STATEMENT
OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED RULEMAKING ON GREENHOUSE GAS EMISSIONS STANDARDS AND FUEL EFFICIENCY STANDARDS FOR MEDIUM- AND HEAVY-DUTY ENGINES AND VEHICLES

DOCKET ID NO. EPA-HQ-OAR-2010-0162

January 25, 2011

The Manufacturers of Emission Controls Association (MECA) is pleased to provide comments in support of the U.S. EPA's proposed rulemaking to establish medium- and heavy-duty greenhouse gas emission standards and corporate average fuel economy standards. We believe an important opportunity exists to significantly reduce greenhouse gas emissions and improve fuel economy from medium- and heavy-duty engines and vehicles.

MECA is a non-profit association of the world's leading manufacturers of emission control technology for mobile sources. Our members have over 35 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 emission controls for gasoline and diesel light-duty vehicles in all world markets. Our industry has played an important role in the emissions success story associated with light-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.

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%. Emissions from the transportation sector contribute about 33% of the CO_2 emissions in the U.S. and accounts for 96% of the radiative-forcing effect from transportation sources. A majority of anthropogenic CO_2 emissions come from combustion of fossil fuels. Despite improvements in vehicle engine efficiency, transportation energy use is expected to grow by 48% between 2003 and 2025. As such, controlling greenhouse gas emissions from the transportation sector is essential to the overall efforts to alleviate long-term impacts on the climate.

There are 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. Our comments focus on available exhaust emission control technologies and the impacts these technologies can have on greenhouse gas emissions.

AVAILABLE TECHNOLOGIES TO REDUCE MOBILE SOURCE GHG EMISSIONS

Carbon Dioxide (CO_2)

As the largest source of U.S. greenhouse gas emission, CO_2 from fossil fuel combustion has accounted for approximately 79% of global warming potential (GWP)-weighted emissions since 1990, growing slowly from 77% of total GWP-weighted emissions in 1990 to 80% in 2006. Of the total, transportation activities accounted for 33% of CO_2 emissions from fossil fuel combustion in 2006. The overall rise in U.S. GHG emissions primarily reflects increased emissions of CO_2 as a result of increasing fossil fuel combustion. Over 60% of the CO_2 emissions resulted from gasoline consumption for personal vehicle use and the remaining emissions came from other transportation activities, including combustion of diesel fuel in heavy-duty vehicles. In 2003, about 81% of transportation GHG emissions in the U.S. came from on-road vehicles, with light-duty vehicles accounting for 62% of total transportation emissions. Heavy-duty vehicles were responsible for 19% of total transportation emissions and nonroad vehicles accounted for 16% of all transportation GHG emissions in 2003. There are a large set of technology combinations that are 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.

Implicit in federal and state greenhouse gas emission analyses is the ability of these advanced powertrain options to meet the applicable criteria pollutant emission standards, such as CO, NOx, and non-methane organic gases (NMOG). All of these advanced, light-duty powertrain options combined with the appropriately designed and optimized emission control technologies can meet all current and future federal and state criteria emission requirements. In this manner, advanced emission controls for criteria pollutants enable advanced powertrains to also be viable options for reducing greenhouse gas emissions. 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 that can be applied to both light-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 powertrains can be achieved with minimal impacts on overall fuel consumption.

Significant criteria emission reductions from diesel vehicles can be achieved through the use of several technologies, including:

Diesel Particulate Filters (DPFs)

Diesel particulate filters (DPFs) remove particulate matter in diesel exhaust by filtering exhaust from the engine. High efficiency DPFs can achieve up to, and in some cases, greater than, 90% reduction in diesel particulate matter (PM). The basis for the design of wall-flow particulate filters is a ceramic honeycomb structure with alternate channels plugged at opposite ends. As the gases pass into the open end of a channel, the plug at the opposite end forces the gases through the porous wall of the honeycomb channel and out through the neighboring channel. The porous wall and the filter cake of particulate matter that forms within and on the surface of the wall serve as the filter media for particulates. Since the filter can fill up over time by developing a layer of retained particles on the inside surface of the porous wall, the accumulated particles must be burned off or removed to regenerate the filter. This regeneration process can be accomplished with a variety of methods including both active strategies that rely on generating external sources of heat (e.g., fuel burners, fuel dosing strategies that utilize fuel combustion over a catalyst, electrical elements, intake air throttling) and passive strategies that utilize catalysts that are displayed directly on the filter element or upstream of the filter.

