Technology Advancement Office

Clean Fuels Program 2010 Annual Report and 2011 Plan Update

March 2011

South Coast Air Quality Management District
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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

Lourdes Cordova Martinez, Community Relations Manager
Fred Minassian, Technology Implementation Manager
Dipankar Sarkar, Technology Demonstration Manager

Al Baez, Program Supervisor
Connie Day, Program Supervisor
Ranji George, Program Supervisor
Joseph Impullitti, Program Supervisor
Lisa Mirisola, Program Supervisor
Larry Watkins, Program Supervisor
Vicki White, Program Supervisor

Howard Lange, Ph.D., Air Quality Engineer II

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
Mei Wang, Air Quality Specialist

Vasken Yardemian, Sr. 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
Christina Kusnandar, Contracts Assistant
Benigna Taylor, Contracts Assistant
Ana Troccoli, Contracts Assistant
Deanna Doerr, Senior Office Assistant
Lizette Acosta, Office Assistant

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

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EXECUTIVE SUMMARY

2010 Annual Report

The South Coast Air Quality Management District (SCAQMD) executed 69 new contracts, projects or studies and modified 7 continuing projects adding additional dollars during Calendar Year (CY) 2010 toward research, development, demonstration and deployment (RDD&D) of alternative fuel and clean fuel technologies. Table 2 (page 22) lists these 76 projects or studies, which are further described in this report. The SCAQMD contributed more than $7.8 million in partnership with other governmental organizations, private industry, academia and research institutes and interested parties, with total project costs of more than $56 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:

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

During CY 2010, the SCAQMD supported a variety of projects and technologies, ranging from near-term to long-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 2010 included development, demonstration and deployment of fuel cell and electric vehicles and infrastructure, development and demonstration of hydrogen technology and infrastructure; further expansion of natural gas alternative refueling infrastructure and vehicle deployment; and demonstrations of emission control technologies on heavy-duty trucks as well as fuels and emission studies.

Eighteen research, development, demonstration and deployment projects or studies and 20 technology assessment and transfer contracts were completed in 2010, as listed in Table 5 (page 53). Appendix C comprises two-page summaries of the technical projects completed in 2010. 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, 2011, after approval by the SCAQMD Governing Board.

2011 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;
- increased activities in electric, hybrid, battery and plug-in hybrid technologies across light-, medium- and heavy-duty platforms; and
- production of transportation fuels and energy from renewable biowaste sources.

Table 6 (page 67) lists the potential projects across the core technologies identified in this report. Potential projects for 2011 total more than $16.1 million, with anticipated leveraging of more than $116 million. The proposed projects may also be funded by revenue sources other than the Clean Fuels Program, especially VOC and incentive projects. The higher project costs projected for 2011 reflect $12.5 million the SCAQMD was awarded in 2010 as well as $78.5 million previously awarded to the SCAQMD in 2009 through the American Recovery and Reinvestment Act (ARRA) as well as other federal and state grant programs.

CLEAN FUELS PROGRAM
2010 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 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.

2010 Overview

This report summarizes the progress of the SCAQMD Clean Fuels Program for CY 2010. 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, 2010, the SCAQMD executed 69 new contracts, projects or studies and modified 7 continuing projects adding additional dollars during CY 2010 that support clean fuels and advanced low-emission technologies. The SCAQMD contribution for these projects was more than $7.8 million, with total project costs of more than $56 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. Notably, in 2009 and 2010 the SCAQMD applied for and was awarded more than $78.5 million and $12.5 million, respectively, in funds through the American Recovery and Reinvestment Act and other federal and state funding programs. These unusually large total project costs in 2010 were the result of successfully leveraging ARRA opportunities, one-time settlement funds and incentive funding. The projects for which these funds were awarded complement and enhance the technology development

and demonstration efforts already being undertaken through the Clean Fuels Program. The SCAQMD will continue to pursue funding opportunities in 2011 to amplify leveraging.

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 estimated 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.

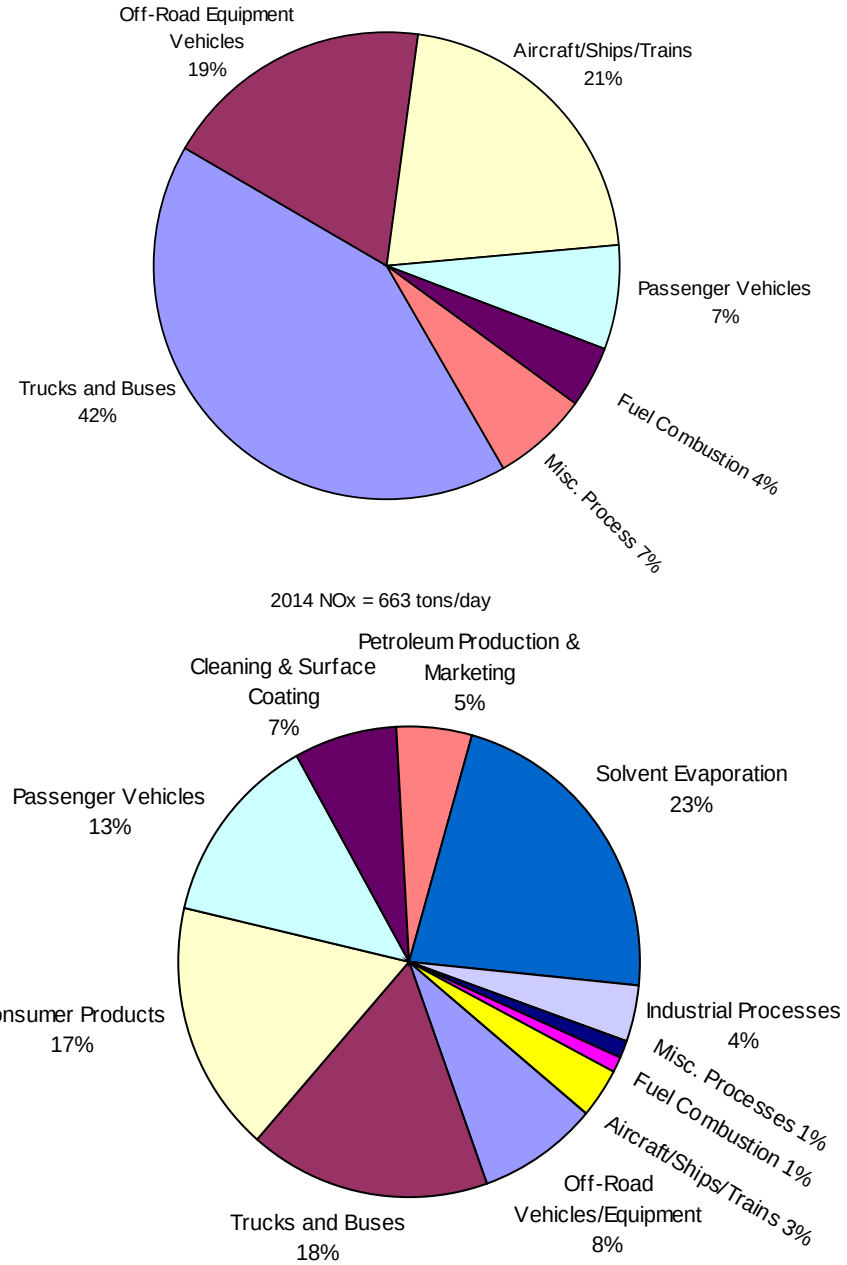


Figure 1: Major Source Contributions (2014)

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.

Greenhouse gas (GHG) emissions and petroleum dependency arising from the heavy use of conventional technologies continue to be a concern and focal point for state and federal government as well as the general public. 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. AB 32 faced a challenge in 2010 when an initiative to suspend it was placed on the November 2010 ballot as Proposition 23, but California voters defeated this proposition, demonstrating California's commitment to air quality and the environment.

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 five 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 2010 the funds available through each of these mechanisms were as follows:

- Mobile sources (DMV revenues) $11,954,978
- Stationary sources (emission fee surcharge) $325,782

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 25) lists the supplemental grants and revenues received in 2010, totaling nearly $5.8 million, and for which contract the funding passes through to.

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 nearly $4 of outside funding for each $1 of SCAQMD funding. For 2010, excluding ARRA and other one-time federal opportunities, one-time settlement funds and incentive funding, the Clean Fuels Program leveraged each $1 to nearly $4 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 2010 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:

- Hybrid and Electric Vehicle Technologies and Related Infrastructure
- Infrastructure and Deployment (predominantly compressed and liquid natural gas)
- Hydrogen Infrastructure and Mobile Fuel Cell Technologies
- Emission Control Technologies
- Engine Systems
- 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 into 2011. 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 below.

Hybrid and Electric 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 on March 27, 2008 and updated test procedures adopted on 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).

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.

Hydrogen Infrastructure and Mobile Fuel Cell 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.

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.

Engine Systems

Medium- and heavy-duty on-road vehicles contributed approximately 36 percent of the Basin's 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.

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 from 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.

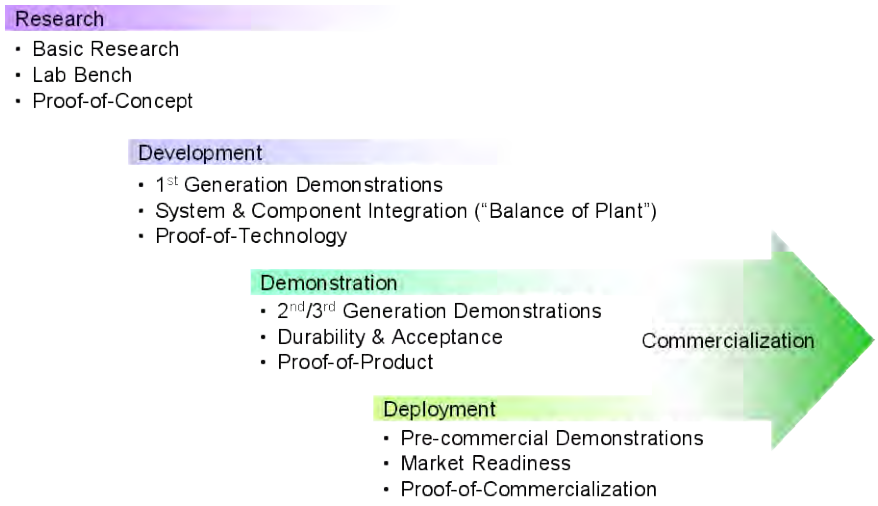


Figure 2: Stages of Clean Fuels Program Projects

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
  - Emission Solutions: 7.6L (NG)
  - 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;
- Plug-in Hybrid Electric Van with EPRI, DaimlerChrysler and SCE;
- Foothill battery electric transit bus; and
- Municipal battery electric utility truck.

➢ 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 2010 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 2010 Project Summaries contained within this report.

Table 1: SCAQMD Major Funding Partners in CY 2010

Research Funding Organizations	Major Manufacturers/Providers
California Air Resources Board	AC Propulsion
California Energy Commission	BAE Systems
U.S. Department of Energy	Calstart
U.S. Department of Transportation	Johnson Matthey
U.S. Department of Energy	Orange County Sanitation Districts
Federal Transit Administration	ServoTech
	SunLine Transit Agency

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 2010. 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 further development and demonstration of fuel cell, plug-in hybrid and electric vehicle technologies and infrastructure; (b) continued demonstration of emission control technologies to reduce NO_x and PM emissions reductions on heavy-duty diesel trucks; and (c) demonstration of biogas retrofit control technologies on stationary equipment.

Develop & Demonstrate Fuel Cell Bus

Fuel cell buses have been successfully demonstrated in recent years in California, across both the United States and Canada. The SCAQMD has long sponsored the development and deployment of fuel cell bus technologies because these heavy-duty vehicles have zero tailpipe emissions, help establish hydrogen refueling infrastructure, and operate in congested urban areas providing the greatest outreach potential through ridership. The next step in the development of this clean air technology is commercialization. The intent of American Fuel Cell Bus (AFCB) project is the development of a newly designed fuel cell bus with a North American chassis, as well as domestically sourced fuel cell and drive components. Success in this program will ensure availability of a U.S.-built product that can offer transit properties the opportunity to buy buses through the Federal Transit Administration (FTA) capital program. Specifically, the program's commercial focus anticipates that the resulting fuel cell bus product would be built and sold profitably.

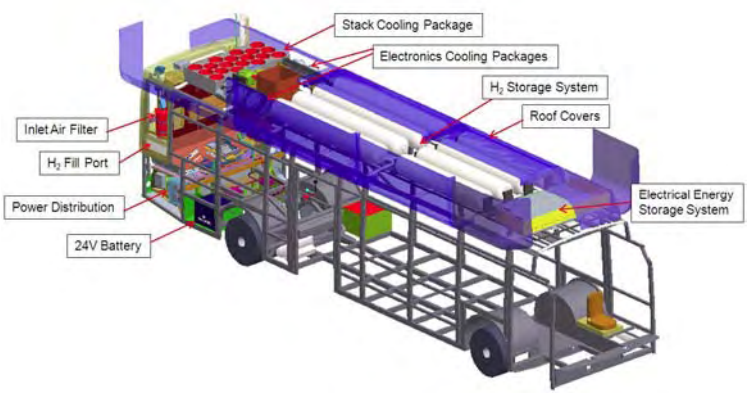


Figure 3: AFCB Layout

A project team assembled by SunLine Transit Agency (SunLine) will execute the AFCB development with BAE Systems as the team leader and system integrator. BAE Systems is one of the world's leading manufacturers of series hybrid-electric buses in the U.S. Supporting BAE Systems are solid suppliers in the transit industry: El Dorado National, a California based company, will design the 40-foot bus, Ballard Power Systems will provide a fuel cell stack manufactured in Lowell, MA, and a collection of supporting companies now engaged in activities with BAE Systems in the development and commercialization of a series electric hybrid drive-train.

Upon completion of the bus slated for Q4 2011, SunLine will incorporate the bus into revenue service in the Coachella Valley. The demonstration will include the hottest summer months, when temperatures often exceed 115 degrees Fahrenheit. Testing in high temperatures is a critical phase for any vehicle development, especially for a fuel cell bus due to the chemical nature of the power plant (as compared to combustion engines).

Figure 4: AFCB Build In Progress

This project furthers the development of fuel cell technology for transit applications with the goal of accelerating the deployment of a commercial product. If successful, this

project will demonstrate a lower cost, reduced weight, and more attractive bus with a longer-lived fuel cell stack to enable an economically competitive, zero-tailpipe emission bus. This project also helps implement CARB's Zero Emission Bus regulation, which requires urban bus fleets to transition to cleaner technologies over time.

Demonstrate Electric Bus & Quick-Charge Infrastructure

Traditionally, the range and charging needs of batteries have been barriers to employ battery powered buses in large-scale applications. Additionally, the weight of traditional buses has made it difficult to feasibly incorporate a battery with sufficient power and energy storage capacity into coach designs. The emerging technologies described herein, however, result in batteries with greater energy storage and faster charge-time capabilities. Combined with lighter coach design, electric propulsion is an environmentally and economically feasible option for transit agencies to consider in their move to clean modes of transport.

Foothill Transit is proposing to replace three diesel buses with Ecoliner electric buses with quick-charge capability and quick-charge infrastructure on an existing route from the City of La Verne to the City of Pomona. The 35-foot Ecoliner bus will carry 37 passengers and will be powered by a 75 kW hour battery. Funding from SCAQMD will support the charging technology, charging station and supplemental charging components associated with the Ecoliner buses. The charging system will connect to the bus from overhead. The charging station includes the architectural and engineering design, the installation and construction of the charging station for two bus locations. The Ecoliner is different than most battery drive vehicles where range is dictated by the number of batteries. The Ecoliner battery utilizes Nanosafe technology, which laboratory tested at four to 10 times the usable charge-discharge cycles over conventional batteries and has a shelf life of up to 25 years. Foothill Transit is the first agency in the world to deploy this technology into heavy-duty transit operations.

Figure 5: Ecoliner Quick Charging Station

Figure 6: Ecoliner Quick Charge Bus

The benefits of this proprietary technology are a safe automated charging system that will perform without human intervention. The total project will encompass 32 months from development through demonstration.

Foothill Transit will collect data on the charge infrastructure and the buses and will disseminate relevant reports to the SCAQMD. These reports will detail all stages of project implementation and evaluation including: operations and maintenance, environmental, and service life data as well as operating characteristics and costs associated with operation and maintenance of the charging infrastructure. To ensure total zero emissions, renewable supplies of electricity for the charging station will be purchased through a broker specializing in hydroelectric, solar, tidal or wind electricity generation.

This project furthers the development of quick-charging infrastructure and battery technology for transit applications with the goal of accelerating the deployment of commercial electric buses. This project will demonstrate lower cost and light weight buses with longer-lasting batteries and quick-

charging infrastructure that is safe and functional. This project will also help to implement CARB's Zero Emission Bus regulation, which requires urban bus fleets to transition to cleaner technologies over time. This project will result in the reduction of 0.47 tons of criteria pollutants and 77.73 tons of greenhouse gas emissions per bus on an annual basis as compared to diesel buses.

Develop & Demonstrate Electric Drive Conversion for Fleet Vehicles

Medium-duty vehicles are responsible for creating a disproportionate amount of emissions in the South Coast Air Basin. Medium-duty vehicles in the 8,500 to 14,000 lb GVWR comprise 2% of the vehicle population, but are responsible for 7.9% of the 2010 on-road mobile source NO_x emissions according to EMFAC2007. The electrification of vehicles in this segment provides an opportunity to significantly reduce emissions. However, the successful deployment of electrified vehicles in this segment requires that specific vocations be properly matched that will take best advantage of the attributes of an electric vehicle. Independent and preliminary evaluations conducted by the National Renewable Energy Laboratory, the Electronic Power Research Institute, and the SCAQMD have shown that the use-profile for neighborhood service and parcel delivery applications would make these vocations an excellent candidate for electrification, through plug-in hybrid electric or fully electric vehicles.

AC Propulsion proposes to convert three service vans in Comcast's fleet to electric vehicles. The vehicles being converted are Ford E250 vans that will be supplied by Comcast. The electric drive system developed by AC Propulsion will utilize similar technology that was used in the BMW Mini Cooper and US Postal Service programs. The system includes an AC induction motor, inverter, charger and 12V power supply. The AC induction motor is controlled by a proprietary power electronics unit that maximizes efficiency over a broad operating range and also allows energy recovery through regenerative braking. Energy storage shall be provided by a lithium ion battery pack sized to provide a driving range of roughly 80 miles. The battery pack will be chargeable from 120V to 240V sources at up to 18 kW, which could translate to a potential charge time of close to three hours.

Figure 7: Comcast Service Van

Additionally, the program shall quantify the performance, operating cost and emissions benefits of the system, as well as refine short- and long-term price targets for a commercially viable electric vehicle conversion for fleet applications.

Optimize & Demonstrate NO_x & PM Emission Control Devices

There were approximately 186,200 diesel vehicles, excluding passenger cars and buses, operating in the Basin at any given time in 2009, and producing over 223 tons per day of NO_x and 9 tons per day of PM emissions (California Air Resources Board EMFAC 2007). Currently, heavy-duty on-highway diesel trucks represent 57% of the diesel vehicles in the South Coast Air Basin and emit more than 204 tons of NO_x and 9 tons of PM, 15 tons of total hydrocarbon (HC) and 57 tons of carbon monoxide (CO) per day. SCAQMD's MATES-III Study results also indicate that diesel emissions are a major contributor to air toxics, accounting for about 84% of the Basin's cancer risk. Selective catalytic reduction (SCR) and diesel particulate filters (DPF) have the potential to significantly reduce these emissions.

Figure 8: Johnson Matthey's SCCRT®

The SCAQMD executed three contracts in 2010 with Johnson Matthey to achieve significant diesel emissions reductions by retrofitting heavy-duty on-highway diesel trucks with Johnson Matthey's combined Selective Catalytic Reduction and Diesel Particulate Filter technologies. These technologies are branded as SCRT® and SCCRT® systems for non-exhaust gas recirculation (EGR) and EGR equipped engines, respectively. Johnson Matthey will retrofit these systems to a total of 173 heavy-duty on-road trucks operated in the South Coast Air Basin as part of this project. These retrofit systems are listed on the "U.S. EPA Emerging Technology List" as capable of reducing PM, NO_x, CO, and HC emissions by at least 90%, 65%, 85%, and 90%, respectively.

Demonstrate Biogas Engine Emission Control Technology

Biogas (digester or landfill gas) fueled engines are engines traditionally operated at landfills, wastewater treatment plants and other sites where waste fuel gas is generated. These engines are generally larger lean-burn engines very similar to natural gas engines and used primarily to power electrical generators. Due to contaminants in the biogas, like siloxane, that are incompatible with catalytic after-treatment devices, biogas engines have generally not been required to install oxidation catalysts and SCR units that natural gas engines use. As a result, the emissions for biogas engines are higher than most permitted engines.

Figure 9: OCSD Biogas Engines

The Technology Advancement Office issued Program Opportunity Notice (PON) #2009-01 soliciting proposals for co-funding clean technology projects. In response to the PON, Orange County Sanitation District (OCSD) submitted a proposal to retrofit a 3,471 horsepower engine operating on biogas from a wastewater treatment plant with a carbon adsorption fuel gas clean-up system and SCR/catalytic oxidizer exhaust emission control technology. This project is largely funded by OCSD with co-funding assistance by SCAQMD. The successful demonstration of this project will support the technology assessment study for the future biogas engine emission limits of Rule 1110.2.

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 2010 reporting period illustrate the impact of the SCAQMD's technology deployment and commercialization efforts.

Deploy Natural Gas Taxicabs Serving the Airports

Taxicabs are an integral part of most metropolitan areas and provide ground transportation service to many individuals traveling to and from commercial airports. Taxis and passenger shuttle vans servicing the five major commercial airports in the South Coast Air Basin use significant amounts of gasoline due to the high annual miles accrued on these vehicles. The largest number of taxicabs operate out of Los Angeles International Airport with about 2,000 taxicabs dedicated to the airport. It is estimated that on average, an individual taxicab or passenger van operating in the South Coast Air Basin may accrue as much as 80,000 miles a year and a typical owner/operator will use this vehicle

for three to four years. With such significant mileage and numbers, taxicabs operating in this region represent a significant source of air pollution and greenhouse gases.

In 2000, the SCAQMD adopted Fleet Rule 1194 "Commercial Airport Ground Access," requiring new vehicle purchases be CARB certified as ultra low emitting vehicles (ULEV) or cleaner. Rule 1194 went a step further and stipulated funding support for the purchase and deployment of alternative fuel-powered taxicabs. The experience and success of its buydown incentive program helped the SCAQMD secure funding through the U.S. Department of Energy Clean Cities Petroleum Reduction Technologies Projects for the Transportation Sector in 2009. The award is a cost share partnership for the conversion of 45 new gasoline-powered Ford Crown Victoria taxicabs to CNG-powered vehicles which provide ground transportation to commercial airports operating in the SCAQMD.

Figure 11: Yellow Cab Taxi

Figure 10: Yellow Cab Taxis Waiting for Passengers

Converting a gasoline-powered vehicle to operate on CNG includes equipment and materials designed to withstand the high pressure of CNG, typically 3,000 to 3,600 psig. The CNG fuel storage tank is typically a steel cylinder reinforced with carbon fiber and is required to meet National Highway Traffic Safety Administration standards.

The direct outcome of this project is an increase in alternative fuel vehicles operating in the South Coast Air Basin. CNG-powered vehicles are the cleanest internal combustion engine powered vehicles available and are also one of the most cost effective means to reducing air pollution and can provide reduction in greenhouse gases by 20 to 25% on a per vehicle basis compared to their gasoline counterpart. An indirect outcome of this project is a demonstration to OEM automobile manufacturers that there is a demand for natural gas-powered vehicles in the U.S. market that could lead to more direct offerings of CNG-powered passenger vehicles to consumers.

Construct & Install Natural Gas Infrastructure

In 2008, the SCAQMD provided funding to California Cartage Company to replace 132 older diesel-fueled trucks with new LNG-fueled trucks. The total funding of $11,880,000 was comprised of $6,600,000 from the Proposition 1B Goods Movement Program, $4,922,000 from federal EPA grant, and $358,000 from the Clean Fuels Fund. As of this date, approximately 120 LNG trucks have been delivered and most of them are in service. California Cartage Company also operates LNG yard hostlers.

To accommodate approximately 150 LNG trucks and yard hostlers, California Cartage Company needed two LNG fueling units at two different locations. The availability of these two fueling stations was very important to the success of this alternative fuel project. Two skid mounted LNG fueling units are to be purchased with a combined fueling capacity of approximately 12,000 gallons, providing sufficient fuel for the California Cartage Company's LNG-fueled heavy-duty truck and yard hostler fleet as well as other local private fleets. The contiguous Ports of Los Angeles and Long

Beach are the single largest source of emissions in the South Coast Air Basin, and port trucks contribute significantly towards these emissions. The SCAQMD strongly supports the use of clean fuels, including natural gas as a transportation fuel. Natural gas vehicles are among the cleanest alternative-fueled vehicles at the present, and the successful demonstration of this project will accelerate and increase the penetration of natural gas fueled trucks in port applications.

Deploy Hybrid Electric Vehicle Trucks and Buses

In 2007, Governor Schwarzenegger signed into law the California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007 (AB 118, Statutes of 2007, Chapter 750). AB 118 created the Air Quality Improvement Program (AQIP), a voluntary incentive program administered by the CARB to fund clean vehicle and equipment projects, air quality research, and workforce training. In April 2009, CARB also approved the AQIP Funding Plan for FY 2009-10, which served as the blueprint for expending the FY 2009-10 AQIP funds. The Funding Plan established the Hybrid Truck & Bus Voucher Incentive Program (HVIP) as the cornerstone of the AQIP for FY 2009-10, accounting for about 60 percent of last year's funds. HVIP provides a meaningful "kick-start" to the low-emission hybrid truck and bus industry; it could help deploy up to 800 vehicles, potentially growing the nation's early market hybrid truck volumes by 50 percent. Since hybrid technology reduces greenhouse gas and criteria emissions, and cuts petroleum use, HVIP provides a strong public benefit by helping speed commercialization of these technologies and supporting a critical ramp-up in production that is necessary to meeting California's clean air goals.

As of October 4, 2010, Calstart had allocated all of the Statewide HVIP funds for FY 2009-10 through approved vouchers for 653 vehicles, which equates to $19,440,000, consisting of 39 public fleets and 614 private fleets. Various categories of vehicles have been awarded vouchers ranging from delivery trucks (beverage, parcel, linen, or fuel) to urban buses and dump trucks. Calstart anticipates that they will be equally successful in the implementation and deployment of the SCAQMD HVIP within the South Coast Air Basin.

Figure 12: Hybrid Beverage Delivery Truck

Figure 13: Hybrid Transit Bus

Figure 14: Hybrid Parcel Delivery Truck

2010 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, 2010.

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, 2010, a total of 76 contracts, projects or studies that support clean fuels were executed or amended, as shown in Table 2 (page 22).

The major technology areas summarized are: hybrid/electric technologies, infrastructure and deployment, hydrogen technology and infrastructure, mobile fuel cell technologies, emission control technologies, engine technologies, fuels/emission studies, stationary clean fuel technologies, health impacts studies, outreach and technology transfer. The distribution of funds based on technology area is shown graphically in Figure 15 (page 20). 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 2010 reporting period are shown below with the total projected project costs:

- SCAQMD Clean Fuels Fund Contribution $7,835,424
- Total Cost of Clean Fuels Projects $56,003,483

Each year, the SCAQMD Governing Board approves funds to be transferred to the General Fund Budget for Clean Fuels administration. For 2010, 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, 2010, are included within this report. Any portion of the Clean Fuels Funds not spent by the end of Fiscal Year 2010-11 ending June 30, 2011, 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 $5,793,712 is listed within Table 3 (page 25). Appendix B lists all Clean Fuels Fund contracts, totaling 134, that were open and active as of January 1, 2011.

For Clean Fuels executed and amended contracts, projects and studies in 2010, the average SCAQMD contribution is approximately 28 percent of the total cost of the projects, identifying that each dollar from the SCAQMD was leveraged with nearly four dollars of outside investment, excluding ARRA and other one-time federal opportunities, one-time settlement funds and incentive funds.

