Cleaner Air for America

THE CASE FOR A NATIONAL PROGRAM TO CUT POLLUTION FROM TODAY'S DIESEL ENGINES

environmental defense
finding the ways that work

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Cover images: Left: Trucks "plugged in" to the IdleAire system (Photo courtesy of IdleAire). Center: Children's baseball team (Doug Menuez/Photodisc Green). Right: Construction equipment retrofit with a diesel particulate filter (Photo courtesy of Johnson Matthey).

Our mission
Environmental Defense is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

The complete report is available online at www.environmentaldefense.org.

Contents

Acknowledgments

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Environmental Defense does not endorse any particular air pollution control technology or method. This report factually describes air pollution control technologies and methods based on published reports.

Executive summary

The U.S. Environmental Protection Agency (EPA) estimates that by 2030, its revolutionary programs to reduce air pollution from new diesel buses and freight trucks and new nonroad diesel equipment will slash diesel emissions by more than 80% from 2000 levels. Collectively, these federal standards are projected to prevent more than 20,000 premature deaths, 15,900 hospital admissions, and over half a million asthma attacks *each year*.

But because these federal standards apply only to new diesel engines and because diesel engines are so durable, the high levels of pollution from existing diesel sources will persist throughout the long lives of the engines in service today. The practical effect of this lengthy transition to cleaner diesel engines is that the children suffering the effects of diesel exhaust today will be raising their own children before the new federal emission standards deliver their full health benefits in 2030.

A national program to cut pollution from today's diesel engines would speed the transition to cleaner diesel engines and achieve healthier air for today's children. To assess the health benefits and costs of a comprehensive diesel emission reduction program for existing engines, as well as to evaluate potential funding levels, Environmental Defense examined two scenarios in which different emission control measures were applied to diesel construction equipment, school buses and transit buses in the core counties of the 50 largest metropolitan areas in the U.S. These 88 counties, along with the District of Columbia, contain 94.6 million people, or one-third of the U.S. population.

We examined construction equipment because these engines have high pollution levels and typically operate for long hours. We included diesel school buses and transit buses because they expose sensitive populations to diesel pollution.

FIGURE 1

Investments in a national diesel control program yield healthy returns

An investment in diesel engine retrofits ranging from $600 million to $1.6 billion yields a multi-year stream of health benefits with a net present value ranging from $10.6 to $19.2 billion.

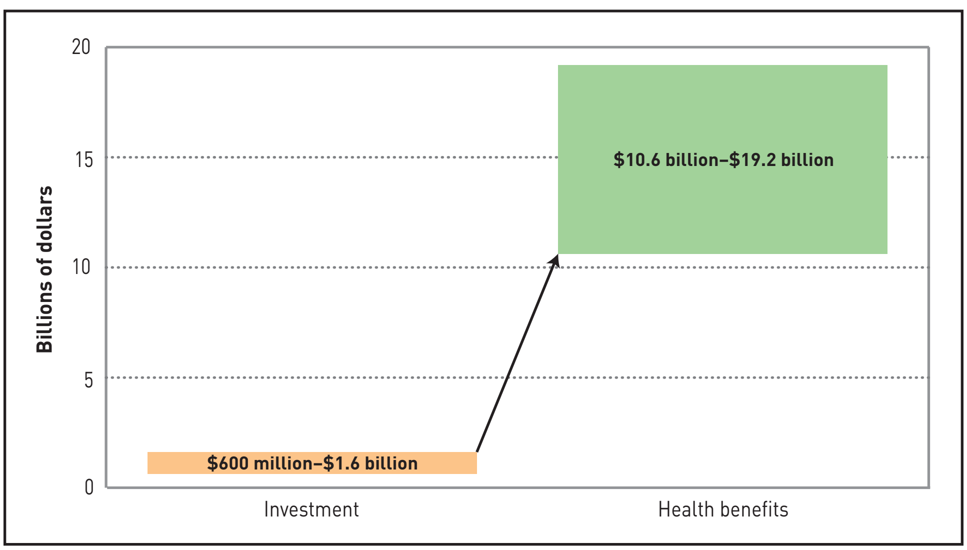
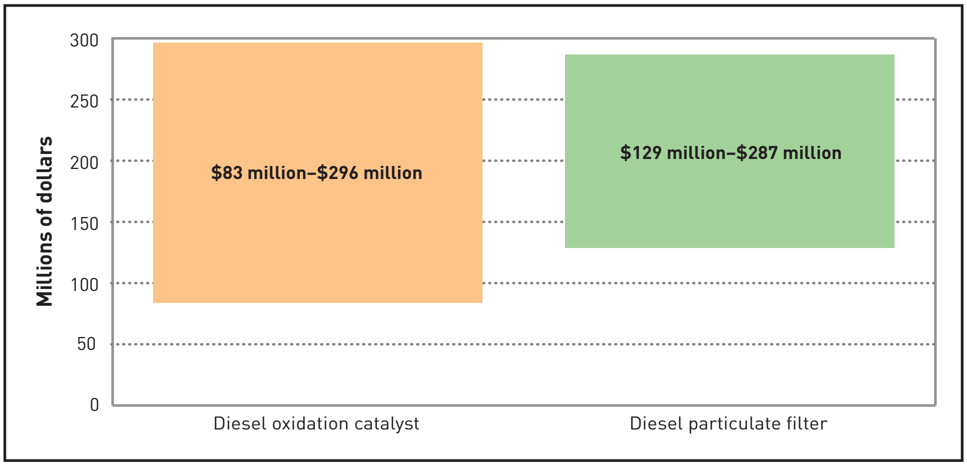


FIGURE 2

Diesel pollution reduction scenarios: range of annual costs when investments spread over seven years



Our two scenarios assumed installation of two widely available emission control measures on construction equipment and buses within the studied counties: diesel particulate filters and diesel oxidation catalysts. Diesel particulate filters can reduce particulate pollution by 80% to 95% per engine, but can only be applied to a limited set of engines. Diesel oxidation catalysts reduce particulate pollution by 20% to 35% per engine, but are significantly lower in price and can be applied broadly across fleets. Thus, these two scenarios illustrate the range of costs to achieve steep reductions from a limited set of engines and more modest reductions over many more engines. The scenarios are illustrative. The appropriate mix of pollution reduction strategies will vary widely across communities.

Using EPA's valuation methodologies, we found that investment in a national diesel pollution control program will yield healthy returns. Figure 1 shows the lump sum costs of applying the two technology scenarios to school buses, transit buses and construction equipment in the 50 most populated cities ranged from $600 million to $1.6 billion. The net present value of the resulting health benefits far exceeded these costs, and ranged from $10.6 billion to $19.2 billion (see Figure 1).

Our analysis provides a benchmark for the level of funding necessary to make a real impact in reducing dangerous emissions from the existing diesel fleet. Over the course of seven years, the emission controls examined in our study would range in cost from approximately $83 million annually to $296 million annually (see Figure 2). *Environmental Defense recommends federal funding for a national program of $296 million annually for seven years.* Federal funding in the higher part of the cost range would increase the ability of a national program to address types of diesel engines and control technologies excluded from our analysis such as locomotive and marine engines and idle reduction strategies. Importantly, it would also provide resources to better accommodate controls for additional pollutants, to support additional communities, large and small, across America that are committed to well-run clean diesel programs, and to address the administrative costs inherent in a program of this scope. The nation's 50 most populated areas, which were examined in our pollution reduction scenarios, are listed in Table 1.

TABLE 1
50 most populated metropolitan areas in the U.S., examined in diesel pollution reduction program scenarios

1. New York City	26. Milwaukee
2. Los Angeles	27. Orlando
3. Chicago	28. Indianapolis
4. Washington-Baltimore	29. San Antonio
5. San Francisco-Oakland	30. Norfolk-Virginia Beach-Newport News
6. Philadelphia	31. Las Vegas
7. Boston	32. Columbus, OH
8. Detroit	33. Charlotte, NC
9. Dallas-Fort Worth	34. New Orleans
10. Houston	35. Salt Lake City
11. Atlanta	36. Greensboro, NC
12. Miami, FL	37. Austin
13. Seattle-Tacoma	38. Nashville
14. Phoenix	39. Providence-Fall River
15. Minneapolis-St. Paul	40. Raleigh-Durham-Chapel Hill
16. Cleveland	41. Hartford
17. San Diego	42. Buffalo, NY
18. St. Louis	43. Memphis
19. Denver	44. Jacksonville, FL
20. Tampa-St. Petersburg	45. Rochester, NY
21. Pittsburgh	46. Grand Rapids, MI
22. Portland, OR	47. Oklahoma City
23. Cincinnati	48. Louisville, KY
24. Sacramento	49. Richmond, VA
25. Kansas City	50. Greenville-Spartanburg, SC

Source: U.S. Census Bureau, 2000

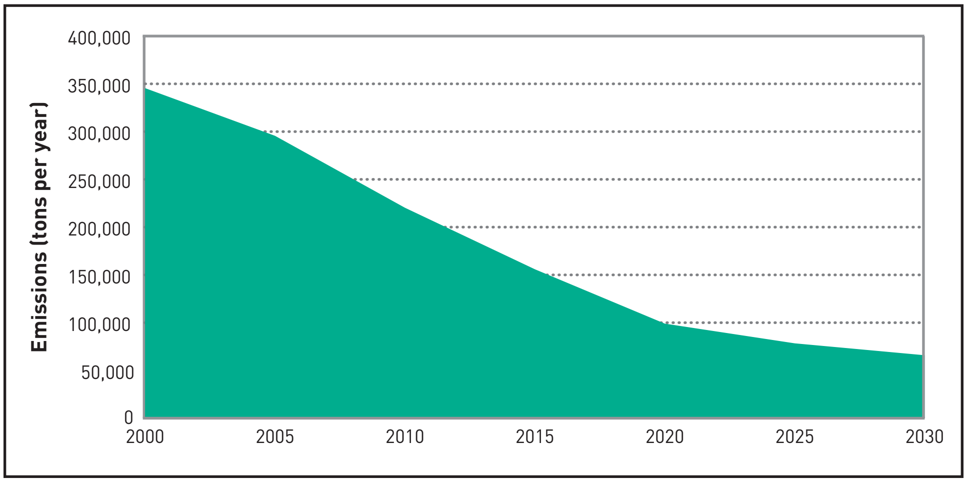
Diesel exhaust is one of the most dangerous forms of air pollution

Diesel exhaust is as ubiquitous as diesel equipment, which is used throughout our economy, in transportation, construction, agriculture and industry, on our highways and streets, in our waters and on our rails. The need for a major national program to reduce diesel pollution is based on the extraordinary level of harm diesel exhaust causes to the people who breathe it. Diesel exhaust and many of its components are considered probable human carcinogens. EPA national air toxics data shows that up to 80% of the total cancer risk Americans face from air pollution can be attributed to diesel exhaust.

Diesel exhaust is made up primarily of microscopic particles that lodge deep in our lungs and deliver toxic pollutants to our bloodstreams along with a variety of hazardous gases like sulfur dioxide and oxides of nitrogen. It is associated with a wide range of health effects beyond cancer, including neurological effects, a weakened immune system, respiratory disease and cardiovascular disease. Diesel exhaust contributes to all the adverse health effects associated with particulate pollution, and also to the formation of ground-level ozone, which is a powerful respiratory irritant associated with asthma attacks, hospitalizations and premature death.

FIGURE 3

Particulate pollution under phase-in of federal standards for diesel trucks, buses, and machinery



The pollution reduction gap

Now is the time for national action to cut pollution from today's diesel engines. The serious health effects of diesel pollution are expressed by EPA's projected benefits of its emission standards for new diesel trucks and buses and nonroad equipment. Once those programs are fully phased in by 2030, EPA estimates 20,000 premature deaths will be prevented *each year.* The same health effects that will be avoided in 2030 are occurring now, and will continue until today's high-polluting diesel equipment is replaced or cleaned up. Because diesel engines are so durable, newer, cleaner engines will be slow to penetrate the market, and EPA projects that only 50 percent of the ultimate annual level of health benefits resulting from the new nonroad engine standards will be achieved by 2020. Figure 3 shows the full particulate pollution reductions under EPA's emission standards for diesel trucks, buses and machinery will not be realized until 2030.

Diesel cleanup programs are working today

Grant, loan and incentive programs to reduce diesel pollution are already being administered by local, state and federal government agencies. On a limited scale, these programs are delivering the promise of lower diesel emissions and speeding the transition to cleaner diesel fleets. The geographic and technological range of these programs demonstrates both the nationwide scope of the diesel pollution problem and the opportunity for an expanded federal effort to deliver cleaner, healthier air to communities across the country. These programs are the proving grounds for a more complete national program. Figure 4 summarizes some of the diesel pollution reduction programs communities across the nation are carrying out today.

A national diesel pollution reduction program: Cleaner Air for America

A well-funded, well-designed national program would accelerate the transition to cleaner diesel technology and close the gap between the clean diesel technology of tomorrow and today's high levels of dangerous diesel pollution.

Environmental Defense strongly supports creation of a new federal grant and loan program organized on the following principles:

1. A diesel pollution reduction program should maximize health and environmental benefits. Projects competing for federal grant and loan funds should be ranked by the health and environmental benefits they will produce, with priority given to projects that offer the greatest protection, especially those that target susceptible subpopulations including children.

2. A diesel pollution reduction program should promote cost-effective solutions. A competitive grant process should minimize costs by encouraging competition among cleaner diesel solutions.

3. Including all industry sectors serves many populations. A national program should serve the broad range of people exposed to diesel exhaust, including schoolchildren and the people who live near and work at railroads, ports, roadways, farms, mines, construction sites and industrial facilities where diesel equipment is used.

4. A program should advance a broad range of solutions. Successful solutions will include pollution control retrofits, replacement of old engines with newer, cleaner models, operational changes such as idle-reduction, and alternative power sources such as truck stop electrification and shore power for marine vessels. All of these solutions should compete for federal funds on the basis of their costs and the benefits they offer.

5. Incentives should be tailored to the specific application. Some sectors will be better suited for grant programs, while for others, loans will provide sufficient incentive for fleet owners to accelerate diesel emission reductions. A national program should be flexible in responding to these differences.

6. A federal grant and loan program should reward state and local efforts. State and local support for emission reduction measures can be rewarded through federal matching funds.

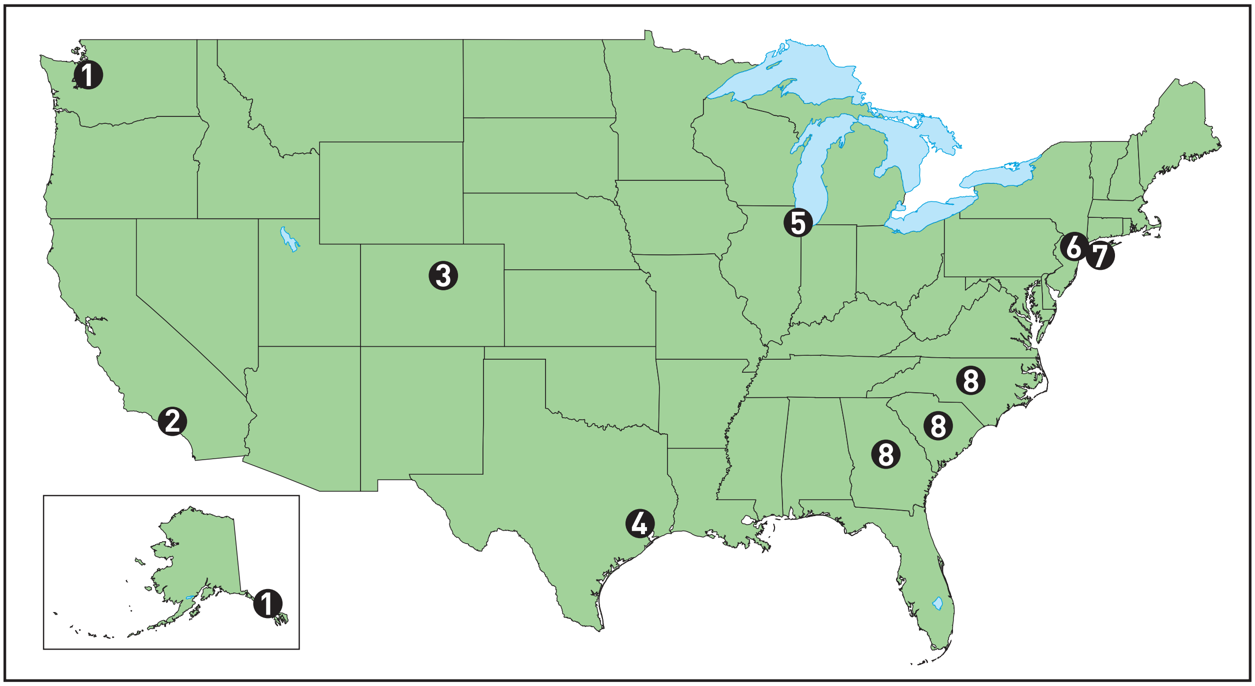
7. A federal program should capitalize on and support community action. The burden of air pollution falls heavily on local governments. Communities are banding together in public-private partnerships to reduce pollution such as the Cleveland Air Toxics pilot project. Projects associated with such collaborative local efforts should be given priority in a federal grant and loan program.

