Special Act 05-07
The Connecticut Clean Diesel Plan

Report to the Joint Committee on the Environment of the Connecticut General Assembly Draft of 12/22/05

Overview

In 2005 the Connecticut General Assembly enacted Special Act 05-07 (the Act)[1] which directed the Department of Environmental Protection (DEP) to develop a diesel emission reduction strategy to reduce the health risks from diesel air pollution consistent with the reduction targets in the Climate Change Action Plan of 2005. The Act identified the following sectors for evaluation:

- Transit buses: reduce diesel particulate matter from transit buses by not less than 85% by December 31, 2010;
- School buses: maximize diesel particulate matter emission reductions from school buses and prevent diesel particulate matter engine emissions from entering the passenger cabin of the buses by December 31, 2010;
- Construction equipment: maximize particulate matter emissions reductions from construction equipment servicing state construction projects valued at $5 million by July 1, 2006.

Section 1(b)(1) of the Act requires DEP to provide "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." DEP has identified a number of additional sources and reduction strategies; a discussion of the most promising reduction strategies can be found in the section entitled "DEP Recommendations for Other Identified Sources".

The DEP began the planning on July 19, 2005 with a kick-off meeting at DEP's offices. As a result of this meeting, four subcommittees were formed to explore and develop information for these sectors. The DEP added on road fleets for consideration, given the relative emissions contribution from the sector. Each group was comprised of government, private industry, public health and the environmental sectors, and given a set of action items and direction to provide feedback to DEP. DEP appointed co-chairs for each subcommittee to serve in an advisory capacity to the DEP throughout the process and to assist in facilitating discussions. The subcommittees have played a critical role in providing information on diesel reduction technologies, clean fuels, financing options, emission reduction strategies, successful case studies and, in addition, have provided valuable feedback to the DEP in the development of comprehensive sector reports and recommendations for implementation. All of the sector reports are posted on the diesel web page at http://www.dep.state.ct.us/air2/diesel/forum.htm. Diesel reduction strategies

[1] For a full text of Special Act 05-07, see Appendix 1.

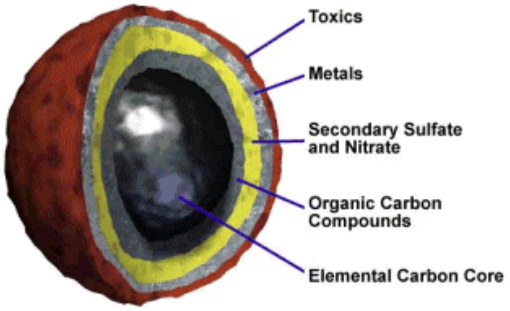
for mobile sources are clearly an appropriate focus to reduce diesel particulate matter (DPM) within Connecticut's urban environment.

Public exposure to fine particulate matter ($PM_{2.5}$) is a health issue in Connecticut and states across the country. On December 17, 2004, the U.S. Environmental Protection Agency (EPA) formally designated New Haven and Fairfield Counties as being in non-attainment with the federal ambient air quality standard for $PM_{2.5}$. Approximately one half of the state's population (1.73 million people) resides in these two counties.

Exposure to $PM_{2.5}$ has been linked to premature death from heart or lung disease. Fine particles, inhaled into the lungs, can aggravate existing heart and lung diseases to cause cardiovascular symptoms, arrhythmias, heart attacks, chronic obstructive pulmonary disease, asthma attacks and bronchitis. EPA has also classified DPM as a probable human carcinogen. $PM_{2.5}$ exposure can affect healthy adults and children. Particulate pollution may be widespread or concentrated in small areas known as hot spots; a busy intersection in an urban setting, for example, could be a hot spot for $PM_{2.5}$. Urban areas, with construction sites and heavy traffic that includes buses and diesel trucks, are often hot spots for $PM_{2.5}$, putting large populations at risk.

Background on Diesel Particulate Matter

DPM is composed of a center core of elemental/black carbon and adsorbed organic carbon (OC) compounds, as well as small amounts of sulfate, nitrate, metals, and other trace elements. Black carbon (BC) is emitted from all combustion processes involving carbonaceous materials. Sources include gasoline and diesel powered vehicles, industrial processes, oil-fueled home heating, residential wood burning and outdoor fires. The lifetime of BC in the atmosphere is on the order of several days to several weeks, depending on the meteorology. Ambient data indicate that long-range transport becomes important with such long lifetimes. A BC spatial-study in Boston indicated that 30% of the BC measured in the greater-Boston area was due to long-range transport. This is consistent with comparing BC measurements at a rural site in Cornwall (≈ 0.33 $\mu g/m^3$) to an urban/neighborhood-scale site in New Haven (≈ 0.90 $\mu g/m^3$).



In urban areas, "tailpipe" emissions are the dominant source of BC. Both gasoline and diesel engines directly emit BC. On a per tailpipe basis, diesel vehicles emit approximately 50 times more BC than gasoline vehicles. However the number of gasoline vehicles is substantially greater than diesel vehicles, therefore the contribution of BC from gasoline vehicles is not insignificant. High emitters are an important focus given that they can emit more than 1000 times the BC emissions of an average gasoline vehicle.

DPM cannot be directly measured due to its complex nature. BC can be used as a surrogate for DPM only in a very localized, micro-scale environment. A micro-scale study at Stiles Street in New Haven, Connecticut at the on-ramp to I-95 showed that DPM concentrations contributed approximately 20% of the $PM_{2.5}$ concentrations. Based on ambient BC data collected at a neighborhood-scale site in New Haven[2] approximately 4% of total ambient $PM_{2.5}$ concentrations and 8% of the greater-New Haven $PM_{2.5}$ emissions could be attributed to DPM.

According to the 2002 MANE-VU[3] emissions inventory for Connecticut, diesel powered mobile sources, which are responsible for approximately 7.5% of the statewide $PM_{2.5}$ emissions, contribute predominantly to local $PM_{2.5}$ urban excess. These emissions, occurring largely along transportation corridors and in urban centers, contribute to greater exposures in those locations. Strategies designed to reduce diesel emissions from motor vehicles in urban centers and along transportation corridors are an important and appropriate focus for diesel reductions. The four subcommittees (transit, school buses, construction, and on-road fleets) identified a wide-range of reduction strategies that are summarized at the end of this section and discussed in detail in each of the sector reports.

Over the past several years Connecticut has benefited from a broad coalition of partners focused on achieving reductions of diesel emissions. These collective efforts have helped to ensure Connecticut's fleet of diesel vehicles is one of the cleanest in the country. As a result of federal requirements requiring cleaner fuels and cleaner diesel engines and also through policies and practices that have encouraged a newer fleet, a solid foundation has been established from which to move forward.

Significant $PM_{2.5}$ Sources Not Specified in the Act

For each sector named in the Act, DEP has developed a strategy that will meet the requirements on the specified schedule. Those options are listed below in Table 1. Additional options have been developed that accomplish the same goals in a more cost efficient manner, often at the expense of delayed implementation. More work needs to be done and this report identifies an extended menu of implementation strategies for consideration, especially in Connecticut's urban centers. In addition, other significant sources of particle pollution, such as heating oil and wood burning, represent high value/low cost environmental opportunities. These strategies are discussed in greater detail and outlined in Tables 3-6 and organized in tiers (1,2 and 3) based upon cost, timeframe for implementation and availability of funding. A more complete analysis can be found in the sector reports following this overview.

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[2] Assumptions were based on long-range BC and $PM_{2.5}$ transport, gasoline vehicles vs. diesel vehicles contributions to urban BC, and average OC:BC ratios for diesel sources, DPM concentrations from New Haven sources are approximately 0.5 μg/m.[3]

[3] The Mid-Atlantic/Northeast Visibility Union (MANE-VU) was formed by the Mid-Atlantic and Northeastern states, tribes, and federal agencies in 2001 to coordinate regional haze planning activities for the region. MANE-VU provides technical assessments and assistance to its members.

Table 1
Strategies that Meet the Diesel Particulate Matter Reductions of Special Act 05-07

Diesel Reduction Strategies	Sector	Benefits/Costs
Retrofit all 1998 and newer transit buses with DPFs by 2010. Replace all 1997 model year (MY) and older buses with vehicles compliant with the 2007 federal standards.	Transit	**Benefits:** Decreases emissions of PM by 2.88 tpy and the resultant exposure nine years sooner than normal turnover. **Costs:** It would cost approximately **$4.5 million** to retrofit all '98 MY and later transit buses.
Mandate retrofit and replacement of the existing school bus fleet by 2010. 1,200 older Type I diesel school buses would be replaced with 2007-compliant buses under current fleet turnover schedules, and 372 Type I buses are currently being retrofitted; this leaves about 3,400 buses to be retrofitted. Focus on retrofits of older buses, selecting emission reduction technologies that will maximize the reduction of diesel particulate exhaust emissions.	School Bus	**Benefits:** This maximizes reductions of fine particulates from the school bus fleet on the most aggressive schedule. **Costs**: *Concerns have been raised on the viability of this option since 139 school district fleets are subject to existing contract provisions that may preclude contract renegotiation.* Costs are estimated at **$6.5 million**[4] if the strategy could be implemented.
Call on DPW, OPM, DECD, and UCONN to adopt Clean Air Construction Contract Specifications for state construction contracts greater than $5 million. The existing DOT contract specification on the I-95 Harbor Crossing Project in New Haven can serve as a model with contract allowances for equipment retrofits. State construction projects employ 15% of the Connecticut equipment inventory, or about 1,617 engines.	Construction	**Benefits:** Reduces emissions from construction equipment at large sites, especially in urban areas, and helps to build a fleet of cleaner construction vehicles for use throughout the state. **Costs:** Costs for full implementation are estimated at **$10.5 million** for DOC technology.

[4] For purposes of estimating cost, DEP's calculation is based upon installation of diesel oxidation catalysts (DOCs) and crankcase controls.

DEP Identified Strategies for Other Identified Sources

What follows are strategies, in addition to the mobile sources specified in the Act, which should be considered for reduction of particulate emissions. The volume of these emissions and relative cost effectiveness of the reductions makes exploration of these avenues an important segment of any comprehensive and holistic plan to reduce particulate emissions in Connecticut.

EPA is currently revisiting the $PM_{2.5}$ air quality standard. An announcement that the standard will become more stringent is expected soon. In order for Connecticut to meet a more stringent standard, DEP needs to consider a full range of options. Section 1(b)(1) of the Act requires DEP to provide "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." Based on stakeholder dialogue and considerable review of the most recent emissions contribution data, DEP believes an effective and responsible diesel and particulate matter emissions reduction plan must contain all sources that contribute to emissions. Including a balanced, cross-sector strategy insures that Connecticut will continue to take a holistic approach toward air pollution control by seeking to maximize reductions of diesel particulate matter and the environmental and public health benefits associated therewith. Section 1(b) of the Act provides DEP the discretion to recommend programs, policies and legislation for achieving reductions of diesel particulate matter beyond those specifically enumerated in the Act. DEP has identified a number of sources and reduction strategies; a discussion of the most promising reduction strategies appears below.

Fine particulates represent just one of Connecticut's many air quality challenges. On January 5, 2005 EPA designated the state as non-attainment with the new more stringent 8-hour ozone standard. $PM_{2.5}$, ozone, climate change, regional haze, and air toxics are all challenges for which we must identify and implement effective solutions. These are not isolated issues with separate and disparate constituencies but rather interrelated problems that can benefit from the implementation of multi-pollutant strategies designed to address all of Connecticut's complex air quality challenges.

DEP has advocated a multi-pollutant approach throughout the stakeholder dialogue, encouraging the evaluation of emission reduction strategies that will achieve multiple air quality goals in a cost-effective statewide program. Accordingly, DEP emphasized the emissions contribution by sector and air pollutant during stakeholder discussions. Emission reduction strategies that reduce other pollutants such as oxides of nitrogen (NO_X) are also included in an effort to identify additional opportunities to reduce ozone precursors.

Require a Low Sulfur Heating Oil and Biodiesel Blend As a Regional Reduction PM Reduction Strategy

According to MANE-VU's 2002 Connecticut emissions inventory, heating oil accounts for 10% of Connecticut's PM $_{2.5}$ emissions from area sources or a total of 834 tons per

year (tpy) (see Figure 1, page 8). By comparison, the four mobile source sectors evaluated in this report, (transit, school buses, construction and on-road fleets) when combined, account for about 1,464 tpy of $PM_{2.5}$.[5]

Approximately 663,146 or 78% of Connecticut households annually consume nearly 545 million gallons of heating oil. Unlike other distillate products, heating oil is not regulated by EPA. The sulfur limit for heating oil is currently set by statute at 3,000 ppm in section 16a-21a Connecticut General Statutes. Reducing the sulfur content of heating oil from 3,000 ppm to 500 ppm will reduce sulfur dioxide emissions by almost 10,000 tpy and represents an 83% reduction from current levels. While reduction potential is not readily available for $PM_{2.5}$, reductions in the combination of direct $PM_{2.5}$ and secondarily-formed $PM_{2.5}$ emissions (primarily sulfates) are also expected to be significant.

Emission reductions of this magnitude for a single source category are extraordinary. In this instance these reductions would outstrip those made through Connecticut's power plant requirements and represents the most cost-effective strategy at little to no cost for implementation.

Table 2
Emission Benefits of Low Sulfur Heating Oil and Biodiesel Blends
(% Reduction compared to 2,500 ppm sulfur fuel)

Pollutant	Reduction with 500 ppm Sulfur Heating Oil/Biodiesel Blend (80/20)
SO_2	84%
PM	>80%
NO_X	20%
Hg	20%
CO_2	17-18%

Emission reduction benefits are further enhanced when a low-sulfur heating oil is blended with biodiesel. This represents possibly the only single strategy that reduces emissions of criteria pollutants, toxics and carbon dioxide. Based upon research by the Northeast States for Coordinated Air Use Management (NESCAUM) the combination of low sulfur heating oil and biodiesel may represent the most effective in-state multi-pollutant strategy Connecticut could consider. In addition, widespread use of this heating oil blend will reduce emissions of NO_X, a precursor pollutant of ground level ozone, by over 100 tpy. As noted in Table 2 considerable emission reductions can be achieved through a bio-diesel blend. The figure provides reductions with a 20% biodiesel blend, however blending at 5% would ensure that supplies are adequate, and can be phased in over time. Biofuels also promote energy security because they can be blended with low sulfur diesel to extend heating oil supplies while further reducing emissions.

Improved efficiency of existing systems (reduced costs & emissions) and the availability of low sulfur fuel enables use of advanced technology condensing furnaces, which are

[5] Transit buses are estimated 3 tpy, school buses 30 tpy, construction 694 tpy and heavy-duty trucks at 737 tpy.

highly efficient. Modern household furnaces are classified as *condensing or non-condensing* based on their efficiency in extracting heat from the exhaust gases. Furnaces with efficiencies greater than approximately 89% extract so much heat from the exhaust that water vapor in the exhaust condenses. Condensing furnaces typically can deliver heating savings of 20%-35% assuming the old furnace was in the 60% Annual Fuel Utilization Efficiency (AFUE) range. Using lower sulfur heating oil substantially lowers boiler and furnace fouling rates resulting in cost savings for homeowners. These savings balance out any increased cost yielding a low cost, almost no-cost, reduction strategy that the General Assembly could enact by revisiting legislation introduced by DEP last session[6] and coupling a 500 ppm sulfur requirement in diesel fuel with the requirement for a biodiesel blend for up 5%.

Biodiesel is made throughout the United States. In July 2005, there were 35 plants operating in the United States and several others plants are now in the planning stage. The National Biodiesel Board maintains a map of current and proposed biodiesel production facilities at www.biodiesel.org/buyingbiodiesel/producers_marketers/ProducersMap-existingandpotential.pdf.

Address Particulate Emissions from Wood burning

DEP continues to evaluate emission reduction strategies to address particle pollution from wood burning. As fuel prices rise, more people are burning wood as a primary fuel source. This is particularly troubling considering the localized environmental effects from the emissions from these largely uncontrolled sources.

Wood burning includes emissions from fireplaces, wood stoves and outdoor wood burning furnaces (OWBFs). All can emit high concentrations of particulate matter and toxic air pollutants in the immediate vicinity and contribute to Connecticut's regional air quality concerns.[7] Colder temperatures are associated with both poor dispersion conditions and increased heating demands; PM levels from wood burning are therefore exacerbated as localized emissions are trapped close to the ground. Last session the General Assembly took an initial step forward and passed Public Act 05-227[8] to address some of the environmental and public health concerns associated with OWBFs. OWBFs are of great concern because they emit large amounts of smoke and particulate matter. This pollution is more than just a nuisance to neighbors; it is a public health, and environmental concern as well.

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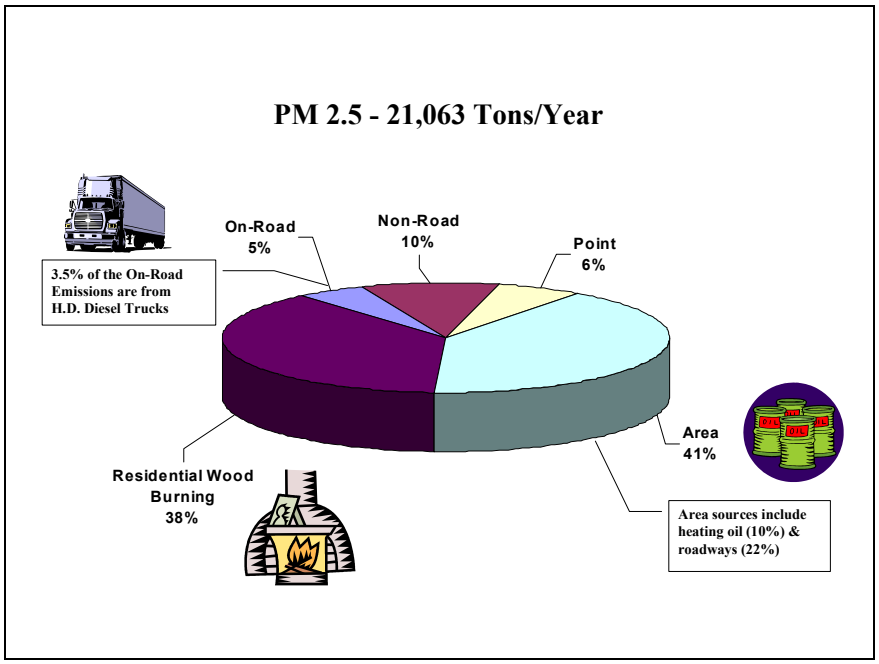
[6] See Raised Bill No. 1151 at http://www.cga.ct.gov/2005/tob/s/2005SB-01151-R00-SB.htm.

[7] For example, OWBFs emit as much as 7 times more particulate matter than the emissions from the wood stoves that were banned by EPA in 1992. The hourly particulate emissions from an OWBF are up to 12 times higher than those from an EPA-certified wood stove and nearly 20 times higher than those of an idling tractor-trailer.

[8] The requirements apply to OWBFs installed after July 11, 2005 and restrict operation to wood that has not been chemically treated and requires a setback of 200 feet from the nearest residence not being served by the unit. DEP has developed a fact sheet that details all of the requirements, the fact sheet can be found at http://www.dep.state.ct.us/air2/consumer/publicactowf.pdf.

According to MANE-VU's 2002 inventory (see Figure 1), the residential wood burning sector is responsible for 38% or 8,062 tons per year of the fine particulate matter emissions in Connecticut.[9] Particle pollution from wood burning poses similar public health concerns to DPM.[10] Increased use of wood burning as a primary source for fuel along with the increasing evidence of the adverse effects of particle pollution has spurred environmental officials across the country to consider strategies to reduce the smoke from the nation's 37 million home chimneys and 10 million wood stoves.

Figure 1



Connecticut municipalities have played and will continue to play the pivotal role in local control of land use in and around areas with OWBFs, and with any future reduction strategies for woodstoves and fireplaces.[11] One potential strategy that has been

[9] There is uncertainty and a lack of confidence in this number due to the limitations on the number of survey responses provided to derive the 38%. DEP has continued to review this number for accuracy by comparing these inventory numbers with ambient monitoring data. One study evaluated showed a nearly 1 to 1 ratio of measured $PM_{2.5}$ ambient concentrations due to wood combustion as compared to fossil fuel combustion from stationary sources. In this study, $PM_{2.5}$ emissions from motor vehicles were broken out into two separate categories and are not part of the fossil fuel component sited above. This study also showed that $PM_{2.5}$ resulting from wood combustion accounted for 24% of all $PM_{2.5}$ measured, while $PM_{2.5}$ from stationary source fossil fuel combustion contributed 26% to the total $PM_{2.5}$. *$PM_{2.5}$ Monitoring Study-Rutland, VT*

[10] For more information see EPA's Health Effects of Wood Smoke web page at: http://www.epa.gov/woodstoves/healtheffects.html

[11] The installation of an OWBF may require local zoning and or building permits depending upon the jurisdiction. Some municipalities may choose to ban or further limit installation of OWBFs within their jurisdictions, others may choose to limit installations near schools, churches, and commercial areas as the Public Act only addresses set back requirements from residences. Municipalities affected by operation of an OWBF have, along with DEP, been charged with enforcement of the provisions of Public Act 05-227.

implemented in other states is to institute a policy of "no burn days" when PM emissions are elevated. States such as California and Colorado have instituted residential burning restrictions during periods of high pollution. Wood burning restrictions are communicated as part of an air quality forecast.

During periods of poor air quality only certified wood burning units can be operated. Wood stoves (including fireplace inserts and pellet stoves) manufactured and sold after July 1, 1992 are required to be certified by the EPA and are identified as such by a permanent EPA-certified label. EPA-certified wood stoves have been tested to meet stringent emissions requirements. They have been designed to burn cleaner and more efficiently, resulting in 50%-60% less pollution. And because they are more efficient, they use two-thirds less wood, saving homeowners both time and money. With the support of contributing retailers and local governments, EPA has sponsored a number of wood stove changeout campaigns in which consumers receive financial incentives (rebates) to replace older stoves with either non-wood burning equipment (for example, vented gas stoves) or EPA certified wood stoves.[12] The DEP expects to further evaluate the emissions contribution from wood burning and subsequently identify possible reduction strategies.

Develop a More Comprehensive Anti-idling Strategy

Exposure to diesel pollutants especially in urban areas is exacerbated when diesel powered vehicles idle excessively. Sooty exhaust emitted by trucks, buses and other diesel engines can make breathing difficult, especially for children, the elderly and other sensitive groups. Idling vehicles create emissions that contribute the formation of smog and ground level ozone, and produce carbon dioxide (a greenhouse gas). Diesel exhaust contains toxic air pollutants, including aldehydes (formaldehyde, acetaldehyde, acrolein), benzene, 1,3-butadiene, and polycyclic aromatic hydrocarbons (PAHs). Measures that encourage drivers to reduce idling are cost effective strategies for decreasing multiple pollutants and have the added benefit of conserving fuel.

Implementation of an effective anti-idling program is a high priority because children riding in, or otherwise exposed to, school buses and other commercial motor vehicles are disproportionately affected by these sources. Generally, children are more vulnerable than adults to air pollutants because they have higher inhalation rates, narrower airways, and less mature immune systems. DEP has a rule in place to limit all vehicle idling to 3 minutes. The Connecticut General Assembly recognized the importance of this issue with respect to school buses in the adoption of PA 02-56, codified at Section 14-277 (b) of the Connecticut General Statutes. Under this section, violation of anti-idling provisions by any school bus driver constitutes an infraction. Public health risks associated with vehicle idling necessitate broader action to include all mobile sources. To this end, enforcement capabilities need to be supplemented with broader police authority to ticket violators for excessive idling.

[12]More information on EPA's Woodstove changeout program is available at http://www.epa.gov/woodstoves/changeout.html.

DEP enforcement efforts have been coupled with an aggressive education and outreach effort to remind drivers to eliminate all unnecessary idling. Research has shown that constant reminders, such as anti-idling signs, significantly improve compliance rates with an idling restriction. Therefore, DEP is continuing its efforts to reduce unnecessary idling and increase awareness of the environmental and health effects of idling on schoolchildren.

The transit sector report proposes that, as part of a continuing education package required for employment and/or licensure, transit bus drivers should review the operators' anti-idling policies as well as the state anti-idling regulations. DEP has partnered with the DOT to develop and post anti-idling signs at Connecticut rest areas to help increase awareness and compliance rates among truck drivers and the general public who visit these facilities. In addition the DEP has provided free anti-idling signs to Connecticut public schools that agree to post them. By the end of 2005 this initiative had reached over 490 Connecticut schools.

Additional measures, similar those adopted by California, could be pursued to further reduce emissions of toxics and criteria pollutants. Regulations requiring the installation of alternative technologies such as diesel fueled auxiliary power systems (APS) and fuel fired heaters could also be required to address overnight truck idling. California regulations require diesel APSs on 2007 and newer truck engines. Truck retrofits utilizing APS technologies coupled with stationary source idle reduction measures such as truck stop electrification could constitute an effective suite of reduction strategies designed to promote the development of an idle-free corridor in Connecticut.

These efforts would mark a perfect convergence of DEP's long-standing goal to reduce diesel emissions in the state and DOT's ongoing research aimed at alleviating the state's deficit of truck stops and rest areas. Raising awareness by expanding DEP's signage program, enhancing enforcement tools, and adopting clean technology requirements are all important elements for a more robust and comprehensive idle reduction strategy. EPA has developed a model rule for states to evaluate for additional enhancements to existing programs. DEP will continue to evaluate these options for implementation in Connecticut's program.

Encourage Fleet Turnover

This is a critical point in time to influence vehicle-purchasing decisions that can have a major impact in reducing emissions of multiple air pollutants in Connecticut. Connecticut has adopted the California Air Resources Board's (CARB's) Heavy-Duty Diesel Engine **(**HDDE) (Not to Exceed) standards, which have become effective with the 2006 MY. Beginning with the 2007 model year, all new heavy duty diesel engines will be required to meet federal emissions standards[13] for $PM_{2.5}$ that are equivalent to or more stringent than the emissions reductions recommended in Special Act 05-07 and have the added benefit of reducing emissions of carbon monoxide and the ozone precursors, NO_X and hydrocarbons. DOT has a policy that results in the turnover the transit fleet every 12

[13] See 40 CFR 86.007-11.

years. Many school bus contracts include clauses relating to average age and oldest vehicles that accomplish fleet turnover on various schedules. In addition, current property tax incentives are motivating on-road fleet owners to replace their vehicles more rapidly.

With the availability of 2007-compliant vehicles, these normal turnovers will result in an opportunity to significantly reduce diesel emissions. Tax incentives, similar to those currently offered for the purchase of hybrid cars, or state funding grants, similar to California's Carl Moyer Program,[14] that encourage earlier retirement and replacement of vehicles are important, short-term options that yield multiple pollutant reductions and help Connecticut to meet the National Ambient Air Quality Standards for ozone and $PM_{2.5}$. Education and outreach promoting the opportunities and benefits associated with accelerated fleet turnover can further enhance the effectiveness of this option.

Strategies for Implementation

Stakeholder discussions have yielded a comprehensive menu of options to consider. DEP has made a concerted attempt to capture all of the recommendations generated through the stakeholder process and has categorized them into short-term, mid-term and long-term actions for implementation. Recommendations have been designated based on the estimated costs, timeframe of implementation and availability of funding; Tier 1 actions should require little to no-cost and can be implemented quickly, while Tier 3 actions will likely require the appropriation of significant funds prior to implementation. A discussion of possible funding approaches is also included to ensure the viability of mid-term and long-term options as part of this comprehensive plan. For a full discussion of the options that follow please see the individual sector reports that follow this overview and supporting materials, which are posted on DEP's website at http://www.dep.state.ct.us/air2/diesel/forum.htm.

[14] For information on the Carl Moyer program, see Appendix 2.

Table 3
Tier 1 Actions for Implementation to Reduce Diesel Emissions in Connecticut

Diesel Reduction Strategies	Sector	Benefits/Costs
Establish a statewide voluntary diesel collaborative. The collaborative would be committed to the development of viable diesel reduction project proposals and aggressively pursue available funding opportunities on the federal level.	All	**Benefits:** Available resources would be used to fund retrofits, repowering or replacement of diesel engines. **Costs:** Administrative costs incurred to develop and manage the disbursement of funds are indeterminate at this time.
Provide education and outreach on fine particulate emissions: **1) Public health:** Build on existing efforts to enhance public awareness of health issues associated with fine particulate exposure. **2) Benefits of fleet turnover:** Develop an education and outreach program for fleet owners promoting the opportunities and benefits associated with accelerated fleet turnover.	All	**Benefits:** Fleet turnover will place the cleanest vehicles available in the CT fleet sooner. Provides reductions of multiple pollutants. **Costs:** Administrative costs to the state for the development and implementation of an education and outreach program.
Fund existing urban transit retrofit proposal with Congestion Mitigation for Air Quality (CMAQ) funds. Call on DOT to award funds to retrofit transit buses in the New Haven and Hartford fleets.	Transit	**Benefits:** PM emissions from transit fleets operating in urban centers will be reduced within a short timeframe. **Costs:** $1,944,800 in CMAQ funding $486,200 in matching funds.
Call on DOT to consider amending the CMAQ program rules to encourage the purchase of AFVs. Specific changes would include: 1. Extending eligibility rules to private companies to apply for funds, 2. Allowing costs of related refueling infrastructure, and 3. Allowing eligible entities to apply for costs of certified AFV conversions and alternative fuel engine repowers.	All	**Benefits:** Expands funding potential to pursue other diesel mitigation projects outlined in this plan. **Costs:** Any reallocation or reprogramming of CMAQ funds will impact present and future CMAQ projects.

Diesel Reduction Strategies	Sector	Benefits/Costs
Continue to recommend the use of clean fuels and retrofits of construction equipment for projects undergoing NEPA and CEPA reviews. DEP will continue to recommend the use of clean fuels and retrofits in comments on environment impact statements or evaluations that are required for federally or state funded construction projects under NEPA or CEPA.	Construction	**Benefits:** Ensures that government project planning takes into account health & environmental benefits associated with diesel mitigation projects. **Costs:** Minimal administrative cost
Revise DEP's regulations governing indirect sources of air pollution to allow for retrofits as a compliance option for applicable DOT projects. Regulatory adoption process currently underway.	Construction	**Benefits:** Encourages retrofits of on-road and off-road construction equipment. **Costs:** Minimal administrative cost.
Amend section 16a-21a Connecticut General Statutes to require a low sulfur bioheat fuel for heating oil. **(500 ppm sulfur up to 5% biodiesel blend)**	Heating Oil	**Benefits:** Single largest emissions reduction strategy proposed in this plan. **Costs:** Initial study results sponsored by NESCAUM indicate that low sulfur heating oil will impose little to no additional costs on homeowners.
Continue to pursue funding opportunities for a stationary idle reduction (truck stop electrification) along the 1-95 corridor. Require any DOT expansion of rest areas to include an idle reduction component.	On-road	**Benefits:** Any funding will assist in the development of an idle-free corridor in Connecticut and reduce idling from trucks. DOT's rest area/service plaza feasibility study should include recommendations on implementing a stationary idle reduction infrastructure. **Costs:** This represents one of the most cost-effective means of reducing emissions of all pollutants from diesel-powered vehicles while conserving energy.

Diesel Reduction Strategies		Sector	Benefits/Costs
Develop model language for school bus provider contracts that are due to expire in the next 2 years. Specify lower age limits for buses, lower average fleet age and increased replacement quotas to encourage replacement with 2007-compliant vehicles.		School Bus	**Benefits:** By encouraging earlier fleet turnover and replacement with cleaner, 2007-compliant buses, $PM_{2.5}$ emissions and exposure will decrease along with emissions of the ozone precursor, NO_X. **Costs:** DEP could, in conjunction with COSTA, develop model language within normal budgetary resources.
Continue to evaluate PM emission contribution from the wood burning sector. To better understand the wood burning impact on PM levels and to identify effective control options.		Wood burning	**Benefits:** An understanding of the scope of the problem is a first step in designing strategies to reduce the significant PM emissions from this source. **Costs:** Administrative costs incurred by further evaluation of PM emissions from the wood burning sector will be absorbed within normal budgetary resources.
Anti-Idling	**Enforcement:** Enforcement capabilities need to be supplemented with broader police authority to ticket violators for excessive idling.	All	**Benefit:** Anti-idling enforcement will reduce DPM emissions and conserves fuel. **Costs:** Minimal.
	Education and Outreach: CT's school bus retrofit program includes an educational component to use retrofit projects as a learning opportunity for middle school students to further understand air quality issues as part of the science curriculum.		**Benefits:** Educating students regarding the importance of anti-idling policies can spread public awareness and increase compliance. **Costs:** Administrative and implementation costs associated with establishing an effective education and outreach program.

Diesel Reduction Strategies		Sector	Benefits/Costs
	Driver Training: As part of a continuing education package required for employment and/or licensure, drivers should review the operators' anti-idling policies as well as the state anti-idling regulations.		**Benefits:** Constant reminders can significantly improve compliance rates with an idling restriction. **Costs:** Administrative costs associated with establishing an effective education and outreach program.
	Increased Signage at Schools, Rest Areas, Distribution Centers and Airports: Constant reminders in the form of signs should significantly improve compliance rates with the DEP's regulatory restriction on idling.		**Benefits:** Anti-idling signs provide constant reminders, which significantly improve compliance rates with an idling restriction. **Costs:** Administrative costs associated with developing signs. A large-scale signage program encompassing all schools, rest areas, distribution centers and airports, colleges/universities could cost as much as $50,000.
Clean Fuels	**Biodiesel:** To take advantage of renewable fuel options, the feasibility and/or effectiveness of adding biodiesel to ULSD to improve lubricity should be further investigated.	All	**Benefits:** Biodiesel is a clean, domestically produced fuel, which will decrease our dependence on foreign oil. **Costs:** Currently, the biodiesel cost differential with ULSD is not significant. In addition, DOE's EPAC program could defray any incremental costs.
	CNG has a demonstrated track record as a clean fuel for buses and some construction equipment.		**Benefits:** CNG is a clean fuel that results in emissions substantially lower than those from diesel fuels.[15] **Costs:** The primary cost of CNG is attributable to vehicle repowering. CNG on an energy content basis is more expensive than diesel fuel.

