**COMMENTS OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON CALIFORNIA AIR RESOURCES BOARD'S PROPOSED
CALIFORNIA GREENHOUSE GAS EMISSIONS
STANDARDS FOR MEDIUM- AND HEAVY- DUTY ENGINES AND
VEHICLES AND PROPOSED AMENDMENTS TO THE TRACTOR-
TRAILER GHG REGULATION**

February 5, 2018

The Manufacturers of Emission Controls Association (MECA) is pleased to provide comments in support of the California Air Resources Board's (ARB) proposed rulemaking to establish medium- and heavy- duty greenhouse gas emission standards for engines of model years 2021 and beyond as well as model year 2020 and later trailers. We believe an important opportunity exists to continue to reduce greenhouse gas emissions from medium- and heavy-duty engines and vehicles by applying the fundamental regulatory structure that has been effective under the first phase of the medium and heavy-duty standards.

MECA provided supportive comments to U.S. Environmental Protection Agency's (EPA) regulation on greenhouse gas emission standards and fuel efficiency phase 2 standards for medium- and heavy-duty engines and vehicles. MECA's comments here largely mirror our comments to EPA's rulemaking submitted on September 25, 2015. MECA commends ARB for proposing to reduce greenhouse gas emissions by establishing mandatory GHG emission standards for new on-road heavy-duty vehicles and engines that are aligned with U.S. national standards beyond 2018.

MECA is an industry trade 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 and efficiency technology for a wide variety of on-road and off-road gasoline and diesel fueled vehicles and equipment in all world markets. Our members provide the technologies that enable heavy-duty on-road vehicles to meet the most stringent NOx and PM emission standards as well as technologies that impact combustion efficiency and improve the overall CO_2 emissions of the powertrain. These technologies include waste heat recovery, turbochargers, turbo-compounding, EGR coolers, EGR valves and other air management technologies, thermal management strategies including insulated dual wall manifolds and exhaust systems, active thermal management approaches, advanced fuel injection and ignition systems. Our industry has played an important role in the emissions success story associated with light and heavy-duty vehicles in the United States and has continually supported efforts to develop innovative, technology-forcing, emissions programs to deal with air quality problems.

Introduction

Anthropogenic activities, particularly the burning of fossil fuels, have changed the composition of the atmosphere in ways that threaten dramatic changes to the global climate. Signs of climate change are evident worldwide and additional changes will have serious impacts on our nation's future. Although transportation is a vital part of the economy and is crucial for everyday activities, it is also a significant source of greenhouse gas (GHG) emissions. Some of the important greenhouse gas emissions from fossil fuel combustion from mobile sources include: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and black carbon. Climate change is also impacted negatively by higher ground-level ozone emissions. Ozone levels are in turn linked to hydrocarbon and NOx emissions from mobile and stationary sources. The adverse health effects of ozone is compounded by rising temperatures caused by climate change. These complex relationships support the need to continue to reduce emissions of criteria pollutants and climate forcing compounds and we commend the agency for making further progress in this effort. Medium and heavy-duty vehicles contribute about 20% of the transportation-related GHG emissions in the U.S. The proposed regulations will have a global impact as the same technologies are deployed to meet future GHG and efficiency standards in other major world economies.

Since the beginning of the industrial revolution, concentrations of CO_2 have increased by nearly 30%, methane concentrations have more than doubled, and nitrous oxide concentrations have increased by approximately 15%. ARB reported that approximately a third of California's NOx emissions and 20% of the state's GHG emissions come from medium- and heavy-duty trucks over 8,500 pounds GVWR. As such, controlling greenhouse gas emissions from the transportation sector is essential to the overall efforts to alleviate long-term impacts on the climate. MECA supports ARB's proposed reductions in greenhouse gas emissions for the heavy-duty truck segment, and believes that the proposed reductions are technically feasible.

