III. RETROFIT PROGRAM TYPES AND EXPERIENCE

A. Program Types

Interest in reducing emissions from diesel engines has existed for decades. In the 1980s, alternative fuels such as propane and compressed natural gas were used in compression ignition engines as an alternative to diesel fuel to reduce petroleum consumption and exhaust emissions. As early as the 1960s and 1970s, DOCs for occupational health reasons were retrofitted on offroad engines operating in enclosed areas such as mines and warehouses. In the 1980s and 1990s emission limits were established for new on-road diesel engines in the U.S. and elsewhere and strategies to reduce emissions from existing diesel engines began to emerge.

By the 2000s, comprehensive, stringent emissions standards for both new on-road and offroad engines had been adopted in the U.S., Europe and Japan. Also, technology-, fuel- and operational-based strategies to reduce diesel emissions from existing engines continued to emerge and the number of on-road and offroad engine applications continued to grow. Today, there are literally thousands of programs in place or being implemented to reduce emissions from existing diesel engines worldwide.

Retrofit programs can be divided into two categories – mandatory and voluntary. Both types of programs are being applied to on-road and offroad engines.

Mandatory programs are created by, and implemented in accordance with, statutory and/or regulatory authority. These programs typically: 1) identify fleet and/or engine applications that are covered by the requirements, 2) specify the emission reductions required (often stated as a percent reduction) and/or technology type (either a specific technology such as DOCs or a requirement to use best available retrofit technology, or BART), 3) establish other compliance requirements such as the sulfur level in diesel fuel, and 4) impose penalties if the requirements are violated.

Voluntary programs are not based on a requirement for the end-user to reduce emissions, but rather on a voluntary commitment to act to achieve a specified goal, such as protecting health and/or reducing visibility impairment. These programs typically include some type of incentive to take action. The incentives can take many forms including:

- Local, state, regional or federal funding.
- Private sector funding including, Supplemental Environmental Projects.
- Tax incentives.
- SIP credits.
- Mobile source emission reduction credits.
- Regulatory flexibility or relief.

- Preferences for contract bid proposals containing provisions for reduced emissions.
- Differentiated port fees.
- Environmental stewardship ("good neighbor").
- Preferential treatment for clean vehicles/equipment (e.g., preferential parking, road toll reductions and/or express toll lanes).
- Direct benefits from fuel economy savings or other operational elements (e.g. idling reduction).

These incentives and funding issues are discussed in more detail in Section IV of this volume.

Numerous examples of voluntary programs designed to reduce diesel emissions from existing engines exist in the U.S. including EPA's Clean Diesel Campaign (www.epa.gov/cleandiesel), the West Coast Collaborative (WCC) (www.westcoastdiesel.org), TERP (www.tnrcc.state.tx.us/oprd/sips/terp.html), the Puget Sound Diesel Solutions Program (www.pscleanair.org/dieselsolutions), Washington's Clean School Bus program, (www.ecy.wa.gov/biblio/0402029.html) and many others.

B. Mandatory Programs

OVERVIEW

Mandatory programs can be divided into two categories: 1) programs that establish requirements for specific emission reductions for specific categories of engine applications and 2) programs that establish contract specifications for clean diesel engines in publicly funded projects (e.g., highway construction). Examples of the first type include the California DRRP, the Switzerland construction equipment retrofit program, the New Jersey Retrofit Program, and the New York City construction equipment retrofit program (Local Law #77). Examples of the latter include the I-95 New Haven Crossing Corridor Improvement Program (the Q Bridge Project) and the Massachusetts Artery/Tunnel Project (the "Big Dig" project). These projects and others are discussed in the sections below.

In establishing a mandatory program, a number of issues must be considered, including:

- Authority to establish a mandatory program.
- Adequate public/political support to establish a mandatory program.
- Adequate resources to implement and enforce the program.
- Category of vehicles or equipment to be covered by the program.

- Compliance strategies to be employed and degree of compliance flexibility.
- Technology approval process.
- Enforcement mechanism to be employed.
- Penalties.

