460 µm [b] | 0.460 mm | IP 450 | Support current standards; harmonised with EN 590 |
| Oxidation stability | 25 mg/L | 2.5 mg/100 mL [b] | 2.5 mg/100 mL [b] | 25 g/m3 | ASTM D2274 | Support current standards; harmonised with EN 590.<br>Support changing measurement units to align with EN 590. |
| Polycyclic aromatic hydrocarbons (PAH) | 11% m/m | 8.0% m/m [b] | 8.0% m/m [b] | 8.0% m/m | IP 391 | Support reducing PAH limit to 8.9% to harmonisation with EN 590 to support introduction of Euro 6 light duty diesel vehicles.<br>Reducing PAH will reduce tailpipe emissions and particulate emissions to in-service Euro 5 diesel light duty vehicles. |

| Diesel parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report and/or EU [b]) | Option C (Options B and C are identical except for 91 RON petrol) | EU diesel standard (EN 590:2013) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Sulfur | 10 mg/kg | 10.0 mg/kg [b] | 10.0 mg/kg [b] | 10.0 mg/kg | ASTM D5453 | Support current standards; harmonised with EN 590. |
| Water and sediment | 0.05 vol% | 0.05% v/v [a] | 0.05% v/v [a] | | ASTM D2709 | Support current standards; harmonised with EN 590. |
| Water—for diesel containing biodiesel | 200 mg/kg | 200 mg/kg [b] | 200 mg/kg [b] | 200 mg/kg | ASTM D6304 | Support current standards; harmonised with EN 590. |

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

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

## Table 6.4: FCAI Position on fuel parameters – Autogas (LPG)

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

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

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

## Table 6.5: FCAI Position on fuel parameters - Biodiesel

| Biodiesel parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report a and/or EU [b]) | Option C (Options B and C are identical except for 91 RON petrol) | EU biodiesel standard (EN 14214:2012) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Acid value | 0.80 mg KOH/g | 0.50 mg KOH/g [a, b] | 0.50 mg KOH/g [a, b] | 0.50 mg KOH/g | | Support harmonisation with EN 14214.<br>Fuel injectors and other metal fuel components can be affected by high acid levels. |
| Carbon residue–10% distillation residue | 0.30% m/m | 0.30% m/m a | 0.30% m/m a | | ASTM D4530 | Support current standards; |
| Copper strip corrosion | Class 1 3 h at 50°C | Class 1 3 h at 50°C [b] | Class 1 3 h at 50°C [b] | Class 1 3 h at 50°C | EN ISO 2160<br>ASTM D130 | Support current standards; harmonised with EN 14214 |
| Density at 15°C | 860–890 kg/m$^3$ | 860–890 kg/m3 [a] | 860–890 kg/m$^3$ [a] | 860–900 kg/m3 | ASTM D1298 | Support current standards; harmonised with EN 14214 |
| Derived cetane number | 51.0 | 51.0 [b] | 51.0 [b] | 51.0 | ASTM D613<br>ASTM D6890 | Support current standards; harmonised with EN 14214.<br>Higher cetane provides for improved efficiency and reduced emissions, particularly particulates. |
| Distillation—T90 | 360°C | 360°C [a] | 360°C [a] | | ASTM D1160 | Support current standards; |
| Ester content | 96.5% m/m | 96.5% m/m [b] | 96.5% m/m [b] | 96.5% m/m | EN 14103 | Support current standards; harmonised with EN 14214 |
| Flash point | 120.0°C | 120.0°C a | 120.0°C a | 101°C | ASTM D93 | Support harmonisation with EN 14214<br>No objection to maintaining current standard of 120.0°C for safety reasons |
| Free glycerol | 0.020% mass | 0.020% m/m [a] | 0.020% m/m [a] | 0.02% m/m | ASTM D6584 | Support current standards; harmonised with EN 14214 |
| Kinematic viscosity | 3.5–5.0 mm$^2$/s | 3.50–5.00 mm2/s [b] | 3.50–5.00 mm$^2$/s [b] | 3.50–5.00 mm2/s | ASTM D445 | Support current standards; harmonised with EN 14214 |

| Biodiesel parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report a and/or EU b) | Option C (Options B and C are identical except for 91 RON petrol) | EU biodiesel standard (EN 14214:2012) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Metals–Group I (Na, K) | 5 mg/kg | 5.0 mg/kg [b] | 5.0 mg/kg [b] | 5.0 mg/kg | EN 14538 | Support current standards; harmonised with EN 14214 |
| Metals–Group II (Ca, Mg) | 5 mg/kg | 5.0 mg/kg [b] | 5.0 mg/kg [b] | 5.0 mg/kg | EN 14538 | Support current standards; harmonised with EN 14214 |
| Methanol | 0.20% m/m | 0.20% m/m [b] | 0.20% m/m [b] | 0.20% m/m | EN 14110 | Support current standards; harmonised with EN 14214 |
| Oxidation stability at 110°C | 6 h | 8.0 h [b] | 8.0 h [b] | 8.0 h | EN 15751<br>EN 14112 | Support harmonisation with EN 14214 |
| Phosphorus | 10 mg/kg | 4.0 mg/kg [b] | 4.0 mg/kg [b] | 4.0 mg/kg | EN 14107 | Support harmonisation with EN 14214 |
| Sulfated ash | 0.020% mass | 0.020% m/m [a] | 0.020% m/m [a] | 0.02% m/m | ASTM D874 | Support current standards; harmonised with EN 14214 |
| Sulfur | 10 mg/kg | 10.0 mg/kg [b] | 10.0 mg/kg [b] | 10.0 mg/kg | ASTM D5453 | Support current standards; harmonised with EN 14214 |
| Total contamination | 24 mg/kg | 24 mg/kg [b] | 24 mg/kg [b] | 24 mg/kg | EN 12662:2014 | Support current standards; harmonised with EN 14214 |
| Total glycerol | 0.250% mass | 0.250% m/m [a] | 0.250% m/m [a] | 0.25% m/m | ASTM D6584 | Support current standards; harmonised with EN 14214 |
| Water and sediment | 0.050% vol | 0.050% v/v [a] | 0.050% v/v [a] | | ASTM D2709 | Support current standards |

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

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

**Table 6.6: FCAI Position on fuel parameters – Ethanol E85**

| **Ethanol E85 parameter** | **Option A** (Business as usual) | **Option B** (Revisions to align with Hart Report a and/or EU b) | **Option C** (Options B and C are identical except for 91 RON petrol) | **EU ethanol E85 standard (CEN/TS 15293:2011)** | **Test method** | **FCAI Position** |
|---|---|---|---|---|---|---|
| Acidity (as acetic acid) | 0.006% m/m | 0.005% m/m [b] | 0.005% m/m [b] | 0.005% m/m | ASTM D1613 | Support harmonisation with EN 15293 |
| Benzene | 0.35% v/v | 0.35% v/v [a] | 0.35% v/v [a] | | Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D5580) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85 | Support current standards |
| Copper | 0.10 mg/kg | 0.10 mg/kg [b] | 0.10 mg/kg [b] | 0.10 mg/kg | EN 15837 (as modified in CEN/TS 15293) | Support current standards; harmonised with EN 15293 |
| Ethanol | 70–85% v/v | 70–85% v/v [a] | 70–85% v/v [a] | 70–85% v/v (summer) 50–85% v/v (winter) | Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D5501) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85 | Support current standards; harmonised with EN 15293 |
| Ethers (5 or more C atoms) | 1.0% v/v | 1.0% v/v [a] | 1.0% v/v [a] | 11% v/v | Industry views are sought on ASTM D6839 as a replacement to the current method (ASTM D4815) as it has greater precision, brings cost savings over time and the reformulyzer (approx. cost $250,000) can also be used for a number of methods in petrol and E85 | Support control of ethers by max oxygen content as per EN standard |
| Distillation—final boiling point | 210°C | 210°C [a] | 210°C [a] | | ASTM D86 | Support current standards |

