WRITTEN COMMENTS OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE AUSTRALIAN GOVERNMENT'S
DRAFT REGULATORY IMPACT STATEMENTS FOR VEHICLE EMISSIONS STANDARDS FOR CLEANER AIR AND IMPROVING THE EFFICIENCY OF NEW LIGHT VEHICLES

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The Manufacturers of Emission Controls Association (MECA) is pleased to provide input to the Australian Government's December 2016 draft regulation impact statements (RIS) for *Vehicle Emissions Standards for Cleaner Air* and *Improving the Efficiency of New Light Vehicles*, as well as the *Better Fuel for Cleaner Air* discussion paper. MECA recommends that Australia move forward with introducing tighter vehicle standards for both noxious emissions and greenhouse gases for both new light-duty and heavy-duty engines and vehicles, including setting tight fuel standards. Aligning Australia's vehicle emissions and fuel quality standards with the Euro 6/VI light-duty and heavy-duty standards, at a minimum, will provide significant economic, climate change and health benefits for the citizens of Australia. Even more public health and climate change protective vehicle emission standards are in place, in most cases, in the United States and Canada, and Australia could maximize the public health and climate change benefits for Australia by taking advantage of the many cost effective vehicle emissions and efficiency technologies that have already been developed and commercialized for the U.S. and Canadian markets. MECA has compared the essential provisions of the European and U.S. vehicle regulatory framework with respect to noxious pollutants in a table that can be found on our website at: http://www.meca.org/regulation/mobile-source-regulatory-comparison.

MECA is a non-profit association of the world's leading manufacturers of emission control technology for mobile sources. Our members have over 40 years of experience and a proven track record in developing and manufacturing emission control technology for a wide variety of on-road and off-road vehicles and equipment, including extensive experience in developing exhaust and evaporative emission controls for gasoline and diesel light-duty vehicles as well as heavy-duty engines in all world markets. Our industry has played an important role in the emissions success story associated with light and heavy-duty vehicles in North America, and has continually supported efforts to develop innovative, technology-forcing, emissions programs to deal with unique air quality problems such as those found in an increasing number of Australian metropolitan areas.

Building on comments MECA submitted in April 2016 (https://infrastructure.gov.au/roads/environment/forum/files/Manufacturers_of_Emission_Controls_Association_MECA.pdf) and based on the options presented in the RIS, we recommend Australia mandate both Euro 6 for light-duty vehicles and Euro VI for heavy-duty vehicles under the Motor Vehicle Standards Act. However, as we discuss in this document, we suggest Australia incorporate elements from the US Tier 3 light-duty vehicle emission program into a Euro 6 framework in order to establish the most effective emission reduction policy. As the RIS notes in its Option 6, mandating Euro 6/VI standards will result in the highest net benefits of the options discussed, estimated as $675M between 2016-2040. In addition, Australia's Government

Guide to Regulation advises that the policy option offering the greatest net benefit should always be the recommended option. MECA strongly recommends that Australia consider the adoption of tighter, U.S.-style evaporative emission requirements for light-duty gasoline vehicles in the future. These tighter evaporative standards will require the use of advanced evaporative emission technologies such as; advanced carbon canisters, onboard refueling vapor recovery (ORVR) and low permeation materials that are being used to meet U.S. Tier 2 and future Tier 3 evaporative emission requirements for light-duty and medium-duty gasoline or flex-fuel vehicles. These technologies are discussed in the MECA report: "Evaporative Emission Control Technologies for Light-Duty Gasoline Vehicles" (available on MECA's website, www.meca.org, under Resources, then Reports). Recently, China's Ministry of Environmental Protection finalized China 6 standards that incorporate elements from the US Tier 3 light-duty vehicle emission program into a Euro 6 framework in order to establish the most effective emission reduction policy. Important elements that were added include fuel neutral standards set at the Euro 6 gasoline limit that phases to a more stringent NOx limit under China 6b of 35 mg/km. China MEP also included U.S. style evaporative standards such as ORVR and 48 hour diurnal limits at the U.S. Tier 2 levels. The China 6 regulation is an excellent example of how the best elements of two different regulatory programs can be combined to achieve the greatest health benefits for the citizens of Australia.

