Technology Advancement Office

Clean Fuels Program 2012 Annual Report and 2013 Plan Update

March 2013

South Coast Air Quality Management District
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South Coast Air Quality Management District
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Henry Hogo, Assistant Deputy Executive Officer, Mobile Sources

Lourdes Cordova Martinez, Community Relations Manager
Fred Minassian, Director of Technology Implementation
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

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
Ashkaan Nikravan, Air Quality Specialist
Shashi Singeetham, Air Quality Specialist
Greg Ushijima, Air Quality Specialist
Mei Wang, Air Quality Specialist
Andrew Yoon, 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
Marjorie Eaton, 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
Frank Motavassel, 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
Richard Carlson, Air Quality Specialist

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EXECUTIVE SUMMARY

The South Coast Air Quality Management District (SCAQMD) historically experiences the worst air quality in the nation due to the natural geographic and atmospheric conditions of the region coupled with the high population density and associated mobile and stationary source emissions. Recognizing this challenge, the state established the Clean Fuels Program in 1988 which affords the SCAQMD the ability to fund the development, demonstration and accelerated deployment of clean technologies. For over 20 years, the Clean Fuels Program has supported technologies such as hydrogen and fuel cells, natural gas engines and infrastructure, battery electric vehicles, plug-in hybrid electric vehicles and fueling infrastructure. The SCAQMD continues to support a wide variety of technologies, in different stages of maturity, to provide a continuum of emission reductions and health benefits over time.

In recent years, it has become increasingly clear that the importation of goods through the Ports of Los Angeles and Long Beach and the subsequent movement of goods throughout the region not only have a dramatic impact on air quality but also the quality of life to the communities along the major goods movement corridors. In recognition of these impacts, the SCAQMD has initiated a concerted effort in the last couple of years on developing zero- and near-zero emissions goods movement technologies, such as electric trucks, plug-in hybrid trucks with all-electric range, zero-emission container transport technologies, trucks operating from wayside power and even electric locomotives. The prioritization of these types of projects as well as potential technologies which assist with their further development and deployment are emphasized in the 2013 Plan Update portion of the report. The 2012 Annual Report highlights the projects contracted during the previous calendar year and reflect the current status of the program.

2012 Annual Report

The SCAQMD executed 69 new contracts, projects or studies and modified 10 continuing projects adding additional dollars during Calendar Year (CY) 2012 toward research, development, demonstration and deployment (RDD&D) of alternative fuel and clean fuel technologies. Table 2 (page 24) lists these 79 projects or studies, which are further described in this report. The SCAQMD contributed approximately $6.1 million in partnership with other governmental organizations, private industry, academia and research institutes, and interested parties, with total project costs of nearly $26.1 million. Table 3 (page 27) provides information on outside funding received into the Clean Fuels Fund ($1.56 million in 2012) as cost-share for contracts executed in this period. Table 4 (page 28) lists federal and state funds awarded to the SCAQMD for programs that align well with the Clean Fuels Program ($6.2 million in 2012), and Table 5 (page 28) provides an update on the nearly $100 million in federal and state funding awarded to the SCAQMD between 2009 through 2011, again for projects that align well with the Clean Fuels Program.

These projects or studies executed in 2012 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 (emphasizing electric and plug-in hybrid electric trucks and zero-emission container transport technologies)
- Infrastructure and Deployment (predominantly compressed and liquid natural gas)
- Hydrogen Technology and Infrastructure
- Mobile Fuel Cell Technologies
- Emission Control Technologies
- Engine Systems (particularly heavy-duty natural gas engines for truck and rail applications)
- Fuels and Emission Studies
- Stationary Clean Fuels Technology (including renewables)

- Health Impacts Studies
- Outreach and Technology Transfer

During CY 2012, 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 2012 included continued expansion of natural gas alternative refueling infrastructure and vehicle deployment; development and demonstration of hydrogen technologies and infrastructure; further development and demonstration of plug-in hybrid and battery electric vehicle technologies and infrastructure with an emphasis on zero-emission goods movement technologies; continued demonstration of emission control technologies on heavy-duty trucks to reduce NO_x and PM; health impact studies ranging from effects of PM particles from heavy-duty biodiesel-fueled vehicles to physical and chemical composition of and health effects from tailpipe PM emissions; and finally two stationary clean fuels projects including one to develop and demonstrate a 300 kW molten fuel cell in conjunction with an exhaust-fired absorption chiller.

As of January 1, 2013, there were 133 open contracts in the Clean Fuels Program; these are summarized in Appendix B.

Twenty research, development, demonstration and deployment projects or studies and 20 technology assessment and transfer contracts were completed in 2012, as listed in Table 7 (page 59). Appendix C comprises two-page summaries of the technical projects completed in 2012. 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, 2013, after approval by the SCAQMD Governing Board.

2013 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 2007 and 2012 AQMPs. While modest NO_x and $PM_{2.5}$ reductions will be necessary to meet the federal $PM_{2.5}$ standards by 2014, significant NO_x and $PM_{2.5}$ reductions will be necessary to meet the federal 8-hour ozone standard of 80 ppb by 2023 and 75 ppb

by 2032; the 1-hour ozone standard by 2022, which is now required as a result of a recent court case even though EPA had previously revoked this standard; and the newly revised federal annual $PM_{2.5}$ standard of 12 $\mu g/m^3$. Given the need for these significant reductions over the next 10-20 year timeframe, mid- and longer-term alternative fuels, hybrid, electric, and fuel cell based technologies 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, including demonstration and deployment of zero-emission cargo container movement systems;
- 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 8 (page 73) lists the potential projects across the core technologies identified in this report. Potential projects for 2013 total more than $16.2 million, with anticipated leveraging of nearly $69 million. The proposed projects may also be funded by revenue sources other than the Clean Fuels Program, especially VOC and incentive projects.

CLEAN FUELS PROGRAM
2012 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.

2012 Overview

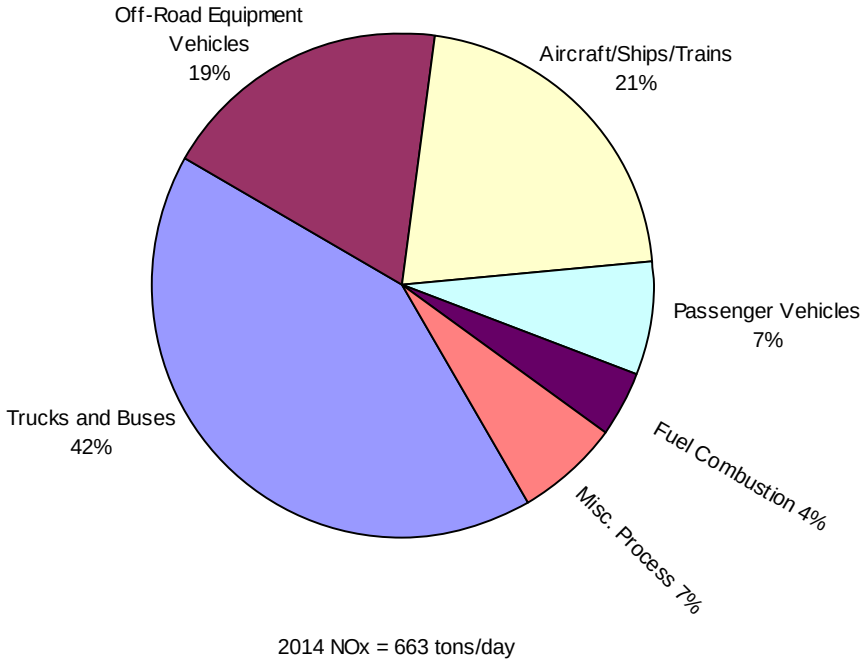
This report summarizes the progress of the SCAQMD Clean Fuels Program for CY 2012. This SCAQMD program co-sponsors projects to develop and demonstrate zero-, near-zero and low-emission clean fuels and advanced technologies and to promote commercialization and deployment of promising or proven technologies 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, 2012, the SCAQMD executed 69 new contracts, projects or studies and modified 10 continuing projects adding additional dollars during CY 2012 that support clean fuels and advanced zero-, near-zero and low-emission technologies. The SCAQMD contribution for these projects was approximately $6.1 million, with total project costs of nearly $26.1 million. These projects address a wide range of issues with a diverse technology mix. This report highlights achievements and summarizes project costs of the SCAQMD Clean Fuels Program in this period. The report also provides information on outside funding received into the Clean Fuels Fund ($1.56 million) as cost-share for contracts executed in this period as well as funds awarded to the SCAQMD for programs that align well with the Clean Fuels Program ($6.2 million in 2012). A status update on the nearly $100 million in federal and state funding awarded to the SCAQMD between 2009 and 2011, again for projects that align well with the Clean Fuels Program, is

