Emissions Control Technology Recommendations for Columbus City School Bus Fleet

February 2009

Prepared by the following organizations:

MORPC

Memo

To: Dr. Gene Harris, Superintendent, Columbus City Schools

From: David Abel, Program Coordinator, Mid-Ohio Regional Planning Commission

CC: Larry Hoskins, COO, Columbus City Schools; Steve Simmons, Transportation Director, Columbus City Schools;
Phil Downs, Fleet Services Supervisor, Columbus City Schools

Date: February 17, 2009

Re: Emissions Control Technology Recommendations for CCS School Bus Fleet

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This report is a collaborative effort of David Abel, Mid-Ohio Regional Planning Commission; David Celebrezze, Ohio Environmental Council; and Brad Couch Clean Fuels Ohio with the assistance of Phil Downs, CCS Fleet Services Supervisor. The purpose of this document is to recommend additional emissions control technology investments for the CCS school bus fleet and identify funding opportunities.

We look forward to continuing our partnership with CCS to improve the emissions performance of their school bus fleet.

Introduction

Four central Ohio counties, including Franklin County, do not meet minimum health-based standards for particle pollution, or what is commonly known as soot. Sources of particle pollution include electric power plants, wood smoke, road dust, and exhaust from diesel vehicles and construction equipment. While both adults and children are exposed to particle pollution in the ambient air (outdoor air), children may receive an additional dose from America's aging diesel school bus fleet. In a 2002 study, the Environmental and Human Health Inc., found that particle pollution levels on some of the school buses they tested were 5-15 times background pollution levels.[1]

The diesel engine is the preferred power source for school bus fleets. Of the roughly 450,000 school buses in the United States, 390,000 are powered by diesel.[2] Diesel engines are known for their reliability, power, and relatively low maintenance costs. However, diesel engines also emit 40 chemicals classified as "hazardous air pollutants" in the Clean Air Act. Furthermore, health scientists have linked diesel exhaust to serious health problems such as coughing, wheezing, increased asthma attacks, reduced lung function, and even premature death.[3]

Fortunately, new engine technology and pollution after treatment devices are available today that can virtually eliminate the unhealthy components of diesel exhaust. Columbus City Schools (CCS) Transportation Department has already retrofitted some of its newer buses with pollution after treatment devices and plans to spend approximately $22 M to replace most of their oldest and dirtiest buses.

The purpose of this document is to (1) recommend additional pollution control technology investments to further reduce student's exposure to particle pollution; and (2) identify grant opportunities.

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[1] John Wargo, Ph.D. (2002) Children's Exposure to Diesel Exhaust on School Buses (http://www.ehhi.org/reports/diesel/) 10.

[2] U.S. EPA Clean School Bus USA (http://www.epa.gov/OMS/schoolbus/basicinfo.htm)

[3] U.S. EPA (1997) Health and Environmental Effects of Particulate Matter (http://www.epa.gov/ttn/oarpg/naaqsfin/pmhealth.html)

What's in Diesel Exhaust

Diesel exhaust contains 40 chemicals classified as "hazardous air pollutants" in the federal Clean Air Act:

acetaldehyde
acrolein
aniline
antimony compounds
arsenic
benzene
beryllium compounds
biphenyl
bis[2-ethylhexyl]phthalate
1,3-butadiene
cadmium
chlorine
chlorobenzene
chromium compounds
cobalt compounds
cresol isomers
cyanide compounds
dioxins and dibenzofurans
dibutylphthalate
ethyl benzene
formaldehyde
hexane
inorganic lead
manganese compounds
mercury compounds
methanol
methyl ethyl ketone
naphthalene
nickel
4-nitrobiphenyl
phenol
phosphorus
Polycyclic Aromatic Hydrocarbons
propionaldehyde
selenium compounds
styrene
toluene
xylene isomers and mixtures
o-xylenes
m-xylenes
p-xylenes

Some of these are know human carcinogens, including benzene, 1,3-butadine, and soot. As a result, the U.S. EPA has classified diesel exhaust as a *probable* human carcinogen; and the California Air Resources Board (CARB) has classified it as *known* carcinogen.