MECA suggests Australia adopt either Alternative B or D from the *Better Fuel for Cleaner Air* report. Alternative B would harmonize fuel standards with the EU, which has demonstrated that these fuels are already available and can be supplied at costs that are competitive in today's marketplace. Standards listed in Alternative D are based on the Worldwide Fuel Charter, which encourages worldwide fuel standard harmonization. Either of these alternatives will result in clean fuel availability in Australia, which will enable effective and durable emission control technologies.

MECA would like to provide some specific recommendations related to Australia's *Improving the Efficiency of New Light Vehicles* RIS. The U.S. is also home to some of the most stringent light-duty and heavy-duty vehicle or engine fuel efficiency/greenhouse gas emission standards. U.S. EPA just recently issued a final determination that the standards are appropriate for model years 2022-2025 after reviewing information collected during a midterm evaluation of the regulation (see: https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas-ghg). These standards can serve as a model on which future Australian vehicle efficiency standards can be built. These efficiency standards have fostered the development and implementation of a myriad of efficiency technologies for both light-duty and heavy-duty vehicles including advanced engine combustion technologies, advanced emission control technologies, turbochargers, multi-speed transmissions, and hybrid powertrains for gasoline, diesel, and alternative fuel applications. Additional information on technologies for reducing greenhouse gas emissions from mobile source (including CO_2, nitrous oxide, methane, and black carbon) are available on MECA's website at: www.meca.org/technology, from the ICCT website (see: http://theicct.org/passenger-vehicles and http://theicct.org/heavy-duty-vehicles), and the U.S. EPA website (see: https://www3.epa.gov/otaq/climate/regulations.htm).

Controlling greenhouse gas emissions from the transportation sector is essential to the overall efforts to alleviate long-term impacts on the climate. As detailed in U.S. EPA's Midterm Evaluation of its Light-Duty Vehicle GHG Emissions Standards for MY 2022-2025, there is a large set of technology combinations available to reduce greenhouse gas emissions from passenger vehicles and light-duty trucks, including fuel efficient, state-of-the-art and future advanced gasoline and diesel powertrains. The vast majority of technologies being deployed across the light-duty fleet represent technologies that have existed for decades and are just now being applied to conventional internal combustion diesel and gasoline engines. Once these cost-effective technologies are deployed, suppliers will develop new technologies to continue reducing vehicle CO_2 and GHG emissions to help their customers meet future standards. For the next several decades, there are likely to be numerous cost effective ways to improve fuel economy without extensive use of strong hybridization or full electrification. We urge Australia to enact performance based policies that facilitate innovation in all areas of vehicle fuel efficiency technologies rather than picking technology winners and losers.

We recommend Australia study U.S. EPA's and the European Commission's off-cycle credit programs, which will reduce real-world CO_2. These programs have offered a process for vehicle manufacturers to apply for off-cycle CO_2 credits through three pathways with increasing levels of complexity. After five years into the U.S. program, the supplier industry has realized that beyond the pre-approved technologies that are included in the off-cycle credit table, the process for credit approval is complex, ill-defined and can stifle early innovation and development at the supplier level before the OEM is prepared to commit the resources necessary to complete a full application. While the current U.S. program offers a methodology for OEMs to apply for off-cycle credits, our members' experience has revealed a few shortcomings. Because the program requires that off-cycle technologies be fully integrated into vehicles, suppliers have a difficult time generating enough evidence to convince their customers to commit resources to demonstrate the technology across a fleet of vehicles without any indication of the amount of credits the technology may deliver.

MECA represents both on-cycle and off-cycle technology suppliers, and therefore we are committed to credit policies that ensure measurable and verifiable CO_2 emission reductions in the real-world. There are several policy examples where certification flexibilities have been used to incentivize early market introduction of advanced technologies. For example the Eco-innovation program that is part of the European Commission's light-duty GHG standards provides a pathway for both technology suppliers and vehicle manufacturers to demonstrate and apply for off-cycle technologies (https://circabc.europa.eu/sd/a/bbf05038-a907-4298-83ee-3d6cce3b4231/Technical%20Guidelines%20October%202015.pdf). Furthermore, examples of regulatory policies that offer a step-wise process towards full certification exist for both diesel retrofits through CARB's conditional verification program and new certification of engines or hybrid powertrains as proposed under CARB's Innovative Technologies Regulation (https://www.arb.ca.gov/msprog/itr/itr.htm). Such a step-wise approach allows for an initial demonstration and conditional pre-approval of a technology's emission reduction potential prior to completing the full certification process. In addition, this type of approach offers manufacturers a pathway to manage uncertainty during the resource-intensive processes of full certification and compliance.

