**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 – PHASE 2**

DOCKET ID NO. EPA-HQ-OAR-2014-0827

September 25, 2015

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 for model years 2018 and beyond. We believe an important opportunity exists to continue to reduce greenhouse gas emissions and improve fuel economy 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 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 and efficiency technology for a wide variety of on-road and off-road gasoline and diesel fueled vehicles and equipment in all world markets. Now that regulated pollutants have been expanded to include CO_2, the portfolio of products offered by our members has expanded to 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.

Proposed Regulatory Structure and Stringency to Incentivize Efficiency Technologies

MECA supports the EPA proposed reductions in greenhouse gas emissions for the heavy-duty truck segment, and believes that the proposed reductions are technically feasible using technologies that are ready for deployment on trucks today. Numerous analyses have estimated greater potential reductions of CO_2 than will be achieved by this proposal suggesting that EPA's Alternative 4 may be the more realistic scenario. EPA's own analysis shows that the faster Alternative 4 implementation timeline provides nearly the same payback periods as the longer Alternative 3 implementation timeline. The Department of Energy's SuperTruck program has demonstrated the magnitude of reductions that engine and vehicle technologies can deliver. A 2024 final implementation date, under Alternative 4, would allow developmental technologies to be optimized and ready for deployment under future, Phase 3 heavy-duty GHG standards to achieve the full potential reductions that exist from this transportation sector. We urge EPA to finalize a set of stringent Phase 2 standards that 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. At a minimum, MECA is supportive of a final rule with a 2024 final phase-in date.

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. Technologies, like turbo-compounding and advanced air management strategies are already being commercialized in Europe whereas others such as Rankine cycle systems and advanced high pressure injection, are under demonstration and technologies with still longer term horizons, such as thermoelectric generators are still in the laboratory. MECA members estimate that using the proposed Alternative 3, 2027 engine efficiency standards, some of these technologies, such as waste heat recovery, will fall significantly short of the penetration rates forecasted in the proposal. 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.

In the absence of sufficiently stringent standards innovative technologies depend on incentives to achieve initial market penetration. 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. We urge EPA to include the advanced technology credits, which were part of the first phase of these regulations, in the final Phase 2 regulation. These credits would help to support continued 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 EPA's 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 insure 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 CO_2 reductions are verifiable and future OBD systems can be used to insure reductions over the life of the vehicle. The proposal 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 EPA to develop methodologies and policies that insure 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