also provided. The SCAQMD will continue to pursue federal and state funding opportunities in 2013 to amplify leverage. Indeed, the California Energy Commission (CEC) and California Air Resources Board (CARB) recently issued Program Opportunity Notices offering substantial funding for: hydrogen, electric vehicle charging, and natural gas fueling projects; and zero-emission off-road equipment demonstrations, respectively.

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 and 2012 AQMPs. The estimated baseline 2014 NO_x, VOC and $PM_{2.5}$ emissions inventory is shown in Figure 1. Based on the 2007 and 2012 AQMPs, significant reductions are necessary to demonstrate attainment with the federal standards.



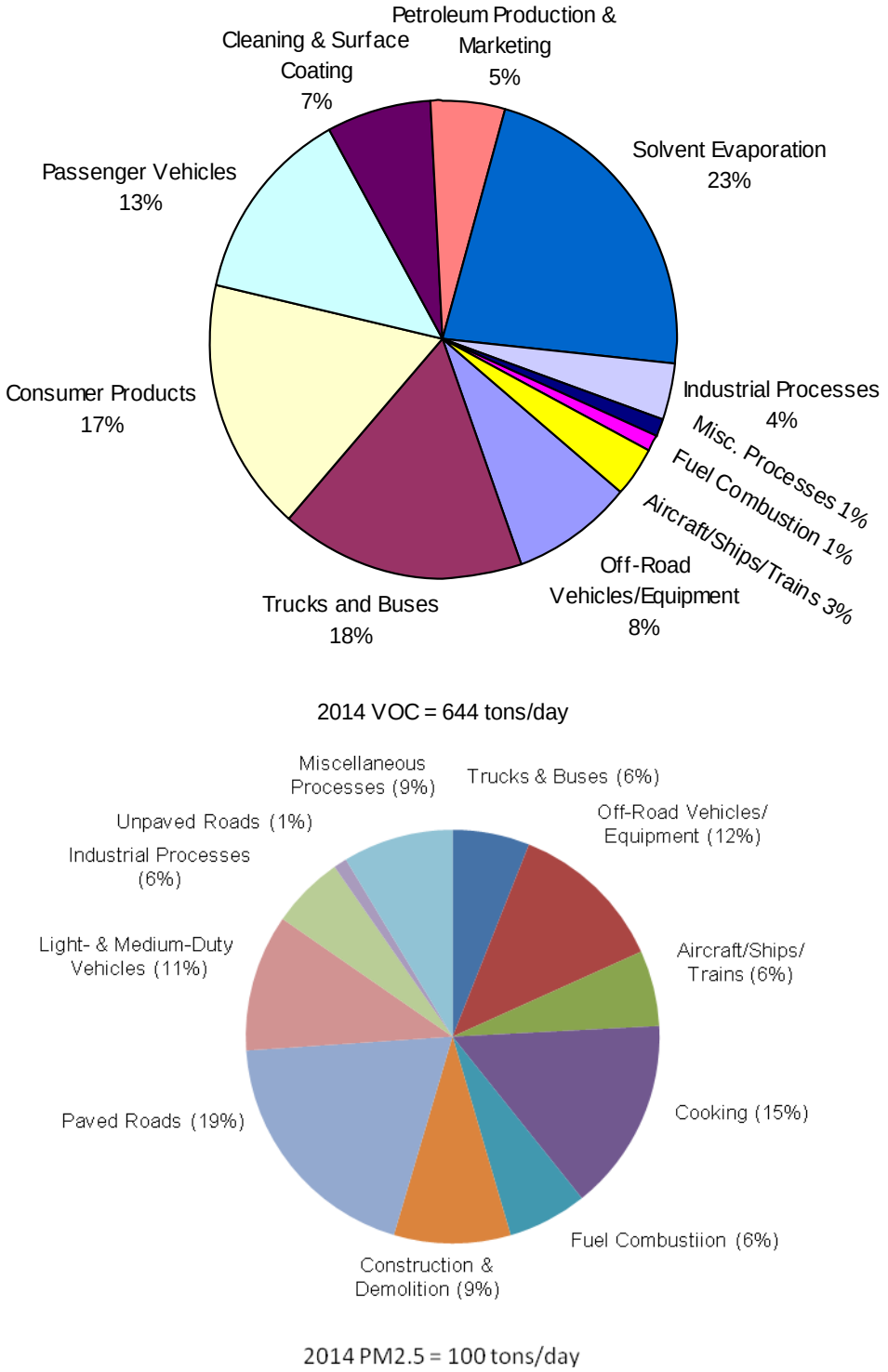


Figure 1: Major Source Contributions (2014)

To fulfill long-term emission reduction targets, the 2007 and 2012 AQMPs rely 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 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. The recently adopted 2012 AQMP identifies the need for approximately 200 tons/day NO_x reductions to

be adopted by 2020 for full implementation by 2023 and in large part focuses control measures for transportation and cleaner fuels with zero-emissions in order to achieve these reductions. This will require the SCAQMD Clean Fuels Program to develop and demonstrate cleaner technologies that can be used as control strategies in the AQMP

Recent health studies also indicate a greater need to reduce NO_x emissions and toxic air contaminant emissions. More importantly, the 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. A MATES IV study was launched in 2012, and while the goal of MATES IV, like the prior studies, will be to assess air toxic levels, update risk characterization, and determine gradients from selected sources, MATES IV has an added ultrafine PM and black carbon monitoring component as well. It is anticipated that a draft report on the findings will be available by late 2013.

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 former Governor (Schwarzenegger) 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 former 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 former Governor signed SB 375 requiring CARB to set regional targets reducing GHG's from cars and light trucks by 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. The current California Governor (Brown) recently released his proposed FY 2013-14 state budget, which consolidates programs funding bicycle, pedestrian and mitigation projects to fund high-priority projects that reduce GHGs consistent with SB 375 objectives. The proposed budget also identifies areas for AB 32 cap-and-trade proceeds including reducing transportation emissions and energy efficiency projects for the electricity and commercial/residential energy sector.

To achieve the goals established by these landmark efforts, last year CARB adopted a LEV III program for Model Year (MY) 2015 to 2025 light- and medium-duty vehicles, amended the Zero-Emission Vehicle Regulation, and amended the Clean Fuels Outlet requirements. These tighter standards for passenger cars and light- and medium-duty trucks will require reduced tailpipe

emissions and nearly no evaporative emissions. CARB also proposed new requirements for zero-emission vehicles lowering the threshold requirement, which means automakers must begin producing zero-emission vehicles by 2016. To achieve the Governor's Executive Order, CARB envisions that 80 percent of vehicles must be all electric, battery electric, hydrogen and/or fuel cell by 2050. In late 2011 CARB also adopted amendments to low-sulfur marine fuel requirements to extend the nautical zone and loosened cargo handling equipment and transportation refrigeration regulations because sufficient retrofit technologies aren't available in the marketplace. In 2011 the Federal government adopted fuel economy and GHG emissions standards for medium- and heavy-duty vehicles for MYs 2014-2018 and propose to move forward with Tier 3 levels for light- and medium-duty trucks and tighter criteria pollutant standards for passenger vehicles.

