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Review of Texas' Clean School Bus Programs

How Far Have We Come and What Is Still Left to Do?

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The complete report is available online at edf.org/transportation/policy/texas-school-buses.

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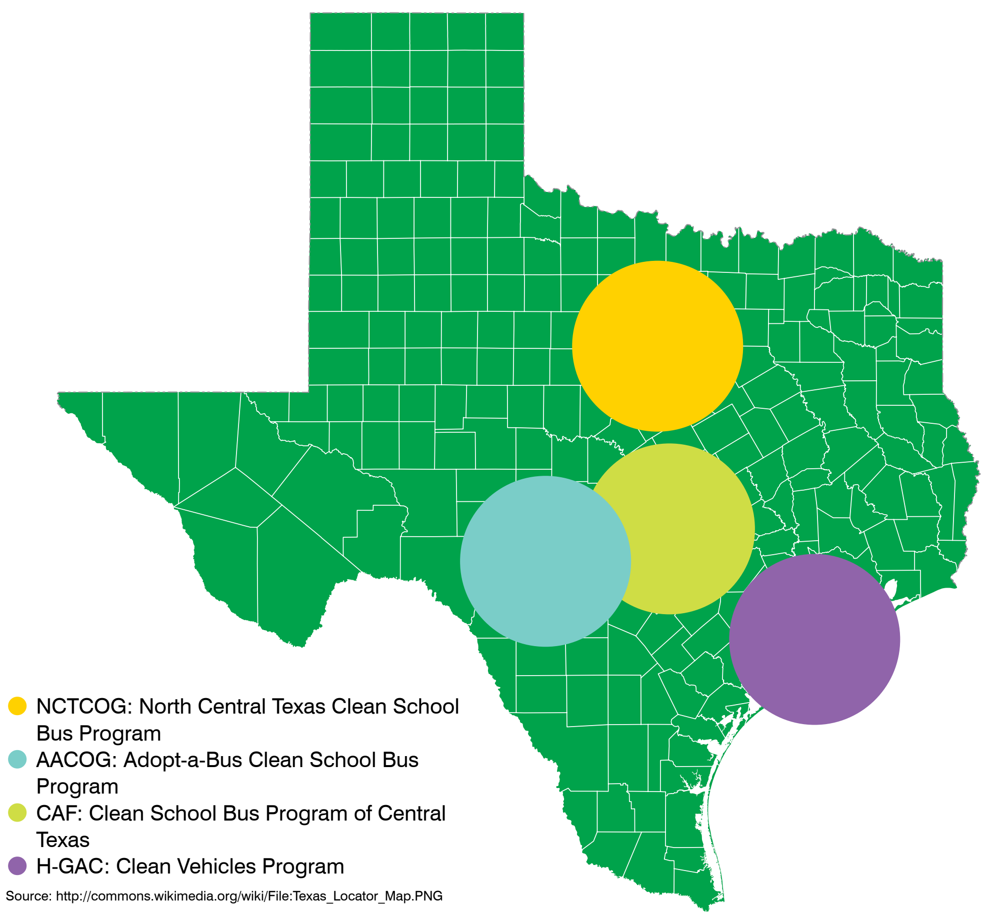
Executive summary

School buses are ever-present in the United States and provide a reliable source of transportation for children attending public and private schools, as well as sports and other extracurricular activities. Approximately 55% of American children use school buses.[1] The most commonly used school bus carries 54 students, offsetting 36 cars on the road.[2] Although they are sometimes cited as unsafe in motor vehicle crashes, a comprehensive study found only 2% of pupil deaths were caused by school buses.[3] In fact, school buses save resources and are quite safe.

The problem is that many school buses are powered by older diesel engines that emit unhealthy pollutants from both the tailpipe and the crankcase as a result of normal engine combustion. Diesel engines produce both solid (e.g., particulate matter) and gaseous (e.g carbon monoxide, nitrogen oxides) emissions that have been shown to be dangerous to breathe. These emissions affect not only students outside the bus, but also the students inside the bus.

Regional Clean School Bus Programs in Texas



Source: http://commons.wikimedia.org/wiki/File:Texas_Locator_Map.PNG

In today's world, school districts are under pressure to cut costs due to budget shortfalls.[4] Because of this, programs for planned school bus fleet replacements are often cancelled due to both the high cost of new buses and the remarkable longevity of diesel engines. Ironic in its outcome, a child's safest ride to school may not be the healthiest.

In Texas, 65% of the school buses in the state's fleet of 38,150 are over six years old.[5] The difference in emissions between school buses manufactured today and those manufactured in the last decade is surprising: new buses are over 50 times cleaner than the oldest buses (i.e., 1988 model year and older) for NO_x and 60 times cleaner for PM. Particulates are well known to aggravate asthma, cause lung inflammation, lead to heart problems, increase the risk of cancer, and can result in premature death. In addition to the serious health concerns caused by school bus emissions, they also result in local air quality issues. Considering that school buses in Texas help to support a total student population of nearly 5 million, the issue is not one to ignore.[6]

Completed Clean School Bus Projects in Texas

To mitigate the harmful emissions from school buses across the state, a number of Clean Bus Programs in Texas were developed to either retrofit or replace the older, more polluting buses. Collectively, these programs have made significant progress towards improving the air quality on the state's school buses: through the end of the 2011 calendar year, 7,068 buses had been retrofit, 700 buses had been replaced, and several other projects (e.g., clean fuels and idle reduction) had been successfully implemented in Texas. Approximately $38 million from federal, state and local funding sources have been used to help districts undertake clean school bus projects, with an average cost of $30,113 per replaced bus and $2,589 per retrofitted bus (note that grants awarded help to offset the cost of projects and rarely cover the entire cost).[7,8]

Completed school bus projects	Replacements	Retrofits
# Cleaned buses	700	7,068
Project costs*	$19,182,282	$17,662,455
Average cost per bus*	$30,113	$2,589

*Average cost calculations computed exclude CAPCOG/CAF projects because project costs provided did not separate replacement and retrofit costs. Source: http://www.tea.state.tx.us/acctres/Enroll_2010-11.pdf

Remaining challenges

Despite the progress that state and regional programs have made in reducing emissions from school buses in Texas, over 700,000 children, or nearly half of the students that rely on school buses for transportation in Texas, still ride dirty buses.[9] To address a wide range of obstacles that have impeded many fleets from participating in the existing programs, including lack of funding, procedural difficulties, and technological challenges, Environmental Defense Fund (EDF) recommends the following revisions to existing programs to ensure that every child in Texas has a clean and healthy ride to school:

- continue to educate and motivate school districts to take advantage of available funding;
- make more funding available for clean school bus projects, especially replacements (In general, school officials prefer replacement projects whenever possible, as new buses not only provide the greatest emissions reductions, but also represent fuel economy benefits and improved maintenance which allow districts to better deal with ongoing budget cuts. However,

retrofit projects provide real emissions reductions and should be utilized when replacement is not an option); and

- target outreach to school districts, especially those in the rural parts of the state that have not taken full advantage of the resources available to them.

	"Newer" buses	"Cleaned" buses	Remaining "dirty" buses
# buses	12,686	7,768	17,696
# estimated students	553,110	338,685	771,546
Proportion	33%	20%	46%

Note: The "Newer Buses" category includes all buses that are five years old or newer, less the number of buses that have been replaced through Clean School Bus Programs. The "Cleaned Buses" category includes all replaced and retrofitted buses. The "Dirty Buses" category includes all buses older than six years old, less the number of buses that have been retrofitted. The estimated students are based on average ridership of 43.6 students per bus.

Evaluation of Clean School Bus Programs in Texas

Health concerns and school buses: what are the issues?

Diesel engines power most of the estimated 480,000 school buses in the United States, and more than 40 known toxic chemicals have been identified in diesel exhaust.[10] Recently, the World Health Organization (WHO) classified diesel exhaust as a known carcinogen, and specifically noted a causal link between exposure to diesel exhaust and lung cancer.[11] One of the most dangerous components of diesel exhaust is particulate matter (PM). The U.S. EPA is particularly concerned with the smallest size particles, 2.5 microns in size and smaller, because they are most easily respired by people and organisms.[12] Particulates are well known to aggravate asthma, cause lung inflammation, lead to heart problems, increase the risk of cancer, and possibly result in premature death.