[15] See Clean Cities' discussion in the On-Road Fleets Sector Report.

Table 4
Tier 2 Actions for Implementation to Reduce Diesel Emissions in Connecticut

Diesel Reduction Strategies	Sector	Benefits/Cost
Call on DPW, OPM, DECD, and UCONN to adopt Clean Air Construction Contract Specifications for state construction contracts greater than $5 million. The existing DOT contract specification on the I-95 Harbor Crossing Project in New Haven can serve as a model with contract allowances for equipment retrofits. State construction projects employ 15% of the Connecticut equipment inventory, or about 1,617 engines.	Construction	**Benefits:** Reduces emissions from construction equipment at large sites, especially in urban areas, and helps to build a fleet of cleaner construction vehicles for use throughout the state. **Costs:** Costs for full implementation are estimated at **$10.5 million** for DOC technology.
Adopt tighter standards for opacity testing for on-road fleets.	Construction/On-Road	**Benefits:** Provides emission reduction benefits through enhanced inspection and maintenance. **Costs:** DMV could incur administrative costs of to revise program rules.
Expand DMV's on-road heavy-duty vehicle emissions testing program to include all vehicles between 18,000 and 25,999 pounds. These vehicles are currently exempt from emissions testing even though vehicles below and above this weight class are subject to emissions testing.	On-road	**Benefits:** Promotes regional consistency in standards for fleets. Provides emission reduction benefits through enhanced inspection and maintenance of vehicles representing 42% of the fleet. **Costs:** Administrative costs to DMV to revise program rules and additional DMV inspectors and testing equipment estimated at $250,000.
Amend Section 14-164i (g) to remove the exemption for school buses from DMV's emissions testing program for diesel-powered commercial vehicles. The first four MYs should be exempted with a reserved option to test anything older.	School Bus	**Benefits:** Inclusion of diesel school buses for emissions testing, conducted as part of the annual safety inspection, will assist in identifying gross polluters and ensure that school bus emission

Diesel Reduction Strategies	Sector	Benefits/Cost
		control systems are properly maintained. **Costs:** DMV could include emissions testing of school buses within annual safety inspection programs at an estimated cost of $50,000/year.
For school buses: allow the natural fleet turnover to take place after the implementation of the HDDE standards. With current fleet turnover rates, this would be accomplished by 2019.	School Bus	**Benefits:** New school buses would have factory-installed DPFs and emissions controls for the ozone precursor, NO_X. **Costs:** Costs are estimated at approximately: **$25-30 million**, over time, to implement a full school bus replacement program. Costs could be budgeted over time and coupled with incentives.
Develop and implement a strategy to address waste haulers. DEP should explore opportunities to leverage existing programs (e.g., solid waste permitting authority) to address air emission impacts of waste haulers.	On-road	**Benefits:** These vehicles are numerous and widely operated in Connecticut so the emission reductions would be significant and widespread. **Costs:** It could cost as much as **$9 million**, over time, to implement a waste hauler retrofit strategy.[16]
Develop "Chip Re-flashing" regulations to require the installation of low-NOx software in eligible HDDVs.	On-road	**Benefits:** Having the ECM microchips replaced reestablishes the NO_X reduction benefits intended by the HDDV manufacturers.[17] **Costs:** DEP program development costs for a regulation can range from $75,000 to $150,000.

[16] Environment Northeast, Waste Collection Vehicles Options Memo, November 10, 2005.

[17] "Aside from reflashing the ECM (or other means to retard advanced timing), there are few other adjustments that can be made that affect NO_x emissions from the *current fleet* of diesel powered vehicles." Klausmeier, Rob and Rick Baker, *Inspection/Maintenance(I/M) Program Options for Diesel Powered Vehicles in Texas, DRAFT REPORT*, August 26, 2003, p. 2-3.

Diesel Reduction Strategies	Sector	Benefits/Cost
In 2005 when OBD technology is available, consider testing OBD-equipped medium and heavy-duty vehicles between 10,001 and 25,999 pounds.	On-road	**Benefits:** Testing vehicles with OBDs helps to maintain the emission control capability of the vehicle. This is time and cost effective. **Costs:** Testing contractors must invest in the testing equipment. The cost is indeterminate at this juncture.
Establish incentives to encourage retrofit and/or replacement of rental equipment used on construction sites.	Construction	**Benefits:** 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. **Costs: Costs:** The cost varies from vehicle to vehicle and may include engineering as well as installation. 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.[18]

Table 5

Tier 3 Actions for Implementation to Reduce Diesel Emissions in Connecticut

Diesel Reduction Strategies	Sector	Benefits/Costs
Retrofit all 1998 and newer transit buses with DPFs by 2010. Replace all 1997 model year (MY) and older buses with vehicles compliant with the 2007 federal standards.	Transit	**Benefits:** Decreases emissions of $PM_{2.5}$ by 2.88 tpy and the resultant exposure nine years sooner than normal turnover.

[18] 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 of the Construction Equipment Sector Report.

Diesel Reduction Strategies	Sector	Benefits/Costs
		Costs: It would cost approximately **$4.5 million** to retrofit all '98 MY and later transit buses.
Mandate DOT's 12-year fleet turnover policy to insure that all transit buses would be compliant with the 2007 standards by 2019 or sooner.	Transit	**Benefits:** Fleet turnover will place the cleanest vehicles available in the CT fleet sooner. New vehicles are much cleaner than retrofit vehicles, reducing PM emissions by approximately 2.88 tpy and NO_X by approximately 755 tpy. **Costs:** It will cost approximately **$3,896,000** to implement a mandatory 12-year fleet turnover program.
Mandate requirements for emissions control technology, requiring, by statute and/or regulation, that ULSD fuel and best available technology (BAT) be used with diesel construction equipment.	Construction	**Benefits:** This has the potential to provide great reductions in PM emissions, but at a high cost. **Costs:** The cost varies from vehicle to vehicle and may include engineering as well as installation. 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.[19] Depending on the technology selected, the cost could range from $10.5 million to $40.4 million. Administrative costs of $200,000 for 4 FTEs would be incurred by the DEP and $100,000 for 2 FTEs for each agency affected.
Establish incentives to encourage retrofit and/or replacement of rental equipment used on construction sites.	Construction	**Benefits:** Since the same equipment rental agencies work with a number of contractors, an effort to provide cleaner rental

[19]Ibid.

Diesel Reduction Strategies	Sector	Benefits/Costs
		equipment will benefit many different construction sites. **Costs:** See preceding discussion.
Offer 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. Examples include waiving the sales tax on new equipment and establishing incentive grants that can be designed to fund retrofits as well as contributing toward the increased cost of Tier 4 equipment.	Construction	**Benefits:** Waiving the sales tax would result in a significantly reduced cost per vehicle, encouraging the replacement of 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. **Costs:** The general fund would incur the cost of any diesel mitigation strategies funded through reduced taxes. The cost of such a tax incentive is indeterminate at this juncture but could be approximated based on an examination of historical sales.
Mandate retrofit and replacement of the existing school bus fleet by 2010. 1,200 older Type I diesel school buses would be replaced with 2007-compliant buses under current fleet turnover schedules, and 372 Type I buses are currently being retrofitted; this leaves about 3,400 buses to be retrofitted. Focus on retrofits of older buses, selecting emission reduction technologies that will maximize the reduction of diesel particulate exhaust emissions.	School Bus	**Benefits:** This maximizes reductions of fine particulates from the school bus fleet on the most aggressive schedule. **Costs**: *Concerns have been raised on the viability of this option since 139 school district fleets are subject to existing contract provisions that may preclude contract renegotiation.* Costs are estimated at **$6.5 million**[20] if the strategy could be implemented.
Inventory state and municipally owned heavy-duty diesel vehicles.	On-road	**Benefits:** 2007-compliant vehicles have much lower PM emissions and lower

[20] For purposes of estimating cost, DEP's calculation is based upon installation of diesel oxidation catalysts (DOCs) and crankcase controls.

Diesel Reduction Strategies	Sector	Benefits/Costs
Assess timeframe by which such fleets will be in compliance with federal 2007 emission standards.		emissions of the ozone precursors, NO_X and hydrocarbons. **Costs:** An inventory of state-owned HDDVs could be accomplished within DEP's normal budgetary resources.
Set up a state clean diesel fund, similar to the Carl Moyer Program in California,[21] the TERP[22] program in Texas or New Jersey's temporary reprogramming of corporate business taxes.	All	**Benefits:** This decreases emissions by providing a source of state funding to encourage retrofit and replacement of diesel-powered vehicles. **Costs:** Establishing a fund similar to those in California, Texas or New Jersey would significantly impact the General Fund, as any such fund would need to generate several million dollars per year to accomplish the goals set forth in SA 05-07 and this plan.
Inventory locomotives and assess viability of retrofit technologies. Provided it is technically feasible and funding is available, proceed to retrofit.	Other	**Benefits:** Railroad equipment accounts for 6 tons of non-road mobile source emissions of PM per year.[23] Reduction potential is significant. **Costs:** The approximate cost to inventory, assess retrofit viability and proceed to retrofit a locomotive would exceed $200,000. Although this seems expensive, this strategy could provide cost-effective emission reductions of approximately $200/ton of NO_X.

[21] See Appendix 2or go to http://www.arb.ca.gov/msprog/moyer/carl_moyer_board_presentation_1_20_05.pdf
[22] See http://www.tceq.state.tx.us/comm_exec/forms_pubs/pubs/rg/rg-388.html.
[23] Source MANE-VU.

Diesel Reduction Strategies	Sector	Benefits/Costs
Inventory marine Vessels (ferries) and assess viability of retrofit technologies. Provided it is technically feasible and funding is available, proceed to retrofit.	Other	**Benefits:** Commercial marine equipment accounts for 175 tons or 8% of non-road mobile source emissions of PM per year.[24] Reduction potential is significant. **Costs:** The approximate cost to inventory, assess retrofit viability and proceed to retrofit a marine vehicle could exceed $200,000. Although this seems expensive, this strategy could provide cost-effective emission reductions of approximately $200/ton of NO_X.

Strategies for Funding

The General Assembly also asked DEP to develop a strategy for securing and leveraging both federal and other funds. Identifying and securing available funding[25] is critical to the implementation of the mid-term and long-term priorities identified above. To date, Connecticut's diesel reduction projects that have included investments in emission reduction technology have been implemented with the use of EPA grants such as Clean School Bus USA, EPA's Voluntary Diesel Retrofit Program, Department of Energy (DOE) funds or through DEP's Supplemental Environmental Project (SEP) funds. Federal funds are available through the Congestion Mitigation and Air Quality (CMAQ) program and the new Diesel Emissions Reduction Act (DERA). Other states such as California and Texas have created statewide funding mechanisms.

If the executive and legislative branches of government concur that such an approach is the appropriate course of action, a separate account could be created under the Environmental Quality fund to be administered by DEP. Alternatively, a fund could be established as an account within the General Fund and set up as a dedicated fund. Either approach will require a full legislative process to authorize the creation of an account, the method for managing the account and the appropriation of funds to be dispersed. The appropriation of funding to create a dedicated funding source for diesel reduction efforts will require the consensus of the executive and legislative branches of government to pursue this as a state priority.

Throughout the stakeholder dialogue, the identification and commitment of funding was a frequent topic of discussion. Since the topic of "financing" is so integral to implementation of many elements of the diesel plan, DEP organized a session on

[24] Ibid.
[25] See section (b)(6) of Special Act 05-07.

financing for the stakeholders.[26] Materials from the session can be found at http://www.dep.state.ct.us/air2/diesel/docs/agenda26oct05.pdf.

Transit retrofits and other transportation projects that reduce air pollution in nonattainment areas can be eligible for Federal Highway Administration (FHWA) funding under the CMAQ program. DOT administers the program in Connecticut to provide partial reimbursements for qualifying programs. The Connecticut Region Council of Governments has submitted a proposal for CMAQ funding to retrofit the Connecticut transit fleets in Hartford and New Haven.

The Diesel Emissions Reduction Act (DERA) from the Energy Policy Act of 2005 contains two sections that will provide grants and loans to states (section 793) and other eligible entities (section 792) to achieve significant reductions in diesel emissions. DERA authorizes a total of $200 million per year for such programs in fiscal years 2007-2011. Assuming that these funds are actually appropriated, this will become a significant source of funding for diesel emissions reductions in the period covered by the Act. Community-based efforts focused on developing viable diesel emission reduction projects should continue. DEP remains committed to facilitate this process to ensure that Connecticut is well positioned to compete effectively for this potential pool of federal funding.

At the state level, California and Texas that have made significant investments by setting up dedicated funding programs have implemented numerous diesel reduction projects as a result. Most recently, the State of New Jersey passed a ballot initiative that will also create a large dedicated funding stream for diesel reduction projects. These examples are illustrative of an option the General Assembly could pursue if funding could be identified for this purpose.[27] Tax credits and exemptions and incentives for alternative fuels are

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[26] The workshop was held on October 26, 2006 and included Michael D. Jackson, Senior Director, TIAX LLC who has worked closely with the State of California on their diesel reduction programs. Jim Blubaugh, the Director, National Clean Diesel Campaign, Office of Transportation and Air Quality, EPA provided a perspective on EPA's national programs and Kenneth D. Simonson, Chief Economist, Associated General Contractors of America, provided an industry perspective.

[27] California's Carl Moyer Program was the first successful statewide program to provide grants for diesel reduction projects. The program began in 1998 and since that time has provided over $150 million in awards to both private and public sector applicants. The California legislature allocates funds annually out of the state's general fund and a local match is required.[27] Funds can be utilized to fund replacement, repowering or retrofits for a wide-range of diesel vehicles and equipment. The program has been widely recognized for its success by industry, the environmental community and the regulatory agencies. Air Quality Management Districts in California have been able to use the program to achieve substantial reductions of PM and NO_X and as result have been able to obtain State Implementation Plan (SIP) credits. More information on the Carl Moyer Program can be found in Appendix 2 and at http://www.arb.ca.gov/msprog/moyer/moyer.htm.

The other large grant program focused on diesel reductions is the Texas Emission Reduction Program (TERP). TERP was modeled on the Carl Moyer Program and has awarded $120 million in grants for diesel retrofits, repowers, and equipment replacement since 2001. The program is funded through a variety of surcharges and inspection fees including diesel equipment rentals and a surcharge on registration fees. Both the Carl Moyer and TERP programs award grants on a competitive basis according to NO_X emission reduction cost-effectiveness. For the first three years of the TERP program, 280 projects had been selected for funding.[27] More information on the TERP program can be found at http://www.tceq.state.tx.us/comm_exec/forms_pubs/pubs/rg/rg-388.html

also discussed in Appendix 1 Mid-term and long-term strategies could be implemented if funding programs could be put in place.

Additional information on sector specific strategies, comments received as well as other information gathered as part of the stakeholder dialogue can be found in the sector reports. All of the reports are posted on the web at: http://www.dep.state.ct.us/air2/diesel/forum.htm.

Tax Credits and Exemptions for Air Pollution Equipment

There are existing tax exemptions available for purchases of air pollution control equipment. Purchases of qualifying air pollution control equipment are exempt from sales and use taxes pursuant to Connecticut General. Statutes Section 12-412(22) and eligible to obtain the municipal property tax exemption pursuant to Connecticut General Statutes Section 12-81(52). The Department of Revenue Services and the Office of Policy and Management have interpreted these exemptions as applying to air pollution control equipment incorporated into or used on real property and have not extended them to mobile pollution sources such as trucks, buses and other off-road equipment. Based on input received from members of the construction sector subcommittee and from the Connecticut Trucking Association extending tax incentives, especially property tax exemptions, to on-road and off-road fleets would provide a significant motivation for pursuing diesel retrofits and/or replacements.

Incentives for Alternative Fuel Vehicles (AFVs) in Connecticut

In Connecticut, there are two grant programs to fund the purchase of AFVs: the DOT AFV program and the US DOE SEP. Since 1994, 21 entities have participated in the DOT AFV program, which provides grants to local governments, and to private companies performing public services to purchase AFVs. This program has assisted in the purchase of 185 AFVs[28] to date. Funding for this program is provided by federal CMAQ dollars and is available to cover 100% of the incremental cost of an AFV. Approximately $1M has been available annually. The program could be more effective if expanded to at least partially cover the costs of related refueling infrastructure as is routinely done in our neighboring states of Massachusetts, Rhode Island, and New York. Funding should be available to private fleets. (Note that CMAQ funding is available to private entities in both New York and Massachusetts for AFV programs.)

In addition to the DOT AFV Program, the national Clean Cities program provides grants through the State Energy Program (SEP) for AFV infrastructure and vehicle purchases, as well as idle reduction strategies. Clean Cities stakeholders throughout the US compete for approximately $6M in annual funding provided by the US DOE. In the last three years, the Clean Cities of Connecticut have been awarded approximately $400,000 in US DOE SEP grants.

Over the past several years, the Connecticut State Legislature has passed numerous incentives to purchase AFVs and to develop related refueling infrastructure. Currently, a

[28] *Analysis of DOT's AFV Program,* 2 Plus, Inc., 2002, http://www.2plus.com/FY%202003%20Alt-Fuel%20Report.PDF.

Corporation Business Tax credit is available for 50% towards the construction of, improvements to, or equipment for any CNG, LNG, LPG (propane) refueling station or an electric vehicle recharging station; and the purchase and installation of equipment used in dedicated or dual fuel CNG, LNG, LPG or electric vehicle conversions. Corporations can also claim a tax credit for 10% of the incremental cost of a new dedicated CNG, LNG, LPG, or electric vehicle. Corporations purchasing a new hybrid with an EPA fuel economy rating of at least 40 mpg, a new dedicated CNG, LPG, hydrogen, or electric vehicle; equipment used in dedicated or dual fuel CNG, LNG, LPG, or electric vehicle conversions; and equipment associated with a CNG or hydrogen filling or electric recharging station are exempt from state sales tax. Fuel taxes are also exempted on CNG and LPG Motor Fuels in Connecticut. Recently, the federal government also passed a host of incentives that will help offset the cost of AFVs. Highlights of these incentives include a federal tax credit towards the purchase of new, dedicated AFVs up to 50% of the incremental cost; a tax credit towards the sale of alternative fuels; and a tax credit to the buyer of CNG refueling equipment up to $30,000 per station. These tax incentives will be in effective after January 1, 2006. These tax incentive programs could be maximized if partnered with grants for AFV purchase and infrastructure development by both public and private fleets. Currently, in New York State, private fleets benefit from the state's AFV tax incentive program and grant programs in areas, such as New York City, that suffer from severe air quality problems.

Procurement

DEP continues to coordinate with the Department of Administrative Services (DAS) to develop a statewide procurement process for diesel reduction technologies and clean fuels. Once completed DAS will have in place a statewide contract from which municipalities can purchase diesel reduction technologies and clean fuels cost effectively.

Raising Awareness of Health Risks of DPM

Section (b)(7) of Special Act 05-07 encourages DEP to make recommendations for programs and policies to raise awareness about the health risks and climate impacts associated with DPM. The DEP has programs in place that begin to address this issue and can serve as models for further education and outreach.

In August of 2005, DEP and the Department of Public Health (DPH) joined forces in an education and outreach campaign on the health effects air pollutants to build partnerships with the local public health directors. There are several resource tools available through DEP and the Department of Public Health (DPH) to assist local health directors in protecting the public from air quality-related health risks, particularly asthma episodes, respiratory distress, and/or increased absenteeism from school.

The Air Quality Alert is a free service offered by EPA, in coordination with the DEP. This service works to notify local health directors, either by e-mail or fax, when high concentrations of ground-level ozone (the main component of smog) and/or elevated levels of particulate matter are predicted in areas throughout Connecticut. When elevated levels of particulate matter or ozone are forecasted, everyone in the affected communities

should be advised to take appropriate precautions throughout the day. The Air Quality Alert system provides appropriate precautions based on the day's air quality forecast.

Because children spend so much time outside, they are at a particularly high risk to pollutants. The Air Quality Alert service can be useful tool to advise the public of unhealthy levels of air pollution may be affecting children and other sensitive populations. It also can be used to advise physical education instructors and/or coaches in towns to consider scheduling less strenuous outdoor activities on predicted high ozone and/or particulate days, or to alert senior centers and/or health care facilities to watch out for increased respiratory distress. Health directors and the public could sign up for the service by accessing the EPA web page at http://www.epa.gov/region01/airquality/smogform.html. Specific air quality forecasts for Connecticut also are available from the DEP website at http://www.dep.state.ct.us/airmonitoring/aqi. asp

DEP and DPH continue to collaborate on effective communication tools to assist local health directors and their communities in obtaining and understanding air quality information.

Indoor Air Quality (IAQ) problems in schools are a recognized public health issue. Legislation passed in 2003 requires that all schools in Connecticut adopt an Indoor Air Quality (IAQ) program. The best and most cost effective of these is the EPA's IAQ Tools for Schools (TfS) program. TfS uses a team approach to finding and correcting indoor air problems. In each school building, a group of administrators, parents, school nurses, teachers and custodians investigates and prioritizes potential indoor air hazards. Short and long-term strategies are then developed and put in to place in order to address the identified issues.

TfS has brought a consortium of state agencies and organizations (the CT School Indoor Environment Resource Team) together to develop an outreach and training program in order to assist local school districts in implementing TfS. School districts can contact DPH for assistance in adopting TfS. The contact number at DPH is (860) 509-7742.

DEP and DPH continue to encourage information sharing with other appropriate contacts at the local level such as the school nurse, gym teacher, summer camp staff, and any other faculty/staff or childcare professionals that may take children outside during unhealthful ozone or particulate matter days, as well as, senior centers and health care/housing facilities for the ill and elderly.

Connecticut's school bus retrofit program includes an educational component to use retrofit projects as a learning opportunity to help middle school students further understand air quality issues as part of their science curriculum. DEP's Connecticut Schools Air Quality Curriculum teaches students about sources of air pollution, how it affects people and the environment, and what the students can do to be leaders for the environment. In conjunction with successful retrofit projects, two Norwich middle schools and several New Haven middle schools have implemented the Connecticut Schools Air Quality Curriculum.

Boys and Girls Clubs throughout the state of Connecticut have used activities from the Connecticut Schools Air Quality Curriculum in the summer of 2003 and 2004. Curriculum materials will be integrated with complementary efforts underway by the Department of Transportation (DOT) and the Institute for Sustainable Energy at Eastern Connecticut State University. This component is currently being developed to educate Connecticut students about climate change, and includes a module on diesel emissions.

While fuel efficiency might be the best selling point, education and outreach related to anti-idling could include comprehensive messaging on the health effects of pollutants emitted by diesel engines. This could be designed to reach transit, school bus and on-road fleet drivers as part of a continuing education package associated with employment or licensure. As is discussed in detail in Attachment A below, DEP's anti-idling signage program could be expanded to include large distribution centers, bus stops, and airports.

Sector Reports and Background Materials

All of the sector reports follow this overview and can be found, along with supporting documents, minutes of the subcommittee meetings, and copies of the forum presentations, on the diesel web page at http://www.dep.state.ct.us/air2/diesel/forum.htm.

Transit Sector Report

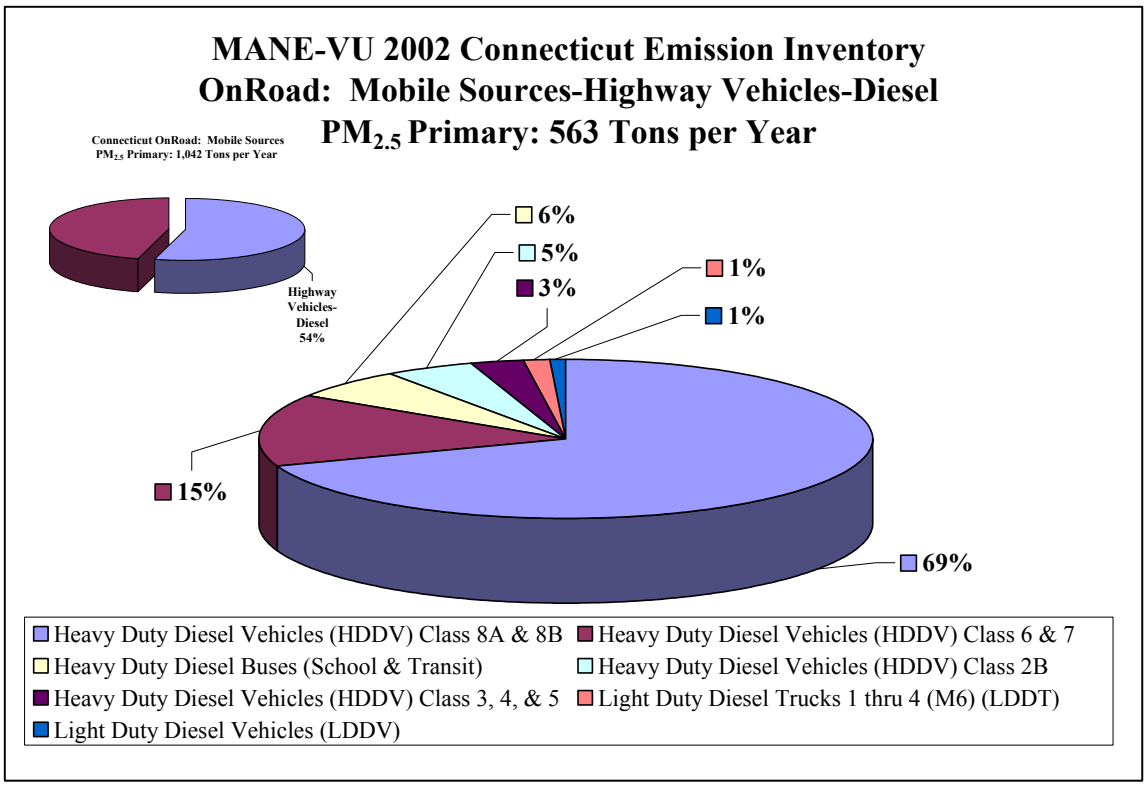
Special Act 05-07
Connecticut Clean Diesel Plan
Transit Sector Report

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. These sources also emit other pollutants that contribute to Connecticut's air quality problems. For example, on-road engines account for about 58 percent of the over 118,000 tons of nitrogen oxides (NO_X) emitted annually in Connecticut, off-road engines about 20 percent, with the remaining 22 percent from stationary and area sources.

Figure 1 represents the emissions of $PM_{2.5}$ from on-road diesel-powered vehicles in Connecticut in 2002. School and transit buses account for 6% of the total emissions of $PM_{2.5}$ or 33.78 tons per year. According to data from Connecticut Transit (CT Transit), transit buses subject to Special Act 05-07 (the Act) are responsible for 3.28 tons of particulate matter per year (or approximately 10% of the emissions from both transit and school buses). (See Table 3 on page 9.)

Figure 1[29]



[29] The Mid-Atlantic/Northeast Visibility Union (MANE-VU) was formed by the Mid-Atlantic and Northeastern states, tribes, and federal agencies in 2001 to coordinate regional haze planning activities for the region. MANE-VU provides technical assessments and assistance to its members.

The General Assembly has directed the Department of Environmental Protection (DEP), pursuant to the Act, to develop a Connecticut clean diesel plan to reduce the health risks from diesel pollution.

The DEP began the planning on July 19, 2005 with a kick-off meeting at the DEP's offices. As a result of this meeting, four subcommittees were formed to explore and develop recommendations for emission reduction strategies for the following sectors: on-road fleets, transit buses, school buses and off-road construction equipment. Each subcommittee included representatives of government, private industry, public health and the environmental sector. A set of action items was provided for consideration along with a directive to provide feedback to the DEP.

The requirements for the implementation strategy for transit buses, as set out in Section 1(b)(2) of the Act, are the most specific of the four sectors.[30] Vehicles covered by this section are publicly owned, not less than twenty-nine feet in length and have a model year of 2006 or earlier. The strategy should reduce emissions of diesel particulate matter by at least eighty-five percent no later than December 31, 2010. Diesel particulate filters (DPFs) are specifically mentioned as a control technology for implementation of this section, but alternative fuels and alternative engine technologies could be employed to reach the specified reductions.

The transit subcommittee was asked to examine the following issues:

- Statewide Baseline,
- Fleet Retrofit, Replacement Retirement Options,
- Clean Fuel Options,
- Anti-Idling,
- Leveraging Opportunities,
- Case Studies – Pilot Projects, and
- Other items Identified by the Group.

On August 17, 2005, the DEP hosted a Diesel Emissions Reduction Policy, Technology and Clean Fuels Forum. The forum was intended to inform the DEP's efforts to develop the Connecticut Clean Diesel Plan by providing experts on policy, control technology and clean fuels the opportunity to present information to all interested stakeholders. Much of the information received through this public input process is relevant to each of the four subcommittees and serves to inform several aspects of this report. The information from that meeting is distilled into a table detailing technology and clean fuel options, emission reduction benefits and cost. This table is reproduced in the Appendix to this report.

The Transit Subcommittee studied the reduction of diesel pollutants from publicly owned or funded motor buses[31] that have an engine model year of 2006 or older and are not less than twenty-nine feet in length. As specified in the Act, a strategy was developed to

[30] See Appendix 1, Special Act 05-07, *An Act Establishing A Connecticut Clean Diesel Plan.*
[31] Motor Buses are specifically defined in section 14-1 (48) of the Connecticut General Statutes.

reduce diesel particulate emissions from transit buses by at least 85 percent, no later than December 31, 2010.[32]

Beginning with the 2007 model year (MY), all new heavy duty diesel engines will be required to meet federal emissions standards for particulate matter (PM) and nitrogen oxides (NO_X)[33] that are equivalent to or more stringent than the emissions reductions recommended in Special Act 05-07. Currently, the Connecticut Department of Transportation (DOT) and CT Transit have a policy in place that sets a 12-year turnover rate as a goal. If the State of Connecticut chose to mandate compliance with this policy and provided the corresponding funding, all transit vehicles would comply with the federal standard by 2019. The provisions in Special Act 05-07 move the compliance date forward to 2010. The transit sector report includes an evaluation of three options to consider as part of the State's diesel reduction efforts.

In developing these strategies, it is important to note that federal regulations mandating the use of ultra low sulfur diesel fuel (ULSD) and 2007 compliant engines will impose separate cost impacts on the transit industry nationwide. Transit operators in Connecticut will be impacted by these costs as well as by costs that may flow from implementation of the Act. Many of the assumptions made in generating the data sets compiled for this report are based on the fact that some costs and benefits would have accrued from the implementation of the federal regulations; every effort was made to isolate the data resulting from the state Clean Diesel Plan alone.

Before this strategy was developed, the Connecticut Region Council of Governments (CRCOG) had submitted a proposal for Federal Highway Administration (FHWA) funding under the Congestion Mitigation and Air Quality (CMAQ) program to retrofit the buses in CT Transit's Hartford-area and New Haven fleets. CRCOG had assembled a very detailed fleet inventory and a set of related data, which was made available to the transit subcommittee to use in completing its inventory. The database that had been compiled for the CMAQ application was expanded and a strategy to cover the entire Connecticut fleet was developed.

II. Transit Sector Report

A. Statewide Baseline

- The current inventory of transit buses in Connecticut is 658, of which it is projected that 487 transit buses will be subject to the Clean Diesel Plan by 2010.[34]

- Assumptions:

[32] Special Act 05-07 specifically identifies an 85% reduction target for diesel particulate matter, however DEP included reductions of other air pollutants such as oxides of nitrogen, carbon dioxide and toxics for consideration by the Committee. Air quality challenges such as ozone nonattainment and climate change require DEP to pursue a multi-pollutant reduction strategy to achieve progress in these areas.
[33] 40 CFR 86.007-11.
[34] See Attachment A.

- With an average turnover period of 12 years, buses from the 1997 MY and older will have been replaced by 2010 and are not included in the total.
- Beginning with the 2007 MY, federal regulations require that all manufacturers include emissions controls on their buses that will meet the requirements of the Act. Therefore, 2007 and later MYs are not included in the projected total for capital costs of transit buses impacted by the Act.
- 2007 and later MY buses are included in the projections of operating cost increases resulting from implementation of the Act.
- Buses that are retained as emergency backups would not be subject to the Act, provided that they meet certain standards for low annual mileage.

B. Fleet Retrofit, Replacement and Retirement Options:

Three options are presented for consideration by the subcommittee as avenues for meeting the goals and objectives specified in the Act. Option 1 is a strategy for installing DPFs on the Connecticut fleet by the end of 2010.

The second option relies on implementation of federal regulations that set emissions standards for all new heavy duty, onroad, diesel engines beginning with the 2007 MY and adherence to DOT's voluntary policy of a 12-year fleet replacement. The 2007 federal emissions standards for PM and NO_X are equivalent to or more stringent than the emissions reductions set out in the Act. Mandating the current fleet turnover rate of 12 years and providing the necessary funding will insure that all state transit vehicles would comply with the federal standard by 2019.

Option 3 assumes that CMAQ funding will be awarded to CRCOG to retrofit the Hartford-area and New Haven transit fleets with DPFs. With additional state funding, the remainder of the state fleet would be replaced with 2007 compliant buses at a mandatory turnover rate of 12 years.

- **Option 1: Installation of Diesel Particulate Filters**

  - **Background:**
    For the transit sector, the Act specifies an 85% reduction target for particulate matter; DPFs are one of the few technology options capable of achieving reductions in this range. DPFs are ceramic devices that collect the PM in the exhaust stream. The high temperature of the exhaust heats the ceramic structure and allows the particles inside to break down (or oxidize) into less harmful components. They can be installed on new and used buses, but must be used in conjunction with ULSD. The combination of DPFs and ULSD can reduce emissions of PM, hydrocarbons, and carbon monoxide by 60 to 90 percent.

    While there is some variation from manufacturer to manufacturer, most DPFs require that the engine temperature exceed 260° C for at least 40% of its duty cycle for effective operation. In many instances, diesel engines

cannot achieve the requisite temperatures and other technology options must be considered.

