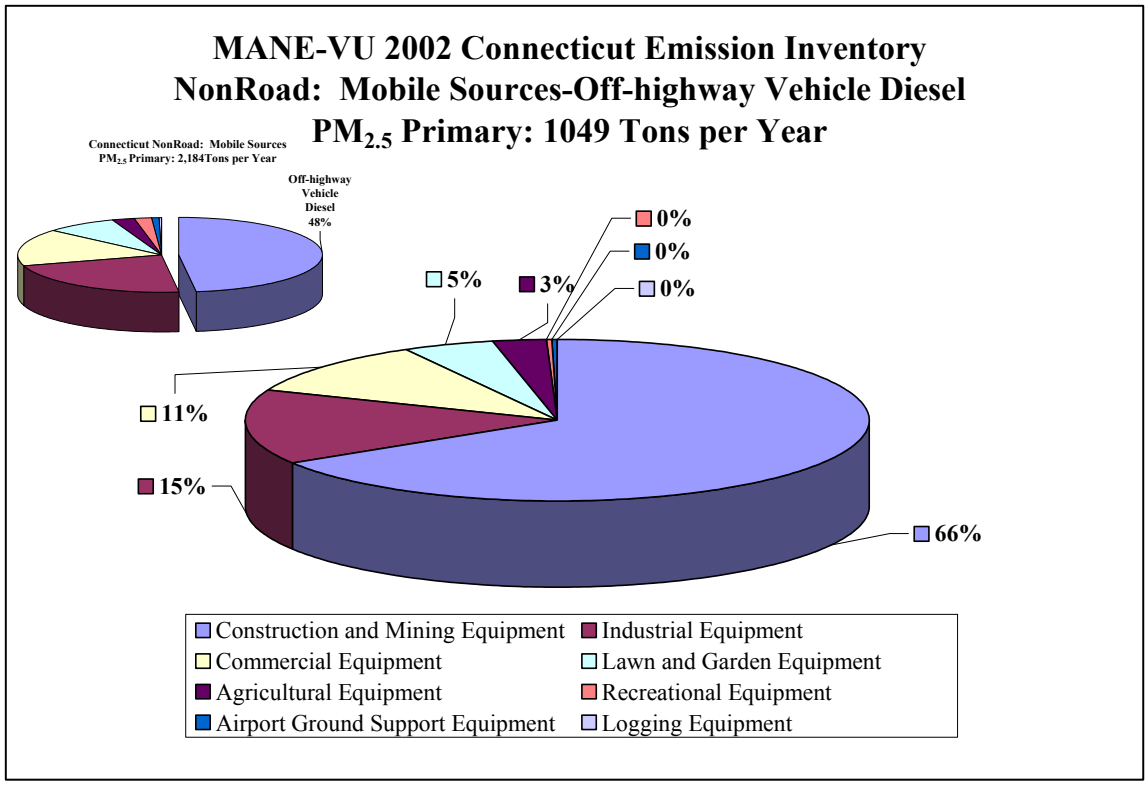
Special Act 05-07
Connecticut Clean Diesel Plan
Construction Equipment Report

I. Introduction

Over 21,000 tons of fine particulate matter ($PM_{2.5}$) are emitted in Connecticut each year. These emissions come from a wide variety of sources including on-road and off-road diesel trucks and buses, the combustion of distillate oil and wood for heating, stationary engines, and portable engines. According to the MANE-VU[1] 2002 Connecticut emissions inventory, primary $PM_{2.5}$ emissions from diesel construction equipment are estimated at 692 tons per year, which is three percent of the total Connecticut primary $PM_{2.5}$ emissions emitted annually, but 43% of the 1,612 tons annually produced by mobile source diesel engines.[2]

Figure 1



[1] The Mid-Atlantic/Northeast Visibility Union (MANE-VU) was formed by the Mid-Atlantic and Northeastern states, tribes, and federal agencies to coordinate regional haze planning activities for the region. MANE-VU provides technical assessments and assistance to its members, evaluates linkages to other regional air pollution issues, provides a forum for discussion, and encourages coordinated actions.
[2] See Figure 1 in the Introduction for total mobile source data. MANE-VU combines construction and mining equipment; in Connecticut, this is assumed to be all construction. See Attachment A.

Emissions per engine are significantly higher than on-road vehicles, in part because the U.S. Environmental Protection Agency (EPA) only began regulating emissions from off-road vehicles in 1996 and standards have not caught up with those for on-road vehicles. The Tier 4 emission standards,[3] which will require that most construction engines be as clean as new on-road engines (meeting a PM standard of 0.01 g/bhp-hr), will not be phased in until the 2011-2012 model years (MY). Because many construction vehicles are specialized, they are not in constant and continuous use; they generally last longer than on-road engines. Therefore, many pre-2011 MY construction vehicles will continue to be in use long after the Tier 4 standards come into effect. For these reasons, reducing diesel emissions from in-use engines will have important environmental and public health benefits.

Because construction engines are concentrated at job sites, sometimes for long periods of time, they can create significant pollution hot spots. The cumulative pollution burden from these engines is of particular concern for workers on the job site and in adjacent or down-wind areas, especially if the job-site is located in an area already overburdened by air pollution from other sources.

Under Section (1)(b)(4) of Special Act No. 05-07,[4] the Department of Environmental Protection (DEP) is required to develop "an implementation strategy, to be phased in not later than July 1, 2006, on projects valued at more than five million dollars, to maximize particulate matter emissions reductions from construction equipment servicing state construction projects, and an estimate regarding the cost and benefits to the state or municipalities of implementing such strategy."

To accomplish this task, the DEP organized a Construction Subcommittee to assist in gathering relevant information to be considered in developing such an implementation strategy. The construction equipment subcommittee was asked to examine the following issues:

- The number of state construction contracts costing more than five million dollars,
- Fleet retrofit, replacement, and retirement options,
- Clean fuel options,
- Anti-idling,
- Model contract language,
- Case studies and pilot projects, and
- Other items identified by the subcommittee.

The Construction Equipment Subcommittee included representatives of government, private industry, public health and the environmental sector. A list of the subcommittee members may be found in Appendix x. Meetings of the Construction Equipment Subcommittee were held on August 31, 2005 and September 14, 2005. This DEP report

[3] See 40 CFR 1039.
[4] See Attachment B, Special Act 05-07, *An Act Establishing A Connecticut Clean Diesel Plan.*

includes a discussion of the information gathered by the subcommittee and considered in the development of the implementation plan.

This report provides details on subcommittee activities and recommendations for moving a diesel emissions reduction program forward. It is important to provide background on statewide diesel emission reduction efforts that have been underway since 2000. These efforts, initiated as a voluntary collaboration among the DEP, the Department of Transportation (DOT), the Department of Motor Vehicles (DMV), the Northeast States for Coordinated Air Use Management (NESCAUM), the Connecticut Construction Industry Association (CCIA), and experts from Parsons Brinckerhoff Inc., provide an important foundation for enhancing Connecticut's diesel emission reduction efforts and further protecting the environment and public health as envisioned by Special Act 05-07.

A public-private partnership was established to reduce emissions from diesel construction equipment in use on the I-95 New Haven Harbor Crossing Improvement Program (the Q Bridge project). The partnership, which came to be known as the Connecticut Clean Air Construction Initiative, incorporated contract specification requirements modeled on Boston's "Big Dig" project. These efforts resulted in the Connecticut Clean Air Construction Initiative and combine emission reductions from construction equipment with the inspection of highway diesel vehicles. The Connecticut Clean Air Construction Initiative has been recognized as a national model and was recently cited by EPA as one of two showcase diesel emission reduction projects in the country. The DEP strongly recommends building and expanding on this successful effort as part of any next steps to further reduce diesel emissions.

The Connecticut Clean Air Construction Initiative establishes minimum specifications that must be met as part of the terms and conditions of the base contract.[5] The costs are included in a contractor's overall bid price. Enforcement mechanisms such as penalties for non-performance and withholding of payment provide incentives for compliance. This successful initiative has resulted in over 150 pieces of diesel powered construction equipment being retrofitted with oxidation catalysts, with a total of 200 retrofits expected by the project's completion.[6]

Efforts are currently underway to build on this successful model and adapt the specifications for all other major state construction projects. The Department of Public Works (DPW), Office of Policy and Management (OPM), and the DEP have adopted this same specification for all future construction projects. An effort is also underway to expand the scope of applicable DOT projects by revising DEP's indirect source permitting regulation, Section 22a-174-100 of the Regulations of Connecticut State Agencies (RCSA).[7]

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[5] The specifications applies to construction equipment on the job site for more than thirty days and that is diesel powered with a horsepower (HP) rating of 60 HP or greater. Retrofit emission control devices or less polluting clean fuels must be used to reduce emissions of carbon monoxide, hydrocarbons, oxides of nitrogen, and particulate matter from such construction equipment.

[6] See Attachment C for more background on the Connecticut Clean Air Construction Initiative.

[7] The DEP is in the process of amending the indirect source permit regulation, RCSA Section 22a-174-100 (Section 100), which requires DEP to issue multiple air quality permits for certain Connecticut DOT

II. Construction Subcommittee Action Items

A. State construction contracts costing more than five million dollars

The requirements of Section (1)(b)(4) of the Act apply to the University of Connecticut (UCONN) and four other state agencies that are involved with state construction projects: the DEP; the DPW; the DOT; and the Department of Economic and Community Development (DECD). The DEP, DPW, DOT, and UCONN enter directly into construction contracts. The DECD loans money for construction projects to such entities as municipalities, but does not usually enter directly into construction contracts.

These state agencies have the following numbers of construction projects valued at more than five million dollars:[8]

- The DPW awards an average of 32 contracts per year with 7 contracts per year exceeding five million dollars.
- The DOT awards an average of 9 contracts per year exceeding five million dollars.
- The DEP administers projects funded by the Clean Water Fund. The costs of three of the six current projects administered by the DEP exceed five million dollars.
- The UCONN 2000 construction program has 35 projects currently in the planning stage. The costs of twenty-two of these projects are five million dollars or greater.
- The DECD awards an average of 3 loans per year for projects exceeding five million dollars.

Thus, for those state agencies reporting in terms of projects per year (DPW, DOT and DECD), on the average, nineteen projects per year meet the five million dollar threshold. For the DEP and UCONN, there are currently 27 planned projects that meet the threshold.

B. Fleet retrofit, replacement, and retirement options

- **Construction Fleet Inventory:**

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highway construction projects. The process has been lengthy, administratively cumbersome and has produced limited environmental benefit. It is important to note that this permit process rarely requires an applicant to reduce emissions and that the DOT is the only applicant for such permits.

The proposed amendments to Section 100 will streamline the current three permit processes into a single permit and provides an alternative compliance mechanism which will result in expanded diesel retrofit efforts for construction equipment. This amendment advances both our strategic goal of reducing diesel emissions from construction equipment and our desire to craft effective and administratively efficient regulations. The DEP has worked closely with the DOT in developing this proposal and they have been supportive of this proposed amendment.

[8] See Attachment D for more detailed information.

A detailed inventory of construction equipment in Connecticut was not available for this planning process, and compiling such an inventory was not within the scope of this effort. DEP utilized inventory information collected by the subcommittee to use as a general guideline. A more detailed inventory would need to be compiled to provide a more definitive assessment of equipment age and typical use.

According to H. O. Penn Machinery, approximately 3,600 pieces of new construction equipment have been delivered for sale in Connecticut since 1998[9]. No data on pre-1998 construction equipment sales was readily available, but it could be extrapolated from several sources. Fuel used in Connecticut construction represents about 0.7 percent of that total fuel used in construction nationwide.[10] EPA estimates that nationwide there are two million pieces of construction equipment in use today.[11] Therefore, it can be estimated that there are 14,000 pieces of construction equipment in Connecticut, from which one can assume that there are about 10,400 pieces of construction equipment older than 1998 model year still in use in the state.

CCIA provided survey data on the age of engines in the Connecticut construction fleet and information on the distribution of engine sizes within the fleet was obtained from EPA. All of the above data were compiled and are presented below in Table 1.

Table 1: Approximate Equipment Inventory[12]

Vehicle Age	Size of Engines (HP)							Total Vehicles
	> 600	300-600	175-300	100-175	75-100	50-75	<50	
1985 and older	70	175	315	665	875	595	805	3500
1986-1990	70	175	315	665	875	595	805	3500
1991-1995	48	119	214	452	595	405	547	2380
1996-2000	59	147	265	559	735	500	676	2940
2001-2005	34	84	151	319	420	286	386	1680
Total Vehicles	280	700	1260	2660	3500	2380	3220	14000

Connecticut's construction industry trends toward a rental based economy, with the tendency for large general contractors to rent equipment for projects. [13] As an

[9] Source: H. O. Penn, also see Attachment E, new construction sales data from East PBE.
[10] Source: the United States Department of Energy, Energy Information Agency; the most recent data available are from 2003.
[11] Source: EPA.
[12] Table format provided by Environment Northeast (ENE), Memo dated November 3, 2005. See Attachment F.
[13] See Attachment G, August 31, 2005 construction subcommittee minutes.

effective strategy to retrofit pieces of equipment in use throughout the state, a diesel emission reduction program should include the equipment rental companies as program partners. Retrofitted equipment utilized on multiple projects provides the maximum emissions reduction benefits at the lowest cost.

- **Fleet Retrofit**:

  Diesel engines retrofitted with emission control devices such as diesel oxygen catalysts (DOCs) and diesel particulate filters (DPFs) can achieve substantial PM emissions reductions. Typically retrofitting involves the addition of the device to remove emissions from the engine exhaust.

  - DOCs are similar to catalytic converters used on cars in that a chemical process is used to convert emissions into less harmful compounds. DOCs have been used for many years on construction equipment and may be one of the most proven retrofit devices for construction equipment. A DOC can reduce emissions by 20 percent for PM, 50 percent for HC and 40 percent for CO. DOCs work best with the use of lower sulfur diesel fuel.

    There are many types of diesel-powered construction equipment, with each manufacturer providing many designs and powering options. While Caterpillar has taken a lead in developing and marketing 200 mounting fixtures for DOCs on its equipment,[14] in most cases DOCs are individually designed for the construction equipment on which they are to be installed. The cost of retrofitting a DOC on a piece of construction equipment being use on the I-95 New Haven Harbor Crossing Improvement Program in 2005 is reported to be about $6,500 installed.[15] A report on the emission controls used at the World Trade Center site in New York City notes that costs of DOC retrofits can vary from $4,000 for a wheel loader to $15,000 for a Caterpillar genset.[16]

  - DPFs collect PM in the exhaust stream and are very effective, removing as much as ninety percent of PM. High exhaust temperature is required for a DPF to work properly. DPFs must be used with ULSD fuel and appropriate duty cycle with sufficiently high exhaust temperatures (ICF Report). With sufficiently high exhaust temperatures DPFs self-clean, or regenerate. Failure to regenerate could lead to plugging, resulting in excessive engine backpressure, which could damage the engine. Plugging could also result from misfueling with high sulfur fuel. DPFs require annual maintenance at an additional cost (up to $500 per filter) and filter replacement at regular intervals (every 5 or more years).

[14] Source Tom Balon, MJ Bradley.
[15] Based on a conversation with Chris Goddard, Project Superintendent, L.G. Defelice, Inc., Contractor for the Q Bridge Project, October 27, 2005.
[16] M. J. Bradley & Associates, Inc., *Investigation of Diesel Emission Control Technologies on Off-Road Construction Equipment at the World Trade Center and PATH Re-Development Site: Project Summary Report*, August 9, 2004, page 51. See Attachment H.