Diesel Exhaust and Children's Health

Children may be more susceptible than adults to the adverse health effects of air pollution. First, children are more active outdoors, and take in air more rapidly. Second, children have more lung surface area compared to their body weight and therefore inhale more air pound-for-pound than adults. Lastly, children's essential defense mechanisms have not yet fully developed, which increases their susceptibility to the harmful effects of pollution.[4]

Brief exposures to particle pollution usually result in upper and lower respiratory symptoms such as cough or wheeze, as well as burning eyes, nose or throat. Some studies have demonstrated that short term exposure to particulate matter can trigger asthma attacks in children with respiratory illnesses. Other studies have looked at the health effects of long-term exposure to particle pollution, and have found that in polluted

[4] Bruce Hill, Ph.D., (2005) A Multi-City Investigation of the Effectiveness of Retrofit Emissions Controls in Reducing Exposures to Particulate Matter in School Buses (http://www.catf.us/publications/reports/CATF-Purdue_Multi_City_Bus_Study.pdf) 6.

cities, children experience a three to five percent relative reduction in lung function growth.[5]

Sources of School Bus Diesel Exhaust

The Clean Air Task Force, a national air pollution research and advocacy non-profit, studied how diesel exhaust enters the cabin of a school bus, and found that it entered, almost exclusively, through the front door of the bus. They monitored emissions entering the cabin from four entry points including leaky rear doors, leaky engine compartments, leaky windows, and the front door. They found that pollution was not typically influenced by steady leakage from the rear door, windows or the engine compartment nor diesels in the roadway, but instead through opening and closing of the bus door during stops.[6]

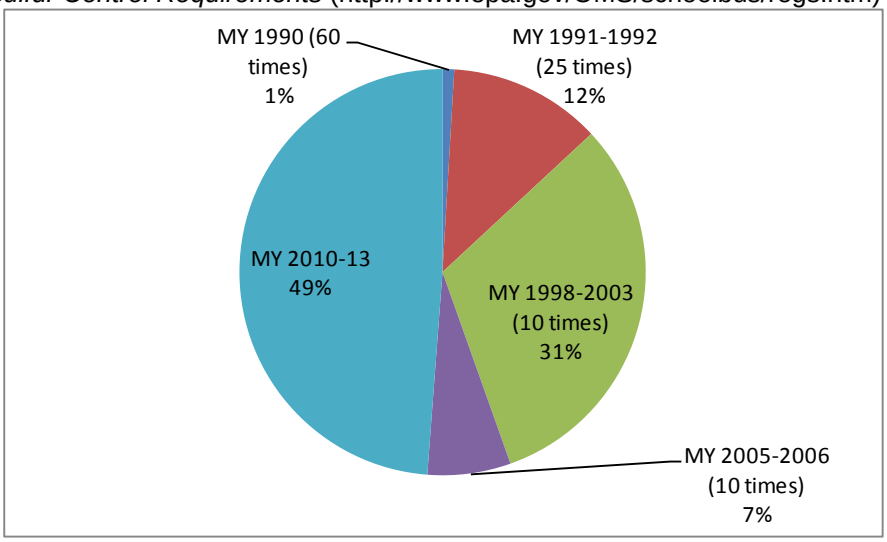
The study also found that wind direction determined whether diesel exhaust entering the front door of the bus came from the engine crankcase or the tailpipe. Emissions from the engine crankcase were particularly strong. In fact, installing a diesel particulate filter on the tailpipe did not measurably reduce fine particulate matter in the cabin – not due to a lack of particle removal efficiency – but instead as a result of the strong crankcase fine particulate matter source under the hood of the bus.