8. Information on program performance should be accessible. EPA should establish standardized metrics to report the progress of grant and loan recipient programs, and should make this information widely accessible.

A well-designed federal grant and loan program to reduce diesel pollution could help foster a variety of clean air programs including: 1) local, state and federal agency leadership in cleaning up government diesel fleets through procurement policies, 2) federal recognition of diesel pollution reduction programs in state air quality management plans, and 3) local collaborative efforts to lower exposure to hazardous air pollution through comprehensive community-based strategies.

The human health and economic case to lower pollution from today's diesel engines is compelling. With sustained federal support, the nation can speed the transition to cleaner diesel engines and achieve cleaner air for America today.

FIGURE 4
Cleaner air for America success stories



❶ **Seattle and Juneau cruise ship docks.** The West Coast Diesel Emissions Reduction Collaborative facilitated Princess Cruise's project to provide shore-based electric power to its cruise ship docks. Shore power will eliminate 13 tons per year of smog-forming oxides of nitrogen (NO_x) and 2 tons per year of particulate pollution emissions in Seattle.

❷ **Los Angeles: Alternative marine power eliminates ship pollution at berth.** The new China Shipping terminal at the Port of Los Angeles will eliminate 1 ton of NO_x and particulate pollution each day it is in use.

❸ **Denver: Hybrid buses serve downtown passengers.** Hybrid electric and compressed natural gas-fueled buses deliver passengers to a downtown pedestrian mall that links offices, shopping and regional transit.

❹ **Houston locomotive retrofit and repower projects:** The Texas Emissions Reduction Project is funding replacement of old switching engines with newer, cleaner models, and repowering engines with hybrid technology. TERP expects to reduce locomotive NO_x emissions by 3300 tons.

❺ **Chicago Anti-Idling Study.** A cooperative public-private demonstration project estimates that available anti-idle technology would eliminate 12.5 tons of NO_x per year at an average-sized rail switching yard.

❻ **New York: Construction contracts require cleaner diesel equipment.** State law requires best available retrofits and ultra low sulfur diesel (ULSD) fuel in all state-controlled construction projects in Lower Manhattan, including at the World Trade Center site. Local Law 77 makes ULSD and best available emission control technology a requirement of all city contracts.

❼ **Hunts Point Truckstop electrification.** Electrified truck stop facilities are reducing idling emissions at this massive meat and produce market located in a New York City neighborhood where one-third of the children suffer from asthma.

❽ **I-85 Truckstops reduce diesel emissions in Georgia, South Carolina and North Carolina.** Electrified stations eliminate idling emissions and save 263,000 gallons of diesel fuel per year at each of three truck stops. Truckers turning off their engines will eliminate 35 tons per year of NO_x and 1 ton per year of PM emissions at each electrified truck stop.

Various locations: EPA's Clean Schoolbus USA Program is making the ride to school healthier for kids in 47 communities scattered across the country.

Introduction

Diesel exhaust is one of the most dangerous and pervasive forms of air pollution. In 2004, the U.S. Environmental Protection Agency (EPA) finalized a program to dramatically reduce pollution from nonroad diesel engines used in construction, agriculture, manufacturing and mining. This program complements the clean air standards for nonroad diesel engines and fuel adopted in 2001 for onroad diesel engines used in trucks and buses. EPA estimates that by 2030, the nonroad and onroad diesel programs together will slash emissions from these fleets by more than 80% from 2000 levels and annually prevent more than 20,000 premature deaths.

EPA's actions to reduce diesel pollution are truly revolutionary. But the emission standards apply only to new engines, and diesel engines are so durable that they are typically used for many years, sometimes for decades. Therefore, the diesel revolution will take years to be fully realized, and its benefits will be delayed as dirty old engines continue to run and pollute for years to come. EPA estimates that by 2020, only half of the annual pulic health benefits of the nonroad diesel rule will be achieved. The children suffering the effects of diesel exhaust today will be raising their own children before the new emission standards deliver their full health benefits in 2030. To realize more immediate health protections for today's children, it is essential to cut pollution from diesel engines that are on the road today.

A program that will reduce diesel pollution today can relieve the burden imposed on the millions of people exposed to the dangerous exhaust from diesel engines now in use. Policymakers can maximize the human health benefits of clean air investments by acting swiftly to close the divide between today's high-polluting engines and the cleaner fleets due years from now.

The technical foundation for cleaning up today's diesel engines is at hand. Cleaner low sulfur diesel fuel is already available in some large markets and will be required for onroad vehicles in 2006. The broad availability of cleaner diesel fuel creates the opportunity to deploy a range of cost-effective emission controls, such as diesel particulate filters, to reduce pollution from existing diesel engines. Similarly, strategies to control engine idling are available to cut emissions from idling trucks, buses, locomotives, and marine engines.

EPA's diesel retrofit program, along with leading state programs like California's Carl Moyer Program and Texas' Emission Reduction Plan, have shown that diesel retrofits are a feasible and cost-effective means to reduce pollution from existing engines. This includes dangerous diesel particulate matter, nitrogen oxides that lead to ozone pollution and the many toxic and carcinogenic chemicals found in diesel exhaust. Federal leadership to expand these programs will deliver the promise of EPA's diesel emission reduction programs to Americans without waiting decades for old engines to wear out.

We review the serious health and environmental threats caused by diesel exhaust, and the striking amount of diesel pollution that will be emitted between now and the full realization of the emission reductions EPA's new diesel standards are designed to achieve. We evaluate the investments necessary to achieve more immediate clean air benefits across America, and the extraordinary dividends in human health protections that will result. Finally, we highlight some of the promising and successful emission reduction programs already in place across the spectrum of existing diesel engines: construction equipment, onroad heavy-duty trucks, school and transit buses, commercial marine engines, and locomotives. These programs are the proving grounds for more far-reaching national action.

CHAPTER 1

Principles for a national diesel retrofit program

The case for reducing pollution from existing diesel engines is compelling. Accelerated retrofit and replacement of existing engines, combined with changes in the way these engines are operated, will yield immediate public health benefits. Chapter 5 examines a variety of successful programs in place now to cut diesel pollution. These programs show that diesel retrofits and other emission reduction strategies for existing diesel engines are both practical and cost-effective. Indeed, the experience gained from the programs in place provides the technical and policy foundation for a more comprehensive national strategy.

This section describes the principles for designing a more comprehensive federal grant and loan program as well as non-financial incentives to cut pollution from today's diesel engines. Such initiatives could have multi-faceted benefits for state and local governments. States could draw on expanded support for diesel pollution abatement programs to lower particulate pollution and ozone, and to cut haze in national parks and wilderness areas. State pollution abatement strategies to address these air quality problems are due in 2007 for ozone and haze, and 2008 for particulate pollution. Enhanced programs to cut pollution from existing diesel engines could also benefit urban and rural communities hard hit by diesel pollution or otherwise seeking federal support for ways to lower the public's exposure to hazardous diesel exhaust.

Design principles for a grant and loan program

Congress should establish a federal grant and loan program that would make funds available to diesel emission reduction projects that deliver public health and environmental benefits in a cost-effective manner. Because of the wide variety of populations affected by diesel emissions and the range of emission reduction strategies available, EPA will need a sufficient degree of flexibility to assess and rank competing projects. By adopting the following design principles, Congress would maximize the benefits of a federal grant and loan program while giving the Agency an appropriate degree of guidance and discretion on the selection of individual projects:

1. A diesel pollution reduction program should maximize health and environmental benefits

The primary consideration in ranking proposed diesel emission reduction projects should be the health and environmental benefits produced by the project. Projects expected to produce the greatest health and environmental benefits include those that: serve areas that fail to meet the health-based national ambient air quality standards, serve areas with high population densities, target susceptible subpopulations including children and the elderly, reduce more than one pollutant and/or air toxic, and assist areas that receive a disproportionate amount of air pollution from diesel equipment.

While assisting communities in achieving the national heath-based air quality standards is an important goal of any national diesel retrofit program, a program should not overlook the health and environmental benefits of projects in areas meeting the national standards. For example, truck stops—where rows of tractor-trailers run their diesel engines constantly to provide heat and electricity for the cab—create local hot spots of poor air quality where truck stop employees, truckers, other travelers, and surrounding neighbors endure high exposure levels. Idle reduction programs can provide important public health benefits to those exposed even if the truck stop is located in an area meeting the health standards.

The contaminants in diesel exhaust also degrade the environment and contribute to haze in national parks. Diesel pollution reduction projects to help protect forests, aquatic ecosystems or scenic vistas can be important in their own right while also lowering harmful human exposure to particulate pollution.

2. A diesel emission reduction program should promote cost-effective solutions

A competitive grants process would minimize costs by creating competition between diesel retrofit solutions. Such competition promotes efficiency across the program design chain including the emission control manufacturers, equipment suppliers, and fleets. As a general guiding principle, those applications that provide greater public health or environmental benefits per dollar should be selected over those with higher unit costs.

The implementing agency will need some flexibility to evaluate cost-effectiveness. Some measures that appear cost-effective in the short run may be less so over time. Even within fleets, some portions of the fleet have more potential for cleanup than others—which also impacts cost-effectiveness. The agency administering the program should also be given flexibility to award some funds to innovative approaches that are not as far along in research, development and deployment but that are nevertheless promising in achieving cost-effective pollution reductions.

3. A program should include all industry sectors and serve many populations

A diesel emission reduction program should not be limited to certain sectors. Instead, a program should promote technology in all sectors including construction, locomotive, school and transit buses, short-haul freight and garbage trucks, marine and ports, and agriculture. Each of these industry sectors is also comprised of a sub-population of Americans including farmers, dockworkers, railway workers, children, laborers, tourists on ferry boats, construction workers, and many others. A national program should attempt to serve all of these populations by supporting pilot projects that will spur development and broader deployment of emission reduction applications suited to each sector.

4. A program should advance a broad range of diesel emission reduction technologies

The goal of a diesel emission reduction program is, of course, to provide public health and environment benefits by reducing diesel pollution. But the technology to provide diesel emission reductions can take many forms. The list of possible applications is expansive and includes: switching to ultra-low sulfur diesel fuel; repowering with more efficient and cleaner engines; installing after-market emission control technology; and idle reduction programs including use of auxiliary power units, and truck stop or port electrification.

A competitive grants program open to all possible technologies will release the power of the market to spur innovation. American entrepreneurs, whether working on after-market emissions control equipment, auxiliary power units, or any other diesel emission reduction solution should be eligible for appropriate incentives. Pre-selecting a subset of technology applications for support would inhibit innovation.

5. Incentives should be tailored to the sector and specific applications

Incentives should be tailored to the economic characteristics of the industry sector and the specific application. The scope of possible diesel emission reduction measures and variety of applications necessitates aligning the economic incentive provided from a grant and loan program with the economic and business characteristics of individual applications. For instance, there may be limited opportunity to recover the capital investment made to retrofit construction equipment. Therefore, a grant for the full capital cost of the equipment may be required to induce retrofit investment. But for truck stop electrification, the story may be quite different. In this case, fuel savings that accrue to truck owners by turning off their engines and utilizing the electric power source at the terminal can be used to pay for the electrification equipment. Rather than a full grant, truck stop electrification proposals may only need a low cost loan program to overcome the “first cost” barrier.

6. A federal grant program should encourage state and local efforts

To provide the greatest amount of public health and environmental benefits, a federal grant program should leverage state and local resources. An example is a provision for matching funds where state and local governments devote some of their own resources to access a larger amount of federal dollars. Such a provision would increase the total supply of funds—and concomitant benefits—and would help demonstrate a community's commitment to the success of the program.

Another form of leverage is nonfinancial. States and local governments could establish specifications requiring retrofit equipment as part of the contract competition for public works projects. States could also establish teams of diesel emission reduction experts that could assist communities with developing diesel emission reduction project proposals, preparing grants applications, designing monitoring and verification programs and other activities. States could also develop their own leadership program by committing to retrofit a portion of the state vehicle fleet. A federal grant program could give additional weight to applications from states that undertake one or more of these practices.

7. A federal program should capitalize on and support community action

EPA has recently established a community-based air toxics program known as Community Action for a Renewed Environment. The program utilizes a multi-stakeholder local collaborative approach to identify community air toxics risks and carry out specific measures to reduce those risks. The proposed measures for the pilot initiative in Cleveland, Ohio included diesel retrofit and idle reduction projects. Community involvement can help ensure diesel emission reduction projects are rigorously implemented and evaluated. Further, communities developing a comprehensive strategy to lower air toxics exposure demonstrate a strong commitment to air quality improvements. To reward this level of community effort and leverage the benefits of federal support, diesel pollution abatement projects that are proposed as part of a broader community-based air toxics initiative should receive some higher funding priority.

8. A program should make information accessible

Expanding the scope of diesel emission reduction efforts requires stakeholder confidence. Equipment owners and operators need to know how diesel pollution control technologies perform in real world conditions. State and local officials relying on diesel emission reduction strategies as part of air quality planning need to know that reduction strategies actually deliver the promised benefits. The public requires similar assurance if taxpayer funds help pay for the projects. To bolster confidence, EPA and the California Air Resources Board must establish a system for prompt, accurate and reliable verification of diesel emission reduction technologies. Further, projects funded under a federal grant and loan program should be subject to appropriate monitoring and verification protocols. EPA should then publicize information on the performance of projects including their cost-effectiveness. By reporting on successful and unsuccessful projects, participants can replicate the successes and avoid potential failures.

Placing a national diesel emission reduction grant and loan program in context

These design principles apply to a voluntary grant and loan program. Such a program can spur the deployment of retrofits and other diesel emission reduction solutions. Retrofit projects funded by the program can serve as platforms for testing and verification of additional equipment configurations—which is necessary for wider deployment. These same projects provide valuable experience for equipment owners and operators, mechanics and maintenance personnel, and engine and emissions control manufacturers. Similarly, local, state and federal air quality managers can better understand the role of diesel emission reductions technologies as part of an overall effort to improve air quality. A federal program that encourages cooperation and the transfer of information between EPA, states, and local stakeholders can accelerate the development of clean air solutions.

While a federal grant and loan program can "seed" solutions that have broader benefits, it is unlikely there will be enough resources in any single retrofit program to address the millions of existing diesel engines. Other policies and programs including non-financial incentives will be required to complement a national voluntary grant and loan program.

STATE AND FEDERAL AGENCY LEADERSHIP

Public agencies should be leaders in incorporating public values into operating decisions and should be the first to avail themselves of diesel emission reduction solutions. The federal government has a series of laws, executive orders, and presidential directives governing its own energy and water management. State governors have issued executive orders specifying goals for renewable energy purchases by state agencies. The President and Congress, along with their state counterparts, could establish similar programs to reduce diesel pollution from existing federal and state fleets.

SPECIFICATIONS IN PUBLIC WORKS CONTRACTS

Another way of promoting the use of cleaner diesel fleets is for local, state and federal governments to include diesel emission reduction practices as a requirement in contracts for public works projects such as highway construction and the building of public facilities. Contracts can include specifications for the use of ultra-low sulfur diesel fuel, installation of emission controls on equipment, and idle reduction practices. Once construction fleets upgrade their equipment and practices for government contracts, the public would continue to receive benefits if the equipment is used in private contracts. This approach has been adopted in several state and local projects already.[1] Establishing such requirements for all federal highway projects would be a dramatic incentive to further deployment of emission reduction strategies.

STATE IMPLEMENTATION PLANS

A strong non-financial incentive for diesel emission reduction programs is their potential eligibility to qualify as emission reduction measures in state and tribal air quality management plans required to restore healthy air or cut haze in national parks. EPA already has prepared guidance for local governments relying on truck idling and switchyard locomotive idling emission reductions in air quality management strategies. EPA should finalize rigorous guidance to assist state, tribal and local air quality managers in determining the amount of emission reductions that can be obtained from various diesel pollution control programs.

LOCAL COLLABORATIVE EFFORTS

Much of the current progress reducing pollution from existing diesel engines has originated from local initiatives such as those in Puget Sound and Sacramento. As noted, Cleveland is pursuing diesel emission reductions as part of a community-based, multi-stakeholder collaborative process to lower air toxics. Recently, regional diesel collaboratives, such as the Midwest Diesel Initiative and the West Coast Diesel Emissions Reduction Collaborative, have brought together affected citizens, industry and public officials to examine diesel emission reduction measures.

A ROLE FOR REGULATION

While this discussion has focused on voluntary programs, in some cases local, state, or federal agencies may determine that some form of regulation is the appropriate solution. For instance, the California Air Resources Board has established a requirement that locomotive and marine engines operating predominately within the state use ultra-low sulfur diesel fuel in 2007, several years before federal law would require. State and local officials must preserve their authority to tailor diesel emission reduction policies to local conditions.

CHAPTER 2

The dangers of diesel pollution

Diesel exhaust is the mix of gas, liquid and solid components that is produced when an engine burns diesel fuel. Its composition depends 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. The small size of the particles in diesel exhaust and the large number of toxic chemicals it contains make diesel exhaust a particularly potent threat to the human body. In addition, oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) in diesel exhaust combine in the presence of sunlight to form ground-level ozone, which poses further serious danger to human health and to the environment.