Authority to Establish a Mandatory Program

The legal issues associated with state and local governments establishing mandatory programs including the issue of federal preemption is discussed in Section II above. Even if federal preemption is not an issue, the state or local agency must have the legal authority to establish a program. This may require passage of new legislation and/or adoption of regulations. In some cases, existing authority can be used. For example, in the Massachusetts Tunnel Artery program, an existing requirement that steps be taken to mitigate odor was used to establish the requirement that DOCs be used on construction equipment.

Adequate Public and Political Support for Adoption of a Mandatory Program

Building the public and political support for a mandatory program can be both challenging and time-consuming. The statutory or regulatory language must be drafted, the need for such a program must be well documented, and a rigorous public process must be followed. This process can often take several years. For example, New Jersey first began evaluating such legislation in 2003 and legislation along with a public referendum to move forward occurred in the fall of 2005. Also, it is important to engage and maintain a dialog with the fleets to be regulated.

Adequate Resources to Implement and Enforce the Program

As part of the assessment to proceed with adopting and implementing a mandatory program, the need for program and the availability of human and financial resources to administer and enforce the program must be considered. A lack of adequate resources will lead to a less than effective program.

Categories of Vehicles/Equipment to Be Covered by the Program

In assessing which applications (e.g., transit buses, construction equipment) are to be covered by the program, a number of factors must be considered including 1) the applications' contribution to ambient pollution and human exposure, 2) the suitability of retrofits to the applications being considered, 3) the cost effectiveness of a retrofit strategy, and 4) the ability to cover the cost of the retrofits (by the fleet operator or others).

Compliance Strategies to Be Employed and Degree of Compliance Flexibility

Typically, the emission reduction requirements are based on application of the BART. In some cases, such as the Massachusetts Tunnel/Artery Project, DOCs were identified as the

technology to be used. In other programs, such as the California DRRP, a specific level of emission control is identified and any technology verified to that level may be utilized. Compliance flexibility is often needed to account for inequities in the marketplace, such as small vs. large fleets, and to allow adequate time to comply in the most cost effective manner for a given fleet.

Technology Approval Process

To be eligible for use in meeting mandatory program requirements a given technology must go through an approval process. EPA and CARB have established a rigorous verification process for retrofit technologies to be used in their programs. Other programs can address this issue by establishing an approval process that accepts either CARB or U.S. EPA verified products.

Enforcement Mechanism to Employed

An important element of any mandatory program is to have in place a means for determining compliance with the retrofit requirements. These enforcement mechanisms can include periodic reporting requirements coupled with field inspections and/or emission testing.

Compliance Penalties

Establishing penalties to encourage compliance is an essential element of a mandatory program. For example, under New York City Local law #77 a contractor found in noncompliance is subject to a civil penalty between $1,000 and $10,000 plus twice the money saved by failure to comply. Contractors making false claims are subject to even harsher penalties.

EXAMPLES OF MANDATORY PROGRAMS

California Diesel Risk Reduction Plan (DRRP)

Background and Legal Authority - In 1998, California's Air Resources Board identified diesel PM emissions as a toxic air contaminant (TAC). Under California law, once a determination was made that diesel PM emissions were a TAC, CARB was required to development and implement a program to reduce the risk of exposure to diesel PM. In 2000, CARB adopted its Diesel Risk Reduction Plan (DRRP) designed to reduce diesel PM emissions by 75% by 2010 and 85% by 2020 (See www.arb.ca.gov/diesel.dieselrrp.htm). The program identified a number of initiatives including more stringent standards for new on- and offroad engines, cleaner diesel fuel (less than 15 ppm sulfur), actions to ensure that in-use vehicles/equipment do not exceed applicable standards, and the control/retrofit of existing on-road and offroad engines.

Retrofit Technology Verification Process - An important element of the DRRP is the retrofit technology verification program under which retrofit technologies such as DPFs, SCR, and fuel emulsions can be approved for use in DRRP regulatory programs. The CARB verification program establishes three levels to which technologies can be approved under a

rigorous verification process: Level 3: PM reductions of 85% or more or less than 0.01 g/bhp-hr; Level 2: PM reductions of 50% or more; and Level 1: PM reductions of 25% or more, as well as an optional 15% minimum NO_x reduction category. A current list of verified products can be found at CARB's verification website at www.arb.ca.gov/diesel/verdev/verdev.htm.

