Heavy-Duty Engine Emissions in the Northeast

Executive Summary

May 1997

Objectives of the Study

The Northeast States for Coordinated Air Use Management (NESCAUM) is an interstate association of air pollution control agencies representing Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. The Association provides technical assistance and policy guidance to our member states on air pollution issues of regional concern in the Northeast.

This study is designed to: (1) inform our member states about the nature and scope of the heavy-duty engine (HDE) emissions problem; (2) characterize total emissions from heavy-duty engines used in highway and nonroad applications; (3) apportion this inventory to elucidate appropriate control priorities; (4) develop analytical tools to evaluate the benefits of various control options; (5) identify critical data gaps; (6) provide recommendations for improving the federal HDE control program; and (7) provide initial recommendations for states to consider in developing their HDE control programs. The NESCAUM states intend to utilize the information summarized in this study to develop a detailed set of policy options for consideration at the state and federal level.

The Need for the Study

Ozone

After more than a quarter century of concerted effort, large areas of the NESCAUM region remain out of compliance with the federal standard for ozone. With the exception of Vermont, all of the northeast states are either partially or wholly designated as ozone nonattainment areas. The recent proposal by the United States Environmental Protection Agency (USEPA) to modify the ozone air quality standard indicates that the problem may be even more widespread than previously believed. Monitoring and modeling data indicate that, on a regional basis, additional control of oxides of nitrogen (NOx) will provide greater ozone reduction benefits than comparable levels of additional hydrocarbon (HC) reductions.

Many areas within the NESCAUM region will be unable to demonstrate future attainment of the current national ambient air quality standard (NAAQS) for ozone without significant further reductions in precursor emissions. Projections suggest that adoption of the 8-hour ozone standard recently proposed by the USEPA will make attainment of this ambient air quality standard even more of a challenge and will require a greater focus on broad-based regional NOx control strategies.

Particulate Matter

Only three areas in the NESCAUM region have been classified as nonattainment for particulate matter (PM) since the PM10 standard was adopted in 1987: Presque Isle, Maine; New Haven, Connecticut; and New York County, New York. However, in light of the compelling epidemiological evidence linking relatively low levels of ambient particulate concentrations to increased mortality and morbidity, the USEPA recently proposed a new NAAQS for fine particulate. If adopted as proposed, the revised NAAQS, based on a PM2.5 indicator, could dramatically alter the current nonattainment situation in the Northeast. In short, many areas of the NESCAUM region now in attainment for PM10 are likely to be in nonattainment with the PM2.5 standards set at the levels proposed.

An important regulatory complexity is introduced by the fact that the fine particulate problem in the Northeast has two dimensions: micro-scale, Òhot spotÓ areas of high PM concentration in which local sources are very important, and a macro-scale regional problem in which long-range pollution transport plays a key role. Both 24-hour and annual nonattainment situations may occur at both micro and macro levels in the region.

Direct Exposure to Diesel Emissions

In addition to its contribution to non-cancer health effects posed by exposure to ozone and fine particles, diesel exhaust has also been classified as a probable human carcinogen by the National Institute for Occupational Safety and Health, the International Agency for Research of Cancer (IARC), and the USEPA. These classifications are based on assessments of human and animal evidence linking whole diesel exhaust with lung cancer.

The first comprehensive assessment of the available health effects information on diesel exhaust was carried out by the IARC in June 1988. The IARC concluded that diesel particulate is probably carcinogenic to humans. Since then, additional studies have further corroborated the link between diesel exhaust exposure and human lung cancer.

USEPAÕs 1994 draft assessment concurred with IARCÕs conclusions that sufficient evidence exists, based on animal studies and limited evidence in human studies, to classify diesel exhaust as a probable human carcinogen. California Office of Environmental Health Hazard Assessment (OEHHA) concluded in their 1994 draft assessment that sufficient evidence exists from human studies to indicate that diesel exhaust is a human carcinogen.

Contribution of Heavy-Duty Engines to Ozone and PM Formation

The pollutants emitted by HDEs include: unburned hydrocarbons, carbon monoxide (CO), oxides of sulfur (SOx), NOx, PM, and other toxic compounds. Diesel-fueled vehicles, which constitute the greater fraction of HDE fleet, emit relatively low levels of HCs and CO, and relatively high levels of NOx and PM. In other words, heavy-duty diesel engines are high emitters of those pollutants which play the most critical roles in the formation of ozone and PM.

HDEs are one of the largest sources of NOx emissions on both the local and regional scale. Together, highway and nonroad heavy-duty engines are responsible for roughly one-third of all NOx emissions in the northeast corridor. The relative importance of this sector as a source of emissions is expected to increase over time as the northeast states implement pollution controls on other sources of NOx emissions and as the regulatory community refines its ability to more accurately measure in-use HDE emissions.

Over 80% of all mobile source-related PM10 emissions and an even higher percentage of PM2.5 emissions are emitted by highway and nonroad diesel engines. Moreover, there is considerable evidence that the current inventories for both NOx and fine particles understate the actual magnitude of HDE emissions. Given the added concern over the public health effects of both ozone and particulates (described in Chapter 3 of this Report), the sizable inventory contribution from diesel engines and the ozone attainment deadlines established in the Clean Air Act, an aggressive near-term policy for controlling emissions from these sources is needed.

