South Coast Air Quality Management District

Technology Advancement Office

Clean Fuels Program 2008 Annual Report and 2009 Plan Update

March 2009

South Coast Air Quality Management District

Governing Board

Chairman

William A. Burke, Ed.D.*
Assembly Speaker Appointee

Vice Chairman

S. Roy Wilson, Ed.D.**
Supervisor, Riverside County

County Representatives

Michael D. Antonovich
Supervisor, Los Angeles County

Bill Campbell
Supervisor, Orange County

Josie Gonzales
Supervisor, San Bernardino County

State Representatives

Jane W. Carney
Senate Rules Committee Appointee

Joseph K. Lyou, Ph.D.
Governor's Appointee

Cities Representatives

Jan Perry
Councilmember, City of Los Angeles
City of Los Angeles

Michael Caiccotti
Mayor, South Pasadena
Los Angeles County, Eastern Region

Tonia Reyes Uranga*
Councilmember, City of Long Beach
Los Angeles County, Western Region

Miguel A. Pulido*
Mayor, City of Santa Ana
Orange County Cities

Ronald O. Loveridge
Mayor, City of Riverside
Riverside County Cities

Dennis R. Yates*
Mayor, City of Chino
San Bernardino County Cities

Executive Officer

Barry R. Wallerstein, D.Env.

*Technology Committee Members **Technology Committee Chairman

South Coast Air Quality Management District
Technology Advancement Office

Chung S. Liu, D.Env, Deputy Executive Officer, Science & Technology Advancement
Matt Miyasato, Ph.D., Assistant Deputy Executive Officer, Technology Advancement Office
Henry Hogo, Assistant Deputy Executive Officer, Mobile Sources

Larry Kolczak, Community Relations Manager
Fred Minassian, Technology Implementation Manager
Dipankar Sarkar, Technology Demonstration Manager

Michael Bogdanoff, Program Supervisor
Connie Day, Program Supervisor
Ranji George, Program Supervisor
Marty Kay, Program Supervisor
Lisa Mirisola, Program Supervisor
Larry Watkins, Program Supervisor
Vicki White, Program Supervisor

Howard Lange, Ph.D., Air Quality Engineer II
Al Baez, Senior Air Quality Engineer

Brian Choe, Air Quality Specialist
Mark Coleman, Air Quality Specialist
Jeff Cox, Air Quality Specialist
Patricia Kwon, Air Quality Specialist
Von Loveland, Air Quality Specialist
Frank Motavassel, Air Quality Specialist
Ashkaan Nikravan, Air Quality Specialist
Shashi Singeetham, Air Quality Specialist
Wei Wang, Air Quality Specialist

Vasken Yardemian, Sr. Staff Specialist
Geri Bowen, Staff Specialist

Greta Grier, Air Quality Inspector II
Arun Kumar, Air Quality Inspector II

Laurie Diton, Senior Administrative Secretary
Drue Hargis, Senior Administrative Secretary
Pat Krayser, Senior Administrative Secretary
Penny Shaw Cedillo, Secretary
Donna Vernon, Secretary
Lani Montojo, Staff Assistant
Michelle White, Staff Assistant
Benigna Taylor, Contracts Assistant
Ana Troccoli, Contracts Assistant
Flor Tumambing, Senior Office Assistant

Other Staff Contributors
Jean Ospital, Ph.D., Health Effects Officer, Planning, Rule Development & Area Sources
Randall Pasek, Off-Road Mobile Source Manager
Dean Saito, On-Road Mobile Source Manager
Paul Wuebben, Clean Fuels Officer
Philip Barroca, Air Quality Specialist
Lori Berard, Air Quality Specialist
David Coel, Program Supervisor
Wei Li, Air Quality Specialist
Andrew Yoon, Air Quality Specialist

Table of Contents

Appendix A

Appendix B

Appendix C

Appendix D

Figures

Tables

EXECUTIVE SUMMARY

2008 Annual Report

The South Coast Air Quality Management District (SCAQMD) executed 72 new projects or studies and modified 6 continuing projects adding additional dollars during Calendar Year (CY) 2008 toward research, development, demonstration and deployment (RDD&D) of alternative fuel and clean fuel technologies in Southern California. Table 2 (page 17) lists these 78 projects or studies, which are further described in this report. The SCAQMD contributed more than $11.3 million in partnership with other governmental organizations, private industry, academia and research institutes and interested parties, with total project costs of more than $57 million.

These projects or studies addressed a wide range of issues and opportunities with a diverse mix of advanced technologies. The following core areas of technology advancement include:

- Infrastructure and Deployment
- Fuels and Emission Studies
- Emission Control Technologies
- Electric and Hybrid Vehicle Technologies
- Engine Technology (particularly in the heavy-duty vehicle sector)
- Mobile Fuel Cell Technologies
- Hydrogen Technology and Infrastructure
- Health Impacts Studies
- Stationary Clean Fuels Technology (including renewables)
- Outreach and Technology Transfer

During CY 2008, the SCAQMD supported a variety of projects and technologies, ranging from near-term to longer-term research, development, demonstration and deployment activities. This "technology portfolio" strategy provides the SCAQMD the ability and flexibility to leverage state and federal funding while also addressing the specific needs of the South Coast Air Basin (Basin). Projects in CY 2008 included demonstration of emission control and aftertreatment technologies in off-road applications, further expansion of the natural gas alternative refueling infrastructure, development of heavy-duty natural gas engines and development of hybrid electric vehicle technologies. The SCAQMD also executed five health impacts and emissions studies to extend analysis of the connection between air pollution and health.

Eighteen research, development, demonstration and deployment projects or studies, 19 technology assessment or outreach projects and 2 incentive projects were completed in 2008, as listed in Table 5 (page 50). Appendix C comprises two-page summaries of the technical projects completed in 2008. In accordance with California Health and Safety Code Section 40448.5.1(d), this report must be submitted to the state legislature by March 31, 2009, after approval by the SCAQMD Governing Board.

2009 Plan Update

The Clean Fuels Program (Program) continually seeks to support the deployment of lower emitting technologies. The design and implementation of the Program Plan must balance the needs in the various technology sectors with technology readiness, emissions reduction potential and co-funding opportunity. The SCAQMD Program is significant, especially during these economically tough times

when both public and private funding available for technology research and development are limited. However, since national and international activities affect the direction of technology trends, the real challenge for the SCAQMD is to identify project or technology opportunities in which its available funding can make a significant difference in deploying progressively cleaner technologies in the Basin.

The overall strategy is based in large part on technology needs identified in the Air Quality Management Plan (AQMP) and the SCAQMD Governing Board's directives to protect the health of residents in the Basin. The AQMP is the long-term "blueprint" that defines:

- the basin-wide emission reductions needed to achieve federal ambient air quality standards;
- the regulatory measures to achieve those reductions;
- the timeframes to implement these proposed measures; and
- the technologies required to meet these future proposed regulations.

The oxides of nitrogen (NO_x), volatile organic compounds (VOC) and particulate matter (PM) emission sources of greatest concern are heavy-duty on-road vehicles, light-duty on-road vehicles and off-road equipment. The Plan Update includes projects to develop, demonstrate and commercialize a variety of technologies, from near term to long term, that are intended to provide solutions to the emission control needs identified in the AQMP. Large NO_x and $PM_{2.5}$ reductions will be necessary to meet the federal $PM_{2.5}$ standards by 2014 and so near- and mid-term reductions are emphasized. Several of the technology areas of focus include:

- reducing emissions from port-related activities, such as cargo handling equipment and container movement technologies;
- mitigating criteria pollutant increases from renewable fuels, such as low-blend ethanol and high-blend biodiesel; and
- increased activities in hybrid and plug-in hybrid technologies across light-, medium- and heavy-duty platforms.

Table 6 (page 61) lists the potential projects across the core technologies identified in this report. Potential projects for 2009 total nearly $16.6 million, with anticipated leveraging of more than $82 million. The proposed projects may also be funded by revenue sources other than the Clean Fuels Program, especially VOC and incentive projects.

CLEAN FUELS PROGRAM
2008 ANNUAL REPORT

Program Background

The Basin, which comprises the Los Angeles, Orange, San Bernardino and Riverside Counties, has the worst air quality in the nation due to a combination of factors, including high vehicle population, high vehicle miles traveled within the Basin and geographic and atmospheric conditions favorable for photochemical oxidant (smog) formation. Due to these challenges, the state legislature enabled the SCAQMD to implement the Clean Fuels Program to accelerate the implementation and commercialization of clean fuels and advanced technologies in the Basin. In 1999, state legislation was passed which amended and extended the Clean Fuels Program. Specifically, as stated in the California Health and Safety Code (H&SC) section 40448.5.1(d), the SCAQMD must submit, on or before March 31 of each year to the Legislature, an annual report that includes:

1. A description of the core technologies that the SCAQMD considers critical to ensure attainment and maintenance of ambient air quality standards and a description of the efforts made to overcome barriers to commercialization of those technologies;
2. An analysis of the impact of the SCAQMD's Clean Fuels Program on the private sector and on research, development t and commercialization efforts by major automotive and energy firms, as determined by the SCAQMD;
3. A description of projects funded by the SCAQMD, including a list of recipients, subcontractors, co-funding sources, matching state or federal funds and expected and actual results of each project advancing and implementing clean fuels technology and improving public health;
4. The title and purpose of all projects undertaken pursuant to the Clean Fuels Program, the names of the contractors and subcontractors involved in each project and the amount of money expended for each project;
5. A summary of the progress made toward the goals of the Clean Fuels Program; and
6. Funding priorities identified for the next year and relevant audit information for previous, current and future years covered by the project.

2008 Overview

This report summarizes the progress of the SCAQMD Clean Fuels Program for CY 2008. This SCAQMD program co-sponsors projects to develop and demonstrate low-emission clean fuels and advanced technologies and to promote commercialization and deployment of promising or proven technologies in Southern California. These projects are conducted through public-private partnerships with industry, technology developers, academic and research institutes and local, state and federal agencies.

During the period between January 1 and December 31, 2008, the SCAQMD executed 72 new projects or studies and modified 6 continuing projects adding additional dollars during CY 2008 that support clean fuels and advanced low-emission technologies. The SCAQMD contribution for these projects was more than $11.3 million, with total project costs of nearly $57.4 million. These projects address a wide range of issues with a diverse technology mix. This report highlights achievements and summarizes project costs of the SCAQMD Clean Fuels Program in this period.

The Need for Advanced Technologies & Clean Fuels

Achieving federal and state clean air standards in Southern California will require emission reductions from both mobile and stationary sources beyond those expected using current

technologies. The need for advanced technologies and clean fuels is best demonstrated by considering the emissions inventory for the Basin and the future emissions levels projected in the 2007 AQMP. The baseline 2014 NO_x and VOC emissions inventory is shown in Figure 1. Based on the 2007 AQMP, significant reductions are necessary to demonstrate attainment with the federal standards.

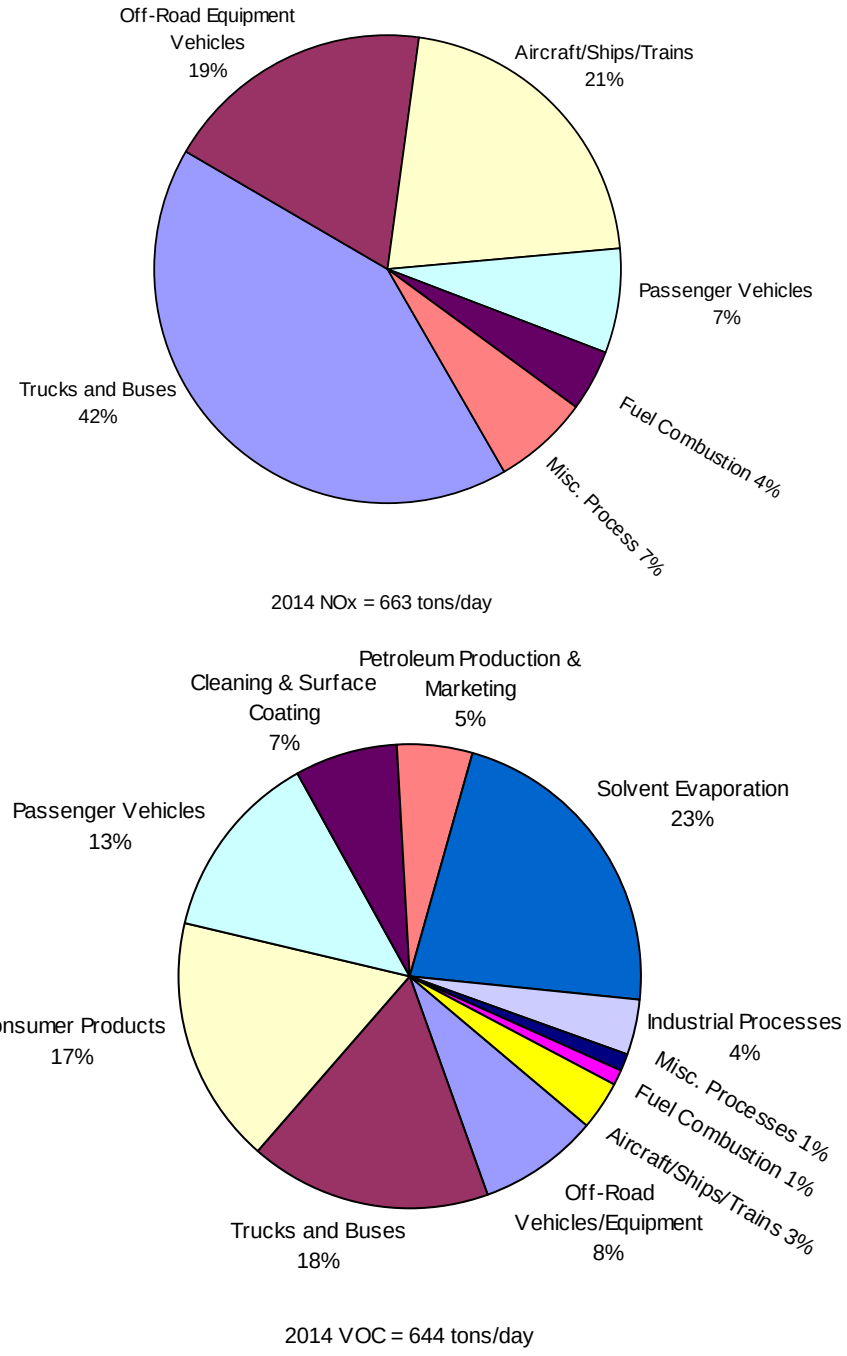


Figure 1: Major Source Contributions (2014)

To fulfill long-term emission reduction targets, the 2007 AQMP relies on advanced technologies that are not yet fully developed for commercial use. Significant reductions are anticipated from implementation of advanced control technologies for both on-road and non-road mobile sources. In addition, the new air quality standards for ozone (0.08 ppm, 8-hour average) and fine particulate

matter, promulgated by the U.S. Environmental Protection Agency (U.S. EPA) in 1997 and 2006, are projected to require additional long-term control measures for both NO_x and VOC.

Recent health studies also indicate a greater need to reduce NO_x emissions and toxic air contaminant emissions. More importantly, the California Air Resources Board (CARB) listed diesel exhaust emissions as a toxic air contaminant in 1998. Subsequently, in 1999, the SCAQMD completed the Multiple Air Toxics Exposure Study (MATES-II) and found that diesel combustion sources (primarily from heavy-duty vehicles) contribute approximately 70 percent to the estimated potential cancer risk from air toxics in the Basin. A follow-on study, MATES-III, in which air quality sampling was initiated in spring 2004 and ended in 2006, was undertaken to evaluate air toxic exposure trends, expand the list of known air toxics and assess local impacts from industrial, commercial and mobile sources. The results have shown a decrease in stationary emitted air toxics and gasoline related air toxics, but continued high levels of emissions from diesel engine sources. The MATES-III report was finalized in spring 2008. Although results showed an overall decrease in toxics exposures throughout the basin, there were localized areas that had increased risk, most notably around the Ports of Los Angeles and Long Beach. This increased risk is likely a result of uncontrolled diesel emissions from goods movement activities, specifically emissions from trucks and cargo handling equipment, locomotives and marine vessels.

Concerns over greenhouse gas (GHG) emissions and petroleum dependency arising from the heavy use of conventional technologies are continuing to increase. In response to these concerns, the federal government has launched several programs (the Hydrogen, Fuel Cells and Infrastructure Technologies Program and the FreedomCAR and Vehicle Technologies Program) to investigate and develop increased efficiency and alternative fuel (including hydrogen) technologies. Independently, the State has adopted goals to reduce long-term dependence on petroleum-based fuels (AB 2076) and the transition to alternative fuels based on life-cycle analyses (AB 1007).

California's Governor took this concern one step further when in January 2007 he established a Low-Carbon Fuel Standard (LCFS) by Executive Order. The LCFS came out of AB 32, the "Global Warming Solutions Act," which was signed by the Governor in fall 2006 and requires California's greenhouse gas emissions to be capped at 1990 levels by 2020. The LCFS standard for transportation fuels will necessitate increased research into alternatives to oil and traditional fuels. In September 2008, the Governor signed SB 375 requiring CARB to set regional targets reducing GHG's from cars and light trucks for 2020 and 2035 and directs regional planning agencies to develop land-use strategies to meet the targets.

In summary, advanced, energy efficient and renewable technologies are needed not only for attainment, but also to protect the health of those who reside within the SCAQMD's jurisdiction; to reduce long-term dependence on petroleum-based fuels; and to support a more sustainable energy future. Conventional strategies and traditional supply and consumption need to be retooled in order to achieve the federal air quality goals. To help meet this need for advanced, clean technologies, the SCAQMD Governing Board continues to aggressively carry out the Clean Fuels Program and promote alternative fuels through the Technology Advancement Office. This Program is intended to assist in the rapid development and deployment of progressively lower-emitting technologies and fuels through innovative public-private partnership. Since its inception, the SCAQMD Technology Advancement Office has co-funded projects in cooperative partnerships with private industry, technology developers, academic and research institutions and local, state and federal agencies. The following sections describe funding, core technologies and advisory oversight of the Clean Fuels Program.

Program Funding

The Clean Fuels Program is established under California H&SC Sections 40448.5 and 40512 and Vehicle Code Section 9250.11. This legislation establishes mechanisms to collect revenues from mobile and stationary sources to support the program objectives and identifies the constraints on the use of funds. In 2008, these funding mechanisms were reauthorized under SB 1646 (Padilla), which removed the funding sunset of January 1, 2010, and reinstated the 5 percent administrative cap.

The Program is funded through a $1 fee on motor vehicles registered in the SCAQMD. Revenues collected from these motor vehicles must be used to support mobile source projects. Stationary source projects are funded by an emission fee surcharge on stationary sources emitting more than 250 tons of pollutants per year within the SCAQMD. For CY 2008 the funds available through each of these mechanisms were as follows:

- Mobile sources (DMV revenues) $12,200,906
- Stationary sources (emission fee surcharge) $301,775

The SCAQMD Clean Fuels Program also receives grants and cost-sharing revenue contracts from various agencies, on a project-specific basis, that supplement the SCAQMD program. Historically, such cooperative project funding revenues have been received from CARB, the California Energy Commission (CEC), the U.S. EPA, the U.S. Department of Energy (DOE) and the U.S. Department of Transportation (DOT). These supplemental revenues depend in large part on the originating agency, its budgetary and planning cycle and the specific project or intended use of the revenues. Table 3 (page 20) lists the supplemental grants and revenues recognized in 2008, which total $500,000.

The final and perhaps most significant funding source can best be described as an indirect source, i.e., funding not directly received by the SCAQMD. This indirect source is the cost-sharing provided by private industry and other public and private organizations. Historically, the Technology Advancement Office has been successful in leveraging its available public funds with more than $3 of outside funding for each $1 of SCAQMD funding. For 2008, the Clean Fuels Program leveraged each $1 to nearly $5 outside funding. Through these public-private partnership, the SCAQMD has shared the investment risk of developing new technologies along with the benefits of expedited development and commercial availability, increased end-user acceptance, reduced emissions from the demonstration projects and ultimately increased use of clean technologies in the Basin. The SCAQMD's Clean Fuels Program has also avoided duplicative efforts by coordinating and jointly funding projects with major funding agencies and organizations. The major funding partners for 2008 are listed in Table 1 (page 11).

Core Technologies

Given the diversity of sources that contribute to the air quality problems in the Basin, there is no single technology or "Silver Bullet" that can solve all of the problems. A number of technologies are required and these technologies represent a wide range of applications, with full emissions benefit "payoffs," i.e., full commercialization and mass deployment occurring at different times. The broad technology areas of focus – the "Core Technologies" – for the Clean Fuels Program are as follows:

- Infrastructure and Deployment
- Emission Control Technologies
- Electric and Hybrid Vehicle Technologies
- Engine Technologies
- Mobile Fuel Cell and Hydrogen Technologies
- Stationary Clean Fuels Technologies

The SCAQMD continually seeks to support the deployment of lower emitting technologies. The Clean Fuels Program is shaped by two basic factors:

1. Low- and zero-emission technologies needed to achieve clean air standards in the Basin; and
2. Available funding to support technology development within the constraints imposed by that funding.

The SCAQMD strives to maintain a flexible program to address dynamically evolving technologies and the latest progress in the state of the technology. Although the SCAQMD program is significant, especially at a time when both public and private funding available for technology research and development are limited, national and international activities affect the direction of technology trends. As a result, the SCAQMD program must be flexible in order to leverage and accommodate these changes in state, national and international priorities. This is especially true given the current economic climate which may continue well in 2010. The ultimate challenge for the SCAQMD is to identify project or technology opportunities in which its available funding can make a difference in achieving progressively cleaner air in the Basin.

Historically, mobile source projects have targeted low-emission developments in automobiles, transit buses, medium- and heavy-duty trucks and non-road applications. These vehicle-related efforts have focused on advancements in engine design, electric power-trains and energy storage/conversion devices (e.g., fuel cells and batteries); and implementation of clean fuels (e.g., natural gas, propane and hydrogen) including their infrastructure development. Stationary source projects have included a wide array of advanced low NO_x technologies and clean energy alternatives such as fuel cells, solar power and other renewable energy systems.

Specific projects are selected for co-funding from competitive solicitations, cooperative agency agreements and unsolicited proposals. Criteria considered in project selection include emissions reduction potential, technological innovation, potential to reduce costs and improve cost effectiveness, contractor experience and capabilities, overall environmental impact or benefit, commercialization and business development potential, cost sharing and consistency with program goals and funding constraints. The core technologies for the SCAQMD programs that meet both the funding constraints as well as AQMP needs for achieving clean air are briefly described blow.

Infrastructure and Deployment

A key element for the widespread acceptance and resulting increased use of alternative fueled vehicles is the availability of the supporting refueling infrastructure. The refueling infrastructure for gasoline and diesel fuel is well established and accepted by the driving public. Alternative, clean fuels such as natural gas, alcohol-based fuels, propane, hydrogen, hydrogen-natural gas mixtures and even electricity are much less available or accessible. To realize the emissions reduction benefits, the alternative fuel infrastructure must be developed in tandem with the growth in alternative fueled vehicles. The objectives of the SCAQMD are to expand the infrastructure to support zero and near-zero emission vehicles through the development, demonstration and installation of alternative fuel vehicle refueling technologies.

Emission Control Technologies

This broad category refers to technologies that could be deployed on existing mobile sources, aircraft, locomotives, marine vessels, farm and construction equipment, cargo handling equipment, industrial equipment and utility and lawn-and-garden equipment. The in-use fleet comprises the majority of emissions, especially the older vehicles and non-road sources, which are typically uncontrolled and unregulated, or controlled to a much lesser extent than on-road vehicles. The authority to develop and

implement regulations for retrofit on-road and non-road mobile sources lies primarily with the U.S. EPA and CARB and to a lesser extent with the SCAQMD.

Low-emission and clean-fuel technologies that appear promising for on-road mobile sources should be effective at reducing emissions from a number of non-road sources. For example, immediate benefits are possible from particulate traps, selective catalytic reduction (SCR) and emulsified fuels that have been developed from diesel applications. Clean fuels such as natural gas, propane, hydrogen and hydrogen-natural gas mixtures may also provide an effective option to reduce emissions from some non-road applications. Reformulated gasoline, ethanol and alternative diesel fuels, such as biodiesel and gas-to-liquid (GTL), also show promise when used in conjunction with advanced emissions controls and new engine technologies. The CARB, U.S. EPA and the SCAQMD have also promulgated regulations that lower the sulfur content of diesel fuels, which provides a direct fuel related PM reduction and improves the efficiency of particulate reduction aftertreatment devices.

Electric and Hybrid Vehicle Technologies

There has been an increased level of activity and attention on hybrid vehicles due to a confluence of factors, including the highly successful commercial introductions of hybrid passenger vehicles by almost all of the automakers, volatility in oil prices and increased public attention on global warming. A Technology Review of the California Zero Emission Vehicle (ZEV) regulation conducted by CARB in the fall of 2007 resulted in some changes to the regulation adopted March 27, 2008 and updated test procedures adopted January 23, 2009, that were submitted to the Office of Administrative Law on February 2, 2009. While the volume of fuel cell vehicles to be supplied by the major automakers by 2011 (2,500) is still expected, an alternative strategy can meet the 2012-2014 requirements with additional "silver plus" vehicles, such as plug-in hybrid electric vehicles (PHEVs) and hydrogen-fueled internal combustion engine (ICE) vehicles. CARB requested staff to propose additional changes for 2015 and beyond that would re-focus the ZEV regulation on encouraging technology advancements for zero emission vehicles, potentially moving implementation of most "silver" ATPZEV hybrid and alternative fuel vehicles to the new low carbon fuel standard regulation and plug-in hybrid vehicles as a greenhouse gas reduction strategy for AB 32 implementation.

As a result, there is now a window of opportunity to leverage state and federal activities in the development and deployment of technologies that can accelerate advanced hybrid technologies, including PHEV, medium- and heavy-duty hybrid vehicle deployment, energy storage technologies, development of medium- and heavy-duty hybrid emission certification cycles, battery durability testing and establishment of driver use patterns. Such technology developments, if successful, are considered *enabling* because they can be applied to a variety of fuels (e.g., gasoline, natural gas, ethanol and hydrogen) and propulsion systems (e.g., ICEs and fuel cells).

Engine Technologies

Medium- and heavy-duty on-road vehicles contributed approximately 36 percent of the Basins' NO_x based on 2005 data. More importantly, on-road heavy-duty diesel engines contributed almost 60 percent of the on-road mobile source $PM_{2.5}$, which has known toxic effects. These figures notably do not include the significant contribution from off-road mobile sources. In fact, CARB's off-road 2006 emission model estimates that diesel-powered off-road construction equipment alone emits 120 tons per day of NO_x and 7.5 tons per day of PM emissions in the Basin. Clearly, significant emission reductions will be required from mobile sources, especially from the heavy-duty sector, to attain the federal clean air standards.

The use of alternative fuels in heavy-duty vehicles can provide significant reductions in NO_x and particulate emissions. The current NO_x emissions standard for heavy-duty engines is 1.2 g/bhp-hr (combined NO_x and VOC emissions) and there is currently only one commercially available heavy-

duty natural gas engine with demonstrated NO_x emissions levels at 0.2 g/bhp-hr (Cummins 8.9L). The SCAQMD, along with various local, state and federal agencies, continues to support the development and demonstration of alternative fueled heavy-duty engine technologies, using compressed natural gas (CNG) and liquefied natural gas (LNG) for applications in transit buses, school buses and refuse collection and delivery vehicles to meet future federal emission standards.

Mobile Fuel Cell and Hydrogen Technologies

Most of the automobile manufacturers have conceded that mass commercial introduction of fuel cell vehicles (FCVs) are likely to be delayed due to the cost, durability and infrastructure issues associated with hydrogen fueling. The SCAQMD continues to support the infrastructure required to refuel these demonstration fuel cell vehicles, but is also actively engaged in finding alternatives to the costly and potential longer term fuel cell power plant technology. As mentioned previously, plug-in hybrid technology could help enable fuel cells by reducing the capacity, complexity and cost of the fuel cell vehicle system. Further bridging technologies being investigated are hybrid or plug-in hybrid hydrogen ICE vehicles and hydrogen-CNG blended ICE vehicles.

Stationary Clean Fuel Technologies

Given the limited funding available to support low-emission stationary source technology development, this area has historically been limited in scope. To gain the maximum air quality benefits in this category, higher polluting fossil fuel-fired electric power generation needs to be replaced with clean renewable energy resources or other advanced near zero-emission technologies, such as solar, wind, geo-thermal energy, bio-mass conversion and stationary fuel cells. Although combustion sources are lumped together as stationary, the design and operating principles vary significantly and thus also the methods and technologies for control of their emissions. Included in the stationary category are boilers, heaters, gas turbines and reciprocating engines. Boilers and heaters vary in size, heat input, process conditions and operating ranges. Gas turbines vary greatly in size and application and are typically natural gas-fired with add-on controls to clean up the flue gas. Stationary ICEs can be either rich-burn or lean-burn. The core technologies for this category focus on using advanced combustion processes, development of catalytic add-on controls, alternative fuels and technologies and stationary fuel cells in novel applications.

Program Review

In 1990, the SCAQMD initiated an annual review of its technology advancement program by an external panel of experts. That external review process has evolved, in response to SCAQMD policies and legislative mandates, into two external advisory groups. The Technology Advancement Advisory Group (one of six standing Advisory Groups that make up the SCAQMD Advisory Council) is made up of stakeholders representing industry, academia, regulatory agencies, the scientific community and environmental impacts. The Technology Advancement Advisory Group, whose members are listed within Appendix A, serves to:

- Coordinate the SCAQMD program with related local, state and national activities;
- Review and assess the overall direction of the program; and
- Identify new project areas and cost-sharing opportunities.

The second advisory group was formed as required by SB 98 (Alarcon). Under H&SC Section 40448.5.1(c), this advisory group must comprise 13 members with expertise in clean fuels technology and policy or public health and appointed from the scientific, academic, entrepreneurial, environmental and public health communities. This legislation further specified conflict-of-interest guidelines prohibiting members from advocating expenditures towards projects in which they have

professional or economic interests. The objectives of the SB 98 Clean Fuels Advisory Group are to make recommendations regarding projects, plans and reports, including approval of the required annual report prior to submittal to the SCAQMD Governing Board. The members of the SB 98 Clean Fuels Advisory Group are also listed in Appendix A.

The review process of the Clean Fuels Program now includes several meetings of the two Advisory Groups, review by the Technology Committee of the SCAQMD Governing Board, public hearing of the Annual Report and Plan Update before the full SCAQMD Governing Board and submittal of the Annual Report to the Legislature by March 31 of every year.

PROGRAM STRATEGY AND IMPACT

Scope and Benefits of the Clean Fuels Program

To reap the maximum emissions benefits form any technology, widespread deployment and thus end-user acceptance must occur. The product manufacturers must overcome technical and market barriers to ensure a competitive and sustainable business. Unfortunately, the time needed to overcome these barriers can be long and the costs high, which tends to discourage both manufacturers and end-users from considering advanced technologies. A combination of real-world demonstrations, education, outreach and regulatory impetus and incentives is necessary to catalyze new, clean technologies. The Clean Fuels Program addresses these needs by co-funding research, development, demonstration and deployment projects to share the risk of emerging technologies with their developers and eventual users.

Figure 2 provides a conceptual design of the wide scope of the Clean Fuels Program. As mentioned in the Core Technologies section, various stages of technology projects are funded not only to provide a portfolio of emissions technology choices but to achieve emission reduction benefits in the nearer as well as over the longer term.

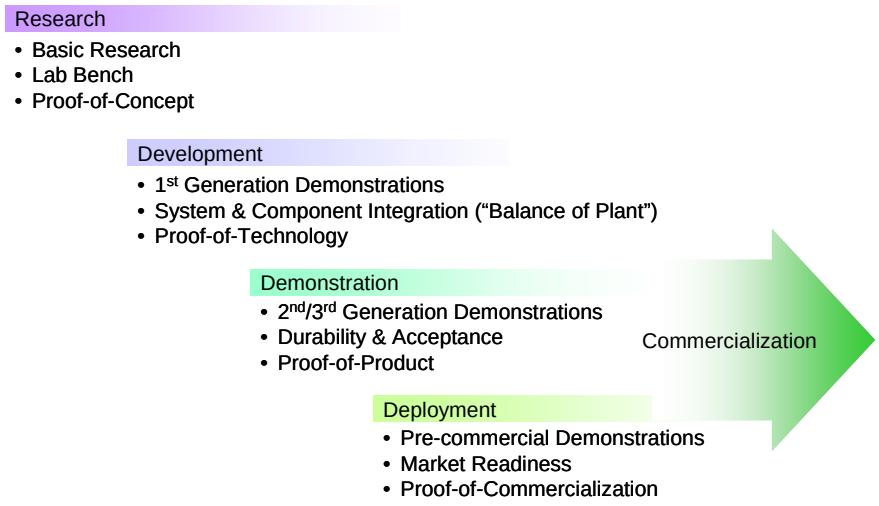


Figure 2: Stages of Clean Fuels Program Projects

Due to the nature of these advanced technology research, development, demonstration and deployment projects, the benefits are difficult to quantify since their full emission reduction potential may not be realized until sometime in the future, or perhaps not at all if displaced by superior technologies. Nevertheless, a good indication of the impact and benefits of the Clean Fuels Program overall is provided by this selective list of sponsored projects that have resulted in commercialized products or helped to advance the state-of-the-technology.

➢CNG Engine Development for Heavy-Duty Vehicles

- Cummins Westport: C8.3L (CNG, LNG), B5.9L (CNG) L10 (CNG), ISL G 8.9L (CNG, LNG)
- Westport Innovations: ISX 15L (LNG)
- Detroit Diesel: Series 60G (CNG/LNG), Series 50G (CNG/LNG);
- John Deere: 6068 (CNG), 6081 (CNG);
- Mack: E7-400G (LNG); and

- Clean Air Partners/Power Systems (Caterpillar): 3126B (Dual Fuel), C-10 (Dual Fuel), C-12 (Dual Fuel).

➢ Fuel Cell Development and Demonstrations
- Ballard Fuel Cell Bus (first of its kind);
- ISE/ThunderPower Fuel Cell Bus; and
- Commercial Stationary Fuel Cell Demonstration with UTC and SoCalGas (first of its kind).

➢ Electric and Hybrid Electric Vehicle Development and Demonstrations
- EPRI hybrid vehicle evaluation study
- Hybrid electric vehicle demonstrations with SCE, UC Davis and AC Propulsion;
- Electric vehicle demonstrations with Santa Barbara Bus Works, Toyota and GM; and
- Plug-in Hybrid Electric Van with EPRI, DaimlerChrysler and SCE.

➢ Aftertreatment Technologies for Heavy-Duty Vehicles
- Johnson Matthey and Engelhard trap demonstrations on buses and construction equipment; and
- Lubrizol optimization and demonstration of oxidation catalysts on CNG, heavy-duty vehicles.

SCAQMD played a leading or major role in the development of these technologies, but their benefits could not have been achieved without all stakeholders (i.e.) manufacturer, end-users and government) working collectively to overcome the technology, market and project-specific barriers encountered at every stage of the research, development, demonstration and deployment process.

Overcoming Barriers

Commercialization and implementation of advanced technologies come with a variety of real-world challenges and barriers. These include project-specific issues as well as general technology concerns.

Technology Implementation Barriers

- Viable commercialization path
- Technology price/performance parity with conventional technology
- Consumer acceptance
- Fuel availability/convenience issues
- Certification, safety and regulatory barriers
- Quantifying emissions benefits
- Sustainability of market and technology

Project-Specific Issues

- Identifying a committed demonstration site
- Overall project cost and cost-share using public monies
- Securing the fuel
- Identifying and resolving real & perceived safety issues
- Quantifying the actual emissions benefits
- Viability of the technology provider

Other barriers include reduced or shrinking research budgets, infrastructure and energy uncertainties and risks, sensitivity to multi-media environmental impacts and the need to find balance between environmental needs and economic constraints. The SCAQMD seeks to address these barriers by establishing relationships through unique public-private partnerships with key stakeholders; e.g., industry, end-users and other government agencies with a stake in developing clean technologies. Partnerships that involve all the key stakeholders have become essential to address these challenges in bringing advanced technologies from development to commercialization.

Each of these stakeholders and partners contributes more than just funding. Industry, for example, can contribute technology production expertise as well as the experience required for compatibility with process operations. Academic and research institutes bring state-of-the-technology knowledge and

testing proficiency. Governmental and regulatory agencies can provide guidance in identifying sources with the greatest potential for emissions reduction, assistance in permitting and compliance issues, coordinating of infrastructure needs and facilitation of standards setting and educational outreach. Often, there is considerable synergy in developing technologies that address multiple goals of public and private bodies regarding the environment, energy and transportation.

The SCAQMD actively seeks additional partners for its program through participation in various working groups, committees and task forces. This participation has resulted in coordination of the SCAQMD program with a number of state and federal government organizations, including CARB, CEC, U.S. EPA and U.S. DOE and several of its national laboratories. Coordination also includes the AB 2766 Discretionary Fund Program administered by the Mobile Source Air Pollution Reduction Review Committee (MSRC), various local air districts, National Association of Fleet Administrators (NAFA), major local transit districts and local gas and electric utilities. The list of organizations with which the SCAQMD coordinates research and development activities also includes organizations specified in H&SC Section 40448.5.1(a)(2).

In addition, the SCAQMD holds periodic meetings with several organizations specifically to review and coordinate program and project plans. For example, the SCAQMD staff meets with CARB staff to review research and development plans, discuss project areas of mutual interest, avoid duplicative efforts and identify potential opportunities for cost-sharing. Periodic meetings are also held with industry-oriented research and development organizations, such as the Manufacturers of Emission Controls Association (MECA), the California Fuel Cell Partnership (CaFCP), the California Stationary Fuel Cell Collaborative and the California Natural Gas Vehicle Partnership (CNGVP). The coordination efforts with these various stakeholders have resulted in a number of co-sponsored projects.

Descriptions of some of the key contracts executed in CY 2008 are provided in the next section of this report. It is noteworthy that most of the projects are co-sponsored by various funding organizations and include the active involvement of manufacturers. Such partnerships are essential to address commercialization barriers and to help expedite the implementation of advanced low-emission technologies. Table 1 below lists the major funding agency partners and manufacturers actively involved in SCAQMD projects for this reporting period. It is important to note that, although not listed, there are many other technology developers, small manufacturers and project participants who make important contributions critical to the success of the SCAQMD program. These partners are identified in the more detailed 2008 Project Summaries contained within this report.

Table 1: SCAQMD Major Funding Partners in CY 2008

Research Funding Organizations	Major Manufacturers/Providers
California Air Resources Board	Advanced Cleanup Technologies Inc.
California Energy Commission	Clean Energy Fuels Corporation
Mobile Source Air Pollution Reduction Review Committee	Port of Los Angeles Port of Long Beach
National Renewable Energy Laboratory	Waste Management Inc.
U.S. Environmental Protection Agency	Westport Power Inc.

The following two subsections broadly address the SCAQMD's impact and benefits by describing specific examples of accomplishments and commercial—or near-commercial—products supported by the Clean Fuels Program in CY 2008. Such examples are provided in the following sections on Technology Advancement's Research, Development and Demonstration projects and Technology Deployment and Commercialization efforts.

Research, Development and Demonstration

Important examples of the impact of the SCAQMD research and development coordination efforts are: (a) the development and demonstration of heavy-duty engines; and (b) the further development of plug-in hybrid and electric vehicle technologies.

Heavy-Duty Engines

Heavy-duty vehicles contribute the majority of NO_x and particulate emissions in the South Coast Air Basin. The SCAQMD has a long history of supporting clean conventional and alternative fuel strategies for this sector of the mobile inventory. One project contracted during CY 2008 is to develop and demonstrate 2010 compliant LNG heavy-duty trucks. Westport Power Inc. proposes to develop, demonstrate and certify an LNG high pressure diesel injection (HPDI) engine used in Class 8 heavy-duty truck applications at or below 0.6 g/bhp-hr NO_x and 0.01 g/bhp-hr PM in early 2008 and 0.2 g/bhp-hr NO_x and 0.01 g/bhp-hr PM emissions in the first quarter of 2009. Westport Power will use a 1.2 g/bhp-hr NO_x 400 HP Cummins ISX HPDI engine as the baseline for their project and will employ a two-phase strategy to achieve the federal 2010 heavy-duty NO_x and PM emissions standards. The truck will then be demonstrated in service for six months to evaluate performance, reliability and emissions reduction potential of the engine.

Plug-In Hybrid and Electric Vehicles

The SCAQMD has actively sponsored the development of PHEVs for light- and medium-duty platforms, but heavy-duty applications are also important. In 2008 for parcel delivery applications, the SCAQMD cost-shared a project with CALSTART to develop and demonstrate four heavy-duty

Figure 3: Parcel Delivery Van

Figure 4: Hydraulic-Hybrid Shuttle Bus

gasoline hybrid electric vehicles for use in the FedEx fleet. The SCAQMD also partnered with the U.S. EPA to develop and demonstrate a hydraulic-hybrid shuttle bus. Unlike hybrid-electric systems, hydraulic hybrids capture braking energy as compressed gas and re-use this energy for propulsion using special hydraulic pump/motors. Of the two basic types of hybrid drives, this project will be a series hydraulic hybrid where the engine is not directly connected to the drive wheels. The U.S. EPA has been developing such a system along with a special low-emission Homogeneous Charge Combustion Ignition (HCCI) engine. This engine and hydraulic drive system has the potential for extremely low emissions and greatly improved fuel economy in heavier vehicles.

Technology Deployment and Commercialization

One function of the Clean Fuels Program is to help expedite the deployment and commercialization of low- and zero-emission technologies and fuels needed to meet the requirements of the AQMP control measures. In many cases, new technologies, although considered "commercially available," require assistance to fully demonstrate the technical viability to end-users and decision-makers.

The following projects contracted during the CY 2008 reporting period illustrate the impact of the SCAQMD's technology deployment and commercialization efforts.

