Clean Air Fleets Diesel Retrofit Program
Denver Front Range

Program Report
September 2006

Acknowledgements

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<u>Program Advisory Team</u>

Adams 12 Five Star Schools

EPA Region 8

Colorado Department of Public Health and Environment

Colorado Motor Carriers Association

Cummins Rocky Mountain

Suncor Energy (USA)

Tri-County Health Department

<u>Clean Air Fleets</u>

Adams 14 Public Schools

Aspen Homes of Colorado

Bartkus Oil Company

Brannan Sand & Gravel Company

Brighton District 27J Public Schools

The City and County of Denver Public Works

Colorado Department of Education

Colorado University Biodiesel

Eco-cycle

Falcon Public School District

Haul Away Recycling

City of Lakewood

Mountain Shores Greenhouse Service

NAPA Auto Parts

New Belgium Brewing Company

Poudre Valley School District

Waste-Not Management

The X-avator

<u>Clean Yellow Fleet's School Districts</u>

Adams 12 Five Star Schools

Adams County School District 50

Aurora Public Schools

Boulder Valley Public School District

Cherry Creek Schools

Colorado Springs School District 11

Colorado Springs Academy School District 20

Denver Public Schools

Douglas County School District

Englewood Schools

Jeffco Public Schools

Littleton Public Schools

Mapleton Public Schools

St. Vrain Valley Public School District

Thompson School District

<u>Retrofit Equipment Provider</u>

Instrument Sales & Service

<u>Trade Associations</u>

Colorado Rock Products Association

Colorado State Pupil Transportation Association

Rocky Mountain Fleet Manager's Association

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Executive Summary

Diesel engines are the backbone of the American economy. They power the vehicles that transport our goods and commodities by railway, roadway and waterway. They power the vehicles that build our cities and critical infrastructure. They provide daily transportation for our friends, families and children. While these diesel powered vehicles are critical to our economy, they also contribute to environmental and health problems.

Over the years, the Environmental Protection Agency (EPA) has introduced new emissions standards for heavy-duty diesel vehicles. Diesel truck manufacturers responded by substantially reducing emissions from newer on-road diesel engines. However, the older legacy fleet continues to pollute at a disproportionate rate compared to newer engines. For instance, a 1990 model year on-road diesel engine emits five times more particulate matter than a 2006 model year engine.

These new standards are critical to reducing air pollution in our nation's cities. However, diesel engines are durable and long lasting. A higher-emitting engine introduced 10 years ago could be on the road for another 10 years. Emissions standards are critical to reduce air pollution but it takes many years to realize the benefits through vehicle retirement. Legacy fleet emissions can be remedied with simple policies and technologies.

Again, EPA has led this effort by introducing its innovative Voluntary Diesel Retrofit Program in 2001 (now called the National Clean Diesel Campaign). This program offers funding to fleets to pursue voluntary retrofit programs. More importantly, the EPA developed a list of verified retrofit technologies to assist fleets in making informed decisions about the performance of various technologies on the market (visit http://www.epa.gov/otaq/retrofit/retroverifiedlist.htm for more information). This verification process has been invaluable to the success of retrofit efforts nationwide.

As diesel emissions became a priority at the national level, the Regional Air Quality Council (RAQC) and the Air Quality Control Commission (AQCC) formed a joint Diesel Stakeholders Work Group in 2002 at the local level to investigate options to reduce diesel emissions in the Denver metropolitan area. After a year of work, the Work Group made recommendations to address emissions from on and off-road diesel vehicles and evaluate the Diesel Inspection/Maintenance Program. Specific information regarding these recommendations can be found at http://www.raqc.org/diesel/Diesel%20WG%20Report%20070202.PDF. The primary recommendations that are addressed in this report include:

- Conducting a diesel fleet survey;
- Development of a fleet outreach and awareness program;
- Creation of a fleet recognition program;
- Encouragement of a best practices program for vehicle maintenance;
- Accelerated vehicle retirement, retrofit, and alternative fuels projects;
- Strategies to reduce vehicle idling; and
- Development of a clearinghouse of incentive programs and emissions requirements.

In 2002, funding opportunities became available to implement the recommendations of the Diesel Stakeholders Work Group on a small scale. The RAQC developed the original Clean Air Fleets (CAF) Program and began gauging fleet interest in retrofit, idling reduction and alternative fuels projects along the Front Range. Original members of the RAQC/AQCC Diesel Stakeholders Work Group indicated that private fleets would be interested in participating. In addition to private fleets, the RAQC determined that school bus fleets would be included in its initial outreach efforts.

Sixteen school districts, comprising approximately 2,000 buses and 28,000,000 vehicle miles traveled (VMT), were surveyed to determine their interest in pursuing alternative fuels, idling reduction, bus retirement and bus retrofit projects along the Front Range. The majority of school districts indicated they were interested in participating in these efforts. While buses are undisputedly the safest mode of transportation for school children, higher emissions from older buses can present a health risk to younger and at-risk children. This is due to the fact that developing lungs have a smaller surface area and a higher inhalation rate. In early childhood a child's respiratory rate is 20 – 40 breaths per minute while an adult averages 12 – 18 breaths per minute.

In 2003, EPA launched its Clean School Bus USA Program. The RAQC pursued this grant funding to expand its diesel emissions reductions projects to school buses. The goals of the RAQC's retrofit projects include:

- Educating fleets about emissions reductions options;
- Maximizing emissions reductions through cost-effective technologies;
- Reducing exposure to children and drivers in buses and at schools and the general public;
- Reducing fuel usage through the use of idling reduction policies and technologies;
- Utilizing alternative fuels to reduce petroleum knowledge; and
- Focusing on minimizing fleet operational costs when implementing emissions reduction programs.

From the initial retrofit programs through the release of this report, the RAQC and its partners have been successful in implementing a number of projects over a short timeframe. These include the original CAF Program, Clean Yellow Fleets for Blue Skies Program (CYFBS), and the Diesel Initiative for Retrofit Technology (D.I.R.T.). Between May 2004 and July 2006, the RAQC and program partners have:

- Retrofitted buses with 619 diesel oxidation catalysts (DOCs);
- Retrofitted buses with 117 closed crankcase filtration (CCF) devices;
- Installed 390 engine preheaters (idling reduction units) saving approximately 114,000 – 146,000 gallons of diesel fuel annually; and
- Provided funding for approximately 240,000 gallons of renewable B100 biodiesel fuel (This B100 biodiesel was blended with conventional diesel fuel in a 5 – 20 percent mixture).

The annual emissions reductions due to these programs include approximately 7.5 tons of particulate matter (PM), 1,818 tons of carbon monoxide (CO), 167 tons of hydrocarbons (HC), and 0.5 tons of oxides of nitrogen (NOx) (emissions reductions by funding source can be found in Appendix A). The cost has been approximately $1,636,000 with a $272,500 local cost-share.

This report includes a description of RAQC programs implemented through mid 2006 and projects planned for the future. While this report is not a 'how-to' guide, it addresses common questions posed by fleets and program managers over the years, the major processes within each program, the lessons learned and the overall program results.

Diesel Retrofit Timeline

This section includes a simple project timeline to assist those fleets and organizations developing diesel retrofit programs. This information will assist with realistic program implementation.

- **2001**: EPA implements its innovative Voluntary Diesel Retrofit Program
- **2002**: RAQC/AQCC convene the Diesel Stakeholders Work Group
- **2002**: RAQC receives its initial funding for diesel fleet outreach and retrofit and utilizes other funding sources to build the CAF Program
- **2003**: EPA launches its Clean School Bus USA Program
- **2003**: RAQC and school district partners receive a $400,000 grant for diesel retrofit and biodiesel fuel for CYFBS Program from EPA's Clean School Bus USA Program
- **2003**: RAQC adds 4 school districts to the original eleven districts and receives $950,000 for diesel retrofit through the Federal Highway Administration's (FHWA) Congestion Mitigation Air Quality (CMAQ) Grant Program
- **2004**: CYFBS retrofit installations begin along with the use of biodiesel fuels
- **2005**: RAQC expands its diesel retrofit effort to off-road vehicles through the development of the $75,000 D.I.R.T. Program
- **2005**: The CMAQ portion of CYFBS is successfully completed
- **2006**: The EPA portion of CYFBS is successfully completed
- **2006**: The RAQC expands the CYFBS Program to include municipalities, counties and the Colorado Department of Transportation and receives a $2.6M CMAQ grant for continued diesel retrofits
- **2006**: The RAQC, EPA Region 8, Colorado Department of Public Health and Environment and the City and County of Denver start the Rocky Mountain Clean Diesel Collaborative

Technologies

There are many technologies available to reduce emissions from diesel engines. At the onset of the CAF Program, simple technologies that were not fuel dependent were chosen since ultra-low sulfur diesel fuel (ULSD) was not available for the use of particulate traps. However, more technologies will be utilized as funding and ULSD fuel becomes available. The section below provides an overview of the technologies and their costs and benefits. Please refer to http://www.epa.gov/otaq/retrofit/retroverifiedlist.htm for more information on the latest EPA approved technologies and vendor contacts. The costs included below are based on prices secured for Denver area retrofit projects.

Diesel Oxidation Catalyst

This technology utilizes precious metals to trigger a chemical reaction to breakdown exhaust gases. In most cases, it is easily installed as a direct muffler replacement for the Original Equipment Manufacturer (OEM) muffler. In addition, the technology:

- Reduces 20 – 30 percent PM, 15 – 40 percent CO and 40 – 65 percent HC;
- Does not affect the OEM warranty;
- Does not require maintenance;
- Lasts a long time; and
- Costs approximately $830 installed for a school bus application but higher cost for non-school bus applications.

Closed Crankcase Filtration

This technology closes off and re-circulates engine exhaust gases from the crankcase through a filter and returns coalesced oil to the engine. This equipment reduces fouling of turbochargers and aftercoolers. In addition, the technology:

- Eliminates 25 percent of a vehicle's emissions from the crankcase and the primary source of in-cab pollutants;
- Does not affect OEM warranty; and
- Costs approximately $950 – $1,800 but has an ongoing filter cost of approximately $40 – $80 per year.

Engine Preheater

These units can heat engine coolant and the passenger cab depending on the unit. This limits engine wear and tear in addition to:

- Reducing fuel usage and emissions;
- Automatic starting with timers and ambient air temperature sensors;
- Eliminating the need to run electrical for block heaters;
- Requiring little ongoing maintenance; and
- Unit cost approximately $1,200 – $2,500;

Biodiesel Fuel

Biodiesel is a domestic, renewable fuel derived from soybean and rapeseed oils or waste grease. Use of this fuel reduces emissions and reliance on foreign oil and helps support our rural economy. Other benefits and costs of biodiesel include:

- Reductions of 0 – 47 percent PM, 0 – 47 percent CO, -10 – 0 percent NOx and 0 – 67 percent HC depending on the blend;
- It can be used in any concentration with petroleum based diesel fuel in existing diesel engines with little or no modification (OEMs support 2% – 20% biodiesel);
- Increased lubricity and potential to extend maintenance intervals;
- Acts as a solvent and can cause filter plugs in older vehicles; and
- The biodiesel supplier is very important as there can be other problems if the fuel is not produced, transported or stored properly.