Vehicle and Equipment Populations & Emissions in the NESCAUM Region

Highway Vehicles and Engines

Heavy-Duty Trucks

In 1994, trucks carried 55% of all freight by volume, leading rail, air, water, and pipeline deliveries in tonnage and revenue. The demand for freight movement is increasing. The vehicle miles traveled (VMT) and ton miles of freight from the trucking sector has been increasing faster than the number of trucks, indicating that trucks are working harder, which increases engine wear, emissions and fuel consumption.

Heavy-duty trucks can be separated into three broad categories according to weight. Vehicles between 6,000 lbs. and 14,000 lbs. gross vehicle weight rating (GVWR) are dominated by gasoline engines and tend to be used more by individuals and in urban settings. This category of vehicles has potential to be included in the existing in-use regulatory structure for light-duty vehicles. Vehicles between 14,000 lbs. and 26,000 lbs. GVWR are divided by fuel type and exhibit a broad array of usage patterns which complicates the design of regulatory control strategies. Vehicles greater than 26,000 lbs. GVWR are dominated by line-haul diesel trucks. This category's relatively small number, similar technology and usage patterns, long useful life, high mileage and relatively high emissions suggest that it deserves particular emphasis when evaluating regulatory priorities. In addition, careful attention should be paid to the for-hire segment of the line-haul truck population which is expanding at a steady rate due to its cost-efficiency over private carriers.

On average, line-haul trucks accumulate the most VMT, the bulk of which occurs at relatively steady, high speeds and under considerable load. This mode of operation is conducive to the generation of high rates of NOx emissions. Smaller trucks typically log fewer miles, but operate a greater percentage of the time in Òstop-and-goÓ traffic conditions, a mode which generates higher rates of PM emissions.

The fleet of heavy-duty trucks is aging and new models promise to be even more durable, easily exceeding 1,000,000 miles with engine rebuilds. Therefore, market strategies to speed vehicle turnover coupled with fuel quality improvements and in-use maintenance and retrofit programs are necessary to achieve timely reductions in heavy-duty truck emissions.

Buses

As with trucks, states possess reasonably good data on the number of transit buses operating in the NESCAUM region. However, data regarding the age of the school and intercity bus fleets are limited. Moreover, there are little data available describing what happens to older buses after they are sold by schools or private companies.

School buses, half of which are diesel-powered, comprise 85% of the total bus population in the NESCAUM region. While school buses dominate the regionÕs bus fleet in terms of the number vehicles, their average annual VMT of 10,000 miles is roughly 1/3 that of transit buses and 1/5 that of interurban buses.

Eight of the nationÕs 25 largest school transportation contractors and five of the ten largest transit bus systems are located in the Northeast. The presence of large government owned bus fleets in the Northeast creates a number of regulatory opportunities. Given that both school and transit buses regularly operate in stop-and-go driving conditions and in close proximity to pedestrians, reducing PM emissions from these vehicles should be considered a priority from a public health perspective.

Since 1992 when the Interstate Commerce Commission dissolved, little information on VMT or vehicle populations has been available for interurban buses in the Northeast. However, given the high mileage and relatively high emissions of interurban buses, controls for this sector merit further consideration.

Nonroad Sector

Emissions from nonroad diesel engines represent a large and growing share of NOx and PM inventories. The nonroad sector follows light-duty vehicles and utilities in terms of emissions generated, and closely approximates the amount of NOx emissions generated by highway diesels. It is suspected that this sector is a significant local source of fine particle emissions. However, the database for nonroad engines and emissions is extremely limited and more research is needed to more accurately portray their emission contributions.

Construction Equipment

According to current State Implementation Plan (SIP) inventories, the construction sector is estimated to represent up to 11% of the PM and 16% of the region's total nonroad NOx emissions. In addition, much of this activity takes place during the summer months when ozone levels are at their highest. The duty cycles, and thus the emissions, of nonroad construction engines vary significantly according to application. For example, a diesel engine used in a rock crusher which operates at a fairly constant load and speed has a very different duty cycle than a nonroad haulage truck. Effective regulations for this sector must target a larger number of manufacturers and a broader group of end users than the on-highway sector.

Agricultural Sector

Almost 100,000 pieces of diesel-powered equipment, or approximately 3.5% of the national agricultural fleet of 2.9 million units, operate in the NESCAUM region. These vehicles travel the equivalent of 133.1 million miles annually using engines which range in size from 7 hp to over 100 hp. Tractors and combines are the most common equipment types. Unlike construction equipment, agricultural equipment is generally used in more rural areas.

Agricultural diesel vehicles constitute 5% of the overall nonroad NOx inventory in the NESCAUM region based on current SIP estimates, making it a fairly significant contributor to ozone formation. Like the construction sector, agricultural equipment is used predominantly in the ozone season.