Demonstrate Aftertreatment Devices on Off-Road Diesel Construction Equipment

There are nearly 70,000 pieces of diesel-powered off-road construction equipment operating in the Basin. As mentioned earlier, CARB's off-road 2006 emission model estimates that 120 tons per day of NOx and 7.5 tons per day of PM emissions are produced by this equipment. In July 2007, CARB approved its "In-Use Off-Road Diesel Vehicles" regulation to address diesel vehicles, including off-road construction vehicles. CARB estimates that the regulation at its peak will retrofit up to 100,000 vehicles and prevent 4,000 premature deaths. However, the regulation is only enforceable if verified devices are available on the market. The MSRC, working closely in conjunction with CARB, developed a broad-based "Showcase" Program to demonstrate and ultimately verify diesel emission control retrofit systems on heavy-duty off-road diesel construction equipment.

Figure 5: Equipment without Aftertreatment

The MSRC and CARB worked closely together to match compatible diesel emissions control devices with appropriate off-road construction equipment and ranked devices and equipment to achieve the broadest demonstration across vehicle classes. The MSRC's "Showcase" Program ultimately provided more than $3.6 million in funding for 16 manufacturers producing 30 devices and 18 equipment owners with 230 off-road vehicles, focusing solely, however, on devices that reduced PM emissions. In late 2007 to address the NO_x component, the SCAQMD Governing Board approved 11 projects totaling more than $1.2 million for 11 fleets to demonstrate devices that reduce both PM and NO_x emissions on 32 pieces of equipment. In 2008 four of these awards were executed into contracts; the remaining projects are expected to result in executed contracts within the first quarter of 2009.

Figure 6: Equipment with Aftertreatment

In 2008 three contracts were executed to also demonstrate the effectiveness of selective catalytic reduction (SCR) technology in reducing NO_x and PM emissions. The project with Community Recycling & Resource Recovery Inc. will demonstrate ten pieces of heavy-duty, diesel-powered construction equipment equipped with SCR combined with diesel particulate filter (DPF) technology. The project with ServoTech Engineering Inc. will demonstrate ServoTech's emission control system consisting of an SCR technology, diesel oxidation catalyst (DOC) and active DPF on heavy-duty diesel-powered construction equipment. And the third project, in partnership with the Placer County Air Pollution Control District, will demonstrate Advanced Cleanup Technologies Inc.'s Advanced Locomotive Emission Control System (ALECS), which will be fabricated to capture exhaust emissions from locomotives being serviced at the Union Pacific Railroad Yard in Roseville, California.

Natural Gas Infrastructure and Deployment

In 2008 the SCAQMD continued to aggressively add and upgrade natural gas refueling facilities to support the need for CNG and LNG fuel by fleet operators subject to clean fuel fleet requirements. In fact, contracts were executed in 2008 for natural gas infrastructure and deployment exceeding $3 million or 28% of the funds executed for this reporting period.

One of the contracts executed in the amount of $358,000 is with California Cartage Company for the deployment of 2010 emissions standards compliant LNG trucks. As part of the $13.8 million Early Grant projects funded under the state's Proposition 1B Goods Movement Emission Reduction Program, the SCAQMD Governing Board approved a contract to replace 132 pre-2003 heavy-duty diesel trucks operating in and around the twin ports of Los Angeles and Long Beach with new LNG trucks. The new LNG trucks will be on a Sterling L Series platform powered by Cummins Westport ISL G, which is the only one commercially available to date that is certified by CARB to meet the EPA's 2010 emission standards of 0.2 g/bhp-hr for NO_x and 0.01 g/bhp-hr for PM.

These Clean Fuels Funds are leveraged against a total project cost of $11.88 million.

Figure 7: LNG Truck

Currently, the Basin has 94 CNG refueling stations and 28 LNG refueling stations, of which approximately half are L/CNG stations, which means they can refuel either liquid or compressed natural gas. There are also 17 hydrogen refueling stations in the Basin. Infrastructure and deployment will continue to be one of the core technologies in 2009 and beyond.

Figure 8: L/CNG Station

2008 FINANCIAL SUMMARY

The SCAQMD Clean Fuels Program supports clean fuels and technologies that appear to offer the most promise in reducing emissions, promoting energy diversity and in the long term, providing cost-effective alternatives to current technologies. In order to address the wide variety of pollution sources in the Basin and the need for reductions now and in the future, the SCAQMD seeks to fund a wide variety of projects to establish a diversified technology portfolio to proliferate choices with the potential for different commercial maturity timing. Given the evolving nature of technology and changing market conditions, such a representation is only a "snapshot-in-time," as reflected by the projects approved by the Governing Board.

As projects are approved by the Governing Board and executed into contracts throughout the year, the finances may change to reflect updated information provided during the contract negotiation process. As such, the following represents the status of the Clean Fuels Fund as of December 31, 2008.

Funding Commitments by Core Technologies

The SCAQMD continued its successful leveraging of public funds with outside investment to support the development of advanced clean air technologies. During the period January 1 through December 31, 2008, at total of 78 contracts, projects or studies that support clean fuels were executed or amended, as shown in Table 2. The major technology areas summarized are: infrastructure and fuel production, fuels/emission studies, emission control technologies, electric/hybrid technologies, engine technologies, mobile fuel cell technologies, hydrogen technology and infrastructure, health impacts studies, stationary clean fuel technologies, outreach and technology transfer. The distribution of funds based on technology area is shown graphically in Figure 9. This wide array of technology support represents the SCAQMD's commitment to researching, developing, demonstrating and deploying potential near-term and longer-term technology solutions.

The project commitments that were contracted or purchased for the 2008 reporting period are shown below with the total projected project costs:

- SCAQMD Clean Fuels Fund Contribution $11,330,299
- Total Cost of Clean Fuels Projects $57,357,659

Each year, the SCAQMD Governing Board approves funds to be transferred to the General Fund Budget for Clean Fuels administration. For 2008, the Board transferred $600,000 for workshops, conferences, co-sponsorships and outreach activities as well as postage, supplies and costs for special conferences. Only the funds committed by December 31, 2008, are included within this report. Any portion of the Clean Fuels Funds not spent by the end of Fiscal Year 2008-09 ending June 30, 2009, will be returned to the Clean Fuels Fund.

Partially included within the SCAQMD contribution are supplemental sponsorship revenues from various organizations that support these technology advancement projects. This supplemental revenue totaling $500,000 is listed within Table 3. Appendix B lists all Clean Fuels Fund contracts, totaling 138, that were open and active as of January 1, 2009.

For Clean Fuels executed and amended contracts and projects in 2008, the average SCAQMD contribution is approximately 20 percent of the total cost of the projects, identifying that each dollar from the SCAQMD was leveraged with more than four dollars of outside investment.

During 2008, the SCAQMD executed contracts, projects, studies or contract amendments with additional funding of more than $11 million for Clean Fuels projects. The distribution of funds is shown in Figure 9 below.

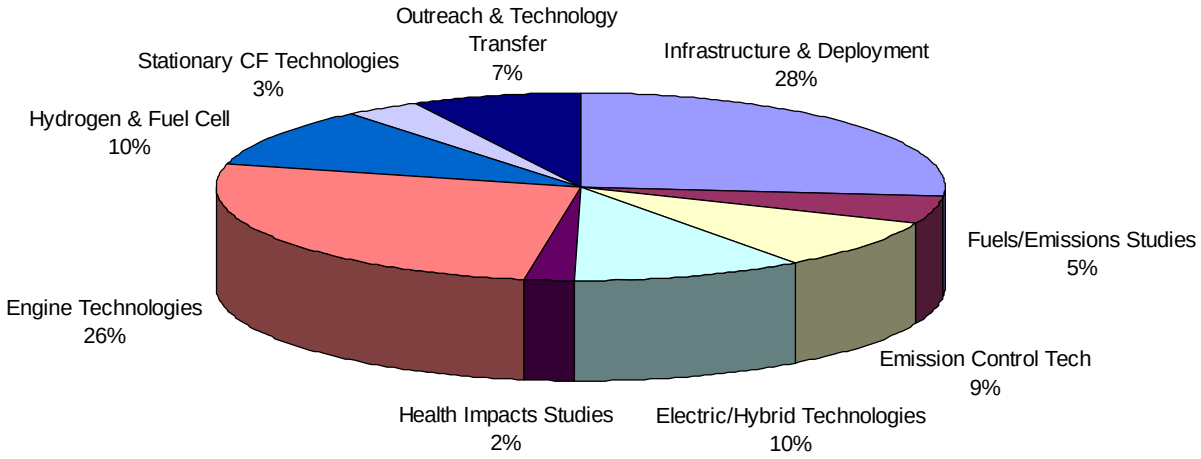


Figure 9: Distribution of Funds for Executed Clean Fuels Projects CY 2008 ($11.3 million)

Review of Audit Findings

State law requires an annual financial audit after the closing of each SCAQMD's fiscal year. The financial audit is performed by an independent Certified Public Accountant selected through a competitive bid process. For the fiscal year ended June 30, 2009, the firm of Thompson, Cobb, Bazilio & Associates, P.C. conducted the financial audit. As a result of this financial audit, a Comprehensive Annual Financial Report (CAFR) was issued. The CAFR noted there were no adverse internal control weaknesses with regard to SCAQMD financial statements, which include the Clean Fuels Program revenue and expenditures. Thompson, Cobb, Bazilio & Associates, P.C. gave the SCAQMD an "unqualified opinion," the highest obtainable. Notably, the SCAQMD has achieved this rating on all prior annual financial audits.

Project Funding Detail

The 78 new and continuing contracts, projects and studies that received SCAQMD funding in 2008 are summarized in Table 2, together with the funding authorized by the SCAQMD and by the collaborating project partners.

Table 2: Contracts Executed or Amended Between January 1 & December 31, 2008

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment						
06017	FuelMaker Corporation	Incentive Buydown Program for CNG Home Refueling Appliances	09/26/05	12/31/09	146,000	146,000
07245	USA Waste of California, Inc. dba L.A. Metro	Purchase & Install New LNG Production Facility using Landfill Gas from Altamont Landfill in Livermore	07/11/08	12/31/13	300,000	13,000,000
07246	USA Waste of California, Inc. dba L.A. Metro	Purchase & Install New LNG Storage Tank at Long Beach LNG Refueling Station	12/24/08	12/31/13	200,000	440,000
08043	University of California Los Angeles	Public Access CNG Refueling Station Upgrade for UCLA Transportation	05/02/08	12/31/13	140,000	350,000
08098	Redlands Unified School District	Purchase & Install New CNG Refueling Station	01/25/08	12/31/13	525,000	700,000
08271	Los Angeles Unified School District	Purchase & Install New CNG Refueling Station	06/03/08	12/31/13	617,480	1,747,000
09165	California Cartage Company	Deployment of 2010 Emissions Standards Compliant LNG Trucks	10/31/08	07/31/16	358,000	11,880,000
Direct Pay	Various	Buydown for Up to 75 Natural Gas-Powered Vehicles for Taxicabs at Commercial Airports	09/05/08	09/05/08	750,000	1,462,500
Fuels/Emissions Studies						
08319	California State University Long Beach Foundation	Student Educational Study to Assess Mixing Effectiveness of a Rotary Cylinder in Improving Diesel NO_x Reduction of an SCR System	06/24/08	12/31/08	17,500	17,500
08263	University of California Riverside/CE-CERT	Evaluate Emissions Impacts from Diesel Biofuel & Biofuel Blends	08/12/08	11/30/09	150,000	1,630,000
08304	Maschinenbau Haldenwang GmbH & Company KG	Pilot Program to Assess Feasibility of Enhancing Smog Check Tests in the South Coast Air Basin	07/16/08	03/01/09	99,423	373,847
09095	University of California Riverside/CE-CERT	Evaluate Emissions Impacts of Ethanol Blend Ratio for Light-Duty Vehicles	10/31/08	09/30/09	250,000	250,000
Emission Control Technologies						
08244	Albert W. Davies, Inc.	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	05/22/08	11/30/09	45,650	158,170
08246	Griffith Company	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	05/14/08	11/30/09	74,550	180,550
08252	City of Culver City	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	07/08/08	09/30/09	38,900	138,475

Table 2: Contracts Executed or Amended Between January 1 & December 31, 2008

Emission Control Technologies (continued)

08261	Community Recycling & Resource Recovery, Inc.	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	12/12/08	09/30/09	363,250	590,895
08272	ECCO Equipment Corporation	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	09/28/08	09/30/09	17,600	17,600
08318	ServoTech Engineering Inc.	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	07/08/08	12/15/09	320,000	990,420
09018	Placer County Air Pollution Control District	Develop & Demonstrate Stationary Emission Control System for Locomotives	09/24/08	05/31/10	50,000	1,132,000
09150	Advanced Cleanup Technologies, Inc.	Develop & Demonstrate Stationary Emission Control System for Marine Vessels	12/05/08	02/28/09	55,000	598,240

Electric/Hybrid Technologies

99109	Toyota Motor Credit Corporation	Three-Year Lease of Two RAV4 Electric Vehicles	04/04/99	02/01/09	7,794	7,794
08294	Balqon Corporation	Purchase & Demonstrate an Electric Yard Hostler	05/15/08	05/31/10	300,000	300,000
08334	CALSTART	Demonstrate Heavy-Duty Hybrid Electric Vehicle for Parcel Delivery Application	10/16/08	09/30/10	325,000	595,000
09017	U.S. Environmental Protection Agency	Develop & Demonstrate Hydraulic-Hybrid Shuttle Bus	10/10/08	10/09/11	500,000	1,960,000
Direct Pay	University of Washington, University of California Polytechnic Pomona, & Wright State University	University Competition to Develop Rechargeable Electric Leaf Vacuum Device	01/15/08	05/02/08	36,555	36,555

Engine Technologies

08037	Thomas Built Buses, Inc.	Integrate & Demonstrate Cummins Westport ISL-G Natural Gas Engine in a Thomas Built School Bus Chassis	01/09/08	03/31/09	250,000	343,250
08146	Blue Bird Corporation	Integrate & Demonstrate Cummins Westport ISL-G Natural Gas Engine in Blue Bird School Bus Chassis	05/15/08	03/31/09	250,000	338,000
08192	Westport Power, Inc.	Develop & Demonstrate 2010 Compliant LNG Heavy-Duty Truck	01/25/08	05/31/10	2,250,000	9,894,027
08224	BAF Industries	Develop & Certify Natural Gas-Powered Pickup Trucks	05/09/08	12/31/09	250,000	675,000

Mobile Fuel Cell Technologies

08218	General Motors Corporation	No-Cost Loan Agreement for GM Fuel Cell Vehicle	02/25/08	05/30/08	0	0
08301	American Honda Motor Company, Inc.	Lease of Two Honda Fuel Cell Electric Vehicles	06/25/08	06/24/09	12,990	12,990

Table 2: Contracts Executed or Amended Between January 1 & December 31, 2008

Mobile Fuel Cell Technologies (continued)

08335	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership in FY 2008 & Provide Support for Regional Coordinator	12/20/08	07/31/09	137,800	2,297,274

Hydrogen Technology and Infrastructure

04011	Air Products and Chemicals, Inc.	Install & Demonstrate an Industrial Pipeline-Supplied Hydrogen Refueling Station in Torrance	08/03/05	12/31/10	89,051	89,051
05165	Air Products and Chemicals, Inc.	Install & Demonstrate Three Electrolyzers (in Burbank, Riverside & Santa Monica) and Two Mobile Fuelers (in Santa Ana & Ontario), with One Year of Hydrogen Fuel	06/21/05	06/15/11	903,332	903,332
08223	BMW of North America LLC	BWM Hydrogen-7 Sedan Vehicle Lease Agreement	04/04/08	05/08/08	0	0
Direct Pay	Smart Chemistry Corporation	Particulate & Gaseous Hydrogen Fuel Analysis at SCAQMD's Hydrogen Refueling Station in Diamond Bar	01/08/08	02/22/08	10,000	10,000
Purchase Order	Hydrogenics Corporation	Repair of Hydrogen Station at SCAQMD's Headquarters in Diamond Bar	01/16/08	04/15/09	5,875	5,875

Health Impacts Studies

09307	California Air Resources Board	In-Vehicle Air Pollution Exposure Measurement & Modeling	09/01/08	04/30/11	250,000	500,000

Stationary Clean Fuel Technologies

09304	Solar Integrated Technologies Inc.	Install Turnkey Rooftop 40 kW Building Integrated Photovoltaic System	12/20/08	12/19/14	390,695	390,695
Direct Pay	Solaire Energy Systems	Repair & Maintenance of Solar 20kW Carport System at SCAQMD Headquarters in Diamond Bar	08/12/08	09/12/08	2,400	2,400

Outreach and Technology Transfer

07167	Tech Compass	Technical Assistance with Hydrogen and Fuel Cell Technologies	03/31/08	12/31/10	75,000	75,000
07185	Joseph C. Calhoun	Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle Technologies	01/29/07	01/31/10	30,000	30,000
07247	TIAX, LLC	Technical Assistance with Low-Emission and Alternative Fuels Technologies	03/19/07	12/31/10	75,000	75,000
08210	Sawyer Associates	Technical Assistance on Mobile Source Control Measures and Future Consultation on TAO Activities	02/22/08	02/28/10	25,000	25,000

Table 2: Contracts Executed or Amended Between January 1 & December 31, 2008

Outreach and Technology Transfer (cont'd)

08254	Maria Robles, R.N.	Administrative Assistance in Organizing Two Air Quality & Health-Related Conferences	05/02/08	12/31/09	149,760	149,760
08311	CALSTART	Technical Assistance with Development, Outreach and Commercialization of Advanced Technology to Transit, Port & Other Activities	07/11/08	05/31/10	75,000	75,000
08337	Gladstein, Neandross & Associates LLC	Coordinate the Southern California Clean Vehicle Technology Expo 2008	09/05/08	01/31/09	54,000	295,265
09004	EDV Commercialization	Technical Assistance on Plug-In Hybrid Electric Vehicles & Associated Technologies	08/20/08	08/31/10	15,000	15,000
09252	JWM Consulting Services	Technical Assistance with Review & Assessment of Advanced Technologies, Heavy-Duty Engines and Conventional & Alternative Fuels	12/20/08	06/30/10	30,000	30,000
Transfer	California Natural Gas Vehicle Partnership	Participate in California Natural Gas Vehicle Partnership	09/05/08	09/04/10	25,000	245,000
Transfer	Transfer from Clean Fuels	Temporary Services for High Emitter Repair or Scrap (HEROS) Program	03/14/08	06/31/08	11,000	11,000
Direct Pay	Department of Motor Vehicles	Anti-Idling Ad in DMV 2008 Commercial Driver Handbook	01/15/08	01/15/08	9,000	14,000
Various	Various Contractors	Co-Sponsorships of 26 Conferences, Workshops & Events, plus 3 Memberships	Various	Various	266,694,	2,153,194

Table 3: Supplemental Grants/Revenue Received Between January 1 & December 31, 2008

Revenue Agreement	Revenue Source	Project Title	Contractor	SCAQMD Project	Total
MOU	Port of Los Angeles	Develop & Demonstrate 2010 Compliant LNG Heavy-Duty Truck	Westport Power, Inc.	Contract #08192	$250,000
MOU	Port of Los Beach	Develop & Demonstrate 2010 Compliant LNG Heavy-Duty Truck	Westport Power, Inc.	Contract #08192	$250,000

Project Summaries by Core Technologies

The following represents summaries of the contracts, projects and studies executed or amended with additional dollars in 2008. They are listed in the order found in Table 2 by category and contract number. The summaries provide the project title, contractors and subcontractors, SCAQMD cost-share, co-sponsors and their respective contributions, contract term and a description of the projects as required by H&SC Section 40448.5.1(d).

Infrastructure and Deployment

06017: Incentive Buydown Program for CNG Home Refueling Appliances

Contractor: FuelMaker Corporation	SCAQMD Cost-Share	$ 146,000
Term: 09/26/05 – 12/31/09	Total Cost:	$ 146,000

In May 2005 the Board approved matching funds with the MSRC and provided $400,000 for a buydown incentive program for 400 natural gas home refueling appliances (HRAs) to broaden the consumer base for light-duty NGVs. Funding for the 400 HRAs was allocated in two contracts: 100 purchases through FuelMaker Corporation and 300 leases through American Honda Motor Company. In February 2007 the Board de-obligated $250,000 from Honda's lease program, reducing the Honda contract to $50,000 and re-apportioned this amount to FuelMaker's purchase program and then commenced an SCAQMD-only sponsored purchase incentive of $2,000 per HRA. In July 2008 the Board approved another amendment to the FuelMaker contract to increase the value by $146,000 based on strong demand for a new total contract value of $496,000, continue the SCAQMD-only buydown incentive and extend the performance period for another 12 months through December 31, 2009. To date, the total number of HRAs purchased through FuelMaker is 241 (100 HRAs @ $1,000 each along with a $1,000 MSRC match and 141 HRAs @ $2,000 each. The lease program was not well received and the Honda contract #06018 ended in early 2008 with only $4,000 expended. Demand for the purchase incentives continues to be high and it is expected that all funds under the FuelMaker contract will be expended by or before the end of the contract term.

07245: Purchase & Install New LNG Production Facility using Landfill Gas from Altamont Landfill in Livermore

Contractor: USA Waste of California, Inc. dba L.A. Metro	SCAQMD Cost-Share	$ 300,000
	Co-Sponsors:	
	Waste Management, Inc.	8,000,000
	Linde Corporation	4,700,000
Term: 07/11/08 – 12/31/13	Total Cost:	$ 13,000,000

USA Waste of California, Inc. has proposed to develop a landfill gas (LFG) to liquefied natural gas (LNG) production facility, producing approximately 10,000 gallons of LNG daily, at its existing landfill Livermore, California. Total budget for the project is estimated to be $13,000,000. USA Waste of California, Inc. will support 100% of the local LNG fleet fueling use with the facility output. The annual usage for the fleets that are committed to using this station is 2,000,000 diesel-equivalent gallons (DEG) of natural gas by the end of the third full year of operation. Construction and operation of this LNG production facility will help ease fueling

supply issues for both USA Waste of California, Inc. as well as other LNG fleet fuel users within the South Coast Air Basin. The facility will also include a 30,000-gallon storage tank as well as a new public access fueling station for LNG-powered fleets in the Bay Area.

07246: Purchase & Install New LNG Storage Tank at Long Beach LNG Refueling Station

Contractor: USA Waste of California, Inc., dba L.A. Metro	SCAQMD Cost-Share	$ 200,000
	Co-Sponsor:	
	Waste Management, Inc.	240,000
Term: 12/24/08 – 12/31/13	Total Cost:	$ 440,000

In the past, several LNG production facilities had un-planned breakdowns that led to short supply of LNG fuel for the Southern California area. The shortages created significant concerns for public and private fleets that rely on continuous deliveries of fuel for their day-to-day operations. This project was in response to the shortages, creating funding to assist contractors in installing new or additional LNG storage either at their own refueling facility or at another site in a cooperative purchasing agreement. USA Waste of California installed a 16,000 gallon tank of additional LNG storage capacity to an existing 16,000 gallons for a total capacity of 32,000 gallons.

08043: Public Access CNG Refueling Station Upgrade for UCLA Transportation

Contractor: University of California Los Angeles	SCAQMD Cost-Share	$ 140,000
	Co-Sponsor:	
	Clean Energy	210,000
Term: 05/02/08 – 12/31/13	Total Cost:	$ 350,000

The Fleet Services Facility at the University of California Los Angeles (UCLA) has successfully operated a CNG refueling station since its installation in 1993 to support the SCAQMD's Clean Fuel Programs. The station is conveniently located in a heavily trafficked area of Los Angeles, just off the San Diego (405) Freeway between the Wi lshire Blvd and Sunset Blvd exits. However, Fleet Services had a dated first generation CNG fueling facility which required a significant upgrade to ensure reliability and performance. Total cost to upgrade this station was projected to be $350,000, of which $140,000 was requested from the SCAQMD to offset a portion of the initial capital investment for the replacement and installation of a natural gas "fast-fill" public-access station. In an effort to reduce upfront costs, Fleet Services entered into an agreement with Clean Energy to fund the remaining 60% of the remaining capital costs required in upgrading the CNG fueling facility.

08098: Purchase & Install New CNG Refueling Station

Contractor: Redlands Unified School District	SCAQMD Cost-Share	$ 525,000
	Co-Sponsor:	
	Redlands USD	175,000
Term: 01/25/08 – 12/31/13	Total Cost:	$ 700,000

Redlands USD has proposed to construct, own and operate a new CNG refueling station at its bus yard in Redlands, California. Total budget for the station is $700,000 for a 150 SCFM CNG station with 7 time-fill bus dispensers and garage upgrades. Redlands USD currently operates 11 CNG school buses. Redlands USD also commits to purchasing an additional CNG bus each year over the next three years and that the annual natural gas throughput of this station will be 21,800 diesel-gallon equivalents (DGE) by the end of the third full year of operation.

08271: Purchase & Install New CNG Refueling Station

Contractor: Los Angeles Unified School District	SCAQMD Cost-Share	$ 617,480
	Co-Sponsor:	
	LAUSD	1,129,520
Term: 06/03/08 – 12/31/13	Total Cost:	$ 1,747,000

LAUSD proposed to construct, own and operate a new time- and fast-fill CNG refueling station at its Sun Valley Bus Garage (SVBG). The SVBG is located on a major stretch of road connecting the CA-170 Hollywood Freeway one-half mile west of the Burbank-Glendale-Pasadena Airport, 1.6 miles east of the location. It is also bordered by the City of Burbank to the south and Interstate 5 Freeway, 3.5 miles to the North. LAUSD's fleet currently consists of 216 low-sulfur active diesel school buses that annually consume 53,000 gallons of diesel fuel. LAUSD currently has on order 40 CNG to be domiciled at the new refueling station and commits to purchasing an additional 30 CNG bused within three years and that the annual natural gas throughput of this station will be approximately 120,000 DGE by the end of the third full year of operation. Total budget for the new CNG refueling station is $1,747,000 for a 280 SCFM CNG station with a single fast-fill and 20 time-fill bus dispensers and garage upgrades.

09165: Deployment of 2010 Emissions Standards Compliant LNG Trucks

Contractor: California Cartage Company	SCAQMD Cost-Share	$ 358,000
	Co-Sponsors:	0
	U.S. Environmental Protection Agency	4,922,000
	California Air Resources Board	6,600,000
Term: 10/31/08 – 07/31/16	Total Cost:	$ 11,880,000

As part of the $13.8 million Early Grant projects funded under the state's Proposition 1B Goods Movement Emission Reduction Program (Prop 1B), the Board approved a contract with California Cartage Company in May 2008 and in July 2008 with an amendment to replace 132 pre-2003 heavy-duty diesel trucks operating in and around the twin ports of Los Angeles and Long Beach with new LNG trucks. The new LNG trucks will be on a Sterling L Series platform powered by Cummins Westport ISL G, which is only one commercially available to date that is certified by CARB to meet the EPA's 2010 emission standards of 0.2 g/bhp-hr for NOx and 0.01 g/bhp-hr for PM. In addition to the $6.6 million funding from Prop 1B Early Grant, SCAQMD is cost sharing the project with $358,000 from the Clean Fuels Fund and $4.922 million from EPA's federal grant under Section 103 of the Clean Air Act to provide sufficient incentives for cleaner LNG trucks over diesel trucks. It is estimated that a successful implementation of this project will

reduce 109 tons of NO_x and 4 tons of PM emissions annually in the South Coast Air Basin, especially around the twin ports which is the single largest fixed source of air pollution in the Basin, with more than 43% of the nation's seaborne container trade. Furthermore, the Multiple Air Toxics Exposure Study III (MATES III) reported that the highest air toxics risks are found near the twin ports and transportation corridors. In addition to the immediate air quality benefits realized by replacing 132 diesel trucks with new clean LNG trucks, it is believed that this project will help jump start further deployment of LNG trucks not only in the Basin but elsewhere in California resulting in significant air quality benefits at both the local and regional levels.

Direct Pay: Buydown for Up to 75 Natural Gas-Powered Vehicles for Taxicabs at Commercial Airports

Contractor: Various	SCAQMD Cost-Share	$ 750,000
	Co-Sponsors:	
	CARB Alternative Fuel Rebate Incentive Program	225,000
	Federal Tax Credit	300,000
	Ford Fleet Incentive	185,500
Term: Ongoing	Total Cost:	$ 1,462,500

Tax credits provide some assistance to taxicab owners to convert their fleets to natural gas to reduce emissions at commercial airports. To further incentivize the purchase of cleaner natural gas vehicles for taxicab services at commercial airports, the SCAQMD Board approved buydown incentives from the Clean Fuels Fund for up to 75 natural gas-powered vehicles for taxicabs at commercial airports. A maximum of $10,000 per vehicle will be available per vehicle and would be further reduced by available tax credits. The emissions reductions associated with this buydown program will be counted as part of the Rule 2202 emissions reduction target.

Fuels/Emissions Studies

08319: Student Educational Study to Assess Mixing Effectiveness of a Rotary Cylinder in Improving Diesel NOx Reduction of an SCR System

Contractor: California State University Long Beach Foundation	SCAQMD Cost-Share	$ 17,500
Term: 06/24/08 – 12/31/08	Total Cost:	$ 17,500

Selective Catalytic Reduction (SCR) systems with urea as the reducing agent have shown to be an effective method in reducing NO_x emissions of diesel engines. Current SCR systems may have low emission reduction efficiency due to many factors including inefficient mixing between the exhaust gas and the injected urea, resulting in ammonia slippage. Various passive mixers such as ring injectors and tabs have shown to improve the mixing process in an SCR system; however, limited studies have been performed on mixing enhancement using controlled dynamic approaches. The objective of the proposed investigation is to assess the effectiveness of using a rotary cylinder at various speeds and Reynolds numbers on mixing enhancement between Urea/Ammonia injection and diesel exhaust emission reductions. Results of the investigation may provide criteria for development of a high efficiency NO_x converter catalyst.

08263: Evaluate Emissions Impacts from Diesel Biofuel & Biofuel Blends

Contractor: University of California Riverside/CE-CERT	SCAQMD Cost-Share	$ 150,000
	Co-Sponsors:	
	California Air Resources Board	1,380,000
	National Biodiesel Board	50,000
	SCAQMD Contract #00182	50,000
Term: 08/12/08 – 11/30/09	Total Cost:	$ 1,630,000

In various diesel engine studies, replacement of petroleum diesel fuel with biodiesel fuel has demonstrated reduced PM, CO and air toxics emissions. Biodiesel is also promoted to reduce greenhouse gas emissions because it can be made from renewable feedstocks, such as soy and canola. Biodiesel can be formulated at varying percentages by blending with petroleum diesel fuel and is commonly used at 20 percent, or B20, to avoid congealing at cold temperatures and possible engine seal and gasket damage which can occur with 100% biodiesel, or B100. Biodiesel and biodiesel blends, however, have a demonstrated tendency to increase NO_x emissions, which exacerbates the ozone and PM2.5 challenges faced in the Basin. In May 2007, CARB approved a biodiesel research study with the University of California Riverside College of Engineering Center for Environmental Research and Technology (CE-CERT) to evaluate the emissions impact from the use of biodiesel fuels in California. The main elements of the study are to compare emissions from the use of biodiesel derived from current and future biodiesel feedstocks common to California at four different blend levels (B5, B20, B50 and B100) to CARB's ultra low-sulfur diesel (ULSD) fuel. The study will include a wide range of pollutants including criteria, toxics, greenhouse gases and non-regulated pollutants. The study will evaluate test engines and vehicles that are common to California and test cycles that represent a range of driving conditions. The study will evaluate the NO_x impact and investigate possible NO_x mitigation strategies, which may include fuel reformulation, additives and/or minor injection timing changes.

08304: Pilot Program to Assess Feasibility of Enhancing Smog Check Tests in the South Coast Air Basin

Contractor: Maschinenbau Haldenwang GmbH & Company KB (MAHA)	SCAQMD Cost-Share	$ 99,423
	Co-Sponsors:	
	MAHA	124,424
	Foundation for California Community Colleges (in-kind)	50,000
	California Air Resources Board (in-kind)	100,000
Term: 07/16/08 – 03/01/09	Total Cost:	$ 373,847

A pilot program is being conducted to assess the feasibility of addressing two limitations within the biennial Smog Check Program. First, PM emissions are not currently measured as part of the biennial Smog Check Program due to practical and technical constraints. MAHA has developed a portable instrument--the MPM4--that may be a viable means to quantify PM during smog check

tests. The instrument uses advanced laser light scattering photometry technology and high-speed processors to provide real-time particle measurements. Second, all-wheel and four-wheel drive vehicles are exempted from loaded mode drive, four-wheel drive, or traction control systems require the rotation of all four wheels, which cannot be accomplished on the current two-wheel, loaded-mode dynamometer system used at Smog Check stations. MAHA is cost-sharing with the SCAQMD the delivery of four portable particulate measuring devices and the delivery and installation of one-all wheel/four-wheel drive dynamometer. The analyzers will be evaluated at CARB's El Monte laboratory and at SCAQMD's High Emitter Repair or Scrap (HEROS) Program test sites. The dynamometer will be utilized at one of the HEROS Program test sites. Data obtained from the equipment will be used to evaluate the potential for broadening the scope of current Smog Check testing.

09095: Evaluate Emissions Impacts of Ethanol Blend Ratio for Light-Duty Vehicles

Contractor: University of California Riverside/CE-CERT	SCAQMD Cost-Share	$ 250,000
Term: 10/31/08 – 09/30/09	Total Cost:	$ 250,000

The Energy Policy Act of 2005 requires an increasing use of biofuels in coming years. With the push towards an increased use of biofuels, there is consideration to further increase the ethanol fraction in gasoline. The objective of this test program is to study the effects of increasingly higher blend ratios of ethanol on tailpipe emissions with respect to a certification fuel using MTBE as an oxygenate. MTBE was originally added to gasoline as an oxygenate to reduce vehicle tailpipe emissions of carbon monoxide and function as an octane enhancer. The use of MTBE has declined due to concerns over water quality issues. MTBE is water soluble and was believed responsible for polluting ground water. The source of the pollution was attributed to gasoline leakage at filling stations. Although MTBE was subsequently banned in California for use as an oxygenate in gasoline, MTBE is still present in the certification fuel used for certifying vehicle tailpipe emissions to regulatory standards. This test program will provide a comparison of tailpipe emissions when a vehicle is certified on certification fuel obtaining MTBE and when operated in the real world on a fuel containing ethanol as an oxygenate. Ethanol blend ratios from 0 to 85% will be tested.

Emission Control Technologies

08244: Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment

Contractor: Albert W. Davies, Inc.	SCAQMD Cost-Share	$ 45,650
	Co-Sponsor:	
	Albert W. Davies, Inc. & Project Partners (in-kind)	112,520
Term: 05/22/08 – 11/30/09	Total Cost:	$ 158,170

In March 2007 the MSRC issued a Request for Qualifications to manufacturers of diesel emission control systems and a Program Announcement for owners for off-road diesel construction equipment. Thirty diesel emission control devices were submitted by 16 manufacturers and 21 applications with a total of 230 pieces of off-road construction equipment were received from eighteen fleet owners. In September 2007 the MSRC approved a total of $3,641,013 to fund all 11 projects with 198 pieces of construction equipment. The SCAQMD partnered with the MSRC

to provide funds for the remaining 11 projects which provide both NO_x and PM emission reductions on 32 pieces of construction equipment with 34 diesel-powered engines. The construction equipment includes scrappers, excavators, dozers, loaders, backhoes, crawler tractors and forklifts powered by diesel engines ranging in sizes from 17 to 692 HP. The scope of the project includes the design, installation and in-field demonstration of SCR system and DPF technologies on diesel-powered construction equipment with the goal of verifying the technologies through CARB at the end of the project. This project demonstrates one piece of construction equipment owned by Albert W. Davies, Inc. The results of the in-field data logging will be used to fabricate the SCR system and DPF technology suitable for heavy-duty construction applications. The fabricated control systems will then be installed at the exhaust of the selected engine and demonstrated in service for at least 700 hours.

08246: Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment

Contractor: Griffith Company	SCAQMD Cost-Share	$ 74,550
	Co-Sponsor:	
	Griffith Company & Project Partners (in-kind)	106,000
Term: 05/14/08 – 11/30/09	Total Cost:	$ 180,550

In March 2007 the MSRC issued a Request for Qualifications to manufacturers of diesel emission control systems and a Program Announcement for owners for off-road diesel construction equipment. Thirty diesel emission control devices were submitted by 16 manufacturers and 21 applications with a total of 230 pieces of off-road construction equipment were received from eighteen fleet owners. In September 2007 the MSRC approved a total of $3,641,013 to fund all 11 projects with 198 pieces of construction equipment. The SCAQMD partnered with the MSRC to provide funds for the remaining 11 projects which provide both NO_x and PM emission reductions on 32 pieces of construction equipment with 34 diesel-powered engines. The construction equipment includes scrappers, excavators, dozers, loaders, backhoes, crawler tractors and forklifts powered by diesel engines ranging in sizes from 17 to 692 HP. The scope of the project includes the design, installation and in-field demonstration of SCR system and DPF technologies on diesel-powered construction equipment with the goal of verifying the technologies through CARB at the end of the project. This project demonstrates two pieces of construction equipment owned by Griffith Company. The results of the in-field data logging will be used to fabricate the SCR system and DPF technology suitable for heavy-duty construction applications. The fabricated control systems will then be installed at the exhaust of the selected engine and demonstrated in service for at least 700 hours.

08252: Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment

Contractor: City of Culver City	SCAQMD Cost-Share	$ 38,990
	Co-Sponsor:	
	City of Culver City & Project Partners (in-kind)	99,575
Term: 07/08/08 – 09/30/09	Total Cost:	$ 138,475

In March 2007 the MSRC issued a Request for Qualifications to manufacturers of diesel emission control systems and a Program Announcement for owners for off-road diesel construction equipment. Thirty diesel emission control devices were submitted by 16 manufacturers and 21 applications with a total of 230 pieces of off-road construction equipment were received from eighteen fleet owners. In September 2007 the MSRC approved a total of $3,641,013 to fund all 11 projects with 198 pieces of construction equipment. The SCAQMD partnered with the MSRC to provide funds for the remaining 11 projects which provide both NO_x and PM emission reductions on 32 pieces of construction equipment with 34 diesel-powered engines. The construction equipment includes scrappers, excavators, dozers, loaders, backhoes, crawler tractors and forklifts powered by diesel engines ranging in sizes from 17 to 692 HP. The scope of the project includes the design, installation and in-field demonstration of SCR system and DPF technologies on diesel-powered construction equipment with the goal of verifying the technologies through CARB at the end of the project. This project demonstrates one piece of construction equipment owned by the City of Culver City. The results of the in-field data logging will be used to fabricate the SCR system and DPF technology suitable for heavy-duty construction applications. The fabricated control systems will then be installed at the exhaust of the selected engine and demonstrated in service for at least 700 hours.

08261: Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment

Contractor: Community Recycling & Resource Recovery, Inc.	SCAQMD Cost-Share	$ 363,250
	Co-Sponsors:	
	Community Recycling & Resource Recovery, Inc.	104,750
	Dinex	50,000
	Extengine	29,225
	Nett Technologies	43,670
Term: 12/12/08 – 09/30/09	Total Cost:	$ 590,895

Based on the California Air Resources Board's Off-Road 2006 emission model, there were approximately 68,600 pieces of diesel-powered construction equipment in the Basin in 2006, which together produced approximately 120 tons per day of NO_x with 7.5 tons per day of PM emissions. SCR combined with diesel particulate filter (DPF) technology is capable of reducing NO_x and PM emissions from heavy-duty diesel trucks by 80 percent. This project is intended to assess the reliability and emission reduction potential of SCR technology combined with DPF technology as an emission control system on off-road construction equipment. The scope of this project includes design, installation and in-field demonstration of the control system on diesel-powered construction equipment with the goal of verifying the technologies through CARB at the end of the project. Community Recycling will select ten pieces of heavy-duty, diesel-powered construction equipment, which will be data logged for temperature and pressure. The results of in-field data logging will be used to fabricate the SCR system and DPF technology suitable for heavy-duty construction applications. The fabricated control systems will then be installed at the exhaust of the selected engines and demonstrated in service for at least 700 hours.

08272: Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment

Contractor: ECCO Equipment Corporation	SCAQMD Cost-Share	$ 17,600
Term: 09/28/08 – 09/30/09	Total Cost:	$ 17,600

In March 2007 the MSRC issued a Request for Qualifications to manufacturers of diesel emission control systems and a Program Announcement for owners for off-road diesel construction equipment. Thirty diesel emission control devices were submitted by 16 manufacturers and 21 applications with a total of 230 pieces of off-road construction equipment were received from eighteen fleet owners. In September 2007 the MSRC approved a total of $3,641,013 to fund all 11 projects with 198 pieces of construction equipment. The SCAQMD partnered with the MSRC to provide funds for the remaining 11 projects which provide both NO_x and PM emission reductions on 32 pieces of construction equipment with 34 diesel-powered engines. The construction equipment includes scrappers, excavators, dozers, loaders, backhoes, crawler tractors and forklifts powered by diesel engines ranging in sizes from 17 to 692 HP. The scope of the project includes the design, installation and in-field demonstration of SCR system and DPF technologies on diesel-powered construction equipment with the goal of verifying the technologies through CARB at the end of the project. This project demonstrates one piece of construction equipment owned by ECCO Equipment. The results of the in-field data logging will be used to fabricate the SCR system and DPF technology suitable for heavy-duty construction applications. The fabricated control systems will then be installed at the exhaust of the selected engine and demonstrated in service for at least 700 hours.

