

Cleaner Diesel Handbook



BRING CLEANER FUEL AND DIESEL RETROFITS
INTO YOUR NEIGHBORHOOD

APRIL 2005

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ENVIRONMENTAL DEFENSE

finding the ways that work

Successes and regional programs

A variety of regional programs have proven successful at reducing harmful diesel pollution. This section of the handbook provides examples of voluntary government or private sector leadership in retrofitting construction equipment, including: New York City's efforts at the World Trade Center and through Local Law 77, Boston's Big Dig Project, Connecticut's New Haven Harbor Crossing Corridor Improvement Program, the Port of Houston Retrofit Program and retrofits at Washington's Puget Sound. Additionally, this section examines examples of successful economic or market incentive programs that provide financial support for cleaner technologies or fuels, such as the Texas Emissions Reduction Plan, the Carl Moyer Program in California, or the EPA Voluntary Diesel Retrofit Program. The diversity of programs described reflects the varying needs of individual projects with respect to equipment, location, fuel availability and other related factors. When planning a retrofit project, it is always important to take individual situation characteristics into account.

"Best available retrofit technologies": New York City

New York City has demonstrated a strong commitment to reducing pollution from diesel engines. This case study discusses three NYC projects:

- the 7 World Trade Center Diesel Emission Reduction project,
- lower Manhattan redevelopment construction commitments, and
- NYC's Local Law 77.

7 WORLD TRADE CENTER SITE³⁴

The Clean Air Communities Diesel Emissions Reduction Project at 7 World Trade Center is the first public-private endeavor of its kind in the city. As former Northeast States for Coordinated Air Use Management (NESCAUM) Executive Director, Ken Colburn stated, "through the application of advanced emission control technology and the use of ultra low sulfur diesel fuel, this Clean Air Communities initiative demonstrates that innovative, clean air progress is possible even at large-scale urban construction sites across the nation."³⁵

In October of 2002, the site converted to ULSD for all equipment. Six pieces of construction equipment have already been retrofitted, and one electric crane is being used in lieu of the typical diesel engine crane technology. It is important to note that these strategies target PM, HC, and CO reductions, not NO_x.

LOWER MANHATTAN REDEVELOPMENT³⁶

Lower Manhattan is a thriving mix of apartments, art galleries, shops and restaurants. More than 4,000 children live throughout lower Manhattan in neighborhoods as diverse as TriBeCa, Chinatown and Battery Park City. With the rebuilding of the World Trade Center site, lower Manhattan will become one of the nation's largest construction sites, teeming with diesel engines. These engines will be operating just steps from school, playgrounds, parks, homes and offices.

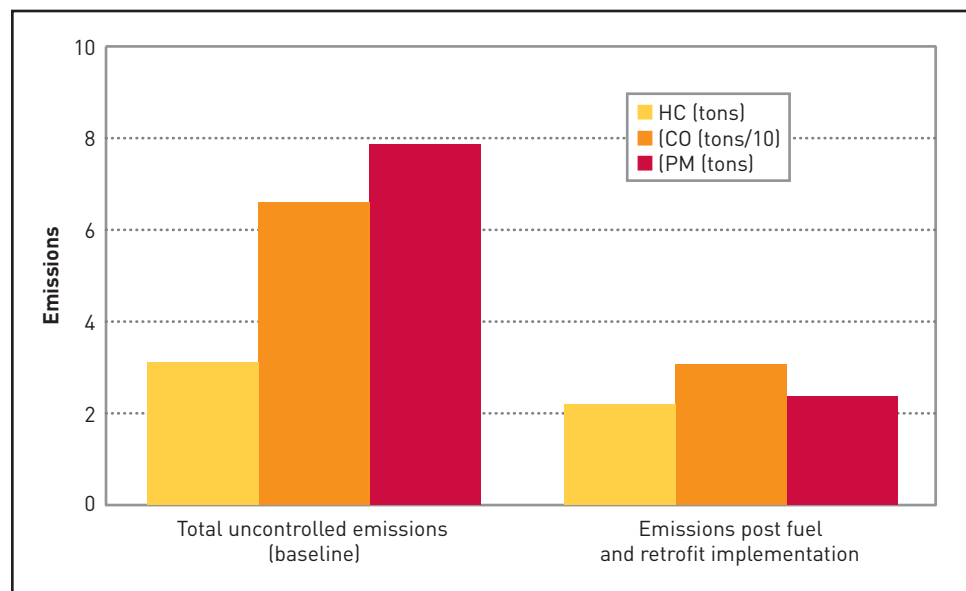
Governor Pataki and New York City have pledged to use the best available retrofits and cleaner diesel fuel in all of the reconstruction efforts. In 2002,