All retrofit technologies used for compliance with the California program must be verified by CARB. Under a Memorandum of Understanding between EPA and ARB, technologies verified under the EPA program in certain instances are also eligible for use in California. The CARB verification program includes several elements including 1) a requirement for product emission testing and a durability demonstration, 2) warranty requirements, 3) in-use testing requirements, and 4) provisions for "delisting" for any violation of the verification requirements (e.g., failure to honor a legitimate warranty claim or failure to demonstrate compliance in-use).

In-Use Emission Reduction Regulations – CARB has adopted a number of individual rules covering both on-road and offroad engines as shown in Table 3-1

Table 3-1, Adopted CARB In-Use Regulations

Engine Application Category	Number of Engines Affected
Transit Buses	8,000
Refuse Trucks	13,000
Stationary Engines	26,000
Transportation Refrigeration Units	40,000
Portable Engines (cranes, drilling equipment, portable pumps)	35,000
Idling School Buses	26,000
Idling Commercial Vehicles	409,000
Intrastate Locomotive and Harbor Craft Fuel	5,000

CARB has under development a number of addition in-use regulatory initiatives as shown in Table 3-2.

Table 3-2, Projected Schedule for Adoption of Additional CARB In-Use Regulations

Anticipated Date of Regulation Adoption	Engine Application Category
2005 or later	Transit Fleet Vehicles (Non Urban Buses)
	Public On-Road Fleets & Private Utilities
	Marine (cargo handling equipment, harbor craft, ship auxiliary engines)
	Stationary Agricultural Equipment
2006 or later	Public and Private Offroad Fleets
	Private On-Road Fleets
2007 or later	Agricultural Offroad Equipment

CARB, under the DRRP, has also signed a Memorandum of Understanding (MOU) with the railroads to significantly reduce emissions in rail yards in California. The MOU establishes several important elements including a statewide locomotive idling reduction program, health assessments, evaluation of advanced emission control technologies and remote sensing technologies and enforcement and penalties for noncompliance with the MOU. CARB is currently evaluating modifications to that MOU.

In designing the regulatory programs for existing diesel engines, CARB has employed an approach based on: 1) the use of best available retrofit technology, 2) phase-in of the compliance requirements, and 3) providing compliance flexibility. First, under the best available control technology approach, retrofit (based on the highest applicability level), repowering with a newer engine, replacing an existing vehicle with a new diesel or alternative fuel vehicle, and vehicle retirement are all options. Second, the phase-in dates for compliance are based on such factors as retrofit technology availability, new vehicle availability, and fuel availability (e.g., availability of ULSD). Finally, CARB seeks to provide compliance flexibility to ease the burden of compliance. This compliance flexibility includes allowing additional time to repower if no retrofit technologies are available, recognizing the special needs of small fleets, evaluating different approaches very low usage fleets and considering early compliance credit.

Challenges/Solutions – The CARB DRRP has served as a model for developing and implementing a comprehensive mandatory-based program. In the process, CARB has faced and is addressing a variety of program challenges. These challenges have included 1) the slower than expected development/application of retrofit technology, 2) developing an effective verification process, and 3) building support for the program among the regulated fleets.

While technological progress is being made in expanding the engine applications for using DPF technology, the speed at which this is occurring is slower than CARB anticipated when it adopted the DRRP. In response, CARB has continued to work closely with the technology developers, extend the compliance deadlines for meeting fleet requirements, and provided substantial compliance flexibility to the regulated fleets.

To build support for (or at least diminish opposition to) the regulatory program, CARB has engaged in early and on-going outreach to the affected fleet owners/operators. In addition, CARB has sought to design each fleet rule with the particular issues present in each fleet application. This effort has included extending compliance deadlines and fashioning compliance flexibility.