08318: Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment

Contractor: ServoTech Engineering Inc.	SCAQMD Cost-Share	$ 320,000
	Co-Sponsors:	
	ServoTech Engineering Inc.	540,000
	County Sanitation Districts of Los Angeles County	130,000
Term: 07/08/08 – 12/15/09	Total Cost:	$ 990,420

This project is to demonstrate the reliability and emission reduction potential of ServoTech's emission control system consisting of an SCR technology, diesel oxidation catalyst (DOC) and active DPF on heavy-duty diesel-powered construction equipment operating in the South Coast Air Basin. This emission control system is expected to be more durable than other SCR with DPF retrofit technologies for construction equipment because it employs a weld-free exhaust system built to withstand aggressive vibrations. Vibrations have been shown to compromise the durability and integrity of retrofit technologies for construction equipment, especially tracked tire bulldozers. ServoTech proposes to establish the baseline NO_x and PM emissions from each engine using a portable ServoTech exhaust gas monitoring system for diesel applications (S-EGM-D100) and conduct an engine dynamometer test on an engine comparable to one of the selected engines to serve as a baseline engine according to the CARB verification test procedures for off-road engines. The results of the baseline emissions and in-field data logging will be used to design and fabricate at least three emission control systems suitable for heavy-duty

construction applications. The fabricated systems will then be installed at the exhaust of each engine and demonstrated in service for 11 hours. ServoTech will again conduct on-board management of the three engines using the portable emission measurement system after the emission control systems have been conditioned (degreened). After the emission control systems have accumulated 1100 hours, one of the systems will be removed and installed on the baseline engine and tested on an engine dynamometer according to CARB verification test procedures.

09018: Develop & Demonstrate Stationary Emission Control System for Locomotives

Contractor: Placer County Air Pollution Control District	SCAQMD Cost-Share	$ 50,000
	Co-Sponsors:	
	Advanced Control Technologies, Inc. (ACTI)	750,000
	Union Pacific Railroad	200,000
	Placer County APCD	100,000
	Sacramento Metropolitan AQMD	25,000
	City of Roseville	7,000
Term: 09/24/08 – 02/28/09	Total Cost:	$ 1,132,000

In August 2006, the Advanced Locomotive Emission Control System (ALECS) was demonstrated at the Union Pacific Railroad Yard in Roseville, California. The ALECS was developed by ACTI. The ALECS consists of a bonnet and duct arrangement to collect emissions from locomotives being serviced and a ground-mounted emission treatment system. The bonnet and ducting system is able to collect emissions from both stopped and slowly moving locomotive. The stationary emission treatment system consists of a PM removal system and a NO_x conversion system. Emission measurements during the demonstration yielded overall average reductions of 92 percent in PM and 97 percent in NO_x. Additionally, locomotive noise was reduced between 5 and 7 decibels. The next phase consists of three tasks addressing the bonnets and ducting system, the Emission Capture System (ECS). In Task 1, an ECS will be fabricated and demonstrate six bonnets capturing the exhaust emissions from six locomotives. The ECS will employ a single induced draft blower and individual pressure control mechanism at each bonnet. The emission treatment system will not be demonstrated while the exhaust from the ECS will be vented to the atmosphere. In Task 2, the best initial site in a rail yard for the ALECS will be identified. This task will consider combined rail yard operations to maximize use of the ALECS. Finally, value engineering will be performed in Task 3 through an in-depth time-and-motion study to identify potential operational changes and considerations. This task will also consider Union Pacific Railroad experience gained in recently configured rail yards.

09150: Develop & Demonstrate Stationary Emission Control System for Marine Vessels

Contractor: Advanced Cleanup Technologies, Inc.	SCAQMD Cost-Share	$ 55,000
	Co-Sponsors:	0
	Advanced Cleanup Technologies, Inc.	244,157
	Port of Long Beach	149,527
	Port of Los Angeles	149,527
Term: 12/05/08 – 02/28/09	Total Cost:	$ 598,240

In August 2006, the ALECS was demonstrated at the Union Pacific rail yard in Roseville, California. The ALECS consists of a bonnet arrangement to collect emissions from locomotives being serviced and a ground-mounted emission treatment system. PM emissions were reduced by 92 percent and NO_x emissions were reduced by 97 percent. Locomotive noise was also reduced between 5 and 7 decibels. The Ports of Long Beach and Los Angeles have proposed to demonstrate the Advanced Marine Emission Control System (AMECS) on a berthed ship. The AMECS will use a different bonnet arrangement from the locomotives to collect the ship emissions. The same treatment system as demonstrated with the locomotives will be used. Similar emission reductions are expected.

Electric/Hybrid Technologies

99109: Three-Year Lease of Two RAV4 Electric Vehicles

Contractor: Toyota Motor Credit Corporation	SCAQMD Cost-Share	$ 7,794
Term: 04/04/99 – 02/01/09	Total Cost:	$ 7,794

The lease of two Toyota RAV4 battery electric vehicles is extended for use in the Technology Advancement Office's Advanced Technology Demonstration Program.

08294: Purchase & Demonstrate an Electric Yard Hostler

Contractor: Balqon Corporation	SCAQMD Cost-Share	$ 300,000
Term: 05/15/08 – 05/31/10	Total Cost:	$ 300,000

In December 2006, the SCAQMD awarded a contract to Balqon Corporation to co-sponsor with the Port of Los Angeles (POLA) the development and demonstration of an electric on-road tow tractor for container movement within and around the Port. The in-field testing has shown that the prototype tow tractor will meet and exceed the duty-cycle requirements for an off-road yard hostler application. The POLA plans to place an order for 20 similar yard hostlers as part of a planned Green Terminal Program. The SCAQMD will join this effort by purchasing an additional yard hostler to use in a loan program for additional cargo handling entities to experience an electric yard hostler in actual operations.

08334: Demonstrate Heavy-Duty Hybrid Electric Vehicle for Parcel Delivery Application

Contractor: CALSTART	SCAQMD Cost-Share	$ 325,000
	Co-Sponsors:	
	Federal Express	195,000
	National Renewable Energy Laboratory	75,000
Term: 10/16/08 – 09/30/10	Total Cost:	$ 595,000

This project is to develop and demonstrate a heavy-duty hybrid electric vehicle for a parcel delivery application. CALSTART will work with its partners to develop and demonstrate four heavy-duty gasoline hybrid electric vehicles for use in the FedEx fleet. The parallel hybrid drive system will be implemented on a Ford E-450 chassis and will be demonstrated in the FedEx fleet for one year to characterize the fuel economy, performance and emissions of the vehicles. Data will also be collected on a representative number of conventional diesel vehicles as comparison. Emissions from the gasoline hybrid will be measured using a chassis dynamometer and compared to existing diesel and diesel hybrid data for this same class of FedEx trucks. In-use emissions testing of the gasoline hybrid and conventional diesel trucks will also be performed to verify the chassis dynamometer results and ensure emissions benefits are preserved.

09017: Develop & Demonstrate Hydraulic-Hybrid Shuttle Bus

Contractor: U.S. Environmental Protection Agency	SCAQMD Cost-Share	$ 500,000
	Co-Sponsors:	
	U.S. Environmental Protection Agency	1,070,000
	Navistar	150,000
	Eaton	100,000
	U.S. Army National Automotive Center	100,000
	California Air Resources Board	40,000
Term: 10/10/08 – 10/09/11	Total Cost:	$ 1,960,000

Hydraulic-hybrid drive systems for vehicles are currently under development. Unlike hybrid-electric systems, hydraulic hybrids capture braking energy as compressed gas and re-use this energy for propulsion using special hydraulic pump/motors. Of the two basic types of hybrid drives, this project will be a series hydraulic hybrid where the engine is not directly connected to the drive wheels. The U.S. EPA has been developing such a system along with a special low-emission Homogeneous Charge Combustion Ignition (HCCI) engine. This engine and hydraulic drive system has the potential for extremely low emissions and greatly improved fuel economy in heavier vehicles. Once developed, it also has the potential for lower cost than hybrid-electric systems in such vehicles. Under a Cooperative Research and Development Agreement (CRADA), the U.S. EPA will develop and demonstrate the newest version of their HCCI engine and hydraulic drive system in a shuttle bus.

Direct Pay: University Competition to Develop Rechargeable Electric Leaf Vacuum Device

Contractors: University of Washington, University of California Polytechnic Pomona, & Wright State University	SCAQMD Cost-Share	$ 36,555
Term: 01/15/08 – 05/02/08	Total Cost:	$ 36,555

On October 5, 2007, the SCAQMD released an RFP announcing a design competition for university engineering students to develop a battery-powered, low-noise backpack leaf vacuum suitable for commercial gardeners. The goal was to develop a machine that could be used to encourage garden equipment manufacturers to produce an environmentally friendly replacement for the gasoline-powered leaf blower. Based on the engineering design proposals that were submitted, three teams were authorized to produce prototype machines. The competing teams were from the University of Washington, Cal Poly Pomona and Wright State University in Ohio. The teams could win monetary awards of from $5,000 up to $40,000 depending upon how well their prototype performed. Each team was allowed up to $5,000 in expense reimbursement for constructing the prototypes. Also, travel expenses were reimbursed for the two out of state teams. The final competition was conducted at SCAQMD headquarters on April 30, 2008. The prototypes were evaluated based on the oral presentations, comparison to the performance specifications in the RFP and ratings by an experienced gardener of the comfort, convenience and effectiveness of the machines during actual-use. Based on the judges' findings, the following monetary awards were distributed:

University of Washington	$10,000
Cal Poly Pomona	$ 8,000
Wright State University	$ 6,000

Although none of the prototypes fully met the design criteria in the original RFP, the two judges representing the manufacturing sector said that the machines had many innovative and practical design features that were worth exploring for development of a commercial machine.

Engine Technologies

08037: Integrate & Demonstrate Cummins Westport ISL-G Natural Gas Engine in a Thomas Built School Bus Chassis

Contractor: Thomas Built Corporation	SCAQMD Cost-Share	$ 250,000
	Co-Sponsor:	0
	Thomas Built Corporation	93,250
Term: 01/09/08 – 03/31/09	Total Cost:	$ 343,250

Since 2000, under its Lower Emission School Bus program, the SCAQMD has awarded funds to school districts to purchase over 500 new CNG school buses as replacement of old diesel school buses and to install PM traps on over 2,500 diesel school buses. Of these new buses, 427 were CNG school buses powered by John Deere CNG engines. John Deere has announced that it is withdrawing from the CNG market at the end of 2007. Cummins Westport plans to fill the void by entering the school bus market with its new 8.9 liter ISL-G engine, which is being certified to the cleanest heavy-duty vehicle standard of 0.2 grams of NO_x/bhp-hr and 0.01 grams of PM/bhp-hr. This project is to integrate and demonstrate the Cummins Westport engine in the Thomas Built school bus chassis.

08146: Integrate & Demonstrate Cummins Westport ISL-G Natural Gas Engine in a Blue Bird School Bus Chassis

Contractor: Blue Bird Bus Corporation	SCAQMD Cost-Share	$ 250,000
	Co-Sponsor:	
	Blue Bird Bus Corporation	88,000
Term: 05/15/08 – 03/31/09	Total Cost:	$ 338,000

Since 2000, under its Lower Emission School Bus program, the SCAQMD has awarded funds to school districts to purchase over 500 new CNG school buses as replacement of old diesel school buses and to install PM traps on over 2,500 diesel school buses. Of these new buses, 427 were CNG school buses powered by John Deere CNG engines. John Deere has announced that it is withdrawing from the CNG market at the end of 2007. Cummins Westport plans to fill the void by entering the school bus market with its new 8.9 liter ISL-G engine, which is being certified to the cleanest heavy-duty vehicle standard of 0.2 grams of NO_x/bhp-hr and 0.01 grams of PM/bhp-hr. This project is to integrate and demonstrate the Cummins Westport engine in the Blue Bird school bus chassis.

08192: Develop & Demonstrate 2010 Compliant LNG Heavy-Duty Truck

Contractor: Westport Power, Inc.	SCAQMD Cost-Share	$ 1,750,000
	Co-Sponsors:	
	Port of Los Angeles	250,000
	Port of Long Beach	250,000
	Clean Energy	500,000
	Westport Power, Inc.	7,144,027
Term: 01/25/08 – 05/31/10	Total Cost:	$ 9,894,027

This project is to develop, demonstrate and certify an LNG HPDI engine used in Class 8 heavy-duty truck applications at or below 0.6 g/bhp-hr NO_x and 0.01 g/bhp-hr PM in early 2008 and 0.2 g/bhp-hr NO_x and 0.01 g/bhp-hr PM emissions in the first quarter of 2009. Westport Power, Inc. is using a 1.2g/bhp-hr NO_x 400 HP Cummins ISX HPDI engine as the baseline for their development, demonstration and certification project and proposes a two-phase strategy to achieve the federal 2010 heavy-duty NO_x and PM emissions standards as early as the first quarter of 2009. The first phase involves using a high capacity exhaust gas recirculation (EGR) system, a variable turbo charger, high pressure natural gas injection, robust controls architecture, an oxidation catalyst and a particulate filter trap to reduce NO_x and PM emissions from the engine to 0.6 and 0.01 g/bhp-hr, respectively. The engine will then be tested for certification and deterioration factor in accordance with the EPA and CARB requirements and integrated into a chassis followed by in-field testing. In the second phase, the 0.6 g/bhp-hr NO_x engine will be equipped with an SCR system to further reduce NO_x emissions to the 0.2 g/bhp-hr NO_x target levels. Majority of the work includes selecting, verifying, integrating and validating the SCR system with the HPDI engine on an LNG heavy-duty truck. The LNG truck will then be demonstrated in service for six months to evaluate performance, reliability and emissions reduction potential of the engine with the aftertreatment technology.

08224: Develop & Certify Natural Gas-Powered Pickup Trucks

Contractor: BAF Industries	SCAQMD Cost-Share	$ 250,000
	Co-Sponsors:	
	BAF Technologies	250,000
	Clean Energy	175,000
Term: 05/09/08 – 12/31/09	Total Cost:	$ 675,000

Further progress in air quality goals and reductions in air toxic exposure depends on the commercial availability of alternative fuel vehicles and other advanced emissions control technologies. Unfortunately, efforts to increase the use of alternative fueled vehicles are becoming more challenging. Both Ford and General Motors have ceased to produce any natural gas-powered vehicles that are offered for sale nationally or in California. Presently, American Honda is the only major automotive manufacturer offering a natural gas-powered vehicle in California. Honda offers a natural gas-powered Civic GX, a small passenger car, but does not offer a natural gas-powered pick-up truck. Public fleets widely use pick-up trucks as service vehicles. To address the need for alternative fueled pick-up trucks, BAF Technologies has developed and certified CARB-compliant natural gas powered pick-up trucks that are derived from gasoline-powered Ford F-150 and F-250 models. BAF Technologies was responsible for tooling, test vehicle development, installation of the natural gas vehicle technology into the base gasoline vehicles, testing and obtaining CARB certification. The project has been successfully completed.

Mobile Fuel Cell Technologies

08218: No-Cost Loan Agreement for GM Fuel Cell Vehicle

Contractor: General Motors Corporation	SCAQMD Cost-Share	$ 0
Term: 02/25/08 – 05/30/08	Total Cost:	$ 0

The lease of one GM Chevy Equinox fuel cell vehicle was executed at no cost for use in the Technology Advancement Office's Advanced Technology Demonstration Program.

08301: Lease of Two Honda Fuel Cell Electric Vehicles

Contractor: American Honda Motor Company, Inc.	SCAQMD Cost-Share	$ 12,990
Term: 06/25/08 – 06/24/09	Total Cost:	$ 12,990

The lease of two Honda fuel cell passenger vehicles is extended for use in the Technology Advancement Office's Advanced Technology Demonstration Program.

08335: Participate in California Fuel Cell Partnership in FY 2008 & Provide Support for Regional Coordinator

Contractor: Bevilacqua-Knight, Inc.	SCAQMD Cost-Share	$ 137,800
	Co-Sponsors:	
	9 automakers; 2 energy providers; 7 government agencies; 13 associate members	2,159,474
Term: 12/20/08 – 07/31/09	Total Cost:	$ 2,297,274

In April 1999, the California Fuel Cell Partnership (CaFCP) was formed with eight members; SCAQMD joined and has participated since 2000. The CaFCP and its members are demonstrating fuel cell passenger cars and transit buses with associated hydrogen fueling infrastructure in California. Since the CaFCP is a voluntary collaboration, each participant contracts with Bevilacqua-Knight, Inc. (BKI) for their portion of CaFCP administration. In 2008, the SCAQMD Board contributed $87,800 for membership and up to $50,000, along with four cubicles at SCAQMD Headquarters, to provide support for the CaFCP Regional Coordinator.

Hydrogen Technology and Infrastructure

04011: Install & Demonstrate an Industrial Pipeline-Supplied Hydrogen Refueling Station in Torrance

Contractor: Air Products and Chemicals, Inc.	SCAQMD Cost-Share	$ 89,051
Term: 08/03/05 – 12/31/10	Total Cost:	$ 89,051

Air Products and Chemicals, Inc. (APCI) owns and operates 17 miles of pipeline in the industrial and commercial districts of Torrance and Wilmington; the only one of its kind in an urban area in North America. The proposed hydrogen fueling station in Torrance will utilize the pipeline system to deliver hydrogen to the fueling site. This will allow hydrogen fueling in a very cost-effective manner without the need for on-site hydrogen generation or additional truck deliveries of hydrogen. The proposed fueling station will be capable of providing hydrogen based upon demand. As the demand increases, the pipeline is capable of supplying the fuel to meet those needs. Additional goals of this project are to develop a safety and operational training plan for the station that could be adapted to future sites and to provide increased public awareness of hydrogen as a vehicle fuel. Automakers expressed concerns regarding the quality of hydrogen from the pipelines provided for fueling fuel cell vehicles. Therefore, pipeline quality hydrogen needed to be further purified to address these concerns and this can be achieved by installing a pressure-swing absorption (PSA) unit or comparable purification system. The AQMD Board approved adding additional dollars for this PSA unit on October 7, 2005. This modification adds these dollars and this additional task and extends the term since station construction has been delayed due to site development and permitting issues.

05165: Install & Demonstrate Three Electrolyzers (in Burbank, Riverside & Santa Monica) and Two Mobile Fuelers (in Santa Ana & Ontario) with One Year of Hydrogen Fuel

Contractor: Air Products and Chemicals, Inc.	SCAQMD Cost-Share	$ 903,332
Term: 06/25/05 – 06/15/11	Total Cost:	$ 903,332

The implementation of ZEVs is a key component in the effort to achieve air quality attainment in the South Coast Air Basin. The "Five Cities" project called for the installation and operation of a network of five hydrogen fueling stations throughout the Basin to support the operation of FCVs and electric-hybrid internal combustion engine vehicles converted to use hydrogen as the fuel that will begin arriving in the Basin before the end of 2005. The five hydrogen fueling stations include: (A) Santa Monica, (B) Riverside, (C) Burbank, (D) Santa Ana and (E) Ontario. Stations A, B & C are supplied by an integral proton exchange membrane (PEM) electrolyzer system. The systems at C & D are self-contained transportable fueling units that can be refilled off-site as needed by APCI. The three stationary sites (A, B and C) will be equipment installation and sales with the transfer of ownership to SCAQMD while the other two sites (D and E) will be leased to SCAQMD by APCI. This funding allowed for maintenance and service for each of the five hydrogen stations and equipment to allow for safe and reliable operation during the five year demonstration period.

08223: BMW Hydrogen-7 Sedan Vehicle Lease Agreement

Contractor: BMW of North America LLC	SCAQMD Cost-Share	$ 0
Term: 04/04/08 – 05/08/08	Total Cost:	$ 0

A one-month lease of one BMW Hydrogen 7 Sedan was executed at no cost for use in the Technology Advancement Office's Advanced Technology Demonstration Program.

Direct Pay: Particulate & Gaseous Hydrogen Fuel Analysis at SCAQMD's Hydrogen Refueling Station in Diamond Bar

Contractor: Smart Chemistry Corporation	SCAQMD Cost-Share	$ 10,000
Term: 01/08/08 – 02/22/08	Total Cost:	$ 10,000

The SCAQMD maintains a hydrogen station at its Headquarters in Diamond Bar. When an apparent problem with fuel purity was identified, Smart Chemistry Corporation was tasked to conduct sampling and analysis of particulates and gaseous content in the hydrogen fuel. The resulting information was used to determine the best course to fix the purity problem.

Purchase Order: Repair of Hydrogen Station at SCAQMD's Headquarters in Diamond Bar

Contractor: Hydrogenics Corporation	SCAQMD Cost-Share	$ 5,875
Term: 01/16/08 – 04/15/09	Total Cost:	$ 5,875

As noted above, the SCAQMD maintains a hydrogen station at its Headquarters in Diamond Bar. Using the sampling and analysis from Smart Chemistry Corporation, a purchase order was then executed in order to improve performance and fuel quality of the hydrogen station. Specifically, Hydrogenics installed two filters, one at the entrance of the dispenser and one at the exit of the electrolyzer, to remove impurities as well as depressured the storage and refilled the electrolyzer. They were also tasked to change the desiccant filters monthly for 15 months. All monies were paid in 2008.

Health Impacts Studies

09307 In-Vehicle Air Pollution Exposure Measurement & Modeling

Contractor: California Air Resources Board	SCAQMD Cost-Share	$ 250,000
	Co-Sponsors:	
	California Air Resources Board	250,000
Term: 09/01/08 – 04/30/11	Total Cost:	$ 500,000

This health effects project will estimate in-vehicle pollutant exposure on freeways and major surface streets. The University of California Irvine (UCI) proposes to measure and model in-vehicle concentration of polycyclic aromatic hydrocarbons, black carbon and $PM_{2.5}$ on freeways and major surface streets in the Los Angeles/Orange County area and the San Bernardino/Riverside County area. These concentration results will be used to develop models of in-transit vehicle exposure to study the impacts of key air pollutants during pregnancy on birth outcomes or childhood occurrence of respiratory diseases and allergies. Five major tasks are proposed for this study: 1) analysis of in-cabin pollutant concentrations by vehicle type and vehicle age during typical Southern California driving conditions; 2) factors contributing to in-vehicle pollutant concentrations; 3) estimation of $PM_{2.5}$ emission factors based on roadway and urban background site measurements and CO_2 based dilution adjustments; 4) development of in-vehicle exposure models for measured air pollutants; and 5) validation of in-vehicle exposure models for black carbon against subject measurements under representative driving conditions. Clean Fuels dollars are being passed through CARB to UCI and CARB is overseeing administration of the project.

Stationary Clean Fuels Technologies

09304: Install Turnkey Rooftop 40 kW Building Integrated Photovoltaic System

Contractor: Solar Integrated Technologies Inc.	SCAQMD Cost-Share	$ 390,695
Term: 12/20/08 – 12/19/14	Total Cost:	$ 390,695

The SCAQMD currently owns and operates two solar electric systems, including an 80 kW (AC) photovoltaic (PV) system on the main building and a 20 kW PV system on a carport located in the parking lot. This project will add to this solar capacity and generate additional clean, renewable electricity for the facility. The project involves a demonstration of two different PV technologies on the same roof above the Conference Center. Solar Integrated will test the performance and reliability of the two systems under similar light conditions for a period of at least five years. The two PV systems will include: 1) a 4Building Integrated Photovoltaic (BIPV) system consisting of thin film laminates applied to a single-ply roofing membrane and 2) a

conventional PV system consisting of crystalline silicon solar panels. Each system will be rated at approximately 40 kW (AC) and the same type of inverter will be used to avoid any inverter effects when comparing the power output of the two photovoltaic systems. This contract is with Solar Integrated Technologies, Inc. to install a turnkey rooftop BIPV system consisting of thin film PV laminates rated at approximately 40 kW (AC). PermaCity will be the contractor for installation of the conventional PV system consisting of crystalline silicon solar panels, but that is a separate contract, which was in process at the end of 2008. This contract requires Solar Integrated Technologies, Inc. to: 1) obtain all permits/approvals for the BIPV system, including the final approval for interconnection to the grid, 2) provide the required information to PermaCity Corporation to complete the application process for the California Solar Initiative (CSI) rebate for the BIPV system, 3) install a turnkey BIPV system rated at approximately 40 kW (AC) and 4) ensure the BIPV system can be monitored through the Fat Spaniel data monitoring system to be installed by PermaCity Corporation at SCAQMD. The total cost for the PV systems shall not exceed $783,617, of which $390,695 is allocated for Solar Integrated's work. The SCAQMD will be eligible for a rebate through CSI program. The CSI rebate monies, estimated to be $193,076, will be returned to the Clean Fuels Fund.

Direct Pay: Repair & Maintenance of Solar 20kW Carport System at SCAQMD Headquarters in Diamond Bar

Contractor: Solaire Energy Systems	SCAQMD Cost-Share	$ 2,400
Term: 08/12/08 – 09/12/08	Total Cost:	$ 2,400

As noted above, the SCAQMD maintains a 20kW photovoltaic carport system at its Headquarters in Diamond Bar. Solaire Energy Systems was tasked with determining and verifying connectivity of the PV system, testing all modules for electrical performance, testing voltage at string levels, inspecting the physical condition of solar modules and preparing a single-line drawing and final report on findings along with recommendations for improvements of the system. Solaire's work was intended to complement the overall PV system project. All work and payments were completed in 2008.

Outreach and Technology Transfer

07167: Technical Assistance with Hydrogen and Fuel Cell Technologies

Contractor: Tech Compass	SCAQMD Cost-Share	$ 75,000
Term: 03/31/08 – 12/31/10	Total Cost:	$ 75,000

On May 5, 2006, the Board approved release of an RFP to solicit proposals to provide technical assistance and public outreach support for advanced, low- and zero-emission mobile and stationary source pollution control technologies. To promote, fund, manage and expedite the development and demonstration of such advanced technology projects, SCAQMD relies on expert input and consultation. Tech Compass was awarded a contract for technical assistance with the development, outreach and commercialization of hydrogen and fuel cell technologies. The principal of Tech Compass has been involved in development, commercialization and deployment of energy and environmental technologies for over 20 years. Tech Compass has worked to successfully bring emerging technologies from development to commercialization. This modification added an additional $75,000 to continue to utilize their technical assistance for future needs.

07185: Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle Technologies

Contractor: Joseph C. Calhoun	SCAQMD Cost-Share	$ 30,000
Term: 01/29/07 – 01/31/10	Total Cost:	$ 30,000

A contract with Joseph C. Calhoun was executed through the RFP process mentioned above. This modification added an additional $30,000 to continue to utilize his technical assistance for future needs. Mr. Calhoun has over 47 years of experience related to air quality including positions as Automotive Engineering Board Member of the CARB, Chief of Motor Vehicle Compliance of CARB and Assistant Director of General Motors Automotive Emissions. Mr. Calhoun provides expertise in alternative fuels for light- and heavy-duty vehicles and outreach for dissemination and commercialization of new technologies. This modification added an additional $30,000 to continue to utilize his technical assistance for future needs.

07247: Technical Assistance with Low-Emission and Alternative Fuels Technologies

Contractor: TIAX, LLC	SCAQMD Cost-Share	$ 75,000
Term: 03/19/07 – 12/31/10	Total Cost:	$ 75,000

A contract with TIAX, LLC was executed through the same RFP process mentioned above. TIAX has provided expertise involving low- and zero-emission vehicles, associated technologies and alternative fuels since the early 1980s. Mr. Jon Leonard is the Technical Director of TIAX's Clean Air Analytics which is a comprehensive program being developed to assess the most cost effective ways to clean up existing fleets of heavy-duty vehicles. Mr. Leonard is currently working as lead consultant for Gateway Cities Council of Governments' Clean Air Program which will reduce emissions from in-use heavy duty vehicles. Mr. Leonard also served as a technical consultant on the truck mitigation of emissions for the Port of Los Angeles. This modification added an additional $75,000 to continue to utilize TIAX and Mr. Leonard's technical assistance for future needs.

08210: Technical Assistance on Mobile Source Control Measures and Future Consultation on TAO Activities

Contractor: Sawyer Associates	SCAQMD Cost-Share	$ 25,000
Term: 02/22/08 – 02/28/10	Total Cost:	$ 25,000

The principal of Sawyer Associates Dr. Robert Sawyer has extensive research experience related to air pollution and its control, energy conversion, combustion processes, fuels, fire safety and rocket and jet propulsion. He also has experience in air pollution and climate change regulatory policy in the state of California and over 45 years of domestic and international experience specializing in automotive emissions, alternative fuels, air pollution and environmental issues. Dr. Sawyer shall provide technical assistance to further develop and refine the mobile source control measures, air toxics control measures, review of AQMD programs such as the Multiple Air Toxics Exposure Study and the Clean Fuels projects, input to greenhouse gas and energy diversity policies and state regulatory activities, such as the ZEV and ZBus regulations.

08254: Administrative Assistance in Organizing Two Air Quality & Health-Related Conferences

Contractor: Maria Robles, R.N.	SCAQMD Cost-Share	$ 149,760
Term: 05/02/08 – 12/31/09	Total Cost:	$ 149,760

The BASIN continues to have some of the poorest air quality in the nation. Recent analyses estimate that the population living within the SCAQMD's jurisdiction suffers significantly disproportionate exposure to unhealthful levels of particulate mater in the U.S. This exposure leads to an estimated 5,400 premature deaths annually due to particulate pollution, as well as more asthma symptoms, hospital admissions and emergency room visits. The SCAQMD's Multiple Air Toxics Study (MATES) III identified cancer risks from toxic air pollutants, such as diesel exhaust, are substantially higher in communities near sources of these pollutants. The SCAQMD sponsored two successful asthma and air pollution conferences in February 2006 and April 2007, the latter featuring a keynote address by Governor Schwarzenegger. An international conference on ultrafine particles was also held in 2006. The high attendance at these conferences illustrates the need for such venues to disseminate information on the health effects of air pollutants to the public, elected officials, other regulatory agencies and public policy makers. Feedback from the attendees also strongly encouraged follow-up conferences. Such venues also present a significant forum for the generation of ideas and policies to attain healthy air quality in the BASIN. Ms. Maria Robles provided outside expertise in support of the two highly successful asthma conferences where she demonstrated the capacity to secure conference sponsors and speakers as well as provide assistance to staff with event planning and miscellaneous administrative support. Ms. Robles shall provide all labor and services necessary to accomplish the tasks to design, organize and coordinate two conference events: 1) an international conference on particle pollution with potential topics to include asthma and other health related effects, exposure with pollutants related to goods movement, ultrafine particles and control technologies and policy options; and 2) an air toxics health conference with potential topics to include emission sources, monitoring, impacts and policy options.

08311: Technical Assistance with Development, Outreach and Commercialization of Advanced Technology to Transit, Port & Other Activities

Contractor: CALSTART	SCAQMD Cost-Share	$ 75,000
Term: 07/11/08 – 05/31/10	Total Cost:	$ 75,000

On November 2, 2007, the Board approved release of an RFP to solicit proposals to provide technical assistance and public outreach support for advanced, low- and zero-emission mobile and stationary source pollution control technologies. CALSTART will provide technical expertise related to the development and commercialization of heavy-duty technologies, especially as related to transit and Port applications. CALSTART has demonstrated capabilities in coordinating user-groups to focus sector needs in order to commercialize technologies, specifically in hybrid truck technologies and advanced technology transit bus applications. CALSTART currently serves as executive secretariat function to the U.S. Federal Transit Administration (FTA) on Bus Rapid Transit (BRT) issues such as vehicle technology, infrastructure and deployment.

08337: Coordinate the Southern California Clean Vehicle Technology Expo 2008

Contractor: Gladstein, Neandross & Associates LLC	SCAQMD Cost-Share	$ 54,000
	Co-Sponsors:	
	PERC	20,000
	Southern California Gas Company	20,000
	Other Sponsors	150,000
	Other Revenue	13,265
Term: 09/05/08 – 01/31/09	Total Cost:	$ 295,265

This is the fourth year the SCAQMD has contracted with GNA to coordinate the Southern California Clean Vehicle Technology Expo. The intent of the EXPO is to give fleet operators the opportunity to learn and exchange information with technology providers, public agencies and peers about regulatory and policy updates, operational strategies and available incentives toward improving air quality in the region. The EXPO was extended to three days this year to allow for a full day focused on funding. Money Monday was a success and covered the nuts and bolts of how to leverage funding from many of the incentive funds now available. Staff from each incentive program was available to meet one-on-one and discuss specific projects and how to apply with the attendees. The remaining two days focused on SCAQMD and CARB fleet rules, cleaner engine and vehicle availability and tax credits and incentives for fleets. Over 700 people attended the EXPO including representatives from 50 cities, the Counties of Orange, Los Angeles, Riverside, Sacramento, San Bernardino, Alameda, Ventura and Santa Barbara and many private fleets.

09004: Technical Assistance on Plug-In Hybrid Electric Vehicles & Associated Technologies

Contractor: EDV Commercialization	SCAQMD Cost-Share	$ 15,000
Term: 08/20/08 – 08/31/10	Total Cost:	$ 15,000

Through the Electric Power Research Institute (EPRI), the SCAQMD participated in the groundbreaking publicly available study "Comparing Benefits and Impacts of Hybrid Electric Vehicle Options," which led to development and demonstration of a plug-in hybrid electric Sprinter van with DaimlerChrysler and a plug-in hybrid electric utility bucket truck with Eaton (Ford platform). The SCAQMD has secured $983,277 co-funding through the U.S. Department of Energy (DOE) for a plug-in hybrid electric vehicle demonstration. Mr. Robert Graham, the principal of EDV Commercialization, was previously with EPRI for nine years as the Electric Transportation Program Manager. Mr. Graham is currently leading the team with EPRI to develop the medium-duty PHEV certification cycle through a DOE earmark in Kansas City. This project has significant synergies with the SCAQMD earmark because it is through the same DOE laboratory (NETL) and will provide some of the cost-share required for the earmark. In order to take advantage of Mr. Graham's experience in working through the DOE process and ensure appropriate leveraging of the Kansas City project, staff executed a contract with his agency to obtain his technical assistance on these endeavors.

09252: Technical Assistance with Review & Assessment of Advanced Technologies, Heavy-Duty Engines and Conventional & Alternative Fuels

Contractor: JWM Consulting Services	SCAQMD Cost-Share	$ 30,000
Term: 12/20/08 – 06/30/10	Total Cost:	$ 30,000

The principal of JWM Consulting Services, J. Wayne Miller, has over 30 years of experience in establishing fuel specifications for commercial distillate fuels and the manufacturing processes. Mr. Miller has compiled, analyzed and reported on emissions data from heavy-duty diesel trucks and off-road mobile sources including locomotives, jet turbines, ocean going vessels and cargo handling equipment and harbor craft. Mr. Miller has served as a technical advisor for the AQMD's SB 98 Clean Fuels Advisory Group for the past six years. He will provide technical expertise on alternative technologies for heavy-duty engines and fuels.

Transfer: Participate in California Natural Gas Vehicle Partnership

Contractor: California Natural Gas Vehicle Partnership	SCAQMD Cost-Share	$ 25,000
	Co-Sponsors:	
	Various Partners	220,000
Term: 09/05/08 – 09/04/10	Total Cost:	$ 245,000

The California Natural Gas Vehicle Partnership (CNGVP) was formed to accelerate the development of advanced natural gas vehicle technologies, to provide a benchmark for lowering emissions from petroleum based engines and to provide a pathway to future fuel cell use in the next two decades. The SCAQMD spearheaded the formation of this strategic alliance, which is comprised of state and federal air quality, transportation and energy agencies, vehicle and engine manufacturers, fuel providers, transit and refuse hauler organizations. Partnership Steering Committee members contribute monies to fund specific projects intended to achieve the goal of the Partnership. In September 2008 the SCAQMD Board approved $25,000 for the SCAQMD's participation on the Steering Committee for a two-year membership.

Transfer: Temporary Services for High Emitter Repair or Scrap Program

Contractor: HEROS Program	SCAQMD Cost-Share	$ 11,000
Term: 03/14/08 – 06/31/08	Total Cost:	$ 11,000

In 2005 the SCAQMD's Board approved a landmark $4 million voluntary pilot program to detect "gross-polluting" cars, pickups and vans using remote sensing and to provide incentives to repair them or scrap and replace them. The program called the High Emitter Repair or Scrap (HEROS) Program is funded through Assembly Bill 923 as follows: $1 million for designated remote sensing; $1 million for testing and repair; $1 million for scrapping and replacement; and $1 million for additional repair, scrapping and replacement, depending on demand. Gross-polluting passenger vehicles may emit 100 times more air pollution than a typical vehicle due to lack of proper maintenance, tampering with exhaust or emission systems and other factors. The Program offers $500 to repair a vehicle or $1,000 to scrap it if repairs prove too costly. Motorists meeting the state's low-income guidelines are eligible for an additional $1,000 to scrap their vehicle if they replace it with a used car certified at the low-emission vehicle (LEV) emission standard. Remote sensing started in late March 2007 and continued throughout the first half of 2008. Additional clerical staff was needed to support the program and funding of $11,000 from the

Clean Fuels Fund was approved to support the additional clerical assistance using temporary agency services.

Direct Pay: Anti-Idling Ad in DMV 2008 Commercial Driver Handbook

Contractor: Department of Motor Vehicles	SCAQMD Cost-Share	$ 9,000
	Co-Sponsors:	
	Bay Area Air Quality Management District	5,000
Term: 01/15/08 – 01/15/08	Total Cost:	$ 14,000

The Department of Motor Vehicles (DMV) issues a Commercial Driver Handbook every year. We partnered with the Bay Area AQMD and Ditching Dirty Diesel Collaborative to place a black & white full-page ad on anti-idling in the 2008 Handbook, both in the English and Spanish versions, of which 700,000 and 250,000 copies will be printed, respectively. The ads included information on the effects of idling, reinforce idling limits and penalties and serve as public awareness and educational opportunity for anyone pursuing a commercial driver's license. The ads provide an essential connection for reaching out to individuals in a sector that contributes heavily to air pollution throughout the state.

Various: Co-Sponsorships of Conferences, Workshops & Events, plus Memberships

Contractor: Various Contractors	SCAQMD Cost-Share	$ 266,694
	Co-Sponsors:	
	Various	1,886,500
Term: Various	Total Cost:	$ 2,153,194

The SCAQMD regularly participates in and hosts or co-sponsors conferences, workshops and events. These funds provide support for 26 events during 2008, plus 3 business council or association memberships. The 26 conferences, workshops and events are as follows: 18th Annual Clean Heavy-Duty Vehicle Conference; Alternative Fuels & Vehicles National Conference and Expo 2008; 9th Annual Western Riverside COG's Advancing the Choice Event; Faster Freight-Cleaner Air; 2008 Semi-Annual Technical Meeting of the Western States Section of the Combustion Institute; 18th Annual On-Road Vehicle Emissions Workshop; 19th Annual U.S. Hydrogen Conference; California Climate Action Registry's 6th Annual Conference; Inaugural Low-Carbon Fuels 2008 Conference; 2nd Clean Air Car Show & Film Festival; Clearing the Air 2008 Conference; Mobile Source Air Toxics Workshop; Ultrafine Diesel Particles & Retrofit Technologies for Diesel Engines Three-Day Course; Haagen-Smit Symposium "Challenge to Change: The Role of Land Use & Transportation in Meeting Climate Change Program Goals"; City of San Fernando CNG Station Grand Opening Event; Winter & Summer Clean Fuels Advisory Retreats; Desert LYCEUM 2008 Summit on Energy "The Environment & Economic Opportunity"; 4th Annual Clean Air Car Showcase; Shell Eco-Marathon Competition; Advancing the Technology Choices for Heavy-Duty Vehicles; U.S. DOE 2008 Western Region Clean Cities Peer Exchange; Alternative Energy & Transportation Expo & Conference Featuring AltCar; Plug-In 2008 Conference; 22nd U.C. Symposium on Aviation Noise & Air Quality "Flying Green"; and attendance & exhibitor participation at five different events. The three memberships for 2008 were for participation in the California Hydrogen Business Council, California Environmental Business Council and U.S. Fuel Cell Council Association.

PROGRESS IN 2008

Key Projects Completed

A large number of emission sources contribute to the air quality problems in Southern California. Given the diversity of these sources, there is no single technology or "silver bullet" that can solve all of the region's problems. Accordingly, the SCAQMD continues to support a wide range of advanced technologies, addressing not only the diversity of emissions sources, but also the time frame to commercialization of these technologies. Projects co-funded by the SCAQMD's Clean Fuels Program include emission reduction demonstrations for both mobile and stationary sources, although legislative requirements limit the use of available funds primarily to on-road mobile sources.

Historically, mobile source projects have targeted low-emission technology developments in automobiles, transit buses, medium- and heavy-duty trucks and off-road applications. These vehicle-related efforts have focused on: 1) advancements in engine design, electric power trains, energy storage/conversion devices (e.g., fuel cells and batteries); and 2) implementation of clean fuels (e.g. natural gas, propane and hydrogen) including their infrastructures. Stationary source projects have included a wide array of advanced low NO_x technologies and clean energy alternatives, such as fuel cells, solar power and other renewable energy systems.

Table 5 provides a list of 39 projects completed in 2008. Summaries of the completed technical projects are included in Appendix C. Selected projects which represent a range of key technologies from near-term to long-term are highlighted below.

Advanced Diesel Emission Control System

Heavy-duty diesel engines are reliable, durable and fuel efficient. They have been a mainstay in transit buses and large trucks. However, diesel emissions of NO_x and particulates cause air quality and public health impacts. Emission standards for heavy-duty engines have become increasingly stringent over the past decade and meeting future standards present significant technological challenges to original equipment manufacturers (OEMs). Generally, the OEMs are looking at several emission control strategies to meet the 2010 emissions standards, including the addition of emission aftertreatment devices such as a combination of NO_x adsorber and particulate filters to reduce nitrogen oxides (NO_x) and particulate matter (PM) emissions, respectively.