Proposed Regulatory Structure and Stringency to Incentivize Efficiency Technologies

MECA supports the ARB's proposed harmonization with the EPA's final heavy-duty Phase 2 GHG standards because those reductions are technically feasible through implementation of technologies that are ready for deployment on trucks today. The Department of Energy's SuperTruck program has demonstrated the magnitude of reductions that engine and vehicle technologies can deliver. We urge ARB to finalize a set of stringent Phase 2 standards that largely align with EPA and would incentivize the deployment of the full spectrum of cost effective technologies developed for engines and vehicles to guide industry investment and maximize environmental benefits.

Technology development has a 15-20 year cycle from the lab to commercialization. This is why stringent standards are a critical signal to industry to make investments today for technologies that will be needed in the future. MECA members are engaged in developing a large portfolio of efficiency technologies that will directly or indirectly impact CO_2 emissions. These technologies include advanced SCR catalysts, passive NOx adsorbers (PNA) and substrates, waste heat recovery, turbochargers, turbo-compounding, EGR coolers, EGR valves and other air management technologies, thermal management strategies including insulated dual wall manifolds and exhaust systems, active thermal management approaches, advanced fuel injection and ignition systems.

Turbo-compounding technologies and advanced air management strategies are just beginning to be commercialized in heavy-duty applications. Others, such as Rankine cycle systems and advanced high pressure injection, are in demonstration stage. Technologies with still longer term horizons, such as thermoelectric generators, are still in the laboratory. In addition, OEMs see promise in the application of 48 volt hybrid technology to the heavy-duty vehicle sector. These technologies, which are just beginning to be commercialized on passenger cars, may enter the heavy-duty market in 2021 and be particularly beneficial to light- and medium-heavy trucks in stop-and-go applications (http://www.truckinginfo.com/channel/equipment/article/story/2018/01/the-future-of-electrical-systems-on-heavy-duty-trucks.aspx). New 48V hybrids can take advantage of smaller and lighter HVAC systems that can be packaged independently of the engine, integrated starter/generator units that are more efficient than current belt-and-pulley systems, and electric boost, electric turbo and turbo-compounding with a high-speed generator and regenerative braking capability to charge batteries.

In the absence of sufficiently stringent standards, innovative technologies depend on incentives to accelerate initial market penetration. Furthermore, without incentives or credits, manufacturers will be forced to halt further development and optimization of emerging technologies to achieve the type of return on investment the trucking industry demands. Some of these technologies are not yet optimized to deliver the return on investment that truck owners require in today's low cost fuel environment. MECA suggests that ARB preserve the ability for manufacturers of hybrid electric vehicles without plug-in capability to receive advanced technology credits past MY2020. For example, we encourage ARB to continue to incentivize technologies like 48 volt mild hybrid trucks, which have not yet made their way to the heavy-duty vehicle market, but will enable the transition to a lower CO_2 emitting fleet. We urge ARB to continue to support development, optimization and testing of efficiency technologies to deliver cost-effective CO_2 reductions in the out years of the Phase 2 regulation and to meet future heavy-duty GHG requirements.

MECA strongly supports the decision to retain the Phase 2 regulatory structure based on separate engine and vehicle standards that has been proven effective under the Phase 1 heavy-duty GHG standards. Our industry and the regulatory agencies have invested significant resources to ensure that the current structure delivers cost-effective and durable emission reductions. Manufacturers have made significant investments in developing engine-based technologies under the first phase of heavy-duty GHG standards that will continue to deliver environmental benefits under this second set of GHG regulations. Engine and powertrain reductions are verifiable and future OBD systems can be used to insure reductions over the life of the vehicle. EPA's regulation includes a number of engine and vehicle technologies that demonstrate significant reductions but may not remain on the vehicle over its lifetime. These include, low friction lubricants, aerodynamic fairings, low rolling resistance tires among others. To achieve the goals of this regulation, we urge ARB to develop methodologies and policies that ensure that the real emission reduction benefits from all technologies remain through the end of life and multiple owners of the vehicle.

