State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

DIESEL RETROFIT LAW
P.L. 2005, C. 219

IMPLEMENTATION, BENEFITS AND LESSONS




NJDEP, Division of Air Quality, Bureau of Mobile Sources
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Contents

List of Tables

List of Figures

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I. EXECUTIVE SUMMARY

The Diesel Retrofit Law (Law) (N.J.S.A. 26:2C-8.1 et seq) is the culmination of staff research, management and legislative support in developing a cost-effective, fully funded program to reduce particulate emissions from diesel vehicles. The Department of Environmental Protection's (Department) research found that 1,000 deaths and 68,000 cases of asthma in the State each year are attributed to the exceedance of the National Ambient Air Quality Standard for particulate matter less than 2.5 microns ($PM_{2.5}$)[1] In addition, 370 premature deaths could be avoided in the State by implementing diesel retrofit, anti-idling, and clean construction programs.

The Department implemented the Law beginning in 2007 with the finalization of the Mandatory Diesel Retrofit rules at N.J.A.C. 7:27-32, and revisions to N.J.A.C. 7:27-14, 7:27A-3.10 and 7:27B-4 and 5. The Mandatory Diesel Retrofit Program (Program) was implemented over ten years with a final closeout on June 30, 2017.

The Law targets school buses and diesel-powered on-road vehicles, including solid waste vehicles that are publicly-owned or used in a public contract. The Law also targets publicly- and privately-owned commercial buses, public utility vehicles and publicly-owned off-road equipment to have tailpipe retrofit control devices installed to meet Best Available Retrofit Technology (BART) standard. BART establishes a minimum particulate emission reduction level whereby any qualified emission control retrofit device that meets or exceeds the standard can be used to satisfy the retrofit requirements. The retrofit devices must be verified by the California Air Resources Board (CARB) as a Verified Diesel Emission Control Strategy, or by the USEPA as a Verified Technology. The Diesel Retrofit Law requires all diesel school buses to be retrofit with Closed Crankcase Ventilation System (CCVS).

The Diesel Retrofit Law also established the Diesel Risk Mitigation Fund, a funding source for all retrofits and provided that the State could not require an owner to retrofit a vehicle unless sufficient funds were available. Funding was provided through a constitutionally dedicated portion of the Corporate Business Tax (CBT). This source was secured through a ballot question during the 2006 general election. Total funding received was $144 million.

The Department's Bureau of Mobile Sources (BMS) developed the necessary rules, contracts and other components necessary to fully implement the Law. BMS conducted extensive outreach to regulated fleet segments and retrofit installers. This included numerous workshops tailored to specific fleet segments, regular meetings with installers, telephone and mailing campaigns, and electronic listservs. Additionally, several of the retrofit installers undertook their own outreach campaigns.

Retrofits could only be performed by an "Authorized Installer" (Installers), an entity whom is contractually approved by the manufacturer to sell, install, and service retrofit devices, and generally act on behalf of the manufacturer. The State bid the retrofitting work and awarded

[1] For detailed references see the December 18, 2006 New Jersey Register, Diesel Retrofit Program Joint Proposed Amendments- Sources (CITE N.J.R. 5267-5268)

contracts to ten Installers. Through the contractual relationship, the Installers were required to incur the costs to purchase and install the retrofits and seek reimbursement from the Department once the owner confirmed that the installation was complete.

The Department succeeded in having 5,916 diesel vehicles retrofit with BART and 7,429 school buses retrofit with CCVS. This action resulted in a cost-effective program that reduced diesel emissions by 78 tons annually. The health benefits gained include reductions in statewide exposure to diesel exhaust and students' chronic exposure to diesel emissions during their daily commute to school. Additionally, the Program assisted the State in attaining its air quality goals, including attainment of the National Ambient Air Quality Standard for $PM_{2.5}$.

In completing this activity, people in New Jersey have benefited from reduced cancer risks due to exposure to diesel exhaust, which poses the highest cancer risk of any air toxic in the State. In addition, the Program reduced ambient levels of $PM_{2.5}$. Using the 2011 National Air Toxics Assessment (NATA) the cancer risks were illustrated for 2011 and projected out to 2020. The projections reflect all emissions reductions from on-road diesel vehicle emissions reduction programs, and fleet turnover. Urban areas and the I-95 corridor received the greatest benefits. Cancer risk on the I-95 corridor is projected to be reduced by an order of magnitude from 100-300 in a million due to exhaust from diesel on-road vehicles, to a risk of 10-100 in a million. Other areas in the south, southeast and northwest are predicted to see an order of magnitude reduction in cancer risk.

Retrofitting is a cost-effective means to reduce pollution from in-use mobile diesel engines. Reducing emissions from vehicles operating in a confined area (route) yields lasting benefits to the local population. The program cost-effectiveness for all BART installations was $81,883/ton of diesel particulates reduced. This was achieved by retrofitting many vehicles early in their useful life, allowing the control device to effectively reduce emissions over a greater time span.

Recommendations

1. Focus ongoing diesel emission reduction strategies on the off-road sector where equipment remains in service longer. The equipment tends to be older and the most stringent emissions standards were introduced later than the on-road sector. BMS has programs and contracts in place to address this sector as funds become available.

2. Limited efforts should be made to retrofit or replace older high-polluting on-road diesel vehicles operating on urban routes.

3. School buses should continue to be inspected under current MVC rules to ensure students are not exposed to elevated levels of diesel exhaust inside a school bus.

4. Future retrofit contracts should include a mechanism to allow contractors to revise labor rates in conjunction with contract extensions.

II. MANDATORY DIESEL RETROFIT PROGRAM

A. Program Overview

The Diesel Retrofit Law was signed in September 2005 by Governor Richard Codey to protect New Jersey residents from the harmful effects of diesel particulate pollution. Numerous studies have shown that exposure to diesel exhaust can aggravate asthma, contribute to cardiopulmonary distress and result in premature death[2]. The United States Environmental Protection Agency (USEPA) National Air Toxics Assessment identifies diesel exhaust as posing the greatest cancer risk of any air toxic in New Jersey. The Law targets school buses and diesel-powered on-road vehicles including solid waste vehicles that are publicly-owned or used in a public contract. The Law also targets publicly- and privately-owned commercial buses, public utility vehicles and publicly-owned off-road equipment. The Diesel Retrofit Law requires all diesel school buses to be retrofit with CCVS. Additionally, the Department was charged to study the potential sources of in-cabin pollution resulting in student exposure to diesel exhaust and determine any need to have school buses retrofit with tailpipe emission controls.