Airport Support Vehicles

Fifty-two commercial, certificated airports operate in the NESCAUM region. It is estimated that at least 3,369 ground service vehicles are in operation at these facilities, not including airport equipment owned and operated by foreign based airlines which are not accounted for in the current NESCAUM inventory. The cumulative emissions from all ground support vehicles at these facilities is considered to be significant.

Locomotives

The availability of general data on locomotives is mixed. There is significant information about commuter rail and Class I freight railroad locomotives, but scarce information regarding intercity rail and the smaller regional and local freight railroads.

The USEPA has proposed locomotive emission standards which will govern new and remanufactured Class I freight locomotive engines. The Clean Air Act preempts states from setting alternative new engine emission standards for freight locomotives. The extent to which individual states can regulate various aspects of in-use emissions from locomotives remains open to question, in light of the further constraints on this authority proposed in the locomotive regulations.

Current SIP inventories appear to greatly underestimate emissions from locomotives. Federal regulation of the locomotive industry for emission purposes should improve the reporting of locomotive population and usage data, thereby increasing the ability of states to more accurately account for those emissions in their inventories.

Marine Engines

Historical population data is available for commercial marine vessels in several databases, but the emissions from these vessels are not well studied. The projections developed in this study, as well as studies conducted at ports in Southern California, suggest that current emission inventory estimates used by the northeast states may significantly understate the contribution of this source sector.

Many recreational boats are required to register with the state in which they reside, therefore, some population information is available. However, the vast majority of recreational boats use smaller, gasoline powered engines.

Control of emissions from marine vessels may be a difficult task. Regulating pollutant emissions from international marine vessels is especially problematic because the U.S. government has little authority to govern the type of fuel used to power these ships, or the amount of time the ship spends at port, idling. A starting point for control strategies may begin with captive fleets within the US, including the Great Lake commercial marine vessel fleet, and the inland waterway fleet. Given the long life of these diesel engines, in-use maintenance, clean fuels, and retrofit/rebuild control measures may be pursued by states to achieve PM and NOx emission reductions from this source category. However, these vessels pass through many state boundaries making federal regulation a better approach than state regulation.

Heavy-Duty Engine Emissions Model

As part of this study, NESCAUM contracted with Michael P. Walsh to develop an emissions model for the heavy-duty engine sector. This model (hereafter referred to as the ÓWalsh modelÓ) is designed to: (1) develop baseline and projection year emission inventories of NOx and PM for both highway and nonroad sources; (2) apportion the HDE inventory in a way which will help states and other interested parties develop a focused control program by better understanding the relative emissions contribution of the various subsectors; and (3) provide an analytical tool which enables users to assess the merit of various control options. This tool can be used for both regional or subregional (state or local) analyses.

Model Design

This spreadsheet model calculates NOx and PM emissions from the HDE fleet by multiplying the population for a given subsector (e.g., heavy heavy-duty trucks, school buses, etc.) by the activity rate (in miles traveled or hours of use) for each type of equipment and an appropriate engine emission factor (in grams per mile or grams per hour).

The regional vehicle/equipment populations and activity rates used in the model are derived from the data collected for this study and presented in Chapter IV of this report. The NOx and HC emission factors for highway vehicles are from the USEPAÕs MOBILE5.a model and particulate emission factors from the PART5 model. The PART5 in-use exhaust emission factors, which assume that engines meet their PM certification standards throughout their useful life, were increased by 50% to account for the fact that in-use emissions on some vehicles are much higher than certification standards due to wear, poor maintenance and tampering.[1]   The nonroad emissions factors used in the model were derived from several sources, detailed in Chapter VI of the report.

The model divides the HDE fleet into three broad groupings: trucks, buses and nonroad equipment. Each of these primary groupings is further broken down into subsectors. For example, the bus sector is apportioned according to school, transit and interurban subsectors. For each of these, the proportion using any of three types of fuelsÑgasoline, diesel or compressed natural gas (selected as a representative alternative fuel for HDEs) are input by the user. The model calculates emissions for a base year (1995) and three projection years (2000, 2005, and 2010). Composite fleet emissions and/or subsector-specific emissions can be generated for each of the four years.

Model Results

Using the model, a HDE emissions inventory for NOx and PM was generated for the NESCAUM region in 1995, 2000, 2005 and 2010 for several scenarios: (1) the base case (i.e., no additional local, state or regional emission controls); (2) an inspection and maintenance (I/M) case; (3) a very low sulfur fuel case; (4) an alternative fuel case; (5) an I/M plus low sulfur fuel case; and (6) a combined I/M, low sulfur fuel, and alternative fuel case. A description of the assumptions used for each

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[1] ÒHeavy Duty Diesel Vehicle Inspection and Maintenance Study, Final Report, Volume II, Quantifying the Problem,Ó Radian Corporation, May 16, 1988.

of these scenarios is provided in Chapter VI.

Base Case

The base case for each year assumes all existing engine emission and fuel standards, including the phase-in of the recently proposed heavy-duty engine highway standards. The model does not account for the benefits from the Tier II and Tier III new engine emission standards recently proposed by USEPA for nonroad diesels, or the recently proposed locomotive standards. The base case results for the various projection years provide useful insights as to the expected changes in emissions from the truck, bus and nonroad fleets over time. It is clear from these results that new truck and bus standards will be effective in reducing the overall emissions from these sectors over time. It is equally clear that the most stringent possible NOx and PM emission standards and enforcement programs will be needed to check the growth in emissions from the nonroad sector. The results for the base case scenario are presented in Tables EX.1 and EX.2.

