Closing the Diesel Divide

PROTECTING PUBLIC HEALTH
FROM DIESEL AIR POLLUTION

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Abbreviations

BUG	backup generator
CAA	Clean Air Act
CARB	California Air Resources Board
CO	carbon monoxide
DPM	diesel particulate matter
EPA	United States Environmental Protection Agency
HC	hydrocarbon
ICE	internal combustion engine
MATES-II	Multiple Air Toxics Exposure Study-II
NAAQS	National Ambient Air Quality Standards
NMHC	nonmethane hydrocarbon
NOx	oxides of nitrogen
NO_2	nitrogen dioxide
O_3	ozone
PM	particulate matter
ppm	parts per million
SOx	sulfur oxides
SO_2	sulfur dioxide
VOC	volatile organic compound

Executive Summary

Diesel engines are the workhorses of the American economy, providing power to almost every type of vehicle used in commerce, as well as to electrical generating equipment used for a variety of applications. The diesel exhaust produced by these engines is among the most dangerous and pervasive sources of air pollution. Its components include particulate matter (PM), implicated in a host of respiratory problems and thousands of premature deaths every year; smog-forming oxides of nitrogen (NOx); sulfur dioxide (SO_2), which forms harmful fine particles and falls back to earth as acid rain; and a noxious brew of toxic chemicals that together pose a cancer risk greater than that of any other air pollutant.

Despite the ubiquity of diesel engines in the United States and the serious public health and environmental threats they pose, diesel engines and diesel fuel are governed by a chaotic patchwork of regulations. Rigorous new standards for large diesel trucks and buses and highway diesel fuel will dramatically cut pollution from these sources beginning in 2006, but other diesel engines remain poorly regulated.

This report examines two sources of diesel pollution that represent holes in the regulatory patchwork: diesel engines in a range of nonroad equipment from lawn tractors to excavators, and stationary internal combustion engines used in electric generators. These two categories encompass a huge range of engines from small loaders and household generators used in residential neighborhoods to massive mining machines and backup generators that provide power to industrial facilities. The United States Environmental Protection Agency's (EPA) forthcoming rule on nonroad diesel engines presents an important opportunity for the federal government to begin closing the diesel divide and to achieve historic reductions of diesel pollution that will allow Americans to breathe easier.

A Journey by Diesel Engine

Accompany a shipment of grain on its journey from a farm in the American heartland to the ship on which it will be exported overseas and you will encounter both the ubiquity of diesel engines in our economy and the poorly designed patchwork of programs that apply to these engines.

The journey starts on a wheat farm, where diesel engines power the tractors and combines used for tilling, planting and harvesting. Diesel-powered pumps deliver water to the fields. Diesel trucks haul the wheat to a grain elevator for storage. From the elevator, trains pulled by diesel locomotives carry the grain to domestic mills or, in many cases, to diesel-powered barges that will in turn carry it to distant markets or ocean ports. At the port, the grain is loaded onto oceangoing vessels by diesel-powered equipment while nearby diesel construction equipment builds the new facilities needed to accommodate the projected doubling of shipping traffic in the next 10 years. Diesel generators stand by to provide backup power to the docks and warehouses. As the grain heads out to sea in a diesel-powered ship, it is guided by a diesel-powered pilot boat, which sees it as far as the open water.

Many of the fundamental characteristics of the diesel engines encountered on this journey are the same. But according to their different uses, these engines are subject to widely divergent emission standards and fuel-content limitations. Low sulfur diesel fuel would both directly reduce harmful SO_2 pollution and enable state-of-the-art control technology to curb other contaminants.

- New highway diesel trucks and buses are subject to stringent limits on PM, NOx and nonmethane hydrocarbons (NMHC) that will take effect between 2007 and 2010. Sulfur content for highway diesel fuel, which is currently limited to 500 parts per million (ppm), will be capped at 15ppm beginning in 2006. As of 2007, many new highway diesel trucks will meet NOx limits that are almost *nine times* more stringent than those for comparable nonroad diesel equipment.
- Nonroad diesel equipment, such as that used in construction and mining, is subject to emission standards for PM and NOx that are considerably less protective than the highway standards. Further, there is currently no federal limit on the sulfur content of the fuel burned in these heavy equipment engines. The sulfur levels average 3,300ppm nationally outside of California, 200 times higher than the 2006 cap for highway diesel. Under current rules a new tier of standards for NMHC, NOx, and carbon monoxide (CO) will apply beginning in 2006. However, the federal government declined to tighten the PM standards. So under rules currently in place a medium-sized construction engine manufactured in 2007 will be allowed to release *30 times* as much PM as a 2007 model year diesel truck or bus.
- Diesel locomotives are subject to modest tiered standards for new and remanufactured engines that limit NOx, PM and hydrocarbon (HC) emissions. Diesel locomotive fuel has no sulfur content limit.
- Small and medium commercial marine engines such as those in barges, tugboats and ferries will be subject to mediocre NOx, PM and CO limits for new engines starting between 2004 and 2007. There is no sulfur content limit for fuel burned in these engines.
- Large oceangoing marine engines already in use are not subject to any federal emission standards or fuel content requirements. EPA very recently finalized essentially meaningless NOx and sulfur oxides (SOx) emissions limits for new engines. The new requirements reflect meager emission standards already being achieved and therefore will not realize any significant clean air benefits. And EPA has repeatedly declined to address pollution from foreign-flagged ships in U.S. territorial waters that make up 95% of all calls on U.S. ports.
- Stationary internal combustion engines, such as diesel-powered electric generators, are not subject to any federal emission standards or fuel content requirements.

It’s Time to Close the Diesel Divide

Though nonroad diesel equipment significantly contributes to emissions of several dangerous air pollutants, federal programs to control this pollution have lagged far behind those for other sources. As a result, overall pollution from nonroad diesel equipment has generally risen. By comparison, in the more than 30 years since the 1970 Clean Air Act was passed, pollution from highway automobiles, as well as from most stationary sources, has significantly dropped.

EPA is expected to propose new rules for nonroad diesel engines including those in construction, surface mining, industrial and farm equipment. This historic federal initiative provides the opportunity for EPA to continue the progress it has made in cleaning up large highway diesel engines by closing the divide between highway engines and their nonroad diesel counterparts.

The American Lung Association and Environmental Defense recommend five key steps to protect public health and the environment from the harmful effects of diesel engines:

Adopt National Nonroad Clean Air Standards Consistent with Onroad Standards. EPA’s upcoming rules should include rigorous federal emission standards and low sulfur fuel requirements for new nonroad diesel equipment that reflect EPA’s recently adopted emission standards for large highway diesel engines. The resulting cuts in PM, NOx and SO_2 pollution will help millions of Americans breathe easier, lower cancer risks, and assist state and local governments across the country to achieve key public health and environmental air quality standards.

Achieve Cleaner Air Today Through Sensible Transition Policies. Nonroad diesel engines are long-lived, so national standards for newly built equipment will not realize their full clean air gains for decades. Policymakers at all levels of government can take sensible steps to protect public health in the meantime. Contract specifications that require contractors to retrofit existing equipment with cost-effective emission control technologies and programs to encourage equipment operators to use cleaner low sulfur diesel fuel are two ways to immediately reduce pollutants from nonroad engines.

Address All Nonroad Engines Comprehensively. Federal and state programs should comprehensively address the pollution from the host of nonroad diesel engines. To fill in the gaps in the regulatory patchwork governing diesel engines, new emission standards and low sulfur fuel programs need to address the full range of engine sizes – from compact loaders to large mining equipment – and the full range of applications – from locomotives to marine engines.

Close the Stationary Diesel Engine Loophole. Stationary diesel engines, such as those used in generating electricity, have similar design, pollution levels and control technology solutions as engines used in other applications, and should be subject to comparable standards. California and Texas have begun grappling with pollution from stationary diesel generators. We urge EPA and the states to put in place comprehensive, protective systems for controlling pollutants from diesel-powered generators.

Ensure Long-Lasting Clean Air Gains Through Effective Program Implementation. Clean air standards must be married to thoughtful implementation strategies to achieve lasting pollution reductions. Both federally- and locally-administered programs must ensure that the emission standards are achieved over a variety of operating conditions, and that programs are designed to create incentives for equipment operators to effectively maintain air pollution control equipment.

State-by-State Benefits of Rigorous Clean Air Standards for Nonroad Diesel Equipment

The table below presents the benefits of rigorous federal emission and fuel standards for nonroad diesel equipment by estimating the number of today's onroad vehicles that would have to be taken out of service to achieve comparable pollution reductions. The estimated benefits are based on a fully implemented, rigorous federal nonroad program and are compared with today's national emissions inventory for all passenger vehicles as well as large diesel trucks and buses. The analysis is presented for each state and is based on the benefits in curbing fine particulate matter ($PM_{2.5}$) from diesel exhaust. The $PM_{2.5}$ from diesel engines is associated with a significant increased risk of lung cancer. Indeed, the best available studies have found that the cancer risk from diesel particulate emissions far exceeds the risk from all other air pollutants.

The analysis demonstrates that in states across the country improving the emission standards for nonroad diesel equipment is one of the single most important measures that can be taken to achieve healthier air. Appendix A explains how these calculations were derived. This appendix also contains an analysis of the benefits from potential NOx and SOx emission reductions.

TABLE 1

Estimated Air Quality Benefits of a Rigorous, Fully Implemented Federal Nonroad Program in Terms of Today's Onroad Vehicles Removed from the Road

State	$PM_{2.5}$
National	**192,713,000 (93% of vehicles)**
Alabama	3,018,000
Alaska	428,000
Arizona	3,584,000
Arkansas	1,819,000
California	23,370,000
Colorado	2,992,000
Connecticut	2,319,000
Delaware	538,000
Wash. D. C.	387,000
Florida	11,058,000
Georgia	5,677,000
Hawaii	826,000
Idaho	892,000
Illinois	8,456,000
Indiana	4,136,000
Iowa	1,981,000
Kansas	1,825,000
Kentucky	2,748,000
Louisiana	3,019,000
Maine	867,000
Maryland	3,638,000
Massachusetts	4,323,000
Michigan	6,754,000
Minnesota	3,373,000
Mississippi	1,949,000
Missouri	3,807,000
Montana	611,000
Nebraska	1,162,000
Nevada	1,416,000
New Hamp.	850,000
New Jersey	5,748,000
New Mexico	1,240,000
New York	12,891,000
North Carolina	5,542,000
North Dakota	429,000
Ohio	7,692,000
Oklahoma	2,341,000
Oregon	2,346,000
Pennsylvania	8,311,000
Rhode Island	715,000
South Carolina	2,743,000
South Dakota	577,000
Tennessee	3,883,000
Texas	14,372,000
Utah	1,538,000
Vermont	414,000
Virginia	4,860,000
Washington	4,048,000
West Virginia	1,216,000
Wisconsin	3,651,000
Wyoming	333,000

Introduction

The essential qualities of diesel engines, including their power, durability and fuel economy, have made them the engine of choice for many applications, including large highway trucks and buses, small lawn tractors and loaders, almost all construction, surface mining and farm equipment, marine engines in both inland and oceangoing duty, locomotives, and electrical generating equipment used for buildings of all sizes and applications.

While the engines used in these different applications share the same technology, they are subject to widely divergent clean air standards. Emissions standards for the nonroad engines used in construction and mining lag far behind those for analogous engines used in onroad applications such as large diesel trucks and buses. The well-documented public health and environmental threats of diesel exhaust demand that nonroad and stationary diesel engines and the fuel they burn be subject to equivalent clean air standards as onroad diesel engines. This report examines the status and impacts of nonroad and stationary diesel engines in the following chapters:

Chapter 1: The Staggering Pollution from Nonroad Sources

Nonroad engines are the largest source of PM and SO_2 in the transportation sector. Over the last thirty years, emissions from passenger cars have fallen significantly, as increasingly strict regulations have led to effective emission control technologies. But diesel nonroad engines are responsible for more pollution today than they were when the Clean Air Act was put into place in 1970.

Chapter 2: Diesel Exhaust Is Dangerous to Public Health and the Environment

The breathtaking hazards posed by diesel exhaust stand in stark contrast to the lack of a comprehensive program to control diesel emissions from all their sources. The critical constituents of diesel exhaust include PM, NOx, SO_2, CO and a laundry list of toxic chemicals. This veritable greatest hits list of dangerous air pollutants contributes to a host of public health and environmental hazards, including cancer risk greater than that posed by any other air pollutant, premature death, both chronic and acute respiratory injury, asthma attacks, ground-level ozone formation, acid deposition, and particulate haze and visibility impairment.

Chapter 3: Diesel Workhorses: From Turf Mowers to Excavators

Construction and surface mining equipment, farm equipment and commercial marine engines are the largest contributors to nonroad diesel pollution. Each presents an opportunity for the United States Environmental Protection Agency (EPA) to dramatically reduce pollution by establishing parity between these engines and their onroad counterparts.