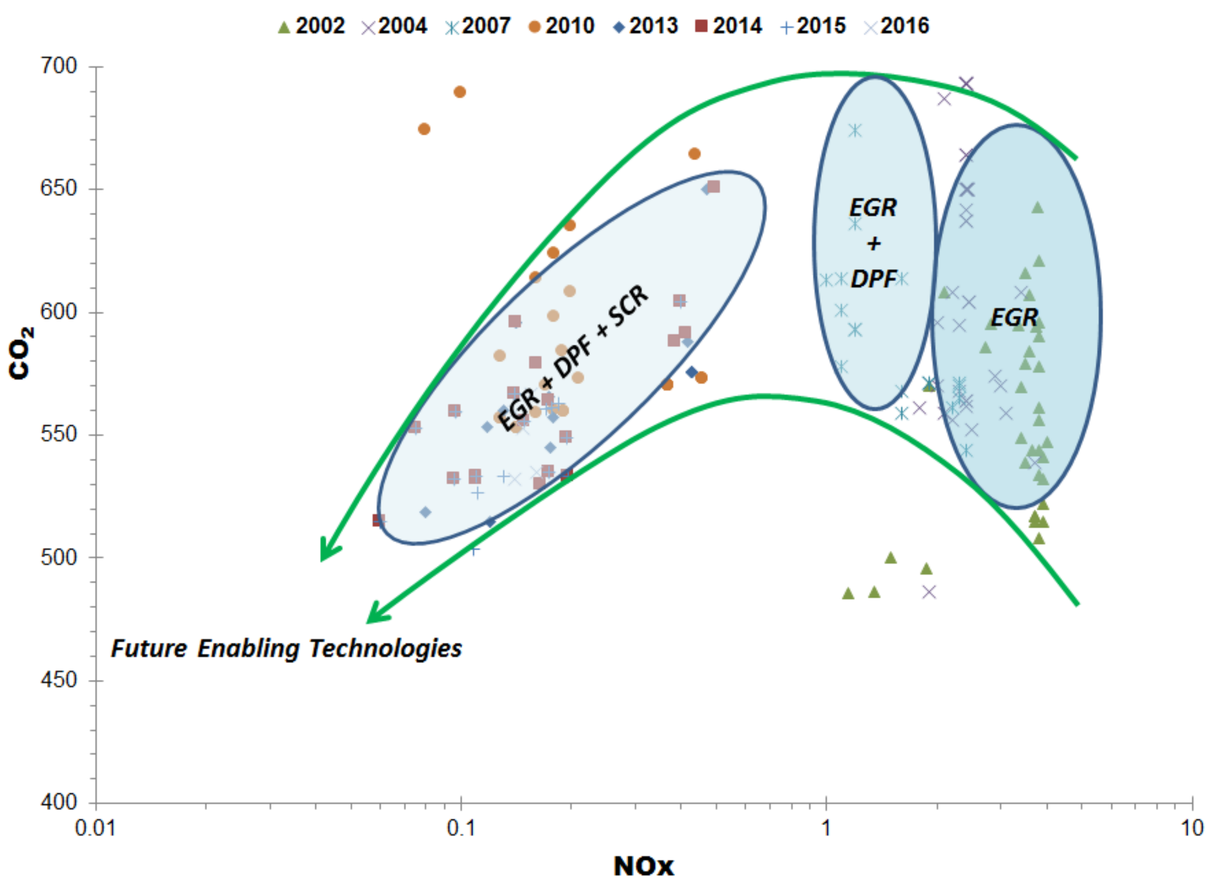
There is a significant linkage between ground level ozone concentrations and climate change impacts. One example was detailed by a group of researchers from the United Kingdom in a 2007 *Nature* publication. In this work, ground-level ozone was shown to damage plant photosynthesis resulting in lower carbon dioxide uptake from plants that have been exposed to higher levels of ozone. Other studies have shown that increasing average annual temperatures, resulting from climate change, are likely to result in even higher levels of ozone in the environment. Emission reductions aimed at lowering emissions of the primary precursors of ozone such as volatile organic compounds (VOCs) and NOx, will have a positive impact on lower ambient ozone levels, 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. 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. These states are concerned about GHG emissions as well as NOx from mobile sources such as heavy-duty engines since the mobile sector represent 50-80% of their NOx inventory. 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, 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. In this manner, advanced emission controls for criteria pollutants enable advanced powertrains to also be viable options for reducing greenhouse gas emissions.

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 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 set by U.S. EPA and the California Air Resources Board. In fact, a review of heavy-duty engine certifications from 2002 to 2015 shows that once emission and efficiency technologies were required on engines, the relationship between CO_2 and NOx emissions at the tailpipe went from a trade-off to a benefit (see Figure 1 below). By setting stringent 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. Figure 1 plots the certification level for NOx and CO_2 from heavy-duty engines over the last 14 years and several generations of emissions technology.

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



Selective Catalytic Reduction (SCR) Catalysts for Diesel Engines

Selective catalytic reduction (SCR), catalysts have been used to significantly reduce NOx emissions from lean combustion engines for decades. The SCR system uses a chemical reductant, usually a urea/water solution, or other ammonia sources (e.g., solid urea or metal chloride amines), to convert nitrogen oxides to molecular nitrogen and oxygen-rich exhaust streams across a suitable catalyst. Upon thermal hydrolysis and decomposition in the exhaust, urea forms CO_2, water and ammonia which serves as the reductant for NOx over the catalyst. As exhaust and reductant pass over the SCR catalyst, chemical reactions occur that reduce NOx emissions to nitrogen and water.