A number of other technologies will be utilized in future retrofit efforts in the Denver area. These technologies include:

Particulate Filter

A diesel particulate filter has thousands of alternately closed small channels that filter out pollutants as exhaust flows through the unit. In most cases, it is installed as a direct muffler replacement for the OEM muffler. In addition, the filter:

- Provides 60 – 90 percent PM reductions, 60 – 90 percent CO reductions and 60 – 95 percent HC reductions;
- Is more difficult to install since the vehicle must be evaluated to determine duty cycle as exhaust temps must be high enough to regenerate the filter;
- Does not affect OEM warranty;
- Requires on-going maintenance and cleaning;
- Requires ULSD fuel, regular diesel fuel will cause filter plugging; and
- Costs approximately $7,000 – $10,000.

Diesel Multi-Stage Filter Muffler (DMF)

The DMF utilizes a two-stage metallic filter to trap and reduce exhaust emissions. In most cases, it is installed as a direct muffler replacement for the OEM muffler. In addition, the DMF:

- Provides up to a 70% PM reduction,
- Is more difficult to install since the vehicle must be evaluated to determine duty cycle as exhaust temps must be high enough to regenerate filter;
- Does not affect OEM warranty;
- Requires no cleaning or maintenance;
- Requires the use of ULSD fuel; and
- Costs approximately $4,000 – $6,000.

Auxiliary Power Units (APU)

These 5-10 horsepower diesel engines supply direct current power, heating and cooling, electricity to charge truck batteries and engine warming for cold weather starting to reduce idling. In addition they:

- Reduce emissions and engine wear and tear;
- Save up to $1,600 in fuel costs and $2,000 in maintenance costs annually;
- Do not affect OEM warranties;
- may not be a viable option for some truck operators because of their size, weight (300 – 400 lbs); and
- Cost approximately $5,000 – $10,000.

There are many other types of technologies and fuel additives available; however, the technologies listed above are the technologies and fuels being utilized in the Front Range. The appropriate technology is dependent upon the goals and funding for a project. Emissions reductions are best achieved by tailpipe technology and reduced idling and fuel usage are best achieved by engine preheaters and APUs. Overall, it is best to utilize these approaches in tandem for a comprehensive emissions and idling reduction program.

Clean Air Fleets Outreach and Awareness Program

Program Development

The CAF Program was the first diesel retrofit and alternative fuels effort developed by the RAQC. The goal of this effort was to provide multi-media outreach and funding to public and private fleets to implement the use of diesel retrofits, alternative fuels and idling reduction programs. There was no cost for public fleets to participate, however, private fleets were required to provide a 20 percent local cost-share.

To achieve these goals, the RAQC applied for two grants to fund this effort. In early 2002, the RAQC applied for $50,000 through the EPA Air Toxics Program. Further grant funding was secured when the RAQC applied for $135,000 through the Denver Regional Council of Governments' (DRCOG) Congestion Mitigation and Air Quality (CMAQ) grant pool through the Department of Transportation's (DOT) Federal Highway Administration (FHWA). In addition to CMAQ and EPA funding, Supplemental Environmental Program (SEP) funds through the Colorado Department of Public Health and Environment (CDPHE) and Conoco Petroleum were secured. Overall, $286,000 in funding was available with a $74,000 local cost-share for retrofits, alternative fuels and outreach that included a workshop, website and a recognition program.

To ensure that all interested fleets had equal access to the funding, an application process was developed. The RAQC convened a Program Advisory Team (PAT) to oversee the development of the process and approval of the applications. This panel of diesel experts included representatives from:

- Adams 12 Five Star Schools;
- CDPHE;
- Colorado Motor Carriers Association;
- Conoco Petroleum (now Suncor Energy (USA));
- Cummins Rocky Mountain;
- EPA Region 8; and
- Tri-County Health Department.

A simple application was developed to determine basic fleet and vehicle characteristics and estimated emissions reductions. The PAT determined a maximum of $2,000 per retrofit device would be sufficient for most technologies on the market not requiring ULSD. The PAT also decided a maximum of $1,000 per fleet for alternative fuels would allow a fleet to test a substantial amount of an alternative fuel. The program would reimburse fleets for the cost differential of an alternative fuel and regular #2 diesel fuel.

During this time, the CAF website at www.cleanairfleets.org was launched. All program policies and procedures and the funding application were posted on the site. In addition, this website became a clearinghouse of information regarding the RAQC's diesel efforts, retrofit technologies, alternative fuels and engine standards and technologies.

Once program development was completed, RAQC staff began conducting outreach to both private and public fleets in the area with primary emphasis placed on the private sector. Staff began by contacting trade associations first followed by individual fleets. Over the course of the program, presentations and information were provided to:

- Brannan Sand & Gravel Company;
- Lafarge North America;
- Colorado Motor Carriers Association;
- Colorado Rock Products Association;
- Colorado Department of Education's State Conference;
- CDPHE's Air Toxics Stakeholders Group;
- The Colorado State Pupil Transportation Association;
- NAPA Auto Parts;
- The Northeast Metro Pollution Prevention Association (NEMPPA);
- Rocky Mountain Fleet Manager's Association (RMFMA).

The RAQC also held its first Clean Diesel Conference in June 2003 to reach fleets. This two day conference addressed a wide variety of diesel related topics including advances in diesel engine technology, Puget Sound's Diesel Solutions Program, Colorado's Diesel I/M Program, alternative fuels and an overview of the CAF Program. The second day was dedicated to NEMPPA's diesel best practices effort focusing on diesel engine maintenance and shop waste minimization. The conference was attended by over 50 participants from public and private fleets.

Over 150 fleets were directly informed of retrofits, alternative fuels and idling reduction through these outreach efforts. Information was also disseminated through potential equipment and fuel providers. These included Cummins Rocky Mountain, Instrument Sales & Service, Sotack Equipment and Blue Sun Biodiesel. This outreach effort led to the installation of 69 retrofits and nineteen biodiesel projects being implemented. The original CAF project was completed in September of 2005.

<u>CAF Program Results & Emissions Reductions</u>

Between 2003 – 2005, program partners installed 69 retrofits. Overall, 29 closed crankcase filtration units, 29 engine preheat systems and 11 DOCs were installed. The retrofitted fleets included:

- Adams 1 Public Schools installed 4 engine preheaters;
- Adams 12 Five Star Schools installed 1 engine preheater;
- Adams 14 Public Schools installed 3 engine preheaters;
- Academy 20 Public School District installed 1 engine preheater;
- Aurora Public Schools installed 2 engine preheaters;
- Boulder County Public Schools installed 1 engine preheater;
- Brannan Sand and Gravel Company installed 3 engine preheaters;
- Brighton District 27J Public Schools installed 4 engine preheaters;
- Cherry Creek Public Schools installed 4 DOCs and 1 engine preheater;
- The City and County of Denver Public Works installed 29 CCF;
- Denver Public Schools installed 5 DOCs and 4 engine preheaters;
- Douglas County Public Schools installed 1 engine preheater;
- Englewood Public Schools installed 1 preheater;
- Falcon Public School District installed 1 engine preheater;
- Haul Away Recycling 1 DOC;

- Mountain Shores Greenhouse Service 1 DOC;
- Poudre Valley School District installed 1 engine preheater; and
- St. Vrain Valley Public Schools installed 1 engine preheater.

In addition to equipment retrofits, 19 biodiesel projects were funded across both private and public fleets. The fleets provided funding to test biodiesel were:

- Adams 1 Mapleton School District;
- Adams 12 Five Star Schools;
- Aspen Homes of Colorado;
- Bartkus Oil Company;
- Cherry Creek Schools;
- City and County of Denver Public Works;
- Colorado University Biodiesel;
- Denver Public Schools;
- Douglas County Schools;
- Eco-Cycle;
- Haul Away Recycling;
- Jeffco Public Schools;
- City of Lakewood;
- Littleton Public Schools;
- Mountain Shore Greenhouse Service;
- New Belgian Brewery;
- St. Vrain Valley Schools;
- Waste-Not Recycling; and
- The X-avator.

Overall program cost is detailed below in Table 1. Table 1 shows that approximately $286,000 was expended on this project. This total includes local cost-share.

Table 1 – Total Equipment & Program Cost by Funding Source

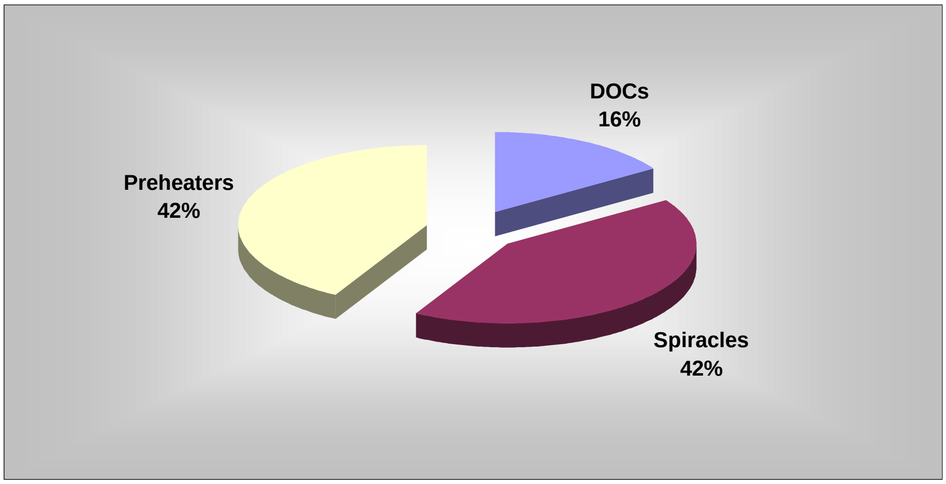
Budget Item	CMAQ	EPA	Other*	Total
Program Administration	$85,094	$9,249	$32,761	$127,104
Promotional Materials	$189	$33,337	$69	$33,595
Web Site		$2,544		$2,544
Workshops		$1,571	$2,020	$3,591
Travel		$3,300	$155	$3,455
Recognition Program			$3,155	$3,155
Diesel Oxidation Catalysts	$39,577			$39,577
Engine Preheaters	$8,540		$33,800	$42,340
Biodiesel	**$1,600		$17,400	$19,000
Other Retrofit***			$11,569	$11,569
Total Reimbursable	$135,000	$50,000	$100,929	$285,930
Local Cost-Share****	$74,186			
Total Expenditures	$209,186	$50,000	$100,929	$285,930

*Non-federal funds from State Supplemental Environmental Programs.