A few of the other dangerous pollutants that are associated with diesel engine exhaust include:

- **Carbon monoxide (CO):** Considered a criteria pollutant under the Clean Air Act, EPA is required to set a National Ambient Air Quality Standard for carbon monoxide. Health effects of carbon monoxide are well known, as it reduces oxygen delivery to vital organs and can lead to death.

- **Sulfur dioxide (SO_2):** Considered a criteria pollutant under the Clean Air Act, EPA is required to set a National Ambient Air Quality Standard for sulfur dioxide. Health effects of sulfur dioxide include respiratory ailments, including aggravating symptoms for people suffering from asthma and other respiratory diseases.

- **Nitrogen oxides (NO_x):** Considered a criteria pollutant under the Clean Air Act, EPA is required to set a National Ambient Air Quality Standard for nitrogen oxides. Health effects of nitrogen oxides are respiratory ailments, including aggravating symptoms for people suffering from asthma and other respiratory diseases.

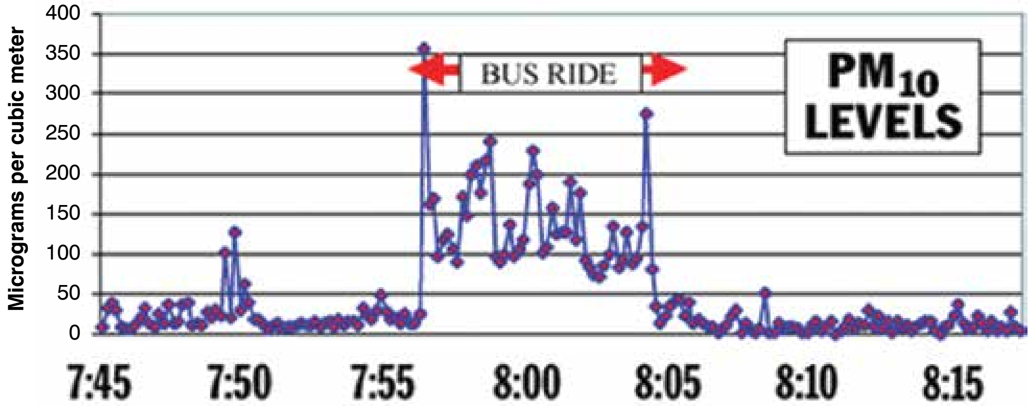
- **Formaldehyde:** EPA's health summary for formaldehyde notes acute toxic effects from inhalation and ingestion, as well as increased cancer risk in occupational studies.[13] Chronic effects include irritation of mucous membranes and contact dermatitis.

School buses emit exhaust from two sources: the tailpipe located at the back of the bus, and the open crankcase, which is located in the engine compartment. Tailpipe exhaust enters the cabin of the bus through open windows and as children enter and exit the front doors. Emissions from the engine's crankcase, carrying volatized engine oil, unburned fuel, exhaust gases and other toxic particles, also enter the bus through the front door. Crankcase emissions are responsible for pollution that can be five to ten times worse than ambient air outside the bus.[14] Figure 1 shows how PM10 emissions from a school bus can enter into the interior, creating an unhealthy environment for students riding the bus to school.

Children are especially susceptible to damaging pollutants because their bodies are still maturing. Requiring two times more air per pound of body weight than adults, a child has a

FIGURE 1

Particulate pollution levels measured with a backpack monitor designed to simulate a child's trip to school



The graph shows elevated exposures to particulates for passengers inside a school bus built before 2007.
Source: http://www.ehhi.org/reports/diesel/diesel.pdf Accessed 8/14/12

heightened rate of respiration. The faster rate of respiration, in combination with undeveloped lungs, makes children more vulnerable to airborne toxins.

Engine standards

In the last few decades, EPA has begun requiring engine and vehicle manufacturers to produce much lower-emitting diesel engines. As a result, buses built today are much cleaner than buses built five or more years ago. To illustrate, Table 1 provides the heavy-duty engine standards for PM and NO_x required for buses over the years. While new buses continue to generate much lower emissions, these improvements can only be realized as older buses and vehicles are retired from operation. EPA has also finalized requirements for new greenhouse gas (GHG) emissions for carbon dioxide (CO_2), nitrogen dioxide (N_2O), and methane (CH_4) that will affect school bus engine standards in the near future.

TABLE 1

Heavy-duty engine emissions standards (g/bhp-hr) for PM, NO_x and GHGs

Pollutant	1988	1990	1991	1994	1998	2004	2007	2010	2014	2017
PM	0.6	0.6	0.25	0.1	0.1	0.1	0.01	0.01	0.01	0.01
NO_x	10.7	6.0	5.0	5.0	4.0	2.375	2.375	0.2	0.2	0.2
CO_2	—	—	—	—	—	—	—	—	567	555
N_2O	—	—	—	—	—	—	—	—	0.10	0.10
CH_4	—	—	—	—	—	—	—	—	0.10	0.10

The improvements in emissions for both NO_x and PM are shown in Figures 2 and 3; new buses are over 50 times cleaner than the oldest buses (e.g., 1988 model year and older) for NO_x, and 60 times cleaner for PM.

FIGURE 2

Improvements in PM emission standards for heavy-duty engines

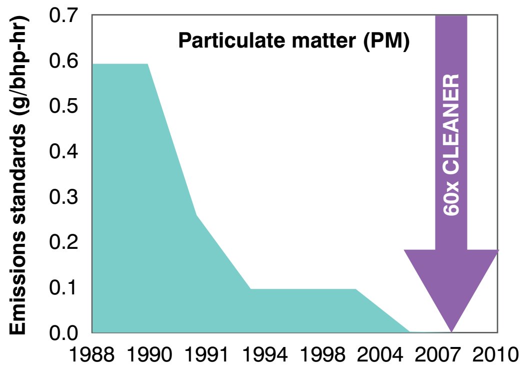
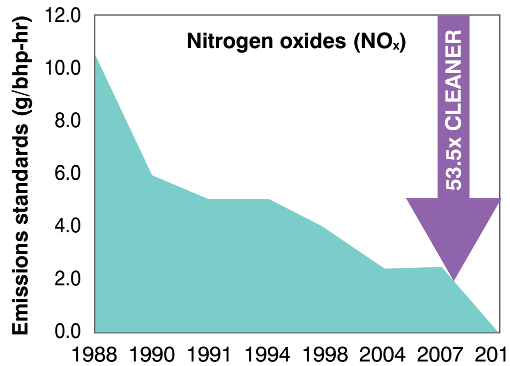


FIGURE 3

Improvements in NO_x emission standards for heavy-duty engines



A report card for how programs in Texas are doing

Efforts in Texas have been at both the state level, through the Texas Commission on Environmental Quality (TCEQ), as well as at the regional level through councils of government organizations and regional clean air organizations. This report provides a summary of the progress made in Texas to protect school children from harmful emissions from diesel school buses. All of the current "Clean School Bus" Programs in Texas are presented in this report, with data on funding sources, project costs and details, technologies utilized, and estimated emissions reductions achieved. A final evaluation of the accomplishments and work yet to be done is provided at the conclusion.

The toolbox: what options are available?

A framework of cost-effective emission reduction strategies, referred to as the "4 Rs," have been endorsed by both EDF and EPA to achieve emissions reductions from school buses:

1. Replacement of vehicles (and subsequent retirement of an older bus in the fleet) lowers emissions by replacing older, dirtier buses with new buses that meet the current, cleaner emissions standards.

2. Retrofits are bolt-on devices that are installed onto an existing vehicle. These solutions are much more cost-effective than outright replacement, but they do not provide as many emissions reductions.

3. Idle **reduction**, through policy or other means, provides significant reductions of emissions, as well as fuel savings for bus fleets. Like all vehicles, school buses use fuel while at idle, and fleets can potentially save thousands of dollars in fuel costs by implementing a policy to reduce all unnecessary idling.

4. Routing improvements can reduce emissions by reducing miles traveled or better siting of passenger stops. Well-organized routing of school buses through towns and cities can reduce the health risks associated with heavy pollution as well as saving countless gallons of gas.