There is a large set of technologies that can significantly reduce, either directly or indirectly, mobile source emissions of CO_2, N_2O (as well as other NOx emissions), CH_4, and black carbon. A range of powertrain technologies can be applied to both heavy-duty gasoline and diesel powertrains to help improve overall vehicle efficiencies, reduce fuel consumption, both of which can result in lower CO_2 exhaust emissions. In many cases, the application and optimization of advanced emission control technologies on advanced heavy-duty powertrains can be achieved in a manner that lowers overall fuel consumption while reducing criteria emissions. Our comments focus on available engine efficiency and exhaust emission control technologies and the impacts these technologies can have on greenhouse gas and criteria emissions.

The link between Ground Level Ozone and Climate Change

There is a significant linkage between ground level ozone concentrations and climate change impacts. Many studies have shown that increasing average annual temperatures, resulting from climate change, are likely to result in even higher levels of ozone in the environment (https://health2016.globalchange.gov/air-quality-impacts). Emission reductions aimed at lowering emissions of the primary precursors of ozone – volatile organic compounds (VOCs) and NOx – will have a positive impact on human health. Policies that aim for additional reductions in ambient ozone levels may become necessary in order to mitigate higher ozone levels that result from climate change. The health-based National Ambient Air Quality Standards require that states focus on reducing their ambient levels of criteria pollutants. California and the Northeast states are struggling to achieve existing federal ozone ambient standards, and are already preparing to meet tighter ozone NAAQS limits in the future. Implicit in federal and state greenhouse gas emission analyses is the ability of advanced powertrain options to meet the applicable criteria pollutant emission standards, such as CO, NOx, and non-methane organic gases (NMOG). Advanced, heavy-duty powertrain options combined with the appropriately designed and optimized emission control and efficiency technologies can meet all current and future federal and state criteria emission requirements.

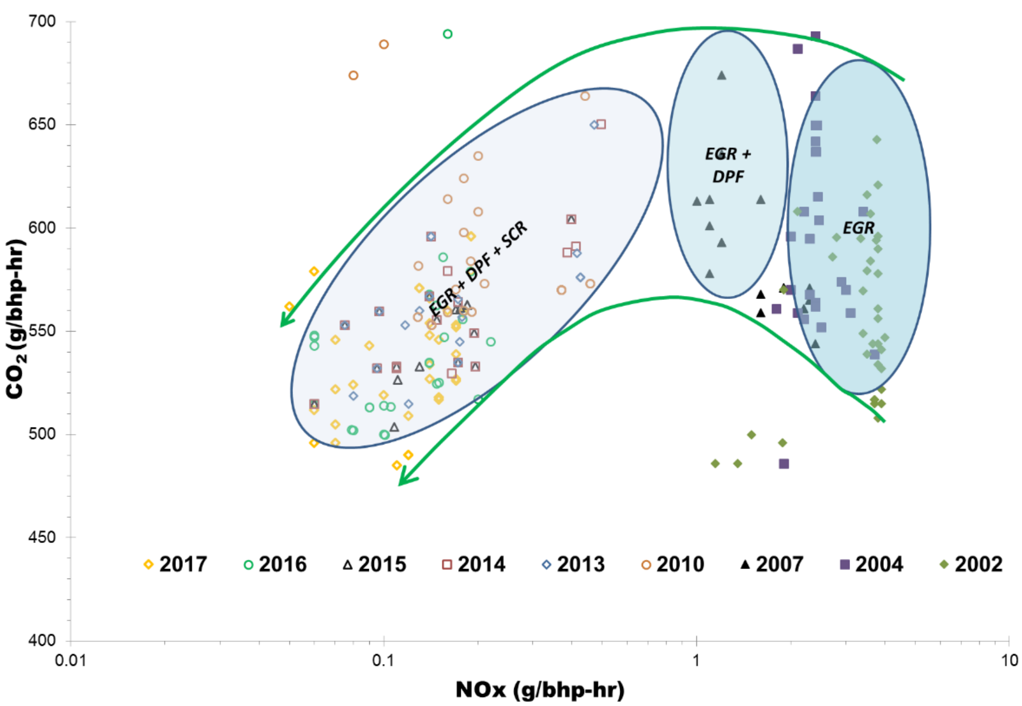
The Relationship between NOx and CO_2 Emissions from the Engine