In one of the first projects of its kind in the nation, CT Transit retrofitted 34 of the 55 transit buses in the Stamford fleet with DPF's and ULSD. This pilot project has provided CT Transit with much valuable information relevant to the implementation of the Act. For example, CT Transit has reported that DPF filters do not function adequately on Detroit Diesel Series 50 engines equipped with Exhaust Gas Recirculation (EGR).[35] There are approximately 191 transit buses equipped with this engine and EGR in the state. These are among the newest and lowest emitting buses in the transit fleet. If the technology does not become available by 2010, an alternative strategy would have to be developed to ensure that this portion of the fleet meets the specified reduction target.

DPFs must be periodically "regenerated" to remove the collected particulate matter. Special ovens are used to bake off the accumulated soot at high temperatures. DPFs can also incorporate passive regeneration techniques, such as the catalyzed particulate filter, or they can incorporate active regeneration techniques, such as the electrically regenerated particulate filter.

- **Assumptions:**
  - While other emissions control technologies are available, projections were made based on the installation of DPFs as specified in subsection (b)(2) of the Act.[36]
  - Effective DPF technology will be available for the Detroit Diesel 50 buses with EGR by 2010. If the technology does not become available, an alternative strategy would need to be developed to achieve the targeted reductions specified in the Act.
  - Buses will continue to be retired and replaced after 12 years.
  - There are 6 buses in the fleet that operate on #2 diesel fuel; in addition to the installation of the DPFs, the engine control module (ECM) computers on these buses will need to be reprogrammed to accommodate the ULSD fuel.
  - Buses that are retained as emergency backups should not be subject to this option; backup buses would be required to meet certain standards for low annual mileage that should be set out in legislation or regulations implementing the Act.
  - DOT and CT Transit will develop a proposed schedule of voluntary retrofit targets to implement Option 1 by 2010; this

[35] According to CT Transit, Detroit Diesel is testing ways of overcoming this problem through re-programming engine controls and through modifications of filters. The manufacturer is responding to pressure from New York City transit operators to find a remedy quickly.
[36] See Appendix 1.

would not be mandatory, but would serve to provide general goals for planning and reporting purposes.[37]

- **Capital Cost Projections**:
  - **Retrofit Costs:** The cost of retrofitting a bus with DPF includes the filter, a backpressure monitor to protect the engine and the installation. The cost for retrofitting 487 buses with DPF filters is estimated to be $3,993,400 ($7,500 per unit). Experience indicates that 15%, or 80 buses, will need unscheduled filter replacements for an additional cost of $536,000. Adding in $3,000 for reprogramming the ECM computers on 6 buses currently using #2 diesel fuel, the total cost for equipment purchase and installation is approximately $4,532,400.[38] (See Table 1.) It is assumed that all retrofit installations will be performed by CT Transit staff; therefore installation costs will be predictable and consistent.

Table 1: Estimate of Initial Cost to Retrofit Statewide Transit Fleet

9/4/2005

	Number	Filters* $6,000	Sensors $1,000	Installation $500	Inflation** $700	ECM $500	Total
Buses – existing buses 1997 or newer	363	$2,178,000	$363,000	$181,500	$254,100	-----	**$2,976,600**
Buses – buses on order for 2005 or 2006 (1)	124	$744,000	$124,000	$62,000	$86,800	-----	**$1,016,800**
Spare filters (15 percent)	80	$480,000	-----	-----	$56,000	-----	**$536,000**
Reprogram ECM computers for #2 diesel buses	6	-----	-----	-----	-----	$3,000	**$3,000**
Total buses to be retrofitted = 487						**TOTAL**	**$4,532,400**

*Includes filters for buses with EGR (see text). A preliminary list of EGR buses is provided below.

CTTRANSIT Hartford = 63
CTTRANSIT New Haven = 84
SEAT Norwich = 5
GBTA Bridgeport = 34
Northeast Transit Waterbury = 5

**Prices are 2005 prices, but purchases will be staggered over 2006, 2007, 2008, and 2009. Assume an average of a $700 increase over all 4 years.

[37] A sample retrofit schedule would be: 20% of the eligible fleet in 2007, 20% in 2008, 30% in 2009 and 30% in 2010.

[38] Costs were derived by CT Transit based on experience with the Stamford fleet and manufacturers' projections.

- **Bus Replacement Costs**: The capital cost of purchasing each 2007 MY bus will be approximately $8,000.00 greater than current replacement prices because emissions controls will be included on all buses manufactured for the 2007 MY and later. Therefore, the increased cost of replacing 171 pre-1998 MY buses due to be retired during the period covered by this legislation is estimated to be $1,368,000. While this is a result of federal regulations, not the state Clean Diesel Plan, it will be a significant extra burden on transit operators, impacting their ability to absorb the costs of the retrofits within their current capital budgets.
- **Economies of Scale v. Inflation and Limits on Supply**: As manufacturers gear up to equip all new buses in the U.S. with DPFs to meet the 2007 federal standards, the costs of the filters may become less than current projections.[39] Conversely, inflation and/or shortages in raw materials could result in increased prices. Cost projections in this report are reasonable estimates based on current information; they include inflation over the period covered by the legislation.

- **Operating Cost Projections**:
  - **Filter Maintenance**: DPFs require an annual cleaning, at $500 per bus, to remove accumulated particulates. More cost-effective methods of cleaning filters are currently under development.[40] By the time the Clean Diesel Plan is fully implemented, the costs associated with annual filter cleaning may be lower than the projections.
  - **Filter Replacement**: After 5 years, filters must be replaced at a cost of $7,500 per bus. With retrofits projected to begin in 2006, the filter replacement costs will not come into the budget until 2011. With an estimate of 130 buses needing filter replacement per year, the annual operating costs for CT Transit would be increased by $975,000 upon full implementation. This leads to an overall annual cost increase of $1,300,000. (See Table 2.)
  - **Fuel Cost Differential**: DPFs require the use of ULSD, which is currently more costly ($0.12 per gallon) than the low sulfur diesel fuel. Federal law requires a changeover to ULSD in 2006 and the baseline cost is expected to change.[41] While any resultant increase in fuel cost cannot be attributed to the state Clean Diesel Plan, it is

[39] In 2000, using 1999 dollars,, EPA projected that filters would cost $2,560 (2007-2011) in the short term and $1,410 in the long term (2012 and beyond). See http://www.epa.gov/otaq/regs/hd2007/frm/exec-sum.pdf.

[40] The cleaning process, which involves heating the DPFs in a special oven, generates ash, which may contain trace metals. The alternative process, which involves blowing out the accumulated fine particulates and lube oil ash, also generates a powdered waste that may require regulation as a hazardous waste.

[41] In a December 2000 Regulatory Announcement, EPA projected that when ultra-low sulfur standards are fully phased in (October 2006) incremental costs are expected to drop to $0.045- $0.05 per gallon more than current costs. See http://www.epa.gov/otaq/regs/hd2007/frm/f00057.pdf.

noted as a potential financial burden that could impact the operators' ability to absorb the increased operating costs associated with the plan.

Table 2: Estimate of "Incremental" Operating & Maintenance Cost of Diesel Filters & ULSD

Statewide Transit Fleet

9/4/2005

Year	# Buses in fleet	Annual filter cleaning $500 = cost/bus		Filter Replacements (5 yrs) $7,500 = cost/bus		Total Annual Cost (2)
		# Buses w/filters	Cost	# Buses needing new filter (1)	Cost	
2007	650	200	$100,000	0	0	**$100,000**
2008	650	400	$200,000	0	0	**$200,000**
2009	650	650	$325,000	0	0	**$325,000**
2010	650	650	$325,000	0	0	**$325,000**
2011	650	650	$325,000	130	$975,000	**$1,300,000**
2012	650	650	$325,000	130	$975,000	**$1,300,000**
2013	650	650	$325,000	130	$975,000	**$1,300,000**

(1) Assume 1/5th of the fleet per year starting 5 years after the first retrofits.

(2) The incremental operating cost does not include the incremental cost of switching to ULSD fuel, since this is a federal requirement that all operators must comply with by September 2006. See text.

- **Emissions Reductions**:

  Using data from tests of New York City transit buses, CT Transit projected that implementation of the requirement for transit buses under the Act will result in a decrease of 87.8% or 2.88 tons of PM per year.[42]

  According to EPA Region 1, 5-9%, of the decrease in particulate emissions can be attributed to the changeover to ULSD alone.[43] This change is mandated by federal regulations and will occur beginning in June 2006 when those regulations take effect. Because DPFs cannot function without ULSD, emissions reductions are represented as resulting from the combination of ULSD and DPFs.

[42] See Attachment B.

[43] See http://www.epa.gov/NE/eco/diesel/retrofits.html. CT Transit figures, based on NYC data indicate that 29.4% could be attributed to ULSD alone. See Attachment C.

Emissions reductions are summarized below in Table 3.[44] While DPFs and ULSD will decrease emissions of particulate matter, they do not decrease the production of NO_X, a major ozone precursor. All of Connecticut has been designated nonattainment for the 8-hour ozone standard, and achieving additional reductions of NO_X and VOCs are critical to solving Connecticut's attainment problem.

Table 3: Estimated Emissions Reductions

Retrofitting Statewide Transit Bus Fleet with Diesel Particulate Filters (1)

9/4/2005

For Entire State Transit Bus Fleet	**PM** particulate matter	**CO** carbon monoxide	**HC** hydrocarbons
Baseline - LSF fuel & no filter (existing) (tons per year)	**3.28**	**32.98**	**3.63**
Clean Diesel Plan - ULSD fuel with filter (tons per year)	**0.40**	**2.00**	**0.25**
Emissions reduction (tons): **Annual**	**2.88**	**30.98**	**3.38**
Emissions reduction (%): **Annual**	**87.8%**	**93.9%**	**93.1%**
Emissions reduction (tons): **Project Life (2)**	**29.11**	**312.96**	**34.16**

Baseline 1 = existing condition with low sulfur diesel fuel and no filters

Clean Diesel Plan = All buses equipped with diesel particulate filters & operating on ULSD fuel

(1) Emissions estimates based on New York City tests.

(2) Project life varies by bus. It is based on emissions reductions achieved over the remaining life of a bus after it is retrofitted. Standard life expectancy of a new bus is 12 years. A 5-year old bus that is retrofitted has a remaining life (project life) of 7 years.

- **Cost Effectiveness**:

  By dividing the increased annual operating cost of $1,300,000 from Table 2 by the annual PM reductions of 2.88 from Table 3, the annual cost will be $451,389 per ton of diesel particulates reduced from the transit bus sector when the Act is fully implemented in 2011.[45] Under the federal 2007 standards (and Option 2), this full annual cost would not be reached until 2019. The savings in health care costs resulting from the PM exposure should be weighed against the cost projections.

[44] DPFs reduce hydrocarbons (HC), a term sometimes used interchangeably with VOCs, and carbon monoxide (CO) as well as PM, but the Act is focused on PM.

[45] The California Air Resources Board (CARB) used a similarly unweighted analysis in its 2002 Staff Report supporting implementation of its transit bus fleet retrofit program. That analysis used emissions estimates generated by a computer model as compared to the actual data used in this report. (See CARB report in Attachment D and CT Transit data in Attachment B.)

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*[46] and referenced in a recent report for the CMAQ Program[47] states that 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.[48]

Transit bus emissions are unique in their public health impact because of the numbers of people directly exposed. According to DOT ridership figures, twenty-seven million Connecticut residents use 658 transit buses in the CT Transit system. Every passenger exiting from or waiting to board an idling bus inhales the pollutants from the diesel exhaust. And while a properly maintained bus with the windows closed will have few pollutants within the passenger compartment, there are obvious situations where passengers inside the bus are exposed to exhaust. In addition, emissions from city buses contribute to $PM_{2.5}$ hot spots and to the concentration of other pollutants affecting all urban residents. Investing in the reduction of emissions from transit buses will therefore have public health benefits that are amplified by the exposure factor.

Given these health concerns, the General Assembly could choose to pursue a funding mechanism to fully implement this section of the Act.

- **Option 2: Federal 2007 Diesel Program with Mandatory Fleet Turnover**:

  In the absence of additional reduction strategies for transit buses, making CT Transit's current 12-year fleet turnover policy mandatory would insure that all transit buses would be compliant with the 2007 standards by 2019. The federal 2007 standards include reductions in NO_X, which are important for attainment of the 8-hour ozone standard. The identification of a funding mechanism to cover the costs of implementation would enhance the feasibility of this option.

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[46] 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

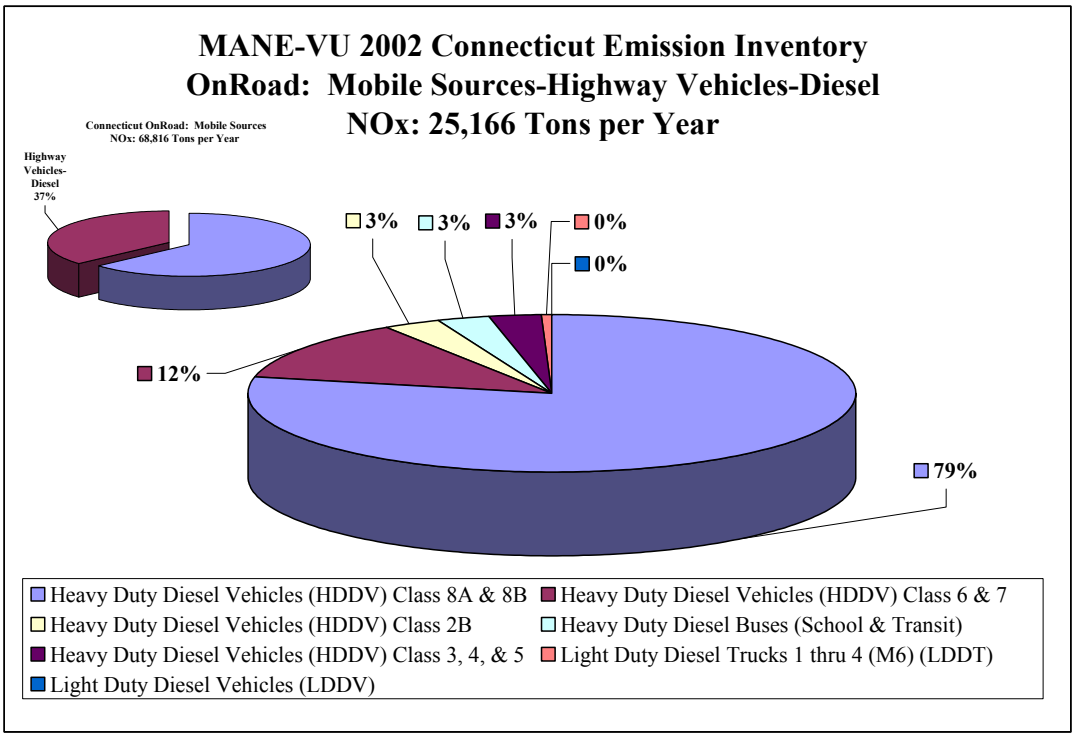
[47] Westcott, Robert F., Cleaning the Air: Comparing the Cost Effectiveness of Diesel Retrofits vs. Current CMAQ Projects, prepared for the Emission Control Technology Association, May 11, 2005. (See Appendix 3.)

[48] The CMAQ report goes on to discuss weighting factors for various pollutants, noting that there is presently no weighting factor for $PM_{2.5}$. In generating a factor for its report, CMAQ assumed that the technology that removed PM would also remove NO_X. Since DPFs do not remove NO_X, that factor and its resultant product are not employed in this analysis. The generation of an appropriate weighting factor to use in this cost/benefit analysis is beyond the scope of this report.

Capital costs would include the differential between the retrofit option and the replacement of the entire fleet with 2007 compliant buses, effectively substituting replacement for retrofits. If each of the 487 buses subject to retrofits under Option 1 were to be replaced by 2007 compliant buses at an increased cost of $8,000.00[49] per bus, the capital cost associated with that early fleet turnover would be increased by $3,896,000. Operating costs of the fully implemented program would be the same as for Option 1 starting in 2019 as opposed to 2011.

Because NO_X is also reduced in the 2007 compliant buses, the cost per ton of pollutants reduced will decrease as compared to the first option. According to Figure 2, school and transit buses account for approximately 755 tons of NO_X emissions per year. Using the 10% factor derived in the discussion of $PM_{2.5}$ emissions (see page 1), transit buses could be expected to contribute about 75 tons of NO_X per year. While 2007 technologies have not been fully developed and tested, it is apparent that even a 50% reduction in NO_X to meet the minimum standard for engines in 2007, added to the 2.88 tons of reduced $PM_{2.5}$, would result in a significant decrease in the annual cost per ton figure from $451,389 to $32,194.

Figure 2



[49] Costs were derived by CT Transit based on experience with the Stamford fleet and manufacturers' projections.

This option provides public health benefits through the reduction of ozone-producing NO_X, but it extends the implementation period of public health risk from exposure to diesel particulates by nine years. The health-related costs stemming from this prolonged exposure should be taken into account when considering this option.[50]

As has been noted in the discussions of Option 1, the increased capital costs of the 2007 compliant buses ($14,500 per bus, $9,541,000 for the entire fleet of 658 buses) and the increased costs associated with operation and maintenance of the DPFs ($1,300,000 per year for the Connecticut fleet) are significant. Also, the increased cost of ULSD fuel (currently $0.12 per gallon[51]) added to recent and dramatic increases in all fuel costs, will impose additional burdens on already stretched transit budgets that need to be addressed. If this option is to be selected and implemented, fully funding this option would be an important first step.

- **Option 3**: **A Combination of Strategies**

Option 3 entails: (1) awarding funds to CRCOG in response to its CMAQ application to retrofit the Hartford-area and New Haven fleets, (2) implementation of the federal 2007 standards, (3) mandating DOT's current 12-year turnover policy and (4) the potential identification of sufficient state funding to replace the remainder of the state transit fleet with 2007 compliant buses. This option will result in a more rapid reduction of $PM_{2.5}$ in Connecticut's urban centers, while furthering the reduction of ozone precursors in the state.

CRCOG's application for CMAQ funds anticipates a total cost of $2,431,000 to retrofit the buses in the Hartford-area and New Haven transit fleets with DPFs; of that total, $486,200 must be provided by matching funds, consistent with requirements of the CMAQ program. Of the 487 buses subject to retrofits under the first option, 275 would be covered by the CMAQ grant.

Under this option, the remaining 212 buses would all be replaced by 2007 compliant buses as they reach a mandated turnover date at 12 years. At $14,500 per bus, the increased capital cost of replacing those buses would be $3,074,000.

The operating costs would be $1,300,000 upon full implementation in 2019, the same as those for the other options. PM emissions would be reduced from the entire fleet and NO_X would be reduced from the 212 buses replaced under this

[50]CARB is proposing to multiply the health impacts of PM by 10, as compared to NO_X , in its new Carl Moyer Program. That is to say, every ton of PM would be regarded as 10 tons for cost effectiveness purposes when compared to NO_X. Source: Michael Jackson, TIAX LLC, *"Evaluating Diesel Reduction Strategies for Cost Benefits: Lessons from the Field,"* DEP Forum, October 26, 2005.

[51] In a December 2000 Regulatory Announcement, EPA projected that when ultra-low sulfur standards are fully phased in (October 2006) incremental costs are expected to drop to $0.045- $0.05 per gallon more than current costs. See http://www.epa.gov/otaq/regs/hd2007/frm/f00057.pdf.

option. The cost effectiveness of Option 3, upon full implementation, becomes $67,692 per ton of pollutants reduced annually.

This option immediately helps to address the problem of PM hot spots in urban areas. The Hartford and New Haven fleets would be retrofitted promptly, thereby furthering environmental justice priorities.

New Haven and Hartford have 147 Detroit Diesel 50 buses with EGR. (See. Table 1.) These engines present the same technological issues raised under Option 1. It is assumed that an effective remedy will be developed that will allow these buses to function successfully with DPFs.

The increased capital costs of the 2007 compliant buses and the increased costs associated with operation and maintenance of the DPFs are, as previously noted, significant. Also, the increased cost of ULSD fuel added to recent and dramatic increases in all fuel costs, will impose additional burdens on already stretched transit budgets that need to be addressed. If Option 3 is to be selected and implemented, the General Assembly should be prepared to take steps to insure that this option is fully funded.

C. Other Clean Diesel Issues

In addition to the three options outlined above, DEP evaluated several other strategies. The following discussion highlights a series of low-cost recommendations.

- **Clean Fuels**:

Since DPFs and 2007 compliant buses require the use of ULSD fuel, other fuels were not evaluated in detail. Utilizing a blend of ULSD with up to 5% **biodiesel** in the transit fleet could improve the lubricity of the ULSD. Biodiesel is a renewable energy source that promotes energy independence. DOT can receive Energy Policy Act credit for utilizing biodiesel in the transit fleet.

Biodiesel is a cleaner-burning version of diesel fuel made from natural, renewable sources such as vegetable oils rather than petroleum. Biodiesel may be used as a blend fuel (as low as 5% to 20% biodiesel) or as a single neat fuel (100% biodiesel). Studies indicate that B100 and biodiesel blends generate less PM than conventional diesel (55% less PM from B100 and 18% less PM from B20), but more nitrogen oxides (6% more NOx with B100) than 100% petroleum diesel and 2-3% more NOx with B20 (when engine tested by a dynamometer) than 100% petroleum diesel[52]. Recent tests by the National Renewable Energy Laboratory has shown a reduction in NOx when the entire vehicle was tested under a load. Because biodiesel contains no sulfur, however, vehicles powered by this fuel can

[52] *Biodiesel, The Clean Green Fuel for Diesel Engines*, US Department of Energy, 2000, http://www.eere.energy.gov/cleancities/blends/pdfs/5450.pdf.

use advanced aftermarket emission control devices to further reduce harmful emissions.[53]

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 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.

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.[54]

- **Anti-Idling**:

Anti-idling programs provide a cost-effective and easy way to improve air quality and immediately reduce the exposure of people to the potential health impacts of diesel exhaust. Idling vehicles create emissions that contribute to smog and ground level ozone, and produce carbon dioxide (a greenhouse gas). Reducing diesel engine idling also saves money by conserving fuel and reducing wear and tear on engine parts. An idling long-haul tractor can consume 0.8-1.2 gallons of fuel per hour; letting a vehicle idle for more than 10 seconds wastes more fuel than shutting it off and restarting it.

Transit buses that idle excessively when discharging or picking up passengers produce unnecessary pollution. Educating drivers and enforcing existing anti-idling regulations can increase the benefits resulting from improved emissions control technology under the Act.

Operators enforce state anti-idling regulations through driver education, frequent notices and random inspections.[55] DEP has developed signs that can be posted at bus stops to increase public awareness while reminding drivers of the anti-idling

[53] Source: Clean Cities Draft Memo dated November 17, 2005.
[54] Ibid.
[55] See Appendix 4, Regulations of Connecticut State Agencies, Sec. 22a-174-18(b) and Attachment E, Notice to CT Transit drivers dated July 21, 2005.

policy. As part of a continuing education package required for employment of licensure, transit bus drivers should review the operators' anti-idling policies as well as the state anti-idling regulations.

- **Funding:**
  - Transit formula funds, CMAQ funds and operating funds would all be available to assist in implementing the Clean Diesel Plan. However, CMAQ and other FHWA funds are well subscribed and shifting funds to pay for retrofits could mean less money for transit services.
  - Option 3 depends upon CMAQ funds to retrofit the Hartford and New Haven transit fleets.
  - Other federal funding may be available through EPA and, under the new Diesel Emissions Reduction Act (DERA) from the Energy Policy Act of 2005, the U.S. Department of Energy (DOE).
  - An innovative solution would be to set up a state clean diesel fund, similar to the Carl Moyer Program in California.[56]

- **Relevant Case Studies and Pilot Projects**
  - Stamford, CT: Many projections of operating and maintenance costs have been based upon CT Transit's experience with its Stamford fleet, which has been operating successfully using DPFs and ULSD since the end of 2001. CT Transit's Stamford fleet was one of the first transit systems in the country to retrofit with DPFs; Region 1 EPA features this program on its website at: http://www.epa.gov/NE/eco/diesel/retrofit_projects.html.
  - New York City is required to retrofit its transit fleet under a state legislated plan similar to Connecticut's Clean Diesel Plan. The subcommittee received information about the problems with Detroit Diesel 50 engines with EGR technology based New York's experience. Information on this program is available at: http://www.mta.nyc.ny.us/nyct/facts/ffenvironment.htm - clean_bus.

III. Transit Subcommittee Recommendations

DEP is recommending consideration of three options for reducing emissions of PM from the state's transit fleet by 85%, as set out in the Act. A set of other effective proposals for decreasing diesel particulate emissions is also included.

A. Option 1: Retrofits

- Retrofit 487 transit buses, 1998 MY and newer, with DPFs by 2010.[57] Replace all 1997 MY and earlier buses with vehicles compliant with the 2007 federal standards.[58] The projected costs are summarized in Table 5 below.

[56] See CARB Carl Moyer Clean Engine Incentive Program Fact Sheet, Appendix 2.

Table 4: Implementation Costs for Special Act 05-07:
Transit Option 1

Projected Capital Cost	$4,532,400
Projected Annual Operating and Maintenance Costs	$1,300,000
Cost Effectiveness for PM Reduction (per ton per year)	$451,389

- Clean Fuel: To take advantage of renewable fuel options, the feasibility and/or effectiveness of adding biodiesel to ULSD to improve lubricity should be further investigated.

B. Option 2: Federal 2007 Requirements with Mandatory Fleet Turnover:

- Mandate 12-year fleet turnover requirements to insure that all transit buses would be compliant with the 2007 standards by 2019; these buses would have emissions controls for NO_X, which are not addressed in the Act.[59]

- Elements of Option 2:
  - Fleet would achieve an 85% reduction in PM emissions by the later date of 2019.
  - The General Assembly should be aware that state funding to cover the increased capital and operating costs would enhance the feasibility of this option. (See Table 6.)
  - To take advantage of renewable fuel options, the feasibility and/or effectiveness of adding biodiesel to ULSD to improve lubricity should be further investigated.
  - The option would lead to some increased health costs resulting from exposure to diesel particulates during the extended implementation period from 2010 to 2019, but also to some benefits from the reduction of NO_X.

Table 5: Implementation Costs for Special Act 05-07:
Transit Option 2

Projected Capital Cost Increase	$3,896,000
Projected Annual Operating and Maintenance Costs	$1,300,000
Cost Effectiveness to reduce PM and NO_X (per ton per year)	$32,194

[57] If the EGR technology for Detroit Diesel 50 buses cannot be modified to allow DPFs to function successfully, a strategy to address these buses should be developed and included in any legislation or regulations implementing the Act.
[58] Buses that are retained as emergency backups should not be subject to the Act. Backup buses would be required to meet certain standards for low annual mileage that should be set out in legislation or regulations implementing the Act.
[59] Buses that are retained as emergency backups should not be subject to the Act.

C. Option 3: A Combination of Strategies:

Award CMAQ funds to CRCOG in response to its application to retrofit the New Haven and the Hartford area fleets.[60] Mandate a 12-year fleet turnover for the remaining buses in the Connecticut fleet to insure that they are compliant with the 2007 standards by 2019; these buses would have emissions controls for NO_X, which are not addressed in the Act.[61]

- **Elements of Option 3:**
  - CRCOG would receive $1,944,800 in CMAQ funding to retrofit the Hartford and New Haven fleets, matching it with $486,200.
  - Mandate a 12-year fleet turnover to insure that the remainder of the state fleet is in compliance by 2019.
  - The General Assembly should be aware that state funding to cover the increased capital and operating costs would enhance the feasibility of this option. (See Table 7.)
  - To take advantage of renewable fuel options, the feasibility and/or effectiveness of adding biodiesel to ULSD to improve lubricity should be further investigated.
  - Implementation of this option will alleviate of PM hot spots in Hartford and New Haven more rapidly. Some increased health costs could result from exposure to diesel particulates in smaller communities during the extended implementation period from 2010 to 2019. Option 3 also provides a significant and accelerated reduction in ozone-producing NO_X emissions in the state.

Table 6: Implementation Costs for Special Act 05-07:
Transit Option 3

Projected Capital Cost Increase (including CMAQ match)	$3,560,200
Projected Annual Operating and Maintenance Costs	$1,300,000
Cost Effectiveness to reduce PM and NO_X (per ton per year)	$67,692

D. Other Recommendations:

- Anti-Idling: As part of a continuing education package required for employment and/or licensure, transit bus drivers should review the operators' anti-idling policies as well as the state anti-idling regulations. Constant reminders in the form of signs at bus stops should significantly improve compliance rates with the DEP's regulatory restriction on idling.

[60] See Footnote 57 regarding a strategy for the EGR technology for Detroit Diesel 50 buses.
[61] Buses that are retained as emergency backups should not be subject to the Act.

- Funding:
  - CMAQ funding is being sought to retrofit the Hartford-area portion and could be sought for retrofitting the remainder of the CT Transit fleet.
  - State funding may be needed to assist in implementation of the Act in light of budgets strained by recent and dramatic increases in fuel costs and increased capital and operating cost burdens unrelated to the Act:
    - Federally mandated conversion to ULSD fuel
    - Capital cost of new buses meeting federal 2007 Standards
    - Increased operating costs related to DPF maintenance on 2007 compliant buses.
  - Municipal fleets can make a cost-effective transition to CNG by taking advantage of funding sources for alternative-fuel vehicle programs, such as CMAQ grants, the US DOE State Energy Program (SEP) funds distributed through the national Clean Cities program.
  - DEP could establish a statewide voluntary diesel collaborative committed to the development of viable diesel reduction project proposals and aggressively pursue available funding opportunities on the federal level.
  - An innovative solution would be to set up a state clean diesel fund, similar to the Carl Moyer Program in California.[62]

IV. Conclusions

Concluding statement on how to move forward with the recommendations and options presented above.

[62] See Appendix 2.