TABLE 2

Feasibility and relative cost for emission reduction options in school buses

The Four "Rs" for school buses	Feasibility and relative cost ($: least expensive, $$$: most expensive)			
	Particulate matter (PM)	Carbon monoxide	Hydrocarbons	Oxides of nitrogen (NO_x)
Replacement	✔($$$)	✔($$$)	✔($$$)	✔($$$)
Retrofits	✔($$)	✔($$)	✔($$)	—
Idle Reduction	✔($)	✔($)	✔($)	✔($)
Routing	✔($)	✔($)	✔($)	✔($)

The best option for total emissions reduction is replacement of buses, but in today's economy, budgets are lean. With the cost of a standard 54-seat school bus ranging from $75,000–$125,000, overhauling entire fleets would impose significant costs on school districts.[15,16] Idle reduction and routing improvements are potentially very inexpensive solutions that may save money for bus operators and should be implemented in all fleets, to the greatest extent possible. However, use of anti-idling policies may be more limited in very hot climates, such as Texas', during certain parts of the year where air conditioning is often a necessity. In addition, after evaluating the most efficient routing options and scheduling periodic review of routes, most fleets will need to consider other options to achieve meaningful emissions reductions. Replacements and operational solutions demonstrate one part of a comprehensive Clean School Bus Program, but more and more, fleets are choosing to install cost-effective retrofit solutions to improve air quality inside their school buses.

Retrofit technologies for cost-effective emissions reductions

Across the country, school districts and communities have successfully implemented emissions reduction projects using retrofit technologies that provide reductions for specific pollutants. Because emissions come in different forms (e.g., PM is a solid, while carbon monoxide is a gas), technologies use different approaches to reduce emissions. Fortunately, reduction technologies that target dangerous PM tend to use relatively less sophisticated and inexpensive technologies. On the other hand, some emission reductions require chemical reactions to occur, and these approaches can be complex and expensive. For example, the current technology to reduce NO_x requires the addition of urea and has not been used in school bus applications. Federal law requires that all devices used to retrofit on-road vehicles, such as school buses, be "verified" by EPA or the California Air Resources Board. The verification process ensures that new devices are carefully evaluated by technical experts and achieve expected emissions reductions safely. Retrofit technology can reduce the amount of $PM_{2.5}$ emitted from a school bus by 50% or more, resulting in $PM_{2.5}$ concentrations equivalent to that of the ambient air. The cost of retrofit devices can range greatly and are often specific to particular engine characteristics and vehicle types. Examples of typical retrofit technology used in school bus applications include the following:

- Diesel particulate filters (DPFs): DPFs are installed between the engine and exhaust pipe of a diesel-powered bus.
- Diesel oxidation catalysts (DOCs): DOCs are advanced catalytic converters that are installed in the exhaust system of a bus.

• Flow-through filters (FTFs): FTFs use a two-part filter to trap and reduce emissions from bus exhaust.

• Closed crankcase filtration systems (CCFSs): By installing a CCFS to capture "blow-by" emissions from the engine, toxic emissions inside the cabin of a bus can be reduced using an air filter.

TABLE 3

Average cost and emissions reductions of retrofit technologies

Technology type	Cost range	Average cost	Average estimated reductions (%)		
			PM	HC	CO
Diesel particulate filter	$9,000–$15,000	$12,000	90%	90%	70%
Diesel oxidation catalyst	$2,000–$3,000	$2,500	30%	55%	50%
DOC + closed crankcase filtration	—	$2,450	29%	56%	37%
Flow-through filter	$8,000–$12,000	$10,000	60%	58%	35%

Emissions reductions estimates based on average of current (as of April 2012) EPA verifications for CCFS+DOC and an EPA summary (http://www.epa.gov/cleandiesel/technologies/retrofits.htm) for other technologies; cost estimates summarized from prior EDF summary ((http://www.edf.org/transportation/policy/clean).

Retrofit devices have the potential to improve the air quality during the ride to school for millions of children and, by doing so, can lower health care costs. It is less expensive per gram inhaled by a student to reduce emissions from school buses than from an average vehicle, even if emission reductions are many times more expensive per gram emitted from school buses than from an average vehicle.[17] Thus, reducing emissions from buses still makes financial sense, even with the costs incurred to clean up buses, because of the significant health benefits in reducing the unhealthy emissions released by school buses. Reducing emissions from dirty vehicles helps alleviate symptoms for asthmatics and others with respiratory ailments, in addition to helping lower the risks of long-term, serious health issues associated with breathing dirty air.

History of Clean School Bus Programs across the country

Awareness of the health risks associated with school bus emissions has grown in the past decade. EPA started its Clean School Bus USA in 2003 as a partnership program between education, transportation, business and other local organizations to bring together the necessary resources to reduce unnecessary idling, retrofit buses, replace the oldest buses, and educate the public about the importance of the issue. This sort of parnership encourages new policies and practices that lower diesel emissions.

Many states and local entities have followed suit with their own Clean School Bus Programs. Several states, including Texas, have developed programs that have made significant improvements in the air quality of children dependent on school bus transportation. Examples of some of the larger programs include:

• **New York:** In the aftermath of the World Trade Center bombings in 2001, the City began passing local laws requiring retrofits on heavy-duty diesel vehicles used in construction, waste management and transportation. The City extended these requirements to school buses in 2006 with Local Law 42 that requires diesel school buses to be equipped with the best available retrofit technologies (BART). In addition, the New York state legislature passed the New York State Clean School Bus Program in 2003 and has been implementing projects throughout the state. EPA Region 2, which includes New York and other mid-Atlantic states, has been very active in establishing partnerships that lead to Clean School Bus project implementation.

- **Washington:** In 2003, the state funded the Washington State Clean School Bus Program to retrofit school buses. Numerous projects have been funded through this program using a voter-approved tax on toxic substances. Other efforts have been coordinated through EPA Regions 9 and 10, as well as the Puget Sound Clean Air Agency.

School buses in Texas

Texas has one of the fastest-growing populations in the country.[18] Coincident with this increase in the general population, student populations are growing each year, and in the 2010–2011 school year, total enrollment approached 5 million students.[19] The state's environmental agency, the Texas Commission on Environmental Quality (TCEQ), and several other regional entities in metropolitan areas have taken the initiative in the last decade to develop programs that address school bus emissions.

School bus profiles in Texas

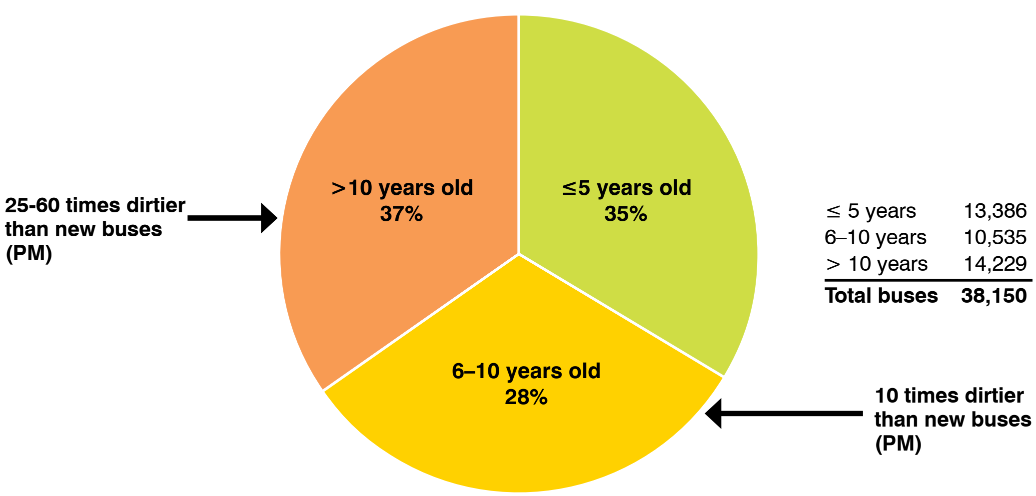
The Texas Education Agency (TEA) compiles data on the state's fleet of vehicles in five-year increments, which roughly correspond to changes in emissions standards for both PM and NO_x. Figure 4 provides an illustration of the Texas school bus fleet's age distribution and how the ages of buses correspond to PM emissions. Most of the school buses transporting Texas school children are emitting between ten and 60 times as much PM as a newer model bus.