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's 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 established the five percent administrative cap instead of the previous cap of two-and-half percent.

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 2012 the funds available through each of these mechanisms were as follows:

- Mobile sources (DMV revenues) $12,188,811
- Stationary sources (emission fee surcharge) $313,712

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 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 27) lists the supplemental grants and revenues received in 2012, totaling more than $1.5 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 $3 to $4 of outside funding for each $1 of SCAQMD funding. For 2012, excluding ARRA and other one-time federal opportunities, one-time settlement funds and incentive funding, the Clean Fuels Program leveraged each $1 to slightly more than $3 of 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 2012 are listed in Table 1 (page 14).

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 (emphasizing electric and plug-in hybrid electric trucks and zero-emission container transport technologies)
- Infrastructure and Deployment (predominantly compressed and liquid natural gas)
- Hydrogen and Fuel Cell Technologies and Infrastructure
- Emission Control Technologies
- Engine Systems (particularly heavy-duty natural gas engines for truck and rail applications)
- Fuels/Emissions Studies
- Health Impacts
- 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 while in the beginnings of recovery remains sluggish. 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. Despite such challenges, SCAQMD's Technology Advancement Office (TAO) develops a comprehensive plan annually to accelerate the development and demonstration of cleaner technologies.

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 2007 and 2012 AQMPs 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. In January 2012, CARB adopted the California Zero Emission Vehicle (ZEV) III requirements and amended the ZEV and Clean Fuels Outlet (CFO) regulations. There are alternative strategies allowed to comply with the ZEV regulation, including producing battery electric vehicles, plug-in hybrid electric vehicles (PHEVs), and hydrogen-fueled internal combustion engine (ICE) vehicles.

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). Electric and hybrid technologies are also being explored to address one of the SCAQMD's 2013 and 2014 priorities, which is to continue demonstration and deployment of zero-emission cargo container movement technologies.

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 alcohol-based fuels, propane, hydrogen, hydrogen-natural gas mixtures and even electricity are much less available or accessible, whereas natural gas has recently become more readily available in light of fracking technologies being employed to access the abundant shale gas deposits throughout North America. Nonetheless, to realize emissions reduction benefits, 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 and Fuel Cell Technologies and Infrastructure

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. A survey of the major automakers conducted by the California Fuel Cell Partnership (CaFCP) estimates that there will be approximately 53,000 fuel cell vehicles by 2017, if sufficient hydrogen infrastructure is available. 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 2007 AQMP 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 0.2 g/bhp-hr. 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 heavy-duty transport trucks, transit and school buses, rail operations, 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. Changes to the composition of these two advisory groups are reviewed by the SCAQMD Board on an as-needed basis, and in fact were considered in 2012, with changes to the membership approved by the SCAQMD Board on May 4, 2012. The current members of the SB 98 Clean Fuels Advisory Group are 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.

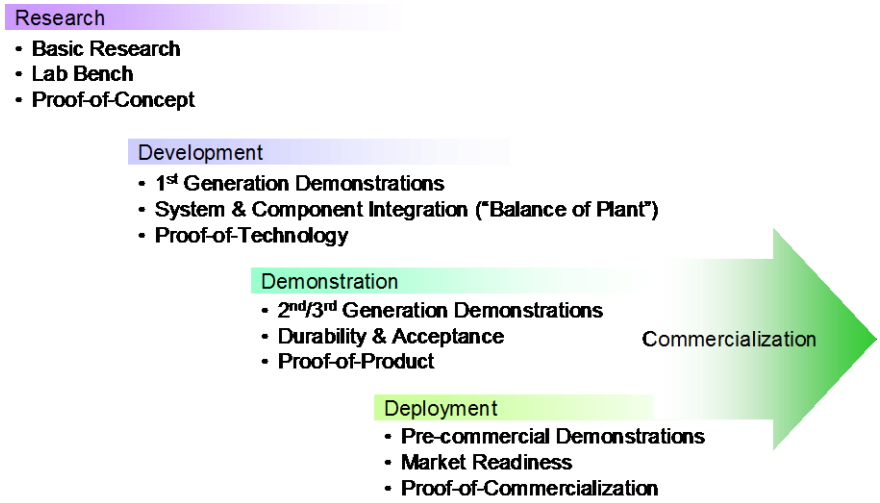


Figure 2: Stages of Clean Fuels Program Projects

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 Power: ISX 15L (LNG), Westport GX 15 L (dual fuel)
- 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;
- Sunline Transit Agency Advanced Fuel Cell Bus projects;
- Commercial Stationary Fuel Cell Demonstration with UTC and SoCalGas (first of its kind); and Orange County Sanitation District hydrogen and combined heat and power generation from biogas using molten carbonate fuel cell technology.

➢ Electric and Hybrid Electric Vehicle Development and Demonstrations
- EPRI hybrid vehicle evaluation study;
- Hybrid electric vehicle demonstrations with SCE, UC Davis and AC Propulsion;
- Plug-in Hybrid Electric Van with EPRI, DaimlerChrysler and SCE;
- Hybrid electric delivery trucks with Azure Dynamics, NREL and FedEx;
- Plug-in hybrid work truck with Odyne Systems;
- Proterra battery electric transit bus and fast charging system;
- Municipal battery electric utility truck;
- South Bay City Council of Governments' electric vehicle project;
- EVI/UPS electric truck; and
- TransPower battery electric heavy-duty truck

➢ Aftertreatment Technologies for Heavy-Duty Vehicles
- Johnson Matthey and Engelhard trap demonstrations on buses and construction equipment; and
- Johnson Matthey SCRT and SCCRT NOx and PM reduction control devices on heavy-duty on-road trucks.

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 2012 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 2012 Project Summaries (beginning page 31) contained within this report.

Table 1: SCAQMD Major Funding Partners in CY 2012

Research Funding Organizations	Major Manufacturers/Providers
California Air Resources Board	Ports of Los Angeles & Long Beach
California Energy Commission	Southern California Gas Company
U.S. & California Departments of Transportation	University of California Riverside/ CE-CERT
U.S. Department of Energy	West Virginia University
U.S. Environmental Protection 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 2012. 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) in-use emissions testing and further demonstration of emission control technologies to reduce NO_x and PM emissions reductions on heavy-duty diesel trucks; (b) a health study developing quantitative cellular assays for use in understanding the chemical basis of air pollutant toxicity.; and (c) stationary clean fuel technologies to reduce fossil fuel emissions by using alternatives such as renewables and fuel cells.

In-Use Emissions Testing & Demonstration of Heavy-Duty Vehicle Retrofit Technologies

On-road heavy-duty engines are now subject to the 2010 U.S. EPA emissions standards of 0.01 gram per brake-horsepower-hr (g/bhp-hr) PM and 0.20 g/bhp-hr NO_x. Some engine manufacturers are using emissions credits which allow them to produce a mixture of engines certified at, below, or above 0.20 g/bhp-hr NO_x. This mixture of engines allows engine manufacturers to comply with the emissions standards on an average basis. These engines are either stoichiometric engines with three-way catalysts or lean-burn engines equipped with exhaust gas recirculation (EGR), selective catalytic reduction (SCR) and/or diesel particulate filter (DPF) technology. While limited-scale studies have shown reduced NO_x and PM emissions from trucks powered by compliant engines, other studies indicate a potential increase in some exhaust emissions. In particular, in a heavy-duty in-use emissions measurement study conducted by the University of Colorado, ammonia emissions from liquefied natural gas trucks were found to be significantly higher due to the nature of spark-ignited engines. Studies conducted by The Netherland Organization (TNO) indicated that heavy-duty diesel engines equipped with SCR technologies have higher NO_x exhaust emissions than their certified levels. As such, additional studies are required to assess the impact of the technologies on emissions from engines used in a variety of applications, particularly since the number of these engines will continue to increase in the future.