SCR catalyst can achieve over 98% NOx conversion in hot operation and over 70% during the cold-start portion of the heavy-duty transient test cycle. SCR catalysts are used on medium and heavy-duty engines around the world to achieve low NOx emission regulations. 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 allow engine manufacturers to further optimize and reduce fuel consumption of these engines through calibration optimization, in-turn providing important reductions in greenhouse gas emissions.

SCR applications on new highway, heavy-duty trucks in both Europe and the U.S. have already been shown to allow engine manufacturers the possibilities of calibrating engines for lower fuel consumption (and lower greenhouse gas emissions), while still meeting applicable NOx emission standards. Engine manufacturers that employed SCR technologies on 2010-compliant heavy-duty, highway engines in the U.S. claimed up to 5% improvements in fuel efficiency vs. engines that did not employ SCR technology. These fuel efficiency improvements are most evident at highway speeds, however in the future, employing thermal management strategies can shorten the warm-up portion of the cold start and facilitate urea injection earlier in the test cycle and thus expand the calibration optimization window to further reduce CO_2 emissions. The high NOx conversion efficiencies associated with SCR catalysts enable engines to be operated at conditions that yield lower fuel consumption. Engine manufacturers are expected to continue to further optimize engine fuel consumption characteristics and SCR system designs to assist in achieving the reductions proposed by EPA under this regulation. One example of future improvements in SCR catalyst system designs on heavy-duty engines is the direct application of SCR catalysts to diesel particulate filter substrates to provide a single catalyst module that provides reductions to all four criteria pollutants: hydrocarbons, CO, NOx, and PM. By deploying the SCR catalyst onto the filter moves the catalyst closer to the engine for faster warm-up, thus allowing earlier urea dosing. These SCR coated filters are already commercialized on several light-duty diesel passenger car models and are expected on heavy-duty highway and off-road engines in the near future. Beyond SCR, a number of other technology advances will facilitate significant criteria emission reductions, efficiency gains and reductions of short lived climate pollutants.

One such technology that has evolved specifically to address NOx emitted at low exhaust temperatures, includes a family of new materials referred to as passive NOx adsorbers (PNA). This catalyst technology is used upstream of the traditional exhaust control system, in combination with the DOC, to trap and store NOx at temperatures below 200^{o}C before urea can be dosed into the hot exhaust. Once the exhaust temperature is sufficient for SCR catalysts to convert NOx to nitrogen, and to allow the urea dosing system to be activated, the NOx stored on the PNA begins to desorb so it can be converted by the ammonia reductant over the SCR catalyst. This emerging technology will be one of the strategies available to engine and vehicle manufacturers to achieve lower cold-start tailpipe NOx levels.

The Advanced Collaborative Emissions Study (ACES) Phase 2 report published in 2012 showed that modern heavy-duty engines are achieving PM and NOx levels well below the federal standards. Recognizing the capability of technologies to deliver complimentary reductions of NOx and GHGs, California has adopted voluntary low NOx standards to incentivize development of state-of-the-art engines and emission controls to achieve NOx levels as low as 0.02 g/bhp-hr which is equivalent to a 90% reduction from EPA’s 2010 highway, heavy-duty engine standards. Certification of cleaner engines ahead of proposing mandatory standards opens up opportunities for the state to direct incentive funds toward the development of cleaner engines. To support their regulatory efforts, ARB is funding a technology demonstration test program at Southwest Research Institute to demonstrate the feasibility to further reduce NOx emissions from heavy-duty engines. Advanced emission technologies like SCR coated filters and passive NOx adsorbers are included in this demonstration test program. EPA is monitoring this important test program as a member of the program's advisory committee.