More than 40 constituents of diesel exhaust are listed by either EPA or the California Air Resources Board (CARB) as hazardous air pollutants or toxic air contaminants. At least 21 of these substances are listed by the State of California as known carcinogens or reproductive toxicants. Numerous governmental agencies and scientific bodies including EPA, the World Health Organization, CARB, and the Health Effects Institute have concluded that diesel exhaust is a probable human carcinogen.

According to the Multiple Air Toxics Exposure Study (MATES-II) conducted by California's South Coast Air Quality Management District, about 70 percent of the total inhalation cancer risk from air pollution for the average Los Angeles resident is due to diesel exhaust.[1] 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* ...."[2] A separate assessment suggested that the result for the United States as a whole is even worse: 80 percent of the total cancer risk from hazardous air pollutants nationwide is associated with the inhalation of diesel exhaust.[3]

Last year, CARB sponsored a risk assessment of diesel exhaust at the J.R. Davis Yard, a busy hub for railcar switching located in Roseville, near Sacramento. It is the busiest rail yard west of the Rocky Mountains, and rail cars are switched there around the clock. Once a rural area, Roseville has boomed in population, and families in new homes live close to this large source of diesel pollution.

The Roseville study concluded that dangerous concentrations of ultra-fine particulates from the rail yard extend out over a now-crowded landscape and affect residents for miles around.[4] Specifically, diesel exhaust from the rail yard contributes an estimated additional cancer risk at a rate between 100 and 500 cases per million people over an area in which between 14,000 and 26,000 people live, and at a rate between 10 and 100 cases per million people over a larger area in which 140,000 to 155,000 people now live. Cancer risks posed to workers in the immediate area of the switching yard were even higher. The study concluded that the cancer risk associated with diesel emissions at the rail yard were substantially higher than the risk posed by diesel emissions on the adjacent interstate highway, I-80, which is itself a major east-west trucking route, and an additional

DAVE HENRY

The J.R. Davis Yard in Roseville, California.

source of dangerous diesel emissions that threatens this growing community.

Diesel exhaust's small particles are a big problem

The small size of the particles in diesel exhaust makes it an efficient means of delivering chemicals into our bodies. Diesel exhaust is easily inhaled deep into the lungs, where its clearance is slow compared to larger particles that are primarily deposited in larger airways.[5] Up to 85% of fine particles remain in the lungs 24 hours after initial exposure.[6] This means that diesel exhaust has easy, long lasting access to the most sensitive parts of the lungs.

Exposure to diesel exhaust has been associated with a wide range of health effects including cancer, neurological effects, a weakened immune system, respiratory disease and cardiovascular disease. A recent evaluation of lung cancer mortality in approximately 55,000 railroad workers between 1959 and 1996 revealed that those regularly exposed to diesel exhaust had a higher risk of dying from lung cancer than workers with limited exposure. The risk of lung cancer mortality for workers who operated diesel-powered trains was 40% greater than that for workers like ticket agents and clerks who were less exposed.[7]

Even short-term exposure to diesel exhaust can have immediate effects like dizziness, headaches, light-headedness, and nausea.[8] People who inhale diesel exhaust can experience nasal irritation, breathing difficulties, cough and chest tightness.[9] Animal studies suggest that exposure to diesel exhaust particulates decreases the body's ability to fight bacterial infections.[10] In both animals and humans, short-term exposure to diesel exhaust causes inflammation in the bloodstream and thickening of the blood, symptoms which are associated with cardiovascular disease and heart attacks and offer a potential explanation for the increase in cardiovascular morbidity from air pollution.[11]

Long term exposure to diesel exhaust has been associated with other respiratory effects including chronic inflammation of lung tissue.[12] Several studies have also linked diesel exhaust particles to asthma, suggesting that these particles can increase the severity of respiratory symptoms in individuals with pre-existing conditions like asthma.[13]

Health effects of fine particulate pollution

Because it is so laden with fine particles, diesel exhaust is implicated in all of the

NO_x pollution from diesel engines

While this report addresses mostly particulate matter, diesel exhaust also contains both oxides of nitrogen (NO_x) and volatile organic compounds (VOCs), which combine in the atmosphere to form ground-level ozone, the primary component of smog. Ozone smog can have serious effects on respiratory health including shortness of breath, chest pains and coughing that can lead to asthma attacks, hospital admissions and emergency room visits, decreased lung function, possible long-term lung damage, and premature death.[17] These consequences are more severe if ozone exposure occurs during physical activity, for example working or exercising outdoors. NO_x also contributes to several other types of pollution including nitrate particulate pollution, regional haze in national parks, nitrogen pollution in our coastal waterbodies and forests, and acid rain in forests, soils and aquatic ecosystems.

Diesel exhaust is a special concern for areas that do not meet the federal air quality standards for ozone due to its major contribution to ozone-forming NO_x. In 2004, EPA found that 474 counties, home to 159 million Americans, do not comply with the federal health-based eight-hour ozone standard.[18] Overall, diesel engines, including highway vehicles (onroad), nonroad engines, marine vessels and locomotives released almost 6.9 million short tons of NO_x in 2002, or 32% of NO_x from all anthropogenic sources. In places like the San Joaquin Valley and Houston, the NO_x levels from diesel engines can be even higher.

Similar to particulate pollution, EPA's revolutionary new emission standards for onroad and nonroad diesel engines will achieve dramatic reductions from current NO_x emission levels by 2030, but most of these reductions will not be achieved for more than a decade.

There are several technologies currently available or in development to accelerate the pace of NO_x reductions from diesel engines, including:

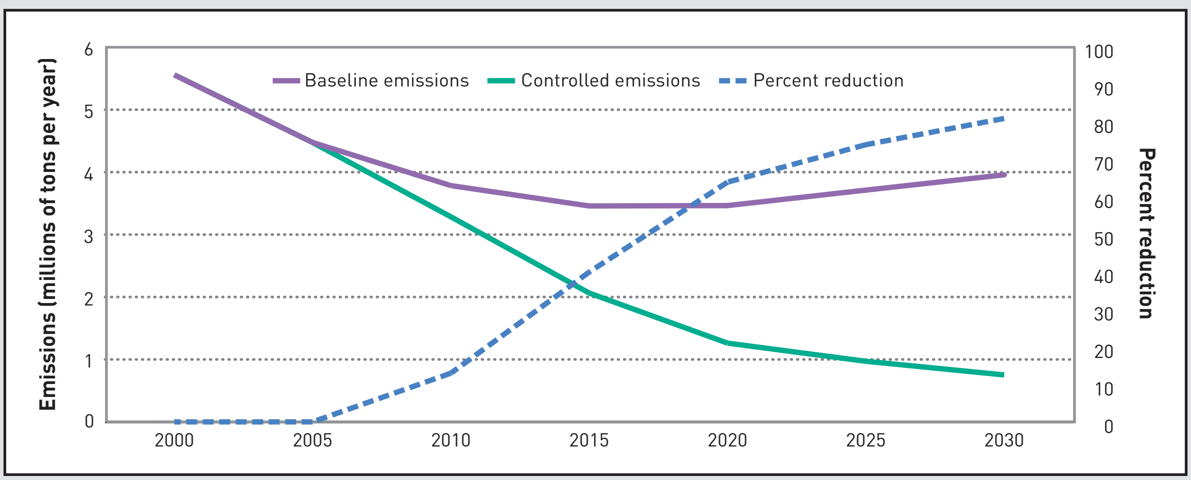
- Selective Catalytic Reduction (SCR), which can achieve a 75–90% reduction in NO_x[19],
- Lean NO_x catalysts, which can achieve a 10–40% reduction in NO_x[20],
- Exhaust gas recirculation, which can achieve a 40% or more reduction in NO_x[21], and
- Fuel emulsifiers, which can achieve a 16–20% reduction in NO_x.

Like any retrofit option, these technologies are not proper for all engines in all locations. Fleet operators and equipment manufacturers will know which technology is appropriate. CARB has determined that NOx removal is cost-effective at a cost of up to $13,600 per ton of NOx reduced.[22] The Texas Emissions Reduction Program follows a similar standard of $13,000 per ton of NO_x reduced.[23]

Communities working to restore and maintain healthy ozone concentrations or otherwise impacted by NOx pollution will need a variety of tools to cut NO_x pollution from today's diesel engines.

FIGURE 5

Current NO_x emissions from diesel engines and reductions under new EPA rules



Reductions show the effect of the 2001 onroad diesel rule and the 2004 nonroad diesel rule. Percent reductions are relative to emissions from all major onroad and nonroad diesel engines categories in the year 2000 except locomotives and commercial shipping.

Source: Estimated from EPA, 2000 and EPA, 2004a

Children, the elderly and the chronically ill bear special risks from diesel exhaust

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.[24] Evidence continues to mount that children, especially those with asthma, are exceptionally sensitive to the effects of fine particle pollution.[25]

CORBIS

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.[26]

dangers that led EPA in 1997 to adopt more protective health-based national ambient air quality standards for fine particles. Last year, EPA released a comprehensive review of recent scientific evidence on the harmful effects of particulate pollution in a report titled Air Quality Criteria for Particulate Matter, commonly known as the PM Criteria Document.[14] The PM Criteria Document detailed a wealth of studies that built upon previously established health impacts of particulate pollution including increased hospital and emergency room visits for respiratory and cardiovascular illness and increased mortality. Respiratory effects from exposure to fine particles include asthma attacks and decreased lung function.[15] The effects on cardiovascular health are just as severe; numerous studies have linked elevated particulate pollution with incidence of irregular heartbeat and increased heart attack risk.[16]

The weight of evidence on the significant morbidity and mortality associated with fine particles is so strong that EPA and the Clean Air Science Advisory Committee have recommended significantly tightening the national air quality standards for fine particles to reduce the immense burden that fine particle pollution places on public health.

CHAPTER 3

The pollution reduction gap

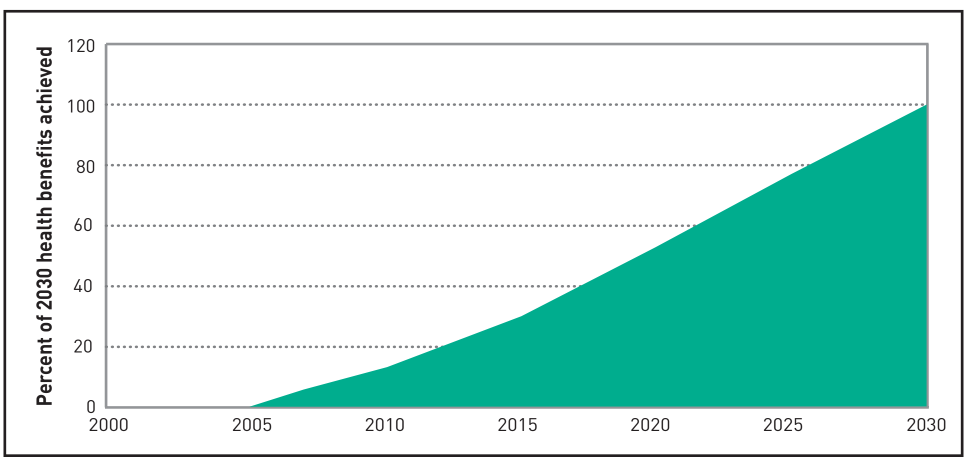
EPA has estimated that by 2030, the diesel rule for onroad trucks and buses will prevent 8,300 premature deaths each year which otherwise would have been caused by exposure to particulate pollution from diesel emissions.[1] EPA projects that the onroad diesel rule will also annually prevent more than 7,000 hospital admissions, 360,000 asthma attacks and more than 1.5 million lost workdays in 2030.[2] The nonroad rule similarly promises tremendous health benefits in 2030, including avoidance of 12,000 premature deaths and 8,900 hospital admissions each year from particulate pollution exposure.[3] The nonroad rule is projected to annually prevent 200,000 cases of exacerbated asthma in children in 2030.[4] Notably, EPA's estimates of the benefits of reduced diesel emissions do not even consider any reduced cancer risk associated with the new rules.

The same health effects that will be avoided in 2030 when implementation of these federal rules matures are occurring today and will continue to occur until high-polluting diesel equipment now in use is replaced or cleaned up. Figure 6 shows the pace at which EPA projects the health benefits from its nonroad diesel rule will be achieved, beginning in 2007, when the first phase of the low-sulfur diesel fuel requirements take effect for nonroad engines. Only about 30% of the ultimate level of annual benefits will be realized by 2015, and just over 50% will be realized by 2020. These numbers suggest that thousands of premature deaths could be prevented each year by speeding the cleanup of nonroad diesel engines in the current fleet.

The slow progress toward the health benefits promised by the new federal diesel rules is mirrored by the rate of diesel emission reductions. Most of the reductions in particulate pollution ($PM_{2.5}$) emissions resulting from the rules will not be achieved for more than a decade. Figure 7 shows projected trends in $PM_{2.5}$ emissions from onroad and nonroad diesel engines. By 2030, the national inventories of $PM_{2.5}$ emissions from diesel engines are projected to be about 80% lower than emission levels in 2000. However, more

FIGURE 6

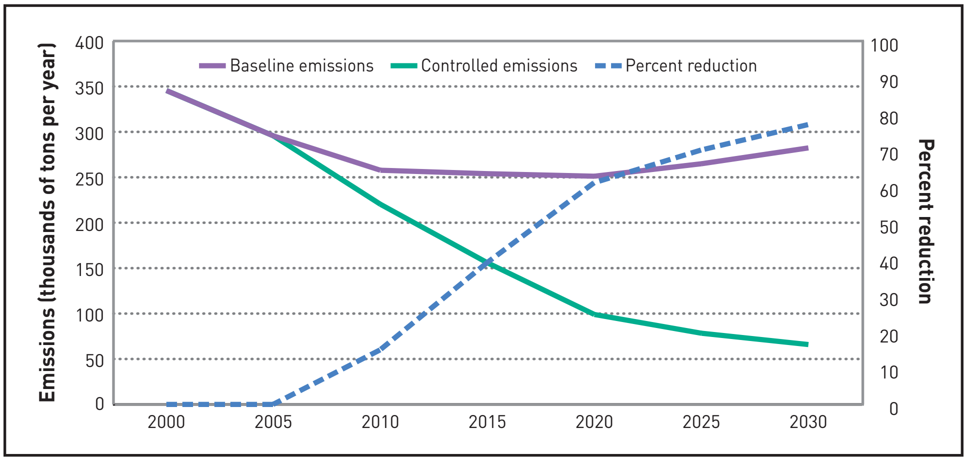
Pace of achieving health benefits from EPA's non-road diesel rule



EPA's report shows monetized benefits, including improved visibility and human health. Health benefits account for 98% of the total.) Source: Adapted from EPA, 2004a, Table 9-16.

FIGURE 7

Current $PM_{2.5}$ emissions from diesel engines and reductions under new EPA rules



Reductions show the effect of EPA's 2001 onroad diesel rule and 2004 nonroad diesel rule. Percent reductions are relative to emissions from onroad and nonroad diesel engines in the year 2000.

Source: Estimated from EPA, 2000 and EPA, 2004a.)

TABLE 2

Median lifetimes for diesel engines used in various types of construction and agricultural equipment

Equipment type	Engine size (hp)	Activity (hrs/yr)	Median engine life (yr)
Row Crop Tractor	300	475	17
Row Crop Tractor	500	475	25
Crawler/Dozer	90	900	9
Backhoe	100	1135	20
Hydraulic excavator	430	1100	11
Grader	220	960	8.2

Estimated using EPA's default emissions modeling assumptions (EPA, 2004b)

than half of the reductions in annual emissions levels will be postponed until after 2015.

Two factors drive the delay in reducing diesel pollution. The first factor is the lapse in time before the emissions standards take effect for new engines. The standards finalized in 2001 for onroad engines will be phased in from 2007–2010, while the phase-in of new standards for nonroad diesel engines is based on engine size, and begins in 2008 with engines smaller than 75 horsepower (hp). Final standards for nonroad engines greater than 750 hp will not be effective until 2015. The second factor is the long lifespan of diesel engines, especially those used in heavy agricultural and construction equipment. As shown in Table 2, under typical operating loads and levels of use, EPA estimates that heavy equipment engines can last for two decades or more, depending on how they are used.

These two factors combine to extend the current high diesel pollution levels for years into the future. At the same time, the long life of diesel engines means that applying available pollution control technologies and practices to existing engines can have immediate and lasting human health benefits.