Switzerland Construction Equipment Retrofit Program

Background and Legal Authority – In 1994, Switzerland classified diesel particulate as a carcinogen. In 1998, the Ordinance on Pollution Control mandated a reduction of diesel PM at construction sites. The ordinance required the use of DPFs achieving a 95% reduction in diesel PM emissions. In 2000, these requirements were extended by the Swiss Environmental Protection Agency (Suva) to cover all underground mining equipment. To date over 7,000 offroad engines, principally used in construction, have been successfully retrofitted with DPFs with an annual failure rate of less than 2%. The goal of the program is to retrofit 15,000 engines and have an annual failure rate of less than 1%. A number of different DPF designs have been

approved for use in the program including both passive systems (e.g. catalyst-based DPFs) and active systems (on-board and off-board external heat regeneration).

Retrofit Technology Verification –The Swiss EPA, beginning in 1998, required that all construction equipment be retrofitted with DPFs capable of achieving at least a 95% reduction in carbon-based PM and a 90% reduction or greater after 2000 hrs of operation. In addition, the verified product must meet a variety of other requirements including 1) opacity limits, 2) no increase in HC, CO or NO_x levels, 3) backpressure limits, 4) have noise attenuation equivalent to the muffler, 5) durability requirements of at least 5,000 hrs, meet safety requirements, and 6) an approved method of ash cleaning and disposal.

The verification process includes both laboratory testing and controlled field testing. The technology must demonstrate compliance with the 95% reduction requirement with a loaded DPF, a new DPF and regenerated DPF, as well as during regeneration. In addition, every DPF-equipped engine is subject to a periodic field inspection using an opacity test (<10%) during free acceleration.

Challenges and Solutions – The Switzerland construction retrofit program is the world's most successful offroad mandatory program in the world. Initially, the failure rate was quite high (10% in 1998), but the annual failure rate fell from 6% in 2000, to about 2% in 2003. Steps taken to reduce the rate of DPF failures in the program included: 1) decertifying DPF designs not meeting the program requirements, 2) introduction of a controlled 2,000 hour field investigation in a typical application, 3) requiring backpressure monitors with at least two alarms, 4) encouraging the deployment of active DPF systems, and 5) requiring DPF manufacturers to collect data on DPF failures and conduct analyses on any defects in design or manufacture.

New York City Fleet Retrofit Program

Background and Legal Authority – In 2002, New York Governor Pataki committed to use cleaner fuels and the best available retrofit technology in all state-controlled lower Manhattan construction projects, including the World Trade Center site. In October 2002, the construction projects at the World Trade Center site converted to ULSD and subsequently, several pieces of construction equipment including two excavators, two tower cranes, and a generator were retrofitted. The New York State legislature in 2004 codified the Governor's commitment.

In December 2003, Local Law #77 was signed into law requiring the phase-in of ULSD and Best Available Technology (BAT) for use in all diesel-powered offroad equipment used in construction projects in New York City. The requirements apply to all diesel offroad engines rated at 50 hp or greater that are owned by, operated by, on behalf of, or leased by a city agency. Some exemptions are provided in the law. The requirements are being phased in with all city-owned, operated, or leased offroad heavy-duty vehicles in lower Manhattan covered in the first phase that took effect in June 19, 2004. The provisions of the law will be fully effective as of December 19, 2005. In April 2005, the New York City Council amended the New York City code to establish similar requirements for city-owned vehicles, vehicles that transport solid waste or recyclable materials, school buses, and sight-seeing buses. These requirements are to be

phased in over time (city-owned vehicles 2007-2012, school buses 2006-2007, refuse/recycle material vehicles 2006, and sight-seeing buses 2007).

Approved Retrofit Technologies – Under the rules adopted in April 2005, BAT is defined as either U.S. EPA or CARB verified technology that achieves the PM reductions at the highest PM reduction classification level for retrofit technologies as shown below:

Level 4 – Strategy reduces diesel particulate matter emissions by 85% or greater or reduces engine emissions to less than or equal to 0.01 grams diesel particulate matter per brake horsepower-hour.

Level 3 – Strategy reduces diesel particulate matter emissions by between 50 and 84%.

Level 2 – Strategy reduces diesel particulate matter emissions by between 25 and 49%.

Level 1 – Strategy reduces diesel particulate matter emissions by between 20 and 24%.