During 2010, the SCAQMD executed contracts, projects, studies or contract amendments with additional funding of more than $7.8 million for Clean Fuels projects. The distribution of funds is shown in Figure 15 below.

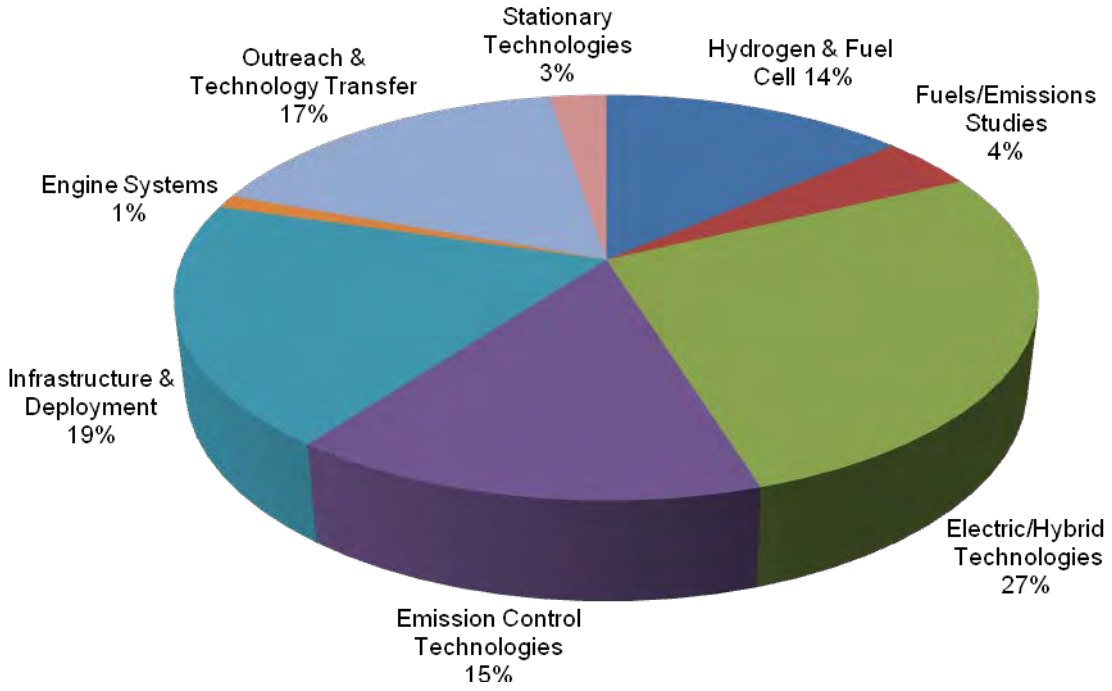


Figure 15: Distribution of Funds for Executed Clean Fuels Projects CY 2010 ($7.8 million)

Both 2009 and 2010 were remarkable years for federal funding opportunities through the American Recovery and Reinvestment Act and other federally funded programs. The SCAQMD applied for and was awarded more than $78.5 million in funds in 2009 and continued this success with more than $12.5 million in 2010 through ARRA and other federal and state funding programs. The projects for which these funds were awarded align well with and enhance the technology development and demonstration efforts already being undertaken through the Clean Fuels Program. The SCAQMD will continue to pursue funding opportunities as these become available. Table 4 (page 25) summarizes these funds and identifies the projects for which they are intended. It is anticipated that contracts drawn against the federal funds received in 2010 will be executed in 2011 and reflected in next year's annual report.

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, 2010, 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. 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 76 new and continuing contracts, projects and studies that received SCAQMD funding in 2010 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 (w/$) between January 1 & December 31, 2010

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment						
09364	Rim of the World Unified School District	Construct & Install a CNG Fueling Station	12/30/10	12/31/14	257,000	425,000
10034	California Cartage Company	Install LNG Fueling Station at the Ports	1/26/10	11/1/14	532,500	1,065,000
10640	Yellow Cab of Greater Orange County	Conversion of 45 Taxicabs to Natural Gas Power for Deployment as Airport Ground Transportation	4/23/10	6/1/12	337,500	675,000
Transfer	Transfer from Clean Fuels	Implementation Support for HEROS I Program	1/1/09	12/3/10	202,349	4,000,000
Transfer	Transfer from Clean Fuels	Implementation Support for HEROS II & AB 118 EFMP Programs	12/3/10	12/3/11	189,855	10,317,073
Fuels/Emissions Studies						
10012	Electric Power Research Institute	Evaluate Impacts & Benefits of Plug-In Fuel Cell Hybrid Vehicles	1/28/10	7/31/10	50,000	100,000
10095	University of California Davis Institute of Transportation Studies	Cosponsor Sustainable Transportation Pathways Program	6/29/10	7/31/12	120,000	2,310,000
10693	West Virginia University Research Corporation	Provide Transportable Laboratory Testing to Quantify Emissions from SCR Technology	9/1/10	8/31/11	76,000	76,000
10722	University of California Riverside/CE-CERT	Re-Establish Testing Facility & Quantify PM Emission Reductions from Charbroiling Operations	8/6/10	6/30/11	60,000	60,000
11519	University of California Riverside	Evaluate Protocols for Measuring Emissions from Cleaning of Application Equipment & Surfaces with Solvent	12/23/10	6/22/11	23,713	47,425
Emission Control Technologies						
10069	Johnson Matthey, Inc.	Develop & Demonstrate SCRT® for NO_x and PM Emissions Control	6/18/10	10/13/13	300,000	1,480,000
10675	California State University Long Beach	Develop Efficient Humid Air System for Diesel NO_x Reduction	5/12/10	9/30/10	28,000	28,000
10696	Johnson Matthey, Inc.	Optimize & Demonstrate SCRT® for NO_x and PM Emissions Control	7/9/10	3/31/12	300,000	2,818,499
10697	Johnson Matthey, Inc.	Optimize & Demonstrate SCCRT® for NO_x and PM Emissions Control	7/9/10	3/31/12	300,000	2,818,499
10112	Sanitation Districts of Los Angeles County	Showcase: Retrofit Select Catalytic Reduction System & Diesel Particulate Filters on Off-Road Construction Equipment	2/26/10	2/21/12	116,450	116,450
11136	ServoTech Engineering	Demonstrate NO_x and PM Emissions Control Technology on Diesel-Powered Construction Equipment	10/15/10	5/31/12	132,000	432,000

Table 2: Contracts Executed or Amended (w/$) between January 1 & December 31, 2010

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Electric/Hybrid Technologies						
99109	Toyota Motor Credit Corporation	One-Year Lease of two RAV4 Electric Vehicles	4/4/99	2/1/11	7,902	7,902
09360	BMW of North America LLC	Lease of Five MiniE Electric Vehicles for One Year	5/5/09	6/25/11	39,510	39,510
10738	Foothill Transit	Demonstrate Quick-Charge Infrastructure for Electric Buses	10/29/10	6/28/13	290,000	6,790,000
11204	AC Propulsion	Develop & Demonstrate Electric Drive Conversion for Fleet Vehicles	12/24/10	10/30/12	300,000	755,767
11205	Calstart	Implement Hybrid Truck and Bus Voucher Incentive Program	12/2/10	3/31/12	1,500,000	1,500,000
Direct Pay	Clean Fuel Connection, Inc.	EV Charger Installations for MiniE Cooper Demonstration Program	1/31/10	3/3/10	2,827	2,827
Engine Systems						
10071	NaturalDrive Partners, LLC	Develop & Certify Natural Gas Chevrolet Impala Sedans	1/15/10	6/30/11	81,388	234,388
Mobile Fuel Cell Technologies						
10501	American Honda Motor Company, Inc.	Lease a Clarity Fuel Cell Vehicle for Three Years	1/21/10	1/20/13	24,001	24,001
10599	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership for CY 2010 & Provide Support for Regional Coordinator	1/1/10	12/31/10	137,800	1,668,200
10650	SunLine Transit Agency	Demonstrate Advanced Fuel Cell Bus (American Fuel Cell Bus)	6/4/10	6/3/13	400,000	10,214,843
Hydrogen Technology and Infrastructure						
04185	Quantum Fuel Systems Technologies Worldwide Inc.	Develop & Demonstrate Hydrogen Internal Combustion Engine Vehicles	10/18/04	8/31/12	73,000	73,000
10061	Hydrogenics Corporation	Maintenance & Data Management for SCAQMD Hydrogen Fueling Station	10/30/09	10/29/11	100,000	100,000
10149	NextEnergy Center	Cosponsor Feasibility, Design & Development of 70 MPa Hydrogen Home Fueling Appliance	5/7/10	11/6/11	63,400	522,000
11150	Hydrogen Frontier, Inc.	Maintenance & Operation of City of Burbank Hydrogen Fueling Station	11/24/10	1/24/15	200,000	1,060,000
Purchase Order	Engineering, Procurement & Construction	Third Party Inspection of SCAQMD Hydrogen Fueling Station	3/17/10	4/26/10	4,763	4,763
Purchase Order	Hydrogenics Corporation	Operate & Maintain City of Burbank Hydrogen Station	3/5/10	12/5/10	50,000	50,000
Purchase Order	MKS Instruments	Rental of Purity Multi-Gas FTIR Instrument to Measure Hydrogen Quality	6/10/10	7/9/10	5,000	5,000
Purchase Order	Telogis	Purchase, Install & Service GPS Receivers for Hydrogen Vehicles	10/29/10	12/31/11	12,000	12,000

Table 2: Contracts Executed or Amended (w/$) between January 1 & December 31, 2010

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Stationary Clean Fuel Technologies						
10114	Orange County Sanitation Districts	Retrofit Digester Gas Engine with Fuel Gas Clean-Up and Exhaust Emission Control Technology	3/25/10	3/24/11	200,000	2,411,882
Outreach and Technology Transfer						
02308	Sperry Capital, Inc.	Evaluate Financial Stability of Potential Contractors	6/25/02	12/31/11	15,000	15,000
02333	University of California Riverside	Technical Assistance on Clean Fuels Technology, Hydrogen, Fuel Cell Technology & Natural Gas Technology	11/1/02	6/30/11	40,000	40,000
09337	Mark Weekly, CPA	Follow-Up Assessment of AQMD's Compliance with Special Revenue Funds & Financial Assistance with Implementation of Incentive Programs	3/3/09	1/31/13	20,000	20,000
10056	Advanced Transportation Technology & Energy, San Diego Community College District	Enhanced Training Technology Program	5/27/10	12/31/11	500,000	500,000
10590	Three Squares Inc.	Technical Assistance with AQMD High School Conference "A World We Can Change"	2/5/10	7/30/10	50,000	50,000
10700	TIAX LLC	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile & Stationary Source Technologies	7/23/10	5/31/12	120,000	120,000
11028	Martin Kay, P.E.	Technical Assistance on Stationary Source Control Measures & Future Consultation on TAO Activities	8/4/10	8/3/11	25,000	25,000
11117	Clean Fuel Connection, Inc.	Technical Assistance for Alternative Fuels, Renewable Energy and Electric Vehicles	9/17/10	12/31/11	50,000	50,000
11148	Joseph C. Calhoun, P.E. Inc.	Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle Technologies	10/8/10	12/31/12	35,000	35,000
11182	Tech Compass	Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis & Aftertreatment Technologies	11/19/10	12/31/12	75,000	75,000
Transfer	Hartford	Insurance for Two Plug-In Hybrid Toyota Prius Vehicles	1/1/10	5/26/10	1,572	1,572
Direct Pay	Various	Cosponsor 25 Conferences, Workshops & Events plus 5 Memberships & Subscriptions	Various	Various	386,894	2,826,882

Table 3: Supplemental Grants/Revenue Received between January 1 & December 31, 2010

Revenue	Source	Project Title	Contractor	SCAQMD Project	Total
09349	City of Los Angeles – Ports of Los Angeles & Long Beach	Install LNG Fueling Station at the Ports	California Cartage Company	#C10034	$532,500
09405	U.S. Environmental Protection Agency	Develop & Demonstrate SCRT® for NO_x and PM Emissions Control	Johnson Matthey, Inc.	#C10069	$900,000
10063	U.S. Environmental Protection Agency	Optimize & Demonstrate SCCRT® for NO_x and PM Emissions Control	Johnson Matthey, Inc.	#C10697	$2,000,000
10064	U.S. Environmental Protection Agency	Optimize & Demonstrate SCRT® for NO_x and PM Emissions Control	Johnson Matthey, Inc.	#C10696	$2,000,000
10739	U.S. Dept. of Energy/National Energy Tech Lab	Purchase of CNG Taxicabs & Shuttle Vans	Yellow Cab of Greater Orange County	#C10640	$337,500
n/a	W.M. Barr & Company, Inc.	Evaluate Protocols for Measuring Emissions from Cleaning of Application Equipment & Surfaces with Solvent	University of California, Riverside	#C11519	$23,712
					$5,793,712

Table 4: Summary of Federal & State Funding Awarded between Jan. 1 & Dec. 31, 2010

Awarding Entity or Program	Award or Execution Date	Purpose	Contractors	Total
U.S. EPA	5/1/10	Demonstrate Emerging Technologies Advanced Maritime Emissions Controls (Revenue Agreement #11030)	Various	$1,500,000
U.S. EPA	6/8/10	Develop & Demonstrate SCRT® for NO_x and PM Emissions Control (Revenue Agreement #09405)	Johnson Matthey, Inc. (#C10069)	$900,000
U.S. EPA	7/16/10	National Clean Diesel Program – School Bus Replacement (Revenue Agreement #11092)	Various	$1,065,465
U.S. EPA/DERA	9/10/10	Retrofit 200 Heavy-Duty Trucks with Diesel Particulate Filters (Revenue Agreement #C09230)	Gardner Trucks	$1,000,000
California Energy Commission/AB118	9/10/10	Alternative and Renewable Fuel and Vehicle Technology Program – Construct & Install 10 NG Fueling Stations	Clean Energy	$2,600,000
California Energy Commission/AB118	9/10/10	Alternative and Renewable Fuel and Vehicle Technology Program – Construct & Install One NG Fueling Station	Earth Fuels	$300,000
California Energy Commission	10/7/10	Implement LNG Drayage Truck Replacement Program (Revenue Agreement #11040)	Various	$5,142,000
				$12,507,465

Project Summaries by Core Technologies

The following represents summaries of the contracts, projects and studies executed or amended with additional dollars in 2010. 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

09364: Construct & Install a CNG Fueling Station

Contractor: Rim of the World Unified School District	SCAQMD Cost-Share	$ 257,000
	Cosponsor:	
	Lower Emission School Bus Program/Fund 80-AB923	168,000
Term: 12/30/10 – 12/31/14	Total Cost:	$ 425,000

In July 2008, the SCAQMD Board awarded Rim of the World Unified School District (RoWUSD) an $845,000 grant to replace five pre-1977 diesel school buses with five new CNG buses and $70,000 for CNG fueling infrastructure and garage upgrades. Based on a site visit and a review of the facility by SCAQMD staff and a CNG consultant, the cost of fueling infrastructure and garage upgrades was estimated at $425,000. In another Board action in December 2008, the SCAQMD Board authorized execution of a contract with RoWUSD to install the needed fueling infrastructure and garage upgrades at a cost not to exceed $257,000 from the Clean Fuels Fund. The fueling infrastructure will accommodate up to 12 CNG buses that will be funded by the SCAQMD.

10034: Install LNG Fueling Station at the Ports

Contractor: California Cartage Company	SCAQMD Cost-Share	$ 532,500
	Cosponsor:	
	Ports of Los Angeles & Long Beach	532,500
Term: 1/26/10 – 11/1/14	Total Cost:	$ 1,065,000

In 2008, SCAQMD provided funding to California Cartage Company to replace 132 heavy-duty Class 8 diesel-fueled trucks with LNG-fueled trucks. These trucks serve the Ports of Los Angeles and Long Beach and were in need of convenient and accessible fueling. This project was to execute a contract with California Cartage Company to install an LNG fueling station at the Ports at an SCAQMD cost not to exceed $532,500 from the Clean Fuels Fund. The remaining project cost of $532,500 was funded by the Ports of Los Angeles and Long Beach. Two skid-mounted LNG refueling units were to be purchased and installed on California Cartage's property at 6150 Paramount Blvd., Long Beach, and 1501 E. Lomita Blvd., Wilmington. California Cartage will be responsible for the day-to-day operation of the refueling units. Both LNG refueling stations will

be accessible to California Cartage's own operators as well as to public LNG truck drivers during weekdays from 7:00 am to 8:00 pm.

10640: Conversion of 45 Taxicabs to Natural Gas Power for Deployment as Airport Ground Transportation

Contractor: Yellow Cab of Greater Orange County	SCAQMD Cost-Share	$ 337,500
	Cosponsor:	
	U.S. Dept. of Energy-Clean Cities	337,500
Term: 4/23/10 to 6/1/12	Total Cost:	$ 675,000

In December 2009 the SCAQMD Board approved funding of $337,500 to match a U.S Department of Energy-Clean Cities award under the Petroleum Reduction Technologies Projects for the Transportation Sector. This project involves the purchase and conversion of 45 new gasoline-powered Ford Crown Victoria to CNG-powered taxicabs, including fuel system retrofit and fuel tank replacement. The program has a three-year life and requires quarterly reporting of fuel use and mileage. These vehicles will be used under real-world conditions and are expected to accrue high mileage during the project life as these vehicles are typically used in providing airport ground transportation service throughout the SCAQMD jurisdiction. The project is expected to provide additional demonstration of CNG-powered high mileage vehicles and a reduction in emissions from petroleum based fuels.

Transfer: Implementation Support for HEROS I Program

Contractor: Transfer from Clean Fuels	SCAQMD Cost-Share	$ 202,349
	Cosponsors:	
	Carl Moyer AB 923 Program	3,647,651
	California Air Resources Board	150,000
Term: 1/1/09 – 12/3/10	Total Cost:	$ 4,000,000

At its December 3, 2010 meeting, the SCAQMD Board approved the transfer of $202,349 from the Clean Fuels Fund to support implementation of the first phase of the SCAQMD's High Emitter Repair or Scrap (HEROS) Program. High emitting vehicles may emit at least 20 times more air pollution than a typical vehicle, due to lack of proper maintenance, tampering with exhaust or emission systems, and other factors. In HEROS I, remote sensing technology was used to identify high-emitting light- and medium-duty vehicles at freeway on-ramps. Owners of high-emitting vehicles that also met Carl Moyer guidelines were offered up to $500 for vehicle repair or $1,000 for vehicle scrap. Low-income eligible participants were also offered an additional $1,000 for replacement of a scrapped vehicle with a CARB-certified Low-Emission Vehicle. The HEROS I Program was intended to accelerate turnover of legacy fleets with deployment of vehicles that meet more stringent emission standards and help meet the clean air goals of the SCAQMD.

Transfer: Implementation Support for HEROS II and AB 118 EFMP Programs

Contractor: Transfer from Clean Fuels	SCAQMD Cost-Share	$ 189,855
	Cosponsors:	
	Carl Moyer AB 923 Program	1,923,155
	CARB AB 118 Enhanced Fleet Modernization Program (EFMP)	2,708,000
	Mercedes Benz USA	1,000,000
	Unocal Settlement "Vehicle Repair, Retirement, & Replacement for Motorists" Program (In-Kind)	4,496,063
Term: 12/3/10 – 12/3/11	Total Cost:	$10,317,073

At its December 3, 2010 meeting, the SCAQMD Board approved the transfer of $189,855 from the Clean Fuels Fund for costs associated with implementation of Phase II of SCAQMD's HEROS Program and for implementation of the vehicle replacement component of CARB's AB 118 Enhanced Fleet Modernization Program (EFMP). These are voluntary programs for the scrap and replacement of high-emitting light- and medium-duty vehicles. Gross-polluting vehicles make up about 10 percent of the South Coast Air Basin's passenger vehicle fleet, and yet they are responsible for more than 50 percent of the air pollution from that fleet. The Foundation for California Community Colleges (FCCC) will implement the two programs and implement a similar vehicle scrap and replacement program, the Unocal Settlement "Vehicle Repair, Retirement, & Replacement for Motorists" Program. Together, resources will be leveraged and efforts made to provide a seamless experience to consumers. A common call center will be used for all three programs and matching incentives levels offered to consumers. Incentives of $4,000 will be offered to low-income eligible participants for scrap and replacement and incentives of $3,000 will be offered to remaining participants. Implementation of these programs provides a significant opportunity to accelerate the turnover of high-emitting vehicles in the South Coast Air Basin with deployment of cleaner low-emission vehicles and help meet the clean air goals of the SCAQMD.

Fuels/Emissions Studies

10012: Evaluate Impacts & Benefits of Plug-In Fuel Cell Hybrid Vehicles

Contractor: Electric Power Research Institute	SCAQMD Cost-Share	$ 50,000
	Cosponsor:	
	California Air Resources Board	50,000
Term: 1/28/10 – 7/31/10	Total Cost:	$ 100,000

This study will provide a first-cut assessment of the cost, environmental and infrastructure characteristics, benefits and possible limitations of plug-in fuel cell vehicles (PFCVs) compared to fuel cell vehicles (FCVs), battery electric vehicles (BEVs) and PHEVs. Preliminary vehicle models will be developed and their costs estimated. State-of-the-art simulation techniques will be used to determine and compare prospective vehicle performance, driving range, energy consumption, operating costs and well-to-wheels (WTW) CO_2 emissions for representative

driving cycles. The report will include a preliminary plan for a more in-depth, broadly scoped comparison of PFCVs with other advanced electric technology vehicles.

10095: Cosponsor Sustainable Transportation Energy Pathways Program

Contractor: University of California Davis Institute of Transportation Studies	SCAQMD Cost-Share	$ 120,000
	Cosponsors:	
	19 energy, automotive and government agencies	2,190,000
Term: 06/29/10 – 07/31/12	Total Cost:	$ 2,310,000

The U.C. Davis Institute of Transportation Studies is conducting a multi-year research and outreach program to develop the theory, tools and methods that allow for self-consistent and transparent comparisons of promising alternative energy and vehicle pathways, and apply these tools and methods in comparative assessments of four general transportation energy pathways in the areas of hydrogen, biofuels, electricity and fossil fuels. The Sustainable Transportation Energy Pathways (STEPS) program has input from a team of multi-disciplinary researchers and support from energy companies, automotive manufacturers and government agencies. STEPS analyses will include a focus on Southern California as the early market for alternative-fueled vehicles, specifically hydrogen fuel cells, plug-in hybrid and battery electric vehicles.

10693: Provide Transportable Laboratory Testing to Quantify Emissions from SCR Technology

Contractor: West Virginia University Research Corp.	SCAQMD Cost-Share	$ 76,000
Term: 9/1/10 – 8/31/11	Total Cost:	$ 76,000

Selective catalytic reduction (SCR) technology and diesel particulate filters (CARB Level III PM control) are capable of reducing NO_x and PM emissions from heavy-duty diesel trucks by 70 and 85 percent or more, respectively. SRC technology is currently being used on new trucks in Europe. This project proposes to assess the reliability and emission reduction potential of Johnson Matthey's selective catalytic regenerating technology (SCRT) system on heavy heavy-duty diesel trucks operating in the South Coast Air Basin. The scope of the project includes design, installation and in-field demonstration of SCRT on 15 heavy heavy-duty diesel trucks in actual commercial service. Two of the trucks, one with at least a 90-day old SCRT system, and the other with a new or relatively fresh SCRT will be tested over transient and steady-state cycles on West Virginia University's transportable chassis dynamometer. The trucks will then be demonstrated in service for six months to evaluate performance, reliability and emissions reduction potential of the SCRT system.

10722: Re-Establish Testing Facility & Quantify PM Emission Reductions from Commercial Charbroiling Operations

Contractor: University of California Riverside/CE-CERT	SCAQMD Cost-Share	$ 60,000
Term: 8/6/10 – 6/30/11	Total Cost:	$ 60,000

This contract was approved by the SCAQMD Board on May 7, 2010. It was fully executed August 6, 2010, and later extended through June 30, 2011, to allow additional time for the completion of testing. The University of California, Riverside, Center for Environmental Research and Technology (CE-CERT) under a previous contract with the SCAQMD developed a protocol to measure emissions from commercial charbroilers. This follow-on contract with CE-CERT is to re-establish a testing facility. CE-CERT staff will then conduct source testing of current control technologies applied to under-fired charbroilers to quantify particulate matter emission reductions in an amount not to exceed $60,000 from the Clean Fuels Fund.

11519: Evaluate Protocols for Measuring Emissions from Cleaning of Application Equipment & Surfaces with Solvent

Contractor: University of California Riverside	SCAQMD Cost-Share	$ 23,713
	Cosponsor:	
	W.M. Barr	23,712
Term: 12/23/10 to 6/22/11	Total Cost:	$ 47,425

Rule 1143 "Consumer Paint Thinners and Multipurpose Solvents" was adopted to address emissions of volatile organic compounds (VOCs) from the use, storage and disposal of consumer paint thinners and multi-purpose solvents. The cleaning of application equipment (e.g., paint brushes) and surface cleaning (e.g., kitchen cabinet door coated with enamel paint) is thought to be major uses of these solvents. There is, however, no data available on the emission rate from these operations. In addition, solvents vary widely in the amount of ozone they are likely to produce in the atmosphere. The ozone producing capacity has been determined for many organic compounds through testing in environmental irradiation chambers and is measured by the maximum incremental reactivity (MIR) to produce ozone. If a solvent has a MIR less than that of ethane and vapor pressure of less than 0.1mm Hg, it is not likely to produce significant amounts of ozone. The primary objective of this project is to develop and validate an approach to measure mass emissions from cleaning paint brushes and surface cleaning using four different low vapor pressure (LVP) solvents, as well as acetone, and then calculate the total ozone formation from each.

Emission Control Technologies

10069: Develop & Demonstrate SCRT® for NO_x and PM Emissions Control

Contractor: Johnson Matthey, Inc.	SCAQMD Cost-Share	$ 300,000
	Cosponsors:	
	U.S. Environmental Protection Agency	900,000
	Johnson Matthey, Inc. (In-Kind)	280,000
Term: 6/18/10 to 10/13/03	Total Cost:	$ 1,480,000

On-road heavy-duty diesel trucks contribute a majority of the total mobile source NO_x and PM emissions within the South Coast Air Basin. Selective catalytic reduction (SCR) and diesel particulate filter (DPF) technologies are capable of significantly reducing both of these emissions, but would benefit from additional field demonstrations. This project will demonstrate Johnson Matthey's SCRT® system on 35 model year 1999 through 2002 heavy-duty Class 8 on-road diesel trucks. SCRT® is Johnson Matthey's trade name for its patented two-stage continuously regenerating trap (CRT®) system combined with a urea-injection based SCR system.

10675: Develop Efficient Humid Air System for Diesel NO_x Reduction

Contractor: CSULB Foundation	SCAQMD Cost-Share	$ 28,000
Term: 5/12/10 to 9/30/10	Total Cost:	$ 28,000

The effects of humid air on the performance of a naturally aspirated three-cylinder diesel engine with low-sulfur diesel fuel have been investigated. The additions of the humidity to the intake air were performed with a variable steam generator using distilled water, where the relative humidity of the intake air was maintained at 95%. The tests were performed at two engine brake horsepower (BHP) levels of 4.45 and 9. The results showed approximately 25% reduction in NO_x emissions at both loads when the relative humidity of the air was increased from 58% (the ambient relative humidity) to 95%. The increase in humidity increased emissions of CO, CO_2 and particulate matter (PM) and the brake specific fuel consumption (BSFC) by 17, 2, 42 and 5 percents, respectively at 4.45 BHP and by 13.8, 3.5, 38 and nearly 10 percent, respectively, at 9 BHP. The results indicate that for both mobile and stationary diesel engines, a humid air system is a viable option for attaining significant reductions in NO_x emissions.

10696: Optimize & Demonstrate SCRT® for NO_x and PM Emissions Control

Contractor: Johnson Matthey, Inc.	SCAQMD Cost-Share	$ 300,000
	Cosponsors:	
	U.S. Environmental Protection Agency	2,000,000
	Johnson Matthey, Inc.	518,499
Term: 7/9/10 to 3/31/12	Total Cost:	$ 2,818,499

On-road heavy-duty trucks contribute substantially to NO_x and PM emissions within the South Coast Air Basin. Selective catalytic reduction systems and diesel particulate filter technologies are capable of significantly reducing NO_x and PM emissions, respectively. This project will

install Johnson Matthey's SCRT® technology on 69 model years 1999 through 2002 on-road heavy-duty diesel trucks to evaluate the effectiveness of their system.