TABLE 3
7 World Trade Center retrofits

Date	Equipment	Retrofit technology
March 2003	Stationary Generator Excavator (CAT 245D, 14.7 l) Excavator (Komatsu PC200, 5.9 l)	DOC DOC DOC
January 2004	Stationary Generator (Rudox, 125 kw, 6.8 l)	Active DPF (Rypos RT500)
May and June 2004	A two-stroke and a four-stroke crane	Metallic High Performance DOC Clean Cat® known by the trade name of “diesel particulate reactors” (by Environmental Solutions World-wide, Inc.)
Pending	The site has plans to retrofit one more piece of equipment, a concrete pump, with a DOC. Rather than purchasing a new DOC, the retrofit will reuse a high-efficiency DOC from one of the cranes after crane use is finished.	

Source: Information provided by Glenn Goldstein at NESCAUM.

FIGURE 5
Total emissions reductions for 7 World Trade Center project



Courtesy of NESCAUM. Includes emissions from equipment that was not retrofit.

Governor Pataki committed to the use of ULSD and best-available retrofits in all state-controlled lower Manhattan construction projects, including at the World Trade Center site. The New York State Assembly and Senate followed Governor Pataki’s lead and passed legislation on June 22, 2004 codifying Governor Pataki’s commitment.³⁷ The law was unanimously approved in both the

House and the Senate and was recently signed into effect by the governor.³⁸ It requires contractors and subcontractors using diesel-powered nonroad vehicles with an engine horsepower rating of 60 HP and above to use only ULSD and to retrofit, where practicable, their equipment with oxidation catalysts, particulate filters or technology with “comparable or better effectiveness.”³⁹

The pollution reduction efforts at 7 World Trade Center have been paralleled at other redevelopment sites in lower Manhattan. In the PATH reconstruction project, for example, three pieces of construction equipment were chosen for retrofits: a Caterpillar XQ2000 Genset and two Caterpillar 966G TG-22 Loaders. Caterpillar, the original manufacturer of all of the pieces of equipment, was chosen to perform the retrofits.

Caterpillar chose to utilize a passive DPF, the CRT™, manufactured by Johnson Matthey. The CRT™ particulate filter is a patented emissions control technology that contains both a platinum oxidation catalyst and a particulate filter. Caterpillar specifies the minimum exhaust temperature must be at least 260°C for at least 40% of the operating time. Though loaders met these minimum requirements, a detailed engineering analysis on the generator's exhaust temperature found that it was an unsuitable candidate for a DPF. The generator was only being used consistently at approximately 20% of its rate and thus lacked sufficient exhaust temperature.

In August of 2003, H.O. Penn (Caterpillar's local dealership) and Caterpillar design engineers installed the DPFs on the two 966G Loaders. The installation process took eight to ten hours, which was approximately double the expected installation time. This delay can probably be attributed to these retrofits being the first installations of this kind performed by H.O. Penn as well as the need to modify several brackets/components during installation. During the emissions testing, the time required to remove the original muffler and replace it with the DPF was cut in half.

