NESCAUM
www.nescaum.org
Northeast States for Coordinated Air Use Management
89 South Street, Suite 602 Boston, MA 02111
Phone 617-259-2000 Fax 617-742-9162
Paul J. Miller, Executive Director

February 20, 2020

Andrew Wheeler, Administrator
U.S. Environmental Protection Agency
Air and Radiation Docket and Information Center
EPA Docket Center, EPA WJC West Building
1301 Constitution Avenue, N.W. Room 3334
Washington, D.C. 20004

Attention: *Docket ID No. EPA-HQ-OAR-2019-0055*

Re: *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine Standards*

Dear Administrator Wheeler:

The Northeast States for Coordinated Air Use Management (NESCAUM) is submitting comments to the U.S. Environmental Protection Agency (EPA) on its Advance Notice of Proposed Rulemaking (ANPR) entitled *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine Standards* [(85 Fed. Reg. 3306-3330 (January 21, 2020)]. NESCAUM is the regional association of state air pollution control agencies in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

NESCAUM strongly supports EPA's development of new engine emission standards and test procedures that will reduce emissions of oxides of nitrogen (NOx) from heavy-duty engines. NOx emissions are a primary precursor to the formation of ground-level ozone and secondary fine particulate matter ($PM_{2.5}$) and contribute to acid deposition, eutrophication, and visibility impairment in the NESCAUM region.

Since the introduction of the 2007/2010 heavy-duty engine emissions standards, there have been significant technology advances that provide a foundation for reducing NOx emissions a further 90 percent. To do this, manufacturers will need to introduce hardware upgrades and new aftertreatment systems that, while significant, build upon the architecture of current emissions control systems. If standards are implemented in the 2027 model year timeframe, manufactures will have ample time to integrate new technologies into heavy-duty engines.

Summary of Recommendations

We offer the following recommendations on the elements detailed in ANPR, which we believe are necessary to ensure a robust regulation that delivers substantial heavy-duty engine emissions reductions.

- Require a new engine NOx emission standard of 0.02 grams per brake horsepower-hour (g/bhp-hr) on the Federal Test Procedure (FTP) and Ramped Modal Cycle (RMC) for model year 2027 and later engines;
- To prevent backsliding, require a new engine PM emission standard of 5 milligrams per brake horsepower hour (mg/bhp-hr) on the FTP and RMC cycles for model year 2027 and later engines;

- Introduce a low load cycle (LLC) for engine certification and require an engine exhaust emission limit of 0.075 g/bhp-hr NOx or lower for model year 2027 and later engines;
- Introduce an idle cycle for new engine certification and require an engine exhaust emissions limit of 10 g/hr NOx or less for model year 2027 and later engines;
- Replace the current Not-to-Exceed (NTE) in-use test protocol with a moving average window (MAW) approach, and maintain the requirement for $PM_{2.5}$ in-use testing;
- Increase the useful life and warranty requirements for heavy-duty engines as specified in these comments; and
- Facilitate heavy-duty vehicle (HDV) inspection and maintenance program development by establishing state implementation plan (SIP) crediting guidance and requiring that engine control module (ECM) information be readily available to regulators and fleets.

An overview of the need for NOx reductions in the Northeast and NESCAUM's specific comments on the ANPR follow.

Impact of NOx Emissions on Public Health and the Environment

The NESCAUM region includes the New York City (NYC) Combined Statistical Area (CSA) with over 23 million people living across portions of Connecticut, New Jersey, New York, and Pennsylvania. It is the largest CSA by population in the United States. While air pollution levels have dropped over the years across much of the United States, the NYC metropolitan area and surrounding region continue to persistently exceed both past and recently revised federal health-based air quality standards for ground-level ozone.

The chronically persistent high ozone concentrations compromise the health and welfare of the citizens living in the NYC CSA and elsewhere in the NESCAUM region. Epidemiological studies provide strong evidence that ozone is associated with respiratory effects, including increased asthma attacks, as well as increased hospital admissions and emergency department visits for people suffering from respiratory diseases. Ozone can cause chronic obstructive pulmonary disease (COPD), and long-term exposure may result in permanent lung damage, such as abnormal lung development in children. There is also consistent evidence that short-term exposure to ozone increases risk of death from respiratory causes.[1] Furthermore, more recent studies show that ozone concentrations below the current National Ambient Air Quality Standards (NAAQS) contribute to the risk of premature death in sensitive populations, such as the elderly.[2]

While ozone is largely a summertime issue, NOx emissions are a year-round problem. During colder seasons, NOx emissions play a role in producing secondary $PM_{2.5}$ through the formation nitrates. $PM_{2.5}$ exposure is associated with a variety of health effects, including reduced lung function, irregular

---

[1] U.S. EPA, "Health Effects of Ozone Pollution," Available at https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution, last updated July 30, 2019 (accessed February 7, 2020).

[2] Di, Q., *et al*. "Air pollution and mortality in the Medicare population." *New England Journal of Medicine* 376: 2513-2522 (2017). DOI: 10.1056/NEJMoa1702747; Di, Q., *et al.* "Association of short-term exposure to air pollution with mortality in older adults." *JAMA* 318: 2446-2456 (2017). DOI: 10.1001/jama.2017.17923.

heartbeat, asthma attacks, heart attacks, and premature death in people with heart or lung disease.[3] The public health and environmental impacts of NOx are summarized in Table 1.

Table 1: Adverse public health and environmental impacts of NOx in the Northeast.

Ozone and $PM_{2.5}$	• Reduces lung function, aggravates asthma and other chronic lung diseases • Can cause permanent lung damage from repeated exposures • Contributes to premature death
Acid deposition	• Damages forests • Damages aquatic ecosystems, e.g., Adirondacks and Great Northern Woods • Erodes manmade structures
Coastal and Marine Eutrophication	• Depletes oxygen in the water, which suffocates fish and other aquatic life in bays and estuaries, e.g., Chesapeake Bay, Narragansett Bay, and Long Island Sound
Visibility Impairment	• Contributes to regional haze that mars vistas and views in wilderness and urban areas

Progress Has Stalled in Reducing the Northeast's Ozone Pollution Burden

For several decades, ozone concentrations in the Northeast trended downward due to the adoption of measures that reduce emissions of ozone precursors. In recent years, however, air quality monitoring data have begun to show a flattening trend. Figure 1 shows the number of days in Connecticut where maximum 8-hour ozone was measured above the 2008 and 2015 ozone NAAQS for each year from 1976 to 2018. After significant improvements in the earlier years, the number of ozone exceedance days in Connecticut have remained level or have slightly increased since 2011. Similar patterns have been recorded in other NESCAUM states.

[3] U.S. EPA, "Health and Environmental Effects of Particulate Matter (PM)," Available at https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm, last updated June 20, 2018 (accessed February 13, 2020).