DPFs have had limited success on construction equipment. Construction equipment duty cycles generally do not provide sufficiently high exhaust temperatures to allow for DPFs to properly operate. In addition, space constraints make it difficult to retrofit DPFs on construction equipment. Engine and exhaust configurations vary significantly from one type of construction vehicle (excavator, dozer, loader) to another, from model to model and from year to year. The costs for purchasing and installing DPFs in construction equipment can range from $15,000 for a wheel loader to $60,000 for a generator.[17] Chosen vehicles generally have to be engineered to accommodate the selected DPF system. One DPF has been certified by the California Air Resources Board (CARB) for use in specific off-road applications. According to EPA, there is limited experience nationally installing DPFs on off-road equipment.

- **Replacement and retirement**:

  EPA has promulgated more stringent requirements for non-road diesel fuel and new non-road diesel engines.[18] For non-road diesel engines, implementation of emission controls will be phased-in from 2008 to 2013 with the emission standards of last stages of the phase-in known as Tier 3 and Tier 4. Construction equipment can last for twenty or more years. Thus, it will take many years for the new, lower emitting construction equipment to replace older, more polluting construction equipment. An effective way to reduce emissions is to replace older construction equipment with new, less polluting construction equipment. Therefore, allowing the use of Tier 4 engines, when they become available, should be a contractual compliance option to further reduce PM emissions.

  A voluntary plan, providing funding and/or tax incentives to contractors to reduce emissions through the purchase and use of new vehicle/engine is another option for accelerating the retirement and replacement process. One successful example of this is Connecticut's property tax exclusion for new diesel trailers in the on-road fleet.

- **Cost Effectiveness**

  Diesel engines emit $PM_{2.5}$ which, when inhaled, can lodge deep in the lungs, aggravating existing heart and lung diseases to cause cardiovascular symptoms, arrhythmias, chronic obstructive pulmonary disease, heart attacks, asthma attacks and bronchitis. A 1999 report published in the *Journal of Transport Economics and Policy*[19] and referenced in a recent report for the CMAQ Program[20] states that

[17] See Attachment H, page 52.
[18] See 40 CFR 1039.
[19] McCubbin, Donald and Mark Delucchi , The Health Costs of Motor-Vehicle-Related Air Pollution, *Journal of Transport Economics and Policy,* September 1999, Vol. 33, Part 3, pp.253-86
[20] Westcott, Robert F., Cleaning the Air: Comparing the Cost Effectiveness of Diesel Retrofits vs. Current CMAQ Projects, prepared for the Emission Control Technology Association, May 11, 2005. (See Attachment I.)

the health costs resulting from exposure to $PM_{2.5}$ in urban areas range from $14.81 to $225.36 per kilogram. That would translate into an average health cost of $109,000 per ton and is ten times more costly than NO_X at $11,322 per ton.

As was noted on the first page of this sector report, construction equipment accounts for 22% of the $PM_{2.5}$ emissions from mobile sources in the state. In the event that funds to implement this plan are limited, construction sites located in urban areas already impacted by air pollution from other sources would have higher priority since these areas have a great impact on city residents.

A very rough estimate of the maximum benefits achievable under the Act can be calculated assuming that all vehicles used in state construction projects could be retrofitted. The DECD has estimated that in 2005, state construction authorizations amounted to $911 million, or approximately 15% of the total value of construction output in Connecticut as measured by the Gross State Product (5.9 billion). The following assumptions flow from this figure and lead to the cost/benefit scenarios presented in Table 2:

- State construction projects are responsible for 15% of the total construction-related PM emissions or 104 tons of PM per year.
- State construction projects employ 15% of the Connecticut equipment inventory, or about 1,617 engines.[21]
- Retrofits would be phased-in over a five-year period from 2006 to 2010.
- Technology Options:
  - DOC technology @ $6,500 (avg.) per engine yields 35% PM reduction (plus 50 percent HC reduction and 40 percent CO reduction)
  - DPF technology @ $25,000 (avg.) yields 85% PM reduction (plus 90% or more reductions in HC and CO)

If all 1,617 pieces of construction equipment were retrofitted,[22] the following costs are estimated for full implementation, though figures from the World Trade Center construction suggest that high costs for some individual vehicles could result in a much higher total. Costs could be incorporated in the particular state project budget or a special appropriated bond fund account could be used to offset project budgets and possibly target specific projects where retrofitting is warranted (i.e. urban areas). Either retrofit option could be paired with incentives to retire and replace older engines with new machines that are compliant with EPA's Tier 4 standards.

[21] 15% of 10,780 construction engines >50 HP = 1,617 engines.
[22] This analysis goes beyond the context of the Act in that it assumes the retrofit of construction equipment used on all state construction projects, not just those greater than $5 million.

Table 2: Potential Cost Benefit Scenarios for Retrofit of All Construction Vehicles Used for State Projects

	DOC	DPF
Benefits (PM reductions)	36.4 tons/year	88.5 tons/year
Cost	$10.51 million	$40.43 million

C. Clean Fuel Options

The use of fuel that burns cleaner than the current offroad diesel fuel (0.3 percent maximum allowable sulfur content) can reduce diesel PM emissions. Fuels with reduced sulfur content such as onroad diesel fuel and biodiesel can decrease diesel PM emissions. The federal onroad diesel maximum allowable sulfur specification is 500 parts per million (ppm) and, in 2006, will become 15 ppm. The 15 ppm sulfur diesel fuel is referred to as ultra-low sulfur diesel (ULSD) fuel and is currently available. For offroad diesel fuel, the new rule requires the maximum sulfur content be 500 ppm by 2007 and 15 ppm by 2010. Some cleaner fuels and retrofit devices may be used together to provide greater PM reductions than either would individually.

- ULSD is diesel fuel that contains less than 15 parts per million sulfur. ULSD will be available nationwide in June 2006, but currently is available in certain parts of the country, including Connecticut. The primary purpose of ULSD is to enable or improve the performance of aftertreatment technologies such as a PM filter. Some case studies suggest that the use of ULSD alone can reduce emissions of PM between 5 and 9 percent.[23] While ULSD-only emission reductions for PM are relatively modest on a per-vehicle basis compared to aftertreatment retrofit, the emission reductions can be significant if an entire fleet is fueled with ULSD. Assuming that vehicles used in state construction projects emit 104 tons of PM per year, annual reductions of 5.2 to 9.4 tons of PM could be achieved by changing to ULSD.

  The price differential between ULSD and regular diesel fuel in Connecticut is currently about 12 cents per gallon.[24] Connecticut uses about 15.7 million gallons of diesel fuel in construction projects each year.[25] The increased cost of converting to ULSD for state construction projects in Connecticut is therefore projected to be $282,600.[26] That converts to an estimated cost effectiveness of between $30,000 and $53,000 per ton of PM reduced by using ULSD in construction equipment on state projects.

[23] The quantity of emissions reductions from the use of ULSD alone will vary depending on the application, level of sulfur reduction, and other fuel characteristics of the replacement fuel (e.g., cetane number, aromatics, PNA). One manufacturer's representative on this subcommittee projected a 20% emissions benefit from ULSD alone.
[24] In 2006, when ULSD is available nationwide, the cost differential is projected to be much less.
[25] Source: the United States Department of Energy, Energy Information Agency; the most recent data available are from 2003.
[26] 15% of 15.7 million gallons x 12 cents per gallon equals $282,600.

- Biodiesel is a domestically produced, renewable fuel that can be manufactured from new and used vegetable oils and animal fats. Biodiesel is safe, biodegradable, and reduces air pollutants such as PM, CO, HC and air toxics. However, emissions of NOx increase with the concentration of biodiesel in the fuel. Some biodiesel produces more NOx than others, and some additives have shown promise in modifying the increases.

  Blends of 20% biodiesel with 80% petroleum diesel (B20) can be used in unmodified diesel engines. Biodiesel can be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems. Pure blends of biodiesel may not be suitable for cold climates. B20 reduces emissions of PM by about 10 percent. However, B20 also increases NOx emissions by approximately 2%. The B20 blend costs about 15 to 30 cents per gallon more than regular diesel fuel. B100 reduces emissions of PM by roughly 40 percent and costs about 75 cents to $1.50 more than regular diesel fuel.

- Compressed Natural Gas (CNG) is a high-quality fuel that is a viable substitute for gasoline and diesel. Nearly 90% of the natural gas consumed in the US is from domestic sources, compared to less than 50% of the oil. Historically CNG, has been less costly than gasoline and diesel fuel on a per gallon equivalent basis nationwide. CNG vehicles demonstrate diesel-like performance with a 90% reduction in noise. They are virtually toxic-free and emit significantly fewer pollutants than diesel vehicles: 40% to 86% less PM and 38% to 58% less NOx for heavy duty natural gas transit buses, school buses, refuse trucks and utility vehicles. Moreover, production of natural gas avoids the pollution risks associated with the manufacture of diesel, such as crude oil spills, releases of toxic pollutants from refineries, and leaks from underground tanks into groundwater.

  The major obstacles to the expanded use of CNG vehicles are their current higher cost compared to conventional diesel vehicles and the costs involved in establishing the infrastructure needed for refueling. Training and garage modifications to accommodate methane detection and ventilation systems may also be needed. Although these costs can be significant – for example the incremental cost of a CNG bus is approximately $25,000 to $40,000 more than a conventional diesel bus -- fleets can make a cost-effective transition to CNG by taking advantage of funding sources for alternative-fuel vehicle programs, such as Congestion Mitigation and Air Quality (CMAQ) grants, the US DOE State Energy Program (SEP) funds distributed through the national Clean Cities program, and federal and State tax incentives.[27]

- Emulsified fuels approved by EPA or CARB – PuriNOX is an emulsified diesel fuel manufactured and distributed by Lubrizol Corporation. The EPA retrofit

[27] Source: Clean Cities Draft Memo dated November 17, 2005

technology list certifies that the use of PuriNOX can reduce PM from 16 to 58% and NOx from 9 to 20%. This certification applies to summer blend PuriNOX only. Some of the properties of summer blend PuriNOX can be problematic when used in construction equipment. Summer blend PuriNOX cannot be used in ambient temperatures less than 20 degrees F. PuriNOX contains water. Thus, there can be a 15% fuel consumption penalty and a 20% power loss penalty when operating at maximum engine horsepower since water has no caloric value, making the real cost to the contractor higher than the fuel cost differential. While PuriNOX requires agitation created by running the engine, some construction vehicles are used for short periods followed by long periods of nonuse. To date none of the contractors or subcontractors has used PuriNOX on the I-95 New Haven Harbor Crossing Improvement Program.[28]

D. Other Clean Diesel Issues

- **Anti-idling**

  Connecticut's regulations regarding idling are found in Section 22a-174-18(b)(3) of the Regulations of Connecticut State Agencies. In general under the idling regulation, motor vehicles, including construction equipment, must be turned off after three minutes of idling. This saves fuel and is a simple and cost effective way to reduce emissions. DOT and DPW contract specifications reference section 22a-174-18(b)(3). Compliance efforts are reinforced through efforts of on-site construction managers in raising awareness of the 3-minute rule and enforcing this provision as part of the terms of the contract.

- **Case studies and pilot projects**

  - **Massachusetts Central Artery/Tunnel project (the Big Dig)[29]**
    - The first and best-known example of contract specifications for diesel retrofits on construction equipment.
    - Demonstrated that DOCs could be retrofitted on construction equipment.
    - Required that construction equipment be kept properly tuned.
    - Required that diesel engines on construction equipment be turned off when not in use and on dump trucks that idle more than five minutes while waiting to load and unload.
    - Established a staging area for trucks waiting to load or unload in a location that reduced the impact on the public.
    - Equipment located in sensitive receptor areas was required to be retrofitted.

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[28] Schattanek, Guido and Weaver, Donna, *Implementation Of Retrofit Program For Diesel Equipment During The Construction Phase The I-95 New Haven Harbor Crossing Improvement Program In Southern Connecticut,* DOT Paper # 999. See Attachment J.

[29] See Attachment J, ICF Report *Emission Reduction Incentives for Off-Road Diesel Equipment Used in the Port and Construction Sectors*, May 19, 2005.

- **New York City Local Law 77**[30]
  - ULSD and best available technology (BAT) must be used in city construction projects.
  - Applies to construction equipment having fifty HP or greater diesel engines.
  - Focus is on PM reductions.
  - Approved technologies include those approved by EPA, CARB, or the commissioner.
  - Implementation of Local Law No. 77 was delayed because of stakeholder efforts to define BAT[31]; the proposed method for selecting BAT on a case-by-case-basis was released for public comment March 29, 2005.[32]

- **NEPA/CEPA Review**: The DEP reviews and comments on environmental documents, such as environment impact statements or evaluations, that are required for federally or state funded construction projects under the National Environmental Policy Act (NEPA) or the Connecticut Environmental Policy Act (CEPA). It has been the DEP's policy for several years to include in its comments the recommendation to use construction equipment with air pollution control equipment and to use clean fuels to reduce exhaust emissions. In addition, the DEP comments stress the importance of construction equipment adhering to the idling regulation as a simple and cost effective way to reduce emissions. The DEP comments recommend that the project sponsor include language similar to the idling regulations in the contract specifications for construction in order to allow the sponsor to enforce the idling restrictions at the project site without the involvement of the DEP. These recommendations are made for all projects subject to NEPA and CEPA requirements due to federal or state funding, including municipal projects and those costing less than five million dollars.

- **Other Items**

  - **Implementation Schedule**: Many of the options are already in place. Implementation of enhancements to and expansion of these options to include all relevant state agencies will be completed by July 1, 2006.

III. Construction Equipment Implementation Recommendations

Implementation Options

There are a variety of available mechanisms to achieve reductions of diesel emissions from construction equipment including mandating statutory or regulatory requirements,

[30] See Attachment K.
[31] See Attachment J, ICF Report, page 63.
[32] Find Notice and Proposed Rule at http://www.ci.nyc.ny.us/html/dep/html/news/notices.html.

adoption of contract specifications, or voluntary approaches. All of these options were considered as part of DEP's evaluation.

- **Option 1: Expand and Enhance the CT Clean Air Construction Initiative:** Under this option, uniform CT Clean Air Construction Contracting Specifications would be adopted by the State of Connecticut for application in construction contracting by any state agency by certain deadlines. DEP, DOT, DPW, DECD and UCONN have already begun, on a voluntary basis, to implement such specifications to reduce diesel emissions[33]; this option would continue and seek to expand on these current accomplishments. If necessary, an executive order could be sought to compel participation. Under Option 1, the adopted specifications would be implemented by each individual agency. The essential requirements to the adopted specifications would include the following:
    - Applicable to construction contracts greater than $5 million;
    - Construction equipment operation must meet the requirements of the idling regulation;
    - The use of highway diesel fuel[34] or other cleaner burning fuel;
    - Retrofit all pieces of construction equipment greater than 50 HP, that are to be on the site more than 30 consecutive days, with EPA or CARB verified oxidation catalysts or other technology that meets the new federal emission standards, through
        - Contract specifications, which require emission reduction technologies as part of a construction contract,[35] these include
        - Contract allowances, which can be set aside to cover retrofit equipment for the successful contract bidder (Since funds for emission control equipment do not appear in the contract, this approach levels the playing field for smaller construction companies, who may not have any retrofitted equipment.); and
    - Maintain a log, identifying pieces of construction equipment and dates used on the project, that will be available for inspection by DEP and the contracting agency to insure compliance with specifications; failure to comply would be a contract violation.[36]

  Subcontractors providing equipment that meets the specifications should have access to the funds set aside under the contract allowance.