10697: Optimize & Demonstrate SSCRT® for NO_x and PM Emissions Control

Contractor: Johnson Matthey, Inc.	SCAQMD Cost-Share	$ 300,000
	Cosponsors:	
	U.S. Environmental Protection Agency	2,000,000
	Johnson Matthey, Inc.	518,499
Term: 7/9/10 to 3/31/12	Total Cost:	$ 2,818,499

On-road heavy-duty trucks contribute substantially to NO_x and PM emissions within the South Coast Air Basin. Selective catalytic reduction systems and diesel particulate filter technologies are capable of significantly reducing NO_x and PM emissions, respectively. This project will install Johnson Matthey's SCCRT® (selective catalytic continuously regenerating trap) technology on 69 model year 2003 through 2006 on-road heavy-duty diesel trucks to evaluate the effectiveness of their system.

10112: Showcase: Retrofit Select Catalytic Reduction System & Diesel Particulate Filters on Off-Road Construction Equipment

Contractor: Sanitation Districts of Los Angeles County	SCAQMD Cost-Share	$ 116,450
Term: 2/26/10 to 2/21/12	Total Cost:	$ 116,450

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 18 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 an 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 up to six pieces of construction equipment owned by the Sanitation Districts of Los Angeles County. 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 engines and demonstrated in service for at least 700 hours.

11136: Demonstrate NO_x and PM Emissions Control Technology on Diesel-Powered Construction Equipment

Contractor: ServoTech Engineering	SCAQMD Cost-Share	$ 132,000
	Cosponsor:	
	ServoTech Engineering	300,000
Term: 10/15/10 to 5/31/12	Total Cost:	$ 432,000

At its March 6, 2009 meeting, the SCAQMD Board approved an award of $132,600 to ServoTech to design, fabricate, install, test and demonstrate an emission reduction retrofit system combining SCR technology with an actively regenerated DPF. ServoTech will install their system on two pieces of construction equipment which will be operated for a minimum of 1 year and 1100 hours. The project includes key steps supporting the CARB verification process, including in-field and laboratory exhaust emission tests to establish emission reduction effectiveness. The demonstration vehicles consist of an excavator and loader. The project has the potential of demonstrating equivalent emissions using a retrofit system for older equipment to Tier 4 standards for new equipment. The system is expected to cost less than repower or replacement with Tier 4 engines. ServoTech has completed the design and fabrication of the first system and plans to install it in early 2011.

Electric/Hybrid Technologies

99109: Three-Year Lease of Two RAV4 Electric Vehicles

Contractor: Toyota Motor Credit Corporation	SCAQMD Cost-Share	$ 7,902
Term: 04/04/99 to 02/01/11	Total Cost:	$ 7,902

The SCAQMD operates a number of alternative fuel vehicles (AFVs), including electric vehicles (EVs) and hybrid-electric vehicles (HEVs). The primary objective of having these vehicles as part of the SCAQMD fleet is to continue to demonstrate the use of zero-emission vehicles in our fleet. Various SCAQMD-owned AFVs are used to demonstrate new clean-fuel vehicles to public and private organizations so that potential purchasers may familiarize themselves with available low-emission technologies. The lease of two Toyota RAV4 battery electric vehicles is extended for use in the Technology Advancement Office's Advanced Technology Demonstration Program.

09360: Lease of Five MiniE Electric Vehicles for One Year

Contractor: BMW of North America LLC	SCAQMD Cost-Share	$ 39,510
Term: 5/5/09 to 6/25/11	Total Cost:	$ 39,510

The SCAQMD leased five Mini Cooper electric vehicles from BMW North America. The electric vehicles are part of a 450 vehicle demonstration program being conducted by BMW North America. BMW has deployed these vehicles in the Los Angeles and New York areas to collect user feedback, which may be used to assist in developing vehicle requirements for an upcoming electric vehicle that BMW has announced to be in development.

10738: Demonstrate Quick-Charge Infrastructure for Electric Buses

Contractor: Foothill Transit	SCAQMD Cost-Share	$ 290,000
	Cosponsor:	
	ARRA-Dept. of Transportation	6,500,000
Term: 10/29/10 to 06/29/13	Total Cost:	$ 6,790,000

Foothill Transit is proposing to replace three diesel buses with Ecoliner electric buses with quick-charge capability and quick-charge infrastructure on an existing route from the City of La Verne to the City of Pomona. The 35-foot Ecoliner bus will carry 37 passengers and will be powered by a 75 kW-hour battery. Funding from SCAQMD will support the charging technology, charging station and supplemental charging components associated with the Ecoliner buses. The charging system will connect to the bus from overhead. The charging station includes the architectural and engineering design, the installation and the construction of the charging station for two bus locations. The benefits of this proprietary technology are a safe automated charging system that will perform without human intervention. The total project will encompass 32 months from development through demonstration. Foothill Transit will collect data on the charge infrastructure and the buses and will disseminate relevant reports to the SCAQMD. These reports will detail all stages of project implementation and evaluation including: operations and maintenance, environmental and service life data as well as operating characteristics and costs associated with operation and maintenance of the charging infrastructure. The SCAQMD Board approved $290,000 to co-fund this project at its May 7, 2010 Board meeting.

11204: Develop & Demonstrate Electric Drive Conversion for Fleet Vehicles

Contractor: AC Propulsion	SCAQMD Cost-Share	$ 300,000
	Cosponsors:	
	AC Propulsion	355,767
	Comcast	100,000
Term: 12/24/10 to 10/30/12	Total Cost:	$ 755,767

AC Propulsion will work in partnership with the SCAQMD and Comcast to convert Ford E250 service vans to electric vehicles. These converted electric service vans will be deployed in Comcast's normal fleet to evaluate their utility, emissions and fossil fuel reduction potential when used as a service vehicle. The successful demonstration of this conversion system could lead to the additional electrification of service vehicles within Comcast's fleet as well as similar applications.

11205: Implement Hybrid Truck and Bus Voucher Incentive Program

Contractor: Calstart	SCAQMD Cost-Share	$ 1,500,000
Term: 12/2/10 to 3/31/12	Total Cost:	$ 1,500,000

In December 2009, the SCAQMD Board approved the allocation of $1.5 million to cost-share the hybrid truck and bus voucher incentive program (HVIP), which is to reduce the high cost of hybrid vehicles within the SCAQMD region. Subsequently in September 2010, the SCAQMD Board authorized the execution of a contract with Calstart to administer and implement the HVIP on behalf of the SCAQMD in accordance with the HVIP requirements specified in the grant

agreement between CARB and Calstart, with the additional requirement that the SCAQMD funds be used only for eligible hybrid vehicles that will be operated in the geographical boundaries of the SCAQMD. The purpose of the HVIP is to offset about half of the incremental cost of eligible medium- and heavy-duty hybrid vehicles to facilitate deployment and help commercialize these lower emitting hybrid vehicle technologies. The HVIP is expected to support a critical ramp-up in production that is necessary to deploy a large number of hybrid vehicles which will help achieve California's clean air goals.

Direct Pay: EV Charger Installations for MiniE Cooper Demonstration Program

Contractor: Clean Fuel Connection, Inc.	SCAQMD Cost-Share	$ 2,827
Term: 1/31/10 to 3/3/10	Total Cost:	$ 2,827

The SCAQMD relocated two electric vehicle charging stations to support the use of the electric Mini Coopers that are being leased through BMW. These charging stations were relocated to facilitate the use of these vehicles in new regions and increase confidence in and ultimately commercialization and deployment of electric vehicles.

Engine Systems

10071: Develop & Certify Natural Gas Chevrolet Impala Sedans

Contractor: NaturalDrive Partners, LLC	SCAQMD Cost-Share	$ 81,388
	Cosponsors:	
	NaturalDrive Partners, LLC	57,200
	(In-Kind)	52,800
	State of Oklahoma (In-Kind)	32,000
	Luxfer Gas Cylinders (In-Kind)	11,000
Term: 1/15/10 to 6/30/11	Total Cost:	$ 234,388

At its April 3, 2009 meeting, the SCAQMD Board approved the execution of a contract to cosponsor the development and certification of natural gas Chevrolet Impala sedans. The Impalas are full-size passenger cars that are widely used in public and private fleets. Currently, there are a limited number of equipment manufacturers that produce full-size CNG sedans. To increase the number and variety of CNG vehicles in fleets, NaturalDrive Partners, LLC will develop and obtain 2011 Model Year or newer CARB certification for CNG sedans that would be derived from the 3.5 and 3.9 liter models of the gasoline-powered Chevrolet Impala.

Mobile Fuel Cell Technologies

10501: Lease a Clarity Fuel Cell Vehicle for Three Years

Contractor: American Honda Motor Company, Inc.	SCAQMD Cost-Share	$ 24,001
Term: 1/21/10 to 1/20/13	Total Cost:	$ 24,001

The Executive Officer approved the execution of a three-year lease contract with Honda for the Honda Clarity FCV. The Clarity has been placed into the SCAQMD fleet but is primarily used in outreach events and public meetings to demonstrate state-of-the-art hydrogen fuel cell vehicles.

10650: Demonstrate Advanced Fuel Cell Bus (American Fuel Cell Bus)

Contractor: SunLine Transit Agency	SCAQMD Cost-Share	$ 400,000
	Cosponsors:	
	Federal Transit Administration/Calstart	4,197,955
	California Air Resources Board	800,000
	BAE Systems	4,152,450
	El Dorado National	354,438
	SunLine Transit Agency	310,000
Term: 6/4/10 to 6/3/13	Total Cost:	$ 10,214,843

The intent of this project is to develop a newly designed fuel cell bus with a North American chassis as well as domestically sourced fuel cell and drive components. Success in this program will ensure availability of a U.S.-built product that can offer transit properties the opportunity to buy buses through the Federal Transit Administration (FTA) capital program. Specifically, the program's commercial focus anticipates that the resulting fuel cell bus product would be built and sold profitably at a price of under $2 million. Also, there is an expectation that extended warranties for the fuel cell and battery pack can be attained, further driving down the warranty costs through significantly longer operating lives than the 2005-generation fuel cells and batteries. Body/chassis weight and noise reductions will maximize the number of passengers each fuel cell bus can accommodate while also maximizing the passengers' level of comfort. Packaging the latest generation fuel cell-hybrid drive system into a physically attractive bus with contemporary styling and which features sufficient U.S. derived content to meet FTA "Buy-America" provisions is very important. The SCAQMD Board initially approved $400,000 for this project on September 7, 2007. Subsequently, the project was reorganized in 2010 and the SCAQMD Board approved the changes at its March 5, 2010 meeting.

10599: Participate in California Fuel Cell Partnership for CY 2010 & Provide Support for Regional Coordinator

Contractor: Bevilacqua-Knight, Inc.	SCAQMD Cost-Share	$ 137,800
	Cosponsors:	
	8 automakers; 2 energy providers; 7 government agencies; 2 fuel cell providers; and 11 associate members	1,530,400
Term: 1/1/10 to 12/31/10	Total Cost:	$ 1,668,200

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 2010, 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

04185: Develop & Demonstrate Hydrogen Internal Combustion Engine Vehicles

Contractor: Quantum Fuel Systems Technologies Worldwide Inc.	SCAQMD Cost-Share	$ 73,000
Term: 10/18/04 to 8/31/12	Total Cost:	$ 73,000

The Five Cities Program has continued to be one of the most significant demonstrations of hydrogen vehicles and fleets by stimulating demand for hydrogen vehicle technologies in California. CARB has granted an extension of the vehicle experimental permits allowing data collection from the Quantum Prius hydrogen vehicles for a full five years. Initial data collection was delayed due to additional time required to finalize the vehicle conversion to hydrogen and to meet SULEV emission levels. The subject contract is an amendment to the existing contract with Quantum Technologies in the amount of $73,000 to provide vehicle maintenance and emission testing during the experimental permit extension period of 18 months.

10061: Maintenance & Data Management for the SCAQMD Hydrogen Fueling Station

Contractor: Hydrogenics Corporation	SCAQMD Cost-Share	$ 100,000
Term: 10/30/09 to 10/29/11	Total Cost:	$ 100,000

Since February 2005, the SCAQMD has operated a hydrogen fueling station at its Diamond Bar headquarters to accommodate its growing fuel cell and hydrogen-fueled vehicle fleet as well as third party hydrogen-fueled vehicles. Since the station's opening, the SCAQMD has contracted with Stuart Energy (now Hydrogenics Corporation), the original station constructor for proper system performance, routine maintenance and data management of the hydrogen fueling station including any repairs or replacements due to equipment failures or breakdown. The original contract expired in September 2009. This contract was executed in 2009 so Hydrogenics could continue to provide maintenance, management and un-interrupted service for the SCAQMD hydrogen fueling station for a period of up to two years. In 2010 the SCAQMD Board authorized an additional $100,000 to ensure sufficient funding for this two-year period.

10149: Cosponsor Feasibility, Design & Development of 70 MPa Hydrogen Home Fueling Appliance

Contractor: NextEnergy Center	SCAQMD Cost-Share	$ 63,400
	Cosponsors:	
	U.S. Dept of Energy	417,600
	NextEnergy Center	41,000
Term: 5/7/10 to 11/6/11	Total Cost:	$ 522,000

A strategy to accelerate the acceptance of hydrogen vehicles is to provide home refueling, similar to fueling for electric and natural gas vehicles. Availability of safe and cost effective home fueling in the form of compressed hydrogen gas can be an important step in successful commercialization of non-fleet hydrogen-fueled light-duty vehicles. A preliminary study has been initiated by GM, Ford, Daimler and Chrysler with project management services provided by NextEnergy Center, and survey, engineering and design services provided by the Gas Technology Institute. The first phase of this project is to conduct a feasibility study with basic design scenarios to determine the cost, detailed design study and lifetime operation characteristics of a 70MPa residential fueling appliance. Based on the successful completion of this phase, the second phase will be the actual development and evaluation of an in-home refueling system with an expected cost of under $10,000 per unit and an intended life equal to or longer than that of the vehicle.

11150: Maintenance & Operation of City of Burbank Hydrogen Fueling Station

Contractor: Hydrogen Frontier, Inc.	SCAQMD Cost-Share	$ 200,000
	Cosponsors:	
	U.S. Dept. of Energy	360,000
	California Air Resources Board	300,000
	California Energy Commission	200,000
Term: 11/24/10 to 1/24/15	Total Cost:	$ 1,060,000

The City of Burbank was one of the participants in the "Five Cities Program," which established hydrogen fueling and a small demonstration fleet of five hydrogen Prius vehicles at each city. Under the Federal Hydrogen to Highways Program, the Dept. of Energy (DOE) and British Petroleum (BP) approached the City to install a larger capacity steam methane reformer (SMR) hydrogen station in place of the SCAQMD electrolyzer. The contract between DOE and BP terminated and the title to the station and all equipment was transferred to the City. Unfortunately, the City did not have sufficient funds or expertise to provide for utilities, operation and maintenance of the facility. Consequently, the City asked for funding assistance from the SCAQMD, CARB, DOE and the CEC. An RFP was released seeking qualified vendors to perform ongoing maintenance and operations for the fueling station. Hydrogen Frontier, Inc. was selected as best qualified from the field of applicants to operate and maintain the City of Burbank hydrogen fueling station, and the SCAQMD Board awarded the contract to Hydrogen Frontier, Inc. with $200,000 from the Clean Fuels Fund for the first year of operation. When the revenue agreements are executed with DOE, CARB and the CEC, the additional funding will be added to the contract to supplement year one and fund the remaining years of the contract.

Purchase Order: Third Party Inspection of SCAQMD Hydrogen Station

Contractor: Engineering, Procurement & Construction	SCAQMD Cost-Share	$ 4,763
Term: 3/17/10 to 4/26/10	Total Cost:	$ 4,763

On January 7, 2010, a gas control panel at the SCAQMD Diamond Bar hydrogen fueling station had a hydrogen detonation event. After an initial investigation at the site it was determined that the event was isolated to the gas control panel. To determine the overall safety of the entire fueling station a third party was engaged to perform a safety analysis. Engineering Procurement & Construction, LLC was hired as an independent third party familiar with hydrogen station design and operation practices to determine if the SCAQMD hydrogen fueling station was safe for restarting and to document deficiencies or safety issues that required correction, if any, to achieve a safe condition for future operations.

Purchase Order: Operate & Maintain City of Burbank Hydrogen Station

Contractor: Hydrogenics Corporation	SCAQMD Cost-Share	$ 50,000
Term: 3/5/10 to 12/5/10	Total Cost:	$ 50,000

A contract with DOE and BP for the operation and maintenance of a hydrogen fueling station at the City of Burbank terminated. Unfortunately, the City did not have sufficient funds or expertise to provide for utilities, operation and maintenance of the facility. The City asked for funding assistance from the SCAQMD, CARB, DOE and the CEC. An RFP was released to secure a contractor to provide operation and maintenance services for the station: however during the interim time between vendor selection and contracting it was imperative to support the City's existing hydrogen Prius fleet and the CARB-sponsored hybrid electric fuel cell bus, which was delivered in April 2010, as well as other fuel cell vehicles operating in the area. A purchase order was executed with Hydrogenics Corporation to provide this interim operation and maintenance services to the City's hydrogen fueling station until such time as a vendor was selected and contracted through the RFP process.

Purchase Order: Rental of Purity Multi-Gas FTIR Instrument to Measure Hydrogen Quality

Contractor: MKS Instruments	SCAQMD Cost-Share	$ 5,000
Term: 6/10/10 to 7/9/10	Total Cost:	$ 5,000

There has been ongoing discussions to determine the level of purity that hydrogen must have in order to be used by fuel cell vehicles (FCVs) stemming from the existing SAE guidelines established by the OEMs. In support of the existing overall network of hydrogen fueling stations and the use of hydrogen as a vehicle fuel, an economical method for determining hydrogen purity is desirable. A standard FTIR gas analysis apparatus that could be used to determine hydrogen purity was designed and built by MKS instruments and rented through this purchase order for hydrogen quality measurements. If applicable and approved by ASTM, this test method should facilitate the usage of this technology for hydrogen contaminant measurement, trace impurity measurements in other gaseous fuels and hydrogen fuel quality analytic measurement option. The FTIR/RGA may be used as a portable device in association with the Hydrogen Quality Sampling Apparatus developed through a different contract with NREL.

Direct Pay: Purchase, Install & Service GPS Receivers for Hydrogen Vehicles

Contractor: Telogis	SCAQMD Cost-Share	$ 12,000
Term: 10/29/10 to 12/31/11	Total Cost:	$ 12,000

CARB has granted an extension of the Five City Program vehicle experimental permits allowing data collection from the Quantum Prius hydrogen vehicles for a full five years. Initial data collection was delayed due to additional time required to finalize the vehicle conversion to hydrogen and to meet SULEV emission levels. Vehicle tracking devices purchased from Telogis will be installed on the Quantum Prius vehicles to collect vehicle trip data. Two tracking devices will be placed on two vehicles at each City to provide continuous data collection that can be easily matched to individual trip-fill data collected by the hydrogen stations.

Stationary Clean Fuels Technologies

10114: Retrofit Digester Gas Engine with Fuel Gas Clean-Up & Exhaust Emission Control Technology

Contractor: Orange County Sanitation District	SCAQMD Cost-Share	$ 200,000
	Cosponsor:	
	Orange County Sanitation Districts	$2,211,882
Term: 3/25/10 to 3/24/11	Total Cost:	$ 2,411,882

The Technology Advancement Office issued Program Opportunity Notice (PON) 2009-01 soliciting proposals for co-funding clean technology projects. In response to the PON, the Orange County Sanitation Districts (OCSD) submitted a proposal to install a biogas clean-up system and retrofit control technologies to reduce emissions from an engine operating on biogas from a wastewater treatment plant. Biogas fueled engines are operated at landfills, wastewater treatment plants and other sites where waste fuel gas is generated. These are generally larger engines used primarily to power electrical generators. Due to contaminants in the biogas which are incompatible with catalytic after-treatment devices, biogas engines have generally not been required to install oxidation catalysts and SCR units that natural gas engines use. As a result, the emissions for biogas engines are higher than most permitted engines. This demonstration project will support the technology assessment study for the future biogas engine emission limits of Rule 1110.2.

Outreach and Technology Transfer

02308: Evaluate Financial Stability of Potential Contractors

Contractor: Sperry Capital, Inc.	SCAQMD Cost-Share	$ 15,000
Term: 6/25/02 to 12/31/11	Total Cost:	$ 15,000

Sperry Capital, Inc. is an independent financial and investment advisory firm that specializes in providing California local agencies with both municipal financial advisory services and independent consulting services for short-term, fixed income obligations. The company has investment banking and financial advisory experience in the areas of health care, transportation, small businesses and other governmental entities. Under this contract, Sperry Capital, Inc. provides financial advice on the financial stability of potential contractors. With the increased

number of contracts resulting from the various Clean Fuels and incentive programs, staff has identified the need to provide financial evaluation of potential contractors and the risks associated with contracting with new and small technology innovation companies. Additional funding in the amount of $15,000 was added to this contract in 2010 from the Clean Fuels Fund to continue to provide these services.

02333: Technical Assistance on Clean Fuels Technology, Hydrogen, Fuel Cell Technology & Natural Gas Technology

Contractor: University of California, Riverside	SCAQMD Cost-Share	$ 40,000
Term: 11/1/02 to 6/30/11	Total Cost:	$ 40,000

The AQMP is the comprehensive regional plan for attaining federal air quality standards in the South Coast Air Basin. In addition to full implementation of current technologies and management practices, near-term advances in current technologies and technological breakthroughs are needed. Air quality projections indicate that the federal standard for ozone is not expected to be met without such breakthroughs. Regular revisions to the AQMP are based on the most current information on technology advancements. The University of California, Riverside (UCR) shall provide technical expertise on air pollution formation and control, advanced vehicle/transportation technologies and systems, and off-road vehicles and equipment, stationary source technologies, atmospheric measurement and modeling and renewable energy. UCR will also perform testing of air filtration technologies to create a list of qualified technologies for installation and maintenance of air filtration systems at schools and similar environments. The installation of air filtration systems has been successfully demonstrated in classroom environments to reduce levels of diesel particulate matter with almost 90% average removal efficiency. Air filtration technologies for schools and similar environments are being used to mitigate diesel emissions from mobile sources near the Ports of Los Angeles and Long Beach associated with goods movement activities. This list of qualified technologies will be included in a new RFP for air filtration installers for the TraPac air filtration program once the list of qualified technologies is determined. The lists of qualified air filtration technologies and installers will be used in current and future air filtration programs, and can be made available to other agencies or organizations.

09337: Follow-Up Assessment of SCAQMD's Compliance with Special Revenue Funds & Financial Assistance with Implementation of Incentive Programs

Contractor: Mark Weekly, CPA	SCAQMD Cost-Share	$ 20,000
Term: 3/3/09 to 1/31/13	Total Cost:	$ 20,000

Mr. Mark Weekly, CPA, is providing consultant services to conduct a follow-up assessment of SCAQMD's compliance with special revenue funds. In the past few years SCAQMD has received significantly more restricted funds, and the staff work and number of contracts issued with those funds has increased dramatically. With the increased activity resulting from the various Clean Fuels and incentive programs, it is necessary to obtain financial evaluation and reporting of internal contract and accounting practices. Mr. Weekly formerly held the position of SCAQMD Controller/Accounting Manager for 18 years. He previously performed an independent review of SCAQMD's revenue generating work program activities (e.g., Clean Fuels, Carl Moyer, Prop 1B, AB2588 "Hot Spots," etc.). This follow-up assessment will assist staff in refining existing processes as well as developing new processes to ensure compliance

with the various fund/program regulations and restrictions. The additional funds added to the contract in 2010 will continue this follow-up assessment and provide assistance with financing or loan guarantees for implementation of incentive programs.

10056: Enhanced Training Technology Programs

Contractor: Advanced Transportation Technology & Energy	SCAQMD Cost-Share	$ 500,000
Term: 05/27/10 to 12/31/11	Total Cost:	$ 500,000

As part of the Chairman's "Helping Hand Initiatives for 2009," the SCAQMD Board approved the execution of a contract with Advanced Transportation Technology & Energy at its September 11, 2009 meeting. Through this contract, ATTE will develop curricula to be offered at local community colleges to ensure that available new low- and zero-emission technologies are properly installed and maintained after their introduction. This project builds upon the SCAQMD's past partnerships with the community college system and other local technology education providers to offer training programs in areas of heavy-duty vehicle emission control equipment, alternative fuel vehicle maintenance, renewable energy (including photovoltaic and solar thermal technology), high voltage vehicle technology and smog technician training.

10590: Technical Assistance with AQMD High School Conference "A World We Can Change"

Contractor: Three Squares Inc.	SCAQMD Cost-Share	$ 50,000
Term: 2/5/10 to 7/30/10	Total Cost:	$ 50,000

The high school conference "A World We Can Change" attracted over 8,000 attendees from 140 high schools from throughout our four-county region, with schools coming from as far as Big Bear and Desert Hot Springs. Students were transported in 170 school buses. Three Squares Inc. (TSI) assisted with event logistics, program agenda and outreach. The conference program included scientific experts, a screening room where environmental films were showcased and a dynamic, interactive Expo Hall, with 93 exhibitors and vehicle displays. The main program session included all conference attendees into one room, where they received lunch, heard from renowned speakers and also highlighted a Clean Vehicle Parade showcasing vehicles powered by alternative fuels. Teachers and students commented on how much they enjoyed the program and the opportunity to learn more about air quality issues and actions they can take to improve air quality within our region. The AQMD Board approved a budget up to $570,000, comprising $300,000 from the Clean Fuels Conference Fund and $270,000 from sponsor and exhibitor revenue. The final budget for the event was approximately $400,000, which included $170,000 from sponsors and exhibitors to support the AQMD in hosting this event.

10700: Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Technologies

Contractor: TIAX LLC	SCAQMD Cost-Share	$ 120,000
Term: 7/23/10 to 5/31/12	Total Cost:	$ 120,000

Mobile sources emit the majority of air pollution in the South Coast Air Basin. In particular, heavy-duty diesel vehicles emit high levels of NOx, a precursor to photochemical smog, as well as diesel particulate exhaust, which has been categorized by CARB as a toxic air contaminant.

The AQMP for the Basin identifies the application of clean-burning alternative fuels (e.g., natural gas, ethanol, and hydrogen), advanced vehicle technologies (e.g., fuel cells, hybrid electric and plug-in hybrid electric vehicles) and advanced stationary source pollution control technologies to meet the national ambient air quality standards. These air quality gains, however, may only be realized if programs are in place to develop, commercialize, and implement these technologies. As a result, the SCAQMD seeks to implement aggressive programs to develop and demonstrate pre-commercial technologies. This contract is being used to leverage staff resources with specialized outside expertise. TIAX has provided expertise involving low- and zero-emission vehicles, associated technologies, and alternative fuels since the early 1980s. TIAX team of scientists and engineers will provide technical expertise across a broad spectrum of emission reduction technologies, policies, and issues.

11028: Technical Assistance on Stationary Source Control Measures & Future Consultation on TAO Activities

Contractor: Martin Kay, P.E.	SCAQMD Cost-Share	$ 25,000
Term: 8/4/10 to 8/3/11	Total Cost:	$ 25,000

Mr. Martin Kay, P.E., will provide technical assistance to further develop and refine the stationary source control measures, air toxics control measures, review of AQMD programs such as the Multiple Air Toxics Exposure Study (MATES) and the Clean Fuels projects, input to natural gas quality "Hot Gas" issues, greenhouse gas and energy diversity policies, and state regulatory activities, such as the CNG Specifications regulation in an amount not to exceed $25,000. Mr. Kay has over 35 years of experience in air pollution and its control, energy conversion, combustion processes, fuels and distributed power generation.