Chapter 4: Closing the Stationary Diesel Engine Loophole

Diesel engines, such as diesel generators, that are categorized as "stationary" internal combustion engines have truly fallen through the cracks of the Clean Air Act. If a generator is moved more than once a year, it is regulated the same as construction equipment. But if an identical generator is not moved more than once a year, it is classified as stationary and is not subject to any federal emission limitations at all. This chapter examines the breadth of the loophole for stationary diesel generators and the pollution that escapes through it.

Chapter 5: Cleaner Fuel to Power Cleaner Engines

EPA has yet to establish any standards for the sulfur content of diesel fuel for use in nonroad equipment. This fuel often contains sulfur levels exponentially higher than the limits that are coming into effect for fuel used in onroad diesel engines. Sulfur dioxide is itself a dangerous pollutant that needs to be controlled. But it is also necessary to control fuel sulfur content because sulfur fouls emission controls. Removing sulfur from diesel fuel is a critical first step that will allow state-of-the-art emissions control technologies to reduce other pollutants in diesel exhaust.

Chapter 6: The Path to Cleaner, Healthier Air

The American Lung Association and Environmental Defense recommend five key steps to begin protecting public health and the environment from the harmful effects of nonroad and stationary diesel engines:

Adopt National Nonroad Clean Air Standards Consistent with Onroad Standards. EPA should apply the rigorous federal emission standards and low sulfur fuel requirements in place for onroad diesel engines to new diesel engines used in nonroad equipment.

Achieve Cleaner Air Today Through Sensible Transition Policies. Requirements for state and municipal contractors to retrofit existing equipment and incentives for equipment operators to use cleaner low sulfur onroad diesel fuel in nonroad engines are two ways that state and local governments can immediately reduce pollution from nonroad engines without waiting for the next generation of equipment to replace existing machines.

Address All Nonroad Engines Comprehensively. To realize broad public health and environmental benefits, federal programs should comprehensively address engine standards and fuel content limits for the full suite of nonroad diesel equipment.

Close the Stationary Diesel Engine Loophole. We urge EPA and the states to put in place programs for controlling pollutants from stationary engines that have not been subject to any federal clean air controls at all.

Ensure Long-Lasting Clean Air Gains Through Effective Program Implementation. Both federally- and locally-administered programs must ensure that the emission standards are achieved over a variety of operating conditions, and that programs create incentives for equipment operators to effectively maintain air pollution control equipment.

CHAPTER 1

The Staggering Pollution from Nonroad Sources

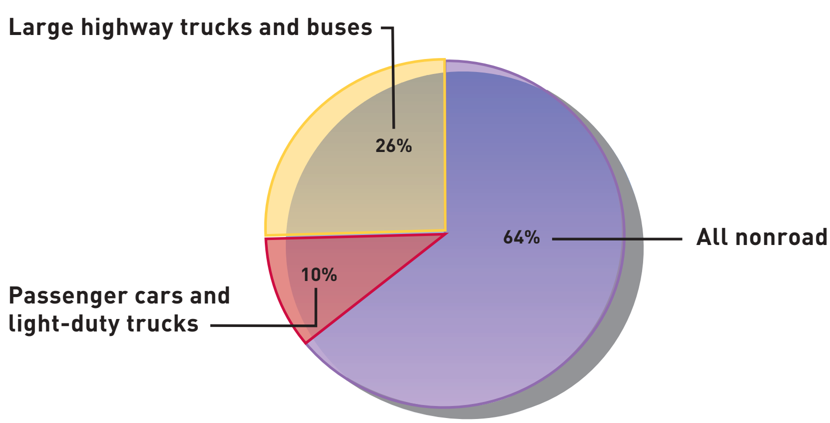
The high pollution levels from nonroad diesel engines reflect the lack of meaningful emission limits as well as the challenges of controlling emissions from engines operating under the extremely varied loads and duty cycles that characterize the broad range of nonroad equipment. These factors combine to make the nonroad sector the source of a disproportionate share of harmful particulates, oxides of nitrogen (NOx), and sulfur dioxide (SO_2).

Particulate Matter

Collectively, nonroad engines, from gasoline lawn and garden equipment to large diesel construction equipment, discharge more dangerous fine particulate matter than any other source in the transportation sector (Figure 1).

FIGURE 1

National $PM_{2.5}$ Emissions from All Mobile Sources, 2001 (452,000 short tons)



Nationally nonroad engines collectively discharge more harmful fine particulates than any other source in the transportation sector.

Note: Represents only anthropogenic and non-fugitive $PM_{2.5}$

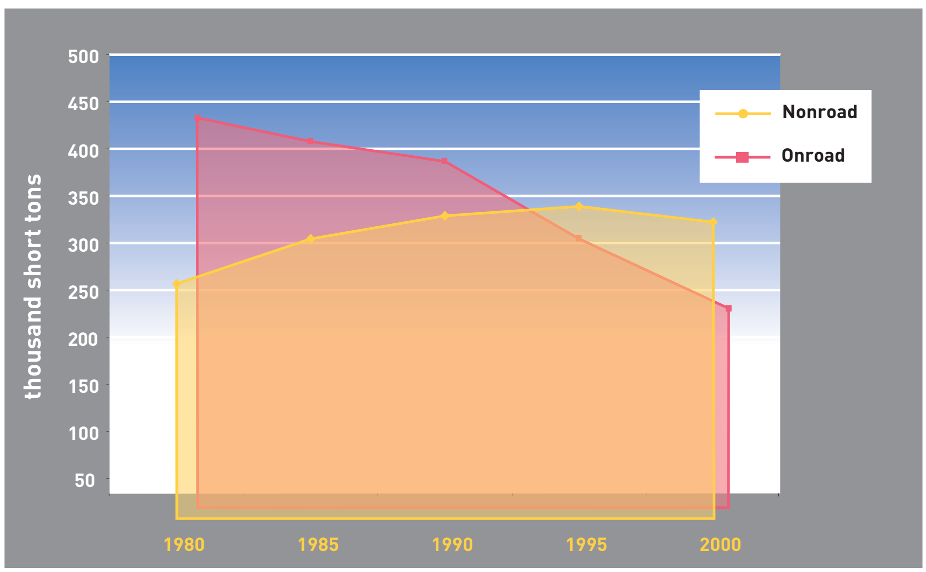
Source: U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf

Despite the fact that nonroad diesel engines are in many cases similar to their onroad counterparts, they emit PM at dramatically higher levels because they have never been required to use state-of-the-art emission controls. For example, in 2007, when nonroad construction equipment will meet new EPA standards, a medium-sized piece of construction equipment will be allowed to release 30 times as much PM as a highway bus.

Figure 2 illustrates the consequences of the disparate approaches to nonroad and onroad engines. National pollution control programs for onroad engines have resulted in a steady decline in emissions from these engines over the last few decades. The comparative failure to control nonroad engines has allowed particulate pollution from these engines to rise from a starting point below onroad engines to current levels that surpass them.

FIGURE 2

National PM_{10} Emissions from All Nonroad and Onroad Sources, 1980-2000



Lagging federal emission standards have allowed the total national particulate emissions from nonroad engines to surpass emissions from onroad engines.

Note: Long-term particulate emissions data for total nonroad sources is available only for PM_{10}, which includes both fine and coarser particles. The particles released from diesel engines are predominantly $PM_{2.5}$ and smaller.

Source: U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf

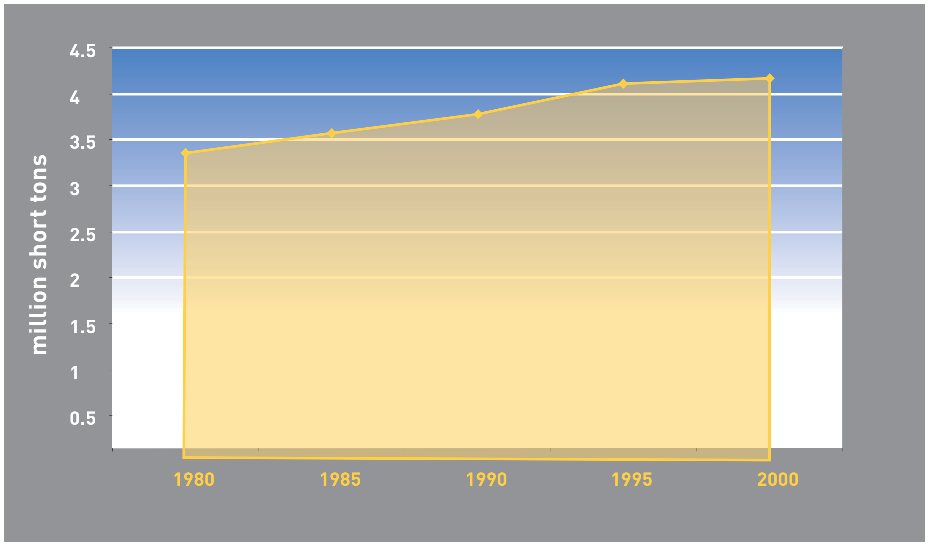
Oxides of Nitrogen

Since 1980, annual NOx emissions from all nonroad engines have increased by nearly 25 percent (Figure 3). These engines collectively discharge a significant portion of the total U.S. NOx emissions inventory (Figure 4).

FIGURE 3

National NOx Emissions from all Nonroad Sources, 1980-2000

Source: U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf

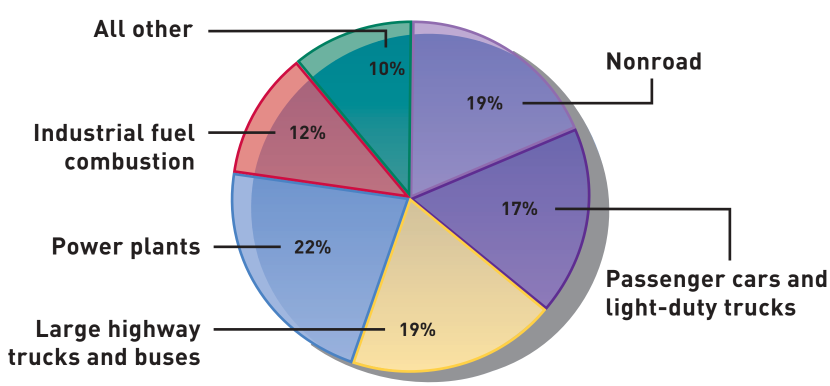


The annual smog-forming NOx emissions from the nation's nonroad engines have risen nearly a million tons in the last two decades.

FIGURE 4

National NOx Emissions by Source Category, 2001 (22.3 million short tons)

Source: U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf



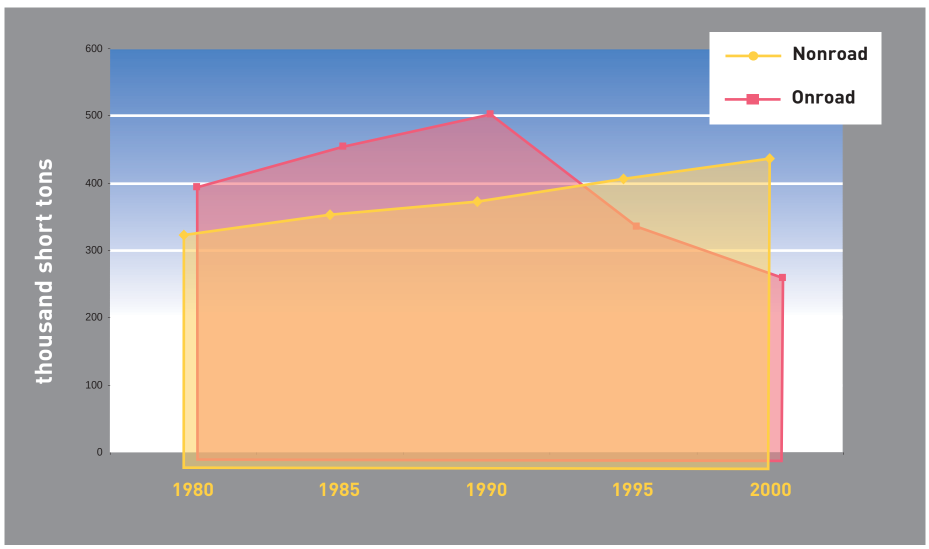
NOx emissions from all nonroad engines nationwide are comparable to the NOx pollution levels from the nation's fleet of power plants.

Sulfur Dioxide

While power plants are unquestionably the nation's largest source of SO_2, the extraordinarily high sulfur levels in nonroad diesel fuel make diesel-powered nonroad engines a significant contributor of SO_2 pollution as well. SO_2 emissions from the nonroad sector grew considerably between 1980 and 2000. Figure 5 contrasts the inexorable rise in SO_2 emissions from nonroad engines with the decrease in SO_2 emissions from onroad sources, which occurred after the national program to lower the sulfur levels in gasoline took effect in 1993. SO_2 emissions from onroad engines will fall even further after stricter fuel sulfur content limits for gasoline are phased in starting in 2004 and diesel beginning in 2006.