For the case of certifying technologies for off-cycle credits, this could begin with initial demonstration of the technology on a limited number of vehicles, combined with fleet simulation data across broader vehicle categories and real-world conditions under which the technology may offer CO_2 reductions. After review of the preliminary data, the ministry could assign a conservative and conditional pre-approved credit value to a technology that the supplier could use to get its OEM customers interested in allocating the resources to complete the full off-cycle credit application. Once introduced into the market, a more accurate and statistically sound assessment of the CO_2 reduction benefits of the technology can be demonstrated following the first year of real-world, market deployment across the manufacturer's fleet. Following a review of the field results, the final credit allocation could be adjusted appropriately based on real-world experience. The on-board diagnostic (OBD) system that records the fuel consumption of a vehicle may be a way to obtain a statistical representation of the real-world off-cycle credit value.

MECA believes that any regulatory requirements associated with greenhouse gas emissions should be based on real-world driving or usage patterns in order to ensure that regulatory standards reflect actual vehicle operations and deliver the greenhouse gas emission reductions that are needed. Vehicle and emission control technology manufacturers need a valid test cycle for greenhouse gas emissions in order to engineer and evaluate vehicles consistent with how they are used by the public. The weighting of the test cycle between urban and highway driving modes will have a significant influence on the choice and optimization of powertrain options that will be used to meet any future greenhouse gas emission or fuel economy standards. Work is already underway in Geneva, Switzerland under the United Nations Working Party on Pollution and Energy (GRPE) harmonization umbrella to bring forward a new light-duty vehicle test cycle for use in quantifying real world greenhouse gas emissions. Australia should utilize test cycles for the purpose of measuring and controlling vehicle greenhouse gas emissions that are representative of real world driving patterns.

Implicit in greenhouse gas emission compliance scenarios is the ability of conventional and advanced powertrain options to meet the applicable noxious emission standards, such as CO, NOx, and hydrocarbons (HC). All of these advanced, light-duty powertrain options combined with the appropriately designed and optimized emission control technologies can meet all current and future noxious emission requirements. In this manner, advanced emission controls for criteria pollutants enable advanced powertrains to also be viable options for reducing greenhouse gas emissions. Future light-duty diesel powertrains will continue to use emission control technologies like diesel particulate filters, NOx adsorber catalysts, and selective catalytic reduction catalysts to meet Euro 6 light-duty exhaust emission standards. Emission control manufacturers are working with their auto manufacturer partners to further optimize these emission control technologies to be more effective at reducing noxious pollutants and play a role in reducing vehicle greenhouse gas emissions. A recent focus of research has been on cold-start emissions where thermal management strategies and new catalyst formulations are being developed to activate catalyst functionality at lower temperatures, earlier in the warm-up cycle. The ability to control NOx over a broader temperature range offers the calibration engineers with a wider operating window for calibrating the engine for greater fuel efficiency and thus lower GHG emissions. Advanced diesel emission control technologies like particulate filters with lower backpressure characteristics, SCR catalysts with improved performance at lower exhaust temperatures, and SCR catalyst coated directly on particulate filter substrates are examples of emerging diesel emission control technologies that will allow future diesel powertrains to be as clean as gasoline engines while retaining the improved fuel consumption characteristics of compression ignition. Coating the SCR directly on the DPF allows the SCR to be moved closer to the turbocharger, thus significantly accelerating heat-up. Several commercial examples of SCR coated filters installed on light-duty vehicles already exist in Europe, and we expect this number to continue to grow.