11117: Technical Assistance for Alternative Fuels, Renewable Energy and Electric Vehicles

Contractor: Clean Fuel Connection Inc	SCAQMD Cost-Share	$ 50,000
Term: 9/17/10 to 12/31/11	Total Cost:	$ 50,000

Mobile sources emit the majority of air pollution in the South Coast Air Basin. In particular, heavy-duty diesel vehicles emit high levels of NO_x, a precursor to photochemical smog, as well as diesel particulate exhaust, which has been categorized by CARB as a toxic air contaminant. The AQMP for the Basin identifies the application of clean-burning alternative fuels (e.g., natural gas, ethanol, and hydrogen), advanced vehicle technologies (e.g., fuel cells, hybrid electric and plug-in hybrid electric vehicles) and advanced stationary source pollution control technologies to meet the national ambient air quality standards. These air quality gains, however, may only be realized if programs are in place to develop, commercialize, and implement these technologies. As a result, the AQMD seeks to implement aggressive programs to develop and demonstrate pre-commercial technologies. This contract is being used to leverage staff resources with specialized outside expertise. Clean Fuel Connection has provided expertise involving low- and zero-emission vehicles, associated technologies, and alternative fuels since the late 1990s. Clean Fuel Connection has over 15 years of experience with zero-emission and low-emission technologies and will provide technical expertise across a broad spectrum of emission reduction technologies, including alternative fuels, electric vehicles, charging infrastructure, and renewable energy under this contract.

11148: Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle Technologies

Contractor: Joseph C. Calhoun, P.E., Inc.	SCAQMD Cost-Share	$ 35,000
Term: 10/8/10 to 12/31/12	Total Cost:	$ 35,000

Mobile sources emit the majority of air pollution in the South Coast Air Basin. In particular, heavy-duty diesel vehicles emit high levels of NO_x, a precursor to photochemical smog, as well as diesel particulate exhaust, which has been categorized by CARB as a toxic air contaminant. The AQMP for the Basin identifies the application of clean-burning alternative fuels (e.g., natural gas, ethanol, and hydrogen), advanced vehicle technologies (e.g., fuel cells, hybrid electric and plug-in hybrid electric vehicles) and advanced stationary source pollution control technologies to meet the national ambient air quality standards. These air quality gains, however, may only be realized if programs are in place to develop, commercialize, and implement these technologies. As a result, the SCAQMD seeks to implement aggressive programs to develop and demonstrate pre-commercial technologies. This contract is being used to leverage staff resources with specialized outside expertise. Under this Contract, Mr. Joseph Calhoun shall provide expertise with low- and zero-emission vehicles including alternative fuels for light- and heavy-duty vehicles, engine technology, stationary sources, emissions analysis, and outreach for dissemination and commercialization of new technologies. Mr. Calhoun has over 49 years of experience related to air quality and has held positions including Automotive Engineering Board Member of CARB, Chief of Motor Vehicle Compliance of CARB, and Assistant Director of General Motors Automotive Emissions.

11182: Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis and Aftertreatment Technologies

Contractor: TechCompass	SCAQMD Cost-Share	$ 75,000
Term: 11/19/10 to 12/31/12	Total Cost:	$ 75,000

Mobile sources emit the majority of air pollution in the South Coast Air Basin. In particular, heavy-duty diesel vehicles emit high levels of NO_x, a precursor to photochemical smog, as well as diesel particulate exhaust, which has been categorized by CARB as a toxic air contaminant. The AQMP for the Basin identifies the application of clean-burning alternative fuels (e.g., natural gas, ethanol, and hydrogen), advanced vehicle technologies (e.g., fuel cells, hybrid electric and plug-in hybrid electric vehicles) and advanced stationary source pollution control technologies to meet the national ambient air quality standards. These air quality gains, however, may only be realized if programs are in place to develop, commercialize, and implement these technologies. As a result, the SCAQMD seeks to implement aggressive programs to develop and demonstrate pre-commercial technologies. This contract is being used to leverage staff resources with specialized outside expertise. TechCompass has over 28 years of professional experience in bringing environmental, energy, and alternative propulsion technologies from the laboratory to the market.

Transfer: Annual Insurance for SCAQMD Alternative Fuel Vehicles

Contractor: Hartford	SCAQMD Cost-Share	$ 1,572
Term: 1/1/10 to 5/26/10	Total Cost:	$ 1,572

In order to showcase and demonstrate advanced, low-emission technologies, the SCAQMD often leases and/or purchases clean alternative fuel vehicles to educate public and private organizations on the benefits of advanced technologies, as well as provide valuable in-use test data to the manufacturers. These vehicles are displayed at outreach events and conferences, used in Ride-and-Drive demonstrations, and are part of the SCAQMD carpool fleet. Private insurance is obtained for these advanced technology vehicles to ensure proper coverage.

Direct Pay: Cosponsor 25 Conferences, Workshops & Events, plus 5 Memberships & Subscriptions

Contractor: Various	SCAQMD Cost-Share	$ 386,894
	Cosponsors:	
	Various	2,439,988
Term: Various	Total Cost:	$ 2,826,882

The SCAQMD regularly participates in and hosts or cosponsors conferences, workshops and events. These funds provide support for the 25 events during 2010, plus 5 business council/association memberships and subscriptions. The 25 conferences, workshops and events are as follows: ICEPAG 2010 and 2011; American Association for Aerosol Research's 2010 Air Pollution and Health Specialty Conference; 21st Annual US Hydrogen Conference; 2010 & 2011 Alternative Fuels & Vehicles National Conference & Expo; 11th Annual Western Riverside County Clean Cities Coalition's Advancing the Choice Event; Women in Green Forum; CAPCOA Climate Change Forum & Expo; Alternative Clean Transportation Expo 2011; Coordinating Research Council's Mobile Source Air Toxics Workshop as well as On-Road Workshop; Santa Monica AltCar Expo; Symposium on Air Quality Measurement Methods, Brandman University High Speed Rail in SoCal Conference; U.S. EPA Environmental Awards Luncheon; EV 101 Carson Workshop; Zero Emission & Low-Carbon Fuels Workshop; California Fuel Cell Partnership's Renewable Hydrogen Workshop; Jet Propulsion Laboratory's Climate Day 2010; 5th Annual Clean Air Car Show; Silicon Valley Leadership Group Plug-in 2010; Heat Pumps Webinar; attendance and exhibitor participation at seven events; and Clean Fuels Advisory Retreats. Platinum membership for the California Hydrogen Business Council and general memberships for the National Hydrogen Business Council and U.S. Fuel Cell Council plus subscriptions to the California Dept of Education's California Public School Directory and California Natural Gas Vehicle Coalition's NGV Fuel Station Directory. Funding was also provided for Spanish translation of outreach documents and office expenses in support of the Clean Fuels Program.

PROGRESS IN 2010

Key Projects Completed

A large number of emission sources contribute to the air quality problems in the South Coast Air Basin. 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 (page 53) provides a list of 38 projects and contracts completed in 2010. 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.

Demonstrate Advanced Technology Boiler

Stationary boilers constitute one of the largest emission source categories in the South Coast District for both NO_x and the greenhouse gas CO_2. Boilers are used to produce steam and hot water for industry as well as commercial, institutional and residential buildings. Boilers have been designed for many years to meet a California minimum efficiency standard of 80 percent. The SCAQMD has mandated that essentially all boilers meet a NO_x limit of 9 ppm, corrected to 3% O2, within a few years.

The Gas Technology Institute (GTI), working with the Cleaver-Brooks Boiler Company and partially funded by the U.S. Department of Energy, has developed an advanced-technology boiler that operates at 92% efficiency and can meet a NO_x limit of 5 ppm while also achieving levels of CO well below those of conventional boilers. GTI's new boiler is intended to displace firetube type boilers in the 3.5 – 35 million Btu/hr size range. This boiler is more compact than a conventional boiler and thus can replace existing boilers without extensive facility modifications. It therefore has good potential as a retrofit technology that can achieve further NO_x reductions in the region while also reducing emissions of CO_2. GTI has estimated that for the segment of SCAQMD's

Figure 16: Advanced Technology Boiler

boiler population that could be replaced by this new technology, NO_x emissions could be reduced by approximately 49 TPY and CO_2 emissions could be reduced by approximately 175,000 metric tpy.

To assist GTI and Cleaver-Brooks in commercializing this new technology, the SCAQMD co-sponsored installation of a GTI advanced-technology boiler at the Clement-Pappas bottling plant in Ontario to replace an existing 20 million Btu/hr boiler. Co-funders included CARB's Innovative Clean Air Technologies (ICAT) program, GTI, Cleaver-Brooks, Clement-Pappas and the Southern California Gas Company. In this project, the ability of the boiler to operate at 92% efficiency and less than 5 ppm NO_x was demonstrated over a six-month period of intensive data collection. The GTI boiler has been carrying the plant's full steam load since February 2009 and the old boiler has been removed. The plant has reported a 24% reduction in fuel usage. GTI is moving ahead with commercializing the technology.

Upgrade & Demonstrate Fuel Cell Bus

In the original project approved by the Board in May 2001, Thor/ISE Research developed the first hybrid electric fuel cell bus, and successfully demonstrated the unique advantages of hybrid drive for hydrogen buses. The bus was successfully demonstrated and subsequently placed in revenue service at SunLine Transit in June 2002, followed by a 30-day demonstration in Los Angeles County. After the expiration of the SCAQMD contract, the bus provided revenue service at Alameda/Contra Costa (AC) Transit where it continued in public service. The bus was retired from service at the end of 2004 as fuel cell warranty funding had expired. The present SCAQMD contract was intended to upgrade the bus; the fuel cell would be replaced with a more powerful fuel cell by Ballard, the lead acid batteries would be replaced with lithium ion batteries and the fuel system would be upgraded from 3600 psi to 5000 psi capability, to attain additional storage and range.

The project costs were to be shared among the SCAQMD, the CARB, and federal sources. The project became known as the AT (Advanced Technology) bus. Upgrade work began early in 2008, with the first progress report to the SCAQMD being for 2008 Q2. By that time ISE was long well in development of the old tanks, fuel cell, battery had been stripped from the bus, a new cooling system had been installed the air system for the fuel cell was in development, and the battery was in development. In parallel at ISE, the design of the BC Transit bus intended to serve the Whistler Village venue of the winter games had moved to fast track development. This design was based on a larger (40') New Flyer bus with a 150kW fuel cell. This bus also incorporated most of the Advanced Technology concepts and hardware. Hence, it became clear that supplying the prototype of the larger bus in fulfillment of the AT bus contract would be a win-win for all parties.

Figure 17: AT Bus System Drawing

The Ballard 150kW fuel cell uses air from an ISE supplied air compressor design and hydrogen from six rooftop mounted tanks which store 45 kg hydrogen at up to 5000 psi. Ballard is sharing the risk, with a 12,000 hour warranty (or five years at most). Electrical energy supply is from a 45kWhr Lithium ion battery system designed for this vehicle. The drawing (Figure 1) shows the disposition of the fuel cell cradle at rear, the six tanks forward top of the bus, and the batteries lower curbside of the vehicle. The cooling units atop the bus serve for cooling

the fuel cell, the electronic drive train components, and the battery. This bus has undergone extensive testing, including EMI, cold chamber at -20C.

The bus was delivered to SunLine in early February and will enter service following installation of radios and driver training. The bus is capable of climbing a 20% grade fully loaded from a stop, and will climb an 8% grade fully loaded at a steady 25mph. It is faster than a diesel bus off the line and will cruise at a steady 62 mph. Vehicle range is in excess of 310 miles, but for operation in cold climates in which case fuel is used for heating the bus. Interior noise is primarily due to air conditioning at 74-76 db worst case. Exterior noise is no more, with a 76db peak in drive-by testing to SAE standards. The biggest advances over earlier fuel cell buses are in availability and Mean Time Between Failures (MTBF), due to extensive validation testing to BC Provincial standards. The fleet of 20 similar (production) buses at Whistler has been accumulating mileage some 20 hours per day; with over 116,000 km accumulated by the first of March (these buses were delivered in December and January). The benefits of this technology are premium transportation with zero tailpipe emissions. The project costs for AQMD were $325,000, total development costs in excess of $2M shared with the ARB and the Canadian program. Twenty production buses based on this design are now in Canada, to be followed with more.

Figure 18: AT Bus in Revenue Service at SunLine

Develop & Demonstrate Heavy-Duty Hybrid-Electric Vehicle

An evaluation of a gasoline hybrid electric vehicle (gHEV) was undertaken with FedEx Express to quantify the emissions and operating cost of this technology when utilized in a delivery vehicle application. FedEx Express is a large commercial fleet that operates more than 30,000 motorized vehicles and has hybrid electric (diesel and gasoline) vehicles currently in service. FedEx Express has deployed 20 gasoline hybrid electric vehicles (gHEVs) on parcel delivery routes in the Sacramento and Los Angeles areas. This project was inclusive of parcel delivery drive cycle data collection and analysis activities, 12-month in-use fuel economy and maintenance costs, and emissions and fuel economy results of chassis dynamometer testing of a gHEV and a comparative diesel truck at the National Renewable Energy Laboratory's (NREL's) Renewable Fuels and Lubricants (ReFUEL) laboratory.

The drive cycle data collection and analysis effort framed the selection of study vehicles and routes and structured the measurement of vehicle emissions and fuel economy on the chassis dynamometer at NREL's ReFUEL laboratory. Tailpipe emissions from the gHEV were substantially lower across all three tested drive cycles than

Figure 19: FedEx Delivery Truck

emissions from the diesel baseline vehicle. Notably, the gHEV exhibited 75–89% lower oxides of nitrogen (NOx) and over 99% lower particulate matter. Laboratory-measured diesel-equivalent fuel economy was similar between the gHEV (7.3 – 11.4 mpg) and diesel vehicle (6.1 – 11.7 mpg). On the most kinetically intensive drive cycle tested in the laboratory, the hybrid exhibited 21% higher fuel economy than the diesel. There was no statistical difference in calculated on-road diesel equivalent fuel economy for the gHEV (7.5 mpg) and diesel (7.9 mpg) study groups. The fuel economy findings are encouraging considering that gasoline engines in general have lower fuel economy than diesel engines. These gHEV's were able to provide similar or improved fuel economy while also providing significantly reduced emissions.

Six similar trucks were selected for this in-use evaluation project. Three of the trucks are gHEVs, and three are conventional diesel trucks that serve as a control group. Comparison data were collected and analyzed for in-use fuel economy and fuel costs, maintenance costs, total operating costs, and vehicle uptime. Based upon the data collected during this study, there was no statistically significant difference in fuel cost per mile or maintenance cost per mile between the gHEV and diesel groups. As a result, there was no statistically significant difference in total operating cost per mile between the gHEV ($0.63/mile) and diesel ($0.59/mile) groups.

The gHEVs experienced a smooth integration and deployment into commercial service. During the study period, the gHEVs performed as expected, experienced a minimum of unscheduled maintenance, and met the expectations of FedEx Express. This technology evaluation was part of a collaborative effort by SCAQMD, U.S. DOE's Vehicle Technologies Program and Calstart.

Evaluate Impacts & Benefits of Plug-In Fuel Cell Hybrid Vehicles

In 2000, Electric Power Research Institute (EPRI) organized a collaborative study to compare the impacts and benefits of various hybrid electric vehicle (HEV) options. That study identified plug-in hybrid electric vehicles (PHEVs) as a new low-emission vehicle electrification concept, and it led to the SCAQMD-supported construction of Daimler Sprinter PHEVs, the world's first PHEVs from a major automobile manufacturer.

This study provides a first-cut assessment of the cost, environmental and infrastructure characteristics, benefits and possible limitations of plug-in fuel cell vehicles (PFCVs) compared to fuel cell vehicles (FCVs), battery electric vehicles (BEVs) and PHEVs. The PFCV can be viewed as an FCV to which a grid-rechargeable (plug-in) battery system has been added that can provide driving range on the battery alone. Compared to FCVs, the PFCV offers the customer lower fuel costs and home refueling with electricity from the grid. In addition, PFCV configurations may enable operation of automotive fuel cell systems in less dynamic modes, with the battery system handling transient requirements. This ability expects to reduce the cost and increase the operating life of fuel cell systems, mitigating two of the most challenging issues faced by FCVs. Compared to BEVs, PFCVs enable vehicle electrification without range limitation or long refueling time, the continuing barriers to the widespread acceptance of BEVs.

All technical tasks of the project have been completed successfully. Several different PFCV vehicles using a mid-size vehicle platform were defined in terms of their architectures and components, and representative FCV, BEV and PHEV configurations were selected for the comparative analysis of vehicle attributes. On this basis, preliminary vehicle models were developed and their costs estimated. State-of-the-art simulation techniques were then used to determine and compare prospective vehicle performance, driving range, energy consumption, operating costs, and well-to-wheels (WTW) CO2 emissions for representative driving cycles. Preliminary estimates were made also of the infrastructure requirements and costs for the vehicles studied. Conclusions from the tasks performed were developed, and a final report summarizing the project activities and results has been prepared. The report includes a preliminary plan for a

more in-depth, broadly scoped comparison of PFCVs with other advanced electric technology vehicles.

The results of these simulations and comparisons led the project team to the following conclusions:

- PFCVs with different combinations of fuel cell power and battery capacity are expected to have manufacturing costs comparable to FCVs. BEVs are projected to be the lowest-cost among the advanced electric technology vehicle (AETV) configurations studied, but for broad acceptance and impact BEV require range-extending strategies (e.g., level 2 and 3 public charging infrastructure; plug-in hybridization) that effectively add to their cost.
- In the fuel cost scenarios adopted for this study PFCVs cost less to operate (substantially so in the nearer term) than FCVs but more than BEVs. In the longer term, PFCVs with 40 miles or more range on batteries will cost less to operate than PHEVs.
- PFCVs charged with California's "low-CO2" electricity create substantially lower WTW CO2 emissions than FCVs and, also, lower emissions than PHEVs. BEVs and the range-extender PFCV create the lowest emissions. CO2 emissions depend greatly on the energy sources used for production of hydrogen and electricity, but all vehicles studied have lower emissions than the conventional cars of today and much lower emissions in likely future energy source scenarios.
- An emerging hydrogen infrastructure can serve 25%-50% more PFCVs than FCVs for the same investment. In the longer term, per-vehicle infrastructure investments for PFCVs increase with battery capacity and electricity use and exceed the investments needed for FCVs. PFCV and BEV infrastructure investment needs appear comparable, and PHEVs are likely to have the lowest per-vehicle infrastructure cost.

This study represents the first public effort to assess the potential value of plug-in fuel cell vehicles as a new zero-emission, high-efficiency, dual-fuel vehicle option that may expand the acceptance of battery electric vehicles and accelerate the introduction of fuel cells in vehicle propulsion applications. An in-depth study and more comprehensive comparisons with the leading AETVs are needed to establish the prospective benefits and competitiveness of PFCVs with sufficient credibility to optimize for possible vehicle development.

In-Use Emissions Testing for Class 7 & 8 Heavy-Duty Diesel & Natural Gas Trucks

Programs such as the Carl Moyer Program and Proposition 1B Goods Movement Program that are administered by the Technology Advancement Office replace older diesel-fueled trucks with newer diesel-fueled and alternative fuel trucks. In order to provide the greatest assurance that NOx emission reductions from these truck replacement projects will be realized in a cost-effective and timely manner, it is necessary to conduct in-use emissions tests. In May 2008, a contract was executed with West Virginia University to conduct in-use emissions testing of model year (MY) 2004 and 2005 Class 7 and 8 heavy-duty diesel trucks.

The main focus of this study was to compare distance-specific NO_x emissions on MY 2004-2005 engines. Chassis dynamometer emissions testing were performed on 15 heavy-duty diesel vehicles using West Virginia University's Transportable Heavy Duty Vehicle Emissions Testing Laboratory stationed at Riverside, CA. Of the six MY 2004 trucks that were tested, three were equipped with oxidation catalysts. Of the nine MY 2005 trucks that were tested, seven were equipped with oxidation catalysts. The emission levels from the vehicles were evaluated using CARB's Heavy Heavy-Duty Diesel Truck (HHDDT) driving cycle. The HHDDT driving cycle is comprised of the Transient Cycle and the Cruise Cycle.

The NOx emission results from this study was compared to a previous E55 study which involved chassis laboratory testing of vehicles equipped with early and late 1990 model year engines. The results of the E55 study showed an overall decrease in NOx emissions from 1991 through 1995. After MY 1995, the Cruise Cycle NO_x emissions increased significantly as shown in Figure 21.

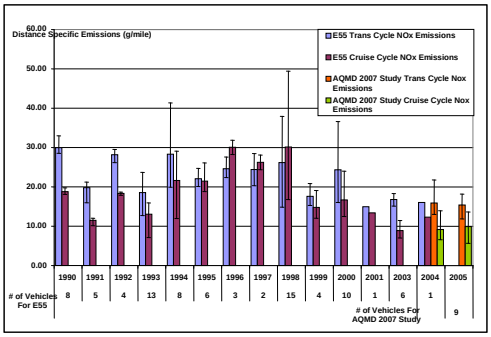


Figure 21: E55 & Current NOx Emission Study

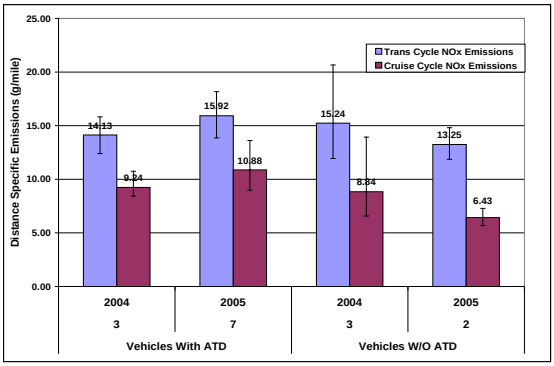


Figure 20: NO_x Emissions with & without Aftertreatment Devices

This was due to the alternate electronic engine control strategy in the cruise mode which engine. The NO_x results for the current study of MY 2004-2005 engines are shown in Figure 20, which indicates lower NO_x emissions as compared to emissions from engines in prior years. Figure 20 shows NO_x emissions from engines with or without oxidation catalysts (after-treatment devices). The NO_x emissions from engines equipped with oxidation catalysts are higher probably due to higher exhaust back pressures in vehicles with after-treatment devices. The results of this current study indicate that vehicles equipped with MY 2004-2005 engines have lower NO_x emissions than vehicles equipped with older model year engines.

Table 5: Projects Completed between January 1 & December 31, 2010

Contract	Contractor	Project Title	Date
Incentive Programs-Alternative Fuels			
04167†	Foothill Transit	Purchase 75 CNG Transit Buses under FY 2002-03 Carl Moyer Program	Jan-10
04169†	City of Santa Monica	Purchase 57 CNG New LNG Transit Buses under FY 2002-03 Carl Moyer Program	Sep-10
04171†	City of Santa Clarita	Purchase 12 CNG New CNG Transit Buses under FY 2002-03 Carl Moyer Program	Dec-10
Infrastructure and Deployment			
05109	Orange County Sanitation Districts	Upgrade CNG Fueling Station in Fountain Valley	Feb-10
05135	Sysco Food Services of Los Angeles, Inc.	Purchase & Install New LNG Fueling Station at City of Walnut Food Distribution Center	Mar-10
10051	BusWest	Lease Buses in Support of Mountain Area CNG School Bus Demonstration Program	Dec-10
Fuels/Emission Studies			
07054	West Virginia University	Conduct In-Use Emissions Testing of Heavy-Duty Refuse Trucks	Mar-10
08034	Maschinenbau Hadenwang GmbH & Company KG	Pilot Program to Assess Feasibility of Enhancing Smog Check Tests in the South Coast Air Basin	Mar-10
09095	University of California Riverside/CE-CERT	Evaluate Emissions Impacts from Ethanol Blends on Vehicle Emissions	Sep-10
10012	Electric Power Research Institute	Evaluate Impacts & Benefits of Plug-In Fuel Cell Vehicles	Jul-10
Emission Control Technologies			
08161†	Engine, Fuel & Emissions Engineering, Inc.	Demonstrate NO_x & PM Emissions Control on Construction Equipment	Oct-10
09018†	Placer County Air Pollution Control District	Develop & Demonstrate Stationary Advanced Locomotive Emissions Control System	May-10
10675	California State University Long Beach Foundation	Develop Efficient Humid Air System for Diesel NO_x Reduction	Sep-10
Electric/Hybrid Technologies			
04032	Electric Power Research Institute	Develop, Demonstrate & Evaluate Plug-In Hybrid Electric Vans in Fleet Use	Mar-10
08294†	Balqon Corporation	Purchase & Demonstrate an Electric Yard Hostler	May-10
08334	Calstart	Demonstrate Medium-Duty Gasoline Hybrid Electric Vehicle in Parcel Delivery Application	Dec-10
Mobile Fuel Cell Technologies			
07356	ISE Research Corporation	Upgrade & Demonstrate Advanced Technology Fuel Cell Transit Bus	Aug-10
10599	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership for CY 2010 & Provide Support for Regional Coordinator	Dec-10

Table 5: Projects Completed between January 1 & December 31, 2010

Contract	Contractor	Project Title	Date
Hydrogen Technologies and Infrastructure			
09410†	California Hydrogen Business Council	Participate in California Hydrogen Business Council	May-10
Stationary Clean Fuels Technology			
99046†	Engelhard Corporation	Field Evaluation of PremAir Ozone Catalyst Technology on AC Units	Dec-10
06071	Gas Technology Institute	Field Demonstration of Advance Technology Boiler in South Coast District	Sep-10
Outreach and Technology Transfer			
07012†	TIAX, LLC	Technical Assistance Related to Air Quality Impacts of Regional Goods	Aug-10
07027†	Engine, Fuel & Emissions Engineering, Inc.	Technical Assistance for Air Quality Impacts & Mitigation	Aug-10
07165†	Clean Fuel Connection, Inc.	Technical Assistance with Compliance of Carl Moyer Program Guidelines	Dec-10
07167†	Tech Compass	Technical Assistance with Hydrogen and Fuel Cell Technologies	Dec-10
07177†	TIAX, LLC	Technical Assistance with Evaluation of Project Proposals for Carl Moyer Program	Dec-10
07185†	Joseph C. Calhoun, P.E., Inc.	Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle Technologies	Jan-10
07247†	TIAX, LLC	Technical Assistance with Low-Emission and Alternative Fuels Technologies	Dec-10
08251†	Gladstein, Neandross & Associates, Inc.	Technical Assistance, Outreach and Implementation of the SOON and the Goods Movement Programs	May-10
09004†	EDV Commercialization	Technical Assistance on Plug-In Hybrid Electric Vehicles & Associated Technologies	Aug-10
09292	Clean Air Now	Provide Funding Support to the Clean Air Challenge Curriculum Project	Oct-10
10477†	University of California Irvine	Cosponsor ICEPAG 2010	Aug-10
10484†	American Association for Aerosol Research	Cosponsor 2010 AAAR Pollution & Health Safety Conference	Aug-10
10589†	National Hydrogen Association	Cosponsor the 21st Annual U.S. Hydrogen Conference	Oct-10
10638†	Alternative Fuel Vehicle Institute	Cosponsor the 2010 Alternative Fuels & Vehicles National Conference and Expo	Sep-10
10660†	Western Riverside Council of Governments	Cosponsor the 11th Annual Western Riverside County Clean Cities Coalition's Advancing the Choice Event	May-10
10670†	Three Squares Inc.	Cosponsor the Women in Green Forum	Nov-10

Table 5: Projects Completed between January 1 & December 31, 2010

Contract	Contractor	Project Title	Date
Outreach and Technology Transfer (continued)			
10718†	California Air Pollution Control Officers Association	Cosponsor CAPCOA Climate Change Forum & Expo	Sep-10

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

CLEAN FUELS PROGRAM
DRAFT 2011 PLAN UPDATE

Technology Funding Priorities for 2011

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. The past two years has been especially difficult for technology partnering due to the dramatic global economic downturn, which has shifted national research and development priorities and opportunities. For example, in 2009 the SCAQMD leveraged more than $78 million in American Recovery and Reinvestment Act (ARRA) funding opportunities to support specific technology areas which allowed redirection of SCAQMD funds to other areas. In the first half of 2010 the SCAQMD was further able to leverage funding by securing more than $12 million from federal and state programs to construct nearly a dozen natural gas stations, retrofit heavy-duty diesel trucks, and increase the number of heavy-duty diesel drayage truck replacements. The challenge for the SCAQMD continues to be how to identify project or technology opportunities in which its available funding can accelerate the commercialization and deployment of progressively cleaner technologies 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 2014 and 2023, 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 2011 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 2011 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 2013. 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 2014 or later.