FIGURE 5

National SO_2 Emissions from all Nonroad and Onroad Sources, 1980-2000



Source: U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf

National SO_2 emissions from nonroad engines are rapidly outpacing onroad emissions due to the combination of growth in the nonroad sector and a rigorous national program to lower the sulfur content of highway gasoline and diesel fuels.

Measuring Emissions from the Nonroad Sector

Precise measurement of emissions from diesel-powered nonroad engines is challenging because of uncertainty in estimating the number of nonroad engines in use and the many different conditions under which they operate. EPA is completing work on a new, updated model for projecting emissions from nonroad engines that is expected to be publicly released in conjunction with the proposed new emission standards for these sources.

The emissions data used in this chapter are based on EPA's most recent national emissions inventory that, in turn, relied on the draft new EPA nonroad model and the recently released updated model for estimating pollution from passenger vehicles. Based on this latest available information, nonroad engines remain one of the single most important contributors to high pollution levels. Without concerted federal and state policies to address the pollution from these engines, the nation will be severely hampered in meeting the health-based national ambient air quality standards (NAAQS) for fine particles and ozone, in cutting haze air pollution in national parks, and in protecting urban populations from one of the nation's most harmful air toxics.

Diesel Exhaust Is Dangerous to Public Health and the Environment

The breathtaking range of hazards posed by diesel exhaust stands in stark contrast to the lack of a comprehensive approach to controlling diesel emissions from all their sources. The critical constituents of diesel exhaust include PM, NOx and SO_2, as well as a laundry list of toxic chemicals that cause both public health and environmental dangers.

What Is Diesel Exhaust?

Diesel exhaust occurs as a gas, liquid or solid and is a result of the combustion of diesel fuel in a compression-ignition engine. Its composition varies depending on the type of engine, the operating conditions, fuel characteristics and the presence of a control system, but it always contains both particulate matter and a complex mixture of hundreds of gases, many of which are known or suspected to cause cancer.[1]

Diesel engines produce far more particulate pollution than gasoline engines. Depending on operating conditions, fuel quality and emission controls, light-duty diesel engines and heavy-duty diesel engines can emit 50 to 80 times and 100 to 200 times, respectively, more particle mass than typical catalytically equipped gasoline-powered engines.[2] Diesel particulate matter is typically fine (< 2.5 microns) or ultrafine (< 0.1 micron) in size. Virtually all of the diesel exhaust particle mass has a diameter of less than 10 microns, 94 percent is less than 2.5 microns, and 92 percent is less than 1.0 microns.[3] Because of the preponderance of small particles, diesel particulate matter is easily inhaled deep into the lungs' bronchial and alveolar regions, where their clearance is slow compared with particles deposited on airways.[4]

More than 40 constituents of diesel exhaust are listed by either the U.S. Environmental Protection Agency or the California Air Resources Board as hazardous air pollutants or toxic air contaminants (Table 2). At least 21 of these substances are listed by the State of California as known carcinogens or reproductive toxicants.

TABLE 2
Toxic Air Contaminants and Hazardous Air Pollutants in Diesel Exhaust

Acetaldehyde*	Chlorine	Methyl ethyl ketone
Acrolein	Chlorobenzene	Naphthalene*
Aluminum	Chromium compounds*	Nickel*
Ammonia	Cobalt compounds*	4-nitrobiphenyl*
Aniline*	Copper	Phenol
Antimony compounds*	Cresol	Phosphorus
Arsenic*	Cyanide compounds	POM (including PAHs)
Barium	Dibenzofuran	Propionaldehyde
Benzene*	Dibutylphthalate	Selenium compounds*
Beryllium compounds*	Ethyl benzene	Silver
Biphenyl	Formaldehyde*	Styrene*
Bis [2-ethylhexyl]phthalate*	Hexane	Sulfuric acid
Bromine	Lead compounds*	Toluene*
1,3-butadiene*	Manganese compounds	Xylene isomers and mixtures
Cadmium*	Mercury compounds*	Zinc
Chlorinated dioxins*	Methanol	

*This compound or class of compounds is known by the State of California to cause cancer or reproductive toxicity. See California EPA, Office of Environmental Health Hazard Assessment, "Chemicals Known to the State to Cause Cancer or Reproductive Toxicity," May 31, 2002.

Note: Toxic air contaminants on this list either have been identified in diesel exhaust or are presumed to be in the exhaust, based on observed chemical reactions or presence in the fuel or oil. See California Air Resources Board, "Toxic Air Contaminant Identification List Summaries, Diesel Exhaust," September 1997, available online at http://www.arb.ca.gov/toxics/tac/factshts/diesex.pdf.

Health Effects Specific to Diesel Exhaust

The major pollutants that make up diesel exhaust each pose threats to public health and the environment. In addition, a growing body of research on the hazards of diesel exhaust shows that this particular combination of pollutants causes significant cancer risk and both acute and chronic health problems.

Cancer risk

Numerous governmental agencies and scientific bodies have concluded that diesel exhaust is a probable human carcinogen (Table 3). The first major study to investigate the contribution of diesel exhaust to people's exposures to toxic air pollutants was the Multiple Air Toxics Exposure Study (MATES-II), conducted by California's South Coast Air Quality Management District in 1998 and 1999 and one of the most comprehensive urban air toxics studies ever undertaken. The results were alarming: 70 percent of the cancer risk from air pollution for those living in the Los Angeles air basin (one of the most polluted in the country) was due to diesel particulate emissions.[5]

As a result of this finding, the California Air Resources Board expanded the study to include all of California. The findings were similar: about 70 percent of the total inhalation cancer risk from air pollution for the average Californian is due to diesel exhaust, and California's Office of Environmental Health Hazard Assessment concluded that "long-term exposure to diesel exhaust particles poses the highest cancer risk of any toxic air contaminant evaluated . . . ."[6] The result for the United States as a whole was even worse: 80 percent of the total cancer risk from all hazardous air pollutants is associated with the inhalation of diesel exhaust.[7]

TABLE 3

History of Determinations of the Carcinogenicity of Diesel Exhaust

Agency	Year	Determination
National Institute for Occupational Safety and Health (NIOSH)	1988	Potential occupational carcinogen
International Agency for Research on Cancer (IARC)	1989	Probable human carcinogen
State of California (under provisions of Proposition 65)	1990	Known by the state to cause cancer
Health Effects Institute (HEI)	1995	Potential to cause cancer
World Health Organization International Programme on Chemical Safety (WHO-IPCS)	1996	Probable human carcinogen
California Air Resources Board (CARB)	1998	Toxic air contaminant (determination based substantially on the cancer risk to humans)
U.S. Department of Health and Human Services National Toxicology Program (U.S. DHHS/NTP)	2000	Reasonably anticipated to be human carcinogen
American Council of Government Industrial Hygienists (ACGIH) (proposed)	2001	Suspected human carcinogen
U.S. Environmental Protection Agency (EPA)	2002	Likely human carcinogen

Sources: National Institute for Occupational Safety and Health, "Carcinogenic Effects of Exposure to Diesel Exhaust," Current Intelligence Bulletin 50 (August 1988). Available online at http://www.cdc.gov/niosh/88116_50.html.

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International Programme on Chemical Safety, World Health Organization, "Diesel Fuel and Exhaust Emissions," Environmental Health Criteria 171 (1996).

California's Air Resources Board, "The Toxic Air Contaminant Identification Process: Toxic Air Contaminant Emissions from Diesel-fueled Engines," fact sheet. Available online at http://www.arb.ca.gov/toxics/dieseltac/factsht1.pdf.

American Conference of Governmental Industrial Hygienists, "Documentation of the Threshold Limit Values and Biological Exposure Limits, Notice of Intended Changes," 2001.

U.S. Environmental Protection Agency, Health Assessment Document for Diesel Engine Exhaust, May 2002, EPA/600/8-90/057F.

Acute health effects

Even a brief exposure to diesel exhaust can have immediate respiratory, neurological, and immunological effects. Healthy volunteers exposed to diesel exhaust for one hour showed a significant increase in airway resistance and increases in eye and nasal irritation.[8] Other symptoms caused by exposure to diesel exhaust include coughs, headaches, light-headedness, and nausea.[9] Epidemiological studies of bus garage workers and miners exposed to diesel exhaust on the job found decreased lung function, increased cough, labored breathing, chest tightness, and wheezing.[10]

Chronic non-cancer health effects

Long-term exposure to diesel exhaust has been associated with a greater frequency of bronchitic symptoms, cough, phlegm, and reductions in lung function. Test animals show effects including chronic inflammation of lung tissue and reduced resistance to infection, as well as significant noncarcinogenic pulmonary effects from long-term exposure.[11]

Children are particularly vulnerable to the harmful health effects of diesel exhaust.

SPECIAL RISKS TO VULNERABLE SUBPOPULATIONS

Children, the elderly, individuals with asthma, cardiopulmonary disease and other lung diseases, and individuals with chronic heart diseases are particularly susceptible to the effects of diesel exhaust.[12] Air pollution affects children more than adults because they inhale more pollutants per pound of body weight and have a more rapid rate of respiration, narrower airways, and a less mature ability to metabolize, detoxify, and excrete toxins. Children also spend more time outdoors engaged in vigorous activities; athletes are similarly susceptible for this reason. Exposures that occur in childhood are of special concern because children's developmental processes can easily be disrupted and the resulting dysfunctions may be irreversible. In addition, exposures that occur early in life appear more likely to lead to disease than do exposures later in life.[13]

Health Effects of Fine Particle Pollution

Because it is so laden with fine particles, diesel exhaust is implicated in all of the dangers that led EPA in 1997 to adopt stricter health-based national ambient air quality standards for fine particles. Research conducted since 1997 has confirmed EPA's findings and further documents the toll that fine particle pollution takes on our health:

- The National Morbidity, Mortality and Air Pollution Study (NMMAPS), an independent study of 90 U.S. cities using uniform methodology, reported that contemporary levels of particulate pollution are killing people. NMMAPS found strong evidence linking daily increases in particulate pollution to increases in death.[14] In May 2002, the NMMAPs investigators at Johns Hopkins University reported an error in the software used to analyze the NMMAPS data. However, reanalysis using adjusted assumptions did not alter the main conclusions of the study (1) that there is strong evidence of an association between acute exposure to particulate air pollution and daily mortality, one day later, (2) that this association is strongest for respiratory and cardiovascular causes of death, and (3) that this association cannot be attributed to other pollutants or the weather.[15] While some other studies of air pollution health effects have used this same software, this error does not affect the validity of the longitudinal studies on which EPA based the $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS).

- A study of 500,000 adults in more than 100 American cities concluded that prolonged exposure to fine particulate air pollution significantly increases the risk of dying from lung cancer and cardiopulmonary causes.[16]

- A study of the relationship between stroke and air pollution indicates that PM_{10}, along with the gaseous pollutants SO_2, NO_2 and CO, is a significant risk factor for acute stroke death.[17]

- New studies and reanalysis of pre-existing work show that chronic exposure to fine particle pollution may lower life expectancy by months or years, not just by a few days.[18]

- A 2002 Dutch study found that people living near a main road and exposed to traffic-related fine particulates and diesel soot were almost twice as likely to die from heart or lung disease and 1.4 times as likely to die of any cause compared to people living further from traffic.[19]

- Studies consistently show a direct correlation between increased hospital admissions and increased exposure to particulate pollution.[20]

- Evidence continues to mount that children, and particularly children with asthma, are especially sensitive to the effects of fine particle pollution.[21]

- Increases in PM_{10} levels have been associated with a rise in the incidence of asthma attacks among adults with asthma three to five days after the pollution levels increased.[22]

Environmental Impacts of Particulate Pollution

Diesel particulate pollution from nonroad and stationary engines is a constituent of regional particulate problems leading to visibility impairment across the country. Fine particles in the lower atmosphere scatter and absorb light, obscuring scenic vistas such as those in national parks.[23] Fine particles also play a major role in creating the "brown clouds" that shroud many western cities, particularly during the winter months.