  Since most projects over $5 million involve federal funds, federal agencies, such as the Federal Highway Administration, would have to be consulted for approval of the contract specifications.

[33] See the DOT sample contract language in Attachment L.
[34] Requiring the use of on-road diesel fuel for off-road application will result in the phase-in of ULSD four years ahead of the EPA schedule.
[35] Successful examples of this approach are the Massachusetts Central Artery/Tunnel project and the Connecticut Clean Air Construction Initiative.
[36] OPM has reported that in the Science Center Project, Turner, the contract manager for the project, is requiring all pieces of equipment over 50 HP to be retrofitted to eliminate record keeping requirements and minimize reporting.

The DEP will schedule and annual meeting with the contracting agencies to assess and revise the construction specifications as new technology and clean fuels that meet the new EPA emission standards become available. Any plan to extend these specifications to contracts less than $5 million would be discussed and developed through these annual meetings.

DEP should also consider the revision to Section 100 of the Regulations of Connecticut State Agencies (RCSA) to allow for construction specifications as a compliance option.

As shown in Table 3 below, this option has an estimated cost of $10 million.[37] State agencies' capital budgets will be impacted and would require additional bond funds to account for these increased costs.

Table 3: Implementation Costs for Special Act 05-07: Construction Option 1 Retrofits

Projected Capital Cost (DOCs)	$10.51 million
Emissions Reduction	36.4 tons/year

- **Option 2: Mandating requirements for emissions control technology:** This approach would require, by statute and/or regulation, ULSD fuel and best available technology (BAT) be used with diesel construction equipment. An example of the BAT approach is New York City's Local Law 77, which requires the use of ULSD fuel and BAT on diesel construction equipment above 50 horsepower owned by the city or used on city-sponsored projects. Because of the many types of construction equipment, each with its own unique characteristics, BAT must be determined on a case-by-case basis. In addition to capital costs, both DEP and the contracting agency will incur administrative costs to conduct technology reviews and to oversee project implementation.

  Retiring and replacing a construction vehicle is, in almost all cases, more expensive than retrofitting that vehicle. The full capital costs of implementing this option cannot be projected because equipment that will meet the Tier 4 standards has not been developed or marketed. Experience with on-road vehicles which are being developed to meet strict emissions standards beginning in 2007 clearly indicate that Tier 4 vehicles will be significantly more expensive than current replacements. DEP anticipates the need to hire a staff of four full-time employees, at an estimated to cost of $500,000, for Option 2; other contracting agencies would have similar administrative staff requirements.

[37] An annual "cost per ton of reduction" cannot be projected due to the probability that implementation will occur in phases over an undetermined length of time.

- **Option 3: Rental Equipment Retrofit/Replacement:** Many contractors supplement their fleets with rental equipment. And since the same equipment rental agencies work with a number of contractors, an effort to provide cleaner rental equipment will benefit many different construction sites. Rental equipment may not be on a construction site long enough to be covered under the contract provisions to fund retrofits. And rental firms may be discouraged by the high costs of maintaining equipment with the most effective emission control devices. Voluntary approaches, as outlined below in Option 4, should benefit the owners of rental equipment. Input from the equipment rental industry, as stakeholders participating in this process, is being solicited as an important contribution to the clean diesel plan for construction equipment.

- **Option 4: Voluntary approaches:** Voluntary approaches usually involve offering funding and incentives to contractors to reduce emissions through the purchase and use of retrofitted control equipment, clean fuels, new vehicle/engine purchases or engine rebuilds. One successful example of this is Connecticut's property tax exclusion for new diesel trailers in the on-road fleet.

  Waiving the sales tax on new equipment would result in a significantly reduced cost per vehicle, helping owners to defray the costs of new equipment and encouraging contractors and other owners to move forward in making decisions to replace older equipment with a cleaner fleet.

  Incentive grants can be designed to fund retrofits as well as contributing toward the increased cost of Tier 4 equipment. Suggested incentives include up to $250 for the installation of a closed crankcase system and $1,000 to $3,000, depending upon the level of PM reductions, for CARB/EPA verified emission control retrofit devices. These incentive grants would be available for a limited time with sunset dates established to promote more rapid action to improve the emission controls on the fleet. This would assist all fleet owners and encourage action by equipment rental companies that may not be easily reached through the contracting process.

- **Option 5: NEPA/CEPA Review**: The DEP will continue to recommend the use of clean fuels and construction equipment with air pollution control equipment when it reviews and comments on environment impact statements or evaluations, that are required for federally or state funded construction projects under NEPA or CEPA.

IV. Conclusions

To be developed after subcommittee review.

Attachment A

MANE –VU Source Data:
Mobile Source, Off-Road Diesel, Construction and Mining Equipment

SCC_L3	SCC_L4	Pollutant Code	Sum of Connecticut (Tons/Year)
Construction and Mining Equipment	Tractors/Loaders/Backhoes	PM25-PRI	114.7
Construction and Mining Equipment	Skid Steer Loaders	PM25-PRI	102.7
Construction and Mining Equipment	Rubber Tire Loaders	PM25-PRI	91.7
Construction and Mining Equipment	Crawler Tractor/Dozers	PM25-PRI	75.3
Construction and Mining Equipment	Excavators	PM25-PRI	71.2
Construction and Mining Equipment	Off-highway Trucks	PM25-PRI	56.2
Construction and Mining Equipment	Rough Terrain Forklifts	PM25-PRI	37.0
Construction and Mining Equipment	Rollers	PM25-PRI	24.4
Construction and Mining Equipment	Scrapers	PM25-PRI	19.6
Construction and Mining Equipment	Graders	PM25-PRI	17.2
Construction and Mining Equipment	Cranes	PM25-PRI	16.0
Construction and Mining Equipment	Trenchers	PM25-PRI	14.6
Construction and Mining Equipment	Bore/Drill Rigs	PM25-PRI	12.2
Construction and Mining Equipment	Other Construction Equipment	PM25-PRI	10.9
Construction and Mining Equipment	Off-highway Tractors	PM25-PRI	9.7
Construction and Mining Equipment	Pavers	PM25-PRI	8.7
Construction and Mining Equipment	Signal Boards/Light Plants	PM25-PRI	3.5
Construction and Mining Equipment	Crushing/Processing Equipment	PM25-PRI	3.4
Construction and Mining Equipment	Paving Equipment	PM25-PRI	1.6
Construction and Mining Equipment	Surfacing Equipment	PM25-PRI	1.1
Construction and Mining Equipment	Concrete/Industrial Saws	PM25-PRI	1.1
Construction and Mining Equipment	Cement and Mortar Mixers	PM25-PRI	0.6
Construction and Mining Equipment	Plate Compactors	PM25-PRI	0.4
Construction and Mining Equipment	Dumpers/Tenders	PM25-PRI	0.3
Construction and Mining Equipment	Tampers/Rammers	PM25-PRI	0.0

Attachment B

Senate Bill No. 920

Special Act No. 05-7

AN ACT ESTABLISHING A CONNECTICUT CLEAN DIESEL PLAN.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. (*Effective from passage*) (a) The Commissioner of Environmental Protection shall, in accordance with the provisions of this section, develop a Connecticut diesel emission reduction strategy.

(b) The Connecticut diesel emission reduction strategy shall recommend programs, policies and legislation for achieving reductions of diesel particulate matter consistent with reduction targets for diesel particulate matter indicated in the Connecticut Climate Change Action Plan 2005. The strategy shall provide the following:

(1) A description of the sources of diesel particulate matter emissions in the state and recommendations for maximizing diesel particulate matter emission reductions from identified sources;

(2) An implementation strategy, and an estimate regarding the cost and benefits to the state or municipalities of implementing such strategy, to reduce, not later than December 31, 2010, the level of diesel particulate matter emissions from motor buses, as defined in section 14-1 of the general statutes, that are publicly owned and funded, have an engine model year of 2006 or older, and are not less than twenty-nine feet in length, by (A) retrofitting the engines of such motor buses with diesel particulate filters in order to achieve a reduction of diesel particulate matter by not less than eighty-five per cent, or (B) using alternative fuels or alternative engine technology in order to achieve a reduction of diesel particulate matter by not less than eighty-five per cent;

(3) An implementation strategy, and an estimate regarding the cost and benefits to the state or municipalities of implementing such strategy, to maximize, not

later than December 31, 2010, diesel particulate matter emission reductions from school buses and to prevent by said date diesel particulate matter engine emissions from entering the passenger cabin of the buses;

(4) An implementation strategy, to be phased in not later than July 1, 2006, on projects valued at more than five million dollars, to maximize particulate matter emissions reductions from construction equipment servicing state construction projects, and an estimate regarding the cost and benefits to the state or municipalities of implementing such strategy;

(5) Recommendations for technical assistance resources to be developed by the commissioner to support the implementation of diesel particulate matter reduction strategies by municipalities and other diesel fleet owners and operators;

(6) A strategy for securing and leveraging federal funds and funds from other sources to defray the costs of meeting the goals set forth in subdivisions (1) to (5), inclusive, of this subsection; and

(7) Recommendations for programs and policies to raise awareness about the health risks and climate impacts associated with diesel particulate matter pollution and the solutions available for reducing emissions of diesel particulate matter.

(c) In developing the report, the commissioner shall make draft recommendations available to the public on an Internet web site, provide opportunity for public comment, at times and locations to maximize public participation, and provide a forum for ongoing written public comment on the strategy.

(d) Not later than January 15, 2006, the commissioner shall submit, in accordance with the provisions of section 11-4a of the general statutes, a report containing the strategy to the joint standing committee of the General Assembly having cognizance of matters relating to the environment, and recommendations for legislation to implement such strategy. The strategy shall contain an addendum of all public comments received by the commissioner. The commissioner shall post a copy of the strategy and the addendum on an Internet web site.

Approved June 24, 2005

Attachment C

Clean Air Construction Initiative:
DOT Fact Sheet

I-95 New Haven Harbor Crossing Corridor Improvement Program

http://www.i95newhaven.com/upload/files/Fact_Sheets/FACTSHEET_CLEANAIR.pdf

I-95 New Haven Harbor Crossing Corridor Improvement Program

CLEAN AIR CONSTRUCTION INITIATIVE

Air quality has a direct effect on human health and the environment. To help improve air quality in Greater New Haven, the Connecticut Department of Transportation (ConnDOT) is implementing new methods for reducing emissions during the I-95 New Haven Harbor Crossing (NHHC) Corridor Improvement Program.

WHAT

During construction on the I-95 NHHC Corridor Improvement Program, equipment used on highway contracts will be part of a pilot emissions reduction program for the State of Connecticut. Several factors make the area and timing ideal for this initiative:

- Construction takes place along a densely-populated corridor. Reduced chemical and particulate emissions will benefit area residents and visitors, as well as laborers working near diesel engines.
- Construction will last for approximately 12 years. The emissions-reduction initiative will reduce the impact on air quality that would otherwise be associated with such a large-scale, long-term construction project.
- One of the nation's first emissions reduction programs is operating successfully on Boston's "Big Dig." ConnDOT is encouraged by Boston's results, and is eager to implement a similar program in Connecticut.

This program was developed through collaboration between:

- ConnDOT
- Connecticut Department of Environmental Protection (CT DEP)
- Northeast States for Coordinated Air Use Management (NESCAUM)
- Connecticut Department of Motor Vehicles (CT DMV)
- Connecticut Construction Industries Association (CCIA)

WHY

ConnDOT is requiring all contractors and sub-contractors to take part in this air-quality improvement program.

In summary, the following contractor requirements apply:

- Emission control devices (such as oxidation catalysts) and/or clean fuels (such as PuriNOx) are required for:
    - Diesel-powered construction equipment, with
    - Engine horsepower (HP) ratings of 60 HP and above, that are
    - On the project or assigned to the contract in excess of 30 days.
- Truck staging zones will be established for diesel-powered vehicles waiting to load or unload materials. The zones will be located where diesel emissions will have the least impact on abutters and the general public.

- Idling is limited to three minutes for delivery and dump trucks and other diesel-powered equipment (some exceptions).

- All work will be conducted to ensure that no harmful effects are caused to adjacent sensitive receptors, such as schools, hospitals, and elderly housing.

- Diesel-powered engines will be located away from fresh air intakes, air conditioners, and windows.

Initial and monthly reporting by contractors will ensure the proper implementation of the air quality improvement program. Non-compliance will be enforced with a 24-hour notice to the contractor to improve a vehicle or remove it from a project.

To introduce this new program to area contractors, three informational meetings regarding clean fuels and equipment retrofitting were conducted in August and September, 2001. The sessions were attended by clean fuel vendors and equipment manufacturers who addressed concerns about equipment maintenance and warranties (see below).

COST

The cost of retrofitting equipment or using clean fuels is included in the general cost of the contract, as bid by each contractor. Whereas a contractor who owns equipment may be more likely to install the retrofit apparatus, one who rents equipment may opt to use clean fuels.

EQUIPMENT MAINTENANCE AND WARRANTIES

On Boston's Big Dig, no adverse operational problems or additional maintenance costs have been reported for construction equipment retrofitted with oxidation catalysts. With proper installation, and as long as a system is not stressed beyond its design limitations, equipment warranties are not affected by installation of retrofit products.

RESULTS

EPA has identified emission control standards that will reduce emissions from diesel construction equipment. With the Connecticut Clean Air Construction Initiative, immediate air quality benefits will be realized through the use of emission control devices and clean fuels on existing construction equipment. Long-term air quality benefits will be realized as new construction equipment is purchased and put into use. Because existing construction equipment can operate for more than 20 years, it may be 20 or more years before the full benefits of EPA's standards are realized.

It has been estimated that on Boston's Big Dig, emission reductions amount to 36 tons/year for carbon monoxide, 12 tons/year for hydrocarbons, and 3 tons/year for fine particulate matter. Estimates for reduced emissions during the I-95 NHHC Corridor Improvement Program are 20 tons/year for carbon monoxide and 2 tons/year for fine particulate matter (with clean fuels or oxidation catalysts) and 8 tons/year for hydrocarbons (with oxidation catalysts only).

GOING FORWARD

With good maintenance, heavy machinery with diesel engines can operate for more than 30 years. Retrofitting an engine will cut the lifetime emissions from that engine to a small percentage of what it is today. The EPA, ConnDOT, and other local agencies support these measures in their dedication to improving the air quality in the State of Connecticut.

Attachment D:

The Number of State Construction Contracts Costing $5 Million or Greater

The following is a list of the number of state construction contracts costing $5 million or greater.

Department of Public Works

The Department of Public Works (DPW) is responsible for most new building and capital improvements for state agencies (excluding the Department of Transportation and the University of Connecticut). The DPW has undertaken the following number of projects within the last 6 fiscal years.