One concern about using DPF technology is failure of the DPF to regenerate, which could lead to excessive

engine backpressure. Backpressure must be checked so that it does not increase to levels that may ultimately damage the engine. For this reason, Caterpillar decided to provide an integrated exhaust backpressure alarm with the retrofits to alert the driver if the backpressure is too much. The alarm, mounted in the cab of the loader, is both visual and audible. If a pre-specified backpressure is exceeded for more than a set time interval the alarm lights up.

The installed cost of the DPFs for the wheel loaders was approximately \$15,000 each. This cost is probably higher than the future cost of retrofits of this type because this was the first installation on a Caterpillar 966G loader for both Caterpillar and H.O. Penn. After the first few installations, labor efficiencies are typically realized, as evidenced by the decreased installation time from the initial installation to the emissions testing installation. Further, as market demand increases, capital costs are expected to decrease. Additional project costs came from the April 2005 price premium of \$0.01–\$0.18 per gallon of ULSD in the New York City area. The use of ULSD is not expected to change maintenance schedules or cost, however, using DPFs is expected to slightly increase maintenance responsibilities and cost. Specifically, the filter technology must be cleaned to maintain emissions reduction benefits. A cleaning contract was not negotiated for this project, but other negotiated contract prices in the New York City area range from \$300 to \$500 per cleaning event. The DPFs have not yet been in service for a year, and have experienced no operational problems.

To establish the emissions reduction potential of the different strategies (ULSD vs. ULSD/DPF), emissions testing was performed using two different types of portable emissions monitoring systems: the Clean Air Technologies

Construction at the World Trade Center site.



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International Montana system and the Environment Canada DOES2 system. Emissions testing was conducted for two weeks between September and October of 2003; significant PM emissions reductions were documented. Both monitoring systems identified PM emissions reductions of 15 to 20% for the use of ULSD alone, and of greater than 90% when ULSD was combined with the DPF. Additionally, the use of the DPF also produced significant CO emissions reductions. The switch to ULSD alone produced CO emissions reductions in the range of 1 to 10%, and more than 85% reductions were achieved when the DPF technology was used with ULSD.⁴⁰

NEW YORK CITY LOCAL LAW 77
Recently, New York City committed to emissions reduction measures for all city-funded construction. New York City Local Law 77 calls on New York City to use clean fuels and advanced emissions-control technologies in all city construction fleets and contracts. The law requires two fundamental

steps.⁴¹ First, it requires the use of ULSD with a maximum sulfur content of 15 ppm in all city contracts, on a schedule set forth in the law. Second, it requires use of “best available” emissions control technology for any class of engine to which the law applies.

Local Law 77 provides a high standard for what shall constitute best available technology, calling on the City to use technologies that reduce both fine particulate matter (PM) and oxides of nitrogen (NO_x). Specifically, Local Law 77 requires that agencies 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.”⁴² The DEP recently promulgated rules defining “best available technology.”⁴³

Retrofits and ULSD have been tested at the 7 World Trade Center site, incorporated into Lower Manhattan Development Corporation design guidelines, and now every Environmental Impact Statement for major reconstruction projects in lower Manhattan, from the Fulton Street transit center to Route

Even private NY contractors have joined the diesel retrofit effort. After Pavarini-McGovern Construction Company was found in violation of a local emissions regulation, they retrofit a 1971 380 HP crane with a DOC and committed to using the fuel-borne catalyst Platinum Plus.

9A, has committed to using advanced retrofits in their environmental impact statements. For example, the Fulton Street Transit Center draft environmental impact statement requires the use of Tier 2 compliant equipment with PM emissions reductions at 85%.⁴⁴ Additionally, many projects in lower Manhattan are already moving ahead with emissions-reduction strategies based on a wide range of technologies.