Oxides of Nitrogen

Historically, NOx control strategies have been driven by the serious problem of ground-level ozone (smog), which generally occurs in the warm weather when NOx combines with volatile organic chemicals under certain atmospheric conditions to create ozone. The severity and frequency of asthma cases are exacerbated by ozone smog. A recent study suggests that exposure to elevated ozone concentrations can actually cause the onset of asthma.[24] Ozone causes coughing, throat irritation and congestion in healthy adults. Millions of Americans live in areas that do not meet the health standard for ozone. Ozone pollution also damages plants, and costs the agriculture industry millions of dollars each year in decreased crop yields.[25]

The dangers of ozone are reason enough to control NOx emissions from sources including diesel engines. But NOx pollution also contributes to the following serious public health and environmental problems that occur year-round and require year-round control strategies in addition to those aimed at summer ozone: (1) formation of nitrate particles that contribute to harmful particulate pollution and obscure views; (2) acid deposition; and (3) eutrophication, or nutrient overloads, in coastal waters that promotes unnatural algal blooms that cloud the water and deprive submerged aquatic vegetation of the light necessary to grow.[26]

Sulfur Dioxide

Nonroad diesel engines are a major source of sulfur dioxide, or SO_2, pollution by virtue of the high sulfur content in the diesel fuel used for nonroad applications. Just as NOx emissions convert in the atmosphere to nitrate, SO_2 pollution converts to sulfate, a fine particle implicated in the serious adverse health effects described earlier. Some studies have focused on the health effects of SO_2:

- A study in Seoul, South Korea found that stroke mortality increased in association with the concentrations of SO_2 and other pollutants.[27]

- A study of children with asthma living in eight polluted U.S. cities found that SO_2 pollution was associated with an increase in morning asthma symptoms.[28]

- In a 1985 study of an air pollution episode in Central Europe, 24-hour concentrations of total suspended particulates and SO_2 were associated with an increase in blood pressure.[29]

Due to its transformation into sulfate particles, sulfur dioxide pollution also is one of the principal contributors to regional haze in national parks and brown clouds in western cities. It is also a major cause of acid deposition.

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3 California Air Resources Board, Emissions Inventory 1995, Technical Support Division, October 1997. Available online at http://www.arb.ca.gov/emisinv/95inven/95inv.htm.

4 J. Schwartz, D. Dockery, and L. Neas, "Is Daily Mortality Associated Specifically with Fine Particles?" Journal of the Air and Waste Management Association 46 (1996): 927–39.

5 South Coast Air Quality Management District, Multiple Air Toxics Exposure Study in the South Coast Air Basin (MATES-II), March 2000, http://www.aqmd.gov/matesiidf/es.pdf.

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7 Scorecard, 2002, calculated from 1999 EPA National-scale Assessment of Air Toxics data. http://www.environmentaldefense.org/pressrelease.cfm?ContentID=75

8 See MATES-II, note 5 supra.

9 "Health Effects of Diesel Exhaust," 2001, note 6 supra.

10 See MATES-II, note 5 supra.

11 California Office of Environmental Health Hazard Assessment, "Health Risk Assessment for Diesel Exhaust" (May 1998). Available online at http://ftp.arb.ca.gov/carbis/regact/diesltac/partb.pdf.

12 U.S.EPA Health Assessment Document for Diesel Engine Exhaust, May 2002, EPA/600/8-90/057F.

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CHAPTER 3

Diesel Workhorses: From Turf Mowers to Excavators

Diesel engines in construction, surface mining and industrial equipment, farm equipment, and commercial marine vessels are a significant local and national source of pollution. EPA action to make the emission and fuel standards for these categories of diesel-powered engines consistent with those for onroad diesel engines and onroad diesel fuel would be an enormous step toward protecting public health and establishing a comprehensive national diesel pollution policy.

This equipment currently is regulated by three tiers of standards that were finalized in 1994 and 1998, and will be phased in through 2008. Even the most stringent of these standards fall far short of the EPA standards for large diesel onroad engines. The difference between onroad and nonroad emissions standards is graphically illustrated by the fact that a medium-sized construction engine manufactured in 2007 will still be allowed to release 30 times as much particulate pollution as an 18-wheeler truck manufactured the same year[1] (Appendix B). Similarly, the NOx standards for nonroad construction, industrial, farm, and mining engines, which will be phased in over the next several years, will allow these nonroad engines to emit between 9 and 16 times as much NOx and NMHC as their onroad counterparts are permitted under federal regulations that will take effect beginning in 2007.[2]

EPA has yet to address the critical issue of sulfur content in diesel fuel used in nonroad engines. Without low sulfur diesel, nonroad engines will continue to be a significant source of SO_2 and will not be able to use state-of-the-art emissions controls to achieve far-reaching cuts in other pollutants.

Efforts to control pollution from nonroad diesel engines are complicated by the vast diversity of these engines and the great variation in the loads and duty cycles under which they operate. While these challenges are real, it is critical for EPA's forthcoming nonroad rule to spur engine manufacturers to bring to bear on nonroad emissions the research and development resources that are now bringing new lower-emission large highway engines to market.

Emissions from construction equipment can create microenvironments in which workers, school children, and nearby residents are exposed to elevated levels of dangerous diesel exhaust.

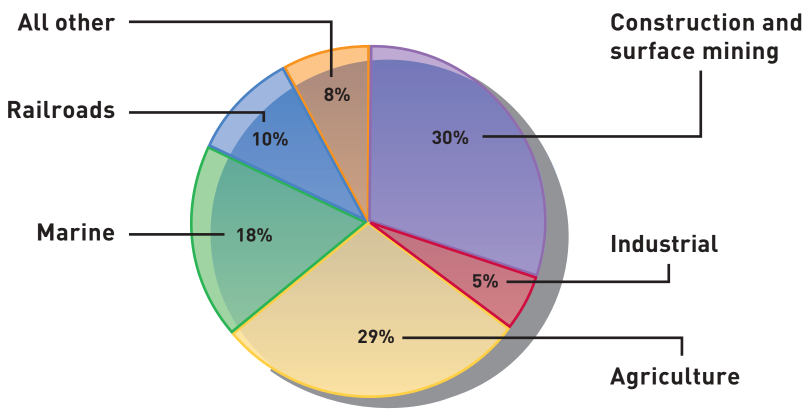
Construction, Surface Mining and Industrial Equipment

Collectively, diesel-powered construction equipment, surface mining equipment and industrial equipment accounts for a massive amount of air pollution. Construction equipment is one of the largest sources of $PM_{2.5}$ among nonroad diesel engines (Figure 6).

Mining equipment also discharges high levels of diesel

FIGURE 6

National $PM_{2.5}$ Emissions from All Nonroad Diesel Sources, 2001 (221,000 short tons)



Note : Surface mining is included with the estimate for construction; construction comprises the majority of emissions in this category.

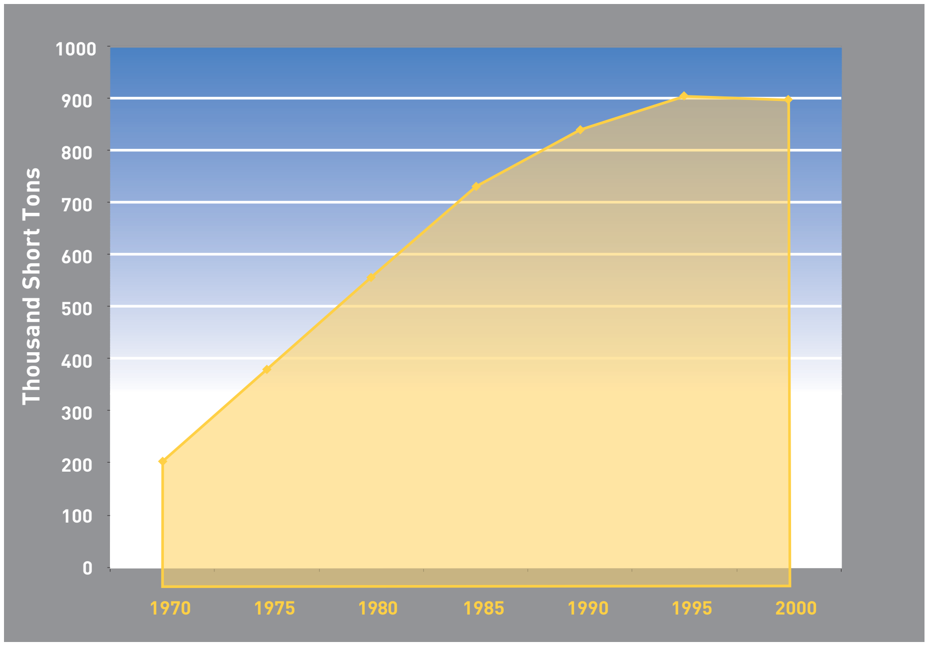
Source: U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf

Construction equipment, agricultural equipment, and marine vessels are responsible for about three-quarters of all national $PM_{2.5}$ emissions from nonroad diesel engines.

exhaust. The process of mining ore bodies such as coal, gravel and copper from the earth's surface requires large diesel-powered equipment like that used in construction activities and some that is specially-designed for mining. Surface mining equipment includes blast-hole drills, mining dozers, and explosive trucks.

Air pollution from most mobile and stationary sources has trended downward since the passage of the Clean Air Act in 1970, but NOx and PM emissions from construction, surface mining and industrial equipment have significantly risen. In that time, NOx emissions from construction, surface mining and industrial equipment have collectively increased more than four-fold (Figure 7). Particulate pollution from these same engines is now more than three times greater than it was in 1970 (Figure 8). While federal emission standards have recently deflected the growth curve, there is enormous progress to be made in curbing this pollution.

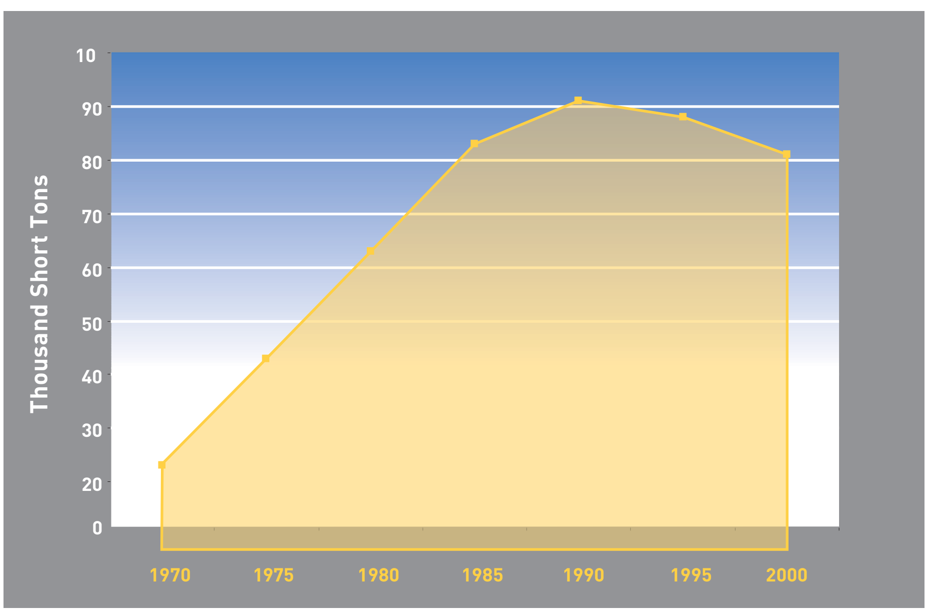
FIGURE 7
National NOx Emissions from Diesel Construction, Surface Mining and Industrial Equipment, 1970-2000



Source: U.S. EPA Emissions Factors and Inventory Group, 1970-2001 Tier-level Nonroad Summaries (2003).

Nationwide smog-forming NOx emissions from diesel construction, surface mining and industrial equipment have dramatically risen since the advent of the 1970 Clean Air Act.

FIGURE 8
National $PM_{2.5}$ Emissions from Diesel Construction, Surface Mining and Industrial Equipment, 1970-2000



Source: U.S. EPA Emissions Factors and Inventory Group, 1970-2001 Tier-level Nonroad Summaries (2003).

Diesel-powered construction, surface mining and industrial equipment nationwide discharge several times the $PM_{2.5}$ today as they did in 1970.

The way in which construction and industrial equipment is used can exacerbate the problems associated with diesel exhaust. Particularly in urban areas, many construction projects take place in confined areas, where many pieces of equipment are operating at once. Under these conditions, construction workers can be exposed to high levels of diesel exhaust, and nearby residents, schoolchildren and workers can also be at risk. Similarly, industrial equipment such as forklifts and other loading equipment is often operated indoors, where poor ventilation can expose workers to elevated levels of dangerous pollutants. And mining activities in numerous states — from Wyoming to West Virginia — discharge high levels of pollutants in part due to the sheer size of the operations. These dangers persist despite the fact that existing technologies could significantly reduce this pollution and make the air at construction, industrial, and mining sites safer for workers and nearby residents.

Big Dig Yields Big Results

State and local governments have tried various methods to lower pollution from construction equipment. The Central Artery Project in Boston, also known as the "Big Dig," is building 161 lane miles of highway in a 7.5-mile corridor directly through the middle of densely populated downtown. Construction equipment is a significant source of air pollution in the Northeast, where it is responsible for approximately 33 percent of PM and 10 percent of NOx from mobile sources.[3] A diverse group of interests recognized that the Big Dig presented an opportunity to test and demonstrate the feasibility of pollution control retrofits to reduce air pollution and lessen the health impact of a major construction project on workers, neighborhoods and regional air quality.