| Ethanol E85 parameter | Option A (Business as usual) | Option B (Revisions to align with Hart Report a and/or EU [b]) | Option C (Options B and C are identical except for 91 RON petrol) | EU ethanol E85 standard (CEN/TS 15293:2011) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Higher alcohols (C3–C8) | 2.0% v/v | 2.0% v/v [a] | 2.0% v/v [a] | 6.0% v/v | ASTM D4815 (note 1) | Support current standards; |
| Inorganic chloride | 1 mg/kg | 1 mg/kg [a] | 1 mg/kg [a] | 1.2 mg/kg | ASTM D7328 | Support current standards; |
| Lead content | 5 mg/L | 5 mg/L [a] | 5 mg/L [a] | | ASTM D3237 | Support current standards; |
| Methanol | 0.5% v/v | 0.5% v/v [a] | 0.5% v/v [a] | 1.0% v/v | ASTM D5501 | Support current standards; |
| Motor octane number (MON) | 87 | 88.0 [b] | 88.0 [b] | 88.0 | | Support harmonisation with EN 15293 |
| Oxidation stability | 360 minutes | 360 minutes [b] | 360 minutes [b] | 360 minutes | ASTM D525 | Support current standards; harmonised with EN 15293 |
| pHe | 6.5–9.0 | 6.5–9.0 [a] | 6.5–9.0 [a] | | ASTM D6423 | Support current standards; |
| Phosphorus | 1.3 mg/L | 0.15 mg/L [b] | 0.15 mg/L [b] | 0.15 mg/L | ASTM D3231 | Support current standards; harmonised with EN 15293 |
| Research octane number (RON) | 100 | 104 [b] | 104 [b] | 104 | | Support harmonisation with EN 15293 |
| Solvent washed gum | 5 mg/100 mL | 5 mg/100 mL [b] | 5 mg/100 mL [b] | 5 mg/100 mL | ASTM D381 | Support current standards; harmonised with EN 15293 |
| Sulfate | 4.0 mg/kg | 4.0 mg/kg [b] | 4.0 mg/kg [b] | 4.0 mg/kg | ASTM D7319 | Support current standards; harmonised with EN 15293 |
| Sulfur | 70 mg/kg | 10.0 mg/kg [b] | 10.0 mg/kg [b] | 10.0 mg/kg | ASTM D5453 | Support harmonisation with EN 15293. Sulphur limit must be 10.0 mg/kg to support introduction of vehicle technology to meet Euro 6 emission standards in-service. |
| Vapour pressure (DVPE) | 38–65 kPa at 37.8°C | 38–65 kPa at 37.8°C [a] | 38–65 kPa at 37.8°C [a] | 35.0–60.0 kPa (summer) | ASTM D5191 | Support current standards; harmonised with EN 15293 |

| Ethanol E85 parameter | **Option A** (Business as usual) | **Option B** (Revisions to align with Hart Report a and/or EU [b]) | **Option C** (Options B and C are identical except for 91 RON petrol) | EU ethanol E85 standard (CEN/TS 15293:2011) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Water | 1.0% m/m | 0.0400% m/m [b] | 0.0400% m/m [b] | 0.0400% m/m | ASTM E1064 | Support harmonisation with EN 15293 |

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

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

## Table 6.7: FCAI Position on fuel parameters – B20 biodiesel

| B20 diesel biodiesel blend parameter | Option A (Business as usual—no standard) | Option B (Revisions to align with B20 discussion paper a and/or EU[b]) | Option C (Options B and C are identical except for 91 RON petrol) | EU B20 diesel biodiesel blend standard (EN 16709:2015) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Acid value | | 0.3 mg KOH/g [a] | 0.3 mg KOH/g [a] | | ASTM D664 | Support proposed Acid limit of 0.3 mg KOH/g.<br>Fuel injectors and other metal fuel components can be affected by high acid levels. |
| Ash | | 0.010% m/m [b] | 0.010% m/m [b] | 0.010% m/m | ASTM D482 | Support harmonise with EN 16709. |
| Biodiesel content | | 5.1% v/v–20.0% v/v [c] | 5.1% v/v–20.0% v/v [c] | 14.0% v/v–20.0% v/v | EN 14078 | Support proposed limit of 5.1% v/v–20.0% v/v. |
| Carbon residue 10% distillation residue | | 0.30% m/m [a] | 0.30% m/m [a] | | ASTM D4530 | Support proposed limit of 0.30% m/m. |
| Copper strip corrosion (3 h at 50°C) | | Class 1 [a] | Class 1 [a] | | ASTM D130 | Support proposed limit to align with diesel standard EN 590 and biodiesel standard EN 14214. |
| Density at 15°C | | 820.0 kg/m3–860.0 kg/$m^3$ [b] | 820.0 kg/m3–860.0 kg/$m^3$ [b] | 820.0 kg/m3–860.0 kg/$m^3$ | ASTM D4052 | Support proposed density limits to harmonise with EN 16709. |
| Derived cetane number | | 51.0 [b] | 51.0 [b] | 51.0 | ASTM D6890 | Support proposed DCN to harmonise with EN 16709.<br>Will also harmonise with diesel standard EN 590 and biodiesel standard EN 14214. |
| Distillation—T90 | | 360°C [b] | 360°C [b] | 360°C | ASTM D1160 | Support proposed Distillation-T90 limit to harmonise with EN 16709. |
| Flash point | | 61.5°C [a] | 61.5°C [a] | Above 55.0% | ASTM D93 | Support harmonizing with EN 16709.<br>No objection to higher (diesel) standard of 61.5°C for safety reasons. |

| B20 diesel biodiesel blend parameter | Option A (Business as usual—no standard) | Option B (Revisions to align with B20 discussion paper a and/or EU[b]) | Option C (Options B and C are identical except for 91 RON petrol) | EU B20 diesel biodiesel blend standard (EN 16709:2015) | Test method | FCAI Position |
|---|---|---|---|---|---|---|
| Kinematic viscosity at 40°C | | 2.000–4.620 mm2/s [b] | 2.000–4.620 mm2/s [b] | 2.000–4.620 $mm^2/s$ | ASTM D445 | Support harmonizing with EN 16709. |
| Lubricity | | 460 µm [a] | 460 µm [a] | | IP 450 | No objection to proposed limit of 460 µm to harmonise with diesel EN 590 limit. |
| Oxidation stability | | 20.0 h [b] | 20.0 h [b] | 20.0 h | EN 15751 | Support harmonizing with EN 16709. |
| Polycyclic aromatic hydrocarbons (PAH) | | 8.0% m/m [b] | 8.0% m/m [b] | 8.0% m/m | EN 12916:2016 | Support harmonizing with EN 16709. |
| Sulfur | | 10.0 mg/kg [b] | 10.0 mg/kg [b] | 10.0 mg/kg | ASTM D5453 | Sulphur limit must be 10.0 mg/kg to support introduction of vehicle technology to meet Euro 6 emission standards in-service. |
| Water | | 200 mg/kg [c] | 200 mg/kg [c] | 260 mg/kg | ASTM D6304 | Support harmonizing with EN 16709.<br>No objection to proposed lower limit of 200 mg/kg. |
| Water and sediment | | 0.05% v/v [a] | 0.05% v/v [a] | | ASTM D2709 | No objection to proposed limit of 0.05% v/v. |

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

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

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

## 7.0 CONCLUSION

The Australian automotive industry is committed to making a strong contribution to national efforts to reduce the impact of global climate change and improve air quality.

Throughout the Ministerial Forum on Vehicle Emissions, the FCAI has strongly supported a comprehensive approach to addressing motor vehicle emissions that includes fuel quality standards, introduction of Euro 6 along with the introduction of a realistic, achievable and market-relevant $CO_2$ standard. $CO_2$ standards or targets need to be considered together with pollutant emission standards and fuel quality standards as they are all interrelated. This same position is held by many governments, research organisations and the global automotive industry.