Summary of Texas' Clean School Bus Programs

In the last decade, several programs have developed in Texas to target harmful school bus emissions through implementation of technologies or other strategies. These programs have actively pursued legislative appropriation, grants and other funding mechanisms in their mission to clean up school bus emissions.

FIGURE 4

School bus age distribution in Texas, 2010–2011 school year



≤ 5 years	13,386
6–10 years	10,535
> 10 years	14,229
Total buses	**38,150**

In 2005, the Texas state legislature granted the TCEQ authorization to develop a statewide program to support clean school bus retrofit projects. This program is complemented by regional programs in Houston-Galveston-Brazoria (Clean Vehicles Program), Dallas-Fort Worth (North Central Texas Clean School Bus Program), San Antonio (Clean School Bus Program) and Central Texas (Clean School Bus Program of Central Texas). In addition to these dedicated Clean School Bus programs, motivated school districts have found other means to support their own emission reduction initiatives by leveraging programs targeting general diesel emissions reductions.

A summary of the dedicated Clean School Bus Programs in Texas are provided below and a final evaluation of the program's accomplishments is discussed in the conclusion.

- **Texas Clean School Bus Program (TCEQ, statewide):** All Texas school districts are eligible to receive clean school bus funding from this TCEQ-administered program. Grants are awarded to purchase and install EPA-verified retrofit technologies on school buses operating on a regular, daily schedule with more than five years of useful life remaining on the bus, and grantees are encouraged to reuse retrofit devices on other buses when retiring a previously retrofitted bus from a fleet. Grantees also agree to educate school district personnel about options that can improve bus fleets and benefit the environment, including the benefits of eliminating unnecessary idling.
- **Clean Vehicles Program (Houston Galveston Area Council, specific counties):** The Houston Galveston Area Council (HGAC) began facilitating emissions reductions projects in 1997 and has overseen a number of clean air programs. The Clean Vehicles Program uses different funding streams to implement various emissions reductions projects in the Houston region. Applicants operating vehicles in Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery and Waller counties are eligible to apply for grant funds. The program may pay up to 100% of the eligible project costs, but grants are ultimately calculated on emissions reductions (i.e., a cap is placed on the dollar amount awarded per ton of pollutant reduced). Projects focus on reduction of NO_x because the program supports the region's obligations under the State Implementation Plan (SIP) and federal transportation conformity requirements. Thus, clean school bus projects have focused on replacing rather than retrofitting buses in order to achieve NO_x reductions.
- **North Central Texas Clean School Bus Program (North Central Texas Council of Governments, specific counties):** In 2003, the American Lung Association of Texas passed management of the DFW Adopt-A-School Bus Program, developed in partnership with EPA, to the North Central Texas Council of Governments (NCTCOG). In 2006, the program was renamed the North Central Texas Clean School Bus Program. The program awards grants to schools, school districts and school bus operators with fleets in 16 counties around the Dallas-Fort Worth metropolitan region (Collin, Dallas, Denton, Ellis, Erath, Hood, Hunt, Johnson, Kaufman, Navarro, Palo Pinto, Parker, Rockwall, Somervell, Tarrant and Wise counties). The main focus of the program is to reduce emissions from school bus fleets by encouraging and assisting in the expedited purchase of clean school buses. In addition, it acts as a clearinghouse for information on technology, legislation, best practices for school bus operators, and clean school bus funding opportunities. Projects focus on reduction of NO_x because the program supports the region's requirements under the State Implementation Plan (SIP) and federal transportation conformity requirements. In order to achieve NO_x reductions, clean school bus projects have focused on replacing buses and installing on-board idle reduction rather than retrofitting buses.

- **Clean School Bus Program (Alamo Area Council of Governments, specific counties):** The Alamo Area Council of Governments (AACOG) Clean School Bus Program began at the request of various school districts interested in improving children's health. The Clean School Bus Program advocates for the reduction of foreign petroleum consumption and supports projects promoting idle reduction, implementation of retrofit technology and bus replacement. It also administers an outreach program to educate parents, schools and students about air pollution, while encouraging sponsors to help fund emissions reduction projects. The AACOG serves the counties of Atascosa, Bandera, Bexar, Comal, Frio, Gillespie, Guadalupe, Karnes, Kendall, Kerr, Medina and Wilson; most emissions reductions projects have been focused in the counties surrounding San Antonio (i.e., Bexar, Comal, Guadalupe and Wilson counties).
- **Clean School Bus Program of Central Texas (CLEAN AIR Force of Central Texas, specific counties):** The CLEAN AIR Force of Central Texas (CAF) has been helping to reduce school bus emissions in the greater Central Texas region (Bastrop, Caldwell, Hays, Travis and Williamson counties) since 2003. The Clean School Bus Program of Central Texas, formerly called the Adopt-A-School Bus Program, is a grant program managed by CAF, a non-profit air quality organization.. This program has successfully partnered with the Capital Area Council of Governments and other local organizations to leverage federal funding opportunities for clean school bus projects in the region. School districts in the region may apply for funds, as they are available, to retrofit older buses or pay up to 50% of the cost of replacing old buses with new, clean-emitting buses. The Clean School Bus Program of Central Texas also works with PTAs to reduce school bus idling, encourage the use of cleaner fuels, and has helped school districts successfully apply for retrofit grants under the TCEQ's Clean School Bus Program.

Funding clean air: how can we pay for projects?

Clean school bus project implementation requires stable and sufficient funding and different programs have accessed various pools of money. Examples include allocating state vehicle title transfer fees and levying taxes (e.g., Washington), legislative appropriation (e.g., Texas), use of Congestion Mitigation and Air Quality (CMAQ) funds for areas out of attainment for criteria pollutants (e.g., New York), environmental fines (e.g., Illinois), and federal grants awarded through EPA (e.g., Diesel Emission Reduction Act [DERA]), as well as the U.S. Department of Energy (e.g., Clean Cities Program). Private donations have also been used to fund projects.

FIGURE 5
Funding for all Clean School Bus Projects in Texas, by source

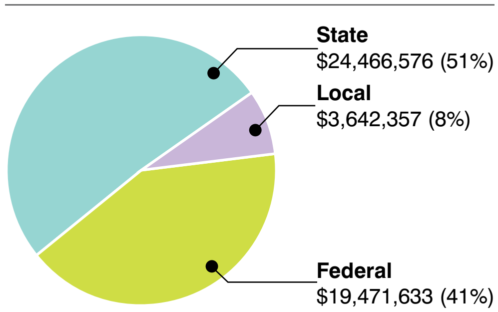


FIGURE 6
Funding levels for Clean School Bus Programs in Texas, by program

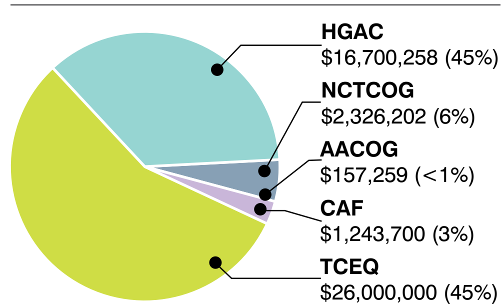
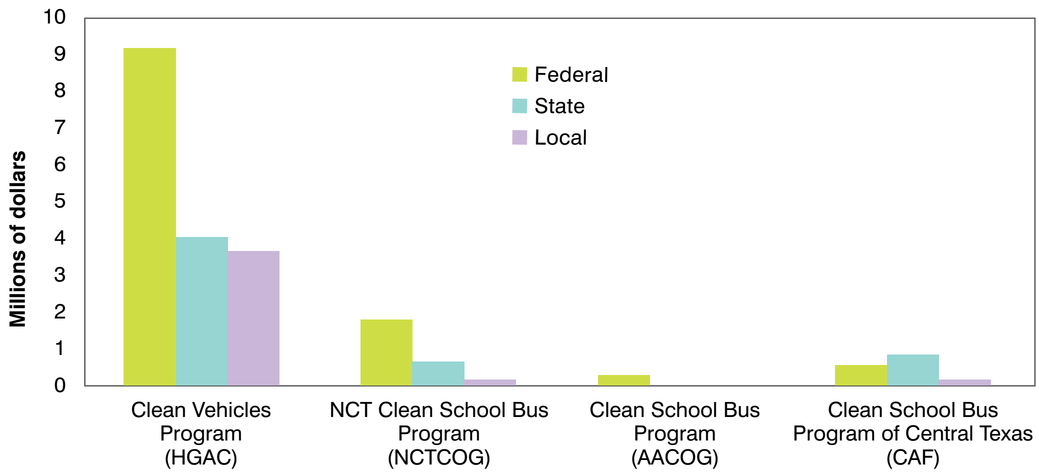