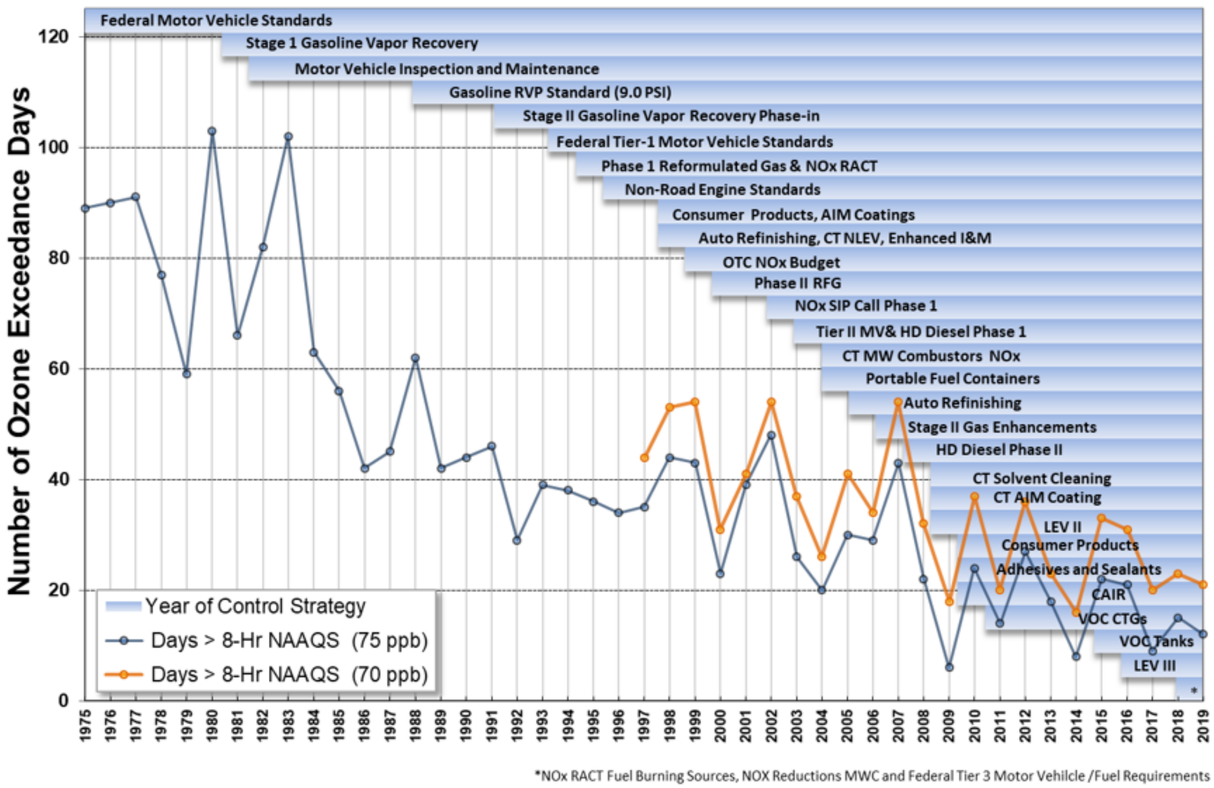

Figure 1: Connecticut 8-hour ozone exceedance trends and implemented NOx control measures.

The Greater Connecticut and New York-Northern New Jersey-Long Island ozone nonattainment areas failed to meet the deadline for moderate nonattainment of the 2008 ozone NAAQS of 75 parts per billion (ppb) and were re-designated to serious nonattainment status for that NAAQS. These areas must now meet the attainment date of 2021 for the 2008 standard. In addition to the stalling trend in ozone improvements, the New York City metropolitan region saw an unusually high peak 1-hour ozone average of 143 ppb in July 2018, a level not seen in the NYC area in more than 10 years.

Figure 1 also includes an extensive list of requirements that have been adopted by Connecticut and other states in the NESCAUM region to reduce emissions of ozone precursors from stationary sources, area sources, fuels, mobile sources, and consumer products. Imposing further control requirements on many of these source categories would be more costly than controlling heavy-duty engine emissions and would create disproportionate economic burden for those sources. Estimates of the costs of additional NOx controls from industrial, commercial, and institutional boilers that are 100 million British Thermal Units per hour in size ranges from $2,700 to $21,000 per ton of NOx reduced as compared to a cost range of $1,000 to $5,000 per ton of NOx reduced from HDVs.[4,5]

In 2018, NESCAUM launched the Long Island Sound Tropospheric Ozone Study (LISTOS) to investigate the evolving nature of ozone formation and transport in the NYC region and downwind. LISTOS involves a large group of researchers from state and federal agencies and academia that bring a diverse set of resources, expertise, and instrumentation skills. LISTOS has provided detailed imagery and data on ozone and its precursors in the Northeast. To illustrate the relative scale of NOx emissions during the 2018 LISTOS effort, Figure 2 readily shows enhanced nitrogen dioxide (NO_2) concentrations (NO_2 is a major component of NOx) observed by satellite along the Northeast Corridor during the 2018 ozone season, with the highest weekday (Mon-Fri) NO_2 concentrations in the New York City area. Much of this NO_2 is associated with transportation sources, and these mobile source sectors are projected to continue to be significant contributors to ozone in future years.[6]

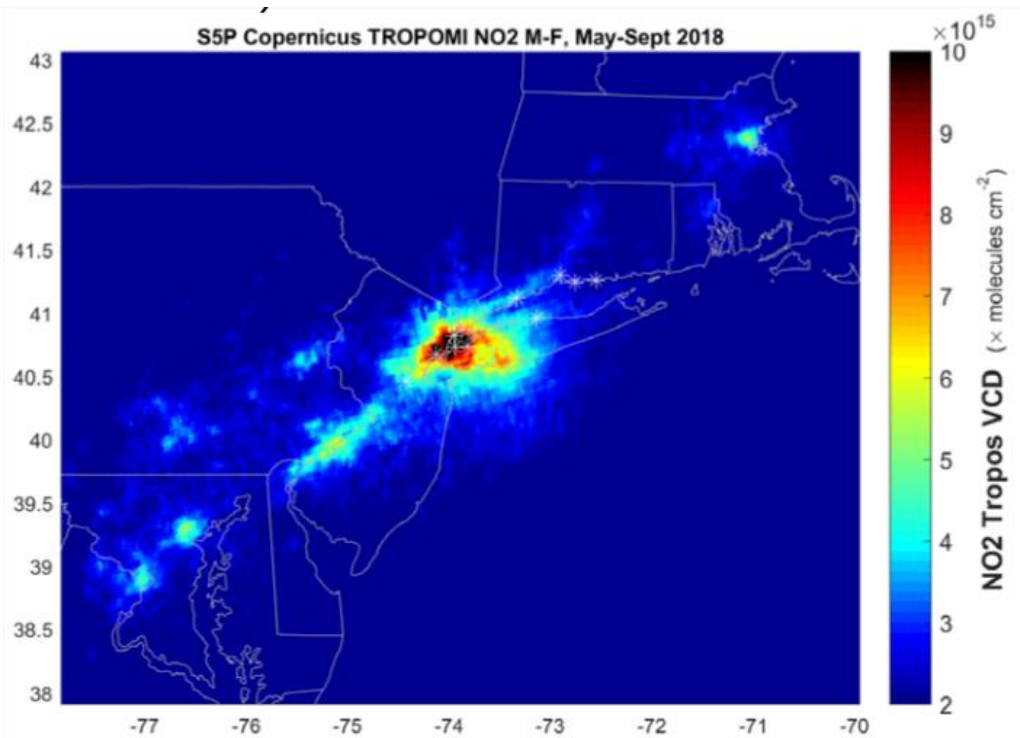

Figure 2: TROPOMI satellite imagery showing high NO_2 concentrations over the NY-NJ-CT metropolitan area during the 2018 ozone season.

---

4 OTC/Lake Michigan Air Directors Consortium (LADCO), "Evaluation of Control Options for Industrial, Commercial and Institutional (ICI) Boilers," May 2010.

5 Manufacturers of Emission Controls Association, "Technology Feasibility for Heavy-Duty Diesel Trucks in Achieving 90% Lower NOx Standards in 2027," February, 2020. Available at http://www.meca.org/resources/MECA_2027_Low_NOx_White_Paper_FINAL.pdf (accessed February 7, 2020).

6 Zawacki, M., *et al.* "Mobile source contributions to ambient ozone and particulate matter in 2025." *Atmos. Envt.* 188: 129-141 (2018).

Figure 3 shows satellite imagery of NO_2 emissions in the Northeast and Mid-Atlantic on a single day in February during the 2019 winter. NO_2 levels are abundant and dominant along transportation corridors and in large cities across the region, again indicating a strong mobile source NOx contribution.