Recommended Pollution Control Technology Investments

In November 2008, the district passed a bond levy, raising $22 M to purchase new school buses. The transportation department plans to purchase approximately 265 buses, replacing many of its pre-1990 model year (MY) buses. This investment will go a long way in reducing student exposure to particulate matter. Yet, even after these replacements, 71 MY 1990-92, higher polluting, buses will remain in the fleet for at least five years. 1990 MY buses and 1991-1992 MY buses emit 60 and 25 times more PM2.5 than a 2007 MY bus, respectively (figure 1). Accelerating the replacement of the 1990-1992 MY group will provide large PM2.5 reductions and significant health benefits.

[5] Hill 6.
[6] Hill 17.

Figure 1
CCS Fleet make-up after $22 M bus purchase
by school bus MY and PM2.5 emissions rate compared to MY 2007
Source: U.S. EPA (2000), *Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements* (http://www.epa.gov/OMS/schoolbus/regs.htm)



Model years 1998-2003, will remain in Columbus' fleet for many years, and are good candidates for exhaust after treatment retrofits. The ideal solution is to retrofit these vehicles with a closed crankcase ventilation system and a diesel particulate filter. This system would reduce PM2.5 emissions by 98 percent, virtually eliminating the health risks.

See Appendix A: *CCS School Bus Fleet Emissions* for detailed fleet emissions.

Funding Opportunities

Identifying additional resources to continue the district's efforts to reduce particulate matter emissions is, without question, a significant challenge. The district will have limited general revenue dollars in the next four years for bus replacement and retrofit investment. However, there are a number of significant grant opportunities that the district can apply for funding. Below is a list of current grant opportunities and what technologies the district may want to consider applying for.

Diesel Emission Reduction Grant (DERG)

Available funding: $11.2 M (up to $5M reserved for public transit)
Application deadline: March 2, 2009

The DERG program is funded with federal Congestion Mitigation and Air Quality (CMAQ) funds, and is administered jointly by the Ohio Department of Transportation, Ohio EPA, and the Ohio Department of Development. This is a reimbursement program;

approved applicants must incur 100 percent of the project costs and then submit invoices for reimbursement of up to 80 percent of eligible costs. Applicants are required to provide a minimum 20 percent cash match. Public fleets can apply for funding to replace or repower vehicles, install retrofits, and/or anti-idling equipment.

We recommend the district apply to replace some of their MY 1990-92 school buses.

U.S. EPA Midwest Clean Diesel Initiative
Available funding: $5 M competitive grant for six Midwest states.
Application deadline: February/March 2009

Federal funding for clean diesel projects is also available through the National Clean Diesel Campaign (NCDC). Last year national funding assistance totaled $27.6 M, with approximately $5M for six Midwestern states. There are efforts in Congress to secure an additional $300-$500M in the Federal Stimulus Bill. Applicants can apply to U.S. EPA Region 5 for replacement, repower, retrofit, and/or idle reduction technology projects. Although this grant does not require matching funds, applicants that do so, are awarded additional points in the scoring criteria.

We recommend the district apply to replace some of their model year 1990-92 school buses.

Ohio Clean Diesel School Bus Fund
Available funding: $895,320 per year
Application deadline: March 2, 2009

Ohio school districts can apply for grants to retrofit MY 1994 and newer buses with exhaust after treatment technologies such as diesel oxidation catalysts (DOC), crankcase ventilation systems (CCFS), or diesel particulate filters (DPF). A 5 percent match is required, either cash or in-kind, and the total project cost cannot exceed $100,000. Districts can apply for multiple grants.

We recommend the district retrofit approximately 11 MY 2003 buses with DPFs and CCFS.

Clean Cities Program – U.S. Department of Energy
Available funding: $6M
Application deadline: March 31, 2009

The Clean Cities Program seeks to decrease U.S. dependence on petroleum in the transportation sector by funding public/private partnership across the nation. As with the National Clean Diesel Campaign, Congress has proposed increasing funding for this program to $300M in the Federal Stimulus Bill. This opportunity has three areas of interest: (1) Refueling Infrastructure for E85 and Other Alternative Fuels; (2) Incremental Cost of Dedicated Alternative Fuel Vehicles, such as compressed natural gas (CNG); and (3) Education/Outreach and Workshops for Petroleum Reduction Fuels and Technologies.