In addition to wall-flow ceramic particulate filters, exhaust filters are also available based on metal substrates that utilize sintered metal filtering elements and tortuous flow paths for directing the particulate-containing exhaust gases through the sintered filter element.

Nearly all new heavy-duty highway diesel engines starting with the 2007 model year in the U.S. are equipped with diesel particulate filters to comply with EPA emission standards for diesel PM.

Selective Catalytic Reduction (SCR) and Lean NOx Adsorber Catalysts for Diesel Engines

Selective catalytic reduction (SCR), lean NOx adsorber catalysts, and combinations of these two technologies can be used to significantly reduce NOx emissions from diesel vehicles. SCR system uses a chemical reductant, usually a urea/water solution, to convert nitrogen oxides to molecular nitrogen and oxygen-rich exhaust streams like those encountered with diesel engines. Upon thermal decomposition in the exhaust, urea decomposes to ammonia which serves as the reductant. As exhaust and reductant pass over the SCR catalyst, chemical reactions occur that reduce NOx emissions to nitrogen and water.

Lean NOx adsorber catalysts have characteristics similar to the catalytic converters used on gasoline, stoichiometric engines but with the addition of materials that adsorb NOx under typical lean engine operations. As the lean NOx adsorber catalyst fills up with adsorbed NOx, a short oxygen deficient or fuel rich regeneration cycle is needed to displace the adsorbed NOx and reduce the NOx over available precious metal catalyst sites using hydrocarbon and CO reductants that are available during this rich regeneration step. These lean NOx adsorber catalysts can also adsorb SOx species that may be present in the exhaust and therefore require ultra-low sulfur levels in the fuel to maximize their performance for reducing NOx. In addition to frequent short NOx adsorber regeneration cycles, these catalysts must also be less frequently purged of adsorbed sulfur species.

SCR catalyst and lean NOx adsorber catalysts for diesel combustion strategies are capable of reducing NOx emissions from 70 to 90%. SCR catalysts are already widely used on late model trucks operating in Europe to control NOx (> 500,000 trucks) and will be used by most heavy-duty engine manufacturers to comply with EPA's 2010 heavy-duty, on-road NOx emission standards. In 2005, SCR using a urea-based reductant was introduced on a large number of on-road diesel heavy-duty engines to help meet the Euro 4 heavy-duty NOx emission standards. More than 200,000 new heavy-duty truck engines are now operating in Europe equipped with SCR systems that use urea as the reductant for reducing NOx emissions. SCR systems are also being used on some new heavy-duty trucks to comply with Japan's 2005 heavy-duty diesel engine emissions standards. The 2007 Dodge Ram pick-up, powered by a Cummins diesel engine, became the first heavy-duty vehicle to meet EPA's 2010 on-road, heavy-duty emission standards (three years in advance of the 2010 standards) by using an advanced emission control system that featured a diesel particulate filter and a lean NOx adsorber catalyst. Applying SCR to diesel-powered engines provides simultaneous reductions of NOx, PM, and HC emissions. In addition to reductions in criteria pollutants, SCR applications on heavy-duty trucks allows engine manufacturers to further optimize and reduce fuel consumption of these engines, providing important reductions in greenhouse gas emissions.

Gasoline Direct Injection Technology

For gasoline vehicles, direct injection technology enables gasoline engines to achieve greater fuel efficiency. In a gasoline direct injection engine, gasoline is directly injected into the cylinder the same way as in a diesel engine. Gasoline direct injection permits more fine-tuned control of the amount of fuel injected as well as control of injection timing independently from valve timing. Gasoline direct injection engines can reduce CO_2 emissions in a number of ways, including better "breathing" efficiency, higher compression ratio, the potential for lean operation and reduction of pumping losses. Gasoline direct injection offers CO_2 emissions reductions ranging from 5% to 20% depending on how it is implemented and the base engine to which it is compared. Again emissions controls ensure that these more fuel efficient gasoline engines meet tough EPA or ARB criteria emission regulations:

- Under stoichiometric conditions, a three-way catalyst can significantly reduce emissions of NOx, HC and CO. The use of three-way catalyst allows for simultaneous conversion of HC, CO, and NOx produced during the combustion of fuel in a spark-ignited engine. Three-way catalyst reduces these air pollutants by up to 99+ percent. The active catalytic materials are present as thin materials on the internal walls of a ceramic or metallic honeycomb substrate. The substrate typically provides a large number of parallel flow channels to allow for sufficient contact area between the exhaust gas and the active catalytic materials without creating excess pressure losses. In 2005, 100% of new cars sold in the U.S. were equipped with a catalytic converter, and worldwide over 90% of new gasoline cars sold had a catalyst.