Fiscal Year	Total Awarded Contracts	Awards in Excess of $5 Million
99-00	52	5
00-01	54	7
01-02	27	12
02-03	22	8
03-04	25	2
04-05	13	5
Average	32	7

Department of Transportation

Year	Awards in Excess of $5 Million
2005	11
2006	11
2007	8
2008	12
2009	5
2010	6
Average	9

Department of Environmental Protection

The Department of Environmental Protection (DEP) administers projects funded by the Clean Water Fund. The costs of three of the six current projects administered by the DEP exceed five million dollars.

University of Connecticut

The University of Connecticut UCONN 2000 construction program has 35 projects currently in the planning stage. The costs of twenty-two of these projects are five million dollars or greater.

Department of Economic and Community Development

The Department of Economic and Community Development (DECD) loans money for construction projects. The DECD does not usually enter directly into construction contracts,

Fiscal Year	**Awards in Excess of $5 Million**
99-00	1
00-01	3
01-02	3
02-03	1
03-04	1
04-05	3
05-06	4
Average	3

Attachment E

Connecticut New Construction Equipment Deliveries

-Mkt		Year								
PL	**Size**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Grand Total**
	20<75Dp D31	28	37	28	32	37	28	28	14	232
	75<85Hp D37	19	18	14	13	17	12	21	8	122
	85<105Hp D39	22	33	24	21	24	22	30	19	195
	105<130 Hp D41	8	9	6	8	11	7	9	4	62
	130<160 Hp D61	12	5	3	3	9	6	8	3	49
	160<190 Hp D65	7	7	7	5	5	5	4	4	44
	190<260Hp D85						2	2		4
	260+Dp D155+	3	2	3	2	5	7	2	1	25
CD Total		99	111	85	84	108	89	104	53	733
	80<100 Hp WA120-150	1	5	2	2	5	7	4	1	27
Wheel loaders	100<120 Hp WA180-200	25	20	8	10	8	5	6	7	89
	120<150 Hp WA250	36	33	33	38	42	43	46	18	289
	150<175 Hp WA320	17	25	33	22	30	21	28	14	190
	175<200 Hp WA380	3	9	7	6	9	11	12	11	68
	200<250 Hp WA420	16	14	10	13	11	8	8	2	82
	250<275 Hp WA450-480	7	9	8	9	3	4	5	7	52
	275<350 Hp WA500	6	10	8	12	12	22	18	2	90
	350<500Hp WA600		2	4	2		1	1		10
WL Total		111	127	113	114	120	122	128	62	897
	82Hp PC95	3	2	1	2		2	5	3	18
Hydraulic Excavators	80<90 PC120	8	14	5	2		2	3	1	35
	85<90 PC128US	36	51	32	40	28	27	34	24	272
	90Hp PC158US	45	50	43	60	40	54	77	45	414

	110-128 PC160/200	13	19	20	14	13	20	20	20	139
	143Hp PC200LC	33	38	27	35	29	43	49	15	269
	143Hp PC228US	18	13	14	31	26	27	34	15	178
	168Hp PC220/270	25	29	23	24	16	20	25	15	177
	179Hp PC300LC	19	23	23	32	18	22	21	14	172
	242Hp PC300HD	8	15	6		11	19	32	11	102
	330Hp PC400	9	15	13	3	13	13	14	2	82
	385Hp PC600				2		1			3
	454Hp PC750			2		3		2		7
	651Hp PC1250						1	1		2
HE Total		217	269	209	245	197	251	317	165	1,870
Moto Graders	145<200 GD655-675	1	1	1	3	1		1	1	9
	45<145 GD555/850	1	4	1	1		1	2	1	11
MG Total		2	5	2	4	1	1	3	2	20
Rigid Trucks	0<40 HD325			3						3
RT Total				3						3
Articulated Trucks	0<26					3		1		4
	26<30	1	12	5	4	3	4	5	3	37
	35 & Over								2	2
	30 <35	1	1			4	8	1	7	22
AT Total		2	13	5	4	10	12	7	12	65
Crawler Loaders	0<105 D21-41	1	1							2
	105+	1		2	1			1		5
CL Total		2	1	2	1			1		7
All		433	526	419	452	436	475	560	294	3,595

This is information supplied to manufacturers of Construction Equipment.

This data does not include small gas powered equipment, Skid steers, Loader backhoes, Mini excavators, Generators. (Small Engine Equipment).

Different manufacturers will vary in HP based on there model, But usually Close in size.

but the sale would be recorded with the same model above.

Most major Manufacturers are included in this report, There maybe other Manufacturers that do not report to this data.

This information is supplied as base line data only, and is not represented as a audited document.

Attachment F

MEMO

To: **Construction Subcommittee**
From: **Madeleine Weil, Environment Northeast**
Date: **November 3, 2005**
Re: **State-Funded Construction Vehicle Options Memo**

Purpose

This memo outlines two potential policy options for reducing PM2.5 from state-funded construction equipment in Connecticut.

Summary

Option 1: Expand the scope of the CT Clean Air Construction Bid Specification to all state-funded construction projects and institute a formal and regular process for updating it over time.

1. Broaden the scope of state projects to which the CT Clean Air Construction Bid Specification applies. Apply the bid specification to all state-funded construction;
    a. By July 1, 2006, in accordance with P.A. 05-7, all state bid specifications on projects valued at $5 million or more should require adherence to the requirements of the CT Clean Air Construction Bid Specification;
    b. By January 1, 2007, the CT Clean Air Construction Bid Specification should apply to all state-funded projects of any value.
2. Establish a regular and formal mechanism for updating the bid specification over time to reflect evolving definition of "minimizing emissions."
    a. The DEP Commissioner should update the CT Clean Air Construction Bid Specification at least once per year;
    b. Annual updates ensure that requirements keep pace with EPA/CARB's verification list. Best available technology, verified by EPA/CARB for use on a particular engine, should be put to use on that engine;
    c. The direct reference to the EPA/CARB verified list reduces uncertainty for contractors and reduces resources needs for DEP.
3. Recommended Funding Options:
    - Contract Specifications – Requirements are built into bid package so costs of compliance are built into overall project financing;
    - Contract Allowances – Competitive bid process excludes costs of compliance with emission control requirements. A clean air retrofit funding allowance is administered to the winning bidder.

Option 2: Adopt Best Available Control Technology (BACT) policy modeled after New York City Local Law 77 (2003). CT DEP could adopt by reference NY DEP's list of "BACT" devices.

Background

Why focus on construction equipment?
Construction equipment engines in Connecticut were estimated to emit 694 tons of PM2.5 in 2002, the most recent year for which the state has data. This amount represents approximately 39% of total PM2.5 emissions from mobile source diesel engines (total = 1796 tons). Construction equipment PM2.5 emissions are significantly higher than emissions from on-road heavy-duty diesel vehicles (total = 563 tons), even though there are far fewer operating units in the state then on-road units.[38]

Emissions per engine are significantly higher than on-road vehicles in part because EPA only began regulating emissions from off-road engines in 1996 and standards have continued to be considerably less stringent. Beginning with the Tier 4 emission standard, (to be phased-in on new engines starting 2011-2012), emissions from most new construction engines will have to be as clean as new on-road engines (meeting a PM standard of 0.01 g/bhp-hr).[39]

Because construction engines are concentrated at job sites, sometimes for long periods of time, they can create significant pollution hot-spots. The cumulative pollution burden from these engines is of particular concern for workers on the job site and in adjacent or down-wind areas, especially if the job-site is located in an area already overburdened by air pollution from other sources.

In sum, construction engines are particularly good targets for diesel emission clean-up efforts because:

1. They are much dirtier than on-road engines;
2. They typically last longer than on-road engines;
3. Federal standards requiring the cleanest available engine technology do not apply to non-road engines until 2011-2012;
4. They are concentrated at job-sites, often in overburdened areas, and create pollution hot spots;

Why start with state-funded equipment?

Connecticut has a responsibility to allocate its purchasing dollars in ways that protect the health and welfare of its residents. By demonstrating this leadership, the state can play a role in lowering the hurdles that prevent other public and private actors from doing the same. Also, state-funded construction constitutes a large portion of the vary large construction contracts executed in the state, partly due to road and bridge projects. Finally, the state is typically the conduit for federal air pollution mitigation funds, such as CMAQ (Congestion Mitigation and Air Quality) funds, which can be used in some cases to defray the costs of diesel retrofits.

Connecticut Special Act 05-7: An Act Establishing a Connecticut Clean Diesel Plan

It was with these factors in mind that the CT General Assembly passed S.A. 05-7, directing the Connecticut DEP to develop:

(4) An implementation strategy, to be phased in not later than July 1, 2006, on projects valued at more than five million dollars, to maximize particulate matter emissions reductions from

[38] MANE-VU 2002 Connecticut Emission Inventory
[39] For engines smaller than 75HP, the Tier 4 PM standard is 0.02 g/bhp-hr.

construction equipment servicing state construction projects, and an estimate regarding the cost and benefits to the state or municipalities of implementing such strategy;

In addition to an immediately implementable strategy for maximizing reductions from state projects over $5 million, the legislature also directed DEP to develop a comprehensive plan for meeting the diesel particulate matter emission reduction targets outlined in the 2005 Climate Change Action Plan:

(b) The Connecticut diesel emission reduction strategy shall recommend programs, policies and legislation for achieving reductions of diesel particulate matter consistent with reduction targets for diesel particulate matter indicated in the Connecticut Climate Change Action Plan 2005.

The targets in this plan amount to approximately a 75% overall reduction in diesel particulate matter emissions by 2015. Achieving this goal in a ten-year timeline would significantly accelerate (by 10-15 years) the air quality benefits that would eventually occur through the implementation of federal new engine rules and business-as-usual fleet turnover. This acceleration would result in fewer diesel-related health impacts, including asthma and other respiratory impacts, cardio-vascular impacts, cancer and premature deaths.

Because construction-related emissions are such a large proportion of overall diesel PM emissions in Connecticut, emission reduction efforts from these engines must be a significant component of this comprehensive 10-year effort. Therefore, the DEP may wish to consider approaching the development of a construction policy from both a short and long-term perspective.

- An immediately implementable strategy for maximizing emission reductions on state-funded projects over $5 million, and
- a 10-year plan to phase out all engines not meeting Tier 4 emission standards.

Connecticut's Construction Fleet

The State of Connecticut does not register non-road vehicles, and therefore does not have a central repository of information about construction vehicles. However, it is possible to construct an approximate picture of Connecticut's construction fleet using information submitted to DEP's Diesel Stakeholder Process.

Number of Engines:

- H.O. Penn Machinery estimates that the total equipment population in Connecticut equals approximately 10,000 units (3,500 units > 100 horsepower (HP) + 6,500 units < 100 HP).

Age of Engines:

- According to a survey by the Connecticut Construction Industry Association, the age-range of member-owned vehicles breaks down in the following way:
    - 25% - 20 years old or older
    - 25% between 15-20 years old
    - 17% between 10-15 years old
    - 21% between 5-10 years old
    - 12% newer than 5 years

Size of Engines:

- The EPA estimates that construction equipment in Connecticut breaks down by size according to the following proportions:

- 2% larger than 600 HP
- 5% between 300-600 HP
- 9% between 175-300 HP
- 19% between 100-175 HP
- 25% between 75-100 HP
- 17% between 50-75 HP
- 23% smaller than 50 HP

Approximate Equipment Inventory:

- Based on the figures above, the following is an approximation of the total inventory of Connecticut construction equipment:

	>600	300-600	175-300	100-175	75-100	50-75	<50	Total
1985 or older	50	125	225	475	625	425	575	2500
1986-1990	50	125	225	475	625	425	575	2500
1991-1995	34	85	153	323	425	289	391	1700
1996-2000	42	105	189	399	525	357	483	2100
2001-2005	24	60	108	228	300	204	276	1200
	200	500	900	1900	2500	1700	2300	10,000

State Contracted Inventory

- The Construction Subcommittee in the CT DEP's Connecticut Diesel Stakeholders Forum was unable to develop an estimate of the number and types of construction equipment contracted by the State of Connecticut for construction projects.

Existing Policy

Since 2001, the Connecticut Department of Transportation has had a Connecticut Clean Air Construction Bid Specification in place requiring contractors to reduce particulate matter emissions from construction equipment used on the I-95 Corridor Improvement Project through New Haven, "the Q-bridge Project." With the amendments agreed upon at the June 8th, 2005 meeting of the South Central Regional Council of Governments, the bid specification should now contain the following baseline requirements:

- All equipment (including non-road) shall use on-road grade fuel, which switches to 15 PPM sulfur content in the second half of 2006;
- All equipment (non-road and on-road) 60 HP and larger shall reduce particulate matter emissions by at least 20% by installing emission control retrofits or using clean fuels;

Reporting requirements and compliance provisions are included in the bid specification, as are certain exemptions.

Option 1 – Expand and enhance the CT Clean Air Construction Initiative

ConnDOT's four years of experience with the existing bid specification has provided a valuable base on which to build a comprehensive emission reduction policy for publicly-funded construction vehicles. However, so far the scope of this effort has been limited to the I-95 Corridor project through New Haven. Under Option 1, the state's next steps would be to:

1. **Broaden the scope** of state projects to which the CT Clean Air Construction Bid Specification applies. Apply the bid specification to all state-funded construction;
2. **Establish a formal mechanism for upgrading the bid specification** to require cleaner equipment over time, as Tier 3 and Tier 4 engines enter the market and high performance

retrofit technology is verified for the off-road market. Through a process of regular review, and reference to certification systems from other states and federal agencies, assure that the bid specification requires equipment to conform to an evolving definition of "maximum emission reductions."

3. **Establish a record-keeping procedure** for maintaining up-to-date information regarding construction equipment used on state-funded projects

1) Broaden the Scope - include all state-funded construction projects

The CT DEP has indicated that the following state agencies are directly involved in contracting for or otherwise funding construction projects:

- Department of Public Works
- Department of Transportation
- Department of Environmental Protection
- University of Connecticut
- Department of Economic and Community Development

Source: Memo, CT DEP, "The Number of State Construction Projects Costing $5 million or Greater," http://www.dep.state.ct.us/air2/diesel/docs/fivemilcontracts.pdf.

Under this option, a uniform CT Clean Air Construction Bid Specification would be adopted by the State of Connecticut for application in construction contracting by any state agency by certain deadlines. For example:

- By July 1, 2006, in accordance with P.A. 05-7, all state bid specifications on projects valued at $5 million or more should require adherence to the requirements of the CT Clean Air Construction Bid Specification, (baseline requirements listed above under "Existing Policy");
- By January 1, 2007, the CT Clean Air Construction Bid Specification should apply to all state-funded projects of any value.

While the Department of Education doesn't directly contract with construction companies, DOE school construction grants to municipalities amounted to more than $3.8 billion between 2000-2005. CT DOE's school construction program should likewise be subject to the CT Clean Air Construction Bid Specification.

2) Establish a regular and formal mechanism for updating the bid specification over time to reflect evolving definition of "maximum emission reductions"

In 2001, the diesel oxidation catalyst was selected as the technology of choice for this project because it was the most widely accepted and least expensive emission reduction option.[40] After more than five years of successful implementation, and in order to bring emissions to their lowest possible level, the DEP can recommend evolving the specification beyond the diesel oxidation catalyst where technology permits.