To estimate the achievable level of NOx inventory reduction through the deployment of technologies capable of achieving a 90% NOx reduction below 2010 levels in the lower 47 states (excluding California), MECA funded an independent emission inventory forecast study, at ENVIRON. This analysis relied on EPA's MOVES2014 emissions inventory model for on-road vehicle emissions to estimate the future NOx reduction potential of a 0.02 g/bhp-hr heavy-duty NOx standard under a federal program. By-model-year emissions were determined for on-road vehicles to develop emissions estimates with and without new potential future emission standards. The model was run to generate emission inventories of NOx, VOC, CO and PM for on-road heavy-duty sources for calendar years 2025, 2030, 2040, and 2050.

When fully implemented, the achievable reductions from tighter NOx regulations on the heavy-duty on-road sector are estimated to be 266,000 tons per year or 730 tons per day in 2050 across the 47 contiguous United States and D.C., excluding California. We believe that these heavy-duty control measures represent the largest opportunity for achieving NOx reductions from the mobile sector going forward. We estimated the incremental cost of the types of additional emission controls that would be necessary to achieve the target reductions from heavy-duty trucks, beyond the exhaust controls already being used to meet current 2010 heavy-duty on-road standards at approximately $500 per vehicle averaged over the medium and heavy-duty highway fleet. Based on the results of our analysis, we estimate that heavy-duty trucks can deliver NOx reductions at a cost of approximately $3,000-$4,000 per ton. The very cost-effective NOx reductions available from the heavy-duty highway sector reflect the continued evolution of diesel exhaust emission controls. It has been more than 15 years since EPA closely examined diesel emission technologies as part of finalizing their 2007-2010 heavy-duty highway engine standards. Manufacturers of these technologies have and continue to improve the base technologies used to control NOx and PM from diesel engines. Significant experience has been provided by commercial roll-out of heavy-duty engines equipped with DPFs and SCR catalyst systems in this sector since 2007. These evolutionary improvements provide the pathway to achieving additional significant, cost-effective NOx reductions from this sector.

MECA believes that further reductions in NOx emissions from new heavy-duty on-road and off-road diesel engines beyond the 2010 on-road and Tier 4 off-road requirements will be possible through the combinations of more advanced diesel engines with advanced diesel exhaust emission control technologies. Much of the system development necessary to meet lower NOx emissions will be focused on the initial cold-start portion of the heavy-duty transient FTP test cycle representing approximately 70% of the total NOx emissions over the entire cycle. The types of future evolutionary technologies deployed, to achieve a future lower NOx standard, will likely include advanced substrates, improved SCR catalysts, more efficient SCR reductant delivery technologies and algorithms, and/or passive NOx adsorber catalysts. Substrate mounting matt materials have also evolved through newer technology generations including innovative, insulating intumescent canning materials that retain heat in the catalyst during periods of engine shutdown. The emission reduction benefits achieved through the deployment of cold start technologies such as advanced thermal management strategies, close-coupled catalysts, low thermal mass materials, improved ammonia dosing strategies among others will extend to increased conversion during low temperature duty-cycle operations. Already in several commercial light-duty diesel applications, higher porosity within the ceramic filter walls has allowed SCR catalyst to be deposited directly onto the DPF and thereby effectively moving the SCR closer to the turbocharger outlet in a more close-coupled position. Faster heat-up of the SCR catalyst has allowed earlier ammonia injection and NOx reduction. The sooner the SCR catalyst is activated in the test cycle, engine calibrators can optimize combustion for reduced CO_2 emissions. Furthermore, these cold-start technologies will allow vehicle manufacturers to deploy hybrid systems, stop-start technologies and waste heat recovery to improve vehicle efficiency while still meeting tighter NOx limits.

MECA believes the time is right for EPA to begin a rulemaking effort aimed at further significant reductions in NOx emissions from heavy-duty highway engines. Improved NOx reduction technologies are available today to deliver ultra-low NOx emissions from these engines. Existing and future ozone non-attainment regions will need these cost-effective NOx reductions to support attainment plans. Engine manufacturers can combine these advanced NOx emission controls with other efficiency technologies to optimize future truck performance to deliver both lower NOx emissions and improved fuel efficiency.