The district may want to consider converting one or two diesel buses to run on CNG. Using CNG to fuel a portion of the district's fleet in the future, could be an effective strategy to cope with rising diesel fuel prices.

Conclusion

The district has made significant progress in reducing emissions from the fleet by installing exhaust after treatment technologies and implementing a plan to replace 265 of its oldest buses. We recommend the district apply for grants to replace as many of the 1990-1992 MY buses as possible. This MY group emits 25 to 60 times more PM2.5 than a 2007 MY bus. The fleet's MY 1998-2003 buses, which will remain in the fleet for up to 10 years, and should be retrofitted with crankcase ventilation systems and a diesel particulate filter.

These emission control technology investments will provide significant air quality and health benefits for Columbus City School students, teachers, bus drivers, and mechanics. While a cost-benefit analysis of these recommendations is not feasible, U.S. EPA conducted an extensive cost-benefit analysis of its 2007 Heavy Duty Diesel Engine rule, which requires engine manufacturers to include many of the technologies recommended in this report as standard equipment on new engines sold in the U.S.. The analysis determined that the new rule would provide substantial public health benefits, such as the yearly avoidance of: approximately 8,300 premature deaths, approximately 5,500 cases of chronic bronchitis, roughly 361,400 asthma attacks, and significant numbers of hospital visits, lost work days, and multiple respiratory ailments (including those that affect children).[7] Similarly, the control technology recommendations in this document, if implemented, would significantly reduce student's exposure to particle pollution and its adverse health impacts.

We look forward to continuing the dialogue with Columbus City Schools to identify resources to further reduce particulate matter pollution in the school bus fleet and provide district students with safe and healthy transportation to school.

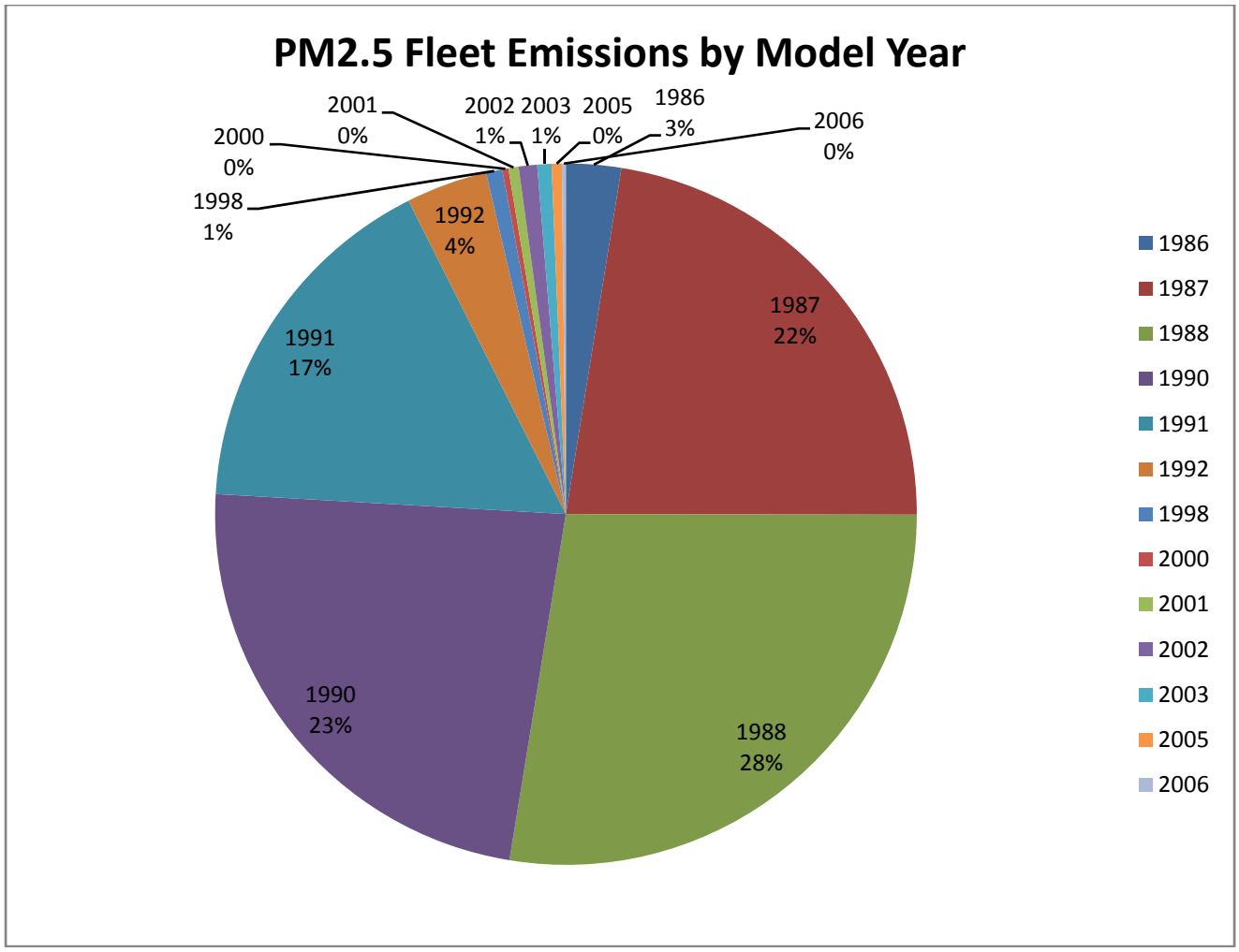
[7] U.S. EPA, (2000) Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements (http://www.epa.gov/otaq/highway-diesel/regs/exec-sum.pdf) 15.