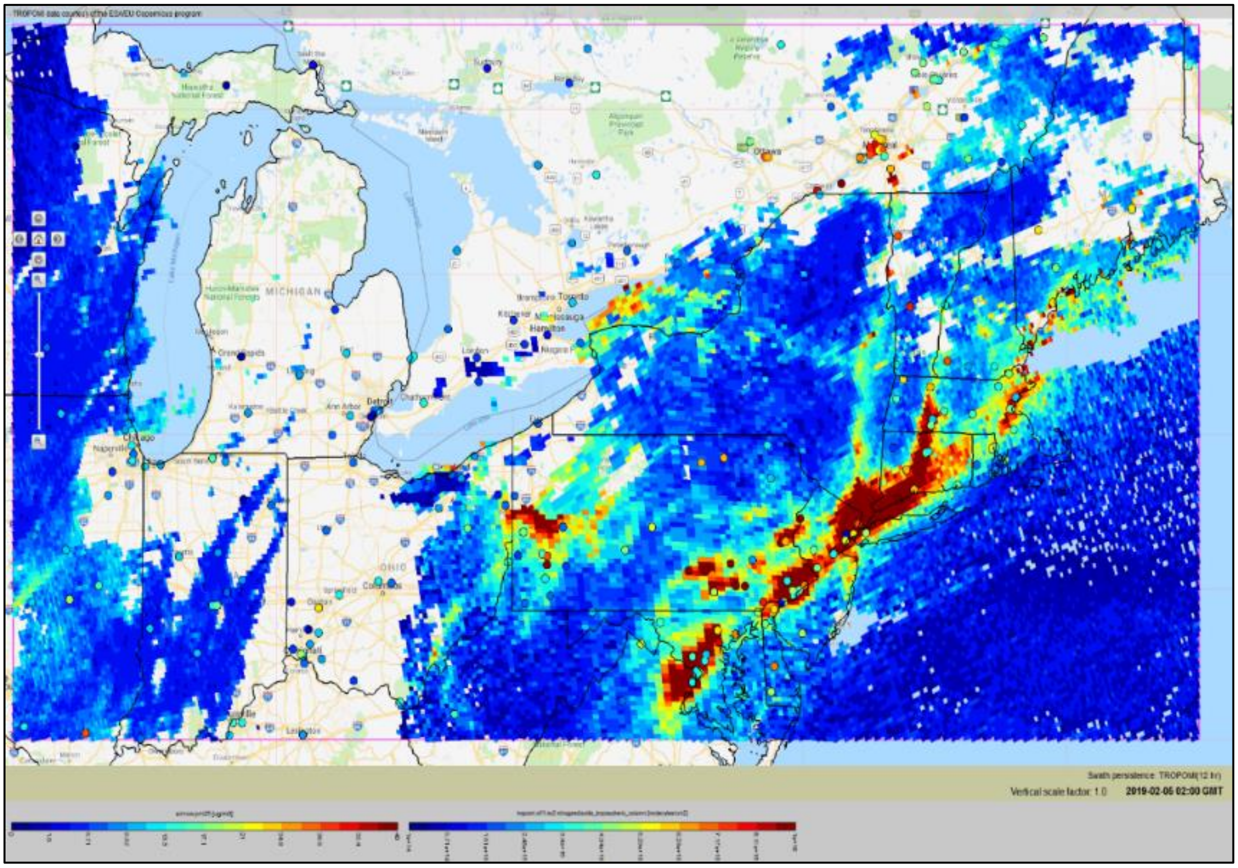

Figure 3: TROPOMI satellite observation of high wintertime NO_2 in mid-Atlantic and northeastern U.S. in February of 2019.

These are major arteries where goods are being transported by truck from the ports of New York, Baltimore, and Philadelphia, which are creating the low elevation release of NO_2. Note how clearly defined the area of red is along I-91 in Connecticut and Massachusetts. In addition to region-wide stagnation on this particular day, the strength of the NO_2 signal also reflects the longer NO_2 lifetime in winter.

The Need for NOx Reductions in the Northeast

To address the region's persistent air quality problems, reducing NOx emissions from heavy-duty engines is of the utmost importance due to its role in local and regional ground-level ozone formation, as well as its contributions to $PM_{2.5}$ (especially in the winter). As shown in Figure 4, on-road heavy duty diesel vehicles are the largest NOx emissions source in the Northeast.

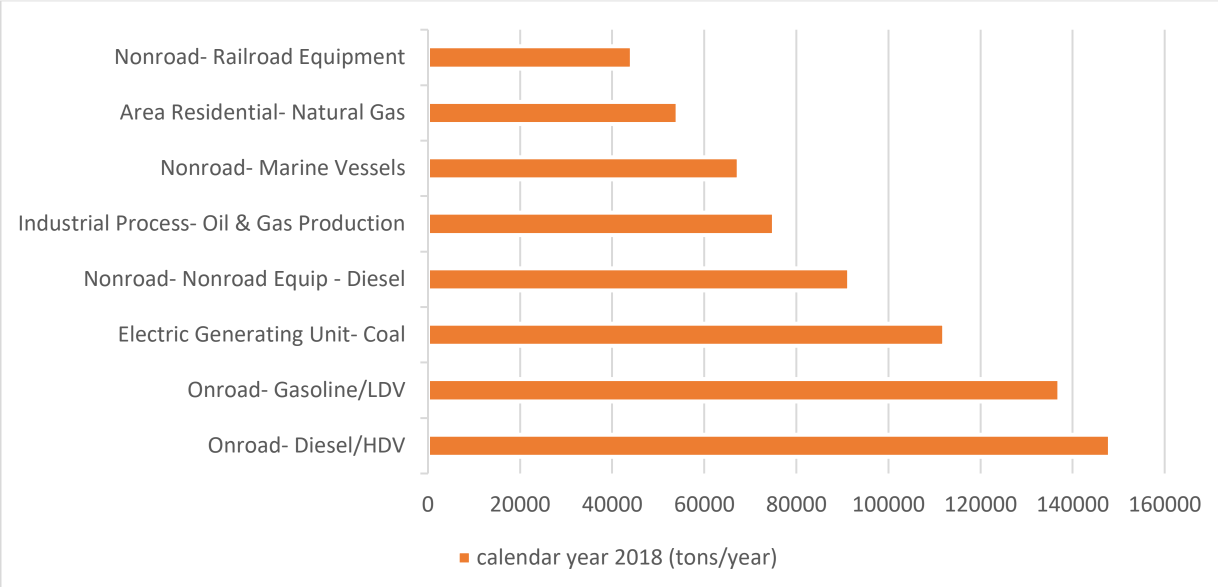

Figure 4: Modeled NOx Emissions in the Northeast (calendar year 2018) Source: OTC.

Moreover, the modeled NOx contribution from HDVs shown in Figure 4 is potentially underestimated because the mobile source model used in developing the inventory does not account for high emitting heavy-duty trucks, such as glider vehicles and HDVs with tampered emission control systems. In-use testing data suggest that real-world NOx emissions are higher than modeled estimates, underscoring the need to achieve substantial NOx reductions from the heavy-duty diesel truck sector.[7]

Absent adoption of stringent new engine NOx standards, emissions from HDVs will increase in the future as truck vehicle miles traveled (VMT) is projected to increase by approximately 20 percent over the next 25 years (Figure 5). This growth in VMT, if not counteracted by increased stringency of new engine emissions standards, will result in significantly increased HDV emissions.

[7] Tan, Y., *et al.* "On-Board Sensor-Based NOx Emissions from Heavy-Duty Diesel Vehicles." *Environ. Sci. Technol.*, 53: 5504-5511 (2019). DOI: 10.1021/acs.est.8b07048.