CHAPTER 4

Cleaning up existing engines is a cost-effective way to protect Americans from the health risks of diesel exhaust

The health effects of diesel exhaust described earlier are not abstract. They are a regular part of life for millions of people who are exposed to diesel exhaust. Diesel exhaust is a special concern for areas that do not meet the federal air quality standards for ozone and particulate matter. In 2004, EPA found 474 counties, home to 159 million Americans, do not comply with the health-based eight-hour ozone standard.[1] EPA also has found that 208 counties do not comply with the health-based fine particulate pollution standard.[2] Air quality managers need to take aggressive action to meet the ozone and particulate air quality standards, protect their population's health, and meet the compliance deadlines they face over the coming years. Immediate retrofit programs can help communities bridge the gap between the statutory deadlines they face to reduce particulate pollution and ozone in the short term and the phase-in of new diesel engine emission reductions over the period from 2007 through 2030. Until existing, high-polluting diesel engines have been replaced with new technology, retrofits are an important means to reduce diesel pollution and achieve the emission reductions these areas need to protect public health and comply with their Clean Air Act obligations.

Reducing pollution from existing diesel engines can also lower harmful exposure to diesel exhaust in areas that meet the federal air quality standards. For existing diesel equipment, the combination of retrofit control technology with ultra-low sulfur fuel can reduce emissions of hazardous diesel particulate matter (PM), dramatically improving both environmental conditions and public health. Catalyzed diesel particulate filters (DPFs) are the most effective retrofits that are widely available now.

COURTESY OF DONNA WEAVER, CONNECTICUT DEPARTMENT OF TRANSPORTATION

Construction equipment retrofit with a diesel oxidation catalyst.

COURTESY OF JOHNSON MATTHEY

Construction equipment retrofit with a diesel particulate filter.

Diesel particulate filters can reduce PM emissions by 80-95%, with simultaneous reductions in hydrocarbon and carbon monoxide emissions.[3] Current equipment costs for DPF retrofits for school buses and construction equipment range from $4500 to $10,000.[4] Even at the upper end of this range, these costs are only a fraction of the typical new equipment price for construction equipment in the 175–300 horsepower size range.[5] Moreover, costs are expected to come down significantly due to economies of scale and as experience with DPF retrofits increases. DPFs must be used in conjunction with ultra-low sulfur diesel fuel and are not appropriate for all applications.

Diesel oxidation catalysts are a well established and cheaper but less effective alternative to DPFs for retrofit applications. They can reduce diesel PM emissions by 20–50%, although there is some concern that DOCs may not reduce ultra-fine particles. DOCs also cut hydrocarbon and carbon monoxide emissions by about 60–90%.[6] Current costs for DOC retrofits to school bus engines and construction equipment range from $700 to $2,500.[7] These retrofit costs are only about 1% of the new equipment price for medium-sized construction equipment.[8] DOCs do not require ultra-low sulfur diesel fuel for operation and can be used in many different applications.

To assess the health benefits and costs of a comprehensive diesel emission reduction program for existing engines, as well as to evaluate potential funding levels, Environmental Defense examined two scenarios in which different emission control measures were applied to diesel construction equipment, school buses and transit buses in the core counties making up the 50 largest metropolitan areas in the U.S. These 88 counties, along with the District of Columbia, contain 94.6 million people, or one-third of the U.S. population.

We examined construction equipment because these engines have high pollution levels and typically operate for long hours. We included diesel school buses

TABLE 3
50 most populated metropolitan areas in the U.S., examined in diesel pollution reduction program scenarios

1. New York City	26. Milwaukee
2. Los Angeles	27. Orlando
3. Chicago	28. Indianapolis
4. Washington-Baltimore	29. San Antonio
5. San Francisco-Oakland	30. Norfolk-Virginia Beach-Newport News
6. Philadelphia	31. Las Vegas
7. Boston	32. Columbus, OH
8. Detroit	33. Charlotte, NC
9. Dallas-Fort Worth	34. New Orleans
10. Houston	35. Salt Lake City
11. Atlanta	36. Greensboro, NC
12. Miami, FL	37. Austin
13. Seattle-Tacoma	38. Nashville
14. Phoenix	39. Providence-Fall River
15. Minneapolis-St. Paul	40. Raleigh-Durham-Chapel Hill
16. Cleveland	41. Hartford
17. San Diego	42. Buffalo, NY
18. St. Louis	43. Memphis
19. Denver	44. Jacksonville, FL
20. Tampa-St. Petersburg	45. Rochester, NY
21. Pittsburgh	46. Grand Rapids, MI
22. Portland, OR	47. Oklahoma City
23. Cincinnati	48. Louisville, KY
24. Sacramento	49. Richmond, VA
25. Kansas City	50. Greenville-Spartanburg, SC

Source: U.S. Census Bureau, 2000

and transit buses because they expose sensitive populations to diesel pollution.

Our two scenarios assumed installation of DPFs and DOCs within the studied counties. Because these two technologies vary significantly in applicability and pollutant removal efficiencies, these two scenarios illustrate the range of costs to achieve steep reductions from a limited set of engines and more modest reductions over many more engines. The scenarios are illustrative. The appropriate mix of pollution reduction strategies will vary widely across communities.

Using EPA's valuation methodologies, we found that investments in a national diesel pollution control program will yield healthy returns. Figure 8 shows the lump sum costs of applying the two technology scenarios to school buses, transit buses and construction equipment in the 50 most populated cities ranged from $600 million to $1.6 billion. The net present value of the resulting health benefits far exceeded these costs, and ranged from $10.6 billion to $19.2 billion.

Our analysis reaches results consistent with the analyses EPA performed for its onroad and nonroad diesel rules, which showed that the societal benefits of each of these rules would vastly outweigh their costs. In the case of the onroad diesel rule for trucks and buses, EPA estimated that, in 2030, the value of the health and welfare improvements it

FIGURE 8

Investments in a national diesel control program yield healthy returns

An investment in diesel engine retrofits ranging from $600 million to $1.6 billion yields a multi-year stream of health benefits with a net present value ranging from $10.6 to $19.2 billion.

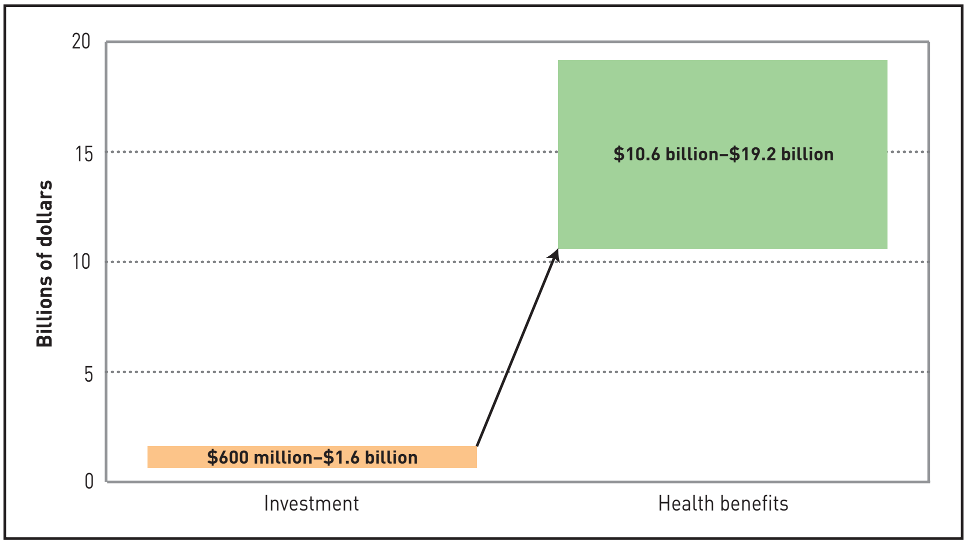
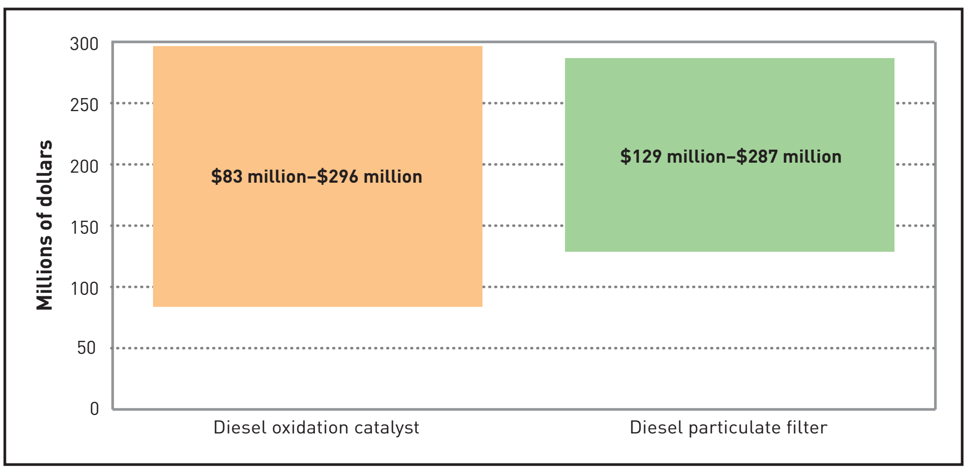


FIGURE 9

Diesel pollution reduction scenarios: range of annual costs when investments spread over seven years



could quantify would outweigh the costs of the rule by more than 15:1.[9] The agency similarly estimated that, in 2030, the benefits of the nonroad diesel equipment rule would outweigh its costs by a ratio of 40:1.[10]

The analysis of diesel retrofit scenarios provides a benchmark for the level of funding necessary to make a real impact in reducing dangerous emissions from the existing diesel fleet. Over the course of seven years, the emission controls examined in our study would range in cost from approximately $83 million annually to $296 million annually (see Figure 9).

Environmental Defense recommends federal funding for a national program of $292 million or more annually for seven years. Funding at the higher part of the

A delivery of ultra low sulfur diesel fuel to New York's World Trade Center site. In late 2006, ULSD will be widely available across the United States

cost range would allow a national program to address types of diesel engines and control technologies excluded from our analysis such as locomotive and marine engines and idle reduction strategies. Importantly, it would also provide resources to better accommodate controls for additional pollutants, to support communities, large and small, across America that are committed to well-run cleaner diesel programs, and to address the administrative costs inherent in a program of this scope.

The health benefits associated with reduced particulate pollution were estimated based on EPA's benefits analysis for the 2004 nonroad diesel rule. The benefits quantified include reduced risk of premature death, non-fatal heart attacks, chronic and acute bronchitis, exacerbated asthma, upper and lower respiratory symptoms, work loss days, and minor restricted activity days. An important limitation of our reliance on EPA's benefits estimates for the nonroad rule is that the benefits of reduced cancer risk from reduced exposure to diesel exhaust are not considered. Furthermore, only the benefits of direct particulate matter reductions were considered in our analysis; the analysis did not account for the co-benefits of hydrocarbon and carbon monoxide reductions from use of DPFs and DOCs or of sulfur oxides reductions from using ultra-low sulfur diesel.

To estimate benefits from retrofit applications, the particulate pollution benefits from the nonroad rule were scaled down by the ratio of particulate emissions reductions from retrofits to the particulate emissions reductions in the nonroad rule. The benefits were also scaled down by the ratio of the current population to the projected 2030 population that was used in the nonroad rule analysis. Other than the population adjustment, our benefits analysis assumes that exposure patterns associated with retrofits will be the same as those associated with new nonroad engine control requirements.

This assumption may lead to underestimation of the health benefits from retrofit programs that target urban areas with relatively high exposure to particulate pollution. The analysis does not account for enhanced benefits to individuals like construction workers who are highly exposed to diesel exhaust at construction sites and school children who are highly exposed while riding on school buses. A recent study conducted in the Los Angeles area found that children riding on diesel-fueled school buses inhale roughly a million times more school bus exhaust (by mass) than non-riders in the general population.[11] Consequently, cleaning up diesel exhaust from school buses is a particularly cost-effective means of reducing such children's exposure.[12] The assumptions and methodologies relied in our retrofit scenario analysis are described in more detail in Appendix B.

CHAPTER 5

Diesel cleanup programs that are working now

A variety of programs at the federal, state and local levels have already begun to close the gap between today's high diesel pollution levels and the reduced diesel emissions of the future. This section describes a sampling of programs across the country that are reducing diesel emissions through solutions that include retrofit and repower projects, accelerated low sulfur fuel use, idle reduction technologies and changes in the way diesel engines are operated.[1] For additional examples of pollution control technologies, please see Environmental Defense's Cleaner Diesel Handbook.[2]

Start spreadin' the news: New York is providing cleaner air today

Retrofit programs will be a critical component to any New York State cleanup plan because 30 counties in New York State currently fail to meet the federal health-based air quality standard for ozone ("smog") including the entire New York metropolitan area, Albany and Rochester.[3] Nearly 90% of New York residents live in one of these counties. Similarly, EPA recently found that the following 10 counties in New York State are out of compliance with the federal health-based standard for particulate pollution: Bronx, Kings, Nassau, New York, Orange, Queens, Richmond, Rockland, Suffolk and Westchester.[4] Diesel pollution is one of New York's most pressing environmental health problems, especially because diesel equipment is being used in areas with very high concentrations of people.

Lower Manhattan is a thriving mix of apartments, art galleries, shops and restaurants, where more than 4,000 children live in neighborhoods as diverse as Tribeca, Chinatown and

Reconstruction at the World Trade Center site in New York City.

Battery Park City. During the reconstruction of the World Trade Center site, lower Manhattan will also be one of the nation's largest construction sites, teeming with diesel engines operating just steps from schools, playgrounds, parks, homes and offices.

The close proximity between this massive construction project and a dense population called out for air quality protections. New York's leaders have responded to that call and are requiring best available retrofits and ultra-low sulfur diesel fuel in state-controlled lower Manhattan construction projects, including the World Trade Center site.[5] Contractors and subcontractors using diesel-powered nonroad vehicles with an engine horsepower rating of 60 hp and above are now required to use ultra-low sulfur diesel fuel and to retrofit, where practicable, their equipment with oxidation catalysts, particulate filters, or technology with "comparable or better effectiveness."[6] At World Trade Center 7, retrofits and other pollution control measures are already in place. Several pieces of construction equipment have been retrofitted, and one electric crane is being used in lieu of a typical diesel engine crane because it does not create any on-site emissions.

New York City also recently extended cleaner diesel requirements to city-funded construction projects. New York City Local Law 77 adds specifications to city contracts requiring the use of ultra-low sulfur diesel fuel and best available emissions-control technologies in all city construction. Local Law 77 also calls for PM and NO_x pollution control technologies, requiring agencies to use technologies that "shall be primarily based on the reduction in emissions of particulate matter and secondarily based upon the reduction in emissions of nitrogen oxides."[7]

Delivering diesel emission reductions where they are needed most

HUNTS POINT ELECTRIFICATION PROJECT, NEW YORK CITY

At the southern tip of the Bronx, just above Manhattan, the extremely poor and mostly minority Hunts Point community has one of the highest asthma rates in the nation. Approximately one out of every three children has asthma in Hunts Point.[8] Given the connection between diesel exhaust and respiratory disease, it is not surprising that Hunts Point is also a hotspot of diesel pollution.

The Hunts Point Cooperative Market includes one of the largest meat markets in the world, as well as the Hunts Point Produce Market, through which 80% of fresh produce in the New York area moves. The market draws hundreds of diesel trucks each day, which are a major source of the 20,000 diesel truck trips through the neighborhood each week. On average, a long-haul truck operator can have an 8–12 hour layover at the Hunts Point market while waiting to load or unload, or to comply with the federal rest period requirements. When trucks idle through this layover, the resulting diesel emissions place a serious burden on the people who live and work in Hunts Point.

Hunts Point, then, was an ideal place for the nation's first operational advanced truck stop electrification project. Sustainable South Bronx, the New York Power Authority and IdleAire Technologies Corporation received a grant from Clean Air Communities to construct a system that can accommodate 28 trucks. At full operation, the project is expected to eliminate 2,000 tons of pollution each year.[9] The Hunts Point project is delivering diesel emission reductions in a community where they are urgently needed.

Cleaner school buses for precious passengers

The pollution that comes from the diesel engines that power school buses can cause respiratory disease and exacerbate long-term conditions like asthma. There are about 450,000 public school buses in the United States and about 390,000 of those run on diesel fuel. About two-thirds of the diesel school buses on the road today were manufactured between 1990 and 2002. These buses can be made much cleaner by upgrading or retrofitting their existing emission control systems. About one-third of all diesel school buses are pre-1990 buses.[10] Because these buses are so dirty and often cannot use diesel pollution controls, the best solution for them is replacement.