The calibration of internal combustion engines is a delicate balance that has to deal with trade-offs to optimize performance and emissions. For example, there is an inverse relationship between PM and NOx emissions that engine manufacturers applied to meet emission standards up through the 2006 heavy-duty highway regulations. In 2007, the requirement to reduce both PM and NOx emissions caused OEMs to install particulate filters on diesel vehicles, which allowed engine calibrators to optimize the combustion in the engine to meet lower NOx emissions while relying on the diesel particulate filter (DPF) to remediate the resulting higher PM emissions. This example of effective emission regulations provided a technology solution to overcome the traditional barriers of engine calibration. In 2010, another game changing technology was installed on most trucks in response to a further tightening of NOx limits. Selective catalytic reduction or SCR allowed calibrators to not only reduce the soot load on filters and soot regeneration as a way of improving fuel efficiency but also to take advantage of another well-known trade-off in combustion thermodynamics between fuel consumption, CO_2 and NOx emissions out of the engine.

Since 2010 the predominant technology to reduce NOx from diesel engines has been SCR, and every generation of SCR systems has led to improvements in catalyst conversion efficiency (a detailed discussion of SCR technology is provided below). The SCR system is just one technology option that has allowed engine and vehicle manufacturers to meet the first phase of heavy-duty GHG standards while still achieving NOx reduction targets from the engine. The portfolio of technology options that are available to reduce greenhouse gas emissions from heavy-duty trucks and engines is continually growing in response to tighter regulations. In fact, a review of heavy-duty engines certified in the U.S. from 2002 to 2017 shows that once emission and efficiency technologies were required on engines, after 2010, the relationship between CO_2 and NOx emissions at the tailpipe went from a trade-off to a benefit.

Figure 1 plots the certification level for NOx and CO_2 from heavy-duty engines over the last 15 years and several generations of emissions and efficiency technologies. The solid (filled) data points represent pre-2010 EPA certified engines while the non-filled data points represent 2010 and newer EPA certifications. To meet pre-2007 emission standards, on-engine NOx controls such as exhaust gas recirculation (EGR) were employed. DPFs were combined with EGR to meet the strict PM emission standard required starting in 2007. The 0.2 g/bhp-hr NOx standard was fully phased in by 2010, and SCR technology was added to all new heavy-duty on-road engines downstream of the engine, and OEMs began relying on the SCR system to remediate any excess NOx emissions as a result of calibration changes made to improve fuel economy. Beginning in 2014, EPA began regulating CO_2 (fuel consumption) from on-road heavy-duty engines. Setting stringent and aligned emission targets for both CO_2 and NOx through realistic regulations and expanding the calibrator's tool box from the engine to the powertrain allowed engineers to achieve both reduced NOx levels and engine efficiency improvements simultaneously. This is demonstrated by Figure 1, which shows that heavy-duty on-road engines certified since 2010, to the left of the inflection point in the curve, are meeting both lower NOx and lower CO_2 levels. In fact, several 2016 and 2017 engine families are achieving certification levels as low as 0.06 g/bhp-hr.

Figure 1: Heavy-Duty Engine Certification Levels for NOx and CO_2



Control of Black Carbon with Particulate Filters

It is estimated that 70% of the black carbon emissions from mobile sources are from diesel-fueled vehicles not equipped with DPFs, with the assumption that 40% of gasoline PM is black carbon and 60% of diesel PM is black carbon. The black carbon concentration and its global heating will decrease almost immediately after reduction of its emission. Black carbon from diesel vehicles can be significantly reduced through emission control technology that has been required on every heavy-duty diesel truck manufactured since 2007.