Attachment A
Inventory of Transit Buses: Model Year 1998 and Newer

Operator	City	Model Year	Existing or on order	Make & Model	# Buses	#2 diesel	# ECM reprog.
CT Transit	Hartford	2001	Existing	New Flyer D40LF	0		0
CT Transit	Hartford	2001	Existing	New Flyer - D40LF Leased	4		0
CT Transit	Hartford	2002	Existing	New Flyer D40LF	40		0
CT Transit	Hartford	2003	Existing	MCI Coaches	7		0
CT Transit	Hartford	2003	Existing	New Flyer D40LF	14		0
CT Transit	Hartford	2003	Existing	New Flyer Leased	6		0
CT Transit	Hartford	2004	Existing	New Flyer D40LF	42		0
CT Transit	New Haven	2003	Existing	New Flyer D40LF	42		0
CT Transit	New Haven	2004	Existing	New Flyer D40LF	42		0
CT Transit	Stamford	1999	Existing	El Dorado	13		0
CT Transit	Stamford	2001	Existing	New Flyer D40LF	32		0
CT Transit	Stamford	2002	Existing	New Flyer D40LF	0		0
CT Transit	Stamford	2003	Existing	New Flyer Hybrid	2		0
GBTA	Bridgeport	1998	Existing	Gillig Phantom 40ft	14		0
GBTA	Bridgeport	2003	Existing	New Flyer 40ft	13		0
GBTA	Bridgeport	2003	Existing	New Flyer 35ft	25		0
HART	Danbury	2001	Existing	Orion-V 35ft	10		0
HART	Danbury	2003	Existing	Trolley Thomas C150	1		0
HART	Danbury	2003	Existing	Orion VII 30ft	1		0
MDT	Middletown	2002	Existing	Gillig 30ft	4		0
MDT	Middletown	2002	Existing	International 30ft	2		0
MDT	Middletown	2003	Existing	Gillig 35ft	3		0
MLTD	Milford	1998	Existing	Thomas Citiliner	1		0
MLTD	Milford	2001	Existing	Thomas TL960 30ft	5		0
NBT	New Britain	1999	Existing	El Dorado 30ft	1	1	1
NETC		2003	Existing	New Flyer D40LF	5	1	5
NTD	Norwalk	1999	Existing	El Dorado 30ft	1		0
NTD	Norwalk	2002	Existing	Thomas SLF230 30ft	4		0
NTD	Norwalk	2003	Existing	Orion VII 35ft	19		0
NTD	Norwalk	2004	Existing	Gillig 29ft	3		0
SEAT	Norwich	2003	Existing	New Flyer 40ft	2		0
SEAT	Norwich	2003	Existing	New Flyer 35ft	3		0
SEAT	Norwich	2004	Existing	Gillig 30ft	2		0
				Subtotal A	**363**		**6**
SEAT	Norwich	2006	Order	not available	18		0
HART	Danbury	2006	Order	not available	10		0
WRTD	Windham	2006	Order	not available	2		0
NTD	Norwalk	2006	Order	not available	3		0
CT Transit	Hfd, NH, Stm	2005	Order	not available	48		0
CT Transit	Hfd, NH, Stm	2006	Order	not available	43		0
				Subtotal B	**124**		**0**
				Total retrofits needed	**487**		**6**

Attachment B

Calculation of Emissions Reductions: PM (particulate matter)

Bus Information *Hartford & New Haven Divisions*								**Emissions rate** *per mile*			**Emissions**			**Savings due to filter & ULSF** *Base 1 minus ALT*		
Operator	**City**	**# Buses**	**Model**	**Year**	**Bus Life Left** *years*	**VMT per bus** *daily*	**VMT** (daily)	**Base 1** fuel=LSD No filter *g/mile*	**Base 2** fuel=ULSD No filter *g/mile*	**ALT** fuel=ULSD **Add Filter** *g/mile*	**Base 1** fuel=LSD No filter *g/day*	**Base 2** fuel=ULSD No filter *g/day*	**ALT** fuel=ULSD **Add Filter** *g/day*	**daily savings** *grams*	**annual savings** *tons*	**lifetime savings** *tons*
CT Transit	Hartford	4	New Flyer - D40LF Leased	2001	8.00	85.0	340	*0.197	*0.139	*0.024	67	47	8	59	0.024	0.189
CT Transit	Hartford	40	New Flyer D40LF	2002	9.00	85.0	3,400	0.197	0.139	0.024	670	473	82	588	0.237	2.130
CT Transit	Hartford	7	MCI Coaches	2003	10.00	85.0	595	0.197	0.139	0.024	117	83	14	103	0.041	0.414
CT Transit	Hartford	14	New Flyer D40LF	2003	10.00	85.0	1,190	0.197	0.139	0.024	234	165	29	206	0.083	0.828
CT Transit	Hartford	6	New Flyer Leased	2003	10.00	85.0	510	0.197	0.139	0.024	100	71	12	88	0.035	0.355
CT Transit	Hartford	42	New Flyer D40LF	2004	11.00	85.0	3,570	0.197	0.139	0.024	703	496	86	618	0.248	2.733
CT Transit	New Haven	42	New Flyer D40LF	2003	10.00	85.0	3,570	0.197	0.139	0.024	703	496	86	618	0.248	2.485
CT Transit	New Haven	42	New Flyer D40LF	2004	11.00	85.0	3,570	0.197	0.139	0.024	703	496	86	618	0.248	2.733
CT Transit	Stamford	13	El Dorado	1999	6.00	85.0	1,105	0.197	0.139	0.024	218	154	27	191	0.077	0.461
CT Transit	Stamford	32	New Flyer D40LF	2001	8.00	85.0	2,720	0.197	0.139	0.024	536	378	65	471	0.189	1.515
CT Transit	Stamford	0	New Flyer D40LF	2002	9.00	85.0	0	0.197	0.139	0.024	0	0	0	0	0.000	0.000
CT Transit	Stamford	2	New Flyer Hybrid	2003	10.00	85.0	170	0.197	0.139	0.024	33	24	4	29	0.012	0.118
GBTA	Bridgeport	14	Gillig Phantom	1998	5.00	85.0	1,190	0.197	0.139	0.024	234	165	29	206	0.083	0.414
GBTA	Bridgeport	13	New Flyer 40ft	2003	10.00	85.0	1,105	0.197	0.139	0.024	218	154	27	191	0.077	0.769
GBTA	Bridgeport	25	New Flyer 35ft	2003	10.00	85.0	2,125	0.197	0.139	0.024	419	295	51	368	0.148	1.479
HART	Danbury	10	Orion-V 35ft	2001	8.00	85.0	850	0.197	0.139	0.024	167	118	20	147	0.059	0.473
HART	Danbury	1	Trolley Thomas	2003	10.00	85.0	85	0.197	0.139	0.024	17	12	2	15	0.006	0.059
HART	Danbury	1	Orion VII 30ft	2003	10.00	85.0	85	0.197	0.139	0.024	17	12	2	15	0.006	0.059

Attachment B

Calculation of Emissions Reductions: PM (particulate matter)

MDT	Middletown	4	Gillig 30ft	2002	9.00	85.0	340	0.197	0.139	0.024	67	47	8	59	0.024	0.213
MDT	Middletown	2	International 30ft	2002	9.00	85.0	170	0.197	0.139	0.024	33	24	4	29	0.012	0.106
MDT	Middletown	3	Gillig 35ft	2003	10.00	85.0	255	0.197	0.139	0.024	50	35	6	44	0.018	0.177
MLTD	Milford	1	Thomas Citiliner	1998	5.00	85.0	85	0.197	0.139	0.024	17	12	2	15	0.006	0.030
MLTD	Milford	5	Thomas TL960	2001	8.00	85.0	425	0.197	0.139	0.024	84	59	10	74	0.030	0.237
NBT	New Britain	1	El Dorado 30ft	1999	6.00	85.0	85	0.197	0.139	0.024	17	12	2	15	0.006	0.035
NETC		5	New Flyer D40LF	2003	10.00	85.0	425	0.197	0.139	0.024	84	59	10	74	0.030	0.296
NTD	Norwalk	1	El Dorado 30ft	1999	6.00	85.0	85	0.197	0.139	0.024	17	12	2	15	0.006	0.035
NTD	Norwalk	4	Thomas SLF230	2002	9.00	85.0	340	0.197	0.139	0.024	67	47	8	59	0.024	0.213
NTD	Norwalk	19	Orion VII 35ft	2003	10.00	85.0	1,615	0.197	0.139	0.024	318	224	39	279	0.112	1.124
NTD	Norwalk	3	Gillig 29ft	2004	11.00	85.0	255	0.197	0.139	0.024	50	35	6	44	0.018	0.195
SEAT	Norwich	2	New Flyer 40ft	2003	10.00	85.0	170	0.197	0.139	0.024	33	24	4	29	0.012	0.118
SEAT	Norwich	3	New Flyer 35ft	2003	10.00	85.0	255	0.197	0.139	0.024	50	35	6	44	0.018	0.177
SEAT	Norwich	2	Gillig 30ft	2004	11.00	85.0	170	0.197	0.139	0.024	33	24	4	29	0.012	0.130
SEAT	Norwich	18	not available	2006	12.00	85.0	1,530	0.197	0.139	0.024	301	213	37	265	0.106	1.278
HART	Danbury	10	not available	2006	12.00	85.0	850	0.197	0.139	0.024	167	118	20	147	0.059	0.710
WRTD	Windham	2	not available	2006	12.00	85.0	170	0.197	0.139	0.024	33	24	4	29	0.012	0.142
NTD	Norwalk	3	not available	2006	12.00	85.0	255	0.197	0.139	0.024	50	35	6	44	0.018	0.213
CT Transit	Hfd, NH, Stm	48	not available	2005	12.00	85.0	4,080	0.197	0.139	0.024	804	567	98	706	0.284	3.408
CT Transit	Hfd, NH, Stm	43	not available	2006	12.00	85.0	3,655	0.197	0.139	0.024	720	508	88	632	0.254	3.053
	Total Retrofits	**487**					**41,395**				8,155	5,754	993	7,161	**2.881**	**29.109**
	All buses	*487*					*41,395*	**Totals in tons/year =**			**3.281**	**2.315**	**0.400**	**2.881**		

**Emissions rates are based on NYC test of diesel particulate filters using Series 50 buses.*

Conversion factors:

907,194 = grams/ton

365 = days per year

Attachment C

Estimated Emissions Reductions (in tons)

Retrofitting Statewide Transit Bus Fleet with Diesel Particultate Filters

8-17-2005

	PM particulate matter	**CO** carbon monoxide	**HC** hydrocarbons
Baseline - LSF & no filter (existing)	**3.28**	**32.98**	**3.63**
Alternative 1 - ULSD & no filter	**2.32**	**23.48**	**0.80**
Alternative 2 - ULSD with filter	**0.40**	**2.00**	**0.25**
Emission reductions due to ULSD:	-	-	-
Emissions reduction (tons): **Annual** *Baseline minus Alt 1*	**0.97**	**9.49**	**2.83**
% Emissions reduction: **annual** *Baseline minus Alt 1*	**29.4%**	**28.8%**	**78.0%**
Emission reductions due to Filter:	-	-	-
Emissions reduction (tons): **Annual** *Alt 1 minus Alt 2*	**1.92**	**21.48**	**0.55**
% Emissions reduction: **annual** *Alt 1 minus Alt 2*	**82.7%**	**91.5%**	**68.8%**
Emission reductions due to ULSD plus Filter:	-	-	-
Emissions reduction (tons): **Annual** *Baseline minus Alt 2*	**2.88**	**30.98**	**3.38**
% Emissions reduction: **annual** *Baseline minus Alt 2*	**87.8%**	**93.9%**	**93.1%**
Emissions reduction (tons): **Project Life** *Baseline minus Alt 2*	**29.11**	**312.96**	**34.16**

Baseline 1 = existing condition with low sulfur diesel fuel and no filters

Baseline 2 = in 2007 all bus fleets will have to use ultra low sulfur diesel fuel (ULSD)

Alternative = Adds diesel particulate filters, but also assumes we will be using ULSD fuel

Attachment D

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD (CARB)

STAFF REPORT: INITIAL STATEMENT OF REASONS

PROPOSED MODIFICATIONS TO THE PUBLIC TRANSIT BUS FLEET RULE AND INTERIM CERTIFICATION PROCEDURES FOR HYBRID-ELECTRIC URBAN TRANSIT BUSES

(Including Appendices E and F)

Report: http://www.arb.ca.gov/regact/bus02/isor.pdf
Appendix E: http://www.arb.ca.gov/regact/bus02/appe.pdf
Appendix F: http://www.arb.ca.gov/regact/bus02/appf.pdf

Attachment E

NOTICE

No. 63-05

TO: All Operators

FROM: Nick Mangene

RE: Excessive Idling

POSTING DATE: July 21, 2005

EFFECTIVE DATE: In Effect

I have just received a letter from the U.S. Environmental Protection Agency that basically serves as a forewarning that they in conjunction with the CDEP will be targeting bus systems in Connecticut to enforce the Connecticut anti-idling law. The campaign will focus on public buses because they often idle excessively in densely populated areas.

The letter also indicates that a similar campaign in Massachusetts cost the MBTA $328,000.00 in fines due to excessive idling violations. In addition, the MBTA was required to introduce a bus idling compliance plan and post signs reminding employees to turn off engines while idling.

In Connecticut, the engine idling rule is 3 minutes and there are *NO* exceptions to the rule.

In response to this forewarning, I am requiring dispatchers to make periodic radio announcements advising operators that their bus MUST be shut down at anytime they are stationary for more than 3 minutes. I am also requiring street supervisors to start a vigorous enforcement campaign. Again, there are NO exceptions to the rule and street supervisors will issue a violation to anyone who violates this rule.

Please refer to section 11.5 of your Employee Handbook for disciplinary penalties.

Remove date: Permanent

School Bus Sector Report

Special Act 05-07
Connecticut Clean Diesel Plan
School Bus Sector Report

I. Introduction

Diesel engines emit fine particulate matter ($PM_{2.5}$) 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. In Connecticut nearly 387,000 children ride approximately 6,500 school buses each day. Approximately 90% of the state school bus fleet is diesel fueled. The amount of time a child spends on the bus every day varies from 20 minutes to several hours per day. Collectively, Connecticut children spend 50 million hours on buses each year. Because the health issues associated with diesel exhaust are exacerbated in children, the Department of Environmental Protection (DEP) has made the reduction of diesel emissions from school buses a priority.

DEP's initial diesel reduction efforts began with an aggressive anti-idling campaign developed in partnership with the Connecticut School Transportation Association (COSTA) in 2000. COSTA and DEP entered into a voluntary Memorandum of Understanding (MOU) designed to eliminate all necessary idling. The MOU and associated training became a model for other states in the region and still an important model for reducing diesel emissions in the school environment.

DEP's anti-idling efforts have also been coupled with retrofit projects designed to achieve reductions through the application of diesel reduction technology. DEP's retrofit efforts prioritized projects based on the health risks posed by diesel exhaust air quality monitoring data and available funding sources. Application of these criteria elevates Connecticut's urban centers in order of priority. In 2002 DEP completed the first full-fleet school bus retrofit project in Norwich, CT to serve as a program model. From the experience gained in the Norwich project DEP initiated projects in New Haven, Hartford and Bridgeport. DEP efforts to date have provided a solid foundation to pursue additional emission reductions and public health benefits from the school bus sector. These efforts provide a foundation for expanding efforts to achieve additional reductions of diesel emissions, especially in urban communities, as envisioned by Special Act 05-07 (the Act).

The School Bus Subcommittee is one of four subcommittees formed to explore and develop information to meet the goals of the Connecticut clean diesel plan required by the Act. The action items assigned to the school bus subcommittee are:

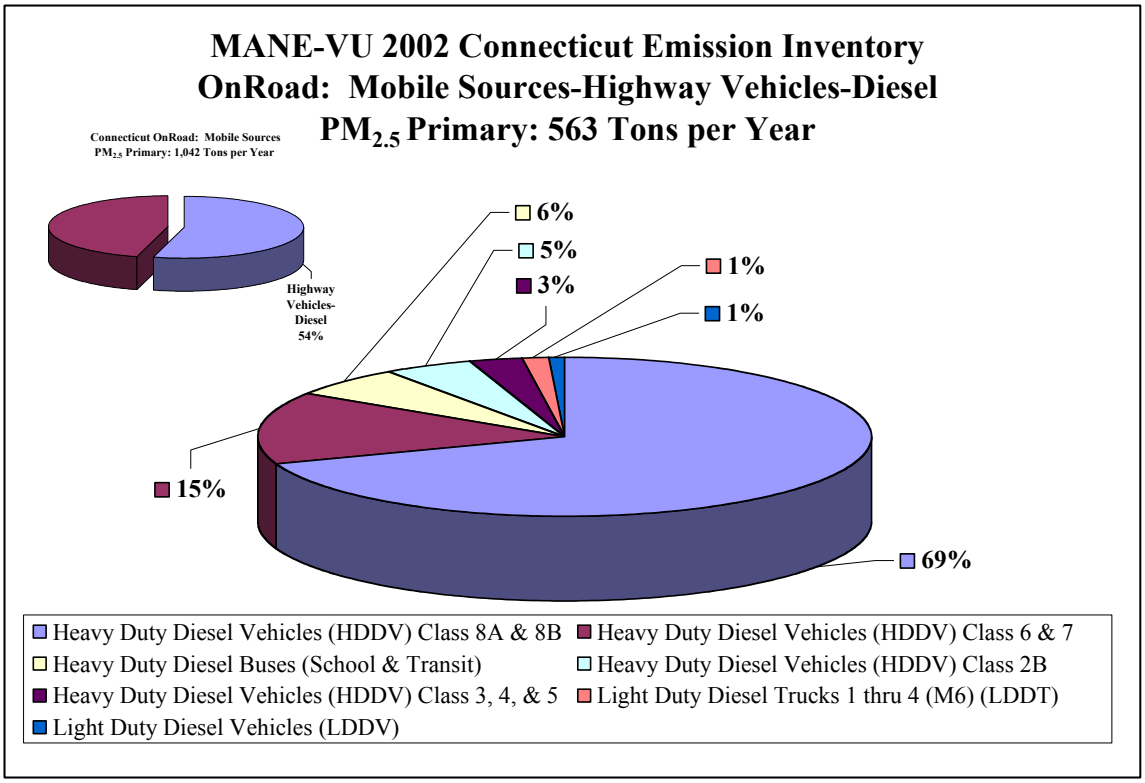
- Number of school buses state-wide;
- Fleet retrofit, (Implementing crank case controls), replacement, and retirement options;
- Clean fuel options;
- Anti-idling efforts;
- Model Contract Language;

- Case studies / pilot projects; and
- Other Items identified by the subcommittee.

The School Bus Subcommittee consists of members from government, private industry, public health and environmental organizations. Representatives from organizations involved in the operations of school buses also participate in the subcommittee, such as: COSTA; Connecticut Association of School Business Officials (CASBO); school district representatives and representatives from companies servicing district's school transportation needs. The committee met on three occasions apart from the general diesel plan meetings and informational forums. Material related to the subcommittee's efforts have been posted on DEP's website.

Figure 1 represents the emissions of $PM_{2.5}$ from on-road diesel-powered vehicles in Connecticut in 2002. The Mid-Atlantic/Northeast Visibility Union (MANE-VU) 2002 Emission Inventory estimates on-road diesel highway vehicles as contributing 563 tons per year of $PM_{2.5}$ in Connecticut. School and transit buses comprise six percent of PM2.5 emissions or 33.78 tons per year. It is estimated that school buses may be responsible for as much as 30 tons of $PM_{2.5}$ emissions per year from mobile source diesel engines in Connecticut.

Figure 1[63]



[63] The Mid-Atlantic/Northeast Visibility Union (MANE-VU) was formed by the Mid-Atlantic and Northeastern states, tribes, and federal agencies in 2001 to coordinate regional haze planning activities for the region. MANE-VU provides technical assessments and assistance to its members.

II. School Bus Report

A. State-wide School Bus Inventory

The statewide school bus inventory is compiled from registration information from the Department of Motor Vehicles' (DMV).[64] Inventory information for this report reflects vehicles registered for operation in the 2004 – 2005 school year. The total number of vehicles registered in the State of Connecticut as school bus transportation vehicles is 7,727. This total includes personal passenger vehicles registered to transport pupils to school.

The total number of common school buses, Type I and Type II school buses (herein after the fleet), in Connecticut is about 7,030. Analysis of the school bus inventory of Type I/II school buses reveals that 6,310, or approximately 90%, of the buses are powered by diesel fuel (gasoline about 7%, and other fuels power the remaining 3% of the fleet).

Historically, the focus of retrofit projects has been on diesel-fueled Type I buses. Type I buses are the typical large yellow buses with a gross vehicle weight rating greater than ten thousand pounds. Type I buses generally seat twenty to ninety passengers and comprise approximately 78% (5,486 buses) of the fleet; of this total, approximately 4,929 (70% of the total) are diesel fueled vehicles. For planning purposes the committee and the DEP evaluated diesel emission reduction options for the diesel-fueled Type I buses.

The other 22% (1,544 buses) are Type II buses, smaller buses under ten thousand pounds gross vehicle weight, which usually seat up to twenty passengers. A breakdown of Type I/II school buses by model year (MY) is provided in Table 1.

Connecticut has about 139 school districts that contract out school bus services and 14 municipally owned school bus fleets. Some of these contracts have clauses that require buses to be no older than 5 or 7 years, with two districts tolerating buses as old as 10 or 12 years. Because of this variation, the average fleet turnover period in Connecticut is about six and one-half years.

Table 1:

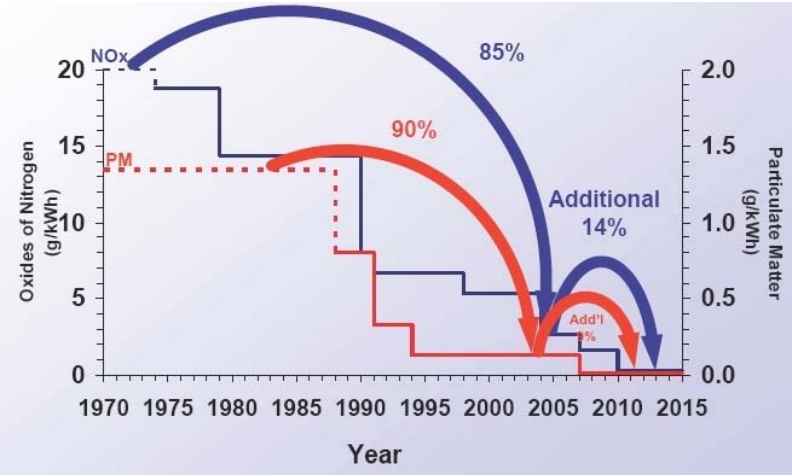
Type I and Type II School Buses Registered For the 2004 – 2005 School Year	
Model Year	Vehicle Count
2006	**47**
2005	**306**
2004	**410**
2003	**426**
2002	**735**
2001	**621**
2000	**719**
1999	**656**
1998	**515**
1997	**537**
1996	**439**
1995	**719**
1994	**183**
1993	**321**
1992	**132**
1991	**127**
1990	**64**
1989	**22**
1988	**21**
1987	**22**
1986	**2**
1985	**3**
1984	**3**
Total	7,030

The contracts covering 139 districts comprise an estimated 85% (COSTA to verify) of the fleet of Type I school buses. Recommendations for diesel reduction efforts will be

[64] The DMV conducts vehicle inspections annually. All vehicles must have DMV inspectors' approval before new registration or registration renewal can be granted. All vehicles must be registered by August 31st of any year in order to operate in that following school year.

most effective when designed within this contractual framework. An analysis of the Connecticut school bus inventory along with EPA applicable heavy-duty engine standards (HDDEs)[65] provides a snapshot of air pollution from school buses. From a PM perspective 90% of the current fleet meets the 1994 standards,[66] which will be effective until 2007. Emissions of NO_X, an ozone precursor, are also important to consider in light of ozone nonattainment. EPA tightened the standards for NO_X in 1998[67]; and in 2004, EPA combined the NO_X standards with the hydrocarbon (HC, another ozone precursor)[68]. Only 11% of the fleet meets the 2004 standards for NO_X + HC. Based on the age of the fleet, fleet rollover strategies will yield the greatest reductions in NO_X.

Figure 2[69]
U.S. On-Highway Emission Standards



B. Fleet Retrofit, Replacement and Retirement Options

The Connecticut diesel emissions reduction strategy required by The Act, states the following, Section 1 subsection (b)(3), pertaining to school buses:

> *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*

[65] The standards can be accessed through EPA's website at: http://www.epa.gov/otaq/retrofit/overoh-all.htm
[66] The 1994 standards for PM are 0.10 g/bhp-hr (grams per brake horsepower hour) for regular engines and 0.07 g/bhp-hr for urban buses.
[67] The 1998 standard for NO_X is 4.0 g/bhp-hr.
[68] The 2004 NO_X + HC standard is 2.5g/bhp-hr; HC contribution cannot exceed 0.5 g/bhp-hr.
[69] Joe Suchecki, Director of Public Affairs, Engine Manufacturers Association, DEP Technology Forum, August 17, 2005.

> *school buses and to prevent by said date diesel particulate matter engine emissions from entering the passenger cabin of the buses;*[70]

According to DMV's inventory data, the Connecticut school bus fleet is comprised of relatively new buses. Based on survey information compiled by DEP and the CASBO, conditions in existing school bus contracts between school districts and transportation providers will insure that the contracted fleet will be comprised of buses meeting the federal 2007 engine standards via the natural process of fleet turnover by 2019. Implementing a mandatory strategy involving both retrofits and replacement will move the achievement date forward to 2010, increasing capital costs, but decreasing the health costs resulting from the additional years of PM exposure. Existing contracts that contain clauses allowing for renegotiation of terms and conditions can accelerate replacement or retrofits; and providing financial incentives enhances this option for reducing emissions on a shorter schedule. These options have different timetables; in general a premium is paid for more rapid reductions but those increased capital costs should be weighed against the increased health costs resulting from the longer implementation periods. The three options are discussed in more detail below.

- **Option 1: Mandatory Retrofit and Replacement**

Due to the implementation of federal on-highway HDDE standards for 2007 and later MY buses,[71] a combined retrofit and replacement strategy will focus on the retrofit of 2006 and earlier MY school buses while replacing retired vehicles with 2007 compliant school buses.

All 2007 and later MY front engine school buses will come equipped with emission reduction technologies designed to achieve significant reductions of $PM_{2.5}$ in the exhaust stream and will prevent emissions from entering the passenger cabin of the buses by the use of crankcase controls.[72] Therefore, retrofits utilizing closed crankcase technology should be an option reserved for pre-2007 MY front-engine[73] school buses that cannot accept more efficient $PM_{2.5}$ emissions reduction controls.

The following technologies for reducing $PM_{2.5}$ emissions were reviewed:

- **Diesel Oxidation Catalyst:** DOCs are devices that use a chemical process to break down pollutants in the exhaust stream into less harmful components. Diesel oxidation catalysts can reduce emissions of PM by 20-26 percent, HC by 50 percent and CO by approximately 40 percent. Oxidation catalysts cost about $1,000 to $2,000, can be installed on any diesel engine, and run on regular diesel fuel. Although installation time

[70] See Appendix 1, Special Act 05-07, *An Act Establishing A Connecticut Clean Diesel Plan.*
[71] 40 CFR 86.007-11
[72] http://www.dieselnet.com/standards/us/hd.html#y2007
[73] DEP research of available literature illustrates very little in-cabin PM emissions from rear engine school buses. Therefore, installation of crankcase controls on rear engine school buses is not the most beneficial investment for targeting PM emission reductions and in-cabin exposure to diesel exhaust.

can vary, field experience suggests it takes about 1 to 3 hours to install an oxidation catalyst.[74]

- **Diesel Particulate Filter:** DPFs are ceramic devices that collect the particulate matter in the exhaust stream The high temperature of the exhaust heats the ceramic structure and allows the particles inside to break down (or oxidize) into less harmful components. They can be installed on new and used buses, but must be used in conjunction with ULSD fuel. Costs can range from $5,000 to $12,000 installed. The combination of PM filters and ULSD, however, can reduce emissions of PM, HC, and CO by 60 to 90 percent.[75]

  - **DPF Maintenance Costs:** Non-catalyzed DPFs must be periodically "regenerated" to remove the collected particulate matter.[76] Special ovens are used to bake off the accumulated soot at high temperatures. The cost of annually regenerating a filter, including labor, is currently estimated to be $500 per engine or $2.5 million annually for the Type I fleet. These filters must also be replaced, generally every five years, at an additional cost to the operators, currently estimated to be $7,500 per vehicle. Assuming that one fifth of the fleet will require new filters every year at a cost of $7.4 million, the total maintenance budget for the state fleet will be increased by $9.9 million. These costs will be phased in as 2007-compliant buses make their way into the fleet.

    Catalyzed or passive DPF systems, such as Johnson-Matthey's CRT and CCRT are continuously regenerating; they contain a catalyzed substrate, which allows the filter to be regenerated during operation, at lower temperatures than those required for burning off the soot on a non-catalyzed filter. These also require regular maintenance to remove accumulated ash. The cost of routine maintenance for a passive DPF system is not known at present. (*Awaiting answer from Fleetguard*)

  - **Suitability:** While highly attractive from the standpoint of PM emissions reduction, DPFs require data-logging and customized engineering for installation on many school bus engines and they cannot be used at all on the oldest buses in the state fleet. DPFs will be factory-installed on the 2007-compliant buses. DPFs are not suitable as an emissions reduction technology for general

[74] Source: EPA.
[75] Source: EPA and CARB
[76] Passive DPF systems, which contain catalyzed substrates, allow the filter to be regenerated during operation at lower operating temperatures than those required for burning off the soot in non-catalyzed filters. If properly maintained, no oven cleaning is required for these systems.

application due to the case-by-case review required. A more detailed statewide inventory of school bus engine (make, model, year) and an assessment of duty-cycles are also important elements in a case-by-case review.

- **Closed Crankcase Filtration System**: A small but significant amount of exhaust gas leaks out from around the seals of the moving pistons in the engine and is conventionally vented to the atmosphere through the crankcase. These vapors, which contain PM, water and traces of oil, can make their way into passenger compartments of trucks and buses. Closed crankcase systems include condensation filters to remove the oil and particulates, pressure regulators to protect the engine and ductwork to route the filtered gases back through the engine instead of to the atmosphere. When the closed crankcase is used in a system with a DOC, PM emissions can be reduced by 30% (as opposed to 20% with the DOC alone). Testing illustrates that closed crankcase filtration systems can significantly reduce the entry of PM into the bus cabins.[77]

The option of a mandatory retrofit/replacement strategy, as submitted by one stakeholder group,[78] would require that 100% of Type I school buses to be replaced (with an engine model year 2007 or newer) or retrofitted with emissions control devices verified by either the US Environmental Protection Agency (EPA) or the California Air Resources Board (CARB) by September 1, 2010. This option is based on the following assumptions:

- 1,200 older Type I diesel school buses would be replaced with 2007-compliant buses under current fleet turnover schedules, and 372 Type I buses are currently being retrofitted; this leaves about 3,400 buses to be retrofitted.[79]
- Buses will be retrofitted with DOCs and closed crankcase systems at a cost of $1,900[80] per bus, installed.[81]
- The DOC/closed crankcase system can decrease PM emissions by approximately 30%.
- It is possible to perform 3,400 retrofits in a five-year period.
- Existing contracts can be renegotiated to accommodate the retrofits by December 31, 2010.

This option leads to a project cost of about $6.5 million, a tailpipe emissions reduction of 9 tons per year[82] and near total elimination of crankcase emissions of

[77] CATF School Bus Particulate Matter Study, January 2005: http://www.catf.us/publications/view/82
[78] See Attachment A: Environment Northeast, "*School Bus Options Menu Memo, Option #2.*"
[79] DMV's inventory does not include a breakdown by engine type. The number of front engine buses from the 3,400 buses would need to be determined.
[80] ENE's original proposal used $1,000, the cost of the uninstalled DOC.
[81] This figure represents capitol cost of the installed retrofits only. Operating costs of crankcase technology, and maintenance and replacement of filters are not included.
[82] This represents 30% reduction from DOC times 30 tons per year from school buses; see page 1.

in-cabin $PM_{2.5}$. With installation occurring over a five-year period, to be complete by the end of 2010, the cost effectiveness in the last year of installation is roughly $144,000 per ton of $PM_{2.5}$ emissions reductions in 2010. This would require 680 installations per year, most likely an unrealistic schedule from an operational standpoint. Even if operationally feasible, this would likely yield still higher installation costs that those estimated.

Any option that seeks to mandate emissions controls and/or replacement would have to take into account existing contracts between school districts and school bus operators in the majority of districts in Connecticut. From DEP's limited survey, it appears that there would be considerable obstacles to overcome related to contract renegotiation. Experience with the few district contracts indicates that the process will require participation and support from the local superintendent, the mayor or town manager, parent/teacher organizations, the school transportation provider and the public. Development of a contract renegotiation track along with complementary compliance schedules will require significant administrative oversight and would likely result in a lengthy timeframe for implementation.

Without renegotiating the contracts, compliance schedules and deadlines would have to be adjusted to be consistent with contract renewal dates. Because so many Connecticut school districts contract out their student transportation services, the goal of maximizing emissions reductions by September 1, 2010 may not be achievable under a mandated emissions control strategy.

Enforcement responsibilities were not outlined in this proposal, however if DEP oversight is intended, this option will incur additional administrative costs that would need to be quantified.

ENE, as part of the Clean Diesel Coalition, submitted a subsequent proposal that refines the mandatory retrofit/replacement option.[83] It contains some creative financing incentives that are discussed in Option 3 of this report and a table of retrofit and replacement scenarios that could be a valuable reference for fleet owners. However, this proposal contains two "requirements" that may render it legally untenable.

- *By September 1, 2007, no school bus with an engine model year of 1993 or older may be used to transport school children in Connecticut; and*
- *School districts and school bus owners must permit existing contracts to be reopened to negotiate compliance with requirements.*

As was discussed above, unless the existing contracts include clauses allowing them to be reopened, there is no clear method to compel renegotiation. A mandatory provision constituting a flat ban of school buses based upon model

[83] See Attachment B.

year[84] may encounter significant legal hurdles in adoption, either in statute or through regulation, and may not justifiable under these circumstances.

- **Option 2: Implementation of EPA's 2007 Standards for Connecticut School Buses**

  Federal regulations, currently in place, set revised standards for on-highway heavy-duty diesel engines beginning with the 2007 MY.[85] All on-highway heavy-duty diesel engines, 2007 and later model years are required to meet revised emission standards that include nitrogen oxides (NO_X) as well as $PM_{2.5}$.[86] Therefore, the phase-in of model year 2007 and later engines will assist greatly in meeting the goals of the Act to reduce $PM_{2.5}$ emissions from school buses and will help Connecticut in reducing emissions of NO_X, an important precursor to ozone formation.

  The average school bus in Connecticut is about 6 years old. In comparison to other states such as California, the Connecticut school bus fleet is relatively clean. Assuming that natural fleet turnover continues and there is not a dramatic increase in the acquisition of school buses prior to the implementation of 2007 standards, the average school bus will be 2007 compliant by 2013. The oldest school buses in the Connecticut contracted fleet are in a few districts that have set the contractual age limit for school buses at 12 years. Therefore, by 2019 the entire Connecticut school bus fleet under contract will be 2007-compliant[87].

  At the time of this writing, the engine manufacturers are still developing vehicles that meet the 2007 standards, however, it is estimated that each vehicle will cost $5,000 to $6,000 more than new school buses purchased in 2006. Turning over the entire fleet of diesel-fueled Type I school buses will ultimately add as much as $25-30 million to the budget for new buses in Connecticut. Cost effectiveness is an annual figure, dependant upon the turnover schedule. Distributing the capital cost evenly across the twelve year period between 2007 and 2019, and including the 85% $PM_{2.5}$ emissions reduction from DPF technology, the cost effectiveness of the capital investment in the last year of the turnover would be about $82,000-$98,000 per ton of $PM_{2.5}$ emissions reduced. This does not include the increased cost of maintaining and replacing the filters on the 2007-compliant buses.

  Compressed Natural Gas (CNG)-powered buses emit 70-90% less PM than pre-2007 diesel -powered buses. Three CNG school buses are included in the Norwich fleet. However, these vehicles can run as much as four times the cost of diesel-powered buses or $25,000 to $40,000 per vehicle. The cost effectiveness of replacing all the Type 1 diesel-powered buses with CNG vehicles would be $25-$40 million per ton of $PM_{2.5}$ emissions reduced in the last year of the

[84] Further investigation is required to determine the age of the buses in the municipal fleets.
[85] http://www.epa.gov/otaq/retrofit/overoh-all.htm
[86] 40 CFR 86.007-11.
[87] Additional research needs to be done to fully evaluate the 14 municipally owned fleets.

turnover. Additionally, CNG vehicles require special refueling facilities as well as special maintenance facilities, both of which are expensive. Although these costs can be significant 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.[88]

- **Option 3: Model Contract Language and Fleet Retrofit/Replacement Incentives:**

  Option 3 focuses on a variety of strategies that could be considered within the context of existing contracts and as elements that could be included for future contracts. This option relies on a collaborative approach that includes a wide range of stakeholders including: the mayor or town manager, the superintendent's office (transportation director and/or the business manager), corporation counsel, parent/teacher organizations (PTOs), citizens and the transportation provider. Facilitated discussions will help to identify common goals and potential obstacles and ensure a public and transparent decision-making process.

  - **Model Contract Language:** In an effort to develop model contract language, the DEP collaborated with CASBO to structure a survey for CASBO members requesting information on contract terms and conditions, including age limits and information on plans to update each fleet.[89] Existing contracts that allow for renegotiation could be revised to incorporate one of the following options to affect fleet age and turnover:
    - Age Limits: Several contracts specify that no bus will be older than a certain age; 10 years is the most common example, some are as high as 12 years. These could be modified to set a 5-year age limit.
    - Average Age of Fleet: Where this clause is present, the average age specified is usually 7 years; sometimes this is used in conjunction with age limits. Such contracts could be modified to require an average age of 5-years.
    - Replacement Quotas: Some districts specify that a certain number of buses be replaced or upgraded each year; one example requires that the two oldest Type I buses be replaced by two new Type I buses. The replacement quota could be doubled, with continued emphasis on replacing the oldest Type I buses in the fleet.
    - Emissions Controls: One contract specifies that new buses have the "greenest" technology available; this could be modified to require purchase of school buses that meet EPA 2007 emissions standards as specified in 40 CFR 86.007-11.