To achieve the Government's policy objective to reduce greenhouse gas and pollutant emissions from road transport an integrated approach that includes a combination of measures such as the increasing use of alternative fuels, improved fuel quality, better infrastructure and traffic management, adopting an eco-driving style using price signals and reducing the average age of the in-service fleet is required.

The FCAI strongly supports ***Option B: Revisions to the fuel standards to harmonise with European standards. Regular unleaded petrol (91 RON) would be phased out. Changes to broaden the scope of the diesel standard.***

Introduction of improved fuel quality standards will deliver environmental and health benefits from both new light vehicles and substantial parts of the 16.8 million in-service light vehicle fleet.

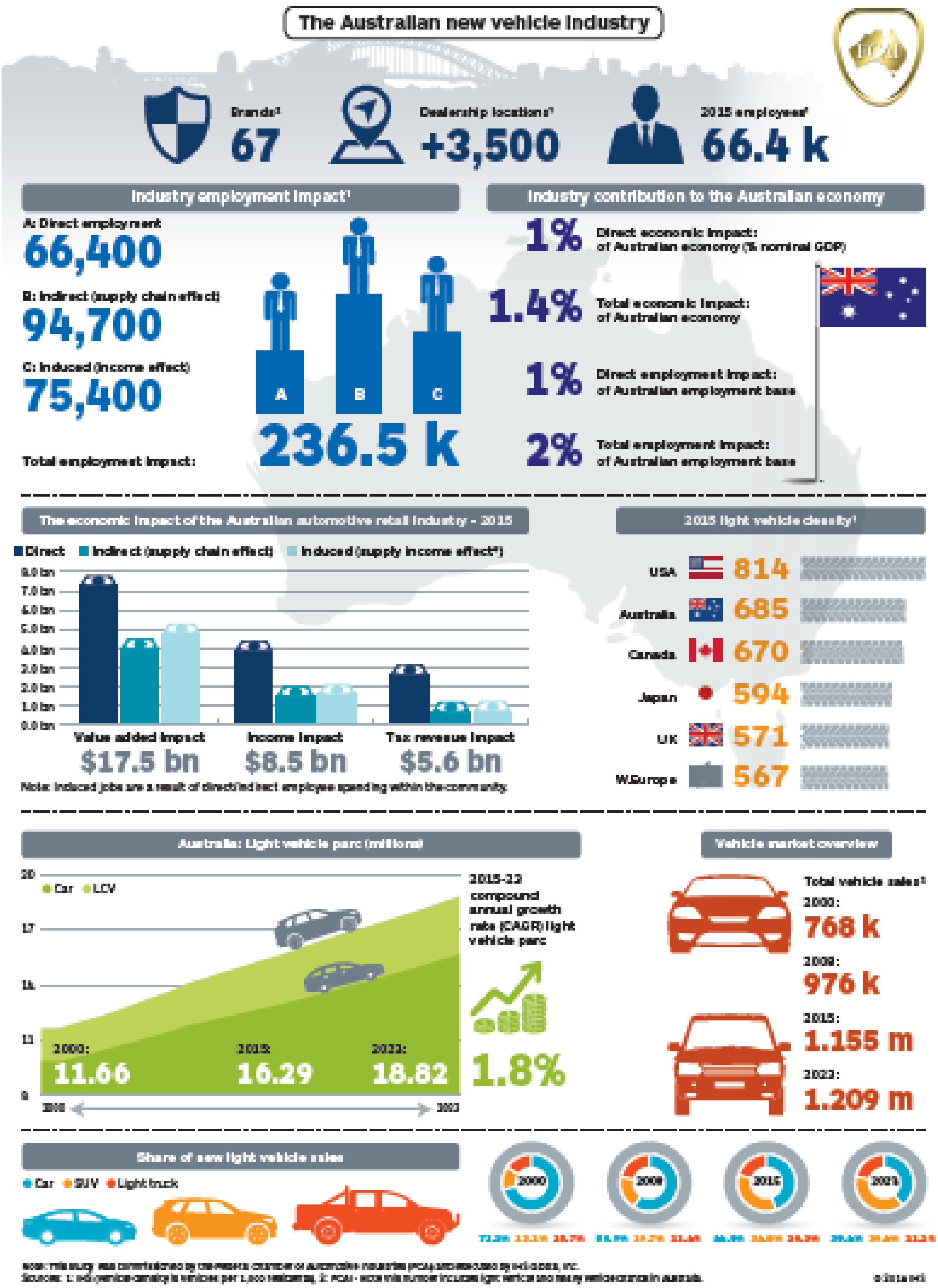
The timeframe for the required fuel to be available to the market will then determine the timeline for the introduction of regulatory $CO_2$ standards and Euro 6 and then the timeline for introduction of new vehicle models with the next stage of engine and emission systems technology. Moving ahead with new emission regulations without resolving fuel quality questions could increase the cost of new vehicles and adversely affect the operability of new emission technologies without delivering the anticipated environmental and health benefits.

If the Government chooses Option C or Option F, it will need to consider the implications for a $CO_2$ standard and the introduction of Euro 6 pollutant emission standards. For example, keeping 91 RON petrol (as proposed in both Option C and Option F) will result in a higher light vehicle $CO_2$ standard, with a lower $CO_2$ abatement, than would be achievable under Option B. Additionally, if Option F (retaining 91 RON petrol and aligning only sulphur with the EN standards) is selected, light vehicles will only be able to meet the initial stage of Euro 6, i.e. Euro 6b.

To deliver the Government's policy objectives, and deliver the environmental and health benefits, from introducing both a light vehicle $CO_2$ standard and Euro 6 emissions standards, EN standard (e.g. 95 RON, 10 ppm sulphur, 35% aromatics petrol) fuel must be widely available in the Australian market. Otherwise, the expected health and environmental benefits will not be delivered in-service.

As part of its final decision-making process, the government should undertake a cost benefit analysis that takes into account the costs and benefits of the $CO_2$ standard, and level/timing of introduction of Euro 6 that can be achieved with the selected fuel standard.

# APPENDIX A THE AUSTRALIAN AUTOMOTIVE INDUSTRY



## APPENDIX B SUMMARY OF FUEL STANARDS REFERENCES

The FCAI's longstanding position that fuel quality standards, $CO_2$ standards and pollutant emission standards all need to be considered together, as they are all interrelated, is not a unique one. It is shared by the global automotive industry, regulators and research organisations alike.

Following is a list of references and quotes from leading international regulators, the automotive industry, research organisations and the Australian Government that demonstrate this position is widely recognised throughout the world.

### *C.1 US EPA*

The US EPA stated in their Tier 3 Motor Vehicle Emission and Fuel Standards:[32]

> *"This program includes new standards for both vehicle emissions and the sulfur content of gasoline, considering the vehicle and its fuel as an integrated system."*

and

> *"The systems approach enables emission reductions that are both technologically feasible and cost-effective beyond what would be possible looking at vehicle and fuel standards in isolation."*

and

> *"EPA is not the first regulatory agency to recognize the need for lower-sulfur gasoline. Agencies in Europe and Japan have already imposed gasoline sulfur caps of 10 ppm, and the State of California is already averaging 10 ppm sulfur with a per gallon cap of 20 ppm."*

The US EPA Tier 3 Gasoline Sulfur program sets an in-service gasoline standard of 10ppm sulphur from 1 January 2017:[33]

> *"The final Tier 3 Gasoline Sulfur program is part of a systems approach to addressing the impacts of motor vehicles on air quality and public health, by considering the vehicle and its fuel as an integrated system. The program sets new vehicle emissions standards to reduce both tailpipe and evaporative emissions, and lowers the sulfur content of gasoline to a 10 ppm average sulfur level."*

### *C.2 European Commission*

The European Commission (EC) also recognises fuel quality standards are linked to both pollutant and $CO_2$ standards. On their website page, "Road transport: Reducing $CO_2$ emission from vehicles[34]" the EC state:

> *"Fuel quality is an important element in reducing greenhouse gas emissions from transport."*

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[32] US Federal Register Vol. 79 No. 81, 28 April 2014, Part II Environmental Protection Agency 40 CFR Parts 79, 80, 85, et al. Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards: Final Rule

[33] United States Environmental Protection Agency, Gasoline, www.epa.gov/otaq/fuels/gasolinefuels/index.htm [accessed 7 July 2015]

[34] European Commission (EC), Climate Action, Road transport: Reducing $CO_2$ emissions from vehicles, http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm [accessed 21 November 2014]

*C.3 International Council on Clean Transportation*

The non-profit research organisation, the International Council on Clean Transportation (ICCT), also recognises the importance of fuel quality standards.