Table EX.1
Base Case PM Emission Summary
for Heavy-Duty Vehicles in the NESCAUM Region
1995Ð2010

Year	Trucks (ton/yr)	Truck % of Total Annual PM	Buses (ton/yr)	Bus % of Total Annual PM	Nonroad (ton/yr)	Nonroad % of Total Annual PM	Total Heavy-duty Emissions (ton/yr)
Base Case							
1995	16,632	56%	4,010	13%	9,306	31%	29,949
2000	10,978	46%	2,625	11%	10,073	43%	23,676
2005	7,345	37%	1,732	9%	10,946	55%	20,023
2010	6,340	32%	1,333	7%	11,940	61%	19,614

Table EX.2
Base Case NOx Emission Summary
for Heavy-Duty Vehicles in the NESCAUM Region
1995-2010

Year	Trucks (ton/yr)	Truck % of Total Annual NOx	Buses (ton/yr)	Bus % of Total Annual NOx	Nonroad (ton/yr)	Nonroad % of Total Annual NOx	Total Heavy-duty Emissions (ton/yr)
Base Case							
1995	134,309	40%	30,424	9%	168,847	51%	333,580
2000	108,693	35%	25,519	8%	178,665	57%	312,877
2005	86,219	29%	21,028	7%	189,932	64%	297,178
2010	63,518	23%	16,118	6%	202,873	72%	282,509

The results of our preliminary modeling analysis suggest that the proposed federal new engine certification standards for heavy-duty highway vehicles will effectively reduce emissions from this sector over the long-term. However, given the magnitude of NOx reductions which urban airshed models indicate will be needed to bring all areas into attainment with the current ozone standard and the near-term attainment deadlines prescribed in the Clean Air Act, additional controls on trucks and buses in areas such as the Northeast will be needed. Promulgation of the proposed 8-hour ozone and fine particulate standards will heighten the need for local, state and regional controls on this sector. Further, public health and environmental officials must consider the adverse effects of exposure to current levels of particulate and toxic emissions from HDEs. Strategies such as inspection and maintenance, clean fuels, and market incentives to speed the introduction of cleaner engines in the heavy-duty fleet must be considered in the near-term.

The recently proposed Tier II and Tier III nonroad diesel engine certification standards have not yet been incorporated into the Walsh model for two reasons. First, the standards have not been finalized. Second, the nonroad diesel proposal is complex in that it involves two tiers, a long phase-in and multiple emission standards based on engine size. At this time, NESCAUM lacks the detailed information needed to accurately portray this proposal in the model. We intend to work with the USEPA and others to determine an appropriate way to imbed these proposed standards into the Walsh model.

These modeling results point to the significant and growing contribution of nonroad engines to NOx and particulate emission inventories and highlight the need for both aggressive federal measures and targeted local, state and regional initiatives aimed at controlling emissions from nonroad engines. As with trucks and buses, the benefits of new federal engine emission standards will likely need to be augmented by state or regional controls in the Northeast.

Optional Control Scenarios

The optional control scenarios were run to assess the potential emission reductions these measures might afford if implemented throughout the NESCAUM region. All control programs modeled to date are assumed to apply only to the highway fleet. Although NESCAUM has not yet modeled the emission benefits of such strategies for the nonroad engines, I/M, low sulfur diesel fuel and alternative fuels are reasonable control options for this sector. While the accuracy of absolute emission reductions predicted for any given scenario are limited by the availability of sound input data, the model provides a sense as to the relative merit of the various control options. The results of the alternative scenarios are summarized in Table EX.3.

As indicated in the results table, I/M programs can provide large PM reductions from trucks and buses by helping to ensure that the engines used in these vehicles maintain certification emission standards throughout their useful life. Similarly, very low sulfur diesel fuel reduces PM emissions in both trucks and buses. Switching from diesel to compressed natural gas can reduce both NOx and PM emissions from these fleets. Obviously, the highest level of emission reductions are achieved through the combined application of the three control measures.

Table EX.3
Heavy-Duty Engine Emissions and Reduction Strategies[1]