[88] Source: Clean Cities Draft Memo dated November 17, 2005.
[89] See Attachment C, CASBO Survey Results.

- **Fleet Retrofit/Replacement Incentives:** Another available option, based on recommendations made by the school bus subcommittee, is to provide incentives to accelerate the replacement of pre-2007 MY school buses. The sales tax and the increased cost for the purchase of a 2007 bus are the only costs directly affiliated with the school bus purchase. ENE's straw proposal asserts that waiving the sales tax on new buses will result in a reduced cost of $4,000 per vehicle, helping to defray the costs of new school buses and encouraging districts to move forward in making decisions to replace older buses with a cleaner fleet. This option would be enhanced by the development an education and outreach program for fleet owners promoting the opportunities and benefits associated with accelerated fleet turnover.

  Incentive grants can be designed to fund retrofits as well as contributing toward the increased cost of 2007-compliant buses. 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. One funding source for such grants might be a state clean diesel fund, similar to the Carl Moyer Program in California,[90] the TERP[91] program in Texas or New Jersey's temporary reprogramming of corporate business taxes.

  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 school districts that own their fleets. Unresolved issues related to this option include determining whether this would be a grant evenly distributed among districts or whether preference would be given to communities with older school buses.

C. Clean Fuel Options

Federal regulations also limit the sulfur content in on-highway diesel fuel to 15 parts per million (ppm) and refiners are to start producing 15 ppm sulfur fuel (designated Ultra Low Sulfur Diesel, or ULSD) beginning June 1, 2006. To meet emission standards for 2007, buses will need to run on ULSD fuel as it is needed by sulfur-intolerant emission control technologies available on 2007 and later MY school buses. The change to ULSD can account for a small but significant reduction in $PM_{2.5}$ emissions.

Alternative fuels and fuel additives can improve the reduction of $PM_{2.5}$ and other harmful pollutants. However, alternative fuels and fuel additives generally do not reduce $PM_{2.5}$ emissions in quantities achieved by retrofit technologies such as DPFs. $PM_{2.5}$ emission

[90] See Appendix 2 or http://www.arb.ca.gov/msprog/moyer/carl_moyer_board_presentation_1_20_05.pdf.
[91] See http://www.tceq.state.tx.us/comm_exec/forms_pubs/pubs/rg/rg-388.html.

reductions witnessed from a natural gas vehicle are comparable to that attained by DPFs, however at an installed cost of up to four times that of a DPF, per unit.

Alternative fuels can be used in conjunction with diesel emissions control technology, but emissions control technology manufacturers have limited information on equipment efficiency with the use of alternative fuels. Utilizing a blend of ULSD with up to 5% biodiesel in the fleet could improve the lubricity of the ULSD. Biodiesel is a renewable energy source that promotes energy independence. School districts and operators can receive Energy Policy Act credit for utilizing biodiesel in their fleets. Engine manufacturers and retrofit technology manufacturers must accept the use of an alternative fuel, in order not to void warranties.[92]

CNG is being used to power three school buses in Norwich and could be considered as an option for replaced buses. A domestic product that helps to decrease our dependence on foreign oil, CNG is a mixture of hydrocarbons, mainly methane, and is produced either from gas wells or in conjunction with crude oil production. Vehicles powered by CNG perform just like vehicles powered by diesel fuel. CNG buses can reduce emissions of PM by about 70 to 90 percent if they meet Clean Fueled Fleet (on-road) requirements or have catalysts. The cost of CNG varies, but generally is comparable to the cost of regular diesel fuel. However, the cost of a new CNG vehicle can be $25,000 to $40,000 higher than a comparable diesel vehicle. Additionally, CNG vehicles require special refueling facilities as well as special maintenance facilities, both of which are expensive.

D. Anti-Idling Provisions

Buses that idle on school grounds or upon discharging or picking up passengers produce unnecessary emissions and expose children to harmful pollutants. Educating drivers and enforcing existing anti-idling regulations can increase the benefits resulting from improved emissions control technology under The Act. Anti-idling measures will also save fuel, reduce noise and reduce engine wear. As part of a continuing education package required for employment and/or licensure, drivers should review the operators' anti-idling policies as well as the state anti-idling regulations.

Connecticut's regulations regarding idling are found in Section 22a-174-18(b)(3) of the Regulations of Connecticut State Agencies[93]. In general, buses that are stopped must be turned off after three minutes of idling. Exceptions exist for passenger safety and comfort in cold or hot weather, under heavy traffic conditions and in cases of mechanical difficulties. Local law enforcement officers have the authority to issue tickets for school bus anti-idling violations. The violations are issued directly to the individual school bus drivers. The State of Connecticut DEP has developed signs that can be posted at bus stops and school grounds to increase public awareness while reminding drivers of the anti-idling policy. By the end of 2005 this initiative had reached over 490 Connecticut schools.

[92] For more information on alternative fuels see: http://www.dep.state.ct.us/air2/diesel/techforum17aug05.htm.
[93] See Appendix 4, Regulations of Connecticut State Agencies, Sec. 22a-174-18(b).

E. Overview of Case Studies and Pilot Projects

There are numerous school bus retrofit projects taking place in Connecticut and throughout the Northeast United States. Connecticut has completed projects in Norwich, CT and New Haven, CT. Funding is at hand for the retrofitting of the fleets in the cities of Bridgeport, CT and Hartford, CT. Retrofit project planning is underway in Bridgeport and Hartford.

- The retrofit project in **Norwich, CT** was completed in 2002 with 42 school buses being retrofitted with DPFs. Buses that did not exhibit duty cycle exhaust temperatures suitable for the use of DPFs, were accommodated by insulating exhaust pipes to attain DPF temperature criteria. The insulation of exhaust streams is not common practice but has been employed in the Norwich retrofit project for buses that did not meet the necessary criteria by a few percents. The option of insulating the exhaust line is not recommended because of the extra costs and questionable effectiveness associated with the insulation process. Norwich has no reported problems with the retrofitted buses. The entire Norwich school bus fleet runs on ULSD fuel.

- **The City of New Have**n carried out a retrofit project in the summer of 2005. The New Haven bus fleet was retrofitted with a combination of diesel emission reduction technologies. The technologies were the Donaldson Spiracle (closed-crankcase filtration systems) units and Diesel Oxidation Catalysts. New Haven exhibits a perfect example of Best Available Control Technology (BACT) implementation, reducing in cabin PM emissions where exhaust PM emission controls could not be applied. New Haven also has no reported problems with retrofitted buses.

III. Diesel Plan School Bus Implementation Recommendations

A. Option 1: Mandatory Retrofit and Replacement

This option is designed to maximize reductions of fine particulate on the most aggressive schedule. The focus of retrofits of older buses will be to select emission reduction technologies that will maximize the reduction of diesel particulate exhaust emissions. DOCs and crankcase control technologies are preferred for this purpose with priority given to front engine (FE) buses of the fleet, since crankcase controls, which reduce exhaust exposure in school bus cabins, are much more effective on FE buses. However, significant implementation issues as discussed previously limit the viability of this option as presented.

Table 2: Implementation Costs for Special Act 05-07:
School Bus Option 1: Mandatory Retrofit/Replacement

Projected Capital Cost of Retrofits *(includes installation)*	$6.5 million
Cost Effectiveness for PM Reduction *(per ton per year)*	$144,000

To assist school districts in evaluating technology options and purchasing at a competitive cost, DEP and the Department of Administrative Services are developing a state wide bid specification for retrofit technologies. This will enable school districts to purchase retrofit equipment off a state contract taking advantage of volume purchasing.

Most projects require retrofitted vehicles to remain in use for a few years in order to assure that it was a beneficial investment. A common obstacle encountered by districts that hire contractors to provide school transportation needs, is dealing with existing contracts that are not approaching expiration. Because it is necessary to work within existing contractual frameworks, the timeline associated with this option is difficult, if not impossible to achieve.

B. Option 2: Implementation of EPA's 2007 Standards for Connecticut's School Buses

Engine manufacturers report that 2007-compliant buses will not be available until late 2006 or early 2007. One option for meeting the goals of The Act in the state school bus fleet is to allow the natural fleet turnover to take place after the implementation of the 2007 HDDE standards. With current fleet turnover rates, this would be accomplished by 2019. New buses would have factory-installed DPFs and emissions controls for the ozone precursor, NO_X. Table 3 represents the costs and benefits associated with replacing the entire fleet with 2007-compliant vehicles. Cost effectiveness is based on capital costs.

Table 3: Implementation Costs for Special Act 05-07:
School Bus Option 2: Natural Fleet Turnover

Projected Capital Cost Increase for 2007-Compliant Buses	$25-30 million
Projected Maintenance Cost Increase at Full Replacement	$9.9 million per year
Cost Effectiveness for PM Reduction *(per ton per year)*	$82,000-$98,000

C. Option 3: Model Contract Language and Fleet Retrofit/Replacement Incentives:

Option 3 focuses on a variety of strategies that could be considered within the context of existing contracts and as elements that could be included for future contracts. Existing contracts that allow for renegotiation could be revised to incorporate one of several options to affect fleet age and turnover. Model language could be developed to assist in future contract negotiations.

To maximize $PM_{2.5}$ emissions reductions, the school bus subcommittee recommended incentives for districts seeking bids to replace their fleets, as rapidly as possible, with 2007 compliant school buses. Passing legislation to waive the sales tax on the purchase

of 2007 compliant buses over the next three to four years would provide a strong incentive. Waiving the sales tax on new buses will have a great impact on districts making a decision to replace older buses with a cleaner fleet.

Another suggestion is to provide an incentive grant for the purchase of new buses, which contributes toward the increased cost of a 2007 bus (further discussions are necessary to determine whether this would be a grant evenly distributed among districts or preference given to communities with older school buses or high ambient air pollution).

D. Other Clean Diesel Recommendations

- **Clean Fuel**

There are currently no shortages in the supply of ULSD in the State of Connecticut. Once a school bus has been retrofitted with any kind of sulfur-intolerant emissions control technology, availability of ULSD is imperative. Back-up buses should be available in the event that ULSD supply becomes an issue or equipment emission control equipment malfunctions. A contract age exemption for back-up buses is a cost-effective suggestion for districts to retain some older buses in the fleet, for this purpose. Strict annual mileage limits would be required for back-up designation.

- **Anti-Idling**

In the continued anti-idling efforts of the State of Connecticut DEP, it is a recommendation of the school bus subcommittee to continue outreach and education. Outreach and education must be deployed to community members and parents of children that ride school buses, school bus drivers and maintainers in order to overcome urban legends stalling anti-idling efforts. Anti-idling practices must take place in bus yards just as they do on school grounds.

One recommendation to achieve this is to place a sticker in the school bus cabin or on the school bus reminding the school bus drivers and operators of anti-idling measures. Sticker distribution can be incorporated at the time of registration of the school bus. Approval process will need to occur in order to place anything on a school bus.

Newer school bus engine technology makes it possible for a bus to operate properly with a shorter warm up time. As the fleet turnover process occurs, replacement of an older bus with a newer bus will assist anti-idling efforts.

- **Inspection and Maintenance**

School buses undergo annual safety inspections prior to registration for operation in a forthcoming school year. Previous efforts to establish an inspection and maintenance program for school buses have been futile. One recommendation is to incorporate emissions testing into the annual safety inspection. Emissions testing of school buses would require a statutory change to Section 14-164c of Connecticut General Statutes.

If DMV inspectors were to conduct emissions testing, the only testing that can be done is an opacity test, since it is the only equipment that can be easily transported onto a fleet site by an inspector. The other option is for fleets to establish a self-inspection program and inspectors to verify that such an inspection has taken place. Section 14-164i-10 of the Regulations of Connecticut State Agencies provides information about the "Licensed dealer and repairer diesel emission inspection program". Adoption of such a program by the school bus fleet in the State of Connecticut will have great benefits in the reduction of PM emissions.

- **Post Retrofit Testing**

Another issue raised is the lack of post-retrofit emissions testing and temperature data logging. It needs to be confirmed that retrofitted buses are experiencing the expected emission reductions. Where the retrofit involved installation of a DPF, inspection of filter availability is possible. Temperature data logging would assure that the buses are meeting temperatures required for the filters to work properly. Currently other states in the Northeast have programs to assure the proper operation of retrofit equipment. New Jersey DEP conducts post-retrofit testing of retrofitted equipment in the state. New York conducts annual inspections to assure proper function of retrofit equipment. In New York equipment not meeting the specified emission reduction levels are subject to a fine that ranges between $1,000 and $10,000.

- **Funding**

DEP remains committed to working with school districts to develop proposals for federal funding. Over the past several years the availability of federal funding has increased rapidly. If Congress appropriates federal funding at the levels authorized under the Diesel Emissions Reduction Act, a significant amount of funding will be available to states. Connecticut has pursued these opportunities very aggressively and should continue to develop viable diesel reduction proposals that can be submitted for future funding opportunities.

IV. Conclusions

Concluding statement on how to move forward with the recommendations and options presented above.

Attachment A

MEMO

To: School Bus Subcommittee
From: Madeleine Weil, Environment Northeast
Date: September 27, 2005
Re: School Bus Options Menu

Contents

- Introduction
- Connecticut's School Bus Fleet
- Scope of Clean-Up Efforts
- Options
  - **#1: New York City School Bus Law**
  - **#2: Achieving significant emission reductions for all CT school buses, and preventing crankcase emissions from entering the cabins of buses**
  - **#2.1: Priority Communities Provision**
  - **#3: Average fleet-age requirement with alternative compliance through emissions reductions**

Introduction

More than 387,000 children ride the bus to school each day in Connecticut. The length of time spent on buses varies from 20 minutes per day to several hours. A child with a 30 minute trip to and from school each day spends 180 hours on a school bus each school year. Cumulatively, Connecticut school children spend more than 50 million hours on school buses each year, (EHHI, Children's Exposure to Diesel Exhaust on School Buses).

Beginning with MY2007, federal law requires that all new school buses will come equipped with diesel particulate filters and closed crankcase ventilation systems, and will meet an OEM PM emission standard of 0.01 g/bhp-hr. This is the most stringent level of protection from emissions possible with today's diesel technology, comparing favorably even with alternative fuels like compressed natural gas.

Over time, Connecticut's school bus fleet will become cleaner as older school buses are phased out and replaced by buses compliant with the MY2007 emission standard. Typically, Connecticut school buses are less than 10 years old, with older outliers in less affluent districts such as Hartford. The Hartford school bus fleet, for instance, currently includes buses up to 14 years old (MY1991). Given these trends, under a business-as-usual scenario, it will be 2012-2014 before the majority of Connecticut school children are protected from diesel pollution to

the full extent possible with today's technology. Children in districts with older buses may not be protected until 2020 or after.

A large body of scientific and medical research has conclusively demonstrated that a) diesel pollution causes serious health problems, b) children are exposed to high levels of diesel pollution on school buses, and c) children are particularly susceptible to health impacts from diesel pollution. With these things in mind, the CT Legislature passed Special Act 05-7, instructing the DEP to develop a diesel emission reduction strategy. The Act specifies that the strategy must contain:

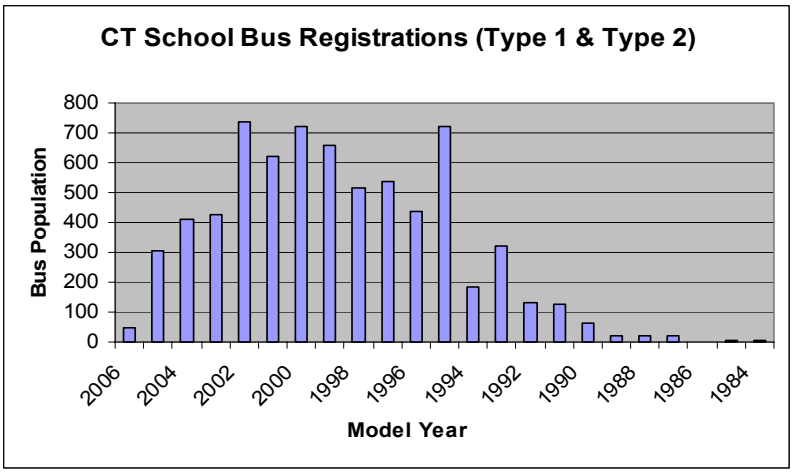
"An implementation strategy, and an estimate regarding the cost and benefits to the state or municipalities of implementing such strategy, to maximize, not later than December 31, 2010, diesel particulate matter emission reductions from school buses and to prevent by said date diesel particulate matter engine emissions from entering the passenger cabin of the buses;"

This Act essentially speeds up the timeframe for achieving the PM reductions that would eventually happen through a business-as-usual fleet turnover schedule under EPA regulations, essentially ensuring that by 2010, all Connecticut school buses will have stringent pollution control technology.

Connecticut's School Bus Fleet

Currently, 5486 Type 1 (full size) and 1544 Type 2 (half-size) school buses are registered to transport students in Connecticut according to the Connecticut Department of Motor Vehicles. All of the Type 1 buses and approximately 35% (535) of the Type 2 buses use diesel fuel. 90% are owned by private bus companies and contracted out for student transport by school districts and the remainder are owned by municipalities or school districts. The Connecticut School Transportation Industry Association has 92 member bus companies that do business in the state of Connecticut (including municipal members).

The age profile for the Connecticut school bus fleet is below (Source: CT DMV, July 2005):



Scope of School Bus Clean Up

Under a business-as-usual scenario, assuming that the age of the Connecticut school bus fleet remains constant, by 2010, approximately 1,924 buses will have been replaced by MY2007 or newer engines. Approximately 5106 buses will remain in the fleet with pre-2007 emission standards. Of that number, approximately 1100 are Type 2 (half-size) buses. These smaller buses are not addressed directly in this options menu. If past trends hold true, by 2010, an estimated 4000 Type 1 buses will require active clean up.

Current School Bus Registrations (Ariel Garcia, CTDEP)

Model Year	Quantity
2006	47
2005	306
2004	410
2003	426
2002	735
2001	621
2000	719
1999	656
1998	515
1997	537
1996	439
1995	719
1994	183
1993	321
1992	132
1991	127
1990	64
1989	22
1988	21
1987	22
1986	2
1985	3
1984	3

Option #1: New York City School Bus Law

Summary

NYC Local Law No. 428-A requires the use of ultra low sulfur diesel fuel and best available retrofit technology for all pre-2007 school buses.

Timing - ULSD

(1) Beginning July 1, 2006, any diesel fuel-powered school bus that is operated by a person who fuels such school bus at any facility at which **ultra low sulfur diesel fuel** is available, or of which such person has the exclusive use and control, or at which such person has the ability to specify the fuel to be made available, shall be powered by ultra low sulfur diesel fuel;
(2) Beginning September 1, 2006, any diesel fuel-powered school bus to which paragraph one of this subdivision does not apply shall be powered by ultra low sulfur diesel fuel.

Timing - BART

Diesel fuel-powered school buses shall utilize the best available retrofit technology in accordance with the following schedule:

i. 50% of school buses used to fulfill each school bus contract by September 1, 2006;
ii. 100% of school buses used to fulfill each school bus contract by September 1, 2007.

BART Definition

"Best available retrofit technology" means technology, verified by the United States environmental protection agency or the California air resources board, for reducing the emission of pollutants that achieves reductions in particulate matter emissions at the highest classification level for diesel emission control strategies, as set forth in **subdivision e** of this section, that is applicable to the particular engine and application. Such technology shall also, at a reasonable cost, achieve the greatest reduction in emissions of nitrogen oxides at such particulate matter reduction level and shall in no event result in a net increase in the emissions of either particulate matter or nitrogen oxides.

BART Determinations

The commissioner shall make determinations, and shall publish a list containing such determinations, as to the best available retrofit technology to be used for each type of diesel fuel-powered school bus to which this section applies. Each such determination shall be reviewed and revised, as needed, on a regular basis, but in no event less often than once every six months.

Subdivision E: BART Classifications

The classification levels for diesel emission control strategies are as follows, with Level 4 being the highest classification level:

i. Level 4 – reduces tailpipe diesel particulate matter emissions by 85 percent or greater or reduces engine emissions to less than or equal to 0.01 grams diesel particulate matter per brake horsepower-hour;
ii. Level 3 – reduces tailpipe diesel particulate matter emissions by between 50 and 84%;
iii. Level 2 – reduces tailpipe diesel particulate matter emissions by between 25 and 49%;
iv. Level 1 – reduces tailpipe diesel particulate matter emissions by between 20 and 24%.

Option #2: Significant emission reductions for all CT school buses, and preventing crankcase emissions from entering the cabins of school buses.

Summary

- By no later than September 1, 2010, all school buses that transport children in Connecticut may be no more than 10 years old. Unless extended, this provision could sunset in 2017 (when all CT school buses will meet 2007 emission standards).
- By no later than September 1, 2010, 100% of Type 1 school buses serving a Connecticut school district must:
    1. Have an engine model year of 2007 or newer; OR
    2. Be retrofit with a CARB/EPA-verified emissions control device certified to reduce PM emissions by at least 25% and a closed crank-case ventilation system; OR
    3. Use an alternative fuel that achieves equivalent or greater PM benefits to option (b) above, or use in combination with options (a) or (b) above.

Minimum Compliance Scenario

This scenario assumes that of approximately 5500 Type 1 buses in Connecticut:

- Approximately 1200 will have turned over to MY2007 or newer engines by 2010 through business-as-usual turnover schedule;
- 4300 will have to be actively cleaned up. This is a conservative estimate, including a 300 bus cushion beyond expectations from past trends to account for potential variation due to the anticipated additional cost of buses meeting MY2007 emission requirements, (see Introduction).

Alternative routes to compliance (with additional emission reduction benefits) include early replacement of school buses with MY2007 or later engines, or retrofitting engines with more sophisticated tailpipe emission control equipment such as a catalyzed wire mesh filter or a diesel particulate filter.

Minimum compliance cost/benefit scenario

Diesel oxidation catalysts + closed-crankcase filters on all 4300 buses
Cost[94] = $1,200 per bus * 4300 buses = $5,160,000
Benefit = 35% tailpipe PM reductions

[94] Cost of DOC + Spiracle Kit for 2004 New Haven School Bus Retrofit Project, (Source: Tracy Babbidge, CTDEP)

Annual Avoided Emissions[95] = 5 tons tailpipe + virtual elimination of crankcase emissions (in-cabin PM2.5)

Implementation

Questions for discussion:

- How would this policy be integrated in to the school bus contracting process?
  - Build requirements into bid specification?
  - Change orders?
  - Which party is responsible for assuring compliance, school district or contractor?
- How the above decisions influence costs and implementation schedule?
- How are costs covered?
  - Absorbed by school districts and bus contractors through contracting process and market competition?
  - Full or part reimbursement from state fund? State matching funds to encourage local investment?
  - Other incentives?

Reporting and Compliance

Under current law, school buses have to register annually with the Connecticut Department of Motor Vehicles, and prior to each school year, each bus must undergo a mandatory safety inspection. We recommend amending the reporting requirements associated with the proposed program to the existing registration requirements. School districts would provide the DMV with documentation of compliance (including engine model, model year, and type of retrofit, date installed, etc.) as a supplemental to the currently-required registration paperwork. Furthermore, the mandatory annual safety inspection would be supplemented by an emissions compliance inspection.

Enforcement

The policy should provide for some form of enforcement provision to compel districts and school bus owners/operators to comply in a timely manner. One example that Connecticut could consider is New York City law which imposes civil penalties on school bus operators or owners who violate the requirements. In New York, owner/operators are liable for a civil penalty between $1,000 and $10,000 in addition to twice the amount of money saved by their failure to comply. An additional civil penalty of $20,000 must be paid in the event that an owner or operator has made a false claim.

Option #2.1: Priority Communities Provision

Summary

- Implement "Best Available Emissions Control" in priority communities, where children are already at risk from elevated levels of PM2.5, as determined by the CT DEP.

[95] Calculated using emission rates in NESCAUM analysis of projected emission reductions for 2004 New Haven School Bus Retrofit Project

- This option is proposed as a supplementary component of Option #2.

Creating incentives for Best Available Emission Control (BAEC)
"Best Available Emissions Control" for school buses results in closed crankcase ventilation and a particulate matter emissions rate of 0.01 g/bhp-hr, the original engine manufacturer (OEM) emissions standard for all new, on-road, heavy-duty diesel engines beginning with MY2007. Retrofitting pre-2007 school bus engines with diesel particulate filters and closed crankcase ventilation systems also results in this standard being met. Using an alternative fuel such as natural gas could also achieve this standard.

Justification
Some Connecticut communities have high levels of ambient air pollution and high incidence of childhood respiratory impacts. For these communities, a higher standard of school bus emission control can and should be sought. A supplemental incentive program should be established to cover some or all of the incremental costs of achieving BAEC in school districts of designated "Priority Communities." This additional incentive would provide support to school districts in priority communities for procuring buses with MY2007 or newer engines, or purchasing/installing diesel particulate filters with closed crankcase ventilation systems. Compared to a minimum compliance scenario (35% PM reductions), BAEC would yield at least 85% PM reductions. These additional benefits would accrue directly to children in overburdened communities, who are particularly vulnerable to the harmful effects of diesel particulate matter.

Implementation
Model contract language for procuring BAEC buses should be designed by DEP and the Department of Administrative Services (DAS). DEP and DAS staff should provide outreach and assistance to designated priority communities so that each is prepared to submit an alternate bid for BAEC buses, in addition to a business-as-usual bid. The increment of cost between the regular bid price and the BAEC bid price could be reimbursed in part or in full through a state incentive program. The school districts should be responsible for providing documentation of school bus procurement, including the business-as-usual bid price and the BAEC price. For school districts that own their own school buses, a model bid specification for purchasing MY2007-compliant buses or BAEC retrofits should be developed and disseminated. Documentation of bid price should be provided to DEP. Provisions for preventing price inflation should be established.

Identification of "Priority Communities"
The Department of Environmental Protection should be responsible for identifying "Priority Communities." In its proposal for school bus retrofit funding from the VEPCO settlement in 2003, the CTDEP utilized statewide air-monitoring data to prioritize school districts based on the overall quality of local air. From CTDEP's 2003 VEPCO plan (http://www.dep.state.ct.us/air2/diesel/docs/vep.pdf):

> "While the emission reduction goals from diesel school bus retrofit projects are focused on reducing the localized exposure risks of school

> children being transported by school buses, the health of children may already be at risk in areas that have elevated levels of particulate matter and ozone pollution. In certain areas of the State, the existing regional air quality can present respiratory and other health problems for children. Priority has been given to districts that are located in areas that face the most serious regional air pollution concerns and would benefit from diesel reduction strategies."

The following Connecticut communities are highlighted in the DEP's plan because they have 3-year annual average particulate concentrations of greater[96] than 12 ug/m^3: Bridgeport, Danbury, Hartford, New Haven, Norwalk, Stamford, Waterbury, Westport. Connecticut's urban areas are disproportionately overburdened by a variety of sources of environmental pollution. Residents tend, on the whole, to suffer disproportionate health impacts associated with pollution (such as asthma). The VEPCO plan also cites methods for prioritizing communities through an environmental justice screen, including identifying "distressed cities" as designated by the DEP's Environmental Equity Program, and "high need urban area" as designated by the Department of Education.

Option #3: Average fleet-age requirement with alternative compliance through emissions reductions

(a) Phase-out of oldest bus engines. Beginning January 1, 2006, no public school district in Connecticut shall enter into a contract for any Type 1 bus with an engine model year older than X years. Beginning September 1, 2010, no public school district shall transport school children in any Type 1 school bus with an engine model year older than X years.

(b) Mitigate crank-case emissions. In order to minimize seepage of emissions into the cabin, all buses must have closed crankcase ventilation systems installed. The terms of this subsection shall apply to all public school buses operated in Connecticut by September 1, 2008.

(c) Phase-in of younger buses. Beginning September 1, 2006, no public school district in Connecticut shall contract for a school bus fleet with an average engine emissions age for full-sized school buses of greater than four years. By September 1, 2010, the average engine emissions age for full-sized school bus fleets operated or contracted by public school districts in Connecticut, based on engine model year, shall be no greater than four years old. Buses with an engine model year that is the same year in which a calculation is being made shall be counted as zero years old. Buses of MY 2007 or later shall be counted as zero years old. The engine emissions age for all other buses shall be counted in whole numbers by subtracting the model year of the bus engine from year in which the calculation is being made.

[96] 12 ug/m^3 is the level to which EPA staff scientists have recommended lowering the federal annual standard for PM2.5 to adequately protect public health. The State of California adopted this standard in 2002 based on extensive review of health-based scientific literature.

(d) Alternative compliance.

a. A bus engine retrofit with an emission control device or using an alternative fuel verified by CARB/EPA to achieve Level 3 PM reductions (≥85%) shall be counted as zero years old;
b. A bus engine retrofit with an emission control device or using an alternative fuel verified by CARB/EPA to achieve Level 2 PM reductions (≥50%) shall be counted as two years old;
a. A bus engine retrofit with an emission control device or using an alternative fuel verified by CARB/EPA to achieve Level 1 PM reductions (≥25%) shall be counted as four years old;

(e) Reporting and Conditions of Registration.

(1) The Department of Motor Vehicles shall establish reporting forms and procedures for public school districts of Connecticut to record their annual progress in complying with the provisions of this section, including information regarding the model year, crank case emissions mitigation system, or alternative compliance system relevant to each Type 1 bus. Reports shall be submitted to the Department of Motor Vehicles with the Student Transportation Vehicle Inspection Report no later than August 31 of each year. The Department of Motor Vehicles shall also provide an annual report to the Department of Environmental Protection no later than December 31, 2006 and each December 31 thereafter on progress in reducing emissions from public school buses until there are no longer any Type 1 school buses older than model year 2007 operating in the state or in the year 20XX, whichever comes first.

(2) The Department of Motor Vehicles shall not re-register any in-use Type 1 school bus that:

A. is not accounted for in a school district's progress report, or
B. is part of a school bus fleet that has failed to demonstrate full compliance with any provision of this section.

(3) Any inconsistencies found during an inspection between actual state of the vehicle and the information contained in the annual progress report regarding the model year, crank case emission mitigation system, or alternative compliance system shall constitute an infraction and prohibit the issuance of an inspection sticker.

(f) Sunset. The requirements of sub-sections (c) and (d) of this section shall expire when there are no longer any Type 1 school buses older than model year 2007 operating in the state or in the year 20XX, whichever comes first.

Attachment B

MEMO

To: **CT Department of Environmental Protection**
From: **Environment Northeast, Clean Water Action, Connecticut Coalition for Environmental Justice, Connecticut Fund for the Environment**
Date: **November 10, 2005**
Re: **School Bus Emissions Reduction Straw Proposal**

Through Special Act 05-7, the Connecticut General Assembly directed the Connecticut Department of Environmental Protection to develop a diesel emission reduction plan containing:

"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;"

To this end, we offer the following policy recommendation to the CT DEP for consideration.

Proposed Policy Summary:

- Establish a minimum "floor" level of emission reductions for all full-sized school buses operating in Connecticut; and
- Create incentives for school districts to go beyond required minimum emission reductions by introducing newer, cleaner engines, advanced diesel retrofit technology, or cleaner fuels.

Element #1 – Requirements[97]:

- By September 1, 2007, no school bus with an engine model year 1993 or older may be used to transport school children in Connecticut;
- By September 1, 2008, all front-engine school bus engines of model year 2006 or older must be retrofit with a closed crankcase filtration system;
- By September 1, 2010, all full-sized school buses transporting children in Connecticut must either:
  - Be equipped with a Level 1, Level 2, or Level 3[98] CARB/EPA verified emission control technology; OR

[97] Requirements presume that by late 2006, all on-road diesel fuel will be ULSD (per federal law).

- Be equipped with an engine from MY2007 or newer; OR
- Use an alternative fuel verified by CARB/EPA to reduce particulate matter (PM) emissions by at least 25% (equivalent to a Level 1 emission control technology).
- School districts and school bus owners must permit existing contracts to be re-opened to negotiate compliance with requirements.

Element #2 – Implementation and Outreach:
CT DEP and CT DAS develop state procurement contracts for a) the purchase of new buses compliant with MY2007 emission standards, b) tailpipe emission control retrofits, and c) closed crankcase filtration systems.

  - Contracts must be available to municipalities and private school bus operators, provided they can demonstrate that the affected school bus is/will be in service in Connecticut;
  - Contracts must be available through CT DAS's e-Procurement website, in a category that clearly identifies the product to municipalities and private school bus operators;
  - At least one contract must be developed for each CARB emission control device verification level: Level 1, Level 2, and Level 3;
  - At least one contract must be developed for a closed crankcase filtration system.
- CT DEP and CT DAS develop an outreach plan and materials for educating school districts and bus companies about the new requirements and paths to compliance.

Element #3 – Financing and Incentives:

- Effective immediately, the state offers a sales tax on new bus purchases up to $4,000 per bus, but only for model years 2007-2010, natural gas or diesel. Waiver sunsets September 1, 2010;
- Effective immediately, for school bus model years 1994-2005, the state provides incentive to school bus owners for the purchase and installation of closed crankcase filtration system (CCFS) retrofit device. The per-unit incentive shall not exceed $250. Incentive sunsets September 1, 2008.
- Effective immediately, for school bus model years 1994-2005 only, the state provides incentive to school bus owners for the purchase and installation of any CARB/EPA-verified emission control retrofit device. In 2006-2007, the per-unit incentive shall not exceed $1000 for a Level 1 device, $2000 for a Level 2 device, and $3000 for a Level 3 device. Incentive levels may be re-evaluated annually, with the goal of maintaining competition in the market for retrofit devices. Incentives sunset September 1, 2010.
- To receive incentive from the state, school bus owners must submit a form to the authorized state agency containing the bus model and year, engine model and year, VIN number, receipt for the retrofit device, and date installed for every

[98] California Air Resources Board, Diesel Emission Control Strategies Verification: Level 1 ≥ 25% reduction PM, Level 2 ≥ 50% reduction PM, Level 3 ≥ 85% reduction PM.

eligible bus. Bus owners must also certify that newly purchased or retrofitted buses will operate in the state of Connecticut for a minimum of four years.
- Potential incentive funding streams may include but are not limited to tax credits, appropriations, and Special Transportation Fund revenues and should be available to both private and public school bus owners.