- 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.

As stated previously, lean NOx adsorber catalyst performance has a high degree of sensitivity to fuel sulfur levels. The current EPA fuel sulfur limits for gasoline (30 ppm average, 80 ppm cap) are too high to allow lean NOx adsorber catalysts to be a viable NOx control strategy for fuel efficient, gasoline lean-burn engines that employ direct fuel injection technology. EPA should seriously consider lowering gasoline fuel sulfur limits to allow NOx adsorber catalysts to be used on such vehicles in order to provide additional options for improving the efficiency and reducing greenhouse gas emissions from gasoline vehicles. NOx adsorber catalysts are already commercially used on gasoline lean-burn light-duty vehicles in Europe and Japan because these markets have gasoline fuel sulfur levels available with a maximum sulfur limit of 10 ppm. California will begin to enforce a 20 ppm fuel sulfur cap on gasoline beginning in 2012 and EPA should consider a similar fuel sulfur cap for the rest of the U.S. in this same timeframe.

The current generation of direct injection gasoline engines is known to have higher PM emissions compared to port injected gasoline engines. Manufacturers are currently working with auto manufacturers on evaluating the potential for lowering PM emissions from direct injection gasoline engines through the use of gasoline particulate filter technologies. Gasoline particulate filter technologies make use of the same filter substrate technologies that have been commercialized for diesel engine PM control applications. Current development activities of gasoline particulate filters (GPFs) are aimed at quantifying their PM capturing efficiency, ensuring the regeneration of these filters for long term performance and durability, and minimizing the backpressure of such filters within the exhaust system. MECA believes that gasoline particulate filters will be a viable technology option for reducing the PM emissions from direct injection gasoline engines in order to ensure that these fuel efficient gasoline engines have PM emissions that are comparable with diesel powertrains that make use of particulate filters or today's best port injected gasoline engines.

Diesel-electric and gasoline-electric hybrid vehicles, that combine either a diesel or gasoline engine with elements of an electric-drive powertrain, offer a range of CO_2 emission reduction possibilities, and again advanced emission controls allow these powertrains to meet even the toughest criteria emission regulations.

Emission controls for gasoline and diesel engines are also generally compatible with low carbon, alternative fuels (e.g., gasoline blends with renewable ethanol or biodiesel blends) that can provide additional reductions in mobile source greenhouse gas emissions. Engine operating strategies and emission control catalyst formulations, however, often need to be optimized depending on fuel composition to ensure that criteria pollutant emissions or other air toxic emissions are minimized. It is also important that specifications associated with any low carbon fuel should be compatible with the use of available exhaust emission control technologies.

Black Carbon

Black carbon is a major component of particulate matter emissions from mobile sources and is believed to have a significant net atmospheric warming effect by enhancing the absorption of sunlight. Black carbon is a mix of elemental and organic carbon emitted by fossil fuel combustion, bio-mass burning, and bio-fuel cooking as soot. Black carbon is a dominant absorber of visible solar radiation in the atmosphere. Anthropogenic sources of black carbon are transported over long distances and are most concentrated in the tropics where solar irradiance is highest. Because of the combination of high absorption, a regional distribution roughly aligned with solar irradiance, and the capacity to form widespread atmospheric brown clouds in a mixture with other aerosols, emissions of black carbon are thought to be the second strongest contribution to current climate change, after CO_2 emissions.

According to scientists at the Scripps Institute of Oceanography and University of Iowa, soot and other forms of black carbon could have as much as 60% of the current global warming effect of carbon dioxide. Black carbon plays a major role in the dimming of the surface and a correspondingly large solar heating of the atmosphere. For example, the retreat of the Himalayan-Hindu Kush glaciers is one of the major environmental problems facing the Asian region. The glacier retreat has accelerated since the 1970s and several scientists have speculated that solar heating by soot in atmospheric brown clouds and deposition of dark soot over bright snow surfaces may be an important contributing factor for the acceleration of glacier retreat. A recent study published in a 2009 issue of *Nature Geoscience* (vol. 2, 2009) by researchers from the NASA Goddard Institute and Columbia University found that black carbon is responsible for 50% of the total Arctic warming observed from 1890 to 2007 (most of the observed Arctic warming over this timeframe occurred from 1976 to 2007).