In 2011, the SCAQMD executed contracts with the University of California Riverside (UCR) and West Virginia University (WVU) to conduct in-use emissions testing, and if needed, to evaluate emission-reduction potential of retrofit technology on existing and new on-road heavy-duty engines. Both WVU and UCR will perform chassis dynamometer tests of in-use emissions of total hydrocarbons, nitrogen dioxide, nitric oxide, NO_x, CO, PM, ammonia, formaldehyde, and toxic air

Figure 3: WVU Transportable Chassis Dynamometer

Figure 4: UCR/CE-CERT Chassis Dynamometer

contaminants from the test vehicles. In addition, if the dynamometer tests results show emissions higher than state or federal allowable limits, WVU will design an oxidation catalyst or identify an alternative retrofit technology capable of reducing ammonia and formaldehyde emissions from natural gas vehicles. The designed or identified retrofit technology will be installed on up to three of the natural gas vehicles, which have three-way catalysts and tested on the chassis dynamometer to assess the performance and emission-reduction potential of the technology.

In late 2011 the Ports of Los Angeles and Long Beach expressed interest in providing cofunding to test additional heavy-duty drayage vehicles. Consequently, both contracts were amended in 2012 to add the augmented funding from the Ports to conduct an additional 11 in-use emissions tests of heavy-duty drayage vehicles. Additional Clean Fuels funds were also added to the WVU's contract to assess in-use emissions from a 2010 U.S. EPA compliant heavy-duty vehicle as the vehicle is driven over a 2,500-mile route between Morgantown, West Virginia, and Riverside, California.

Demonstration of NO_x and PM Emissions Control Technology on Diesel-Powered Construction Equipment

Aftertreatment emission control technologies have shown substantial emission reductions in diesel engines and have been widely adopted for heavy duty on-road diesel engines. These technologies include diesel particulate filters (DPFs), oxidation catalysts, and selective catalytic reduction (SCR) systems. Application of these technologies to heavy-duty off-road equipment is now occurring for new engines to meet Tier 4 standards.

Use of these technologies in heavy-duty off-road retrofit applications for older in-use engines offers early and cost-effective emission reductions. However, technologies that are successful in new on-road vehicles, such as combined DPF and SCR systems, may be difficult to transfer to in-use off-road equipment because of limited space for component installation and more severe shock/vibration conditions than on-road conditions. Successful demonstrations, particularly with in-use equipment, facilitate fleet acceptance, regulatory approval, and provide real-world experience to technology developers.

Figure 5: Off-Road Equipment Equipped with Retrofit Technology

In 2012, a contract was executed with Puritech US, LLC to demonstrate a novel retrofit technology for in-use heavy duty

diesel-powered construction equipment. The technology includes a diesel particulate filter, a non-selective catalytic converter, and a diesel fuel injection system. This system will provide reductions in particulate emissions and NO_x. Although offering less NO_x reduction than SCR, this technology may be more readily implemented in off-road equipment due to reduced design and installation complexity compared to combined SCR and DPF systems. The technology being demonstrated will potentially provide average emission reductions over 85% for PM and over 50% for NO_x from older in-use equipment.

This demonstration includes installation of the technology on a 410-hp Tier 2 bulldozer and a 480-hp Tier 1 steel wheel compactor. After retrofit, the equipment will be operated for a minimum of 1000 hours at a landfill site. During the demonstration period, the equipment will be monitored for backpressure, exhaust temperature, and NO_x emissions. Information from the demonstration will be used to compare emissions reductions, durability, and cost effectiveness to SCR/DPF retrofit technologies. This project may also be used as part of the durability demonstration required for CARB verification.

Develop Quantitative Cellular Assays for Use in Understanding the Chemical Basis of Air Pollutant Toxicity

Current regulatory efforts are focused on reduction of emissions of motor vehicles, including diesel fueled vehicles involved with goods movement in Southern California. These reductions are aimed at meeting ambient air quality standards for PM10 and PM2.5 as well as reducing exposure to toxic air contaminants. As lower emitting technologies are deployed and particle emissions go down, however, a question remains as to the toxicity of the remaining emissions. Although advanced technologies are very effective at lowering the mass of emissions, there are concerns that other substances such as volatile and semi-volatile organic compounds may be emitted that have potential health effects.

The objective of this research is to develop a biological mechanism based analytical procedure to characterize the toxicity of air pollutants. The initial phase of the study will be to develop and characterize a standard in quantities sufficient to be employed in subsequent toxicity analyses of vehicle emissions and ambient pollutants. Quantitative dose response toxicity assays can then be conducted with, for example, emissions from advanced technology engines to compare with results from assays using the standard diesel emissions. This will provide a measure of the relative toxic potency of vehicle emissions that can be directly compared in standard assays.

Once developed, the procedures may be used to address questions such as which specific chemicals in pollutant samples are associated with cellular toxicity, to assess the relative effects of particulate versus vapor phase of emissions, and to compare toxic responses of emissions from different fuel types. These results will be important in forming the scientific basis to quantify how reducing emissions and promoting alternate technologies may improve public health.

The results of this project will provide information to help understand the linkage between sources, chemical composition, and the toxicity of emissions from motor vehicles, which will provide a strong scientific basis on which to develop and to assess strategies designed to protect the public from exposure to motor vehicle emissions.

Demonstrate 300kW Molten Fuel Cell Along with An Exhaust-Fired Absorption Chiller

The Board has long supported the development and demonstration of stationary fuel cells as demonstrated by the SCAQMD's ONSI 200kW PC-25 Phosphoric Acid Fuel Cell demonstration project for stationary power generation in 1993. Although this fuel cell is no longer in operation, SCAQMD recognizes the need for additional clean distributed generation (DG) infrastructure for growing energy demand. Major attributes of DG include the reduction of transmission and distribution line losses, the capture and use of waste heat, and increased electric power reliability for the consumer. Fuel cells produce almost zero criteria pollutant emissions, and they are extremely

quiet. Fuel cells can also be designed to capture process waste heat, and this recovered heat can be used for space heating, heating water and, when connected to an absorption chiller for building cooling. The UCI project, Development and Demonstration of a Novel High-temperature Fuel Cell Absorption Chiller System, was awarded $1,480,000 from the CEC. By demonstrating these fuel cells, the commercialization for many diverse applications from commercial to residential can be accelerated along with public awareness of this clean fuel technology.

UCI proposes a combined cooling, heat and power (CCHP) system that will be installed on the University of California, Irvine campus at the Multipurpose Science and Technology Building. This system integrates a highly efficient, high-temperature molten carbonate fuel cell with an exhaust-fired absorption chiller, which utilizes the exhaust heat from the fuel cell to generate cooling. The system will provide 300 kW of reliable, clean electricity and 40 tons of cooling to the campus building, while producing virtually zero criteria pollutants. Overall the system is expected to achieve an efficiency approaching 70%. The goal of the project is to provide a "showcase" installation that will inform the California architectural and developer communities to the attributes of fuel cell based CCHP technology.

Figure 6: Artist Rendering of "Showcase" Installation

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 2012 reporting period illustrate the impact of the SCAQMD's technology deployment and commercialization efforts.