FIGURE 7

Differences in funding source for regional Clean School Bus Programs



In Texas the majority of funding comes from the state through two main sources: a specific allocation to the Texas Clean Bus Program from the Texas Emissions Reduction Plan (TERP) legislative appropriation, and from competitive grants that some school districts have pursued that are through TERP's Emissions Reduction Incentive Grants Program (ERIG). The statewide Texas Clean School Bus Program was created and funded by the state legislature in 2007. Since then, the program has received biannual state funding. Support for clean school bus projects have also been funded through state Supplemental Environmental Projects (SEPs) where a third party that may have been required to pay an environmental penalty can divert the money into a beneficial environmental program. SEP proceeds generally go straight to regional Clean School Bus Programs from the TCEQ. In addition to the direct allocation to the Clean School Bus Program, TERP may also benefit school bus projects through awards to regional organizations that administer sub-grants for funding. Other sources of state funding exist for certain areas in the state, as well. Statewide, funding for clean school bus projects in Texas have come from federal, state, and local sources, as shown in Figure 5.

The majority of federal funding has come from CMAQ funding to the state's ozone nonattainment areas (Houston, Dallas) and from competitive clean air grants from EPA (DERA, Blue Skyways). In addition to DERA grants that are competed for nationally through EPA regions, the DERA program also includes an annual state allocation for emission reduction activities; in recent years, Texas has used this funding for the Clean School Bus Program. As this report was being finalized, a $1M DERA award had just been awarded to Aldine ISD (Houston area) to retrofit 65 school buses.

Clean School Bus Programs in Texas received over $47 million in funding for their programs from a wide variety of sources, with TCEQ's statewide Clean School Bus Program and HGAC's Clean Vehicles program (school bus component) receiving most of the funding. Not all of the funding received for the TCEQ Clean School Bus Program was spent on school buses; some of the unspent funding was used for TERP ERIG projects.

The four regional programs (HGAC's Clean Vehicles for school bus projects only, NCTCOG's North Central Texas Clean School Bus Program, AACOG's Clean School Bus Program and CAF's Clean School Bus Program of Central Texas) rely on different sources of funding for their projects, as shown in Figure 7.

A comprehensive summary of how the key programs in Texas receive funding for clean school bus programs is shown in the Appendix. Many of the programs leverage sources from multiple grant programs and funding streams, requiring careful administration and creative approaches to ensure that all program requirements are met. Administrators for each program provided updated data in spring 2012.

The good news: completed school bus projects in Texas

Clean school bus programs in Texas have made significant progress towards improving the air quality on the state's school buses. Through the end of the 2011 calendar year, 7,068 buses have been retrofitted, 700 buses have been replaced, and several other projects related to clean fuels and idle reduction have been successfully implemented in Texas. Completed clean school bus projects have cost approximately $38 million, with an average cost of $30,113 per replaced bus and $2,589 per retrofitted bus. [20,21] It is important to realize that grant funding generally only offsets a portion of the cost for full replacement of a bus or retrofit, but in many cases, the availability of any funding ensures that school districts can move forward with a project.

TABLE 4

Summary of all completed Clean School Bus Projects in Texas, through 2011

	Replacements	Retrofits
# cleaned buses	700	7,068
Project costs*	$19,182,282	$17,662,455
Average cost per bus*	$30,113	$2,589

*Average cost calculations computed exclude CAPCOG/CAF projects because project costs provided did not separate replacement and retrofit costs.

Individual programs varied in terms of how they complete clean school bus projects; the summary of all projects by program is shown in Table 5.

TABLE 5

Summary of completed Clean School Bus Projects in Texas, by program

Project achievements by program	Total "cleaned" buses	# replaced buses	# retrofitted buses	# retrofitted buses (with % PM reduction)*			
				DPF ~90%	DOC ~30%	CCFS ~29%	FTF ~60%
TCEQ's Clean School Bus Program	6,487	-	6,487	364	2,443	5,136	1,356
NCTCOG's North Central Texas Clean School Bus Program	65	65	-	-	-	-	-
HGAC's Clean Vehicle Program	542	495	47	-	40	47	-
AACOG's Clean School Bus Program	22	2	20	-	20	-	-
CAF's Clean School Bus Program of Central Texas	308	63	245	3	44	198	-
TCEQ's TERP ERIG Program	344	75	269	-	269	-	-
All Texas Totals	7,768	700	7,068	367	2,816	5,381	1,356

*Note: The TCEQ Clean School Bus Program allows buses to install CCFS alone, unlike other programs that require a DOC+CCFS system because EPA and CARB verify these systems together. Some programs track DOC+CCFS systems separately, while others track them together. As a result, a bus can have multiple retrofits and/or retrofits may be counted "twice," so the sum of all retrofits does not equal the total retrofitted buses. DPF (Diesel Particulate Filter), DOC (Diesel Oxidation Catalyst), CCFS (Closed Crankcase Filtration System), FTF (Flow-Through Filter)

Emissions reductions

Not all programs track estimated emissions reductions achieved through grant-funded projects, most notably the TCEQ's Clean School Bus Program. Other programs are required to track reductions based on specific requirements of individual grants, and these reductions are not always calculated in the same manner across programs. As a result, it is impossible to accurately summarize estimates from all programs together or compare program estimates with each other.

To fairly compare approximate reductions across all programs in Texas, a very simple estimate of achieved emissions reductions was calculated using the same methodology for all programs. Normally, with quality data, a more sophisticated approach to estimating the true benefits of a clean school bus project would be undertaken, to estimate future emissions reductions projected that takes into account both the current and new emissions profiles over a remaining life that is determined by the current age of the bus. Unfortunately, important variables were difficult to determine because of inaccessibility of data (e.g., no centralized fleet reporting for Texas school buses to capture annual fuel consumption data) and bundling of data (e.g., TEA's practice of reporting the school bus population in arbitrary categories), so the emissions estimates are provided with the following limitations:

- School buses emit pollutants while traveling on routes, before and after routes, and while idling. The estimates on emissions below only capture emissions during on-road travel by using an average annual mileage calculated across all buses operating all routes throughout Texas.
- Estimates are based upon averages, instead of particular school buses that might be operating differently than the "typical" bus.
- The TEA reports the Texas school bus age distribution for the 2010–2011 school year was comprised of approximately one-third newer buses (less than five years old), one-third older buses (six to ten years old), and one-third oldest buses (more than ten years old). Within these time categories, it is impossible to discern which buses meet certain standards because the exact model year of the engine in each bus must be known to determine this information.
- More information on the rationale for assumptions and approach used for calculating emissions reductions are provided in the Appendix. In general, the following assumptions were used:
    - Average annual miles/bus = 8,156 miles
    - Average model year for replaced buses = 1991
    - Average model year for retrofitted buses = 1996
    - Remaining lifetime for replaced buses = 15 years
    - Remaining lifetime for retrofitted buses = five years, but expect retrofit to be used one more time on different bus

Table 6 shows a conservative estimate of the NO_x and PM reductions achieved in Texas, calculated using the same, simple methodology. For comparison, emissions reductions reported by the individual programs (when available) are also shown.