The ongoing Big Dig retrofit project has already resulted in the installation of state-of-the-art pollution control devices, such as oxidation catalysts, on 120 vehicles and there are plans to retrofit 100 more. These retrofits will reduce total pollution by approximately 200 tons over the remaining four to five years of the project. This is equivalent to removing 1,300 diesel buses from Boston streets for one full year. These retrofits have proven to be cost effective.[4]

Boston's retrofit approach encourages innovation, fleet turnover and the use of newer, cleaner, state-of-the-art vehicles and pollution controls. The Big Dig project is an example of an effective, innovative way for state and local governments to protect their citizens from diesel pollution.

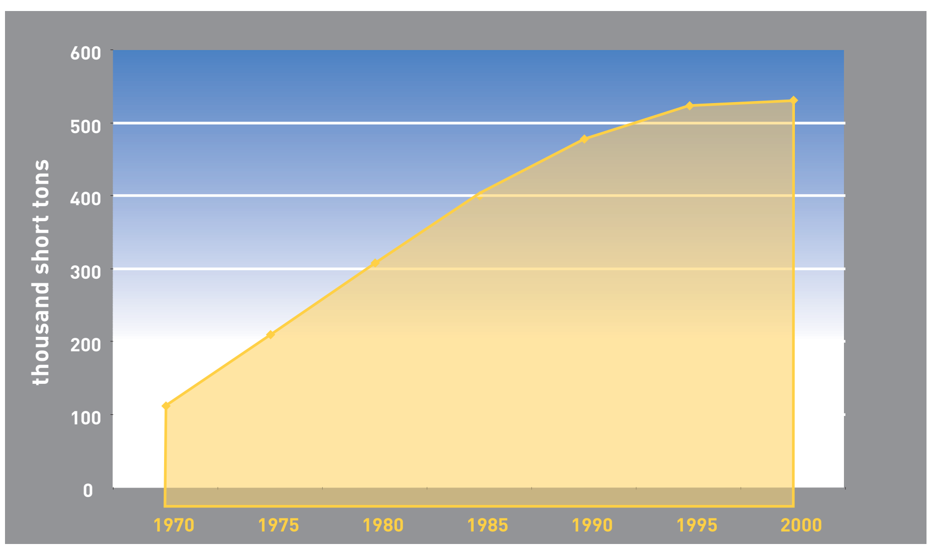
Farm Equipment

Diesel equipment is used in all aspects of farming, from pumping irrigation water, to plowing, planting, harvesting and processing crops. Because the engines used in this equipment are inadequately controlled, they pollute an amount out of proportion to their actual number. Collectively, diesel engines used in agriculture produce more than half a million tons of smog-forming air pollution each year. EPA estimates that farm equipment is responsible for 15 percent of all diesel nonroad NOx emissions and nearly a third of diesel nonroad $PM_{2.5}$ emissions.[5]

Improving the emissions and fuel standards for agricultural equipment will protect the health of farmers and farm workers, reduce the adverse effects of smog on crop yields, and lower equipment maintenance costs.

Pollution from farm equipment has grown rapidly. Since 1970, annual NOx emissions from farm equipment have risen by more than five-fold (Figure 9). And while annual fine particulate matter emissions have begun to decrease in recent years, they are still at levels more than three times greater than in 1970. Farm equipment sales are growing at an estimated annual rate of 2.4 to 3.1 percent.[6] Without sensible policies to cut the pollution from these engines, farm equipment will continue to be a growing source of air pollution.

FIGURE 9
National NOx Emissions from Diesel Agricultural Equipment, 1970-2000



Source: U.S EPA Emissions Factor and Inventory Group, 1970-2001 Tier-level Nonroad Summaries (2003).

Smog-forming NOx emissions from diesel-powered agricultural equipment have risen five-fold nationally since 1970, now totaling more than half a million tons annually.

Farmers and farm workers have a strong stake in effective emission standards for farm equipment. Many farm vehicles operate very slowly, or even at a standstill. This can create microenvironments in which farm workers are exposed to high levels of dangerous diesel exhaust just as construction and industrial equipment operators are. A 1999 German study examined diesel exhaust exposure in drivers of bulldozers, excavators, graders, and tractors and found the operation of heavy-duty diesel equipment was associated with increased risk of lung cancer.[7]

Diesel exhaust poses an additional threat to the profitability of farming. Ozone formed when NOx combines with other pollutants in the atmosphere is responsible for crop yield loss each year. Ozone damage results in stunted growth and reproduction, reduced resistance to harsh weather, and browning and spotting on leaves. The financial loss caused by ozone damage is huge. It has been estimated that California farmers lost $333 million to ozone crop damage in 1984 and $265 million in 1989. Similarly, Georgia's farm industry loses an estimated $250 million to ozone damage every year.[8] Controlling NOx emissions from diesel farm equipment will reduce ozone formation and help limit crop damage.

The engines used in farm tractors are comparable to heavy-duty highway truck engines. But agricultural equipment is subject to the same weak emission standards as construction, surface mining and industrial equipment. By the time the most recent federal onroad heavy-duty diesel standards apply in 2007, a farm tractor will be allowed to emit more than nine times the NOx+NMHC pollution and 30 times the PM pollution as an onroad tractor-trailer truck.[9] The same technology used to control emissions from a big truck's diesel engine could be used to control the farm tractor's pollution as well.[10]

Because farmers often keep their equipment for a very long time, incentive-based programs to encourage retrofits with pollution control equipment and repowers that replace old engines with newer, cleaner models are an important way to reduce farm equipment pollution. California's Carl Moyer Program has helped farmers as well as owners of other nonroad vehicles to offset the cost of retrofitting and repowering high-polluting equipment. For farmers choosing to replace an old engine, the program makes up the cost difference between a typical new engine and a cleaner engine. In the first two years of the program, numerous pieces of farm equipment were re-powered, resulting in an average annual reduction of 1,440 pounds of NOx per vehicle, as well as the improved fuel efficiency and reduced maintenance associated with newer more reliable equipment.[11] Incentive programs like California's are an important way of encouraging turnover in long-lived fleets and demonstrating the benefits of cleaner farm equipment.

Plowing Ahead to Cleaner Air

Randy Kazarian manages 7000 acres of his own and other farmers' vineyards in California's highly polluted San Joaquin Valley. After years of seeing and breathing soot from diesel farm equipment, Randy decided to repower one of his tractors through the Carl Moyer program. Since then, he has converted most of his own equipment to newer engine models, and finds them cleaner, more efficient, safer and more durable. Now he encourages the vineyard owners he works for to take advantage of the Carl Moyer program to re-power their older, dirtier machines with new engines. The program has made it possible for Randy to use cleaner equipment for the same cost as standard equipment, by paying the initial price differential of the cleaner engine. Thanks to the Carl Moyer incentive program, Randy is committed to using cleaner equipment and spreading the word about it in his industry.

Commercial marine engines contribute to unhealthy air pollution in major port cities and cities adjacent to major inland waterways.

Commercial Marine Vessels

Diesel engines power the majority of the commercial shipping fleet used in both inland waterways of the United States and in oceangoing international shipping. The marine industry uses an estimated 10 percent of petroleum diesel fuel sold in the United States.[12] Domestically, pollution from marine diesel engines has increased dramatically in the past decades.

Globally, diesel-powered marine engines also contribute a huge share of air pollution. Shipping traffic accounts for more than 14 percent of global sulfur emissions and more than 16 percent of global nitrogen emissions from petroleum use.[13]

One of the central reasons shipping produces so much pollution is that marine diesel engines burn fuel far dirtier than any other diesel application. The U.S. inland shipping fleet runs on diesel fuel that can average 3,000-5,000ppm sulfur, much like uncontrolled land-based nonroad engines. But the oceangoing fleet uses fuel containing 10 times as much sulfur, 30,000-45,000ppm.

Dirtiest of the Dirty: Marine Residual Fuel

Among the dirty high sulfur fuels burned in diesel engines, none is dirtier than the residual fuel that powers large oceangoing ships. Residual fuel, also known as bunker fuel, is the tar-like product left behind after all the lighter petroleum fractions are refined from crude oil. Sulfur content in marine residual fuel can range as high as 45,000 ppm, or an astonishing 4.5 percent sulfur. EPA reports that, worldwide, residual fuel averages 27,000ppm sulfur. This is more than 10 times the average sulfur level in the distillate diesel fuel used in smaller marine engines and land-based nonroad heavy equipment and nearly 2,000 times the 15ppm level soon to be required for highway diesel fuels.[14] The extraordinarily high sulfur content in residual fuel makes shipping one of the biggest sources of SOx emissions on the planet, despite the relatively small number of large ships in existence. And, as with other applications now powered by high-sulfur fuel, high sulfur levels make it impossible to apply most state-of-the-art emission control technologies to marine vessels.

EPA's newly issued standards for large marine engines do not place any limits on residual fuel sulfur content. Instead, EPA has left limiting this huge source of pollution up to the very uncertain prospects of an international treaty addressing shipping emissions. This treaty, known as MARPOL Annex VI, contains no general limit on residual fuel sulfur content, but does provide an opportunity to create SOx Emission Control Areas in which residual fuel cannot exceed 15,000 ppm sulfur. Given the uncertainty whether this treaty will ever be ratified, EPA has in effect indefinitely postponed addressing this critical source of pollution.

Oceangoing ships, associated harbor vessels such as tugboats, and dockside cargo loading equipment make ports air pollution hotspots. The two busiest U.S. ports, Los Angeles and Houston, are located in metropolitan areas with some of the country's worst air pollution. The American Lung Association has consistently awarded Los Angeles the title of smog capital of the year, and Houston recently ranked 5th.[15] Los Angeles also has some of the highest particulate concentrations in the country. In the Los Angeles basin, oceangoing ships, tugs and other commercial watercraft collectively account for 48 tons per day of smog-forming NOx emissions.[16] This is comparable to the daily NOx pollution discharged by 1.5 million passenger cars and is nearly as much NOx pollution as the top 350 emitting industrial facilities in the basin.[17]

Pollution from commercial marine engines is not restricted to coastal ports. Ninety percent of U.S. inland waterways are outside of port areas, and researchers have only now begun to understand that shipping emissions in these areas are a significant additional source of pollution. One study has estimated that commercial shipping traffic on inland rivers and the Great Lakes contributes 60 percent of the NOx emissions from all commercial shipping in the U.S., 33 percent of the total PM, and 48 percent of both HC and CO.[18]

Emissions along inland waterways are concentrated in a compact area, much as highways concentrate emissions from cars and trucks. Thus, ship emissions along these waterways can be locally significant, even where they do not make up a significant portion of a regional or statewide inventory of emissions. Researchers at Carnegie Mellon University have established that shipping traffic in the Pittsburgh area accounts for as much NOx emissions as a major metropolitan superhighway, and have concluded that "at least on an annual basis — waterborne transport can produce as much NOx as a region's freeways, even in large riverside cities (e.g. St. Louis, Nashville and New Orleans) where significant automobile commuting occurs."[19]

Historically, marine engines have not been subject to any federal emissions controls. EPA promulgated standards for a limited number of commercial marine engines in 1999, but it has only begun to address this growing source of air pollution. EPA's December 1999 commercial marine vessel rule established limited standards for small- and medium-sized engines such as those used in ferries, tug boats and barges.[20] But EPA's standards apply only to new engines, and will have no impact at all on existing engines that will be rebuilt for decades to come.

Notwithstanding their significant air pollution, EPA has taken only tentative steps toward controlling emissions from large oceangoing ships. In rules finalized in January 2003, EPA established a weak NOx standard that essentially codifies existing emissions levels for U.S.-flagged ships. The rule does not regulate foreign-flagged ships in U.S. territorial waters, which make up 95 percent of all calls to U.S. ports.

According to the American Association of Port Authorities, containerized shipping traffic in the United States doubled in the last decade, and is expected to double again in the next decade.[21] The shipbuilding boom required to meet the growing demand for international shipping presents an opportunity to build cleaner, state-of-the-art marine engines that will begin to reverse the longstanding record of air pollution from shipping. Renewed federal leadership and innovative state and local measures are necessary to ensure that marine diesel engines do not remain a massive pollution source for decades to come.

Cleaning up the air above our waters: Ports begin to reduce air pollution

Incentive programs have funded $22 million worth of air quality improvements at the Port of Los Angeles. Cranes that unload cargo have been converted to electric power, and smaller craft including tugboats and other harbor craft have been converted from old diesel engines to electric, compressed natural gas and newer, lower-polluting diesel engines. Operational changes are also yielding results. The Port's voluntary speed reduction program calls for ships in the port area to slow down to reduce NOx pollution. This simple step has lowered NOx emissions by an estimated two tons a day.[22]

The Port of Houston has tested emulsified diesel fuel in yard tractors and cranes at the port and achieved NOx reductions of 25 percent, and PM reductions of 30 percent. It's possible that even greater reductions can be achieved. The Texas Waterways Operators Association has entered into an agreement with EPA, the Texas Commission on Environmental Quality and the Houston-Galveston Area Council to reduce NOx emissions from barges and other craft operated by the trade association's members. By replacing old engines, retrofitting existing engines, and reducing idling time, vessel operators expect to lower NOx emissions by 1.1 tons a day, which would be a significant step for the ozone-plagued Houston area.[23]

[1] U.S. EPA, "Emission Standards Reference Guide for Heavy-Duty and Nonroad Engines," September 1997; 66 Fed.Reg. 5,002 (Jan. 18, 2001).