	Heavy-Duty Trucks				Buses				Nonroad				TOTAL			
YEAR	PM (ton/yr)	% Reduction from Base Case	NOx (ton/yr)	% Reduction from Base Case	PM (ton/yr)	% Reduction from Base Case	NOx (ton/yr)	% Reduction from Base Case	PM (ton/yr)	% Reduction from Base Case	NOx (ton/yr)	% Reduction from Base Case	PM (ton/yr)	% Reduction from Base Case	NOx (ton/yr)	% Reduction from Base Case
Base Case																
1995	16,632		134,309		4,010		30,424		9,306		168,847		29,948		333,580	
2000	10,978		108,693		2,625		25,519		10,073		178,665		23,676		312,877	
2005	7,345		86,219		1,732		21,028		10,946		189,932		20,023		297,179	
2010	6,340		63,518		1,333		16,118		11,940		202,873		19,613		282,509	
I/M Case[2]																
1995	16,632	0%	134,309	0%	4,010	0%	30,424	0%	9,306	0%	168,847	0%	29,948	0%	333,580	0%
2000	8,198	25%	108,693	0%	2,625	0%	25,519	0%	10,073	0%	178,665	0%	20,896	12%	312,877	0%
2005	5,702	22%	86,219	0%	1,345	22%	21,028	0%	10,946	0%	189,932	0%	17,993	10%	297,179	0%
2010	5,155	19%	63,518	0%	1,090	18%	16,118	0%	11,940	0%	202,873	0%	18,185	7%	282,509	0%
Low Sulfur Fuel Case[3]																
1995	16,632	0%	134,309	0%	4,010	0%	30,424	0%	9,306	0%	168,847	0%	29,948	0%	333,580	0%
2000	9,858	10%	108,693	0%	2,295	13%	25,519	0%	10,073	0%	178,665	0%	22,226	6%	312,877	0%
2005	6,221	15%	86,219	0%	1,382	20%	21,028	0%	10,946	0%	189,932	0%	18,549	7%	297,179	0%
2010	5,203	18%	63,518	0%	958	28%	16,118	0%	11,940	0%	202,873	0%	18,101	8%	282,509	0%
Alternative Fuel Case[4]																
1995	16,632	0%	134,309	0%	4,010	0%	30,424	0%	9,306	0%	168,847	0%	29,948	0%	333,580	0%
2000	10,673	3%	104,919	3%	1,659	37%	23,293	9%	10,073	0%	178,665	0%	22,405	5%	306,877	2%
2005	7,018	4%	81,397	6%	1,474	15%	18,665	11%	10,946	0%	189,932	0%	19,438	3%	289,994	2%
2010	5,884	7%	58,095	9%	1,094	18%	14,282	11%	11,940	0%	202,873	0%	18,918	4%	275,250	3%
I/M plus Low Sulfur Case																
1995	16,632	0%	134,309	0%	4,010	0%	30,424	0%	9,306	0%	168,847	0%	29,948	0%	333,580	0%
2000	7,077	36%	108,693	0%	2,295	13%	25,519	0%	10,073	0%	178,665	0%	19,445	18%	312,877	0%
2005	4,578	38%	86,219	0%	995	43%	21,028	0%	10,946	0%	189,932	0%	16,519	17%	297,179	0%
2010	4,018	37%	63,518	0%	714	46%	16,118	0%	11,940	0%	202,873	0%	16,672	15%	282,509	0%
I/M plus Low Sulfur plus Alternative Fuel Case																
1995	16,632	0%	134,309	0%	4,010	0%	30,424	0%	9,306	0%	168,847	0%	29,948	0%	333,580	0%
2000	6,772	38%	104,919	3%	1,328	49%	23,293	9%	10,073	0%	178,665	0%	18,173	23%	306,877	2%
2005	4,251	42%	81,397	6%	737	57%	18,665	11%	10,946	0%	189,932	0%	15,934	20%	289,994	2%
2010	3,562	44%	58,095	9%	475	64%	14,282	11%	11,940	0%	202,873	0%	15,977	19%	275,250	3%

Model Assumptions:

[1] Based on 1992 figures grown to appropriate base year values. Emission factors derived from USEPA Mobile.5a and Part5 models.
USEPA tier 1, proposed tier 2 & 3 nonroad standards not included in model.

[2] I/M is defined as eliminating the emission deterioration factor and bringing vehicle engines into compliance with original certification standards.

[3] 0.01%

[4] Assumes: truck use of alt fuels rises from 2% (1995) to 5% (2000), 7% (2005) 10% (2010);
urban and school bus use rises from 2-3% (1995) to 25% (2000), 35% (2005), 50% (2010);
interstate use rises from 0%(1995) to 10% (2000), 20% (2005), 25 (2010)

NESCAUM has modeled just a sample of the potential state and local control options, to date. Importantly, there are a host of strategies that have not been incorporated into the Walsh model which can be implemented to achieve NOx reductions. For example, the model may be expanded in the future to allow an assessment of the benefits associated with raising the minimum cetane number of diesel fuel. It is our intention to continue to add such control options to the model over time. This spreadsheet represents a useful tool to assist regulators in assessing and developing appropriate control pathways.

While NESCAUM will continue to revise and expand this model to incorporate new data and additional control options, the results of current runs of the model provide useful insights into the contribution of the various sectors to overall HDE emissions of particulate and NOx, now and in the future. These results also suggest the level of reductions which might be achieved through a subset of possible state control programs for heavy-duty engines in the NESCAUM region.

A copy of the Walsh model is provided with this report to enable interested readers to conduct their own emission analyses. User instructions and a more detailed description of the design of the model, as well as its inputs and assumptions are presented in Chapter VI of this report. The model, as provided, includes aggregate population estimates for the entire eight state NESCAUM region. State, local or fleet level populations and growth rates can be substituted according to the interests of the user.