Recently, a new category of catalysts has emerged for both diesel and gasoline applications, specifically targeting cold-start and low temperature emissions. These catalysts are generically referred to as passive NOx adsorbers (PNAs). This family of catalysts serves to physically adsorb NOx at low temperatures, from the time of first ignition, until the active NOx conversion catalyst reaches the light-off temperature. Above temperatures of approximately $200^{o}C$ the NOx adsorber passively releases the NOx so it can be chemically converted to nitrogen by the three-way catalyst (TWC) or SCR catalyst downstream in the tailpipe. In gasoline applications, the PNA can be combined with a hydrocarbon adsorption functionality to help vehicle manufacturers achieve the tighter HC and NOx limits. In diesel applications, the PNA can be combined with the oxidation functionality of the diesel oxidation catalyst (DOC) to achieve low HC and CO emissions and the proper concentration of NO_2 for the SCR. The PNA is just one example of how cold-start technologies can be used for more fuel-efficient engine calibration. To deploy both conventional and advanced catalysts, substrate manufacturers have developed high porosity flow-through and filter substrate materials with high cell densities to allow higher catalyst loadings and lower back pressures. The higher geometric surface area of these high cell density substrates provides the OEMs with flexibility to design system architectures for improved activity or smaller size. Both the size and back pressure of emission control devices can be used to improve the fuel economy of the vehicle.

A range of powertrain technologies, including engine turbochargers, exhaust gas recirculation systems, advanced fuel systems, variable valve actuation technology, advanced transmissions, hybrid powertrain components, and powertrain control modules, can be applied to both light-duty gasoline and diesel powertrains to help improve overall vehicle efficiencies and reduce fuel consumption, both of which can result in lower CO_2 exhaust emissions. Auto manufacturers will take advantage of the synergies between advanced emission control technologies and advanced powertrains to assist in efforts to optimize their performance with respect to both greenhouse gas and criteria pollutant exhaust emissions. MECA believes that light-duty diesel powertrains provide a cost-effective, durable approach for vehicle manufacturers to improve the average fuel economy of their fleets, particularly in the larger power category that includes small pick-up trucks and SUVs. A recent analysis was completed by the Martec Group for the U.S. EPA's Midterm Evaluation of its light-duty GHG rule for model years 2022-2025. It provides an updated cost-benefit analysis for light-duty cars and trucks that details the cost benefits of diesel powertrains as part of a more fuel efficient light-duty fleet (http://www.martecgroup.com/wp-content/uploads/2016/05/The-Martec-Group-White-Paper-Diesel-Engine-Technology-and-the-Midterm-Evaluation-Summer-2016.pdf).

For gasoline vehicles, direct injection technology has been deployed at a rapid pace, enabling gasoline engines to achieve greater fuel efficiency. Although significant advances have also occurred in improving the efficiency of naturally aspirated engines, GDI is expected to continue to dominate new gasoline car sales in the U.S. and Europe. Emissions controls ensure that these more fuel-efficient gasoline engines meet tough EPA or European noxious emission regulations. Under stoichiometric conditions, three-way catalysts are used to achieve ultra-low emissions of NOx, HC and CO. Advanced high performance, three-way catalysts are available and will continue to evolve and be optimized to ensure that future gasoline direct injection engines will meet the toughest criteria pollutant emissions standards with minimal impacts on overall vehicle exhaust system backpressure and fuel consumption. One facet of the Euro 6 light-duty standards for gasoline vehicles that is more stringent than the U.S. Tier 2 or Tier 3 light-duty standards is with respect to particle emissions from gasoline direct injection (GDI) engines. Due to the tendency of GDI engines to emit large amounts of PM, in 2011, the European Commission established a particle number emission standard for light-duty vehicles powered by GDI engines as a part of their upcoming Euro 6c light-duty emission standards. This PN standard is set at 6×10^{11} particles/km, starting in September 2017, measured using the European PMP particle measurement protocol; see: http://circa.europa.eu/Public/irc/enterprise/automotive/library?l=/technical_committee/december_confirmed/text-02122011pdf/_EN_1.0_&a=d). This level of particle number emissions has been estimated to be approximately equivalent to 0.3 mg/km on a mass basis in MECA's ultrafine particle report (see: "Ultrafine Particulate Matter and the Benefits of Reducing Particle Numbers in the United States," published in July 2013 under Reports at: http://www.meca.org/resources/reports). This Euro 6c GDI particle number standard is approximately 20 times more stringent than the current U.S. Tier 2 PM limit, six times more stringent than the U.S. Tier 3 PM standard that begins its phase-in with model year 2017, and approximately twice as stringent as California's 0.6 mg/km light-duty PM standard that currently comes into effect starting with model year 2025. This European GDI particle number limit will cause auto manufacturers to introduce cleaner technologies such as advanced fuel injection systems and/or gasoline particulate filters to comply with the European Euro 6c GDI particle number limit.

