

Clean School Bus USA

Virginia Clean Cities Project Case Study Report

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Contact: Chelsea Jenkins, Virginia Clean Cities *or* Ryan Cornett, Virginia Clean Cities

Email: cjenkins@hrccc.org, rcornett@hrccc.org

Phone: (757) 256-8528

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Region 3 Clean School Bus USA

1. PROJECT DESCRIPTION

Goals

From March of 2008 to December of 2010, Virginia Clean Cities provided program management and administrative support for the Clean School Bus USA Middle Peninsula Project. The objective of this project was to promote healthful air, especially for student riders, by reducing diesel exhaust emissions from school buses in Virginia's Middle Peninsula and Piedmont region through the deployment of alternative fuels and technologies paired with a concentrated outreach and education campaign. Specifically, the project originally had 5 goals, which are listed with a brief description of project components that addressed each:

1. Installation of exhaust after-treatment devices

A total of 70 diesel oxidation catalysts were installed in Gloucester County (40), King & Queen County (11), Middlesex County (11), and Essex County (8). Virginia Clean Cities worked with the Virginia Department of Environmental Quality to secure an extra \$58,000 of funding to be used towards additional diesel oxidation catalyst retrofit. The amount of funding each school district qualified for was calculated based on percentage of total fleet size amongst 4 districts.

2. Use of biodiesel blends and, possibly, a propane demonstration

A total of approximately 347,080 gallons of biodiesel at a B5 blend were used in buses in Gloucester and King & Queen Counties. The project paid up to \$.06/gallon to equalize the cost difference of the fuel blend.

3. Idle reduction through driver training

Virginia Clean Cities met and exceeded this goal through the deployment of Webasto idle-reduction engine block heaters in a total of 24 buses in Virginia. The units were installed by Virginia Beach and Albemarle County, and driver-training sessions in those districts were held in May and December of 2010, respectively. Funding from this program was used to purchase 14 of the 24 units, and the remaining units were procured as a result of a pleasant yet unanticipated contribution by the Department of Environmental Quality and the Mid-Atlantic Air Management Association (see item #4, below).

4. Early replacement of old buses with cleaner new ones

Gloucester County replaced 5 diesel buses with 5 Bluebird Vision propane buses. Virginia Clean Cities was able to leverage its relationship with Virginia Department of Environmental Quality and the Mid-Atlantic Air Management Association who provided funds to subsidize the cost of 5 propane school buses for Gloucester County Public Schools.

5. Leveraging outcomes with three complementary grants and news coverage

Virginia Clean Cities leveraged several other grants including:

1) The Dragon Run Biodiesel project affects all of the Middle Peninsula counties and encompasses portions of the land area of four of the six counties.

This federally-financed initiative explored ways in which increased use and possible small-scale production of biodiesel could provide economic value to farmers and other landowners and, therefore, help to preserve current and historic agrarian and sylvan land uses to buffer a unique and sensitive watershed that is protected by a Special Area Management Plan.

2) A biofuels preparedness and fuel quality workshop series funded by the Commonwealth of Virginia and the National Biodiesel Foundation produced quick guides and internet-accessible resources for fleets, distributors, retailers and users of biodiesel and other biofuels. The resources were made available to Middle Peninsula school districts and will be an essential part of the biodiesel transition.

3) Funding for Gloucester's 5 propane buses and Virginia Beach's 10 idle-reduction units was obtained through a Virginia ARRA State Clean Diesel Campaign grant.

In total, over 100 buses were either fitted with diesel oxidation catalysts, idle-time reducing engine block heaters, replaced with propane buses, or fueled with a biodiesel blend. The project has been a great success and this report will further outline all activities, details, and deliverables associated with its completion in December 2010.

Project Partners

Dragon Run Steering Committee
Gloucester County Schools
King & Queen County Schools
Kingmor Supply
Matthews County Schools
Middlesex County Schools
Mid-Atlantic Air Management Association
Phillips Energy
Virginia Biodiesel Refinery LLC
Virginia Clean Cities
Virginia Department of Environmental Quality
Virginia Division of Energy
Virginia Beach Schools
Albemarle County Schools
Webasto
Virginia Mobile Air Conditioning Systems
Bluebird Corporation
Commonwealth Bus Sales

2. TECHNOLOGIES

Vehicles and Engines Affected/Procured

In all a total of 70 buses with either T444E, DT466E engine makes were retrofitted with diesel oxidation catalysts in Middlesex, Essex, King & Queen, and Gloucester Counties. A total of 24 buses were retrofit with Webasto Thermotop engine block heaters in Albemarle County and Virginia Beach. Gloucester County replaced 5 diesel buses with Bluebird Vision propane buses. Finally, over 347,000 gallons of B5 biodiesel was used by Gloucester and King & Queen Counties as part of the biodiesel buy-down portion of the project. A detailed description of every vehicle used in the Clean School Bus projects is included in the

attached excel file. The file includes Bus Number, Year, Make, Model, Engine, and Route Type. All data related to emissions and cost reductions is also included.