- More mature technologies, those ready to begin field *demonstration* in 2011, are expected to result in a commercial product in the 2012-13 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, one of government's roles is to support and offset any incremental cost to help accelerate the transition and use of the cleaner technology. The increased use and proliferation of these cleaner technologies often depends on this initial support and funding as well as efforts intended to increase confidence of stakeholders that these technologies are real, cost-effective in the long term and will remain applicable.

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. In fact, the AQMD historically has leveraged its funds $1 for every $4 of total project costs.

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. Upgrades and expansions are also needed to refurbish or increase capacity for some of the stations installed five years ago as well as standardize fueling station design, especially to ensure growth of alternative fuels throughout the South Coast Air Basin and beyond.

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 natural gas as a vehicle fuel from renewable feedstocks and biowaste;
- 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. Some areas of focus include:

- demonstration of remote sensing to target different high emission applications and sources;
- studies to identify the health risks associated with ultrafines and ambient particulate matter including their composition to characterize their toxicity and determine specific combustion sources;
- in-use emissions studies to determine the impact of PHEVs and EVs on local air quality as well as the benefit of telematics on emissions reduction strategies; and
- lifecycle energy and emissions analyses to evaluate conventional and alternative fuels.

Emission Control Technologies

Although engine technology and engine systems 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

There has been a resurgence of interest and activities on electric drive technologies for PHEVs and BEVs. The SCAQMD seeks to support projects to address the main concerns regarding cost, battery lifetime, travel range, charging station infrastructure and manufacturer commitment. Integrated transportation systems can encourage further reduction of emissions by matching the

features of electric vehicles (zero emissions, zero start-up emissions, limited range) to typical consumer demands for mobility by linking them to transit.

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:

- evaluation and demonstration of light- and medium-duty plug-in hybrid electric vehicles;
- demonstration of full performance and niche application battery electric vehicles;
- demonstration of advanced energy storage technologies;
- demonstration of integrated programs that make best use of electric drive vehicles through interconnectivity between fleets of electric vehicles and mass transit, and web-based reservation systems that allow multiple users;
- demonstration of heavy-duty hybrid vehicles including hydraulic and series hybrid concepts;
- development and demonstration of hybrid and electric technologies for goods movement, e.g., linear inductive motors, magnetic levitation and battery-powered container tugs;
- development of streamlined implementation procedures to prepare and accelerate EV market penetration and commercialization; and
- demonstration and installation of EV infrastructure to support the electric/hybrid electric vehicle fleets currently on the roads or soon entering the market.

Engine Systems

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 using an optimized systems approach 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;
- development and demonstration of clean alternative fuel engines for off-road applications;
- development and demonstration of hybrid electric technologies for off-road applications;
- evaluation of alternative engine systems such as compressed air propulsion and hydraulic plug-in hybrid vehicles; and

- development and demonstration of engine systems that employ advance fuel or alternative fuels, engine design features, improved exhaust or recirculation systems, and aftertreatment devices.

Hydrogen Technologies and Infrastructure

Hydrogen use as a vehicle fuel offers an attractive combination of benefits including zero-tailpipe emissions, petroleum displacement and greenhouse gas emissions reduction, with unmatched driving range (longest) and refueling time (shortest) amongst zero emissions vehicle technologies. While technical hurdles have kept fuel cell vehicles from quickly advancing to commercial deployment, they are now emerging in fleets that will be significantly deployed in the south coast region of California. The SCAQMD supports hydrogen and fuel cell technologies as one option in our technology portfolio and 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 2011 Plan Update identifies key opportunities consistent with both organizations while clearly leading the way for pre-commercial demonstrations of OEM vehicles. 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 in the South Coast Air Basin, there are areas where cleaner fuel 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 reliable, 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 22 below presents the potential allocation of available funding, based on SCAQMD projected program costs of $16.1 million for all potential projects. The expected actual project expenditures for 2011 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 2011 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.

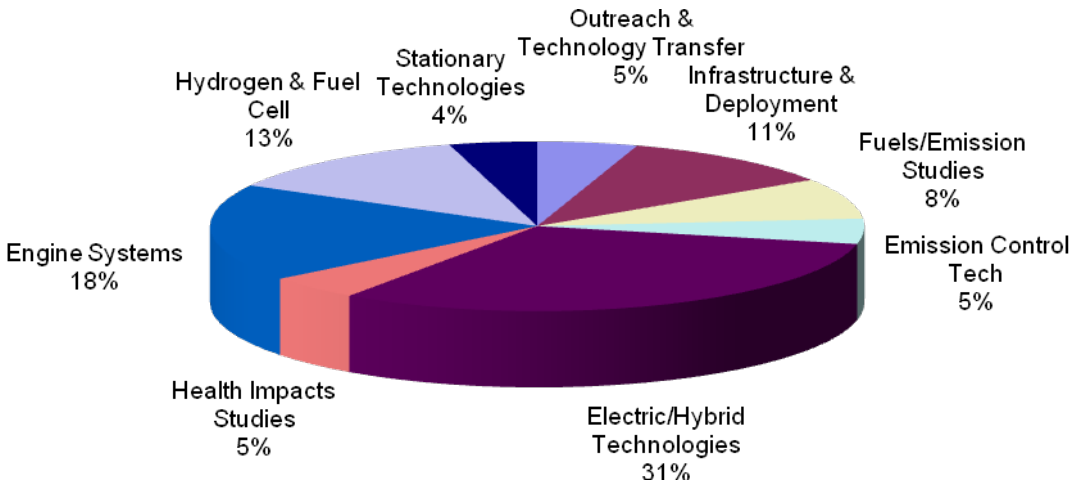


Figure 22: Projected Cost Distribution for Potential SCAQMD Projects 2011 & Beyond ($16.1M)

PROGRAM PLAN UPDATE FOR 2011

This section presents the Clean Fuels Program Plan Update for 2011. 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.

In 2009 and early 2010 the SCAQMD was awarded more than $94 million in funds through the American Recovery and Reinvestment Act and other federal and state funding sources for projects that complement and accelerate project efforts in the Clean Fuels Program

These federal and state awards are reflected in the expected total costs within Table 6 which summarizes potential projects for 2011 as well as in the redistribution of AQMD costs in some areas. For example, the allocation of SCAQMD funds for emissions control technologies and infrastructure and deployment have been reduced because of the DERA, EPA and CEC funds received in 2009 and 2010. Whereas, AQMD project costs for electric and hybrid-electric technologies are projected higher because of anticipated CEC co-funding for hybrid and full electric heavy-duty projects as well as the need to begin pushing for the infrastructure needed to support these electric/hybrid electric fleets, while the project total is down because ARRA projects in this area are already partially underway. Additionally, the AQMD contribution and project totals for engine systems have been increased significantly because of near-term opportunities for co-funding from the DOE, NREL and CEC for heavy-duty natural gas engine system development and demonstration.

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	2,000,000
Develop, Maintain & Expand Natural Gas Infrastructure	1,000,000	2,000,000
Demonstrate LNG Manufacturing and Distribution Technologies Including Renewables	250,000	7,000,000
Subtotal	$1,750,000	$11,000,000
Fuels/Emission Studies		
In-Use Emissions Studies for Advanced Technology Vehicle Demonstrations	750,000	1,000,000
Conduct Emissions Studies on Biofuels and Alternative Fuels	100,000	1,300,000
Identify and Demonstrate In-Use Fleet Emissions Reduction Technologies & Opportunities	400,000	2,000,000
Subtotal	$1, 250,000	$4,300,000
Emission Control Technologies		
Develop and Demonstrate Advanced Aftertreatment Technologies	525,000	5,000,000
Demonstrate On-Road Technologies in Off-Road and Retrofit Applications	250,000	1,000,000
Subtotal	$775,000	$6, 000,000
Electric/Hybrid Technologies		
Demonstrate Light-Duty Plug-In Hybrid & Battery Electric Vehicles and Infrastructure	500,000	2,000,000
Develop and Demonstrate Medium- and Heavy-Duty Hybrid Vehicles and Infrastructure	4,000,000	45,000,000
Demonstrate Alternative Energy Storage	300,000	2,000,000
Develop and Demonstrate Electric Container Transport Technologies	250,000	5,000,000
Subtotal	$5,050,000	54,000,000
Engine Systems		
Develop and Demonstrate Advanced Alternative Fuel Medium- and Heavy-Duty Engines and Vehicles	2,500,000	20,000,000
Develop and Demonstrate Alternative Fuel and Clean Conventional Fueled Light-Duty Vehicles	500,000	1,500,000
Subtotal	$3,000,000	$21,500,000

Table 6: Summary of Potential Projects

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Hydrogen Technologies and Infrastructure		
Develop and Demonstrate Hydrogen Vehicles	100,000	2,000,000
Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations	1,750,000	6,000,000
Subtotal	$1,850,000	$8,000,000
Mobile Fuel Cell Technologies		
Develop and Demonstrate Fuel Cells in Vehicle Applications	195,000	4,000,000
Subtotal	$195,000	$4,000,000
Health Impacts Studies		
Evaluate Ultrafine Particle Health Effects	500,000	3,000,000
Conduct Monitoring to Assess Environmental Impacts	250,000	1,000,000
Subtotal	$750,000	$4,000,000
Stationary Clean Fuel Technologies		
Develop and Demonstrate Reliable, Low Emission Monitoring Systems	250,000	500,000
Develop and Demonstrate Clean Stationary Technologies	250,000	750,000
Develop and Demonstrate Renewables-Based Energy Generation Alternatives	200,000	1,000,000
Subtotal	$700,000	$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	**$16,120,000**	**$116,250,000**

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: $2,000,000

Description of Technology and Application:

Natural gas vehicles (NGVs) 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: Develop, Maintain & Expand Natural Gas Infrastructure

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

This program would support the development, maintenance and expansion of natural gas fueling station technologies to 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 help with the implementation of SCAQMD's fleet rules. 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 public agencies, private fleets and school districts.

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 has the potential to significantly reduce the installation and operating costs of NGV refueling stations, besides improving the refueling time. While new or improved NGV stations have an indirect emissions reduction benefit, they help facilitate the introduction of low-emission, NGVs in private and public fleets in the area, which have a direct emissions reduction benefit. The increased exposure and fleet and consumer acceptance of NGVs would lead to significant and direct reductions in NOx, VOC, CO, PM and toxic compound emissions from mobile sources. 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: Demonstrate LNG Manufacturing and Distribution Technologies Including Renewables

Expected SCAQMD Cost: $250,000

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 2014. 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: In-Use Emissions Studies for Advanced Technology Vehicle Demonstrations

Expected SCAQMD Cost: $750,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

Hybrid electric, hybrid hydraulic, plug-in electric hybrid and pure EVs will likely all play a unique role in the future of transportation. Each of these transportation technologies has attributes that could provide unique benefits to different transportation sectors. Identifying the optimal placement of each transportation technology will provide the co-benefits of maximizing the environmental benefit and return on investment for the operator.

The environmental benefit for each technology class will be highly duty-cycle and application specific. Identifying the attributes of a specific application or drive cycle that would take best advantage of a specific transportation technology would speed the adoption and make optimal use of financial resources in the demonstration and deployment of a technology. The adoption rates would be accelerated since the intelligent deployment of a certain technology would ensure that a high percentage of the demonstration vehicles showed positive results. These positive results would spur the adoption of this technology in similar applications, as opposed to negative results derailing the further development or deployment of a certain technology.

The proposed project would conduct a characterization of application specific drive cycles to best match different transportation technologies to specific applications. The potential emissions reductions and fossil fuel displacement for each technology in a specific application would be quantified on a full-cycle basis. This information could be used to develop a theoretical database of potential environmental benefits of different transportation technologies when deployed in specific applications.

Potential Air Quality Benefits:

The development of an emissions reduction database, for various application specific transportation technologies, would assist in the targeted deployment of new transportation technologies. This database coupled with application specific vehicle miles traveled and population data would assist in intelligently deploying advanced technology vehicles to attain the maximum environmental benefit. These two data streams would allow vehicle technologies to be matched to an application that is best suited to the specific technology, as well as selecting applications that are substantial enough to provide a significant environmental benefit. The demonstration of a quantifiable reduction in operating cost through the intelligent deployment of vehicles will also accelerate the commercial adoption of the various technologies. The accelerated adoption of lower emitting vehicles will further assist in attaining the AQMD's air quality goals.

Proposed Project: Conduct Emissions Studies on Biofuels and Alternative Fuels

Expected SCAQMD Cost: $100,000

Expected Total Cost: $1,300,000

Description of Technology and Application:

Biofuels are potentially an 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.

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 Reduction Technologies and Opportunities

Expected SCAQMD Cost: $400,000

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. In addition, many new vehicles are now equipped with telematics enabling motorists to obtain transportation information such as road conditions to avoid excessive idling and track information about the vehicle maintenance needs, repair history, tire pressure and fuel economy. Telematics have been shown to reduce emissions from new vehicles. Unfortunately, the in-use fleet lacks telematic systems--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 emission 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);
- electrical auxiliary power unit replacements; and
- development, deployment and demonstration of smart vehicle telematic systems

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.

Emission Control Technologies

Proposed Project: Develop and Demonstrate Advanced Aftertreatment Technologies

Expected SCAQMD Cost: $525,000

Expected Total Cost: $5,000,000

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 off-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: $250,000

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 2010, which is an order of magnitude decrease in just six years. Off-road engines, however, have considerably higher emissions limits depending on the engine size. For example, Tier-3 standards for heavy-duty engines 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 and Battery Electric Vehicles and Infrastructure

Expected SCAQMD Cost: $500,000

Expected Total Cost: $2,000,000

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 EVs 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 EV strategy allows reduced emissions and improved fuel economy. In 2009, CARB adopted Plug-In Hybrid Electric Vehicle Test Procedure Amendments and Aftermarket Parts Certification and several automobile manufacturers have announced demonstration or early production plans of "blended" plug-in hybrid electric, extended-range electric vehicles (E-rEV), or highway capable battery electric vehicles (BEVs). Electric utilities refer to PHEVs, E-rEVs and BEVs as plug-in electric drive vehicles (PEVs) and are working with automakers to support PEVs. The recent adoption of revised recommended practice SAE J1772 will enable vehicles to charge from 120V (Level 1) or 240V (Level 2) using a common conductive connector overnight or in a few hours. Japan has adopted a Fast DC charging standard that could charge a passenger car in 30 minutes or less, and demonstrations will help provide data to adopt a recommended practice in the U.S.

Integrated programs can interconnect fleets of electric drive vehicles with mass transit via web-based reservation systems that allow multiple users. These integrated programs can match the features of EVs (zero emissions, zero start-up emissions, short range) to typical consumer demands for mobility in a way that significantly reduces emissions of pollutants and greenhouse gases.

At recent auto shows, automakers have displayed concept plug-in fuel cell vehicles. Development and demonstration of dual fuel, zero emission vehicles could expand the acceptance of battery electric vehicles and accelerate the introduction of fuel cells in vehicle propulsion.

This project category is to develop and demonstrate: 1) various PEV architectures; 2) anticipated costs for such architectures; 3) customer interest and preferences for each alternative; 4) prospective commercialization issues and strategies for various alternatives; 5) integration of the technologies into prototype vehicles and fleets; 6) necessary infrastructure to demonstrate the potential clean air benefits of these types of vehicles; and 7) support for local government outreach and charging installation permit streamlining

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. Given the variety of PEV systems under development, it is critical to determine the true emissions and performance of PEVs. Demonstration of optimized prototypes would enhance the deployment of near-ZEV and 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 OEMs to expedite introduction of near-zero and 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 Infrastructure

Expected SCAQMD Cost: $4,000,000

Expected Total Cost: $45,000,000

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. Development and validation of emission test procedures is needed, but is complicated due to the low volume and incredible variety of medium and heavy duty vehicles.

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 utilizing off-peak re-charging, with advanced battery technologies such as lithium-ion; 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 and related charging infrastructure will be considered.

Federal recovery act funding combined with state and local support is accelerating the development and demonstration of medium-duty plug-in hybrid electric truck platforms. Analysis of project data and use profiles will help optimize drive systems, target applications for early commercialization and fill gaps in product offerings.

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 OEMs 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: $300,000

Expected Total Cost: $2,000,000

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. Energy storage systems optimized to combine the advantages of ultracapacitors and advanced batteries could yield further benefits. 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 and resulting emissions 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: Develop and Demonstrate Electric Container Transport Technologies

Expected SCAQMD Cost: $250,000

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 could be stand-alone systems that use magnetic levitation (maglev), linear synchronous motors or linear induction motors on dedicated guideways. A more near-term design could use existing roadways electrified (through catenary electric lines or linear electric motors) and modified trucks equipped to run on electricity to move the containers. In both scenarios, 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. Dedicated container freight systems are not designed to carry any operators or passengers on the guideways, where the over-the-roadway system may require the operator to actively control the transport of the container. 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. General Atomics has also developed a Magnetruck concept where an electric truck with the container on a trailer is moved by linear motors embedded in the road. 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 that use electric propulsion for the containers on fixed guideways or modified trucks able to operate on electricity which will 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 Systems

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

Expected SCAQMD Cost: $2,500,000

Expected Total Cost: $20,000,000

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 lower and the PM emissions target is below 0.01 g/bhp-hr. To achieve these targets, an effective emission control strategy must employ advance fuel or alternative fuels, engine design features, improved exhaust or recirculation systems, and aftertreatment devices that are optimized using a system approach. 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 have 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: $500,000

Expected Total Cost: $1,500,000

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.

Hydrogen Technologies and Infrastructure

Proposed Project: Develop and Demonstrate Hydrogen Vehicles

Expected SCAQMD Cost: $100,000

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: $1,750,000

Expected Total Cost: $6,000,000

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: $195,000

Expected Total Cost: $4,000,000

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: $500,000

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 on a per-mass basis than other fractions. Several technologies have been introduced and others 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. Recent studies have shown that control technologies applied to mobile sources have been effective in reducing the mass of particulates emitted. However, there is also evidence that the number of ultrafine particles on and near roadways has increased, even while the mass of particulates has decreased. To have a better understanding of changes in ultrafine particulate emissions from the application of the new 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, measurements and chemical composition of ultrafine particulates will be done, as well as studies conducted to characterize their toxicity. The composition of the particulates can further be used to determine the contribution from specific combustion sources. Additionally, engine or chassis dynamometer testing may 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 technologies for alternative fuels, aftertreatment and new engines in order to determine the health benefits of such technologies.

Potential Air Quality Benefits:

The Air Quality Management Plan for the South Coast Basin relies on significant penetration of low-emission vehicles to attain federal clean air standards . Reduction of particulate emissions from the combustion of diesel and other fuels 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. 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 mobile 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 mobile 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.

Stationary Clean Fuel Technologies

Proposed Project: Develop and Demonstrate Reliable, Low 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 Renewables-Based Energy Generation Alternatives

Expected SCAQMD Cost: $200,000

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
Pending Appointment	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, 2011

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment						
02061	Downs Commercial Fueling, Inc.	Purchase & Install New L/CNG Fueling System at Commercial Fueling Station in Temecula	5/25/05	04/30/14	$203,137	$833,333
05250	Downs Commercial Fueling, Inc.	Purchase & Install New L/CNG Fueling System at Commercial Fueling Station in Temecula	11/04/05	04/30/14	04/30/14	$833,333
06028	Consolidated Disposal Service, LLC	Purchase & Install CNG Fueling System at Long Beach Waste Transfer Station	11/23/05	07/31/14	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
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	410,000
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

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment (continued)						
07153	Foothill Transit	Purchase & Install New Public Access CNG Refueling Station in Irwindale	11/02/09	12/31/12	250,000	3,350,000
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
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	06/23/11	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
08044	Beaumont Unified School District	Install Limited Access CNG Refueling Station	03/05/09	12/31/13	288,000	615,994
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	01/04/08	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
09348	AFV Fleet Services	Demonstrate Two Natural Gas Powered Police Vehicles	04/03/09	03/18/12	75,000	75,000
09364	Rim of the World Unified School District	Construct & Install a CNG Fueling Station	12/30/10	12/31/14	257,000	425,000
10034	California Cartage Company	Install LNG Fueling Station at the Ports	01/26/10	11/01/14	532,500	1,065,000
10054	Applied LNG Technologies Inc.	Upgrade & Perform Emergency Repairs of L/CNG Refueling Facility	10/30/09	12/31/14	113,359	226,719
10055	Waste Management Collection & Recycling	New Public Access CNG Refueling Station in Santa Ana	12/11/09	12/31/14	250,000	1,622,558
10181	BAF Technologies	Demonstrate Natural Gas Powered Police Vehicle	12/31/09	08/31/11	34,500	34,500
10640	Yellow Cab of Greater Orange County	Conversion of 45 Taxicabs to Natural Gas Power for Deployment as Airport Ground Transportation	04/23/10	06/01/12	337,500	675,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Fuels/Emission Studies						
07181	California Air Resources Board	Physical, Chemical & Toxilogical Assessment of the Semi-Volatile & Non-Volatile Fraction of PM	04/01/06	04/01/11	338,975	677,950
08033-2	California Air Resources Board	Test Particulate Measurement Device for In-Use Vehicles	06/25/07	06/23/11	123,927	504,514
08263	University of California Riverside/CE-CERT	Evaluate Emissions Impacts from Diesel Biofuel & Biofuel Blends	08/12/08	06/30/11	150,000	1,630,000
08320	University of Denver	Remote Sensing Measurements of On-Road Emissions from Heavy-Duty Diesel Vehicles	02/06/09	01/31/13	161,041	161,041
09290	University of California Riverside	Evaluate Emissions Impacts from Natural Gas Blends on Vehicle Emissions	01/30/09	08/31/11	50,000	450,000
10066	National Renewable Energy Laboratory	CRADA – Loan of 70 MPa Hydrogen Quality Sampling Apparatus to AQMD	11/02/09	12/30/15	0	0
10095	University of California Davis-Intelligent Transportation Systems	Cosponsor Sustainable Transportation Pathways Program	06/29/10	07/31/12	120,000	2,310,000
10693	West Virginia University Research Corporation	Provide Transportable Laboratory Testing to Quantify Emissions from SCR Technology	09/01/10	08/31/11	76,000	76,000
10722	University of California Riverside/CE-CERT	Re-Establish Testing Facility & Quantify PM Emission Reductions from Charbroiling Operations	08/06/10	06/30/11	60,000	60,000
11519	University of California Riverside	Evaluate Protocols for Measuring Emissions from Cleaning of Application Equipment & Surfaces	12/23/10	06/22/11	23,713	47,425
Emission Control Technologies						
07236	National Renewable Energy Laboratory	Investigate the Role of Lubricating Oil on Particulate Matter Emissions from Vehicles	03/23/07	12/30/15	100,000	446,887
08033-3	California Air Resources Board	Demonstrate Retrofit SCR System for NO_x Emission Reduction Using Crystalline Matrix Storage for Ammonia	06/25/07	06/23/11	78,500	338,268
08068	Johnson Matthey Inc.	Develop & Demonstrate SCR Technology for NOx and PM Emissions	12/14/07	01/31/11	254,000	731,500
08246	Griffith Company	Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment	5/14/08	08/24/11	191,000	297,000
08252	City of Culver City	Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment	07/08/08	03/31/12	38,900	138,475
08253	Tiger 4 Equipment Leasing	Demonstrate NOx & PM Emissions Control Technologies on Diesel Powered Construction Equipment	01/13/09	08/24/11	17,600	17,600