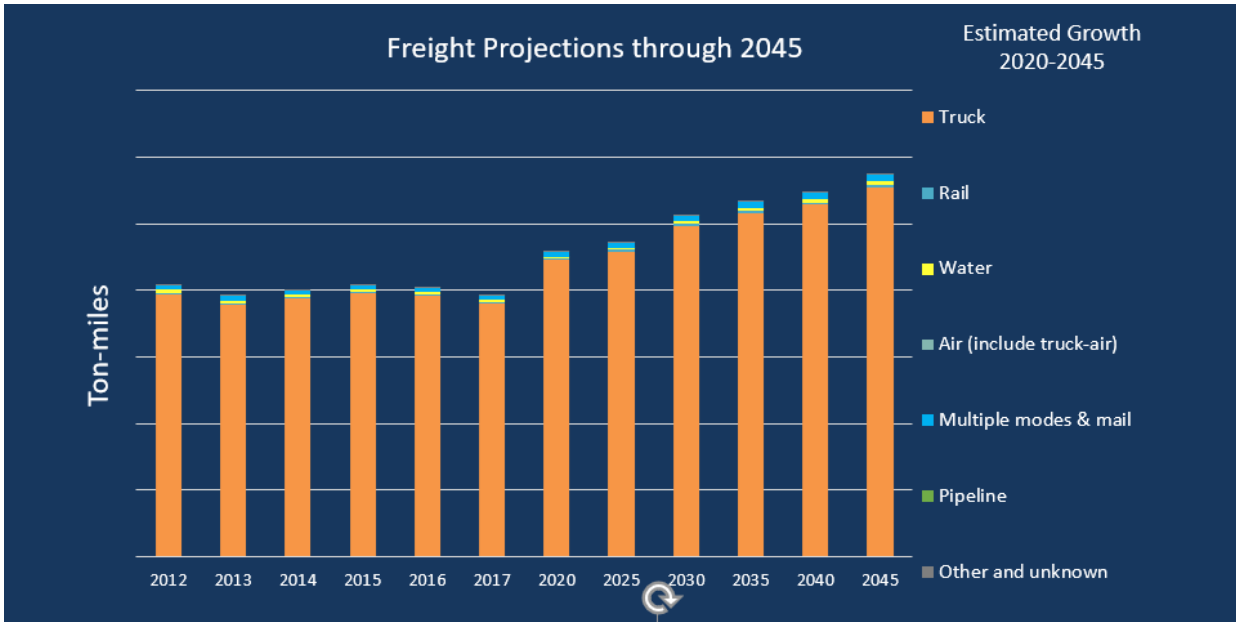

Figure 5: U.S. freight growth projections from 2020 to 2045. Source: Freight Analysis Framework Data Tabulation Tool.[8]

Due to the importance of heavy-duty engines to the overall NOx inventory, states in the Northeast have for decades measured, quantified, modeled, and published information on heavy-duty engine emissions in the region and articulated the need for further heavy-truck NOx reductions. Independently, and collaboratively with EPA and industry, states have conducted in-use testing, implemented early heavy-truck periodic and roadside inspection and maintenance programs, and piloted selective catalytic reduction (SCR) and other technologies to reduce emissions from HDVs.

In 2016, many of the NESCAUM member state agencies joined with the South Coast Air Quality Management District (SCAQMD) and other agencies in petitioning the US EPA to undertake a rulemaking to revise the on-road heavy-duty engine exhaust emission standards for NOx from 0.2 g/bhp-hr to 0.02 g/bhp-hr.[9] Also in 2016, NESCAUM requested that the Secretary of Energy incorporate research into advanced NOx reduction technologies in the Department of Energy (DOE) SuperTruck Program, given the substantial contribution heavy-duty trucks make to NOx pollution in the region.[10]

[8] Oak Ridge National Laboratory, Center for Transportation Analysis, "Freight Analysis Framework Data Tabulation Tool (FAF4)." Available at https://faf.ornl.gov/fafweb/Extraction1.aspx (accessed February 7, 2020).
[9] South Coast Air Quality Management District, *et al.* "Petition to EPA for Rulemaking to Adopt Ultra-Low NOx Exhaust Emission Standards for On-Road Heavy-Duty Trucks and Engines," June 3, 2016. Available at https://www.epa.gov/sites/production/files/2016-09/documents/petition_to_epa_ultra_low_nox_hd_trucks_and_engines.pdf (accessed February 7, 2020).
[10] NESCAUM letter to Dr. Ernest Moniz, Secretary, U.S. Department of Energy, re: SuperTruck II Initiative, May 18 2016. Available at http://www.nescaum.org/documents/nescaum-doe-supertruckii-nox-tech-lttr-20160518.pdf/.

EPA's response to the 2016 petition clearly acknowledges the importance of NOx reductions to the Northeast and other states.[11] In addition, EPA's *Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles—Phase 2* final regulation also detailed the importance of NOx reductions to the Northeast, stating that:

> EPA received compelling letters and comments from [NACAA, NESCAUM, OTC, and SCAQMD], explaining the critical and urgent need to reduce NOx emissions that significantly contribute to ozone and fine particulate air quality problems in their represented areas. The comments describe the challenges many areas face in meeting both the 2008 and recently strengthened 2015 ozone NAAQS. These organizations point to the significant contribution of heavy-duty vehicles to NOx emissions in their areas.[12]

NESCAUM's specific comments on the ANPR are provided in the following sections.

Comments on Standards and Test Cycles

1. NOx Emission Certification Limit on the RMC and FTP

Emission standards for medium- and heavy-duty engines were last finalized in 2001, nearly 20 years ago. Since then, extensive experience in implementation and monitoring has provided a substantial body of evidence supporting more stringent standards over the FTP and RMC cycles. Recent studies and modeling analyses support the introduction of a heavy-duty engine FTP and RMC NOx exhaust emission standard that are 90 percent more stringent by model year 2027 than today's standard of 0.20 g/bhp-hr.[13,14]

Advanced catalyst formulations, passive and active thermal management strategies, approaches to reducing pumping losses, engine calibration and hardware changes, and electrification are examples of technologies that can be used to reduce NOx emissions to a level of 0.02 g/bhp-hr in 2027 while maintaining carbon dioxide (CO_2) emissions at levels required by the Phase 2 heavy-duty greenhouse gas (GHG) standards. Given these advances in emissions control, NESCAUM urges EPA to require a NOx emissions limit of 0.02 g/bhp-hr on the RMC and FTP certification cycles for model year 2027 and later engines. Some of these technologies will most likely be explored prior to model year 2027 to meet the EPA Phase 2 GHG and California Air Resources Board (CARB) 2024 Low NOx programs.

The following is a description of technologies that can be used by manufacturers to meet this emissions level.

---

[11] U.S. EPA, "Memorandum in Response to Petition for Rulemaking to Adopt Ultra-Low NOx Standards for On-Highway Heavy-Duty Trucks and Engines," December 20, 2016. Available at https://www.epa.gov/sites/production/files/2016-12/documents/nox-memorandum-nox-petition-response-2016-12-20.pdf (accessed February 7, 2020).

[12] 81 Fed. Reg. 73478 (Oct. 25, 2016), at 73523.

[13] Manufacturers of Emission Controls Association, "Technology Feasibility for Heavy-Duty Diesel Trucks in Achieving 90% Lower NOx Standards in 2027," February 2020. Available at http://www.meca.org/resources/MECA_2027_Low_NOx_White_Paper_FINAL.pdf (accessed February 7, 2020).

[14] Southwest Research Institute, "Update on Heavy-Duty Low NOx Demonstration Programs at SwRI," September 26, 2019. Available at https://ww3.arb.ca.gov/msprog/hdlownox/files/workgroup_20190926/guest/swri_hd_low_nox_demo_programs.pdf (accessed February 7, 2020).