Demonstration of Battery and Neighborhood Electric Vehicles

In July 2012, the SCAQMD awarded co-funding to South Bay Cities Council of Governments (SBCCOG) to demonstrate Battery Electric Vehicles (BEVs) in the South Bay Cities region where the Local Use Vehicle demonstration project has promoted the use of Neighborhood Electric Vehicles (NEVs) with local residents, select businesses, municipalities and government entities. A demonstration of longer range BEVs will help address some limitations of the previous NEV demonstration project and provide guidance for community planning efforts for new BEV models that have recently become available.

The SBCCOG has demonstrated Neighborhood Electric Vehicles (NEVs) in their Local Use Vehicle (LUV) program with about 100 drivers and found that NEVs can provide on an average 26% of the total commuter trips and 23% to 33% emission reductions. Beginning in June 2009, SBCCOG evaluated NEVs from several manufacturers for local applications. The LUV project is demonstrating six NEVs by testing additional community applications such as retiree and multi-family residences and commercial uses.

Figure 7: Local Use vehicles ready for demonstration (2009 – early 2013)

Participants in the SBCCOG NEV demonstration project needed access only to 110V (Level 1) Electric Vehicle Supply Equipment (EVSE). BEVs have larger battery packs, longer range, and may need 220V (Level 2) charging infrastructure. Since the South Bay is a built-out community with older electrical infrastructure, SBCCOG wants to determine the minimal level of charging access required to make BEV usage successful. Participants will vary in their existing access to electricity, which will start with Level 1 charging and an opportunity to try Level 2 charging will be provided by this project.

The BEV demonstration is intended to leverage the previous LUV program and encourage deployment of BEVs in appropriate applications, provide usage data for policy making decisions, complement ongoing and planned initiatives such as sub-regional PEV Readiness Planning, and analyze the transition from current passenger vehicles to include BEVs.

Figure 8: Battery Electric Vehicles to be demonstrated by SBCCOG (2013-2015)

Develop & Demonstrate Natural Gas-Powered Police Pursuit Vehicle (PPV)

Law enforcement and emergency vehicles are exempt from California's tailpipe emission standards. In addition, these vehicles are also not subject to the SCAQMD's Fleet Rules, which require public fleets and private fleets under contract with most public agencies to purchase and operate clean and alternative fuel vehicles. Law enforcement agencies are expressing an interest in using natural gas powered vehicles to reduce emissions from their jurisdiction and potentially reduce vehicle operating costs. However, the primary concern of law enforcement is vehicle performance and where, not necessarily if, a natural gas powered police vehicle can be utilized. Most law enforcement agencies have deployed the Ford Crown Victoria for much of its police vehicle work. The Ford Crown Victoria is the flagship of most police agencies throughout the country. Ford discontinued production of this vehicle following the 2011 model year. Since most law enforcement agencies deploy the Ford Crown Victoria and have a history with its performance, this project will provide law enforcement agencies the opportunity to compare comparable vehicles utilizing different fuel types. The demonstration vehicle is a 2011 FCV with the 4.6L V-8 that is converted from gasoline power to dedicated CNG.

A-1 Alternative Fuel Systems (AFS) is a Fresno, California, based company which converts light- and medium-duty vehicles to CNG and is the lead contractor on this project. The demonstration vehicle is a fully outfitted PPV including light bar, hard rear seat, prisoner screen, push bumper, and multi-jurisdictional radio. The CNG system is manufactured by Impco Technologies, and the vehicle is outfitted with 15.1 GGE Type 3 CNG tanks. The PPV has upgraded brakes and suspension.

The demonstration will occur over a two year period and has attracted interest from more than a dozen cities and law enforcement agencies in the SCAQMD jurisdictional area. Due to the overwhelming interest in this project, a second police vehicle demonstration program is under development which will utilize a different make of vehicle. .

Figure 10: PPV Converted to Natural Gas (side view)

Figure 9: PPV Converted to Natural Gas (back view)

2012 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, 2012.

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, 2012, a total of 79 contracts, projects or studies that support clean fuels were executed or amended, as shown in Table 2 (page 24).

The major technology areas summarized are: hybrid/electric technologies, infrastructure and deployment, fuels/emission studies, emission control technologies, hydrogen technology and infrastructure, mobile fuel cell technologies, engine systems, stationary clean fuel technologies, health impacts studies, outreach and technology transfer. The distribution of funds based on technology area is shown graphically in Figure 11 (page 22). 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 2012 reporting period are shown below with the total projected project costs:

- SCAQMD Clean Fuels Fund Contribution $6,087,173
- Total Cost of Clean Fuels Projects $26,050,998

Each year, the SCAQMD Governing Board approves funds to be transferred to the General Fund Budget for Clean Fuels administration. For 2012, the Board transferred $700,000 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, 2012, are included within this report. Any portion of the Clean Fuels Funds not spent by the end of Fiscal Year 2012-13 ending June 30, 2013, 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 $1,519,241 is listed within Table 3 (page 27). Appendix B lists all Clean Fuels Fund contracts, totaling 133, that were open and active as of January 1, 2013.

For Clean Fuels executed and amended contracts, projects and studies in 2012, the average SCAQMD contribution is approximately 23 percent of the total cost of the projects, identifying that each dollar from the SCAQMD was leveraged with more than three dollars of outside investment.

During 2012, the SCAQMD executed contracts, projects, studies or contract amendments with additional funding of approximately $6.1 million for Clean Fuels projects. The distribution of funds is shown in Figure 11 below.

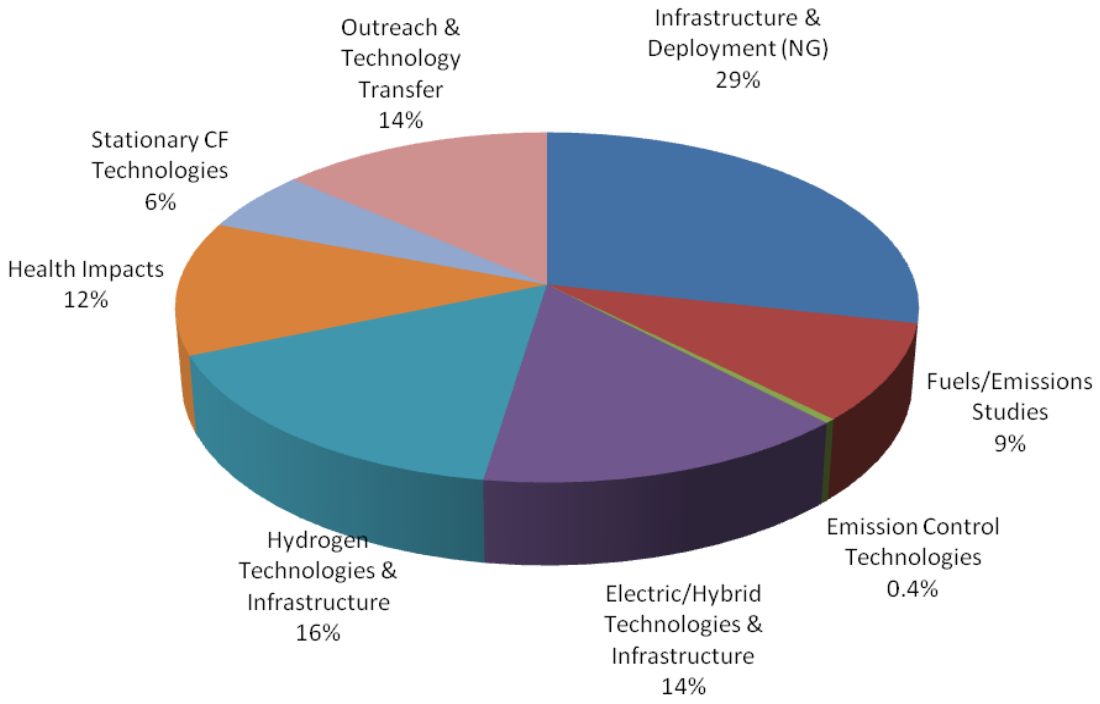


Figure 11: Distribution of Funds for Executed Clean Fuels Projects CY 2012 ($6.1 million)

As noted in the last annual report, the SCAQMD applied and was awarded nearly $100 million between 2009 and 2011 through the American Recovery and Reinvestment Act as well as other federally and state-funded programs to implement projects that align well with the Clean Fuels Program. The SCAQMD continued to seek funding opportunities and in 2012 was awarded an additional $6,198,993 for similar complementary projects. Table 4 (page 28) provides a breakdown of these $6.2 million awards. Table 5 (page 28) provides an update and project status of the $100 million in awards from 2009 and 2011.