This project was initiated to develop, test and qualify a highly cost effective Advanced Diesel Emission Control System (ACECS) for the Volvo MD11 engine that will allow the engine to meet the 2010 regulatory NO_x and PM levels of 0.2 g/bhp-hr and 0.01 g/bhp-hr, respectively. The test engine was equipped with a catalyzed diesel particulate filter (DPF) and a selective catalytic reduction (SCR) and programmed with two different engine calibrations, namely the low-NO_x and the low fuel-consumption (low-FC). The complete exhaust aftertreatment was developed to meet the 2010 emission standards for heavy-duty diesel engines. The two engine calibrations considered produced different exhaust conditions; hence, the DPF was challenged with two different DPF loadings and exhaust temperatures. In particular, due to the presence of a DOC upstream of the

Figure 10: Volvo MD11 engine with ADECS on the test bed in WVU Engine and Emissions Research Laboratory (EERL)

SCR, the exhaust temperature determined the NO_2 level and, depending on the value of NO_2/NO ratio, was responsible of the overall NO_x conversion efficiency of the SCR. Therefore, the DOC-DPF-SCR integrated system was challenged to respond to different exhaust conditions while maintaining the emissions at the desired levels. In particular, the urea dosage injection strategy accounted for the different NO_x levels and exhaust temperatures associated with the two engine calibrations. Furthermore, the soot produced by the low-NO_x and low-FC maps led to varying frequencies of passive and active regeneration of the DPF.

The tailpipe brake specific NO_x result was obtained with the low-NO_x/low-PM map, which produced 0.19 g/bhp-hr over the ESC cycle and 0.23 g/bhp-hr for FTP with only minimal ammonia slip, below 10 ppm, which indicated an accurate urea calibration. The low engine-out NO_x (slightly below 1 g/bhp-hr) and the SCR efficiency of 77% enabled attainment of the 2010 $_{NOx}$ standards. The high engine-out PM over an FTP (0.3 g/bhp-hr) was efficiently filtered by the DPF to the regulated standard of 0.01 g/bhp-hr. The DOC oxidized nearly 100% of the total HC and 99% of the CO emissions to well below the regulatory standards. This calibration could be engaged during low loads and low exhaust temperature and cold start conditions of the engine operation, where the SCR performance would drop dramatically

The calibration techniques developed in this study can be employed by engine manufacturers to significantly reduce their development time. The novel combination of the engine modifications, DPF, SCR, pre-SCR exhaust and urea mixers and the low-NO_x/high PM and low FC calibration schemes offer a very attractive technology for not only new engines, but also retrofitting older engines to achieve the 2010 emission.

Stationary Fuel Cell Demonstration

Fuel cells are advanced clean air technologies with potential for extremely high efficiencies, power independence and most, importantly, reduced or near-zero air pollutant emissions. However, cost has been the major barrier to fully realizing the air quality benefits of fuel cell technology due to low production rates. In recognition of the high initial cost of fuel cells, SCAQMD is joining efforts with private entities and public agencies to co-sponsor several fuel cell projects within the South Coast Air Basin. One such project involves the collaboration of SCAQMD, Alliance Power, Inc., California Public Utilities (Self-Generation Program), Fuel Cell Energy (FCE), TST-Timco and California Metals Coalition to install, operate and maintain two 250 kW (DFC3000A) FCE molten carbonate fuel cell units for a combined heat and power at TST-Timco facility. In addition, the project secondary objectives were to further the creation of niche markets for fuel cells, provide an incentive for businesses to install fuel cells to accelerate commercialization, gain operational experience, develop a reliable database and achieve public awareness for the efficiency and air quality benefits.

Figure 11: 250 kW Fuel Cell Unit

The FCE Molten Carbonate Direct Fuel Cell power plants produce electricity using methane from natural gas or other alternative gaseous fuels. Within the fuel cell process, the methane is converted to hydrogen, which then reacts with oxygen (from ambient air) to generate electricity. The DFC300A fuel cell has a rated electrical efficiency of 45% (LHV) and is certified by the California Air Resources Board

(CARB) with 0.07 pound (lb) or less NO_x, 0.10 lb or less of CO and 0.02 lb or less of VOC per MWh.

The fuel cell cogeneration system installed at the TST facility has successfully operated since August 2006. The following table summarizes the fuel cell performance during the 12-month:

Table 4: Fuel Cell Performance from August 2006 thru July 2007

Parameter	Unit 52	Unit 53
Rated Fuel Cell Capacity (kW)	250 kW	250 kW
Total Operating Hours (hrs)	7,828 Hrs	8,175 Hrs
Total Time in Period (hrs)	8,568 Hrs	8,568 Hrs
Availability (%)	91 %	95 %
Total Energy Produced (kWh)	1,865,626 kWh	1,923,057 kWh
Average Electric Output (kW)	238 kW	235 kW
Peak Electric Output (kW)	260 kW	249 kW
Capacity Factor (%)	87 %	90 %
Fuel Usage (BTU)	13,688 mmBTUs	15,265 mmBTUs
Heat Rate (BTU/kWh) LHV	7,337 BTUs / kWh	7,938 BTUs / kWh
Electrical Efficiency (%) LHV	47 %	43 %

Performance data collected during this project add to the demonstrated successful operating experience for stationary, molten carbonate fuel cells. Molten carbonate fuel cells provide the highest electrical efficiency of any currently available distributed generation technology for base-load applications in the 0.5 to 5 MW size range, with significantly lower air pollutant emissions, including carbon dioxide (CO_2). Since this project was completed, over 6 MW of additional DFC fuel cell generating capacity has been installed in California, including 3 projects (2.5 MW) nearing completion in the SCAQMD. The DFC molten carbonate fuel cell technology is commercially-ready product for the distributed generation market. Increased demand for the equipment is needed to reduce production costs and make the technology cost-competitive without financial incentives.

Develop, Demonstrate & Certify Medium-Duty NG Engine to Meet 2010 Emission Standards

Early generation natural gas engines employed stoichiometric combustion concepts. Stoichiometric combustion offers low emissions potential when combined with three-way catalysts. However, traditional stoichiometric engine technology had been limited by high in-cylinder temperatures, leading to very high engine out NOx emissions, knock limited power density, poor thermal efficiency and lower durability.

Historically, Cummins Westport Inc.'s (CWI) natural gas engines have utilized spark ignition (SI) and lean-burn combustion in order to provide a significantly improved combination of emissions, torque, durability and fuel economy vs. traditional stoichiometric engines. However, lean combustion SI systems are likely to experience difficulties in achieving future NOx and NMHC reductions, as further leaning of the air/fuel ratio mixtures to reduce NOx would result in ignition and combustion difficulties.

This project was to develop, demonstrate and certify CWI's natural gas engine to meet the 2010 Federal and California emission standards by 2007. Analysis and experimental data showed that a compelling combination of low emissions, increased power density and increased fuel efficiency could be achieved by utilizing cooled exhaust gas recirculation (EGR) with a stoichiometric combustion principle, in combination with a three-way exhaust catalyst. CWI refers to this technology collectively as SI-EGR technology. This program resulted in commercial release of the ISL G engine with SI-EGR technology.

The ISL G has been commercially launched and has replaced CWI's C Gas Plus and L Gas Plus engines in North America. ISL G was targeted at urban bus and refuse collection truck markets initially. CWI worked with most major North American bus and refuse truck OEMs during the ISL G development program, thus leading to broad OEM availability of ISL G in 2007. CWI is pursuing ISL G availability in additional medium- and heavy-duty vehicle applications (e.g., street sweepers, medium-duty trucks, yard hostlers, shuttle buses and school buses) and is working with OEMs in each of these market segments. ISL G availability in these applications is anticipated to begin in 2008.

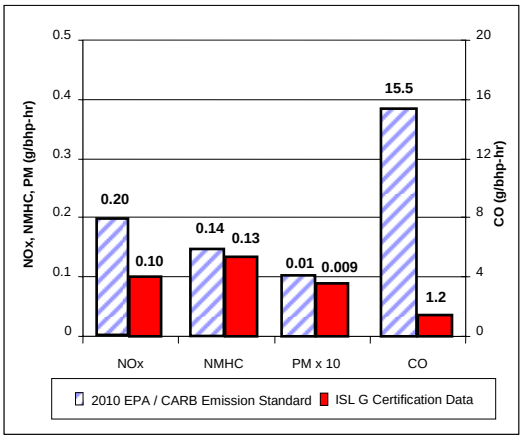


Figure 12: 2010 Standard vs. ISL G Data

Plug-In Hybrid Electric Vehicle Development and Demonstration

Plug-in hybrid electric vehicles are hybrid vehicles with larger batteries that can be recharged to enable longer distances traveled without engine operation and higher overall fuel economy. For longer trips, they can also be refueled by gasoline or other alternative fuel, depending on design. Reducing the number of engine cold starts, increasing zero emission distance traveled and increasing fuel economy provide important emission reductions, especially in disproportionately impacted urban areas.

The University of California (UC) Davis has a long history of developing mechanical continuously variable transmissions for plug-in hybrid electric vehicles. The UC Davis Yosemite PHEV (converted Ford Explorer) has a 15 kWh battery which is much larger than commercially available hybrids, has a larger electric motor and decreased internal combustion engine to about one-third the size of the conventional vehicle.

This project evaluated the plug-in sports utility vehicle (SUV) performance and efficiency using modeling tools developed by UC Davis and data from the UC Davis Yosemite SUV and analyzed the benefits of incorporating a continuously variable transmission (CVT) over a discrete gear transmission in a plug-in hybrid electric sport utility vehicle.

The Yosemite PHEV was demonstrated in operation to the US DOE during Future Truck competition in 2003-2004. DOE Future Truck competitors must accomplish goals to reduce greenhouse gas emissions, criteria tailpipe

Figure 13: UC Davis Converted Ford Explorer to Plug-In Hybrid Electric

emissions and fuel consumption, without compromising vehicle safety, performance, utility, or value. In 2003, UC Davis placed second overall. Research results were also presented at the 2004 International CVT and Hybrid Transmission Congress.

Results of the development and testing of the plug-in SUV (compared to baseline gasoline Ford Explorer 4WD) include 67% reduction in greenhouse gas emissions, 80% reduction in petroleum consumption, 30 mpgge, 0-60 mph acceleration in 7.0 seconds and California SULEV tailpipe emissions or lower.

Fuel Cell Vehicle Maintenance Facility

A facility to support service, maintenance and testing of fuel cell powered vehicles was needed to support operation of a fleet of zero-emission vehicles (ZEV) within the South Coast Air Basin in conjunction with the USDOE Fuel Cell Technology Validation Program.

Designing new or modifying existing facilities to accommodate hydrogen fuel cell vehicles safely have been based on tailoring established building codes and standards which govern gasoline and natural gas. Such tailoring has involved case-by-case interpretations of non-hydrogen codes and standards to hydrogen. In the absence of well defined codes and standards for this type of facility, an engineering and analytical approach was used to design the hydrogen safety systems for the workshop. This project demonstrated the application of a Computational Fluid Dynamic (CFD) method used to model the proposed workshop design to predict the most probable behavior of potential leaking hydrogen within the facility.

Figure 14: Fuel Cell Vehicle Maintenance Facility in Long Beach

The application of the hydrogen detection and mitigation technology that was used to make the DCRTNA workshop safe for hydrogen vehicles is not breakthrough and has existed for many years. What is new is the use of CFD modeling tools to develop and prove out the design of a hydrogen detection and mitigation system. Use of this modeling in the design of future facilities can be used to minimize the additional cost of constructing or retrofitting fuel cell vehicle maintenance facilities and enable faster zero emission vehicle deployment.

Table 5: Projects Completed Between January 1, 2008 & December 31, 2008

Contract	Contractor	Project Title	Date
Incentive Programs-Alternative Fuels			
01157	Waste Management of Los Angeles	Purchase 20 Natural Gas Refuse Trucks	Jun-08
01159	Waste Management of San Gabriel	Purchase 20 Natural Gas Refuse Trucks	Jun-08
Infrastructure and Deployment			
03099	Sanitation Districts of Los Angeles	Purchase & Install LNG-L/CNG Refueling Station at Puente Hills Landfill Facility	Jul-08
03102	USA Waste of California, Inc.	Purchase & Install LNG-L/CNG Refueling Station at La Metro Hauling District	Jun-08
06018†	American Honda Motor Co., Inc.	Incentive Buydown Program for CNG Home Refueling Appliance	Mar-08
Fuels/Emission Studies			
08319	California State University Long Beach Foundation	Student Educational Study to Assess Mixing Effectiveness of a Rotary Cylinder in Improving Diesel NO_x Reduction of an SCR System	Dec-08
Emission Control Technologies			
05067	Cummins, Inc.	Demonstrate Advanced Diesel Emission Control System in Low-Sulfur Diesel-Fueled Heavy-Duty Engines	Jan-08
05196	West Virginia University Research Corporation	Demonstrate & Evaluate Advanced Diesel Emission Control System in Low-Sulfur Diesel-Fueled Heavy-Duty Engines	Aug-08
Electric/Hybrid Technologies			
04019	University of California Davis	Optimization & Demonstration of Plug-In Hybrid Electric Vehicles	Jan-08
Engine Technologies			
05244	Cummins Westport, Inc.	Develop, Demonstrate & Certify Heavy-Duty Natural Gas Engine to Meet 2010 Emission Standards	Apr-08
Hydrogen Technologies and Infrastructure			
04009†	Energy Conversion Devices, Inc.	Integrate & Develop an ICE Hybrid Vehicle Utilizing Metal Hydrides for On-Board Hydrogen Storage	Jan-08
06209	City Engines, Inc.	Develop & Demonstrate Heavy-Duty Hydrogen & Natural Gas Mixture Engine	Aug-08
07033	SunLine Transit Agency	Expand Reformer System & Upgrade Hydrogen Refueling Station in Coachella Valley	Sep-08
08223†	BMW of North America LLC	BMW Hydrogen Seven-Vehicle Lease Agreement	May-08

Table 5: Projects Completed Between January 1, 2008 & December 31, 2008

Mobile Fuel Cell Technologies

04003	DaimlerChrysler RTNA, Inc.	Install & Demonstrate Fuel Cell Vehicle Maintenance Facilities in Long Beach	May-08
04126†	American Honda Motor Co., Inc.	Lease of One Honda Fuel Cell Electric Vehicle	May-08
05104	Alliance Power, Inc.	Stationary Fuel Cell Demonstration in South Coast Air Basin	Sep-08
08218†	General Motors Corporation	No-Cost Loan Agreement for GM Fuel Cell Vehicle	May-08

Stationary Clean Fuels Technology

03292	Occidental College, Los Angeles	Professional Wet Cleaning Technology Demonstration & Pilot Incentive Program	Dec-08
07017	Gas Technology Institute	Field Demonstration of 5-PPM FIR Burner on a Watertube Boiler	Jul-08

Outreach and Technology Transfer

02114	Gladstein, Neandross & Associates, LLC	Outreach Support of Low-Emission Clean Fuel Heavy-Duty Vehicles	Feb-08
04097	CALSTART	Ongoing Operation & Improved Functionality of Clean Air Maps Internet Website	Jun-08
05008	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership & Provide Support for Regional Coordinator	Jul-08
05101†	Joseph C. Calhoun, P.E., Inc.	Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle Technologies	Jan-08
06147†	Pinnacle	Consulting Services in Preparation of Mobile Source Emissions Element of 2007 AQMP	Mar-08
06161†	Saint Malo Solutions	Consulting Services in Preparation of Mobile Source Emissions Element of 2007 AQMP	Mar-08
07360†	Gladstein, Neandross & Associates, LLC	Host the Southern California Clean Vehicle Technology Expo 2007	Jan-08
08053†	Electric Drive Transportation Association	Co-Sponsor EVS23-Sustainability: The Future of Transportation Electric Vehicle Symposium	Feb-08
08189†	CALSTART	Co-Sponsor the 8th Annual Clean Heavy-Duty Vehicle Conference	Aug-08
08190†	Alternative Fuel Vehicle Institute	Co-Sponsor the Alternative Fuels & Vehicles National Conference & Expo 2008	Aug-08
08191†	Western Riverside Council of Governments	Co-Sponsor 9th Annual WRCOG's Advancing the Choice Event	May-08
08193†	Gladstein, Neandross & Associates, LLC	Co-Host Faster Freight-Cleaner Air 2008 Conference	Aug-08
08222†	Western States Section of the Combustion Institute	Co-Sponsor the 2008 Semiannual Technical Meeting	Mar-08

Table 5: Projects Completed Between January 1, 2008 & December 31, 2008

Outreach and Technology Transfer (continued)

08227†	Coordinating the Research Council, Inc.	Co-Sponsor the 18th Annual On-Road Vehicle Emissions Workshop	Sep-08
08240†	National Hydrogen Association	Co-Sponsor the 19th Annual On-Road Vehicle Emissions Workshop	Oct-08
08241†	California Climate Action Registry	Co-Sponsor CaCAR's 6th Annual Conference	Oct-08
08242†	Gladstein, Neandross & Associates, LLC	Co-Sponsor the Inaugural Low-Carbon Fuels 2008 Conference	Aug-08
08243†	City of South Pasadena	Co-Sponsor the 2nd Clean Air Car Show & Film Festival	Aug-08
08270†	University of California Riverside	Co-Sponsor the Clearing the Air 2008 Conference	Aug-08

†Two-page summary report (as provided in Appendix C) is not required for level-of-effort technical assistance contracts, leases or co-sponsorships, or was unavailable at time of printing this report.

CLEAN FUELS PROGRAM
2009 PLAN UPDATE

Technology Funding Priorities for 2009

The Clean Fuels Program continually seeks to support the deployment of lower emitting technologies. Planning has been and remains an ongoing activity for the program, which must remain flexible to address evolving technologies and the latest progress in the state-of-the-technology. Although the SCAQMD program is significant, especially at a time when both public and private funding available for technology research and development is limited, national and international activities affect the direction of technology trends. The real challenge for the SCAQMD is to identify project or technology opportunities in which its available funding can make a difference in making progressively cleaner technologies a reality in the Basin.

The overall strategy is based in large part on technology needs identified in the AQMP for the Basin and the Governing Board's directives to protect the health of residents of Southern California. The AQMP is the long-term "blueprint" that defines the basin-wide emission reductions needed to achieve ambient air quality standards by 2015 and 2024, the regulatory measures to achieve those reductions, the timeframes to implement these proposed measures and the technologies or types of technologies required to meet these future proposed regulations. As previously identified, the NO_x and VOC emission sources of greatest concern are heavy-duty on-road and off-road and light-duty on-road vehicles.

In addition to providing for specific control measures based on known technologies and control methods, the Clean Air Act has provisions for more general measures based on future, yet-to-be-developed technologies. These "black box" measures are provided under Section 182(e)(5) of the Clean Air Act for regions that are extreme non-attainment areas, such as the South Coast Basin. This 2009 Plan Update includes projects to develop, demonstrate and commercialize a variety of technologies, from near-term to long-term, that are intended to provide solutions to the emission control measures identified in the AQMP.

Within each technical area, there exists a range of projects that represent near-term to long-term efforts. The SCAQMD Clean Fuels Program tends to support development, demonstration and technology commercialization efforts, or deployment, rather than fundamental research. The general time-to-product for these efforts, from long-term to near-term, is described below.

- Technology *development* projects are expected to begin during 2009 with durations of about two years. Additional field demonstrations to gain long-term verification of performance, spanning up to two years, may also be needed prior to commercialization. Certification and ultimate commercialization would be expected to follow. Thus, development projects identified in this plan are expected to result in technologies ready for commercial introduction as soon as 2011. Projects are also proposed that may involve developing emerging technologies that are considered longer term and, perhaps higher risk, but with significant emission reduction potential. Commercial introduction of such long-term technologies would not be expected until 2012 or later.
- More mature technologies, those ready to begin field *demonstration* in 2009, are expected to result in a commercial product in the 2010-11 timeframe. Technologies being field demonstrated generally are in the process of being certified. The field demonstrations provide a controlled environment for manufacturers to gain real-world experience and address any end-user issues that may arise prior to the commercial introduction of the

technology. Field demonstrations provide real-world evidence of a technology's performance to help allay any concerns by potential early adopters.

- *Deployment* or technology commercialization efforts focus on increasing the utilization of clean technologies in conventional applications. It is often difficult to transition users to a non-traditional technology or fuel, even if such a technology or fuel offers significant societal benefits. As a result, it is government's role to support and offset any incremental cost to ensure the transition and use of the cleaner technology. The sustained use and proliferation of these cleaner technologies often depends on this initial support and funding.

Technical Priorities

The SCAQMD program maintains flexibility to address dynamically evolving technologies and incorporating the latest progress. The major technical program areas are identified below with specific project categories discussed in more detail in the following section.

Not all project areas will be funded, due to cost-share constraints, focus on the control measures identified in the AQMP and the availability of suitable projects. The technical areas identified below are clearly appropriate within the context of the current air quality challenges and opportunities for technology advancement. Within these areas there is significant opportunity for SCAQMD to leverage its funds with other funding agencies to expedite the implementation of cleaner alternative technologies in the Basin.

It should be noted, however, that these priorities may shift during the year in keeping with the diverse and flexible "technology portfolio" approach. Changes in priority may occur to (1) capture opportunities such as cost-sharing by the state government, the federal government, or other entities, or (2) address specific technology issues which affect residents within the SCAQMD's jurisdiction. As such, these technical areas are not listed by priority but rather based on proximity to commercialization and large-scale deployment.

Infrastructure and Deployment

The importance of refueling infrastructure cannot be overemphasized for the realization of large deployment of alternative fuel technologies. Significant demonstration and commercialization efforts are underway to support the deployment of natural gas vehicles. CNG and LNG refueling stations are being positioned to support public and private fleet applications as incentives for natural gas vehicles are made available to fleet operators.

Besides these technologies, some key issues that must be overcome for public acceptance involve the development of fire and safety codes and standards, cost and economics of the new fuels, public education and training and emergency response capability. Some of the projects expected to be developed and co-funded for infrastructure development include:

- Development and demonstration of CNG as a vehicle fuel from renewable feedstocks;
- Development and demonstration of advanced, cost effective CNG and LNG stations;
- Deployment of natural gas home refueling appliances for light-duty vehicles;
- Investigation of LNG manufacturing and distribution technologies; and
- Early commercial deployment of alternative fuel light-duty vehicles.

Emissions, Fuels and Health Impacts Studies

The monitoring of pollutants in the Basin is extremely important, especially when focused on a particular sector of the emissions inventory (to identify the technology responsibility) or receptor in the pollution (to assess the potential health risks). Recent studies indicate that smoggy areas can produce irreversible damage to children's lungs. This information highlights the need for further emissions and health studies to identify the emissions from high polluting sectors as well as the health effects from these technologies:

- demonstrate remote sensing to target different high emission applications and sources;
- conduct studies to identify the health risks associated with ultrafines and ambient particulate matter; and
- emissions studies for low blends of ethanol (E10) and blends of biodiesel (>B20).

Emission Control Technologies

Although engine technology research is required to reduce the emissions at the combustion source, post-combustion cleanup methods are also needed to address the current installed base of on-road and off-road technologies. Existing diesel emissions can be greatly reduced with aftertreatment controls such as particulate matter traps (PM traps) and catalysts, as well as lowering the sulfur content or using additives with diesel fuel. Gas-to-Liquid (GTL) fuels, formed from natural gas or other gas rather than petroleum feedstock and emulsified diesel provide low-emission fuels for use in diesel engines. As emissions from engines become lower and lower, the lubricant contributions to VOC and PM emissions become increasingly important. The most promising of these technologies will be considered for funding, specifically:

- evaluation and demonstration of new emerging liquid fuels, including alternative diesel and GTL fuels;
- development and demonstration of advanced aftertreatment technologies for mobile applications (including particulate traps and selective catalytic reduction catalysts);
- development and demonstration of low VOC and PM lubricants for diesel and natural gas engines; and
- development and demonstration of advanced air pollution control equipment.

Electric and Hybrid Technologies

Although no major automobile manufacturer currently produces light-duty passenger EVs, the recent modifications to the state Zero Emission Vehicle (ZEV) regulation have resulted in renewed interest in EVs for fleet and niche applications. The SCAQMD seeks to support projects to address the main concerns regarding cost, battery lifetime, travel range, charging station infrastructure and manufacturer commitment.

There also remains high interest by the major automobile manufacturers for hybrid electric technologies in both light-duty and heavy-duty applications as well as off-road equipment. In particular, diesel and gasoline fueled hybrid electric vehicles and specialty light-duty pure electric vehicles have entered the commercial market. Such vehicles offer the benefits of higher fuel economy and range as well as lower emissions. Hybrid electric technology is not limited to gasoline and diesel engines and can be coupled with natural gas engines, microturbines and fuel cells for further emission benefits. Opportunities to develop and demonstrate technologies that could enable expedited widespread use of electric and hybrid electric vehicles in the Basin include the following:

- demonstration of full performance and niche application battery electric vehicles;
- demonstration of advanced energy storage technologies;
- evaluation and demonstration of light and medium-duty plug-in hybrid electric vehicles;
- demonstration of heavy-duty hybrid vehicles including hydraulic and series hybrid concepts; and
- development and demonstration of hybrid and electric technologies for cargo handling equipment, e.g., linear inductive motors, magnetic levitation and battery-powered container tugs.

Engine Technologies

The use of alternative fuels can provide significant reductions in NO_x and PM emissions, especially in heavy-duty diesel engines for on-road, off-road and marine applications. Natural gas engines have shown significant promise, with the greatest benefit coming from heavy-duty diesel truck and bus replacement with new natural gas vehicles in urban areas.

In order for alternative fuel heavy-duty engines to achieve commercial acceptance and market penetration, their performance, durability and cost-effectiveness, in addition to emissions reduction, must be demonstrated to the end user. Future projects will support the development, demonstration and certification of alternative fuel engines to broaden their application and availability. Specifically, these projects are expected to target the following:

- continued development and demonstration of alternative fuel medium-duty and heavy-duty engines and vehicles;
- demonstration of low- and zero-emission engines for cargo handling activities;
- development and demonstration of clean alternative fuel engines for non-road applications; and
- evaluation of alternative engine systems such as compressed air propulsion and pneumatic plug-in hybrid vehicles.

However, as the 2010 federal limit approaches, the focus by manufacturers has shifted from engine development to deployment in various applications as described in the Infrastructure and Deployment section.

Hydrogen Technologies and Infrastructure

Although hydrogen as a vehicle fuel offers an attractive combination of benefits including zero-tailpipe emissions, petroleum displacement and greenhouse gas reduction strategy, technical hurdles have kept fuel cell vehicles from quickly advancing to commercial deployment. The SCAQMD is dedicated to assisting the federal and state governments in commercializing fuel cell vehicles by supporting the required refueling infrastructure. In particular, the production of hydrogen from renewable sources is of interest, either using photovoltaics and electrolyzer technologies or biomass feedstocks and reformation technologies, due to the potential for lower greenhouse gas emissions compared to conventional fuels. Such renewable energy projects would provide data to help understand and benchmark critical parameters for enabling these technologies.

Furthermore, in order to realize nearer-term air quality benefits, the SCAQMD is actively investigating "bridging" technologies which can fill the gap until fuel cell vehicles become commercially viable. Future projects are expected to include the following:

- development and demonstration of hydrogen-CNG vehicles for medium- and heavy-duty vehicle applications as well as stationary power applications; and
- continued development and demonstration of distributed hydrogen production and refueling stations, including energy stations with electricity and hydrogen co-production and higher pressure (10,000 psi) hydrogen dispensing.

Mobile Fuel Cell Technologies

As mentioned in the previous section, fuel cell vehicles are of high interest due to their zero-tailpipe emissions, petroleum independence and reduced greenhouse gas emissions. Considerable research, development and demonstration efforts are already underway to address these issues by some of the largest automobile manufacturers and fuel suppliers. Yet more work is needed to improve the performance and range of these vehicles, reduce costs, develop a viable fueling infrastructure and obtain public acceptance for a new technology in everyday applications.

The SCAQMD is actively working with the California Fuel Cell Partnership and the California Hydrogen Highway Network to further the commercialization of mobile fuel cells. The 2009 Plan Update identifies key opportunities consistent with both organizations while clearly leading the way for the development and demonstration of mobile applications. Future projects may include the following:

- development and demonstration of cross-cutting fuel cell applications (e.g. plug-in hybrid fuel cell vehicles);
- development and demonstration of fuel cells in off-road and marine applications; and
- demonstration of fuel cell vehicles in controlled fleet applications in the Basin.

Stationary Clean Fuel Technologies

Although stationary source emissions are small compared to mobile sources, there are areas where cleaner technology can be applied to reduce NO_x, VOC and PM emissions. For example, inspections suggest there is a large population of small combustion generators within the Basin that are operating outside their permit limits due to poor maintenance, deliberate tuning for different performance, operation outside equipment design, or changes in fuel quality. Cleaner, more robust distributed generation technologies exist that could be applied to not only improve air quality, but enhance power quality and reduce electricity distribution congestion. Projects conducted under this category may include:

- development and demonstration of low-emission stationary technologies (e.g., low NO_x burners, fuel cells, or microturbines); and
- evaluation, development and demonstration of advanced control technologies for miscellaneous stationary sources.

Target Allocations to Core Technology Areas

Figure 15 below presents the potential allocation of available funding, based on SCAQMD projected program costs of nearly $16.6 million for all potential projects. The expected actual project expenditures for 2009 will be much less than the total SCAQMD projected program cost since not all projects will materialize. The target allocations are based on balancing technology priorities, technical challenges and opportunities discussed previously and near-term versus long-term benefits with the constraints on available SCAQMD funding. Specific contract awards throughout 2009 will be based on this proposed allocation, the quality of proposals received and evaluation of projects against standardized criteria and ultimately SCAQMD Governing Board approval.

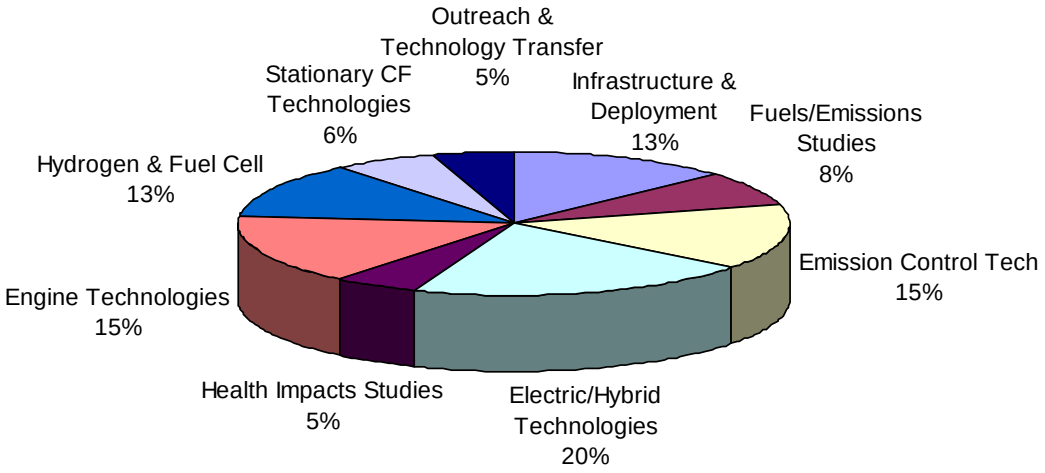


Figure 15: Projected Cost Distribution for Potential SCAQMD Projects 2009 & Beyond ($16.6M)

PROGRAM PLAN UPDATE FOR 2009

This section presents the Clean Fuels Program Plan Update for 2009. The proposed projects are organized by program areas and described in further detail, consistent with the SCAQMD budget, priorities and the best available information. Although not required, this Plan also includes proposed projects that may be funded by revenue sources other than the Clean Fuels Program, specifically related to VOC and incentive projects.

On February 17, 2009, President Obama signed the American Recovery and Reinvestment Act of 2009 (Stimulus Bill) to address the historic national financial crisis. Staff analysis of the Stimulus Bill has indicated large funding opportunities for many technology areas contained within the Clean Fuels Program, most notably electric drive, diesel emission reduction, hydrogen and fuel cell technologies. The SCAQMD has been conducting analyses of funding areas and meeting with different federal agency staff to identify stimulus funding opportunities to complement existing Governing Board policies and initiatives related to research, development, demonstration and deployment. Although the Plan Update already reflects these project areas and these federal activities remain extremely fluid, the SCAQMD will continue to evaluate how the Stimulus Bill may potentially impact the project areas in the Plan Update for 2009, identify areas of potential leveraging, and move forward with plans to seek Stimulus Bill funding for this region to enhance the Plan Update for 2009.

Each of the proposed projects described in this plan, once fully developed, will be presented to the SCAQMD Governing Board for approval prior to contract initiation. This development reflects the maturity of the proposed technology, identification of contractors to perform the projects, host site participation, securing sufficient cost-sharing to complete the project and other necessary factors. Recommendations to the SCAQMD Governing Board will include descriptions of the technology to be demonstrated and in what application, the proposed scope of work of the project and the capabilities of the selected contractor and project team, in addition to the expected costs and expected benefits of the projects as required by H&SC 40448.5.1.(a)(1). Based on communications with all of the organizations specified in H&SC 40448.5.1.(a)(2) and review of their programs, the projects proposed in this plan do not appear to duplicate any past or present projects.

Funding Summary of Potential Projects

The remainder of this section contains the following information for each of the potential projects summarized in Table 6.

Proposed Project: A descriptive title and a designation for future reference.

Expected SCAQMD Cost: The estimated proposed SCAQMD cost share as required by H&SC 40448.5.1.(a)(1).

Expected Total Cost: The estimated total project cost including the SCAQMD cost share and the cost share of outside organizations expected to be required to complete the proposed project. This is an indication of how much SCAQMD public funds are leveraged through its cooperative efforts.

Description of Technology and Application: A brief summary of the proposed technology to be developed and demonstrated, including the expected vehicles, equipment, fuels, or processes that could benefit.

Potential Air Quality Benefits: A brief discussion of the expected benefits of the proposed project, including the expected contribution towards meeting the goals of the AQMP, as required by H&SC 40448.5.1.(a)(1). In general, the most important benefits of any technology research, development

and demonstration program are not necessarily realized in the near term. Demonstration projects are generally intended to be proof-of-concept for an advanced technology in a real-world application. While emission benefits, for example, will be achieved from the demonstration, the true benefits will be seen over a longer term, as a successfully demonstrated technology is eventually commercialized and implemented on a wide scale.

Table 6: Summary of Potential Projects

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Infrastructure and Deployment		
Deploy Natural Gas Vehicles in Various Applications	500,000	5,000,000
Upgrade Natural Gas Infrastructure	1,000,000	1,000,000
Develop and Demonstrate Advanced Natural Gas Systems for Refueling Stations	175,000	4,000,000
Demonstrate Manufacturing and Distribution Technologies including Renewables	500,000	7,000,000
Subtotal	$2,175,000	$17,000,000
Fuels/Emission Studies		
Conduct Emissions Studies on Biofuels	500,000	1,300,000
Identify and Demonstrate In-Use Fleet Emissions Reductions	500,000	2,000,000
Perform Study of Comparative Emissions of Alternative Fuel and Conventional Fuel Engines	250,000	1,000,000
Subtotal	$1,250,000	$4,300,000
Emission Control Technologies		
Develop and Demonstrate Advanced Aftertreatment Technologies	2,000,000	5,200,000
Demonstrate On-Road Technologies in Off-Road and Retrofit Applications	437,500	1,000,000
Subtotal	$2,437,500	$6,200,000
Electric/Hybrid Technologies		
Demonstrate Light-Duty Plug-In Hybrid Electric Vehicles	1,500,000	5,000,000
Develop and Demonstrate Medium- and Heavy-Duty Hybrid Vehicles and Systems	1,000,000	5,000,000
Demonstrate Alternative Energy Storage	250,000	2,600,000
Transfer and Demonstrate Hybrid and Electric Technologies to Conventional Applications	150,000	500,000
Develop and Demonstrate Electric Container Transport Technologies	500,000	5,000,000
Subtotal	$3,400,000	$18,100,000
Engine Technologies		
Develop and Demonstrate Advanced Alternative Fuel Medium- and Heavy-Duty Engines and Vehicles	250,000	4,000,000
Develop and Demonstrate Alternative Fuel and Clean Conventional Fueled Light-Duty Vehicles	750,000	5,000,000
Develop and Demonstrate Clean Container Transport Technologies	1,500,000	5,000,000

Table 6: Summary of Potential Projects

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Engine Technologies (continued)		
Evaluate, Develop and Demonstrate Compressed Air Vehicle Technology	100,000	250,000
Subtotal	$2,600,000	$14,250,000
Hydrogen Technologies and Infrastructure		
Develop and Demonstrate Hydrogen Vehicles	250,000	2,000,000
Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations	1,500,000	9,000,000
Subtotal	$1,750,000	$11,000,000
Mobile Fuel Cell Technologies		
Develop and Demonstrate Fuel Cells in Vehicle Applications	350,000	3,500,000
Subtotal	$350,000	$3,500,000
Health Impacts Studies		
Evaluate Ultrafine Particle Health Effects	312,500	3,000,000
Conduct Monitoring to Assess Environmental Impacts	250,000	1,000,000
Assess Sources and Health Impact of Particulate Matter	250,000	300,000
Subtotal	$812,500	$4,300,000
Stationary Clean Fuel Technologies		
Develop and Demonstrate Low-Cost Emission Monitoring Systems	250,000	500,000
Develop and Demonstrate Clean Stationary Technologies	250,000	750,000
Develop and Demonstrate Renewable-Based Energy Generation Alternatives	475,000	1,000,000
Subtotal	$975,000	$2,250,000
Outreach and Technology Transfer		
Assessment and Technical Support of Advanced Technologies and Information Dissemination	400,000	800,000
Support for Implementation of Various Clean Fuels Vehicle Incentive Programs	400,000	400,000
Subtotal	$800,000	$1,200,000
TOTALS FOR POTENTIAL PROJECTS	**$16,550,000**	**$82,100,000**

Technical Summaries of Potential Projects

Infrastructure and Deployment

Proposed Project: Deploy Natural Gas Vehicles in Various Applications

Expected SCAQMD Cost: $500,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

Natural gas vehicles have been very successful in reducing emissions in the South Coast Air Basin due to the deployment of fleets and heavy-duty vehicles utilizing this clean fuel. In order to maintain the throughput, utility and commercial potential of the natural gas infrastructure and the corresponding clean air benefits, deploying additional models of NGVs in existing applications are needed. This technology category seeks to support the implementation of early-commercial vehicles in a wide variety of applications, such as taxis, law enforcement vehicles, shuttle buses, delivery vans, transit buses, waste haulers, class 8 tractors and off-road equipment such as construction vehicles and yard hostlers.

Potential Air Quality Benefits:

Natural gas vehicles have inherently lower engine criteria pollutant emissions than conventional vehicles, especially in the heavy-duty applications where older diesel engines are being replaced. Incentivizing these vehicles in city fleets, goods movement applications and transit bus routes help to reduce the local emissions and exposure to nearby residents. Natural gas vehicles also can have lower greenhouse gas emissions and increase energy diversity depending on the feedstock and vehicle class. Deployment of additional NGVs is in agreement with the SCAQMD AQMP as well as the state's Alternative Fuels Plan as part of AB1007 (Pavley).

Proposed Project: Upgrade Natural Gas Infrastructure

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

As natural gas fueling equipment begins to age or has been placed in demanding usage, components begin to age and deteriorate. This program offers an incentive to facilities to replace worn-out equipment or to upgrade existing fueling and/or garage and maintenance equipment to offer increased fueling capacity to the public and school districts.

Potential Air Quality Benefits:

While having no direct impact on air emission reductions, new CNG stations will help facilitate the introduction of low-emission, NGVs initially in private and public fleets in the area. Such increased penetration of NGVs will provide direct emissions reductions of NO_x, VOC, CO, PM and air toxic compounds throughout the Basin.

Proposed Project: Develop and Demonstrate Advanced Natural Gas Systems for Refueling Stations

Expected SCAQMD Cost: $175,000

Expected Total Cost: $4,000,000

Description of Technology and Application:

This program would support the development, demonstration and implementation of natural gas fueling station technologies to reduce private investment costs, increase the overall number of such fueling stations in strategic locations throughout the Basin, reduce the cost of natural gas equipment, standardize fueling station design and construction and provide outreach in two key market segments.

Small Refueling Stations. Small private and public fleets are currently constrained in their NGV refueling choices and do not possess in-house expertise or financial resources to design or install a fueling station. They are also unaware of governing codes or standards affecting such an installation. Providing outreach and financial incentives and reducing the cost and improving the safety, reliability and performance life of fueling station equipment could significantly increase the penetration of natural gas fueling stations.

Large Fast-Fill NGV Refueling Stations. Conventional gasoline refueling stations typically refuel between 100 to 300 vehicles per day. The perceived high costs of a fast-fill NGV refueling station that could refuel a similar number of vehicles has significantly curtailed the growth of a NGV refueling infrastructure. The project is intended to provide outreach and financial incentives, advance the technology of compressors, gas-dryers, dispensers, fuel meters and other major subsystems of a NGV fueling station system. The proposed improvements are expected to improve the performance and lower the capital cost and operating costs of fast-fill NGV refueling stations.

Potential Air Quality Benefits:

The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. NGVs have significantly lower emissions than gasoline vehicles and represent the cleanest internal combustion engine powered vehicles available today.

The project would significantly reduce the installation and operating costs of NGV refueling stations, besides improving the refueling time. This would lead to the expansion of the NGV fueling infrastructure and greater consumer acceptance, which in turn should support expedited commercial implementation of NGVs. The increased exposure and fleet and consumer acceptance of NGVs would lead to significant and direct reductions in NO_x, VOC, CO, PM and toxic compound emissions from mobile sources.

Proposed Project: Demonstrate Manufacturing and Distribution Technologies including Renewables

Expected SCAQMD Cost: $500,000

Expected Total Cost: $7,000,000

Description of Technology and Application:

Lack of statewide LNG production results in increased fuel costs and supply constraints. The cost of transporting LNG from production facilities out-of-state increases the fuel cost anywhere from 15 to 20 cents per gallon of LNG and subjects users to the reliability of a single supply source. High capital costs prevent construction of closer, large scale liquefaction facilities. Small-scale, distributed LNG liquefaction systems may provide 25 percent lower capital costs than conventional technology per gallon of LNG produced. Because these smaller plants can be sited near fleet customers, costs for transporting the LNG to end users are much lower than those for remote larger plants. Beyond these cost reductions, the smaller plants offer key benefits of much smaller initial capital investment and wider network of supply than the larger plant model. Renewable feed stocks including landfill gas, green waste and waste gases can be processed to yield LNG or CNG.