NO_x reductions are sought under the rules. Under the existing Local Law #77, the City commissioner is responsible for developing a list of technologies that meet the BAT requirements. A proposal is being considered to more closely align the requirements for construction equipment with the requirements applicable to other on-road fleets.

Program Implementation – Since the program is just getting underway, implementation experience is limited. The program requires annual reporting requirements. Also penalties are available for violation of the requirements including penalties of $1,000 to $10,000 and fines in the amount of twice the amount of money saved by failing to comply with the requirements or making false claims. The penalty for filling a false claim regarding the use of ULSD or a BAT can reach $20,000.

I-95 New Haven Crossing Corridor Improvement Program (Q-Bridge Project)

Background and Legal Authority – The Connecticut Department of Transportation (ConnDOT) established a provision in the state highway construction contracts requiring all contractors and subcontractors to reduce emissions from diesel-powered construction equipment with engines rated at 60 hp or greater. Initially, the requirement applied to construction on the Q Bridge corridor project (7.2 mile segment of I-95 in New Haven), but the specification has been

extended to other I-95 construction projects as well. Equipment that will be on the construction site for more than 30 days is subject to the requirements. As of early 2005, approximately 85 pieces of equipment have been retrofitted with DOCs.

Approved Technologies – Retrofit technology must be either EPA or CARB verified and must be capable of reducing PM by 20%, CO by 40% and HC by 50%. The contract provision was written so that DOCs and fuel emulsions could be used, but it is worded broadly enough to enable other technologies as well.

Funding – The cost of retrofit technology and clean fuels is included in the contract as incidental costs.

Enforcement Provisions – Contractors must provide a list of existing diesel construction equipment, including equipment that will be retrofitted and/or will use clean fuels. This report must be updated monthly. ConnDOT tracks project equipment on a bi-monthly basis and if it discovers any noncomplying equipment, a Notice of Noncompliance is sent and the contract must remove the equipment from the construction site or bring it into compliance within 24 hours of receipt of the notice. After a 24-hour period, if the noncompliance still exists, payments are withheld for any work on which the noncomplying vehicle was used for the period the equipment was out of compliance.

C. Voluntary Programs

OVERVIEW

In the U.S., literally hundreds of voluntary retrofit initiatives are underway or being planned. The programs and projects vary in size ranging from EPA's nationwide Voluntary Retrofit Program to projects involving retrofits of less than 10 engines in a single fleet. These initiatives include technology-based (e.g., DPF, DOC, SCR, CCV), fuel-based (e.g., ULSD, biodiesel, alternative fuels, diesel emulsions) and/or operation-based (e.g., reduced idling) strategies. The objectives of these program vary. Some programs are designed to demonstrate the applicability and emission control capability of new retrofit technologies, while others are designed to help achieve attainment with applicable NAAQS, reduce exposure to toxic pollutants, and/or protect sensitive populations. Finally, the incentives supporting these various program are varied (e.g., availability of public or private funding, obtaining SIP credits).

The process for developing a voluntary retrofit program is discussed in Section II above. Identifying funding sources and acquiring funds, as well as identifying and utilizing incentives for voluntary programs are discussed in Section IV below. Building support and providing public outreach for voluntary programs are discussed in Section V below.

EXAMPLES OF VOLUNTARY PROGRAMS

Below is a description of various types of voluntary retrofit programs that include strategies for offroad engines. Information on the projects discusses such items as funding sources, incentives employed, technology/strategies employed, and challenges/solutions.

Carl Moyer Program

Overview and Legal Authority – The Carl Moyer Program was established in 1998 by the California legislature and is administered by CARB. The program provides grants throughout California to promote diesel emission reductions. Moyer funds can be used to cover the cost of replacement, repowering, or retrofits of virtually all on- and offroad diesel engines. Until recently, the program focused on NO_x emissions reductions, but changes were enacted by the legislature in 2004 to allow consideration of projects designed to reduce exclusively PM or HC emissions.