Element #4 – Reporting, Compliance, and Enforcement:
- Reporting requirements should be amended as a supplemental to existing annual registration requirements due to CT DMV prior to each school year. Documentation of compliance should include bus model and year, engine model and year, type of retrofit, date installed, date and amount of state rebate received. For school buses complying with the use of a clean fuel (at least Level 1 CARB/EPA-verified) documentation must include clean fuel receipts (each delivery);
- Supplement mandatory annual safety inspection with emission control compliance inspection;
- Establish civil penalties for non-compliance and additional penalties for making false claims. Penalty money should be directed into a CT Diesel Risk Mitigation Fund.

Element #5 – Priority Community Provision:
- When penalty funds, state SEP funds, federal funds, or funds from other state or non-state sources become available, these should be first allocated toward further offsetting costs of achieving "best available" emissions control in "priority communities."
    - The "best available" standard is attained by all new buses (MY2007 and newer) and by diesel buses retrofit with Level 3-verified diesel particulate filters and closed crankcase filtration systems. A clean alternative fuel (such as natural gas) could also achieve this standard;
    - "Priority communities" (to be identified by the CT DEP) are CT communities that have high levels of ambient air pollution and high incidence of childhood respiratory impacts.

Estimated Potential Costs and Benefits to State:
- Costs/Benefits depend on the compliance decisions made. The following chart outlines 6 potential scenarios, with varying selection rates of the lowest cost and lowest benefit option (Level 1 DOC + CCFS retrofit) and the highest cost and highest benefit option (new bus, MY2007 and beyond). Costs and benefits of actual implementation scenarios that may include Level 2 and Level 3 retrofit selections will fall within the range below. Assumptions:
    - 5500 full-sized diesel school buses[99]

[99] DMV inventory, provided by Ariel Garcia, DEP (9/7/05).

- Average annual bus mileage = 18,000 miles[100]
- Cost to state of Diesel Oxidation Catalyst (DOC) incentive = $1000
- Cost to state of Closed Crankcase Filtration System (CCFS) incentive = $250
- Cost to state of New Bus incentive = $4000 (lost state sales tax revenue)
- Uncontrolled bus PM emission rate = 0.17 g/mi[101]
- Bus with DOC + CCFS retrofit PM emission rate = 0.1105 g/mi (35% reduction)
- New bus, MY2007 and beyond, emission rate = 0.017 g/mi (90% reduction)

	L1 retrofit (DOC/CCFS) selection	New bus selection	DOC Cost	CCFS Cost	New Bus Cost	**Total Program Cost**	**Annual PM Benefit (tons/year)**
Scenario 1	100%	0%	$5,500,000	$1,375,000	$0	**$6,875,000**	**6.49**
Scenario 2	80%	20%	$4,400,000	$1,100,000	$4,400,000	**$9,900,000**	**8.53**
Scenario 3	60%	40%	$3,300,000	$825,000	$8,800,000	**$12,925,000**	**10.57**
Scenario 4	40%	60%	$2,200,000	$550,000	$13,200,000	**$15,950,000**	**12.62**
Scenario 5	20%	80%	$1,100,000	$275,000	$17,600,000	**$18,975,000**	**14.66**
Scenario 6	0%	100%	$0	$0	$22,000,000	**$22,000,000**	**16.7**

- The primary beneficiaries of this projected 6.49-16.7 ton annual PM reduction would be school children and bus drivers. Several studies have found that fine particulate matter levels inside school buses is significantly higher than outside (5-10 times higher). Cumulatively, Connecticut children spend more than 50 million hours on school buses per year. Expected benefits included avoided health impacts, avoided health care costs, and avoided school absences. [102]

[100] COSTA, *Safety Gram*, (http://www.epa.gov/ne/eco/diesel/assets/pdfs/costa_safetygram.pdf). States average daily mileage for Connecticut school buses = about 100 miles. 100 miles per day * 180 school days per year = 18,000 miles per year. This may underestimate total annual mileage because it does not include summer-time travel.

[101] 0.17 g/mi is the EPA Mobile6 emission factor for 1994 school bus. EPA staff is currently reviewing the accuracy of this emission factor – they believe it underestimates emissions. In NESCAUM's "School Bus Emission Reductions" analysis, prepared for New Haven school bus retrofits in Dec. 2002, an emission factor of 0.25 g/mi was used. The more conservative number was selected for this analysis. Using the 0.25 g/mi factor would increase benefits to 9.55 tons (Scenario 1) to 24.55 tons (Scenario 6).

[102] EHHI, *Children's Exposure to Diesel Exhaust on School Buses,* 2002, http://www.ehhi.org/reports/diesel/, CATF, *A Multi-City Investigation of the Effectiveness of Retrofit Emissions Controls in Reducing Exposures to Particulate Matter in School Buses,* 2005, http://www.catf.us/publications/view/82, also CARB (2003), NRDC (2001).

Attachment C

CASBO SCHOOL BUS CONTRACT SURVEY

11/14/2005

District Name:	Contact Name:	# Buses in Fleet	Term of current contract?	Expiration Date (MM/YYYY):	Does your contract include a renegotiation clause.	Plans to update your fleet?	Provide Language from existing contract:	Briefly explain plans to update:
Ansonia	John Crist	15	5	Jun-10		No		
Bethel	Jay Hubelbank	22	5	Jun-09	No	Yes		12 year age limit.
Bolton	Chris Chemerka							
Branford	Tashie Rosen	34	5	Jun-10		No		
Bridgeport	Laidlaw	108 Type I, 70 Type II	5	Jun-10		No		Bridgeport has contract language that requires the 'greenest' technology available for new vehicles.
Bristol	William Smyth	104	5	Jun-09	No	Yes		Annual upgrade of 5 buses per year. Our oldest vehicle is 1996 vintage and most vehicles are 2000 vintage and up.
C.E.S.	Jim Carroll	25	3	Jun-08		No		
Canton	Tom Sullivan							
Cornwall	Sam Herrick	5	5	Jun-06	No	Yes		10yr age limit, may put averageage limit in future contracts.
Cromwell	Rick Mandeville	14	4	Jun-07	Yes		Several section exist	New contract will require new(er) busses
East Granby	Eve Spencer	9	5	Jun-10	No	Yes		The contract states that average age of bus can be no more than five years with no single bus older than ten years
East Haddam	Robert Carroll	13	5	Jun-09		No		Throughout the term of the contract, no bus shall be more than 10 yrs old.

CASBO SCHOOL BUS CONTRACT SURVEY

11/14/2005

District Name:	Contact Name:	# Buses in Fleet	Term of current contract?	Expiration Date (MM/YYYY):	Does your contract include a renegotiation clause.	Plans to update your fleet?	Provide Language from existing contract:	Briefly explain plans to update:
East Hampton	Kevin M. Reich	21	5	Jun-10	Yes	No	This contract shall be effective from July 1,2005 to June 30 , 2010,unless terminated in accordance with the provisions of the contract.In the third year of the contract the Board will vote to consider a new four year agreement commencing July 1 ,2008.the	
East Lyme	Don Meltabarger	22	5	Jun-08	Yes		Term of Contract: In addition, the board may extend contract beyond expiration date between contractor and Board upon mutual agreement	
East Windsor	Timothy Howes	15	3	Jun-06	No	No		
Education CT	Bert Hughes	60			Yes	No		
Granby	H. Traver	27	2 of 5	Jun-07	Yes			
Guilford	Andy Potochney	31	5	Jun-05	No			
Litchfield	Peg Perusse	14	5	Jun-08	Yes	No	This Agreement may be amended or modified at any time by mutual written agreement, which shall be signed by the duly authorized representatives of the Board and the contractor. Any such written amendment shall be attached.	
Madison	Arthur Sickle	47	5	Jun-09	Yes	Yes		Our contract requires a maximum average age of the fleet to be no older than 7 years old, with no single bus older than 10 years old.
Manchester	Patricia F. Brooks							

CASBO SCHOOL BUS CONTRACT SURVEY

11/14/2005

District Name:	Contact Name:	# Buses in Fleet	Term of current contract?	Expiration Date (MM/YYYY):	Does your contract include a renegotiation clause.	Plans to update your fleet?	Provide Language from existing contract:	Briefly explain plans to update:
Mansfield	Jeff Smith	16	1	Jun-06		No		We have an average age in contract which means buses get purchased each year
Meriden	Corinne Eisenstein	58 Type I, 20 Type II	3 years with two one year options to renew	Jun-07		No		
Milford	Philip G. Russell	60	5	Jul-10	Yes		5 year contract period.	
Monroe	Steven R DeVaux	30	5	Jun-10	Yes	No		
Monroe	Steven R DeVaux	33	5	Jun-10	Yes			
New Canaan	M. Lagas	60	5	Jun-07	Yes	Yes		More emission control equipment on vendor-provided vehicles
New Fairfield	Theresa Yonsky	21 large, 5 vans	4	Jun-06	No	Yes		Contract bids this year, some newer buses will be expected to be added to the fleet.
New Milford	T. Corbett	47	5 Years	Jun-08		Yes		Prior to the end of our contract we will be developing specifications for a new contract. Our existing fleet is 8 yrs old so we will be looking to update equipment.

CASBO SCHOOL BUS CONTRACT SURVEY

11/14/2005

District Name:	Contact Name:	# Buses in Fleet	Term of current contract?	Expiration Date (MM/YYYY):	Does your contract include a renegotiation clause.	Plans to update your fleet?	Provide Language from existing contract:	Briefly explain plans to update:
North Stonington	Charles McCarthy	18	5	Sep-09	No	Yes		The new contract requires the bus company to replace a specified number of buses each year until the entire fleet is replaced.
Norwich	M. Picard							
Old Saybrook	M & J Bus Co.	12	5	Jun-05	Yes	Yes	Reopener: A successor contract may be negotiated in the 5th year of this current contract.	12 year age llimit.
Oxford	Richard E. Carmelich III	18	5	Jun-07	No	No		
Plymouth	Gerry Perusse	16	last year 2 year option	Jun-06	Yes			
Putnam	Nancy T Cole	17	n/a own fleet	n/a				Buses are included in the town capital improvement plan; 2 each year
Region #10	Dave Lenihan	25	5	Jun-08		No		The contract calls for buses over 7 years old to be replaced
Region #4	Steve Spires	14	5	Jun-06	No	No		
Region #8	Bill Mazzara	18	5	Jun-08		No		
Regional #12	Bob Giesen	27	5	Jun-09	No	No		

CASBO SCHOOL BUS CONTRACT SURVEY

11/14/2005

District Name:	Contact Name:	# Buses in Fleet	Term of current contract?	Expiration Date (MM/YYYY):	Does your contract include a renegotiation clause.	Plans to update your fleet?	Provide Language from existing contract:	Briefly explain plans to update:
Regional # 6	Jerry Domanico	11	5	Jun-09	No	Yes		Contract stipulates that: 'Contractor will add two new Type I vehicles and retire the two oldest Type I vehicles each subsequent year for the life on the contract.'
Regional #16	William Stowell	25	5	Jun-10		No		
Regional #18	Marilyn M. Warren	18	5	Jun-10		No	Basically it states that change orders have to be agreed to by both parties.	
Ridgefield	Gary Green	55	7	Jun-10		No		
Rocky Hill	Gregory Turansky	11	5	Jul-08	No	No		
Salem	Kim Gadaree	9	5	Jun-06	No	No		
Shelton	Al Cameron	54	5	Jun-08	No	Yes		Our last contract allowed the fleet operator to keep low milage vehicles up to 10 years on the road. Next contract we will require an all new fleet.
Simsbury	David P. Holden	30	5	Jun-10	No	Yes		Based upon attractiveness financially, we would retrofit buses. DEP needs to provide financial incentive.
Somers	Bill Boutwell	15	6	Jun-07	Yes		The terms of this agreement may be modified in whole or in part by mutual agreement of both parties. Any such change shall be reduced to writing and signed by authorized representatives of both parties.	

CASBO SCHOOL BUS CONTRACT SURVEY

11/14/2005

District Name:	Contact Name:	# Buses in Fleet	Term of current contract?	Expiration Date (MM/YYYY):	Does your contract include a renegotiation clause.	Plans to update your fleet?	Provide Language from existing contract:	Briefly explain plans to update:
Southington	Sherri DiNello	56	5	Jun-09	No	Yes		We require that buses used in our district are no more than 7 years old. So the contractor continues to purchase new buses.
Stafford	Jill Gregori	34	5	Jun-10	Yes	Yes	Previous to the opening of the new elementary school, either party may reopen the contract for the pur	Contract language: Vehicles will be no older than ten (10) yers at the beginning of each school year. The average age of the fleet utilized in any given contract year will not exceed seven (7) years at the beginning of each school year.
Suffield	Ed Basile	21	5	Jun-08	No	No		
Tolland	Jane A Regina	28	5	Jun-09		No		
Wethersfield	Karen Clancy	18	5	Jun-08	Yes	No	The contractor and the Board agree to negotiate the cost of any additional equipment that the Board may require that is not covered by laws, rules, regulations, policies and standards of the federal government, the State of Connecticut.	
Wethersfield	Gary Miller, Int Bus. Mgr.							
Windham	Jeff Nelson	26	5	Jun-09	No	No		
Windsor	S. Grobard	60	5	Jun-06	No	Yes		Our contract states buses must be no older than 10 years. the contractor purchases 10- 15 new buses each year.

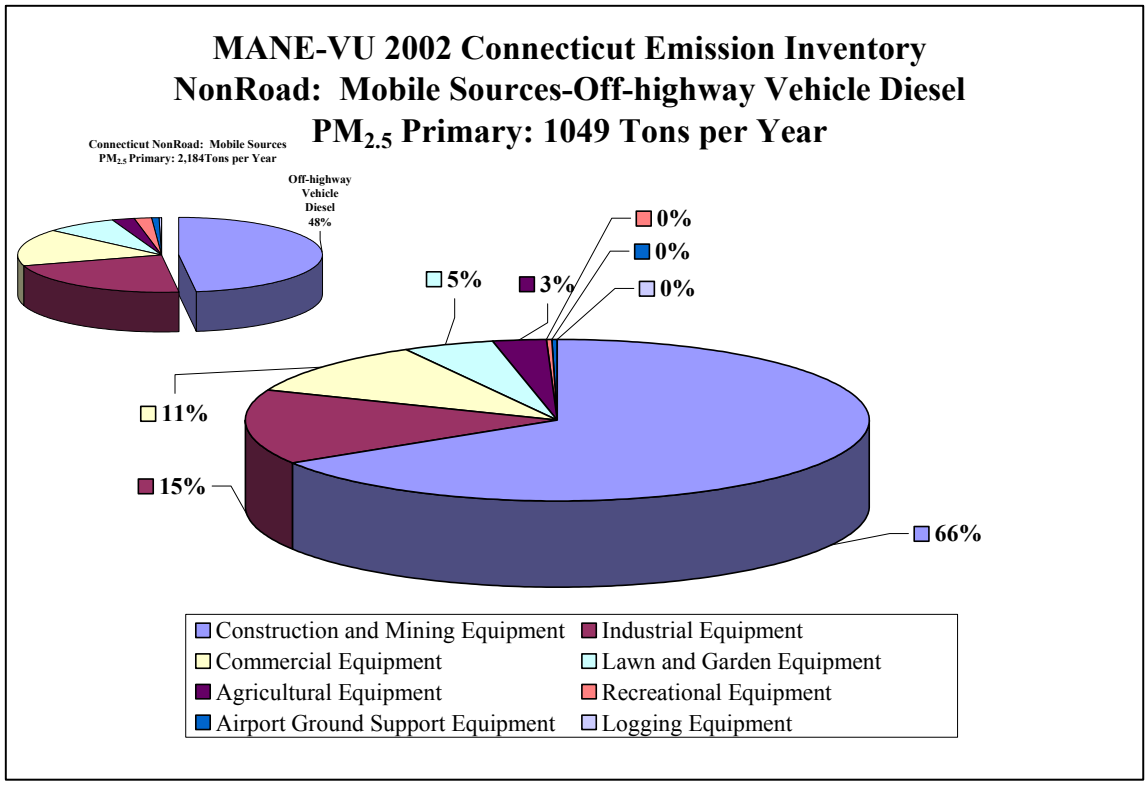
Construction Equipment Report

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[103] 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.[104]

Figure 1



[103] 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.
[104] See Figure 1 in the Overview section 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,[105] 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,[106] 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 5. Meetings of the Construction Equipment Subcommittee were held on August 31, 2005 and September 14, 2005. This DEP report

[105] See 40 CFR 1039.
[106] See Appendix 1, 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.[107] 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.[108]

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).[109]

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[107] 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.

[108] See Attachment B for more background on the Connecticut Clean Air Construction Initiative.

[109] 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:[110]

- 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. DOT to provide information on DOT owned off-road equipment.
- 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 DEP maintains an inventory of approximately 40 pieces of off-road equipment having engines of 50 horsepower or greater. These vehicles are used in state parks and hatcheries and include tractors, mowers, loaders, backhoes and bulldozers. Compiling an exact inventory of DEP owned off-road equipment will require more effort.
- 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.

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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.

[110] See Attachment C for more detailed information.

B. Fleet retrofit, replacement, and retirement options

- **Construction Fleet Inventory:**

  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[111]. 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.[112] EPA estimates that nationwide there are two million pieces of construction equipment in use today.[113] 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[114]

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

[111] Source: H. O. Penn, also see Attachment D, new construction sales data from East PBE.
[112] Source: the United States Department of Energy, Energy Information Agency; the most recent data available are from 2003.
[113] Source: EPA.
[114] Table format provided by Environment Northeast (ENE), Memo dated November 3, 2005. See Attachment E.

Connecticut's construction industry trends toward a rental based economy, with the tendency for large general contractors to rent equipment for projects.[115] As an 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,[116] 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.[117] 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.[118]

  - 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

[115] See Attachment F, August 31, 2005 construction subcommittee minutes.
[116] Source Tom Balon, MJ Bradley.
[117] Based on a conversation with Chris Goddard, Project Superintendent, L.G. Defelice, Inc., Contractor for the Q Bridge Project, October 27, 2005.
[118] 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 G.

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).

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.[119] 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.[120] 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*

[119] See Attachment G, page 52.
[120] See 40 CFR 1039.

and Policy[121] and referenced in a recent report for the CMAQ Program[122] states that 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.[123]
- 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,[124] 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

[121] 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

[122] 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 Appendix 2.)

[123] 15% of 10,780 construction engines >50 HP = 1,617 engines.

[124] 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.

to retire and replace older engines with new machines that are compliant with EPA's Tier 4 standards.

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.[125] 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.[126] Connecticut uses about 15.7 million gallons of diesel fuel in construction projects each year.[127] The increased cost of converting to ULSD for state construction projects in Connecticut is therefore

[125] 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.
[126] In 2006, when ULSD is available nationwide, the cost differential is projected to be much less.
[127] Source: the United States Department of Energy, Energy Information Agency; the most recent data available are from 2003.

projected to be $282,600.[128] 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.

- 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.[129]

[128] 15% of 15.7 million gallons x 12 cents per gallon equals $282,600.
[129] Source: Clean Cities Draft Memo dated November 17, 2005

- Emulsified fuels approved by EPA or CARB – PuriNOX is an emulsified diesel fuel manufactured and distributed by Lubrizol Corporation. The EPA retrofit 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.[130]

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)[131]**
    - 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.

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[130] 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 H.

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

- 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.

- **New York City Local Law 77**[132]
  - 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[133]; the proposed method for selecting BAT on a case-by-case-basis was released for public comment March 29, 2005.[134]

- **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

[132] Ibid.
[133] See Attachment I, ICF Report, page 63.
[134] Find Notice and Proposed Rule at http://www.ci.nyc.ny.us/html/dep/html/news/notices.html.

Implementation Options

There are a variety of available mechanisms to achieve reductions of diesel emissions from construction equipment including mandating statutory or regulatory requirements, 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[135]; 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[136] 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,[137] 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.[138]

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

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[135] See the DOT sample contract language in Attachment J.

[136] 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.

[137] Successful examples of this approach are the Massachusetts Central Artery/Tunnel project and the Connecticut Clean Air Construction Initiative.

[138] 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.

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.

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.[139] 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

[139] 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.

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.

- **Option 3: Rental Equipment Retrofit/Replacement:** Many contractors supplement their fleets with rental equipment. 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. EPA recently awarded a grant to the Oregon-Columbia Chapter of Associated General Contractors (AGC) for a pilot project to study the issue of retrofits on construction rental equipment that will be used on a major bridge project. 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. Such grants could be made from a state clean diesel fund, similar to the Carl Moyer Program in California,[140] the TERP[141] program in Texas or New Jersey's temporary reprogramming of corporate business taxes.

[140] See Appendix 2 or http://www.arb.ca.gov/msprog/moyer/carl_moyer_board_presentation_1_20_05.pdf.
[141] See http://www.tceq.state.tx.us/comm_exec/forms_pubs/pubs/rg/rg-388.html.

To address funding issues, DEP could establish a statewide voluntary diesel collaborative committed to the development of viable diesel reduction project proposals and aggressively pursue available funding opportunities on the federal level. Developing an education and outreach program for fleet owners that promotes the opportunities and benefits associated with accelerated fleet turnover will enhance a voluntary emissions reduction program.

- **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

S	SCC_L4	Pollutant Code	Sum of Connecticut ons/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

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 C

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 D

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 E

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.[142]

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).[143]

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

[142] MANE-VU 2002 Connecticut Emission Inventory
[143] 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.[144] 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*

[144] 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"[145] 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.[146] 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."*[147]

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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[145] *Ibid*, (9).
[146] ICF Consulting for U.S. EPA, *Emission Reduction Incentives for Off-Road Diesel Equipment Used in the Port and Construction Sectors*, 2005 (59).
[147] 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.[148]

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.

[148] 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 F

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 G

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 H

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

Guido Schattanek
Parsons Brinckerhoff Inc., One Penn Plaza, New York, NY 10119

Donna Weaver
Connecticut Department of Transportation, 2800 Berlin Turnpike, Newington, CT 06131

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™, 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°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 certificati[illegible]umber; 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 a[illegible]on 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

Highway Vehicles Opacity Test Results

important positive effect.

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

Mr. Frank Kaminski from DOT, Ms. Tracy Babbidge, and Mr. Paul Bodner from DEP, Alyssa Glide from NESCAUM, Lt. David Maestrini from DMV, and Ms. Faith Gavin-Kuhn from CCIA for their efforts in the process and implementation of the Connecticut I-95 NHHC Diesel Emission Control Program.

REFERENCES

1. Connecticut. Department of Motor Vehicles. *Connecticut's Heavy Duty Diesel Emissions Program.* http://www.dmvct.org/ *March* 2001.
2. Connecticut. Department of Transportation. I-95 New Haven Corridor Improvement Program. www.i95newhaven.com
3. Diesel Technology Forum. *Retrofit Tool Kit.* www.dieselforum.org/retrofit/success
4. U.S. EPA. *Air and Radiation. Heavy-duty Diesel Emission Reduction Project Retrofit/Rebuild Component*. Prepared by Northeast States for Coordinated Air Use Management. EPA420-R99-014. June 1999.
5. U.S. EPA. Office of Mobile Sources, Assessment and Modeling Division. *Exhaust Emission Factors for Non-road Engine Modeling – Compression-Ignition*. Report No. NR-009A. June 1998
6. U.S. EPA. *Voluntary Diesel Retrofit Program.* www.epa.gov/otaq/retrofit/index.
7. Schattanek , Guido, Kasprak, A, Weaver , D, Cooper, C. "*Implementation of Retrofit/Clean Fuel Programs for Diesel Equipment During the Construction Phase of Two Large Transportation Projects*" Presented paper at the AWMA 95th Annual Meeting. Baltimore, Maryland. June 2002. Paper No. 42536

8. Schattanek, G. *Technical Memorandum - I-95 Q Bridge Project – Projected Air Pollution Benefits and Costs of Diesel Engine Retrofit and/or Clean Fuels Program for the Construction Phase.* December 4, 2000.
9. Schattanek, G. *Technical Memorandum - I-95 Q Bridge Project – Summary of Projected Air Pollution Benefits and Costs of Diesel Engine Retrofit and/or Clean Fuels Program for the Construction Phase.* December 7, 2000.

KEY WORDS

Diesel Retrofit Program

Oxidation Catalysts

Emission Control Equipment

Clean Fuels

Pollution Reduction

Construction Equipment

Attachment I

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 J
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]

On-Road Fleets Report

Special Act 05-07
Connecticut Clean Diesel Plan
On-Road Fleets Subcommittee Report

I. Introduction

Over 21,000 tons of fine particulate matter 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. These sources also emit other pollutants that contribute to Connecticut's air quality problems. For example, on-road engines account for about 58 percent of the over 118,000 tons of nitrogen oxides emitted annually in Connecticut, off-road engines about 20 percent, with the remaining 22 percent from stationary and area sources.

The General Assembly has directed the Department of Environmental Protection (DEP), pursuant to Special Act 05-07[149], to develop a Connecticut clean diesel plan to reduce the health risks from diesel pollution and to help the state meet federal air quality standards for fine particulate matter.

The DEP began the planning on July 19, 2005 with a kick-off meeting at DEP's offices. As a result of this meeting, four subcommittees were formed to explore and develop information on the following sectors: on-road fleets, transit buses, school buses and off-road construction equipment. Each group, comprised of the government, private industry, public health and the environmental sectors, was provided a set of action items and directed to report back to DEP. The on-road fleets subcommittee was directed to examine the following issues:

- State-wide baseline;
- Evaluate fleet retrofit, replacement retirement options;
- Evaluate clean fuel options;
- Anti-idling;
- Leveraging opportunities;
- Case studies –pilot projects; and
- Other Items identified by the subcommittee.

On August 17, 2005, the DEP hosted a Diesel Emissions Reduction Policy, Technology and Clean Fuels Forum. The forum was intended to inform the DEP's efforts to develop the Connecticut Clean Diesel Plan by providing experts on policy, control technology and clean fuels the opportunity to present information to all interested stakeholders. Much of the information received through this public input process is relevant to each of the four subcommittees and serves to inform several aspects of this report.

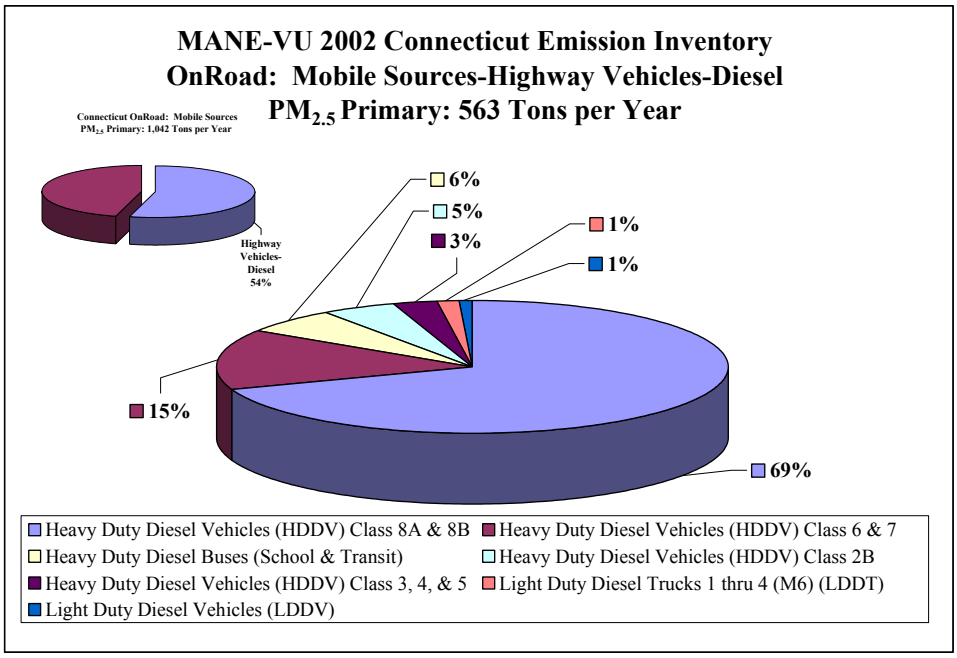
[149] See Appendix 1, Special Act 05-07, *An Act Establishing A Connecticut Clean Diesel Plan*.

II. On-Road Fleets Report

A. State-wide baseline:

Figure 1 below represents a projection of the particulate matter ($PM_{2.5}$) emissions from on-road diesel-powered vehicles. In Connecticut, on-road heavy-duty diesel vehicles account for 92% of the total emissions of fine $PM_{2.5}$ or almost 518 tons per year.

Figure 1



With respect to oxides of nitrogen (NO_X), a precursor to ground level ozone, heavy-duty diesel vehicles over 10,000 pounds gross vehicle weight emit 25,115 tons of NO_X per year. This is approximately 22% of all NO_X emitted in Connecticut each year.

The Department of Motor Vehicles (DMV) provided baseline inventory data on the number of commercial vehicles over 14,000 pounds gross vehicle weight rating registered in Connecticut. This information is provided in Table 1 by gross weight group and in Table 2 by fleet distribution for each model year. DMV noted that the data provided did not include state or municipally owned and operated vehicles.[150]

[150] Municipalities are not required to assign municipal license plates to specific vehicles. DMV provided an example that a municipal license plate could be on a police car one day and a garbage truck the next. To accurately determine the number of municipally owned and operated heavy-duty vehicles, DEP would need to either inspect each municipality or otherwise conduct a specific inquiry. DEP did not possess the resources to do so within the timeframes imposed by Special Act 05-07.

Table 1

Commercial (cc 02) over 14,000 and over per weight group	
Group Total	**Gross Weight Group**
0	LESS THAN 5,000
0	5,000 to 7,999
0	8,000 to 9,999
0	10,000 to 11,999
0	12,000 to 13,999
6,974	14,000 to 15,999
3,772	16,000 to 17,999
1,408	18,000 to 19,999
645	20,000 to 21,999
863	22,000 to 23,999
4,083	24,000 to 25,999
1,772	26,000 to 27,999
799	28,000 to 29,999
663	30,000 to 31,999
6,787	32,000 to 35,999
344	36,000 to 39,999
256	40,000 to 44,999
333	45,000 to 49,999
2,721	50,000 to 54,999
292	55,000 to 59,999
646	60,000 to 64,999
1.085	65,000 to 69,999
1,969	70,000 to 74,999
2,018	75,000 to 79,999
4,921	80,000 AND OVER
42,351	**Total**

Highlighted information indicates that 42% of the on-road fleet is between 10,000 pounds and 26,000 pounds. Currently, this portion of the fleet is not subject to any emissions testing.

Table 2

Commercial (cc 02) over 14,000 and over per weight group	
Vehicle Year	**Vehicle Count**
1908 – 1980 combined	2,490
1981	315
1982	233
1983	281
1984	512
1985	768
1986	952
1987	1402
1988	1496

1989	1089
1990	933
1991	671
1992	733
1993	947
1994	1287
1995	2055
1996	1511
1997	1988
1998	1915
1999	3236
2000	3,595
2001	3,280
2002	2,270
2003	2,260
2004	2,768
2005	2,659
2006	705
Total	**42,351**

Table 3
placeholder for ConnDOT fleet information

The inventory compiled as part of the diesel planning effort provides a useful first step but would require additional refinement to serve as an effective tool for designing comprehensive diesel emission reduction strategies for Connecticut's on-road fleet. The following discussion provides an overview of programs currently in place designed to reduce emission from on-road diesel vehicles. This provides a useful starting point for considering future program enhancements.

Heavy Duty Diesel Inspection and Maintenance

Pursuant to the Connecticut General Statutes section 14-164i, Connecticut established a roadside emissions testing program for heavy-duty diesel vehicles greater than 26,000 gross vehicle weight rating (school buses are exempt). Due to the regional nature of air pollution and the multi-state operation of many on-road fleets, DMV implements on-road testing in conjunction with other Northeast states including New York, Massachusetts, New Jersey and Rhode Island The emission testing is done in conjunction with safety or weight inspections performed by the Department of Motor Vehicles (DMV). The emission test is conducted by measuring the smoke emitted by a heavy-duty diesel vehicle using an opacity meter. Those vehicles with smoke opacity exceeding the standards are required to be repaired. This program while limited to resource constraints can effectively target gross emitters. Under the current roadside emissions testing utilizing DMV's limited resources, three DMV inspectors test about 2,000 heavy-duty diesel vehicles per year.

In an effort to increase the numbers of vehicles tested annually, and utilize limited resources more efficiently, the DMV has recently established a self-testing for fleets or

dealers having ten or more heavy-duty diesel vehicles. Using the same procedures and standards as the roadside emission testing program, owners or dealers can self-certify their vehicles meet the Connecticut opacity standards. The environmental benefits and from the self-certification can be further enhanced through the adoption of tighter standards implemented throughout the Northeast. Consistent regional standards will provide regulatory certainty and will greatly streamline administrative processes by providing reciprocity for testing throughout the Northeast. Efforts are currently underway to coordinate implementation of more stringent opacity standards throughout the NESCAUM region.

Heavy Duty Diesel Engine-Not to Exceed Standards

In 2003 DEP adopted Section 22a-174-36a of the Regulations of State Agencies (Section 36a) in order to fill the time gap in federal regulation of heavy duty diesel engines (HDDE) and close a loophole that would have allowed dirtier heavy-duty diesel engines to be built during the 2005 and 2006 model years that could increase diesel exhaust emissions nationally by as much as 800,000 tons over the lifetime of the offending engines – *the equivalent of 30 million cars*. Section 36a requires that any new vehicles equipped with heavy-duty diesel engines of model years 2006 and beyond sold or otherwise transferred in Connecticut must first be certified for sale under California's emission control program.

DEP has estimated that this regulation will prevent a total of 1200 tons of excess NO_X emissions in calendar years 2005 and 2006 combined. Additional substantial increases would be expected for as long as these diesel engines remained in use, up to thirty years. The cost effectiveness of the proposed diesel regulation is estimated to be at the lower-end of other DEP measures to reduce NO_X emissions. EPA and California have estimated the lifetime cost to manufacture a clean 2005 and 2006 model year diesel engine to be approximately $800.[151]

DMV will ensure compliance through the vehicle registration process. DMV will make registration of HDDEs contingent on the registrant possessing a valid manufacturer's certificate of origin stating that the subject engine is approved by CARB for sale in the State of California. Thus, the state will ensure reporting and enforcement of the requirements of Section 36a. The penalty for failure to possess the necessary documentation is a denial of registration. DMV enforcement will ensure that these emissions reductions will be realized.