The initial objective of the CT Clean Air Construction Initiative in 2001 was to ensure that "*every effort will be made to implement measures to minimize emissions during the construction*

[40] Guido Shattanek, Alex Kasprak, Donna Weaver, Coralie Cooper, *Implementation of Retrofit/Clean Fuel Programs for Diesel Equipment During the Construction Phase of Two Large Transportation Projects*, 2002, (12-13).

period"[41] on the I-95 Corridor project through New Haven. This is a project that is scheduled to continue through the year 2014. To comply with the spirit of the Initiative, the state needs a periodic and formal mechanism to ensure that the contract specification continues to reflect the evolving state of technology and its effectiveness in "minimizing emissions." This will be particularly important as Tier 3 and Tier 4 engines enter the Connecticut market and high performance emission control retrofits are verified for use in non-road applications. Implementation of a mechanism to update the standard could take the following shape;

- To keep pace with new verifications brought about by changes in technology, by December 1, 2006, and every December 1 thereafter, the DEP Commissioner publishes an updated version of the CT Clean Air Construction Bid Specification. Updates reflect emission control verifications added to CARB and EPA's verified lists;
- The objective of annual updates is to ensure that the best available technology, verified by CARB or EPA for use on a particular engine, is put into use on that engine when used in the fulfillment of a contract with the state of Connecticut.
- By maintaining a direct reference to the CARB/EPA verified list, the bid specification reduces uncertainty for contractors and reduces the resources DEP allocates to updating the specification.

3) Establish a record-keeping procedure for maintaining historical and current information regarding construction equipment used on state-funded projects

- Inventory should include: number of engines, type of equipment, use of equipment, type and size of engine, engine model year, time spent on job.

Finance Options

Contract Specification

So far, the Connecticut Clean Air Construction Initiative has successfully used a contract specification to cover costs of emission control equipment. Contract specifications require that the contractor build the costs of meeting emission control requirements into the company's bid package.[42] The experience with the Boston Central Artery / Tunnel "Big Dig" project and the Connecticut Clean Air Construction Initiative showed that:

> *"when implementing a retrofit program for offroad construction equipment, it is best to include the requirement for emission control equipment as 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, thus avoiding the use of economic incentives to bring contractors into the program."*[43]

Since the costs of contract specifications appear in the bid package, the state pays these costs through the financing package of the overall construction project. ConnDOT has treated the costs of the Connecticut Clean Air Construction Initiative as "incidental" project costs.

Contract Allowance

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[41] *Ibid*, (9).
[42] ICF Consulting for U.S. EPA, *Emission Reduction Incentives for Off-Road Diesel Equipment Used in the Port and Construction Sectors*, 2005 (59).
[43] Guido Shattanek, Alex Kasprak, Donna Weaver, Coralie Cooper, *Implementation of Retrofit/Clean Fuel Programs for Diesel Equipment During the Construction Phase of Two Large Transportation Projects*, 2002, (15).

Alternatively, funding for retrofits could be administered through a "Contract Allowance" which functions essentially as a grant to the winning bidder. This method levels the playing field for bidders and does not disadvantage smaller businesses that may have a harder time competing for contracts if retrofit specifications are built into the bid package.[44]

One promising source of outside funding for contract allowances is the Federal Highway Administration's CMAQ (Congestion Mitigation and Air Quality) program. In the 2005 U.S. Transportation Bill, retrofits of diesel operated construction equipment were noted as priorities for receiving CMAQ funding.

Potential Costs and Benefits – Rough Estimate

The Construction Subcommittee was unable to estimate the number or types of construction equipment that is used on state funded construction jobs. In the absence of specific information, it is still possible to develop a rough estimate of costs and benefits.

The CT Department of Economic and Community Development estimated that in 2005, state construction authorizations amounted to $911 million, or approximately 15% of the total value of construction output in Connecticut as measured by Gross State Product ($5.9 billion).

Assume:

- State construction projects are responsible for 15% of total construction-related PM emissions: 15% of 694 tons = 104.1 tons per year
- State construction projects employ 15% of the Connecticut equipment inventory: 15% of 7,700 construction engines >50 HP = 1155 engines

Potential Cost Benefit Scenarios

	Low End	Middle	High End
Benefits	36.4 tons/yr	52 tons/yr	88.5 tons/yr
Cost	$2.31 million	$3.46 million	11.55 million

Low End assumptions: 35% PM reduction, DOC technology, $2000 (ave) per engine
Middle assumptions: 50% PM reduction, CWMF technology, $3000 (ave) per engine
High end assumptions: 85% PM reduction, DPF technology, $10,000 (ave) per engine

Beyond State Projects

A contract specification can be utilized by any participant in the market for construction services, public or private. Municipalities and large private actors with public service missions (colleges and universities, for instance) may be willing to follow the state's lead in adopting contract specifications that protect the public health. The state could facilitate this by publicizing the benefits of the Connecticut Clean Air Construction Initiative and providing assistance to policy makers and procurement officers at the local level who are interested in adopting a similar specification. This outreach effort could multiply the total emission reduction benefits to be gained from the construction sector.

[44] ICF Consulting for U.S. EPA, *Emission Reduction Incentives for Off-Road Diesel Equipment Used in the Port and Construction Sectors*, 2005 (59).

Option 2 – Adopt Best Available Control Technology requirement (NYC Local Law 77)

See the following documents:

- New York City Local Law 77 (12/22/03): http://www.nyccouncil.info/pdf_files/bills/law03077.pdf
- Notice of Promulgation of Chapter 14 of Title 15 of the Rules of the City of New York Rules Concerning the Use of Ultra-Low Sulfur Fuel and Emissions Control Technology in Nonroad Vehicles Used in City Construction (3/29/05): http://www.ci.nyc.ny.us/html/dep/html/news/notices.html
- DDC Ultra Low Sulfur Diesel Manual: http://www.nyc.gov/html/ddc/html/ddcgreen/documents/lowsulfur.pdf

Attachment G

CONSTRUCTION SUBCOMMITTEE MEETING
REPORT OF MEETING
AUGUST 31, 2005

Attendees:

Name	Organization
Faith Gavin Kuhn	CCIA
Donna Weaver	DOT
John Cohen	CCEJ
Madeleine Weil	Environment Northeast
Steve Washburn	H.O. Penn Machinery
Bill Menz	DEP
Tracy Babbidge	DEP
Cynthia Holden	DOT
Roger Smith	Clean Water Action
Charles Rothenberger	CT. Fund for the Environment
Mark Mitchell	CCEJ

Transactions:

Construction Projects over 5 Million Dollars:

- DPW- 7 per year, 1999-2005
- ConnDOT- 2005-11, 2006-11, 2007-8, 2008-12, 2009-5, 2010-6

All equipment on job site (onroad and nonroad) =454, average over the last five years per job=30-40, non-road over 60 HP=105

- DEP- Contracts to municipalities, 6 this year more than $5 million- waste water treatment. Tracy will investigate.
- DECD? Bill contacted Peter Simmons, will follow-up.
- UCONN- spreadsheet with capitol projects, but confusing.

DEP's To Do- Comprehensive spreadsheet, all agencies: #jobs, #pieces of equipment, engine age and size, if available. Target due date, one week, Bill will circulate to group.

Technology and Clean Fuels

- DEP put together a spreadsheet with technology options. Recommendations include installed price range, case studies links, ULSD should be listed out separately, cost per ton reductions (ICF report has estimates for CA and TX case studies), links where products used.
- How should certain tiers be addressed? Do they need retrofitting?
- Recommend an acronym definition key.

Idling:

- DOT and DEP idling regulations currently differ from DPW's- could be consolidated.
- Enforcement- typically only when people complain.
- Include anti-idling in regular training course for inspectors. Each department has it's own inspector's but only DEP can enforce. Infraction authority for local police will be on DEP's legislative agenda this year. Construction industry worries that police assigned to job site will issue tickets.
- Idling regulations could be published by CCIA for members.

Q-Bridge

- Contract B bid specification- at June meeting of South Central CT Council of Governments, DOT committed to revising the Contract B bid specification to a) require the use of on-road grade diesel for non-road equipment and b) extend the bid specification emission reduction requirement to dump trucks. DOT has not yet amended this bid specification, but will follow up and report back to group. Current bid specification applies to non-road greater than 60 HP. MA,CA, NY are using 50 HP. Few engines between 50-60 HP. Current advertisement schedule will be reported at next meeting.
- DPF pilot project- The specification will be advertised in a trade magazine for comment. Comment period to be determined. Initial announcement was for two projects, one in New Haven, one in Fairfield County. Hopefully, two projects will be used to include specification. Funding for two DPF's of expected to run about $50,000 including testing. Funding will come from the project.

DEP Diesel Website:

- Now on-line. Email DEP with things to post, suggestions about usability, etc. Address is www.dep.state.ct.us/air 2/diesel/ then Connecticut's Diesel Reduction Initiatives.
- Old Lyme, Westport and Fairfield submitted to Clean School Bus USA- grant applications posted online.
- New Haven application for construction retrofits posted online.
- Add CARB website link.
- Add grants.

Policy Examples:

- CCIA provided MA Highway Department specification- requires DPF or DOC retrofit for all highway department projects, does not require CARB or EPA verification. Tracy will follow up with Kristine Kirby, MA DEP.
- NYC Local Law 77- requires ULSD and BACT for all construction equipment working on City projects. City funded. (MRW email memo 8/12)
- CARB- currently developing in-use construction regulations (MRW email memo 8/25)
- Texas and California diesel retrofits are state funded.

Subcommittee Tasks

- Tracy and Bill will develop spreadsheet of state projects over $5 million and associate equipment detail where available: # pieces of equipment, duration on job, type/size, engine/vintage.
- Steve will see whether equipment delivery data is available pre-1998.
- Madeleine and Steve will work on developing equipment inventory and emissions inventory for cost/benefit analysis.
- Madeleine will prepare memo about construction retrofit case studies with links to reports.
- Cindy and Donna will follow-up on the amendments to the Contract B specification and the timing of advertising the DPF pilot project specification.
- Donna and Bill will research DPW, DOT and DEP anti-idling specifications.
- Tracy will contact Kristine Kirby on Massachusetts specification.
- Tracy will find out where Indirect Source Permit Regulations are.

Other Notes:

- Industry trending towards rental-based economy. Smaller contractors typically own machines, sometimes sub-contract, sometimes sit in the yard. Bigger businesses tend to rent more.
- Equipment that travels on-road should be registered with DMV.
- Portable generators greater than 60 HP- subject to Q-Bridge requirements. Several retrofitted.
- New regulations for the Indirect Source Permit to include Diesel Reduction Initiative currently at the Attorney General's office. Once regulations include comments for the AG's office they will go to notice.
- The next meeting will be on September 14, 2005 at 10:30 AM at CCIA.

Attachment H

Investigation of Diesel Emission Control Technologies on Off-Road Construction Equipment at the World Trade Center and PATH Re-Development Site

http://www.mjbradley.com/documents/PANYNJ_WTC_Final_Report-09Aug04.pdf

Attachment I

Cleaning the Air:
Comparing the Cost Effectiveness of
Diesel Retrofits vs. Current CMAQ Projects

An Analysis Prepared for the Emission Control Technology Association

by Robert F. Wescott, Ph.D.
Economic Consultant
Washington, DC

May 11, 2005

Robert F. Wescott, Ph.D. is a Washington, DC-based economic consultant with 25 years of professional experience working on macroeconomic and industry/public policy issues. Dr. Wescott served as Special Assistant to the President for Economic Policy at the White House and as Chief Economist at the President's Council of Economic Advisers. From 1982-93 he was Chief Economist at Wharton Econometrics (WEFA Group), the private economic analysis firm, where he oversaw all economic modeling, forecasting, and consulting operations. Dr. Wescott also was an official in the Research Department of the International Monetary Fund where he did research on global economic risks and policy challenges. In 1990 he was research director at the International Center for the Study of East Asian Development in Kitakyushu, Japan. He holds a Ph.D. in Economics from the University of Pennsylvania, 1983.

Cleaning the Air:
Comparing the Cost Effectiveness of
Diesel Retrofits vs. Current CMAQ Projects

Executive Summary

- A key goal of U.S. air pollution programs, including the Congestion Mitigation and Air Quality (CMAQ) program created in 1990, has been to clean the air in cities to improve public health and lower medical costs. But while the CMAQ program has emphasized reductions of carbon monoxide, hydrocarbons, and ozone, recent research finds that the top air pollution problem in urban areas today is fine particulate matter, which is particles with a diameter of 2.5 micrometers or less ($PM_{2.5}$).

- This pollutant, $PM_{2.5}$, is a primary airborne threat to human health today costing more than $100,000 per ton in health costs. Researchers estimate that $PM_{2.5}$ is two to twenty times as harmful to human health as nitrous oxide, more than one hundred times as dangerous as ozone, and 2000 times as dangerous as carbon monoxide on a per ton basis.

- Diesel engine exhaust is a source of $PM_{2.5}$ emissions in urban areas. Approximately one third of these diesel emissions are due to on-road vehicles and about two thirds are due to off-road equipment, such as construction equipment.

- Diesel retrofit technology is currently available that is highly effective at reducing $PM_{2.5}$ emissions. Diesel oxidation catalysts (DOCs) are well suited for retrofitting older off-road vehicles and diesel particulate filters (DPFs) are highly efficient at reducing these pollutants where new low sulfur diesel fuels are available, as is already the case in most urban areas.

- From the point of view of cost effectiveness, diesel retrofits are superior to almost all current CMAQ strategies, including ride-share programs, van-pool arrangements, HOV lanes, traffic signalization, bike paths, and all strategies that attempt to modify behavior (like encouraging telecommuting.) Most of these CMAQ strategies cost $20,000 to $100,000 per ton equivalent of pollutant removed, and some cost as much as $250,000 per ton removed.

- Under conservative assumptions, diesel retrofits cost only $5,340 per ton equivalent of pollutant removed, In fact, among all CMAQ strategies, only emission inspection programs appear to exceed the cost effectiveness of diesel retrofits.

- Expanding the range of CMAQ projects to include diesel retrofits for construction equipment and off-road machinery in urban areas could be a highly effective way to spend public monies. More than 100 million Americans live in areas of the country where $PM_{2.5}$ levels exceed the EPA's guidelines.

Background

Cleaning the air to improve human health and lower medical costs has been an objective of U.S. government policy since at least the Clean Air Act of 1970. Concerns about poor air quality, especially in urban areas, led to the creation of the Congestion Mitigation and Air Quality (CMAQ) Program in 1990, which has set aside a portion of transportation monies for the past 15 years to fund innovative projects to reduce carbon monoxide, hydrocarbons, nitrous oxides, and smog in so-called non-attainment areas.[45] Vehicle emission inspection programs, high-occupancy vehicle (HOV) travel lanes, van pool programs, park-and-ride lots, and bike paths are examples of CMAQ projects.

There has been significant progress in the past 35 years in reducing carbon monoxide and hydrocarbon emissions and smog. Scientists, however, have been able to identify new airborne health risks whose costs are now becoming more fully appreciated. Notably, particulate matter (PM) has been found to have especially pernicious health effects in urban areas. Increasingly it is becoming understood that diesel engine emissions in urban areas, both from on-road trucks and buses and from off-road construction and other equipment, are a significant source of fine particulate matter pollution. This leads to a number of questions:

- What is the current assessment of the top health risks from air pollution from mobile sources in urban areas?
- What is the role of emissions from diesel engines?
- How does diesel retrofit technology to clean engine emissions after combustion compare with current CMAQ projects in terms of cost effectiveness?
- Are CMAQ funds currently being deployed in the most cost effective manner possible?

This paper examines these questions by reviewing the recent scientific, environmental, economic, and health policy literature.