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
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	03/31/12	363,250	590,895
08272	ECCO Equipment Corporation	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	09/28/08	08/21/11	17,600	17,600
08318	ServoTech Engineering Inc.	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	07/08/08	12/15/11	320,000	990,420
08321	Environmental Systems Products	Remote Sensing Measurements of On-Road Emissions from Heavy-Duty Diesel Vehicles	08/12/08	01/31/12	38,000	38,000
09000	Shimmick Construction	Demonstrate NO_x & PM Emissions Control Technologies on Diesel Powered Construction Equipment	09/11/09	03/31/12	38,900	38,900
10069	Johnson Matthey, Inc.	Develop & Demonstrate SCRT for NO_x and PM Emissions Control	06/18/10	10/13/13	300,000	1,480,000
10696	Johnson Matthey, Inc.	Optimize & Demonstrate SCRT for NO_x and PM Emissions Control	07/09/10	03/31/12	300,000	2,818,449
10697	Johnson Matthey, Inc.	Optimize & Demonstrate SCCRT for NO_x and PM Emissions Control	07/09/10	03/31/12	300,000	2,818,449
10112	Sanitation Districts of Los Angeles County	Showcase: Retrofit Select Catalytic Reduction System & Diesel Particulate Filters on Off-Road Construction Equipment	02/26/10	02/21/12	116,450	116,450
10125	University of California Riverside	Demonstrate Projects for Renewable Feedstock to Energy and Fuel Technologies	12/11/09	01/10/11	101,369	211,883
11136	ServoTech Engineering	Demonstrate NO_x and PM Emissions Control Technology on Diesel-Powered Construction	10/15/10	05/31/12	132,000	432,000
Electric/Hybrid Technologies						
99109	Toyota Motor Credit Corporation	Three-Year Lease of Two RAV4 Electric Vehicles	04/04/99	02/01/11	94,767	94,767
05260	Energy Control Systems Engineering, Inc.	Conversion of Light-Duty Vehicle to Plug-In Hybrid Vehicles	09/09/05	10/31/11	260,000	985,000
08063	Quantum Fuel Systems Technologies Worldwide, Inc.	Develop & Demonstrate 20 Plug-In Hybrid Electric Vehicles	01/22/08	12/15/14	2,095,613	2,815,266
08067	Calstart	Demonstrate Hydraulic-Hybrid Shuttle Bus	10/30/07	03/31/11	250,000	1,210,000
08219	A123Systems Inc.	Develop & Demonstrate Ten Plug-In Hybrid Electric Vehicles	06/05/09	06/04/15	622,667	962,667
09017	U.S. Environmental Protection Agency	Develop & Demonstrate Hydraulic-Hybrid Shuttle Bus	10/10/08	10/09/11	500,000	1,960,000
09023	ISE Corporation	Develop & Demonstrate a Battery Electric Transit Bus	08/07/09	05/31/11	290,000	2,285,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Electric/Hybrid Technologies (continued)						
09301	Electric Power Research Institute	Develop & Demonstrate Plug-In Hybrid Electric Vehicle Delivery Vehicle	06/30/09	03/31/11	964,320	2,164,320
09345	South Bay City Council of Governments	Demonstrate Medium-Speed Electric Vehicles	06/19/09	07/31/11	178,825	178,825
09360	BMW of North America LLC	Lease of Five Mini-E Cooper Electric Vehicles for One Year	05/05/09	06/25/11	40,110	40,110
09427	City of Santa Monica	Demonstrate Battery Electric Class 4 Utility Truck	12/15/09	06/14/11	87,205	210,910
10738	Foothill Transit	Demonstrate Quick-Charge Infrastructure for Electric Buses	10/29/10	06/28/13	290,000	6,790,000
11204	AC Propulsion	Develop & Demonstrate Electric Drive Conversion for Fleet Vehicles	12/24/10	10/30/12	300,000	755,767
11205	Calstart	Implement Hybrid Truck and Bus Voucher Incentive Program	12/02/10	03/31/12	1,500,000	1,500,000
Engine Systems						
08192	Westport Power, Inc.	Develop & Demonstrate 2010 Compliant LNG Heavy-Duty Truck	01/25/08	06/30/11	1,750,000	9,394,027
10041	McNeilus Truck and Manufacturing	Develop Prototype Natural Gas-Powered Concrete Mixer Truck and Demonstrate its Performance and Emissions	11/06/09	06/30/11	100,000	380,000
10071	NaturalDrive Partners, LLC	Develop & Certify Natural Gas Chevrolet Impala Sedans	01/15/10	06/30/11	81,388	234,388
Mobile Fuel Cell Technologies						
10501	American Honda Motor Company, Inc.	Lease a Clarity Fuel Cell Vehicle for Three Years	01/21/10	0120/13	24,001	24,001
10650	SunLine Transit Agency	Demonstrate Advanced Fuel Cell Bus (American Fuel Cell Bus)	06/04/10	06/03/13	400,000	10,214,843
Hydrogen Technologies and Infrastructure						
04011	Air Products and Chemicals, Inc.	Install & Demonstrate an Industrial Pipeline-Supplied Hydrogen Fueling Station in Torrance	08/03/05	02/28/12	489,051	944,761
04185	Quantum Fuel Systems Technologies Worldwide	Develop & Demonstrate Hydrogen Internal Combustion Engine Vehicles	10/18/04	08/31/12	2,182,851	3,328,631
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
10046	Air Products and Chemicals Inc.	Develop & Demonstrate Renewable Hydrogen Energy and Refueling Station	12/21/09	05/31/13	750,000	8,436,735
10061	Hydrogenics Corporation	Maintenance & Data Management for the AQMD Hydrogen Refueling Station	10/30/09	10/29/11	188,000	188,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Hydrogen Technologies and Infrastructure (continued)						
10149	NextEnergy Center	Cosponsor Feasibility, Design & Development of 70 MPa Hydrogen Home Fueling Appliance	05/07/10	11/06/11	63,400	522,000
11150	Hydrogen Frontier, Inc.	Maintenance & Operation of City of Burbank Hydrogen Fueling Station	11/24/10	01/24/15	200,000	1,060,000
Health Impacts Studies						
07181	California Air Resources Board	Physical, Chemical & Toxilogical Assessment of the Semi-Volatile & Non-Volatile Fraction of PM	04/01/06	04/11/11	338,975	677,950
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	06/23/11	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	06/23/11	142,326	284,652
09307	California Air Resources Board	In-Vehicle Air Pollution Exposure Measurement & Modeling	09/01/08	04/30/11	250,000	500,000
Stationary Clean Fuels Technology						
05207	SolSource Energy	Install an 80 kW Solar Panel System at SCAQMD Headquarters	06/06/05	06/05/11	360,000	693,000
09303	Permacity Solar	Install 40kW (AC) Crystalline Silicon System at AQMD HQs	01/30/09	01/29/15	387,162	387,162
09304	Solar Integrated Technologies Inc.	Install Turnkey Rooftop 40 kW Building Integrated Photovoltaic System	12/20/08	12/19/14	390,695	390,695
10114	Orange County Sanitation Districts	Retrofit Digester Gas Engine with Fuel Gas Clean-Up and Exhaust Emission Control Technology	03/25/10	03/24/11	200,000	2,411,882
Outreach and Technology Transfer						
00069	Walsh Consulting	Technical Assistance Relating to the Use of Alternative Fuels in Mobile Sources	02/17/00	02/28/12	35,000	35,000
02308	Sperry Capital, Inc.	Evaluate Financial Stability of Potential Contractors	06/25/02	12/31/11	50,000	50,000
02311	Cole, Jerald A.	Technical Assistance for Development, Outreach, & Commercialization of H2 Infrastructure & Reforming Technology	08/09/02	06/30/11	30,000	30,000
02333	University of California, Riverside	Technical Assistance on Clean Fuels, Hydrogen, Fuel Cell & Natural Gas Technologies	11/01/02	06/30/11	70,000	70,000
04049	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance for Alternative Fuels Engine Technology	11/21/03	04/30/11	120,000	120,000
04146	Tom Gross	Technical Assistance for Hydrogen & Fuel Cell Technologies	06/23/04	05/31/11	25,000	25,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (continued)						
05121	Sullivan, Cindy	Development, Analysis & Technology Implementation of Incentive Programs	03/14/05	03/31/11	75,000	75,000
05126	St. Croix Research	Development, Outreach & Commercialization of LNG, CNG and Hydrogen Fuels	03/15/05	03/31/11	25,000	25,000
05127	Protium Energy Technologies	Development, Outreach & Commercialization of Hydrogen and Fuel Cell Technologies	03/14/05	03/31/12	60,000	60,000
05128	Mid-Atlantic Research Institute LLC	Development, Outreach & Commercialization of Advanced Heavy-Duty and Off-Road Technologies	08/08/05	03/31/11	40,000	40,000
05171	James Hazelton	Technical Assistance on AB 1222 Advisory Group	04/08/05	03/31/11	$45,000	$45,000
05198	Don Stedman	Technical Assistance for Remote Sensing Programs for Light-Duty Vehicles and Locomotives	05/30/05	11/30/12	25,000	25,000
07059	Dowling Associates, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods	12/19/06	11/30/12	68,000	68,000
07060	Don Breazeale and Associates, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods Movement	11/15/06	11/30/12	58,000	58,000
07062	The Tioga Group, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods	12/19/06	11/30/12	58,000	58,000
07129	Breakthrough Technologies Institute, Inc.	Technical Assistance with Fuel Cell Technology	12/01/06	03/31/12	40,000	40,000
07130	Burnett & Burnette	Technical Assistance with CNG Technology	01/17/07	12/31/11	60,000	60,000
07314	Engine, Fuel and Emissions Engineering, Inc.	Technical Assistance with Advanced Heavy-Duty and Off-Road Technologies	06/25/07	12/31/11	60,000	60,000
08210	Sawyer Associates	Technical Assistance on Mobile Source Control Measures and Future Consultation on TAO Activities	02/22/08	02/28/12	25,000	25,000
08254	Maria Robles, R.N.	Administrative Assistance in Organizing Two Air Quality & Health-Related Conferences	05/02/08	07/31/12	149,760	149,760
08311	CALSTART	Technical Assistance with Development, Outreach, and Commercialization of Advanced Technology to Transit, Port & Other Activities	07/11/08	05/31/112	75,000	75,000
09183	Gary Full	Technical Assistance on Remote Sensing Measurement Technologies as Applied to Auto, Heavy-Duty Diesel and Other Mobile Sources	02/20/09	06/30/12	20,000	20,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (continued)						
09184	University of California Riverside	Technical Assistance on Advanced, Low- and Zero-Emission Technologies and Implementation Activities	01/23/09	08/30/11	60,000	60,000
09185	Clean Fuel Connection Inc.	Technical Expertise on the CARB EMFAC Mobile Emissions Model and Other Related Mobile Source Issues	05/08/09	06/30/12	50,000	50,000
09252	JWM Consulting Services	Technical Assistance with Review & Assessment of Advanced Technologies, Heavy-Duty Engines, and Conventional & Alternative Fuels	12/20/08	06/30/12	30,000	30,000
09253	Nexant, Inc.	Technical Assistance on Alternative Fuels Life-Cycle Analyses	01/02/09	06/30/12	20,000	20,000
09255	Stan Lisiewicz	Technical Assistance with Caltrans	01/29/09	12/31/11	10,000	10,000
09337	Mark Weekly, CPA	Follow-Up Assessment of AQMD's Compliance with Special Revenue Funds	03/03/09	01/31/13	35,000	35,000
10056	Advanced Transportation Technology & Energy, San Diego Community College District	Enhanced Training Technology Program	05/27/10	12/31/11	500,000	500,000
10700	TIAX LLC	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile & Stationary Source Technologies	07/23/10	05/31/12	120,000	120,000
11028	Martin Kay	Technical Assistance on Stationary Source Control Measures & Future Consultation on TAO Activities	08/04/10	08/03/11	25,000	25,000
11117	Clean Fuel Connection, Inc.	Technical Assistance for Alternative Fuels, Renewable Energy and Electric Vehicles	09/17/10	12/31/11	50,000	50,000
11148	Joseph C. Calhoun, P.E. Inc.	Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicle	10/08/10	12/31/12	35,000	35,000
11182	Tech Compass	Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis & Aftertreatment Technologies	11/19/10	12/31/12	75,000	75,000

Appendix C

Final Reports for 2010

SCAQMD Contract 05109 **February 2010**

Upgrade CNG Fueling Station in Fountain Valley

Contractor
Orange County Sanitation District

Cosponsors
Clean Energy
SCAQMD

Project Officer
Larry Watkins

Background

The South Coast Air Quality Management District (SCAQMD) issued RFP #P2004-09 to increase the number of publicly accessible alternative fueling stations in the South Coast Air Basin. Orange County Sanitation District (OCSD) partnered with Clean Energy, operating the largest number of public access compressed natural gas (CNG) fueling stations in the South Coast Air Basin, to submit a proposal to upgrade its fueling station. OCSD's station was originally installed several years ago; thus, it still had first-generation technology. Funding would offset the capital costs of installation of new technology that would permit payment via credit card. OCSD's proposal was subsequently awarded, the subcontract to Clean Energy was executed, and construction commenced.

The completion of the upgrade at this facility owned by OCSD completed the SCAQMD's goal of a prior grant contract 02157 entered into with Clean Energy wherein all publicly accessible stations owned by Clean Energy at that time would be upgraded so that payment by credit cards would be possible. This would ensure that owners and operators of natural gas vehicles (NGVs) could eliminate carrying numerous proprietary fueling cards in order to fuel with natural gas throughout the South Coast Air Basin. Natural gas fueling stations would then mirror traditional fueling stations. Clean Energy's expertise in this type of equipment upgrade ensured a smooth transition for OCSD. Due to the amount of funding and capital available for this project, Clean Energy and OCSD entered into an agreement wherein Clean Energy would retain ownership of the public access dispenser and card reader, while the OCSD maintains ownership of the remaining equipment at the facility. Clean Energy provides operation and maintenance service for all equipment at this facility through a long-term agreement with OCSD.

Project Objective

OCSD's fueling station is strategically located off the 405 Freeway at the Euclid exit. This station is frequently used by taxi drivers such as those traveling to and from John Wayne Airport and throughout major cities such as the City of Irvine, Fountain Valley, Costa Mesa, Huntington Beach and Newport Beach. The objective of this project was to upgrade technology at a first-generation natural gas fueling station so that NGV owners and operators could easily pay for fuel by using credit cards at the pump. Payment for fuel would include major credit cards such as MasterCard and Visa, creating uniform fuel purchasing opportunities for natural gas users.

Technology Description

In 2002, Clean Energy was awarded an SCAQMD grant to upgrade all of its publicly accessible natural gas fueling stations in the South Coast Air Basin with card reader technology that mirrors the technology used at traditional fueling (gasoline/diesel) stations. The upgrade of this aspect of CNG fueling allowed for easier access for drivers of CNG vehicles. The public access component of this station utilizes storage, compression, piping and various other equipment of the private access station. In addition, the public access component includes a fueling island with dispenser and CRIND (card reader in dispenser) capable of accepting payment by credit card. The software component of this technology is continually reviewed and upgraded. The hardware component, the cabinet which houses the system, was also recently upgraded.

CNG Refueling Station

Status

This station was successfully completed as of February 2005. The system was tested and accepted by the OCSD. Fueling transactions have commenced.

Results

Emission reductions resulting from the project are derived from a fueling convenience factor. The incorporation of using credit cards to purchase fuel mirrors the traditional fueling options at retail gasoline/diesel stations. Individuals who purchase natural gas vehicles will be able to purchase fuel at this location. This convenience will further assist in the marketing efforts to expand the use of natural gas vehicles by taxis, shuttles, and private consumers.

Benefits

Increasing the number of publicly accessible fueling stations that accept payment by credit card is mandatory to increasing the number of NGVs operated in the South Coast Air Basin. This station, conveniently located off the 405 Freeway, offers fueling for an NGV operator traveling through Orange County. Further, this station increases the support of the fleet rules implemented by the SCAQMD since taxi owner and operators will be able to utilize this facility.

Project Costs

The initial budget for this project was estimated to be $80,000 with the SCAQMD's cost share being 30% or a maximum of $24,000. This project was completed at a total cost of $82,414.28. The SCAQMD's cost share of $24,000 represents 29% of the final cost of the cost to provide public access.

Commercialization and Applications

The equipment at this facility has been tested, proven and is commercially available.

SCAQMD Contract 05135 **March 2010**

Purchase & Install New LNG Fueling Station at City of Walnut Food Distribution Center

Contractor

Sysco Food Services of Los Angeles, Inc.

Cosponsors

SCAQMD
MSRC
U.S. Department of Energy

Project Officer

Larry Watkins

Background

Numerous goals of the SCAQMD Fleet Rules (1190 Series), California Air Resources Board (CARB) 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, and San Pedro Bay Ports Clean Air Action Plan (CAAP) are met through the development of natural gas fueling stations to support the deployment of heavy-duty alternative fuel vehicles. 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

Sysco's Walnut facility is less than a mile from the CA-60 and is easily accessible from the Brea Canyon Road or Fairway Drive off-ramps. It is also located 2.0 miles from the 57 Freeway. The development of this LNG infrastructure aimed to achieve the following:

- Reduce air pollution emissions and diesel consumption from heavy-duty motor vehicles traveling throughout Southern California.
- Provide a vital LNG infrastructure link along the Interstate Clean Transportation Corridor (*ICTC*).
- Provide an LNG fueling site necessary to initially provide capacity for Sysco to operate its heavy-duty trucks.
- Allow Walnut/City of Industry to continue as a transportation hub for this industrially zoned area by providing the needed infrastructure for clean fuel natural gas vehicles.
- Allow for the expanded market penetration of additional clean fuel, natural gas vehicles along the *ICTC* and especially along CA-60.

Technology Description

Sysco solicited bids for a turnkey LNG fueling facility, with input and assistance from project sponsors and the ICTC Project. General Physics/NorthStar's proposal was accepted as it provided for the establishment of infrastructure that meets Sysco's performance needs in a cost-effective manner.

Currently, the station is operating with one 16,400-gallon storage vessel; however, the station was constructed with concrete footings to allow for the addition of a second 16,400-gallon vessel. Other civil improvements have been also been constructed to accommodate an additional LNG fuel dispensing system.

The station saturates the entire contents of the storage tank immediately upon refill. This automatically occurs when the offload operator changes the selector switch from "offload" to "dispense." Saturation is accomplished by circulating LNG through an ambient vaporizer and back into the tank. The station operator can select variable saturation set points between 25 and 125 psig. The station's system is able to saturate a 10,000-gallon delivery in less than 30 minutes.

Status

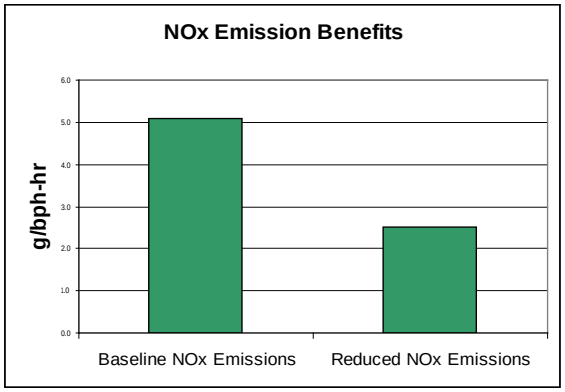
General Physics, under contract with Sysco LA, completed the construction of various civil improvements: underground improvements, foundations, phone equipment, electrical equipment, concrete, masonry, fence, asphalt and landscape work as shown above. General Physics

Inc. teamed with NorthStar and also under contract with Sysco LA, completed the construction of the LNG station components.

The system has been tested by General Physics and also inspected and accepted by the appropriate permitting agencies.

Results

The station development supported the deployment of low-emission natural gas trucks that significantly reduce diesel consumption and toxic emissions of priority pollutants within the region. Sysco deployed 53 class-8 International 9100 tractors equipped with Caterpillar C-12 engines, which fuel at the LNG station. These



engines achieve a50% reduction in NOx emissions, and use a combination of approximately 85% natural gas and 15% diesel fuel to achieve CARB optional low NOx certification. The projected emission reductions and diesel displacement for the 53 units are meeting the performance goals. However, due to engine availability, Sysco was forced to postpone additional deployments until 2009.

Benefits

The 53 natural gas trucks currently utilizing the natural gas refueling station provide the following emission and diesel displacement benefits:

- The reduction of approximately 60 tons of NOx; and
- The displacement of over 950,000 gallons diesel fuel.

Natural gas engines continue to provide a technologically feasible option for reducing emissions and diesel consumption. In addition to standing as a role model for other private fleets, Sysco is currently working with Sterling and Cummins Westport to deploy new trucks powered by the ISL G engine, which meets the 2010 engine standard of 0.2 g/bhp-hr of NOx. LNG trucks provide NOx emission and diesel consumption benefits without adverse effects to water pollution, solid waste or other toxic emissions.

Project Costs

The total cost of the infrastructure development is $1,135,714. The cost includes civil construction improvements, final design package and installation and testing of various equipment, such as the LNG control panel, LNG dispensing pump, and LNG dispenser.

The $250,000 allocated by the SCAQMD for infrastructure development represents 22% of the total station costs. Additional funds were provided by MSRC ($200,000), US DOE/CEC ($150,000), SCAQMD-Carl Moyer Program ($200,000). Costs beyond the gran5 funding, which totaled $335,714, were paid by Sysco LA.

Commercialization and Applications

The LNG fueling station has functioned properly since installation, but the dual-fuel engines and on-board storage tanks have had persistent failures in the following areas: check valve failures; faulty fuel gauges; loss of fuel tank vacuum; engine misfires; and engine overheating.

Sysco LA worked with Power Systems, Clean Air Partners and NexGen to make repairs under warranty. On-board LNG storage vessels were re-evacuated to restore the proper vacuum. Upgrades to the ECM programming, as well as mechanical retrofits, were able to stabilize the performance of the engines.

Sysco L.A.'s successful LNG truck project is a source of pride for the project partners. Sysco continues to work with engine manufacturers and others in the natural gas industry to ensure that a heavy-duty LNG engine becomes available so the transition from diesel can be continued.

SCAQMD Contract 10051 **December 2010**

Lease Buses in Support of Mountain Area CNG School Bus Demonstration Program

Contractor
BusWest

Cosponsors
SCAQMD
MSRC

Project Officer
Lori Berard

Background

Implementation of the Demonstration Program was initiated through the Mobile Source Air Pollution Reduction Review Committee (MSRC), which awarded Bus West $90,928 for the lease of two CNG school buses to be demonstrated by Bear Valley Unified School District (BVUSD) for a period of one year. Contract #MS07004 was executed on July 2, 2007 in order to effectuate the award. Temporary refueling infrastructure for the Program was provided under a separate contract with a different Contractor.

The MSRC approved the continuation of the Program and an augmentation of BusWest's contract in an amount up to $90,928, with the understanding that the AQMD might provide some of the necessary funding. AQMD then agreed to partner with the MSRC on this Program and provide $80,000 in funding toward the lease extension, thereby reducing the MSRC's funding increase to $10,928. The total MSRC contract value is $101,856. The lease rate for the two buses is $22,732 per quarter. This contract for $80,000 in funding will take effect immediately upon exhaustion of the MSRC funds. The Demonstration Program concluded in August 2010.

Project Objective

Through the Mountain Area CNG School Bus Demonstration Program, CNG school buses are introduced to a school district that had not previously used CNG school buses, and school districts are provided with a "hands-on" exposure to CNG school buses. The demonstration Program enables the school district to use the CNG school buses on assigned routes during normal school days in order to experience the operational and refueling characteristics of CNG buses. Furthermore, the Demonstration Program allows the school district to assess CNG school bus performance in mountainous terrain, high altitude and varying weather conditions

Technology Description

Two 2008, Type D, CNG powered, Thomas Built Buses school buses. These buses were powered by a John Deere 8.1L CNG engine with a diesel oxidation catalyst (DOC).

Status

This project was completed on October 1, 2010. This allowed Bear Valley Unified School District to utilize the two buses for a period equal to one school calendar year.

Results

The program was a success. The winter of 2009-2010 provided the district with average to above-average levels of cold weather and snow. The CNG powered buses' performance was equal to that of diesel powered buses that were operated on

different routes on the same days. The high altitude never was a problem. The school district wanted to keep operating the buses but financial constraints prohibited it. The Director of Transportation and Lead Mechanic mentioned on more than one occasion that these buses have performed above their expectations.

Of the minor maintenance issues that were experienced none were the result of severe weather conditions or high altitude.

Benefits

The benefit of this demonstration program is that it provides a track record indicating that CNG powered school buses can operate successfully in high altitude and/or cold weather applications.

Project Costs

The SCAQMD provided $80,000 while the MSRC provided $101,864.

SCAQMD Contract 07054 **March 2010**

Conduct In-Use Emissions Testing of Heavy-Duty Refuse Trucks

Contractor
West Virginia University
Cosponsor
SCAQMD

Project Officer
Mike Bogdanoff

Background

Starting in the late 1980's, heavy-duty diesel engine emissions standards have been steadily moving toward increasingly stringent control over engine-out emissions. Engine manufacturers have continually been involved in engine development to meet these emission standards enforced by the USEPA. Of the exhaust pollutants that have been regulated, the most significant has been the reduction of engine-out NO_x and PM. Engine manufacturers also face the challenge of reducing NOx and PM without affecting the fuel economy of the engine.

In 2005, Heavy-Duty On-Road Fleet Modernization was added to the Carl Moyer Program. Fleet modernization provides incentives to replace old high-polluting heavy-duty vehicles with newer, lower emission replacement vehicles. The fleet modernization source category provides real emission benefits by retiring high-polluting vehicles earlier than would have been expected through normal attrition.

Project Objective

This fleet modernization project, initiated by SCAQMD as part of the Carl Moyer program, involved the West Virginia University (WVU) Transportable Heavy Duty Vehicle Emission Testing Laboratory to carry out chassis dynamometer testing on 15 heavy-duty trucks. The study was aimed at assessing the levels of NO_x emissions from heavy-duty vehicles that were operating in the South Coast Air Basin (SCAB) which were equipped with Model Year 2004 and 2005 engines.

Project Status

The project was completed in the summer of 2007.

Technology Description

The work plan involved the vehicles to be exercised over the HHDDT transient and cruise chassis dynamometer cycles in order to evaluate the distance-specific vehicle emissions. Chassis dynamometer emissions testing on the 15 vehicles was conducted in accordance with regulations stipulated in CFR 40, part 86, Subpart N. The vehicle inertial test weights were set to 56,000 lbs.

Figure 1. HD Truck on Chassis Dynamometer

A set of eddy current power absorbers connected to the wheel hub were used to simulate the road load and aerodynamic drag load on the vehicle. All regulated emissions, which included carbon monoxide (CO), carbon dioxide (CO2), oxides of nitrogen (NO_x), total hydrocarbons (THC) and gravimetric particulate matter (PM) were measured and reported on a distance specific basis. Fifteen heavy-duty vehicles were identified to be tested in this study. Six of these vehicles were powered by MY 2004 engines and nine were powered by MY 2005 engines.

Results

The NO_x emission profiles from the current study are also compared with previous E55 project data which involved chassis laboratory testing of

vehicles equipped with early and late 1990 model year engines. The results of the previously obtained E55 test data revealed an overall decrease in NOx emissions from early 1991 till 1995. Significant differences in NO_x emissions on the order of 30% were observed between transient and cruise operation until 1995, after which the cruise cycle NO_x emissions increased significantly. This was due to the alternate electronic engine control strategy (i.e. "defeat devices") in the cruise mode which engine manufacturers used to attain better fuel economy. After the consent decree signed late in 1998, NOx emissions in cruise mode decreased significantly. A provision of the consent decree required the manufacturers to meet the 2004 emission standard 15 months ahead of time. Hence Model Year 2003 engines were actually developed to satisfy 2004 emission norms. The 2003 Model Year in-use data obtained from vehicle manufacturers DDC, Cummins and Caterpillar produced average brake specific NOx emissions of less than 2.5g/bhp-hr as mandated by the USEPA. This trend is also seen in the WVU chassis laboratory data of vehicles equipped with 2003 Model year engines as illustrated in Figure 1.

The NO_x results of the current study of Model Year 2004 and 2005 engine equipped vehicles shown in Figure 2 is averaged for all vehicles of the respective Model Years irrespective of whether they were fitted with a after-treatment device or not. Figure 3 shows the effect of after-treatment device on NOx emissions by comparing emissions from vehicles equipped with after-treatment devices and those without after-treatment devices. The greatest difference was seen within Model Year 2005 vehicles with and without after-treatment devices. This could be due to the higher exhaust back pressure in vehicles equipped with after-treatment devices.

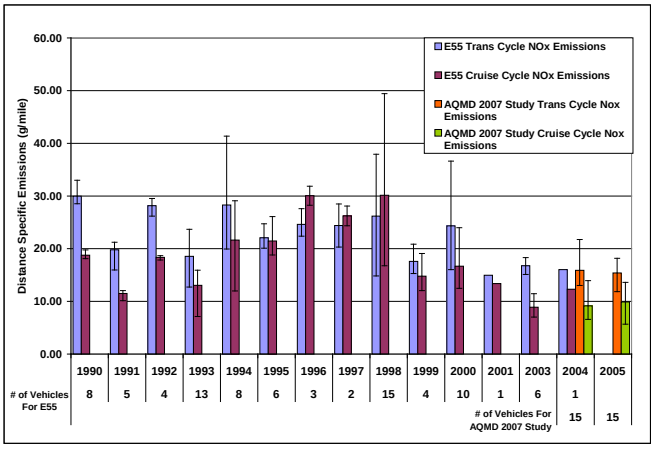


Figure 2. NO_x Emissions Comparison Between E55 Data and Fleet Modernization Test Data

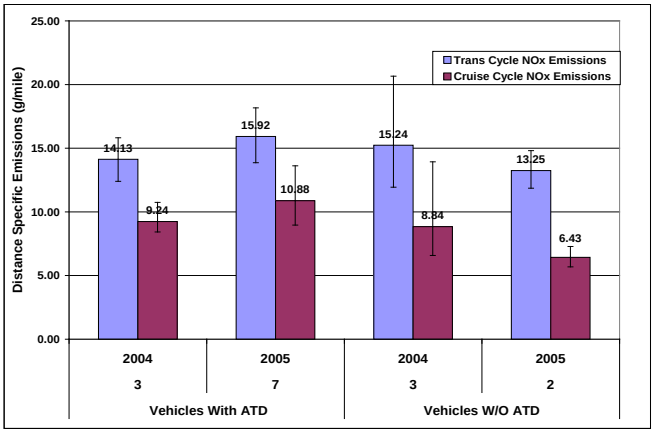


Figure 3. NO_x Emissions Comparison Between Vehicles Equipped With and Without After-Treatment Devices

Project Costs

The project was completed with the $240,000 allocated for this study from SCAQMD. No additional funding was required.

Conclusion

The results of the study clearly indicated significant reduction in total heavy-duty diesel vehicle emissions through replacement of later model year engines with newer engines, which were compliant with current regulations. Programs of such nature, can effectively contribute to improving ambient air quality status.

SCAQMD Contract 08304 **March 2010**

Pilot Program to Assess Feasibility of Enhancing Smog Check Tests In South Coast Air Basin

Contractor

MAHA Maschinenbau Haldenwang GmbH & Co

Cosponsors

CARB
SCAQMD
Foundation for California Community Colleges

Project Officer

Lori Berard

Background

Currently, PM emissions are not measured as part of California's biennial Smog Check Program. In addition, all-wheel and 4-wheel drive vehicles are exempted from loaded mode testing for purposes of measuring NOx emissions. Maschinenbau Haldenwang (MAHA) proposed to cost-share with the SCAQMD a pilot project demonstrating use of four portable particulate measuring devices and one all-wheel/4- wheel drive dynamometer at CARB's El Monte laboratory and at SCAQMD's High Emitter Repair or Scrap (HEROS) Program test sites. Data obtained from the proposed equipment will be used to evaluate the potential for broadening the scope of current Smog Check testing and facilitate the development of a uniform methodology that could be implemented in the Smog Check Program.

MAHA has provided equipment training and support to SCAQMD, CARB, and FCCC "in person" on multiple occasions. MAHA has provided equipment support through frequent conference calls and by maintaining continuous email contact with both AQMD and ARB regarding analyzer usage.

Shown below is a photo of the 4-wheel dynamometer installed and in operation at El Camino College in Torrance the week of June 29, 2009.