A. Advanced Catalyst Formulation

Since 2010, aftertreatment systems have been optimized to improve NOx conversion efficiency, reduce system weight, and lower catalyst loading. These advances have brought higher compliance margins and lower certification levels while still meeting GHG standards. Specific improvements include changes to ceramic substrates, advanced methods to coat substrates, integration of SCR into the diesel particulate filter (DPF) substrate, and increased catalyst surface areas. Advanced SCR chemistries increase the NOx performance at low temperatures and reduce nitrous oxide (N_2O) formation.[15] Integrating the SCR into the DPF substrate enables faster warm-up as it puts the SCR closer to the engine. Increased catalyst surface area enables uniform catalyst coating and reduces backpressure and related fuel consumption penalties.

B. Cylinder Deactivation

Cylinder deactivation (CDA) is a technology that has been used in light-duty vehicles for decades and it is now being adapted for use in heavy-duty vehicles. For example, both Daimler Trucks and Navistar are each using CDA as part of their DOE SuperTruck program research to demonstrate a 55 percent brake thermal efficiency. CDA combines hardware and computing power to shut down some of an engine's cylinders at low load conditions and keeps the engine speed in an efficient portion of the engine map without cooling the exhaust. By doing this, the remaining active pistons work harder and more efficiently, thus reducing fuel use and generating more heat that can be used to heat catalysts. In addition, shutting off an engine's cylinders reduces air flow through the engine and exhaust, which enables heat retention in the exhaust system during low engine load operation. These conditions, enabled by CDA, improve the SCR's ability to effectively reduce emissions.

During low load operation, CDA has resulted in exhaust temperatures increasing by more than 100°C. This is particularly important for vehicles that spend considerable time idling and in stop-and-go operation typical of urban driving. A recent presentation by Eaton showed simultaneous NOx and CO_2 reductions for heavy-trucks using CDA, including beverage trucks, urban buses, and combination trucks.[16] The presentation indicated significant NOx reductions on low load cycles, such as the beverage, Orange County bus, new low load, and heavy-duty FTP, while simultaneously achieving CO_2 reductions of up to five percent. Eaton noted there are 14 million CDA systems already in use in light-duty vehicles, and the results indicate that technology transfer can occur from light- to heavy-duty vehicles. They also indicate an approach for avoiding noise, vibration, and harshness (NVH) with CDA, which is important for vehicle driver comfort.

C. Advanced Engine Architectures

Modification of the basic architecture of the engine itself can yield significant efficiency gains and when coupled with the aftertreatment approaches described above also yield highly effective emissions control.

---

[15] International Council on Clean Transportation, "Future Heavy-Duty Emission Standards, An Opportunity for International Harmonization," November, 2019. Available at https://theicct.org/publications/future-hdv-standards-harmonization (accessed February 7, 2020).

[16] Dorobantu, M., Director, Technology Planning and Government Affairs, Eaton, "The Case for 48V in Commercial Vehicles," Integer Emissions Summit USA, Indianapolis, IN, November 20, 2019.

Opposed piston engines allow for airflow control to alternately boost and limit exhaust temperatures through the duty cycle to benefit catalyst activity and longevity. The reduced combustion system surface area allows more heat to be transformed into useful work. Development of this engine technology for electric range extenders, light truck, Class 8 tractor, and heavy tracked vehicle use is currently underway at Nissan, Achates Power, and Cummins with sponsorship from DOE ARPA-e, CARB, and the U.S. Army.[17, 18, 19]

D. 48-Volt Technology

Light-duty passenger vehicles have used 48-volt technology for years and it is a promising technology for use in heavy-duty vehicles. The 48-volt, or mild hybridization, approach can include electric motor/generators, regenerative braking, stop/start, and electric boost. 48-Volt technology also enables electrification of components, including electric turbos, electronic exhaust gas recirculation (EGR) pumps, air conditioning compressors, electrically heated catalysts, electric cooling fans, oil pumps, and coolant pumps that reduce GHG emissions. In addition to reducing idling, stop/start provides a thermal management benefit to the aftertreatment by preventing cooling airflow through the aftertreatment during some idle conditions.

48-volt systems also enable electric power take-off (PTO) systems. Electric PTO systems can avoid the use of engine-powered auxiliary power units (APU) and reduce idling of the main engine during hoteling. PTO systems are commonly used in vocational trucks to power cherry pickers, trash compactors, and other functions of vocational vehicles. Because of its benefits, 48-volt technology is being employed by most of the SuperTruck II teams.

E. Passive and Active Thermal Management

Examples of passive and active thermal management include some of the technologies already described. SCR coating of DPFs and close-coupled SCR catalysts are both passive thermal management strategies that move the catalyst closer to the engine where exhaust temperatures are higher. Cylinder deactivation is considered an active thermal management strategy in that it requires a change to the engine to increase exhaust temperatures.

Other thermal management strategies, such as insulated dual wall manifolds and optimized urea dosing calibration, have improved the effectiveness of exhaust emissions reduction technologies. Electric catalyst heating accelerates catalyst warm-up and ensures operating temperatures independent of engine load.

---

[17] Patil, S., Ghazi, A., Redon, F., Sharp, C. *et al*., "Cold Start HD FTP Test Results on Multi-Cylinder Opposed-Piston Engine Demonstrating Rapid Exhaust Enthalpy Rise to Achieve Ultra Low NOx," SAE Technical Paper 2018-01-1378, 2018,doi:10.4271/2018-01-1378.
[18] Patil, S., Sahasrabudhe, A., Youngren, D., Redon, F. *et al*., "Cold-Start WHTC and WHSC Testing Results on Multi-Cylinder Opposed-Piston Engine Demonstrating Low CO2 Emissions while Meeting BS-VI Emissions and Enabling Aftertreatment Downsizing," SAE Technical Paper 2019-26-0029, 2019, doi:10.4271/2019-26-0029.
[19] Cummins and Achates Power to Develop Advanced Combat Vehicle Engine to Improve Protection and Performance of U.S. Armed Forces, News Release September 28, 2017. Available at https://www.cummins.com/news/releases/2017/09/28/cummins-and-achates-power-develop-advanced-combat-vehicle-engine-improve (accessed February 13, 2020).

These strategies allow catalysts to work at lower exhaust temperatures, reducing NOx during idling or stop-and-go operation.

F. Battery-Electric and Fuel Cell Vehicles

Battery electric and fuel cell HDVs have zero tailpipe emissions and hold the potential to substantially reduce overall HDV emissions. Certification and commercial availability of battery electric and fuel cell vehicles have increased dramatically over the past few years: Over 100 medium- and heavy-duty electric and fuel cell vehicles are listed on the CARB Heavy-Duty Vehicle Incentive Program website as eligible for an incentive under the program.[20] These vehicles include step vans, school buses, urban buses, intercity buses, pick-up trucks, utility trucks, tractors, refuse trucks, and others spanning 8,500 pounds (lb) gross vehicle weight rating (GVWR) to over 26,000 lb GVWR.

As certification of zero emission heavy-duty trucks increases, the pace of fleet electrification is accelerating: Amazon has announced the purchase of 100,000 Rivian electric trucks; UPS announced the purchase of 10,000 Arrival electric delivery trucks; Ryder/FedEx is purchasing 1,000 Chanje delivery vans; and Anheuser Busch announced the purchase of 800 Nikola Class 8 zero emission trucks. An investor owned utility – Dominion – is sponsoring up to 1,500 electric school buses with bi-directional charging for electric grid service capability in Virginia. This is just a partial list of recent announcements by private fleets.

Municipal fleets are also moving to vehicle electrification: New York's Metropolitan Transit Agency has committed to purchasing 500 electric urban buses; Los Angeles Sanitation recently announced it will not purchase trucks with internal combustion engines after 2022 and will pursue full electrification of the city's solid waste fleet by 2035; White Plains, NY and other cities are demonstrating electric school buses. These are just a few examples of municipal, transportation authority, and state fleet electrification.