**This amount was billed to CMAQ prior to FHWA determination that fuel was not reimbursable but approved by FHWA/CDOT since it had already been submitted.
***Private fleet retrofit cost-share.
****The $74,186 utilized as local cost-share is actually non-federal SEP funding from the "Other" funding category.

Figure 1 below shows the equipment breakdown installed under the Clean Air Fleets Program. Overall, engine preheaters and closed crankcase filtration systems were the primary focus of the program.

Figure 1 – Equipment Installations



Annual emissions reductions for the total program were estimated at up to 0.25 tons per year (TPY) of PM, 56 TPY of CO, +1 TPY of NOx and 5 TPY of HC. These emissions reductions were developed utilizing average operating parameters of the retrofitted vehicles, EPA certification standards and then applying percentage reductions from EPA's Verified Retrofit Technology List (see Appendix B for methodology). Because this was a voluntary retrofit program, no modeling was required or performed. Overall, the annual cost per ton reduced was approximately $4,800.

Lifetime benefits for the project were developed using a straight-line calculation and a seven year life of equipment. The life of equipment is based on warranties and real world reports on DOC life. All engine preheat technology is professionally maintained by ISS for many years. Over seven years, the project results in the reduction of tons of 1.75 PM, 393 tons of CO, +7 tons of NOx and 37 tons of HC. The cost per ton over the life of the project has not been estimated since it requires costs for ongoing maintenance over the project life which are not available at this time.

Additional benefits in the form of fuel reductions were realized through the use of biodiesel fuels and engine preheaters. Overall, the project displaced approximately 19,000 gallons of petroleum based diesel fuel with renewable B100 biodiesel fuel. This B100 biodiesel was blended in a 5 – 20 percent mixture with conventional diesel fuel. In addition to displacing petroleum fuel, petroleum usage was reduced further through idle reduction from 29 engine preheaters. Estimates indicate that 9,000 – 11,000 additional gallons of fuel were saved through fleet idle reduction efforts.

CAF Lessons Learned

This first effort was a critical learning experience for all stakeholders. Overall, the program:

- ✓ ***Increased awareness and understanding of retrofit technologies and alternative fuels;***
- ✓ ***Identified fleets interested in retrofit and alternative fuels programs;***
- ✓ ***Determined the obstacles to success; and***
- ✓ ***Identified program improvements.***

By utilizing the combined knowledge of a few critical stakeholders, RAQC was able to better understand the technologies and fuels being proposed. During program development, importing ULSD was discussed to allow for the installation of particulate traps. The PAT, OEMs and area fleets indicated a simpler approach should be implemented using readily available DOCs, engine preheaters and biodiesel fuel. By utilizing simple technologies that were easier to install and maintain, instead of utilizing more complex technologies, the RAQC was able to build a record of success and trust with area fleets.

Overall, most fleets were receptive to hearing about new technologies and fuels. Through the implementation of this program the RAQC determined that public fleets were willing to test all cost-effective technologies and fuels. However, private fleets were primarily interested in alternative fuels and engine preheaters but not tailpipe or crankcase retrofit equipment. A number of private fleet operators indicated that they would increase the retirement of older, dirtier, less fuel efficient vehicles and replace them with newer, cleaner, more fuel efficient vehicles rather than retrofit them to simply reduce emissions. Penetrating the private sector is still an ongoing challenge.

When this effort was first developed, government agencies and equipment providers in the Denver area had limited knowledge of retrofit programs. Based on knowledge at the time, the “decentralized” program model utilizing an application process was implemented. This program model allowed fleets to purchase equipment individually instead of through centralized bids. The early goal of the program was to limit paperwork and tracking to reduce the barriers to fleets applying for the funds and reduce processing timeframes.

However, as the program matured, both the outreach and application processes consumed more resource time than was anticipated. Convening the PAT to approve applications slowed the process down. In addition, costs varied for retrofit equipment and installations. These were critical lessons that led to program improvements as these efforts evolved.

The original CAF program also provided a test bed to develop internal and external processes for program management on a small scale. These lessons learned proved invaluable in the CYFBS effort. The RAQC developed the CYFBS Program with a more “centralized” program model focused on developing a partnership of fleets to reduce outreach requirements, submitting grants based on the partnership’s needs and developing request for proposals (RFPs) to control costs.

Clean Yellow Fleets for Blue Skies Program (Phase I)

Program Development

In 2003, the EPA began its Clean School Bus USA Retrofit Program with $5 million dedicated to reducing emissions from the nation's school bus fleets to protect children's health. The RAQC sought to capitalize on the momentum of the Clean Air Fleets Program and interest expressed by some school districts by investigating the development of a large diesel retrofit program to address emissions from school buses. This program's goals included:

- Educating fleets about emissions reductions options;
- Maximizing emissions reductions through cost-effective technologies;
- Reducing exposure to children and drivers in buses and at schools and the general public;
- Reducing fuel usage through the use of idling reduction policies and technologies;
- Utilizing alternative fuels to reduce petroleum usage; and
- Focusing on minimizing fleet operational costs when implementing emissions reduction programs.

To determine the feasibility and interest in a retrofit effort, the RAQC developed a survey to gauge the interest of area school districts to implement a program. Through this survey, the RAQC determined that of the 16 districts surveyed, 13 were very interested in a retrofit and alternative fuels program. During the survey process, the RAQC was asked to present its proposed retrofit program to the Metro Area Transportation Efficiency Study group (MATES). This group strongly endorsed the RAQC proposal for a retrofit and alternative fuels program.

A stakeholder group was convened to develop a plan for the CYFBS Program. The stakeholder group consisted of the following 12 school districts (see Appendix C for locations):

- Adams 12 Five Star Schools;
- Aurora Public Schools;
- Cherry Creek Schools;
- Colorado Springs District 11;
- Colorado Springs Academy District 20;
- Denver Public Schools;
- Douglas County School District Re-1;
- Jeffco Public Schools;
- Littleton Public Schools;
- Mapleton Public Schools;
- St. Vrain Valley School District; and
- Thompson School District.

The group determined that DOCs, engine preheaters and biodiesel fuel were the best technologies to achieve program goals. A grant application was submitted to the EPA requesting $500,000 for DOCs, engine preheaters and biodiesel fuel. EPA awarded the group $400,000 with a $35,000 local cost-share provided by program partners for DOCs and B20 biodiesel fuel.

During development of the EPA grant, the group decided to expand the program by applying for CMAQ funding. During development of this grant four more school districts joined the effort. They included:

- Adams County School District 14;
- Adams County School District 50;
- Englewood Schools; and
- Boulder Valley School District.

During the project development process, Adams County School District 14 left the group. The remaining fifteen districts developed a $950,000 grant with a $237,500 local cost-share for DOCs, closed crankcase filtration units and engine preheaters. Overall, there was a 20 percent local cost-share requirement for the funding. Grantees were required to provide a 10 percent local cost-share while discounts realized through the RFP process met the other required 10 percent. The group was awarded this funding in 2004.

Unfortunately, CMAQ funds can only be used in the Denver metro area. Therefore, two districts, Colorado Springs Districts 11 and 20, were ineligible for CMAQ funding.

The group then scheduled a Vendor Workshop in February 2004 to learn about the current technologies on the market. Overall sixteen school districts were in attendance to hear presentations from fourteen vendors on their company's various technologies and fuels.

Based on lessons learned from the CAF Program, the RAQC and its partners agreed to release three RFPs to control the costs of the DOCs, closed crankcase filtration, engine preheaters and biodiesel fuel. The RFPs were released through Denver Public Schools (the RFPs are available at www.cleanairfleets.org). After a review period, all vendors were required to submit written questions to clarify any questions about the program or RFPs. All vendors were then required to attend a pre-bid meeting where the answers to the written questions were provided to all vendors.

Five vendors responded to the Biodiesel RFP. The fuel vendors had difficulty providing the information requested in the RFP and the stakeholder group found many of the proposals non-responsive. In addition, it became apparent that many school districts did not want to change their fuel provider due to long-standing relationships they had developed with them. After attempting to gather the required information and work through changing the majority of districts to a new fuel provider, the group felt the Biodiesel RFP was compromised and cancelled it. The group agreed that biodiesel would be subsidized from any approved supplier that met the Biodiesel RFP specifications.

Four vendors responded to the DOC RFP and two responded to the engine preheater RFP. One vendor, Instrument Sales & Service (ISS), was selected to provide both DOCs and engine preheaters for the program. ISS was able to provide the equipment at the following prices:

- DOCs at $750 uninstalled and $830 installed;
- Spiracle closed crankcase filtration at $950; and
- Engine preheaters at $1,100 - $2,500 depending on heater size and bus configuration.

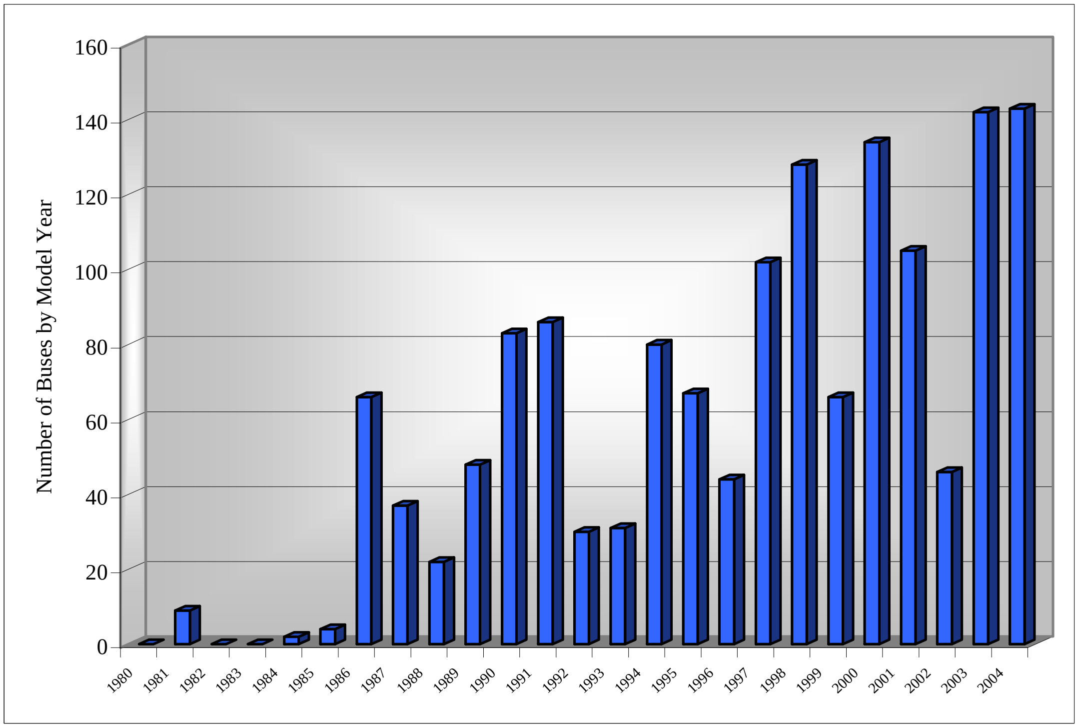
In October 2004, the RAQC and participating school districts held a press event to launch the program. Fifteen districts were in attendance and one school district brought a bus load of children to the event. All media in the Denver area attended and heard presentations from various VIPs including keynote speaker Robbie Roberts, Region 8 Administrator for the EPA. The RAQC and school district participants also spoke of the importance of diesel retrofit efforts in the Denver region.