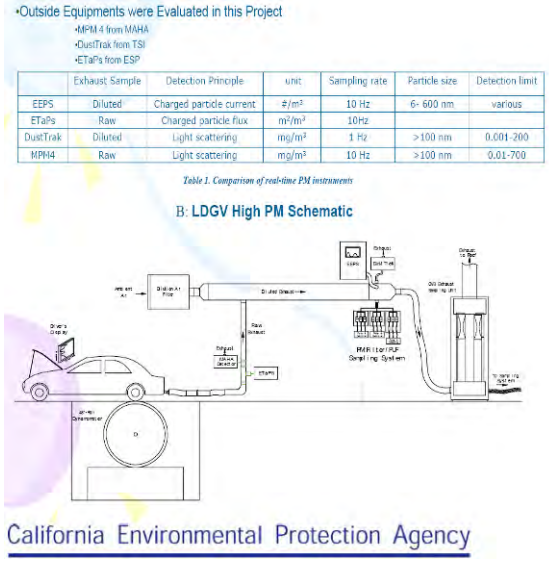
Figure 1. Training and demonstration performed by MAHA USA and MAHA Germany for SCAQMD, CARB and FCCC on June 26, 2009.

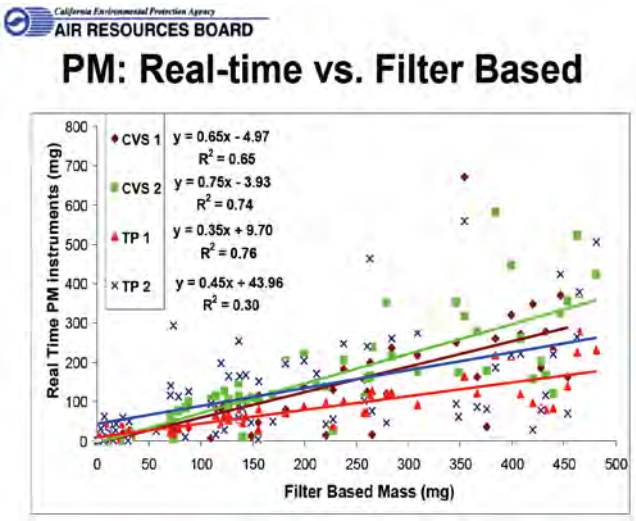
Results

In 2009 CARB tested 4 real-time PM analysers in one of its emission laboratory test cells to compare performance of the real-time analysers with the gravimetric filter method used for vehicle certification. The standard US FTP certification test procedure was used, with all instruments sampling in parallel (2 in the raw exhaust and 2 in the CVS system.

Even though the MPM-4 was measuring PM in hot, wet exhaust directly from the tailpipe, rather than the dry, temperature controlled diluted sample in the CVS, it performed best of all the instruments and had the highest correlation with the reference filter mass method: $R^2 = 0.76$.

Figure 2.
Figure 3.





Note: (MPM-4 is Instrument TP1 in the Chart

Benefits

Demonstration of a particulate measurement device for in-use vehicles is included in the March 2006 update of the Technology Advancement Plan under *Identify and Demonstrate In-Use Fleet Emission Reductions*. Through this project, a potential device for measuring PM emissions during Smog Check was demonstrated. Current measurement technology is unable to fully characterize excessive PM emissions. This new technology under the Smog Check Program is capable of quickly identifying excessive emissions as well as validating their repair. Approximately 40% of the total on-road mobile source tailpipe emissions of PM in California are from light-duty gasoline vehicles.

Project Costs

This project was conducted with MAHA at a cost not to exceed $99,423 from the SCAQMD. The remainder of the $373,847 project costs was supported by the other project partners: CARB, the Foundation for California Community Colleges, and MAHA.

Commercialization and Applications

Mandatory emission limit values for vehicles need to be adapted to current vehicle technology conditions. Afterwards, there could be a gradual renewal of emission testing devices for vehicle emissions, by introducing the new instruments with alternative measuring methods capable of measuring the particulate mass concentration of vehicles in a precise and reliable manner. This measuring procedure could be compulsory for all vehicles, with a transition period of 2 years. To this intent, these new devices could already be certified today as an alternative for current measuring instruments and it would facilitate an eventual compulsory exchange.

SCAQMD Contract 09095 **September 2010**

Evaluate Emissions Impacts from Ethanol Blends on Vehicle Emissions

Contractor

University of California, Riverside/CE-CERT

Cosponsor

SCAQMD

Project Officer

Jeff Cox

Background

The impact of emissions from gasoline fueled vehicles is one of the most important contributions to consider for ambient air quality. Over the past several years, the gasoline fuel specifications have undergone several changes. Initially, MTBE was added to the gasoline in California. As water-related issues precluded the use of MTBE in gasoline, a transition was made to ethanol to meet oxygenate requirements. With the push to use increasingly higher levels of renewable fuels, there is a push to further increase the ethanol level in gasoline. With each transition in the composition of the fuel, it is important to fully understand the impacts the new fuels have on exhaust emissions.

Project Objective

The objective of this program is to examine the effects of different fuels on tailpipe emissions for a representative in-use fleet of gasoline vehicles. A total of 6 vehicles including one Flexible Fuel Vehicle (FFV) were tested for this program. Each vehicle was tested on 4 to 6 fuels with different fuel formulations. The fuel formulations include a current cert fuel (MTBE), E5.7, and E10, E20 and, for the FFV, E50 and E85. Vehicles were tested over the Federal Test Procedure (FTP) in at least duplicate on each fuel combination. Data was analyzed to evaluate and identify any potential trends in the emissions with respect to the different fuel parameters.

Technology Description

The test matrix included 7 vehicles. The vehicles were selected in 3 categories:

- Tech 3: 1981-1985 vehicles having a 3-way catalyst with closed loop fuel control
- Tech 4: 1986-1995 vehicles
- Tech 5: 1996-2010 vehicles

Two vehicles from each of Tech 3 and Tech 4, and three vehicles from Tech 5 categories were obtained. The testing included one late model Flexible Fuel Vehicle (FFV).

The test fuels included CARB Phase 2 and 3 certification fuels, 10, 20, 50 and 85% ethanol blended fuels. The CARB Phase 2 certification fuel (CARB #2) utilizes 11% MTBE to provide the oxygen content with no ethanol content. The CARB Phase 3 certification fuel (RFG2 or CARB #3) contained an ethanol content of 5.7% by volume.

Status

This project was completed in December of 2010. The results have been submitted for publication in a peer reviewed journal.

Results

Two Federal Test Procedure (FTP) tests were conducted for each vehicle/fuel combination, with a subset of test combinations also being tested a third time. Regulated emissions and fuel economy were measured for all test combinations, while toxic emissions were measured for one Tech 4 and one Tech 5 vehicle.

The THC and NMHC emissions increased for E85 but not the lower ethanol blends for the FFV. The CO emissions showed similar trends to those of THC and NMHC emissions, with earlier model vehicles showing a statistically significant decrease as the ethanol level increased. Ethanol did not have a significant impact on CO for the newer vehicles, however. The experimental results showed mixed trends for NO_x, with some older vehicles showing an increase in NO_x emissions as ethanol level increased. The newer vehicles did not show any statistically significant impacts of ethanol on NO_x emissions, although the ethanol blends generally had lower emissions than the CARB 2. CO_2 emissions did not show any significant trends between the fuels. In addition, fuel economy

showed a decrease with increasing levels of ethanol for the five latest model vehicles. This is consistent with the lower energy content for the fuels with higher ethanol contents.

In general, carbonyl emissions were lower for the ethanol blends than those of CARB 2 and CARB 3 fuels, with the exception of the E85 fuel. The predominant compounds were formaldehyde, acetaldehyde and acetone, while heavier carbonyls were only detected in very low concentrations for all fuels and both vehicles. Carbonyl emission levels were higher for the Tech 4 vehicle than those of the Tech 5 FFV. The most consistent trend for carbonyl emissions was an increase in acetaldehyde emissions with increasing ethanol, which is consistent with ethanol being a precursor for the formation of acetaldehyde. It should be mentioned that the use of E85 resulted in significantly higher formaldehyde and acetaldehyde emissions than for the CARB fuels and the other ethanol blends. The largest contribution to total carbonyl emissions was during the cold-start phase of the FTP, when the engine was cold and the catalyst was below its light-off temperature.

Similar to carbonyl emissions, 1,3-butadiene and BTEX emissions were found in lower levels for the Tech 5 FFV than the Tech 4 vehicle. In general, the addition of ethanol resulted in lower toxic emissions for the Tech 4 vehicle, compared to the CARB 2 fuel, with E20 having the lowest BTEX emissions. For the Tech 5 FFV, 1,3-butadiene showed the most consistent trends, with CARB 2 having the highest emissions and emissions decreasing as a function of ethanol level. For toluene, and *m-, p-*, and *o*-xylene, for the Tech 5 FFV, the highest emissions were found for the CARB 2 fuel, while the E20 and E50 fuels interestingly showed higher emissions of these species than the other ethanol blends, i.e., CARB 3, E10, and E85. Benzene and 1,3-butadiene emissions were undetectable and other aromatics were at low levels for the E85 fuel.

The results show some consistent trends with increasing ethanol content for some vehicles, but for other vehicles it appears that a more complex set of factors are impacting the emissions results. The older vehicles showed the most consistent trends for the regulated emissions, with reductions in THC/MNHC and CO emissions and increasing NO_x emissions with increasing ethanol content. This can be attributed to the leaning of the air-fuel mixture with the increasing levels of ethanol/oxygen in the fuel, and the inability of the ECM to adjust to this change. For the vehicles that did not show consistent trends for the regulated emissions, these vehicles may be less sensitive to changes in fuel properties or may have ECMs that can readily adjust to the ethanol content in the fuel, or some other factors may be in play, such as interactions with other correlated fuel properties like fuel volatility, or combustion-related effects like changes in the adiabatic flame temperature. The unregulated emissions showed some trends with decreasing BTEX emissions with increasing ethanol for the Tech 4 vehicle and very low levels of toxic aromatics for the E85 fuel for the Tech 5 FFV, but the BTEX emissions did not appear to be directly correlated to fuel aromatic levels, although the CARB 2 fuel did have the highest levels of benzene, ethylbenzene, and *p/m* xylenes. Overall, the results indicate that the impact of ethanol on emissions for the in-use gasoline vehicle fleet can depend on a number of factors, including the mix of vehicle technologies and the ability of these vehicles to adjust to the level of ethanol in the fuel, the sensitivities of different vehicles to changes in ethanol content, interactions with other fuel properties, such as volatility, as well as other potential factors.

Benefits

The information obtained from this program will be very valuable in evaluating and mitigating any potential air quality impacts from the increased use of alternative fuels, and in particular ethanol. By understanding the impacts of alternative fuels on vehicle emissions, we can better ensure these fuels can be implemented in a way that preserves or improves air quality, while at the same time meeting goals for petroleum displacement and reductions in greenhouse gases.

Project Costs

The SCAQMD provided full funding for this project in the amount of $289,184.

Commercialization and Applications

This research will have important implications for the expanded use of ethanol in commercial vehicle, and what impacts this might have vehicle performance. Currently, there is insufficient information available to allow the use of ethanol at higher percentages than 10% in older gasoline vehicles.

SCAQMD Contract #10012 **July 2010**

Evaluate Impacts & Benefits of Plug-in Fuel Cell Vehicles

Contractor

Electric Power Research Institute

Cosponsors

South Coast Air Quality Management District
California Air Resources Board
Electric Power Research Institute

Project Officer

Lisa Mirisola

Background

In 2000, the Electric Power Research Institute (EPRI) organized a collaborative study to compare the impacts and benefits of various hybrid electric vehicle (HEV) options. That study identified plug-in hybrid electric vehicles (PHEVs) as a new low-emission vehicle electrification concept, and it led to the AQMD-supported construction of Daimler Sprinter PHEVs, the world's first PHEVs from a major automobile manufacturer.

In 2010, a small team of experts in advanced electric technology vehicles (AETVs) organized by EPRI identified the plug-in fuel cell (hybrid) vehicle (PFCV) as a new concept with potentially important advantages over fuel cell- and battery-powered vehicles. Based on the team's initial assessment, EPRI proposed a first-cut study to analyze PFCV concepts and compare their cost and environmental characteristics with those of FCVs, BEVs and PHEVs. The study was initiated by the team in February 2010 with support from AQMD and CARB.

Project Objective

To develop a first-cut assessment of the cost, environmental and infrastructure characteristics, benefits and possible limitations of PFCVs compared to FCVs, BEVs and PHEVs. Also, if the assessment is positive, develop a plan for an AETV comparison study to establish the advantages and limitation of PFCVs in detail for a confident assessment of the potential of PFCVs.

Technology Description

The PFCV can be viewed as an FCV to which a grid-rechargeable (plug-in) battery system has been added that can provide driving range on the battery alone. Compared to FCVs, the PFCV offers the customer lower fuel costs and home refueling with electricity from the grid. In addition, PFCV configurations may enable operation of automotive fuel cell systems in less dynamic modes, with the battery system handling transient requirements. This ability expects to reduce the cost and increase the operating life of fuel cell systems, mitigating two of the most challenging issues faced by FCVs. Compared to BEVs, PFCVs enable vehicle electrification without range limitation or long refueling time, the continuing barriers to the widespread acceptance of BEVs.

Although the component technologies for PFCVs are largely developed (for FCVs and BEVs, respectively) the design basis for complete PFCVs that can demonstrate the attributes of the concept does not appear to exist, and no engineered PFCVs have been built.

Status

All technical tasks of the project have been completed successfully. Several different PFCVs using a mid-size vehicle platform were defined in terms of their architectures and components, and representative FCV, BEV and PHEV configurations were selected for the comparative analysis of vehicle attributes. On this basis, preliminary vehicle models were developed and their costs estimated. State-of-the-art simulation techniques were then used to determine and compare prospective vehicle performance, driving range, energy consumption, operating costs, and well-to-wheels (WTW) CO2 emissions for representative driving cycles. Preliminary estimates were made also of the infrastructure requirements and costs for the vehicles studied. Conclusions from the tasks performed were developed, and a final report summarizing the project activities and results has been prepared. The report includes a preliminary plan for a more in-depth, broadly scoped comparison of PFCVs with other advanced electric technology vehicles, for consideration, participation and support by a

group of stakeholder organizations from the automobile and energy industries and from government agencies responsible for development of advanced transportation technologies and for energy and environmental regulation.

Results

State-of-the-art modeling techniques were used to determine the performance, driving range, energy consumption, operating costs, and WTW CO_2 emissions for PFCV and the other AETV configurations in simulated operation over representative driving cycles. Preliminary estimates were made also of the infrastructure requirements and costs likely to be associated with the introduction of the vehicles studied.

The results of these simulations and comparisons led the project team to the following conclusions:

1. PFCVs with different combinations of fuel cell power and battery capacity are expected to have manufacturing costs comparable to FCVs. BEVs are projected to be the lowest-cost among the AETV configurations studied, but for broad acceptance and impact BEV require range-extending strategies (e.g., level 2 and 3 public charging infrastructure; plug-in hybridization) that effectively add to their cost.
2. In the fuel cost scenarios adopted for this study PFCVs cost less to operate (substantially so in the nearer term) than FCVs but more than BEVs. In the longer term, PFCVs with 40 miles or more range on batteries will cost less to operate than PHEVs.
3. PFCVs charged with California's "low-CO_2" electricity create substantially lower WTW CO_2 emissions than FCVs and, also, lower emissions than PHEVs. BEVs and the range-extender PFCV create the lowest emissions. CO_2 emissions depend greatly on the energy sources used for production of hydrogen and electricity, but all vehicles studied have lower emissions than the conventional cars of today and much lower emissions in likely future energy source scenarios.
4. An emerging hydrogen infrastructure can serve 25%-50% more PFCVs than FCVs for the same investment. In the longer term, per-vehicle infrastructure investments for PFCVs increase with battery capacity and electricity use and exceed the investments needed for FCVs. PFCV and BEV infrastructure investment needs appear comparable, and PHEVs are likely to have the lowest per-vehicle infrastructure cost.

Although these conclusions support the expectation of PFCVs, they are based on a first-cut study of limited scope. An in-depth study and more comprehensive comparisons with the leading AETVs are needed to establish the prospective benefits and competitiveness of PFCVs with sufficient credibility to decide on further scrutiny and possible development.

Benefits

This study represents the first public effort and account to assess the potential value of PFCVs as a new low-emission, high-efficiency dual fuel vehicle option that may accelerate the introduction of fuel cell vehicles and expand the acceptance of battery electric vehicles. The study sets the stage for a collaborative effort of stakeholders in advanced electric technology vehicles to validate the study's positive but preliminary conclusions on the value of PFCVs, and to expand the study scope to a broader range of vehicle types and more detailed future energy scenarios in which PFCVs would take the fullest advantage of an integrated hydrogen-electricity transportation energy system.

Project Costs

The table below shows the contributions of each project participant.

Participant	Funding
SCAQMD	$ 50,000
California Air Resources Board	$ 50,000
Electric Power Research Institute	$ 10,000
Total	$ 110,000

Commercialization and Applications

The modern plug-in fuel cell vehicle is a new concept that has not yet been reduced to an engineering design or prototypical vehicle. Nevertheless, because the PHEV's component technologies are largely developed, one or more PFCV types may be developed in the nearer term (within 5 years) such that the value of PFCVs in enabling or accelerating the commercial introduction of FCVs and/or BEVs may begin to be realized within this decade. However, efforts to design and develop PFCVs are unlikely to begin before the concept is more fully understood in terms of its technology options, characteristics, advantages and limitations, and potential for beneficial impacts. The proposed Phase 2 study may be the start of these efforts.

SCAQMD Contract # 10675 **September 2010**

Develop Efficient Humid Air System for Diesel NO_x Reduction

Contractor

California State University Long Beach Foundation

Cosponsor

SCAQMD

Project Officer

Alfonso Baez

Background

Humid air system or fumigation is an effective approach in reducing diesel NO_x emissions. In this method, water vapor is injected in the intake air supplied to the engine cylinders. The process reduces the local temperature in the cylinder and raises the specific heat of the air-fuel mixture which also contributes to the elimination of the hot spots in the engine cylinder. With decreased temperature, NO_x reduction is achieved. With an optimized system, fumigation can reduce NO_x emission without significant increases in hydrocarbon emissions. Other benefits of the process include longer life of the engine components due to reduced cycle temperature and reductions in carbon deposits. Such a system has been tested on oceangoing vessels (OGV). However, since the system required distilled water, for OGV applications an additional system needed to be developed for converting sea water to distilled water, the initial investment cost for the installation of such a system has prevented its wide application in OGVs.

Efforts in 2009 studied the effects of humid air systems on the diesel NO_x and CO emissions of a three cylinder diesel engine. The humid air systems were an air-assisted distilled water atomization system and a Honeywell air humidifier model HE-120. The experiments were performed for both low sulfur and 20% bio-diesel (B20) fuels. Results showed, while the water atomization was effective in reducing NO_x emissions by more than 60%, it could not be sustained over time due to water accumulation within the engine cylinders and eventual choking conditions.

Project Objective

The present investigation was focused on adding humidity to the intake air of a high speed diesel engine with low sulfur diesel fuel for reducing its NO_x emissions. The addition of the humidity is performed with distilled water. For diesel trucks, distilled water can be supplied in the form of a tank and with slight modifications to the engine intake air system, NO_x reduction can be achieved.

Technology Description

A Vanguard 3-cylinder liquid-cooled aspired diesel engine connected to an electric dynamometer with a maximum output power of 20 BHP at 3600 rpm, along with a Rosco 3000 fog machine with distilled water were used. To maintain saturation conditions, a reservoir connected to the Rosco machine is opened to the ambient air at one end and connected to the diesel air intake at another end. The engine tests were conducted at 4.45 and 9 BHP at 1440 and 1620 engine RPMs respectively. The emission measurements were performed using a Horiba PG-250 emission analyzer.

A large wind tunnel with 36 inch squared cross section working area and 192 inches in length was used for particle matter (PM) measurements. The wind tunnel speed was 3.9 m/sec. The diesel exhaust was fed to the wind tunnel and PM measurements were performed using a TSI DustTrak model 8520 with 2.5 µm inlet nozzle.

Figure 1 shows the diesel engine with the steam generator and the Horiba emission analyzer.

Figure 1: Diesel engine with water atomizer and humidifier

Status

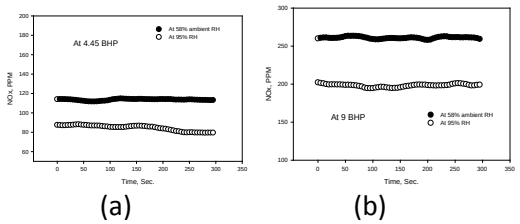
The project has been completed and the final report was submitted on September 30, 2010.

Results

Figure 2 shows the NO_x emissions with and without the humid air system. Similar graphs have been generated for the other outputs and Table 1 summarizes the average results along with the power output, the fuel consumed, the amount of steam used when humidity was added, and the break specific fuel consumption (BSFC). As the results show, there are substantial reductions in NO_x emissions at both engine loads. For 4.45 BHP, there is about 23% reduction in NO_x emissions, while for 9 BHP, the reduction is approximately 26%. NO_x reduction is a function of the combustion temperature. For the run with 9 BHP, the temperature of the exhaust at the engine outlet was near 300C, while for the run with 4.45 BHP, the temperature was near 200C which indicates the potential of increased NO_x reduction at a higher combustion temperature.

The ratios of the steam added to the fuel consumed are respectively 1.44 and 1.625 for 4.45 and 9 BHP respectively. While the results indicate that the increased power requires a higher rate of steam supplied, however, it should be mentioned that with this system, it was not possible to match the exact amount of the steam required to maintain the 95% relative humidity and there are possibilities of wasted steam, as was observed by condensations collected in the humidifier container. However, it might be safe to say that for such systems, a tank storage of approximately twice the size of the fuel tank for the distilled water is required to ensure adequate supply of the steam to the air intake for the maximum NO_x reduction.

With the added humidity, there are approximately 5% and 10% increases in the BSFC, 2% and 3.5% increases in CO2, 17% and 13.8% increases in CO and 42% and 38% increases in PM.



(a) (b)

Figure 2. Variation of NOx Emissions with and without Humid Air System, (a) BHP=4.45, (b) BHP = 9.

	BHP	NOx (PPM)	CO (PPM)	CO_2 (PPM)	PM (mg/m^3)	Fuel (gram/min)	BSFC	Steam (gram/min)
Standard Air, 58% RH	4.45	113	179.65	3.045	0.107	9	0.267	0
Humid Air, 95% RH	4.24	84	210.28	3.111	0.152	9	0.280	13
Standard Air, 58% RH	8.95	261	428.83	7.90	4.432	22	0.325	0
Humid Air, 95% RH	8.89	198	488.01	8.18	6.13	24	0.357	39

Table 1. Averaged Measured & Calculated Values

In general, carbon monoxide emissions of diesel engines are nearly 5-10 times less than the comparable gasoline engines while their NOx emissions are higher by the same order of magnitude. Since a diesel engine is more efficient that a gasoline engine, any emission control strategy that results in significant reductions in NO_x emission with less percentage increase in carbon monoxide emissions can benefit air quality and the environment. The present investigations indicate that the humid air system has the potential to meet these objectives in mobile and stationary diesel engines.

Benefits

The current investigation provides results on a low cost method for reducing NO_x emissions of stationary and mobile diesel engines. Further investigations are underway to develop a continuous system to maintain the level of humidity of the intake air according to the engine load, and field test it with a mid-size diesel bus.

Project Costs

The project was completed with $28,000 in funding from the SCAQMD and cost-share contributions in the form of space and laboratory equipment and additional person-hours provided by CSUBL Foundation.

Commercialization and Applications

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

SCAQMD Contract #04032 **March 2010**

Develop, Demonstrate & Evaluate Plug-In Hybrid Electric Vans in Fleet Use

Contractor

Electric Power Research Institute

Cosponsors

SCAQMD
DaimlerChrysler

Project *Officer*

Lisa Mirisola

Background

In 2003, EPRI and DaimlerChrysler initiated a three-part collaborative effort to develop and demonstrate a plug-in hybrid electric vehicle (PHEV) based on the Sprinter vehicle platform, deliver prototype Sprinter PHEVs to fleets within the United States, and explore these benefits in the context of commercial fleet use. As part of this effort, EPRI assumed the responsibility of managing data acquisition and analysis. This report focuses on evaluation of the PHEV Sprinter tested by the SCAQMD.

Project Objective

The project's objectives are to determine vehicle component and control system performance and to identify potential areas for system improvement. A key parameter in evaluating system performance is energy economy. Insufficient data was available to account for fuel consumption, so the analysis emphasized component and control system operating characteristics.

Technology Description

The Sprinter PHEV is based on the pre-transmission parallel hybrid-electric-vehicle (HEV) architecture. This architecture couples an electric motor and internal combustion engine to the input shaft of the transmission. The engine and electric motor work in parallel to deliver the driver's requested propulsion power. The electric motor is used to allow electric-only operation, capture braking energy, and assist in efficient engine operation (Figure 1).

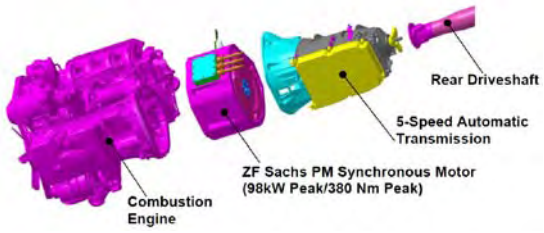


Figure 1 – PHEV Sprinter's engine, electric motor and transmission configuration.

The Sprinter PHEV was designed with significant electric drive power and battery energy. The battery can be charged from an external source, allowing the vehicle to implement a charge-depleting control strategy. The vehicle can operate in electric-only mode at low speed and low aggressiveness. At higher speeds or aggressive driving conditions, the vehicle operates in a blended mode charge-depleting control strategy where the engine is used in combination with the motor. In this mode, priority is given to discharging the battery, but the use of the engine decreases battery energy usage. Both electric-only and blended charge-depleting control strategies have been shown to significantly decrease fuel consumption and improve tailpipe emissions.Once the battery has been depleted, it operates as a charge-sustaining hybrid electric vehicle (HEV). The HEV operation continues to provide fuel economy and emissions benefits while maintaining the battery charge level.

Status

DaimlerChrysler provided a limited set of data parameters. The data that was made available was analyzed to provide information from the Sprinter PHEV. The real-world dataset proved insufficient for a detailed energy management assessment. The component data did allow for statistical evaluation

of many components' real-world operating schedule. The component data was also used to determine the vehicle's control state: charge-depleting or charge-sustaining. Battery data was used to approximate battery internal resistance as a possible indicator of battery degradation.

Results

Plug-in hybrid electric vehicles utilize a complex set of components and control strategies, so summarizing the analysis results into one graph is impossible. The various system layers demand a multi-domain evaluation. Figure 2 below is presented to illustrate the data analysis capabilities.

Evaluating the engine and motor operating regions provides insight into how well matched the components are to the control strategy implementation. The control strategy selects component operating points for a given driver demand and vehicle state. The component's efficiency at that point will determine the energy consumption. An operating point's frequency of use provides insight into whether component tuning can be used to further improve net fuel economy. For example, Figure 2 shows engine use during hybrid operation, and indicates that control is good, but could be improved by decreasing low and negative torque operation.

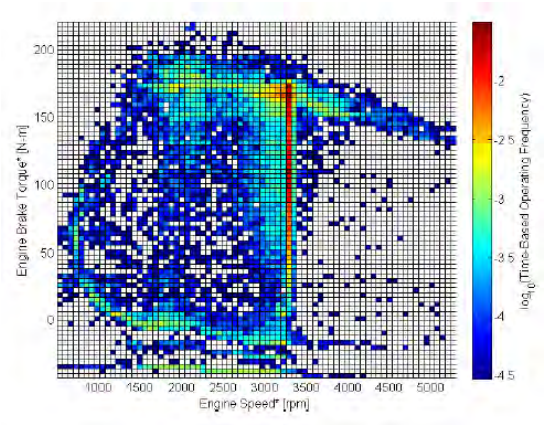


Figure 2 – Engine operating frequency during hybrid vehicle operation.

The battery was evaluated in several ways. The battery's voltage, current, temperature, and charge state were combined to perform an operation frequency analysis. The batteries were also subjected to an internal resistance calculation routine that allowed for an in-situ estimation of the pack-level charge and discharge resistance.

The internal resistance maps demonstrated a high degree of uncertainty due to the uncontrolled nature of normal vehicle operation. The results indicate that degradation was not unusually high, but laboratory testing is necessary to create a more accurate estimate of battery degradation.