The Health Costs of Air Pollution

In the 1960s and 1970s the key health risks from air pollution were deemed to come from carbon monoxide, hydrocarbons (or volatile organic compounds, VOCs), nitrous oxides (NO_x), and smog, and early clean air legislation naturally targeted these pollutants.[46] During the past ten years or so, however, researchers have identified new pollutants from mobile sources that have particularly harmful health effects, especially in urban areas. Top concern today centers around particulate matter, and especially on fine particulate

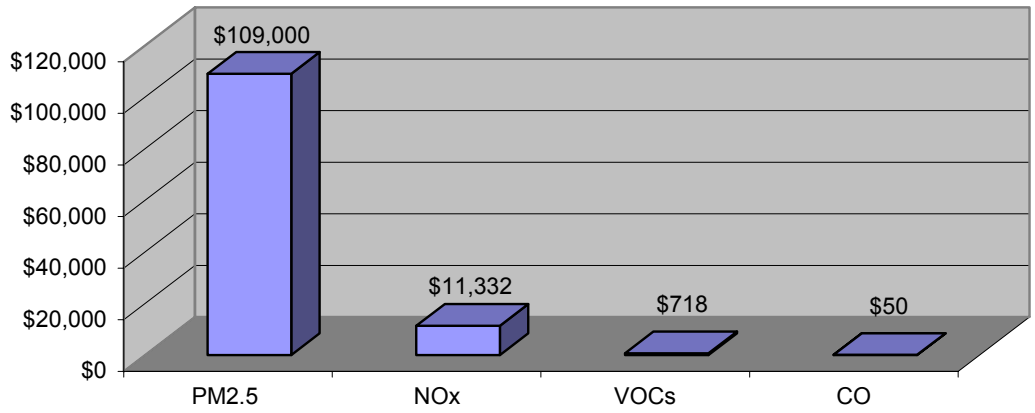
[45] The EPA has formal criteria for the definition of non-attainment areas, but generally these are the large U.S. cities.
[46] Catalytic converters installed on all cars since the mid 1970s, for example, have targeted these pollutants.

matter. Fine particulates, with a diameter of less than 2.5 micrometers ($PM_{2.5}$), can get trapped in the lungs and can cause a variety of respiratory ailments similar to those caused by coal dust in coal miners. A significant portion of $PM_{2.5}$ emissions in urban areas come from off-road diesel equipment. According to analysis by the California Air Resources Board, on-road engines account for about 27% of PM emissions in California and off-road equipment is responsible for about 66% of PM emissions.[47]

Analysis by Donald McCubbin and Mark Delucchi published in the *Journal of Transport Economics and Policy* evaluates the health costs of a kilogram of various air pollutants, including CO, NO_x, $PM_{2.5}$, sulfur oxides (SO_x), and VOCs.[48] These researchers estimate health costs from such factors as, hospitalization, chronic illness, asthma attacks, and loss work days for the U.S. as a whole, for urban areas, and for the Los Angeles basin. For urban areas, they find the range of health costs per kilogram of CO was from $0.01 to $0.10, NO_x was from $1.59 to $23.34, $PM_{2.5}$ was from $14.81 to $225.36, SO_x was from $9.62 to $90.94, and VOCs was from $0.13 to $1.45. Taking the mid-points of these estimates, a kilogram of $PM_{2.5}$ therefore was nearly 10 times more costly from a health point of view than a kilogram of NO_x, more than 150 times more costly than a kilogram of VOCs, and more than 2000 times more costly than a kilogram of CO. On a per ton basis, a ton of $PM_{2.5}$ causes $109,000 of health costs, a ton of NO_x costs $11,332, a ton of VOCs costs $718, and a ton of CO costs $50 (Chart 1).

Chart 1

Health Costs per Ton, Urban Areas (Midpoint Estimate)



Source: McCubbin and Delucchi (1999)

[47] *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, California EPA Air Resources Board, October 2000, p. 1.

[48] McCubbin, Donald and Mark Delucchi (1999), The Health Costs of Motor-Vehicle-Related Air Pollution, *Journal of Transport Economics and Policy*, September, Vol. 33, Part 3, pp. 253-86.

Effectiveness of Diesel Retrofit Filters

Given the high health costs of $PM_{2.5}$, significant effort has gone into the development of technological solutions to deal with the problem. The best technologies involve the use of post-combustion filters with a catalyzing agent, which together trap and break down dangerous pollutants before they are emitted into the air. All new diesel trucks will be required to use these technologies by 2007 according to U.S. EPA rules, and off-road equipment will have to use these technologies by 2010. (Rules require 95% reductions in emissions of several pollutants, as well as a 97% cut in the sulfur levels in diesel fuel.)[49] However, given that the lifespan of a diesel engine can be 20-30 years, it will take decades to completely turn over America's diesel fleet. Therefore, by lowering emissions from older diesels, retrofits are an effective path to cleaner air over the next few decades.

Diesel retrofit filters are highly effective at their chief function: preventing dangerous pollutants from ever entering the air. Diesel oxidation catalysts (DOCs), at $1,000 to $1,200 per retrofit, reduce PM by about 30% and can work with current higher sulfur diesel fuels. This yields a large benefit when installed on older, higher-polluting vehicles. In addition to their PM reducing capabilities, these filters also can cut the emission of carbon monoxide and volatile hydrocarbons by more than 70%.

Diesel particulate filters (DPFs), which generally cost $4,000-$7,000 per engine, are far more efficient. They are specifically targeted at keeping more dangerous PM out of the air than are DOCs. In fact, they can reduce $PM_{2.5}$ pollution from each vehicle by more than 90%, yielding an enormous cut in emissions over the life of the diesel engine, even when installed on newer, cleaner diesel vehicles. An additional requirement of DPFs, however, is that the vehicle must run on newer very low sulfur fuels. High sulfur fuel leads to sulfate emissions from the filter due to the very active catalysts needed to make the filters function properly. Thus, DPFs are most effective as a solution for vehicles in urban areas—such as construction equipment and urban fleets—where very low sulfur fuels are already available.[50]

These technologies are not new or experimental; they are already in use around the world. There are 2 million of these two technologies already at work in heavy-duty diesel vehicles worldwide. Further, there are 36 million DOCs and 2 million DPFs in use on passenger vehicles in Europe alone, where these technologies are currently being used, reaping cost-effective health benefits over the long term.

The CMAQ Program

The CMAQ program is the only federally funded transportation program chiefly aimed at reducing air pollution.[51] Its historical purpose has been twofold: to reduce traffic

[49] "EPA Dramatically Reduces Pollution from Heavy-Duty Trucks and Buses, Cuts Sulfur Levels in Diesel Fuel," *Environmental News*, EPA, 12/21/00

[50] Very low sulfur diesel fuel will be available nationwide by 2006.

[51] Transportation Research Board of the National Research Council: *The Congestion Mitigation and Air Quality Improvement Program: Assessing 10 Years of Experience* (2002) p.1.

congestion and to fund programs that clean up the air Americans breath. Within its air quality mission, it is designed primarily to help non-attainment areas (mainly polluted urban zones) reach attainment for air quality standards under the Clean Air Act.[52] Historically many CMAQ projects have tried to change travel and traffic behavior in order to achieve its goals. These transportation control measures (TCMs) have been designed both to reduce traffic congestion as well as improve air quality. An example is a bicycle path. Designed to reduce the number of drivers on the road, bike paths could, in theory, achieve both goals. Further examples are vanpools, ridesharing and park and ride programs, and HOV lanes: all current CMAQ projects. Other projects have addressed emission reductions directly, as for example, through funding for state automobile emission inspection programs.

As a condition for reauthorizing the CMAQ program in 1998, the U.S. Congress required that a detailed 10-year assessment of the program be conducted. This review was performed by the Transportation Research Board of the National Research Council and was completed in 2002. This review found that CMAQ has been less than successful in reducing congestion and suggested that the most beneficial way for CMAQ to use its funds is to focus on air quality.[53] It also found that TCMs were less cost effective than measures to directly reduce emissions, such as through inspection programs.

Furthermore, the study suggested that CMAQ's focus within the domain of air quality is misplaced. CMAQ programs have targeted the gases considered the most dangerous pollutants for many years, like hydrocarbons, carbon monoxide, and nitrous oxides. While these gases pose recognized health and environmental risks, recent work has shown that the dangers of these substances pale in comparison to the danger of fine particulate matter.[54] In the words of the study, "Much remains to be done to reduce diesel emissions, especially particulates, and this could well become a more important focus area for the CMAQ program."[55] Further, discussing the fact that diesel-related CMAQ programs could be the most cost-effective, the study states, "had data been available on particulate reductions… the ranking of strategies focused on particulate emissions… would likely have shown more promising cost-effectiveness results."[56]

Comparing the Cost Effectiveness of Diesel Retrofits with Other CMAQ Projects

Given that $PM_{2.5}$ emissions from diesel engines are a leading health concern, that effective technology exists today to clean the emissions of off-road diesel equipment used extensively in the middle of American cities (non-attainment areas), and that the CMAQ 10-year review highlights the possible use of CMAQ funds for diesel retrofit projects, it is logical to compare the cost effectiveness of these diesel retrofits with current CMAQ projects. *The CMAQ Program: Assessing 10 Years Experience* (2002) estimates the median cost per ton of pollutant removed for 19 different CMAQ strategies and these

[52] ibid, p.1
[53] ibid, p.13
[54] ibid, p.13
[55] ibid, p.74
[56] ibid, p.131

estimates provide the comparison base. Published estimates for diesel retrofits are compared with these estimates.

As a first step in comparing the cost effectiveness of pollution reduction strategies, it must be noted that the CMAQ cost effectiveness estimates are presented as "cost per ton equivalent removed from air," with weights of 1 for VOCs, 4 for NO_x, but 0 for $PM_{2.5}$.[57] Relying upon the McCubbin and Delucchi health cost estimates, however, even weighted NO_x should be considered more damaging than VOCs. That is, even though 0.25 ton (the 1:4 ratio above) of NO_x removed counts as the CMAQ equivalent of one ton of pollution removed, it has a higher health cost than a ton of VOCs ($11,332 / 4 = $2,883 for NO_x vs. $718 for VOCs). As a second step, conservatively assume that all CMAQ projects remove the more damaging pollutant (NO_x). This still means that a ton of $PM_{2.5}$ reduction would be worth at least 9.45 tons of regular CMAQ reductions ($109,000 for $PM_{2.5}$ / $11,332 for NO_x).

Diesel retrofits are estimated to cost $50,460 per ton of $PM_{2.5}$ removed by the California Air Resources Board (CARB).[58] This estimate is very conservative and substantially higher than that cited by industry sources. Using the CARB cost estimate, diesel retrofits cost $5,340 per ton equivalent of air pollution removed ($50,460 / 9.45), based upon the CMAQ definition of ton equivalent and on the conservative assumption that CMAQ projects remove the most damaging pollutant reviewed. If a less conservative and more realistic assumption is used – that CMAQ projects remove a mix of NO_x and VOCs – then the cost-effectiveness of diesel retrofits becomes substantially more favorable, and could be as low as $332 per ton of CMAQ pollutant removed.

This analysis means that diesel retrofits for construction equipment are highly cost effective when compared with current CMAQ strategies. As shown in Table 1 and Chart 2, some CMAQ strategies cost more than $250,000 per ton of pollutant removed (teleworking), and many are in the $20,000 to $100,000 per ton range (traffic signalization, park and ride lots, bike paths, new vehicles, etc.). The only current CMAQ project category that exceeds the cost effectiveness of diesel retrofits is emission inspection programs.

Other studies also conclude that diesel retrofits are highly cost effective compared with current CMAQ projects. The Diesel Technology Forum compared the benefits and costs of CMAQ projects with diesel retrofits for transit buses (for NO_x pollution reduction) and concluded that retrofits are a better use for CMAQ funds than any other typical CMAQ project, with the exception of inspection and maintenance programs and speed limit enforcement.[59] Also, the California EPA's Air Resources Board has estimated that diesel

[57] Importantly, the study's $PM_{2.5}$ weight of 0 does not reflect $PM_{2.5}$'s health costs, but rather that fact that standards have not yet been set for it by the U.S. EPA. As the CMAQ 10-year review says, "$PM_{2.5}$ is generally regarded as the pollutant with the most pernicious health consequences, though to date standards have not been promulgated for its regulation for both measurement and economic reasons." (p. 295).
[58] California Air Resources Board, "Staff Analysis of PM Emission Reductions and Cost-Effectiveness," Sept. 6, 2002.
[59] "The Benefits of Diesel Retrofits," Diesel Technology Forum. See http://dieselforum.org/retrofit/why_ben.html.

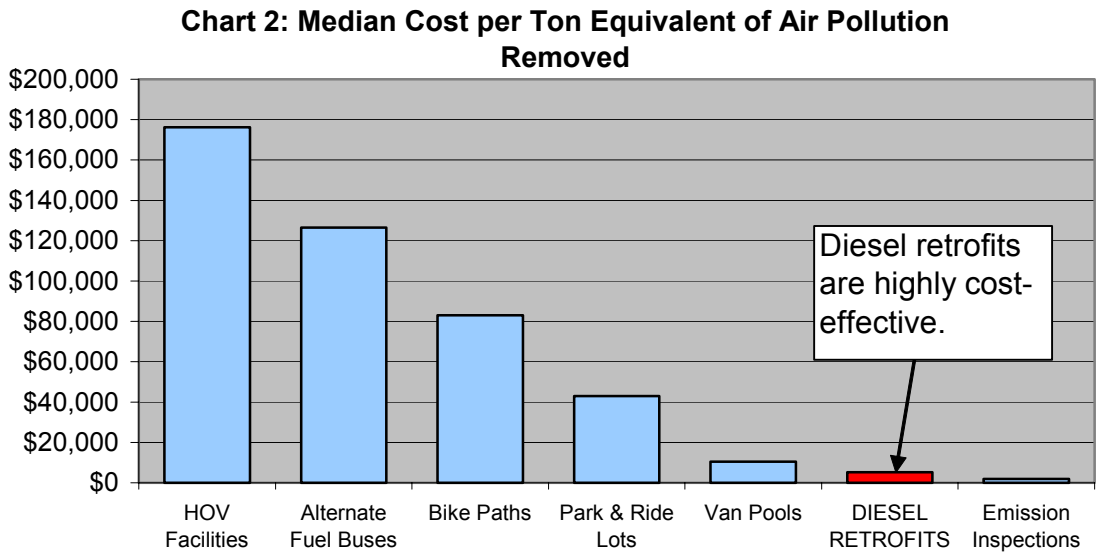
retrofits have a benefit of between $10 and $20 for each $1 of cost.[60] And the U.S. EPA, in its justification for new on-road diesel rules in 2007 and off-road rules in 2010 estimates the benefits for diesel particulate filters at roughly $24 for each $1 of cost.[61]

Table 1: Cost-Effectiveness of Current CMAQ Strategies And Diesel Retrofits
(Median cost per ton equivalent of air pollution removed)

	Median Cost	Rank
Inspection and Maintenance	$1,900	1
DIESEL RETROFITS	**$5,340**	**2**
Regional Rideshares	$7,400	3
Charges and Fees	$10,300	4
Van Pool Programs	$10,500	5
Misc. Travel Demand Management	$12,500	6
Conventional Fuel Bus Replacement	$16,100	7
Alternative Fuel Vehicles	$17,800	8
Traffic Signalization	$20,100	9
Employer Trip Reduction	$22,700	10
Conventional Service Upgrades	$24,600	11
Park and Ride Lots	$43,000	12
Modal Subsidies and Vouchers	$46,600	13
New Transit Capital Systems/Vehicles	$66,400	14
Bike/Pedestrian	$84,100	15
Shuttles/Feeders/Paratransit	$87,500	16
Freeway Management	$102,400	17
Alternative Fuel Buses	$126,400	18
HOV Facilities	$176,200	19
Telework	$251,800	20

Source: All costs from *The CMAQ Improvement Program: Assessing 10 Years of Experience, (2002),* except diesel retrofit costs, which are from author's calculations.