2. PM Standard on the FTP/RMC

Exposure to diesel $PM_{2.5}$ is associated with increased hospitalizations and emergency room visits due to exacerbation of chronic heart and lung diseases, other serious health impacts, and premature death. As a toxic air contaminant, diesel PM poses especially serious health risks.[21,22] In CARB's latest assessment of diesel engine exhaust emissions, it considers establishing an engine exhaust emission limit of 5 mg/bhp-hr to maintain the reductions achieved to date in PM emissions and to prevent DPFs with higher porosity and lower backpressure but with lower filtration efficiency from becoming mainstream.[23] States in the Northeast are committed to reducing diesel PM emissions. An example of this commitment is the

---

[20] *See* Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), https://www.californiahvip.org/how-to-participate/#Eligible-Vehicle-Catalog (accessed February 13, 2020).
[21] U.S. EPA, Integrated Risk Information System (IRIS): Diesel engine exhaust, p. 11, February 28, 2003. Available at https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0642_summary.pdf.
[22] California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. Technical Support Document for Cancer Potency Factors, 2009.
[23] California Air Resources Board (CARB), "California Air Resources Board Staff Current Assessment of the Technical Feasibility of Lower NOx Standards and Associated Test Procedures for 2022 and Subsequent Model Year Medium-Duty and Heavy-Duty Diesel Engines," April 18, 2019. Available at https://ww3.arb.ca.gov/msprog/hdlownox/white_paper_04182019a.pdf (accessed February 7, 2020).

implementation of HDV smoke opacity inspection and maintenance programs in the region. NESCAUM strongly supports the establishment of a 5 mg/bhp-hr standard on the FTP and RMC for diesel engines.

3. Establish an Engine Dynamometer Low Load Cycle and Corresponding NOx Standard

A recent analysis performed by the International Council on Clean Transportation (ICCT) analyzed the in-use test data from on-road trucks in Europe and the U.S. and showed that U.S. trucks were emitting NOx at approximately 50 percent higher levels than European trucks using very similar exhaust system configurations and volumes.[24] The study found the difference in NOx emissions is mainly attributable to the different in-use test requirements. Because the limitations of low-temperature NOx conversion by SCR systems were not anticipated, U.S. engines were not calibrated to address NOx emissions in low load operation. In contrast, European truck manufacturers are required to limit NOx emissions at low load, and thus calibrated their emission control systems to control low temperature NOx emissions.

Heavy-duty diesel engines emit significant NOx emissions at low speed and low load operation. This is because current SCR systems require exhaust temperatures of approximately 200°C to reduce NOx emissions. However, low load and low speed operation typically result in engine exhaust temperatures below 200°C. Below 200°C, urea injection is stopped to prevent urea deposits from forming around the injector, mixer or on the SCR catalyst. CARB estimates that while vehicle miles traveled at low speed represent only 10 percent of heavy-duty diesel miles traveled, the NOx emissions from such operation are expected to constitute half of all heavy-duty diesel NOx by 2030.[25]

The Manufacturers of Emission Controls Association (MECA) have identified a number of technologies that can be used to reduce low load and low speed NOx emissions, including gaseous and heated urea dosing systems, cylinder deactivation, mild hybridization (including 48 Volt components), the use of EGR cooler bypass during low load conditions, dual urea dosing, close-coupled SCR catalysts, and other approaches.[26] Some of these strategies have been commercialized in light-duty vehicles and are now being applied in heavy-duty vehicles. MECA found that a 0.075 g/bhp-hr NOx standard can be met on a low load cycle for 2027 model year vehicles. [27]

NESCAUM urges EPA to establish a heavy-duty diesel engine low load cycle in addition to the current FTP and RMC cycles. The test cycle should include sustained low load operation, motoring, high to low load transitions, and low to high load transitions, typical of urban driving. The emissions limit should correspond to a limit of 0.075 g/bhp-hr for 2027 model year and later engines.

---

[24] Badshah, H., Posada, F., and Muncrief, R., "Current State of NOx Emissions from In-Use Heavy-Duty Diesel Vehicles in the United States," White Paper, International Council on Clean Transportation, November 2019. Available at https://theicct.org/sites/default/files/publications/NOx_Emissions_In_Use_HDV_US_20191125.pdf (accessed February 7, 2020).
[25] California Air Resources Board (CARB), "California Air Resources Board Staff Current Assessment of the Technical Feasibility of Lower NOx Standards and Associated Test Procedures for 2022 and Subsequent Model Year Medium-Duty and Heavy-Duty Diesel Engines," April 18, 2019. Available at https://ww3.arb.ca.gov/msprog/hdlownox/white_paper_04182019a.pdf (accessed February 7, 2020).
[26] Manufacturers of Emission Controls Association, "Technology Feasibility for Model Year 2024 Heavy-Duty Diesel Vehicles in Meeting Lower NOx Standards," June 2019.
[27] Manufacturers of Emission Controls Association, "Technology Feasibility for Heavy-Duty Diesel Trucks in Achieving 90% Lower NOx Standards in 2027," February, 2020. Available at http://www.meca.org/resources/MECA_2027_Low_NOx_White_Paper_FINAL.pdf (accessed February 7, 2020).

4. Establish a Federal Idle Standard for Diesel Engines

EPA requests comment on the need and appropriateness of setting a federal idle standard for diesel engines. NESCAUM strongly urges EPA to adopt a federal idle standard for diesel engines since idling-related NOx emissions is a significant contributor to overall heavy-duty vehicle NOx emissions: An ICCT analysis of the EPA's Heavy-Duty In-Use Testing program database shows that idling-related HDV NOx emissions represents 20 percent of total NOx.[28]

CARB anticipated the anti-idling Airborne Toxic Control Measure would result in APUs being used to reduce main engine idling, such as during long haul truck overnight hoteling. Instead, manufacturers' default compliance strategy for their 50 state certified products has been to make the main propulsion engine itself meet the 30 g/hr performance requirement of "California Clean Idle Certified" engines. Despite the widespread application of these 30 g/hr NOx idle emission control strategies, some engines are still being produced that emit hundreds of grams of NOx per hour in categories originally exempted from California's APU-based anti-idling regulations.[29]

CARB in its recent staff assessment discusses a mandatory idle limit of 10 g/hr for model year 2024-2026, prior to the potential implementation of the Cleaner Trucks Initiative.[30] NESCAUM urges EPA to require an idling standard in model year 2027 of 10 grams/hr or less. Some of the same technologies listed above for control of heavy-duty NOx emissions at low load and low speed operation could be used to cost effectively control heavy-truck idle emissions.

In-Use (Not-To-Exceed) Testing Protocol and Emissions Standards

EPA requests comment on the HDV NTE standards. These standards are used to evaluate HDV emissions – not on specific test cycles – but during normal vehicle operating conditions. The current NTE standards set in-use emissions limits of 1.5 times the FTP limit (plus a portable emissions measurement system or "PEMS" margin) for NOx, PM, and hydrocarbons (HC) and 1.25 times FTP emissions limit (plus PEMS margin) for carbon monoxide (CO). They apply to a range of engine operations that EPA refers to as the "NTE zone." Emissions in the NTE zone are only considered valid if they last 30 seconds or longer, and do not occur during any excluded conditions. Excluded conditions are specified engine, aftertreatment, and ambient conditions. In addition, the NTE zone does not include operating points from 0 to 30 percent of maximum torque and maximum power.