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, 2012, the firm of Simpson and Simpson, CPAs 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. Simpson and Simpson CPAs 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 79 new and continuing contracts, projects and studies that received SCAQMD funding in 2012 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, 2012

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment						
11548	Mansfield Gas Equipment Systems, Inc.	Buydown Incentive Program for CNG Home Refueling Appliance "Phill"	09/07/12	06/30/14	60,000	$ 356,000
11561	SuperShuttle International	Convert 34 Passenger Vans to Natural Gas-Power for Deployment as Airport Ground Transportation	06/01/11	10/31/14	144,300	144,300
12259	A-1 Alternative Fuel Systems	Demonstrate Natural Gas-Powered Police Vehicle	04/20/12	10/19/14	65,000	65,000
12267	West Covina Unified School District	Upgrade CNG Fueling Facility	10/12/12	12/31/17	60,000	60,000
12273	Border Valley Trading Ltd.	Construct LNG Fueling Station	02/10/12	07/30/13	251,865	504,030
12386	Agility Fuel Systems	Demonstrate Natural Gas-Powered Police Vehicle	06/01/12	06/30/13	54,000	54,000
12851	Clean Energy	Construct Two LNG Fueling Stations	10/05/12	12/31/18	400,000	3,018,118
12852	City of Covina	Construct Public Access CNG Fueling Station	10/12/12	12/31/18	200,000	618,429
12854	Waste Management, Inc.	Upgrade LNG Fueling Station at Baldwin Park Facility	08/17/12	12/31/18	300,000	1,588,100
13059	Rim of the World Unified School District	Construct CNG Fast-Fill Station	10/05/12	01/31/18	200,000	400,000
Fuels/Emissions Studies						
11611	West Virginia University Research Corporation	In-Use Emissions Testing and Demonstration of Retrofit Technology for On-Road Heavy-Duty Engines	07/08/11	10/07/13	239,368	302,343
11612	University of California Riverside	In-Use Emissions Testing and Demonstration of Retrofit Technology for On-Road Heavy-Duty Engines	08/26/11	08/25/13	76,638	76,638
12154	University of California Riverside/CE-CERT	Cellulosic Biofuel Feedstock Analysis	01/20/12	03/31/13	235,000	235,000
Emission Control Technologies						
12124	Gaio Trucking, Inc.	Retrofit Heavy-Duty Diesel Trucks with Diesel Particulate Filters	09/28/11	03/31/14	(5,000)	(18,408)
12150	Puritech US, LLC	Demonstrate NO_x and PM Emission Control Technologies on Diesel-Powered Construction Equipment	02/14/12	04/30/13	72,000	172,000
12186	Pipeline Carriers Inc.	Retrofit Heavy-Duty Diesel Trucks with Diesel Particulate Filters	12/16/11	09/30/14	(75,000)	(75,000)
12485	California State University Long Beach Foundation	CSULB CEERS Student Education Study for Development of a Humid Air System and Exhaust Scrubber for Diesel Engine Emissions Reduction	06/29/12	03/31/13	28,000	28,000

Table 2: Contracts Executed or Amended (w/$) between January 1 & December 31, 2012

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Electric/Hybrid Technologies						
99109	Toyota	Lease One Toyota RAV4 Electric Vehicle	04/04/09	02/01/13	3,951	$ 3,951
09345	South Bay City Council of Governments	Demonstrate Medium-Speed Electric Vehicles	06/19/09	04/30/13	119,815	230,478
12020	Coulomb Technologies	Install Electric Charging Infrastructure	10/05/12	04/04/14	70,000	70,000
12825	BMW of Monrovia	Lease Two BMW ActiveE Electric Vehicles for Two Years	03/23/12	03/22/14	31,065	31,065
12889	BMW of Monrovia	Lease Two BMW ActiveE Electric Vehicles for Two Years	03/23/12	03/22/14	31,065	31,065
13042	South Bay City Council of Governments	Demonstrate Battery Electric Vehicle	11/02/12	05/01/15	320,000	528,078
13251	Selman Chevrolet Company	Lease Two 2012 or Newer Chevrolet Volt Extended-Range Electric Vehicles for Three Years	11/28/12	11/27/15	31,375	31,375
Direct Pay	Dept. of Motor Vehicles	DMV Title Transfers for 20 Converted MY2010 Ford Escape Hybrid Vehicles to Plug-In Hybrid Electric Vehicles using Advanced Lithium-Ion Battery Systems	07/13/12	07/13/12	9,000	9,000
Direct Pay	Fladeboe CODA	Purchase Two 2012 CODA Electric Vehicles	08/31/12	08/31/12	82,000	82,000
Direct Pay	Longo Toyota	Purchase Two Toyota Prius Plug-In Hybrid Vehicles	08/08/12	08/08/12	88,000	88,000
Direct Pay	South Bay Cities Council of Governments	Develop Zero Emission Vehicle Demonstration Project and Implementation Plan	03/30/12	9/21/12	19,983	19,983
Purchase Order	ATVLS, Inc.	Install Electric Vehicle Chargers	06/26/12	09/20/12	20,182	20,182
Purchase Order	Clean Fuel Connection Inc.	Install Electric Vehicle Chargers	01/01/12	08/30/12	11,266	11,266
Purchase Order	On Target Electric, Inc.	Install Electric Vehicle Chargers	02/07/12	10/03/12	28,946	28,946
Transfer	The Hartford	Insurance Coverage for Hybrid Vehicles in SCAQMD's Demonstration Fleet	08/30/12	08/30/12	12,000	12,000
Hydrogen Technologies & Infrastructure						
07292	University of California Irvine	Develop Hydrogen Storage Capability for Gas Blending Facility	08/31/12	06/30/13	200,000	688,000
10061	Hydrogenics Corporation	Maintenance and Data Management for SCAQMD's Hydrogen Station	10/30/09	12/30/13	130,000	130,000
11555	University of California Los Angeles	Construct Hydrogen Fueling Station	12/07/12	12/31/19	400,000	2,589,990
12057	Linde, LLC	Expand Hydrogen Fueling Infrastructure	11/02/12	11/02/18	250,000	2,732,177
13146	California State University Los Angeles	Lease One Toyota Prius Hydrogen-Fueled Vehicle	11/08/12	03/31/14	0	0

Table 2: Contracts Executed or Amended (w/$) between January 1 & December 31, 2012