TABLE 6

Emission reduction estimates for NO_x and PM

Emissions reduction estimates by program	# replaced buses	# retrofitted buses	Emisions reductions (tons)			
			NO_x (tons)		PM (tons)	
			Estimate	Program	Estimate	Program
TCEQ Clean School Bus Program	-	6,487	0	-	62	-
NCTCOG's North Central Texas Clean School Bus Program	65	-	90	71	6.9	5.2
HGAC's Clean Vehicle Program[a]	495	47	682	179	53	-
AACOG's Clean School Bus Program	2	20	2.8	2.9	0.36	0.37
CAF's Clean School Bus Program of Central Texas	63	245	87	42	8.5	7.1
TCEQ's TERP ERIG Program[b]	75	269	103	99	10	-
All Texas Totals	700	7,068	965 tons	-	141 tons	-

a Note: Although projects date back to 1995, follow-up monitoring to verify usage or emission reductions was not done until 2004.

b For TCEQ ERIG program, estimates only included replacement and fuel project reductions; although DOCs had emissions associated with them, the program is a NO_x only program, and DOCs do not reduce NO_x. These were assumed to be an error in the TERP summary.

Cost-effectiveness

Grant programs evaluate the efficacy of their programs by calculating the cost-effectiveness of projects to better understand the cost of reducing a given amount of pollutants. Aggregate cost-effectiveness values for all emission reduction projects in Texas are presented in Table 7, using the estimates of emissions reductions calculated above. The same limitations that were described for the emissions reductions estimates apply to these cost-effectiveness values because emissions reductions estimates are used to calculate cost-effectiveness. No discount factor was used.

TABLE 7

Cost effectiveness of Clean School Bus Projects in Texas

Cost effectiveness (all Texas projects)	Replacements	Retrofits
Total buses (#'s)	700	7,068
Total buses used in CE analysis[a]	637	6,823
Total cost ($)	$19,182,282	$17,662,455
Lifetime estimated NO_x reductions	878 tons	0 tons
Lifetime estimated PM reductions	67.5 tons	64.5 tons
NO_x cost-effectiveness ($/ton)	$22,000/ton	N/A
PM cost-effectiveness ($/ton)	$284,000/ton	$274,000/ton

[a] Average cost calculations computed exclude CAF projects because project costs provided did not separate replacement and retrofit costs.

EPA completed a study in 2007 that summarized the cost-effectiveness of various diesel PM retrofit scenarios and suggested that school bus projects should achieve a cost-effectiveness of $12,000 to $49,100 per ton of PM reduced for DOC technologies and a cost-effectiveness of $12,400 to $50,500 per ton of PM for DPF technologies.[22] These are vastly different numbers than what was calculated for Texas projects and presented in Table 7. The discrepancies can be explained by the simplistic emissions reductions estimate method used for the Texas programs, conservative assumptions for emissions factors because of limited data, and a very conservative estimate of 15 years for school bus life. In addition, one of the key sources of emissions reductions that is missing in the above summary is an estimate of the reductions associated with idling; anecdotal estimates suggest that some buses idle 20-30% of the time, but without accurate fuel consumption data or accurate idling data, it is impossible to estimate the proportion of emissions reductions associated with idling a cleaner or retrofitted school bus engine.

Clean School Bus Program report cards

Individual summaries of the Clean School Bus Programs in Texas are presented below.

TCEQ Texas Clean School Bus Program

This program has been successful in providing ISDs throughout the state with the opportunity to retrofit school buses. In fact, over 25% of buses retrofit through this program came from areas that are not currently listed as a "TERP-eligible area," which have historically been priority areas for TCEQ due to air quality concerns. This program has a high success rate (95%) for project completion. In 2011, the program returned almost $7 million to the general TERP fund allowing other TERP programs to fund projects because the program believed that ISD demand for retrofits was low and that project funding might be difficult to spend. As part of TERP, the Clean School Bus Program is currently authorized until 2019. The program received another allocation for 2012 of $203,968 through EPA's DERA

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TCEQ Clean School Bus Program

Total cleaned school buses	6,487
Average # school buses cleaned/year	1,297
PM reduced (program estimate)	Not tracked
NO_x reduced (program estimate)	Not tracked
# replaced school buses	0
# retrofitted school buses	6,487
Age of program (began in 2008)	5 years
Total cost of all projects	**$16,832,856**
Total funding received	**$26,000,000**

state program that has not been included in any of these figures. Additionally, the program just made a large award to Brownsville ISD for over $1.7 million to retrofit 129 buses with DPFs; because the award was just announced, the numbers are not reflected in the totals for completed projects.

NCTCOG North Central Texas Clean School Bus Program

NCTCOG has focused on NO_x emissions through accelerated replacements of school buses. This program has included several alternative school bus replacements, including six buses that were replaced with compressed natural gas (CNG) buses and 19 buses that were replaced with propane buses.

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NCTCOG North Central Texas Clean School Bus Program

Total cleaned school buses	65
Average # school buses cleaned/year	13
PM reduced (program estimate)	5.2 tons
NO_x reduced (program estimate)	71 tons
# replaced school buses	65
# retrofitted school buses	0
Age of program (began in 2007)	5 years
Total funding received	$2,326,202
Total cost of all projects (grant awards)	**$2,228,375**

HGAC Clean Vehicles Program

This program has focused on replacement of school buses, primarily because the region is in nonattainment for NO_x and is required to demonstrate progress towards NO_x emissions reductions. Although projects date back to 1995, follow-up monitoring to verify usage or emission reductions was not done until 2004. A large portion of program funding comes from Congestion Mitigation and Air Quality (CMAQ) funds from the U.S. Department of Transportation, as well as state and federal supplemental environmental projects that organizations may elect to pay into in lieu of environmental penalties.

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HGAC Clean Vehicles Program

Total cleaned school buses	542
Average # school buses cleaned/year	32
PM reduced (program estimate)	Not tracked
NO_x reduced (program estimate)	179 tons
# replaced school buses	495
# retrofitted school buses	47
Age of program (began in 1995)	17 years
Total funding received	$16,800,258
Total cost of all projects	**$16,700,258**

AACOG Clean School Bus Program & Adopt-A-School Bus

AACOG submitted a grant application in response to an EPA solicitation under the Blue Skyways Collaborative, Clean School Bus USA Program. The program continues to solicit sponsors, but has not completed any further projects to date.

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AACOG Clean School Bus Program & Adopt-A-School Bus

Total cleaned school buses	22
Average # school buses cleaned/year	4.4
PM reduced (program estimate)	0.37 tons
NO_x reduced (program estimate)	2.86 tons
# replaced school buses	2
# retrofitted school buses	20
Age of program (2007 grant)	5 years
Total funding received	$157,259
Total cost of all projects (incl. cost-share)	**$217,947**

CAF Clean School Bus Program of Central Texas

The Clean School Bus Program of Central Texas is managed by the CLEAN AIR Force of Central Texas. They have successfully implemented several large-scale projects to retrofit and replace school buses in Central Texas. Three of the projects were funded by EPA, one was funded through a large state Supplemental Environmental Project, and one was completed through a private donation. In addition to managing their own projects, CAF has been instrumental in assisting ISDs in their area access retrofit funding for over 500 buses through the TCEQ program (reflected in the TCEQ's Clean School Bus Program Report Card). This program has also worked extensively to reduce idling at ISDs in their region.

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CAF Clean School Bus Program of Central Texas

Total cleaned school buses	308
Average # school buses cleaned/year	34
PM reduced (program estimate)	7.1 tons
NO_x reduced (program estimate)	42.8 tons
# replaced school buses	63
# retrofitted school buses	245
Age of program (began in 2003)	9 years
Total funding received	$1,243,700
Total cost of all projects	**$1,172,176**

TCEQ Texas Emissions Reduction Plan (TERP) Emissions Reductions Incentive Grants (ERIG)

Although the TCEQ's TERP ERIG program is focused on general diesel emissions projects, the program collects data on school buses that use the program for replacement projects. The program is only focused on NO_x reduction, although early on it funded some PM retrofits and a clean fuel project.

REPORT CARD ✔

TCEQ TERP ERIG Program

Total cleaned school buses	344
Average # school buses cleaned/year	31
PM reduced (program estimate)	Not tracked
NO_x reduced (program estimate)	99.7 tons
# replaced school buses	75
# retrofitted school buses	269
Age of program (began in 2001)	11 years
Total cost of all projects	**$1,153,147**

The bad news: Texas still has a long way to go

Although good progress has been made in cleaning up the state's fleet of school buses, much remains to be done. To date, only 7,768 of the state's dirty buses have been cleaned, and the road ahead is likely to be even more difficult in lean economic times.