In their inaugural *State of Clean Transport Policy*[35] report, released in 2014, the ICCT states:

> *"A key requirement to world-class vehicle standards, and thus cleaner vehicles, is the availability of ultralow-sulfur fuels."* (Page 4)

and

> *"Fuel quality, most notably the sulfur content of gasoline and diesel, is key to the implementation of advances emission controls. For optimal function of emission controls, … Euro 6/VI-equivalent vehicles require fuel as low as 10 ppm sulphur."* (Page 18)

*C.4 World Wide Fuel Charter*

The global auto industry position is based on the World Wide Fuel Charter[36] (WWFC) which is an extensive and comprehensive compilation of research and testing of engine, fuel and control systems by a wide group of expert contributors. The objective of the WWFC is to promote global harmonisation of fuel to:

- Reduce the impact of motor vehicles on the environment by enabling reduced vehicle fleet emissions;
- Facilitate the delivery of optimised fuels for each emission control category, which will minimize vehicle equipment complexities and help reduce customer costs (purchase and operation); and,
- Increase customer satisfaction by maintaining vehicle performance for a longer period of time.

The WWFC contains both minimum specifications of necessary fuel quality parameters and a summary of the impact of the various fuel parameters on vehicle operation. In the "Technical Background" section there is an excellent overview of the research conducted on the effects of octane and sulphur, in gasoline. The WWFC includes the following statements on octane:[37]

> *"Vehicles are designed and calibrated for a certain octane rating."*
>
> *"Engines equipped with knock sensors can handle lower octane ratings by retarding the spark timing, but this will increase fuel consumption, impair drivability and reduce power; and knock may still occur."*
>
> *"Increasing the minimum octane rating available in the marketplace has the potential to help vehicles significantly improve fuel economy and, consequently, reduce vehicle $CO_2$ emissions. While the improvement will vary by powertrain design, load factor and calibration strategy, among other factors, vehicles currently designed for 91 RON gasoline could improve their efficiency by up to three percent if manufacturers could design them for 95 RON instead."*

In relation to Sulphur, the WWFC[38] states:

> *"Sulphur has a significant impact on vehicle emissions by reducing the efficiency of catalysts."*

[35] Miller, Joshua D., Facanha, Cristiano, The International Council on Clean Transportation (ICCT), the State of Clean Transport Policy: A 2014 synthesis of vehicle and fuel policy development, 2014.
[36] ACEA, Auto Alliance, EMA and JAMA, World Wide Fuel Charter, September 2013, 5th Edition, www.acea.be [accessed 9 October 2010]
[37] WWFC 5th Edition, p.17
[38] WWFC, 5th edition, pp.17-19

*"Sulphur also adversely affect heated exhaust gas oxygen sensors"*

*"Reductions in Sulphur will provide immediate reductions of emission from all catalyst-equipped vehicles on the road."*

*"Sulphur removal requires prolonged rich operating conditions…"*

Relevant to the consideration of a gasoline octane rating and level of sulphur for Australia, the WWFC outlines the required parameters for various fuel categories. The ones of specific relevance to Australia are (Page 1):

**Category 4:**

Markets with advanced requirements for emission control, for example, markets requiring US Tier 2, US Tier 3 (pending), US 2007 / 2010 Heavy Duty On-Highway, US Non-Road Tier 4, California LEV II, EURO 4/IV, EURO 5/V, EURO 6/VI, JP 2009 or equivalent emission standards. Category 4 fuels enable sophisticated NOx and particulate matter after-treatment technologies.

**Category 5:**

Markets with highly advanced requirements for emission control and fuel efficiency, for example, those markets that require US 2017 light duty fuel economy, US heavy duty fuel economy, California LEV III or equivalent emission

The maximum sulphur level for both Category 4 and Category 5 gasoline is 10 ppm and Category 5 gasoline specifies a minimum of 95 RON (refer pages 6 and 7).

Cetane is a measure of the compression ignition of a diesel fuel and as such is a significant fuel quality parameter in diesel. In the Technical Background (page 41), the WWFC outlines:

*"Higher cetane generally enables improved control of ignition delay and combustion stability, especially with modern diesels which use high amounts of exhaust gas recirculation (EGR)."*

and

*"Cetane influence on NOx is very significant … particularly at low speeds where reductions of up to 9% are achieved"*

and

*"The cetane increase also reduced HC emissions by 30-40%."*

The WWFC specifies a minimum Cetane Index of 55.0 for both Category 4 and Category 5 diesel.

### *C.5 Department of Environment*

The Department of Environment is currently reviewing the Fuel Quality Standards Act 2000. As part of the review two reports were released:

- A report prepared by Orbital Australia in 2013, "Review of Sulphur Limits in Petrol." [39]
- A 2014 report by Hart Energy, International Fuel Quality Standards and Their Implications for Australian Standards.[40]

[39] Orbital Australia Pty Ltd, 2013, Review of Sulphur Limits in Petrol, Produced for Fuel Policy Section, Department of Sustainability, Environment, Water, Population and Communities, 10 Jun 2013.

[40] Hart Energy Research and Consulting, October2014, International Fuel Quality Standards and Their Implications for Australian Standards, Final Report

Orbital Australia reviewed existing standards and research on the impacts of sulphur levels in petrol and similar conclusions to the WWFC extracts above;

- Fuel standards work in partnership with vehicle emission standards to reduce emissions.
- Exhaust emissions will be higher with existing Australia market fuels (150 ppm or 50 ppm sulphur) than if low sulphur (10 ppm) petrol is introduced.
- Reducing sulphur levels (to 10 ppm) would allow use of some specific technologies and also reduce fuel consumption through the reduction of frequency of catalyst regeneration.

The Orbital report also acknowledges the potential for degraded performance, operability and durability of some vehicle technologies due to low quality market fuel.

The 2014 Hart Energy report, *International Fuel Quality Standards and Their Implications for Australian Standards*, demonstrates where Australian fuel quality standards are behind international levels and provides a series of recommendations where Australian fuel quality specifications need to be reviewed and upgraded in line with international standards. In the Section 1.2 Key Findings, Hart stated:

> *"In Hart Energy Research and Consulting's view, there are a number of specifications in Australian gasoline, diesel and E85 that may require changes."*

Hart then recommended that for sulphur in gasoline (petrol):

> *"Align with the EU, Japan and South Korea by reducing the limit from the current 150 ppm for all grades and 50 ppm for premium-grade (PULP) to 10 ppm max for all grades to enable advanced emission controls on the vehicles that are being produced and driven in markets such as Australia today."*

(Note: in their 2015/16 rulemaking process to introduce Euro 6 vehicle pollutant emission standards, the Indian Government has recognised that availability of 10 ppm sulphur petrol is necessary.[41]

### *C.6 Climate Change Authority*

The FCAI considers that the analysis undertaken by the Climate Change Authority when developing its cost/benefit analysis of mandatory $CO_2$ targets[42] did not address the implications of in-service fuel and subsequent in-field vehicle performance. In particular, the Climate Change Authority paper uses certification results to develop its benefit analysis. The certification fuel is 95 RON 10 ppm sulphur petrol.