Children's exposure to diesel pollution on school buses is of particular concern for several reasons:

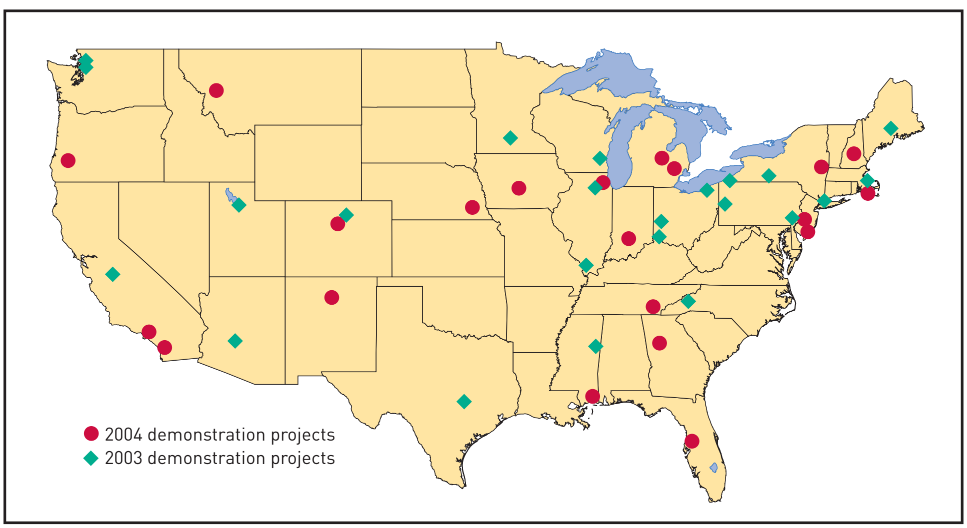
1. Across the country millions of children ride the school bus every day;

2. Air pollution affects children more than adults because children inhale more pollutants per pound of body weight, have a more rapid rate of respiration and narrower airways, are less able to metabolize and rid their bodies of certain toxins, and are exposed during developmental stages when the impacts can be lasting; and

3. Some studies indicate that children in school buses are exposed to airborne particulate pollution concentrations 5–15 times higher than background levels.[11]

The EPA created the Clean School Bus USA program to help lower children's exposure to diesel exhaust. In 2003, this program allocated $5 million to 17 demonstration projects involving about 4,000 school buses. EPA expects these projects to remove more than 200,000 pounds of diesel particulate pollution from the air over the next ten years. In 2004, EPA awarded another $5 million for 20 retrofit and replacement projects, and this year, will award $7.5 million in a cost-shared grant program that will assist school districts in upgrading their diesel fleets.[12]

FIGURE 10
EPA's Clean School Bus USA program has supported demonstration projects across the country



Source: http://www.epa.gov/otaq/schoolbus/demo_projects.htm

Clean School Bus USA has reduced children's exposure to diesel exhaust in communities across the country, including:

- **Michigan.** In the greater Lansing area, the Okemos Public Schools will equip 40 to 50 buses with diesel oxidation catalysts and crankcase filtration systems.[13] The Okemos School District serves approximately 4,000 children who attend five elementary schools, two middle schools and one high school.[14]
- **New Mexico.** Working in partnership with the State Department of Education, state officials will replace three older diesel school buses with new compressed natural gas (CNG) buses.[15] The CNG-fueled school buses will achieve substantial emissions reductions relative to the conventional diesel-fueled buses they replaced.[16]
- **Oregon.** Sharon Banks of the Lane Regional Air Pollution Authority successfully created a market for ultra low sulfur diesel (ULSD) fuel in Lane County, Oregon. The objective was to bring ULSD fuel to Lane County at an affordable price ahead of EPA's 2006 mandate. To bring the price of ULSD fuel down to a competitive level, Ms. Banks built broad-based demand. City managers, county administrators, school districts, transit authorities, municipal waste haulers, large private fleets, fuel distributors and public utilities were all involved in the endeavor. The program has been a tremendous success. In the short period from October 1, 2004 to February 1, 2005, the Lane Clean Diesel Project received commitments from its partners to purchase over 2 million gallons of ULSD. Additionally, the Lane Regional Air Pollution Authority has received a grant from EPA's Clean School Bus Program to help make ultra-low sulfur diesel available to 15 fleets across Oregon and to retrofit 42 school buses with particulate matter filters.[17]
- **Tennessee.** Of the approximately 8,000 school buses in Tennessee, 95% are powered by diesel engines.[18] Tennessee's Clean School Bus program is a joint effort between the Tennessee Department of Education and the Department of Environment and Conservation, in partnership with local governments, school systems and local communities.

In-cabin exposure and crankcase emissions

Recent studies have shown that a child riding inside of a diesel school bus may be exposed to considerably more diesel particulate pollution than car commuters. Pollution inside the bus comes from both the tailpipe and from the crankcase. Crankcase emissions, on average, make up between 10–25% of total engine emissions over a prescribed test cycle but become very high (50–80%) on a relative basis when idling.[20]

The Clean Air Task Force recently completed a study that sheds light on technologies that provide cleaner air *inside* the school bus. [21] Emissions control technologies that focus solely on the tailpipe do not clean up all of the pollution inside the bus, although they are effective at lowering pollution for someone who is standing near the bus.[22] Similarly, emissions control technologies that focus solely on the crankcase will not clean up all of the pollution inside the school bus. The study found that a diesel particulate filter-crankcase emission control technology combination used with ultra low sulfur diesel fuel virtually eliminated the pollution inside the bus.

With the support of a grant from EPA's Clean School Bus program, 83 school buses will be equipped with diesel oxidation catalysts through a public/private partnership between the Chattanooga-Hamilton County Air Pollution Control Bureau and First Student Inc., a local private bus contractor.[19]

One straightforward way to lower pollution from school buses is to turn them off when they are not in use. A school bus that is idling pollutes the air, wastes fuel, and imposes unnecessary costs for school districts facing tight budget constraints. A typical school bus burns about half a gallon of fuel per hour of idling.[23] If 100 buses reduced idling time by just 10 minutes each day, they would realize a fuel savings of some 1500 gallons per year. This translates into more than $2250 annual savings in fuel costs.[24] School districts that establish idle-free zones can lower harmful diesel pollution while saving money for other educational priorities.[25]

Denver and San Francisco find alternative routes for cleaner transit

Many transit districts have fleets with high-polluting diesel buses. Local governments are considering a variety of solutions to reduce harmful diesel exhaust in urban areas while meeting transit needs.

For the last five years, Denver's Regional Transportation District has operated 36 "EcoMark" buses on a downtown pedestrian mall, connecting some 50,000 passengers per day to shopping, business, and regional bus and light rail routes along the mile-long mall. These hybrid buses run on a combination electric/compressed natural gas engine. Electric power is provided by batteries that are charged by an alternator and regenerative braking (the buses also have a small compressed natural gas engine that recharges the bank of batteries). Instead of a diesel engine, the buses have a 2.5-liter Ford industrial engine fueled by the compressed natural gas tanks. The Regional

COURTESY OF THE REGIONAL TRANSPORTATION DISTRICT OF DENVER, CO

Hybrid compressed natural gas RTD Shuttle.

Transportation District has found that the hybrid buses produce lower emissions and have lower operating costs than the diesel buses previously used on the route.[26]

Last year, San Francisco voters approved the "Healthy Air Enforcement Act," which requires the city's Municipal Railway to replace all of its pre-1991 diesel buses with cleaner technology by 2007. The Municipal Railway's goal is to eliminate all bus emissions by 2020, when it hopes to operate a fleet powered exclusively by hybrid engines, batteries, and fuel cells. San Francisco has placed its first order for diesel-electric hybrid buses that are already in use in Seattle, Boston and New York.

Reducing the high cost of idle time

Idling occurs when an engine runs but the vehicle is not moving. There are several reasons why engines idle: to keep fuel and engines warm and avoid problems restarting in cold weather, for the comfort of drivers and passengers on a hot summer days and cold winter nights, or simply to be ready to move the vehicle on short notice. But idling wastes fuel and pollutes the air. Further, new technologies provide alternatives to the functions served by idling.

As part of EPA's SmartWay Transport Partnership, EPA estimates that truck and locomotive idling consumes over *1 billion gallons* of diesel fuel annually. The average truck uses 0.8 gallons of fuel an hour while idling.[27] An idling locomotive switching engine consumes 3–4 gallons of fuel per hour in normal weather and in extremely cold weather (below 15°F) it can use up to 8–11 gallons per hour at idle.[28] Marine vessels and non-road vehicles also idle their engines.

EPA estimates that long-duration idling by freight trucks annually emits 11 million tons of carbon dioxide, 180,000 tons of nitrogen oxides, and 5,000 tons of particulate matter. EPA also projects that locomotive switcher long-duration idling emits 12,000 tons of nitrogen oxides and 500 tons of particulate matter annually.[29]

An individual long-haul truck idles about six hours a day, 310 days a year or about 1,860 hours per year.[30] The trucking industry has analyzed the impact of idling on engines; both in terms of maintenance and engine wear costs. Excessive idling creates the need for more oil and filter changes. Similarly, the longer the idling time, the sooner the engine needs to be rebuilt. Engine wear is a function of fuel consumed, and long- duration idling consumes significant fuel. The trucking industry estimates that, due to the need for more oil changes and earlier overhaul costs, long-duration idling costs the average truck owner $1.13 per day.[31]

One solution to the problem of idling is simply to turn the engine off, which saves fuel and money and virtually eliminates pollution. When this is not a viable solution, there are several other options available. Though this discussion focuses on truck idling, many of these solutions can be used on any diesel engine. These solutions include:

- **Auxiliary power generators.** Auxiliary power generators are powered by 1-, 2-, 3- or 4-cylinder diesel engines and produce 110- to 220-volt electricity to run AC-powered devices, from heaters and air conditioners to microwaves.[32]
- **Auxiliary power units (integrated).** Auxiliary power units typically include an internal combustion engine, compressor and alternator and are fully integrated into the truck's own heating, ventilating and air conditioning (HVAC) system to provide climate control, battery charging and engine heating.[33]

- **Electrical Power on and off board.** Truck Stop Electrification allows truckers to "plug in" vehicles to operate necessary systems without idling the engine. Options for truck stop electrification include stand-alone systems that are owned and operated by the truck stop and can provide heating, ventilation, and air conditioning directly to the sleeper compartment as well as combined systems that require both on-board and off-board equipment.[34]

- **Engine idle management technology.** An automatic engine shut down/start up system controls the engine (start and stop) based on a set time period or on ambient temperature, and other parameters (e.g., battery charge).[35]

- **Fuel-fired and other no-idle heat and/or HVAC systems.** These systems include air conditioners that operate on battery power or heaters that use a small fraction of the diesel fuel that is burned by an idling engine.[36]

I-85: North Carolina, South Carolina and Georgia are trucking toward cleaner air

With the support of a $1.5 million grant from the National Association of State Energy Offices, energy and environmental agencies in North Carolina, South Carolina and Georgia have sponsored a project to electrify 150 parking spaces at three truck stops along the busy interstate highway corridor (I-85) that connects Atlanta with Charlotte and Raleigh-Durham.[37] Each electrified truck stop is expected to save 263,000 gallons of fuel annually, and prevent 2,700 tons of carbon dioxide, 35 tons of nitrogen oxides, 15 tons of carbon monoxide, 1.8 tons of hydrocarbons and 1 ton of particulate emissions each year.[38]

All three of these truck stops use the IdleAire system, which provides an external heating, ventilation and air conditioning unit installed above each truck parking space. Heat and air are delivered to the truck cab through a service delivery console and return air

HTTP://WWW.IDLEAIRE.COM/NEWSROOM/PHOTOS

Trucks "plugged in" to the IdleAire system.

supply that is connected through the passenger window of the truck's cab or through a built-in access point available in newer trucks.[39] Drivers can also access the internet and cable television.

Independent truck owners and fleets have signed agreements with IdleAire to pay $1.40 to $1.65[40] per hour to use its standard services. An idling truck wastes about 0.8 gallons of fuel per hour, which translates into about $1.75 wasted every hour (May 2005, the retail cost of highway diesel fuel was about $2.18[41] a gallon). Combined with the trucking industry's estimate that maintenance for long-duration idling costs about $1.13 per day, truck idling is an expensive practice. When the significant health benefits of reduced pollution are considered, truck stop electrification is a solution makes both economic and environmental sense.

Ship to shore: reducing commercial marine pollution

Commercial marine vessels contribute to air pollution along our coasts, in and around ports, and along inland waterways hundreds of miles from the open sea. Control of this overlooked pollution source has only recently become a priority for EPA and state and local officials. Emission control programs for ships lag far behind land-based sources. And foreign-flagged marine vessels present unique jurisdictional issues that do not apply to land-based sources.

Despite these challenges, commercial marine pollution can be reduced in the near-term by retrofitting and repowering ships. The following programs are already in place and delivering cleaner air in and around domestic ports.

Shore power: reducing emissions from ships at berth in Los Angeles, Juneau and Seattle

Large ships generally turn off their primary propulsion engines when they are parked at berths loading and unloading cargo or passengers, activities collectively called "hotelling." But they continue to run smaller auxiliary engines

COURTESY OF THE PORT OF LOS ANGELES

A barge crane lifts electrical cable plugs to the first AMP vessel to call at the port.

COURTESY OF THE PORT OF LOS ANGELES

A terminal at the Port of Los Angeles is designed to accommodate and simultaneously charge two Alternative Marine Power vessels.

to provide electricity, heating and cooling. On oceangoing vessels, these engines often run on the same extremely high-sulfur bunker fuel that they burn at sea. Because the overwhelming majority of these huge vessels are subject to no international air pollution regulations or only weak restrictions applicable to the newest engines, this dirty bunker fuel is burned in crowded port areas without any emission controls whatsoever.

This practice of powering a ship at berth with the ship's own engines creates the paradoxical situation in which electricity is produced by the uncontrolled burning of one of the dirtiest fuels in the world within sight and breathing distance of land-based vehicles and stationary sources subject to rigorous standards designed to protect public health from the very same pollutants. West Coast ports have begun to address the problem of ship emissions at berth by providing shore power facilities that allow ships to plug into land-based electricity and turn off their engines. The U.S. Navy has provided shore power at naval bases for many years, but it is only in the last few years that shore power facilities have been built for large commercial ships.

The Los Angeles area has both the worst ozone (smog) in the country and two of the busiest ports. The booming international cargo business at the ports of Los Angeles and Long Beach is expected to triple by 2020, which means that ship emissions will increase dramatically over the next 15 years as well.

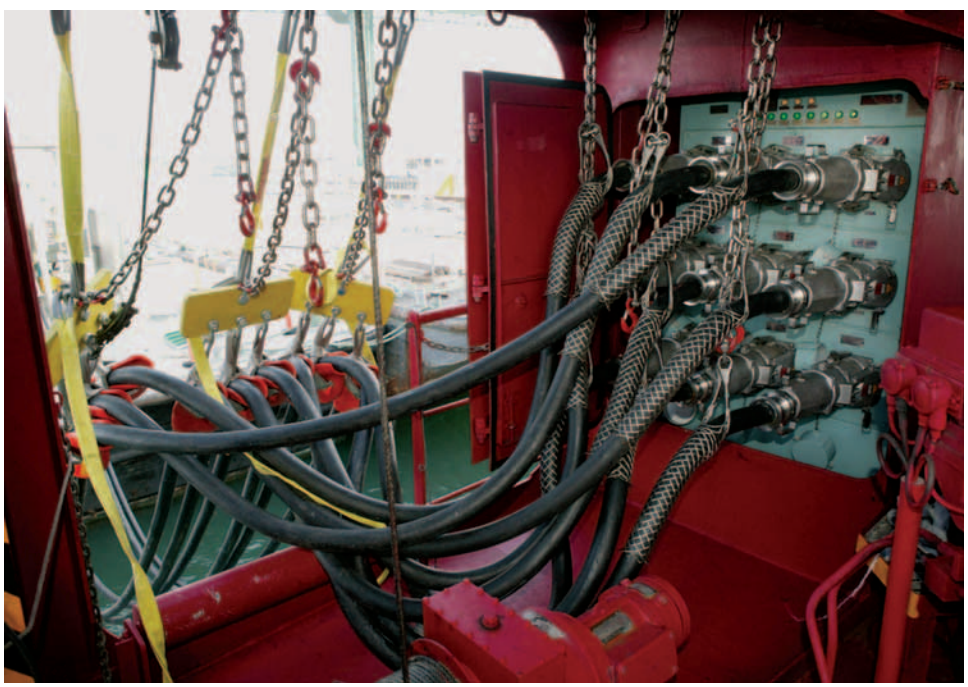
Last summer, the world's first shore power facility for container ships opened at the Port of Los Angeles. As a result of a settlement of lawsuits brought by the Natural Resources Defense Council, Coalition for Clean Air and local citizens' groups, the City of Los Angeles equipped the China Shipping Terminal at Berth 100 with alternative marine power capable of providing electrical service to two large container ships simultaneously.

Container ships dominate both the shipping traffic and the pollutant emissions inventory at Los Angeles. According to the Port of Los Angeles, a container ship on a typical port call using its own engines produces emissions equivalent to 69,000 diesel truck miles. By contrast, a container ship using the shore-based alternative marine power system is expected to eliminate an estimated one ton of NOx and particulate pollution per day in port.

Shore power projects require significant capital investments in electrical infrastructure and modifications to existing ships. The Port of Long Beach recently commissioned a detailed study of the feasibility and cost-effectiveness of shore power facilities for oceangoing cargo ships.[42] That study concluded that for ships that frequently call at the same port and have high power needs at berth, investment in shore power facilities is a cost-effective way of reducing hotelling emissions. It also concluded that other measures including alternative fuels, alternative engines, and emission controls such as diesel oxidation catalysts are feasible means of reducing emissions from oceangoing ships at berth.

Princess Cruises, part of the world's largest cruise line, Carnival Corporation, has begun providing shore power for passenger cruise vessels. In 2001, it became the first cruise line to use shore power when it provided electrical service to its passenger terminal in Juneau, Alaska. By 2004, seven Princess cruise ships were equipped to use shore power in port.