Conclusion and Recommendations

Strengthening the Federal Heavy-Duty Engine Control Program

Given the limited authority which states have to regulate emissions from heavy-duty vehicles, the need for a stringent and comprehensive federal program is imperative.

Heavy-Duty Highway Program

New Engine Standards

- The NESCAUM states support the NMHC + NOx standard of 2.4 g/bhp-hr proposed in the NPRM regarding the *Control of Emissions of Air Pollution from Highway Heavy-Duty Engines* as being an appropriate and cost effective control measure for the 2004 time frame.

- Given the harmful health effects associated with exposure to diesel emissions and the likely adoption of new and more stringent ambient standards for fine particulate matter, NESCAUM implores USEPA to include a more stringent standard for direct particulate emissions from heavy-duty engines in the final rule. Specifically, we recommend promulgation of a 0.05 g/bhp particulate standard as part of this rulemaking. The technical viability and cost effectiveness of this standard should be assessed as part of the technology review which USEPA and industry have agreed to.

Certification Program

- NESCAUM urges USEPA to critically assess the current heavy-duty highway test procedure and consider such options as random cycle testing to minimize the impact of off-cycle emissions. We also recommend that the Agency's defeat device policy be used more aggressively to protect against control strategies that sense off-cycle operation and optimize engine operation for power and fuel economy at the expense of emissions.

- The certification testing protocol should be updated to require manufacturers to demonstrate that engines remain emission durable throughout their actual lives, rather than the somewhat arbitrary regulatory useful life currently used for certification and compliance purposes.

- Although NESCAUM supports the theoretical concept of averaging, banking and trading, we are concerned about its historical application with regard to the heavy-duty engine certification program. Our primary concern is that engine manufacturers have little incentive to set family emission limits at the appropriate level, considering in-use deterioration, because there is no credible enforcement program to identify engine families which are not achieving certification levels in-use. Consequently, engine manufacturers have an incentive to ÓshaveÓ their compliance margins and maximize banked credits.

In-Use Testing and Enforcement

- NESCAUM is concerned that the full potential benefits of the proposed new certification standards will not be realized unless the in-use compliance component of the federal heavy-duty highway program is substantially strengthened.

- The presence of a viable federal recall testing program will provide an incentive for manufacturers to design more emissions durable engines.

USEPA must make funding the federal recall testing program a fiscal priority.

- NESCAUM also proposes that EPA require new heavy-duty engines to be equipped with onboard diagnostic systems (OBD) capable of: (1) determining when emission limits are exceeded; (2) notifying the driver that there is a problem; and (3) storing accessible information regarding the nature of the malfunction. For vehicles such as line-haul trucks, such systems may be an especially critical component of any future state or local strategies to address the maintenance of in-use engines.

Heavy-Duty Nonroad Engine Program

New Engine Standards

- The recently issued advanced notice of proposed rulemaking (ANPRM) for nonroad diesel engines represents an important step toward reconciling the stringency of nonroad engine standards with those for highway engines. However, as the ANPRM was only recently released, the NESCAUM states have not yet fully assessed the proposed Tier II and III standards for nonroad heavy-duty engines. NESCAUM does, however, believe that more stringent NOx and PM standards for these sources are necessary, technologically viable and cost-effective.

Certification Program

- With respect to nonroad diesel engines, NESCAUM urges EPA to develop a transient test procedure capable of accurately measuring not only NOx, but also PM emissions.

In-Use Testing and Enforcement

- Most of the comments made with regard to the in-use enforcement component of the heavy-duty highway engine program apply to the nonroad sector as well. Of particular concern is the need for a credible testing program which adequately characterizes the in-use emissions of HDEs used in nonroad equipment. It is critical that the federal government send a clear message that engine manufacturers will be held liable for emissions from their products throughout their useful lives.

Data and Analytical Needs

- Our examination of the current heavy-duty vehicle control program leads to the general conclusion that both state and federal agencies are underpredicting actual emissions from the heavy-duty fleet.

Inventory Data

Engine Populations

- Efforts should focus on improving estimates of the number, type and age of engines used in construction and agricultural equipment. For urban areas with fine particle problems, efforts should be undertaken to assess the seasonal flux in activity patterns for construction equipment.

- Effort should be devoted to linking raw engine population data with ownership information. It is necessary to characterize engine population data according to fleet size, end-use, and use patterns in order to design viable in-use control strategies

- There is considerable anecdotal evidence suggesting that malmaintenance and tampering are important concerns. A credible survey of a statistically significant number of vehicles should be conducted to gauge the prevalence of these practices.

- The differing truck classification systems used by federal agencies such as USEPA and USDOT (FHWA) pose a problem for policy makers. Development of a national vehicle population database using common classification schemes should be pursued.

Engine Activity

- Our existing understanding of nonroad engine activity rates require considerable refinement. Efforts should focus on the construction and agriculture sectors (tractors, loaders, backhoes). To gather accurate and detailed data, a survey of equipment owners in the NESCAUM region should be initiated. In addition to basic information about equipment usage, seasonal variations and the interaction between equipment age and usage rates needs to be better understood.