Taken together, these exclusions and exemptions amount to a significant amount of engine operating time and NOx emissions. EPA's analysis of existing in-use NTE test data indicates that less than five percent of a typical time-based dataset are valid NTE events subject to the in-use NTE standards.[31] An ICCT

---

[28] Badshah, H., Posada, F., and Muncrief, R., "Current State of NOx Emissions from In-Use Heavy-Duty Diesel Vehicles in the United States," White Paper, International Council on Clean Transportation, November 2019. Available at https://theicct.org/sites/default/files/publications/NOx_Emissions_In_Use_HDV_US_20191125.pdf (accessed February 7, 2020).
[29] CARB, "Airborne Toxic Control Measures to Limit Diesel-Fueled Commercial Motor Vehicle Idling." Available at https://ww3.arb.ca.gov/msprog/truck-idling/truck-idling.htm, last reviewed July 7, 2016 (accessed February 13, 2020).
[30] California Air Resources Board (CARB), "California Air Resources Board Staff Current Assessment of the Technical Feasibility of Lower NOx Standards and Associated Test Procedures for 2022 and Subsequent Model Year Medium-Duty and Heavy-Duty Diesel Engines," April 18, 2019. Available at https://ww3.arb.ca.gov/msprog/hdlownox/white_paper_04182019a.pdf accessed February 7, 2020).
[31] 85 Fed. Reg. 3306 (January 21, 2020), at 3322.

study of NTE data concluded that the NTE protocol evaluates less than 10 percent of the total emissions data to determine compliance for heavy-duty in-use NOx emissions.[32] In the same study, ICCT found that the average emission value of 0.18 g/bhp-hr obtained from its NTE evaluation is significantly lower than the value of 0.42 g/bhp-hr obtained when the NTE data are evaluated on a total route basis.[33] EPA, in its analysis, also found high heavy-duty diesel engine NOx emissions during many of the excluded periods of operation, suggesting there may be great potential to improve in-use performance by considering more of the engine operation when the Agency updates the protocol for in-use compliance.[34]

Given the limitations of the NTE, CARB has announced its intention of abandoning the NTE protocol and moving toward a MAW approach. The MAW has been developed and implemented in Europe and has the advantage of including a much greater proportion of in-use emissions than the NTE, including low load and idle data. Under the MAW method, mass emissions are calculated for subsets of a complete data set, called windows. The window size is defined by the work, or CO_2 emissions, over the window.

NESCAUM requests that EPA replace the NTE with a stringent moving average window method that requires maximum emissions control for each of idle, low load, and medium/high load conditions. Such a method should include all emissions from a test day into the evaluation and make compliance decisions that are resilient to activity shifts in duty cycle. The metric standard should be in units such that values do not hyperbolically diverge when approaching low load and idle conditions as is seen with the current work-based units. NESCAUM recognizes the value of testing over the variability of actual in-use duty cycles and recommends EPA retain the ability to apply the method to emissions test days obtained from a wide variety of vocations and applications. We support the ideas outlined by CARB in its 2019 white paper, namely the use of a modified Euro VI In Service Conformity (ISC) method, which is based on a MAW approach. We urge EPA to adopt a MAW approach for in-use testing consistent with CARB's approach as outlined in a staff presentation at the September 2019 Heavy-Duty Low NOx Public Workshop.[35] Adjustments may be needed to the windowing definition to assure reasonable weighting of low load and high load windows when including the very lowest load factor windows. NESCAUM urges EPA to continue working closely with CARB to finalize a mutually agreeable method addressing these issues. To the extent that EPA is able to introduce changes to the federal in-use testing program prior to 2027, we urge the Agency to align its protocol with CARB's.

NESCAUM urges EPA to include the following specific elements in a revised in-use protocol:

1) Utilize a MAW approach;
2) Remove the minimum power requirement for window validity;
3) Require urban driving during in-use testing;
4) Account for emissions that occur during filter regeneration;

---

[32] Badshah, H., Posada, F., and Muncrief, R., "Current State of NOx Emissions from In-Use Heavy-Duty Diesel Vehicles in the United States," White Paper, International Council on Clean Transportation, November 2019. Available at https://theicct.org/sites/default/files/publications/NOx_Emissions_In_Use_HDV_US_20191125.pdf (accessed February 7, 2020).
[33] Ibid.
[34] Ibid.
[35] California Air Resources Board (CARB), "Heavy-Duty Low NOx Program, Proposed Heavy-Duty In-Use Compliance Testing," Public Workshop CARB Staff Presentation, Diamond Bar, CA, September 26, 2019. Available at https://ww3.arb.ca.gov/msprog/hdlownox/files/workgroup_20190926/staff/02_hdiut.pdf (accessed February 7, 2020).

5) Align the cold-start definition for in-use testing with the one used in engine dynamometer testing by setting a maximum temperature of 30°C for the aftertreatment system at the start of data evaluation; and
6) Continue to require in-use data to be publicly available.

The Need for Continued HDV PM PEMS Testing

EPA requests comment on the need to measure PM emissions during in-use testing of DPF-equipped engines – under the current regulations or a future program. EPA's rationale for potentially eliminating a PM PEMS measurement requirement is that PM PEMs measurement is more complicated and time-consuming than for gaseous pollutants such as NOx. EPA adds in the ANPR that eliminating it for some or all in-use testing would provide significant cost savings.

NESCAUM is strongly opposed to ending the heavy-duty diesel truck PM PEMS testing requirement. Exposure to diesel PM has been linked to increased cancer and non-cancer health risks. EPA considers diesel exhaust a likely human carcinogen via inhalation.[36] CARB has listed diesel exhaust as a chemical known to cause cancer and has developed quantitative factors for estimating cancer risk from exposures.[37] In June 2012, the International Agency for Research on Cancer, which is part of the World Health Organization, classified diesel exhaust as a known human carcinogen (Group 1) based on an increased risk for lung cancer.[38] Short-term exposures may cause lung irritation and exacerbation of asthma or allergies, while chronic exposures may result in lung cancer or lung damage.[39] Recent peer-reviewed research continues to strengthen the growing body of scientific evidence that acute and chronic adverse health impacts, including premature mortality, occur from exposure to PM levels below current federal health standards.[40,41] In the Northeast, elevated levels of PM are responsible for increased hospitalization, lost work and school days, and increased mortality and morbidity. Low income communities are disproportionally impacted by diesel PM emissions, since they are often located near industrialized areas with high levels of truck traffic.

Trends in heavy duty diesel aftertreatment have been toward higher porosity DPFs to reduce backpressure and improve engine efficiency. This, however, has been at the cost of the order of magnitude overcompliance initially seen for DPF equipped engines. Suggestions have been made in industry that DPFs may not be necessary for extremely high engine-out NOx calibrations, however there are concerns about the lifetime of PM control durability as these systems age. These approaches may be much less resilient to small aging related changes in the engine than DPF type approaches. Regardless, it can be

---

[36] U.S. EPA, Integrated Risk Information System (IRIS): Diesel engine exhaust, p. 11, February 28, 2003. Available at https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0642_summary.pdf (accessed February 13, 2020).
[37] California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. Technical Support Document for Cancer Potency Factors, 2009.
[38] International Agency for Research on Cancer, World Health Organization. IARC: Diesel Engine Exhaust Carcinogenic (Press Release No. 213), June 12, 2012.
[39] U.S. EPA. Health Assessment Document for Diesel Engine Exhaust (EPA/600/8-90/057F). Prepared by the National Center for Environmental Assessment, Washington, DC, for the U.S. EPA Office of Transportation and Air Quality, 2002.
[40] Di, Q., *et al.* "Association of short-term exposure to air pollution with mortality in older adults." *JAMA* 318: 2446-2456 (2017). DOI: 10.1001/jama.2017.17923.
[41] Di, Q., *et al.* "Air pollution and mortality in the Medicare population." *New England Journal of Medicine* 376: 2513-2522 (2017). DOI: 10.1056/NEJMoa1702747.

anticipated that emissions controls and their optimization and/or de-contenting will continue in ways that would be expected to have in-use PM implications that should be quantified by the HDV PEMS measurement programs.

For the above reasons, NESCAUM urges EPA to maintain the requirement that truck manufacturers continue PEMS testing of PM to ensure that certification limits are met in normal operation.