The Juneau shore power facility was completed through an innovative partnership between Princess, the City of Juneau and Alaska Electric Power & Light Company. Princess bore the cost of retrofitting its ships—at $500,000 each—to accept shore power.[43] The City and Borough of Juneau set aside $300,000 from cruise passenger fees as a contribution to the cost of the land-based expenditures related to the project, and Princess paid the remainder of the $2.5 million in capital costs to provide shore power. Alaska Electric Light and



COURTESY OF THE PORT OF LOS ANGELES

A full ship "plug in" of Alternative Maritime Pier.

Power Company agreed to segregate the amount Princess pays for shore power in a fund to defray the cost of wintertime power generation and thereby reduce local consumers' power bills.

In 2004, Princess expanded its shore power program to Washington State, with the installation of shore power facilities in Seattle to serve the same ships that dock at Juneau and ply the Inside Passage route between the Pacific Northwest and Alaska. The Puget Sound Clean Air Agency, Port of Seattle and EPA all participated in this project. The project was facilitated through the West Coast Diesel Emissions Reduction Collaborative, an international partnership of federal government agencies from the U.S., Canada and Mexico, as well as state and local governments and non-profit and private sector partners from California, Oregon, Washington, Alaska and British Columbia.[44]

Princess paid $1.8 million in capital costs to construct shore power facilities and EPA made a $50,000 grant to fund Seattle City Light's extension of high capacity electrical service to the terminal. The Puget Sound Clean Air Agency predicts that this shore power project will reduce NO_x emissions by 14.5 tons and particulate pollution by 2.5 tons during the 2005 cruise season.[45]

Reducing emissions from small harbor craft in New York and Los Angeles

Oceangoing vessels calling in U.S. ports are major polluters, but each large ship only stays a few days in a given port. Smaller harbor craft that remain in port year-round pollute much less on a per-ship basis, but because they operate continuously in a relatively small area, their emissions can add up to a major contribution to local pollution. For instance, in New York Harbor, the small towboats that push and pull large vessels through port are the second largest source of ship emissions, behind only oceangoing ships.

Ferryboats are also a major source of NO_x pollution in New York. Before September 2001, ferries carried 85,000 commuters a day into and out of Manhattan.[46] After the September 11 terrorist attacks, private ferry service doubled to 1,000 trips a day. More than 40 boats ply these routes, and ferry traffic is expected to increase as the redevelopment of Lower Manhattan moves forward. At present, these boats are not required to have pollution controls. So while passengers are enjoying a scenic trip to work, the diesel engines that power their ride discharge almost 20% of the total NO_x emissions from all ships of any size in the New York Harbor.

In response to the growing problem of ferry pollution, a coalition of state, city, federal, educational and environmental organizations, including Environmental Defense, is working with ferry operators to cut ferry pollution. The Private Ferry Emissions Reduction Initiative will use $6.8 million from New York City's Department of Transportation, the New York State Energy Research and Development Authority, and the Federal Transit Administration to evaluate, demonstrate and then deploy emission reduction technologies on virtually all private ferries now serving New York City. By the time it is complete, the Private Ferry Project aims to achieve a 75-95% reduction in ferry pollution.

California's Carl Moyer Program funds the incremental cost of repowering harbor craft such as tugboats with new, cleaner engines rather than replacements that would produce the same level of emissions as the existing engines. Through 2002, 130 small vessels in the Los Angeles area were repowered with the assistance of $19.5 million in incentive program funds. As a result, almost 1,400 tons of NO_X emissions and 55 tons of particulate pollution have been eliminated each year.[47]

Locomotive emissions: moving to the front of the train in California, Illinois and Texas

Like commercial marine ships, locomotive engines are among the last sources of diesel pollution that EPA has left to address through rigorous emission controls. Yet just like any other diesel engines, locomotives produce the same dangerous blend of chemicals and particulate matter that endangers the people who breathe their emissions. EPA is currently reviewing its emission standards for new and remanufactured locomotive engines.

Long-haul rail service delivers cargo across the country. The business of switching rail cars and assembling cars into trains for this service takes place at switching yards where rail lines meet. As shown in the study of Union Pacific's Roseville, California switching yard, discussed earlier, the concentration of pollutants from locomotives gathered at switching yards can make these facilities dangerous hotspots of toxic pollution. To make matters worse, these yards are often located in dense urban population centers, where residents and workers are already exposed to pollution from many other sources. The huge growth of imports arriving by container ships has led to rail congestion at port facilities, which also tend to be located near large populations.

Railroads and the communities in which they operate have begun to recognize that locomotives must be a part of comprehensive plans to reduce diesel pollution. The Port of Los Angeles last year adopted its first rail policy, which calls for the development of facilities to handle an expected quadrupling of cargo volumes by 2025 and aims to reduce traffic congestion by speeding cargo loading and shifting truck traffic to rail.[48]

Union Pacific, the nation's largest rail carrier, has just put in service its first hybrid switching locomotive, used to switch cars at Los Angeles area ports.

COURTESY OF RAILPOWER TECHNOLOGIES CORP.

Green Goat, hybrid locomotive.

The hybrid locomotive operates on an electric battery and a diesel engine that recharges the battery. Union Pacific projects that the hybrid engine will emit 80-90% less NO_x, and use 40–70% less diesel fuel than a standard diesel-powered switching engine.[49] Expansion of this technology could have a dramatic impact on locomotive emissions at ports and switching yards across the country.

The Texas Emissions Reduction Project (TERP) focuses on reducing NO_x emissions in areas violating the federal health-based ozone standard. TERP has committed almost $20 million to reduce locomotive emissions in the Houston-Galveston area, which suffers the highest ozone levels in the state. The Houston locomotive projects include replacement of old switching engines and repowering locomotives with cleaner hybrid technology. TERP officials expect these projects to reduce NO_x emissions by more than 3,300 tons, at an average cost of about $5900 per ton.

Chicago is another major hub of rail traffic, situated at the point where several east-west rail lines dip around the southern end of the Great Lakes. One-third of all long-haul rail traffic in the country passes through Chicago, and the largest U.S. rail yard, the Belt Rail Yard, is located there. EPA and the City of Chicago sponsored a locomotive idle reduction demonstration project in 2002 and 2003. The governments recruited Burlington Northern Santa Fe Railway Company, the Wisconsin Southern Railroad Company, and Kim Hotstart Company, a manufacturer of idle reduction systems, as partners in the project. Based on the successful performance of idle reduction systems in Chicago, EPA estimated that anti-idle retrofits at a typically sized rail yard with five switching engines would eliminate 12.5 tons of NO_x at a cost of $1,420 per ton of NO_x reduced.[50]

Conclusion

Cleaner air for America is at hand

EPA has adopted bold national emission standards that are transitioning the nation to cleaner new diesel freight trucks, buses and diesel equipment. Because diesel engines are long-lived and fleet turnover is slow, this transition will occur incrementally over the next twenty to thirty years. Innovative action in a variety of local communities has demonstrated that programs to lower the pollution from today's diesel engines are not only viable but highly beneficial. Our detailed analysis quantifying the benefits and costs, using EPA methodologies, shows that the human health benefits of broadly expanding these programs to additional communities across America exceed the costs by at least a 12 to 1 ratio. A well-designed program to lower pollution from existing diesel engines operating today will accelerate the nation's transition to cleaner, new engines and achieve momentous human health benefits. With expanded federal support and community leadership, cleaner air for America is at hand.

APPENDIX A

The national pollution burden from diesel engines

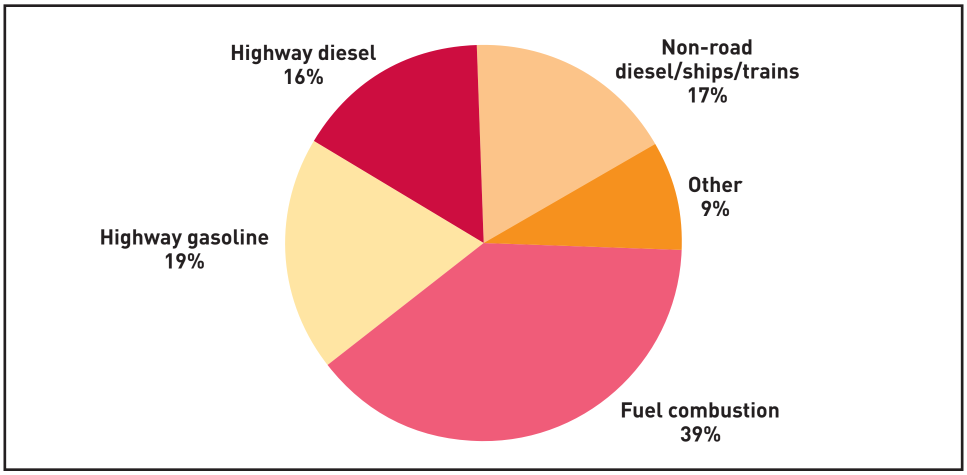
Diesel engines are used throughout the U.S economy in onroad vehicles, non-road equipment and vehicles, marine vessels and locomotives, and in stationary applications to power equipment such as pumps and loading equipment and to generate electricity. Diesel exhaust is a particularly potent collection of dangerous chemicals, and a significant contributor to national inventories of several key pollutants, including nitrogen oxides, volatile organic compounds, fine particulates, sulfur dioxide, and carbon dioxide, a critical greenhouse gas.

Diesel and smog: nitrogen oxides and volatile organic compounds

Diesel exhaust contains both NO_X and VOCs, which combine in the atmo-

FIGURE 11

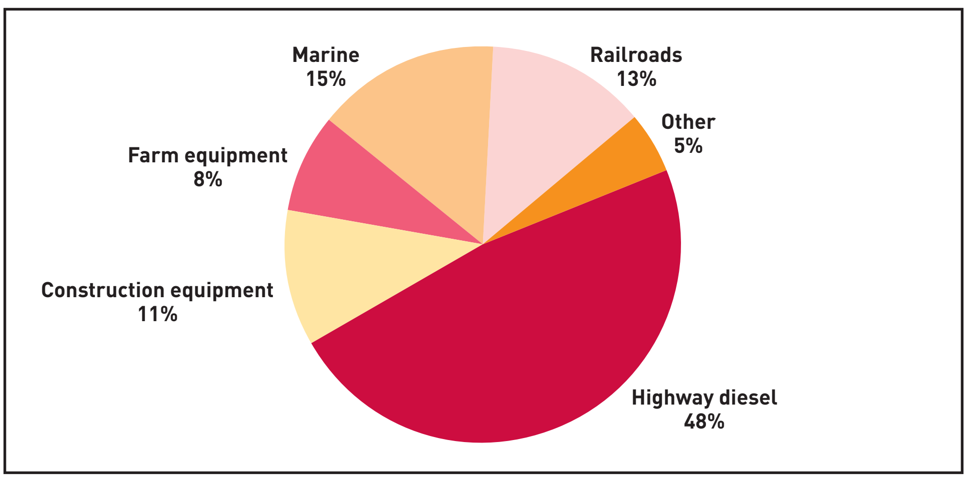
National NO_x emissions by source category, 2002 (21.1 million short tons)



Source: U.S. EPA National Emission Trends

FIGURE 12

National NO_x emissions from all diesel sources, 2002 (6.9 million short tons)



Source: U.S. EPA National Emission Trends sphere to form ground-level ozone, the primary component of smog. NO_X also contributes to several other types of pollution including nitrate particulate pollution, nitrogen deposition and acid deposition. Diesel engines are responsible for about one-third of all NO_x pollution from anthropogenic sources, see Figure 11. The highway sector and nonroad sector are each responsible for about half of the NO_x emissions from all diesel sources, see Figure 12.

Fine particulate matter

Diesel engines produce far more particulate pollution than gasoline engines. Depending on operating conditions, fuel quality and emission controls, light-duty diesel engines can emit 50-80 times and heavy-duty diesel engines can emit 100 to 200 times more particle mass than typical catalytically equipped gasoline-powered engines.[1] Diesel particulate matter is typically fine (< 2.5 microns) or ultrafine (< 1 micron) in size. Virtually all of the diesel exhaust particle mass has a diameter of less than 10 microns, 94% is less than 2.5 microns, and 92% is less than 1.0 microns. [2] The small size of diesel particulate matter makes it a particularly efficient and dangerous means of delivering harmful chemicals into our bodies.

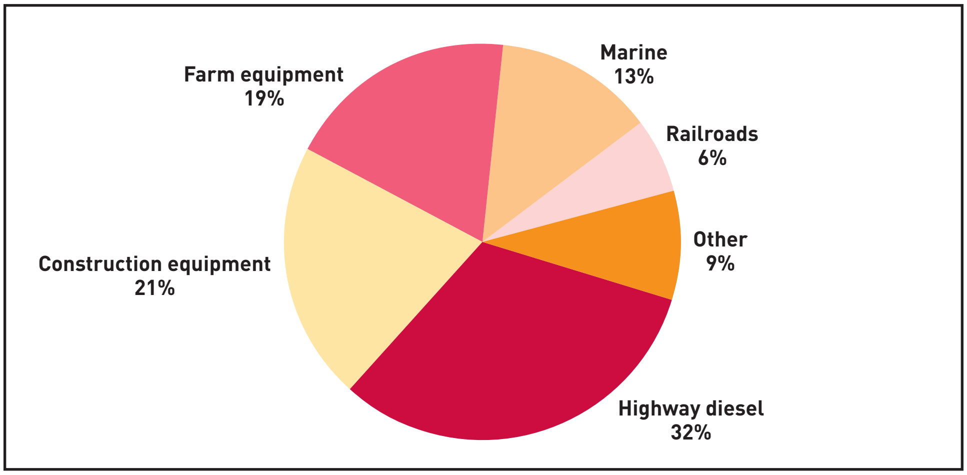
Diesel engines are a major source of fine particle pollution. In 2002, diesel engines released approximately 314,000 short tons of $PM_{2.5}$ and accounted for almost 5% of total fine particle pollution in 2002. [3] Nonroad diesel vehicles created about two-thirds of those emissions.

Sulfur dioxide

Sulfur dioxide emissions contribute to the formation of secondary fine sulfate particles that threaten health and impair visibility as well as acid deposition that harms ecosystems. Diesel engines discharged 510,000 tons of sulfur dioxide in 2002, or 3% of the sulfur dioxide released from all anthropogenic sources. Nonroad engines and marine equipment released most of the SO_2 from diesel sources, largely because they have operated on diesel fuel with high sulfur content. [4]

As new restrictions on highway diesel fuel sulfur content take effect in 2006 for onroad vehicles and in 2010 and

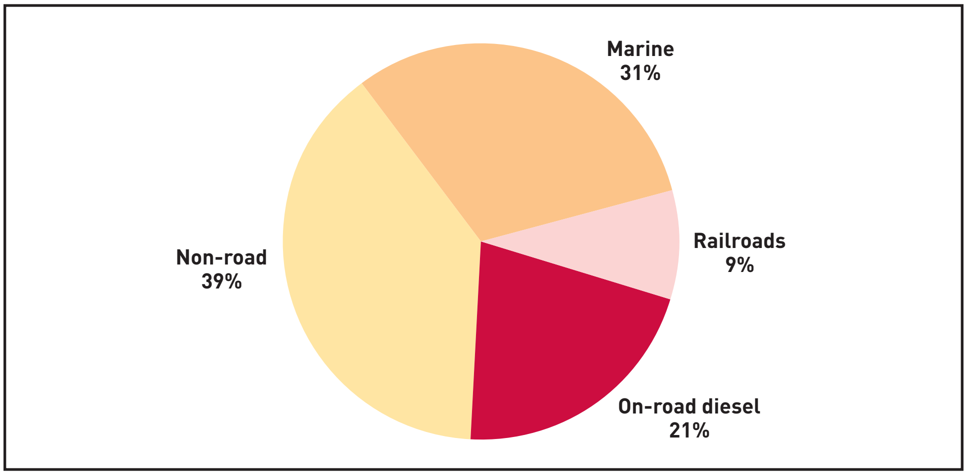
FIGURE 13
National $PM_{2.5}$ emissions from all diesel sources, 2002 (314,00 short tons)



Source: U.S. EPA National Emission Trends

FIGURE 14

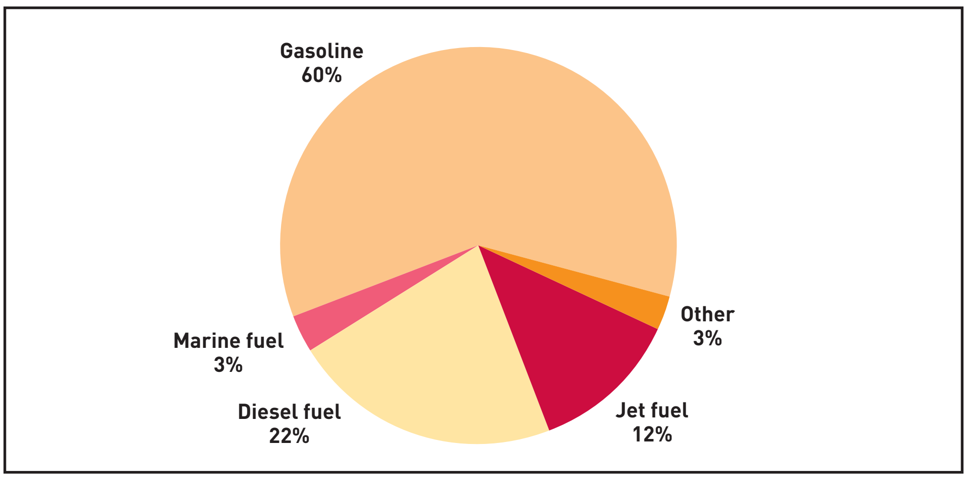
National SO_2 emissions from all diesel sources, 2002 (510,00 short tons)



Source: U.S. EPA National Emission Trends

FIGURE 15

National CO_2 emissions from transportation, 2003 (1,874.7 million metric tons)



Source: U.S. DOE Energy Information Administration

2012 for nonroad equipment, the levels of sulfur dioxide emissions from those diesel engines will fall dramatically. However, the dirtiest of the diesel fuels, the residual fuel burned in oceangoing vessels, is not subject to any current or proposed restriction on sulfur. Sulfur content in marine residual fuel can range as high as 45,000 ppm, or a staggering 4.5% sulfur. EPA reports that, worldwide, residual fuel averages 27,000 ppm sulfur. This is nearly 2,000 times the 15 ppm level soon to be required for onroad diesel fuels. [5] The extraordinarily high sulfur content in residual fuel makes shipping one of the biggest sources of SO_2 emissions on the planet, despite the relatively small number of large ships in existence.