If the equivalent fuel is not available in the market, it cannot be guaranteed that the same result will be delivered in service, especially if a vehicle owner is likely to use ULP which, in Australia, is currently regulated to be 91 RON 150 ppm (max) sulphur. Therefore, the FCAI questions whether the full benefit as calculated will be delivered and considers that this cost/benefit analysis cannot form the basis for any rigorous regulatory analysis without additional testing to confirm in-service operation on market fuel will deliver the same result. Otherwise, to deliver the estimated benefits, the market fuel would have to be consistent with the certification fuel (i.e. 10 ppm sulphur, 95RON) to fully deliver a continued reduction in $CO_2$ emissions.

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[41] Shakun & Company (Services) Private Limited, Copy of Notification, Motor Vehicles Act, G.S.R 18(E), (published in the Gazette of India on 22nd Febuary 2016).

[42] Australian Government Climate Change Authority (CCA), Light Vehicle Emission Standards for Australia: Research Report, June 2014

*C.7 Australian Institute of Petroleum*

In their 2013 publication, *Downstream Petroleum 2013*,[43] the Australian Institute of Petroleum acknowledged the benefits of cleaner fuels in reducing vehicle pollutant emissions (p.12):

> *"Government regulated fuel quality standards facilitate the introduction of advanced engine technologies. Benefits include improved urban quality (through reduced smog and particulates from motor vehicles), reduced greenhouse gas emissions, and improved fuel efficiency."*

*C.8 FCAI Position*

The FCAI has been consistent in its call for concomitant market fuel since 2010 in the FCAI's submission to the 2010 Regulatory Impact Statement (RIS) considering the introduction of Euro 5/6 emission standards. The Australian Design Rules for mandating Euro 5 vehicle emission standards (ADR 79/03 and ADR 79/04) specifies 95 RON 10 ppm sulphur petrol as the test fuel.

If the Government wants to introduce light vehicle $CO_2$ standards as the next step in light vehicle pollutant emissions standards (i.e. Euro 6), compatible market fuel must be available, otherwise the benefits estimated using the results of the regulation certification laboratory testing will not be delivered on the road.

While 95 RON is available as Premium Unleaded Petrol (PULP) the Australian fuel quality standard allows up to 50 ppm sulphur in premium (95 or 98 RON). For correct operation of vehicles with advanced pollution emission equipment (i.e. meeting Euro 6b and Euro 6c) PULP with a maximum 10 ppm sulphur is required in the market.

The diesel fuel quality standard has specified a maximum of 10 ppm sulphur since 2009. Diesel fuel refined in Australia meets this standard.

[43] Australian Institute of Petroleum (AIP), Downstream Petroleum 2013, www.aip.com.au [downloaded 25 March 2016]

# APPENDIX C EURO 6 SUMMARY

**Summary of Euro 6 for Petrol Engine Light Vehicles in both EU and UN Regulation (ver 3)**

**Table 1: Euro 6 as introduced into the EU[i,ii]**

| Euro 6 Level[iii] | | 6b | 6c | 6d Temp | 6d[iv] |
|---|---|---|---|---|---|
| Date of introduction | New approvals | 1 Sep 14 | | 1 Sep 17 | 1 Jan 20 |
| | All vehicles | 1 Sep 15 | 1 Sep 18 | 1 Sep 19 | 1 Jan 21 |
| Emission Limits | THC (mg/km) | 100 | 100 | 100 | 100 |
| | NMHC (mg/km) | 68 | 68 | 68 | 68 |
| | NOx (mg/km) | 60 | 60 | 60 | 60 |
| | CO (mg/km) | 1,000 | 1,000 | 1,000 | 1,000 |
| | PM[v] (mg/km) | 4.5 | 4.5 | 4.5 | 4.5 |
| | PN (Nb/km) | $6.0 \times 10^{12}$ | $6.0 \times 10^{11}$ | $6.0 \times 10^{11}$ | $6.0 \times 10^{11}$ |
| OBD Thresholds | CO (mg/km) | 1,900 | 1,900 | 1,900 | 1,900 |
| | NMHC (mg/km) | 170 | 170 | 170 | 170 |
| | NOx (mg/km) | 150 | 90 | 90 | 90 |
| | PM (mg/km) | 25 | 12 | 12 | 12 |
| Tests: lab | NDEC | | | Can use either NEDC or WLTP | |
| | WLTP | | | | |
| Tests: on-road | RDE | | | Temporary C.F.[vi] & monitoring phase | Final C.F.[vii] |

**Table 2: UN-R83/07 (Euro 6)[viii]**

| Euro 6 Level[ix] | | 6b | 6c | 6d Temp | 6d |
|---|---|---|---|---|---|
| Date of introduction | New approvals | 1 Sep 2014 | 1 Sep 2017 | TBD | TBD |
| | All vehicles | 1 Sep 2015 | 1 Sep 2018 | TBD | TBD |
| Emission Limits | THC(mg/km) | 100 | 100 | | |
| | NMHC (mg/km) | 68 | 68 | | |
| | NOx (mg/km) | 60 | 60 | | |
| | CO (mg/km) | 1,000 | 1,000 | | |
| | PM (mg/km) | 4.5 | 4.5 | | |
| | PN[v] (Nb/km) | $6.0 \times 10^{12}$ | $6.0 \times 10^{11}$ | | |
| OBD Thresholds | CO (mg/km) | 1,900 | 1,900 | | |
| | NMHC (mg/km) | 170 | 170 | | |
| | NOx (mg/km) | 150 | 90 | | |
| | PM (mg/km) | 25 | 12 | | |
| Tests: lab | NDEC | | | | |
| | WLTP | | | | |
| Tests: on-road | RDE | | | | |

**Glossary:**

| | |
|---|---|
| (red) | Not part of regulation/standard |
| (orange) | Temporary or alternative standard/limit |
| (green) | Part of regulation/standard |

NEDC – New European Drive Cycle; the current laboratory based drive cycle which is used to measure light vehicles CO2 and pollutant emissions

WLTP – Worldwide harmonised Light vehicle Test Procedure; the new laboratory based drive cycle which is used to measure light vehicles CO2 and pollutant emissions

RDE – Real Driving Emissions; a European on-road test to regulate light vehicles pollutant emissions (NOx and PN) from Sep 2017

C.F – Conformance Factor; the multiple of the laboratory based test limits for pollutant emissions (NOx and PN) that set the limits for the RDE.

RM – Reference mass: the unladen mass of the vehicle increased by 100 kg.

Unladen mass - the mass of the vehicle in running order unoccupied and unladen with all fluid reservoirs filled to nominal capacity including fuel, and with all standard equipment.

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i Commission Regulation (EU) 2016/427 of 10 March 2016

ii Delphi, 2016/2017 Worldwide Emissions Standards, Passenger Cars and Light Duty

iii Emission limits and OBD thresholds in this table apply to M1 (passenger cars up to 9 seats and maximum mass not exceeding 3.5 tonnes) and N1 Class I vehicles (i.e. LCVs up to 1305kg RM). There are different (increased) emission limits and OBD thresholds for N1 Class II (1305kg<RM≤1760kg) and N1 Class III (RM>1760 kg

iv Unknown if emission limits and OBD thresholds will be revised with introduction of WLTP

v PN (particulate number) only apply to GDI engines

vi Temporary conformity factor: NOx limit x 2.1 (incl. measurement tolerance)

vii Final conformity factor: NOx and PN limit x 1.5 (1.0 + 0.5 measurement tolerance). Measurement tolerance of 0.5 subject to regular reviews and possible adjustment.

viii Date of entry into force:22 January 2015

ix Emission limits and OBD thresholds in this table apply to M1 (passenger cars up to 9 seats and maximum mass not exceeding 3.5 tonnes) and N1 Class I vehicles (i.e. LCVs up to 1305kg RM). There are different (increased) emission limits and OBD thresholds for N1 Class II (1305kg<RM≤1760kg) and N1 Class III (RM>1760 kg

## APPENDIX D FCAI RESPONSE TO DEE QUESTIONS OF 22 MAY 2017

The following are questions received from the Department of Environment and Energy (DEE) and responses provided by the FCAI on 22 May 2017 (subsequent to the Better fuel for cleaner air Discussion Paper).