Efforts to develop the Program originated within the Department's Division of Air Quality (DAQ). Increasing evidence about the negative health impacts of chronic exposure to $PM_{2.5}$ and diesel exhaust pressed DAQ into action. Research efforts revealed an opportunity to reduce exposure by using commercially available emissions control equipment that had recently become a viable option for on-road diesel vehicles and off-road equipment. Research and modelling revealed the benefits of targeting certain types of vehicles and off-road equipment to maximize health and air quality benefits in the most cost-effective manner.

Diesel-powered commercial buses, solid waste vehicles and all other diesel-powered publicly-owned vehicles and off-road equipment are required to have tailpipe retrofit control devices installed to meet BART standard. Tailpipe retrofit devices work by significantly reducing exhaust emissions of diesel particulates by capturing and destroying these particles or reducing their toxicity. BART establishes a minimum particulate emission reduction level whereby any qualified emission control retrofit device that meets or exceeds the standard can be used to satisfy the retrofit requirements. The retrofit devices must be verified by the California Air Resources Board (CARB) as a Verified Diesel Emission Control Strategy, or by the USEPA as a Verified Technology. CARB and USEPA provided emission testing results and certified the devices. Vehicles equipped with a 2007 or newer model year diesel engine that meets the newest emissions standards, as determined during the federal emissions certification process, were not subject to the retrofit requirements.

The Diesel Retrofit Law also established the Diesel Risk Mitigation Fund, a funding source for all retrofits and provided that the State could not require an owner to retrofit a vehicle unless sufficient funds were available. Additionally, the Law required that all devices must be installed by an Installer listed on a State Contract specifically issued for the purposes of the Program's rules.

[2] For detailed references see the December 18, 2006 New Jersey Register, Diesel Retrofit Program Joint Proposed Amendments- Sources (CITE N.J.R. 5267-5268)

Principle health benefits of the Program are described in the Legislative Findings (P.L. 200 c. 219). The Legislature recognized the extraordinary health risks imposed by chronic exposure to diesel exhaust and chose to pursue reducing diesel emissions in the State to improve public health, quality of life and reduce other societal costs. In the Preamble, the Legislature highlighted key reasons for passing the Law. Highlights include:

- Emissions of fine particles into the air pose an extraordinary health risk. The Department's research found that 1,000 deaths and 68,000 cases of asthma in the State each year are attributed to the exceedance of the federal fine particulate standard (PM2.5) in the State, and that 370 premature deaths could be avoided in the State by reduction of fine particle emissions from diesel engines.

- Exhaust emissions from diesel-powered vehicles and equipment contribute substantially to the fine particle problem, and pose both cardiovascular and cancer risks;

- USEPA classified diesel exhaust as likely to be carcinogenic to humans by inhalation at environmental exposures; and has also identified diesel particle matter and diesel exhaust organic gases as a mobile source air toxic.

- Studies repeatedly have found links between exposure to fine particles and health effects including premature death and increased incidents of asthma, allergies, and other breathing disorders.

- Emissions from diesel school buses directly impact the health of school children throughout the State.

B. Funding for Retrofit Costs

Funding was provided through a constitutionally dedicated portion of the Corporate Business Tax (CBT). This source was secured through a ballot question during the 2006 general election. The funding amount is seventeen percent of the four-percent portion of the CBT that was dedicated to mitigating ground water pollution caused by leaking underground storage tanks. In practical terms, this amounted to an estimated $14.3 million per year. This funding was allocated from January 1, 2006 through December 31, 2015. In 2014 another amendment truncated the scheduled allocations to end June 30, 2015. Total funding received was $144 million. The MVC could share a $1.15 million annual portion for administrative costs.

C. Program Charge

The Bureau of Mobile Sources (BMS) developed the necessary rules, contracts and other components necessary to fully implement the Law. Most of the Program tasks were developed and executed by BMS, with additional tasks and inputs from Compliance and Enforcement, Budget and Finance, MVC and Treasury.

D. Program Elements from N.J.A.C. 7:27-32

- Regulated Diesel Vehicles and Equipment –

  - All diesel school buses used for student transportation.
  - Diesel Solid Waste Vehicles that are publicly-owned or used in service as part of a public contract.
  - Publicly-Owned Commercial Buses (NJ Transit)
  - Private Commercial Buses
  - Public Utility Vehicles
    - On-road diesel vehicles
    - Self-propelled off-road equipment
  - A vehicle or piece of equipment meeting these categories is not regulated if it is a diesel vehicle with a diesel engine certified to meet a particulate standard of 0.01 g/bhp-hr, or off-road equipment with a diesel engine certified to meet a particulate standard of 0.015 g/bhp-hr.

- BART – Establishes minimum emission control standards for certain vehicle types and model years. Identifies certification standards for meeting requirements. BART could be met using the required level or emission control or one that was more stringent. For example, BART 3 devices were often used to satisfy the BART 2 requirement.

- CCVS - Defined to include equipment that completely captured crankcase fumes and reintroduced them into the combustion process. This allowed vehicles with existing systems to be in compliance with the requirements. Systems that passed filtered crankcase fumes to the atmosphere did not qualify.

- Outreach – BMS conducted extensive outreach to regulated fleet segments and retrofit installers. This included numerous workshops tailored to specific fleet segments, regular meetings with installers, telephone and mailing campaigns, and electronic listservs. Additionally, several of the retrofit installers undertook their own outreach campaigns.

- Inventory and Cost Estimate Submittals – Fleets were required to submit an inventory of all diesel vehicles and equipment, and indicate the regulated status of each and the method of compliance. These were submitted on a standard form (Excel spreadsheet) that included drop-down menus for required information including retrofit types and vehicle manufacturers. The form could only be submitted through the DEP Online portal where it would be migrated into the New Jersey Environmental Management System (NJEMS).

- Review and Approval Process – All inventory and cost estimate submittals were reviewed by program staff for completeness, technical accuracy and reasonable cost. All documents and decisions were recorded in NJEMS.