The ACES Phase 2 study that evaluated the PM emissions from 2010 technology heavy-duty engines showed that DPF-equipped engines emit PM at one to two orders of magnitude below the current standard of 0.01 g/bhp-hr and deliver over 99% PM capture efficiency over their lifetime. MECA encourages ARB to develop policies and/or incentives that reward vehicle and engine manufacturers for employing technologies such as particulate filters that provide significant reductions in mobile source black carbon emissions in sectors that don't already use them, such as unfiltered Tier 4 off-road engines and diesel engines less than 19 kW.

It is worth noting that stoichiometric, heavy-duty natural gas engines have been shown to emit large numbers of ultrafine particulates that are largely the result of the consumption of lubricant oil during the engine combustion process (see ARB's funded work published by West Virginia University on particle emissions from stoichiometric natural gas bus engines published in *Environmental Science & Technology* in June 2014). These stoichiometric heavy-duty engines are currently certified without filters due to their low particulate mass emissions. The mass of metal oxide ash particles from these natural gas engines were an order of magnitude greater than the mass of metal oxide ash emitted from a 2010 technology diesel engine equipped with a DPF and SCR system. The oxidative stress potential (OS) of the PM was also characterized in-vitro through DTT and ROS assays. High correlation coefficients were observed between the mass of lube oil-derived elemental species and both DTT and macrophage ROS, suggesting that the chemical species forcing oxidative stress are metallic in nature. The authors further suggest that, although the PM mass emissions from natural gas vehicles are low, the presence of nucleation mode solid metal particles could pose significant health risks in the alveolar regions of the respiratory system due to the higher surface area of these nanoparticles. In addition, MECA sponsored research at Southwest Research Institute to determine the characteristics of particle emissions from ultra-low NOx engines capable of meeting 0.02 g/bhp-hr. The authors concluded that an ultra-low NOx natural gas engine equipped with a three-way catalyst emits significantly more solid particles (2-5 times), primarily comprised of metal ash, than an ultra-low NOx diesel engine equipped with an SCR coated filter (SAE 2018-01-0362). Filters on these stoichiometric natural gas engines would significantly reduce the ultrafine particle emissions from these engines and provide additional climate and public health benefits. MECA encourages ARB to investigate the health and climate benefits of applying filters to these engines to reduce black carbon and ultrafine metal oxide exposure.

Heavy-Duty Glider Kits and Glider Vehicles

MECA strongly supports the requirement that the engines installed in glider vehicles meet the same criteria and GHG emission requirements as new engines certified in the same model year. Recently, EPA has signaled its intent to remove the glider requirements that were finalized in the final federal Phase 2 regulation. MECA opposes this change in course by the EPA and provided comments to that effect. MECA strongly supports ARB's decision to maintain glider provisions in the state of California if EPA decides to repeal the federal glider provisions.

Glider vehicles are marketed as "new motor vehicles" because they use a new chassis, although they currently can continue to use engines that are 15-20 years old. A November 15, 2017 EPA memo (Docket ID: EPA-HQ-OAR-2014-0827-2379) concluded that the engines installed in nearly all of these glider vehicles were certified to model year 1998-2002 engine standards. For reference, engines certified between 1998 and 2002 were only required to meet 4.0 g/bhp-hr NOx and 0.1 g/bhp-hr PM without the use of advanced aftertreatment or on-engine EGR. These NOx levels are 20 times higher than today's current NOx emission standard of 0.2 g/bhp-hr and 200 times higher than the California optional low-NOx standard of 0.02 g/bhp-hr. The PM levels are 10 times higher than today's 0.01 g/bhp-hr standard.