Once the program was officially launched and the RFP process was complete, five critical areas required policy and process development. These included:

- Bus eligibility criteria;
- Funding allocations for both fuel and hardware (See Appendix D for details);
- District bus identification;
- Installation plan; and
- Payment processing.

School districts initially identified large, active route buses between the model years of 1980 – 2004 as the best candidates for retrofitting. Districts provided RAQC with data showing their fleet composition to assist with the eligibility determination. Figure 2 shows districts had approximately 1,500 large, active route buses between the model years 1981 – 2004 across the fifteen participating districts.

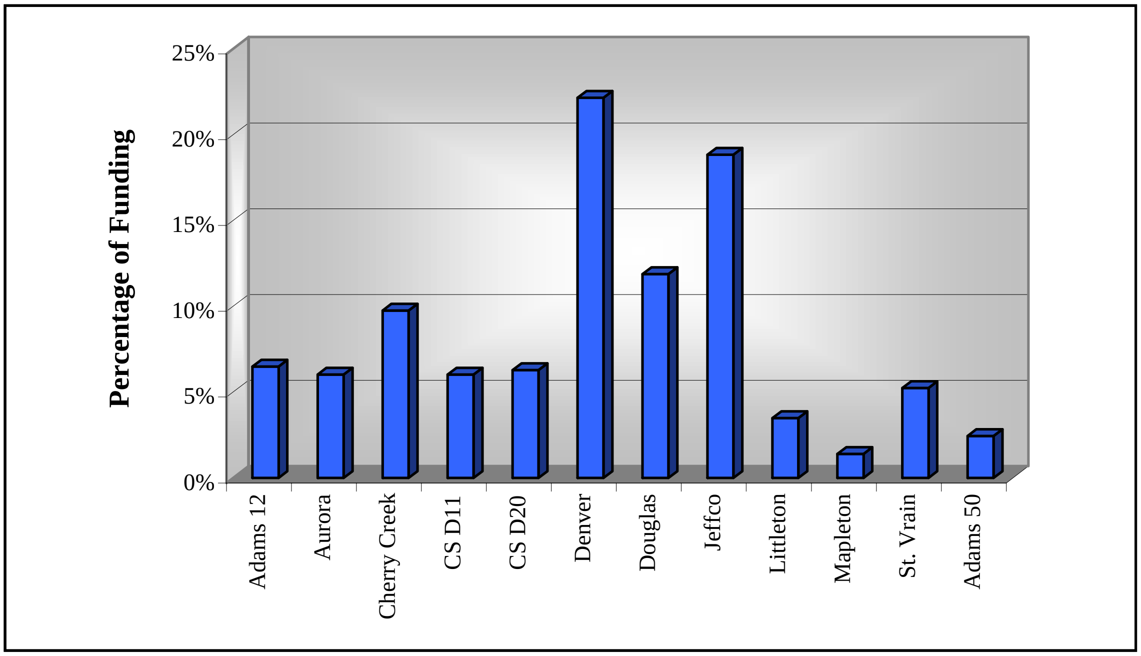
Figure 2 – Type C/D Buses by Model Year (1980 – 2004)



Districts and RAQC agreed that 1987 through 1997 model year buses should be the primary candidates for retrofit since they have the highest emissions based on EPA certification data. Analysis indicated this equated to approximately 700 eligible buses and funding was allocated to the districts based on this bus count. However, during implementation of the CMAQ portion of the program, it became clear that there were not enough buses in the model year range and more model years were added. Bus eligibility was extended to include 1987 – 2000 model year buses. Overall, there approximately 1,000 buses within these model years.

After determining bus eligibility, equipment and fuel funding allocations were addressed. Biodiesel funding was determined based on the proportion of all diesel vehicles in each fleet due to the fact many fleets have central fueling facilities. Figure 3 shows the percentage of funding initially provided to each fleet.

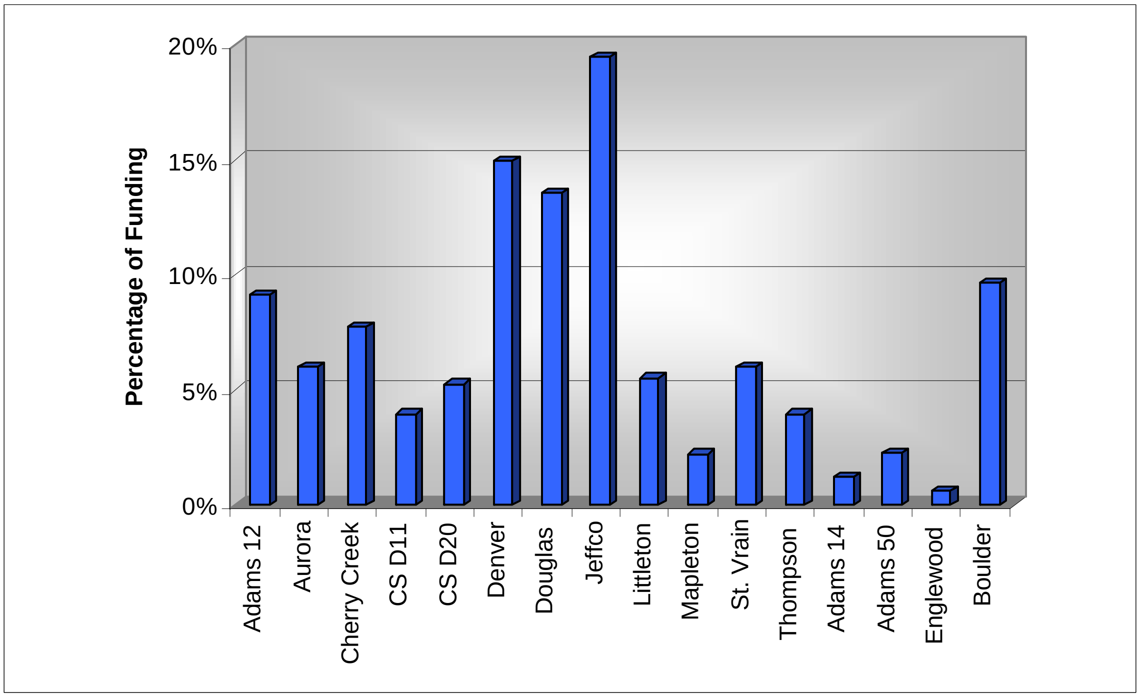
Figure 3 – Biodiesel Funding Allocation per District



Based on the funding allocation process, the largest fleets received the greatest amount of biodiesel funding. Three fleets, Denver, Jefferson County and Douglas County received almost 50 percent of the total program funding.

The funding allocation for retrofit hardware was developed based on the number of eligible large (Type C and D buses), route buses in each participating district. No sub buses or activities buses were eligible for retrofit during Phase I of the project. This allocation was more difficult to determine since there were two different funding sources, EPA and CMAQ, each with different districts eligible for the funding. Therefore, Figure 4 shows the approximate percentage of funding provided to each district (Appendix E details the exact amount of funding per district).

Figure 4 – Equipment Funding Allocation by District



Upon completion of the eligibility guidelines and the funding allocations, school districts were asked to determine which buses they would retrofit. Districts utilized an order sheet developed by RAQC staff that utilized the critical parameters (i.e., model year, bus manufacturer, engine specifics, front/rear engine bus, etc.) to determine if a bus was a good candidate for retrofit and the cost of the specific equipment for that type of bus. RAQC staff worked with the districts for approximately one month developing the order sheets.

Once the order sheets were finalized, they were provided to ISS to order the retrofit equipment. The initial plan was to have ISS only inspect those buses they had questions about. ISS did not agree with this plan, but in the interest of time, the decision was made to follow this process. Due to a variety of factors discussed in the Lessons Learned Section below, ISS determined they would need to inspect all buses to be retrofitted.

Over the next two months, ISS inspected all the buses on the order sheets to ensure that the DOCs, closed crankcase filtration or preheater retrofit was appropriate for that bus. During these inspections, ISS provided substitutions when a bus identified by a district was found to be inappropriate for a certain technology. During this process, approximately 20 percent of the buses initially identified for retrofit required substitutions.

While these tasks were being completed, the RAQC and participating districts developed an installation plan for ISS to follow. The group decided that ISS would arrive and stay at a particular district until all DOCs, closed crankcase filtration and preheater retrofits were installed. Upon completion of the installation of a particular technology, ISS would then invoice the districts and RAQC. This installation plan was developed to minimize the flow of paperwork and ensure the school district would know when ISS would be on their property for management and security purposes. Program partners and ISS agreed with the plan and ISS was instructed to start with the smallest districts first to ensure all processes worked prior to moving to larger districts.

The final piece of program planning to be addressed was the payment process. It was agreed that upon completion of work in a district for a particular piece of technology, ISS could invoice for the equipment. The goal was to incentivize ISS to move quickly through each district. Once a technology was fully installed in a district, ISS would invoice both the district and the RAQC. RAQC would contact the district to approve the invoice and the district would provide timesheets showing the district's 10 percent local cost-share. The RAQC would then submit this information to either EPA or the Colorado Department of Transportation (CDOT), the agency that oversees the CMAQ process, for reimbursement. The district would pay ISS net 30 days. The RAQC would reimburse the district within 60 days.