- Fleet Recordkeeping - Fleets were required to keep a Compliance Form in each vehicle as well as a copy in their place of business. The Compliance Form is a one-page document that provides a DEP inspector, or one licensed by the MVC, all pertinent information for vehicle inspections and to ascertain the compliance status of a vehicle.

- Installation Verification - All retrofits were required to be inspected for presence of the retrofit device on the correct vehicle. The One-Time Compliance Inspection (OTCI) was to be performed by a trained inspector licensed by the MVC. BMS staff provided all training, and inspected the off-road equipment retrofits.

- Warranties – 5-year coverage for defects and workmanship. Applies to both the device and installation.

- Authorized Installers and Retrofit Contracts – Retrofits could only be performed by an Installer, an entity whom is contractually approved by the manufacturer to sell, install, and service retrofit devices, and generally act on behalf of the manufacturer. The State bid the retrofitting work and awarded contracts to ten Installers. Through the contractual relationship, the Installers were required to incur the costs to purchase and install the retrofits and seek reimbursement from the Department once the owner confirmed that the installation was complete. Fleets had the option to pursue certification through the manufacturer to become an authorized installer to allow them to self-install the retrofits. New Jersey Transit Corporation used this approach. For more information, please refer to New Jersey State Contract T-2541 (2008) Retrofit Device and Installation Reimbursement.

- Reimbursements- The reimbursement process was conducted through the DEP Online Portal. Once the vehicle owner submitted a signed Compliance Form, indicating approval of the completed installation, BMS would make the vehicle available for the Installer to electronically apply for reimbursement. The Installers separately submitted all supporting documentation through the mail.

E. Emission Control Reductions

The Law tasked the Department to establish particulate emission control levels for regulated vehicles using a BART approach. The Law defines BART as

> *the equipment, retrofit device, or fuel, or any combination thereof, designated by the United States Environmental Protection Agency as a verified technology for diesel retrofit programs, or by the California Air Resources Board as a verified technology for diesel*

emissions control, for use on or in specific makes, model years, types, and classes of on-road diesel vehicles or off-road diesel equipment, and that, as determined by the Department of Environmental Protection, may be used on or in regulated vehicles or regulated equipment, at a reasonable cost, to achieve substantial reduction of fine particle diesel emissions.

The Department performed an extensive evaluation of commercially available emission control systems that were or anticipated to be reviewed for verification by either USEPA or CARB. Vehicle age, usage, compatibility, device costs and other characteristics were considered. This approach allowed other types of qualified control apparatus to be introduced into the program as they became available if they met or exceeded the minimum BART required for a regulated vehicle or equipment. Allowed tailpipe retrofit devices included diesel particulate filters, diesel oxidation catalysts and flow through filters. Additionally, BART was defined so that the installation and use of the retrofit device or the use of the special fuel would not jeopardize the original engine warranty and included additional specific warranty provisions for the device and vehicle. Fuel-based control strategies were not included due to uncertainty in their availability across the remaining useful life of the vehicles and, the difficulty in verifying fleets' exclusive usage to satisfy program requirements.

Three BART levels were established and assigned to different types and ages of regulated vehicles and equipment. Table 1 describes the different BART levels, how they are implemented, and key considerations to their use. The BART emission control levels (BART 1, BART 2, and BART 3) mimicked the emission control brackets used by CARB. CARB's verification process did not provide any further detail on the exact amount of particulate emission reductions that could be expected from any retrofit system.

Table 1 – BART Descriptions

BART Levels	How it works	Considerations
Level 3: 85% PM reduction (Diesel Particulate Filter)	Filter physically traps elemental carbon particles then oxidizes them to form gases (primarily CO2). Most filters also have catalysts so soluble organic portion of particle is also destroyed.	• Must use Ultra-Low Sulfur Diesel Fuel (ULSF); • Clean filter once per year to remove incombustible ash; • Can be difficult to use with pre-1994 engines; • Sensitive to exhaust temperature unless active regeneration is available.
Level 2: 50-84% PM reduction (Flow through filter)	Exhaust passes through tortuous path catalyzed substrate which lengthens residence time thereby allowing more particles to be destroyed; no carbon accumulation	• Most effective with ULSF; • Reduces "wet fraction" of the diesel particle and a large portion of the carbon core. • Less effective than a Level 3 device but is also less likely to clog.
Level 1: 25-49% PM reduction (usually Diesel	Diesel Oxidation Catalyst. Exhaust passes through catalyzed honeycomb substrate where the wet fraction and most	• Most effective with ULSF; • Reduces "wet fraction" of the diesel particle only. Carbon core passes through and is emitted.

Oxidation Catalyst or Emulsified Fuel)	toxics of the particle are reduced. no carbon accumulation	

The required BART for each type and age of regulated vehicle or equipment is described in Table 2.

Table 2 - Minimum Emission Control Requirements

Vehicle or Equipment Type	**Engine Model Year**	**Minimum BART Level**	**Minimum control efficiency (particulate emission reduction by weight)**
School Bus (voluntary tailpipe controls)	2006 and older	BART 3	85%
School Bus (required crankcase controls)	2006 and older	CCVS	Not applicable
Commercial buses	2007 and newer	NONE	Not applicable
	1994-2006	BART 3	85%
	1988-1993	BART 2	50%
	1987 & older	BART 1	25%
Solid waste vehicle	2007 and newer	NONE	Not applicable
	1988-2006	BART 2	50%
	1987 & older	BART 1	25%
On-road vehicle other than a commercial bus or solid waste vehicle	2006 and older	BART 2	50%
Off-road equipment >175 horsepower	1996 – 2014	BART 3	85%

F. School Bus Study and Emission Controls

The Law at N.J.S.A. 26:2C-8.32 directed the Department to complete a study to identify and quantify the relative contributions of crankcase and tailpipe emissions to the fine particles in the cabin, and evaluate the feasibility of retrofitting school buses with tailpipe emission controls (Study). The Department contracted Rowan University to perform the Study. The Study concluded that particulate emissions in the cabin originated from the open crankcase vent that is often found on diesel school buses, mostly entering the cabin when the door opened. The Study recognizes that school buses in New Jersey are subject to a rigorous biennial safety inspection by MVC's School Bus Inspection Unit. This inspection includes an inspection of all cabin seals. Early data collection in the study was scrapped since the test vehicle was found to have a damaged rear door seal as well as other defective seals that likely would not meet MVC standards. Staff observed and measured dust and exhaust intrusion at the rear door. MVC inspected the bus and determined that it would not have passed a New Jersey inspection. Had this problem not been noticed and resolved, the conclusions would have been different and would have led the Department to require a BART 3 device on all school buses at an estimated cost of $78 million. This cost would have precluded retrofitting of many other regulated diesel

vehicles and given a false sense of security from conclusions drawn from a defective data collection process.