Ensuring Long-Term Emissions Performance

Deterioration of emission controls can increase emissions from in-use vehicles. NESCAUM offers comment on the following areas:

Warranty Provisions

Section 207(a) of the Clean Air Act requires manufacturers to provide an emission warranty that offers protection for purchasers from costly repairs of emission controls during the warranty period. The warranty generally covers all expenses related to diagnosing and repairing or replacing emission-related components. The current warranty requirements for heavy-duty engines are five years or 50,000 miles (whichever occurs first) for light-duty trucks, gasoline heavy-duty engines, and light heavy-duty diesel engines. For all other heavy-duty diesel engines, the warranty period is five years or 100,000 miles, whichever occurs first.

The current warranty periods may cover less than a single year for some Class 8 vehicles. A longer emission warranty period could provide an extended period of protection for purchasers, as well as a greater incentive for manufacturers to design emission control components that are more durable and less costly to repair. Longer periods of warranty could also encourage truck owners to repair their vehicles throughout the warranty period and for a greater fraction of the vehicle life – reducing emissions, improving fuel consumption, reducing exposure to emissions, reducing the frequency of down-time, and saving operators money.

NESCAUM supports the following warranty periods for model years 2027-2030:

- 110,000 miles/7 years for heavy-duty gasoline engines
- 150,000 miles/7 years for light heavy-duty diesel engines
- 220,000 miles/7 years for medium heavy-duty diesel engines
- 450,000 miles/7 years for heavy heavy-duty diesel engines

NESCAUM supports the following warranty periods for model year 2031 and later:

- 160,000 miles/10 years for heavy-duty gasoline engines
- 210,000 miles/10 years for light heavy-duty diesel engines
- 280,000 miles/10 years for medium heavy-duty diesel engines
- 600,000 miles/10 years for heavy heavy-duty diesel engines

Useful Life

Under the Clean Air Act, an engine or vehicle's useful life is the period for which the manufacturer must demonstrate, to receive EPA certification, that the engine or vehicle will meet the applicable emission standard, including accounting for deterioration over time. Section 207(c) of the Act requires manufacturers to recall and repair engines if "a substantial number of any class or category" of them "do not conform to the regulations…when in actual use throughout their useful life." Section 202(d) of the Act directs EPA to "prescribe regulations under which the useful life of vehicles and engines shall be determined" and establishes minimum values of 10 years or 100,000 miles, whichever occurs first. Under this authority, EPA has established the following useful life mileage values for heavy-duty engines:

- 110,000 miles for gasoline-fueled and light heavy-duty diesel engines
- 185,000 miles for medium heavy-duty diesel engines
- 435,000 miles for heavy heavy-duty diesel engines

According to EPA's analysis of engine rebuild intervals drawn from a 2013 ICF study commissioned by EPA, actual in-use lifetimes for LHD, MHD, and HHD diesel engines are much higher than the current regulatory useful life requirements. EPA's analysis of the ICF study, which relied on a MacKay & Company survey of heavy-duty vehicle operators, found that the average rebuild ages, which correspond roughly to an engine's in-use lifetime, are:

- 315,000 miles for gasoline-fueled and light heavy-duty diesel engines
- 458,000 miles for medium heavy-duty diesel engines
- 909,000 miles for heavy heavy-duty diesel engines

Given that heavy-duty engines' actual in-use lifetimes are much longer than current regulatory lifetimes, as seen from the MacKay & Company survey data of heavy-duty vehicle operators, NESCAUM supports the following useful lifetimes for 2027 -2030 model years:

- 155,000 miles/12 years for heavy-duty gasoline engines-
- 190,000 miles/12 years for light heavy-duty diesel engines
- 270,000 miles/11 years for medium heavy-duty diesel engines
- 600,000 miles/11 years for heavy heavy-duty diesel engines

NESCAUM encourages EPA to adopt the following useful lifetimes for model years 2031 and later:

- 200,000 miles/15 years for heavy-duty gasoline engines
- 270,000 miles/15 years for light-heavy duty diesel engines
- 350,000 miles/12 years for medium-heavy duty diesel engines
- 800,000 miles/12 years for heavy-heavy duty diesel engines

Tampering

In the ANPR, EPA notes that enforcement activities continue to find evidence of tampering nationwide and describes EPA's new National Compliance Initiative (NCI) to reduce the manufacture, sale, and installation of defeat devices on vehicles and engines. The ANPR states that emission system parts are physically removed or "deleted" electronically through the hardware, which can disable these components, and the one key method to enable such actions is through tampering with the ECM calibration.

NESCAUM strongly supports EPA's proposed approaches to prevent tampering with the ECM:

- requiring manufacturers to provide public access to unique data channels that can be used by owners or enforcement agencies to confirm emission controls are active and functioning properly;
- developing methodologies that flag when ECMs are flashed with improper calibrations;
- preventing cyber security hacking activity; and
- Support development of tamper-proof communication protocols between sensors, actuators, and control units.

In addition, NESCAUM urges EPA to facilitate HDV inspection and maintenance program development by establishing state implementation plan (SIP) crediting guidance.

Incentives for Early Action

NESCAUM urges EPA to incentivize early introduction of the cleanest engines and technologies for model year engines and vehicles through 2026, which could include NOx credit programs, flexibilities, or other voluntary incentives. We also urge the Agency to evaluate the current incentives established under the Phase 2 heavy-duty GHG regulation, which provides multipliers for advanced technologies such as electric vehicles. Incentives under a NOx regulation should be crafted with the Phase 2 program in mind to avoid double counting of credits. EPA actions should seek to increase the market deployment of these pre-compliant or over-compliant products beyond the existing state and local mandates in place for each model year. We urge EPA to craft incentives such that continued progress is assured toward attainment as each technology transitions from technology demonstration to reaching mainstream market competitiveness enabled volumes.

EPA also requests comment on the development of incentives for alternative fuel vehicles, such as vehicle operating on natural gas and dimethyl ether. Although the use of these fuels in heavy-duty engines, when properly calibrated, can reduce NOx and PM emissions, NESCAUM opposes the development of incentives for the fuels. This is based on the need to achieve significant reductions in both GHG emissions and criteria pollutant emissions from HDVs. Alternative fuel vehicles do not provide a significant enough benefit to warrant special incentives.

Summary of NESCAUM Recommendations for Certification Emissions Standards

Significant developments in engine and aftertreatment since 2010 provide a suite of technology options available to manufacturers to meet new standards. In addition, a 2027 model year requirement affords manufacturers ample time to integrate emission reduction technologies into new engines. Below are the program elements we believe are required in the Cleaner Trucks Initiative proposed rulemaking to ensure a robust heavy-duty engine emission program:

- Require a new engine NOx emission standard of 0.02 g/bhp-hr on the FTP and RMC for model year 2027 and later engines;
- To prevent backsliding, require a new engine PM emission standard of 5 mg/bhp-hr on the FTP and RMC cycles for model year 2027 and later engines;
- Introduce a low load certification test cycle and require an engine exhaust emission limit of 0.075 g/bhp-hr NOx or lower for model year 2027 and later engines;

- Introduce an idle cycle for new engine certification and require an engine exhaust emissions limit of 10 g/hr NOx or less for model year 2027 and later engines;
- Replace the current NTE in-use test protocol with a MAW approach, and maintain the requirement for $PM_{2.5}$ in-use testing;
- Increase the useful life and warranty requirements for heavy-duty engines as specified in these comments; and
- Require availability of service information and tools within the reach of small fleets and owner/operators. Facilitate HDV inspection and maintenance program development by establishing SIP crediting guidance and requiring that ECM information be readily available to regulators and fleets.

We look forward to working with EPA in the development of new heavy-duty engine emissions standards and test procedures and stand ready to assist the Agency in this effort.

Sincerely,

Paul J. Miller
Executive Director

cc: NESCAUM Directors
Anne Idsal, EPA OAR
William Charmley, EPA OTAQ
Lynne Hamjian, EPA Region 1
Richard Ruvo, EPA Region 2