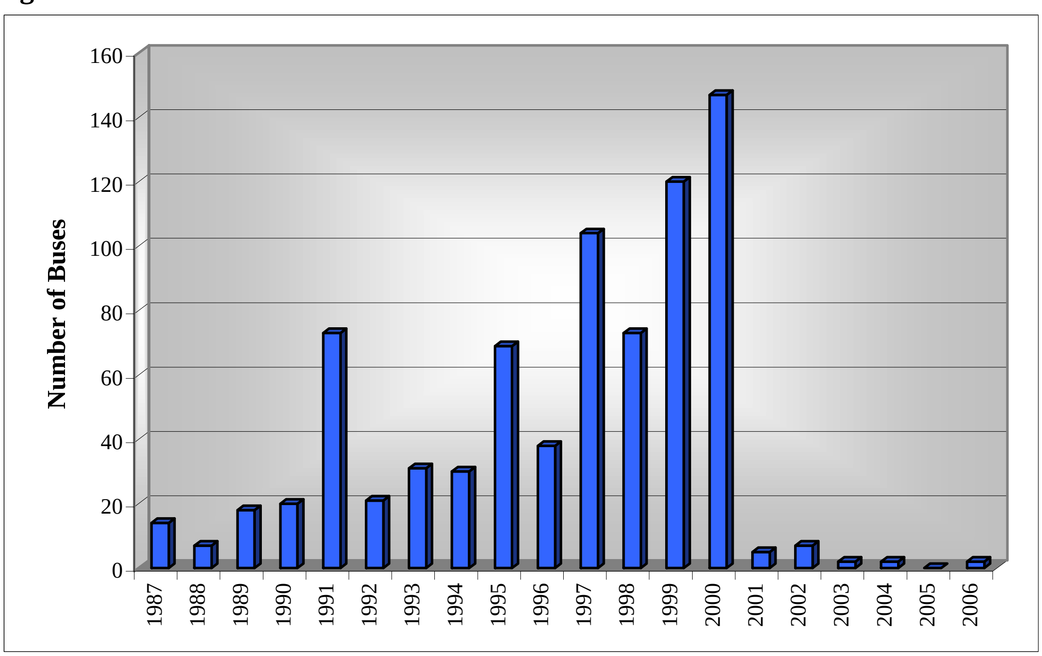
With all program planning complete, ISS began installing equipment in 2004. The majority of installations under the EPA grant were completed in July 2004 with some final installations in early 2006. Installations for the CMAQ portion of the grant were completed at the end of 2005.

Upon completion of a majority of the retrofit installations, the RAQC held a recognition event for all school districts involved in the program. The event featured speakers, an award ceremony followed by a luncheon. All participating school districts brought three to five critical staff that worked on the project so that all program participants were recognized for a job well done.

CYFBS Program Results & Emissions Reductions

Between 2003 and January 2006, approximately 1,060 pieces of retrofit equipment were installed on approximately 800 buses in 15 school districts across the Front Range. Figure 5 below shows the model year distribution of the 800 retrofitted buses.

Figure 5 – Model Years of Buses Retrofitted



Program planning was critical to this effort but required flexibility once actual hardware installations began. Figure 5 above shows that equipment was installed on model years ranging between 1987 – 2006. Fleet management is a fluid situation due to vehicle acquisition and retirement and shifting operational demands. As hardware installation progressed, fleet management requested flexibility to meet their operational needs. In other cases, smaller districts asked to retrofit buses outside the model year range when they completed retrofit of all other eligible buses. RAQC staff met those needs and allowed some preheaters to be installed on 2001 – 2006 buses.

Overall program cost is detailed below in Table 2. Table 2 shows approximately 1,060 equipment installations for a total program cost of $1.6M (expenditures by district can be found in Appendix E). This cost is inclusive of all staff time dedicated to the project. Overall, this breaks down to an average cost per installed unit of approximately $1,330 ($1.587M total cost - $184,644 biodiesel = $1.403M)/1,057 total units = $1,330). Original projections for the CMAQ project estimated that only 250 DOCs, no closed crankcase filtration and 333 preheaters would be installed for the funding. This goal was met and exceeded.

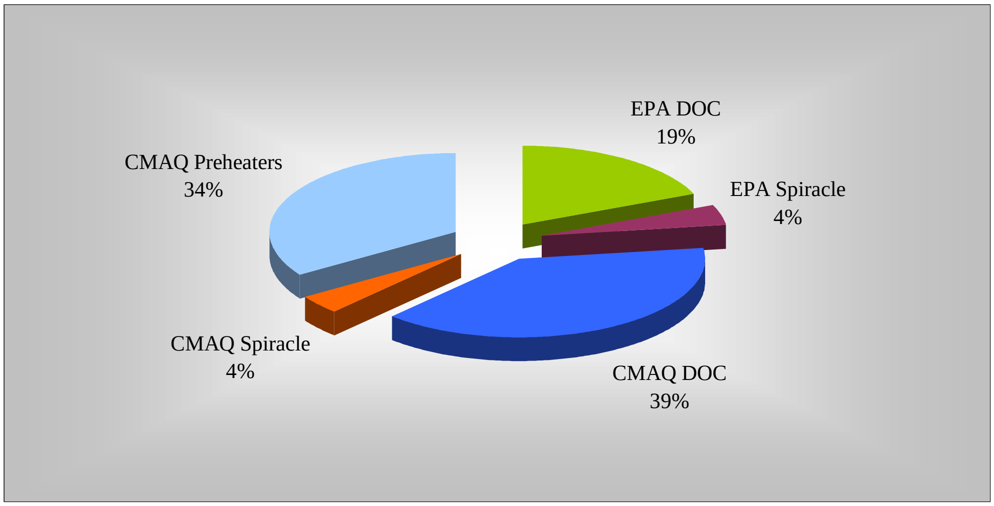
Table 2 – Total Equipment & Program Cost by Funding Source

	Total Units	Total Cost	Average Cost Per Unit*
EPA DOC	196	$ 170,039	$ 868
EPA Spiracle	46	$ 45,317	$ 985
EPA Biodiesel		$ 184,644	
Local Cost-Share		$ 35,027	
Subtotal	242	$ 435,028	
CMAQ DOC	412	$ 327,229	$ 794
CMAQ Spiracle	42	$ 41,377	$ 985
CMAQ Preheaters	361	$ 531,334	$ 1,472
Program Administration		$ 50,060	
Local Cost-Share		$ 237,499	
Subtotal	815	$ 1,187,499	
Totals	1,057	$ 1,587,500	$ 1,502

*The cost differential between EPA DOCs and CMAQ DOCs is due to EPA paying for the installation of the units while the districts covered the cost of CMAQ DOC installations as a part of their local cost-share.

Figure 6 details the types of equipment purchased over the course of the project by funding source. Figure 6 clearly shows that DOCs to reduce tailpipe emissions were the primary focus of the project.

Figure 6 – Hardware Retrofits by Funding Source



Annual emissions reductions for the total program were estimated at up to 7 TPY of PM, 1,660 TPY of CO, 1.5 TPY of NOx and 160 TPY of HC (emissions reductions by district by funding source can be found in Appendix E). These emissions reductions were developed utilizing average operating parameters of the retrofitted buses, EPA certification standards and then applying percentage reductions from EPA's Verified Retrofit Technology List (see Appendix B for methodology). Utilizing certification standards for the emissions calculations provides a more conservative calculation since it does not account for engine degradation over many years. Because this is a voluntary retrofit program, no modeling was required or performed. Overall, the annual cost per ton reduced was approximately $900.

Lifetime benefits for the project were developed using a straight-line calculation and a seven year life of equipment. The life of equipment is based on warranties and real world reports on DOC life. All engine preheat technology is professionally maintained by ISS for many years. Over seven years, the project results in the reduction of 49 tons of PM, 11,630 tons of CO, 10.5 tons of NOx and 1,130 tons of HC. The cost per ton is over the life of the project has not been estimated since it requires costs for ongoing maintenance over the project life which are not available at this time.

Additional benefits in the form of fuel reductions were realized through the use of biodiesel fuels and engine preheaters. Overall, the project displaced approximately 220,000 gallons of petroleum based diesel fuel with renewable B100 biodiesel fuel. This B100 biodiesel was blended with conventional diesel fuel in a 5 – 20 percent mixture. In addition to displacing petroleum fuel, petroleum usage was reduced further through idle reduction from 361 engine preheaters. Estimates indicate that 105,000 – 130,000 additional gallons of fuel were saved through district efforts.

The final assessment of the program shows strong emissions reductions, displaced petroleum usage and reduced fuel usage. Through the lessons learned through CAF, the RAQC and its partners reduced the annual costs per ton of PM, CO, NOx and HC from $4,800 to $900. In addition, this program positively impacted the health and safety of a minimum of up to 48,000 Colorado school children riding on the 800 retrofitted buses. Health benefits were also experienced by other children at schools where buses idle and the general public at-large.

CYFBS Lessons Learned

There were many lessons learned during the operation of a project of this size. Below are the critical program aspects that should be taken into account when designing a large retrofit project. Focus on:

- ✓ ***Developing partnerships to ensure program success;***
- ✓ ***Tasking air quality experts to find project funding;***
- ✓ ***Preparing for flexible planning and decision-making;***
- ✓ ***Developing RFPs in anticipation of future program needs;***
- ✓ ***Keeping bus identification simple;***
- ✓ ***Constant monitoring and feedback on program progress and equipment installations;***
- ✓ ***Setting the expectations regarding the payment process early;***
- ✓ ***Developing solid management and tracking at the onset of the program; and***
- ✓ ***Assisting others with program replication state and nationwide.***

Fleet partnerships are the base for all successful retrofit programs. Finding fleets that are motivated and forward thinking makes implementation of these efforts easier. Fleet outreach and education are still required but are minimized when a fleet is interested in participating. Finding trade associations for fleets being asked to participate in retrofit efforts is a cost-effective way to recruit them. The lesson learned is that "can-do" fleets create innovation and program success. Colorado's school districts demonstrated any program can be a success with this attitude.

However, emissions reduction projects are not the primary mission of fleets from school districts to private construction companies. The barriers to applying for these funds for most organizations seem daunting from their perspective. Fleets will participate if air quality professionals find and manage the funding. After a couple of successful projects, fleets will understand the grant process and can sustain these projects on their own.

Another key to success in these efforts is solid planning during program design and flexible decision-making during program implementation. Program goals must still be met but participant needs must be met at the same time. From bus acquisition and retirement, to changing management decisions, fleet needs change over time and must be accommodated. Some districts determined that they could not spend all the funding they had initially requested while others requested more funding. Had all fleets been required to adhere to unyielding policies at all times, the program would not have been successful.

Another critical aspect of a successful retrofit program is a solid equipment and fuel bidding process with good specifications for both. If RFPs are going to be released for a project, ensure they allow flexibility to modify the program in the future. Develop RFPs to:

- Address all diesel vehicles, not only school buses;
- Include language that asks for a menu of prices for all diesel vehicles;
- Include a menu of technologies; and

- Include cooperative language to allow any interested fleet to purchase from the contract anywhere within a region or state.

Even if an agency is only planning on retrofitting school buses with DOCs as their initial project, the agency should include the items above in their RFP. RAQC and DPS developed RFPs that were school bus specific. One was for DOCs and closed crankcase filtration and the other was for engine preheaters. Upon completion of Phase I of this project, the RAQC and its school district partners were ready to utilize new technologies on other applications besides school buses. In addition, municipalities, counties and CDOT all indicated they were interested in participating in future retrofit projects. However, as RAQC began implementing Phase II, it was found that no addenda could be made to the existing RFPs. Therefore, RAQC is required to bid out any new technologies for non-school buses.