This Study supported the need to eliminate atmospheric venting of crankcase emissions. It also obviates any need to retrofit school buses with tailpipe emission controls provided that school buses do not idle while queued and are periodically inspected for cabin seal integrity. New Jersey's idling regulations prevent school buses from idling while in queue.

G. Authorized Installers/State Contract for Retrofits

The Law required the Department to administer the Diesel Risk Mitigation Fund as a means of reimbursing fleets the cost to purchase and install the retrofits. The Department and the Purchase Bureau within Treasury deliberated extensively to determine the optimal way to provide cost reimbursements that satisfied the Law. The decision was made to bid the retrofitting work out to Installers of the retrofit systems whom had been authorized by the retrofit manufacturers. Individual contracts would be awarded to as many Installers deemed necessary for the Department to conduct its business. Ultimately, contracts were awarded to ten Installers of CCVS and BART.

Key components of the retrofit contracts were designed to ensure that the Installer satisfied all relevant requirements as specified in the Law. Major components included a 5-year equipment and installation warranty, guarantee of EPA or CARB certification as applicable, continuing service and product support, owner training, bid pricing as a percent discount from list price, and standardized ranges of labor costs for installations. The concept of requiring bidders to bid by specifying the discount rate from list price allowed the Department to maintain a dynamic range of CCVS and BART. This is important since the USEPA and CARB can de-verify devices if a flawed concept is discovered, the manufacturer fails to maintain long-term requirements such as high mileage testing, or, the currently verified device does not satisfy revised standards.

H. Program Timeline 2005-2017

Table 3 – Diesel Retrofit Program Milestones

Year	Month	Phase
2006	August	Diesel Law (N.J.S.A. 26:2C-8.1 et seq) Signed
	November	Corporate Business Tax Resolution Passed
2007	June	School Bus Study Begins
	August	CCVS Funds Certification
	September	Rules Adopted
2008	January	Retrofit Contracts Awarded
	March	School Bus DPF Pilot
	March	Solid Waste Vehicle Cost Estimates Due
2009	May	School Bus Study Ends
2010	March	Public Commercial Bus Cost Estimates Due

	September	Private Commercial Bus Cost Estimates Due
	September	School Bus Retrofits Due
2011	September	Public Utility Vehicle Cost Estimates Due
2014	November	Corporate Business Tax Amendment
2016	January	Retrofit Contract Expires
	December	Deadline to Complete All Retrofits
2017	June	Closeout Completed - All Retrofits Reimbursed

I. Program Steps and Processes

1. Inventory/Cost Estimate

    - Owners of regulated vehicles evaluated their fleet for required compliance by inventorying diesel-powered vehicles and equipment, identifying which vehicles were regulated and how they would comply (compliance method), select BART/CCVS and/or compliance method in conjunction with an Installer(s) and obtain cost estimates to retrofit. Compliance methods included
        - Notice of Intent to Comply – met required BART level
        - Fleet Plan – request lower BART level
        - Exempt – cannot be retrofit, included supporting documentation
        - Non-regulated/due later
        - Retirement – vehicle is retired from service or limited to 1,000 miles per year

2. Online Submittal
    - The owner's inventory of diesel vehicles and equipment, compliance methods and cost estimates to retrofit, were input onto a spreadsheet (form) and submitted via electronic upload through the DEP Online portal.
    - This data is then migrated into NJEMS. The forms were available on the BMS website at www.stopthesoot.org.

3. Department Review
    - A project manager was assigned to each submittal. He or she reviewed each submittal for completeness, technical soundness and compliance with the rules. Major elements included matching the vehicle identification number (VIN) against the MVC registration database, ensuring that the EPA engine family is compatible with the EPA or CARB verification of the retrofit device, reasonable cost and technical soundness. All other non-retrofitting compliance methods were reviewed for compliance with the rule. After the review, each vehicle was approved or rejected. The owner was notified by letter.
    - Any rejected vehicles were made available to the owner via a cost-estimate modification This made the vehicles that required correction available for revision in their DEP Online account. The owner made the necessary corrections and

resubmitted the information as part of the cost-estimate modification. After submittal, BMS reevaluated the information.

4. Retrofit
    - Upon receipt of written approval by the Department, the owner coordinated with the Installer to have the CCVS or BART installed. The owner downloaded compliance forms from their DEP Online account for each regulated vehicle. Upon satisfactory completion of each retrofit, the owner signed the compliance form and sent a copy to the Department to commemorate completion.

5. Reimbursement
    - BMS received the owner-signed compliance form and logged it into NJEMS, thereby releasing the vehicle information to the Installer's DEP Online account. The Installer then completed an online reimbursement application for BMS review. Once completed, a check is generated by Treasury for the reimbursement and a letter was sent to the Installer indicating the amount and applicable vehicle retrofits.

6. One-Time Compliance Inspection
    - Each retrofit was inspected for the presence of the approved retrofit on the correct vehicle. Inspections were performed during the annual vehicle emissions or safety inspection process required by the MVC. All inspections were performed by licensed inspectors whom were trained by BMS staff to perform a OTCI. BMS staff inspected the off-road equipment retrofits.

7. Annual Submittals
    - The Law requires an annual submittal for all BART inventories. The BMS made this available through the DEP Online portal. The fleet owner could make any changes necessary, including no changes, to reflect the most current make-up of their fleet. The annual submittal also allowed fleet owners to provide information such as revised BART or vehicle mileage updates.

III. PROGRAM RESULTS

Program results for CCVS are characterized separately from program results for BART since school bus owners were NOT required to submit an inventory of all diesel vehicles and equipment unless they owned other regulated vehicles or equipment in addition to their school buses.