Nitrous Oxide (N_2O)

While total N_2O emissions are much lower than CO_2 emissions, N_2O is approximately 298 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. N_2O is emitted directly from motor vehicles and its formation is highly dependent on temperature, NO_2 to NOx ratio entering the SCR catalyst, ammonia to NOx ratio, the SCR catalyst formulation and the temperature of the catalyst over the test cycle. Temperatures favorable for N_2O formation (approximately 250^o C) are achieved inside catalytic converter systems, especially during cold-start conditions when engine exhaust temperatures are lower.

EPA is proposing to tighten the N_2O cap and deterioration factor by 50% from 100 mg/bhp-hr to 50 mg/bhp-hr and 20 mg/bhp-hr to 10 mg/bhp-hr, respectively. This is to ensure that climate change impacts of this potent greenhouse gas are minimized on future medium- and heavy-duty vehicles. Furthermore because 75% of engine families certified in 2014 already meet a 50 mg/bhp-hr N_2O level, the agency is concerned that engine manufacturers may emit higher levels in the future as they optimize the overall CO_2 emissions of engines. EPA estimates that a 40 mg/bhp-hr N_2O emission reduction has the CO_2 equivalent climate impact of a 2.6% improvement in engine efficiency. Although MECA members believe that meeting the proposed N_2O levels will be achievable, it will be challenging given the types of engine developments that we expect to see in the future. In particular we expect that future engines will have higher engine-out NOx levels in the exhaust as a way of achieving lower CO_2 levels. Furthermore, overall cooler exhaust temperatures may be expected as a result of efficiency technologies such as turbo-compounding being deployed upstream of the exhaust emission control system. Furthermore, it is important to consider N_2O emissions in-light of future regulations such as the 0.02 g/bhp-hr heavy-duty NOx standard under consideration by California. Below, we discuss the primary formation mechanisms for N_2O and some approaches that may be used in the future to achieve lower levels of N_2O emissions on future diesel engines.

At low temperatures, around 250^{o} C, the predominant mechanism for N_2O formation is by the decomposition of ammonium nitrate, whereas at high temperatures, above 500^{0} C, the primary mechanism is ammonia oxidation. Nitrous oxide can form at intermediate temperatures (300-350^{0} C) if the NO_2 to NOx ratio exceeds 50%. Excess ammonia injection across the SCR catalyst can also lead to an increase in N_2O formation if the ammonia to NOx ratio exceeds 1.0. A recent study published by the Society of Automotive Engineers (SAE Technical Paper 2013-01-2463) concluded that the test cycle, cycle exhaust temperature, system design and urea injection calibration all play a role in the formation of N_2O on the SCR catalyst. The authors observed that the inlet conditions of the SCR catalyst had the greatest effect on the formation of nitrous oxide.

Another SAE technical paper (2015-01-0997) studied the effect of SCR catalyst type on the formation of N_2O. The authors observed that the lowest N_2O emissions were observed from a vanadia/titania SCR and Cu-zeolite SCR systems. Furthermore the Cu-zeolite SCR exhibited little deactivation after aging. The authors found that the system design, linear versus muffler, can impact the overall NOx performance and N_2O emissions as a result of the average temperature of the SCR catalyst in each configuration relative to the optimal temperature for N_2O formation. Upstream components such as the DOC and DPF can also impact the N_2O levels based on their relative activity to form higher NO_2/NOx ratio feedgas to the SCR. The authors of this paper discuss ways to formulate the precious metal composition and loading on the DOC and DPF to minimize their contribution to N_2O formation while still maintaining high NOx conversion efficiency. For all SCR systems, the N_2O emissions could be reduced by tighter urea dosing control to limit excess ammonia, by targeting an optimal amount of ammonia storage in the SCR catalyst and reducing engine-out NOx.