While the equipment could be rebid, the RAQC and its partners could lose some of the lowest costs in the nation for DOCs, closed crankcase filtration and engine preheats. If this equipment is not rebid, another contractor could win the second bid introducing multiple contractors into the program, complicating program management and logistics. It is best to develop one flexible RFP to avoid becoming involved in a never ending bid process.

The bus identification process is another area that will be simplified in future retrofit efforts. The plan in Phase I was to have school districts fill out order sheets that identified each bus they would retrofit. The order sheets would simply be forwarded to ISS for ordering the equipment and installation kits.

Once ISS received the order sheets, they made the determination that they would have to physically inspect each bus. The primary issue that required a change to the plan was due to the fact that bus manufacturers install certain components in one place on one bus and the next bus on the line may have these components in a different location. Therefore, the contractor may be required to fabricate parts to ensure the equipment fits. Another issue that came up was some buses already had DOCs installed in the factory. In many cases, there was no way to tell which ones had DOCs until an inspection was performed. One final area that project managers must be aware of is that some districts install other products on the chassis of the bus. A common installation on the chassis found in the Denver area is a retarder. This piece of equipment is large enough to require exhaust system modifications. This was not anticipated at the beginning of the project.

One final area that became problematic during the bus identification process was that many districts identified 1991 and pre-1991 buses for retrofit since they had higher emissions. The contractor made inspecting these buses a priority. The primary reason was that 1991 buses can have 1990 engines in them. Any pre-1991 engines present problems for retrofit since there is no verified technology for them.

The lesson learned was that a retrofit contractor will probably have to physically inspect each bus that a fleet would like to retrofit. While this may be time consuming, it is better than purchasing equipment that can not be returned. Having the fleet and the retrofit contractor work directly together with program management ensuring program goals are met is the best process. It is important to note this process can take a long period of time and program timetables must reflect this.

Upon completion of the order process, the installation process began. ISS was instructed to begin installations in one small district to test the program’s processes and procedures, then move to the next largest and continue this process until installations were complete. ISS followed this plan in the early stages of the program. However, as the project progressed, ISS began spot installations across many districts reducing their installation efficiency. Once this problem was identified, ISS rectified the problem.

As equipment installation progressed, stakeholders determined that a small percentage of installations generated complaints from fleet technicians. ISS identified the main area of complaint as those vehicles that had retarders and other equipment installed on the chassis which interfered with the installation and caused small exhaust leaks. ISS brought Donaldson engineers, the DOC manufacturer, to the Denver area to solve the problem once it was identified.

The lesson learned throughout the installation process is that having communication and feedback from all program partners is critical. It is also important to have a motivated contractor like ISS. Once feedback from program partners identified a problem, ISS implemented internal procedures to ensure quality assurance and hired an applications engineer.

Another area that public agencies need to make clear to participating fleets is that many of the federal funding sources do not have short reimbursement timeframes. In Phase I, it took up to 60 days to reimburse a fleet for equipment or fuel. The lesson learned is that making this clear at the beginning of the project and notifying fleet accounting departments limits conflicts later in the project.

Another area to address when implementing a large diesel retrofit effort is management and tracking. These projects require constant communication between fleets, contractors and program management. Performing weekly calls with the contractor and monthly updates with fleets allows program management to identify problems early before they become widespread. In addition, large projects require solid tracking systems for reporting purposes. Pay attention to this issue at the beginning of the project and many problems will be avoided during and after the project is complete.

The final issue to address upon completion of a large retrofit project is replication. When the RAQC and stakeholder districts began this project, there was limited information available regarding how to implement this type of program. This report is an effort to rectify this and provide assistance to program managers in implementing these efforts. Providing a candid discussion of the successes, challenges and lessons learned is critical to ensure good government and policy making.

Further Down the Road on Diesel Emissions

Rocky Mountain Clean Diesel Collaborative

After a number of years working on diesel emissions reductions programs, the Denver Metro Area has become a leader in diesel retrofit programs. Again, partnerships have been critical to the success of these efforts.

The RAQC intends to continue the momentum built by the dedication of the stakeholders that have been involved in this effort. Currently, EPA Region 8, CDPHE, the City and County of Denver and the RAQC are developing the Rocky Mountain Clean Diesel Collaborative (RMCDC).

The RMCDC is a partnership between EPA Region 8, RAQC, CDPHE and the Denver Department of Environmental Health. Our vision is to expand beyond government agencies into the private sector as well as future growth into all of Region 8. Building upon the success of EPA's National Clean Diesel Campaign, the RMCDC strives to reduce diesel emissions by:

- Upgrading ("retrofit") existing diesel engines with better emission control technologies (diesel oxidation catalysts or particulate filters);
- Converting to a cleaner burning fuel (biodiesel or ultra low sulfur diesel);
- Encouraging policies and practices to reduce unnecessary idling;
- Replacing oldest engines/vehicles with new, less polluting engines/vehicles; and
- Assisting with granting, leveraging, and securing funds to expand diesel emission reduction efforts.

The RMCDC's key messages are:

- Unnecessary idling pollutes the air, wastes fuel and money, and causes excess engine wear;
- A retrofitted engine is a cleaner engine because it has been fitted with a device designed to reduce pollution and/or use cleaner fuel;
- Eliminate the black soot from exhaust pipes of trucks, buses, and construction equipment;
- Reduce premature mortality, asthma attacks, lost work days, and other health impacts; and
- Unique challenges for the Rocky Mountain region: high altitude, cold weather climate, large land areas with small populations, predominantly attainment areas.

Diesel Initiative for Retrofit Technology Program (D.I.R.T.)

The goal of the D.I.R.T. Program is to work with the off-road diesel industry to find private companies that operate around sensitive populations and would like to differentiate themselves from their competitors by utilizing “clean” technology. Program partners will work with the Rocky Mountain Fleet Manager’s Association (RMFMA), American General Contractors and other fleet and trade associations to find interested private companies. Public fleets that work around sensitive populations will also be recruited. However, one of the main goals of this effort is to recruit a private fleet to test the program technology.

The retrofit technology that will be used for the D.I.R.T. Program will be DOCs in conjunction with closed crankcase filtration technology. The DOCs are proven technology that are easy to install and require little to no maintenance. However, closed crankcase filtration is new to the Denver area and much of the United States for off-road applications. Overall, the program has $75,000 in funding with a $7,500 local cost-share.

Clean Yellow Fleets for Blue Skies Program (Phase II)

The RAQC and district partners will implement Phase II of the CYFBS in 2006 to continue the program within the seven-county, metro-Denver region. Two approaches will be employed to meet the program’s goals of diesel idling and emissions reduction. The first will be to install idling and diesel emissions reduction equipment on fleet vehicles at participating school districts, State facilities, municipalities and counties. The second is to train equipment operators and supervisors about reducing vehicle idling and fuel usage.

Overall, the RAQC and participating fleets will install idling and emissions reduction equipment on approximately 800 – 1,500 in-use diesel vehicles and develop idling reduction policies and training for equipment operators and supervisors. The total budget for this project is $3,304,000. Of this amount, $2,643,200 is requested from CMAQ and the remaining $660,800 is local cost-share provided by school districts, municipalities, counties and CDOT.

Retrofit Program Conclusions

The conclusions from the Denver Front Range's retrofit experience are clear. Focus on five simple goals to ensure success of a retrofit effort. These are:

- ✓ ***Building partnerships;***
- ✓ ***Finding dedicated program champions;***
- ✓ ***Remaining flexible;***
- ✓ ***Communicating; and***
- ✓ ***Keeping it simple.***

Building partnerships is fun and brings the experts in their particular arenas together to build successful programs. Dedicated program champions will emerge from this process and simplify implementing a retrofit program. A partnership with a "can-do" attitude is an unstoppable force.

Remember to remain flexible and communicate with program partners. Fleet management is a dynamic arena with vehicle purchasing and retirement, shifting priorities and personnel turnover. What is planned today will change tomorrow. Attempting to keep it simple when possible seems to be a difficult goal in the public sector. Retrofits are cost-effective and usually simple to install. Unfortunately, developing the processes to implement a program are not.

With this report in hand, agencies can avoid pitfalls that slow down retrofit programs. The RAQC and all its program partners over the years hope that this information is helpful. Remember, encountering and overcoming challenges is part of any program.

APPENDICES A - E

Appendix A – Emissions Reductions by Funding Source

Table A1 - Annual Emissions Reductions by Funding Source (TPY)

Funding Category	PM	CO	HC	NOx
CAF – CMAQ	0.25	56.2	5.35	-1.14*
CYF – EPA	3.2	711.2	60.3	-13.6*
CYF – CMAQ	3.9	949.9	101	15.1
Total	7.35	1,818.3	166.65	0.36

*Increases in NOx are due to the use of biodiesel.

Appendix B - Emissions Reduction Methodology

Table B1 - Emissions Standards and Equipment Reductions (g/bhp-hr)*

	PM10	CO	NOx	HC	Hours per year	Brake Horsepower
1980 - 1990	0.6	15.5	6	1.3	1,680	196
1991 - 1993	0.25	15.5	5	1.3		
1994 - 1997	0.1	15.5	5	1.3		
1998 - 2003	0.1	15.5	4	1.3		
2004 - 2006	0.1	15.5	2	1.3		
Idle Data (grams/hour)**	2.57	94.6	144	12.6		
Equipment Emissions Reductions						
					Hours per day	Hours per year
Preheaters	84%	84%	84%	84%	1.5	315
DOC Reductions	20%	40%	0%	50%		
Spiracle Only Reductions***	8%	6%	0%	13%		

*Data from 1997 EPA Emissions Standards Reference Guide for Heavy Duty and Nonroad Engines at http://www.epa.gov/otaq/cert/hd-cert/stds-eng.pdf.
** April 1998 EPA Office of Mobile Sources - 'Emissions Facts' Datasheet
***In some cases a closed crankcase ventilation system was installed on a bus with an OEM catalyst already installed, therefore, the program did not take credit for the DOC emissions reductions.
****Equipment life is determined utilizing warranty and real world data.