[60] "Perspectives on California's Diesel Retrofit Program," California EPA, Air Resources Board, presentation by C. Witherspoon, June 3, 2004.
[61] See, for example, "2007 Heavy-Duty Highway Final Rule," U.S. EPA, May 2000, which can be found at http://www.epa.gov/otaq/diesel.htm.



Conclusions

The top air pollution problem in U.S. urban areas today is almost certainly $PM_{2.5}$, which is estimated to cost more than $100,000 per ton in health costs. A major source of $PM_{2.5}$ emissions in urban areas is diesel engine exhaust. Approximately one third of these diesel emissions are due to on-road vehicles and about two thirds are due to off-road equipment. Off-road equipment in urban areas is a particular problem, because it gives off exhaust at ground level,frequently near large groups of people.

Diesel retrofit technology is currently available that is highly effective at reducing $PM_{2.5}$ emissions. DOCs are well suited for retrofitting older off-road vehicles and DPFs are highly efficient at reducing these pollutants where new low sulfur diesel fuels are available, as is already the case in most urban areas.

From a cost effectiveness point of view, diesel retrofits are superior to almost all current CMAQ strategies, including ride-share programs, van-pool arrangements, HOV lanes, traffic signalization, bike paths, and all strategies that attempt to modify behavior (like encouraging teleworking.) Only emission inspection programs exceed the cost effectiveness of diesel retrofits based upon conservative assumptions. Expanding the range of CMAQ projects to include diesel retrofits for construction equipment and off-road machinery in urban areas could be a highly effective way to spend public monies.

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Attachment J

Implementation Of Retrofit Program For Diesel Equipment During The Construction Phase The I-95 New Haven Harbor Crossing Improvement Program In Southern Connecticut

Paper # 999

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ABSTRACT

The Connecticut Department of Transportation (DOT) implemented a diesel vehicle emission control program during the construction phase of the I-95 New Haven Harbor Crossing Improvement Program (I-95 NHHC) in Southern Connecticut. The I-95 NHHC project includes the reconstruction of Interstate I-95 from Exit 46 in New Haven to Exit 54 in Branford, and the replacement of the Pearl Harbor Memorial Bridge. Construction of the 7.2-mile corridor started in 2002 and is expected to take more than twelve years to complete.

The I-95 NHHC diesel vehicle emissions control program required that diesel powered construction equipment either retrofit the engine with emission control devises, and/or use clean fuels.

This paper focuses on the results of the program after over 70 pieces of diesel powered construction equipment have been retrofitted with oxidation catalysts during the first three years of construction. It includes: a summary of the development of the emission control specifications and estimated emission reductions and cost; a description of the information process to contractors, the inspection-verification process, and the tracking procedures put in place to ensure continuation of the program as it moved from development to implementation phase. It also covers practical issues such as what contractors do with the emission control devices once the equipment leaves the project.

INTRODUCTION

The need for reducing emissions from heavy-duty diesel engines is clear. The diesel engine has been a workhorse of the 20th century. It is reliable, fuel-efficient, durable, easy to repair, and inexpensive to operate. But diesel engines produce significant levels of particulates (PM) and nitrogen oxides (NOx), mostly when overloaded during acceleration from a stop.

Current estimates indicate that emissions from such engines in the Northeast States account for roughly 33% of the NOx and 80% of the PM emitted by all mobile sources. In addition, since diesel engines that power construction equipment are more polluting than equivalent diesel engines for normal highway use (due to the lack of any emission controls until 1996), the reduction of these emissions has not only the potential to improve ambient air quality for the region, but more importantly, it has significant air quality benefits to those who live or work in or adjacent to construction areas.

A major step in reducing diesel emissions was taken in May 2004 with the approval of the new U.S. Environmental Protection Agency (EPA) Clean Non-road Diesel Rule. This new Tier 4 emission standards for non-road engines will apply to diesel engines used in most kinds of construction, agricultural, and industrial equipment. The new rule includes a nationally mandated reduction of sulfur content in non-road diesel fuel from approximately 3,000 parts per million (ppm) average today to 500 ppm by 2007, and 15 ppm by 2010, and the phased implementation of emission control technology on non-road diesel engines after 2008. However, due to the durability of diesel engines it will take almost two decades to have the diesel engines that power construction equipment replaced with the new mandated cleaner engines.

The diesel engine retrofit program discussed in this paper started as a way to reduce emissions before cleaner fuels and cleaner engines become part of the standard manufacturing process. Currently, there is an expanding list of emission reduction technologies, which has been approved by Environmental Protection Agency (EPA) and California Air Resources Board (CARB) for diesel engines and clean fuels. The most commonly known technologies can be grouped into three main categories:

- Fuel modifications: including synthetic diesel, water-in-diesel emulsions, biodiesel, ultra low sulfur diesel, and fuel additives.
- Engine Design/fuel modifications: including exhaust gas recirculation (EGR), dimethyl ether, and natural gas.
- After Treatment /add-on pollution control devices: including oxidation catalysts, diesel particulate filters (DPF), lean catalysts, and selective catalytic reduction (SCR).

The I-95 NHHC diesel emission control program focused on add-on pollution control devises with the option of cleaner diesel fuels. Since currently there are several areas within the US where these types of programs are being evaluated and/or are starting to be implemented, the experience of this large transportation project can serve as a road map toward implementation of these programs in other areas.

I-95 NHHC OVERVIEW

The I-95 NHHC administered by the Connecticut DOT consists of the construction of a new State Street Commuter Railroad Station, the widening of I-95 from Exit 46 in New Haven to Exit 54 in Branford, the replacement of the existing Pearl Harbor Memorial Bridge (Q Bridge) with a new 10 lane bridge, and the reconstruction of the I-95/I-

91/Route 34 Interchange. The existing Q Bridge built in 1958 to carry 40,000 vehicles per day, was operating in 1993 at a level of over 120,000 per day. By 2015 a traffic level of 140,000 to 150,000 vehicles per day has been forecasted.

The project is located in the municipalities of New Haven, East Haven and Branford, which are a serious non-attainment area for ozone (O_3), and non-attainment for PM_{10} and $PM_{2.5}$ for the New Haven area only.

The construction of this 7.2-mile corridor, which started in 2002 and will take more than twelve years to complete, will include more than 200 pieces of diesel powered construction equipment. Construction is divided in five phases under four major contracts. Four contracts have been awarded with the first one completed in June 2004. The first contract (called Contract D) started June 2002. Contract C1 (working in the East Haven area) is scheduled to finish November 2005. Two other contracts have just been awarded.

DIESEL EMISSION CONTROL PROGRAM DEVELOPMENT

The DOT started to look at the possibility of a retrofit program linked to the I-95 NHHC one year before the advertising of the first construction contract. In October 2000, DOT formed an air quality working group, which investigated the benefits and costs of implementing a diesel emission control program. The group included personnel from various offices within DOT, and experts from Parsons Brinckerhoff (PB), New England States for Coordinated Air Use Management (NESCAUM), Connecticut Department Environmental Protection (DEP), Department of Motor Vehicles (DMV), and Connecticut Construction Industries Association (CCIA).

It was decided early on that the Diesel Emission control Program called "Connecticut Clean Air Construction Initiative" would combine the non-road diesel powered equipment with the inspection of highway diesel vehicles. The highway diesel vehicles are already regulated by the DMV under a heavy-duty diesel emissions regulation. In the state of Connecticut the DMV conducts opacity tests on heavy-duty diesel vehicles.

Selected Technologies

Four different scenarios (technologies) that could be implemented to reduce air emissions during construction were identified. Two included diesel engine retrofit technologies, such as oxidation catalysts and/or four way catalysts; while two others included the use of cleaner fuels, Biodiesel B-20 Blend™ and/or PuriNOx™. Any of these four technologies could be applied partially and in combination with the others. All had logistical and cost advantages and disadvantages that were evaluated prior to implementation.

An evaluation of emission benefits and costs for each technology was performed during 2001. The methodology used to estimate the emission reductions from the diesel retrofit and/or clean fuels program followed the same procedure used for State Implementation Plan credit calculations recommended by NESCAUM, i.e.:

- Estimation of baseline emission factors for CO, HC, NOx and PM_{10} by equipment type in grams per brake horsepower hour.

- Estimation of baseline emissions (tons/year) based on equipment type, usage, and hours of operation.
- Estimation of emission reductions for each type of equipment retrofitted and/or type of fuel for applicable pollutants.

Emission rates for CO, HC, NOx, and PM from diesel powered construction equipment were estimated using the EPA NONROAD Emission Model.

A paper presented by the same authors at the 2002 AWMA annual meeting (Paper No. 42536) described the technology selection process up to the development of the emission control specifications (pre-construction phase).

Considering that this was a voluntary pilot program for DOT, it was decided to use the most widely accepted technology and fiscally responsible emission reduction options.

As such, the following technologies were selected:

- Oxidation catalysts due to its wide acceptance and proven experience,
- Clean fuels listed with the EPA or CARB which could achieve specific NOx and PM emissions reductions.

It was decided that the program would include the option of either retrofitting with oxidation catalysts or use a clean fuel such as the emulsified diesel fuel PuriNOx^{TM}. This would provide the contractors more flexibility in situations where equipment would not remain on site for long periods of time.

Four way catalysts were considered to be too experimental and too costly for a pilot program. The use of Biodiesel was rejected because of the possible NOx increases.

A blind survey of construction equipment conducted by CCIA indicated that the Connecticut non-road equipment fleet is primarily an average of 1980's vintage. The makeup of the construction fleet can range from brand new to 55 years old. Construction companies nursed their equipment from job to jobs and large companies sell their old equipment to smaller firms extending the equipment life cycle.

The existence of so many pre-1994 (Tier 1) pieces of equipment limited the option of using diesel particulate filters (DPF). The success of DPFs have been mostly on highway trucks and buses, with more limited cases on construction equipment. In addition, most of the manufacturers of DPF listed in the EPA retrofit technology list are designed for post 1994 diesel engines, and also require the use of ultra low sulfur diesel.

DPFs require exhaust temperature profiles above 210 degrees Centigrade for at least 40% of time, and the NO_x /PM ratio greater than 20%, preferably greater than 30%. Pre 1994 non-road construction equipment engines typically have extremely low NOx/PM ratios. Essentially they are spewing a lot more PM. In addition, they were designed for a higher sulfur fuel, which presents additional hurdles for the proper functioning of DPFs.

Emission Reductions Potential and Costs

Oxidation Catalysts

At the time the evaluation for the I-95 NHHC Program started, the Central Artery/Tunnel (CA/T) Project in Boston, Massachusetts had already installed approximately 70 oxidation catalysts on a variety of construction equipment with positive results. Based on the EPA technology retrofit list, oxidation catalysts are expected to achieve a minimum of 20% reductions for PM, 40% reductions for CO, and 50% reductions for HC in all heavy-duty diesel engines. The average cost per piece of equipment in the CA/T project was $ 2,500, which translated into a cost of $8/Horse-power (HP), which was used for this assessment.

Table 1 below presents a summary of the emissions reductions and costs for each one of the major contracts as forecasted during the pre-construction evaluation.

Table 1: Projected Emission Reductions and Cost of Diesel Oxidation Catalysts

Contract	Total Number of Units	Total Engine HP	Total Utilized Annual Hp-hr	Annual Emission Reductions			Total Projected Cost
				CO	HC	PM_{10}	
	#	hp	hp-hr/yr	tons/year	tons/year	tons/year	(dollars)
Contract B	71	18,999	17,255,587	29.3	11.1	2.5	151,992
Contract C	62	15,817	14,212,442	24.2	9.0	2.0	126,536
Contract D	31	8,367	7,781,314	14.3	5.4	1.2	66,936
Contract E	58	15,592	14,070,826	25.6	9.7	2.1	124,736

Source: Guido Schattanek, Technical Memorandum – I-95 NHHC – Projected Air Pollution Benefits and Costs of Diesel Retrofit and/or Clean Fuels Program For Construction Phase, Connecticut. Department of Transportation, December 4, 2000

Clean Fuels

PuriNOx™ is an emulsified diesel fuel manufactured and distributed by Lubrizol Corp. in Ohio. It can be used on any diesel engine without modifications. It was considered as a good alternative to reduce NOx and PM_{10} since the EPA retrofit technology list certifies that use of this fuel can reduce PM from 16 to 58% and NOx from 9 to 20%.

The cost of PuriNOx™ at the time was approximately 16-cents per gallon above the cost of N°2 diesel fuel according to the Massachusetts distributor. Since PuriNOx ™ contains close to 20% of water, the relative cost differential depends on the wholesale cost of

diesel fuel (i.e. the higher the diesel fuel cost the lower the differential). It also carries a fuel consumption penalty since water has no caloric power, making the real cost to the contractor higher than the fuel cost differential.

Table 2 below also presents a summary of the emissions reductions and costs for each one of the major contracts as forecasted during the pre-construction evaluation.

Table 2: Projected Emission Reductions and Cost of use of PuriNOx^{TM} fuel.

Contract	Total Number of Units	Total Engine HP	Total Utilized Annual Hp-hr	Annual Emission Reductions		Total Projected Cost
				NOx	PM_{10}	Annualized
	#	hp	hp-hr/yr	tons/year	tons/year	(dollars)
Contract B	71	18,999	17,255,587	30.0	2.5	138,045
Contract C	62	15,817	14,212,442	24.9	2.0	113,700
Contract D	31	8,367	7,781,314	13.7	1.2	62,251
Contract E	58	15,592	14,070,826	24.8	2.1	112,567

Source: Guido Schattanek, Technical Memorandum – I-95 NHHC – Summary of Projected Air Pollution Benefits and Costs of Diesel Retrofit and/or Clean Fuels Program For Construction Phase, Connecticut. Department of Transportation, December 7, 2000

Equipment Size Applicability And Length Of Time On Site

An evaluation of the emission benefits, as a function of HP-hours of operation and fuel consumption for each contract, indicated that if all equipment with engine size over 60 HP were retrofitted, more than 98% of the emission benefits of retrofitting all equipment would be achieved. As a result, 60 HP became the smallest engine size that would be retrofitted. In terms of duration of the equipment on the construction site, the main issues were if specialized equipment would need exemption because they would be only needed for some special operation, and how to deal with rental equipment without limiting the contractor's options. The minimum time limit required for exemption started at 100 days, and latter was shortened to 30 days in order to limit the possibility that contractors will rotate equipment to avoid complying with the program.

Payment Options

Current DOT standard specifications related to environmental compliance are in the form of either "incidental" or "pay" items.