It is estimated that 70% of the black carbon emissions from mobile sources are from diesel-fueled vehicles, with the assumption that 40% of gasoline PM is black carbon and 60% of diesel PM is black carbon. Up to 25% of the carbon footprint of a heavy-duty diesel truck is associated with black carbon exhaust emissions. Since black carbon particles only remain airborne for weeks at most compared to carbon dioxide, which can remain in the atmosphere for more than a century, removing black carbon would have an immediate benefit to both global warming and public health. The black carbon concentration and its global heating will decrease almost immediately after reduction of its emission. For these reasons and the growing body of scientific evidence that links black carbon emissions with climate change, MECA believes that EPA should include black carbon emissions as part of its overall greenhouse gas emission control strategy.

Black carbon from diesel vehicles can be significantly reduced through emission control technology that is already commercially available. High efficiency diesel particulate filters (DPFs) on new and existing diesel engines provide nearly 99.9% reductions of carbon emissions. During the regeneration of DPFs, captured carbon is oxidized to CO_2 but this filter regeneration still results in a net climate change benefit since global warming potential of black carbon has been estimated to be as high as 4,500 times higher than that of CO_2 on a per gram of emission basis. To meet EPA's 2007 heavy-duty engine PM standards, essentially all new, on-road heavy-duty diesel engines are now equipped with high efficiency DPFs. It is estimated that the installation of DPFs will reduce PM emissions from U.S. heavy-duty diesel vehicles by 110,000 tons per year. Current California and EPA light-duty emission standards for diesel particulate matter also require the use of a high efficiency DPF on new light-duty diesel vehicles.

Because older diesel engines emit significant amounts of PM, there are also significant opportunities to reduce black carbon emissions through diesel retrofit programs that make use of retrofit DPF technology. The number of vehicles retrofitted, the number of programs, and the interest in new programs for DPFs have grown significantly over the past few years with more than 250,000 DPFs installed as retrofits to date in a variety of world markets. Retrofit filters can provide large benefits in human health through reductions in diesel PM and climate change benefits through reductions in black carbon emissions on both existing, on-road and off-road diesel engines. California has already tackled black carbon emissions from existing mobile sources through its ambitious Diesel Risk Reduction Plan and their associated regulatory initiatives that target the reduction of diesel particulate emissions from all existing diesel engines over the next ten to fifteen years. In most of these California regulatory programs existing diesel engines will need to be retrofit with high efficiency DPFs or replaced/repowered with engines that are equipped with high efficiency filters by OEMs. Similar regulatory programs could be implemented within other states or by EPA to reap the public health and climate change co-benefits associated with reductions in black carbon emissions. Incentive funding programs like California's Carl Moyer program or the federal Diesel Emission Reduction Act (DERA) also can be used as a strategy for mobile source retrofit programs at the state or federal level that target black carbon reductions. Incentive funds for filter retrofits might also be generated by a national greenhouse gas cap-and-trade program.

Nitrous Oxide (N_2O) and Methane (CH_4)

While total N_2O emissions are much lower than CO_2 emissions, N_2O is approximately 310 times more powerful than CO_2 at trapping heat in the atmosphere. One of the anthropogenic activities producing N_2O in the U.S. is fuel combustion in motor vehicles. In 2006, N_2O emissions from mobile source combustion were approximately 9% of total U.S. N_2O emissions. It is estimated that the N_2O emissions account for about 2% of the total GHG emissions from a typical light-duty vehicle. N_2O is emitted directly from motor vehicles and its formation is highly dependent on temperature and the type of emission control system used. Temperatures favorable for N_2O formation are achieved inside catalytic converter systems, especially during cold-start conditions when engine exhaust temperatures are lower.

Catalyst efficiency and age are also important factors in N_2O formation. At higher efficiencies and lower ages, N_2O formation is lower. In addition to direct N_2O emissions, NOx emissions from mobile and stationary sources have a significant impact on atmospheric N_2O levels. On late model light-duty gasoline vehicles, modern three-way catalyst-based emission control technology combined with effective cold-start engine calibration strategies are very effective at controlling vehicle nitrous oxide emissions. Light-duty vehicle N_2O emission tests results recently published by ARB and Environment Canada in *Atmospheric Environment* (vol. 43, 2009) indicate that vehicles certified to the lowest emission certification categories (e.g., certified to ARB's SULEV standards) also have extremely low N_2O emissions (in the range of 0.0-1.5 mg/km).

Tightening of hydrocarbon and NOx emission standards over time with the parallel introduction of more effective emission control systems have resulted in lower emissions of N_2O from today's vehicles compared to older vehicles certified to less stringent hydrocarbon and NOx standards. The performance of NOx emission control technologies for diesel vehicles such as SCR catalysts and lean NOx adsorber catalysts can also be optimized to minimize N_2O emissions from diesel engines.