**DEE Question 1.**
**Vehicle technology currently available (or not available) in the Australian Market due to our current fuel standards.**

- What physical or electronic changes are made to car engines and emissions systems for the Australian market to cater for our current fuel quality?
- Other than Euro 6, what technologies are not currently available to Australians because of the quality of our fuel? For example, what technologies are available in Europe that are not available in Australia?
- How do the above two points impact on how much Australians are paying for vehicles and the levels of fuel efficiency and vehicle emissions from these vehicles?

**FCAI response**

Brands provide different powertrains in Australia than in Europe due to a range of reasons including consumer choice.

The quality of market fuel plays a critical role in powertrain determinations by vehicle manufacturers. Currently many brands specify their mainstream models to be capable of operating on regular unleaded petrol (i.e. 91 RON 150 ppm sulphur) while being certified on 95 RON 10 ppm sulphur petrol. There are performance, emission and fuel consumption trade-offs in doing this. It may also restrict those same brands using certain technologies such as downsizing engines that achieve the same power output (i.e. vehicle performance) as a European model.

The draft RIS, Improving the efficiency of new light vehicles, Table 3 (p. 24) provides a range of examples of models with different powertrains in Australia than offered in Europe.

In addition to different powertrains, some brands offer the same engine with a slightly lower power output. For example, the Mazda 3 offered in Australia has a 2.0 litre engine with a power output of 114 kW and fuel consumption of 5.9 l/100 km. The Mazda 3 offered in the UK has the same 2.0 litre engine, but with a slightly increased power output of 120 kW and better fuel consumption of 5.1 l/100 km. This change in power output is achieved by a higher compression ratio in the UK variant than in the Aust variant to take advance of operating on 95 RON.[44]

The ABMARC Technical Report: Engine and Emission System Technology, provides an overview of the impact on engine efficiency with higher octane fuel (pp. 31-32).

If the Australia fuel standard continues to lag behind the European standard (and similar fuel standards in other advanced markets) Australians will not be able to access the latest in vehicle technology. When Euro 6d (which has an increased focus on in-service use and compliance with RDE) is introduced, vehicles will need market fuels commensurate with the emission standard (i.e. EN standard fuels) in order to comply with the on-road emissions elements.

[44] Engine data from Mazda Australia website (www.mazda.com.au) and Mazda UK website (www.mazda.co.uk) [downloaded 17 May 2017].

**DEE Question 2.**
**Vehicle Technology that will not be made available in the future if current Fuel Standards are retained**

- What technologies would Australia miss out on, in the future, if current fuel standards are retained?
- How would this impact how on much Australians are paying for vehicles and the levels of fuel efficiency and vehicle emissions from these vehicles?

**FCAI response**

If the current fuel standards are retained Australia will not be able to access the latest generation of engine and emission system technology.

The Technical Background in the World Wide Fuel Charter (WWFC) states that a minimum 95 RON petrol as the market fuel will "enable manufacturers to optimise powertrain hardware and calibrations for thermal efficiency and $CO_2$ reductions."[45] The technology changes introduced for higher octane fuel to improve fuel consumption includes higher engine compression ratio, direct injection systems and higher boost pressures for turbocharging.46

Many brands are already supplying GDI models to Europe and/or intend to introduce GDI engines with gasoline particulate filter (GPF) to comply with Euro 6c in Europe. GPF are required to meet the particulate number (PN) requirement and OBD thresholds under Euro 6c (and Euro 6d).

High sulphur fuel generates negative impact on injector deposit and it causes an increase of PM/PN. Therefore, petrol with a maximum 10ppm sulphur and 35% v/v aromatics is required to guarantee the emission control performance of PN in real world applications and to meet the in-service test and performance requirements of Euro 6d (i.e. RDE).

Without EN 228 standard petrol (95 RON 10 ppm sulphur) as the base grade market fuel, brands may introduce shorter service intervals and specify operation on 95 RON to compensate for higher sulphur levels. These strategies are necessary to ensure effective operation of the vehicle, however, they will increase consumer cost of ownership.

[45] World Wide Fuel Charter, 5th Edition (p. 17)
[46] Riccardo, March 2016, The Influence of Fuel Octane on Fuel Consumption (p. 9)

**DEE Question 3.**

**Research Octane Number and existing fleet**

- What is the benefit to the existing (in service) Euro 5 fleet optimised for 91 RON of moving to 95 RON?
  - o We cannot find a reference within your submission of a 1 – 2 % fuel efficiency benefit. The ABMARC study, attached to your submission (p.31) says that existing vehicles that have been designed to run on 91 RON fuel may experience a 'small improvement in fuel efficiency' if they have been calibrated to run on a range of fuel RON grades.
  - o Could you please provide evidence / test results which quantify the fuel efficiency gains of using 95 RON petrol in vehicles that have been optimised for 91 RON or a range of RON grades?
- What are the operability issues of operating a 95 RON vehicle on 94.7 RON E10? i.e. is 95 RON the same as 95.0?

**FCAI response**

A study undertaken by JAMA (Japanese Automobile Manufacturers Association) in 2013 found a fuel consumption improvement of between 1 and 5% for in-service vehicles using 95 RON petrol (compared with using 90 RON).[47]

Other international experience by FCAI member brands supports this position.

It is important to note, that this improvement is relevant to vehicles that have been designed to operate on 95 RON as well as the base grade market fuel (91 RON in the case of Australia).

Since 2004 with Euro 3 (introduced as ADR 79/00 from January 2002 for new model diesel vehicles) all light petrol engine vehicles have been certified on 95 RON 10 ppm sulphur petrol. As the average age of passenger cars is 9.8 years[48] (light commercials are slightly higher at 10.5 years), more than 50% of the existing light vehicle fleet has been certified to operate on 95 RON fuel. By 2022[49] more than 90% of petrol engine light vehicles will have been certified on 95 RON petrol.

Which in-service vehicles will deliver a fuel consumption benefit (and the level of fuel consumption improvement) from operating on 95 RON (compared with 91 RON) will vary by model, vehicle operation and condition.

In terms of operability issues of an E10 fuel. It must be remembered that E10 in Australian (94RON) is actually a ULP spec fuel that has up to 10% ethanol added. Therefore, various other fuel parameters (sulphur and aromatics for example) will exceed EN228 (and also the current Aust PULP standard). Therefore, any vehicle operating on E10 will generate more pollutant emissions than if the vehicle was operating on a fuel meeting EN228 (or even the current Aust PULP standard). Therefore, more pollutants (e.g. SOx) will be captured on the catalyst, and the vehicle will need to run rich more often to regenerate the catalyst, resulting in an increased fuel consumption.

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[47] JAMA report in Asian Clean Fuels Association Newsletter "JAMA: towards upgrading regular gasoline to 95 RON, June 2014.
[48] ABS 93090DO001_2016 Motor Vehicle Census, Australia, 31 Jan 2016
[49] The FCAI's estimated earliest date of introduction of higher fuel standards, Euro 6 and accelerated $CO_2$ rate of reduction

**DEE Question 4.**

**Research Octane Number and new (future) vehicles**

- You have previously told us that new vehicles calibrated by the manufacturer to run on 91 RON fuel would achieve a fuel efficiency gain of approximately 5% if they had instead been calibrated to run on 95 RON fuel. Could you provide supporting evidence for this?