Industry and government agree that LNG promises to capture a significant share of the heavy-duty vehicle and engine market. LNG is preferred for long distance trucking as it provides twice the energy per unit volume as CNG. This translates to longer driving ranges and lower-weight vehicle fuel storage.

The main objectives of this project are to investigate, develop and demonstrate:

- commercially viable methods for converting renewable feed stocks into CNG or LNG;
- economic small-scale natural gas liquefaction technologies;
- utilization of various gaseous feed stocks locally available;
- commercialize incentives for fleets to site, install and use LNG and L/CNG refueling facilities; and
- strategic placement of LNG storage capacity sufficient to provide supply to users in the event of a production outage.

Potential Air Quality Benefits:

The SCAQMD relies on the significant penetration of zero- and low-emission vehicles in the South Coast Basin to attain federal clean air standards by 2015 This project would help develop a number of small-scale liquefaction technologies that can reduce LNG costs to be competitive with diesel fuel. Such advances are expected to lead to greater infrastructure development. This would make LNG fueled heavy-duty vehicles more available to the commercial market leading to direct reductions in NO_x, PM and toxic compound emissions.

Fuels/Emission Studies

Proposed Project: Conduct Emissions Studies on Biofuels

Expected SCAQMD Cost: $500,000

Expected Total Cost: $1,300,000

Description of Technology and Application:

Biofuels are one potentially important strategy to reduce petroleum dependence, air pollution and greenhouse gases. Biofuels are in fact receiving increased attention due to national support of and state activities resulting from AB 32, AB 1007 and the Low-Carbon Fuel Standard. These efforts are necessary to address the promulgation and deployment of low greenhouse gas emitting fuels and technologies if the state hopes to meet the 2020 target to reduce GHG emissions to 1990 levels as required by AB 32. However, to ensure that such fuels and technologies have low criteria pollutant emissions, specifically NO_x and PM, the emissions from lower carbon fuels, such as blends of biodiesel and ethanol, must be further analyzed.

In various diesel engine studies, replacement of petroleum diesel fuel with biodiesel fuel has demonstrated reduced PM, CO and air toxics emissions. Biodiesel is also promoted to reduce greenhouse gas emissions because it can be made from renewable feedstocks, such as soy and canola. Biodiesel can be formulated at varying percentages by blending with petroleum diesel fuel and is commonly used at 20 percent or B20 to avoid congealing at cold temperatures and possible engine seal and gasket damage which can occur with 100% biodiesel (B100). Biodiesel and biodiesel blends, however, have demonstrated a tendency to increase NO_x emissions, which exacerbates the ozone and $PM_{2.5}$ challenges faced in the Basin.

Ethanol is another biofuel that is gaining increased national media and state regulatory attention. The amount of ethanol in gasoline is currently 5.7% or E6 to replace the banned MTBE as an oxygenate to reduce CO emissions. There are efforts to further increase the ethanol content to 10% or E10 and higher as a means to increase the amount of renewable fuels in the state. Contemporary light-duty vehicles, however, are not equipped to manage increased levels of ethanol and could result in higher criteria pollutant emissions. As such, an investigation into the tailpipe emissions for commercial gasoline (E6), the certification fuel which is still based on MTBE gasoline and higher ethanol blends (e.g., E10) is warranted.

In December 2007, the Governing Board approved two projects involving emission studies on biofuels. The first project will evaluate the emissions from using biodiesel derived from current and future feedstocks common to California at different blend levels (B5, B20, B50 and B100). This study will include a wide range of pollutants including criteria, toxics, greenhouse gases and non-regulated pollutants. The study will evaluate test engines and vehicles that are common to California and test cycles that represent a range of driving conditions. The study will also evaluate the NO_x impact and investigate possible NO_x mitigation strategies, which may include fuel reformulation, additives and/or minor injection timing changes. The second project will evaluate the emissions from using five different ethanol-gasoline blends in light-duty vehicles. The results of these two projects may provide direction for the next step as well as identify areas that may need to be addressed in future projects.

Potential Air Quality Benefits:

If biodiesel and biodiesel blends can be demonstrated to reduce air pollutant emissions with the ability to mitigate any NO_x impact, this technology will become a viable strategy to assist in meeting air pollutant standards as well as the goals of AB 32 and the Low-Carbon Fuel Standard. The use of

biodiesel is an important effort for a sustainable energy future. Emission studies are critical to understanding the emission benefits and any tradeoffs (NO_x impact) that may result from using this alternative fuel. With reliable information on the emissions from using biodiesel and biodiesel blends, the AQMD can take actions to ensure the use of biodiesel will obtain air pollutant reductions without creating additional NO_x emissions that may exacerbate the basin's ozone problem.

Proposed Project: Identify and Demonstrate In-Use Fleet Emissions Reductions

Expected SCAQMD Cost: $500,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

New technologies, such as alternative fueled heavy-duty engines, are extremely effective at reducing emissions because they are designed to meet the most stringent emissions standards while maintaining vehicle performance. Unfortunately, the in-use fleet--particularly heavy-duty engines in trucks, buses, construction equipment, locomotives, marine vessels and cargo handling equipment--have fairly long working lifetimes (up to 20 years due to remanufacturing in some cases). Even light-duty vehicles routinely have lifetimes exceeding 200,000 miles and 10 years. And it is the in-use fleet, especially the oldest vehicles, which are responsible for the majority of emissions.

This project category is to investigate near-term emissions control technologies which can be economically applied to reduce emissions from the in-use fleet. The first part of the project is to identify and conduct proof-of-concept demonstrations of feasible candidate technologies, such as:

- remote sensing for heavy-duty vehicles;
- annual testing for high mileage vehicles (>100,000 miles);
- replace or upgrade emissions control systems at 100,000 mile intervals;
- on-board diagnostics with remote notification;
- low-cost test equipment for monitoring and identifying high emitters;
- test cycle development for different class vehicles (e.g. four wheel drive SUVs); and
- electrical auxiliary power unit replacements.

The second phase of the project is to validate the technology or strategy on a larger demonstration project over a longer period of time.

Potential Air Quality Benefits:

Many of the technologies identified can be applied to light-duty and heavy-duty vehicles to identify and subsequently remedy high-emitting vehicles in the current fleet inventory. Estimates suggest that 5 percent of existing fleets account for up to 80 percent of the emissions. Identification of higher emitting vehicles would assist with demand-side strategies, where higher emitting vehicles have correspondingly higher registration charges, which is included in Chapter 4 of the 2007 AQMP as a potential control strategy.

Proposed Project: Perform Study of Comparative Emissions of Alternative Fuel and Conventional Fuel Engines

Expected SCAQMD Cost: $250,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

Various makes and models of heavy-duty engines using alternative fuels have been developed and deployed in the Basin. The certification procedure requires laboratory tests on the engine emissions performance as well as those of conventional heavy-duty diesel engines. It is important to assess the emissions performance of these engines in actual operation to determine if the engines are operating properly and the expected benefits of alternative fuels are being realized, including potential toxic emissions.

The objective of this project is to assess the on-road emission performance of heavy-duty engines using alternative fuels, including natural gas, dual fuel and emerging liquid fuels such as Fischer-Tropsch liquids. The testing of equivalent heavy-duty engines using baseline fuels is needed to assess the relative emission performance. Diagnostic procedures will also be performed to help identify any mal-performing system.

Another emerging area of interest is the emissions from biofuels, especially low level blends of ethanol and high level blends of biodiesel. Low level blends of ethanol (E10) may have increased permeation and evaporative emissions from light duty vehicles. Also, a mixture of ethanol concentrations, e.g., between E10 and E85, has unknown tailpipe emissions, so a study to understand these effects is desired. Although there have been extensive studies conducted to quantify tailpipe emissions from biodiesel blends, an in-use emissions study would be useful to quantify the actual performance on a case-by-case basis.

Potential Air Quality Benefits:

This proposed program supports several 2003 AQMP On-Road Mobile Sources Control Measures, including M4, "Heavy-Duty Diesel Vehicles; Early Introduction of Low-NO_x Engines" and M5, "Heavy-Duty Diesel Vehicles; Additional NO_x Reductions in California." Certification of low-emission vehicles and engines and their integration into the Basin's transportation sector, is a high priority under the AQMP and the SIP. In addition, the identification of diesel exhaust particulate as a toxic air contaminant by CARB and the determination that diesel exhaust contributes over 70 percent of the increased cancer risk due to air pollution in the Basin suggest an urgency to expedite the implementation of clean alternatives to diesel engines to protect public health.

This program is intended to evaluate low-emission alternative fuel heavy-duty engine technology and compare such emissions to heavy-duty diesel emissions. For example, the expected benefit of replacing one 4.0 g/bhp-hr heavy-duty diesel engine with a 2.0 g/bhp-hr natural gas engine in a vehicle that consumes 10,000 gallons of fuel per year is about 800 lb/yr. This proposed project will also determine in-use emission performance and provide an indication of actual vs. certified performance.

Emission Control Technologies

Proposed Project: Develop and Demonstrate Advanced Aftertreatment Technologies

Expected SCAQMD Cost: $2,000,000

Expected Total Cost: $5,200,000

Description of Technology and Application:

There are a number of aftertreatment technologies which have shown substantial emission reductions in diesel engines. These technologies include diesel particulate filters (DPFs), oxidation catalysts, selective catalytic reduction (SCR) systems and NO_x adsorbers. This project category is to develop and demonstrate these aftertreatment technologies alone or in tandem with an alternative fuel to produce the lowest possible PM, ultrafine particles, nanoparticles, NO_x, CO, carbonyl and hydrocarbon emissions in retrofit and new applications.

Possible projects include advancing the technologies for on-road retrofit applications such as heavy-duty line-haul diesel engines, street sweepers, waste haulers and transit buses. Applications for non-road may include construction equipment, yard hostlers, gantry cranes, locomotives, marine vessels, ground support equipment and other similar industrial applications. Potential fuels to be considered in tandem are low-sulfur diesel, emulsified diesel, biodiesel, gas-to-liquids, hydrogen and natural gas. This project category will also explore the performance, economic feasibility, viability (reliability, maintainability and durability) and ease-of-use to ensure a pathway to commercialization.

Potential Air Quality Benefits:

The transfer of mature emissions control technologies, such as DPFs and oxidation catalysts, to the non-road sector is a potentially low-risk endeavor that can have immediate emissions reductions. Further development and demonstration of other technologies, such SCR and NO_x adsorbers, could also have NO_x reductions of up to 90%.

Proposed Project: Demonstrate On-Road Technologies in Off-Road and Retrofit Applications

Expected SCAQMD Cost: $437,500

Expected Total Cost: $1,000,000

Description of Technology and Application:

Heavy-duty on-road engines have demonstrated progress in meeting increasingly stringent Federal and state requirements. New heavy-duty engines have progressed from 2 g/bhp-hr NO_x in 2004 to 0.2 g/bhp-hr NO_x in 2007, which is an order of magnitude decrease in just three years. Off-road engines, however, have considerably higher emissions limits depending on the engine size. For example, Tier-3 standards, which took effect in 2006, require only 3 g/bhp-hr NO_x. There are apparent opportunities to implement cleaner on-road technologies in off-road applications. There is also an opportunity to replace existing engines in both on-road and off-road applications with the cleanest available technology. Current regulations require a repower (engine exchange) to only meet the same emissions standards as the engine being retired. Unfortunately, this does not take advantage of recently developed clean technologies.

Exhaust gas cleanup strategies, such as SCR, electrostatic precipitators, baghouses and scrubbers, have been used successfully for many years on stationary sources. The exhaust from the combustion source is routed to the cleaning technology, which typically requires a large footprint for implementation. This large footprint has made installation of such technologies on some mobile sources prohibitive. However, in cases where the mobile source is required to idle for long periods of time, it may be more effective to route the emissions from the mobile source to a stationary device to clean the exhaust stream.

Projects in this category will include utilizing proven clean technologies in novel applications, such as:

- demonstrating certified LNG and CNG on-road engines in off-road applications including yard hostlers, switcher locomotives, gantry cranes, waste haulers and construction equipment;
- implementing lower emission engines in repower applications for both on-road and off-road applications; and
- application of stationary best available control technologies, such as SCR, scrubbers, baghouses and electrostatic precipitators, to appropriate on- and off-road applications, such as idling locomotives, marine vessels at dock and heavy-duty line-haul trucks at weigh stations.

Potential Air Quality Benefits:

The transfer of mature emission control technologies, such as certified engines and SCR, to the non-road and retrofit sectors offers high potential for immediate emissions reductions. Further development and demonstration of these technologies will assist in the regulatory efforts which could require such technologies and retrofits.

Electric/Hybrid Technologies

Proposed Project: Demonstrate Light-Duty Plug-In Hybrid Electric Vehicles

Expected SCAQMD Cost: $1,500,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

All of the major automobile manufacturers are currently developing and commercializing hybrid-electric vehicles, which now come in a variety of fuel economy and performance options. These commercial hybrid electric vehicles integrate a small internal combustion engine, battery pack and electric drive motors to improve fuel economy (e.g., Honda Insight) or performance (e.g., Lexus RX400h).

The SCAQMD has long supported the concept of using increased batteries to allow a portion of the driving cycle to occur in all-electric mode for true zero emission miles. This battery dominant strategy is accomplished by incorporating an advanced battery pack initially recharged from the household grid or EV chargers. This "plug-in" hybrid electric vehicle strategy allows reduced emissions and improved fuel economy. Only recently have the automobile manufacturers openly admitted and publicized pursuit of this strategy.

This project category is to develop and demonstrate: (1) various HEV architectures; (2) anticipated costs for such architectures; (3) customer interest and preferences for each alternative; (4) prospective commercialization issues and strategies for various alternatives; and (5) integration of the technologies into prototype vehicles and fleets to demonstrate the viability and clean air benefits of these types of vehicles.

Innovative approaches to HEV systems are also under development that could improve performance, fuel efficiency and reduce emissions relative to the first HEVs commercially introduced. Innovations that may be considered for demonstration include: advancements in the auxiliary power unit, either ICE or other heat engine, especially using alternative fuels including natural gas and hydrogen; battery-dominant hybrid systems utilizing off-peak re-charging; and advanced battery technologies such as lithium-ion. Both new designs and retrofittable technologies will be considered.

Potential Air Quality Benefits:

The 2007 AQMP identifies zero- or near zero-emitting vehicles as a key attainment strategy. HEV technologies have the potential to achieve near-zero emissions but with the range of a conventional gasoline-fueled vehicle, a factor expected to enhance consumer acceptance. This proposed project will evaluate various HEV systems and their performance and identify the most appropriate protocols with which to test real-world HEVs. Given the variety of HEV systems under development, it is critical to determine the true emissions and performance of HEVs. Demonstration of optimized prototypes would improve the viability of near-ZEV HEV technologies and enhance the deployment of near-ZEV technologies.

Expected benefits include the establishment of criteria for emissions evaluations, performance requirements, customer acceptability of the technology, etc. This will help both regulatory agencies and original equipment manufacturers to expedite introduction of near-zero emitting vehicles in the South Coast Basin, which is a high priority of the AQMP.

Proposed Project: Develop and Demonstrate Medium- and Heavy-Duty Hybrid Vehicles and Systems

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

Hybrid technologies have gained momentum in the light-duty sector with commercial offerings by most all of the automobile manufacturers. Unfortunately, the medium- and heavy-duty platforms are where most emissions reductions are required, especially for the in-use fleet due to low turnover. This project category is to investigate the use of hybrid technologies to achieve similar performance as the conventional fueled counterparts while achieving both reduced emissions and improved fuel economy.

Platforms to be considered include utility trucks, delivery vans, shuttle buses, transit buses, waste haulers, construction equipment, cranes and other off-road vehicles. Innovations that may be considered for demonstration include: advancements in the auxiliary power unit, either ICE or other heat engine; battery-dominant hybrid systems (PHEV) utilizing off-peak re-charging; and hydraulic energy storage technologies where applicable. Alternative fuels are preferred in these projects, e.g., natural gas, LPG, hydrogen, GTL and hydrogen-natural gas blends, but conventional fuels such as gasoline, clean diesel, or even biodiesel may be considered if the emissions benefits can be demonstrated as equivalent or superior to alternative fuels. Both new designs and retrofittable technologies will be considered.

Potential Air Quality Benefits:

The 2007 AQMP identifies zero- or near zero-emitting vehicles as a key attainment strategy. Hybrid technologies have the potential to redirect previously wasted kinetic energy into useable vehicle power. This proposed project category will evaluate various hybrid systems and fuel combinations to identify their performance and emissions benefits. Given the variety of hybrid systems under development, it is critical to determine the true emissions and performance of these prototypes, especially if both emissions and fuel economy advantages are achieved.

Expected benefits include the establishment of criteria for emissions evaluations, performance requirements and customer acceptability of the technology. This will help both regulatory agencies and original equipment manufacturers to expedite introduction of near-zero emitting vehicles in the South Coast Basin, which is a high priority of the AQMP.

Proposed Project: Demonstrate Alternative Energy Storage

Expected SCAQMD Cost: $250,000

Expected Total Cost: $2,600,000

Description of Technology and Application:

The SCAQMD has been involved in the development and demonstration of energy storage systems for electric and hybrid-electric vehicles, mainly lead acid and nickel-cadmium battery packs. Over the past few years, additional technology consisting of nickel sodium chloride and lithium-ion batteries has shown robust performance. Other technology manufacturers have also developed energy storage devices including flywheels, hydraulic systems and ultracapacitors. This project category is to apply these advanced storage technologies in vehicle platforms to identify best fit applications, demonstrate their viability (reliability, maintainability and durability), gauge market preparedness and provide a pathway to commercialization.

The long-term objective of this program is to decrease the fuel consumption without any changes in performance compared to conventional vehicles. This program will support several projects for development and demonstration of different types of low-emission hybrid vehicles using advanced energy strategies and conventional or alternative fuels. The overall net emissions and fuel consumption of these types of vehicles are expected to be much lower than traditional engine systems. Both new and retrofit technologies will be considered.

Potential Air Quality Benefits:

Certification of low-emission vehicles and engines and their integration into the Basin's transportation sector is a high priority under the 2007 AQMP. This program is expected to develop hybrid technologies that could be implemented in medium- and heavy-duty trucks, buses and other applications. Benefits will include proof of concept for the new technologies, diversification of transportation fuels and lower emissions of criteria, toxic pollutants and greenhouse gases.

Proposed Project: Transfer and Demonstrate Hybrid and Electric Technologies to Conventional Applications

Expected SCAQMD Cost: $150,000

Expected Total Cost: $500,000

Description of Technology and Application:

Current battery electric technology may be applicable to a number of applications beyond conventional passenger cars. For example, studies conducted by a number of different parties suggest that a high percentage of consumer/commuter driving patterns total no more than 25 miles a day. From an air quality perspective, it may be particularly advantageous to identify and implement zero-emission vehicles in conditions where low mileage and heavy stop-and-go duty cycles are prevalent.

The objective of this program area is to identify and demonstrate applications that can best utilize zero- and near zero-emission technologies, such as neighborhood electric vehicles, electric scooters, passenger trams and low-speed cargo tugs. Applications to be included in this program include, but are not limited to, station cars, shared cars, fixed route fleets and other innovative applications, with potential linkages to transit through intelligent transportation systems.

The development of energy efficient systems reduces emissions associated with energy generation and is a criterion for projects funded under this category.

Potential Air Quality Benefits:

The 2007 AQMP identifies zero- and nearly zero-emitting ventures as a key attainment strategy. This project would demonstrate the viability of zero-emission technologies in innovative applications. Other benefits would include increased exposure and user acceptance of advanced technologies, direct emission reductions from in-basin demonstrations and the potential for increased use and resulting emission reductions of the demonstrated technologies through their expedited commercialization.

Proposed Project: Develop and Demonstrate Electric Container Transport Technologies

Expected SCAQMD Cost: $500,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

Advanced transport systems can be used to transfer cargo containers from the ports to both local and "distant" intermodal facilities, thereby significantly reducing emissions from on-road trucks and locomotives and will also reduce traffic congestion in local transportation corridors. Such systems use magnetic levitation (maglev), linear synchronous motors or linear induction motors on dedicated guideways. Containers are transported relatively quietly and without direct emissions. The footprints for such systems are similar to conventional rail systems but have reduced impact on adjacent property owners including noise and fugitive dust. These systems can even be built above or adjacent to freeways or on the berm of or elevated above existing river flood control channels. Container freight systems are not designed to carry any operators or passengers on the guideways. Current container transport concepts have been developed by General Atomics with California State University, Long Beach (GA-CSULB) and the Texas Transportation Institute (TTI). GA-CSULB has built a prototype system at GA's San Diego facility using maglev. This Electric Cargo Conveyor (ECCO) demonstration moves 20-foot containers. The elevated ECCO system costs about $100M per mile and $1.50 per container-mile for operation. TTI's concept for its "Freight Shuttle System" (FSS) uses linear induction propulsion in combination with steel wheels on a flat steel running surface, similar to conventional rail. The elevated FSS system costs about $20M per mile and $0.10 per mile in operating costs. Both systems utilize a lightweight carriage in which the containers are carried. Automatic cranes can be used to load and unload the containers.

Potential Air Quality Benefits:

On-road heavy-duty diesel truck travel is an integral part of operations at the ports moving cargo containers into the Basin and beyond. The 2007 AQMP proposes to reduce emissions from this activity by modernizing the fleet and retrofitting NO_x and PM emission controls on older trucks. An alternative approach, especially for local drayage to the nearby intermodal facilities, is to use advanced container transport systems. These use electric propulsion for the containers on fixed guideways and eliminate local diesel truck emissions. The emission benefits have not yet been estimated because the fate of the displaced trucks has not been determined.

Engine Technologies

Proposed Project: Develop and Demonstrate Advanced Alternative Fuel Heavy-Duty and Medium-Duty Engines and Vehicles

Expected SCAQMD Cost: $250,000

Expected Total Cost: $4,000,000

Description of Technology and Application:

The objective of this proposed program is to support development and certification of near commercial prototype low-emission heavy-duty alternative fuel engine technologies and demonstration of these technologies in on-road vehicles. The NO_x emissions target for this program area is 0.2 g/bhp-hr and PM emissions target is below 0.01 g/bhp-hr. This program is expected to result in several projects, including:

- demonstration of advanced engines in medium-duty and heavy-duty vehicles;
- development of durable and reliable retrofit technologies to convert engines and vehicles from petroleum fuels to alternative fuels; and
- anticipated fuels for these projects include but are not limited to CNG, LNG, LPG, emulsified diesel and GTL fuels. The program proposes to expand field demonstration of these advanced technologies in various vehicle fleets operating with different classes of vehicles.

The use of alternative fuel in heavy-duty trucking applications has been demonstrated in certain local fleets within the Basin. These vehicles typically require 200-300 horsepower engines. Higher horsepower alternative fuel engines are beginning to be introduced. However, vehicle range, lack of experience with alternative fuel engine technologies and limited selection of appropriate alternative fuel engine products has made it difficult for more firms to consider significant use of alternative fuel vehicles. For example, in recent years, several large trucking fleets have expressed interest in using alternative fuels. However, at this time the choice of engines over 350 HP or more is limited. Continued development of cleaner dedicated natural gas or other alternative fuel engines such as natural gas-hydrogen blends over 350 HP would increase availability to end-users and provide additional emission reductions.

Potential Air Quality Benefits:

This program is intended to expedite the commercialization of low-emission alternative fuel heavy-duty engine technology in California, both in the Basin and in intrastate operation. The emission reduction benefit of replacing one 4.0 g/bhp-hr heavy-duty engine with a 0.2 g/bhp-hr engine in a vehicle that consumes 10,000 gallons of fuel per year is about 1400 lb/yr of NO_x. Clean alternative fuels, such as natural gas, or natural gas blends with hydrogen can also reduce heavy-duty engine particulate emissions by over 90 percent compared to current diesel technology. This program is expected to lead to increased availability of low-emission alternative fuel heavy-duty engines. Fleets can use the engines and vehicles emerging from this program to comply with SCAQMD fleet regulations.

Proposed Project: Develop and Demonstrate Alternative Fuel and Clean Conventional Fueled Light-Duty Vehicles

Expected SCAQMD Cost: $750,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

Although new conventional fueled vehicles are much cleaner than their predecessors, not all match the lowest emissions standards often achieved by alternative fuel vehicles. This project would assist in the development, demonstration and certification of both alternative-fueled and conventional-fueled vehicles to meet the strictest emissions requirements by the state, e.g., SULEV for light-duty vehicles. The candidate fuels include CNG, LPG, ethanol, gas-to-liquid (GTL), bio-diesel and ultra low-sulfur diesel. The potential vehicle projects may include:

- certification of CNG light-duty sedans and pickup trucks used in fleet services;
- resolution of higher concentration ethanol (E-85) affect on vehicle fueling system ("permeation issue");
- certification of E85 vehicles to SULEV standards; and
- assessment of "clean diesel" vehicles, including hybrids and their ability to attain SULEV standards.

Other fuel and technology combinations may also be considered under this category.

Potential Air Quality Benefits:

The 2007 AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. Pursuant to AQMP goals, the SCAQMD has in effect several fleet rules that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. This program is expected to lead to increased availability of low-emission alternative-and conventional-fueled vehicles for fleets as well as consumer purchase.

Proposed Project: Develop and Demonstrate Clean Container Transport Technologies

Expected SCAQMD Cost: $1,500,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

At the ports of San Pedro Bay, cargo containers are moved from the docks either by railroad train or by truck. Generally speaking, railroad trains move containers long distances (greater than 500 miles) while trucks are used for shorter hauls (less than 400 miles). Because of limited rail capacity at the dock, many containers are also moved individually by truck to railroad intermodal yards 4 to 20 miles away (drayage) where the containers are then loaded on to trains for their long-distance trips. In order to reduce truck emissions and roadway congestion, various systems have been proposed to move containers over dedicated guideways using electrical propulsion. However, such systems cost from $20M to $100M per mile to construct. Two alternatives have been proposed: 1) short-haul shuttle trains using ultra-low-emission locomotives; 2) and drayage truck trains with multiple container trailers using ultra low-emission truck tractors. Ultra low-emission technologies such as LNG, CNG, SCR, particulate filters including DPFs, diesel oxidation catalysts (DOCs) and hybrid drive trains are available for locomotives and truck tractors.

It is proposed that a short-haul shuttle train with ultra low-emission locomotives be demonstrated in the South Coast Air Basin. This will involve developing and demonstrating the above stated emission technologies on freight locomotives. In addition, a system for building such trains will need to be developed for locally bound containers, likely at the railroad intermodal yards. While the economics of a shuttle train will be less attractive than a long-haul train, the cost effectiveness for emission reductions will be competitive with other emission strategies when considering the reductions from displaced trucks and eliminated traffic congestion.

The second proposal is to develop and demonstrate "truck container trains" to minimize drayage emissions. Such "trains" would use low-emission natural-gas truck tractors and travel at reduced speeds on either dedicated lanes on existing roadways, or on dedicated roadways. In order for such a system to be viable, the natural-gas truck tractors would need to be reconfigured to handle the excessive load of multiple trailers as well as to minimize emissions. Also, existing container trailer chassis would need to be revised in order to handle tandem trailers. (Three-trailer trucks are allowed on highways in certain states and four-trailer trucks are used in Australia). This project would develop the specifications for the natural-gas truck tractor, determine the optimum number of containers that could be trailored, determine a specification for the revised container trailer chassis and suggest regulatory and legislative changes that would be needed for operating such a system. Following this design effort, a demonstration project would be expected.

Potential Air Quality Benefits:

On-road heavy-duty diesel trucks are an integral part of operations at the ports by moving cargo containers into the Basin and beyond. The 2007 AQMP proposes to reduce emissions from this activity by modernizing the fleet and retrofitting NO_x and PM emission controls on older trucks. An alternative approach is to use "advanced container transport systems" which cost from $20M to $100M per mile for about 5 miles. The proposed short-haul shuttle train with ultra-low-emission locomotives will cost much less and eliminate one to two hundred truck trips per train from the ports and the associated traffic congestion. Similarly, the truck container train will cost much less than the container transport system and have emission benefits greater than modernizing or retrofitting the fleet because fewer truck tractors will be needed. Nonetheless, new truck tractors and revised container trailer chassis will need to be developed and purchased with a net cost probably more than modernizing the fleet. However, the emission benefits will be greater and proportional to the number

of containers included in the container train since one truck trip will be eliminated for each extra container.

Proposed Project: Evaluate, Develop and Demonstrate Compressed Air Vehicle Technology

Expected SCAQMD Cost: $100,000

Expected Total Cost: $250,000

Description of Technology and Application:

Pneumatic engines derive their power from the expansion of high pressure air. These motors may be either a turbine or reciprocating type motor. The high pressure air used to drive the motor is stored on-board the vehicle in dedicated storage cylinders. The energy extracted from the air is solely attributable to its storage at high pressure, since air does not contain any intrinsic energy. The lack of intrinsic energy requires a relatively large volume of air to be stored at a pressure in the vicinity of 4500 psi to have any appreciable energy storage. The requirement for such high pressure air will necessitate either a centralized filling network of large compressors, or a distributed system of smaller home compressors, or a combination of the two. However, even the high pressure home filling compressors will be significantly more sophisticated than the low pressure compressors used for filling automobile tires.

The energy density of compressed air is significantly less than the liquid fuels currently used for transportation. The reduced energy density will limit the use of a vehicle solely powered compressed air. A vehicle solely powered by compressed air will be limited to applications comparable to a neighborhood electric vehicle, which has a limited driving range and operating speed. These vehicles must be small and extremely lightweight to offset the limited energy storage associated with compressed air.

A dual fuel version of the air motor could be developed to compensate for the limited energy density of compressed air. A combination of compressed air and the combustion of a fossil fuel could enable a vehicle to be operated for extended ranges at speeds greater than those attainable by a neighborhood vehicle. The use of an engine powered by compressed air and fossil fuels would be comparable in concept to a plug-in hybrid electric vehicle.

Potential Air Quality Benefits:

The program is intended to investigate the feasibility and potential applications of using compressed air as an energy storage medium for vehicular transportation. The use of stored energy in the form of compressed air will enable a more diverse and potentially cleaner, energy portfolio to be used for vehicular transportation. Current transportation fuels are predominantly liquid fossil fuels. Storing electrical energy in the form of compressed air could enable the use of renewable energy sources, such as wind, solar, hydroelectric and geothermal, in addition to traditional sources, such as nuclear and natural gas fueled power plants, to be used for transportation.

Hydrogen Technologies and Infrastructure

Proposed Project: Develop and Demonstrate Hydrogen Vehicles

Expected SCAQMD Cost: $250,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

The SCAQMD has been involved in the development and demonstration of light-duty and heavy-duty vehicles operating on hydrogen as their primary fuel including a full-size transit bus. Hydrogen burning ICE vehicles provide a transition platform to advance hydrogen refueling technologies, gain valuable experience with hydrogen as a vehicle fuel and promote cleaner fuels to the public. The proposed project category is to continue developing and demonstrating additional platforms, including light-duty vehicles, which can be utilized in city fleets and medium-duty shuttles, which can be operated in city and airport fleets.

Potential Air Quality Benefits:

Certification of low-emission vehicles and engines and their integration into the Basin's transportation sector are a high priority under the 2007 AQMP. This program is expected to develop hybrid technologies that could be implemented in medium- and heavy-duty trucks, buses and other applications. Benefits will include proof of concept for the new technologies, diversification of transportation fuels and lower emissions of criteria and toxic pollutants.

Proposed Project: Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations

Expected SCAQMD Cost: $1,500,000

Expected Total Cost: $9,000,000

Description of Technology and Application:

Alternative fuels, such as hydrogen and the use of advanced technologies, such as fuel cell vehicles, may be necessary to meet future clean air standards. A key element in the widespread acceptance and resulting increased use of alternative fuel vehicles is the development of an infrastructure to support the refueling of vehicles, cost-effective production and distribution and clean utilization of these new fuels.

A major challenge to the entry and acceptance of direct-hydrogen fuel cell vehicles is the limited number of hydrogen refueling sites. This program would support the development and demonstration of hydrogen refueling technologies. Proposed projects would address:

- *Fleet and Commercial Refueling Stations:* Further expansion of the hydrogen fueling network based on retail models, providing renewable generation, other strategic refueling locations and increased dispensing pressure of 10,000 psi and compatibility with existing CNG stations may be considered.
- *Energy Stations*: Multiple-use energy stations that can produce hydrogen for fuel cell vehicles or for stationary power generation are considered an enabling technology with the potential for costs competitive with large-scale reforming. System efficiency, emissions, hydrogen throughput, hydrogen purity and system economics will be monitored to determine the viability of this strategy for hydrogen fueling infrastructure deployment and as a means to produce power and hydrogen from renewable feedstocks (biomass, digester gas, etc.).
- *Home Refueling Appliances*: Home refueling/recharging is an attractive advancement for alternative clean fuels due to the limited conventional refueling infrastructure. Similar to the natural gas home refueling appliance currently commercially available, this project would evaluate a hydrogen home refueler for cost, compactness, performance, durability, emission characteristics, ease of assembly and disassembly, maintenance and operations. Other issues such as building permits, building code compliance and UL ratings for safety would also be evaluated.

Potential Air Quality Benefits:

The 2007 AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. Pursuant to AQMP goals, the SCAQMD has in effect several fleet rules that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. Fuel cell vehicles constitute the cleanest alternative-fuel vehicles today. Since hydrogen is a key fuel for fuel cell vehicles, this program would address some of the barriers faced by hydrogen as a fuel and thus assist in accelerating its acceptance and ultimate commercialization. In addition to supporting the immediate deployment of the demonstration fleet, expanding the hydrogen fuel infrastructure should contribute to the market acceptance of fuel cell technologies in the long run, leading to substantial reductions in NO_x, VOC, CO, PM and toxic compound emissions from vehicles.

Mobile Fuel Cell Technologies

Proposed Project: Develop and Demonstrate Fuel Cells in Vehicle Applications

Expected SCAQMD Cost: $350,000

Expected Total Cost: $3,500,000

Description of Technology and Application:

This proposed project would support the demonstration of promising fuel cell technologies for applications using direct hydrogen in proton exchange membrane (PEM) fuel cell technologies. Battery fuel cell hybrids are another potential technology being mentioned by battery experts as a way of reducing costs and enhancing performance of fuel cell vehicles.

With the implementation of the California Hydrogen Highway Network, supplemented by the existing and planned hydrogen refueling stations in the Southern California area, pre-production vehicles are planned for demonstration in controlled fleets, such as local cities, transit authorities and airports. Some of these pre-production vehicles include light-duty trucks as well as small to full size transit and shuttle buses. Fleets are useful demonstration sites because economies of scale exist in central refueling, in training skilled personnel to operate and maintain the vehicles, in the ability to monitor and collect data on vehicle performance and for manufacturer technical and customer support. These vehicles could include hybrid-electric vehicles powered by fuel cells and equipped with batteries capable of being charged from the grid and even supplying power to the grid. This category may include projects in the following applications:

On-Road:
- Light-Duty Vehicles
- Transit Buses
- Shuttle Buses
- Medium-Duty Trucks (Utility or Other)

Non-Road:
- Vehicle Auxiliary Power Units
- Construction Equipment
- Lawn and Garden Equipment
- Cargo Handling Equipment

Potential Air Quality Benefits:

The 2007 AQMP identifies the need to implement zero-emission vehicles. SCAQMD adopted fleet regulations require public and some private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. In the future, such vehicles could be powered by zero-emission fuel cells operating on hydrogen fuel. The proposed projects have the potential to accelerate the commercial viability of fuel cell vehicles. Expected immediate benefits include the establishment of zero- and near zero-emission proof-of-concept vehicles in numerous applications. Over the longer term, the proposed projects could help foster widescale implementation of zero-emission fuel cell vehicles in the Basin. The proposed projects could also lead to significant fuel economy improvements, manufacturing innovations and the creation of high-tech jobs in Southern California, besides realizing the air quality benefits projected in the AQMP.

Health Impacts Studies

Proposed Project: Evaluate Ultrafine Particle Health Effects

Expected SCAQMD Cost: $300,000

Expected Total Cost: $3,000,000

Description of Technology and Application:

Reducing diesel exhaust from vehicles has become a high priority in the South Coast Air Basin since CARB identified the particulate phase of diesel exhaust as a surrogate for all of the toxic air contaminant emitted from diesel exhaust. Additionally, recent health studies indicate that the ultrafine portion of particulate matter may be more toxic than other fractions. Several technologies have been introduced and are under development to reduce diesel emissions. These include among others low-sulfur diesel fuel, particulate matter traps and heavy-duty engines operating on alternative fuel such as CNG and LNG. To have a better understanding of changes in ultrafine particulate emissions from the application of these technologies and the health effects of these emissions, an evaluation and comparison of ultrafine particulate matter and the potential impacts on community exposures are necessary.

In this program, engine or chassis dynamometer testing will be conducted on heavy-duty vehicles to measure, evaluate and compare ultrafine particulate matter, PAH and other relevant toxic emissions from different types of fuels such as CNG, low-sulfur diesel, etc. These tests may also include comparisons with the application of particulate matter retrofit traps. This program needs to be closely coordinated with the development of new aftertreatment technologies for alternative fuels and new engines. Additionally, epidemiologic and toxicological studies will be conducted as well as measurements of ambient levels to better understand the health effects and potential community exposures from ultrafine particles.

Potential Air Quality Benefits:

The 2007 AQMP relies on the significant penetration of low-emission vehicles in the South Coast Basin to attain federal clean air standards by 2010. Reduction of particulate emissions from the use of diesel fuel is a major priority in achieving these standards. This project would help to better understand the nature and amount of ultrafine particulates generated by different types of fuels and advanced control technologies as well as provide information on potential health effects of ultrafine particles. Such an understanding is important to assess the emission reduction potentials and health benefits of these technologies. In turn, this will have a direct effect on the policy and regulatory actions for commercial implementation of alternative fuel vehicles in the Basin.

Proposed Project: Conduct Monitoring to Assess Environmental Impacts

Expected SCAQMD Cost: $250,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

Facilities, buildings, structures, or highways which attract mobile sources of pollution are considered "indirect" sources. Ambient air monitoring near sources such as ports, airports, rail yards, distribution centers and freeways is important to identify the emissions exposure to the surrounding communities and provide the data to then conduct the health impacts due to these sources. The SCAQMD is currently monitoring particulate air quality at several Long Beach sites, Wilmington and Carson. This project category would identify other areas of interest to conduct ambient air monitoring, conduct the emissions monitoring, analyze the data and assess the health impacts from the sources. The projects would need to be at least one year in duration in order to properly assess the air quality impacts in the area.

Potential Air Quality Benefits:

The proposed project will assist in the evaluation of adverse public health impacts associated with indirect sources. The information will be useful in (a) determining whether indirect sources have a relatively higher impact on residents living in close proximity; and (b) providing guidance to develop some area-specific control strategies in the future should it be necessary.

Proposed Project: Assess Sources and Health Impacts of Particulate Matter

Expected SCAQMD Cost: $250,000

Expected Total Cost: $300,000

Description of Technology and Application:

Previous studies of ambient levels of toxic air contaminants, such as the MATES series of studies, have found that diesel exhaust is the major contributor to health risk from air toxics. Analyses of diesel particulate matter in ambient samples have been based on measurements of elemental carbon. While the bulk of particulate elemental carbon in the South Coast Air Basin is thought to be from combustion of diesel fuels, it is not a unique tracer for diesel exhaust.

The MATES III study collected particulate samples at ten locations in the South Coast Air Basin. Analysis of particulate bound organic compounds was utilized as tracers to estimate levels of ambient diesel particulate matter as well as estimate levels of particulate matter from other major sources. Other major sources that were taken into consideration include automobile exhaust, meat charbroiling, road dust, wood smoke and fuel oil combustion. Analyzing for organic compounds and metals in conjunction with elemental carbon upon collected particulate samples was used to determine contributing sources.

The measurement of organic compounds as tracers from specific sources is a technique that has been used in numerous source apportionment studies and published within the scientific literature. The resulting data on levels of tracers can be evaluated using Chemical Mass Balance Models and other source apportionment techniques, such as Positive Matrix Factorization, to estimate source contributions to particulate matter. The resulting estimates of ambient diesel particulate matter can then be used to assess potential health risks.

Additionally, other related studies may be conducted, such as toxicity assessment based on age, source (heavy-duty, light-duty engines) and composition (semi-volatile or non-volatile fractions) to better understand the health effects and potential community exposures.

Potential Air Quality Benefits:

Results of this work will provide a more robust, scientifically sound estimate of ambient levels of diesel particulate matter as well as levels of particulate matter from other significant combustion sources. This will allow a better estimation of potential exposures to and health effects from toxic air contaminants from diesel exhaust in the South Coast Air Basin. This information in turn can be used to determine the health benefits of promoting clean fuel technologies.

Stationary Clean Fuel Technologies

Proposed Project: Develop and Demonstrate Low-Cost Emission Monitoring Systems

Expected SCAQMD Cost: $250,000

Expected Total Cost: $500,000

Description of Technology and Application:

Currently, the inability of air/fuel ratio control (AFRC) systems to keep rich-burn engines in compliance contributes significantly to air pollution in the basin. Low-cost emission monitoring systems are needed for small-to-intermediate size combustion devices, including stationary engines, boilers, heaters, furnaces and ovens that are not large enough to justify a continuous emission monitoring system (CEMS). This class of combustion device is often permitted on the basis of a single demonstration or periodic demonstrations of NO_x and CO emissions meeting SCAQMD rule requirements or a RECLAIM concentration limit. However, SCAQMD unannounced tests on engines and boilers, have found that in many cases NO_x and/or CO levels have increased significantly above levels that have been initially or periodically demonstrated due to equipment malfunction and/or inadequate operator attention. It is suspected that the same may be true of heaters, furnaces and ovens.