During the period between 1998 and 2002, NO_x emissions were reduced from approximately 4,950 on-road and offroad engines (2,870 diesel repowers and 2,080 diesel engines replaced with alternative fueled or electric engines). During that period, CARB estimates that the Program resulted in reduced NO_x emissions of more than 5,100 tons annually at an average cost-effectiveness of approximately $3,000/ton. In addition, CARB estimates that the program has resulted in a reduction of 320 tons of PM emissions annually.

Eligibility Requirements – CARB has established program guidelines and distributes the funds to the California's air quality management districts. The districts in turn are responsible for soliciting proposals and awarding funds in accordance with the CARB guidelines. CARB distributes funds to the air districts based on two criteria: 1) attainment of the federal ozone standard and 2) population. Each district receives a minimum funding allocation currently set at $100,000 annually, which is set to increase to $200,000 in 2006. To ease the financial burden, the state legislature has capped the local matching fund limit at $12 million. Retrofit technologies used in the program must be CARB verified.

As noted, the local air quality districts select projects. The State Legislature has established the following minimum program requirements (the districts can impose more stringent requirements):

- Engine/vehicle replacements must be with newer ones certified to meet more stringent emission standards and retrofit and repower projects must use equipment certified by CARB as achieving at least a 15% reduction in NO_x with no increase in other emissions.

- Project cost-effective threshold or "cap" is $13,600/ton of NO_x removed.

- Projects must have a minimum life of 5 years.

- Equipment/equipment most spend at least 75% of the time (vehicles – miles and equipment – operating hours) in the state for a minimum of 5 years.

Funding – The California legislature allocates funding from the state's general funds and requires a local match of $1 for every $2 of state funds. In 2004, the Legislature provided for additional funding from an adjustment of the tire fee and allowed districts to raise motor vehicle registration fees by $2 to raise matching funds for the program. From 1998 through 2004, the State Legislature allocated approximately $152.5 million for the Program. Funding for the Program is expected to increase significantly in 2005 by up to $140 million annually. During the period 1998 to 2002, the funding distribution by application type was: on-road (45%), agriculture pumps (25%), marine vessels (19%), other offroad (10%), and locomotives (1%).

Program Experience – The Carl Moyer Program was the first large-scale publicly funded program in the U.S. designed to reduce diesel exhaust emissions (initially NO_x only) and the program has been very successful. It has garnered broad support from both the State Legislature and the public and is widely recognized as a highly effective funding program to reduce emissions from existing diesel engines. The program has faced several challenges, including difficulty for some construction companies to commit to the 75% usage requirement and to participate due to the project funding caps. Another challenge has been to insure equitable treatment of small companies.

Texas Emissions Reduction Program

Overview and Legal Authority – The Texas Emission Reduction Program (TERP) was established by the Texas legislature in 2001 (Senate Bill 5) and modified in 2003 (House Bill 1365). The Texas Commission on Air Quality (TCAQ) administers the program. The program establishes incentives for projects to reduce NO_x emissions in 41 Texas counties in nonattainment or near-nonattainment areas. In the first three years of the program, approximately 300 projects were funded (See www.tnrcc.state.tx.us/oprd/sips/terp.htlm).

Eligibility Requirements – The program has establishes a list of eligible projects and general eligibility criteria. Eligible project types include:

- New vehicle/equipment purchases and leases.

- Replacement of old vehicle/equipment with newer models.

- Repowering existing engines.

- Retrofit and add-on devices (technologies such as SCR, EGR, DPFs and fuel emulsions have been employed).

- Infrastructure for idle reduction, electrification systems, and qualifying fuel infrastructure.

The general eligibility criteria include:

- Activity must be at least 25% cleaner for NO_x than baseline vehicle/equipment.
- Grant request must not exceed $7,000/ton.
- Engines and retrofit/add-on devices must be EPA or CARB certified/verified.
- Funded equipment must operate a minimum of 75% in the affected areas for at least 5 years.

Funding – The main source of funding for TERP projects comes from revenues generated from fees and taxes:

- Portion of vehicle title fee - $20 for nonattainment areas; $15 for other areas (70% of revenues generated).
- 2% surcharge for sale, lease, rental, storage and use of heavy-duty diesel offroad equipment (15%).
- 2.5% surcharge for sale, lease or use of pre-1997 heavy-duty vehicles over 14,000 lbs GVWR; 1% for 1997 or later (6%).
- 10% surcharge on registration fees for truck tractors and commercial motor vehicles (6%).
- 10% fee on commercial motor vehicles required to be inspected (3%).