[2] Ibid.

[3] Massachusetts Diesel Retrofit Program, Executive Summary, August 23, 2000. Available online at http://www.state.ma.us/dep/bwp/daqc/files/rfit823.doc

[4] Ibid.; See, http://www.epa.gov/otaq/retrofit/documents/bigdig_case_01.htm

[5] U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf

[6] U.S.EPA, "Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines" (August, 1998) 93-94.

[7] I. Bruske-Hohlfeld et al., "Lung Cancer Risk in Male Workers Occupationally Exposed to Diesel Motor Emissions in Germany," American Journal of Industrial Medicine 36 no. 4 (October 1999) 405–14.

[8] U.S. EPA, "Fact Sheet: Health and Environmental Effects of Ground Level Ozone."; U.C. Davis, "The Economic Assessment of California Field Crop Losses Due to Air Pollution" (1989) 19.; Campaign for a Prosperous Georgia, "Southern Fried Air: Georgia's Dirty Power Plants and How to Clean Our Air Now" (Atlanta, 1998) 12.

[9] U.S. EPA, "Emission Standards Reference Guide for Heavy-Duty and Nonroad Engines," September 1997.

[10] U.S.EPA, "Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines" (August, 1998) 19-32.

[11] California Air Resources Board, "The Carl Moyer Program Status Report" (April 13, 2001) 34.

[12] Available online at http://www.biodiesel.org/markets/mar/default.asp.

[13] J.J. Corbett, P.S. Fishbeck and S.N. Pandis, "Global Nitrogen and Sulfur Emissions Inventories for Oceangoing Ships," Journal of Geophysical Research, 104 (D3) 3457–3470.

[14] 68 Fed. Reg. 9,745 at 9,768. (February 28, 2003).

[15] American Lung Association, "State of the Air Report" (2002). Available online at http://www.lungusa.org/air2001/

[16] California's South Coast Air Quality Management District, "Draft Air Quality Management Plan," 2003. Available online at http://www.aqmd.gov/aqmp/docs/App3AttchA.pdf. See also http://www.aqmd.gov/news1/portpr.htm

[17] See Draft Air Quality Management Plan, 2003, note 16, supra.

[18] James J. Corbett and Paul S. Fischbeck, "Emissions from Waterborne Commerce Vessels in United States Continental and Inland Waterways," Environ. Sci. Technol. (2000) 3254-3260.

[19] Ibid.

[20] 64 Fed. Reg. 73,299 (December 29, 1999).

[21] Available online at http://www.aapa-ports.org/industryinfo/currentissues.html.

[22] Polakovic, Gary, "Finally Tackling L.A.'s Worst Air Polluter, " L.A. Times, February 10, 2002

[23] Houston Galveston Area Council, June 22, 2001 press release.

CHAPTER 4

Closing the Stationary Diesel Engine Loophole

Under national air quality policy, there is a narrow legal thread that divides those engines classified as "nonroad" mobile pollution sources and those categorized as "stationary" pollution sources. In short, the legal distinction hinges on the residence time of the engine. An engine that is moved from site to site more than one time a year is deemed mobile and therefore regulated under the federal program for nonroad engines.[1] This means that a diesel generator on wheels that is relocated more than once a year is classified as a nonroad mobile engine. But if a similar diesel generator remains in place at an industrial site for more than 12 consecutive months it is categorized as a stationary engine. These two generators are categorized differently for legal purposes even though the engines themselves are largely the same, as are the airborne contaminants discharged, the fuel used, and the available technology solutions to control their exhaust.

The consequences of these legal delineations are momentous. The federal government is directed by the Clean Air Act to control air pollutants from mobile nonroad engines. Because the federal government has primary jurisdiction to establish emission standards for the pollution sources deemed mobile, disparate state emission standards for nonroad engines are generally preempted.

In contrast, both EPA and the states have broad concurrent authority to control pollution discharged from stationary diesel generators or other stationary engines. But EPA's pollution control program for stationary sources tends to focus on large, centralized pollution sources such as refineries, smelters, pulp and paper mills and power plants. EPA therefore devotes few resources to smaller, more-dispersed engines that collectively have serious air pollution impacts. In practice, EPA has never established air quality standards for stationary diesel-powered engines.[2] While federal emission standards for nonroad diesel engines lag behind their onroad counterparts, the same stationary diesel engines have been overlooked altogether.

EPA recently explained the legalistic distinction between "nonroad" and "stationary" engines:

> Stationary engines are used in many applications where they can be installed in a fixed location, such as power generators or irrigation pumps. Nonroad (mobile) applications include these same types of equipment if they are made to be portable (or transportable). For example, a generator mounted on a pallet or a trailer would generally not be considered stationary.[3]

There is increasing urgency to address this divide that allows stationary diesel generators and other stationary diesel engines to elude any meaningful emission standards. Stationary diesel engines have long been used in a variety of applications including agricultural use, and oil and gas extraction. Oil and gas activities have recently exploded in places like the Rocky Mountain West, contributing to rising air pollution levels. Likewise, the increasing reliance on distributed generation sources (see box on next page) to meet new electricity demand is expanding the use of high-polluting diesel generators. Diesel generators also are a predominant source of back-up power. The California Energy Commission estimates that diesel alone provides more than 90 percent of large backup electric generating power in California.[4]

Curbing the Harmful Pollution from Small-Scale Electric Generators

Economic forces and deregulation in the energy market have led to growth in smaller, more dispersed sources of electrical power commonly referred to as "distributed" generation. Distributed generation often serves niche market needs and includes small wind generators, fuel cells, small turbines, gas-fired combined cycle power generators, and diesel-powered internal combustion engines. Unlike conventional power stations, which are large and centralized, distributed generation sources tend to be smaller and are scattered across metropolitan areas.

Distributed generation sources may serve important local needs in providing a reliable, affordable, and secure energy source. But the very attributes that give them a nimble, niche role in the energy market also have allowed them to elude meaningful air quality standards. Few states or localities regulate air pollution from these sources. Even though these sources are smaller in scale, diesel electric generators and other distributed generation sources can both individually and collectively have serious air pollution and public health impacts.

Diesel generators are the most harmful category of distributed generation, producing levels of particulates and smog-forming contaminants many times greater than other distributed generation sources.[5] Such diesel generators may be located near homes, businesses, schools, and other population centers. Environmental Defense recently conducted an extensive risk assessment of backup diesel generators in the San Diego, San Joaquin, Sacramento and Los Angeles areas and found that over 150,000 school children attend schools in high-risk zones.[6]

Closing the Diesel Divide

EPA is on the right track in developing new emission standards and fuel content requirements to curb the airborne contaminants from high-polluting diesel nonroad engines. But EPA needs to ensure the same clean air program is applied to the stationary diesel engines that have altogether eluded comprehensive air pollution abatement requirements. In California alone, one of the few states with a reliable inventory, there are more than 16,000 stationary diesel engines including both emergency backup generators and prime engines.[7] Unlike backup generators, which typically operate on a limited basis, primary engines run on a regular basis to supplement or substitute energy from the power grid.

These stationary diesel engines have a pollution potency many times that of other engines. A typical diesel generator discharges more than 10 times the particulate-related pollution of a gas-powered internal combustion engine.[8] So 16,000 diesel generators release as much harmful particulate pollution as more than 160,000 other conventionally-powered generators. Because diesel particulates are one of the most dangerous airborne contaminants, closing the regulatory loophole for stationary diesel engines is a public health imperative.

The process to clean up diesel generators can begin now. Several states have begun tackling the pressing air pollution problem associated with diesel generators. In 2001, Texas established the nation's first statewide emission standards for new small-scale generators.[9] In east Texas, which contains the most polluted areas of the state, the emission standards for distributed generating facilities are essentially based on micro-turbine technology.[10] The standards in west Texas assume that high usage small-scale generators are powered by natural gas.[11]

As part of its statewide Diesel Risk Reduction Program, the California Air Resources Board is developing emission standards for stationary diesel engines more far-reaching than those adopted in Texas. The proposed California standards would establish particulate and NO_x emission limits on new and existing diesel generators used in both prime and emergency backup applications.[12] Importantly, the draft California rules would go beyond the Texas program by establishing standards for stationary diesel engines currently operating.

The policy transition to cleaner stationary diesel engines should be smooth. Air pollution control technologies can be transferred from nonroad mobile engines to stationary engines. Stationary engines should be even easier and less costly to control than nonroad equipment which is mobile and operated under a variety of conditions.

There are also important policy parallels. Indeed, an effective pollution abatement program for new stationary diesel engines must have some of the same core attributes as a well-designed program for new nonroad mobile engines. These include rigorous particulate and NO_x emission standards, complementary low sulfur fuel standards, procedures to certify that new engines in fact meet the emission standards, and effective in-use testing to ensure that durable pollution cuts are achieved in practice.[13]

There are also material differences. Due to their different regulatory classifications, stationary source pollution control programs may establish emission standards for existing engines and equipment. Given the enormous public health gains to be made, states and the federal government should follow California's lead and put in place rigorous emission standards for existing stationary diesel engines. This will ensure the important work to close the stationary engine diesel loophole is comprehensive and, most importantly, will help secure cleaner, healthier air in the near-term.

[1] EPA's definition of "nonroad engine" is codified at 40 CFR 89.2 and was adopted on June 17, 1994 after an extensive rulemaking process. 59 Fed. Reg. 31,306 (June 17, 1994). EPA's definition interprets several provisions of the federal Clean Air Act including the definition of "stationary source" in section 302(z), the definition of "nonroad engine" in section 216(10), the definition of "nonroad vehicle" in section 216(11), and the definition of "stationary source" in section 111(a)(3) of the Act.

[2] Under a court-ordered schedule EPA for the first time recently proposed emission standards for reciprocating internal combustion engines including diesel-powered engines. But these standards only apply to large stationary engines co-located with other large pollution sources, thereby excluding vast numbers of engines. In addition, EPA's proposed standards do not limit particulate matter or smog-forming nitrogen oxides, two key harmful contaminants. 67 Fed. Reg. 77,829 (December 19, 2002).

[3] U.S. Environmental Protection Agency, "Emission Regulations for Stationary and Mobile Engines," EPA 420-F-034 (Sept. 2002) 1-2.

[4] California Energy Commission, BUGS 1: Database of Public Back-up Generators (BUGS) in California, (Aug. 15, 2001).

[5] Jim Lents and Juliann Emmons Allison, "Can We Have Our Cake and Eat it Too? Creating Distributed Generation Technology to Improve Air Quality" (Energy Foundation, Dec. 1, 2000) 13-18.

[6] Nancy Ryan, Kate Larsen, and Peter Black, "Smaller, Closer, Dirtier: Diesel Backup Generators in California" (New York: Environmental Defense, 2002). Available online at http://www.environmentaldefense.org/documents/2272_BUGsreport.pdf

[7] California Air Resources Board, "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles," Oct. 2000, app. 2, p. 17. Available on-line at http://www.arb.ca.gov/diesel/documents/rrpapp2.PDF.

[8] Lents & Emmons Allison, note 5, supra, 13-18.

[9] Texas Natural Resources Conservation Commission (since renamed), "Air Quality Standard Permit for Electric Generating Units" (adopted May 23, 2001), establishes emission standards for units 10 MW or less. Texas explained the need for the standards: "The Public Utility Commission (PUC) of Texas anticipates that small electric generating units (EGUs) may become an attractive option for electric customers as an alternative to central station generating units as a primary source of electricity due to electric restructuring and electric reliability concerns." Ibid. at p. 3.

[10] "The initial East Texas standards . . . recogniz[e] the unique ozone problems in East Texas and should allow for authorization of fuel cells, micro turbines, clean turbines using catalytic combustors or flue gas cleanup, and the very cleanest reciprocating engines using catalytic converters." Texas Air Quality Standard Permit for Electric Generating Units at p. 5.

[11] "The West Texas standards . . . should allow for clean reciprocating engines to register under the standard permit, as well as clean diesel engines operating as peaking units" defined as units that operate less than 300 hours a year. Texas Air Quality Standard Permit for Electric Generating Units at p. 5 & 18.

[12] California Air Resources Board, "Proposed Airborne Toxic Control Measure To Reduce Diesel Particulate Matter Emissions from In-Use Stationary Diesel-Fueled CI Engines Greater than 50 Horsepower and To Reduce Diesel Particulate Matter Emissions from New Stationary Diesel-Fueled CI Engines" (November 2002 discussion drafts).

[13] Lents & Emmons Allison, note 5, supra, 23-29.