EPA also conducted emissions testing on two 2015 glider vehicles and compared the results to original equipment (OE) trucks of the same model year and similar characteristics (Docket ID: EPA-HQ-OAR-2014-0827-2417). The agency concluded the NOx, CO, THC, and PM emissions from the glider vehicles were significantly higher than the same model year OE tractors with newer engines over all test cycles. More specifically, the data presented in the document show that glider NOx emissions were 5-20 times higher and the glider PM emissions were up to 450 times higher than the MY2015 OE truck and engine. Similar trends were observed for hydrocarbon and carbon monoxide emissions. These data indicate that one glider vehicle has the potential to emit as much pollution as tens to hundreds of new trucks.

The existing loophole has stimulated the growth of glider truck sales by tenfold, detailed in the November 15, 2017 EPA memo referenced above, which also presented data from glider industry surveys. The memo concluded that the industry's sales have increased from 1,000 to 10,000 units between 2010 and 2015. As new engines become cleaner in the future the contribution from glider vehicles will continue to grow.

MECA recognizes that there are legitimate uses for glider kits. For example, if a truck chassis is damaged in an accident, an older engine in good condition can be salvaged and installed in a new chassis. To allow for these legitimate applications, EPA's Phase 2 regulation placed a reasonable 300 unit cap, per manufacturer, on glider kits with engines that do not meet the standards for the year of glider kit manufacture. This cap was determined based on a careful review of glider kit volumes by manufacturers in order to minimize the economic impact on the industry. Glider kit manufacturers are still able to sell unlimited numbers of glider trucks above this cap with engines that meet the latest standards. This 300 unit cap is supported in a 2013 article on glider vehicles in the online publication *Heavy-Duty Trucking* as a profitable volume of vehicles for glider manufacturers (http://www.truckinginfo.com/channel/equipment/article/story/2013/04/the-return-of-the-glider.aspx). This article also states that most glider buyers prefer engines without emission controls and explains why the most popular engines installed in gliders are from before 2002, even before EGR was installed on engines.

In its regulatory impact analysis for the Phase 2 rule, EPA estimated that the significant increase in the glider market could nearly double the emissions of NOx and PM2.5 from Class 8 trucks. An International Council on Clean Transportation (ICCT) analysis shows that the EPA proposal to repeal the glider kit sales cap will result in 3.5 times more cumulative NOx emissions from the class 7-8 truck sector over the next decade (https://www.theicct.org/blog/staff/glider-proposal-means-resurrecting-dirty-diesel). This analysis was based on the data obtained by EPA's survey of the industry (annual sales of 10,000 units in 2015 growing to 17,400 in 2027). As new engines become cleaner in the future, the contribution from glider vehicles will continue to grow. The emissions increase due to the allowance of glider sales is projected to be even greater if EPA sets a new low-NOx emission standard, which the agency and California have signaled will be a near term regulatory priority.

An unlimited exemption of glider vehicles from the current emission requirements would represent a huge loophole in the regulation. This loophole currently creates an uneven playing field that undermines the billions of dollars of investments that our companies have made to deliver the latest clean diesel technologies. As sales of gliders continue to climb, this increases the potential to erode the new engine and vehicle market, and that would, in turn, threaten tens of thousands of U.S. jobs for our companies. The glider kit and glider vehicle provision in the Phase 2 heavy-duty rule took an important step in closing the loophole that previously existed by limiting gliders produced with non-compliant engines beginning in 2018.

Methane Emissions from Stoichiometric Natural Gas Engines

Because methane is a potent climate forcing agent with Global Warming Potential (GWP) that is 25 times greater than CO_2 over a period of 100 years, we agree that consideration should be given to both upstream and downstream methane emissions from the growing fleet of natural gas trucks. EPA's Greenhouse Gas Reporting Program (GHGRP) is an important source for updating the upstream GHG inventories from the production and transportation of this alternate fuel. As the interest in natural gas as a transportation fuel grows, it leads to expansion of the fuel production and transportation infrastructure. MECA supports further regulation of methane emissions from natural gas production facilities because the upstream production, distribution and transportation of methane may be a significant contributor to the overall GHG contribution from this fuel sector.