Demonstrations of newer technologies in recent years could result in a commercially viable alternative to CEMs that is both reliable and feasible in terms of lower costs. For example, manufacturers of flue gas analyzers have, in recent years, developed low-cost multi-gas analyzers suitable for portable or stack-mounted use. Some preliminary testing of a new type of AFRC, which uses a different type of O2 sensor known as a wide-band O2 sensor, is another alternative that can be analyzed. A more technical approach might to deploy technology utilizing the O2 signature of a post-catalyst O2 sensor and additional control concepts being developed by manufacturers. Since an underlying problem has been that engine, catalyst and AFRC manufacturers have developed systems independently, a system being co-developed to perform continuous diagnostics to assist operators in keeping rich-burn engines in compliance is possibly another alternative for demonstration.

Potential Air Quality Benefits:

The 2007 AQMP indicates that in 2010 stationary sources, i.e., stationary engines, boilers, heaters, furnaces and ovens, will account for about 11 percent of total NO_x emissions and about 6 percent of total CO emissions. There has been a long-standing compliance problem with rich-burn IC engines in the basin and evidence indicates that many of these devices are operating with NO_x and/or CO emissions above levels required in their permits. Projects could potentially reduce a significant class of NO_x and CO emissions that are in excess of the assumptions in the AQMP and further enhance SCAQMD's ability to enforce full-time compliance.

Proposed Project: Develop and Demonstrate Clean Stationary Technologies

Expected SCAQMD Cost: $250,000

Expected Total Cost: $750,000

Description of Technology and Application:

Stationary sources, including VOC sources such as large printing facilities and furniture manufacturers, have become cleaner and cleaner due to the regulatory requirements for low emissions and the advancements in technology to meet those requirements. Best Available Control Technology (BACT) regulations, however, are only required for new, modified, or relocated sources. This project category is to develop and demonstrate new technologies that can provide emissions reductions in new installations or as retrofit modifications. Possible technology examples include:

- low NO_x technologies (burners and ICEs);
- low-Btu gas technologies (e.g., digester, landfill, or diary gases);
- alternative fuels and hydrogen blends;
- alternative diesel fuels (emulsified, gas-to-liquids, biodiesel with aftertreatment);
- low-emission refinery flares;
- catalytic combustion;
- cost-effective fuel cell and fuel cell hybrid distributed generation;
- fumes-to-fuel technology to replace thermal oxidizers and capture VOC emissions for electricity generation while ensuring no emission of air toxics; and
- boiler optimization design and strategies to improve efficiencies.

Depending on the technology, a proof-of-concept project, demonstration, or pre-commercial deployment would be considered to garner further information on the technology. Issues to investigate include viability (reliability, maintainability and durability) of the technology, cost-effectiveness and operator ease-of-use in order to assess commercialization.

Potential Air Quality Benefits:

The SCAQMD has a substantial number of older, small, stationary source technologies within its jurisdiction. Since these devices are not subject to continuous emissions monitoring system requirements, evidence suggests that these devices may not be operating at their permitted NO_x, CO, hydrocarbon and PM emissions levels. Replacing these devices with cleaner and more reliable technologies or technology/fuel combinations can have dramatic reductions in all of these criteria pollutants. VOC emission reductions may also be achieved at larger stationary VOC sources to achieve the new federal ozone and $PM_{2.5}$ standards.

Proposed Project: Develop and Demonstrate Renewable-Based Energy Generation Alternatives

Expected SCAQMD Cost: $475,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

The objective of this proposed program is to support the development and demonstration of clean energy, renewable alternatives in stationary and mobile applications. The technologies to be considered include thermal, photovoltaic and other solar energy technologies; wind energy systems; energy storage and conservation; biomass conversion; and other renewable energy and recycling technologies. Innovative solar technologies, such as solar thermal air conditioning and photovoltaic-integrated roof shingles, are of particular interest. Also, in the agricultural sections of the Basin, wind technologies could potentially be applied to drive large electric motor-driven pumps to replace highly polluting diesel-fired pumps. Besides renewable technologies, using electrolyzer technology could be used to generate hydrogen, a clean fuel. Hydrogen, when used in regular engines, can substantially reduce tail-pipe emissions, while in fuel cells the emissions are reduced to zero.

The project is expected to result in pilot-scale production demonstrations, scale-up process design and cost analysis, overall environmental impact analysis and projections for ultimate clean fuel costs and availability. This program is expected to result in several projects addressing technological advancements in these technologies that may improve performance and efficiency, potentially reduce capital and operating costs, improve reliability and user friendliness and identify markets that could expedite the implementation of successful technologies.

Potential Air Quality Benefits:

The 2007 AQMP identifies the development and ultimately the implementation of non-polluting power generation. To gain the maximum air quality benefit, polluting fossil fuel-fired electric power generation needs to be replaced with clean renewable energy resources or other advanced zero emission technologies, such as hydrogen fuel cells, particularly in a distributed generation context.

The proposed program is expected to accelerate the implementation of advanced zero-emission energy sources. Expected benefits include directly reducing the emissions by the displacement of fossil generation; proof-of-concept and potential viability for such zero-emission power generation systems; increased exposure and user acceptance of the new technology; reduced fossil fuel usage; and the potential for increased use, once successfully demonstrated, with resulting emission benefits, through expedited implementation. These technologies would also have a substantial influence in reducing global warming emissions.

Outreach and Technology Transfer

Proposed Project: Assessment and Technical Support of Advanced Technologies and Information Dissemination

Expected SCAQMD Cost: $400,000

Expected Total Cost: $800,000

Description of Project:

This program supports the assessment of clean fuels and advanced technologies, their progress towards commercialization and the dissemination of information on demonstrated technologies. The objective of this program is to expedite the transfer of technology developed as a result of Technology Advancement projects to the public domain, industry, regulatory agencies and the scientific community. This program is a fundamental element in the SCAQMD's outreach efforts to expedite the implementation of low-emission and clean fuels technologies and to coordinate these activities with other organizations.

This program may include the following:

- technical review and assessment of technologies, projects and proposals;
- support for alternative fuel refueling and infrastructure;
- advanced technology curriculum development, mentoring and outreach to local schools;
- emissions studies and assessments of zero-emission alternatives;
- advanced technology vehicle demonstrations
- preparation of reports, presentations at conferences, improved public relations and public communications of successful demonstrations of clean technologies;
- participation in and coordination of workshops and various meetings;
- support for training programs related to fleet operation, maintenance and refueling of alternative fuel vehicles;
- publication of technical papers, reports and bulletins; and
- production and dissemination of information, including web sites.

These objectives will be achieved by consulting with industry, scientific, health, medical and regulatory experts and co-sponsoring related conferences and organizations, resulting in multiple contracts. In addition, an ongoing outreach campaign will be conducted to encourage decision-makers to voluntarily switch to alternatively fueled vehicles and train operators to purchase, operate and maintain these vehicles and associated infrastructure.

Potential Air Quality Benefits:

SCAQMD adopted fleet regulations requiring public and private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. Expected benefits of highlighting success stories in the use of advanced alternatively fueled vehicles could potentially expedite the acceptance and commercialization of advanced technologies by operators seeking to comply with the provisions of the recently adopted SCAQMD fleet rules. The resulting future emissions benefits will contribute to the goals of the AQMP.

Proposed Project: Support for Implementation of Various Clean Fuels Vehicle Incentive Programs

Expected SCAQMD Cost: $400,000

Expected Total Cost: $400,000

Description of Project:

This program supports the implementation of zero-emission vehicle incentives program, the Carl Moyer incentives program and the school bus incentives program. Implementation support includes application approval, grant allocation, documentation to the CARB, verification of vehicle registration and other support as needed. Information dissemination is critical to successful implementation of a coordinated and comprehensive package of incentives. Outreach will be directed to vehicle dealers, individuals and fleets.

Potential Air Quality Benefits:

As described earlier, the SCAQMD will provide matching funds to implement several key incentives programs to reduce diesel emissions in the Basin. Furthermore, the SCAQMD recently adopted fleet regulations requiring public and private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. Expected benefits of highlighting zero-emission vehicle incentives could potentially expedite the acceptance and commercialization of advanced technologies by operators seeking to comply with the provisions of the recently adopted SCAQMD fleet rules. The resulting future emissions benefits will contribute to the goals of the AQMP. The school bus program and the Carl Moyer incentives program will also reduce large amounts of NO_x and PM emissions in the basin in addition to reducing toxic air contaminants.

Appendix A

SCAQMD Advisory Groups

Technology Advancement Advisory Group

Tom Cackette	California Air Resources Board
Tim Carmichael	Coalition for Clean Air
Dr. Blair Folsom	Independent Consultant in Combustion Technology
James Uihlein	Chevron
John D. Harper, Jr.	Small Business Coalition
Philip J. Hodgetts	Clean Air Now
Pending Appointment	U.S. Department of Transportation
Dr. Sigmund Gronich.	U.S. Department of Energy
Pending Appointment	Port-Related
Charles Mitzutani	California Energy Commission
Dan Moran	Quality Body Works
Lee Wallace	Sempra Energy
William R. West	Southern California Edison

SB 98 Clean Fuels Advisory Group

Tom Plenys	Coalition for Clean Air
Dr. Blair Folsom	Independent Consultant in Combustion Technology
Dr. John Froines	UCLA Center for Occupational and Environmental Health/UCLA School of Public Health
Dr. Fritz Kalhammer	Independent Consultant in Energy and Process Technology
Jason Mark	Energy Foundation
Dr. Melanie Marty	Office of Environmental Health Hazard Assessment
Dr. Wayne Miller	Center for Environmental Research and Technology University of California, Riverside
Dr. Vernon Roan	Center for Advanced Studies in Engineering University of Florida
Brian Runkel	California Environmental Business Council, Inc.
Dr. Scott Samuelsen	Combustion Laboratory/National Fuel Cell Research Center/University of California, Irvine
Dr. George Sverdrup	National Renewable Energy Laboratory
Dr. Nicholas Vanderborgh	Independent Consultant in Fuel Cell Technologies
Michael Walsh	Independent Consultant in Motor Vehicle Pollution Control

Appendix B

Open Clean Fuels Contracts as of January 1, 2009

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Incentive Programs-Alternative Fuels						
04167	Foothill Transit	Purchase 75 CNG Transit Buses under FY 2002-03 Carl Moyer Program	05/25/05	01/31/10	727,500	727,500
04169	City of Santa Monica	Purchase 57 New LNG Transit Buses under FY 2002-03 Carl Moyer Program	08/04/04	09/30/10	407,732	407,732
04171	City of Santa Clarita	Purchase 12 New CNG Transit Buses under FY 2002-03 Carl Moyer Program	07/28/04	07/31/10	126,000	4,203,432
Infrastructure and Deployment						
03098	Taormina Industries	Develop LNG-L/CNG Fueling Station	11/26/02	07/31/09	203,682	213,000
04015	WM Energy Solutions, Inc.	LNG Production at Bradley Landfill	11/06/03	09/30/09	300,000	5,277,000
04085	City of Banning	Construct Natural Gas Fueling Station	03/26/04	08/31/09	140,000	725,000
05109	Orange County Sanitation Districts	Upgrade CNG Fueling Station in Fountain Valley	02/04/05	02/28/10	24,000	80,000
05135	Sysco Food Services of Los Angeles, Inc.	Purchase & Install New LNG Fueling Station at City of Walnut Food Distribution Center	05/25/05	03/31/10	250,000	1,102,476
05250	Downs Commercial Fueling, Inc.	Purchase & Install New L/CNG Fueling System at Commercial Fueling Station in Temecula	11/04/05	12/31/10	$203,137	$833,333
06000	Gas Equipment Systems, Inc.	Purchase & Install New CNG Fueling System at County of LA Dept. of Beaches and Harbors' Malibu Facility	09/05/06	12/31/12	150,000	525,000
06017	Fuelmaker Corporation	Incentive Buydown Program for CNG Home Fueling Appliance	09/26/05	12/31/09	496,000	596,000
06028	Consolidated Disposal Service, LLC	Purchase & Install CNG Fueling System at Long Beach Waste Transfer Station	11/23/05	12/31/11	222,038	740,127
06029	Clean Energy	Upgrade CNG Fueling Station at SoCalGas Santa Monica Facility	10/26/05	12/31/11	190,000	634,500
06030	Clean Energy	Purchase & Install CNG Fueling Station at Foothill Transit's Pomona Facility	04/13/06	12/31/11	92,506	250,000
06031	R.F. Dickson Company, Inc.	Upgrade CNG Station at Bellflower Facility	04/13/06	12/31/11	211,148	703,828
06042	UCLA Fleet & Transit Services	Upgrade Existing CNG Public Access Station with Dispenser & Card Reader	09/05/06	12/31/11	15,921	31,842
06043	County Sanitation Districts of Los Angeles	Purchase & Install CNG Fueling Station at Joint Water Pollution Control Plant in Carson City	03/10/06	12/31/11	250,000	850,000
06074	City of Sierra Madre	Purchase & Install New Public Access CNG Fueling Station at City Yard	03/16/06	12/31/11	73,776	368,880
06082	Clean Energy	Purchase & Install New 24-Hour Public Access CNG Fueling Station at SoCalGas's Canoga Park Facility	03/13/06	12/31/11	250,000	842,050

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment (continued)						
06084	Clean Energy	Upgrade Existing LNG Facility to L/CNG at Riverside County Waste Management Dept's Aqua Mansa Facility in Riverside	04/13/06	12/31/11	120,000	400,000
06091	City of Whittier	Purchase & Install New Public Access CNG Fueling Station at City Yard	03/18/06	12/31/11	150,000	450,000
06139	Lake Elsinore Unified School District	Purchase & Install New Public Access CNG Fueling Station at Maintenance Yard	06/29/06	12/31/11	128,000	367,000
06237	Whittier Union High School District	Upgrade Existing Public Access Station with New Dispenser and Card Reader	10/02/06	12/31/12	15,921	31,842
06238	Gas Equipment Systems Inc.	Purchase & Install New CNG Fueling Systems at City of San Fernando Public Works Dept Yard	12/15/06	12/31/12	73,200	486,000
07014	Gas Equipment Systems Inc.	Purchase & Install New CNG Fueling System at County of Los Angeles, Dept. of Beaches & Harbors Facility In Zuma Beach	12/15/06	12/31/12	150,000	525,000
07051	City of Pasadena	Purchase & Install New Public Access CNG Fueling Station	12/28/06	12/31/12	165,000	550,000
07149	City of San Bernardino	Purchase & Install New Public Access LNG-L/CNG Station at City of San Bernardino Municipal Service Yard	06/25/07	12/31/12	164,861	1,399,110
07151	Menifee Unified School District	Purchase & Install New Public Access CNG Station	01/25/07	12/31/12	75,000	414,500
07152	Newport-Mesa Unified School District	Purchase & Install New Limited Public Access CNG Station	05/16/07	12/31/12	150,000	375,000
07243	City of Commerce	Purchase & Install New Public Access L/CNG Station	05/16/07	12/31/12	250,000	1,300,000
07244	SunLine Transit Agency	Upgrade Existing Public Access CNG Stations in Thousand Palms & Indio	04/04/07	12/31/12	90,000	180,000
07245	USA Waste of California, Inc., dba L.A. Metro	Purchase & Install New LNG Production Facility using Landfill Gas from Altamont Landfill in Livermore	07/11/08	12/31/13	300,000	13,000,000
07246	USA Waste of California, Inc., dba L.A. Metro	Purchase & Install New LNG Storage Tank at Long Beach LNG Refueling Station	12/24/08	12/31/13	200,000	440,000
07253	Colton Joint Unified School District	Local Match to Purchase & Install CNG Station	03/19/07	12/31/09	170,000	1,348,408
07320	Orange County Transportation Authority	Install New CNG Station in the City of Santa Ana	12/21/07	12/31/12	350,000	5,841,729
08033-1	California Air Resources Board	Demonstrate LPG Stop-Fill Unit	06/25/07	06/24/10	75,000	498,900
08043	University of California Los Angeles	Public Access CNG Refueling Station Upgrade for UCLA Transportation	05/02/08	12/31/13	140,000	350,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment (continued)						
08098	Redlands Unified School District	Purchase & Install New CNG Refueling Station	01/25/08	12/31/13	525,000	700,000
08101	Pupil Transportation Cooperative	Upgrade Existing Public Access CNG Station	12/31/07	12/31/13	187,154	300,000
08271	Los Angeles Unified School District	Purchase & Install New CNG Refueling Station	06/03/08	12/31/13	617,480	1,747,000
09165	California Cartage Company	Deployment of 2010 Emissions Standards Compliant LNG Trucks	10/31/08	07/31/16	358,000	11,880,000
Fuels/Emission Studies						
00188	University of California, Riverside	Testing Support & Emissions Assessment	07/17/00	07/31/09	100,000	100,000
06157	City of Santa Monica	Develop & Demonstrate Biodiesel Fuel with Selective Catalytic Reduction	06/26/06	06/30/09	140,000	280,000
06086	West Virginia University	Perform Emissions Testing of up to Four Cleaire Longview Systems on Waste Collection Vehicles	01/17/07	04/30/09	180,000	180,000
07020	California Air Resources Board	Analysis of Liquefied Petroleum Gas Samples	08/30/06	06/30/09	10,000	20,000
07054	West Virginia University	Conduct In-Use Emissions Testing of Refuse Trucks	12/13/06	05/31/09	740,000	740,000
07181	California Air Resources Board	Physical, Chemical & Toxilogical Assessment of the Semi-Volatile & Non-Volatile Fraction of PM	04/01/06	04/01/10	338,975	677,950
07196	California Air Resources Board	Environmental Justice Saturation Monitoring of Selected Pollutants in Wilmington	01/01/06	12/31/09	100,000	400,000
08033-2	California Air Resources Board	Test Particulate Measurement Device for In-Use Vehicles	06/25/07	06/24/10	125,000	504,514
08263	University of California Riverside/CE-CERT	Evaluate Emissions Impacts from Diesel Biofuel & Biofuel Blends	08/12/08	11/30/09	150,000	1,630,000
08304	Maschinenbau Haldenwang GmbH & Company KG	Pilot Program to Assess Feasibility of Enhancing Smog Check Tests in the South Coast Air Basin	07/16/08	03/01/09	99,423	373,847
09095	University of California Riverside/CE-CERT	Evaluate Emissions Impacts of Ethanol Blend Ratio for Light-Duty Vehicles	10/31/08	09/30/09	250,000	250,000
Emission Control Technologies						
01173	National Renewable Energy Lab	Advanced Diesel Fuels, Engines, NOx Absorber Catalyst & Diesel Particulate Filter Project for Heavy-Duty Engine Application	06/11/01	12/31/09	260,000	1,920,435
07236	National Renewable Energy Laboratory	Investigate the Role of Lubricating Oil on Particulate Matter Emissions from Vehicles	03/23/07	12/31/09	200,000	446,887
08033-3	California Air Resources Board	Demonstrate Retrofit SCR System for NOx Emission Reduction Using Crystalline Matrix Storage for Ammonia	06/25/07	06/24/10	78,500	338,268

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Emission Control Technologies (continued)						
08068	Johnson Matthey Inc.	Develop & Demonstrate SCR Technology for NOx and PM Emissions	12/14/07	01/31/09	254,000	731,500
08244	Albert W. Davies, Inc.	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	05/22/08	11/30/09	45,650	158,170
08246	Griffith Company	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	05/14/08	11/30/09	74,550	180,550
08252	City of Culver City	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	07/08/08	09/30/09	38,900	138,475
08261	Community Recycling & Resource Recovery, Inc.	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	12/12/08	09/30/09	363,250	590,895
08272	ECCO Equipment Corporation	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	09/28/08	09/30/09	17,600	17,600
08318	ServoTech Engineering Inc.	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	07/08/08	12/15/09	320,000	990,420
09018	Placer County Air Pollution Control District	Develop & Demonstrate Stationary Emission Control System for Locomotives	09/24/08	05/31/10	50,000	1,132,000
09150	Advanced Cleanup Technologies, Inc.	Develop & Demonstrate Stationary Emission Control System for Marine Vessels	12/05/08	02/28/09	55,000	598,240
Electric/Hybrid Technologies						
99109	Toyota Motor Credit Corporation	Three-Year Lease of Two RAV4 Electric Vehicles	04/04/99	02/01/09	38,742	38,742
04032	Electric Power Research Institute	Develop, Demonstrate & Evaluate Plug-In Hybrid-Electric Vans in Fleet Use	04/27/04	03/31/10	475,000	1,525,000
05260	Energy Control Systems Engineering, Inc.	Conversion of Light-Duty Vehicle to Plug-In Hybrid Vehicles	09/09/05	10/31/09	130,000	539,000
06182	ISE Research Corporation	Develop & Demonstrate a Natural Gas Hybrid-Electric Transit Bus	08/25/06	08/31/09	300,000	1,050,000
07265	Descanso Gardens	Demonstrate Electric Tram	04/20/07	01/20/09	96,000	121,000
07293	Balqon Corporation	Develop & Demonstrate Electric Tow Tractor for Transportation Containers from Shipping Terminals	04/27/07	06/30/09	527,000	527,000
08063	Quantum Fuel Systems Technologies Worldwide, Inc.	Develop & Demonstrate 20 Plug-In Hybrid Electric Vehicles	12/31/07	12/15/14	2,095,613	2,815,266

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Electric/Hybrid Technologies (continued)						
08067	Calstart	Demonstrate Hydraulic-Hybrid Shuttle Bus	10/30/07	03/31/10	250,000	1,210,000
08294	Balqon Corporation	Purchase & Demonstrate an Electric Yard Hostler	05/15/08	05/31/10	300,000	300,000
08334	CALSTART	Demonstrate Heavy-Duty Hybrid Electric Vehicle for Parcel Delivery Application	10/16/08	09/30/10	325,000	595,000
09017	U.S. Environmental Protection Agency	Develop & Demonstrate Hydraulic-Hybrid Shuttle Bus	10/10/08	10/09/11	500,000	1,960,000
Engine Technologies						
07306	Emission Solutions, Inc.	Develop, Demonstrate & Certify Heavy-Duty Natural Gas Engine Meeting 2010 Emission Standards	06/28/07	03/31/09	400,000	1,200,000
08037	Thomas Built Buses, Inc.	Integrate & Demonstrate Cummins Westport ISL-G Natural Gas Engine in a Thomas Built School Bus Chassis	01/09/08	03/31/09	250,000	343,250
08146	Blue Bird Corporation	Integrate & Demonstrate Cummins Westport ISL-G Natural Gas Engine in Blue Bird School Bus Chassis	05/15/08	03/31/09	250,000	338,000
08161	Engine, Fuel & Emissions Engineering, Inc.	Demonstrate NOx & PM Emissions Control on Construction Equipment	12/31/07	02/28/09	135,830	330,850
08192	Westport Power, Inc.	Develop & Demonstrate 2010 Compliant LNG Heavy-Duty Truck	01/25/08	05/31/10	2,250,000	9,894,027
08224	BAF Industries	Develop & Certify Natural Gas-Powered Pickup Trucks	05/09/08	12/31/09	250,000	675,000
Mobile Fuel Cell Technologies						
04004	Mercedes-Benz USA, LLC	Demonstrate Two Fuel Cell Vehicles at SCAQMD in Diamond Bar	02/04/05	06/04/09	240,000	1,240,000
05122	Plug Power Inc.	Demonstrate 3 PEM Stationary Fuel Cells in South Coast Air Basin	03/14/05	07/31/09	257,500	572,604
07356	ISE Research Corporation	Upgrade & Demonstrate Fuel Cell Bus	11/02/07	08/31/09	325,000	1,275,000
08301	American Honda Motor Company, Inc.	Lease of Two Honda Fuel Cell Electric Vehicles	06/25/08	06/24/09	12,990	12,990
08335	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership in FY 2008 & Provide Support for Regional Coordinator	12/20/08	07/31/09	137,800	2,297,274
Hydrogen Technologies and Infrastructure						
03201	University of California, Irvine	Develop & Demonstrate Hydrogen Fueling Stations in Orange County	10/16/03	11/30/09	863,400	983,400
04011	Air Products and Chemicals, Inc.	Install & Demonstrate an Industrial Pipeline-Supplied Hydrogen Fueling Station in Torrance	08/03/05	12/31/10	489,051	944,761

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Hydrogen Technologies and Infrastructure (continued)						
04111	Stuart Energy	Maintenance & Data Management for the SCAQMD Hydrogen Fueling Station	02/16/05	02/16/09	80,000	80,000
04185	Quantum Fuel Systems Technologies Worldwide	Develop & Demonstrate Hydrogen Internal Combustion Engine Vehicles	10/18/04	08/31/10	2,109,851	3,505,631
05165	Air Products and Chemicals Inc.	Install & Demonstrate Three Electrolyzers (in Burbank, Riverside & Santa Monica) and Two Mobile Fuelers (in Santa Ana & Ontario), with One Year of Hydrogen Fuel Supply	06/21/05	06/15/11	3,885,332	3,885,332
Health Impacts Studies						
05037	California Air Resources Board	Enhanced Exposure Assessment of Health Effects of PM	06/28/04	05/31/09	501,814	4,392,814
07359	University of Southern California	Study on Combustion Exhaust and Respiratory Health of Port Community Children	12/14/07	08/31/09	489,300	2,989,300
08033-4	California Air Resources Board	Spatiotemporal Analysis of Air Pollution and Mortality in California Based on the American Cancer Society Cohort	06/25/07	06/24/10	374,988	749,976
08033-5	California Air Resources Board	Extended Analyses of Air Pollution & Cardiopulmonary Disease in the California Teachers Study Cohort	06/25/07	06/24/10	142,326	284,652
09307	California Air Resources Board	In-Vehicle Air Pollution Exposure Measurement & Modeling Assessment of Pregnant women in the National Children's Study	09/01/08	04/30/11	250,000	500,000
Stationary Clean Fuels Technology						
99046	Engelhard Corporation	Field Evaluation of PremAir Ozone Catalyst Technology on AC Units	10/06/98	12/31/10	0	0
05207	SolSource Energy	Install an 80 kW Solar Panel System at SCAQMD Headquarters	06/06/05	06/05/11	360,000	693,000
06071	Gas Technology Institute	Field Demonstration of Advance Technology Boiler in South Coast District	03/15/06	09/01/09	135,000	612,146
09304	Solar Integrated Technologies Inc.	Install Turnkey Rooftop 40 kW Building Integrated Photovoltaic System	12/20/08	12/19/14	390,695	390,695
Outreach and Technology Transfer						
97113	JME Inc.	Review & Assessment of Technical Proposals Regarding ATTB Ultracapacitor System	05/08/97	03/31/09	15,000	30,000
00069	Walsh Consulting	Technical Assistance Relating to the Use of Alternative Fuels in Mobile Sources	02/17/00	02/28/10	20,000	20,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (continued)						
02295	Synchroenergies Inc.	Technical Assistance on Lubricants, Fuels, Combustion, Alternative Energy Sources, & High Performance Fluid Technologies	05/23/02	06/30/09	25,000	25,000
02308	Sperry Capital, Inc.	Evaluate Financial Stability of Potential Contractors	06/25/02	12/31/09	20,000	20,000
02311	Cole, Jerald A.	Technical Assistance for Development, Outreach, & Commercialization of H2 Infrastructure & Reforming Technology	08/09/02	06/30/09	30,000	30,000
02333	University of California, Riverside	Technical Assistance on Clean Fuels, Hydrogen, Fuel Cell & Natural Gas Technologies	11/01/02	06/30/09	$30,000	$30,000
02335	Neil C. Otto	Technical Assistance on Fuel Cell Technology	08/09/02	06/30/09	30,000	30,000
04049	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance for Alternative Fuels Engine Technology	11/21/03	04/30/09	60,000	60,000
04053	Marathon Technical Services	Technical Assistance for Alternative Fuels Infrastructure	11/21/03	12/31/09	40,000	40,000
04146	Tom Gross	Technical Assistance for Hydrogen & Fuel Cell Technologies	06/23/04	05/31/09	25,000	25,000
05121	Sullivan, Cindy	Development, Analysis & Technology Implementation of Incentive Programs	03/14/05	03/31/09	75,000	75,000
05126	St. Croix Research	Development, Outreach & Commercialization of LNG, CNG and Hydrogen Fuels	03/15/05	03/31/09	25,000	25,000
05127	Protium Energy Technologies	Development, Outreach & Commercialization of Hydrogen and Fuel Cell Technologies	03/14/05	03/31/10	60,000	60,000
05128	Mid-Atlantic Research Institute LLC	Development, Outreach & Commercialization of Advanced Heavy-Duty and Off-Road Technologies	08/08/05	03/31/09	40,000	40,000
05171	James Hazelton	Technical Assistance on AB 1222 Advisory Group	04/08/05	03/31/09	$45,000	$45,000
05198	Don Stedman	Technical Assistance for Remote Sensing Programs for Light-Duty Vehicles and Locomotives	05/30/05	11/30/10	25,000	25,000
06173	Maria Robles	Administrative Assistance Services Related to Organization of International Conferences on Asthma and Port Emissions Control Technologies	05/12/06	08/31/09	125,000	125,000
07012	TIAX, LLC	Technical Assistance Related to the Air Quality Impact of Fuel Ethanol Usage	09/15/06	08/31/10	100,000	100,000
07027	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance for Air Quality Impacts & Mitigation	09/29/06	08/31/00	25,000	25,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (continued)						
07028	TIAX, LLC	Technical Assistance for Air Quality Impacts & Mitigation of Regional Goods Movement	09/21/06	08/31/09	50,000	50,000
07059	Dowling Associates, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods	12/19/06	11/30/10	68,000	68,000
07060	Don Breazeale and Associates, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods Movement	11/15/06	11/30/10	58,000	58,000
07062	The Tioga Group, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods	12/19/06	11/30/10	58,000	58,000
07129	Breakthrough Technologies Institute, Inc.	Technical Assistance with Fuel Cell Technology	12/01/06	03/31/10	40,000	40,000
07130	Burnett & Burnette	Technical Assistance with CNG Technology	01/17/07	12/31/09	40,000	40,000
07167	Tech Compass	Technical Assistance with Hydrogen and Fuel Cell Technologies	03/31/08	12/31/10	75,000	75,000
07185	Joseph C. Calhoun, P.E., Inc.	Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle Technologies	01/29/07	01/31/10	50,000	50,000
07247	TIAX LLC	Technical Assistance with Low-Emission and Alternative Fuels Technologies	03/19/07	12/31/10	125,000	125,000
07314	Engine, Fuel & Emissions Engineering, Inc.	Technical Assistance with Advanced Heavy-Duty and Off-Road Technologies	06/25/07	12/31/09	60,000	60,000
07342	Douglas R. Lawson	Technical Assistance for Mobile Source Technologies	06/21/07	08/31/09	15,000	15,000
08210	Sawyer Associates	Technical Assistance on Mobile Source Control Measures and Future Consultation on TAO Activities	02/22/08	02/28/10	25,000	25,000
08254	Maria Robles, R.N.	Administrative Assistance in Organizing Two Air Quality & Health-Related Conferences	05/02/08	12/31/09	149,760	149,760
08311	CALSTART	Technical Assistance with Development, Outreach, and Commercialization of Advanced Technology to Transit, Port & Other Activities	07/11/08	05/31/10	75,000	75,000
08337	Gladstein, Neandross & Associates LLC	Coordinate the Southern California Clean Vehicle Technology Expo 2008	09/05/08	01/31/09	54,000	295,265
09004	EDV Commercialization	Technical Assistance on Plug-In Hybrid Electric Vehicles & Associated Technologies	08/20/08	08/31/10	15,000	15,000
09136	Coordinating Research Council	Cosponsor the Mobile Source Air Toxics Workshop	10/22/08	07/31/09	5,000	80,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (continued)						
09159	Manufacturers of Emission Controls Association	Cosponsor the Ultrafine Diesel Particles & Retrofit Technologies for Diesel Engines Three-Day Course	11/13/08	01/31/09	20,000	100,000
09252	JWM Consulting Services	Technical Assistance with Review & Assessment of Advanced Technologies, Heavy-Duty Engines, and Conventional & Alternative Fuels	12/20/08	06/30/10	30,000	30,000

Appendix C

Final Reports for 2008

AQMD Contract # 01157 **June 2008**

Purchase 20 Natural Gas Refuse Trucks

Contractor
Waste Management (WM) of Los Angeles

Cosponsors
None

Project Officer
Connie Day

Background
Waste Management (WM) of Los Angeles has been transitioning its refuse fleet to alternative fuel over the last ten years due to economic conditions, market availability of vehicles, environmental regulatory incentives, and internal management goals to diversify fuel sources. WM has partnered with multiple public agencies in order to deploy and promote the use of alternative fuel trucks. For this project, WM had originally applied to the SCAQMD for funding for 20 CNG trucks. However, due to several distinct advantages that LNG has over CNG (longer range before refueling, lower costs, and fuel availability in the region), WM requested and received permission from the SCAQMD to purchase LNG trucks through this contract.

Project Objective
The purpose of this project was to reduce emissions from refuse collection trucks through the use of low-emission natural gas engines. Through financial assistance from the SCAQMD Carl Moyer Program, Waste Management purchased 20 new LNG refuse trucks and has kept these low emission vehicles in service within the geographical boundaries of the SCAQMD.

Technology Description
Waste Management of Los Angeles deployed twenty 2003 Mack LNG trucks: 10 Mack LE 613 trucks and 10 2003 Mack MR 688S trucks. Both models are powered by the Mack E7G 325 LNG engine.

Status
WM purchased all units by the close of October 2002 and took delivery of all units prior to June 2003. These 20 trucks are still in front line service at WM's Los Angeles fleet location.

During the project, WM did not experience any "fatal" problems with these units. However, WM did experience performance and efficiency issues with the LNG Mack trucks since their deployment and Mack Trucks continues to work through these issues with WM.

WM also has experienced issues with manufacturing quality in the fuel tank insulation. However, over time, Mack Trucks and WM have resolved most of the major mechanical failures, which has greatly increased the reliability of these vehicles.

Results
Since WM's electronic vehicle tracking system has not been completely updated with pre-2004 fueling records, 2008 actual fuel use data was used to project overall emission benefits from this contract. From January 1, 2008 through December 31, 2008, the 20 LNG trucks have used 274,373 gallons of LNG, displacing approximately 137,186.5 gallons of diesel fuel. Each truck averaged 13,719 LNG gallons per year, for a projected total 3,292,476 LNG gallons and 1,646,238 diesel gallons displaced (12 year project life, 20 units). Based on this fuel consumption, these Mack LNG trucks achieved significant emission reductions over comparable diesel vehicle equivalents. This project has eliminated 0.22 tons of toxic PM

emissions and 10.9 tons of smog-causing NOx in 2008 and will reduce 4.38 tons of PM and 130.4 tons of NOx over the 12 year contract life. Based on the latest figures from the California Air Resources Board's Low Carbon Fuel Standard Well-to-Wheels Transportation Assessment, these LNG trucks have also achieved a 20% emission benefit over comparable trucks running on ULSD.

The tradeoff for these reduced emissions has been in power performance and multiple engine control system component bugs, as described in the previous section of this report. Improvement in energy efficiency and fuel economy would be future objectives.

Benefits

The replacement of these trucks has greatly reduced exposure to toxic diesel emissions in residential and commercial areas. These trucks were deployed in low-income and minority communities already experiencing disproportionate air toxics impacts, thereby helping achieve the SCAQMD's environmental justice policies. Specifically, the fleet serves the communities of Carson, Lynwood and North Long Beach. Additionally, although it was not a stated project goal in 2002, these trucks have reduced global warming emissions over comparable diesel units. These trucks are not known to increase problems with water pollution, solid waste, global warming or other toxic emissions. In addition, these were the first 20 LNG vehicles in the fleet, whereas there are now 42 LNG vehicles. Experience with these first 20 units was critical in helping deploy more LNG units, and therefore achieve significant regional emission reductions.

In its initial application, WM projected that this project would reduce 200 tons of NOx and 3.98 tons of PM over 12 years and displace 2.4 million gallons of diesel. Based on current vehicle use patterns, actual NOx reductions will be less than anticipated but still significantly better than comparable diesel units. PM emissions will be slightly better.

Project Costs

The actual cost to implement the entire project was $3,988,473. The SCAQMD paid $41,460 per vehicle, totaling $829,200. WM cost-shared the remaining $3,159,273. These costs correspond to the original estimate.

Commercialization and Applications

Although Mack Trucks no longer manufactures a natural gas vehicle, WM continues to grow its natural gas refuse fleet with Autocar Trucks powered by the Cummins Westport ISL G natural gas engine. WM has experienced a number of technical difficulties with the Mack trucks that continue to be resolved with the manufacturer. WM continues to improve its ability to operate and maintain LNG vehicles.

Despite lower fuel economy, LNG continues to be favorably priced compared to diesel, helping to offset maintenance costs on the Mack natural gas engines. With the newer generation of natural gas engines, reliability rivals that of diesel and the maintenance cost gap is decreasing. WM expects that with the lower cost of fuel, increased reliability, and increasing costs of diesel emission mitigation, natural gas powered trucks will be the cost effective and environmentally friendly choice for the future.

In addition, drivers report satisfaction with the decrease in engine noise and exhaust fumes while operating natural gas powered trucks over diesel powered trucks. WM customers have also commented positively on the lower noise produced by WM's natural gas engines.

WM remains committed to deploying CNG and LNG vehicles within its fleet in California, given the environmental and economic benefits that CNG and LNG provide and is working with suppliers to look for opportunities to reduce the cost differential.

AQMD Contract # 01159 **June 2008**

Purchase 20 Natural Gas Refuse Trucks

Contractor
Waste Management (WM) of San Gabriel

Cosponsors
None

Project Officer
Connie Day

Background
WM has been transitioning its refuse fleet to alternative fuel over the last ten years due to economic conditions, market availability of vehicles, environmental regulatory incentives, and internal management goals to diversify fuel sources. WM has partnered with multiple public agencies to deploy and promote the use of alternative fuel trucks. For this project, WM originally applied to the SCAQMD for funding for 20 CNG trucks. However, due to several advantages that LNG has over CNG (longer range, lower costs, and fuel availability in the region), WM requested and received permission from the SCAQMD to purchase LNG trucks through this contract.

Project Objective
The purpose of this project was to reduce emissions from refuse collection trucks through the use of low-emission natural gas engines. Through financial assistance from the SCAQMD Carl Moyer Program, WM purchased 20 new LNG refuse trucks and has kept these low emission vehicles in service within the geographical boundaries of the SCAQMD.

Technology Description
WM of San Gabriel deployed twenty 2003 Mack LNG trucks: nineteen 2003 Mack LE 613 trucks and one 2003 Mack LE 613 truck. Both unit types were equipped with the Mack E7G 325 LNG engine.

Status
WM purchased all units by the close of October 2002 and took delivery of all units prior to June 2003. All 20 trucks are still in front line service at WM's San Gabriel fleet location.

During the project, WM experienced serious problems with two of these units that were unrelated to their LNG fueling systems and related to normal refuse operations. These units were out of service for nearly all of 2008 but are now repaired and running. WM experienced multiple performance and efficiency issues with the LNG Mack trucks since their deployment and Mack Trucks continues to work through these issues with WM.

WM also has experienced issues with manufacturing quality in the fuel tank insulation. However, over time, Mack Trucks and WM have resolved most of the major mechanical failures, which has greatly increased the reliability of these vehicles.

Results
Since WM's electronic vehicle tracking system has not been completely updated with pre-2004 fueling records, WM used 2008 actual fuel use to project overall emission benefits from this contract. From January 1, 2008 through December 31, 2008, the 18 active Mack LNG trucks have used 163,847 gallons of LNG fuel, displacing approximately 81,923 gallons of diesel fuel. Each truck averaged 9,103 LNG gallons per year, for a projected total 2,166,420 LNG gallons and

1,083,210 diesel gallons displaced (12 year project life, 20 units, two units down for a single year). Based on this fuel consumption, these Mack LNG trucks achieved significant emission reductions over comparable diesel vehicle equivalents. This project has eliminated 0.12 tons of toxic PM emissions and 6.79 tons of smog-causing NOx in 2008 and will reduce 1.3 tons of PM and 81.5 tons of NOx over the 12 year contract life. Based on the latest figures from the California Air Resources Board's Low Carbon Fuel Standard Well-to-Wheels Transportation Assessment, these LNG trucks have also achieved a 20% emission benefit over comparable trucks running on ULSD.

The tradeoff for these reduced emissions has been in power performance and multiple engine control system component bugs, as described in the previous section of this report. Improvement in energy efficiency and fuel economy would be future objectives.

Benefits

The replacement of these trucks has greatly reduced exposure to toxic diesel emissions in residential and commercial areas. These trucks were deployed in low-income and minority communities already experiencing disproportionate air toxics impacts, thereby helping achieve the SCAQMD's environmental justice policies. Specifically, the fleet serves the communities of El Monte, Baldwin Park, Irwindale, Basset-Valinda, South Whittier and East Los Angeles/ Belevedere. Additionally, although it was not a stated project goal in 2002, these trucks have reduced global warming emissions over comparable diesel units. These trucks are not known to increase problems with water pollution, solid waste, global warming or other toxic emissions. In addition, these were the first 20 LNG vehicles in the fleet, whereas there are now have 57 LNG vehicles. Experience with these first 20 units was critical in helping deploy more LNG units, and therefore achieve significant regional emission reductions.

In its initial application, WM projected that this project would reduce 200 tons of NOx and 3.98 tons of PM over 12 years and displace 2.4 million gallons of diesel. Based on current vehicle use patterns, actual reductions will be less than anticipated but still significantly better than comparable diesel units.

Project Costs

The actual cost to implement the entire project was $4,033,733.41. SCAQMD paid $41,460 per vehicle totaling $829,200. WM cost-shared the remaining $3,204,599.41. These costs correspond to the original estimate.

Commercialization and Applications

Although Mack Trucks no longer manufactures a natural gas vehicle, WM continues to grow its natural gas refuse fleet with Autocar Trucks powered by the Cummins Westport ISL G natural gas engine. WM has experienced a number of technical difficulties with the Mack trucks that continue to be resolved with the manufacturer. WM continues to improve its ability to operate and maintain LNG vehicles.

Despite lower fuel economy, LNG continues to be favorably priced compared to diesel, helping to offset maintenance costs on the Mack natural gas engines. With the newer generation of natural gas engines, reliability rivals that of diesel and the maintenance cost gap is decreasing. WM expects that with the lower cost of fuel, increased reliability, and increasing costs of diesel emission mitigation, natural gas powered trucks will be the cost effective and environmentally friendly choice for the future.