Beginning with the 2007 model year, all new heavy duty diesel engines will be required to meet federal emissions standards for PM that are equivalent to or more stringent than the emissions reductions recommended in Special Act 05-07 plus lower emissions of the ozone precursors, NO_X and hydrocarbons.[152] California has adopted these standards for

[151] California Air Resources Board, *Staff Report and Initial Statement of Reasons on Amendment to Adopt NTE and ESC Emission Test Procedures for the 2005 and Subsequent Model Year Heavy-Duty Diesel Engines* (October 20, 2000) at 34.
[152] 40 CFR 86.007-11.

2007 and later model years and Section 36a will insure that heavy-duty diesel vehicles (HDDVs) sold in Connecticut meet the 2007 standards as well.

Heavy Duty Diesel Engine-Chip Reflash Program

Another program strategy to consider is chip reflash. In the mid-1990s, the United States Department of Justice (US DOJ), EPA, and CARB discovered that the seven major engine manufacturers had designed their 1993 through 1998 model heavy-duty diesel engines to operate with advanced electronic engine controls that resulted in excessive NO_X emissions. Approximately 1.3 million engines were produced and calibrated to "pass" the US EPA heavy-duty diesel engine dynamometer certification test in the laboratory. However, when these engines were operated in the vehicle under "real world" conditions, the electronic calibration would change, altering the fuel delivery characteristics and causing elevated NO_X levels. From its investigation, in October 1998, DOJ, EPA and CARB announced completion of separate Consent Decrees (CD) with each of these seven heavy-duty engine manufacturers. The companies included Caterpillar, Cummins, Detroit Diesel, Mack Trucks, Navistar International, Renault, and Volvo.

Under the provisions of the CDs, the manufacturers are required to provide to their dealers modified software (the "Low-NO_X Rebuild Kit" or "chip reflash") that reduces the extent of the injection timing advance that causes the excess NO_X emissions. The dealers are to install the kits at the time the vehicle is brought in for a major engine rebuild/overhaul.

The rate of reflash has been considerably lower than what was envisioned under the CDs; the primary reason being that engine rebuilds occur at considerably higher elapsed vehicle mileage than what was contemplated when the CDs were negotiated. In response to this unacceptably low reflash rate, ARB has adopted a mandatory program, not tied to the time of rebuild, but rather to a prescribed period by which owners must bring their vehicles into the dealer to have the reflash operation performed, with all costs borne by the engine manufacturers.

All of the northeast states are also concerned that chip reflash has not occurred at the projected rate and are now considering a mandatory program, modeled after the California program. The following table illustrates the potential NO_X emissions (tons per day) that could be reduced in the Northeast if the states adopt a reflash program.

State	NO_X Reductions tons per day (TPD) from in-state registered vehicles
Connecticut	3.5
Maine	1.4
Massachusetts	6.7
New Hampshire	2.0
New Jersey	9.7

New York	16.1
Rhode Island	0.8
Vermont	0.9
Northeast Total	41.1

NESCAUM is in the process of developing a model "reflash" rule, DEP will continue to evaluate this as a potential reduction strategy. If DEP were to adopt a regulatory chip reflash rule, program development costs for a regulation could range from $75,000 to $150,000 plus associated administrative costs (2 FTEs).

Anti Idling and Truck Stop Electrification

Each year, U.S. trucks consume more than 800 million gallons of diesel fuel—without even moving. Truckers idle their engines while they rest for a variety of reasons, including heating or cooling, preventing start-up problems, or to operate electrical equipment. Conserving diesel fuel that would otherwise be idled away represents an opportunity to reduce petroleum consumption. Studies have shown that a typical long-haul tractor-trailer idles approximately 1,830 hours per year. Across the industry, this practice consumes more than 800 million gallons of diesel fuel annually, approximately 8 million gallons in Connecticut. Excessive idling also contributes to air pollution and noise. Although many states, including Connecticut, have enacted laws and regulations to reduce idling, truckers must also comply with federal mandatory rest requirements and many states, including Connecticut. At times there are limitations that make compliance with federal rest requirements and anti-idling provisions difficult. EPA has developed a draft model rule that provides a useful blueprint for considering additional enhancement to existing anti-idling efforts. DEP will continue to partner with EPA in evaluating various models that could enhance Connecticut's existing efforts.

This year DEP partnered with Secondi Bros. Truck Stop in Milford, CT to secure funding from EPA to begin the construction of an idle-free corridor through the state by the successful use Advanced Truck Stop Electrification (ATSE) technology. The Secondi site is a well-situated truck stop facility located at the confluence of interstates I-95 and I-91, the most traveled area in Connecticut, and one of the most traveled in the northeast. Because this area is a primary transportation corridor between New England and the rest of the country, it is an ideal location for such a project. The potential health benefits from reducing diesel emissions in a state with nonattainment areas for both 8-hour ozone and $PM_{2.5}$ are also strong considerations for investing in idle reduction technology in this location and for developing an idle free corridor in the state. DEP will continue to pursue funding opportunities as this represents an effective diesel reduction strategy for Connecticut's on-road fleet.

The following discussion provides a general overview of potential implementation options put forward as part of the stakeholder process. Additional research and analysis will assist greatly in refining the options for future consideration.

B. Evaluation of Fleet Retrofit, Replacement Retirement Options

Information provided at the Diesel Emissions Reduction Policy, Technology and Clean Fuels Forum indicated there are several technologies available to reduce in-use emissions from on-road heavy-duty diesel vehicles. This information is available at: http://www.dep.state.ct.us/air2/diesel/techforum17aug05.htm

In addition to information provided by various stakeholders at the Diesel Emissions Reduction Policy, Technology and Clean Fuels Forum, the DEP received a memorandum dated November 10,2005, from Environment Northeast (ENE) outlining policy mechanisms, estimated costs and benefits and implementation options to reduce diesel PM emissions from waste collection vehicles in Connecticut.[153] Solid waste collection vehicles (SWCVs) are heavy diesel-powered trucks that produce the normal range of pollutants associated with heavy-duty diesel engines. In addition, the lift and crush mechanisms increase the operational time of the diesel engines and vehicle idle time in residential neighborhoods and at disposal facilities. These special characteristics of SWCVs increase their emissions and the resultant danger to public health.

New Haven, alone, operates 18 SWCVs; the statewide fleet is estimated to be 1,200 SWCVs. Based on information received from the Connecticut Resource Recovery Authority (CRRA) a total of 2,087 vehicles, owned by just over 300 solid waste haulers, are licensed by CRRA to dispose at the Mid-Connecticut, Wallingford and Bridgeport facilities.[154] Additional research must be done to develop a more detailed inventory for other facilities in the State. Many of these concentrate their activities in urban areas where levels of air pollution are already elevated due to other air pollution sources. Controlling emissions from SWCVs would help to reduce exposure to diesel emissions. According to ENE, waste vehicles should be prioritized for retro-fit or re-powering because they:

- Travel at low speeds and idle frequently in neighborhoods and commercial centers directly exposing people to their exhaust;
- Operate in significant numbers in urban areas where diesel emission reductions should be prioritized; and
- Are likely to be either publicly owned or privately owned but under public contract.

ENE identified three models on which a Connecticut plan could be based to substantially reduce emissions from waste collection vehicles. These models are:

- **The California model,**[155] under which the "best available control technology" (BACT) requirement is applied to all 12,000 public and private waste collection vehicles on a phase-in basis by 2010;

[153] Environment Northeast, Waste Collection Vehicles Options Memo, November 10, 2005, see Attachment A.

[154] Many of these vehicles are not SWCVs, but trucks owned by construction, landscaping and other firms that handle and dispose of solid waste.

[155] More details of the CARB model can be found at www.arb.ca.gov/msprog/SWCV/SWCV.htm.

- **The New Jersey model**, under which the "best available retrofit technology" (BART) is applied to all 2180 publicly owned or publicly contracted waste collection vehicles beginning in 2007; and
- **The New York City model**,[156] under which an estimated 2,500 waste collection vehicles under city contract must use ULSD and meet a BACT standard by March 1, 2006 (publicly owned waste collection vehicles must implement BACT on a phase-in basis by 2012.

ENE notes that prior to developing a plan and choosing an appropriate model for Connecticut, DEP must complete an inventory of waste collection vehicles, specifically including the following information:

- Total number of waste collection vehicles;
- Vehicle owner and operating location;
- Engine model year and manufacturer; and
- General duty-cycle information.

In its memo, ENE projects that retrofitting all the SWCVs in the state with diesel particulate filters, the most effective and costly aftermarket emissions control technology, would cost up to $9 million and have a cumulative benefit of reducing up to 100 tons of PM emissions.[157]

C. Evaluation of Clean Fuel Options

In addition to information provided by various stakeholders at the Diesel Emissions Reduction Policy, Technology and Clean Fuels Forum, the DEP received a memorandum dated November 17, 2005, from Connecticut's Clean Cities coordinators.[158] The memorandum, entitled "Incorporating Alternative Fuel Vehicles into Connecticut's Diesel Mitigation Plan" provided background information on the Clean Cities program, a summary of Connecticut's alternative fuel vehicle (AFV) programs, highlights of current AFV fleets in Connecticut, and highlights of other state alternate fuel vehicle programs. The Clean Cities coordinator's memorandum also contained specific recommendations for inclusion into the On-road fleets portion of the diesel plan.

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[156] New York City's local laws 39 and 40 can be found at http://www.nyccouncil.info/pdf_files/bills/law05039.pdf and http://www.nyccouncil.info/pdf_files/bills/law05040.pdf.

[157] See Attachment A.

[158] The Clean Cities program is a Department of Energy voluntary program established by the 1992 Energy Policy Act to advance the nation's economic, environmental, and energy security by supporting local decisions, the effect of which contributes to the reduction of petroleum consumption by on-road vehicles. Clean Cities carries out this mission through a network of eighty-eight volunteer coalitions across the USA. The state of Connecticut has four "Clean Cities": Greater New Haven, Southwest Connecticut, Capital Area, and Norwich. For more information on Clean Cities, go to the DOE Clean Cities website: www.eere.energy.gov/cleancities

According to the US Department of Energy, Connecticut is currently home to 1106 Compressed Natural Gas (CNG), 52 dedicated electric, and 648 Flexible Fuel Ethanol Vehicles[159]. The State is also home to 4 biodiesel stations (1-New Haven and 3-CT DOT), which dispense B20, a blend of 20% vegetable oil and 80% conventional diesel fuel. Connecticut Clean Cities estimates that the current AFV programs in the state are responsible for displacing approximately 75,000 gallons of diesel fuel annually[160]. The diesel displacement figures are based on the use of heavy duty natural gas vehicles in Fairfield Trumbull, Stratford and Norwich, the use of dedicated electric trolleys in New Haven, and the Connecticut Department of Transportation's (DOT's) statewide use of B20.

While the 1992 Energy Policy Act defines numerous fuels as "alternative fuels", the most viable and widespread alternative fuels in use in Connecticut to date have been CNG and biodiesel. The future potential to increase the use of these fuels is seen as a short term and long term replacement for conventional diesel fuel.

Natural Gas 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 emit significantly fewer pollutants than diesel vehicles: 40% to 86% less PM and 38% to 58% less NO_X for heavy duty natural gas transit buses, school buses, refuse trucks and utility vehicles.

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. 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.

Biodiesel is a cleaner-burning version of diesel fuel made from natural, renewable sources such as vegetable oils rather than petroleum. Biodiesel may be used as a blend fuel (as low as 5% to 20% biodiesel) or as a single neat fuel (100% biodiesel). Studies indicate that B100 and biodiesel blends generate less PM than conventional diesel (55% less PM from B100 and 18% less PM from B20), but more nitrogen oxides (6% more NO_X with B100) than 100% petroleum diesel[161] and 2-3% more NO_X with B20 (when engine tested by a dynamometer) than 100% petroleum diesel[162]. Recent tests by the

[159] Source: DOE's Energy Information Administration's "Alternative Fuels Estimated Data 2000", http://www.eia.doe.gov/cneaf/alternate/page/datatables/table4.html

[160] Note: figure does not include displacement from gasoline powered vehicles.

[161] *Biodiesel, The Clean Green Fuel for Diesel Engines*, US Department of Energy, 2000, http://www.eere.energy.gov/cleancities/blends/pdfs/5450.pdf.

[162] *Biodiesel, The Clean Green Fuel for Diesel Engines*, US Department of Energy, 2000, http://www.eere.energy.gov/cleancities/blends/pdfs/5450.pdf.

National Renewable Energy Laboratory have shown a reduction in NO_X when the entire vehicle was tested under a load. Because biodiesel contains no sulfur, however, vehicles powered by this fuel can use advanced aftermarket emission control devices to further reduce harmful emissions.

Up until recently B100 biodiesel was as much as a dollar more than regular diesel fuel per gallon. In the last few months, due to federal legislation, the price of biodiesel has dropped to the same as regular diesel regardless of the blend percentage. Biodiesel blend fuels are increasingly popular because they can be used in conventional engines with few or no modifications.

Alternative Fuel Infrastructure

The eight states comprising the NESCAUM region have the following alternative fueling infrastructure:

As of 11/21/2005

NESCAUM REGION	CNG	E85	LPG	ELEC	BD	HY	LNG	Totals by State
Connecticut	11	0	19	4	1	0	0	35
Maine	0	0	12	0	3	0	0	15
Massachusetts	9	0	28	29	1	0	0	67
New Hampshire	0	0	19	8	11	0	0	38
New Jersey	18	0	14	0	1	0	0	33
New York	33	6	47	1	0	0	0	87
Rhode Island	6	0	4	1	0	0	0	11
Vermont	1	0	12	10	4	0	0	27
Totals by Fuel:	78	6	155	53	21	0	0	313

D. Evaluation of Anti-Idling Provisions

The DEP maintains regulatory authority that prohibits excessive idling of all motor vehicles. See the Regulations of Connecticut State Agencies section 22a-174-18(b)(3)(C) at: http://www.dep.state.ct.us/air2/regs/mainregs/sec18.pdf.

DEP's anti-idling regulations apply to every vehicle in Connecticut, including heavy-duty diesel vehicles. Anti-idling programs provide a cost-effective and easy way to improve air quality and immediately reduce the exposure of people to the potential health impacts of diesel exhaust. Idling vehicles create emissions that contribute to the formation of smog and ground level ozone, and produce carbon dioxide (a greenhouse gas). Diesel exhaust even contains toxic air pollutants, including aldehydes (formaldehyde, acetaldehyde, acrolein), benzene, 1,3-butadiene, and polycyclic aromatic hydrocarbons (PAHs). The United States Environmental Protection Agency (EPA) estimates that nationally diesel engines are the third largest source of fine particles, which can cause

lung damage and aggravate respiratory conditions including asthma and bronchitis. These emissions can have a direct effect on the health of adults and children who inhale the exhaust.

Reducing diesel engine idling also saves money by conserving fuel and reducing engine wear. Because an idling engine is not operating at its optimal temperature, incomplete combustion occurs, allowing fuel residue to condense on engine parts like spark plugs and can even contaminate engine oil.

EPA is developing a "model" rule on anti-idling. About half of the country has state or local laws limiting the amount of time heavy-duty vehicles can idle, and many of these laws differ from location-to-location, making compliance especially difficult for truck drivers. The purpose of EPA's effort is to create more consistency in idling laws across the country. EPA's effort will inform states or localities as to the consensus view of what constitutes an effective and fair idling law.

In furtherance of this effort, EPA sponsored a meeting on July 26, 2005, in Hartford, Connecticut, to develop a model state idling law. Participants included representatives from states and local governments, trucking industry, and environmental and community groups.[163,164]

Compliance and outreach are vital to the success of any regulatory program. Constant reminders, such as anti-idling signs, significantly improve compliance rates with an idling restriction. Therefore, DEP is continuing its efforts to reduce unnecessary idling and increase awareness of the environmental and health effects of idling on schoolchildren, by providing free anti-idling signs to Connecticut public schools that agree to post them.

DEP has partnered with the Connecticut Department of Transportation to develop and post anti-idling signs at Connecticut rest areas to help increase awareness and compliance rates among truck drivers and the general public who visit these facilities.

Heavy-duty Idling Enforcement Case Study:

EPA announced on November 1, 2005 that Wal-Mart Stores Inc. (Wal-Mart) is taking steps to reduce diesel truck idling at its 4,000 facilities across the U.S. The anti-idling project results from a clean air enforcement action in Massachusetts and Connecticut brought by EPA's New England regional office.

Wal-Mart entered into the settlement based on EPA's complaint that Wal-Mart trucks were illegally idling at Wal-Mart stores in Massachusetts and Connecticut. In fall 2004,

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[163] This document summarizes the views and opinions of the participants who were working towards consensus on a model state idling law.
http://www.dep.state.ct.us/air2/diesel/docs/epahartfordantiidlesummary.pdf

[164] The EPA presentation to initiate the meeting is provided as the second document.
http://www.dep.state.ct.us/air2/diesel/docs/epaantidlelawdev.pdf

EPA inspectors observed trucks owned by Wal-Mart and by other trucking companies idling for long periods of time at six different Wal-Mart properties in Connecticut and Massachusetts. Inspectors observed delivery vehicles idling during the day as well as sleeper cabs idling at night. EPA's action signifies their intent to enforce idling regulations that are part of a state's federally enforceable air quality plans and is the country's first multi-state anti-idling case. The settlement agreement will result in Wal-Mart taking action across the country to address truck idling. Wal-Mart intends to train their drivers, post signs at all Wal-Mart facilities, and notify other delivery companies of Wal-Mart's policy to prohibit idling. Wal-Mart will also pay a modest civil penalty to the federal government.

According to EPA, a typical idling truck burns nearly a gallon of fuel per hour. A fleet of 7,000 trucks, about the size of Wal-Mart's fleet, idling for one hour a day would burn 2.1 million gallons of diesel fuel each year, and create 415 tons of smog-forming pollutants, 10 tons of harmful particulate matter, and 23,000 tons of carbon dioxide, which contributes to global climate change.

According to EPA, the following states and localities have anti-idling restrictions in place. The states with anti-idling restrictions include all or part of Arizona, California, Colorado, Connecticut, Delaware, Georgia, Hawaii, Maryland, Massachusetts, Minnesota, Missouri, Nevada, New Hampshire, New Jersey, New York, Pennsylvania, Texas, Utah and Virginia. Several states (including Massachusetts, Connecticut, Virginia, New Jersey, Hawaii and portions of Texas) have included these idling restrictions in their state implementation plan, making those rules federally-enforceable. Municipal governments that have developed anti-idling requirements to attain cleaner air include Maricopa County, AZ; Denver, CO; District of Columbia; Atlanta, GA; Owatonna and St. Cloud, MN; St. Louis, MO; Clark County and Washoe County, NV; New York City, NY; Allegheny County and Philadelphia, PA; Brazoria County, Chambers County, Fort Bend County, Galveston County, Harris County, Liberty County, Montgomery County and Waller County, TX; Salt Lake County, UT.

Several idle control technologies can aid fleets in limiting idling time and complying with state regulations. Automatic shutdown devices can switch off parked trucks after predetermined time intervals. Auxiliary Power Units (APUs) – which typically only consume between 0.05 and 0.2 gallons of fuel per hour – can provide heat, air conditioning, and power without running the main engine. Trucks can be fitted with devices that allow them to plug into electrical outlets to provide power and climate control for the cab when parked. These idle control devices typically have a payback time of one to two years in fuel costs alone and can significantly reduce wear and tear on engines.

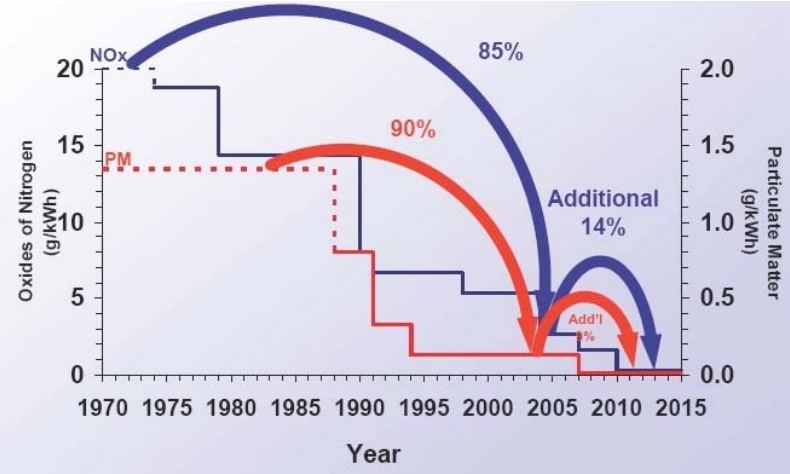
E. Identification and Evaluation of Leveraging Opportunities

The on-road fleets subcommittee sought to identify existing programs and/or funding streams for inclusion in the recommendations. This approach is based on fundamental reasoning that it is often more efficient to use limited resources to improve existing

programs or re-direct existing funding streams rather than develop entirely new programs. As such, the following were identified as areas where possible leveraging opportunities exist:

1. Programs
   - On-road emissions testing of HDDVs – tighter standards & wider applicability;
   - Anti-idling – greater outreach & stronger penalties; and
   - Implementation of federal emission standards for on-road HDDVs (fleet turnover);

Figure 2
U.S. On-Highway Emission Standards

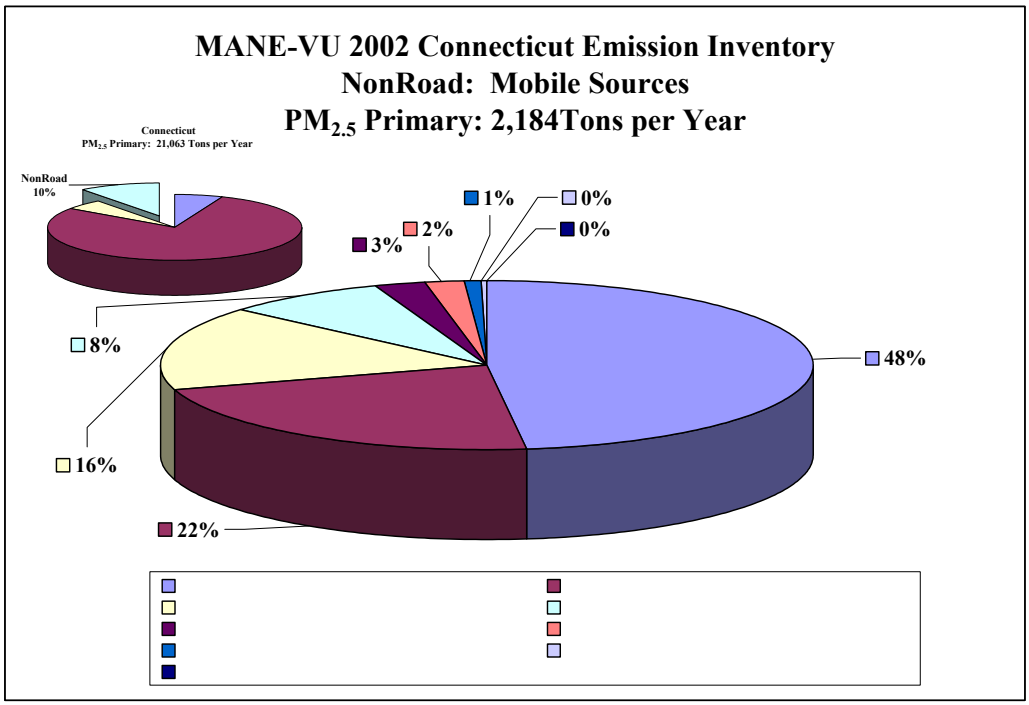


2. Funding
   - Fuel tax options to promote early use of ultra-low sulfur diesel (ULSD) fuel;
   - Tax incentives to promote purchase of new 2007 and later model year compliant HDDVs (fleet turnover); and
   - Seek funding from petroleum gross receipts tax – increased fuel prices have greatly increased funds collected under this tax.

F. Other Mobile Sources of Diesel Emissions

Two other sources, though not related to on-road fleets, were presented for consideration by the group: locomotives and marine diesel engines. There are three types of locomotive diesel
engines: line-haul (e.g., freight), passenger and switch. Diesel marine applications include category 1 commercial vessels, such as police boats and fishing vessels; category 2 commercial vessels such as ferries and tugboats; and recreational vessels such as powerboats. According to the U.S. EPA, by 2030 locomotives and marine sources will emit 45% of national diesel PM emissions and 27% of national NO_X emissions. Furthermore, by 2007 the sulfur content of locomotive and marine diesel fuel will be reduced to 500 parts per million (ppm). The sulfur content of this fuel will be further reduced to 15 ppm sulfur between 2012 and 2014.

Figure 3



A. Locomotives.

Diesel powered locomotives emit high rates of PM, NO_X and other hazardous air pollutants and are under-regulated relative to other mobile sources of air pollution. In some northeast states, over half of locomotive emissions come from commuter and passenger rail operations. According to MANE-VU Railroad equipment accounts for 6 tons of Connecticut's non-road mobile source emissions of PM per year. Because of this, reducing locomotive PM and NO_X is a priority in order to lower public exposure to these pollutants. Similarly, locomotives that spend a lot of time idling are also a significant health concern. Switcher locomotives spend up to eighty percent of their total operation time idling. This activity increases the exposure of diesel exhaust to surrounding community.

Local railroads include switching and terminal operations and small line-haul operators. Switch locomotives assemble and disassemble trains at local rail yards. Passenger rail in New Haven includes Amtrak's intercity service and commuter service provided by the DOT. While line-haul freight trains are the largest national source of locomotive emissions, commuter and switching operations may have significant local impact on air quality and public health. DEP has an evaluation underway to identify the most cost effective strategies for reducing emissions from locomotives. Since regulation of this sector is reserved to the federal government, locomotives would be a logical priority for voluntary reduction strategies and as a focus for funding. Newly adopted federal standards will reduce NO_X and diesel PM emissions from locomotives as follows:

1. Tier 0 Standards – new 2001 locomotives and rebuilds of 1973-2001 locomotives will reduce NO_X by 30-33%.

2. Tier 1 Standards – new 2002-04 locomotives will reduce NO_X by 50%.

3. Tier 2 Standards – new 2005 and subsequent locomotives will reduce NO_X by 60% and diesel PM by 50%.

Non-federal locomotive standards could include:

1. Locomotives operators could be made subject to an anti-idling standard. Pilot projects in CT and MA demonstrate that installation of auxiliary power units
(APUs) can reduce idling fuel consumption by up to 85% - resulting in fuel savings up to 25,500 gallons per year.

2. A pilot demonstration project is underway in Boston to test a DOC on a commuter train. Diesel PM reductions are anticipated to be 15-35%. ***update from Tom Balon?***

3. The State of California has entered into a voluntary pollution reduction agreement[165] with Union Pacific Railroad Company and BNSF Railway Company to expeditiously implement a number of measures to reduce emissions from locomotives and rail yards in California. Such measures include:

- Installing idling reduction devices on California-based locomotives within 3 years;
- Phasing out non-essential idling by locomotives within six months;
- Identifying and repairing locomotives with excessive smoke; and
- Maximizing the use of ULSD (15 ppm sulfur) by January 1, 2007, six years before such fuel is required by federal regulation.

The approximate cost to inventory, assess retrofit viability and proceed to retrofit a locomotive would exceed $200,000. Although this seems expensive, this strategy could provide cost-effective emission reductions of approximately $200/ton of NO_X.

B. Marine Vessels (Ferries): MANE-VU data indicate that commercial marine equipment in Connecticut accounted for 175 tons or 8% of non-road mobile source emissions of PM in 2002. This is nearly six times the PM emissions from transit and school buses combined. Newly adopted federal standards for marine

[165] The California Air Resource Board, upon considering the preemption issues raised by the Interstate Commerce Commission Termination Act of 1995 (ICCTA), determined there is a strong potential of preemption on any state or local regulation addressing locomotives. As such, CARB proceeded with a voluntary agreement.

engines consist of several sets of emission standards, which vary based on engine size and fuel type. The standards apply to new gasoline and diesel powered marine engines manufactured after the effective date of the standards between 2004 and 2007. The approximate cost to inventory, assess retrofit viability and proceed to retrofit a marine vehicle could exceed $200,000. Although this seems expensive, this strategy could provide cost-effective emission reductions of approximately $200/ton of NO_X. More detailed information on the federal marine diesel engine emission standards is available at: http://www.epa.gov/otaq/marine.htm

III. On-Road Strategies

The current inventory is somewhat limited to develop detailed evaluation of fleet-wide emission reduction options. Prior to developing fleet specific emission reduction strategies and choosing an appropriate model for Connecticut, a complete inventory of on-road vehicles is needed, specifically including the following information:

- Number vehicles by fleet type;
- Vehicle owner and operating location;
- Engine model year and manufacturer; and
- General duty-cycle information.

A draft strategy for reducing emissions from waste haulers is included below although more research is necessary to fully evaluate implementation steps.

A. Strategies for near term implementation (building upon existing programs)

1. Expand on-road heavy-duty vehicle emissions testing program to include all vehicles between 18,001 and 25,999 pounds GVWR. These vehicles are currently exempt from emissions testing even though vehicles below and above this weight class are subject to emissions testing.[166]
2. Consider adopting Heavy-Duty Inspection and Maintenance (Heavy Duty I&M) for 2005 and later On-Board Diagnostic Trucks. Heavy-Duty I&M could be implemented in concert with DMV's Fleet/Dealer Certification program and could be evaluated for inclusion in DMV's existing program.
3. Expand anti-idling program through a combination of outreach and enhanced enforcement through legislative action to authorize municipal police officers to issue citations for violation of idling regulation. As part of a continuing education package required for employment and/or licensure, drivers should review the operators' anti-idling policies as well as the state anti-idling regulations.
4. Continue to apply for federal funding as it is made available for on-road heavy-duty diesel retrofits, truck stop electrification or truck stop auxiliary power units.

[166] This strategy would require an investment in additional DMV resources currently estimated at $250,000 for additional personnel and testing equipment.

5. Develop an education and outreach program for fleet owners promoting the opportunities and benefits associated with accelerated fleet turnover.

B. Strategies for mid-term implementation (leveraging opportunities)

1. Develop and implement a strategy to address waste haulers. These vehicles are numerous and widely operated in Connecticut. DEP should explore opportunities to leverage existing programs (e.g., solid waste permitting authority) to address air emission impacts of waste haulers.

2. Seek CMAQ funding for truck stop auxiliary power units (APUs) and for development of truck stop electrification (TSE) infrastructure.

3. Develop "Chip Re-flashing" regulations to require the installation of low-NO_X software in eligible HDDVs.

4. Consider including OBD-equipped medium duty vehicles between 10,001 and 25,999 pounds GVWR into the bi-annual emissions testing program upon contract renewal.

C. Strategies for long-term implementation

1. Inventory locomotives and assess viability of retrofit technologies. Provided it is technically feasible and funding is available, proceed to retrofit.

2. Inventory marine Vessels (ferries) and assess viability of retrofit technologies. Provided it is technically feasible and funding is available, proceed to retrofit.

3. Inventory state and municipally owned heavy-duty diesel vehicles. Assess timeframe by which such fleets will be in compliance with federal 2007 emission standards.

However, based upon DEP's research and the input provided by stakeholders DEP has focused on waste haulers as a priority fleet and has developed several options for reducing emissions from waste haulers. Several reasons support the prioritization of waste haulers for retrofits. Typically this fleet:[167]

- Travels at low speeds and idle frequently in neighborhoods and commercial centers directly exposing people to their exhaust;
- Operates in significant numbers in urban areas where diesel emission reductions should be prioritized; and
- Is likely to be either publicly owned or privately owned but under public contract.

Option 1: Mandatory Retrofits for Waste Haulers

[167] See Attachment A.

A mandatory retrofit program can be pursued through one of three mechanisms: a statutory requirement, adoption of new regulations or inclusion as a permit condition. These three approaches are discussed in more detail below.

Statutory Provision: The General Assembly could craft legislation to require the installation of "best available control technology" (BACT) requirement. This is similar to the New York City model, under which an estimated 2,500 waste collection vehicles under city contract must use ULSD and meet a BACT standard by March 1, 2006 (publicly owned waste collection vehicles must implement BACT on a phase-in basis by 2012. In its memo, ENE projects that retrofitting all the SWCVs in the state with diesel particulate filters, the most effective and costly aftermarket emissions control technology, would cost up to $9 million and have a cumulative benefit of reducing up to 100 tons of

- PM emissions.[168] Emissions reductions from SWCVs could also be accomplished through implementation of new air quality regulations, as in California, or through permit conditions.
- **Turnover and Incentives:** As with other sectors, incentives to encourage early retirement and replacement of vehicles with cleaner SWCVs that comply with the 2007 standards could be very effective in reducing emissions of both PM and NO_X.

Option 2: Heavy Duty Diesel Inspection and Maintenance Program

Expand on-road heavy-duty vehicle emissions testing program to include all vehicles between 10,001 and 25,999 pounds GVWR. These vehicles represent 42% of the fleet and are currently exempt from emissions testing even though vehicles below and above this weight class are subject to emissions testing.

Option 3: Anti-Idling and Truck Stop Electrification

DEP's anti-idling regulations apply to every vehicle in Connecticut, including heavy-duty diesel vehicles. Anti-idling programs provide a cost-effective and easy way to improve air quality and immediately reduce the exposure of people to the potential health impacts of diesel exhaust. Reducing diesel engine idling also saves money by conserving fuel and reducing engine wear. Enforcement capabilities need to be supplemented with broader police authority to ticket violators for excessive idling.

IV. Conclusion

Concluding statement on how to move forward with the recommendations and options presented above.

[168] ibid.