CHAPTER 5

Cleaner Fuel to Power Cleaner Engines

Diesel fuels are refined from the fraction of crude oil that is left behind when lighter petroleum products such as gasoline are made. The refining process tends to concentrate contaminants such as sulfur, which naturally occurs in many crude oils, into the remaining fuel. Diesel fuel used in highway engines currently cannot contain more than 500ppm sulfur.[1] Under new national regulations, this limit will fall to 15ppm sulfur in 2006.[2] By contrast, the sulfur content of diesel fuel burned in nonroad engines averages 3,300ppm.[3] Only California has a stricter limit of 500ppm sulfur for nonroad diesel fuel.[4] Large oceangoing ships use fuel containing far more sulfur, as much as 45,000ppm.[5]

In recent federal regulations for large diesel trucks and buses, EPA adopted a comprehensive systems approach, pairing strict emissions limits for new engines with a 15ppm limit on the sulfur content in diesel fuel. This 15ppm limit will dramatically and immediately reduce sulfur dioxide emissions, which transform into harmful fine particles. Sulfur also fouls catalytic converters and clogs particulate traps. Low sulfur diesel fuel, therefore, also enables state-of-the-art emissions control technology for other pollutants.

Fuel sulfur content limits are becoming a standard element of diesel emission reduction programs. The progress made around the world in lowering the sulfur content of diesel fuel demonstrates the general viability of low sulfur diesel requirements.

The European Union requires that low sulfur gas and diesel will be introduced by January 1, 2005 and will be mandatory in onroad vehicles by 2009. The maximum allowable sulfur in these fuels will be 10ppm. The current level of sulfur in diesel fuel is 350ppm. Moreover, the EU now calls for sulfur free diesel fuel in nonroad mobile vehicles, such as farm and construction equipment, beginning in 2009.[6]

In Sweden, virtually all the diesel fuel now sold for both onroad and nonroad applications is "Urban 1," limited to 10ppm sulfur. Sweden introduced its low sulfur diesel fuel 10 years ago.[7] Finland grants consumer tax incentives for use of 10ppm "city diesel." In Australia, onroad diesel sulfur content will be limited to 50ppm by 2006.[8] Denmark provides consumer tax incentives and 100 percent of the highway diesel fuel currently sold is 50ppm. Germany, likewise, offers a consumer tax credit for 10ppm diesel fuel. Switzerland is offering financial incentives for very low sulfur diesel fuel.[9] Hong Kong is considering requiring 50ppm sulfur in its onroad diesel fuel. Mexico, India and Japan have limited onroad diesel fuel to 500ppm, and Japan will phase in new requirements for 50ppm beginning this year. The United Kingdom provides tax incentives and 100 percent of its highway diesel fuel is 50ppm.[10] While most of these low sulfur diesel fuel programs focus on the onroad sector, the host of nations across the globe carrying out these programs demonstrates both the ability to lower the sulfur content in diesel fuels and the far-reaching support for such action.

The European Automobile Manufacturers Association, the Alliance of Automobile Manufacturers, the Engine Manufacturers Association, the Japan Automobile Manufacturers Association, and others have worked to harmonize fuels worldwide. First established in 1998, the Worldwide Fuel Charter promotes "greater understanding of the fuel quality needs of motor vehicle technologies and [harmonizes] fuel quality worldwide in accordance with vehicle needs." The Worldwide Fuel Charter recommends sulfur levels of 5 to 10ppm for markets that require advanced emission controls, to enable sophisticated NOx and PM after-treatment technologies.[11]

In anticipation of EPA action to expand our nation's low sulfur fuel program to the nonroad diesel sector, the American Petroleum Institute proposed in 2002 that U.S. refiners complete the transition to 15ppm low sulfur diesel for nonroad engines by 2010.[12]

[1] 55 Fed. Reg. 34,120 (August 21, 1990).

[2] 66 Fed. Reg. 5,001 at 5,006 (January 18, 2001).

[3] 64 Fed. Reg. 26,142 at 26,148 (May 13, 1999).

[4] The California Diesel Fuel Regulations. Title 13, California Code of Regulations, Section 2281(a)(1) (as last amended June 4, 1997).

[5] 68 Fed. Reg. 9,745 at 9,768 (February 28, 2003).

[6] Parliament and Council Reach Agreement on Sulphur-free Fuels (December 12, 2002). Available online at http://www.euractiv.com/cgi-bin/cgint.exe/3232980-531?targ=1&204&OIDN=1504413; Directive of the European Parliament and of the Council on the Quality of Petrol and Diesel Fuels and Amending Directive 98/70/EC (May 11, 2001) 4. Available online at http://europa.eu.int/eur-lex/en/com/pdf/2001/en_501PC0241.pdf

[7] Michael Walsh, "International Experience on Ultra Low Sulfur Diesel and Biodiesel," (January 2000) 17. Tax incentives for Swedish city diesel were introduced in 1990 to promote use of environmentally friendly fuels. This led to a huge increase in low sulfur diesel popularity and encouraged several refiners to invest in production of cleaner fuels. As a result of this head start, Swedish manufacturers are now taking advantage of the growing demand in Europe for low sulfur diesel. Available online at http://www.cai-infopool.org/downloads/diesel-low-sulfur-and-biodiesel-worldwide.pdf

[8] The Measures for a Better Environment initiative includes commitments to establish a diesel standard for road transport fuel with a sulfur content of no more than 500ppm by the end of 2002 and to establish a mandatory diesel standard with a sulfur content of no more than 50ppm sulfur by 2006. Available online at http://www.ea.gov.au/atmosphere/airquality/measures.html

[9] Swiss law calls for an additional tax of 3 to 5 cents per liter to be levied, beginning in 2004, on fuels containing more than 10ppm of sulfur. Fuels with a sulfur content of less than 10ppm, which the Swiss will consider sulfur-free, will be exempt from the tax.
Available online at http://www.aecc.be/en/news/docs/sep-oct%202002%20news%20en.pdf

[10] All international numbers come from www.eia.doe.gov/oiaf/archive/aeo01/conf/EIA%20Energy%20Modeling%20Conference%20final.ppt see slide 10.

[11] Worldwide Fuel Charter, December 2002. Available online at http://www.autoalliance.org/fuel_charter.htm.

[12] Eric Pianin, "New Rules in Works for Diesel Emissions," Washington Post (December 30, 2002).

CHAPTER 6

The Path to Cleaner, Healthier Air

A Federal and State Partnership

Millions of Americans live in areas with air pollution levels above the national health standards for fine particles and ozone. Toxic air pollutants pose a significant public health threat in communities nationwide. Ecosystems from Acadia to Yosemite suffer from the effects of air pollution. And haze casts a pall over national parks across the country. Pollution from diesel-powered nonroad engines is implicated in all of these problems.

While states are responsible for crafting air pollution management plans to lower harmful air pollution concentrations, the federal government has primary jurisdiction to design emission standards for nonroad engines. This gives the states a strong stake in a protective federal program. States need rigorous federal emission standards for diesel-powered nonroad engines so that other pollution sources do not bear a greater responsibility under local clean air plans. And, most importantly, states need these pollution cuts to achieve and maintain clean, healthy air.

But federal action alone will not immediately solve this problem. These engines are long-lived, sometimes operating for decades. State and local governments will need to help clean up existing engines and spur the transition to cleaner engines. A concerted federal and state partnership is necessary. Federal leadership and local innovation will help realize the potential public health and environmental benefits from cleaning up these engines. Following are some of the parallel federal and local measures that are necessary to get these engines on the path to cleaner, healthier air.

Federal leadership

EPA is expected shortly to propose new emission standards and companion low sulfur fuel requirements for both large and small diesel nonroad engines. This combined approach that addresses the engines and the fuel that powers them as a system is necessary to realize the pollution cuts and air quality protections from available pollution control technology. But to be fully effective, EPA's systems approach must be centered in a well-designed framework. The American Lung Association and Environmental Defense recommend EPA address the following core elements:

- Apply onroad engine and fuel standards to comparable nonroad engines. EPA's 2001 emission standards for large diesel-powered highway engines, including trucks and buses, were based on state-of-the-art emission control technologies and 15ppm low sulfur diesel fuel. These strategies are equally viable for a wide range of nonroad engine applications. EPA's new clean air standards should spur engine manufacturers to bring to bear on nonroad emissions the research and development resources that are bringing cleaner heavy-duty highway engines to market. The European Union is leading the way. In 2002, the EU finalized a program calling for sulfur free diesel fuels in nonroad vehicles, such as farm and construction equipment, beginning in 2009.[1]

- Key timing of standards to public health and environmental imperatives. Numerous areas will be required to achieve the national health-based air quality standards for fine particles and ozone between 2007 and 2009. EPA must implement protective new emission standards for particulate and ozone-forming nitrogen oxides from nonroad diesel engines on a timeline to assist these areas in protecting public health and meeting critical Clean Air Act deadlines.
- Address nonroad diesel engines comprehensively. EPA's historic initiative to curb pollution from these overlooked engines must be comprehensive. Diesel-powered nonroad engines ranging in size from compact loaders to enormous mining equipment are high-polluting sources. Failing to address the harmful pollutants from any of these engines will leave some communities, both East and West, behind in realizing the potential clean air benefits. And it may be years before EPA again addresses these pollution sources.
- Extend clean air requirements to commercial marine vessels and locomotives. EPA should take action now to achieve immediate clean air gains by requiring far-reaching application of low sulfur diesel fuel for nonroad engines. Like other nonroad engines, locomotives and commercial marine vessels are powered by high sulfur fuel. These engines should not be left behind in curbing the harmful levels of SO_2 discharged from high sulfur fuels and achieving state-of-the-art emission standards for other contaminants. It is also important to address the sulfur content of the residual fuel burned in ocean-going ships, since this fuel can contain 10 times as much sulfur as today's land-based nonroad fuels, and more than 2,000 times the sulfur that will be allowed in highway vehicles starting in 2006.
- Design programs effectively to make pollution reductions a reality. The gains from protective emission standards can be eroded by poor program design. EPA will achieve durable clean air progress by fashioning a program that ensures the emission standards are achieved during the full life of the engine. Effective testing and certification procedures, on-board diagnostics, in-use standards, and enforcement are the four pillars of protective emission standards.

Clean Fuel Maintenance Dividend for Farmers and other Heavy Equipment Operators

While low sulfur diesel fuel is important to achieve public health and environmental benefits, it will also benefit engine operation and maintenance. Low sulfur fuel will reduce the wear and tear on heavy equipment. Farmers and other heavy-equipment operators using low sulfur fuel will realize a dividend in avoided maintenance expenditures that will help offset higher fuel costs. This will translate into prolonged engine life and less frequent parts replacement.[2]

The maintenance dividend for low sulfur fuel in large onroad vehicles was estimated to be about $600 over the life of the engine or a fuel cost savings of about 1 cent per gallon.[3] The cost savings for nonroad equipment will likely be much higher. This is because baseline sulfur levels in nonroad fuel are about six times higher than onroad fuel. So the maintenance benefits of dramatically lowering nonroad sulfur content to 15 parts per million will exceed the estimated onroad benefits. And these benefits will be further enhanced for nonroad engines due to their longer lives and greater maintenance needs.

Innovation at the state and local level

State and local governments have advanced innovative measures to curb pollutants from diesel-powered nonroad engines. These programs illustrate the varied opportunities for clean air action at the local level. Some examples follow:

- Contract specifications. State and local governments have latitude to establish clean equipment contract terms for prospective contractors for building construction, public landscape maintenance, and road construction and maintenance. Northeastern states conducted such a pilot program for Boston's "Big Dig" and New York Governor George Pataki recently announced that he would establish contract specifications requiring best available retrofit technology for equipment used in the reconstruction of lower Manhattan.
- In-use restrictions. Carefully designed constraints on the operation of nonroad equipment are legally permissible. Anti-idling programs, for example, are not emission standards preempted under federal law. And local inspection and maintenance programs to regulate in-use compliance with established federal emission standards complement federal measures.
- Programs to encourage voluntary retrofits, repowers and clean engine purchase. California's Carl Moyer program is the premier state effort to foster clean diesel engines. Through state-appropriated funds, the program pays the marginal cost differential between the purchase of a conventional diesel engine and a cleaner diesel engine. The program has not only lowered harmful pollution but it has provided an instructive proving ground for new technology.

- State Low Sulfur Diesel Fuel Programs. States can lower SO_2 and power the transition to cleaner diesel equipment by requiring nonroad low sulfur fuel content requirements. In 2001, EPA approved the Texas low sulfur nonroad diesel fuel program without a waiver of federal preemption requirements for fuel. EPA explained that the statutory preemption provisions were limited to fuel used "in a motor vehicle or a motor vehicle engine" and did not preempt nonroad diesel equipment. Therefore, no waiver was required for EPA's approval of the Texas nonroad low sulfur fuel requirements.[4]
- Procurement and Maintenance of Government Equipment. State and local governments operate nonroad and stationary diesel equipment for a variety of government functions. By purchasing cleaner new equipment and retrofitting and repowering their existing equipment, government agencies can reduce pollution in their communities and set an example of environmental leadership.