MECA members in Europe are demonstrating the ability of coating these advanced TWC formulations directly onto a gasoline particulate filter (GPF) in place of the underfloor converter. This allows GDI engines to comply with the Euro 6c PN requirements starting in 2017 as well as the more challenging RDE requirements that will soon be implemented in Europe and other parts of the world. Catalyzed GPFs are being demonstrated in place of today's underfloor catalysts, making this a cost-effective technology for meeting tighter criteria and particulate standards in the future. Numerous papers have shown no measurable impact of GPFs on vehicle fuel economy or CO_2 emissions (Emiss. Control Sci. Technol. DOI 10.1007/s40825-016-0033-3, SAE Technical papers: 2015-01-1073, 2016-01-0941, 2016-01-0925). MECA projects that the incremental cost of a catalyzed GPF above that of an underfloor converter is likely to be in the range of USD$50-$60 in the 2025 time-frame making GPFs a cost-effective option for meeting low PM and PN standards with no impact on fuel economy.

Manufacturers may choose to deploy lean GDI engines in the future to achieve further efficiencies from gasoline engines. Under lean combustion conditions, similar emission control technologies used on diesel vehicles can be used to reduce emissions from lean, gasoline direct injection powertrains. These include particulate filters to reduce PM emissions and SCR and/or lean NOx adsorber catalysts to reduce NOx emissions. While lean NOx adsorber catalyst performance has a high degree of sensitivity to fuel sulfur levels, the tighter sulfur requirements under Tier 3 light-duty emission standards will allow lean NOx adsorber catalysts to be considered a viable NOx control strategy for fuel efficient, gasoline lean-burn engines that employ direct fuel injection technology. Work at the Oak Ridge National Lab has shown that these lean GDI engines can result in significantly higher PM and PN emissions than even stoichiometric GDI engines. The effectiveness of using a GPF to significantly reduce particulate emissions from a lean GDI engine was published in SAE Technical Paper 2016-01-0937.

In conclusion, MECA believes that cost-effective technologies are available to deliver additional needed reductions in noxious emissions and further climate change benefits to the citizens of Australia. At a minimum, Australia should move forward with finalizing another round of light-duty and heavy-duty vehicle and engine noxious emission standards that follow the Euro 6/VI standards, including setting tight fuel quality standards. Significant additional reductions in the light-duty sector are achievable by structuring a regulatory program that follows the U.S., fuel neutral Tier 2 or Tier 3 light-duty exhaust and evaporative emission programs. MECA recommends that if Australia chooses to adopt Euro 6/VI emission standards that serious consideration be given to including more stringent gasoline vehicle evaporative emission standards that are based on U.S. Tier 2 or Tier 3 evaporative standards to realize significant, cost-effective reductions to vehicle fuel-based hydrocarbon emissions. The U.S. light-duty and heavy-duty vehicle and engine efficiency standards also provide Australia with a good template for further reductions in greenhouse gas emissions. Once finalized, these regulations will provide the citizens of Australia with significant economic, air quality and climate change benefits. MECA encourages Australia to finalize their next set of vehicle emissions and efficiency regulations as soon as possible. If these regulations can be finalized in late 2017 or early 2018, these more stringent standards could begin their phased-in implementation by 2020. Australia's commitment to move forward with more stringent emissions and efficiency standards for mobile sources also will set a powerful example for the rest of Southeast Asia to follow. MECA members stand ready to work with their customers to deliver the needed emission control and efficiency technologies that will allow future new passenger cars and trucks in Australia to comply with more stringent standards. MECA also recommends that Australia should ensure that the emission reductions expected under existing and future standards for mobile sources are realized by implementing rigorous and robust compliance and enforcement programs.

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