A. BART Program Results

The following results are compiled from Inventory and Cost Estimate submittals in NJEMS. Table 4 shows that there are 25,373 vehicles in the database of those required to be submitted under the inventory requirements at N.J.A.C. 7:27-32.12(a)1 for BART retrofits. Of these vehicles 6,480 (25.5%) were submitted with cost estimates as a Notice of Intent to Comply or a Fleet Plan. After attrition, 5,916 vehicles had BART installed and were subject to

reimbursement. An almost equal number of vehicles were approved for an exemption (28.3%) due to technical infeasibility or because the vehicle was an emergency vehicle. Another 8.8% were retired, thereby producing an emissions benefit through limited or discontinued use. Therefore, a total of 34.3% of the population produced an emission benefit from BART retrofits and retirements. Another 37.4% were not regulated because they were too new, were not a targeted vehicle or are dedicated
emergency vehicles.

Table 4 –BART Compliance –Cost Estimate Submittals

Compliance Method	Number of Vehicles	Percent of Vehicles
Notices of Intent to Comply	5788	22.8%
Fleet Plan	692	2.7%
Exempt	7186	28.3%
Retirement	2222	8.8%
Non-Regulated (included in inventory)	9485	37.4%
Totals	25373	100.0%
Total Fleet Plans and Notices of Intent to Comply	6480	25.5%

Table 5 depicts the distribution of BART installations. Three-fourths of BART retrofits met the BART 3 requirements. This is due to several factors. The majority of installed BART 3 systems relied upon an on-board catalytic converter (passive regeneration) to burn off the accumulated soot. All BART 2 systems installed as part of the program were installed on solid waste vehicles where the vast majority were the Donaldson Diesel Multi-Stage Filter (DMF). None of the Public Utility Vehicles received a BART 2 device since none were verified when cost estimates were due. BART 1 systems, which included only Diesel Oxidation Catalysts, were the least used option. This is due in part because most vehicles had a more stringent minimum BART level and thus would need technical justification for a less stringent emission control. In many cases vehicles were exempted when a BART 1 device was not verified for specific vehicle application.

The dynamic nature of the CARB and USEPA verification programs proved to greatly influence the types of BART systems used in the Program. Both USEPA and CARB strived to continually advance more stringent retrofit technologies. Manufacturers responded by advancing diesel particulate filters (BART 3) to meet them. CARB also required manufacturers to periodically resubmit updated verification packages to include a business case for anticipated retrofit sales. Two manufacturers noted that it was difficult to make a business case for a BART 1 or BART 2 device when CARB's fleet regulations required annual averaging of fleet emissions with increasing stringency, thus deterring fleets from installing lower level controls since they would not help fleets to comply. Devices with low sales projections were given low priority for review. The USEPA and CARB programs also periodically increased stringency of the emission control requirements, specifically with respect to the fraction of nitrogen dioxide that could be emitted as

part of total oxides of nitrogen (NOx) emissions. Some manufacturers demonstrated their product's compliance, while others had to re-engineer. Several retrofit systems were de-verified because they could not meet the revised standards. None of the remaining BART 2 systems met the requirement and thus made them unavailable as a compliance option for the public utility vehicles.

Table 5 - BART Compliance by level –Cost Estimate Submittals

BART Level	Quantity	Portion
BART 1	670	10%
BART 2	957	15%
BART 3 with passive regeneration	3551	55%
BART 3 with active regeneration	1302	20%
Total	6480	100%

Table 6 - Distribution of Submittals - BART by Authorized Installer

	School Bus	Solid Waste Vehicle	Public Commercial Bus	Private Commercial Bus	Public Utility Vehicles	Public Utility Vehicle - Off Road	Total BARTs	Total %
ADDA/JT	33	764	24	1074	1473	0	3368	52.0%
Cummins Power Systems	58	247	0	0	80	3	388	6.0%
Drive Train Truck Parts	0	19	0	0	0	0	19	0.3%
Fleetsource	0	7	0	0	0	0	7	0.1%
Foley Inc.	116	432	0	143	282	2	975	15.0%
Mid-Atlantic Truck Centre	0	6	0	0	58	0	64	1.0%
NJ Transit	0	0	774	0	0	0	774	11.9%
Ransome International	0	11	1	0	873	0	885	13.7%
R&H Truck Parts	0	0	0	0	0	0	0	0.0%
Total							6480	

Table 6 depicts the number of cost estimates received by BMS in association with each Installer. More than half were associated with a joint venture between Atlantic Detroit Diesel–Allison (now Stewart & Stevenson Power Products) and Johnson & Towers. Three other installers – Foley Inc, NJ Transit and Ransome International - performed the majority of the remaining BART installations.

B. CCVS Program Results

BMS approved cost estimates for 7,567 CCVS installations, of which 7,429 were completed. Another 4,426 exemption requests with supporting documentation were approved. In all but one case, the diesel engine already had a CCVS installed by the original equipment manufacturer. The one exception lacked space to effectively install the retrofit CCVS. Full counts are contained in Table 7.

School buses needing a CCVS were subject to an operational deadline where they could not use the bus at the commencement of the school year beginning in Fall 2010 if a CCVS was not installed. The Program did not establish a deadline to submit a cost estimate to install a CCVS. Fleets were also not required to report a retirement and relied upon the MVC biannual school bus inspections to remove non-compliant buses. Because of this, fleets were inconsistent in using the retirement compliance method since school buses are retired due to age restrictions and other operational needs. Many of these retirements were buses that were listed on the submittal but were planned retirements due the regulated maximum age for which a school bus can be used for student transport in New Jersey. Others were planned retirements due to excessive wear, damage, or high maintenance costs. Therefore, BMS cannot clearly characterize retirements as a selected compliance method because of this inconsistency.

Table 7 – School Bus Compliance Methods

Compliance Method	Submittal
CCVS	7567
Exempt	4426
Retirement	1305

The Department had seven Installers of CCVS retrofits available on the retrofit contract. Table 8 depicts the distribution of cost estimates approved by the BMS per each Installer. BMS did not normally prescribe an Installer for a fleet and relied on the fleets' normal business relationships with the local industry. Some installers pursued fleets' participation more actively than others. The largest portion of CCVS installations were performed by Foley Inc, followed by the joint venture between Atlantic Detroit Diesel-Allison and Johnson & Towers (ADDA/JT). One installer, R&H Truck Parts and Service, did not receive any business from school bus owners.