Working Together to Close the Loophole for Stationary Diesel Generators

Well-designed federal and local programs to curb emissions from nonroad engines will realize important clean air progress. These policies provide the foundation for curbing pollution from companion stationary diesel generators currently not regulated by the federal government. We urge EPA and local policymakers to make clean air protections for diesel engines comprehensive by applying the same protective emission standards and fuel requirements to diesel generators. EPA should act in parallel with its current nonroad initiative to leverage its technical resources, rationalize its policy, and eliminate this growing loophole. Meanwhile, states can follow the leads of California and Texas in addressing these dangerous pollution sources.

An Important Role for Congress: Support for Clean Diesel Engines in New Transportation Legislation

Congress can help lead the concerted effort to protect public health and the environment from diesel exhaust. Congress should expand support for EPA's highly successful and cost-effective diesel retrofit programs when it reauthorizes federal transportation funding. EPA has worked hand-in-hand with local officials to begin cleaning up existing diesel engines — from school buses in New Haven to the heavy-duty construction equipment that will rebuild lower Manhattan. An enhanced federal diesel retrofit program would extend the benefits of diesel clean-up to more communities. It will provide a critical bridge to the eventual phase in of new emission standards. And it will secure a cleaner, healthier environment today.

A City in Recovery

For people who live and work downtown in New York City, air quality has been a constant concern since September 11. Even today, adverse health effects remain, and potentially dangerous dust still has not been cleaned from all building interiors, rooftops or ventilation systems. Though much has been done, important steps still need to be taken to reduce exposure to harmful airborne contaminants.

For the next several years lower Manhattan will be one of the nation's largest construction sites, teeming with diesel engines. These vehicles will be operating just steps from schools, playgrounds, parks, homes and offices. There is an urgent need for diesel vehicles, especially nonroad vehicles at the World Trade Center site, to take practical steps to lower their discharge of fine particulates and other damaging airborne contaminants.

Environmental Defense published a briefing paper outlining opportunities for diesel retrofits and cleaner fuels in lower Manhattan, and worked with government officials and business leaders to secure commitments to implement the best available measures.In September 2002, New York Governor George Pataki and the New York State Department of Environmental Conservation announced a plan to reduce harmful emissions from construction vehicles being used in the reconstruction of lower Manhattan. The plan calls for use of ultra low sulfur diesel fuel and the "best available retrofit technology" for each piece of construction equipment. New York's plan can serve as a model for cities around the United States.

[1] Parliament and Council Reach Agreement on Sulphur-free Fuels (December 12, 2002). Available online at http://www.euractiv.com/cgi-bin/cgint.exe/3232980-531?targ=1&204&OIDN=1504413; Directive of the European Parliament and of the Council on the Quality of Petrol and Diesel Fuels and Amending Directive 98/70/EC (May 11, 2001) 4. Available online at http://europa.eu.int/eur-lex/en/com/pdf/2001/en_501PC0241.pdf

[2] 66 Fed. Reg. 5,002 at 5,099 (Jan. 18, 2001).

[3] Ibid.

4 66 Fed. Reg. 57,196 at 57,205 (Nov. 14, 2001), ("[T]he Texas LED rule, which applies to diesel fuel for both highway and nonroad use, is not preempted under this statutory provision to the extent it applies to diesel fuel for nonroad use.").

Estimated Benefits of Rigorous, Fully Implemented Federal Emission Standards and Low Sulfur Fuel Requirements for Nonroad Diesel Engines in Terms of Today's Onroad Vehicles Removed From the Road

Introduction

In June 2002, a consortium of state and local air pollution control officials completed a study assessing the public health and welfare benefits of rigorous federal emission and fuel standards for nonroad diesel engines.[1] The study estimated that in 2030, which was assumed to be a representative year for a fully implemented rule, the overall annual emission reduction benefits would be as follows:

Estimated Annual Emission Reductions in 2030 Resulting from a Rigorous, Fully Implemented Nonroad Engine Program[2] (tons)

	Based on STAPPA/ALAPCO Recommended Nonroad Diesel Standards
$PM_{2.5}$	150,660
NOx	1,170,000
SOx	392,000

This data reflects the changes expected to be made in EPA's nonroad emission model in 2003. The estimated emission reduction benefits assume that a federal program for nonroad diesel engines would include emission standards for PM and NOx, and low sulfur fuel content requirements that are the same in stringency and timing as the federal requirements for large onroad diesel engines published in 2001. Specifically, the key assumptions include EPA adoption of a rule containing the following elements:

- A 15ppm nonroad low sulfur diesel fuel standard to take effect in June 2006 with the same flexibility and schedule as the onroad low sulfur diesel fuel program;
- A PM engine standard equivalent to 0.01 grams per brake horsepower hour to be fully applicable in 2007;
- A NOx engine standard of 0.2 grams per brake horsepower hour to be phased in between 2007 and 2010.[3]

Consultant John F. Kowalczyk, an expert on air pollution from mobile sources and former member of EPA's Mobile Sources Technical Review Subcommittee, used these estimated emission reductions to translate the projected air pollution benefits of a rigorous nonroad program into the number of today's onroad vehicles that would have to be taken out of service to achieve comparable pollution reductions.

Methodology

EPA's 2001 national emissions inventory contains the most recent projected emissions for the onroad transportation sector. The onroad sector of this inventory includes emissions from all light-duty passenger vehicles and trucks as well as heavy-duty trucks and buses. The EPA emissions inventory is in most cases based on the new EPA MOBILE6 model. The table below shows EPA's estimated 2001 national onroad emissions for NOx, $PM_{2.5}$ and SOx.

EPA 2001 National Onroad Emissions Inventory[4]

	Emissions (tons)
NOx	8,249,000
$PM_{2.5}$	162,000
SOx	261,000

The table below shows the national emission reductions benefits from the nonroad diesel program recommended by state and local air pollution officials as a percentage of EPA's total national 2001 emissions for onroad engines.

Air Quality Benefits of STAPPA/ALAPCO Recommended National Nonroad Standards as a Percentge of the EPA 2001 National Onroad Emissions Inventory

Pollutants Reduced from Nonroad Standards	Percent of EPA National 2001 Onroad Vehicle Emissions Inventory
NOx	14%
$PM_{2.5}$	93%
SOx	150%

Results

The air quality benefits of the emission and fuel standards for nonroad diesel engines recommended by state and local air pollution control officials can be approximately expressed as the equivalent number of today's onroad vehicles that would have to be taken out of service to achieve comparable pollution reductions. The table below multiplies the percentages in the table immediately above (the percent of onroad emissions resulting from rigorous nonroad standards) by the number of onroad vehicles in the United States as well as in each individual state.

There were 201,246,906 total estimated onroad vehicles in the United States in 2001.[5] Individual state vehicle counts have been estimated assuming that state vehicles are in direct proportion to the state population data as of July 1, 2001 from the U.S. Census.

[1] STAPPA/ALAPCO (The State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials), "The Dangers of the Dirtiest Diesels: The Health and Welfare Impacts of Nonroad Heavy-Duty Diesel Engines and Fuels," (June 2002), available on-line at: http://www.4cleanair.org/FINALNonroadHDDReport.pdf

[2] Ibid. at 17.

[3] Ibid. at 4 & 17.

[4] U.S. EPA, National Emissions Inventory Average Annual Emissions, All Criteria Pollutants Including 1980, 1985, 1989-2001 (Feb. 2003). Available online at http://www.epa.gov/ttn/chief/trends/trends01/trends2001.pdf

[5] U.S. EPA, "Fleet Characterization Data for MOBILE 6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates, and Projected Vehicle Counts for Use in MOBILE 6," EPA 420R-01-047 (Sept. 2001), available on-line at: http://www.epa.gov/otaq/models/mobile6/r01047.pdf

TABLE 1
Estimated Air Quality Benefits of a Rigorous, Fully Implemented Federal Nonroad Program in Terms of Today's Onroad Vehicles Removed from the Road

State	NOx	$PM_{2.5}$	SOx*	Total of Pollutants ($NOx + PM_{2.5} + SOx$)
National	**29,014,000 (14% of vehicles)**	**192,713,000 (93% of vehicles)**	**150% of vehicles**	**40,827,000 (20% of vehicles)**
Alabama	454,000	3,018,000	“	637,000
Alaska	64,000	428,000	“	90,000
Arizona	540,000	3,584,000	“	757,000
Arkansas	274,000	1,819,000	“	385,000
California	3,518,000	23,370,000	“	4,936,000
Colorado	450,000	2,992,000	“	632,000
Connecticut	349,000	2,319,000	“	489,000
Delaware	81,000	538,000	“	114,000
Wash. D. C.	58,000	387,000	“	82,000
Florida	1,665,000	11,058,000	“	2,335,000
Georgia	855,000	5,677,000	“	1,199,000
Hawaii	124,000	826,000	“	174,000
Idaho	134,000	892,000	“	188,000
Illinois	1,273,000	8,456,000	“	1,605,000
Indiana	623,000	4,136,000	“	874,000
Iowa	298,000	1.981,000	“	417,000
Kansas	274,000	1,825,000	“	386,000
Kentucky	414,000	2,748,000	“	580,000
Louisiana	455,000	3,019,000	“	637,000
Maine	132,000	867,000	“	183,000
Maryland	548,000	3,638,000	“	768,000
Massachusetts	651,000	4,323,000	“	913,000
Michigan	1,017,000	6,754,000	“	1,427,000
Minnesota	507,000	3,373,000	“	712,000
Mississippi	293,000	1,949,000	“	411,000
Missouri	573,000	3,807,000	“	804,000
Montana	92,000	611,000	“	129,000
Nebraska	175,000	1,162,000	“	245,000
Nevada	213,000	1,416,000	“	299,000
New Hampshire	128,000	850,000	“	180,000
New Jersey	865,000	5,748,000	“	1,214,000
New Mexico	186,000	1,240,000	“	407,000
New York	1,940,000	12,891,000	“	2,722,000
North Carolina	834,000	5,542,000	“	1,170,000
North Dakota	64,000	429,000	“	101,000
Ohio	1,158,000	7,692,000	“	1,625,000
Oklahoma	352,000	2,341,000	“	494,000
Oregon	353,000	2,346,000	“	495,000
Pennsylvania	1,251,000	8,311,000	“	1,756,000
Rhode Island	108,000	715,000	“	151,000
South Carolina	413,000	2,743,000	“	579,000
South Dakota	87,000	577,000	“	128,000
Tennessee	585,000	3,883,000	“	820,000
Texas	2,164,000	14,372,000	“	3,035,000
Utah	232,000	1,538,000	“	325,000
Vermont	62,000	414,000	“	87,000
Virginia	732,000	4,860,000	“	1,027,000
Washington	609,000	4,048,000	“	855,000
West Virginia	183,000	1,216,000	“	407,000
Wisconsin	550,000	3,651,000	“	771,000
Wyoming	50,000	333,000	“	70,000

* The SOx emission reductions that would result from the STAPPA/ALAPCO recommended nonroad diesel fuel standards exceeds the total SOx emissions from onroad fuel by 50%. This reflects the extraordinary high sulfur content in nonroad diesel fuel, which averages 3300ppm nationwide outside of California.

Appendix B

Comparison of EPA Emissions Standard for Large Highway and Nonroad Diesel Engines

NOx+HC and PM Emission Standards for Large Onroad and Nonroad Diesel Engines (g/bhp-hr)

Large Onroad	2003	2004	2007
	4 (NOx only) 0.1	2.4 0.1	0.34 0.01

Nonroad	2000	2001	2002	2003	2004	2005	2006	2007	2008
kW<8 (hp<11)	7.8 0.75					5.6 0.60			
8<=kW<19 (11<=hp<25)	7.1 0.60					5.6 0.60			
19<=kW<37 (25<=hp<50)	7.1 0.60				5.6 0.45				
37<=kW<75 (50<=hp<100)	6.9 (NOx only) N/A				5.6 0.30				3.5 **
75<=kW<130 (100<=hp<175)	6.9 (NOx only) N/A			4.9 0.15				3.0 **	
130<=kW<225 (175<=hp<300)	6.9 (NOx only) 0.40			4.9 0.15			3.0 **		
225<=kW<450 (300<=hp<600)	6.9 (NOx only) 0.40	4.8 0.15					3.0 **		
450<=kW<560 (600<=hp<750)	6.9 (NOx only) 0.40		4.8 0.15				3.0 **		
kW>=560 (hp>=750)	6.9 (NOx only) 0.40						4.8 0.15		

Tier1 Tier2 Tier3 **Tier3 PM standards yet to be set

Source: U.S. EPA, Emission Standards Reference Guide for Heavy-Duty and Nonroad Engines, September 1997; 66 Fed. Reg. 5,002 (Jan. 18, 2001); 63 Fed. Reg. 56,967 (October 23, 1998).

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