**FCAI response**

The Government's "Improving the efficiency of new light vehicles" draft RIS (table 2, p.23) outlines many proven technologies that could be used to improve fuel consumption. Many of these technologies are already incorporated into vehicles around the world. The FCAI submission to this draft RIS provided an example of a vehicle model (Chevrolet Tahoe) that had undergone significant fuel consumption improvements through the adoption of technology to deliver a 22.5% improvement in fuel consumption (pp. 32-33).

A JAMA 2013 study (reported by ACFA) showed the fuel efficiency will improve by between 2 and 8% by upgrading to 95 RON. This will vary depending on the engine technology with up to 8% improvement for supercharged engines, and between 2 and 4% for conventional engines (due to compression ratio increase, ignition time optimisation and transmission shift optimisation).[50]

International experience of FCAI member brands has shown that utilising many of these technologies within a cost competitive environment up to 5% fuel consumption improvement can be achieved by designing and optimising the vehicle to operate on 95 RON fuel. For example, if a downsized engine is used to deliver the same power output and coupled with an advanced transmission to deliver the required vehicle performance, the vehicle can also be reduced in overall mass.

[50] JAMA report in Asian Clean Fuels Association Newsletter "JAMA: towards upgrading regular gasoline to 95 RON, June 2014.

# APPENDIX F JAMA RESEARCH ON AROMATICS AND PM

The Japanese Automotive Manufacturers Association (JAMA) provided a summary of research conducted on the impact of aromatics in gasoline on particulate matter (PM).

**Key message from research:**

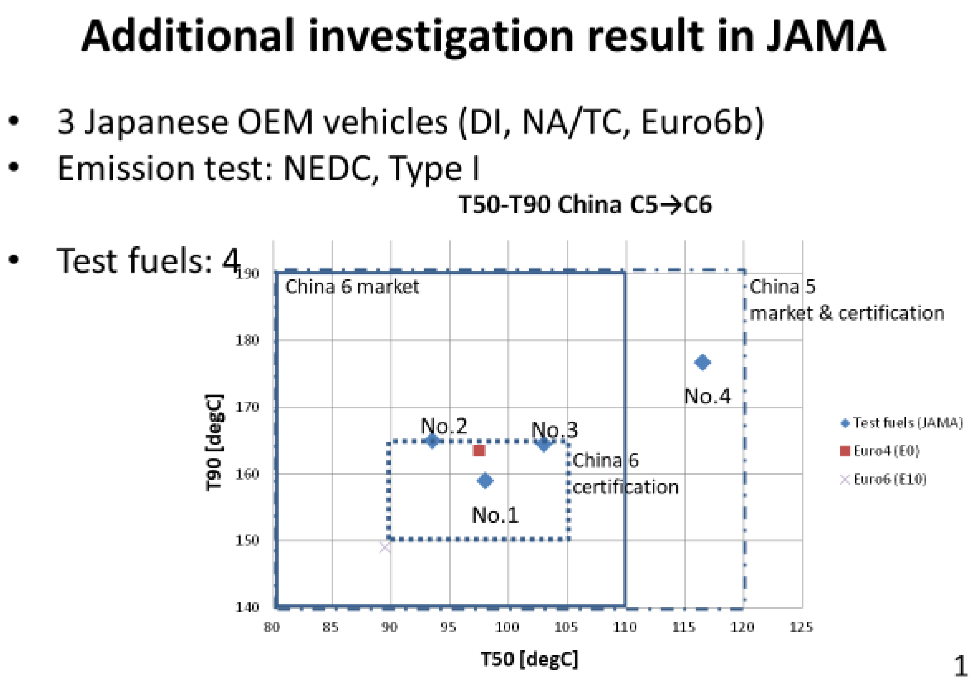
- Total and type of aromatics drive PM and PN emissions from gasoline engines.
- Need to control total aromatics, i.e. upper limit, and/or types of aromatics to achieve PM and PN limits.
- Engine and emission system is also a factor in delivering reduced emissions. For all test fuels, Vehicle C (with PFI turbo charged engine) delivered the lowest PM.

**Research supports the following positions:**

- Need 35% limit for aromatics to meet PN limits in Euro 6.
- Aromatics pool average is not suitable;
    - Would allow large quantities of high carbon chain aromatics (e.g. C9, C10, C11, C12) within the pool limit.
    - Could not be certain that the vehicle will meet the PN limits in-service through the 160,000 km requirement.

**Chart 1:**

- Shows the four (4) test fuels used in the research in measured by T90 and T50[51].
- The four test fuels have different levels of aromatics, and also different levels of type of aromatics.
- Referring to Charts 5 and 6, Fuel 3 and Fuel 4 have more ‘heavier’ (C9, C10 and C11) than Fuel 1 or Fuel 2.




[51] T90 and T50 are the temperatures at which 90% and 50% of the gasoline boil off.

**Chart 2:**

- Provides information on the three (3) test vehicles; all with Euro 6b engines/emission systems.
    - Vehicle A has 1.6 litre, 4-cylinder, DI (direct injection) boosted (turbo-charged) engine.
    - Vehicle B has 1.6 litre, 4-cylidner, DI (direct injection), normally aspirated engine.
    - Vehicle C has 2.0 litre, 4-cylidner, PFI (port fuel injected) boosted (turbo-charged) engine.

## Additional investigation result in JAMA
## Test vehicles

| | Vehicle A | Vehicle B | Vehicle C |
|---|---|---|---|
| **Emission Class** | **EU6b** | **EU6b** | **EU6b** |
| displ.(L) | 1.6L | 1.5L | 2.0L |
| Engine Layout | L4 | L4 | L4 |
| **Fuel injection type** | **DI** | **DI** | **DI+PFI** |
| **Boosting system** | **Charged** | **NA** | **Charged** |
| Recommended fuel | 95RON | 95RON | 95RON |

2

**Chart 3:**

- The PM measurement for each of the test vehicles tested on each of the 4 test fuels on the NEDC laboratory test.
- This clearly shows an increase in PM, for each vehicle, with higher aromatics (as measured by T90).

## PM(mass) – T90

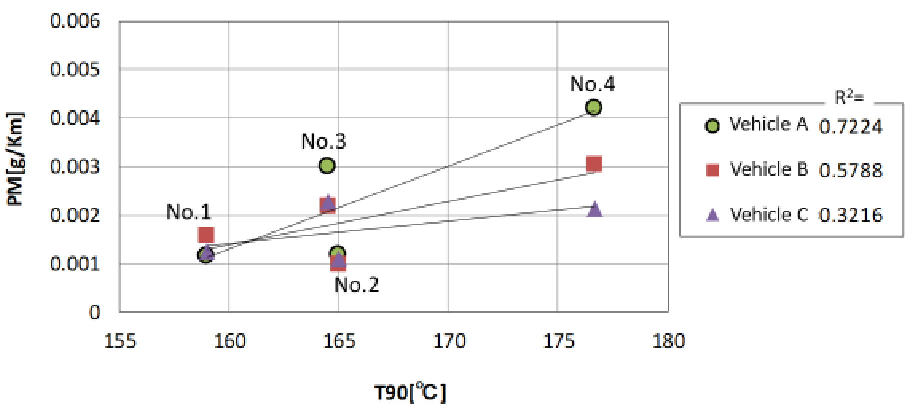



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**Chart 4:**

- Shows low PM in fuels with low overall % of aromatics (i.e. Fuel 1 and Fuel 2).
- Results for Fuel 3 and Fuel 4 demonstrate that even with lower total aromatics (i.e. Fuel 4 has approx. 27% aromatics compared with Fuel 3 with approx. 35%), higher PM can be produced. This is a function of the type of aromatics. Charts 5 &6 that show Fuel 4 has more heavier aromatics, (C10 & C11) than Fuel 3.