Carbon dioxide—a global warming pollutant

Human-induced increases in atmospheric carbon dioxide (CO_2) and other greenhouse gases are shrouding the

Earth, pushing temperatures to extremes, melting glaciers and disrupting natural systems. Much of the CO_2 emitted domestically is a result of burning fossil fuels. Total emissions of CO_2 in the U.S. reached 5.9 billion metric tons in 2003. Transportation played a large role in this pollution, emitting 1.9 billion metric tons of CO_2. In 2003, the combustion of diesel fuel contributed 22% of the CO_2 released from transportation sources.[6]

APPENDIX B

Methodology used to estimate the benefits and costs of pollution reduction scenarios for existing diesel engines

This appendix describes the methodology used to analyze the benefits and costs of two scenarios to reduce pollution from existing diesel engines. E3 Ventures, a technical consultant retained by Environmental Defense, performed this analysis. The two scenarios reduced emissions of fine particulate pollution ($PM_{2.5}$) by retrofitting diesel construction equipment, school buses, and transit buses with (1) diesel particulate filters (DPFs) or (2) diesel oxidization catalysts (DOCs). The scenarios applied two pollution reduction technologies to diesel equipment in the core counties of the following 50 largest metropolitan areas in the United States.

The scenarios covered some 88 counties and Washington, D.C. with 94.6 million people or one-third of the 2001 total U.S. population.

The monetary benefits analysis used methods and assumptions similar to those used by the U.S. Environmental Protection Agency in its regulatory analysis of the nonroad diesel rule.[1]

TABLE 4

50 most populated metropolitan areas in the U.S., examined in diesel pollution reduction program scenarios

1. New York City	26. Milwaukee
2. Los Angeles	27. Orlando
3. Chicago	28. Indianapolis
4. Washington-Baltimore	29. San Antonio
5. San Francisco-Oakland	30. Norfolk-Virginia Beach-Newport News
6. Philadelphia	31. Las Vegas
7. Boston	32. Columbus, OH
8. Detroit	33. Charlotte, NC
9. Dallas-Fort Worth	34. New Orleans
10. Houston	35. Salt Lake City
11. Atlanta	36. Greensboro, NC
12. Miami, FL	37. Austin
13. Seattle-Tacoma	38. Nashville
14. Phoenix	39. Providence-Fall River
15. Minneapolis-St. Paul	40. Raleigh-Durham-Chapel Hill
16. Cleveland	41. Hartford
17. San Diego	42. Buffalo, NY
18. St. Louis	43. Memphis
19. Denver	44. Jacksonville, FL
20. Tampa-St. Petersburg	45. Rochester, NY
21. Pittsburgh	46. Grand Rapids, MI
22. Portland, OR	47. Oklahoma City
23. Cincinnati	48. Louisville, KY
24. Sacramento	49. Richmond, VA
25. Kansas City	50. Greenville-Spartanburg, SC

Source: U.S. Census Bureau, 2000

Because many of the assumptions used in the analysis are based on national-scale information, the results are similar across all cities and average values were used to estimate the retrofit costs and benefits.

The analysis assumes retrofit equipment costs range from $4,500 to $10,000 for DPFs, and from $700 to $2,500 for DOCs.[2] Particulate pollution removal efficiencies (for direct particulate matter) are assumed to range from 80% to 95% for DPFs, and from 20% to 35% for DOCs.[3] The analysis also assumes that 40% of on-road engines (i.e., transit and school buses) manufactured after 1994 and 20% of all non-road engines (i.e., construction equipment) can be retrofit with a DPF, and that 80% of all on- and non-road diesel engines can be retrofit with a DOC. To compare the annual benefits of PM2.5 emission reductions from engine retrofits with annualized costs, the analysis assumes that retrofits occur midway through a 15-year depreciating engine life, and amortizes equipment costs over seven years.

$PM_{2.5}$ emission rates for existing vehicles were obtained for each of the counties included in this analysis from EPA's National Emissions Inventory (NEI) for 2001.[4] NEI emissions for school and transit buses are included in the Heavy Duty Diesel Vehicle-Bus (Transport and School Bus) vehicle category, which includes emissions from brakes, tires and exhaust. Exhaust emissions were separated out and used exclusively in this analysis. NEI emissions for construction equipment are included in the Construction & Mining Equipment vehicle category. This category includes pavers, plate compactors, rollers, scrapers, paving equipment, surfacing equipment, signal boards/light plants, trenchers, bore/drill rigs, excavators, concrete/industrial saws, cement and mortar mixers, cranes, graders, off-highway trucks, crushing/processing equipment, rough terrain forklifts, rubber tire loaders, tractors/loaders/backhoes, crawler tractor/dozer, skid steer loaders, off-highway tractors, dumpers/tenders, and other construction equipment.

County-level counts of school and transit buses were estimated using NEI emissions and vehicle miles traveled (VMT) data. Based on the MOBILE6 model, school buses are assumed to travel 9,939 miles annually and transit buses are assumed to travel 35,113 miles annually. School and transit bus VMT data were divided by these annual averages, respectively, to estimate the number of school and transit buses in each county. The resulting bus number estimates were compared with other databases such as the Department of Transportation's National Transit database. Because the NEI-VMT derived bus estimates for some of the areas examined in this analysis appeared lower than suggested in other databases, the estimated number of buses for all counties was doubled. County-level counts of construction vehicles were obtained from EPA's Office of Transportation and Air Quality.

Because DPFs are effective on vehicles manufactured after 1994, this analysis estimates the age distribution of state school bus fleets using data reported in the Union of Concerned Scientists' 2002 report: *Pollution Report Card: Grading America's School Bus Fleets.* Age distributions for transit bus fleets are based on MOBILE6 Fleet Characterization Data.

The estimate of the health benefits associated with $PM_{2.5}$ emission reductions from diesel engine retrofits and the associated monetization of those benefits was based on direct scaling with the $PM_{2.5}$ emission reductions and associated health benefits and monetary benefits under the EPA Nonroad Diesel Engine Rule as reported in Chapter 9 of the *Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines* (hereinafter "Regulatory Analysis"). The estimated benefits in the Regulatory Analysis are based on 2030 data, which assume full implementation of the nonroad diesel rule.[5] The corresponding benefits associated with the two retrofit scenarios (i.e., DPFs and DOCs) were estimated by applying the ratio of $PM_{2.5}$ emissions reductions from the retrofit scenarios to the $PM_{2.5}$ emission reductions assumed in the Regulatory Analysis. The benefits of the retrofit scenarios were further scaled back to account for the difference between projected 2030 U.S. population and 2001 U.S. population levels.

Although the health benefits associated with diesel engine retrofits continue over several years, the retrofit analysis estimates annual PM-related health benefits, and does not discount future benefits that occur in later years. Furthermore, although there is a recognized time lag between reductions in PM exposure and decreases in the occurrence of adverse health effects, the retrofit analysis applies the simplifying assumption of full realization of reductions in PM exposure and reductions in adverse health impacts (i.e. the analysis does not apply a distributed lag structure to the benefits estimation).

The retrofit analysis estimates the monetary value of the health benefits associated with diesel engine retrofits by applying the unit values used for economic valuation of the PM-related health endpoints reported in the nonroad diesel Regulatory Analysis to the (health) incidence reductions associated with each retrofit scenario. All monetary values are expressed in 2000 dollars. PM-related health endpoints include premature mortality, chronic bronchitis, non-fatal heart attacks, respiratory hospital admissions, acute bronchitis, asthma exacerbations, upper and lower respiratory symptoms, work loss days, and minor restricted activity days.

With the exception of non-fatal heart attacks, the nonroad diesel Regulatory Analysis expresses the monetary values of health-related benefits associated with reduced PM exposure as point estimates. However, the monetary benefits of reduced non-fatal heart attacks assume illness costs and lost earnings in later years and are discounted at rates of three and seven percent. The economic value of reduced work loss days is estimated by applying 2001 average metropolitan-area wage data from the Bureau of Labor Statistics.

Estimating the benefits of diesel pollution reduction scenarios

The range of capital costs associated with retrofitting construction equipment, and school and transit buses in the 88 counties and Washington, D.C. included in this analysis is shown in the Table 5. Although diesel oxidization catalysts are less expensive than diesel particulate filters, the aggregate costs of DOC retrofits are higher than those of

TABLE 5
Range of estimated capital costs and benefits

	DPF	DOC	Value used in analysis
Low capital cost estimate	$731.0 million	$470.0 million	$600.5 million
High capital cost estimate	$1.62 billion	$1.68 billion	$1.65 billion
Low value of benefits estimate	$10.6 billion	$18.1 billion	$10.6 billion
High value of benefits estimate	$10.9 billion	$19.2 billion	$19.2 billion

DPF retrofits because more engines can be retrofit with a DOC.

Table 5 also shows the range of benefits associated with the diesel engine retrofit scenarios. These benefits accrue over the remaining life of a retrofitted engine, which this analysis assumes to be seven years. The monetary values of the health benefits are related to $PM_{2.5}$ emission reductions, which are in turn related to the $PM_{2.5}$ reduction efficiencies of the retrofit technology and the number of engines that are retrofitted.

The net present value (NPV) of the benefits associated with diesel engine retrofits was analyzed (1) considering the lowest benefit stream within the four scenarios analyzed which was DPF retrofits with a relatively low PM removal rate of 80 percent, and (2) considering the highest benefit stream which was DOC retrofits with a relatively high PM removal rate of 35 percent.

The benefits of diesel engine retrofits—the avoided instances of adverse health effects—span the remaining useful life of the retrofitted engine, which this analysis assumes to be seven years. The monetary value of health benefits increases over time. The increasing value of some benefits, such as avoided premature deaths and avoided work loss and minor restricted activity days, are related to wage and price levels, while the monetary value of other benefits, such as chronic and acute bronchitis, non-fatal heart attacks, respiratory hospital admissions, asthma exacerbations, and upper and lower respiratory symptoms, are related to health care costs, which are increasing much more rapidly than the overall price level. Total national health expenditures in the U.S. increased by 7.7% in 2003 over 2002—four times the rate of inflation in 2003.[6] Over the next several years, health care expenditures are forecast to increase by 7.1% annually[7], as compared to the long-range consumer price index forecast of 2.4 percent.[8]

The two retrofit scenarios (i.e., DPFs and DOCs) were selected because they reflect widely available technology and two substantially different approaches to diesel pollution reduction strategies. The DPF scenario reflects the application of technology that can achieve a very high degree of particulate pollution removal for the engines affected but can only be applied to a limited set of engines. Conversely, the DOC scenario reflects lower price technology that achieves significantly less particulate pollution removal on a per engine basis but can be more widely applied across fleets thereby reaching a greater set of engines. The DOC scenario estimated 605,000 diesel engines would be fitted with pollution control devices. The DPF scenario estimated 148,500 engines would be fitted with DPF pollution controls. In actual practice in any single community, the solutions to reduce diesel pollution from existing engines would vary widely depending on technological and policy considerations. Further, the options available would include a suite of technological solutions, operational practices such as idle reduction, and engine replacement.

Notes

Chapter 1

[1] See Environmental Defense, *Cleaner Diesel Handbook* at http://www.environmentaldefense.org/go/dieselhandbook for several examples.

Chapter 2

[1] South Coast Air Quality Management District, Multiple Air Toxics Exposure Study (MATES-II) in the South Coast Air Basin, March 2000. See http://www.aqmd.gov/matesiidf/es.pdf. Last accessed May 3, 2005.

[2] California Office of Environmental Health Hazard Assessment and American Lung Association, Factsheet "Health Effects of Diesel Exhaust," 2001. See http://www.oehha.ca.gov/public_info/facts/dieselfacts.html. Last accessed May 3, 2005.

[3] Environmental Defense, Scorecard, 2002, calculated from 1999 EPA National-scale Assessment of Air Toxics data. See http://www.environmentaldefense.org/pressrelease.cfm?ContentID=75. Last accessed May 3, 2005.

[4] California Air Resources Board "Roseville Rail Yard Study," Oct. 14, 2004. See http://www.arb.ca.gov/diesel/documents/rrstudy/rcexecsum.pdf. Last accessed May 3, 2005.

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

[6] Brown, J. S.; Zeman, K.L.; Bennett, W.D. (2002) "Ultrafine particle deposition and clearance in the healthy and obstructed lung." Am. J. Respir. Crit. Care Med. 166: 1240–1247.

[7] Garshick, E.; Laden, F.; Hart, J.E.; Rosner, B.; Smith, T.J.; Dockery, D.W.; Speizer, F.E. (2004) "Lung Cancer in Railroad Workers Exposed to Diesel Exhaust." Environmental Health Perspectives 112: 1539–1543.

[8] California Office of Environmental Health Hazard Assessment and American Lung Association, Factsheet "Health Effects of Diesel Exhaust," 2001. See http://www.oehha.ca.gov/public_info/facts/dieselfacts.html. Last accessed May 3, 2005.

[9] South Coast Air Quality Management District, Multiple Air Toxics Exposure Study (MATES-II) in the South Coast Air Basin, March 2000. See http://www.aqmd.gov/matesiidf/es.pdf. Last accessed May 3, 2005.

[10] California Office of Environmental Health Hazard Assessment, "Health Risk Assessment for Diesel Exhaust" (May 1998).

[11] Nemmar, A.; Hoet, P.H.M.; Dinsdale, D.; Vermylen, J.; Hoylaerts, M.F.; Nemery, B. (2003) "Diesel Exhaust Particles in Lung Acutely Enhance Experimental Peripheral Thrombosis." Circulation. 107:1202–1208.

Salvi, S.; Blomber, A.; Rudell, B.; Kelly, F.; Sandstrom, T; Holgate, S.T.; Frew, A. (1999) "Acute Inflammatory Responses in the Airways and Peripheral Blood After Short-Term Exposure to Diesel Exhaust in Healthy Human Volunteers." Am. J. Respir. Crit. Care Med. 159:702–709.

[12] California Office of Environmental Health Hazard Assessment and American Lung Association, Factsheet "Health Effects of Diesel Exhaust," 2001. Available online at http://www.oehha.ca.gov/public_info/facts/dieselfacts.html.

[13] Nel, A.E.; Diaz-Sanchez, D.; Ng, G.; Hiura, T.; Saxon, A. (1998) "Enhancement of allergic inflammation by the interaction between diesel exhaust particles and the immune system." J. Allergy Clin. Immunol. 102(4 pt 1):539–554.

McConnell, R.; Berhane, K.; Gilliland, F.; London, S.J.; Vora, H.; Avol, E.; Gauderman, W.J.; Margolis, H.G.; Lurmann, F.; Thomas, D.C.; et al. "Air pollution and bronchitic symptoms in southern California children with asthma." Environ. Health Perspect. 107(9):1–9 (1999).

[14] EPA, National Center for Environmental Assessment, Air Quality Criteria for Particulate Matter (October 2004). Available online at http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903.

[15] Delfino, R.J.; Quintana, P.J.; Floro, J.; Gastanaga, V.M.; Samimi, B.S.; Kleinman, M.T.; Liu, L.J.;Bufalino, C.; Wu, C.F.; McLaren, C.E. (2004) "Association of

FEV1 in asthmatic children with personal and microenvironmental exposure to airborne particulate matter." Environ. Health. Perspect. 112: 932–941.

Penttinen, P.; Timonen, K.L.; Tuttanen, P.; Mirme, A.; Ruuskanen, J.; Pekkanen, J. (2001) "Ultrafine particles in urban air and respiratory health among adult asthmatics." Eur. Respir. J. 17: 428–435.