In another recent paper published at the 2015 SAE Congress (SAE paper Number 2015-01-1030), the authors looked at ways to design the SCR catalyst architecture to target lower N_2O emissions from the system. Because the front part of the SCR catalyst is more prone to form N_2O, the authors looked at coating the front of the SCR substrate with a vanadia-SCR formulation and the rear of the substrate with a standard Cu-zeolite SCR. Further optimization may be possible through the use of modeling tools to identify the SCR formulation and coating volume combinations that minimize N_2O emissions and maximize NOx conversion.

Advanced gasoline and diesel powertrains for medium- and heavy-duty vehicles in conjunction with advanced emission control technologies can be optimized to minimize N_2O emissions. Catalyst manufactures can utilize a number of approaches to reduce N_2O emissions from the exhaust emission control components and therefore MECA believes that the proposed N_2O emission cap is achievable with the use of appropriately designed emission controls on today's medium- and heavy-duty powertrain options. The proposal further provides manufacturers with the flexibility of meeting emission caps or factoring in emissions of N_2O or

CH_4 into the CO_2-equivalent emissions calculation of the overall vehicle. MECA supports continuing this proposed flexibility introduced under Phase 1 of this regulation.

Control of Black Carbon with Particulate Filters

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, in the form of soot, emitted by fossil fuel combustion, bio-mass burning, and bio-fuel cooking. 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. 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 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. 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 U.S. heavy-duty diesel truck manufactured since 2007. 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. 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 the global warming potential of black carbon has been estimated to be as high as 2,200 times higher than that of CO_2 on a per gram of emission basis. It is estimated that the installation of DPFs has reduced PM emissions from U.S. heavy-duty diesel vehicles by 110,000 tons per year. 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 EPA 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.

Control of PM from Auxiliary Power Units

Auxiliary power units or APUs are used on heavy-duty trucks during "hoteling" at truck stops or other suitable rest areas. During long periods of idling, the APU provides power to auxiliary systems such as cabin electricity and air conditioning so that the main truck engine can be turned off. Because APUs have diesel engines less than 10 horsepower, they burn less fuel than the main engine and thus reduce CO_2 emissions. Under Tier 4 standards, the small displacement of these engines allows them to operate without exhaust emission controls such as diesel particulate filters and as a result they emit 5-10 times more PM emissions than the much larger displacement but filter-equipped main truck engine idling for the same amount of time. The California Air Resources Board recognized this fact and in 2008, included as part of their anti-idling regulations for heavy-duty trucks, a requirement that APUs must be retrofit with a particulate filter capable of achieving at least an 85% reduction in PM or have the APU exhaust diverted through the main DPF in the exhaust system of the truck. To achieve an 85% PM reduction, the particulate filter must be a wall flow device, or similar. ARB has verified four of these retrofit devices, made by third-party manufactures, for installation on existing APU engines. Due to the relatively cold exhaust temperatures of these small engines, the DPF filters installed on APUs must use either all active or a combination of passive and active regeneration to periodically clean the soot from the filter. Active regeneration can be accomplished through the use of a fuel burner or electrical heater upstream of the filter element that can be activated if the back pressure is too high.

California's APU Air Toxics Control Measure (ATCM) regulation demonstrates that it is feasible to control PM from small APU engines and several companies are supporting this market. The technology is commercially available and has been implemented on APUs since 2008 as part of the state's Diesel Risk Reduction Plan (DRRP). In the Phase 2 proposal, EPA estimates the potential PM reduction impacts from installing DPFs on APUs as approximately 3,000 tons in 2035. Because these engines operate for many hours in a single location, the health impact from PM exposure to people that work, stop or live near rest areas and truck stops may be of greater concern than might be indicated by a simple mass-based inventory. Groups of trucks operating their APUs at a truck stop are similar to a stationary point source. California based their requirements for using PM controls on stationary sources on the health-based cancer risk of PM exposure around a point source exceeding one in a million. To better quantify the emissions impacts of installing emission controls on small diesel engines, such as APUs, TRUs and other small off-road engines, CARB is funding a demonstration program at UC-Riverside. MECA is supporting this effort with technology and expertise and we encourage EPA to seriously consider requiring DPF technology on APU engines as part of this regulation. We agree with EPA's cost estimates for a DPF retrofit on an existing APU, that cost includes the expense of verifying the device and the need for a separate control unit to monitor and regenerate the filter. We believe that the cost would be significantly lower if the filter could be integrated onto the APU engine at the time of manufacture or the APU exhaust is routed into the truck exhaust, upstream of the DPF, at the time of vehicle manufacture and incorporates economies of scale that an OEM can achieve with larger numbers of engines.