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Hydrogen Technologies & Infrastructure (cont'd)						
Direct Pay	Smart Chemistry	Hydrogen Fuel Analyses for SCAQMD's Hydrogen Station	04/11/12	05/20/12	4,000	$ 4,000
Health Impacts Studies						
12197	University of California Riverside/CE-CERT	Health Effects of PM Particles from Heavy-Duty Biodiesel-Fueled Vehicles	01/13/12	09/12/13	207,500	207,500
12208	University of California Riverside/CE-CERT	Determine the Physical and Chemical Composition and Associated Health Effects of Tailpipe PM Emissions	01/21/12	07/19/13	175,000	1,375,000
12865	University of California Los Angeles	Develop Quantitative Cellular Assays for Use in Understanding the Chemical Basis of Air Pollutant Toxicity	06/08/12	07/07/14	368,457	368,457
Stationary Clean Fuel Technologies						
10723	Eastern Municipal Water District	Retrofit Digester Gas Engine with NO_xTech Aftertreatment Emission Control Technology	03/16/12	03/15/13	85,000	889,000
13030	University of California Irvine	Demonstrate 300kW Molten Fuel Cell with Exhaust-Fired Absorption Chiller	10/12/12	04/11/15	257,500	4,013,500
Outreach & Technology Transfer						
10700	TIAX LLC	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Technologies	07/23/10	05/31/13	70,000	70,000
11117	Clean Fuel Connection Inc.	Technical Assistance for Alternative Fuels, Renewable Energy and Electric Vehicles	09/17/10	12/31/12	41,000	41,000
12064	Joseph C. Calhoun, P.E., Inc.	Technical Assistance with Low- and Zero-Emission Vehicles, Technology and Emissions Analysis	06/01/12	12/31/14	20,000	20,000
12214	Calstart	Development, Initiation & Implementation of a Clean Vehicle Outreach Project	01/27/12	10/29/12	12,000	12,000
12309	TIAX LLC	Technical Assistance with Low- and Zero-Emission Vehicles, Fuel Cells and Fueling Infrastructure	04/06/12	04/05/14	75,000	75,000
12312	Calstart	Technical Assistance with Low- and Zero-Emission Technology, Goods Movement, Alternative Fuels, Transit Applications and Fueling Infrastructure	03/29/12	10/29/12	12,181	12,181
12313	CSA America Inc.	CNG Fuel System Inspection Certification Courses	07/13/12	05/31/13	14,100	28,200
12380	The Tioga Group	Technical Assistance Related to Emissions, Advanced Technologies and Goods Movement	04/13/12	04/30/14	25,000	25,000

Table 2: Contracts Executed or Amended (w/$) between January 1 & December 31, 2012

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (cont'd)						
12381	Integra Environmental Consulting Inc.	Technical Assistance Related to Emission Inventories, Goods Movement and Off-Road Sources	04/06/12	04/30/14	25,000	$ 25,000
12453	Tech Compass	Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis and Aftertreatment Technologies	06/21/12	05/30/14	75,000	75,000
13052	The Better World Group	Assist with Completing & Publicizing SCAQMD's Clean Air Tips Celebrity Video	11/16/12	11/30/12	11,000	11,000
13081	Burnett & Burnett	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Technologies	11/01/12	04/30/14	40,000	40,000
13194	Clean Fuel Connection Inc.	Technical Assistance with Alternative Fuels, Renewable Energy and Electric Vehicles	12/07/12	12/06/14	30,000	30,000
13198	Gladstein, Neandross & Associates, LLC	Technical Assistance with Alternative Fuels, Emissions Analysis and On-Road Sources	12/14/12	12/13/14	75,000	75,000
Direct Pay	Electric Drive Transportation Association	Support National Education Campaign, Participate as 2013 Membership and Cosponsor 2013 Conference	10/01/12	09/30/13	50,000	1,000,000
Direct Pay	Various	Cosponsor 18 Conferences, Workshops & Events plus 3 Memberships	01/01/12	12/31/12	244,516	2,694,546

Table 3: Supplemental Revenue Grants Received into Clean Fuels Fund between Jan. 1 & Dec. 31, 2012

Revenue Agreement	Revenue Source	Project Title	Contractor	SCAQMD Project	Project Total $
10739	U.S. Dept. of Energy/Clean Cities Petroleum Reduction Technologies Prog.	Purchase of CNG Shuttle Vans	SuperShuttle International Inc.	#11561	$ 38,150
11617	Southern California Gas Company	Natural Gas-Powered Vehicle Training and Safety and Fuel Cylinder Inspection Program	CSA America Inc.	#12313	14,100
12152	California Energy Commission	Construct New Natural Gas Fueling Stations	Border Valley Trading; City of Covina; Clean Energy; Rim of the World USD; & Waste Management	#12273; #12852; #12851; #13059; #12854	1,351,865
12877	Ports of Long Beach & Los Angeles	In-Use Emissions Testing & Demonstration of Retrofit Technology of On-Road Heavy-Duty Engines	West Virginia University; & University of California Riverside	#11611; #11612	153,276
					$1,557,391

Table 4: Summary of Federal & State Funding Awarded between Jan. 1 & Dec. 31, 2012

Awarding Entity or Program	Award Date	Purpose	Contractors	Project Total $
DOE DE-FC26-08NT06812	Oirg: 9/30/08 Current: 07/01/12	Plug-In Hybrid Electric Urban Delivery Truck Technology Demonstration	Volvo Technology of America, Inc. Contract #12862	$ 984,000
U.S. EPA DERA DE-00T96201-1	09/11/12	Replace 50 Medium Heavy-Duty Diesel Trucks with New Full Electric Battery-Powered Medium Heavy-Duty Vehicles	RFP closed 09/12/13	1,045,993
Dept. of Energy Vehicle Technologies Program DE-EE0005961	09-28-12	Develop, Demonstrate and Deploy at least 13 Class 8 Battery Electric Heavy-Duty Trucks and Fuel Cell Hybrid Electric Trucks **(Revenue Agreement #13082 – Executed 10/30/12)**	4 Contractors	4,169,000
				$6,198,993

Table 5: Update of Federal & State Funding Awarded between Jan. 1, 2009 & Dec. 31, 2011

Awarding Entity or Program	Award Date	Purpose	Contractors	Project Total $
U.S. EPA/DERA DE 96085601	02/03/09	Retrofit 200 Heavy-Duty Trucks with Diesel Particulate Filters **(Revenue Agreement #09320 – Executed 02/18/09) – Project Completed**	Various	$ 1,000,000
CARB (from U.S. EPA/DERA Program) G08-DERA-02	05/22/09	Placement of up to 43 aftertreatment devices (retrofit traps) on public school buses operating on diesel fuel **(Revenue Agreement #G-08-DERA-02 – Executed 05/22/09) – Project Completed**	3 School Districts	898,000
U.S. EPA/DERA Program EM-00T16601	09/25/09	Implement Heavy-Duty Diesel Drayage Truck Replacement Program **(Revenue Agreement #10119 – Executed 10/28/09)**	Various	7,500,000
U.S. EPA/DERA Program (Emerging Technologies) 2A 83442501 2A 83442101	08/31/09	Implement program to optimize and demonstrate selective catalytic regenerating and selective catalytic continuously regenerating technologies on on-road heavy-duty diesel trucks **(Revenue Agreements #10064 & #10063 - Executed 10/20/09) Project Completed**	Johnson Matthey Contracts #10696 and #10697	4,000,000
Dept. of Energy/ Transportation Electrification Program DE-EE0002549	12/14/09	Develop U.S. manufactured next-generation batteries and electric vehicles and to fully integrate plug-in hybrid electric vehicle systems for 378 medium-duty utility and delivery trucks and shuttle buses **(Revenue Agreement #10193 - Executed 03/25/10) – project in progress**	Electric Power Research Institute Contract #10659	45,443,332
Dept. of Energy/ Clean Cities Program DE-EE0002562	12/18/09	Expansion of an LNG corridor from Ontario to Las Vegas, which would include both vehicles and infrastructure and be implemented in conjunction with the United Parcel Service (UPS) (Revenue Agreement #10467 - Executed 03/04/10) – project in progress	4 Contractors	5,591,611

Table 5: Update of Federal & State Funding Awarded between Jan. 1, 2009 & Dec. 31, 2011 (cont'd)