Comparisons to programs in other states

Texas has its own set of challenges and issues, but it is interesting to note how programs in Texas compare to other areas of the country. Two states have been particularly active with Clean School Bus Programs: Washington and New York. Washington State began its Clean School Bus Program in 2003 after the state legislature passed a bill to establish funding. This program has had fairly consistent funding through the Model Toxics Control Act (MTCA) that taxes hazardous substances such as petroleum products, pesticides and some chemicals. To date, the program has retrofit 6,430 school buses and 1,999 other vehicles, as well as replaced 83 buses. The program administrator, the WA Department of Ecology, estimates that the program reduces PM emissions each year by 17.8 tons, at a cost to date of approximately $29 million. In comparison to Texas, Washington State has a population of only 6.8 million (24% of the population is under 18), compared to Texas' 25.6 million (27% of the population is under 18).[23] Yet, Washington has cleaned up approximately the same number of school buses to ensure that proportionally more of their children have a healthy ride to school.

In New York, the state's New York State Energy Research and Development Authority (NYSERDA) administers a statewide program for its Clean Air School Bus program. The program has been funded initially from the 1996 Clean Water/Clean Air Bond Act and has been supplemented through environmental settlement funds. To date, the program has awarded approximately $6.7 million in grants to clean up 3,122 buses with retrofit technology. The program also funds coolant heater installations, which are idle-reduction devices. The program is no longer able to fund projects in New York City because of local laws mandating that school buses be retrofit;[24] like many grant programs nationwide, there is a restriction on grant awards that help a vehicle meet current federal, state or local regulations. The New York Power Authority (NYPA) has also been involved with school bus retrofits and assisted the New York City Board of Education in retrofitting up to 1,500 buses at a cost of $6 million.[25] Because the state of New York has been more regulation-driven than Texas, which has preferred voluntary initiatives to emissions reduction (i.e., the TERP program), it is difficult to accurately gauge how well Texas is doing in comparison. It is clear, however, that New York has taken a very strong regulatory approach to protecting the health of its children and communities, and as a result, dirty school buses are not operated in many cities and counties in the state.

Lessons learned in Texas

Despite the clear data suggesting that children's health is compromised when old, dirty school buses remain in operation, it is still a challenge to ask fleets to retrofit or replace buses. The obstacles that have impeded many fleets include lack of funding, procedural difficulties and technological challenges.

Lack of funding: Especially today, school district budgets are lean. Unlike other areas of the country, like New York and California, air quality initiatives in Texas have been driven by voluntary incentives, rather than regulation. As a result, fleets can be unwilling to "voluntarily" make capital expenditures from limited budgets that have costs not only associated with the purchase, but also with ongoing maintenance, even in light of the significant health benefits. However, because Texas has not implemented any air quality regulations on buses, proactive school districts can apply for federal and state funds to implement emissions reductions projects. Even though all of the Clean School Bus Programs in Texas help school bus fleets offset costs in full or in part, most of the regional programs focus only on projects that address NO_x. This eliminates the most cost-effective, PM-reducing devices as eligible projects, which are the focus of the state program. NO_x-reduction projects in school buses target replacements that are clearly excellent solutions for reducing total emissions, but limited funds mean that only a fraction of the state's fleet is "cleaned." This is the case with regional programs in Dallas-Fort Worth and Houston-Galveston-Brazoria that use their programs to show progress with the SIP that is required under the federal Clean Air Act because of ozone issues in those regions. Although these programs can be used for some types of clean school bus projects, their goals are to improve ambient air quality on a larger scale, not solely to address emissions in and around buses. More funding is needed for less-restrictive projects that target the dangerous PM emissions of school buses (i.e., not just focused on NO_x reduction) to ensure safer air quality for school children.

Red tape and procedural issues: School districts are faced with numerous administrative challenges. While all state agencies in Texas operate on the state's fiscal calendar (September to August), school districts have a 40-week school year to accommodate and for which to plan. Delays on the part of state agencies can also thwart proactive school districts. For example, a recent round of TCEQ's Clean School Bus Program funding was delayed by nearly a year because of issues with contract pricing in the Texas Comptroller's Office. With this delay, school districts can find themselves in a difficult position, since buses need to be taken out of operation to complete retrofits. Ideally, these types of projects would take place outside of the school year, but with delays, school districts may forego the opportunity to install devices, even with available grant funding because buses are needed for day-to-day transport activities. Resources used to administer these types of grants may also be fully utilized during the school year and not available except during a short window outside the normal school year. Streamlining programs to allow school districts to access funding and implement projects is essential.

Technology challenges: All retrofit devices undergo a fairly extensive technological verification procedure by either EPA or the California Air Resources Board (CARB) to ensure that emissions are reduced as claimed and that the device is safe. Occasionally, these agencies approve a device that later is found to have potential risks. This scenario occurred in September 2011, with a diesel particulate filter manufactured by Cleaire (the Longmile DPF). CARB, who verified the original device, issued an advisory to school districts recommending any buses retrofitted with this device be grounded immediately due to safety risks. In December 2011, CARB reinstated the verification for these devices, but the situation was a significant disruption to school bus fleets, as devices had to be replaced. Although incidents like this have not occurred frequently, they can be a concern for fleets and communities alike.

Additionally, some retrofit technologies can have operational drawbacks. DPFs collect ash and other non-combustible components of oil, and over time, these substances accumulate. Many DPFs require manual cleaning every 12 to 24 months, requiring fleets to purchase a special machine costing between $200 and $400. CCFS are also unpopular due to the ongoing need for maintenance; device filters must be replaced after 500 hours of operation or each oil change. Although flow-through filters require no maintenance after installation, they have two major limitations. First, they increase fuel use by approximately 1% because the device exerts backpressure on the bus's engine that results in greater resistance that in turn increases fuel consumption. Second, for the device to work consistently, it must maintain a minimum exhaust temperature of 250˚C for 35% of the bus's operating time; this requirement can be difficult to achieve in a stop-and-go drive cycle that most buses follow. These drawbacks have discouraged many districts from choosing this technology type, as fleet managers are often reluctant to spend time completing the necessary engine tests to ensure that exhaust engines reach these appropriate temperatures. Use of these types of technologies has been somewhat limited in Texas, as can be seen by implemented projects: after 2009, flow-through filter technology has no longer been used, and use of DPFs and CCFS decreased after 2008.

What is left to do?

Work still needs to be done to protect the health of Texas children and improve the air quality in and around school buses until all of Texas' oldest buses are either replaced or retrofitted. As of the 2010-2011 school year, TEA reported that nearly two-thirds of current school buses were more than six years old, emitting *at least* ten times as much PM as newer buses and much more in many cases because a large proportion of the fleet is even older.

Assuming an average ridership of approximately 43.6 students per bus, based on TEA average daily ridership for all programs (1,663,638 students) and the total number of buses operating in the state (38,150 buses), Table 8 shows a comparison between the number of students benefitting from clean school bus projects to date and the remaining buses needing to be cleaned up. Nearly half of the students that rely on school buses for transportation in Texas are exposed to unhealthy air.

TABLE 8

Texas' remaining dirty buses and the students still exposed to unhealthy air

	"Newer" buses	"Cleaned" buses	Remaining "dirty" buses
# buses*	12,686	7,768	17,696
# estimated students	553,110	338,685	771,546
Proportion	33%	20%	46%

*Note: The "Newer Buses" category includes all buses that are five years old or newer, less the number of buses that have been replaced through Clean School Bus Programs. The "Cleaned Buses" category includes all replaced and retrofitted buses. The "Dirty Buses" category includes all buses older than six years old, less the number of buses that have been retrofitted.

Addressing the more than 17,000 buses that remain to be cleaned will be a challenge, but funding opportunities still exist today. The challenge is in continuing to motivate ISDs to take advantage of available funding, while making more funding available for clean school bus projects. In general, ISDs prefer replacement projects whenever possible, as new buses not only provide the greatest emissions reductions, but also represent fuel economy benefits and improved maintenance which allow districts to better deal with ongoing budget cuts. However, retrofit projects provide real emissions reductions and should be utilized when replacement is not an option.