Tailpipe/CCV Emissions Reductions:

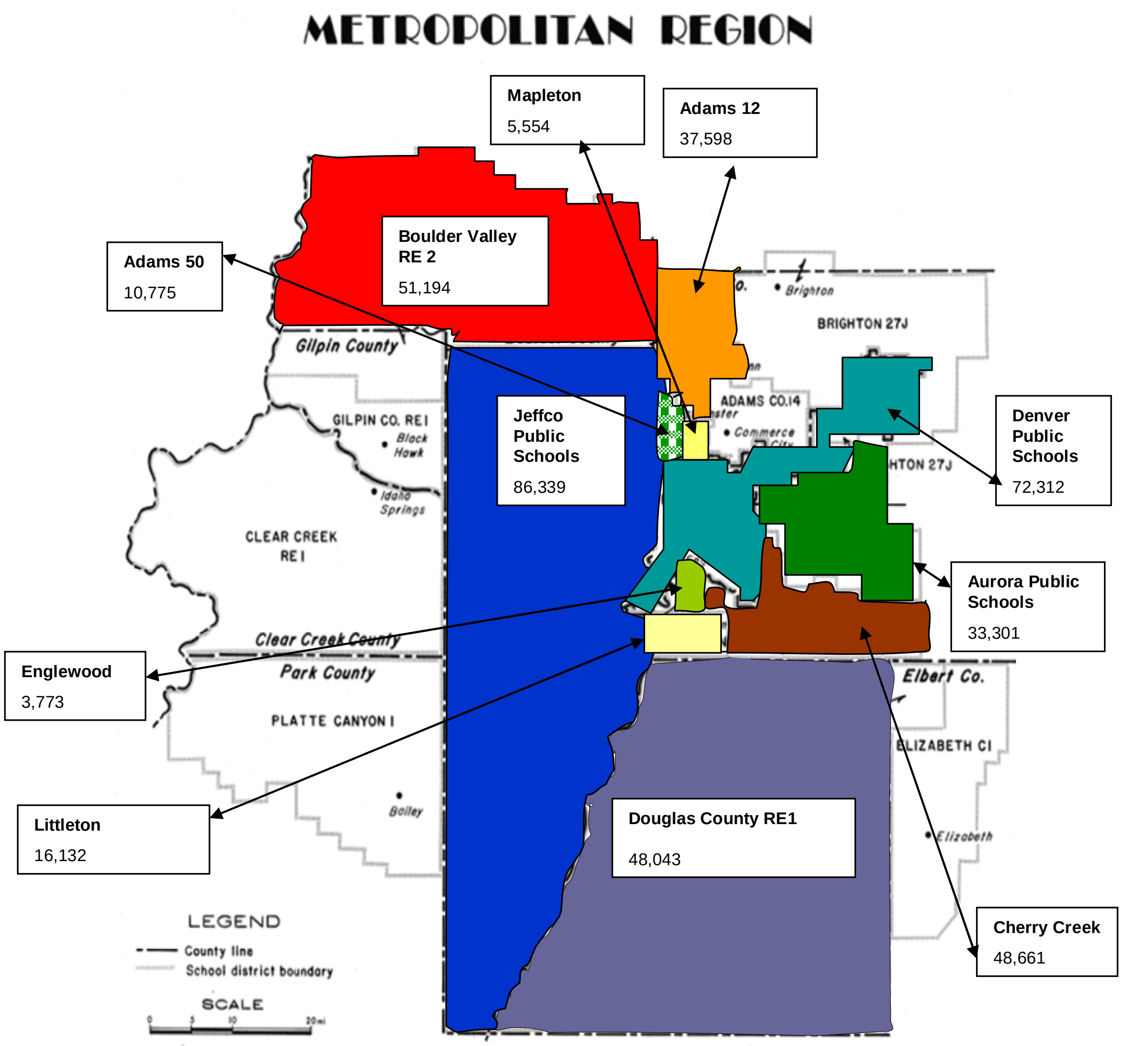
The operating time of a bus in the Denver region was determined to be approximately 1,680 hours annually. The emissions were then determined by utilizing each retrofitted bus's engine model year emissions certifications multiplied by the horsepower multiplied by the annual usage. The appropriate technology reductions were then applied to determine the reduced emissions.

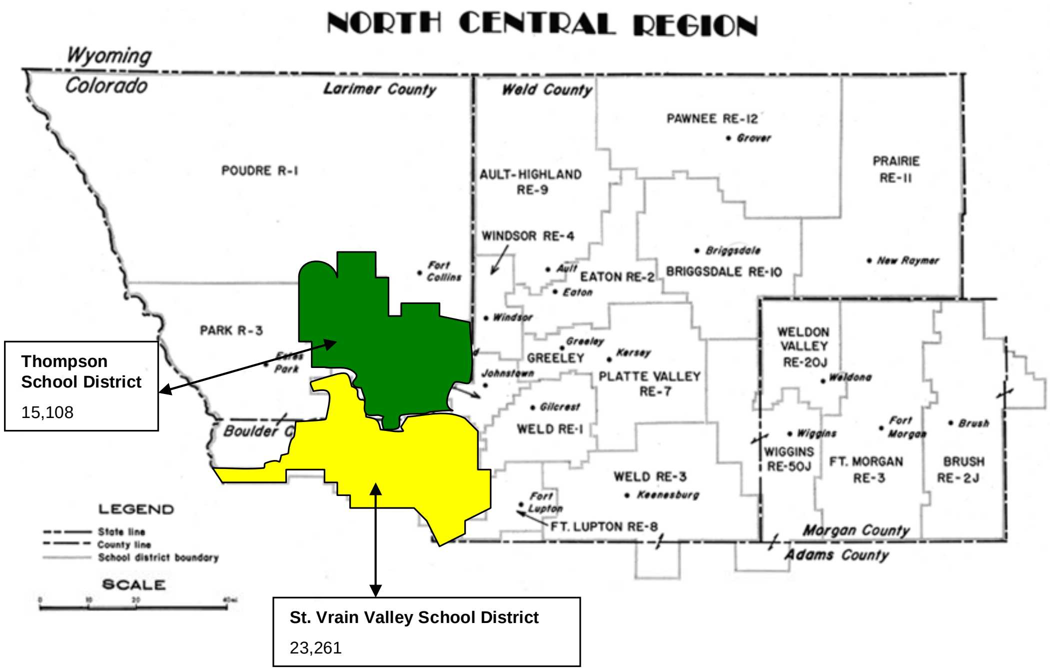
For example: A 1991 bus emits 0.25 g/bhp-hr. The vehicle's emissions are calculated as 0.25g/bhp-hr*196(brakehorsepower = 240hp*80%=196)*1,680 hours of operation=82,320 grams PM or 181 pounds of PM on an annual basis. The emissions reduction for a DOC is 20 percent of 181 pounds for a 36.2 pound reduction for a DOC equipped bus. This is a conservative estimate since a 1991 engine does degrade over time and this degradation is not included in the calculations.

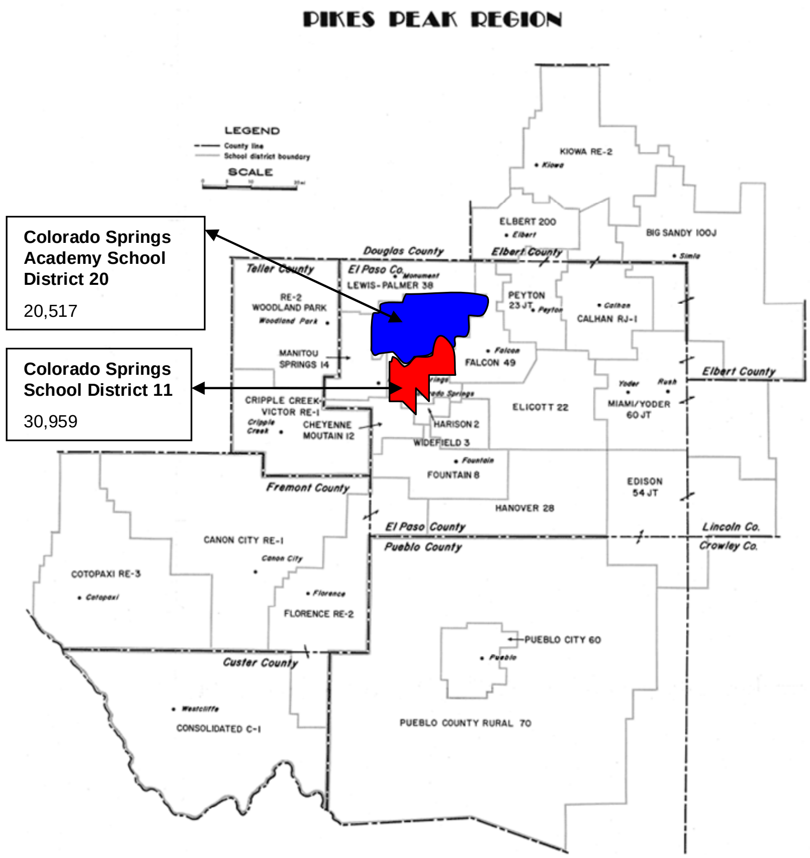
Idling Emissions Reductions:

Buses that were retrofitted with an engine preheater were assumed to have approximately 315 hours of idle time reduced annually (1.5 hours per day*5 days per week*42 weeks per year). Emissions results were then determined for a bus idling its engine for 315 hours per year with the idle data from Table B1. The emissions reduction of 84 percent ((1.5 gallon/fuel per hour from non preheated engine-0.24 gallon/fuel per hour preheated)/1.5 gallon fuel per hour = 84 percent reduction) was then applied to this to determine the emissions reduction.

Appendix C – District Locations and Number of Students




NORTH CENTRAL REGION
Wyoming
Colorado
Larimer County
Weld County
PAWNEE RE-12
Grover
PRAIRIE RE-11
POUDRE R-1
AULT-HIGHLAND RE-9
WINDSOR RE-4
Fort Collins
Ault
EATON RE-2
Eaton
Briggsdale
BRIGGSDALE RE-10
New Raymer
PARK R-3
Estes Park
Windsor
Greeley
GREELEY
Kersey
PLATTE VALLEY RE-7
Johnstown
Gilcrest
WELD RE-1
WELDON VALLEY RE-20J
Weldona
Wiggins
WIGGINS RE-50J
Fort Morgan
FT. MORGAN RE-3
Brush
BRUSH RE-2J
WELD RE-3
Keenesburg
Fort Lupton
FT. LUPTON RE-8
Morgan County
Adams County
Boulder C
LEGEND
State line
County line
School district boundary
SCALE
Thompson School District
15,108
St. Vrain Valley School District
23,261


PIKES PEAK REGION
LEGEND
County line
School district boundary
SCALE
Colorado Springs Academy School District 20
20,517
Colorado Springs School District 11
30,959
KIOWA RE-2
Kiowa
ELBERT 200
Elbert
BIG SANDY 100J
Simla
Douglas County
Elbert County
Teller County
El Paso Co.
Monument
LEWIS-PALMER 38
RE-2 WOODLAND PARK
Woodland Park
PEYTON 23 JT
Peyton
Calhan
CALHAN RJ-1
MANITOU SPRINGS 14
Falcon
FALCON 49
Elbert County
Yoder
Rush
CRIPPLE CREEK-VICTOR RE-1
Cripple Creek
CHEYENNE MOUTAIN 12
HARISON 2
ELICOTT 22
MIAMI/YODER 60 JT
WIDEFIELD 3
Fountain
FOUNTAIN 8
EDISON 54 JT
Fremont County
HANOVER 28
El Paso County
Pueblo County
Lincoln Co.
Crowley Co.
CANON CITY RE-1
Canon City
COTOPAXI RE-3
Cotopaxi
Florence
FLORENCE RE-2
Custer County
PUEBLO CITY 60
Pueblo
Westcliffe
CONSOLIDATED C-1
PUEBLO COUNTY RURAL 70

Appendix D - Funding Allocation and Guidelines

Introduction

When allocating your retrofits, EPA funding can only be used on 1991 – 2000 vehicles. CMAQ funding can be designated for model years 1987 – 2000. Therefore, you must designate which funding you are using to buy the retrofit equipment. An area for CMAQ and for EPA funding is included on the ISS worksheet.