Over the first three years of the program, an estimated $128 million was provided. For the period 2005-2008, an estimated $525 million is expected to be available for projects.

Program Experience – Overall the program has been quite successful. TCAQ officials noted that several factors are needed to insure a successful program, including:

- Developing a good database early in the program.
- Conducting public outreach ("marketing") to promote support and understanding of the project.
- Having adequate resources for the contracting side of the program (contract development, record keeping, monitoring, and auditing).

West Coast Collaborative

Overview – The West Coast Collaborative is a partnership between federal, state, and local governments, the private sector and environmental organizations in California, Oregon,

Idaho, Washington, Alaska, British Columbia and Mexico (see www.westcoastdiesel.org). EPA Region IX and X are taking the lead in coordinating the Collaborative's activities. The goal of the partnership is to leverage significant federal funds (the goal is up to $100 million) with other funding sources to reduce pollution from the most significant diesel sources in the most affected communities and to improve air quality and public health. Originally designed to focus on projects along the Pacific coast, the Collaborative is now extending its area of activity in the U.S. to all states in EPA Regions IX and X. The Collaborative is focusing on variety of diesel applications, including agriculture, construction, locomotive and rail, and marine vessels and ports equipment.

Projects – The Collaborative plans to employ the full range of strategies to reduce emissions from existing diesel engines, including technology-based (e.g., repower, rebuild, retrofit), fuel-based (e.g., ULSD, biodiesel, diesel emulsions, alternative fuels), and operation-based (e.g., electrification, reduced idling).

To date, the Collaborative has initiated a number of projects, including:

- I-5 Truck Idle Reduction Project.
- Locomotive Idle Reduction Project in San Joaquin Valley.
- Clean Diesel Fuel Technology Evaluation for San Francisco Bay Marine Port.
- Oregon Reduced Idling at Truck Stops.
- Princess Cruises Shore Power in Seattle.

Puget Sound Diesel Solutions

Overview -- The Puget Sound Clean Air Agency (PSCAA), along with a consortium of partners from both the public and private sectors, established the Diesel Solutions Program. The Program is designed to reduce emissions from diesel engines in the Puget Sound region (Seattle/Tacoma metropolitan areas; see www.pscleanair.org/dieselsolutions). The Program is focusing on a number of strategies to reduce emissions from existing diesel engines, and has been a pioneer in promoting diesel retrofit programs and creating a regional market for ULSD.

Projects – Under the Diesel Solutions Program, a total of approximately 80 individual projects have been initiated. These projects cover such applications as school buses, transit buses, refuse trucks, city-owned vehicles, port equipment, and marine vessels. Examples of projects in the offroad sector include:

- *Sea-Tac Airport Runway Three Construction Project* – All on-road and offroad vehicles/equipment fueled with ULSD. Plan for up to 10 offroad engines to be equipped with DOCs.

- *Port of Seattle* – Multifaceted initiative that includes use of ULSD, B20, reduced idling education, DOC retrofit on cargo handling equipment and shore power for ocean-going vessels (Princess Cruise Lines).
- *Port of Tacoma* – Use of ULSD for port-operated equipment and DOC retrofit on straddle carriers used to move cargo containers.

- *Washington State Ferry Project* – Convert 24-vessel fleet from high sulfur diesel (3500 ppm sulfur) to low sulfur diesel (350 ppm). Conduct a pilot program operating three ferries on B20 and one ferry on ULSD.

Funding – EPA provided approximately $1 million in initial funding to support this program. PSCAA, the Washington State Department of Ecology, EPA Region 10, and the private sector have provided additional funding. In addition, the 2003 Washington State Legislature authorized funding to retrofit approximately 7,500 school buses throughout the state of Washington. In 2005, the Washington State Legislature appropriated additional funds for school bus retrofits as well as $2 million for retrofitting other types of vehicles and equipment in the state.