The Big Dig⁴⁵

The Central Artery Project in Boston, also known as the “Big Dig,” has built 161 lane miles of highway in a 7.5-mile

corridor directly through the middle of densely populated downtown. The project, which began in September 1991 and is currently scheduled to be substantially completed by the end of 2005,⁴⁶ presented an historic opportunity to test and demonstrate the feasibility of pollution control retrofits. Use of these retrofits helps to minimize the impact of such a large-scale project by reducing air pollution and lessening the health impact of a major construction project on workers, neighborhoods and regional air quality.

The Massachusetts Turnpike Authority (MTA) in collaboration with the Massachusetts Department of Environmental Protection (DEP) and NESCAUM, chose to retrofit construction equipment with diesel oxidation catalysts. Although other technologies achieve higher particulate reduction rates than DOCs, the MTA preferred DOCs for several reasons—primarily because the very clean diesel fuel (15 ppm of sulfur or less) needed to operate other technologies was not available at the time the Big Dig began.

Retrofit requirements were incorporated into Big Dig construction contracts.



MASSACHUSETTS TURNPIKE AUTHORITY

The Big Dig retrofit project has resulted in the installation of DOCs on approximately 200 pieces of construction equipment—this includes small in-tunnel cranes,⁴⁷ lifts, excavators, bulldozers, generators and compressors. This effort will achieve air emissions reductions that are the equivalent of removing 1,300 diesel buses off of Boston streets for a full year.⁴⁸

The Big Dig retrofit project is a true success: **No adverse operational problems or additional maintenance costs have been experienced by Big Dig construction equipment retrofitted with DOCs.**⁴⁹ Additionally, preliminary estimates of area-wide emissions reductions from the retrofitted equipment amount to approximately 36 tons per year for carbon monoxide, 12 tons per year of hydrocarbons, and 3 tons per year of PM.⁵⁰

The Massachusetts Highway Department provided funding to contractors to purchase the emissions control devices. According to Alex Kasprak, Environmental Engineer, Massachusetts Turnpike Authority, one of the lessons learned from the Big Dig project is that it is best to include the requirement for emissions control equipment as part of the contract's bid package. By doing so, the cost of the retrofit equipment can be included as part of the overall contract cost. This will also ensure that the maximum number of offroad pieces of equipment can be retrofitted.⁵¹ Overall, the Big Dig retrofit program is now being used as a model by regulatory agencies to encourage other construction projects to utilize retrofitted diesel equipment.⁵²

I-95 New Haven Harbor Crossing Corridor Improvement (NHCC Project)⁵³

Eighty-three diesel oxidation catalysts have successfully been installed at the Connecticut NHCC project. In addition, construction contractors have volunteered to use low sulfur diesel (500 ppm sulfur content) on all their nonroad equipment. The NHCC project is part of Connecticut's Clean Air Construction Initiative and was launched to protect laborers as well as residents from harmful construction emissions along a densely populated corridor. Construction began in 2001.

The Connecticut Clean Air Initiative was a mutual effort of the Connecticut Department of Transportation (ConnDOT), the Connecticut Department of Environmental Protection, the Connecticut Department of Motor Vehicles, and the Connecticut Construction Industry Association to come up with real-world solutions to air quality problems. With compromise, a contract specification was evolved from the above mentioned agencies to improve the quality of life through this long duration construction project.

ConnDOT is requiring all contractors and subcontractors to take part in the Connecticut Clean Air Construction Initiative. The cost to purchase the DOCs and the cleaner fuels was included in the overall contract cost, as bid by each contractor. At present, all contractors have decided to install DOCs. Although other technologies achieve higher particulate reduction rates than DOCs, they were preferred primarily because low sulfur diesel fuel

“The Big Dig diesel construction retrofit program has proven that retrofitting construction equipment with DOCs is very feasible, and provides beneficial air quality improvements in terms of emission reduction and odor control.”