Heavy-Duty Glider Kits and Glider Vehicles

MECA strongly supports the agency's proposal to require that the engines installed in glider vehicles meet the same criteria and GHG emission requirements as new engines certified in the same model year. The recent rapid growth in the number of glider vehicles sold since 2007 to over 5,000 vehicles a year shows the large emissions impact that this category of high emitters has on the overall contribution of PM and NOx from heavy-duty engines. As new engines become cleaner in the future the contribution from glider vehicles will continue to grow. Glider vehicles are classified as "new motor vehicles" because they use a new chassis, although they can continue to use engines that are 10-15 years old and emit 20-40 times more pollution than vehicles equipped with a new engine. The existing exemption of glider vehicles from the latest pollution requirements represents a huge loophole in the regulation. Using this "new motor vehicle" designation under the clean air act, glider vehicles could potentially qualify for clean air incentive funding under some state in-use fleet programs while not meeting the intent or emission reduction goals of those programs. Glider vehicles, equipped with old diesel engines, or converted to alternative fuels could potentially compete for funding with newly manufactured trucks, replacement engines or retrofit emission control devices. The proposed glider kit and glider vehicle provision in this proposal takes an important step towards closing this loophole and MECA supports inclusion of this provision in the final regulation and moving the implementation date ahead of the proposed 2018 start date. There should be no "dirty diesel" loophole left in EPA's regulatory programs.

MECA is concerned that the present proposed limited grandfathering of glider vehicle production for existing small businesses would still allow the continued production of up to 300 assembled gliders a year, per company. This exemption poses a significant threat to air quality as 300 trucks could emit the same amount of NOx as 7500 new heavy duty trucks. EPA should include a phase-out of this glider loophole completely that reduces the 300 glider kit limit per small existing business over a course of three years after which full compliance is required. This should provide sufficient time for small businesses to adapt their business models to produce and maintain clean diesels. Retaining a 300 per year limit indefinitely could result in a disproportionate number of dirty vehicles to continue to be produced and remain in the fleet for decades to come. To minimize the opportunity to abuse this exemption, EPA might consider limiting the conditions under which a glider vehicle may be purchased to legitimate situations such as when a vehicle is damaged in an accident and the engine can be salvaged. Requirements should include record keeping guidelines to support legitimate transactions to purchase glider vehicles.

Methane and PM 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 applaud the agencies consideration of 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 domestic energy source and transportation fuel grows, it leads to expansion of the fuel production and transportation infrastructure. We are encouraged with EPA's intentions to further regulate methane emissions from natural gas production facilities. 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 believe that the proposed provisions to control fugitive methane emissions from natural gas vehicles and engines represent 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. We support the EPA's inclusion of boil-off requirements for LNG vehicles in the Phase 2 proposal and to require closed crankcases on all 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, EPA should consider developing a separate set of engine efficiency standards that better reflect the full life cycle emissions of natural gas vehicles including leakage and upstream emissions.

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. 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 EPA to investigate the health and climate benefits of applying filters to these engines and enact appropriate policies that force the use of high efficiency filters on these engines to reduce ultrafine metal oxide exposure.

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, representing 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 being discussed today in California. 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 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 particular for heavy-duty highway engines, MECA urges EPA to begin a rulemaking effort as soon as possible aimed at further NOx reductions from heavy-duty engines.

In conclusion, MECA commends EPA for taking important steps to continue 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. MECA believes that the proposed reductions for greenhouse gas emissions from heavy-duty vehicles proposed by EPA are technically and economically feasible under a 2024 implementation timeframe. 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.

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