- Pay items are those that the contractor bids a unitary price for, can be measured on site, and once verified by an inspector, are paid for according to the contract's unitary price. This payment method is common for such items as the application of calcium chloride, water for dust control, and/or fences for wind or erosion control. The contractor has to perform these tasks in order to get paid.
- Incidental items are those where that the cost is included in a contractor's overall bid price, and not specifically identified. One of the critical issues associated with incidental items is enforcement (i.e., what monies are retained for non-compliance). DOT has a 24-hour provision normally used for environmental aspects, where once the contractor is notified that they are not performing a contractual task, the Department can have the task performed by a third party, with the cost billed to the contractor.

It was decided that the retrofit program would be included in project contracts as an incidental item, with some special enforcement provisions.

Diesel Vehicle Emissions Controls Specification

Current DOT standard specifications related to airborne emissions include 1.10.04 Air quality Control, 9.42 Calcium chloride for dust control, and 9.43 Water for dust control. The retrofit/clean fuel program has been issued in what is called a Notice to Contractors (NTC). In the bid package the NTC is a legally binding specification in the Special Provision portion, and is linked to all future I-95 NHHC contracts.

The final form of the specification can be summarized as follow:

- All diesel powered construction equipment with engine horsepower (HP) ratings of 60 HP and above, that are on the project or are assigned to the contract for a period in excess of 30 days shall be retrofitted with Emission Control Devices and/or use Clean Fuels in order to reduce diesel emissions. In addition, all motor vehicles and/or construction equipment shall comply with all pertinent State and Federal regulations relative to exhaust emission controls and safety.
- The reduction of emissions of CO, HC, NOx, and PM will be accomplished by installing retrofit emission control devices or by using less polluting clean fuels.
- The retrofit equipment shall consist of oxidation catalysts, or similar retrofit equipment control technology that is included in the EPA Verified Retrofit Technology List, and certified to provide a minimum of emission reductions of 20% PM, 40% CO, and 50% HC.
- The Clean Fuels shall consist of PuriNOx^{TM}, or other low NOx and PM emission diesel fuel that can be used without engine modification, and it is certified to reduce the emission of NOx, and PM by more than 10% and 30% respectively when compared to N^{o}2 diesel fuel as distributed and sold in the State.
- Construction shall not proceed until the contractor submits a certified list of the diesel powered construction equipment that will be retrofitted with emission control devices or that will use Clean Fuels. The list shall include (1) the equipment number, type, make, and contractor/sub-contractor name; (2) the

emission control device make, model and EPA certification number; and/or (3) the type and source of fuel to be used.

- The contractor shall submit monthly summary reports, updating the same information stated above, and include certified copies of the clean fuel delivery slips for the report time period, noting which vehicles received the fuel. The addition or deletion of diesel equipment shall be included on the monthly report.

- The contractor shall establish truck-staging zones that are waiting to load or unload material at the contract area. Such zones shall be located where the diesel emissions from the trucks will have minimum impact on abutters and the general public.
- Idling of delivery and/or dump trucks, or other diesel powered equipment shall not be permitted during periods of non-active use, and it should be limited to three minutes in accordance with Regulations of Connecticut State Agencies 22a-174-18, subsection (a)(5).
- A Diesel Emissions Mitigation plan will be required for areas were extensive work will be performed in close proximity (i.e. less than 50 feet) to sensitive receptors.

If a diesel equipped vehicle is found to be in non-compliance with this specification, the contractor will be issued a Notice of Non-Compliance and given a 24-hour period in which to bring the vehicle into compliance or remove it from the project.

Heavy-Duty Diesel Highway Vehicles Emissions Opacity Test Regulation

The DMV performs the inspections in conjunction with any safety or weight requirement at any official weighing area or other location designated by them.

The DMV Program specifies that only diesel-powered commercial motor vehicles consisting of the following characteristics should be tested:

- Vehicles over 26,000 lbs. GVWR
- Vehicles designed to transport sixteen or more passengers
- Vehicles transporting hazardous material and those required to be placarded

Roadside tests have been in operation for 4 years. The failure rate is averaged at approximately 16-18 percent. Vehicles that fail are subject to a potential $300 fine, and must submit proof of repairs. Second encounters with previously failed vehicles show a drastic reduction in smoke opacity. For the year 2003, a total of 1447 vehicles were tested out of which 246 exceeded the states opacity standards.

The I-95 NHHC program arranged with the DMW for a pre-construction opacity test for all contractors and sub-contractors. DMV goes to either the maintenance garage or a convenient job site to run through the opacity / safety testing.

The benefit of the DMV being invited by the contractor is that a waiver of fines and an opportunity to correct any safety violation within a reasonable time. If the contractor is caught on the road, a fine is levied and potential loss by automatic towing. The system reduces the chance of the contractor having delays and increase safe and emission

compliant equipment on these Contracts. A visual inspection tag is applied to all equipment that passes the DMV inspection.

Contractor Information Process – Public Notice of Retrofitting

Once the requirements for the diesel vehicle control specification were determined, the air quality working group started the preparations for a contractor information and dissemination program. This program focused on how to explain the benefits and requirements of the Connecticut I-95 Diesel Emission Control Program to contractors and prospective bidders. One of the main purposes was to acquaint contractors with specification requirements and with vendors of emission control devices and clean fuel distributors. CCIA distributed invitations and several presentations were made at the DOT training facility.

These presentations included speakers from DEP, EPA, NESCAUM, Caterpillar, DOT, DMV, and the CA/T retrofit program. Emission control vendors and clean fuel distributors were also invited to set up booths with their products. The presentations lasted a full morning which included an overview of federal and state regulations, the experience obtained through the CA/T retrofit program, engine-manufacturers points of view, the specification requirements, and a demonstration of the smog opacity test performed by the DMV on heavy-duty vehicles.

DIESEL EMISSION CONTROL PROGRAM IMPLEMENTATION

By the fall of 2004 the program had installed approximately 72 oxidation catalysts on a variety of construction equipment with positive results. This represents 60 percent of all the equipment used during the current contracts. From the beginning of the first contract the DOT had devised a tracking system where each contractor and sub-contractor had to provide a list of the non-road diesel powered equipment with detail information for each piece of equipment that will be allowed to operate within the construction area.

The following information was required for each piece of non-road diesel powered equipment:

- Contractors/ Sub-Contractors name
- Date of Equipment arrival on Site
- Equipment number (ID)
- Equipment Type (Description)
- Make, Model & Task (i.e. Caterpillar M318 Excavator)
- Rental/Lease company and name
- The Make of the Emission Control Devise
- Model/number
- EPA verification number

When the equipment is on site for 30 days:

- Date of installation of retrofit device

- Or option to use clean fuels

It was also required to prepare a monthly report including:

- What has been retrofitted and the date
- Make, model number, manufactures make
- What Equipment has left the site and the date of departure
- Copies of certified clean fuel delivery
- What piece of equipment received clean fuel

Emission Controls Selected - Benefits and Costs

The diesel oxidation catalysts manufactured by Lubrizol Engine Control Systems (ECS) and Clean diesel Technologies (CDT) have been the vendors of choice by the Contractors and Sub-Contractors. Both oxidation catalysts are certified by EPA to achieve a minimum of 20% reductions for PM, 40% reductions for CO, and 50% reductions for HC.

The prices have ranged from $800 to $2000. The only problem was the availability because the demand increase during the start of the second contract associated with the I-95 Program.

In conjunction with CDT catalysts, a Sub-contractor is using the CDT Fuel Borne Catalyst Plus in their aged on-road fleet and non-road construction equipment. This product combination is certified by EPA to achieve up to 50% reductions for PM, CO, and HC. The sub-contractor appears to be very satisfied with the results based on their fuel economy and the emission reduction with the catalysts.

While a number of papers have been published on the long-term durability of oxidation catalysts used in highway diesel applications, relatively few data are available on the durability of catalysts used in non-road construction machines. As of now, some of the oxidation catalysts have been operating for two years on this program without any complaints from the contractors. No tests have been performed yet, but we hope that in the future some of the emission control equipment could be tested to verify the durability of their performance.

None of the contractors and subcontractors opted for *PuriNOx*™ as a clean fuel alternative. All of the contractors have gone with oxidation catalysts. The worries voiced by the contractors regarding the use of *PuriNOx*™ were that the fuel needed agitation, and freezing concerns over winter temperature while in the construction vehicles. No test of *PuriNOx*™ have been performed on any the I-95 NHHC contracts.

An important aspect of these contracts is that all contractors and sub-contractors had been using on-road diesel fuel for all of their non-road and on-road equipment. The on-road diesel fuel has an average sulfur content of 400 ppm today in New England versus a 3,000 ppm sulfur content average for the non-road diesel fuel. By using on-road (400 ppm sulfur) diesel fuel for construction equipment (which is not required by law today) the PM reductions due to the lower sulfur content are in the order of 30% when compared to the non-road high sulfur fuel.

The sub-contractors were at a disadvantage because very few primary contractors help the sub with the cost of retrofit equipment. DOT is looking into programs willing to dispersing funds for these disadvantage sub-contractors in permanently putting retrofit equipment on their old non-road equipment.

One of the issues that we have been investigating is what contractors do with the emission control devices once the construction equipment leaves the work area. Various strategies were implemented with different contractors. The first primary contractor (Out of State) purchased 22 oxidation catalysts and moved them on and off the 28 pieces of construction equipment as they came in and out of the job site. Now that the job is finished all the retrofit devices are removed from the equipment and in storage. The attachment of the retrofit devices was engineered for easy detachment and therefore not as permanent installation.

The second primary contractor (Major Connecticut firm) has committed to keep the retrofit devices on even after the equipment has left the job site. This firm has 17 pieces of construction equipment retrofitted with oxidation catalysts at this time working on other jobs throughout the State of Connecticut. The installation of the retrofit devices engineered by this company was more secure and sturdy, and therefore more permanent.

The difference between the two primary contractors might be that the two-year difference between the first and second contract has made the retrofit program more accepted. The CCIA commitment to educate, and be a working partner with the contractors also had a important positive effect.

Highway Vehicles Opacity Test Results

As of this date, there have been six inspections by the DMV to insure that the On-Road vehicles met Connecticut standards. Approximately 15 vehicles are tested at a time. Approximately five have fail since the Opacity/safety checks were started and were corrected within a week. New inspections are scheduled for Contract C1 when new equipment comes on the job site and/or any new Sub-contractor starts working. Two new contracts starting in 2005 will also have the DMV inspection program coordinated with the contractors on site.

CONCLUSION

The I-95 NHHC retrofit program had the advantage of using the experience of the CA/T project in Boston, which had retrofitted over 100 pieces of equipment by the time this program started implementation. The most positive aspect of initiating the retrofit program was the creation of an air quality-working group that met on a regular basis (every six weeks) almost one year before the bid documents had to be ready for the advertising of the first contract.

The group was able to convince all of the affected parties to buy into the retrofit program. It was very important to obtain a clear understanding of the program benefits, costs, who was going to pay, and how the concept would be translated into a required specification as part of the bid documents early on in the program.

It was also critical to include the requirement for emission control equipment in the contract's bid package. By doing so, the cost of the retrofit equipment was included as part of the overall contract cost, thus avoiding the use of economic incentives to bring contractors into the program.

The major concerns expressed by contractors who participated in the I-95 NHHC retrofit program were to get assurances from the manufactures of emission control equipment that the emission control device will not affect equipment performance. Once those issues were resolved, it was also very important to have a good tracking system to make sure that the contractors and sub-contractors would not avoid the retrofit requirements by rotating equipment or using other clever maneuvers.

The I-95 NHHC diesel retrofit program proved that retrofitting construction equipment with oxidation catalysts is very feasible, and that it has significant benefits in terms of emission reductions, odor control, and visible smoke. When considering that the costs of the oxidation catalysts are on the order of one percent of the total cost of the construction equipment to be retrofitted, and the emission reductions are in the order of 20 to 50 %, this program is a very effective way to reduce diesel emissions and odor. By having this requirement in the final remaining contracts, it is estimated that an additional 130 pieces of off-road construction equipment will be retrofitted with oxidation catalysts. This should bring the total number of retrofits to approximate 200 by the time the I-95 NHHC project ends.

ACKNOWLEDGEMENT

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KEY WORDS

Diesel Retrofit Program

Oxidation Catalysts

Emission Control Equipment

Clean Fuels

Pollution Reduction

Construction Equipment

Attachment K

ICF Report

Emission Reduction Incentives for Off-Road Diesel Equipment Used in the Port and Construction Sectors

Final Report
May 19, 2005

http://www.dep.state.ct.us/air2/diesel/docs/icf.pdf

Attachment L

Sample Contract Specification Language

NOTICE TO CONTRACTOR – VEHICLE EMISSIONS

All motor vehicles and/or construction equipment (both on-highway and non-road) shall comply with all pertinent State and Federal regulations relative to exhaust emission controls and safety.

The contractor shall establish staging zones for vehicles that are waiting to load or unload at the contract area. Such zones shall be located where the emissions from the vehicles will have minimum impact on abutters and the general public.

Idling of delivery and/or dump trucks, or other equipment shall not be permitted during periods of non-active use, and it should be limited to three minutes in accordance with the Regulations of Connecticut State Agencies Section 22a-174-18(b)(3)(c):

> No mobile source engine shall be allowed "to operate for more than three (3) consecutive minutes when the mobile source is not in motion, except as follows:
>
> (i) When a mobile source is forced to remain motionless because of traffic conditions or mechanical difficulties over which the operator has no control,
>
> (ii) When it is necessary to operate defrosting, heating or cooling equipment to ensure the safety or health of the driver or passengers,
>
> (iii) When it is necessary to operate auxiliary equipment that is located in or on the mobile source to accomplish the intended use of the mobile source,
>
> (iv) To bring the mobile source to the manufacturer's recommended operating temperature,
>
> (v) When the outdoor temperature is below twenty degrees Fahrenheit (20 degrees F),
>
> (vi) When the mobile source is undergoing maintenance that requires such mobile source be operated for more than three (3) consecutive minutes, or
>
> (vii) When a mobile source is in queue to be inspected by U.S. military personnel prior to gaining access to a U.S. military installation."

All work shall be conducted to ensure that no harmful effects are caused to adjacent sensitive receptors. Sensitive receptors include but are not limited to hospitals, schools, daycare facilities, elderly housing and convalescent facilities. Engine exhaust shall be located away from fresh air intakes, air conditioners, and windows.

A Vehicle Emissions Mitigation plan will be required for areas where extensive work will be performed in close proximity (less than 50 feet (15 meters)) to sensitive receptors. No work will proceed until a sequence of construction and a Vehicle Emissions Mitigation plan is submitted in writing to the Engineer and approved by the

Engineer prior to the commencement of any extensive construction work in close proximity (less than 50 feet (15 meters)) to sensitive receptors. The mitigation plan must address the control of vehicle emissions from all vehicles and construction equipment.

If any equipment is found to be in non-compliance with this specification, the contractor will be issued a Notice of Non-Compliance and given a 24 hour period in which to bring the equipment into compliance or remove it from the project. If the contractor then does not comply, the Engineer shall withhold all payments for the work performed on any item(s) on which the non-conforming equipment was utilized for the time period in which the equipment was out of compliance.

Any costs associated with this "Vehicle Emissions" notice shall be included in the general cost of the contract. In addition, there shall be no time granted to the contractor for compliance with this notice. The contractor's compliance with this notice and any associated regulations shall not be grounds for claims as outlined in Section 1.11 – "Claims".[FJK4]