Table 8 - Distribution of CCVS Submittals by Authorized Installer

Installer	Quantity	Portion
ADDA/JT	2359	31%
Cummins Metropower/ Powersource	123	2%
Fleetsource	69	1%
Foley Inc	3654	48%
Ransome International	1347	18%
R&H Truck Parts and Service	0	0%
Wolfington Body Company	15	0%
Total	7567	

Four different brands of CCVS were bid by the seven Installers. Of these, the Donaldson CCVS was most widely used. The Racor and International CCVS were identical except for the labelling, as the International CCVS known to be produced by Racor. Cummins manufactured its' own CCVS products.

Table 9 - Distribution of CCVS Manufacturers' Product

CCVS Manufacturer	Quantity	Portion
CUMMINS	123	2%
INTERNATIONAL	1343	18%
DONALDSON	5306	71%
RACOR	657	9%
TOTAL	7429	100%

C. Emissions Benefits

The net benefit of BART retrofits due to the Program is an annual reduction of 78 tons of diesel particulate emissions from BART installations, and reduced student exposure to diesel exhaust while riding school buses. Emissions benefit calculations were based on a 10-year useful life for BART 2 and BART 3 devices, and a 5-year useful life for BART 1. The emissions benefit from vehicle retirements has not been counted nor is it included in this report because of the wide variation in potential remaining life of the retired vehicles. The benefit of retirements is thought to be an additional five to fifteen percent beyond the program particulate emissions benefits. CCVS emissions benefits were not calculated since there is not an available set of emission factors for crankcase emissions from older diesel engines and, these emissions are not included in the State emissions inventory. Table 10 depicts the final program results. Program cost-effectiveness is calculated to be $81,883 per ton of PM2.5.

Table 10 – Particulate Emissions Benefits, Costs, and Cost – Effectiveness

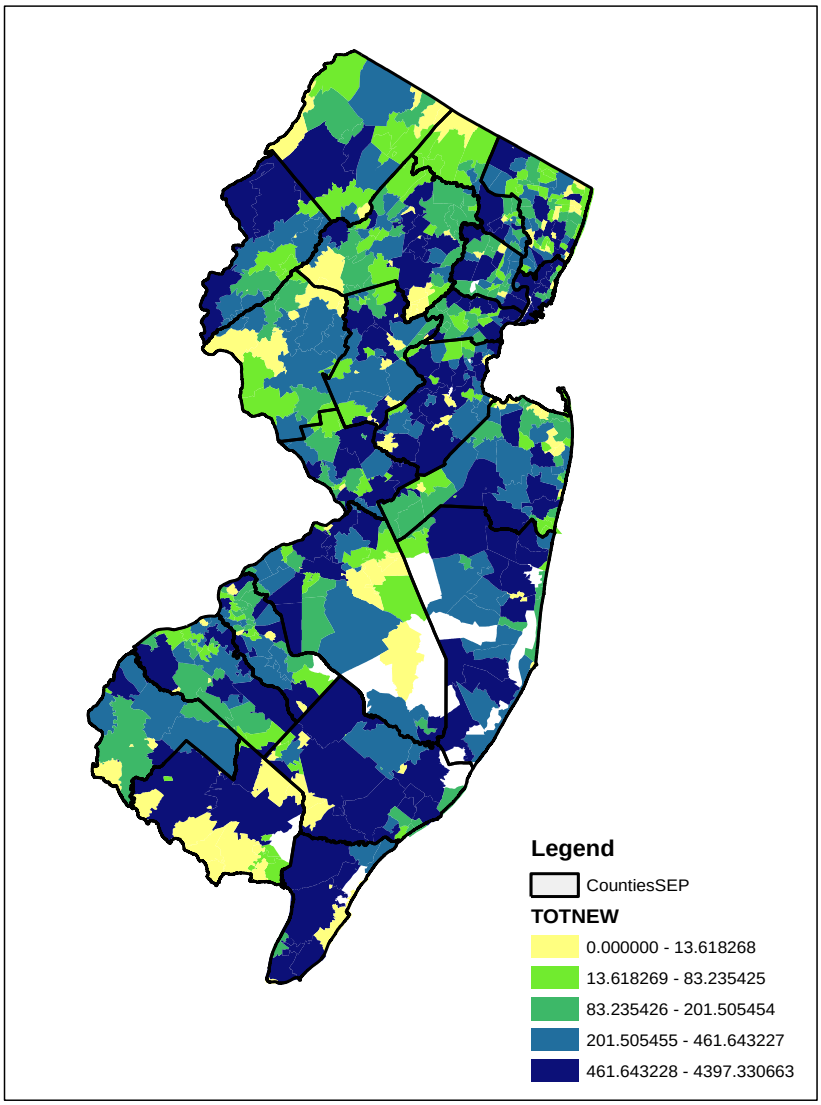
Diesel Populations Regulated Under Diesel Risk Reduction Final Law		Percent of Targetted Pop	Regulated Vehicle Total Retrofit Cost, year beginning		Cost-Benefit	PM Emissions Benefit (tons/year) by vehicle or equipment type
Using Table 1	Retrofit Populations		Deadline - Cost Estimate	Reimbursed Costs	Lifetime $/ton	
SWCVs 2006 & Older (Gov't	1355	10%	2008	$11,208,034	$134,667	9
SC&M Trucks non-SWCV	2508	19%	2012	$31,507,536	$125,663	18
Commercial Buses	1842	14%	2011	$21,224,876	$43,552	49
School Bus CCVS	7429	56%	2010	$6,753,601		0
Off Road > 175hp	5	0%	2012	$96,033	$5,649	2
School Bus BART	206			$2,089,413	$208,941	1
Total	13345			$72,879,494		
		BART Cost & Effectiveness		$64,036,479	$81,883	78

D. Distribution of Benefits

Figure 1 depicts the statewide distribution of annual diesel particulate emissions reductions from all vehicles retrofit with BART under the Diesel Retrofit Law. Emissions benefits were assigned using the zip code of each vehicle's designated storage location. It includes all retrofits completed by the end of calendar year 2013, which is 79% of all BART installations. An additional 1,273 installations occurred after this map was constructed. However, we do not anticipate a significant difference in the distribution of emissions benefits, but instead greater benefit levels statewide.