Conclusions

Texas has come a long way and has achieved real improvements in air quality on school buses. To date, programs throughout the state have retrofit or replaced 7,768 buses. Over 700 buses have been replaced and 7,068 buses have been retrofit with DPF, DOC, CCFS or FTF technologies. Over $38 million has been spent on these projects, with funding received from the federal and state government, as well as from local donors. Although the state has made progress with its clean school bus initiatives, almost half of the students that rely on school buses for transportation in Texas still ride dirty buses. With the momentum from successes to date, communities, ISDs and government officials need to continue the school bus clean-up by finding funding for these types of projects, by completing clean school bus projects, and by investing in these projects through budget and legislative funding allocations.

Funding remains an unknown for many of the programs in Texas, especially those at the regional level who rely on competitive federal grant programs like DERA. DERA has been scaled back in recent years, and with all competitive grants, there is no guarantee of award. Because the TCEQ Clean School Bus Program moved nearly $7 million back to the TERP program, it suggests a decreased demand for retrofit projects by ISDs, despite the proven health benefits. More education is needed to encourage ISDs across the state to continue to use this program.

The road ahead for cleaning up school buses in Texas is not straightforward, given concerns over budgets and funding availability. However, opportunities exist for ISDs to make student and community health a priority. These opportunities should be utilized to the greatest potential possible. Replacement projects clearly achieve the most emissions reductions and are preferable for most ISDs, but in order to fund more of these opportunities, allocations must be made that prioritize diesel emissions reduction projects. Retrofit projects are a more cost-effective approach, but currently are not eligible projects in several of the regional programs. School children are not able to easily advocate on their own behalf, so it is up to the rest of Texas to keep this public healthcare issue a priority.

APPENDIX

Emissions calculations assumptions and rationale

A simplified approach to estimating emissions achieved was used because of the lack of thorough data available. Normally, with specific information available for each school bus to be replaced or retrofitted (e.g., annual fuel used, annual miles travelled, model year of old engine/bus, etc.), variables can be entered into a sophisticated emissions model, such as the EPA MOVES model or EPA Diesel Emissions Quantifier to provide a realistic assessment of emissions reductions likely to result from a particular project.

Instead, emissions reductions were calculated by estimating a baseline emissions figure and subtracting the estimated retrofit or replacement emissions figure for NO_x and PM. Assumptions used for each variable used in the calculation are explained below:

- Average annual miles/bus = 8,156 miles (TEA; based upon actual mileage for the entire fleet for all services and total number of buses)
- Average model year for replaced buses = 1991 (based upon TCEQ ERIG program data for 75 funded school bus projects)
  - PM standard for 1991 model years: 0.3 g/bhp
  - NO_x standard for 1991 model years: 5.0 g/bhp
- Average model year for retrofitted buses = 1996 (many retrofit technologies are applicable for engines 1996 and newer)
  - PM standard for 1996 model years: 0.1 g/bhp
  - NO_x standard for 1996 model years: 5.0 g/bhp
- Remaining lifetime for replaced buses = 15 years (National Association of State Directors of Pupil Transportation Services; assumed 15 years as conservative estimate even though 250,000 miles is sometimes used as threshold for replacement and current Texas average annual mileage would be less than half of the 250,000 mile limit)
- Remaining lifetime for retrofitted buses = Five years, but expect retrofit to be used one more time on different bus (general requirement for many grant programs)
- For NO_x calculation, use of TxLED diesel was assumed.
- For all retrofit projects, average reduction percentages were used (see Table 3 of this report).
- The number of retrofit technologies used on Texas buses exceeds the number of retrofitted buses because many buses can be retrofit with more than one technology. However, it is assumed that most of the multi-technology bus retrofits were DOC+CCV because EPA and CARB verify these technologies together. To avoid double-counting reductions from retrofit technologies, the number of CCV devices was reduced by the difference between total retrofit technologies (9,880) and total buses retrofit (7,068).
- For simplicity, replacement projects were assumed to meet a PM standard of 0.01 g/bhp and a NO_x standard of 1.0 g/bhp. Although the current NO_x standard is 0.2 g/bhp, manufacturers have been phasing these engines in. Many engines are not meeting this standard currently, and it is more likely that new buses have been certified to a slightly dirtier level.

Detailed funding sources for Clean School Bus Projects in Texas, by program

Funding source	TCEQ TERP ERIG Program*	TCEQ Clean School Bus Program	HGAC Clean Vehicles Program	NCTCOG Clean School Bus Program	AACOG Clean School Bus Program	CAF Clean School Bus Program	Totals
	Eligible areas	All TX	HGB region	DFW region	SA region	Austin region	
STATE							
TCEQ: Clean School Bus Program, TERP	—	$18,000,000	—	—	—	—	$18,000,000
Air Emissions Reduction Credit Organization	—	—	$200,000	—	—	—	$200,000
Local Initiative Funds	—	—	$287,325	—	—	—	$287,325
Supplemental Environmental Projects	—	—	$3,496,027	$580,076	—	$750,000	$4,826,103
TCEQ: TERP ERIG*	$1,153,147	—	—	—	—	—	$1,153,147
FEDERAL							
Border Mobile Source	—	$722,993	—	—	—	—	$722,993
DOE: Clean Cities	—	—	—	—	$157,259	—	$157,259
EPA: Blue Skyways	—	$500,000	—	$376,674	—	$338,700	$1,215,374
EPA: Diesel Emissions Reduction Act (DERA) American Recovery & Reinvestment Act (ARRA)	—	$1,730,000	—	$202,033	—	—	$1,932,033
EPA: DERA State Allocation	—	$744,756	—	—	—	—	$744,756
EPA: DERA Federal	—	—	$185,860	$475,586	—	$150,000	$811,446
Supplemental Environmental Projects	—	$4,302,251	$375,000	—	—	—	$4,677,251
USDOT: Congestion Mitigation and Air Quality	—	—	$8,534,688	$675,833	—	—	$9,210,521
LOCAL							
Private donations	—	—	$3,621,357	$16,000	—	$5,000	$3,642,357
Totals	**$1,153,147**	**$26,000,000**	**$16,700,258**	**$2,326,202**	**$157,259**	**$1,243,700**	**$47,580,566**

*Note: TERP ERIG program funding is not dedicated solely to school buses.

Emissions reduction estimates

	# replaced buses		# retrofitted buses				
			Per bus				
	Per bus	Total (700 buses)	DPF	DOC	CCFS	FTF	Total (7,068 buses)
NO_x-annual reductions	0.09 tons	63 tons	—	—	—	—	—
PM-annual reductions	0.007 tons	4.9 tons	0.002 tons	0.001 tons	0.001 tons	0.001 tons	6.6 tons
NO_x-lifetime reductions	1.4 tons	980 tons	—	—	—	—	—
PM-lifetime reductions	0.11 tons	77 tons	8.0 tons	20 tons	18 tons	20 tons	66 tons

Notes

1 http://www.saferoutespartnership.org/resourcecenter/quick-facts. Accessed 4/2/12.

2 http://www.schoolbusfacts.com/. Accessed 4/2/12.

3 http://onlinepubs.trb.org/onlinepubs/sr/sr269.pdf. Accessed 4/2/12.

4 http://www.mysanantonio.com/news/education/article/Financial-cuts-a-slow-death-for-Texas-schools-3467646.php. Accessed 4/10/12.

5 Texas Education Agency. 2010-2011 School Transportation Report. Provided by TEA via email on 4/9/2012.

6 http://www.tea.state.tx.us/acctres/enroll_index.html. Accessed 4/2/12.

7 In this report, funding received and project costs are shown separately. The numbers are not the same because of differences in project timing and the fact that some ISDs may never complete a project for which a grant was awarded due to various circumstances.

8 Average cost calculations computed exclude CAF projects because project costs provided did not separate replacement and retrofit costs.

9 Assuming an average ridership of approximately 43.6 students per bus, based on Texas Education Agency (TEA) average daily ridership for all programs (1,663,638 students) and the total number of buses operating in the state (38,150 buses).

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