—Alex Kasprak, Environmental Engineer, Massachusetts Turnpike Authority, CA/T Project

“I am very proud of Connecticut’s success in this Clean Air Construction Initiative. The State of Connecticut’s various Departments and the Connecticut Construction Industry Association (CCIA) worked and are still working to benefit the people of Connecticut by trying to improve the quality of life in locations where transportation projects are occurring. We are sensitive to those that live or work in an area where construction is going on, day after day, and how it affects those people’s lives. This Initiative is a step in the right direction. As technologies improve, greater air quality can be achieved.”

—Donna Weaver, Transportation Planner, Office of Environmental Planning, Connecticut Department of Transportation

(500 ppm sulfur content), rather than the ULSD (15 ppm of sulfur or less) needed to operate other technologies, was used for the project. Estimates for reduced emissions from the program are 20 tons per year for carbon monoxide, 2 tons per year for fine particulate matter (with clean fuels or oxidation catalysts) and 8 tons per year for hydrocarbons (with oxidation catalysts only).⁵⁴

Because of the success of the Connecticut Clean Air Initiative on ConnDOT projects, other agencies such as the Connecticut Department of Public Works and the Connecticut Department of Economic and Community Development are also requiring their construction contractors to follow the ConnDOT specification. Three or four diesel oxidation catalysts have been installed on two projects as a result.

Port of Houston⁵⁵

The Port of Houston is the sixth largest port in the world,⁵⁶ and a significant contributor to NO_x emissions in the eight counties of the Houston-Galveston area. All eight counties in this region fail to comply with EPA’s health-based eight-hour ozone standards.⁵⁷ Although the Port of Houston Authority is not the largest contributor to emissions in the area, they have become the region’s leader in emissions reduction activities and commitments.

Through demonstration testing of the alternative fuel PuriNOxTM on rubber-tire

gantry crane with a 550 horse-power engine, the Port of Houston Authority (PHA) has reduced NO_x emissions by 25% and PM emissions by 50%.⁵⁸ In September of 2003, the Port Authority converted 39 yard tractors and yard cranes to PuriNOx and enacted the requirement that any new equipment purchased be able to use the technology.⁵⁹ Approximately 49 pieces of cargo-handling equipment are currently operating on PuriNOx for a NO_x emissions reduction of approximately 21 tons per year at a total cost of \$216,000. According to Roger Guenther, container facilities manager at Barbour’s Cut Container Terminal, “It’s just a different fuel, nothing special has to be done to the equipment. I could put diesel back in any of the offroad vehicles and they would run just fine. I can’t tell any difference from one to the other.”⁶⁰

The PHA also applied for and received \$337,000 in state funding (see the Texas Emissions Reduction Program section below) to replace two Fireboat FARNSWORTH propulsion engines with engines that produced 5.6 tons less NO_x per year.⁶¹ Additionally, the PHA has purchased several new yard tractors and container handlers with clean engine technology, resulting in NO_x emissions reductions of 6.9 tons per year at a cost of \$21,500.⁶² Further, the PHA purchased 33 ultra-low emissions vehicles or propane vehicles for their onroad fleet.⁶³ The PHA plans to extend its retrofit program (which involves either retrofitting vehicles with oxidation catalysts,



New equipment purchased by the Port of Houston Authority must run on PuriNOx, an alternative fuel that reduces NO_x emissions.

switching their fuel use to PuriNO_x, or both) to between 50 and 250 vehicles.⁶⁴ In total, the PHA has reduced NO_x emissions by 33.5 tons per year with the assistance of \$574,000 in TERP funding.

Puget Sound in Washington⁶⁵

Washington State's Puget Sound Clean Air Agency has formed a coalition, known as Diesel Solutions®, to dramatically reduce diesel engine pollution in the region. The first step in this program was to work with Conoco/Phillips and U.S. Oil to ensure that ULSD was locally available. Since ULSD was made available, 800 school buses have been retrofitted, mostly with DOCs.