Emissions and Cost Analysis

Biodiesel

A total of 347,080 gallons of biodiesel at a B5 blend were put in use in the project period by Gloucester and King & Queen Counties. A total of \$20,057 in differential cost was paid throughout the project. According to the National Biodiesel Board's calculator, this level of B5 results in a reduction of CO₂ of over 3%, a reduction of NO_x of slightly under 1%, and a reduction of Particulate Matter of over 3% these and other emissions reductions can be viewed in *Figure 1*.

Figure 1: Biodiesel usage emissions reductions (based on usage of 347,080 gallons of B5)

Average Change	PM	HC	CO	NOx	SO2	CO2
Percent Reductions	-3.14	-5.44	-3.23	0.49	-5.00	-3.92
Pounds of emission reductions	-116.40	-157.95	-1,295.76	256.17	-76.53	-279,585.26

Diesel Oxidation Catalysts

Diesel Oxidation Catalysts were installed on 40 buses in Gloucester County, 11 buses in Middlesex, 11 in King & Queen, and 8 in Essex. Including installation, the total cost for the retrofits was \$38,520. Fueling or mileage records were unavailable for the buses that had DOCs installed. However, we can calculate an estimate of emissions reductions by using an average amount of miles traveled based on information that we received from Gloucester County.* Based on these calculations, the 70 buses during the 32-month period from installation to present traveled an estimated 1,769,600 miles. According to EPA verified emission reductions by DOCs, at least 39.32 tons of emissions were reduced. *Figures 2* and *3* show before and after photos of DOC installations, and *Figure 4* shows emissions calculations for DOC retrofits.

Figure 2: Muffler before DOC installation



Figure 3: Muffler after DOC installation



* As part of the propane component of this project, Gloucester compiled information which included average miles travelled for their propane buses as well as two other control fleets. These buses travelled similar routes over similar terrain as the 70 DOC buses. It can also be reasonably assumed that the variance in route type and length represented in these control groups is to some extent representative of the 70 in this component.

Figure 4: DOC emissions reductions

Oxides of Nitrogen emissions w/o catalyst: 1,769,600 miles x 12 g/mile = 21,235,200 grams	(23.4 tons)	Oxides of Nitrogen reduced due to DOC: 21,235,200 grams x .2 = 4,247,040 grams	
Particulate Matter emissions w/o catalyst: 1,769,600 miles x .3 g/mile = 530,880 grams	(.6 tons)	Particulate Matter reduced due to DOC: 530,880 grams x .2 = 106,176 grams	(.12 tons)
Hydrocarbon emissions w/o catalyst: 1,769,600 miles x 3.9 g/mile = 6,901,440 grams	(7.6 tons)	Hydrocarbons reduced due to DOC: 6,901,440 grams x .5 = 3,450,720 grams	(3.8 tons)
Carbon Monoxide emissions w/o catalyst: 1,769,600 miles x 46.5 g/mile = 82,286,400 grams	(90.7 tons)	Carbon Monoxide reduced due to DOC: 82,286,400 grams x .4 = 32,145,560 grams	(35.4 tons)

Propane

The Propane pilot in Gloucester County showed a decrease in the cost per mile using propane versus conventional diesel. Over the course of the project, the five propane buses were compared to control groups that included four similar diesel buses and the rest of Gloucester's fleet. * The five propane buses had a lower fuel economy, but the drastically reduced cost in vehicle maintenance made the five propane buses cost an average of 44.4 cents per mile versus an average of 49.4 cents per mile for the control group and 54.9 cents per mile for the rest of the fleet. Based on a 15-month period between October 2009- November 2010, Gloucester County saved \$6,897.57 in fuel and maintenance costs on their 5 propane buses. In total it is estimated that they reduced their petroleum usage by 68 barrels and eliminated 8.4 short tons of greenhouse gas emissions. Appendix B of this report includes a case study done by VCC highlighting this project.