Attachment A

MEMO

To: On-road Fleets Subcommittee
From: Madeleine Weil, Environment Northeast
Date: November 10, 2005
Re: Waste Collection Vehicle Options Memo

Purpose

This memo outlines potential policy options for cleaning up waste collection vehicles in Connecticut. Feedback from the group regarding policy mechanisms, estimated costs and benefits, and implementation avenues is welcome as it will help improve assessment.

Background

Waste collection vehicles have been targeted for priority clean-up efforts by other jurisdictions engaged in comprehensive diesel emission reduction programs.

These jurisdictions have prioritized waste collection vehicles because they:

- Travel at low speeds and idle frequently in neighborhoods and commercial centers where people are directly exposed to exhaust;
- Operate in significant numbers in urban areas where reductions in diesel emissions should be prioritized; and
- Are likely to be publicly-owned, or privately-owned but publicly-contracted**.**

Clean Up Option Summaries

- California model – BACT mandate applies to all public and private waste collection fleets (est. 12,000 vehicles). Costs will be passed on to customers (estimated $1 per household per year). Mandate phased in through 2010;
- NJ model – BART mandate applies to all publicly-owned or publicly-contracted fleets (state, county, municipal, est. 2180 vehicles). Costs will be reimbursed by state "Diesel Risk Mitigation Fund;"
- NYC model – ULSD and BACT is required in the fulfillment of solid waste contracts or recyclable materials contracts with a city agency (est. 2,500 vehicles). Costs will be built into City contracts, contractors must comply by March 1, 2006. Publicly-owned diesel vehicles (including solid waste vehicles) must phase-in BACT between 2007 and 2012;

CT's Waste Collection Fleet

- For this options memo, it has been estimated that 1200 waste collection vehicles operate in Connecticut. This estimate is based on the DEP's observation that the California vehicle population can be used as a proxy, (the CT vehicle population is typically 1/10th the size of CA).[169]
- It is recommended that a complete inventory of waste collection vehicles in Connecticut be developed. This would include:
    - number of waste collection vehicles
    - engine vintage;
    - engine manufacturer;
    - ownership, (public/private);
    - location of fleet.

Priority Communities

Some communities in Connecticut are more at risk than others from elevated levels of $PM_{2.5}$. These communities should be prioritized for expedited emission reductions if resources do not permit immediate statewide implementation.

[169] Paul Farrell, DEP, 9/8/05

Option 1 – High PM Reductions: "Best-Available Control Technology" requirement, maximizes emission reductions on ALL waste collection vehicles by 2010 (based on CARB's Waste Collection Vehicle Regulation), see *www.arb.ca.gov/msprog/SWCV/SWCV.htm*.

Application:

- The requirement would apply to owners of waste collection vehicles.
    - An "owner" can be a private company operating independently or under contract, or a city, state or federal agency;
    - "Waste collection vehicles" are diesel-fueled trucks over 14,000 pounds used to collect residential or commercial solid waste or recyclable materials;

Compliance:

- How would owners comply with the BACT requirement?
    - Purchasing an engine certified to the 2007 model year PM standard of 0.01 g/bhp-hr
    - Installing an EPA/CARB-verified retrofit device that reduces PM by the greatest amount possible for the particular engine and application (see BACT levels below):
        - The right BACT retrofit device depends on if:
            - The device is certified for the engine;
            - The duty cycle of the vehicle matches requirements;
            - The engine warranty can not be voided by using the device.
        - Engines too old to be retrofitted need to be repowered so that an emission control device can be installed;
    - Using an alternative fuel engine, alone or in combination with one of the options above, that reduces PM at least as much as a BACT retrofit device.

What would qualify as a BACT retrofit device:

- "BACT" is a technology or clean fuel verified by the EPA or CARB to reduce particulate matter (PM). To qualify as "BACT," a fuel or technology must reduce the engine's PM to the highest level possible. There are three levels of CARB-verified diesel emission control strategies:
    - **Level 1** reduces PM at least 25%
    - **Level 2** reduces PM at least 50%
    - **Level 3** reduces PM at least 85% or reduces PM emissions to at least 0.01 g/bhp-hr

Costs:

- Assume owners are most likely to retrofit 1991-2006 engines with a passive DPF or a DOC.
    - A DPF would cost approximately $5,000 - $8,000 (including installation and backpressure monitor);
    - A DOC would cost $3,000 - $4,000 (including installation, no backpressure monitor necessary).

- Older engines may need to be repowered before they can be retrofitted with a DPF or a DOC.
    - The average cost of a repower is $45,000, with a range of $21,000 - $90,000. Total average cost, with a filter installation, would be about $50,000.
    - Alternatively, older engines can be replaced with new 2007-compliant diesel vehicles or alternative fuel vehicles.

How would costs be covered:

- Since waste collection is a fee-based activity, CARB expects vehicle owners to raise fees to pay for the costs of compliance. CARB expects municipalities and service providers to work together to amend or renegotiate contracts as needed so that service fees reflect the service providers costs for compliance.
- CARB estimates that total costs of compliance will average out to about $1 per household, statewide.

Timeframe:

- Implementation requirements are phased in through 2010, based on engine model year, see schedule to the right, (http://www.arb.ca.gov/diesel/factsheets/trashtruck.pdf);
- Compliance extensions are given for early implementation, and for engines that have no verified control strategies.

IMPLEMENTATION BY ENGINE MODEL YEARS

Group 1 **	1988 - 2002	DEADLINE
	10 % BACT	December 31, 2004
	25 % BACT	December 31, 2005
	50 % BACT	December 31, 2006
	100 % BACT	December 31, 2007
Group 2a *	1960 -87	(Fleets of 15 or more vehicles)
	15 % BACT	December 31, 2005
	40 % BACT	December 31, 2006
	60 % BACT	December 31, 2007
	80 % BACT	December 31, 2008
	100 % BACT	December 31, 2009
Group 2b **	1960 - 87	(Fleets of 14 or fewer vehicles)
	25 % BACT	December 31, 2007
	50 % BACT	December 31, 2008
	75 % BACT	December 31, 2009
	100 % BACT	December 31, 2010
Group 3 **	2003 - 06	(includes dual & bi-fuel engines)
	50 % BACT	December 31, 2009
	100 % BACT	December 31, 2010

* GROUP 2a: level 1 technology may not be used as BACT

** Owners with total fleets of 1-3 vehicles may delay compliance until the final deadline for each group.

Enforcement:

- CARB will enforce the regulation through roadside inspections and visits to maintenance yards or terminals;
- Civil penalties will be assessed for non-compliance, and may range from $500 per day to $25,000 per day, depending on the violation.

Estimated Costs and Benefits in Connecticut:

Adopting a similar program in Connecticut would require BACT for an estimated 1200 waste haulers (the entire estimated population).

- Costs:
    - Assuming the highest level of BACT (a passive diesel particulate filter) is feasible for every truck, total estimated capital costs equal:
        - 1200 trucks * $7,500[170] = $9 million
    - Assuming that retrofits are phased in over four years between 2007, and 2010, the operating cost of cleaning filters equals:
        - 2008: 300 filters * $500[171] = $150,000

[170] Cost of diesel particulate filter, installation, and backpressure monitor used in calculations by the Transit Bus subcommittee, based on CT Transit experience.

[171] Cost of annual filter cleaning used in calculations by the Transit Bus subcommittee, based on CT Transit experience.

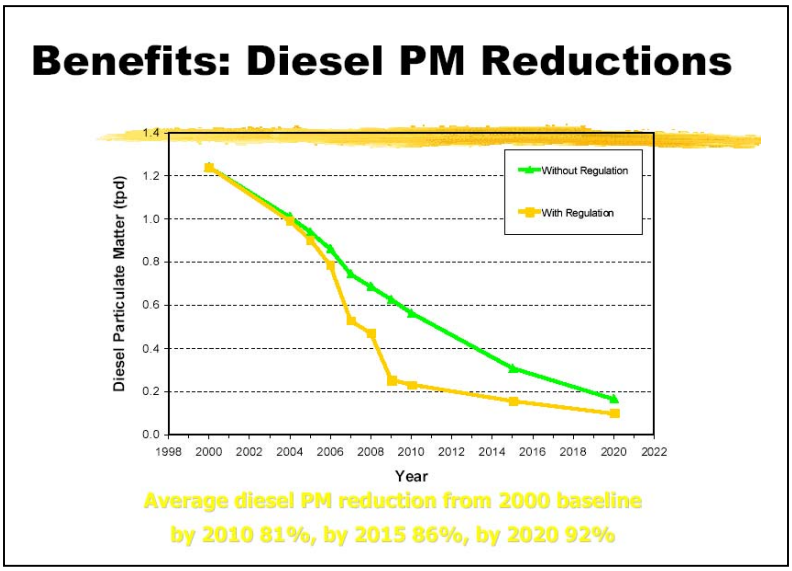
- 2009: 600 filters * $500 = $300,000
- 2010: 900 filters * $500 = $450,000
- 2011: 1200 filters * $500 = $600,000

- Cost Caveats:

- For some engines, particularly pre-2002 Mack engines, the BACT will be a wire mesh filter (or high-performance DOC) rather than a DPF. These installations are much cheaper, (estimated $3,000 versus $7,500) and they do not require annual filter cleanings.

- Under this option, owners would be required to repower waste collection trucks older than 1991 (average cost $50,000 per truck) or replace engines with new 2007-compliant models. It is not known how many older, pre-1991 trucks operate in Connecticut.

- Benefits:
  - Connecticut benefits pro-rated from CARB's benefit assessment (see chart below):



Connecticut waste collection emissions (tons per day)

	2010	2015
Without regulation	0.058	0.03
With regulation	0.022	0.016

- Estimated annual benefits of regulation in 2010: 13.14 tons PM reduced
- Estimate cumulative benefits of regulation: 100 tons PM reduced

California Contact:

- Richard Varenchik, California Air Resources Board, 626-575-6730

California Progress To Date:
The California Air Resources Board is currently preparing a progress report on implementation by Group 1 fleets subject to the December 31, 2004 deadline (see implementation chart on previous page). So far, they have received reports covering 8400 Group 1 vehicles. 3040 of these vehicles have been brought into compliance by the following means:

- 194 LNG (liquefied natural gas) vehicles
- 552 CNG (compressed natural gas) vehicles

1619 DOC (diesel oxidation catalyst) retrofits

- 676 DPF (diesel particulate filter) retrofits

Staff Reports on Implementation - (Richard Varenchik)

- When the rule came into effect in early 2004, a DOC qualified as BACT for many sanitation trucks because few DPFs had been verified at that time. Fleet owners rushed to retrofit with DOCs to avoid more costly DPFs. Now, DOCs would no longer be considered BACT for a large majority of sanitation trucks;
- The early compliance rule allows fleet owners to delay 100% implementation by two years (from 2007 to 2009) if they bring 50% of their fleet into compliance by July 2005. Several of the large fleet owners took this route by retrofitting 50% of their fleet with DOCs early in 2004 (before a variety of DPFs were verified);
- To staff's knowledge, no truck has been brought into compliance through a repower plus a retrofit. Instead, fleet owners are choosing to retire old trucks, or shift them to back-up duty. Trucks that are going to be retired in less than one year and back-up trucks are exempt under CARB's rule;
- Advice from Varenchik: Classifying the sanitation fleet into groups with separate implementation phase-in periods has made this rule difficult to administer. He recommends avoiding the group classifications by applying a standard phase-in schedule fleet-wide.

Option 2 – Medium PM Reductions: "Best-Available Retrofit Technology" requirement, maximizes emission reductions on waste collection vehicles that are publicly-owned or privately-owned but used in public contracts by 2010 (based on New Jersey's Waste Collection Vehicle Regulation), see *www.arb.ca.gov/msprog/SWCV/SWCV.htm*.

Application:

- The requirement would apply to any diesel solid waste vehicle registered in the State that is:
    - Owned by the State or any political subdivision thereof, or a county or municipality or any political subdivision thereof;
    - Owned by a person who has entered into a contract with the State or any political subdivision thereof, or a county or municipality or any political subdivision thereof, to provide solid waste services;

Compliance:

- Fleet owners would submit a "fleet retrofit plan" to the DEP that documents a BART determination for every regulated solid waste vehicle.
    - BART devices must be EPA/CARB verified, and reduce the engine's PM emissions by the highest feasible level (just like the CARB regulation above);
    - If BART is not feasible for a particular engine, an owner may negotiate an enforceable commitment to retire and replace the engine with a 2007-compliant vehicle, or an older vehicle with BART installed.
- More than one owner or a group of owners may submit a "combined-fleet retrofit plan."
- Any owner or group of owners of 75 or more regulate vehicles may submit to DEP a "fleet-averaging plan," as long as the net percentage reductions at least equal to the net reductions that would have been achieved through a fleet retrofit plan or a combined fleet retrofit plan.
- The DEP would be required to review, and approve or disapprove of fleet retrofit plans, and make determinations to fleet owners.

Costs and how they would be covered:

- Retrofit costs per vehicle are assumed to be the same as in California. However, New Jersey has explicitly said that no owner shall be required to repower or replace engines;
- Before retrofits installations are required, the NJ State Treasury must certify that money has been developed in the Diesel Risk Mitigation Fund and the DEP must certify that the money is sufficient to cover costs of the approved fleet retrofit plan;
- In New Jersey, the Diesel Risk Mitigation Fund is capitalized by a reallocation of a portion of the Corporate Business Tax currently dedicated to hazardous substance discharge remediation and underground storage tank upgrades.

Timeframe and Reporting:

The legislation adopted this year in New Jersey gives the NJ DEP 270 days to adopt rules and regulations necessary for implementation;

- After these rules and regulations are adopted, owners of waste collection vehicles must submit an inventory and fleet retrofit plan to NJ DEP within 180 days;
- Each year, owners must submit a progress report and modifications to the fleet retrofit plan every year by the anniversary of the original submission.

Estimated Costs and Benefits in Connecticut:
Adopting a similar program in Connecticut would require BACT for an estimated 880 waste haulers (public and publicly-contracted vehicles, estimated number of vehicles pro-rated from New Jersey based on population).

- Costs:
  - Assuming the highest level of BACT (a passive diesel particulate filter) is feasible for every truck, total estimated capital costs equal:
    - 880 trucks * $7,500[172] = $6.6 million
  - Assuming that retrofits are phased in over four years between 2007 and 2010, the operating cost of cleaning filters equals:
    - 2008: 220 filters * $500[173] = $110,000
    - 2009: 440 filters * $500 = $220,000
    - 2010: 660 filters * $500 = $330,000
    - 2011: 880 filters * $500 = $440,000
  - Cost Caveats:
    - For some engines, particularly pre-2002 Mack engines, the BACT will be a wire mesh filter (or high-performance DOC) rather than a DPF. These installations are much cheaper, (estimated $3,000 versus $7,500) and they do not require annual filter cleanings.
    - Under this option, owners would not be required to repower, rebuild or replace engines, so no additional costs are expected for pre-1991 engines.
- Benefits:
  - Pro-rated from New Jersey DEP's benefit assessment (estimated annual benefit of 14 tons PM);
    - Estimated annual benefit of regulation in 2010: 5.6 tons PM reduced;
    - Estimate cumulative benefits of regulation: 42.9 tons PM reduced.

[172] Cost of diesel particulate filter, installation, and backpressure monitor used in calculations by the Transit Bus subcommittee, based on CT Transit experience.
[173] Cost of annual filter cleaning used in calculations by the Transit Bus subcommittee, based on CT Transit experience.

Option 3 – Lower PM Reductions: "Best-Available Retrofit Technology" requirement, maximizes emission reductions on waste collection vehicles that are owned by the state or used in state contracts by 2010 (based on New York City's waste collection vehicle policy, Local Laws 39 and 40), see:
http://www.nyccouncil.info/pdf_files/bills/law05039.pdf
http://www.nyccouncil.info/pdf_files/bills/law05040.pdf

Application:

- Would require the use of ultra-low sulfur diesel and best available retrofit technology in the fulfillment of solid waste contracts and recyclable materials contracts with any state agency;
    - State agency includes any subdivision of government for which expenses are paid in whole or in part from the state treasury;
- Would apply to contracts entered into or renewed after the policy becomes effective;
- Would require the use of ultra-low sulfur diesel and best available retrofit technology on all publicly-owned waste collection diesel vehicles.

Compliance:

- Any solid waste contract or recyclable materials contract let by any state agency would specify that all diesel fuel-powered vehicles used in the performance of the contract should utilize ULSD and BART – requirements would be noted in bid specification;
- Contractors would fulfill requirements by:
    - Utilizing vehicles with 2007-compliant engine models;
    - Installing BART, an EPA/CARB-verified emission control device that reduces the engine's PM emissions by the highest feasible level;
    - Using an alternative fuel engine, alone or in combination with one of the options above, that reduces PM at least as much as a BART retrofit device.
- No contractor would be required to replace BART for three years after the first installation;
- All contracts must permit independent monitoring of the contractor's compliance;

Reporting and Enforcement:

- Contractors must submit waste collection fleet retrofit reports to contracting agency and DEP;
- Because there is no good way to ensure that all contracted waste collection vehicles are regularly inspected, hefty penalty provisions could be used as a deterrent to non-compliance;
    - New York City's law specifies that in the event of a violation, a civil penalty of not less than $1000 and not more than $10,000 will be assessed, in addition to twice the amount of money saved by such contractor for failure to comply. If a contractor has been found to have made a false claim, New York City may assess an additional civil penalty of $20,000.

Timeframe:

- Because this policy option applies only to state-contracted waste haulers, it could take effect shortly after its enactment (4 months, suggested);

Limitations:

- This proposed state-owned vehicle and state contracting policy should be considered a first step toward a broadly applied waste collection vehicle policy. Ultimately, municipal vehicles, municipally-contracted vehicles, and private vehicles need to be cleaned up to maximize emission reductions from this category of diesels.

Estimated Costs and Benefits in Connecticut:

The costs and benefits of this policy are unknown at this point because the number of waste collection vehicles contracted to fulfill solid waste and recyclable materials contracts with the state of Connecticut is unknown.

New York Contact:

- Spiro Kattan, Department of Sanitation New York (DSNY), 718-334-9205

New York Progress to Date:

All DSNY vehicles are now subject to Local Law 39 requiring BART for all city-owned and city-contracted diesels. Prior to adoption of the local laws, DSNY introduced a number of pilot projects testing various types of diesel emission retrofits. The information below pertains to these pre-local law pilot demonstration projects. So far, a variety of emission control retrofit systems have been installed:

- Donaldson DOC + Crankcase systems - 100 installations on MACK LE sanitation trucks;
- Johnson Matthey Fleetguard CCRTs - 50 installations on MACK LE sanitation trucks;
- Johnson Matthey Fleetguard CRTs - 100 installations on Cummins M11 with crane carrier cab chassis;
- Environmental Solutions Worldwide CWMF (catalyzed wire mesh filter) – 50 installations on MACK LE sanitation trucks;
- Englehard DPX – 30 installations on MACK LE sanitation trucks.

Staff Reports on Implementation - (Spiro Kattan)

- Pilot demonstrations have been very successful. DSNY is happy with retrofits and expertise gained through experience with several technologies;
- All projects have benefited from close working relationship between DSNY and technology vendors;
- Installations began with custom-design prototypes that were adapted to the application. Based on this experience, vendors developed plug and play kits that can now be applied to all vehicles of a similar model/vintage;
- Cummins M11s with CRTs have since been rotated out of the fleet. Some CRTs were relinquished with the vehicles, others have been removed with the vehicle and returned to Cummins for re-use;

- CCRTs on MACK LE trucks will be scheduled for a regular cleaning once per year. Originally, CCRTs were cleaned with compressed air, but now will be sent out to get baked (service procured through competitive bid process). Baking (Level 2 cleaning) recovers DPFs to 95% their original condition;
- Training implemented for technicians in all districts by product vendors;
- DSNY is now assessing how to move forward with BART mandates for all vehicles (sanitation trucks and others). BART will mean different technologies for different vehicles and duty cycles – no one size fits all in a large, diversified fleet like DSNY's. DSNY expects to comply with Local Law 39 by implementing additional retrofits and modernizing the fleet with MY2007 and newer trucks.

Appendices

Appendix 1

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

Appendix 2

The Carl Moyer Clean Engine Incentive Program
December 2004

What is the Carl Moyer Program?

The Carl Moyer Program provides monetary grants to private companies and public agencies that clean up their heavy-duty engines more than required by air pollution regulations. For example, instead of rebuilding a 1983 diesel engine for $7,000, a company may choose to repower with a 1991 certified diesel engine at a cost of $30,000. A grant for up to the difference (or "incremental cost") – $23,000 – may be available through the Carl Moyer Program in order to buy the lower emission engine and provide clean air benefits.

What types of projects qualify for the Carl Moyer Program?

Projects that reduce emissions from heavy-duty on and off-road equipment qualify for Carl Moyer Program grants. This includes on-road trucks over 14,000 gross vehicle weight, and off-road equipment such as construction and farm equipment; marine vessels and locomotives; stationary agricultural equipment; forklifts; and airport ground support equipment. In addition, new legislation in 2004 expands the program to include additional agricultural sources of air pollution as well as passenger cars. ARB staff is evaluating protocols for funding projects to reduce emissions from additional agricultural sources and cars.

How is the size of the Carl Moyer Program grant determined?

Carl Moyer Program grants are based on the "incremental cost" and the emission benefits of the project. Your local air district can assist you in determining the funding for which you are eligible.

How can I apply for a Carl Moyer Program grant?

Carl Moyer Program grants are issued locally by air pollution control districts and air quality management districts. Air districts must adhere to minimum guidelines developed by the Air Resources Board in awarding grants; however, districts may choose to set more stringent criteria. Each district has its own application and selection timeline and process. Contact your local air district for additional information. Carl Moyer Program contacts for each local air district are listed on the next page of this fact sheet.

Where can I get more information about Carl Moyer Program grants?

For additional information, contact your local air district (see the next page of this fact sheet) or contact Lucina Negrete at the Air Resources Board at (916) 445 6138 or mailto:lnegrete@arb.ca.gov.

Appendix 3

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.[174] 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

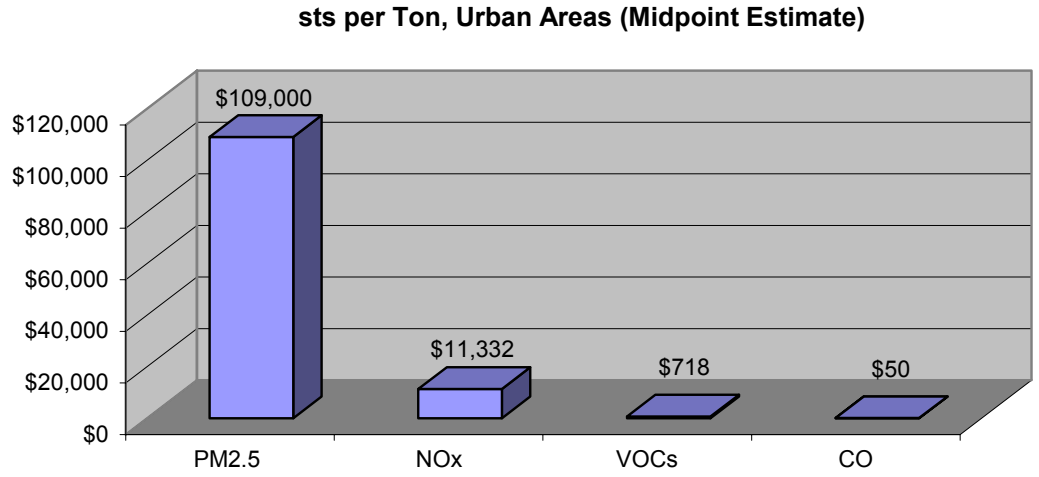
In the 1960s and 1970s the key health risks from air pollution were deemed to come from carbon monoxide, hydrocarbons (or volatile organic compounds, VOCs), nitrous oxides (NO_x), and smog, and early clean air legislation naturally targeted these pollutants.[175] During the past ten years or so, however, 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 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.[176]

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, $PM_{2.5}$,

[174] The EPA has formal criteria for the definition of non-attainment areas, but generally these are the large U.S. cities.
[175] Catalytic converters installed on all cars since the mid 1970s, for example, have targeted these pollutants.
[176] *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*, California EPA Air Resources Board, October 2000, p. 1.

sulfur oxides (SO_x), and VOCs.[177] 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



Source: McCubbin and Delucchi (1999)

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.)[178] 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.

[177] 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.
[178] "EPA Dramatically Reduces Pollution from Heavy-Duty Trucks and Buses, Cuts Sulfur Levels in Diesel Fuel," *Environmental News*, EPA, 12/21/00

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.[179]

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.[180] Its historical purpose has been twofold: to reduce traffic 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.[181] 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.[182] 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

[179] Very low sulfur diesel fuel will be available nationwide by 2006.
[180] Transportation Research Board of the National Research Council: *The Congestion Mitigation and Air Quality Improvement Program: Assessing 10 Years of Experience* (2002) p.1.
[181] ibid, p.1
[182] ibid, p.13

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.[183] 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."[184] 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."[185]

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 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 $PM_{2.5}$.[186] 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).[187] 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.

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[183] ibid, p.13
[184] ibid, p.74
[185] ibid, p.131
[186] 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).
[187] California Air Resources Board, "Staff Analysis of PM Emission Reductions and Cost-Effectiveness," Sept. 6, 2002.

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.[188] Also, the California EPA's Air Resources Board has estimated that diesel retrofits have a benefit of between $10 and $20 for each $1 of cost.[189] 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.[190]

Table 1: Cost-Effectiveness of Current CMAQ Strategies And Diesel Retrofits

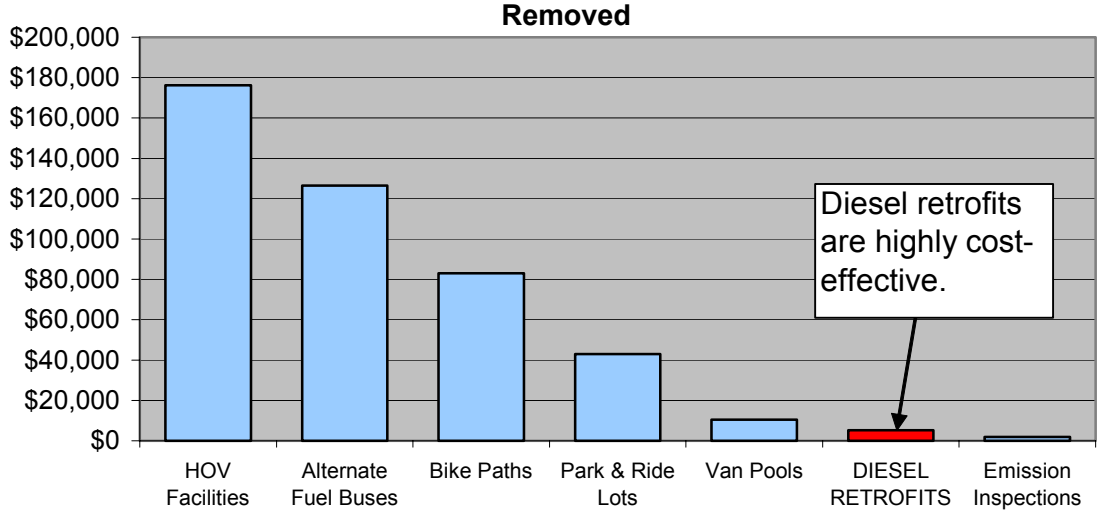
(Median cost per ton equivalent of air pollution removed)

	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

[188] "The Benefits of Diesel Retrofits," Diesel Technology Forum. See http://dieselforum.org/retrofit/why_ben.html.
[189] "Perspectives on California's Diesel Retrofit Program," California EPA, Air Resources Board, presentation by C. Witherspoon, June 3, 2004.
[190] 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.

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

Chart 2: Median Cost per Ton Equivalent of Air Pollution Removed



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.

List of References

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

California EPA Air Resources Board, "Staff Analysis of PM Emission Reductions and Cost-Effectiveness," September 2002.

Diesel Technology Forum, "The Benefits of Diesel Retrofits," (See http://dieselforum.org/retrofit/why_ben.html.)

Environmental Protection Agency, "2007 Heavy-Duty Highway Final Rule," May 2000. (See http://www.epa.gov/otaq/diesel.htm.)

Environmental Protection Agency, "EPA Dramatically Reduces Pollution from Heavy-Duty Trucks and Buses, Cuts Sulfur Levels in Diesel Fuel," *Environmental News*, December 2000.

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.

South Coast Air Quality Management District (SCAQMD), "Multiple Air Toxics Exposure Study (MATES-II), Final Report, July 2000.

Transportation Research Board of the National Resources Council, *The Congestion Mitigation and Air Quality Improvement Program: Assessing 10 Years of Experience*, 2002.

Witherspoon, C. "Perspectives on California's Diesel Retrofit Program," California EPA Air Resources Board, June 2004.

Appendix 4

Regulations of Connecticut State Agencies

Section 22a-174-18. Control of particulate matter and visible emissions.

EFFECTIVE APRIL 1, 2004

(b) Visible emission standards.

(1) Stationary sources without opacity CEM equipment. Except as provided in subsection (j) of this section, an owner or operator of any stationary source without opacity CEM equipment for which opacity is measured using visual observation shall not exceed the following visible emissions limits:
   (A) Twenty percent (20%) opacity during any six-minute block average as measured by 40 CFR 60, Appendix A, Reference Method 9; or
   (B) Forty percent (40%) opacity as measured by 40 CFR 60, Appendix A, Reference Method 9, reduced to a one-minute block average.

(2) Stationary sources with opacity CEM equipment. Except as provided in subsection (j) of this section, an owner or operator of a stationary source for which opacity is measured using opacity CEM equipment shall not exceed the following visible emissions limits:
   (A) Twenty percent (20%) opacity during any six-minute block average; or
   (B) Forty percent (40%) opacity during any one-minute block average.

(3) Mobile sources. Except as provided in subsection (j) of this section, no person shall cause or allow:
   (A) Any visible emissions from a gasoline powered mobile source for longer than five (5) consecutive seconds;
   (B) Visible emissions from a diesel powered mobile source of a shade or density equal to or darker than twenty percent (20%) opacity for more than ten (10) consecutive seconds, during which time the maximum shade or density shall be no darker than forty percent (40%) opacity; or
   (C) A mobile source to operate for more than three (3) consecutive minutes when such 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.

Appendix 5
Subcommittee Members

Transit Sector Subcommittee

Co-Chairs:	
Tom Maziarz	**CRCOG**
Mike Sanders	**ConnDOT**
Sarah Barbrow	EDF
Juliet Burdelski	Planning Partners, Sustainable Trans.
Jean Cronin	Hughes & Cronin
Jon Cohen	CCEJ
Danae Dwyer	ENE
Paul Farrell	CTDEP
Thomas Gorman	GBTA*
Ed Hall	Cummins
Margaret Japp	CCEJ
Orrin Johnson	HO Penn
Dennis Jolly	ConnDOT
Patrice Kelly	CTDEP
John Kennedy	Kennedy Technical Services
Steven Levy	Sprague
Peter Mariconda	GBTA*
Jeffrey Nyanteh	Caterpillar
Patricio Silva	EDF
Michael Smalec	CNG/SGC
Michael Stoddard	ENE
Michael Tucchio	Creative Technologies, Inc. Alt. Fuel Veh.
Stephen Warren	CT Transit
Madeleine Weil	ENE
Samuel Wilson	GHTD**

*The Greater Bridgeport Transit Authority
** The Greater Hartford Transit District

School Bus Subcommittee

Co-Chairs:	
Bill Moore	**COSTA**
Ariel Garcia	**CT DEP**
Susan Amarello	**CT DEP**
Roger Smith	CLEAN WATER ACTION
Cyril Alapatt	CLEAN WATER ACTION
Madeleine R. Weil	ENVIRONMENT NORTHEAST
Danae Dwyer	ENVIRONMENT NORTHEAST
Jessie Stratton	ENVIRONMENT NORTHEAST
Sarah Barbrow	ENVIRONMENTAL DEFENSE
Teddi Barra	New Haven School Transportation
Giovanni Zinn	City of New Haven
Kylene Fredrick	CCM
David Lavson	CAPSS
Kachina Walsh-Weaver	CCM
Cliff Gibson	LAIDLAW
Christopher Phelps	ConnPIRG
Nancy Harris	CASBO
Maureen Picard	CASBO
Paula Schenck	UCHC
Michael Tucchio	Creative Technologies, Inc. Alt. Fuel Veh.
Juliet Burdelski	Planning Partners, Sustainable Trans.
John Kennedy	Kennedy Technical Services

Construction Subcommittee

Co-Chairs:
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Madeline Weil, ENE
Bill Menz, CTDEP
Cindy Sweeten-Holden, CTDOT

SARAH BARBROW	EDF
JEFF BOLTON	DPW
EDWARD HALL	CUMMINS NTL POWER
STEVEN J LEVY	SPRAGUE ENERGY
P J MASON	EAST PBE INC
BILL MENZ	DEP
CHARLES ROTHENBERGER	CT FUND FOR THE ENVIRONMENT
PATRICIO SILVA	EDF
DARRELL STARK	CUMMINS
STEVE WASMBURN	HO PENN
DONNA WEAVER	DOT
MADELEINE R.WEIL	ENE

On-Road Fleets Subcommittee

Co-Chairs:
Deputy Commissioner Portonova, DMV
Lt. Dave Maestrini, DMV
Paul Farrell, CTDEP

SARAH BARBROW	EDF
PAUL FARRELL	DEP
EDWARD HALL	CUMMINS NTL POWER
CHRIS A HERB	INDEP CT PETRO ASSO
PAUL HOAR	
STEVEN J LEVY	SPRAGUE ENERGY
DAVID MAESTRINI	DMV
PETER MARICONDA	GBTA
MARK MITCHELL	CCEJ
ANTHONY PORTANOVA	DMV
MICHAEL J.RILEY	CTA
PATRICIO SILVA	EDF
ROGER SMITH	CLEAN WATER ACTION
MICHAEL STODDARD	ENE
SCOTT VAN DE WEGHE	HO PENN MACHINERY CO
MADELEINE R.WEIL	ENVIRONMENT NORTHEAST
SAMUEL WILSON	GHTD
GIOVANNI ZINN	NEW HAVEN CITY PLANNING