Unit Costs

Diesel Oxidation Catalysts

Option	Cost per Unit	Cost per Unit plus Trip Cost*
DOC w/o Install	$751.30	$751.30
DOC w/ Install	$829.30	$845.36
DOC + Spiracle Closed Filtration	$1,814.47	$1,830.53

* This trip cost applies to Colorado Springs District 11 and 20, Douglas County, St. Vrain, and Thompson school districts.

Engine Preheat Systems

Option	Engine Only Preheat (w/o luggage compartment)	Engine Only Preheat (w luggage compartment/rear fuel tank)	Engine/Passenger Compartment (w/o luggage compartment)	Engine/Passenger Preheat (w luggage compartment/rear fuel tank)
Standard Transit with Forward Controls	$1,244.00	$1,449.27	$2,450.00	$2,722.30
Standard Transit with Rear Engine	$1,465.37	$1,535.44	$2,757.97	$2,827.63
Standard Conventional Bus	$1,244.00	$1,387.79	$2,450.00	$2,571.34

* Add trip cost of $16.06 for Colorado Springs District 11 and 20, Douglas County, St. Vrain, and Thompson school districts.

EPA Funding

Below we have provided an estimated number of DOCs and DOC + Spiracle a school district may purchase. This is just a guide and the RAQC is flexible to your needs.

Please provide these numbers to your accounting department. On all invoices to the RAQC, please include the grant number.

Federal Code: CFDA 66.034
Grant Number: XA-83147601

EPA Funding (1991 – 2000 model year vehicles)

	Biodiesel Funding	**DOC Funding**	**Total Funding**	**# of DOCs ($829.30 per unit)****	**Maximum # of DOC + Spiracle**
Adams 12	$ 12,974	$ 19,079	$ 32,052	23	2
Aurora	$ 12,039	$ 12,500	$ 24,539	15	1
Cherry Creek	$ 19,512	$ 16,118	$ 35,631	19	2
CS D11*	$ 12,039	$ 7,895	$ 19,934	9	1
CS D20*	$ 12,558	$ 10,526	$ 23,085	12	1
Denver	$ 44,318	$ 31,250	$ 75,568	37	4
Douglas*	$ 23,768	$ 28,289	$ 52,057	33	4
Jeffco	$ 37,675	$ 37,500	$ 75,175	45	4
Littleton	$ 6,954	$ 11,513	$ 18,467	13	1
Mapleton	$ 2,802	$ 4,605	$ 7,408	5	1
St. Vrain*	$ 10,483	$ 12,500	$ 22,983	14	1
Thompson*		$ 8,224	$ 8,224	9	1
Adams 50	$ 4,878		$ 4,878		
	$200,000	**$ 200,000**	**$ 400,000**	**239**	**23**

* Travel fee of $16.06 applies.
** Districts may use fractional amounts to purchase additional equipment. Any remainder not claimed by the district will be allocated to smaller districts.

DOCs

- EPA funding MUST be used on model years between 1991 and 2000.
- Installation costs for ISS to perform the installs are covered. If you would like, you can install them and purchase more units.
- Spiracle units must be installed by ISS due to engine warranty issues.
- Retrofits for Type C & D route buses only.

CMAQ Funding

Below we have provided an estimated number of DOCs, DOC + Spiracle, and Scholastic heaters a school district may purchase. The number of TSL17s a district could purchase was not estimated due to the number of potential bus configurations and costs but expect this model to be the majority a district's preheat purchases. This is just a guide and the RAQC is flexible to your needs.

CMAQ Funding (1987 – 2000 model year vehicles)

	Preheat Funding	DOC Funding	Total Funding	# of DOCs ($751.3 per unit)**	Maximum # of DOC + Spiracle	Maximum # of Scholastics***
Adams 12	$ 41,554	$ 41,554	$ 83,107	55	4	4
Aurora	$ 27,225	$ 27,225	$ 54,449	36	2	2
Cherry Creek	$ 35,106	$ 35,106	$ 70,211	46	4	4
Denver	$ 68,062	$ 68,062	$ 136,124	90	6	6
Douglas*	$ 61,614	$ 61,614	$ 123,228	80	6	6
Jeffco	$ 96,003	$ 96,003	$ 192,006	127	6	6
Littleton	$ 25,075	$ 25,075	$ 50,151	33	2	2
Mapleton	$ 10,030	$ 10,030	$ 20,060	13	1	1
St. Vrain*	$ 27,225	$ 27,225	$ 54,449	35	2	2
Thompson*	$ 17,911	$ 17,911	$ 35,822	23	2	2
Adams 14	$ 5,732	$ 5,732	$ 11,463	7	1	1
Adams 50	$ 10,747	$ 10,747	$ 21,493	14	1	1
Englewood	$ 2,866	$ 2,866	$ 5,732	3	1	1
Boulder*	$ 45,852	$ 45,852	$ 91,704	59	4	4
	$475,000	**$ 475,000**	**$ 950,000**	**627**	**42**	**42**

* Travel fee of $16.06 applies.
** Districts may use fractional amounts to purchase additional equipment. Any remainder not claimed by the district will be allocated to smaller districts.
*** The number of TSL17s a district can purchase was not estimated due to the many different bus configurations and costs.

Preheats

- Can only be installed by ISS.
- Install on 1987 – 2000 model year vehicles with 1987 – 1997 taking first priority.

DOCs

- CMAQ funding can be used on model years between 1987 and 2000 with older buses as a higher priority.
- Installation of the units must be performed by the districts to meet the grant match.
  - We will provide a training with ISS for your technicians.
- Spiracle units must be installed by ISS due to engine warranty issues.
- Retrofits for Type C & D route buses only.

Appendix E – CYFBS Grant Funding and Equipment Counts by District

E1 – CYFBS Grant Funding and Equipment Counts by District

	EPA DOC	EPA CCV	EPA Biodiesel	Total EPA Expenditures		CMAQ DOC	CMAQ CCV	CMAQ Preheater	Total CMAQ Expenditures		Project Expenditures
Adams 12	24	2	$16,458	$38,331		43	0	32	$89,720		$128,052
Aurora	12	2	$10,594	$22,516		34	5	23	$64,868		$87,384
Cherry Creek	19	0	$19,512	$35,269		46	0	30	$73,224		$108,493
D11	17	0	0*	$18,353		0	0	0	0		$18,353
D20	20	0	$18,065	$38,540		0	0	0	0		$38,540
Denver	33	4	$43,276	$74,578		87	6	67	$158,903		$233,481
Douglas	30	0	$5,978	$30,857		45	0	73	$130,020		$160,877
Jeffco	0	38	$40,221	$77,658		12	31	52	$135,601		$213,259
Littleton	13	0	$8,867	$18,634		20	0	0	$15,026		$33,660
Mapleton	5	0	$2,778	$6,924		18	0	4	$24,170		$31,094
St. Vrain	14	0	$14,017	$25,855		21	0	30	$62,034		$87,889
Thompson	9	0	0	$7,608		12	0	7	$28,014		$35,623
Adams 50	0	0	$4,878	$4,878		17	0	7	$25,677		$30,555
Englewood	0	0	0	0		3	0	1	$4,097		$4,097
Boulder	0	0	0	0		54	0	35	$88,587		$88,587
Total	196	46	$184,644	$400,000		412	42	361	$899,940		$1,299,940

*D20 administered D11's biodiesel purchases.

E2 – Emissions Reductions by Pollutant by Funding Source by District*

PM - TPY

	Adams 12	Aurora	Cherry Creek	CS D11	CS D20	Denver	Douglas	Jeffco	Littleton	Mapleton	St. Vrain	Thompson	Adams 50	Englewood	Boulder	Totals
EPA	0.19	0.13	0.14	0.19	0.36	0.38	0.28	0.10	0.09	0.04	0.10	0.07	0.00	0.00	0.00	2
CMAQ	0.25	0.34	0.31	0.00	0.00	0.95	0.45	0.21	0.15	0.13	0.12	0.09	0.17	0.03	0.68	4
Totals	0.44	0.47	0.45	0.19	0.36	1.33	0.73	0.31	0.24	0.17	0.22	0.16	0.17	0.03	0.68	6

CO - TPY

	Adams 12	Aurora	Cherry Creek	CS D11	CS D20	Denver	Douglas	Jeffco	Littleton	Mapleton	St. Vrain	Thompson	Adams 50	Englewood	Boulder	Totals
EPA	54.61	27.63	42.72	38.22	44.97	75.49	67.45	12.28	29.23	11.24	31.48	20.24	0.00	0.00	0.00	456
CMAQ	97.56	78.70	104.25	0.00	0.00	199.40	103.19	38.43	44.97	40.58	48.04	27.17	38.22	6.77	122.38	950
Totals	152.17	106.32	146.97	38.22	44.97	274.89	170.64	50.72	74.20	51.82	79.52	47.41	38.22	6.77	122.38	1405

HC - TPY

	Adams 12	Aurora	Cherry Creek	CS D11	CS D20	Denver	Douglas	Jeffco	Littleton	Mapleton	St. Vrain	Thompson	Adams 50	Englewood	Boulder	Totals
EPA	5.78	2.95	4.48	4.01	4.71	8.02	7.07	2.33	3.06	1.18	3.30	2.12	0.00	0.00	0.00	49
CMAQ	10.25	8.41	10.95	0.00	0.00	21.12	10.88	4.92	4.71	4.26	5.06	2.85	4.03	0.71	12.86	101
Totals	16.03	11.36	15.43	4.01	4.71	29.15	17.95	7.25	7.78	5.44	8.36	4.98	4.03	0.71	12.86	150

NOx - TPY

	Adams 12	Aurora	Cherry Creek	CS D11	CS D20	Denver	Douglas	Jeffco	Littleton	Mapleton	St. Vrain	Thompson	Adams 50	Englewood	Boulder	Totals
EPA																
CMAQ	1.34	0.97	1.26	0.00	0.00	2.81	3.06	2.18	0.00	0.17	1.26	0.29	0.29	0.04	1.47	15
Totals	1.34	0.97	1.26	0.00	0.00	2.81	3.06	2.18	0.00	0.17	1.26	0.29	0.29	0.04	1.47	15

*Emissions calculations do not include biodiesel emissions