Idle Reduction

This project provided 14 Webasto Thermotop engine block heaters to Albemarle County at a cost of \$28,835 and a leveraged grant provided 10 to Virginia Beach. For the Virginia Beach Idle Reduction pilot, data collected indicates that the installed fuel operated heaters have reduced total excessive idling by an average of 13.5 minutes per bus per day, or 23% based on averages. Our data also shows that the fuel cost due to idling was the same in the months of January, February and March 2011 as in the year prior, though, if the increase in the average fuel price between the periods is factored in, each heater has saved each bus \$.64 per day. For a 180-day school year, this represents a \$1,152.00 savings due to idle reduction. Emissions were also reduced by an average of 23% per bus. Based on a 180-day school year, the ten heaters installed in Virginia Beach reduced total emissions by 2.68 tons. The Albemarle project, which saw heaters deployed this quarter, is only beginning to report back data, but the results are likely to be similar.

3. OUTREACH AND PUBLICITY

Events

In addition to numerous meetings with project partners to inform, analyze data, and plan project components, several outreach-focused events were held throughout the project period:

2/27/08: Clean School Bus Kick-off Meeting

Introduced fleets and project partners to the project proposed and discuss implementation, timelines and logistics. Virginia Clean Cities discussed DOC benefits and cost effectiveness, as well as installation logistics and convenient scheduling.

10/11/08: Dragon Run Day

* Appendix A of this report includes the reporting template mentioned here

Virginia Clean Cities sponsored the 4th annual Dragon Run Day at Thousand Trails Campground in Gloucester County, and planned a media event to provide “I Saved a Dragon” Awards to Gloucester County Public Schools, Dennis Sulick of Virginia Biodiesel Refinery, and John Phillips of Phillips Oil & Gas. Virginia Delegate Harvey Morgan spoke. VCC also manned a booth that featured materials on the Dragon Run Clean School Bus project, and answered questions from the public. Gloucester County provided a school bus that had a DOC installed.

Figure 3: Biodiesel in the Middle Peninsula was branded as “Dragon Power”



Figure 4: VCC and Virginia Biodiesel Refineries Booth



11/12-14/08: Propane Engine Fuel Summit, Detroit, MI

The following individuals attended the Propane Engine Fuel Summit in Detroit, Michigan on November 12-14, 2008:

- Roger Kelly* – Fleet Administrator, Gloucester County Public Schools
- Michael Brown* – Associate Director of Pupil Transportation, Virginia Department of Education
- John Phillips* – Owner and President, Phillips Oil & Gas
- Chelsea Jenkins* – Coordinator, Hampton Roads Clean Cities Coalition

All questions that project partners had concerning propane buses were answered, clearing the way for the propane component of this project to be a success. Bluebird officials gave a tour of the Bluebird Propane Vision answered questions about the bus, refueling, safety, maintenance, etc.

3/18-19/09: Virginia Propane Engine Fuel Road Show

Propane road show events were held in Poquoson and Fairfax over two days and attracted a total of over 175 participants. The events included presentations by VCC, Propane Education and Research Council, the Virginia Propane Gas Association, Blossman Propane and Gas, Clean Fuel USA, Roush, Blue Bird, and American Alternative Fuel. Several propane vehicles were also displayed, including a Blue Bird Propane Vision School Bus, Roush Propane F-150, a propane taxi, and several propane fueled lawn tools.

Figure 5: Road Show events were well attended



Figure 6: Gloucester County officials with Bluebird Propane Vision Bus



10/26/09: Gloucester County Propane Media Event

Chelsea Jenkins coordinated a media event in Gloucester County Public Schools on Monday, October 26, 2009. Congressman Rob Wittman, Delegate Harvey Morgan, School Board Chair Ann Burrus, and other dignitaries attended the event. It was extremely successful and was covered in the local newspaper as well as on Wavy TV 10.*

Figure 7: Gloucester officials at media event



Publications

The following publications were produced by Virginia Clean Cities throughout the grant period to highlight successes of the project:

Aug/Sept Edition Stakeholder Update (available at <http://www.hrccc.org/wp-content/uploads/2010/04/26/stakeholders-update/Stakeholder-Update.pdf>, see page 2)

- Southeast Forward Fuels Fix Summer Edition – Virginia Clean Cities article (available at http://eerc.ra.utk.edu/etcfc/sefix/eazines/SEFuelsFix_Summer10_Final.pdf, see pg 6)
- Presentation at AFVi (available at <http://afvi.org/NationalConference2008/presentations/>, see Sunday, May 11 session “Other People’s Money”)
- Dragon Run Day Press Release, also sent to 1,100 stakeholders via email
- Dragon Run Day Event Page- <http://www.mppdc.com/dragon/dragonrunday.shtml>
- Website Information (see our website www.hrccc.org)
- Success Story (See our site <http://www.hrccc.org/home/successstories.html>)
- “From Preservation to Propane: An Unlikely Story” – presented to fellow Clean Cities