Operating Experience – The Diesel Solutions Program has been operating for approximately five years and has been very successful. The Program has served as a model for other regions and for individual fleets interested in ULSD, biodiesel, and retrofit initiative. ULSD is now available throughout the Puget Sound region. PSCAA officials report that the incremental cost of ULSD came down over time and now costs a few cents per gallon more than conventional gasoline. Retrofit programs have included both DOCs and DPFs. The DOC programs have been very successful and well-received. With regard to the DPF programs, some fleets have experienced problems with premature filter plugging. The principal cause has been failure to achieve the exhaust temperatures necessary to regenerate the filter. Where there have been problems, the technology providers are working with the fleet operators to find solutions. A key positive factor in the success of both the DOC and DPF programs has been the strong commitment to the program by fleet personnel, particularly the technicians, to resolve problems.

Salem Harbor Power Plant Retrofit Pilot Project

Overview -- In the late 1990s NESCAUM, together with the Manufacturers of Emission Controls Association (MECA), individual emission control manufacturers, and Environment Canada conducted a pilot demonstration program on construction-type equipment at the Salem Harbor power plant near Boston, Massachusetts. The project, which was one of the first of its kind in the U.S., was designed to demonstrate the applicability and emission reduction

capabilities of retrofit technologies on construction equipment. The success of this program provided important information to support other retrofit projects involving offroad engines and led to the implementation of the voluntary and mandatory phases of Massachusetts Central Artery/Tunnel Project construction equipment DOC retrofit program. The Salem Harbor project also serves as an excellent model in designing, implementing and evaluating a comprehensive pilot demonstration on offroad engines.

Program Elements -- The vehicles involved in the program and the technology employed are shown in Table 3-3 below.

Table 3-3, Salem Harbor Project Vehicles

Type	Engine	Rated Power	Retrofit Technology
Dumptruck	DT466 International	210 hp	DOC
Wheel Loader	TD63KBE Volvo	150 hp	DOC w/wo FBC
Bulldozer	TD-25 G Cummins	450 hp	DOC
Backhoe	3054DIT Caterpillar	84 hp	Active Uncatalyzed DPF
Wheel Loader	988 Caterpillar	320 hp	Catalyzed DPF

The test fuel for the offroad engines was diesel fuel with 530 ppm sulfur; 390 ppm sulfur diesel fuel for the dumptruck. Environment Canada developed specific emission test cycles for each piece of equipment based on time/temperature and also videotaped the equipment in operation. Emission testing included field tests (exhaust sampling/analysis) conducted by Environment Canada and laboratory testing by the U.S. EPA. A comparison of the data indicated a reasonable correlation between the field and laboratory test results.

Funding – The Massachusetts Department of Environmental Protection provided $50,000 in SEP funds. MECA and its members contributed technical and program support and donated the emission control technology. NESCAUM and Environment Canada also contributed technical and program support.

Operating Results – The Project demonstrated that retrofit technology could be successfully installed and operated on a variety of construction equipment and that significant emission reduction could be achieved. Results from the Project included:

- *Dumptruck* – The average operating exhaust temperatures were very low (205°C with a peak of 299°C and as a result the HC, CO and PM efficiency of the DOC was compromised. For example the PM mass efficiency was only 17%.

- *Volvo Wheel Loader* – Some issues with the testing equipment occurred, but the project partners were able to establish that the equipment with DOCs achieved a 52% reduction in PM mass. The equipment was then evaluated using the DOC plus a platinum fuel-borne catalyst (FBC). The reductions attributable to the FBC were inconclusive due to variations in the baseline emission tests.

- *Bulldozer* – The DOC-equipped bulldozer achieved a 24% reduction in PM mass. CO emissions were substantially reduced, but HC emissions were not. The lack of HC control may have been caused by the extended periods of idling during which exhaust temperature necessary to support catalytic conversion of the HC were not achieved.

- *Backhoe* – The active DPF achieved PM mass reductions of 81%.

- *Caterpillar Wheel Loader* – The DPF-equipped wheel loader achieved a 97% reduction in PM mass and over a 60% reduction in CO and HC.