Approximately two dozen pilot projects used DPFs for the retrofits. The average retrofit cost has been between

\$1,200 and \$8,000 per vehicle, and projects are financed through a state-wide retrofit program developed as part of the EPA Voluntary Diesel Retrofit Program. The next step in the program is to retrofit diesel engine construction equipment with pollution control technology. As part of this effort, the Puget Sound Clean Air Agency has requested retrofits in their comments on local project environmental impact statements, and has been speaking with a number of construction companies.⁶⁶

The Texas Emissions Reduction Program⁶⁷

In 2001, the Texas State Legislature established the Texas Emissions Reduction Program, enacted through Senate Bill (SB) 5. The goals of the TERP, as stated in SB 5, are to: "assure that the air in the state is safe to breathe and meets minimum federal standards established under the Federal Clean Air Act (42. U.S.C. Section 4707); develop multi-pollutant approaches to solving the state's environmental problems; and adequately fund research and development that will make the state a leader in new technologies that can solve the state's environmental problems while creating new business and industry in the state."⁶⁸

The TERP covers 41 counties in the state where air quality violates or is close to violating EPA standards.⁶⁹ Projects are eligible for financial assistance through a number of programs, including: the Emissions Reduction Initiative Grants Program, which offers incremental funding for NO_x emissions reduction activities; the Small Business Program, which offers grants to small businesses for pollution reduction measures; the Heavy-Duty Motor Vehicle Purchase or Lease Incentive Program, which allows the Texas Com-

mission on Environmental Quality to reimburse a purchaser or lessee of a new onroad heavy-duty vehicle for the difference in price between that vehicle or a higher-emitting diesel-powered vehicle; and the Light-Duty Motor Vehicle Purchase or Lease Incentive Program, which (though currently unfunded) is intended to provide financial incentives for the purchase of light-duty motor vehicles that are EPA-certified at a lower NO_x emissions standard than regular light-duty motor vehicles.

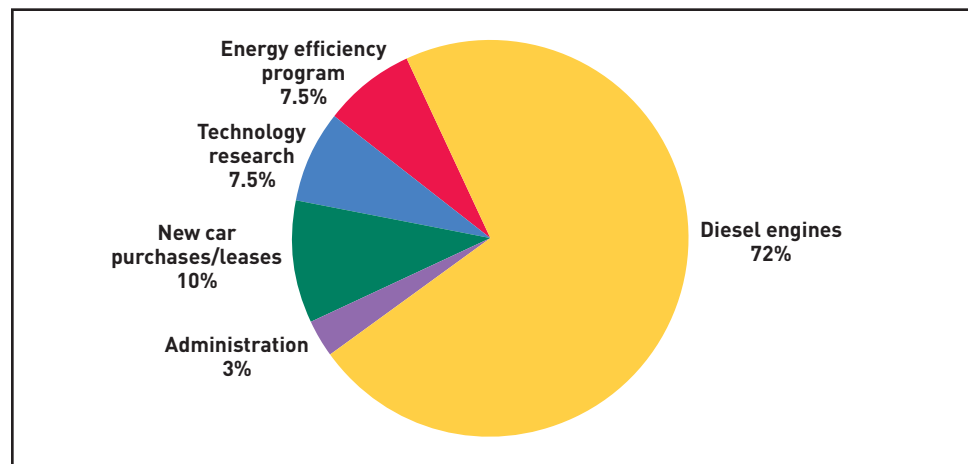
TERP will offer a total of approximately \$130 million in funding for emissions reductions programs each year over the next three years.⁷⁰