Engine Emissions Data

- Chassis-based emission testing methodologies that correlate with engine-based certification standards must be developed for NOx and direct particulate emissions. Chassis-based testing is necessary to support maintenance programs, to screen out vehicles for enforcement testing, and to provide meaningful information about the effectiveness of HDE control programs.

- **Population Growth Rates**

  The vehicle population growth rates presented in the model are hypothetical. As more specific regional growth rates are identified, the emission modeling will become more accurate. Individual users are encouraged to replace these with the growth rates specific to their fleets.

Technology-Based State Control Options

Fuel Reformulation

- States should carefully assess the benefits and costs of adopting diesel fuel reformulation strategies because the emissions reductions can be significant. Fuel controls can reduce emissions from all sectors of diesel-powered equipment and accrue these benefits immediately upon program implementation. There are three critical diesel fuel parameters which effect emissions: sulfur, aromatics and cetane number. The addition of oxygenates can also serve to reduce emissions from engines operating on diesel fuel.

- Increasing the minimum allowable cetane number for diesel fuel serves to improve ignition quality and lower emissions of all major pollutants. As part of its assessment of ozone precursor control options, the Ozone Transport Assessment Group (OTAG) concluded that increasing the cetane number from 45 to 50 would reduce NOx plus HC emissions at a cost ranging from $840 to $2000 per ton, which is very competitive with other control options. The projected incremental cost increase associated with this improvement ranged from 0.8 cents per gallon to 1.9 cents per gallon.

- The addition of oxygenate to diesel fuel, which Òleans-outÓ the air/fuel mixture, represents a potentially viable PM control strategy. Results from limited testing suggest that the addition of 2% (by weight) oxygen can reduce PM emissions in heavy-duty diesel engines by 10% to 15%, without adversely affecting NOx emissions.
- NESCAUM recommends that the northeast states carefully consider a comprehensive diesel reformulation program which

targets both NOx and PM emissions. Selection of an appropriate diesel fuel for the region will depend on a detailed analysis of changes in engine technology, refinery costs and implementation issues.

- The federal low sulfur diesel regulations have provided meaningful reductions in PM emissions from the highway fleet. Extending this requirement to nonroad fuel could provide important additional reductions in PM.

Inspection and Maintenance

- Malmaintenance and deliberate tampering with engine components which affect emissions are thought to result in significant excess emissions from the heavy-duty fleet. States should consider using I/M programs as a means for the identification and repair of under-maintained and tampered engines. Since there are no federal guidelines for heavy-duty I/M programs, states have considerable flexibility in the design of these programs including: the types and ages of vehicles to test; the emission levels or ÒcutpointsÓ to use in determining compliance; the penalty or remedy for noncompliance; and the type, frequency and location of testing.

- Visible smoke is a good indicator of malmaintenance and/or tampering since well maintained, current technology diesel engines should not have visible black smoke emissions.

- From a logistical standpoint, both random roadside testing and periodic testing at fleet facilities represent viable options for future enforcement programs.

- In addition to smoke tests, states might consider the use of visual inspections of emission control systems and components to identify deliberate tampering or the presence of worn or defective parts which affect emissions. Such inspections appear to be more viable in the garage-based environment rather than in conjunction with roadside pullovers.

- The availability of OBD systems on heavy-duty vehicles would provide a valuable tool for assessing in-use emission performance, especially with regard to NOx.

- Given the technology changes expected to occur as a result of the proposed heavy-duty truck and bus standards, states should consider a multi-phase inspection and maintenance program which evolves sequentially with changes in engine and emission control technology. Smoke opacity testing represents a reasonable first step in the evolution of heavy-duty I/M. The technology exists to allow quick and inexpensive tests for visible smoke emissions.

- There is a need for better data which correlates measurable reductions in smoke emissions to changes in an engine's fine particulate matter emissions.

- USEPA leadership and cooperation is essential to the development of effective state I/M programs for heavy-duty vehicles. Development of a cost effective "short-test" for heavy-duty engine emissions should become an Agency priority.

Transportation Control Measures

- State air quality control agencies should assess the emission reduction opportunities associated with restricting the spatial and temporal use of HDEs. Strategies which route heavy-duty traffic away from areas with high pedestrian densities should be explored.

- Limits can also be placed on certain heavy-duty vehicle operating parameters such as idling. While many local communities have the authority to regulate vehicle idling, more aggressive enforcement may be warranted to deter excessive idling.

Market-Based Control Options

Trucks

Voluntary Low Emission Standards for HDEs

- States should pursue the credit-based incentive approach similar to that developed by the California Air Resources Board and implemented in the South Coast Air Quality Management District. Such an approach would require the northeast states to adopt low NOx certification standards for heavy-duty engines, allowing the vehicle purchaser/operator to claim mobile emission reduction credits (MERCs) for the operation of these cleaner-than-required engines. Such a program would stimulate the market for advanced technology engines, and therefore create an incentive for manufacturers to voluntarily produce some models of cleaner heavy-duty engines. The market value of the MERCs would provide an incentive for purchasers of heavy-duty engines to demand cleaner vehicles from the engine manufacturers.