Coordinators about the history of this project. See <http://www.hrccc.org/home/successstories.html>

- Press Release and media event invite (see our site <http://www.hrccc.org/propane/propanehome.html>)
- Fact Sheet “Gloucester County Propane School Bus Case Study” (see <http://dl.dropbox.com/u/4023759/GC%20Propane%20Fact%20Sheet.pdf>)
- Gloucester Media Event YouTube- <http://www.youtube.com/watch?v=ke1zHZkgxfo>

Educational Outreach

VCC conducted driver training in idle-reduction technologies and practices in Albemarle County and Virginia Beach during installations of idle-reduction technology. All affected bus drivers and mechanics were in attendance and heard presentations from VCC, Webasto, and VMACS. Also, VCC developed with MARAMA an idle-reduction curriculum for 5th-7th graders. As part of this project, VCC produced an SOL

* Press clippings:

http://www.wavy.com/dpp/news/local_news/Local_wavy_gloucester_propane_school_buses_20091027

<http://www.lgean.org/news.cfm#4835>

review that outlined idle-reduction teaching opportunities that were in line with Virginia's Standard's of Learning.

4. LESSONS LEARNED

Lessons learned in this project revolve mostly around creating buy-in to get people to be “early-adopters” and precedent-setters when it comes to new fuels and technology. This is not always an easy task. For example, VCC had issues with finding a school district to adopt idle-reduction technology. The idea was pitched to several districts before Albemarle chose to take part. VCC also encountered issues finding biodiesel suppliers who would convert or install biodiesel pumps. In total, though, the project highlighted some great successes in creating buy-in through hard work at the front-end with contacts in school districts to ensure that all of their questions were answered in a satisfactory way. VCC worked hard to provide exhaustive information from several sources for stakeholders to consider as they weighed their decisions. As we learned, when you have engaged fleet managers and directors from the start, you're much more likely to smoothly work through any issues they encounter down the road.

Another lesson that is a consideration for future projects is the question of data collection. VCC learned that a close relationship with fleet administrators and standardized, user-friendly reporting templates are highly important for gathering accurate and useful data. While there were logistical issues with data retrieval for the DOC and biodiesel projects (either the buses weren't specifically defined, or were defined but no method to track them accurately existed) the propane and idle-reduction projects proved to be successful at creating a record of a positive application of an alternative fuel or technology.

APPENDIX A

Data reporting template and example for GCPS Propane Project

PROPANE SCHOOL BUS DATA								
Data Range:								
Bus Information (Engine Make, Model, Bus Make, Model):								
Count	Bus Number	Mileage	Fuel Use [gal]	MPG	Fuel Cost [\$/DOE]	Maintenance Cost	Maintenance Detail	Route Information
1								
2								
3								
4								
5								

DIESEL SCHOOL BUS DATA												
Data Range:												
Count	Bus Number	Mileage	Fuel Use [gal]	MPG	Engine Make	Engine Model	Bus Make	Bus Model	Fuel Cost [\$/DOE]	Maintenance Cost	Maintenance Detail	Route Information
1												
2												