In the 2004 grant application period, the Texas Commission on Environmental Quality had approximately \$127.5 million available for grant programs. Eligible projects include new purchases, replacements, retrofits, repowers, and refueling projects.⁷¹ The projects from the first round of grants are expected to reduce NO_x emissions by over 3,500 tons over their lifetime, at an average cost of about \$5,175 per

ton reduction.⁷² The projects funded by the second round of these grants are expected to reduce NO_x emissions by almost 13,600 tons over the life of the projects, at an average cost of \$5,960 per ton reduction.⁷³ In 2004, the average cost per ton reduction of NO_x emissions was approximately \$5,800. This represents a lower average cost per ton NO_x emissions reduction than achieved by 2002-2003 grants funds, which offered over \$28 million in funding to reduce NO_x emissions by over 4,100 tons over the life of the projects at an average cost of approximately \$8,362 per ton.⁷⁴ The Emissions Reduction Grant Incentive Program NO_x cost-effective criteria will be capped at \$7,000 per ton reduction in 2005.⁷⁵ Grant award details are available at: <http://www.tnrcc.state.tx.us/oprd/sips/terp.html> and more information can be found at: <http://www.tnrcc.state.tx.us/oprd/sips/terp.html>.

California's Carl Moyer Program⁷⁶
 The Carl Moyer Memorial Air Quality Standards Attainment Program

FIGURE 6
TERP funding distribution, 2001 (approximately \$130 million)



When the Texas Emissions Reduction Plan is fully implemented, the majority of funds will go toward replacing older diesel engines with cleaner-burning models.

Source: TNRCC. "Clean Air Incentives." Natural Outlook, Fall 2001. Online resource, available at: http://www.tceq.state.tx.us/assets/public/comm_exec/pubs/pd/020/01-04/clean_air.pdf Last accessed 04/12/05.

provides funds on an incentive basis for the incremental cost of cleaner than required engines and equipment. Funding is available for nonroad equipment 50 hp or greater. Eligible projects include cleaner onroad, offroad, marine, locomotive and stationary agricultural pump engines, as well as forklifts, airport ground support equipment, and auxiliary power units. The program achieves near-term reductions in NO_x emissions, which are necessary for California to meet its clean air commitments under the State Implementation Plan. In addition, local air districts use these NO_x emissions reductions to meet commitments in their conformity plans, thus preventing the loss of federal funding for local areas throughout California. The program also seeks to reduce particulate matter (PM) and hydrocarbons.

The California Air Resources Board (CARB) is responsible for the development and oversight of the majority of the Carl Moyer Program. CARB distributes Carl Moyer funding to California's 35 local air districts, which then screen applications and distribute the funding to diesel engine owners. The program has provided grants for projects such as repowering nonroad equipment, agricultural irrigation pumps, sweepers, tractors and marine vessels. It has also helped to fund the purchase of new natural gas refuse trucks and buses.

Governor Schwarzenegger recently signed AB923, which authorized increasing motor vehicle registration fees and tire fees to support programs, such as the Carl Moyer Program, that reduce air pollution. Through year six of the Carl Moyer Program, it had received approximately \$154 million dollars in total funding.⁷⁷ With its recent re-

authorization, up to \$140 million a year of incentive funding is available for air pollution mitigation technologies.⁷⁸ More information is available on the Carl Moyer Program web site at: <http://www.arb.ca.gov/msprog/moyer/moyer.htm>.

The EPA Voluntary Diesel Retrofit Program

The Environmental Protection Agency, through the Office of Transportation and Air Quality, has developed a program to encourage voluntary diesel retrofits. This program uses economic incentives, which can be applied at the federal, regional, state, and local levels, to produce emissions reductions through the use of pollution control technology. One tool used by this program is grants, which have been awarded to various parties to help fund the cost of retrofit projects. Information on recent grants is available on the EPA Voluntary Diesel Retrofit Program web site.

EPA is also in the process of developing a policy to allow diesel engine retrofits to count as credits that can be traded or used to offset stationary source emissions. As a corollary to this program, EPA has developed a verification program to ensure that pollution control technology providers advertised emissions reductions. More information on the EPA verification process is available in the "Onroad and Nonroad EPA/CARB Verification" section of this handbook. Further information on the Voluntary Diesel Retrofit Program, verified technologies, and financial incentives for the use of pollution control technology can be found on the EPA Voluntary Diesel Retrofit web site, at: <http://www.epa.gov/otaq/retrofit/index.htm>.