MECA is a long supporter of technology and fuel neutral standards and we supported EPA's proposed provisions to control fugitive methane emissions from natural gas vehicles and engines as representing a fair and balanced approach to addressing the CO_2-equivalent emissions from the growing natural gas vehicle sector. Because of the low vapor pressure of this alternate fuel, the potential source of emissions goes beyond just the tailpipe. Similar to the case of evaporative emissions from gasoline vehicles, it is important to control the non-combustion related emissions from natural gas engines and fuel systems. While EPA proposed to require that all new natural gas-fueled engines have closed crankcases starting with MY 2021, and require a five-day hold time for new LNG vehicles (based on SAE standard J2343) to limit boil-off emissions, the agency did not finalize these requirements. MECA urges ARB to include provisions in California's Phase 2 regulation to limit the emissions of methane from natural gas vehicles. MECA supports the reclassification, starting in 2021 under Phase 2, of natural gas engines according to their primary intended service classes, similar to compression ignition engines. Although MECA lacks the expertise in suggesting the life cycle climate impacts, a number of ongoing studies by California, EPA and others may provide additional insight into how this may be done in the near future. California's Low Carbon Fuel Standard provides methodology that producers may employ to revise climate impacts of newly developed production pathways and this may serve as a model of how that may be done for upstream methane emissions. If natural gas truck applications continue to grow, as some market analysts predict, ARB should consider developing a separate set of GHG standards that better reflect the full life cycle emissions of natural gas vehicles including leakage and upstream emissions.

SUMMARY

The transportation sector is a major source of California's GHG emissions, and these emissions are forecast to continue increasing rapidly, reflecting the anticipated impact of factors such as economic growth, increased movement of freight by trucks, ships, and rail, and continued growth in personal travel. There are significant opportunities to reduce greenhouse gas emissions from the transportation sector through the design of fuel efficient powertrains that include advanced exhaust emission controls for meeting even the most stringent criteria pollutant standards. These emission control technologies allow all high efficiency powertrains to compete in the marketplace by enabling these powertrains to meet current and future criteria pollutant standards. Similarly, experimental or developmental engine efficiency technologies rely on a stringent set of CO_2 standards and incentives or advanced technology credits to penetrate the market. Credit opportunities offered under the Phase 1 program should be extended in the final Phase 2 rule.

The engine certification levels for criteria pollutants and CO_2 since 2010 demonstrate that these fuel-efficient powertrain designs, combined with appropriate emission controls and efficiency technologies, can be optimized to improve overall CO_2 emissions of the vehicle while also achieving ultra-low NOx and other criteria pollutant emissions. This optimization extends beyond carbon dioxide emissions to include other significant greenhouse gases such as methane and nitrous oxide.

Diesel particulate filters are extremely effective at removing black carbon emissions from diesel engines. Effective climate change policies should include programs and incentives aimed at reducing black carbon emissions from unfiltered new off-road engines and new gasoline and natural gas on-road heavy-duty engines, which have been found to emit high numbers of particles. In addition, ARB should continue to control black carbon and PM emissions from existing heavy-duty engines through effective retrofit programs that implement filters on the full range of in-use engines, regardless of fuel, operating in California.

In conclusion, MECA commends California for proposing to reduce greenhouse gas emissions by largely harmonizing with federal heavy-duty Phase 2 GHG emission standards. MECA believes that a wide variety of advanced powertrain options are available for reducing carbon dioxide emissions from these vehicles and engines. Our industry is prepared to do its part and deliver cost-effective advanced emission control and efficiency technologies to the heavy-duty sector to assist in achieving lower greenhouse gas emissions, while also meeting future reductions in NOx and other criteria pollutants.

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