Appendix A

CCS School Bus Fleet Emissions

(As of February 2009)

			Tons			kg			
Units	MY	Notes	NOx	PM2.5	CO	NOx	PM2.5	PM2.5 %	CO
9	1986		1.89	0.27	0.63	1714.579	244.9399	2.53%	571.5264
80	1987		16.8	2.4	5.6	15240.7	2177.243	22.49%	5080.235
98	1988		20.58	2.94	6.86	18669.86	2667.123	27.55%	6223.287
83	1990		17.43	2.49	5.81	15812.23	2258.89	23.34%	5270.743
54	1991		10.58	1.78	2.64	9598.015	1614.789	16.68%	2394.968
12	1992		2.4	0.4	0.6	2177.243	362.8739	3.75%	544.3108
40	1998	40 DOCs installed 2006	6.88	0.08	0.96	6241.431	72.57478	0.75%	870.8974
18	2000	18 DOCs installed 2006	2.88	0.03	0.43	2612.692	27.21554	0.28%	390.0894
30	2001	30 DOCs installed 2006; 30 CCFS install 2009	4.8	0.05	0.71	4354.487	45.35924	0.47%	644.1012
48	2002	DOCs installed OEM; 48 CCFS install 2009	7.68	0.09	1.15	6967.179	81.64663	0.84%	1043.262
35	2003	DOCs installed OEM	5.6	0.07	0.83	5080.235	63.50293	0.66%	752.9633
26	2005	DOCs installed OEM; install 26 pre-heaters 2009	2.5	0.05	0.6	2267.962	45.35924	0.47%	544.3108
10	2006	DOCs installed OEM; 6 equipped with OEM pre-heaters	0.98	0.02	0.24	889.041	18.14369	0.19%	217.7243
Totals:			101	11	27	91,626	9,680		24,548


PM2.5 Fleet Emissions by Model Year
2001 0%
2002 1%
2003 1%
2005 0%
1986 3%
2006 0%
2000 0%
1998 1%
1992 4%
1987 22%
1991 17%
1990 23%
1988 28%
1986
1987
1988
1990
1991
1992
1998
2000
2001
2002
2003
2005
2006