Early Vehicle Retirement/Scrappage

- States could undertake a MERC trading system that would provide credits for the early retirement of heavy-duty engines. The value of the MERCs generated by the scrappage of older engines would serve to partially offset the cost of acquiring new, cleaner HDEs.

Heavy Duty Engine Retrofit/Rebuild

- States should consider developing programs designed to promote the retrofit of existing engines with advanced emissions controls or the rebuilding of engines with emission upgrade kits.

New Engine Purchase Incentives

- Programs such as low-interest loans, rebates, or tax breaks that reduce the cost to the fleet owner/operator of new, clean engine purchases should be adopted by states to stimulate more rapid fleet turnover.

Cleaner State Fleets

- State and local government should commit to the purchase of cleaner heavy-duty fleet vehicles for their fleets. Ideally, federal fleets should also increase their commitment to cleaner heavy-duty engines. Government demand for cleaner technologies will stimulate the market to produce a broader range of low emission heavy-duty engines at a lower cost.

State-wide NOx/PM Emission Budgets for Local Fleets

- States should consider the implementation of NOx/PM emission budgets for the owners/operators of local and intrastate truck fleets. To affect reductions from this source sector, a target budget could be set at some level below current emissions. Using the budget approach, a declining mass emission target or emission rate performance standard gives the owner/operator of the business the discretion to obtain reductions wherever they can be achieved most cost-effectively. Especially when implemented on a wide scale, this flexibility allows the market to drive demand for cleaner technology and fuels, without requiring agencies to require specific technologies or reformulations.

Regional NOx/PM Emission Budget

- Emissions from the interstate trucking sector presents an important challenge to the NESCAUM states. Individual state measures to either require or incentivize emission reductions from these vehicles are of limited use in the absence of a consistent, regional commitment. Although emissions from this sector are not expected to grow as much as from the nonroad sector, the contribution of interstate trucks is significant and warrants a committed, regional reduction effort. We recommend that the NESCAUM states work together to develop a NOx/PM emission budget for interstate trucks that operate in the region. The budget could be predicated on the OTC memorandum of understanding (MOU) for NOx reductions from large stationary sources. Such a budget would establish a declining slope over time for NOx and PM emissions and be implemented with a trading system to maximize compliance flexibility and lower costs for the affected sources.

Buses

Transit Bus Fleets/School Bus Fleets

- States should consider adopting market strategies that provide incentives to reduce emissions from transit and school buses. In particular, the implementation of emission budgets is strongly recommended since budgets are a proven method of obtaining enforceable emission reductions from defined sources, while providing compliance flexibility to the affected sources.

Interstate Buses

- The NESCAUM states could develop a NOx/PM emission budget for interstate buses that operate in the region. The budget would establish a declining slope over time for NOx and PM emissions and be implemented with a trading system to maximize compliance flexibility for the affected sources.

Nonroad

Green Construction Projects

- State contracts could be structured to favorably weight bids from contractors who demonstrate reduced emissions from current levels. For example, the commitment to use cleaner fuels, low average age of equipment, recent rebuilds or retrofitting with control devices would be rewarded in the bid review process.

Emission Budgets for Construction Projects

- For construction projects financed by non-government entities, emission budgets should be established for projects exceeding a threshold size, based upon a quantitative measure such as cost. Total emissions from these projects would be capped proportional to project size, allowing the contractor to obtain the needed reductions in the most cost-effective manner. This approach could be extended through the use of a trading mechanism, whereby a contractor would have an incentive to bring the entire project to completion Óunder budget.Ó The difference between the budget level and the actual emissions from the project could be sold as credits to aid in offsetting potential excess emissions associated with another project.

Airports

- Ground service vehicles at airports comprise a useful target sector to which emission budgets may be applied. Where actual in-use data are lacking on emissions from these vehicles, the budget may be designed using assumptions regarding emissions and activity levels from these vehicles. Over time, more accurate information can be gathered and used in the budget program. Because of the aggregated emission tracking used by the budget system, reductions that are relatively expensive from some vehicle types can be avoided in favor of less expensive reductions from other sources. Designing a declining total limit over time provides on-going incentives for improvements in emission reduction options for the affected sources.

NOx/PM Emission Budgets for Nonroad Fleets

- For many of the same reasons that a budget approach has been recommended for interstate trucks and buses, we recommend that the NESCAUM states consider using the NOx/PM emission budget concept for fleets of nonroad equipment which operate in the region. Intrastate locomotives and intrastate marine fleets are potential candidates for inclusion in a statewide budget.

  Based on the interstate operation typical of line-haul locomotive and many commercial marine vessel fleets, a regional NOx/PM emission budget may be a more effective tool for obtaining cost-effective emission reductions from this source category. For all the same reasons that a regional budget has been recommended for interstate trucks and buses, we recommend that the NESCAUM states work together to develop a NOx/PM emission budget for these nonroad sources. The budget could establish a declining slope over time for NOx and PM emissions and be implemented with a trading system to maximize compliance flexibility for the affected sources. Especially when implemented on a broad geographic scale, this flexibility would allow the market to drive demand for cleaner technology and fuels, without regulatory agencies mandating specific technologies.