According to the United Nation's International Panel on Climate Change (IPCC), methane is more than 20 times as effective as CO_2 at trapping heat in the atmosphere. Over the last 250 years, the concentration of CH_4 in the atmosphere has increased by 148%. Methane is a byproduct of imperfect fuel combustion. Methane emissions from mobile sources are emitted from exhaust from vehicles using hydrocarbon fuels, but the anthropogenic contribution of road transport to the global methane inventory is less than 0.5%. Emissions of CH_4 are a function of the type of fuel used, the design and tuning of the engine, the type of emission control system, the age of the vehicle, as well as other factors. Although CH_4 emissions from gasoline vehicles are small in terms of global warming potential when compared to N_2O emissions, they can be high in natural gas-fueled vehicles, as methane is the primary component of natural gas.

On medium- and heavy-duty gasoline vehicles, modern three-way catalyst-based emission control technology is effective at reducing all hydrocarbon exhaust emissions including methane. Tightening of hydrocarbon emission standards over time with the parallel introduction of more effective emission control systems have resulted in lower emissions of methane from today's vehicles compared to older vehicles certified to less stringent standards. Catalyst designs can also be optimized in concert with engine control strategies to oxidize methane exhaust emissions from motor vehicles, including vehicles that operate exclusively on natural gas or bi-fuel vehicles that can operate on either natural gas or gasoline.

Advanced gasoline and diesel powertrains for medium- and heavy-duty vehicles in conjunction with advanced emission control technologies can be optimized to minimize emissions of both N_2O and CH_4 emissions. In their proposal, EPA has included an emissions cap for both N_2O and CH_4 emissions (0.05 g/bhp-hr for each gas for tractors and vocational vehicles and 0.05 g/mi for each gas for pickups and vans) to ensure that climate change impacts of these two potent greenhouse gases are minimized on future medium- and heavy-duty vehicles. MECA believes that these emission caps are achievable with today's medium- and heavy-duty vehicle powertrain options and should be included in the final EPA regulations.

Ground-Level Ozone

There is a significant linkage between ground level ozone concentrations and climate change impacts. One example was detailed by a group of researchers from the United Kingdom in a 2007 *Nature* publication. In this work, ground-level ozone was shown to damage plant photosynthesis resulting in lower carbon dioxide uptake from plants that have been exposed to higher levels of ozone. Other studies have shown that increasing average annual temperatures are likely to result in even higher levels of ozone in the environment. Emission reductions aimed at lowering ambient ozone levels, such as lower emissions of volatile organic compounds

(VOCs) and NOx, will have a positive impact on climate change, as well as human health. Policies that aim to reduce ambient ozone levels may also become more necessary and important to either mitigate the climate change impacts of ground level ozone or to mitigate higher ozone levels that result from climate change.

SUMMARY

Looking ahead, transportation greenhouse gas 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. The transportation sector is the largest source of domestic CO_2 emissions, producing 33% of the nation's total in 2006. 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. MECA believes that advanced emission control systems have a critically important role in future policies that aim to reduce mobile source greenhouse gas emissions. 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. In nearly all cases, these fuel-efficient powertrain designs, combined with appropriate emission controls, can be optimized to either minimize fuel consumption impacts associated with the emission control technology, or, in some cases, improve overall fuel consumption of the vehicle. This optimization extends beyond carbon dioxide emissions to include other significant greenhouse gases such as methane and nitrous oxide. In the case of gasoline vehicles, additional climate change benefits could be obtained by lowering federal gasoline fuel sulfur levels to enable the use of lean NOx adsorber catalysts on gasoline lean-burn engines.

Diesel particulate filters are particularly effective at removing black carbon emissions from diesel engines and effective climate change policies should include programs aimed at reducing black carbon emissions from existing diesel engines through effective retrofit programs that implement filters on the full range of in-use diesel engines operating in the U.S.

Ground level ozone also has a strong linkage to climate change. EPA needs to continue its efforts to review and adjust criteria pollutant programs for all mobile sources going forward to not only provide needed health benefits from technology-forcing emission standards but also the co-benefits these emission standards have on climate change.

In conclusion, MECA commends EPA for taking important steps to reduce greenhouse gas emissions and improve fuel economy from medium- and heavy-duty vehicles. MECA believes that a 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 these cost-effective advanced emission control technologies to the market.

CONTACT:

Joseph Kubsh
Executive Director
Manufacturers of Emission Controls Association
2020 N. 14th Street
Suite 220
Arlington, VA 22201
Tel.: (202) 296-4797
E-mail: jkubsh@meca.org