In addition, drivers report satisfaction with the decrease in engine noise and exhaust fumes while operating natural gas powered trucks over diesel powered trucks. WM customers have also commented positively on the lower noise produced by WM's natural gas engines.

WM remains committed to deploying CNG and LNG vehicles within its fleet in California given the environmental and economic benefits that CNG and LNG provide and is working with suppliers to look for opportunities to reduce the cost differential.

AQMD Contract #03099 **July 2008**

Purchase & Install LNG-L/CNG Refueling Station at Puente Hills Landfill Facility

Contractor

Los Angeles County Sanitation Districts (LACSD)

Cosponsors

California Energy Commission
Mobile Source Air Pollution Reduction Review Committee

Project Officer

Larry Watkins

Background

LACSD has always been in the forefront of implementing advanced technology for improving air quality relating to the landfill operations. The LACSD started implementing an alternative fuel program in 1993 and is now aggressively pursuing the integration of alternative fueled vehicles into its fleet. The LACSD is constructing a new material recovery facility (MRF) in which 41 new transfer trucks will be needed to transport the residuals to other landfill sites. In addition, the SCAQMD has passed the 1190 series of fleet rules requiring the use of alternative fuel vehicles. This fueling facility was seen as a good solution to the fueling demand of the LACSD's fleet and the landfill customers' fleet.

Project Objective

The project objectives of constructing a LNG and L/CNG fueling facility at the MRF under this Grant Program are:

- An integrated fueling infrastructure for the demand of the LACSD's fleet.
- A convenient fueling location for the landfill customers that utilize the MRF or landfill daily.
- Improves air quality in the SCAQMD region by eliminating extra trips for fueling.
- Promotes and supports purchase of alternative-fuel vehicles for landfill customers who cannot afford to build their own fueling infrastructure.

Technology Description

The station is designed with two 15,000-gallon LNG storage tanks and with CNG fueling capability providing 3,000 psi and 3,600 psi. The Sanitation Districts' current fleet of alternative fueled vehicles consists of both CNG and LNG vehicles.

Athens Disposal Company has committed to using the fueling station to fuel their fleet of LNG packers. Other waste haulers are being actively pursued to use the fueling station. In addition, public access to CNG fueling will be available. The potential customer base is large, as approximately 1,500 trucks go through the Landfill daily and about another 550 trucks will go through the MRF each day. The projected annual fuel throughput from these haulers is about 350,000 gallons per year of diesel equivalent, conservatively.

Status

The station construction was completed in March 2004. The normal start-up procedures for the fueling station included a purging and nitrogen cold shock process, a nitrogen leak test, and an operational demonstration of each of the station's normal operations. The County Fire Department inspected the system, checked all safety alarms, and signed off the permit. On-site personnel will receive at least one day training in the proper operation and maintenance of equipment. Preventive maintenance procedures will be established and a site-specific log will be provided and reviewed.

Results

This project was originally proposed as an LNG fueling station with one 16,000-gallon storage tank using a single dispenser with two hoses and having a proposed annual throughput of approximately 800,000 gallons per year of diesel equivalent. However, following further evaluations of the future demand of both LNG and CNG usage, the design of the station was subsequently expanded to provide CNG fueling capability as well as LNG. The fueling facility has two 15,000-gallon horizontal storage tanks of LNG, using 2 dispensers and 2 hoses. The CNG fueling has 37,000 standard cubic feet of CNG storage delivering at 3,000 and 3,600 psi. This fueling station will support all types of vehicles, ranging from passenger cars to heavy-duty trucks.

Benefits

This project will benefit the environment of the South Coast Air Basin in several ways, especially in the reduction of diesel particulate emissions and the increased efficiency of having an LNG/L-CNG fueling facility located at the Puente Hills MRF. LACSD has been forced to purchase diesel vehicles instead. In response to this turn of events, LACSD has contracted with Athens Disposal Company for use of the fueling station for their fleet of 15 LNG trucks, and other haulers have expressed interest as well, including the City of Long Beach and Burrtec Waste Industries. Furthermore, LACSD and the SCAQMD are partnering in a demonstration project with Cummins to test five transfer trucks with LNG engines that will meet the stricter 2007 emissions standards. In addition to the on-road vehicles, the LACSD also operates a fleet of LNG off-road equipment, which currently consists of an LNG wheeled loader and two CNG street sweepers, and is in the process of repowering four more loaders and two wheeled tractors.

Project Costs

The total cost of this turnkey project is $1,489,312, which is higher than the proposal. The reason for this increase is that the design of this station was expanded to provide CNG fueling capability and to add a second 15,000-gallon LNG storage tank. The total funding received from various sources for this station is $1,268,750, of which the AQMD provided $560,000, and the LACSD is funding the balance of the station cost.

AQMD Contract #03102 **June 2008**

Purchase & Install LNG-L/CNG Refueling Station at La Metro Hauling District

Contractor

USA Waste of California, Inc. (Waste Management)

Sponsor

N/A

Project Officer

Larry Watkins

Background

Waste Management has started the process of replacing the older diesel powered collection trucks in its fleet located in Long Beach with low emission trucks powered by LNG. LNG fueling infrastructure was not previously available in Long Beach.

Project Objective

Waste Management submitted a proposal for construction and operation of an LNG station in response to RFP No. 2002-19 on December 4, 2001. That station was completed on October 20, 2002 and is in operation. Waste Management's fleet of 22 new Mack collection trucks with Mack E7G 325HP LNG engines refuel at the station daily.

Project Description

The new LNG station has a storage capacity of 16,000 LNG gallons, which permits the efficient delivery of a full tanker load of fuel. The station now has a single dispenser but Waste Management will add a second dispenser if needed.

Status

The project was completed on October 20, 2002 and a final report has been submitted to the SCAQMD.

LNG Fuel Station and Storage Tank

Results

The station was completed on October 20, 2002 and has operated satisfactorily since completion. Fuel usage is currently about 40,000 gallons per month. This throughput will increase significantly as Waste Management continues the replacement of older diesel trucks with LNG powered vehicles and as other refuse or industrial fleets in the area choose to refuel at this station.

LNG Station Control Panel and Dispenser

Costs

Waste Management's original estimate of costs associated with this project was $600,000.00. SCAQMD provided funding in the amount of $400,000.00. The actual completed cost including construction, excavation, design, permitting and other related cost was $541,725.91. This savings resulted from Waste Management's contracting with North Star, Inc. for the construction of a series of LNG stations.

AQMD Contract #08319 **December 2008**

Student Educational Study to Assess Mixing Effectiveness of a Rotary Cylinder in Improving Diesel NO_x Reduction of an SCR System

Contractor
CSULB Foundation

Cosponsors
None

Project Officer
Martin Kay

Background

According to the California Air Resources Board (CARB) in 2010, on-road heavy duty diesel trucks are estimated to account for up to 28% or 559 tons per day of oxides of nitrogen (NOx) and up to 12 % of particulate matter (PM) emissions inventory statewide. Truck idling contributes significantly to these emissions. Idling emissions are significant at the port terminals and distribution centers where long waiting periods are required for loading and unloading operations, and at rest areas and traffic stops, among others. CARB proposed regulation to reduce idling emissions from new trucks starting with the 2008 model year. The regulation requires manufacturers to either meet an emissions standard or have a timer system that automatically shuts off the engine after five minutes of continuous idling.

Diesel emissions are significant at the two major ports of Los Angeles (LA) and Long Beach (LB). The LA-LB ports handle more than 43% of the total seaborne cargo and are responsible for nearly a quarter of diesel emissions in the region. Big rig trucks, diesel locomotives and mammoth container ships contribute significantly to the region's air pollution with severe impact on local communities. Many schools are very close to the port traffic and railroad lines and are significantly affected by these emissions as well.

The introduction of selective catalytic reduction (SCR) systems using urea as the reducing agent has been shown to be effective in reducing NOx emissions in diesel engines. Urea is produced by combining ammonia and carbon dioxide at high pressure; it is easy to transport and is a stable solution within normal climatic conditions. When it is injected into the exhaust of a diesel engine, it is first hydrolyzed to produce ammonia, which reacts with the exhaust gases to produce nitrogen and water.

SCR systems may have low NOx conversion capacity due to many factors including the inefficient mixing process between the exhaust gases and the injected urea. To improve the mixing process and high NOx conversion, mixers can be placed upstream or downstream of the injection point and the location of the injection should be in a uniform exhaust flow condition.

Project Objective

In the present investigation, a rotary cylinder was used as a dynamic mixer for improving the performance of an SCR system. The goal was to improve the mixing process between the injected reductant and the diesel exhaust for increased NOx reduction. The dynamics of flow around a cylinder is dominated by large scale vortical structures that are separated from the cylinder and travel downstream. The asymmetric pressure distribution around the cylinder creates lift and drag forces which are Reynolds number dependant. The vortex from a stationary cylinder includes regions of concentrated vorticity that are shed into downstream flow from alternate sides of the cylinder. The presence of vorticity results in entrainment and mixing in the downstream wake.

For a rotary cylinder, the asymmetric pressure distribution and shedding vortices are increased and the directions of rotation of these vortices depend on the ratio of tangential velocity to the free stream velocity. For ratios less than and around 1, the direction of rotations are opposite and when it is higher than 3, rotary vortices have the same direction. These vortices and oscillatory motions can be used for control of the cylinder wake and under certain circumstances should significantly increase the entrainment and mixing process in the downstream direction.

Technology Description

The questions are how the mixing process between the urea or ammonia and the exhaust gases are affected with a finite aspect ratio rotary cylinder placed downstream of the injector and whether significant mixing can be achieved with small to moderate rotary speeds, which were the objectives of the present investigation. A high mixing process should increase the performance of the SCR system and improve its NOx conversion capability.

In the current and developing SCR system, passive mixers have been used as a means of improving the performance of the SCR system. In the current project, a dynamic approach has been used.

Status

The project has been completed and the final report was submitted on December 2, 2008.

Results

The present investigation was divided into two parts. In part one, the mixing effectiveness of opposed flow injection and a rotary cylinder with 1000, 5000, and 10000 rev./min on a heated turbulent jet was investigated using air as both as exhaust and injecting fluid. The experiments were carried out in an air-jet facility and mixing effectiveness was investigated using a single hot wire sensor in conjunction with a single channel of TSI IFA-100 intelligent flow analyzer and a small J-type thermocouple. Results for this part of the investigation indicated that the rotary cylinder induce momentum and turbulence into the wake, resulting in increased turbulence and shear which should enhance the mixing process downstream.

Based on part I of the investigation, an injector-rotary cylinder system was developed for the exhaust of the diesel engine and tested at a moderate engine loading condition with ammonia gas as the reductant. Figures 1 and 2 show the rotary cylinder and the rotary cylinder installed at the exhaust of the diesel engine.

Figure 1. The Rotary Cylinder and Diesel Exhaust Installation

The exhaust temperature was at approximately 272 C at the location of the injection, and the rate of ammonia injected was at approximately 100 ml/min. Results [Figure 2] indicate an average of 26% NOx conversion with rotary cylinder at high rate of rotation.

Further studies are underway with addition of a vanadia-titanium catalyst with both active and passive mixers and results will be presented in the near future.

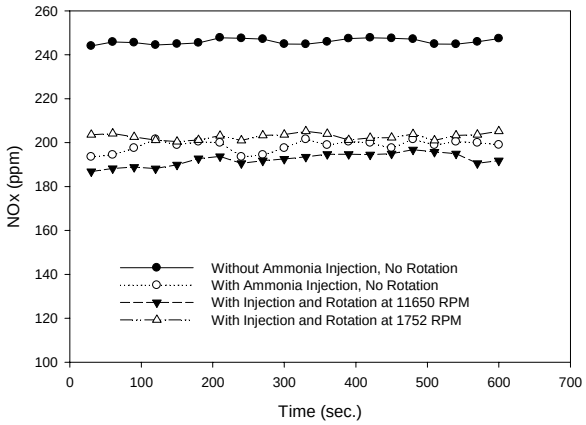


Figure 2. NOx Emissions After the Diesel Oxidation Catalyst

Benefits

The current investigation improves the mixing effectiveness of injected ammonia into the exhaust of a diesel engine by further reducing NOx by more than 4%. Further investigations are underway to assess the overall NOx reduction capacity of a rotary cylinder with an SCR catalyst. Reduction of NOx emissions can significantly improve air quality in the LA/LB ports area and in the Southern California region.

Project Costs

The project was completed with funding from the SCAQMD in the amount of $17,500 along with in-kind contributions in the form of space and laboratory equipment and additional person-hours.

Commercialization and Applications

Further phases of the investigation should be completed before technology development and commercialization.

AQMD Contract #05067 **January 2008**

Demonstrate Advanced Diesel Emission Control System in Low-Sulfur Diesel-Fueled Heavy-Duty Engines

Contractor
Cummins, Inc.

Cosponsors
U.S. Department of Energy
California Air Resources Board

Project Officer
Adewale Oshinuga

Background
SCAQMD has championed the development of low emission technologies for use in the District. Their focus on natural gas engines has shown those to be capable of very low emissions, but extra weight and space claimed by fuel storage on board a vehicle causes significant concern for some commercial applications. Refuse collection vehicles are not able to accept such penalties. This research initiative is to explore diesel engine technologies, achieve 2007/2010 emissions standards with ultra low sulfur diesel fuel and maintain or improve engine fuel economy.

Project Objective
The goals of the project were to demonstrate 2010 emissions technologies with an engine commonly used in refuse collection vehicles. Specifically, the targets were:

- 0.2 g/hp-hr BSNOx and 0.01 g/hp-hr particulate emissions,
- unregulated NO2 emissions not to exceed 20 % NOx target, and
- minimize engine fuel economy penalty.

Technology Description
Cummins' approach for the project was to develop combustion processes to achieve significant reductions in NOx engine-out emissions and treat the exhaust gases to achieve NOx & PM emission targets.

Cummins has successfully developed cooled exhaust gas recirculation (EGR) on other engine platforms. In this project, Cummins proposed to develop cooled EGR technology further and achieve even lower engine-out NOx emissions. Practical aftertreatment systems were planned to reduce brake specific NOx (BSNOx) and particulate emissions further to achieve 2010 emission goals. Particular attention was focused on in-cylinder combustion to improve engine fuel efficiency.

Status
The technical work consisted of applying analysis-led design tools, advanced combustion and performance modeling. An ISL engine was equipped with advanced technologies including high pressure common rail fuel system, variable geometry turbocharger, EGR systems and advanced controls. A Selective Catalytic Reduction (SCR) system and a robust particulate filter was added in the engine exhaust stream. Figure 1 shows the engine set up in a test cell. A combination of modeling and steady state engine testing were employed to optimize the engine performance and emissions. Transient cycle emissions and 500 hour durability tests were run. All engine tests were run with ultra low sulfur diesel.

The project has been completed, key goals of the project demonstrated, and the final report has been submitted to SCAQMD.

Figure 1: Engine Layout

Results

In-cylinder combustion technologies were developed to achieve 0.50 g /bhp-hr NOx engine out emissions. Steady state engine emission tests confirmed 0.57 g/bhp- hr NOx engine-out emissions. Composite fuel consumption improvement of over 5 % was demonstrated for an engine calibration at 0.5 g NOx versus baseline ISL engine. Average BSNO2 was less than 20% (0.04) of target NOx. Adsorber catalyst technologies for NOx were evaluated and found to be cost prohibitive.

Transient FTP cycle tests with the final engine configuration showed following results:

- BSNOx = 0.112 g/bhp.hr
- BSCO = 0.167 g/bhp.hr
- BSHC = 0.007 g/bhp.hr,
- PM = 0.012 g/bhp.hr.
- BSFC > 5 % improvement (composite)

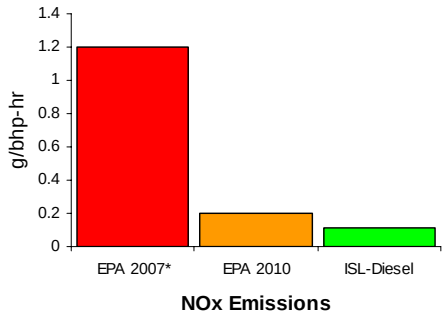


Figure 2: NOx emission results

Figure 2 shows NOx emissions from the prototype engine versus 2007 /2010 standards. These above results highlight that the significant project deliverables were achieved.

A 500 hour durability test with the prototype engine was completed. Emission tests after durability testing showed that the emissions recipe was sustainable. The learning from this technology will be applied to future product development.

Benefits

The combined application of EGR, high pressure common rail fuel system, a diesel particulate filter and an SCR catalyst has the potential to achieve 2010 EPA engine emissions, without significant fuel economy issues. Vehicles can use low sulfur diesel fuel and conventional diesel fuel tanks. It is envisaged that such technologies offer competitive ownership costs in refuse vehicle applications.

Project Costs

The total project cost was $5,354,394. The cost sharing amongst the sponsors was: AQMD $700,000, CARB 50,000, U.S. DoE $700,000 and Cummins Inc. $3,904,394.

Commercialization and Applications

This project has demonstrated the capabilities of cooled EGR, high pressure common rail, diesel particulate filter and SCR catalyst system. No major limitations have been identified that would restrict this technology from going into a commercial application. Cummins plans to develop an ISL product for 2010 that will include SCR technology elements studied in this project. Cummins enjoys a market share of approximately 35% in the residential refuse vehicle market.

AQMD Contract #05196 **August 2008**

Demonstrate & Evaluate Advanced Diesel Emission Control System in Low-Sulfur Diesel-Fueled Heavy-Duty Engines

Contractor

West Virginia University

Project Officer

Adewale Oshinuga

Background

Diesel engines constitute a valuable solution to the growing demand for higher fuel efficiencies, especially in relation to the rapid growth of fuel prices in recent years. However, the substantially lean conditions typical of diesel exhaust pose a serious challenge to the traditional exhaust aftertreatment devices. The Selective Catalytic Reduction (SCR) technology has proven to be a viable technology for reducing emissions of oxides of nitrogen (NOx) from heavy-duty diesel engines. The diesel particulate filter (DPF) significantly reduces particulate matter (PM); primarily, the solid carbon component of total PM. A comprehensive system including an advanced engine design, with novel engine calibration strategies, and an exhaust aftertreatment system with a DPF, SCR, and an optional active regeneration system can achieve the 2010 regulatory NOx and PM emission levels, without fuel penalties.

Figure 1: Volvo MD11 Engine with ADECS on the Test Bed in WVU Engine and Emissions Research Laboratory (EERL)

Project Objective

The objective of the study was to develop, test, and qualify a highly cost effective Advanced Diesel Emission Control System for the Volvo MD11 engine that will allow the engine to meet the 2010 regulatory NOX and PM levels of 0.2 g/bhp-hr and 0.01 g/bhp-hr, respectively.

Technology Description

In this study the test engine was equipped with a catalyzed DPF and an SCR, and programmed with two different engine calibrations, namely the low-NOx and the low fuel-consumption (low-FC). The complete exhaust aftertreatment was developed to meet the 2010 emission standards for heavy-duty diesel engines. The two engine calibrations considered produced different exhaust conditions; hence, the DPF was challenged with two different DPF loadings and exhaust temperatures. In particular, due to the presence of a DOC upstream of the SCR, the exhaust temperature determined the NO2 level and, depending on the value of NO2/NO ratio, was responsible of the overall NOx conversion efficiency of the SCR. Therefore, the DOC-DPF-SCR integrated system was challenged to respond to different exhaust conditions while maintaining the emissions at the desired levels. In particular, the urea dosage injection strategy accounted for the different NOx levels and exhaust temperatures associated with the two engine calibrations. Furthermore, the soot produced by the low-NOx and low-FC maps led to varying frequencies of passive and active regeneration of the DPF.

It should be noted that the absence of carbon downstream of the DPF introduced new dynamic effects viz. PM formation, growth, and composition. Additionally, changes in the PM characteristics occurred as the diesel exhaust flowed through the SCR, which was located downstream of the DPF. This study determined that chemical and physical characteristics of the SCR-out PM are related to engine-out PM; and the novel engine calibrations, which were developed, minimized SCR-out PM emissions.

Status

The project is completed.

Experimental Setup

For this study a MY07 Volvo engine was used. The engine was modified and equipped with cooled exhaust gas recirculation (EGR) and electronically actuated variable geometry turbocharger (VGT); overhead cam with unit mechanically activated injectors, EUI3 systems, able to provide injection

pressures up to 2400 bar. Ultra low sulfur diesel fuel (ULSD) with a maximum sulfur content of 6 ppm was used. The engine oil used was Rotella-T, 15W-40 from Shell with a specified sulfur content of maximum 0.4% on a mass basis (according to API CJ-4/ASM).

The exhaust aftertreatment system used for this study consisted of a DOC-DPF assembly placed upstream of the SCR catalyst.

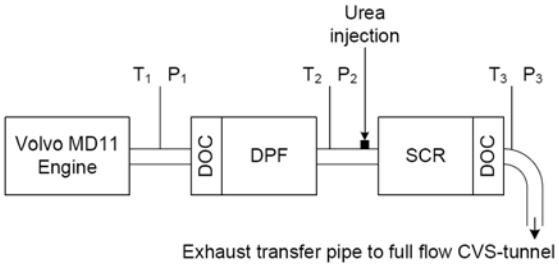


Figure 2: Engine and Aftertreatment Setup

The DPF was a "space saver", catalyzed wall-flow type DPF, manufactured by Fleetgard. The DOC was placed upstream the filter (pre-catalyst), thus allowing continuous passive regeneration. The SCR system, manufactured by Johnson Matthey, was designed to meet the EURO IV and provided with an additional oxidation catalyst downstream to account for excess of ammonia.The urea injection system consisted of urea tank, urea injector and urea pump unit, which was equipped with an independent controller that exchanged information with the ECU via CAN network.

The testing was conducted at the WVU EERL in accordance with the requirements of the Code of Federal Regulations (CFR) 40 Parts 86 and 1065.

A HFID was employed to measure hydrocarbons; NDIR analyzers to detect carbon monoxide (CO) and carbon dioxide (CO2); CLD analyzer for NOx and NO measurement; and a NDUV analyzer for simultaneous measurement of NO, NO2 and ammonia (NH3). In addition to gravimetric measurements, PM concentrations and size distributions were measured during transient engine operations using a Differential Mobility Spectrometer (DMS) from Cambustion (DMS-500 Fast Particulate Spectrometer) and an SMPS model 3080 from TSI.

Results

The MY07 MD-11 Volvo engine, programmed with the low-NOx map and integrated with the aftertreatment system, was developed to meet the 2010 emission limits. The best tailpipe BSNOx result was obtained with the low-NOx/low-PM map, which produced 0.19 g/bhp-hr over the ESC cycle and 0.23 g/bhp-hr for FTP with only minimal ammonia slip, below 10 ppm, which indicated an accurate urea calibration. The low engine-out NOx (slightly below 1 g/bhp-hr), and the SCR efficiency of 77% enabled attainment of the 2010 NOx standards. The high engine-out PM over an FTP (0.3 g/bhp-hr) was efficiently filtered by the DPF to the regulated standard of 0.01 g/bhp-hr. The DOC oxidized nearly 100% of the total HC and 99% of the CO emissions to well below the regulatory standards. This calibration could be engaged during low loads and low exhaust temperature, and cold start conditions of the engine operation, where the SCR performance would drop dramatically.

Higher SCR efficiency (12%) and higher NO2/NO ratio (40%) were associated with the low-NOx calibration, which produced low bsPM. The low-FC calibration exhibited an exhaust temperature 4% lower than the low-NOx/high-PM calibration; a higher NOx ratio (46%), and an overall higher SCR efficiency (2%). On the other hand, the improved efficiency was not high enough to bring down the higher engine-out NOx to the level of the emission standards, thus leading to higher tailpipe bsNOx levels.

The 300 hour durability test on the integrated system, the engine with the DPF and SCR programmed with low-NOx map emitted bsNOX at levels slightly higher than the standards.

Benefits

The hardware and the calibration techniques produced in this study can help improve the exhaust aftertreatment system control strategies under different engine calibrations. Engine controls can be effected to strategically switch between different maps in order to exploit the NO2 promotional effect, and achieve low NOx and low PM emissions.

Project Costs

The project's budget was $750,000 with AQMD providing $350,000. The project was completed within the budget.

Commercialization and Applications

The calibration techniques developed in this study can be employed by engine manufacturers to significantly reduce their development time. The novel combination of the engine modifications, DPF, SCR, pre-SCR exhaust and urea mixers, and the low-NOx/high PM and low FC calibration schemes offer a very attractive technology for not only new engines, but also retrofitting older engines to achieve the 2010 emission standards.

AQMD Contract # 04019 **January 2008**

Optimization & Demonstration of Plug-In Hybrid Electric Vehicles

Contractor
UC Davis

Cosponsors
Electric Power Research Institute
US DOE Argonne National Lab
Yolo-Solano AQMD
Ford
Ovonics

Project Officer
Lisa Mirisola

Background
By displacing energy from mobile petroleum combustion with electricity, plug-in hybrid electric vehicles have the potential to change the way that transportation energy is consumed in California, with benefits in terms of reductions in petroleum use, criteria pollutants, greenhouse gases, and other factors.

Project Objective
The project objectives included evaluation of the plug-in SUV performance and efficiency using modeling tools developed by UC Davis and data from the UC Davis Yosemite SUV, and analysis of the benefits of incorporating a continuously variable transmission (CVT) over a discrete gear transmission in a plug-in hybrid electric sport utility vehicle.

Technology Description
The UC Davis Yosemite PHEV (converted Ford Explorer) has a 15 kWh battery which is much larger than that in existing hybrids, has a larger electric motor and decreased internal combustion engine about one-third the size of that in the conventional vehicle.

The UC Davis PHEV uses a mechanical continuously variable transmission (CVT) to control engine and electric motor operation. With a fully charged battery, the vehicle was designed to provide up to 45 miles of charge depleting electric blended range until the battery state of charge reaches 20%, when the vehicle automatically switches to charge sustaining hybrid operation. During charge depleting operation, the internal combustion engine engages when the vehicle speed exceeds 45 mph and on demand under high load conditions.

Status
This project was completed January 31, 2008 and the final report is on file at AQMD with technical details of the project. The final report is also posted on the UC Davis website. The Yosemite PHEV was demonstrated in operation to the US DOE during Future Truck competition in 2003-2004. The vehicle was also brought to the 2007 Electric Vehicle Symposium (EVS23) in Anaheim for display.

Results
Results of the development and testing of the plug-in SUV (compared to baseline gasoline Ford Explorer 4WD) include:

- 67% reduction in greenhouse gas emissions,
- 80% reduction in petroleum consumption,
- 30 miles per GGE,

- 0-60 mph acceleration in 7.0 seconds, and
- California SULEV tailpipe emissions or lower.

DOE Future Truck competitors must accomplish goals to reduce greenhouse gas emissions, criteria tailpipe emissions, and fuel consumption, without compromising vehicle safety, performance, utility, or value. In 2003, UC Davis placed 2nd Overall.

Research results were also presented at the 2004 International CVT and Hybrid Transmission Congress.

Benefits

Plug-in hybrid vehicles can provide reduced emissions, increased efficiency, reduced global warming gases, and more efficient use of the electric grid when charging at night.

The benefits demonstrated by this project were anticipated at the project's start. The full benefits of plug-in hybrid vehicles would be more obvious if the hybrid vehicle certification cycle were modified to better characterize plug-in hybrid vehicle operation.

Project Costs

The vehicle was completed according to the originally projected costs of the project, which were $458,000, but funding did not include ongoing maintenance or any further demonstration costs. The AQMD's cost-share for this project was $150,000.

Commercialization and Applications

There are a variety of anticipated or potential vehicle applications for plug-in hybrid electric technology, providing opportunities for new developers. Several major automakers have recently announced planned introductions of plug-in hybrid passenger vehicles starting in 2010, although battery warranties for plug-in hybrid passenger vehicles remain to be proven, and the cost of this new technology in low initial volumes is a challenge.

AQMD Contract #05244 **April 2008**

Develop, Demonstrate & Certify Heavy-Duty Natural Gas Engine to Meet 2010 Emission Standards

Contractor
Cummins Westport, Inc. (CWI)

Cosponsors
National Renewable Energy Laboratory (NREL)
Utilization Technology Development (UTD)

Project Officer
Naveen Berry

Background
CWI manufactures a broad product line of spark ignited (SI) gaseous fueled engines for commercial vehicle applications. With the pending U.S. EPA/ CARB 2010 emission regulations, a step change in emissions technology is required for CWI's engines.

Project Objective
The objective of this project was to develop, demonstrate and commercialize advanced technologies and methods for controlling exhaust emissions in a medium-duty natural gas engine to meet 2010 Federal and California emission standards by 2007.

Technology Description
Early generation natural gas engines employed stoichiometric combustion concepts. Stoichiometric combustion offers low emissions potential when combined with three-way catalysts. However, traditional stoichiometric engine technology had been limited by high in-cylinder temperatures, leading to very high engine out NOx emissions, knock limited power density, poor thermal efficiency and lower durability. Historically, CWI's natural gas engines hae utilized spark ignition and lean-burn combustion in order to provide a significantly improved combination of emissions, torque, durability and fuel economy vs. traditional stoichiometric engines. However, lean combustion SI systems are likely to experience difficulties in achieving future NOx and NMHC reductions, as further leaning of the air/fuel ratio mixtures to reduce NOx would result in ignition and combustion difficulties. Analysis and experimental data showed that a compelling combination of low emissions, increased power density and increased fuel efficiency could be achieved by utilizing cooled exhaust gas recirculation (EGR) with a stoichiometric combustion principle, in combination with a three-way exhaust catalyst. CWI refers to this technology collectively as SI-EGR technology.

Status
All project work is complete and a final report documenting all project details has been delivered to SCAQMD.

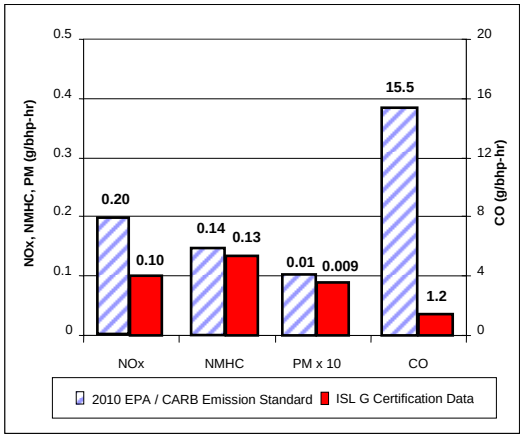
Results
This program resulted in commercial release of the ISL G engine with SI-EGR technology.

Specific results of the program include:

- Developed new engine fuel system and EGR air handling components to ensure

adequate and consistent mixing of charge air, EGR and fuel.

- Developed new electronic control strategies and a new electronic control module (ECM), based on the latest generation of ECMs used on CWI diesel engines.
- Developed new power cylinder components optimized for SI-EGR combustion.
- Developed a range of ratings from 280 to 320 hp initially. The ratings range was expanded from 250 to 320 hp following product launch.
- Developed a new three-way catalyst suitable for commercial vehicles.
- Demonstrated ISL G at six fleets (four public transit agencies and two refuse collection fleets), which confirmed engine operation in a variety of operating environments, including hot and cold weather, and high altitude operation.
- Certified ISL G to U.S. EPA/CARB 2010 emission levels. The following graph depicts the emission test data, as reported on the 2008 CARB Executive Order for ISL G.
- Commercialization of the ISL G engine, with production availability beginning Jun/07.



Benefits

ISL G provides the following benefits:

- Emissions – ISL G is the first engine certified to the U.S. EPA/CARB 2010 standards for commercial vehicles. ISL G provides up to 25% reduction of greenhouse gas emissions when compared to diesel powered vehicles on a "well to wheels' basis.
- Economics – Natural gas fuel cost advantages vs. diesel fuel enable lowest life cycle cost for customers with high annual fuel use. ISL G qualifies for California and Federal incentives.
- Energy Security – ISL G is capable of operation on a diverse range of fuels, including conventional natural gas, landfill gas, and bio-methane, thus reducing reliance on imported oil.

Project Costs

Contract #05244 estimated a total project cost of $5.943 million for the ISL G development, demonstration and commercialization program, with $1.390 million contributed by SCAQMD. The total project cost exceeded $5.943 million, with CWI funding the incremental cost.

In addition to the funding support from SCAQMD, CWI secured partial funding support from the NREL per contract ZCI-5-44118, and UTD (a division of Gas Technology Institute) per contract 2.5.J.

Organization	**Funding Contribution**
South Coast AQMD	$1.390M
NREL	$0.600M
UTD	$0.350M
Total Funding	**$2.340M**

Commercialization and Applications

The ISL G has been commercially launched, and has replaced CWI's C Gas Plus and L Gas Plus engines in North America. ISL G was targeted at urban bus and refuse collection truck markets initially. CWI worked with most major North American bus and refuse truck OEMs during the ISL G development program, thus leading to broad OEM availability of ISL G in 2007. CWI is pursuing ISL G availability in additional medium- and heavy-duty vehicle applications (e.g., street sweepers, medium-duty trucks, yard hostlers, shuttle buses and school buses), and is working with OEMs in each of these market segments. ISL G availability in these applications is anticipated to begin in 2008.

AQMD Contract #06209 **August 2008**

Develop & Demonstrate Heavy-Duty Hydrogen & Natural Gas Mixture Engine

Contractor
City Engines, Inc. (City)

Cosponsors
Los Angeles County Metropolitan Transportation Authority (LACMTA)

Project Officer
Naveen Berry

Background
City planned to develop a flex-fueled internal combustion engine suitable for heavy-duty applications. The engine would be capable of being powered by either natural gas or a 30% mixture of hydrogen and natural gas (HCNG). Powering the engine on HCNG was expected to provide significant NOx reductions.

Project Objective
The project would develop a heavy-duty engine that could be flex-fueled and obtain low NOx emissions, while achieving high brake thermal efficiency. The NOx emissions from the engine are expected to be below 2010 standards without the use of an exhaust catalyst. The engine developed would be a drop-in replacement for the Detroit Diesel 50 G engine that is now out of production.

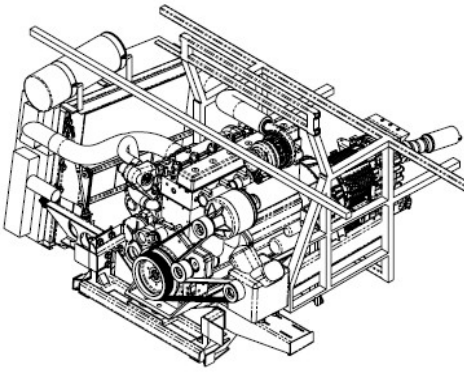
Technology Description
City proposed to modify a Doosan 11.0L engine to operate on a mixture of 30% hydrogen blended into natural gas. The combustion of a 30% HCNG mixture, along with the proper head design and engine calibration has shown significant reductions in engine-out NOx emissions. The hydrogen addition extends the lean limit of combustion that allows the low level of NOx emissions without significantly increasing the hydrocarbon emissions.

Status
The project has been terminated, commensurate with City going out of business.

City signed contracts with LACMTA / SCAQMD on 8/28/06. At that time, City was in final negotiations for a major investment by Doosan Infracore of Korea, which did not materialize. City undertook the contracts with LACMTA / SCAQMD assuming that the overheads would be covered by Doosan's investment. All the engine work anticipated using Doosan 11-liter engines for the demonstration.

The work completed on the project is the receipt of four basic Doosan 11-liter engines; as well as the dynamometer testing and tuning of the base engine on CNG and HCNG under various cylinder head configurations. There was also work completed on the engineering/design to configure the Doosan engine and attached components to fit in LACMTA's buses. All those tasks were completed satisfactorily and paid for by LACMTA / SCAQMD.

City tried to obtain additional equity financing from others without success. City terminated operations since it did not have sufficient funding to support their operations. As a consequence, the HCNG engine project was terminated.



Results

Initial testing and mapping of the engine with 30% HCNG, along with an optimized head design, yielded engine-out NOx values of 0.13 g/bhp-hp. These test results were measured on a 13 mode test, and verified through independent testing at Southwest Research Institute. The engine-out NOx emissions of the HCNG engine were below the levels required to meet the 2010 standard of 0.2 g/bhp-hr

Benefits

The development of the HCNG engine demonstrated that a 30% mixture of hydrogen with natural gas, along with the proper engine calibration and design, can yield significant NOx reductions. The magnitude of the NOx reductions is significant enough to meet 2010 NOx standards without the use of exhaust aftertreatment.

Project Costs

The SCAQMD paid $185,000 towards the development of the HCNG engine, prior to the cancellation of the project. The SCAQMD's commitment towards the project total was $500,000.

Commercialization and Applications

The engine developed as part of this project proved to effectively reduce NOx emissions below 2010 standards. However, there are challenges in commercializing the product since the developer is no longer in business. Commercialization would either require a significant cash infusion to re-start City Engines, Inc., or the licensing of their technology to another company.

AQMD Contract #07033 **September 2008**

Expand Reformer System & Upgrade Hydrogen Refueling Station in Coachella Valley

Contractor
SunLine Transit Agency

Cosponsors
SunLine Transit Agency
Federal Transit Administration (FTA)

Project Officer
Naveen Berry
Larry Watkins

Background
In 2000, SunLine started looking into a reformer based technology to drive the hydrogen production cost down to below $4.00 per kilogram. The preferred technology chosen was a reformer-based system. A prototype unit was built, installed and tested in 2004-2006 by HyRadix. HyRadix developed and installed a Commercial Hyradix Adéo™ Auto-thermal Reformation (ATR) reformer capable of refueling 220 kg per day in late 2006. The hydrogen produced is used for hydrogen buses and automotive hydrogen cars tested in the Coachella Valley @ 1000 kg/month.

Project Objective
The AQMD agreement consisted of replacing the prototype reformer with the commercial HyRadix Adéo™ Hydrogen Generator capable of producing up to 220 kg/day, as well as a six-year maintenance agreement to guarantee reformer operation. It also included the installation of a 60 kg of hydrogen storage unit. An upgrade was completed for the current single hose hydrogen dispenser into a two hose dispenser, one for light-duty vehicles and one for fast-filling full size buses. Installation of a Fuel-Force 814-C hydrogen fuel island card reader with magnetic stripe reader was completed. Upgrade of the current booster compressor with a PDC booster compressor to allow fast high pressure recovery time was completed.

Technology Description
The ATR reformer offers unique capabilities in start-up and turn-down ratios. The ATR operating capability between 25% and 100% also helps in producing the exact hydrogen production demand required. The footprint makes the installation relatively simple. The unit utilizes a Pressure Swing Absorption system to ensure hydrogen purity from 99.95 to 100%.

Onsite hydrogen production offers a hydrogen station cost savings when the hydrogen produced costs less than $15 per kilogram. Although agreements can be made to purchase hydrogen below $10 per kilogram, equipment cost (leasing) over the long term add cost to this number. Owning and operating a station offers the flexibility to produce hydrogen on an as-needed basis. There are no penalties or surcharges for delivery for not meeting the minimum amount required.

Status
This project was completed on September 30, 2008. Currently, the reformer unit has logged over 12,800 hours to date with only minor problems occurring with auxiliary components such as the cooling tower, DI water system and one event with the PSA controls. The burner igniter also experienced an early failure and needed to be replaced at 2300 hours. HyRadix developed a bolt-on upgrade for the burner that addressed this early component failure.

New Reformer Installed

The new storage task incurred significant problems and delays in the procurement phase and a different manufacturer was needed to accomplish this task. The dispenser upgrade also incurred problems from the manufacturer for the upgrade and a

different contractor was used to accomplish this task. Many car manufacturers have begun to utilize this hydrogen station for early vehicle testing and introduction. The card reader system did not incur any delays. The Booster compressor upgrade was accomplished with no issues or delays.

Results

The operation of the unit in 2007 offers the best description of the hydrogen cost averaging $7.00 per kg. SunLine began working with HyRadix on a plan to reduce the operational cost by running the unit at maximum efficiency and only for hours to produce the hydrogen required. When demand fell below 200 kg per month the cost of hydrogen was above $7.00/kg. In 2008, the cost of natural gas was up to over 100% of the cost compared to 2007. The higher cost attributed to an increase in cost per kg, energy prices were detailed in the data for 2008.

Benefits

In 2006, the SunLine hydrogen station became part of the California Hydrogen Highway (CaH2) network. As part of the CaH2 Network the SunLine hydrogen station must provide public access to hydrogen customers 24/7. The station access was one of the most challenging aspects to achieve. An agreement between automotive manufacturers was usually needed before any fueling was conducted. Hydrogen fills were sold as a service provided on a per-fill basis because no California Division of Measurement Standards (DMS) standard existed. In the 3rd quarter of 2008, SunLine requested DMS check the hydrogen station for accuracy. The accuracy of the 5000 dispenser was within a repeatable tolerance (<2%) and 2% by weight in the customer's favor. DMS instructed SunLine that no hydrogen could be sold on a kg basis until the standards are adopted. The estimated time for standards is 2nd qtr 2009.

Project Costs

The total project cost was $1.2 million with no budget overrun. The total payment from AQMD was $640,000 for this project.

Commercialization and Applications

Some early testing of a Partial Oxidation reformer in 2000 was conducted with a Hydrogen Burner Technologies (HBT) unit, but no hydrogen was ever compressed with the HBT equipment. In 2004, a prototype Adéo™ was installed and tested; this equipment provided hydrogen for two years. Valuable experience was gained through the operation of the Adéo™ prototype unit during 2004 through 2006 that led to the development of a new commercial Adéo™ unit by HyRadix.

The California Division of Measurement Standards will be implementing hydrogen dispenser purity and measurements standards in 2009. SunLine hopes to have the hydrogen dispensers prototype approved with the new standards and be able to provide hydrogen sales on a per kilogram basis similar to CNG sales.

AQMD Contract #04003 **May 2008**

Install & Demonstrate Fuel Cell Vehicle Maintenance Facilities in Long Beach

Contractor
DaimlerChrysler RTNA, Inc.