COST ANALYSIS of PROPANE vs. DIESEL FUELED SCHOOL BUSES

2009.229 - 2010.075

Bus	Fuel Type	Fuel Use [gal]	Description	Bus Make	Engine	MPG	3-monthly Range	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	MPG	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]	Fuel Cost [\$/DOE]
1	P	270	3475hr	8x36	11L	38.94	104	129.1	3,274.2	42	104	33.3	33.3	4.0	37.2	3.8	11.8	1	
2	P	270	3475hr	8x36	11L	38.94	105	130.1	3,315.9	42	105	33.5	33.5	4.0	37.2	3.8	11.8	1	
3	P	270	3475hr	8x36	11L	38.94	105	130.1	3,315.9	42	105	33.5	33.5	4.0	37.2	3.8	11.8	1	
4	P	270	3475hr	8x36	11L	38.94	106	140.4	3,641.0	43	107	34.0	34.0	4.0	37.2	3.8	11.8	1	
5	P	270	3475hr	8x36	11L	38.94	106	140.4	3,641.0	43	107	34.0	34.0	4.0	37.2	3.8	11.8	1	
6	P	270	3475hr	8x36	11L	38.94	108	128.1	3,341.9	43	108	33.8	33.8	4.0	37.2	3.8	11.8	1	
Sum							3,312	1,681.7	3,757.7	42	304	33.8	33.8	3.8	37.2	3.8	11.8	6	
7	D	200	16700hr	4x75r	2+4B	31.38	101	128.8	3,171.0	38	101	31.5	31.5	3.0	33.0	3.0	9.7	1	
8	D	200	16700hr	4x75r	2+4B	31.38	101	128.8	3,171.0	37	102	31.0	31.0	3.0	33.0	3.0	9.7	1	
9	D	200	16700hr	4x75r	2+4B	31.38	101	131.0	3,217.7	38	102	31.5	31.5	3.0	33.0	3.0	9.7	1	
10	D	200	16700hr	4x75r	2+4B	31.38	102	131.0	3,217.7	37	103	31.0	31.0	3.0	33.0	3.0	9.7	1	
11	D	200	16700hr	4x75r	2+4B	31.38	102	131.0	3,217.7	37	103	31.0	31.0	3.0	33.0	3.0	9.7	1	
Sum							3,302	1,481.0	3,458.0	37	313	31.0	31.0	3.0	33.0	3.0	9.7	5	
See School Bus Fleet							3,312	1,681.7	3,757.7	42	304	33.8	33.8	3.8	37.2	3.8	11.8	6	

APPENDIX B

Gloucester County Propane Case Study

Case Study: Gloucester County Public Schools Propane School Bus Pilot

<p>GLOUCESTER COUNTY SCHOOL DISTRICT</p> <p>Transportation Department 5644 George Washington Memorial Highway Gloucester, VA 23061 (804) 693-2127 rkelly@glcsd.net Transportation Director: Roger Kelly</p>
<p>BACKGROUND FACTS</p> <p>The pupil transportation system operates approximately 100 buses transporting over 6,000 students to and from school each day. Bus drivers must operate their vehicles on roads ranging from interstate highways to remote, rugged secondary roads. Operating over 1,000,000 miles per year, pupil transportation is the vital link between the home and an effective educational program at school.</p> <p>Current Annual Propane Usage: (6,933 gallons) Annual Savings: (app. \$8.14/mile and app. 19 labor hours/year) Predicted Annual Emissions Savings: (68 barrels of petroleum and 8.3 short tons of greenhouse gas emissions)</p>
<p>FLEET FACTS</p> <p>Total School Buses: 115</p> <ul style="list-style-type: none"> 5 Blue Bird Vision Propane School Buses 110 Diesel School Buses <p>Other Vehicles/Deployed Emissions Reduction Technology</p> <ul style="list-style-type: none"> 85 Biodiesel use in winter months; B20 in summer months. Idle Reduction Devices
<p>ADDITIONAL COMMENTS/QUOTES</p> <ul style="list-style-type: none"> Director of Transportation, Roger Kelly said that "Using propane-powered school buses is a step in the right direction to significantly decrease vehicle emissions and improve the air quality for our students." School Board Chairperson, Anne Burruss: "The positive impact on cost savings, morale of both drivers and students, the benefits realized from a safety standpoint are major pluses in our purchase of the propane buses last year. As a School Board member, it was and continues to be, a source of great pride in being first in the Commonwealth of Virginia for these vehicles to be in a school bus fleet." Bus Driver Comments: "Awesome!", "Quiet ride", "Makes driving a pleasure!", "Seems to have more get-up-and-go"

Petroleum Use and Greenhouse Gas Emissions Comparison

Diesel and Propane School Bus Comparison:
Gloucester County Public Schools, VA

Fuel Type	Petroleum Barrel Usage
Diesel	125.7
Propane	57.7

Fuel Type	Greenhouse Gas Emissions (Short Tons)
Diesel	12.2
Propane	3.1

Fuel and Cost Per Mile Comparison

Diesel and Propane Comparison:
Gloucester County Public Schools, VA

Fuel Type	Fuel Cost (\$/Gallon)
PROPANE	\$2.25
DIESEL	\$2.52
FUEL	\$2.26

Fuel Type	Cost Per Mile (\$/Mile)
PROPANE	\$0.9019
DIESEL	\$0.9690
FUEL	\$0.9448

Sources

Argonne National Laboratory Green Fleet Footprint Calculator
 Online at: http://www.transportation.anl.gov/modeling_simulation/GREET/footprint_calculator.html