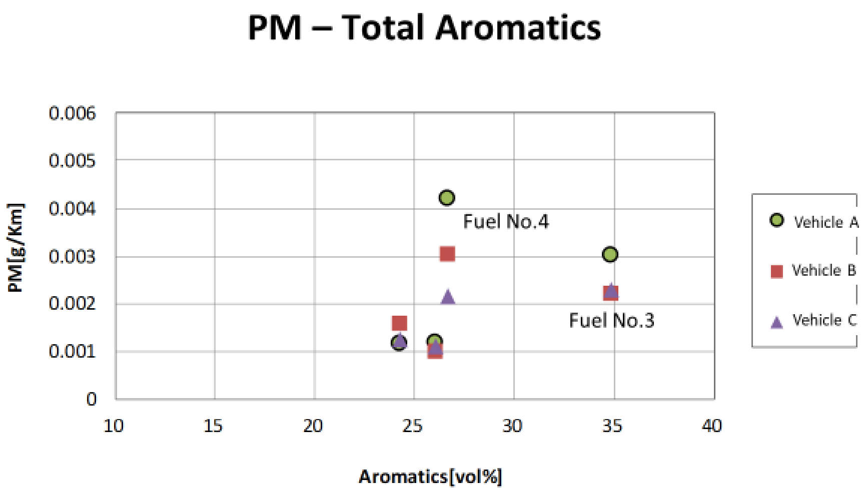


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**Chart 5:**

- Shows that the type of aromatics is important, i.e. Fuel 4 with more high carbon chain aromatics (C11 & C12) produces more PM (see results of tests in Chart 3.

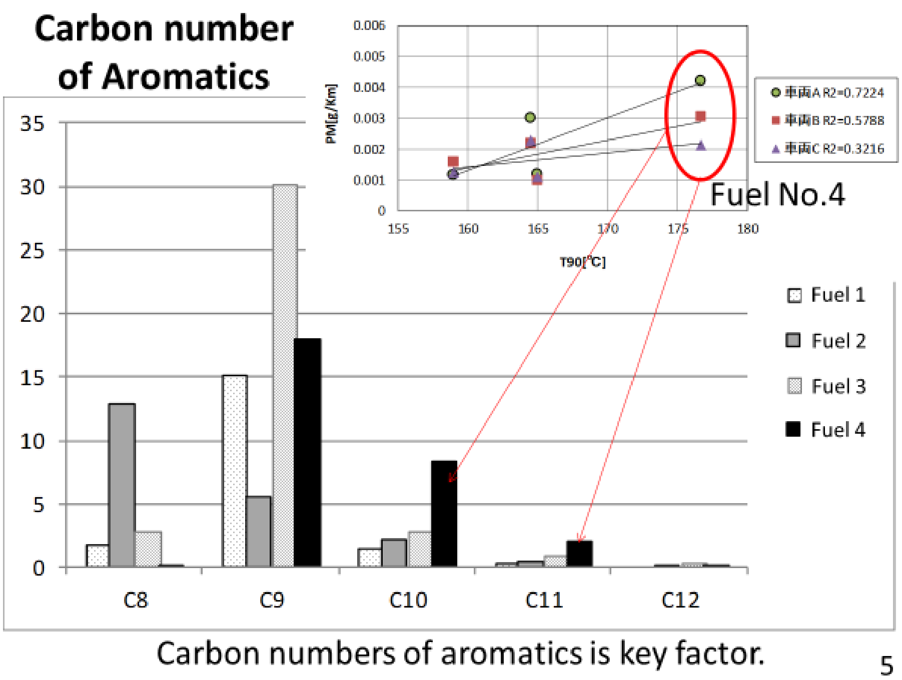


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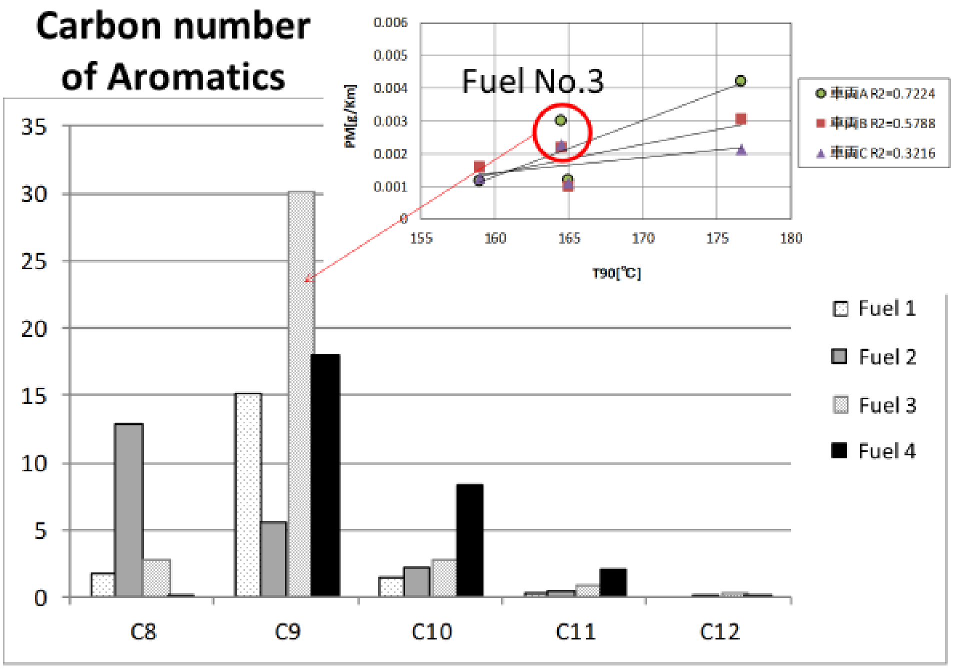
**Chart 6:**

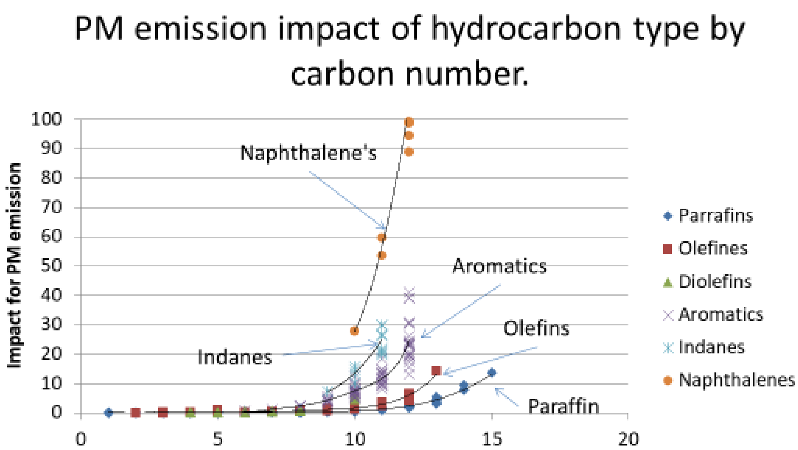
- Shows that total aromatics content is also important, i.e. when combined with results from Chart 4, which shows that Fuel 3 has a greater total (%) of aromatics than Fuel 2, even though made from the low aromatics (e.g. C9), and produces more PM.




Total aromatics also has relation to PM emission. 6

**Chart 7:**

- Supports previous (charts 5 & 6) showing that high carbon number (C10 and over) aromatics have high impact on PM emissions.




*Source:*
*Koichiro Aikawa.*
*"Fuel Effect on PM emission from Gasoline Engine Vehicle". JSAE symposium. Influence of Automobiles on Air Environment. Tokyo. 2015.*

High carbon number (C10 over) of Naphtalenes, Indanes, Aromatics are high impact for PM emission clearly.

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