H. Desqueroux et al. (2002) "Short-Term Effects of Low-Level Air Pollution on Respiratory Health of Adults Suffering From Moderate to Severe Asthma," Environmental Research Vol. 89 (Section A):29–37.

16 Devlin, R.B.; Ghio, A.J.; Kehrl, H., et al. (2003) "Elderly humans exposed to concentrated air pollution particles have decreased heart rate variability." Eur. Respir. J. 21(suppl 40):76–80.

Gold, D.R.; Litonjua, A.; Schwartz, J.; Lovett, E.; Larson, A.; Nearing, B.; Allen, G.; Verrier, M.; Cherry, R.; Verrier, R. (2000) "Ambient Pollution and Heart Rate Variability." Circulation 101: 1267–1273.

Magari, S.R.; Hauser, R.; Schwartz, J.; et al. (2001) "Association of heart rate variability with occupational and environmental exposure to particulate air pollution." Circulation. 104:986–991.

Pekkanen, J.; Peters, A.; Hoek, G., et al. (2002) "Particulate air pollution and risk of ST-segment depression during repeated submaximal exercise tests among subjects with coronary heart disease: the Exposure and Risk Assessment for Fine and Ultrafine Particles in Ambient Air (ULTRA) study." Circulation. 106:933–938.

Peters, A.; Liu, E.; Verrier, R. L.; Schwartz, J.; Gold, D. R.; Mittleman, M.; Baliff, J.; Oh, J. A.; Allen, G.; Monahan, K.; Dockery, D. W. (2000) "Air pollution and incidence of cardiac arrhythmia." Epidemiology 11: 11–17.

Peters, A.; von Klot, S.; Heier, M.; Trentinaglia, I.; Hormann, A.; Wichmann, E.; Lowel, H. (2004) "Exposure to Traffic and the Onset of Myocardial Infarction." New England J. of Medicine 351: 1721–1730.

Peters, A.; Dockery, D.W.; Muller, J.E.; et al. (2001) Increased particulate air pollution and the triggering of myocardial infarction. *Circulation*. 103:2810–2815.

17 62 Fed. Reg. 38,856 (July 18, 1997); Bell, M.L.: McDermott, A.; Zeger, S.L.; Samet, J.M.; Dominici, F. (2004) "Ozone and Short-term Mortality in 95 US Urban Communities, 1987–2000." Journal of the American Medical Association 292:2372–2378.

18 See http://www.epa.gov/ozonedesignations/. Last accessed April 5, 2005.

19 See http://www.meca.org/jahia/Jahia/engineName/filemanager/pid/229/retrofitfact.PDF?actionreq=actionFileDownload&fileItem=214. Last accessed April 28, 2005.

20 Paul W. Park, "Correlation Between Catalyst Surface Structure and Catalyst Behavior: Selective Catalytic Reduction with Hydrocarbon." May 21, 2002. EMSL 2002. Richland, Washington. See http://www.emsl.pnl.gov/new/emsl2002/abstracts/park.doc. Last accessed April 28, 2005. The California Air Resources Board has verified a Lean NO_x catalyst at a 25% reduction in NO_x. The verified Lean NOx catalyst is used in combination with a Diesel Particulate Filter. See http://www.arb.ca.gov/diesel/verdev/level3/level3.htm. Last Accessed April 28, 2005.

21 See http://www.meca.org/jahia/Jahia/engineName/filemanager/pid/229/retrofitFAQ%20%28revised%29.pdf?actionreq=actionFileDownload&fileItem=712. Last accessed April 28, 2005.

22 California Air Resources Board. "The Carl Moyer Memorial Air Quality Standards Attainment Program Guidelines: Approved Revision 2003." September 30, 2003. See http://www.arb.ca.gov/msprog/moyer/2003moyerguide.pdf Last accessed May 3, 2005

23 Texas State House of Representatives. "House Bill 1365." §8(a) Effective June 22, 2003. See http://www.capitol.state.tx.us/cgi-bin/tlo/textframe.cmd?LEG=78&SESS=R&CHAMBER=H&BILLTYPE=B&BILLSUFFIX=01365&VERSION=5&TYPE=B Last accessed May 3, 2005.

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

25 See, e.g., Norris, G., et al. (1999) "An Association Between Fine Particles and Asthma in Emergency Department Visits for Children in Seattle," Environ. Health Perspect. 107: 489–493.

Tolbert, P.E., et al. (2000) "Air Quality and Pediatric Emergency Room Visits for

Asthma in Atlanta, Georgia," Am. J. Epidemiol. 151:798–810.

Gauderman, J.W., et al. (2000) "Association Between Air Pollution and Lung Function Growth in Southern California Children," American Journal of Respiratory and Critical Care Medicine 162:1383–1390.

[26] American Academy of Pediatrics, "Ambient Air Pollution: Respiratory Hazards to Children," American Association of Pediatrics News, 1993. See also Landrigan, P., et al. (1998) "Children's Health and the Environment: A New Agenda for Prevention Research," Environmental Health Perspectives 106 (suppl. 3): 787–94

Chapter 3

[1] EPA (2000) Regulatory Impact Analysis: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, Table VII-19, EPA420-R-00-026, December 2000.

[2] Ibid.

[3] EPA (2004a) Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines, Table 9-11, EPA420-R-04-007, May 2004.

[4] Ibid.

Chapter 4

[1] See http://www.epa.gov/ozonedesignations/. Last accessed April 5, 2005

[2] See http://www.epa.gov/pmdesignations/documents/Apr05/factsheet.htm. Last accessed April 27, 2005. Also, see generally, http://www.epa.gov/pmdesignations/. Last accessed April 5, 2005

[3] See http://www.meca.org/jahia/Jahia/engineName/filemanager/pid/229/retrofitfact.PDF?actionreq=actionFileDownload&fileItem=214 Last accessed on April 4, 2005

[4] *Summary of Products That Are Reported to Reduce Particulate Emissions From Diesel-Fueled Engines.* Report Appendix IX, California Air Resources Board; 10/2000. See http://www.epa.gov/otaq/retrofit/documents/meca1.pdf Last Accessed on April 5, 2005

[5] EPA (2004) Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines, Table 6.5-3, EPA420-R-04-007, May 2004

[6] See http://www.meca.org/jahia/Jahia/engineName/filemanager/pid/229/retrofitfact.PDF?actionreq=actionFileDownload&fileItem=214. Last accessed on April 4, 2005

[7] *Summary of Products That Are Reported to Reduce Particulate Emissions From Diesel-Fueled Engines.* Report Appendix IX, California Air Resources Board; 10/2000. See http://www.epa.gov/otaq/retrofit/documents/meca1.pdf Last Accessed on April 5, 2005.

[8] EPA, 2004, Table 6.5-3

[9] EPA (2000) Regulatory Impact Analysis: Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, EPA420-R-00-026, December, Table ES-5.

[10] EPA (2004a) Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines, EPA420-R-04-007, May 2004, Table 9-17.

[11] Marshall, Julian D. and Eduardo Behrentz, "Vehicle Self-Pollution Intake Fraction: Children's Exposure to School Bus Emissions," Environ. Sci. Technol. 39, 2559–2563 (2005).

[12] Id.

Chapter 5

[1] The diversity of programs described here reflects the varying needs of individual projects with respect to equipment, location, fuel availability, and other related factors. This is not a comprehensive list of successful retrofit projects across the country and Environmental Defense does not endorse any particular retrofit technology or retrofit technology manufacturer.

[2] Environmental Defense's *Cleaner Diesel Handbook* may be found at http://www.environmentaldefense.org/go/dieselhandbook

[3] See http://www.epa.gov/ozonedesignations/regions/region2desig.htm. Last accessed April 18, 2005.

[4] See http://www.epa.gov/pmdesignations/finaltable.htm. Last accessed April 18, 2005.

[5] New York State Assembly. N.Y. ALS Chapter 259, Assembly Bill 11700 (2004). New York State Governor's Office. "Press Release: Governor Signs Bill Creating the

Coordinated Construction Act for Lower Manhattan." August 10, 2004. See http://www.state.ny.us/governor/press/year04/aug10_1_04.htm Last accessed May 3, 2005.

[6] Ibid.

[7] New York, NY, Local Law 77, §2(f)(1) (2003). See http://www.nyccouncil.info/pdf_files/bills/law03077.pdf. Last accessed May 2, 2005

[8] See http://www.cleanaircommunities.org/projects/huntspoint.html. Last accessed May 3, 2005.

[9] Ibid.

[10] See http://www.epa.gov/cleanschoolbus/basicinfo.htm. Last accessed on April 13, 2005.

[11] See *Children's Exposure to Diesel Exhaust on School Buses,* http://www.ehhi.org/reports/diesel, last accessed on April 13, 2005. See also Marshall, J.D.; Behrentz, E. (2005) "Vehicle Self-Pollution Intake Fraction: Children's Exposure to School Bus Emissions," Environ. Science Technol. 39, 2559–2563. The Natural Resources Defense Council and the Coalition for Clean Air issued a report examining children's exposure to diesel exhaust on school buses called, *No Breathing in the Aisles.* This report found that a child riding inside a diesel school bus may be exposed to as much as four times the level of diesel exhaust as someone riding in the car immediately in front of that same bus. See http://www.nrdc.org/air/transportation/schoolbus/schoolbus.pdf. Last accessed April 13, 2005.

[12] See http://www.epa.gov/cleanschoolbus/funding.htm. Last accessed April 13, 2005

[13] See http://www.epa.gov/otaq/schoolbus/demo_projects.htm. Last accessed April 13, 2005.

[14] See http://okemos.k12.mi.us/users/admin/about.htm. Last accessed April 16, 2005.

[15] See http://www.epa.gov/otaq/schoolbus/demo_projects.htm. Last accessed April 13, 2005.

[16] See http://www.cleanairfleets.org/altfuels.html. Last accessed April 16, 2005.

[17] See http://www.epa.gov/otaq/schoolbus/demo_projects.htm. Last accessed April 13, 2005.

[18] See http://cleanairtn.org/tnschoolbus.php. Last accessed April 16, 2005.

[19] See http://www.epa.gov/otaq/schoolbus/demo_projects.htm. Last accessed April 13, 2005.

[20] Information based on Donaldson letter to Environmental Defense dated March 25, 2004.

[21] See http://www.catf.us/publications/view/82. Last accessed April 13, 2005.

[22] The CATF study found that a bus equipped with a diesel oxidation catalyst (DOC) showed cabin levels of ultrafine particles, black carbon and PAH that were similar in magnitude to those observed in conventional buses. Thus, the CATF found it difficult to ascertain whether a DOC provided any in-cabin benefit. See http://www.catf.us/publications/view/82. Last accessed April 27, 2005

[23] See http://www.epa.gov/cleanschoolbus/antiidling.htm. Last accessed April 27, 2005.

[24] See http://www.epa.gov/cleanschoolbus/idle_fuel_calc.htm. Last accessed April 27, 2005. EPA uses a fuel cost of $1.50 per gallon to make this calculation although the Energy Information Administration shows current highway diesel retail prices at about $2.18 per gallon.

[25] EPA's website offers guidance about setting up anti-idling programs. See http://www.epa.gov/cleanschoolbus/antiidling.htm. Last accessed April 27, 2005.

[26] Regional Transportation District, "State-of-the-art FREE MallRide facts." See http://www.rtd-denver.com. Last accessed May 2, 2005.

[27] See http://www.epa.gov/smartway/idlingimpacts.htm. Last accessed May 2, 2005

[28] Ibid.

[29] Ibid.

[30] See http://www.ctre.iastate.edu/pubs/truck_idling/gaines.pdf, slide 6. Last accessed May 3, 2005.

[31] See http://www.epa.gov/smartway/idlingimpacts.htm. Last accessed May 2, 2005.

[32] See http://fleetowner.com/equipment/whatsnewin/fleet_whats_new_auxiliary/. Last accessed May 2, 2005.

[33] Ibid.

[34] See http://www.eere.energy.gov/cleancities/idle/truck_elec.html. Last accessed May 2, 2005.

[35] See http://www.epa.gov/smartway/idlingalternatives.htm. Last accessed May 2, 2005.

[36] See http://www.nitesystem.com/index.cfm/news?id=4. Last accessed May 2, 2005.

[37] See http://www.eere.energy.gov/state_energy_program/project_brief_detail.cfm/pb_id=727. Last accessed May 2, 2005.

[38] See http://daq.state.nc.us/news/pr/2004/diesel_10252004.shtml. Last accessed May 2, 2005.

[39] See http://www.idleaire.com/technology. Last accessed May 2, 2005.

[40] See http://www.idleaire.com/products_and_services/fleets/. Last accessed June 10, 2005.

[41] See http://tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp. Last accessed May 30, 2005.

[42] ENVIRON, *Cold Ironing Cost Effectiveness Study*, prepared for the Port of Long Beach, March 30, 2004. See http://www.polb.com/pdfs/4_environment/Cold-Ironing-Report.pdf. Last accessed May 3, 2005.

[43] Princess Cruise Lines, Press release, "Princess Ships to Connect to Shore Power in Seattle for 2005 Summer Season," September 30, 2004. See http://www.princess.com/news/article.jsp?newsArticleId=na703. Last accessed May 3, 2005.

[44] For a description of the West Coast Diesel Emissions Reduction Collaborative, see http://www.westcoastdiesel.org/. Last accessed May 2, 2005.

[45] Correspondence with Tom Hudson, Puget Sound Clean Air Agency, December 22, 2004.

[46] The New York, Northern New Jersey, Long Island Nonattainment Area Commercial Marine

Vessel Emissions Inventory (prepared for the Port Authority of New York and New Jersey, USACE, New York District, Starcrest Consulting Group, LLC, April 2003), page 88.

[47] Overview of State and Local Air Quality Needs and Requirements to Reduce Emissions at Marine Ports," presentation of Henry Hogo, South Coast air Quality Management District, at the U.S. Maritime Administration Workshop on Maritime Energy and Clean Emissions, January 2002, http://www.marad.dot.gov/NMREC/conferences_workshops/jan%2029-30%202002/hogo.pdf. Last accessed May 8, 2005. Carl Moyer Program 2004 Guidelines, available online at http://www.ncuaqmd.org/marine_vessel2004guidelines.pdf. Last accessed May 2, 2005

[48] Port of Los Angeles, News Release, "Board of Harbor Commissioners Approve First-Ever Port of Los Angeles Rail Policy," August 13, 2004. See http://www.ewire.com/display.cfm/Wire_ID/2261. Last accessed May 3, 2005

[49] Los Angeles Times, "New Hybrid Locomotive's Emissions Are Clean As A Whistle," March 25, 2005.

[50] EPA, "Case Study: Chicago Locomotive Idle Reduction Project," March, 2004, EPA420-R-04-003. See http://www.epa.gov/smartway/documents/420r04003.pdf. Last accessed May 3, 2005.

Appendix A

[1] U.S. Department of Health and Human Services, "Tenth Report on Carcinogens," National Toxicology Program, Research Triangle Park, NC, 2002. See http://ehp.niehs.nih.gov/roc/tenth/profiles/s069dies.pdf. Last accessed May 2, 2005

[2] California Air Resources Board, Emissions Inventory 1995, Technical Support Division, October 1997.

[3] U.S. Environmental Protection Agency, "1970 - 2002 Average annual emissions, all criteria pollutants," 2005. See http://www.epa.gov/ttn/chief/trends/trends02/trendsreportallpollutants010505.xls. Last accessed June 10, 2005.

[4] Ibid.

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

[6] U.S. DOE Energy Information Administration, "Emissions of Greenhouse Gases in the United States 2003," DOE/EIA-0573(2003), December 2004. See http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html. Last accessed May 2, 2005

Appendix B

[1] EPA (2004a), *Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines,* EPA420-R-04-007 (May 2004).

[2] California Air Resources Board, *Summary of Products That Are Reported to Reduce Particulate Emissions From Diesel-Fueled Engines.* Report Appendix IX, Oct. 2000. See http://www.epa.gov/otaq/retrofit/documents/meca1.pdf. Last accessed on April 5, 2005.

[3] Manufacturers of Emission Controls Association, http://www.meca.org/jahia/Jahia/engineName/filemanager/pid/229/retrofitfact.PDF?actionreq=actionFileDownload&fileItem=214. Last accessed on April 4, 2005.

[4] U.S. EPA, National Emission Inventory (NEI), Emission Factor and Inventory Group, Office of Air Quality Planning and Standards, January 2005.

[5] This analysis is based on the EPA Regulatory Analysis for proposed nonroad diesel rule (preliminary scenario), in order to avoid the scaling adjustments EPA applied to the final nonroad diesel rule.

[6] Smith, Cowan, Sensenig, and Catlin. "Health Spending Growth Slows in 2003." *Health Affairs,* 24:1 (2005).

[7] Heffler, Smith, Keehan, Borger, Clemeus, and Truffer. "U.S. Health Spending Projections for 2004-201," *Health Affairs,* February 23, 2005.

[8] Blue Chip consensus projection of annual consumer price index for 2007–2011. Blue Chip Economic Indicators, March 10, 2005.

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