The map shows that the most densely populated areas of the State received the highest level of benefit. This is in keeping with the Law's requirement that the Department give priority to urban areas. The areas with the highest level of benefit (dark blue) represent an emission reduction range of between ¼ to 2¼ annual tons of diesel particulate. While this highest level of benefit is distributed somewhat uniformly statewide, it must be noted that the reductions are spread across the surface area of each zip code. Municipalities and zip codes from more urban areas, including the I-95 corridor, have a much smaller surface area and commensurately denser population. Thus, the higher level of emission benefit is actually more potent since it is spread across a smaller area while affecting a greater number and concentration of people.

Figure 1 - Mandatory Retrofit Program – Diesel Particulate Emissions Reductions from BART Installations through end of CY2013



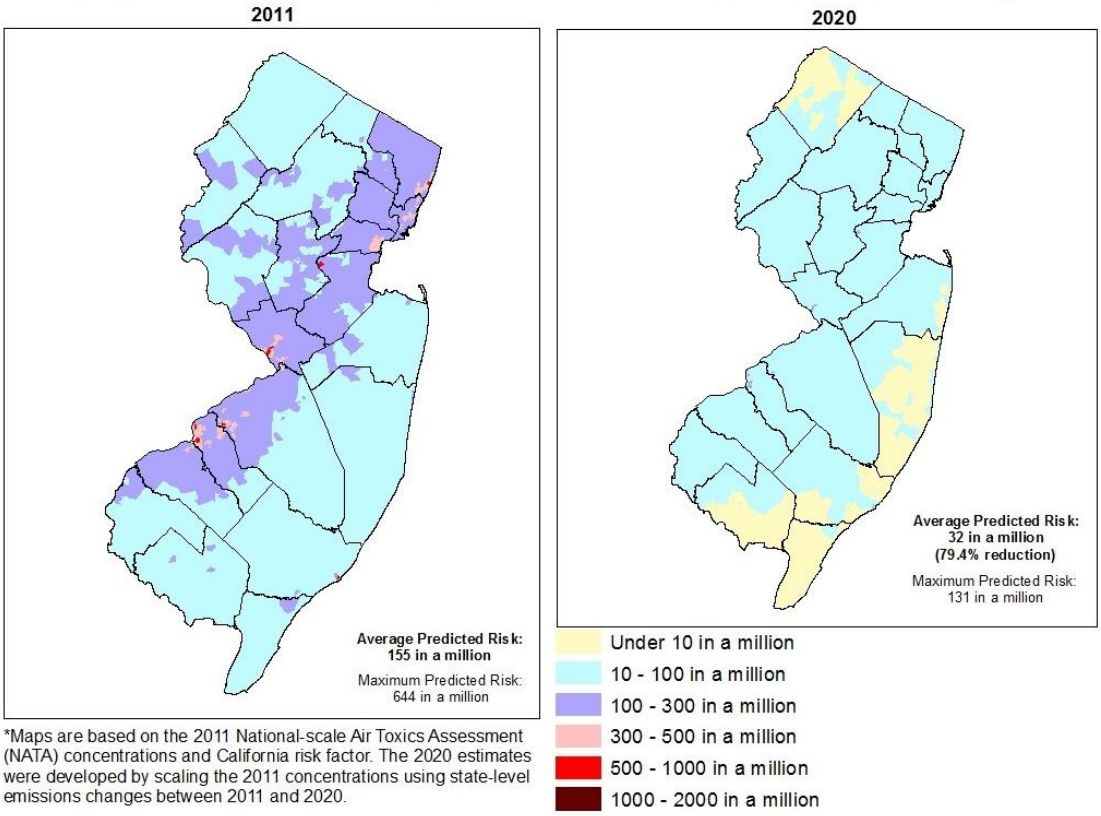
TOTNEW means new reductions from BART installations
Counties SEP are the borders separating each county

E. AIR TOXICS

Implementation of the Law yielded a statewide reduction in cancer risk from diesel exhaust. Diesel exhaust poses the highest cancer risk of all air toxics in New Jersey. The 2011 National Air Toxics Assessment (NATA) performed by the USEPA for calendar year 2011 revealed that diesel exhaust in New Jersey posed a statewide cancer risk of 327 persons for every million people. The Department extrapolated data from on-road diesel vehicles and found their contribution to be 155 in a million.

The cancer risk caused by on-road diesel vehicles is depicted in Figure 2. Risks are illustrated for both 2011 and projections to 2020. The maps reflect all emissions reductions from on-road diesel vehicle emissions reduction programs. While fleet turnover to newer, cleaner vehicles provided the greatest impact, retrofit program benefits are also included. Cancer risk on the I-95 corridor is reduced an order of magnitude from 100-300 in a million generally, with some pockets having 300-500 in a million or 500-1,000 in a million cancer risk from exhaust from diesel on-road vehicles, with the majority reduced to a risk of 10-100 in a million. Other areas in the south, southeast and northwest are predicted to see an order of magnitude reduction in cancer risk. A key issue in reducing cancer risk caused by exposure to diesel exhaust is to reduce emissions from consistent contributors such as local vehicles that operate in limited areas, including public utility vehicles, and those that operate on regular routes such as buses and solid waste collection vehicles.

Figure 2 - Estimated Health Risk from On-road Diesel Particulate in New Jersey



*Maps are based on the 2011 National-scale Air Toxics Assessment (NATA) concentrations and California risk factor. The 2020 estimates were developed by scaling the 2011 concentrations using state-level emissions changes between 2011 and 2020.

IV. LESSONS LEARNED

Lessons learned from implementing the Program include:

- Importance of school bus safety inspections. MVC's safety inspections for school buses includes measured standards for windows, doors and other cabin seals. It is designed to maintain the sealed integrity of the passenger cabin and prevent intrusion of exhaust. The rear of the bus is particularly vulnerable since a moving bus creates a vacuum which tends to draw in exhaust when rear door seals are defective. The front door and firewall seals are also more vulnerable because of their proximity to open crankcase vents and the engine compartment.