Additional details can be found in EPRI report 1017673 titled *Plug-in Hybrid Electric Vehicle Evaluation and Test Data Analysis*, which was provided to the SCAQMD Project Officer.

Benefits

Although key data were not provided to perform an energy management analysis, the data that were provided permitted a detailed analysis of component operation over different operating modes. The analysis allows for a real-world characterization of component operation which can serve as feedback to component design and calibration for further improvement in vehicle energy economy. The limitations encountered in performing this analysis have also helped to inform data requirements for future projects.

Project Costs

This was a cofunded project for which SCAQMD provided $475,000. Original total estimated project costs were $1,575,000. At the completion of the project, total project costs were $1,697,342. SCAQMD costs remained unchanged at $475,000. EPRI and its members provided $673,336; SCE provided in-kind of $74,006 and DaimlerChrysler in-kind of $475,000.

Commercialization and Applications

Given that further information sharing, research, and development is invested in the data collection and analysis, detailed vehicle reports could be produced. These reports would provide insight into the energy management strategy performance in the various operating modes. These analyses can assist automakers in tuning their hardware selection and control algorithms for superior energy management.

SCAQMD Contract #08334 **December 2010**

Demonstrate Medium-Duty Gasoline Hybrid Electric Vehicle in Parcel Delivery Application

Contractor
Calstart

Cosponsors
FedEx Express
National Renewable Energy Laboratory (DOE)
SCAQMD

Project Officer
Jeff Cox

Background
Introduction of hybridized gasoline engine drivetrains in place of existing diesel engines may provide improved emissions and efficiency. Introduction of plug-in hybrid-electric vehicles (PHEV) can provide even greater fuel efficiency. Lifecycle costs of PHEVs are not well known and remain a barrier to making a viable business case.

Project Objective
The purpose of this project was to demonstrate and evaluate a medium-duty gasoline hybrid-electric vehicle (GHEV) in a parcel delivery truck application and compare it to baseline diesel vehicles in fuel use and emissions. Another objective includes PHEV modeling and evaluation of business case and technology pathway from hybrid-electric to PHEV vehicles. CALSTART worked with partners FedEx Express, Azure Dynamics, and the National Renewable Energy Laboratory (NREL) to evaluate the gasoline hybrid-electric vehicle in use in the FedEx Express fleet. Engine, Fuel & Emissions Engineering lab (EFEE) conducted the on-road emissions testing.

Technology Description
The GHEVs are built upon a Ford E-450 stripped chassis and powered by a Ford 5.4L gasoline engine and Azure Dynamics Balance™ Hybrid System. Modeling and lifecycle cost analysis of a potential plug-in hybrid are evaluated as well.

Status
The project was completed in December 2010. The final report is on file as well as individual reports under the different tasks. The individual reports provide extensive detail on the 12-month evaluation, laboratory testing, on-road emissions and PHEV modeling work and business case.

Figure 1: Gasoline hybrid-electric vehicle

Results
The vehicles were evaluated in the laboratory using a chassis dynamometer. Both diesel and GHEV were compared on three duty cycles: 1) NYCC, 2) OC Bus, and 3) HTUF4.

All the criteria emissions decreased considerably for the GHEV compared to diesel, as shown in Table 1.

Table 1: GHEV criteria emissions reductions by drive cycle in laboratory testing.

Duty Cycle	GHEV Emissions Reductions (%)			
	NOx	CO	THC	PM
NYCC	74.5	88.9	100	99.8
OC Bus	86.2	90.0	100	99.9
HTUF4	89.0	58.6	89.9	99.8

The GHEV showed a 20% improvement in fuel economy (measured in diesel equivalent mpg) in

the NYCC cycle and no significant improvement in the other cycles (OC Bus and HTUF4).

The emission and fuel economy results from on-road measurements were similar to the laboratory testing. The GHEV exhaust had virtually no PM, very low HC (0.1 vs. 0.5 g/km for diesel) and lower NOx (1-2 vs. 3-4 g/km for diesel). The fuel economy measured during the on-road testing was 8 mpg for the GHEV and 9 mpg for the diesel vehicles.

The fuel economy was tracked during the 12-month evaluation. Compared on a diesel equivalent miles per gallon basis, the GHEV showed similar values to the diesel units (Figure 2).

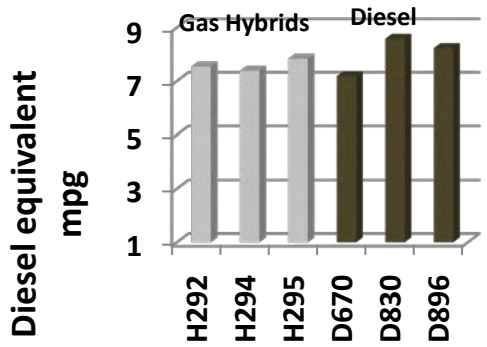


Figure 2: Diesel equivalent miles per gallon for GHEV and diesel vehicles.

The average fuel economy for the GHEV trucks was 7.5mpg and for the diesel trucks 7.9mpg. These results are positive given that diesel engines generally have higher fuel economy than gasoline. On a total operating cost per mile basis the two vehicle systems are very close. The GHEV total operating cost is $0.63/mi and the diesel is $0.59/mi.

Potential benefits of a plug-in design using fuel consumption and vehicle cost trade-offs were evaluated. Increased battery, component mass, and battery wear on fuel consumption were accounted for in the model and lifecycle costs analysis (15 years lifecycle). Under a current economic scenario – fuel cost $3/gallon and energy storage cost $700/kWh – the additional lifecycle cost ranges from $22,000 to $25,000 for a PHEV with 22kWh energy storage. Battery costs have a dominant impact on the additional lifecycle costs and duty cycle and daily miles have a much smaller impact. Under a future economic scenario – fuel cost $5/gallon and energy storage $300/kWh – the additional lifecycle cost ranges from $6,500 to $18,000 depending on the duty cycle and daily miles. The dependence on duty cycle indicates the importance of strategic deployment in targeted routes.

We evaluated the business case of using a PHEV for grid support (vehicle-to-grid or V2G power) when parked after regular work hours. This analysis showed that using the last three year market values of grid regulation services in California (CAISO), there was at least one year when this was quite positive economically. The net lifecycle benefit over 15 years from V2G was up to $25,000, which can totally offset the incremental lifecycle costs of a PHEV. The additional use of plug-in vehicles for V2G may significantly improve their business case

Benefits

The GHEV trucks provide equal fuel economy results to diesel trucks but with considerably reduced emissions. The performance and operating costs per mile are very similar. The reduced emissions are clearly an important advantage of the GHEV trucks.

Based on the emissions testing results from this project we estimate that if 20% of parcel delivery trucks in this class size operating in the South Coast Basin (estimated at 1,000 vehicles) were replaced by the GHEV, the reduction in emissions annually would be 70 tons NOx, 34 tons CO, and 5 tons PM.

Project Costs

The project was completed within budget. The total cost of the project was $595,000. The SCAQMD contributed $325,000 to this project. Co-funding from FedEx and NREL provided additional $270,000. Actual in-kind contributions exceeded the co-funding amount.

Commercialization and Applications

Gasoline hybrid-electric trucks in this class are commercially available and have entered commercial fleets in some numbers. Greater penetration is likely with a reduction in cost and assistance from effective incentive programs.

Introduction of PHEV systems in this class and application is of great interest. However, the business case needs to be improved – additional lifecycle costs reduced. This can be accomplished via reductions in cost, energy storage better sized for the drive cycle and in finding additional use for plug-in vehicle capabilities, such as their use for V2G power. Demonstration and business case studies of plug-in vehicles and their use for V2G is needed to test out the real-life application of the concept.

SCAQMD Contract #07356 **August 2010**

Upgrade and Demonstrate Advanced Technology Fuel Cell Transit Bus

Contractor
ISE Corporation

Cosponsors
CARB
Calstart
SunLine Transit Agency
SCAQMD

Project Officer
Joseph Impullitti

Background
In June 2002 ISE delivered the first hybrid electric drive fuel cell bus, a 30' El Dorado with a 60kW UTC fuel cell, to the SunLine Transit Agency of Coachella Valley. This bus was developed with the aid of substantial funding from Thor Industries, the parent company of El Dorado, (plus matching funds from the public) and hence it has been referred to as "The Thor Bus". Following extensive testing through the summer, SunLine put the bus into revenue service in November 2002. The bus was retired from service late in 2004 after developing some issues that reduced its availability with the expiration of the fuel cell warranty.

Two years elapsed in finding funding to replace the fuel cell and make other improvements. The present AQMD contract was intended to upgrade the bus:

- The fuel cell would be replaced with a more powerful fuel cell by Ballard,
- The lead acid batteries would be replaced with lithium ion batteries, and
- The fuel system would be upgraded from 3600 psi to 5000 psi capability, to attain additional storage and range.

The project costs were to be shared among the AQMD, CARB, and federal sources. The project became known as the AT (Advanced Technology) transit bus.

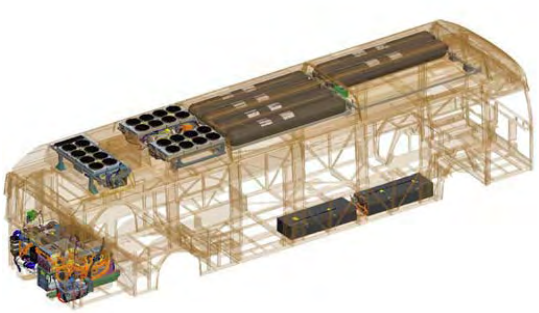
Upgrade work began early in 2008, with the first progress report to the AQMD being for 2008 Q2. By that time ISE was well along in development:

- The old tanks, fuel cell, and battery had been stripped from the bus, a new cooling system had been installed,
- The air system for the fuel cell was in development, and
- The battery was in development.

In parallel at ISE, the design of the BC Transit bus intended to serve the Whistler Village venue of the 2010 Winter Olympics had moved to fast track development. This design was based on a larger (40') New Flyer bus with a 150kW fuel cell. This bus also incorporated most of the Advanced Technology concepts and hardware. Hence it became clear that supplying the prototype of the larger bus in fulfillment of the AT bus contract would be a win-win for all parties.

Project Objective
To provide a state of the art Advanced Technology fuel cell bus with longer life and improved reliability.

Technology Description
The Ballard 150kW fuel cell uses air from an ISE supplied air compressor design and hydrogen from six rooftop mounted tanks which store 45 kg hydrogen at up to 5000 psi. Ballard is sharing the risk, with a 12,000 hour warranty (or five years at most). Electrical energy supply is from a 45kWhr lithium ion battery system designed for this vehicle. The drawing shows the disposition of the fuel cell cradle at rear, the six tanks forward top of the bus, and the batteries lower curbside of the vehicle. The cooling units atop the bus serve for cooling the fuel cell, the electronic drive train components, and the battery. This bus has undergone extensive testing including EMI cold chamber at -20^{o}C.



AT Bus System Drawing

Status

The bus was delivered to SunLine in early February and will enter service following installation of radios and driver training.

Results

The bus is capable of climbing a 20% grade fully loaded from a stop, and will climb an 8% grade fully loaded at a steady 25mph. It is faster than a diesel bus off the line (see data at right) and will cruise at a steady 62 mph. Vehicle range is in excess of 310 miles, but for operation in cold climates in which case fuel is used for heating the bus. Interior noise is primarily due to air conditioning at 74-76 db worst case. Exterior noise is no more, with a 76db peak in drive-by testing to SAE standards. The biggest advances over earlier fuel cell buses are in availability and mean time between failures (MTBF), due to extensive validation testing to BC provincial standards. The fleet of 20 similar (production) buses at Whistler has been accumulating mileage some 20 hours per day, with over 116,000 km accumulated by the first of March (these buses were delivered in December 2009 and January 2010).

Benefits

Premium transportation with zero tailpipe emissions.

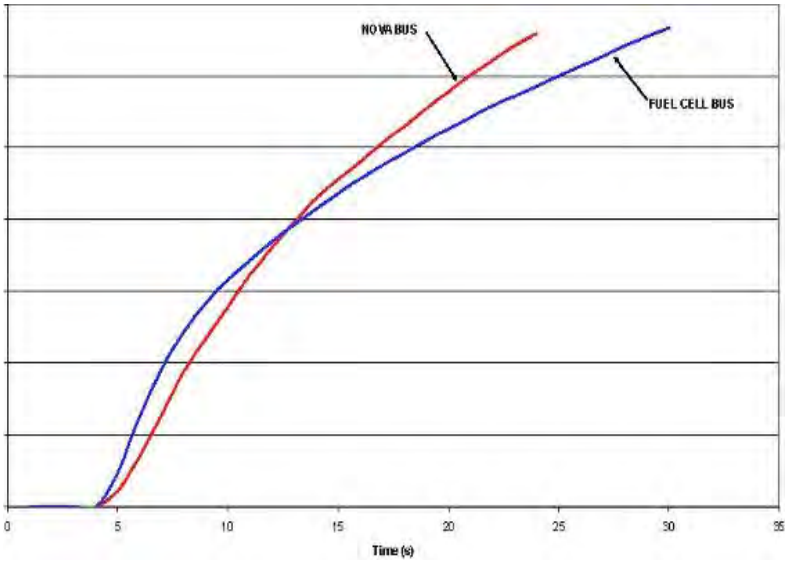
Project Costs

AQMD costs of $325,000, total development costs in excess of $2M shared with the ARB and the Canadian program.

Commercialization and Applications

Twenty production buses based on this design are now in Canada, to be followed with more. With additional orders the price can be reduced well into the $1M range.

Nova Bus vs. Fuel Cell Bus Acceleration



SCAQMD Contract #10599 **December 2010**

Participate in California Fuel Cell Partnership for CY 2010 & Provide Support for Regional Coordinator

Contractor

Bevilacqua-Knight, Inc.

Cosponsors

8 automakers; 2 energy providers; 7 government agencies; 2 fuel cell providers; and 11 associate members

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 30 organizations interested in demonstrating fuel cell vehicle and fueling infrastructure technology.

Project Objective

There were several goals for 2010:

- Establish and maintain a common vision for the market transition of FCV's in California;
- Facilitate the deployment of commercial fueling stations and coordinate with OEM vehicle plans;
- Support practical codes and standards development;
- 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 through technology demonstrations and outreach.

Status

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 final report covers the SCAQMD contract 10599 for 2010 membership. This contract was completed on schedule in 2010.

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 Daimler's B Class F-Cell, GM's Chevy Equinox, Honda's FCX Clarity, Hyundai's Santa Fe, Kia's Sportage and Borrego, Nissan's XTrail, Toyota's FCHV-ADV, and Volkswagen's HyMotion. The fuel cell transit buses include four Van Pool buses with UTC fuel cells integrated by ISE (three placed at AC Transit and one at Sunline Transit) and one bus from Proterra (battery dominant with a Hydrogenics FC range extender—to be placed at the City of Burbank). CaFCP is also planning for additional buses at AC Transit, Sunline Transit, and SFMTA.

Results

Specific accomplishments include:

- Automotive members placed over 350 fuel cell passenger vehicles on California roads from

1999 through 2010, including the first retail customers starting in 2005;
- Transit agency members have demonstrated 13 fuel cell buses since 1999, with 4 still currently in operation (see technology description);
- There are now 6 open access hydrogen fueling stations in operation in California. There are also 21 additional private stations 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 organized or participated in several ride & drive events, especially the National Hydrogen Association Annual Conference May 3-6 at the Long Beach Convention Center.
- The CaFCP continued to upgrade its comprehensive up-to-date website focusing on efforts in California, held monthly public open house in West Sacramento, and participated in technical and educational conferences.

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 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 engage in fueling infrastructure activities. 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 vehicle reliability and durability, fueling infrastructure and storage options, and increasing public knowledge and acceptance of the vehicles and fueling.

From 2010-2012, CaFCP's goals relate to Building Market Foundations through coordinated individual and collective effort.

SCAQMD Contract #06071 **September 2010**

Field Demonstration of Prototype Super Boiler

Contractor

Gas Technology Institute

Cosponsors

DOE	AQMD
UTD	Aqua-Chem
CEC	Clement Pappas & Co.
CARB ICAT	GRI

Project Officer

Howard Lange

Background

GTI and Cleaver-Brooks have developed a new gas-fired steam generation system—the Super Boiler—for increased energy efficiency, reduced equipment size, and reduced emissions. The system consists of a fire-tube boiler with a unique staged furnace design, a two-stage burner system with engineered internal recirculation and inter-stage cooling integral to the boiler, unique convective pass design with extended internal surfaces for enhanced heat transfer, and a novel integrated heat recovery system to extract maximum energy from the flue gas. With these combined innovations, the Super Boiler technical goals were set at 94% HHV fuel thermodynamic efficiency, operation on natural gas with <5 ppmv NOx, <5 ppmv VOC, <30 ppm CO (ref 3%O_2), and 50% smaller than conventional boilers of similar steam output.

Project Objective

The objective of the proposed project was to demonstrate the Super Boiler technology in an industrial setting with the following tasks: Host site selection, Design and fabrication of the Super Boiler, Installation of the Super Boiler, Performance testing, Marketing analysis, and Long term testing and evaluation.

The industrial demonstration site selected was a bottling plant owned by Clement Pappas & Co. located in Ontario, California; and the required boiler output was determined to be 300 HP.

Technology Description

The Super Boiler combustion system is based on two-stage combustion which combines air staging, internal flue gas recirculation, inter-stage cooling, and unique fuel-air mixing technology to achieve low emissions rather than external flue gas recirculation which is most commonly used today. The two-stage combustion provides lower emissions because of the integrated design of the boiler and combustion system which permits precise control of peak flame temperatures in both primary and secondary stages of combustion. Single-stage combustion systems used today have limitations because they try to control the peak flame temperatures in one stage using external flue gas and hence flame temperatures often exceed 2800°F at which point thermal NOx formation occurs, hence these single-stage burners cannot achieve less than approximately 9 ppmv NOx.

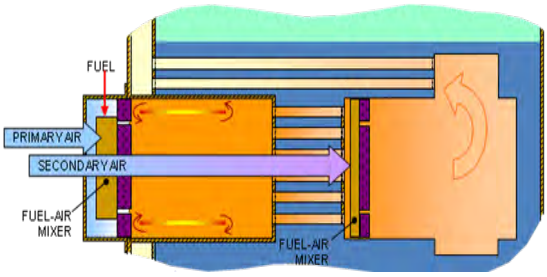


Figure 1. Super Boiler Two-Stage Burner

In addition, to reduce equipment size, the Super Boiler's dual furnace design increases radiant heat transfer to the furnace walls, allowing shorter overall furnace length, and also employs convective tubes with extended surfaces that increase heat transfer by up to 18-fold compared to conventional bare tubes. In this way, a two-pass boiler can achieve the same efficiency as a traditional three- or four-pass fire-tube boiler design. The Super Boiler is consequently up to 50% smaller in footprint, has a smaller diameter, and is up to 50% lower in weight, resulting in very compact design with reduced material cost and labor costs, while requiring less boiler room floor space.

For enhanced energy efficiency, the heat recovery system (HRS) uses a transport membrane

condenser (TMC), a humidifying air heater (HAH), and a split-stage economizer to extract maximum energy from the flue gas (Figure 2).

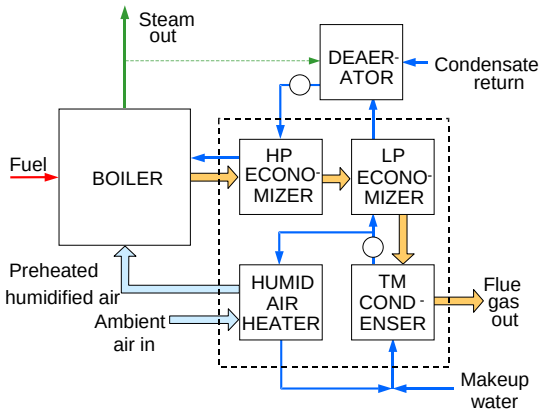


Figure 2. Advanced HRS Layout

The TMC is a new innovation that pulls a major portion of water vapor produced by the combustion process from the flue gas along with its sensible and latent heat. This results in nearly 100% transfer of heat to the boiler feed water. The split-stage economizer preheats boiler feed water in the same way as a conventional economizer, but extracts more heat by working in tandem with the TMC and HAH to reduce flue gas temperature. These components are designed to work synergistically to achieve energy efficiencies of 92-94% which is 10 to 12% higher than today's typical fire-tube boilers.

Status

The Super Boiler technology at Clement Pappas & Co. has been in operation and carrying the plant load since February 2009. At the end of 2009, the HAH was removed and replaced with a conventional fin-tube air heater. Since then the boiler has been carrying the plant load since January 2010. The site has claimed a 24% reduction in fuel use.

Results

The 300 hp Super Boiler at Clement Pappas & Co. has operated successfully to date for over one year with emission data collected over a 6 month long term testing period from Feb. 23, 2009 to Aug. 31, 2009. The project team demonstrated the ability of the Super Boiler to deliver an average 92% fuel-to-steam conversion, 5 ppmv average NOx, and 60 ppmv average CO emissions at stack oxygen in the range of 1.5 to 3.0 vol% (dry basis), which met the original goals while operating under steady conditions. Although there were occasional spikes of NOx and CO during startup, such anomalies are relatively insignificant on a 15-minute averaging basis as is called for in AQMD's Rule 1146 which regulates emissions for large boilers.

Benefits

Super Boiler technology can potentially replace 1148 existing fire-tube boilers in the AQMD territory, not counting new installations. An eight-year phase-in plan that also takes into account new facilities or facility expansions in the AQMD region forecasts installation of 176 boilers or heat recovery retrofits by 2020. Total fuel savings are projected to reach $10 million by 2020. The potential emissions reduction, if we assume replacement of all South Coast AQMD boilers over 20 years old, would result in annual emissions of 59 tons of NOx and 142 tons of CO, which translates to avoidance of 49 tons of NOx and 515 tons of CO. These reductions are the result of both efficiency increase and specific emissions.

Project Costs

The total project cost was $1,719,092, which was shared by the eight cosponsors as follows:

Sponsor	Percentage	Costs
DOE	33.4%	$574,480
UTD	26.6%	$458,255
CEC	13.8%	$236,621
CARB-ICAT	8.1%	$139,097
AQMD	7.9%	$135,000
Aqua-Chem, Inc.	6.3%	$108,715
Clement Pappas & Co.	3.5%	$60,000
GRI	0.4%	$6,924
Total Project Cost		$1,719,092

Commercialization and Applications

The TMC Heat Recovery system has been licensed to Cannon Boiler Works for retrofit applications for boiler and other applications. Even though the burner technology at Clement Pappas & Co. has demonstrated low NOx and CO emissions, reliable service and compact design into a fire-tube boiler of this cutting edge technology still requires further operation time to prove the technology to boiler end users and potential commercialization partners.

SCAQMD Contract #09292 **October 2010**

Provide Funding Support to the Clean Air Challenge Curriculum Project

Contractor

Clean Air Now, Inc.
Subcontractor: Enterprise for Education

Cosponsors

South Coast Air Quality Management District
Shell Hydrogen
Shell Oil Foundation
The City of Riverside
Southern California Edison

Project Officer

Lisa Mirisola

Background

The math- and science-based Clean Air Challenge Curriculum Program (CAC) started in 1995 as a curriculum product of the well-established publisher Enterprise for Education of Santa Monica, Calif. Since its first printing in 1998, CAC has been revised six times to broaden its academic strengths and hone its approach to air quality education. In 2006, the AQMD Governing Board approved $140,000 co-funding for development of the CAC to meet California State Science Content Standards and to provide training and materials to middle and high school science teachers and their students.

Project Objective

In 2009, the Board approved $60,000 co-funding for the CAC to continue to provide training and materials to middle and high school science teachers in our region. CAC addresses air quality, its health effects, and cleaner technology.

The two-to-three week curriculum unit comprises approximately 17 hours of engaging labs and lessons that address five essential questions:
• What is air pollution and how is it formed?
• Does air pollution affect people?
• How significant a problem is air pollution in our community?
• Can we make better choices to clean up our air?
•What conclusions can we draw from our study?
As students address these questions, they learn how to be part of the solution to improving air quality.

A major component of the CAC is comprehensive teacher training, typically at seven-hour workshops held on Saturdays. At the conclusion of each workshop, each teacher receives:
• A 120-page Teacher's Companion book, with numerous lesson plans and projects for independent investigations.
• A box of lab supplies, including graduated cylinders, thermometers, well plates, dyes, magnifying glasses, and ozone detection strips.
• A renewable hydrogen fuel cell car kit with solar panel and lesson plans.
• A 30-minute video (VHS or DVD format).
• Two booklets for each of their students: the 40-page, full-color Case Study booklet and the 48-page, two-color Data Log lab booklet. (120 each)
• Access to a Web site rich in supporting resources http://www.clean-air-challenge.net/.
• Ongoing help via email and telephone from program specialists, and
• A $100 stipend upon proof of implementation.

October 2008 District Clean Air Awards in LA

Clean Air Now received the AQMD's award for "Public Education of Air Quality Issues". This award highlighted the CAC Curriculum Program for its impact on improving students' knowledge of air pollution, its health effects, and mitigating technologies and consumer choices.

Status

The project was extended to October 31, 2010 in order to complete project analysis and final reporting. Due to additional cost-share funding received from Southern California Edison, additional teachers were trained late in 2009. Subcontractor, Enterprise for Education suspended some of its operations in 2010 due to sudden loss of personnel, resulting in unexpected program disruptions. Operations are now back to normal.

Results

Due to greater than expected cost-share, we were able to train more teachers than stated in the contract. This not only resulted in a larger than predicted program for 2009, but the per teacher costs and per student costs of the program were reduced to $1,104 and $9.20 respectively. Clean Air Now subcontracted with Enterprise for Education to conduct the Clean Air Challenge Curriculum Program (CAC) by holding eight teacher workshops within the District to train 154 middle and high school science teachers. Those teachers, in turn, had materials and the potential to provide laboratory exercises and class lessons for 16,651 students living in the Southern California. With cumulative $110,000 acquired co-sponsorship from Shell Oil Foundation, Shell Hydrogen, the city of Riverside, and Southern California Edison, Clean Air Now was more than able to meet its contractual requirements to the District for CAC.

Results by workshop follow:

Workshops	Teachers Trained	Rec'd Stipend
UCLA – April 4, 2009	24	83%
Irvine – March 28	23	65%
Rancho Cucamonga - 5/2	12	67%
Signal Hill - April 25	19	68%
Pasadena - May 16	17	78%
Riverside – April 25	15	80%
Diamond Bar – 4/04/09	22	70%
Rosemead – November 14	22	73%
South Coast Basin Total	154	74%

Almost three quarters (74%) of the teachers trained in 2009 implemented CAC within their classrooms, and therefore received the stipend.

Benefits

There is a dearth of students entering the math, science, and engineering fields. The teachers have commented that the CAC curriculum makes these topics enjoyable to the students, improving their odds of exploring these disciplines further. As school budgets have been stretched, many laboratories and their needed supplies have been abandoned by school districts. The CAC provides a vehicle for bringing these needed resources back into the classroom in a very manageable way. The CAC allows the students to better understand how their actions affect our planet, while learning how to use sound scientific principles to solve some of our most urgent problems.

Overall, the CAC has trained more than 1,532 teachers and reached over 183,840 students in the United States. Through the support of CAC's many sponsors, the program has been offered now in five states (California, Colorado, Nevada, Texas, and Delaware) and three countries (US, China, and India). This year, the CAC will be introduced in Australia and Spain.

Project Costs

Total funding was $171,689, of which the AQMD contribution was $60,000, resulting in a cost share of 35%. Greater than expected Co-sponsorship cost-share contributions resulted in a greater project scope without additional cost to the AQMD. Additional sponsors included Clean Air Now, Shell Oil Foundation, Shell Hydrogen, Southern California Edison, Enterprise for Education, and the city of Riverside. Project costs were on target with original proposal.

Commercialization and Applications

The Clean Air Challenge program is popular with teachers and students. Clean Air Now and Enterprise for Education have documented program costs and benefits, both qualitatively and quantitatively.

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
ARRA-American Recovery & Reinvestment Act
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