Cosponsor
Mercedes Benz USA (MBUSA)
US Department of Energy (USDOE)

Project Officer
Lisa Mirisola

Completed building addition to MBUSA Los Angeles Technical Center

Background
To support a fleet of zero-emission vehicles (ZEV) within the South Coast Air Basin to achieve air quality improvement and in conjunction with the USDOE Fuel Cell Demonstration Program a facility to support service, maintenance and testing of fuel cell powered vehicles was needed. DC-RTNA decided to utilize an existing corporate facility in Long Beach CA, the Mercedes Benz Los Angeles Technical Center for this purpose.

To service and maintain the vehicles that are fueled with hydrogen a workshop within the facility had to be made "hydrogen safe". It was decided to build an addition to the existing building in order to satisfy the requirements of the RTNA fuel cell support group. The building addition would consist of a workshop and office which will share a common wall and entrance with the existing structure. The fuel cell workshop will be made "hydrogen safe" by means of a hydrogen detection and ventilation system.

Project Objective
To install and demonstrate a fuel cell vehicle maintenance facility in Long Beach California; to design a workshop within the facility that is equipped with hydrogen safety systems which are cost effective in protecting personnel, the environment and property.

Technology Description
Designing new or modifying existing facilities to accommodate hydrogen fuel cell vehicles safely has been based on tailoring established building codes and standards which govern gasoline and natural gas. Such tailoring has involved case-by-case interpretations of non-hydrogen codes and standards to hydrogen. In the absence of well defined codes and standards for this type of facility an engineering and analytical approach was used to design the hydrogen safety systems for the workshop. A computational fluid dynamic (CFD) method was used to model the proposed workshop design to predict the most probable behavior of potential leaking hydrogen within the facility.

Analysis of other "hydrogen safe" fuel cell support facilities such as the California Fuel Cell Partnership in Sacramento, Toyota Motors and Honda Motors in Torrance helped to reinforce

and validate the design direction of the Long Beach facility.

Status

The "Fuel Cell Vehicle Maintenance Facility Demonstration" was completed on April 26, 2006 and is fully operational.

Results

The outcome of the Fuel Cell Vehicle Maintenance Facility project is a state of the art hydrogen vehicle facility that fulfills the requirements of maintaining the present and future fleets of hydrogen fuel cell vehicles in southern California. Currently there are 13 fuel cell vehicles in the DaimlerChrysler fleet in the Los Angeles area; 11 A-Class F-Cell's and 2 Sprinter fuel cell van. The fleet customers in addition to SCAQMD are SCE, UPS, UCLA and Los Angeles World Airport. The DaimlerChrysler southern California fuel cell fleet has accumulated over 67,000 miles in 24 months beginning 2/22/2005. The temporary and permanent facility at the LATC was utilized for visits by vehicles in the fleet during the 24 month period. The purpose of the visits included vehicle maintenance, software and hardware updates and data retrieval.

Benefits

For DaimlerChrysler the facility is and will continue to be a center for deployment of clean fuel and advanced propulsion vehicles, information and data gathering, testing and development of new designs and a source of feedback on vehicle performance to engineering so they can improve and refine future products. Externally DaimlerChrysler brings to southern California and the South Coast Air Quality Basin vehicles that when commercialized will impact the air quality in the region.

Costs

The construction costs of the building extension that includes the offices and workshop was $2,006,734. The hydrogen safety portion of the facility construction costs which includes hydrogen modeling, detection and mitigation system was $201,687, about 10% of the total construction costs. Combined, the tools and equipment for the workshop and the costs for the hydrogen safety system was $294,242; of this amount the AQMD provided $253,000.

The application of the hydrogen detection and mitigation technology that was used to make the DCRTNA workshop safe for hydrogen vehicles is not breakthrough and has existed for many years. What is new is the use of CFD modeling tools to develop and prove out the design of a hydrogen detection and mitigation system.

AQMD Contract #05104 **September 2008**

Stationary Fuel Cell Demonstration in the South Coast Air Basin

Contractor

Alliance Power, Inc. (Alliance)
FuelCell Energy, Inc. (FCE)
Otto H. Rosentreter Company
Snowden Electric Company
California Metals Coalition

Cosponsors

Self-Generation Incentive Program, administered by the SoCal Gas Company
US DOD (Fuel Cell Climate Change Program)

Project Officer

Adewale Oshinuga

Background

TST Inc. contracted with Alliance to install a 500-KW fuel cell cogeneration system to improve energy efficiency and control costs at their Fontana facility. As part of the project, Alliance responded to a competitive Request for Proposals issued by SCAQMD for the Demonstration of Natural Gas, Stationary Fuel Cells in the South Coast Air Basin in August 2004.

Project Objective

The objectives of the SCAQMD demonstration program were to: (1) further the creation of markets for fuel cells; (2) provide an incentive for businesses to install fuel cells in order to accelerate commercialization; (3) gain operational experience; (4) develop a reliable database; and (5) achieve public awareness for the efficiency and air quality benefits.

Technology Description

Molten Carbonate Direct Fuel Cell (DFC) power plants manufactured by FCE produce electricity using methane from natural gas or other alternative gaseous fuels. Within the fuel cell process, the methane is converted to hydrogen, which then reacts with oxygen (from ambient air) to generate electricity. The DFC300A fuel cells have a rated electrical efficiency of 45% (LHV). Additional information about the DFC technology is available at www.fce.com.

Since the DFC fuel cell technology is not a combustion process, emissions from molten carbonate fuel cells are very low. FCE obtained a CARB DG Certification (DG-003) for the DFC300A power plant with the following emission characteristics:

- <0.07 lbs NOx/MWh
- <0.10 lbs CO/MWh
- <0.02 lb VOC/MWh
- Particulate emissions comparable to a limit corresponding to natural gas with fuel sulfur less than 1 grain per 100 scf.

Status

Construction of the project began in April 2006, with the fuel cells delivered to the site in June 2006. The project was completed in August 2006 and the fuel cells continue to operate at the site. A final report is on file at SCAQMD with complete technical details of the project. The few unanticipated project issues that arose were related to site-specific implementation issues, and did not significantly affect fuel cell performance.

Results

The fuel cell cogeneration system installed at the TST facility has successfully operated since August 2006. The following table summarizes the fuel cell performance during the 12-month demonstration period. Performance during the demonstration was consistent with expectations of 95% equipment availability and greater than 42% electrical efficiency.

Fuel Cell Performance
August 2006 through July 2007

Parameter	Unit 52		Unit 53	
Rated Fuel Cell Capacity (kW)	250	kW	250	kW
Total Operating Hours (hrs)	7,828	Hrs	8,175	Hrs
Total Time in Period (hrs)	8,568	Hrs	8,568	Hrs
Availability (%)	91	%	95	%
Total Energy Produced (kWh)	1,865,626	kWh	1,923,057	kWh
Average Electric Output (kW)	238	kW	235	kW
Peak Electric Output (kW)	260	kW	249	kW
Capacity Factor (%)	87	%	90	%
Fuel Usage (BTU)	13,688	mmBTUs	15,265	mmBTUs
Heat Rate (BTU/kWh) LHV	7,337	BTUs / kWh	7,938	BTUs / kWh
Electrical Efficiency (%) LHV	47	%	43	%

Benefits

Performance data collected during this project add to the demonstrated successful operating experience for stationary, molten carbonate fuel cells. Molten carbonate fuel cells provide the highest electrical efficiency of any currently available distributed generation technology for base-load applications in the 0.5 to 5 MW size range, with significantly lower air pollutant emissions, including carbon dioxide (CO_2).

Widespread installation of molten carbonate fuel cells in new or existing distributed generation applications could reduce criteria pollutant and CO_2 emissions compared to other distributed generation technologies currently available.

Project Costs

The total project cost for the 500-KW fuel cell cogeneration facility, including installation and monitoring, was $2,876,875, slightly over the budgeted amount of $2,780,000. The cost overrun was related to modifications required to the fuel cell water treatment systems to comply with City of Fontana Planning Department requirements that prohibit the use of water softeners in Fontana. As a result, the water treatment systems in the fuel cells had to be redesigned and fabricated at a cost of over $90,000 to the project.

A critical piece of the project's success was the securing of grants from the South Coast Air Quality Management District, the California Self-Generation Incentive Program, and the Department of Defense to offset the cost of the fuel cell equipment. Grant funds from these organizations totaled $2,315,000, of which the AQMD provided $565,000.

Commercialization and Applications

Since this project was completed, over 6 MW of additional DFC fuel cell generating capacity have been installed in California, including three projects (2.5 MW) nearing completion in the SCAQMD. The DFC molten carbonate fuel cell technology is a commercially-ready product for the distributed generation market. Increased demand for the equipment is needed to reduce production costs and make the technology cost-competitive without financial incentives.

AQMD Contract #03292 **December 2008**

Professional Wet Cleaning Technology Demonstration & Pilot Incentive Project

Contractor

Occidental College, Pollution Prevention Center

Cosponsors

Southern California Edison, The California Wellness Foundation, California Air Resources Board, Marisla Foundation, Panta Rae Foundation, Los Angeles Department of Water & Power

Project Officer

Matt Miyasato, Ph.D.

Background

In the South Coast Air Basin, there are currently over 2,500 professional garment cleaners in operation. In December 2002, the SCAQMD has adopted a rule (Rule 1421) to phase-out perchloroethylene (PCE) dry cleaning due to ongoing adverse health and environmental risks and the availability of alternatives. While PCE dry cleaning was the dominant technology at the time, most cleaners who have replaced their PCE equipment have installed hydrocarbon dry cleaning, which is also regulated by the SCAQMD as a VOC (Rule 1102). One opportunity to eliminate toxic and/or smog-forming emissions from commercial cleaners is a technology known as professional wet cleaning (PWC). While PWC has been demonstrated to be a technically viable, cost-effective, energy-efficient substitute, its diffusion has been hampered by a number of barriers. Under a prior contract with the SCAQMD, the Pollution Prevention Center established 8 PWC demonstration sites in order to encourage the diffusion of this technology in the South Coast region. Under this contract, PPC expanded the project by established 14 additional PWC sites.

Project Objective

The aim of the project was to help "jump-start" the use of PWC by providing the marketplace environment that is essential for its commercial development, by accomplishing the following objectives:

- Develop a $175,000 equipment grant program to assist 14 cleaners in the region in switching from PCE dry cleaning to PWC.
- Provide financial and technical assistance to dry cleaners in switching to PWC.
- Conduct an outreach campaign to educate dry cleaners about the viability of PWC and to identify applicants for the grant program.
- Re-evaluate the overall viability of the professional wet cleaning after the new demonstration sites have been created.

Technology Description

Professional wet cleaning is a water-based process that uses computer-controlled washers and dryers, specialized detergents, and tensioning finishing equipment to clean delicate garments that are typically dry cleaned. PWC washer's computer controls mechanical action, fluid levels, temperature, and extraction parameters. Specially designed bio-degradable cleaning agents prevent dye bleed, give clothes body and shape, and minimize shrinkage. PWC dryer's precise moisture control detects moisture levels in garments and prevents shrinkage from over-drying. Tensioning finishing equipment uses steam, hot air, and tension to efficiently shape and press garments.

Status

The project was completed in December 2008. The Final Report, completed December 23 2008, is on file with complete technical details of the project.

Results

Educational Outreach: A total of 16 information articles were developed for the regional trade press, 32 direct mailers were sent to cleaners, 40 workshops were held, 703 cleaners attended workshops, and 34 applications were received by cleaners interested in becoming demonstration sites.

Creation of Demonstration Sites: 14 PCE dry cleaners received demonstration grants to switch to PWC. The new sites were geographically distributed throughout the SCAQMD region: 8 in Los Angeles county, 4 in Orange County, 1 in Riverside county, and 1 in San Bernardino county.

Evaluation of Technology: A study identified several criteria to evaluate the success of each cleaner's conversion to PWC in addition to analyzing the factors that facilitate an effective transition from PCE dry cleaning to PWC. Study results indicate that cleaners switching from PCE dry cleaning to PWC maintained their level of service, reduce their operating costs, and avoid regulations and liability concerns. In addition, significant energy benefits were identified. The study also pointed to training, proper installation of equipment and machine programming, as well as the availability of demonstration facilities for new cleaners to observe the cleaner cleaners process, as the primary factors that can facilitate a transition to this new technology.

	Professional Wet Cleaning	PCE Dry Cleaning
Technical Performance	Same	Same
Operating Cost	Lower	Higher
Energy Use	Lower	Higher

Benefits

The project was successful in further establishing the viability of PWC as an alternative to traditional dry cleaning. The demonstration sites created by the project continue to host educational workshops tours for anyone interested in PWC, and are contributing to the commercialization of this pollution prevention technology. Knowledge of how to more successfully do PWC is accumulating as cleaners improve and develop wet cleaning methods. An increase in the range and quality of wet cleaning equipment and products now available is indicative of the development of an infrastructure supportive of PWC. There are now over one hundred cleaners in the SCAQMD region exclusively using PCE.

From a policy perspective, the success of the project contributed to the passing of three laws and regulations that will help to reduce toxic air emissions from the dry cleaning industry and commercialize non-toxic and non-smog-forming alternatives. In 2002, the SCAQMD ruled to phase-out PCE dry cleaning by 2020. In 2003, California passed legislation creating a Non-Toxic Dry Cleaning Incentive Trust Fund, which funds a statewide demonstration and grant programs for non-toxic and non-smog-forming garment care technologies. In 2007, the California Air Resources Board voted to phase-out PCE dry cleaning throughout California.

Project Costs

The AQMD share of this project was $311,000, of which $16,000 was provide from the Clean Fuels Fund. The total cost of the project was $500,000.

Commercialization and Applications

This project has further established that PWC can successfully process the full range of garments traditionally dry cleaned. In addition, operating costs and energy use was shown to be significantly lower in PWC compared to PCE dry cleaning. The number of equipment and detergent manufacturers selling PWC has grown substantially during the course of the project. While the number of dedicated PWC shops now numbers over one hundred in the greater Los Angeles region, to capture a dominant market share, PWC must still overcome significant market barriers include: resistance to the technology by equipment distributors (who make more money selling traditional dry clean equipment), cleaners' concerns about the 'dry clean' care label, cleaners' fearing that customers will begin home washing garments if they knew that the cleaner was using a water-based technology. On the other hand, enforcement of the California Fire Code, which requires the installation of sprinkler systems for facilities using combustible dry clean solvent machines (including hydrocarbon and silicone), is likely to drive more cleaners to PWC. In addition, if the Federal Trade Commission requires that garment manufacturers label garments with a 'professional wet clean' label where appropriate, customers will begin to demand this service and cleaners will feel more comfortable making the switch to PWC.

AQMD Contract #07017 **July 2008**

Field Demonstration of 5-PPM FIR Burner on a Watertube Boiler

Contractor
Gas Technology Institute

Cosponsors
Southern California Gas Company
Coen Burner Company

Project Officer
Howard Lange

Background

This project addressed large industrial boilers rated at or above 20 MMBtu/hr, most of which are watertube boilers. Existing boilers in this size category have NOx limits of 40, 30 or 9 ppm[1], depending on the date of permitting; new boilers in this size category are limited to 9 ppm NOx, the current NOx BACT. This project was to demonstrate an advanced ultra-low-NOx burner capable of operation at or below 5 ppm NOx and 30 ppm CO. This burner technology, called forced internal recirculation (FIR), has been developed by the Gas Technology Institute (GTI) and the Coen Burner Company, a leading supplier of burners used in industrial boilers.

The FIR technology already had been commercialized in a 12-ppm firetube boiler, which is offered by the Johnston Boiler Company. The 9-ppm version intended for larger boilers had been demonstrated on one industrial boiler; and this project was to demonstrate it on a second boiler, owned by Cal Tech, while also seeking to demonstrate 5-ppm operation.

AQMD co-funded this project because the target NOx and CO emission levels are well below current BACT levels for this class of boilers, and the technology offers additional advantages in terms of improved boiler efficiency and avoidance of ammonia-based NOx control. Since this technology is retrofitable to most boilers, there is also the potential to reduce emissions from the existing boiler population.

Project Objectives

The objectives of the proposed project were to demonstrate the ability of a 62 MMBtu/hr FIR burner on a 50,000-lb/h package watertube boiler to meet the targets listed below:

- Stack NOx emissions at or below 5 ppm;
- Stack CO emissions at or below 30 ppm;
- Stack total hydrocarbon (THC) emissions at or below 10 ppm;
- Ability to deliver 50,000 lb/hr of 100-psig steam;
- Turndown of at least 5 to 1; and
- Smooth reliable startup and response to facility steam demand.

Technology Description

The FIR burner concept, shown in Figure 1, combines premixed combustion, internal recirculation of partial combustion products, and controlled air or fuel-air staging. These techniques promote stable, uniform combustion, minimize peak flame temperatures, prevent the formation of high-oxygen pockets, and enhance heat transfer to reduce second-stage combustion temperatures.

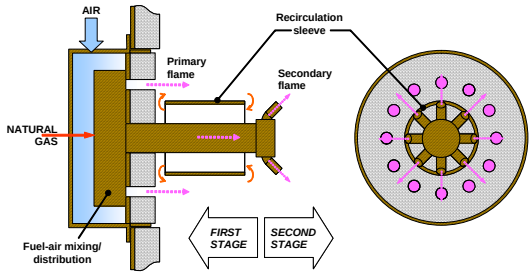


Figure 1. FIR Burner Technology

[1] All emissions are reported in ppmvd (parts per million by volume, dry) on a 3% O_2 basis.

These effects combine to dramatically reduce NOx formation while maintaining good fuel burnout characteristics. Moreover, this is achieved at higher energy efficiency than competing burners that use high levels of flue gas recirculation (FGR), high excess air, steam injection, or water injection to achieve ultra-low NOx emissions

The fuel/air-staged FIR burner had been shown capable of sub-9 ppmv NOx on the first industrial boiler on which it was demonstrated, and in further laboratory testing, it was found to be possible to reduce NOx as low as 5 ppmv by applying a suite of modifications. Details of these modifications are considered proprietary, but in general terms they include:

- The use of a small amount (5-10%) of FGR directed to the second stage, with the option to redirect a portion also to the first stage air inlet.
- Improved fuel-air premixing and "tunable" transverse staging, integrated into an advanced mixing header assembly with variable nozzle sizes and replaceable spuds.

Status

The FIR burner, including the 5-ppm hardware, was installed in the boiler at Cal Tech. Coen and GTI experienced difficulty in achieving 9-ppm operation together with stable burner operation. After more than 18 months of various burner modifications and short tests, Cal Tech requested that the burner be removed so they could return the boiler to normal operation. At that point, GTI requested that the project be terminated.

Results

The project showed that the 9-ppm version of the FIR burner intended for large watertube boilers needs further development. Although operating successfully at less than 9 ppm NOx on one industrial boiler, the technology was not successfully extrapolated to the Cal Tech boiler, which appeared to be a similar boiler. Because of this problem, it was not possible to enter into the planned field demonstration of 5-ppm operation on this boiler.

Benefits

If successfully demonstrated and deployed, staff estimates NOx reductions of 1,191 tons per year for the existing, applicable boiler population. Further reducing the NOx BACT for new boilers from 9 ppm to 5 ppm would save an additional 2.4 tons per year of NOx emissions each year going forward.

Project Costs

For the fabrication, installation and testing work that was completed up to the termination of the project, SoCalGas paid $90,000 and Coen contributed $320,957 for labor, materials and expenses. Coen's contribution was well in excess of their planned $120,000 contribution. AQMD's obligations were limited to hardware and work specifically related to reducing the NOx from 9 to 5 ppm, toward which AQMD paid $19,671.

Commercialization and Applications

GTI would like to offer the FIR burner as an energy-efficient alternative to more conventional ultra-low-NOx (9-ppm) burners. GTI believes a 5-ppm option for boilers within the geographical boundaries of the South Coast District is feasible if the market appears strong enough. However, the technology needs further development before its potential for commercial viability can be assessed.

AQMD Contract #02114 **February 2008**

Outreach Support of Low-Emission Clean Fuel Heavy-Duty Vehicles

Contractor

Gladstein, Neandross & Associates LLC (GNA)

Cosponsors

GNA leveraged support from 49 public and private agencies to support the efforts of this contract

Project Officer

Connie Day

Background

SCAQMD is committed to assisting in the deployment of alternative fuel vehicles (AFVs) in order to improve regional air quality. It has promoted these efforts through a number of projects ranging from public outreach activities, targeted fleet operator information workshops, AFV infrastructure development projects and projects such as the Interstate Clean Transportation Corridor (ICTC), a public-private partnership to link the Southwestern United States via a clean fuel infrastructure loop to support AFV deployments.

The SCAQMD Fleet Rules (1190 Series), California Air Resources Board (ARB) Diesel Risk Reduction Plan, California Energy Commission (Energy Commission) Strategy for Reducing Petroleum Dependency in California and California Alternative Fuels Plan (AB 1076 and AB 1007), U.S. Environmental Protection Agency (EPA) West Coast Collaborative to Reduce Diesel Emissions, the San Pedro Bay Ports Clean Air Action Plan (CAAP), SCAQMD's own Air Quality Management Plan and Clean Port Initiative goals are met through the deployment of AFVs. These vehicles provide an economically and operationally feasible strategy for reducing NOx, diesel particulate matter (PM) and Greenhouse Gas (GHG) emissions while at the same time displacing use of gasoline and diesel.

Project Objective

SCAQMD executed a contract with GNA to accelerate market penetration of low-emission, heavy-duty AFVs. The following task orders were issued under this contract:

- TO#1-3, Technical Assistance, Infrastructure Support and Secure AFV Project Funding: These projects supported the ICTC public-private partnership to generate fleet interest in purchasing heavy-duty AFVs, help develop infrastructure links to support AFVs in the SCAQMD region and to help fleets secure public funding to implement their vehicle and fuel projects.
- TO#4A, Ride and Drive at SCAQMD: This event promoted low-emission heavy- and medium-duty vehicles to fleet decision-makers.
- TO#4B, AFV Expo: The Southern California AFV Expo (EXPO) was a two-day event targeted at fleet operators and purchasing decision-makers to educate attendees about AFV and low-emission technology product availability, funding opportunities and fleet rules.
- TO#4C, CRRA R&D at Speedway: GNA organized a Ride and Drive at the California Resource Recovery Association's annual event to exhibit natural gas refuse recovery vehicles.
- TO#4.1, City of Commerce: GNA helped secure commitments to develop the City of Commerce LNG/LCNG station
- TO#5, City of Commerce: GNA helped the City of Commerce build an LNG/LCNG Station. GNA secured funding, developed and reviewed responses to the station RFP, helped locate an appropriate site, and coordinated user fleet involvement in the station development project.
- TO#6, Fleet Modernization: The Carl Moyer Heavy-Duty Truck Fleet Modernization Program Outreach aimed to educate truck and fleet owners about funding opportunities for newer trucks through the grant award program and to help the SCAQMD identify and secure cost-effective projects.
- TO#7, Carl Moyer Program Cost-Effectiveness Marketing Plan: This task was to identify marketing strategies, sector targets, and outreach improvements to secure cost-effective projects for the Carl Moyer program.

Each of these Task Orders supported the project objective to reduce emissions by means of AFVs.

Technology Description

These projects emphasized natural gas technologies, especially for heavy- and medium-duty vehicles, since they provide the cleanest available engines. Heavy-duty engines for model year 2003 through 2006 were required to meet a NOx standard of 2.5 g/bhp-hr NOx plus NMHC. During that time, no diesel engine was certified to meet the Optional Low NOx standard of 1.8 g/bhp-hr NOx and NMHC. However, 18 natural gas engines were certified at this low emission level. Heavy-duty natural gas engines now meet the extremely low emission 2010 on-road standard of 0.2 g/bhp-hr.

Status

The contract term was from May 2001 through December 2007. GNA has provided monthly reports and status updates on each of the applicable task orders throughout the project.

Results

Through all its Ride & Drive, event, marketing, outreach, and infrastructure development projects, SCAQMD has encouraged communication among manufacturers, station developers, fuel providers, funding agencies and fleets. The ICTC has encouraged the clean technology market by developing natural gas refueling infrastructure and developing fleet support for the deployment of low emission vehicles. The entire project has therefore accelerated market penetration of AFVs and contributed to the reduction of mobile source emissions.

- ICTC used seed money from SCAQMD to help secure $28.9 million (to date) in order to: build 23 natural gas fueling stations and to deploy 505 heavy-duty and 160 light duty natural gas and LPG vehicles.
- Many hundreds of fleet operators were able to test drive and "kick the tires" of the light-, medium- and heavy-duty AFVs on display at various regional Ride and Drive activities.
- Over 450 of Southern California's public and private fleet vehicle operators attended the EXPO, held at the Ontario Convention Center on December 2-3 of 2002. The event structure allowed fleet operators to address key concerns and examine opportunities with AFVs.
- The Commerce LNG/LCNG Station is now under development, and will soon provide critical fueling access to multiple heavy-duty fleets in an underserved region for alternative fuels.
- GNA spoke with over 130 fleet operators and vehicle owners and delivered program information to over 3,500 during the course of its Fleet Modernization Outreach. GNA organized an information workshop at SCAQMD which attracted 70 attendees. GNA identified 6 possible Fleet Modernization Projects for SCAQMD to pursue.
- GNA delivered a report to SCAQMD detailing marketing strategies and recommendations for the Carl Moyer Program on January 15, 2008.

Benefits

Project tasks such as the events, marketing and outreach activities helped increase market penetration and fleet acceptance of alternative fuel and low emission technologies. These task orders promoted funding opportunities, allowed fleet operators to examine the newest emission reduction technologies, and offered strategies for implementing successful AFV station and vehicle projects. These activities have all been critical for SCAQMD to achieve its emission reduction goals by creating an overall more favorable environment for alternative fuels. Projects such as the ICTC have helped produce more directly quantifiable air quality benefits by reducing emissions of priority pollutants (NOx and PM) by **380 tons annually**. Additionally, the ICTC helped reduce diesel consumption by approximately 6.8 million gallons annually and helped generate $89 million in economic activity.

Project Costs

For many of the events and ICTC tasks, GNA secured significant co-funding from a variety of sources. The SCAQMD's direct contribution was not-to-exceed $250,000. $100,000 was dedicated to ICTC partnership projects.

Commercialization and Applications

SCAQMD's efforts have increased deployments of AFVs and increased alternative fuel throughput in the region, despite limited availability of AFV product (compared to diesel). Consumer education about gasoline and diesel prices, alternative fuels, emission regulations and grant/tax incentives is critical to expanding the deployment of AFVs. By continuing to implement outreach efforts, assist in the development of natural gas refueling stations, and familiarize fleets about technology and funding options, SCAQMD continues to move forward in meeting its clean air goals.

AQMD Contract #04097 **June 2008**

Ongoing Operation & Improved Functionality of Clean Air Maps Internet Website

Contractor
CALSTART, Inc.

Cosponsors
See Table in Project Cost section

Project Officer
Phil Barroca

Background

Projects which ease the transition to alternative fuel use are inherently important to the acceptability and success of the Clean Fuels Program. In particular, mechanisms or programs which provide alternative fuel vehicle (AFV) operators with information on locations and operational status of alternative fuel stations are important during the development and early growth period of the commercial alternative fuel infrastructure. The Internet is a cost-effective and broad-reaching informational instrument accessible to all AFV users.

Project Objective

The intent of this project is to provide AFV operators with a reliable and up-to-date resource for locating operable alternative fuel stations while alternative fueling infrastructure is allowed to expand and mature.

This project continues the operation and maintenance and expands the capabilities of the poly-fuel website CleanCarMaps.com. CleanCarMaps (CCM) is a web-based resource for identifying and locating alternative refueling stations as well as providing additional information regarding station operating hours, directions, payment methods and operating status. CCM lists alternative fuels such as electric inductive small & large paddle, electric conductive, compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), biodiesel, ethanol, hydrogen and methanol. The project is intended to improve communication between CCM and alternative fuel station stakeholders resulting in "real-time" status of station operation and help minimize unnecessary trips to non-operating fueling stations. The project is also designed to provide "in-transit" or "on-the-fly" information on alternative fuel stations. A toll-free number will connect AFV operators with a live operator which has access and familiarity with the CCM website. The operator will provide the AFV operator with information on alternative fuel station location, directions, etc.

Technology Description

The technology utilized in this project is an interactive Internet website. The website posts information on alternative fuel stations. This information is regularly updated by CALSTART, utilizing information provided by website users as well as alternative fuel stakeholders. The project intends to enhance the frequency of communication between the CCM manager and the various fuel station operators.

Mobile phone technology is also utilized to provide AFV operators the ability to interface with a third party website user, e.g. Automobile Club of Southern California/AAA operators.

Status

This project was scheduled for three years with 12 consecutive quarterly reports, three annual reports, a draft final report and final report. The project was extended two quarters to allow some additional performance. The Draft Final Report and Final Report are pending completion and review.

Two tasks were evaluated by the Project Officer as not fully meeting project specifications: Task 2 - Improved Functionality and Task 3 - New Functionality. Task 2 - Improved Functionality required improving communication between CCM and the natural gas fueling providers to improve "real-time" operational status. Pre-program approval meetings attended by CALSTART, SCAQMD, and Clean Energy representatives, indicated technology was in-place to provide daily telecommunication from Clean Energy to the CleanCarMaps manager. Daily communication improves "real-time" station status which is

important with limited refueling infrastructure. This level of communication was not achieved and was limited to telephone information exchange every other day.

Task 3 - New Functionality required developing and maintaining an "in-transit" information system with AAA Emergency Roadside Service (ERS). This service allows AFV operators en route to call for information on alternative fuel station locations and directions. AAA operators would access CCM and relay AFV station information from the CCM website to AFV operators through a toll-free number. AAA had changes in their management resulting in a change in their commitment to meet and provide this service in a satisfactory manner. CALSTART identified a different organization, the Better World Group (BWG), to provide the intended ERS. Although BWG has met the performance criteria of service, their operating hours do not meet the project objectives of 7 days per week, 24 hours per day. The BWG operates Monday through Friday from.8:00 am to 5:00 pm.

Results

The project has resulted in maintaining and expanding some of the capabilities of the website identified in the project schedule. Additional alternative fuel stations have been identified on the website, as they became operational during contract period of performance.

CCM has gained a larger continual user list as evidenced by the number of web user hits and identifying CCM as a frequently used site. Overall, the CleanCarMaps.com website is serving a growing AFV owner population and is providing customers with the ability to locate AFV refueling stations in southern and northern California and Arizona, helping to expand the range and use-ability of AFVs.

Benefits

Alternative fuel technology has been and continues to be a major component in achieving emission reductions from both stationary and mobile sources. This project complements existing efforts promoting alternative fuel technology in the mobile sector, as well as facilitates a public outreach effort to private, public and commercial operators of AFVs. The success of the alternative fuel program in the mobile sector is dependent in part on the ease of use and minimizing the adversity of operating and refueling these vehicles. Since alternative fueling stations are not yet at conventional fuel station levels, information on station locations and fuel availability becomes a vital component to all operators of AFV (public, private, and commercial sectors). A centralized information resource with comprehensive, reliable, and current data on station locations and operating status is a cost-effective solution in the transition to alternative fuels in the mobile sector. The expansion of AFVs in the SCAQMD may be partly attributed to the increase in fueling infrastructure. The project has resulted in improved communication between CALSTART and alternative fuel stakeholders particularly station operators.

Project Costs

Final project costs are yet to be determined and provided by CALSTART. Below is a table of the sponsors and the amount they agreed to contribute at the outset of the project. To date, the amount of funding provided by SCAQMD is $83,535. The project has a remaining unpaid balance of $26,465.

Funding Source	Cost Yr 1	Cost Yr 2	Cost Yr 3	Total
SCAQMD	$40,000	$35,000	$35,000	$110,000
Federal Transit Administration	$20,000	$15,000	$15,000	$50,000
Auto Club	$10,000	$10,000	$10,000	$30,000
CNGVC, CFCI, NEVC, WPGA, CHBC	$10,000	$10,000	$10,000	$30,000
The Gas Company	$10,000	$10,000	$10,000	$30,000
Clean Energy	$10,000	$10,000	$10,000	$30,000
Pacific Gas & Electric	$10,000	$10,000	$10,000	$30,000
Gladstein & Associates	$5,000	$5,000	$5,000	$15,000
OEM's (Ford, GM, Honda)	$10,000	$10,000	$10,000	$30,000
Totals	**$125,000**	**$115,000**	**$115,000**	**$355,000**

Commercialization and Applications

The CleanCarMaps.com website is managed by CALSTART with sponsorship from various stakeholders in alternative fuel and alternative energy. Task 5 of this project required CALSTART to improve awareness of the website and seek corporate sponsorship to continue and expand its functionality.

AQMD Contract #05008 **July 2008**

Participate in California Fuel Cell Partnership & Provide Support for Regional Coordinator

Contractor

Bevilacqua-Knight, Inc.

Cosponsors

Steering team members through 2008 are auto manufacturers (Chrysler, Daimler, Ford, General Motors, Honda, Hyundai, Nissan, Toyota and Volkswagen), energy providers (BP, Chevron, and Shell Hydrogen), technology companies (Ballard Power Systems and UTC Fuel Cells), and government agencies (the California Air Resources Board, the California Energy Commission, the South Coast Air Quality Management District, the U.S. Department of Defense National Automotive Center, U.S. Department of Energy, the U.S. Department of Transportation, and the U.S. Environmental Protection Agency).
Associate partners are hydrogen gas suppliers (Air Products and Chemicals, Inc., and Praxair), hydrogen fueling station infrastructure providers (Pacific Gas and Electric, Proton Energy Systems, Inc., Stuart Energy, and Ztek), methanol supplier (Methanex), and bus transit agencies (AC Transit in the Alameda-Contra Costa area, Santa Clara Valley Transportation Authority in the Bay Area, and SunLine Transit Agency in the Palm Springs area).

Project Officer

Lisa Mirisola

Background

Established with eight members in 1999, the California Fuel Cell Partnership (CaFCP) is a collaboration in which private and public entities are independent participants. It is not a joint venture, legal partnership, or unincorporated association. Therefore, each participant contracts with Bevilacqua-Knight, Inc. for their portion of CaFCP administration. SCAQMD joined the CaFCP in April, 2000, and the CaFCP has grown to include over 30 organizations interested in demonstrating fuel cell vehicle and fueling infrastructure technology.

Project Objective

For 2004-2008, there were several goals:

- Facilitate members' placement of fuel cell vehicles and fuel stations in California;
- Promote fuel station interoperability ("common-fit" protocols);
- Promote practical codes and standards;
- Prepare communities for vehicles and fueling stations, and train first responders;
- Coordinate with other fuel cell vehicle demonstration programs worldwide; and
- Enhance public awareness and understanding.

Technology Description

The CaFCP members together or individually are demonstrating fuel cell passenger cars and transit buses and associated fueling infrastructure in California. The passenger cars include DaimlerChrysler's F-Cell, Ford's Focus FCV, GM's HydroGen 3, Honda's FCX, Hyundai's Santa Fe FCEV, Nissan's Xterra & XTrail FCV, Toyota's FCHV Highlander, and Volkswagen's HyMotion. The fuel cell transit buses, all with Federal Transit Administration support, include four hydrogen-fueled Van Hool buses with UTC fuel cells integrated by ISE and three hydrogen-fueled Gillig buses with Ballard fuel cells.

Status

The Partnership is directed by a Steering Team composed of one executive member from each of the full members. The Steering Team provides policies and direction for the organization. An Executive Director manages the partnership programs through subcommittees of the Steering Team, and a Working Group, in which teams comprised of member representatives set annual goals with CaFCP staff to demonstrate progress regarding fuel cell passenger vehicles, fuel infrastructure, bus programs, safety, and communications. The Partnership has an administrative staff on-site at the West

Sacramento headquarters facility and has added staff at SCAQMD in Diamond Bar, CA.

The members of the CaFCP intend to continue their cooperative demonstration efforts and have set goals through 2012, subject to a budget approved annually. This summary covers the SCAQMD contract period 2004-2008.

Results

Specific accomplishments include:

- Automotive members placed just over 200 fuel cell passenger vehicles on California roads from 1999 through 2008, including the first retail customers starting in 2005;
- Transit agency members have demonstrated nine fuel cell buses since 1999, with seven currently in operation;
- There are currently 24 hydrogen fueling stations in operation in California, clustered in regional networks in northern and southern California;
- CaFCP staff and members continue to train local fire departments and work with emergency response organizations to coordinate with other state and national efforts;
- The CaFCP has a comprehensive up-to-date website focusing on efforts in California, holds monthly public open house in West Sacramento, participates in technical and educational conferences, and plans annual outreach events.

Benefits

Compared to conventional vehicles, fuel cell vehicles can offer zero or near-zero smog-forming emissions, reduced water pollution from oil leaks, higher efficiency, and much quieter and smoother operation. If alternative or renewable fuels are used as a source for hydrogen, fuel cell vehicles will also encourage greater energy diversity and lower greenhouse gas emissions (CO2).

By combining member efforts, the CaFCP can accelerate and improve the commercialization process. The members have a shared vision about the potential of fuel cells as a practical solution to California's environmental issues and similar issues around the world. The Partnership provides a unique forum where technical and interface challenges can be identified early, discussed, and potentially resolved through cooperative efforts.

Project Costs

Auto members provide vehicles, the staff and facilities to support them. Energy members provide fuel and fueling infrastructure. The Partnership's annual operating budget is over $2 million, and includes facility operating costs, program administration, joint studies, public outreach and education. Each member makes an annual contribution of approximately $88,000 towards the common budget. Some government agencies contribute additional in-kind products and services. SCAQMD provides an additional $50,000 annually to support a Southern California Regional Coordinator and provides office space for additional staff in-kind at SCAQMD.

Commercialization and Applications

While research by multiple entities will be needed to reduce the cost of fuel cells and improve fuel storage and infrastructure, the CaFCP can play a vital role in demonstrating fuel cell reliability and durability, fueling infrastructure and storage options, and increasing public knowledge and acceptance of the vehicles and fueling.

For the next four years (2009-2012), CaFCP's goals relate to Building Market Foundations:

- Automakers will deploy greater numbers of fuel cell vehicles in diverse applications to demonstrate improved durability, range, and reduced cost;
- Fuel providers will deploy hydrogen fueling stations that are safe, accessible, user-friendly, and reliable to facilitate greater fuel cell vehicle mobility within a network, and explore sustainable hydrogen pathways including renewable resources;
- Government members will reduce barriers to commercialization, enhance public awareness, assist with demonstrations as needed, conduct research & development, and encourage & support sustainable hydrogen pathways including renewable resources; and
- Technology companies will develop & deliver components that support automakers and fuel providers in meeting their goals, demonstrate technology progress and educate about commercial viability.

Appendix D

List of Acronyms

LIST OF ACRONYMS

AFRC—air/fuel ratio control
APCD—Air Pollution Control District
AQMD—Air Quality Management District
AQMP—Air Quality Management Plan
ARB—Air Resources Board
BACT—Best Available Control Technology
BSNOx—brake specific NOx
CAAP—Clean Air Action Plan
CAFR—Comprehensive Annual Financial Report
CARB—California Air Resources Board
CCF—California Clean Fuels
CEC—California Energy Commission
CEMS—continuous emission monitoring system
CFD—computational fluid dynamic
CNG—compressed natural gas
CO_2—carbon dioxide
CO—carbon monoxide
CY—calendar year
DCM—dichloromethane
DDC—Detroit Diesel Corporation
DEG—diesel equivalent gallons
DGE—diesel gallon equivalents
DF—deterioration factor
DMS—Division of Measurement Standards
DMV—Department of Motor Vehicles
DOC—diesel oxidation catalysts
DOE—Department of Energy
DOT—Department of Transportation
DPF—diesel particulate filters
DRI—Desert Research Institute
ECM—emission control monitoring
EPRI—Electric Power Research Institute
ESD—emergency shut down
EV—electric vehicle
FCV—fuel cell vehicle
FTP—federal test procedures
g/bhp-hr—grams per brake horsepower per hour
GC/MS—gas chromatography/mass spectrometry
GGE—gasoline gallon equivalents
GHG—Greenhouse Gas
GTL—gas to liquid
H&SC—California Health and Safety Code
HCCI—Homogeneous Charge Combustion Ignition
HCNG—hydrogen-compressed natural gas (blend)
HEV—Hybrid electric vehicle
HPDI—High Pressure Diesel Injection
ICE—internal combustion engine
ICEV—internal combustion engine vehicle
ICTC—Interstate Clean Transportation Corridor
LCFS—Low-Carbon Fuel Standard
Li—lithium ion
LIMS—Laboratory Information Management System
LNG—liquefied natural gas
LPG—liquefied petroleum gas or propane
MATES—Multiple Air Toxics Exposure Study
MECA—Manufacturers of Emission Controls Association
MPFI—Multi-Port Fuel Injection
MSRC—Mobile Source Air Pollution Reduction Review Committee
MTA—Metropolitan Transportation Authority
NAFA—National Association of Fleet Administrators
NGV—natural gas vehicle
NMHC—non-methane hydrocarbon
NOx—oxides of nitrogen
NREL—National Renewables Energy Lab
OBD—On-Board Diagnostics
OCTA—Orange County Transit Authority
OEM—original equipment manufacturer
PAH—polyaromatic hydrocarbons
PbA—lead acid
PCM—powertrain control module
PHEV—plug-in hybrid vehicle
PM—particulate matter
PM2.5—particulate matter ≤ 2.5 microns
PM10—particulate matter ≤ 10 microns
PPM—parts per million
RDD&D—research, development, demonstration, and deployment
RTA—Riverside Transit Agency
SCAB—South Coast Air Basin or "Basin"
SCAQMD—South Coast Air Quality Management District
SCE—Southern California Edison
SCR—selective catalytic reduction
SI—spark ignited
SULEV—super ultra-low emission vehicle
TC—total carbon
THC—total hydrocarbons
TO—task order
U.S.EPA—United States Environmental Protection Agency
ULEV—ultra low emission vehicle
VOC—volatile organic compounds
WVU—West Virginia University
ZEV—zero emission vehicle