- Retrofitting is a cost-effective means to reduce pollution from in-use mobile diesel engines. Reducing emissions from vehicles operating in a confined area (route) yields lasting benefits to the local population. The program cost-effectiveness for all BART installations was $81,883/ton of diesel particulates reduced. This was achieved by retrofitting many vehicles early in their useful life, allowing the control device to effectively reduce emissions over a greater time span. Applying the same approach to a new program beginning in 2018 or later would yield lower cost-effectiveness. This is partially due to the diminished remaining useful life of the remaining compatible vehicles. In addition, newer diesel vehicles and off-road equipment have far more stringent emission controls and would not benefit from a retrofit system. Therefore, the fleet of available vehicles to retrofit is diminishing. Any further retrofits should focus upon off-road equipment, which traditionally has a longer useful life and until recently, were subjected to substantially less stringent emissions standards. Additional efforts may focus on older urban delivery and other "route" vehicles to reduce the greatest amount of exposure to diesel exhaust.

- State contract approach to reimbursement offered predictable pricing and provided adequate internal controls. BMS, in conjunction with Treasury, opted to utilize the state procurement process to reimburse retrofit costs. This approach offered several benefits but came with a high initial administrative burden. The procurement process is cumbersome and, in the case of large multi-million dollar, multi-vendor contracts, requires significant deliberation, planning and processing. Additionally, one-half of a full-time employee is needed to oversee contract activity and act as the contract manager. Fixed labor costs made retrofit activity less appealing to the contractors later in the contract life. The primary benefits of using the state procurement process include

    - Incorporation of internal controls inherent within the procurement rules and statutes. This includes fixed pricing, contractor disciplinary procedures, standardized cost tracking mechanisms and separation of staff responsibilities.

    - Utilization of the existing administrative infrastructure for reimbursements

    - Regulated fleets experienced no out-of-pocket costs to purchase and install the retrofits since the contract allowed for direct reimbursements to the installers.

- Future endeavors should incorporate a mechanism to allow contractors to revise labor costs in the event that the contract is extended beyond its initial term. The retrofit contract was initiated for a four-year term, and later extended an additional four years. Labor rates in the retrofit contract could not be revised. During the later years of the contract some vendors began to decline work, claiming that it was not profitable or resulted in a net loss to perform the work. Program staff encountered this in several situations and believe that more vehicles could have been retrofit if the labor rates were revised.

- Datalogging is critical for successful operation of catalyst-based BART. Early in the program, some installers were lax in performing datalogging candidate vehicle's exhaust temperature profiles prior to installing a BART system. Most of this occurred in association with BART 2 devices commonly referred to as a "flow-through filter" or tortuous path catalytic-converter, where the device manufacturer claimed that the systems were designed to be difficult to plug with unburnt soot, when installed on a compatible vehicle (which included exhaust temperature profiling). In actuality, cooler engine exhaust temperatures lead to heavy accumulations of unburned soot that would eventually combust and melt the system's internal substrate, causing the filter to malfunction and allowing hot melted metal to exit the tailpipe. Installations of all these devices have been remedied at no cost to the state or vehicle owners. The state contract did not require submission of data logs, only to have the Installer ensure compatibility within the manufacturer's specifications. Installers have since reliably data-logged candidate vehicle's exhaust temperatures resulting in very few subsequent compatibility problems.

- Condition of older vehicles often makes retrofitting difficult without repairs. Older diesel vehicles are often identified as higher emitting and targeted for retrofitting. Targeting these vehicles is a prudent strategy but requires a mechanism to address the initial condition of the engine/emissions controls, balanced with the remaining anticipated use of the vehicle. The program encountered some vehicles that were worn beyond tolerance. There seemed to be an entrenched culture of "it still runs good". As an example, one municipality had a 14-year old solid waste vehicle that operated eight hour days, five days per week. It had never had an engine rebuild and used "only 4 quarts of oil a day". Yet this vehicle was retrofit with a BART 3 device and the owner could not understand why the filter clogged frequently. With an estimated 28,000 hours of use on the engine, it was well beyond its' useful life. Four quarts of daily oil burning is not only a sign of excessive mechanical wear, but is also a significant pollution source and likely the source of the frequent filter clogs.

  One remedy to balance the need to retrofit against vehicles near the end of their useful life was to define vehicle retirements to include a commitment to restricted use of the vehicle. In this case, the program allowed an owner to "retire" a vehicle but keep it in-use with a mileage restriction of no more than 1,000 miles per year. This allowed entities to keep these vehicles for emergency purposes such as during snow removal and natural disasters. The owner was required to provide the vehicle's odometer readings during

each annual submittal. The retired vehicles that remained in operation are still subject to the periodic inspection program where they receive an annual smoke opacity emissions test.

- Nobody Used the Fleet Averaging Plan Option. A fleet averaging plan option was requested by the Department's management to be in the program laws and rules. Program rules at N.J.A.C. 7:27-15 and 16, and guidance documents were established to accommodate the requested feature. Staff anticipated a high administrative burden for the Department's review and compliance assurance. Fleets were apprised of the option, yet none of the fleets opted for this approach.

V. CONCLUSION AND RECOMMENDATIONS

The Department succeeded in having 5,916 diesel vehicles retrofit with BART and 7,429 school buses retrofit with CCVS. This action resulted in a cost-effective program that reduced diesel emissions by 78 tons annually. Gains include the health benefits appreciated from a reduction in statewide exposure to diesel exhaust and students' chronic exposure to diesel emissions during their daily commute to schools. Additionally, it assisted the State in attaining its air quality goals including attainment of the National Ambient Air Quality Standard for $PM_{2.5}$. In completing this activity, people in New Jersey have benefited from reduced cancer risks from exposure to diesel exhaust, which poses the highest cancer risk of any air toxic in the State and, reduced ambient levels of $PM_{2.5}$. Urban areas and the I-95 corridor received the greatest benefits.

Recommendations

1. Focus ongoing diesel emission reduction strategies on the off-road sector where equipment remains in service longer. The equipment tends to be older and the most stringent emissions standards were introduced later than the on-road sector. BMS has programs and contracts in place to address this sector as moneys become available.

2. Limited efforts should be made to retrofit or replace older high-polluting on-road diesel vehicles operating on urban routes.

3. School buses should continue to be inspected under current MVC rules to ensure students are not exposed to elevated levels of diesel exhaust inside a school bus.

4. Future retrofit contacts should include a mechanism to allow contractors to revise labor rates in conjunction with contract extensions.