Awarding Entity or Program	Award Date	Purpose	Contractors	Project Total $
Dept. of Energy/ Clean Cities Program DE-EE0002547	12/18/09	Implement a natural gas drayage truck replacement program **(Revenue Agreement #10480 - Executed 1/26/10) – projects in progress**	Various	$ 9,408,389
Dept. of Energy/ Clean Cities Program DE-EE0002545	03/12/10	Ontario LNG Station Upgrade **(Revenue Agreement #10685 - Executed 05/07/10) – project in progress**	TBD	150,000
U.S. EPA EM 00T34701	04/21/10	Truck Replacement (diesel to diesel and diesel to zero emission), install shorepower to two ships, demonstrate a combined diesel particulate filter and selective catalytic reduction system on two tugboat engines. **(Revenue Agreement #10707 – Executed 05/06/10) – pass-through contracts in process**	4-5 Contractors	5,000,000
U.S. EPA DE 83420301	04/28/09	Develop & Demonstrate SCRT® for NO_x and PM Emissions Control **(Revenue Agreement #09405 - Executed 06/02/09) – Project Completed**	Johnson Matthey, Inc. Contract #10069	900,000
U.S. EPA DE-83468501	06/23/10	Demonstrate Emerging Technologies Advanced Maritime Emissions Controls **(Revenue Agreement #11030 – Executed 07/23/10) – Pass-through contracts in process**	Advanced Cleanup Technologies Inc.	1,500,000
U.S. EPA DE 00T37701	06/30/10	National Clean Diesel Program – School Bus Replacement **(Revenue Agreement #11029 - Executed 07/16/10) – Deliverables Completed**	Various	1,065,465
California Energy Commission ARV-09-003	09/02/10	Develop U.S. manufactured next-generation batteries and electric vehicles and to fully integrate plug-in hybrid electric vehicle systems for 378 medium-duty utility and delivery trucks and shuttle buses **(Revenue Agreement #11043 - Executed 09/02/10) – project in progress**	Electric Power Research Institute Contract #106591	5,000,000
California Energy Commission/AB118	09/10/10	Alternative and Renewable Fuel and Vehicle Technology Program – Construct & Install One NG Fueling Station **(Revenue Agreement #12286 – Executed 02/22/12)**	Earth Energy Fuels	300,000
California Energy Commission ARV-09-002	10/07/10	Implement LNG Drayage Truck Replacement Program **(Revenue Agreement #11040 - Executed 10/07/10) – project in progress**	Various	5,142,000
California Department of Transportation	06/15/11	Replace Existing Heavy-Duty Diesel Trucks with New Heavy-Duty Natural Gas Trucks **(Revenue Agreement #11458 – Executed 07/12/11)**	Various	1,799,612
California Air Resources Board(AB 118	04/05/11	Purchase Cordless Electric Lawnmowers **(Revenue Agreement #11595 – Executed 04/05/11)**	Various	494,314
U.S. EPA (Clean Air Technology Initiative Program) A 00909411	12/15/10	Demonstrate Battery Electric Heavy-Duty Trucks & Install Air Filtration Systems at Schools or Community Centers **(Revenue Agreement #11530 – Executed 01/11/11) – Project Completed**	TransPower Contract #11614 and IQAir North America #13055	400,000
U.S. EPA EM-83493501	07/14/11	Implement Garden Equipment and Boiler Efficiency Incentive Programs to Demonstrate Reductions in Ozone and PM2.5 Air Pollution in LA-San Bernardino Nonattainment Areas (Revenue Agreement #11598 – Executed 3/25/11)	Various	1,270,000

Table 5: Update of Federal & State Funding Awarded between Jan. 1, 2009 & Dec. 31, 2011 (cont'd)

Awarding Entity or Program	Award Date	Purpose	Contractors	Project Total $
California Energy Commission ARV-10-045	05/20/11	Administer the SoCalEV Infrastructure Project (Install or Upgrade Up to 315 Electric Vehicle Charging Stations throughout Southern California) **(Revenue Agreement #12295 – Executed 03/22/12)**	Various	$ 840,750
California Air Resources Board (AB 118 AQIP)	08/10/11	Demonstrate Combined DPF and SCR Technologies on Marine Vessels **(Revenue Agreement #12022 – Executed 08/10/11)**	HUG	439,000
U.S. Department of Energy (Clean Cities Program)	09/26/11	Plug-In Electric Vehicle Infrastructure Planning **(Revenue Agreement #12167 – Executed 11/12/11)**	6-7 Contractors Pending	1,000,000
Southern California Gas Company	06/24/11	Develop, Integrate & Demonstrate Heavy-Duty Natural Gas Engines and Vehicles **(Revenue Agreement #11722 – Executed 06/24/11)**	National Renewable Energy	500,000
California Department of Transportation	06/15/11	Replace Existing Heavy-Duty Diesel Trucks with New Heavy-Duty Natural Gas Trucks **(Revenue Agreement #11458 – Executed 07/12/11)**	TBD	1,799,612
				$99,642,473

Project Summaries by Core Technologies

The following represents summaries of the contracts, projects and studies executed or amended with additional dollars in 2012. 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

11548: Buydown Incentive Program for CNG Home Refueling Appliance "Phill"

Contractor: Mansfield Gas Equipment Systems, Inc.	SCAQMD Cost-Share	$ 60,000
	Cosponsor	
	MSRC/AB 2766 Discretionary Fund Program	296,000
Term: 09/07/12 – 06/30/14	Total Cost:	$ 356,000

Gasoline and diesel fueled mobile sources are a significant source of emissions in the SCAQMD and alternative fueled vehicles are a means of reducing these emissions. This project will continue the momentum for the expansion of natural gas home refueling appliances and passenger car alternative fuel vehicles. This project, in conjunction with the MSRC will provide a buy-down incentive of $2,000 per eligible consumer towards the purchase and installation of the CNG home refueling appliance, marketed under the name Phill. The program objective is to promote the introduction and utilization of Advanced Technology/Partial Zero Emission (AT-PZEV) vehicles in the South Coast Air Basin, and thereby benefit the public by reducing mobile source emissions and improving air quality.

11561: Convert 34 Passenger Vans to Natural Gas-Power for Deployment as Airport Ground Transportation

Contractor: SuperShuttle International	SCAQMD Cost-Share	$ 144,300
Term: 06/01/11 – 10/31/14	Total Cost:	$ 144,300

In February 2012, to augment a previous award, the Board approved additional funding to match a U.S. DOE Clean Cities award under the Petroleum Reduction Technologies Projects for the Transportation Sector. The additional funding comprises $106,150 from Clean Fuels plus pass-through revenue of $38,150 awarded by U.S. DOE Clean Cities, and will be used to purchase and convert 14 additional new gasoline-powered Ford E-350 passenger vans to CNG-power, including fuel system retrofit and fuel tank replacement. This augments the existing ongoing project to convert 20 Ford E-350 passenger vans to dedicated CNG for airport ground transportation service, bringing the revised total number of CNG conversions under this project to 34 vehicles. 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 in throughout the SCAQMD's jurisdiction.

12259: Demonstrate Natural Gas-Powered Police Vehicle

Contractor: A-1 Alternative Fuel Systems	SCAQMD Cost-Share	$ 65,000
Term: 04/20/12 – 10/19/14	Total Cost:	$ 65,000

Law enforcement and emergency vehicles are exempt from most tailpipe emission standards and are not subject to the District's Fleet Rules, which require fleets to purchase clean and alternative fuel vehicles. Many law enforcement agencies deploy the gasoline-powered Ford Crown Victoria vehicle in their fleet. This project will provide multiple local law enforcement agencies the opportunity to demonstrate a dedicated CNG-powered 2011 model year Ford Crown Victoria police pursuit vehicle. More than twelve local law enforcement agencies have already expressed an interest in demonstrating and evaluating the performance of the CNG-powered police vehicle and will use this opportunity to consider CNG-powered vehicles in future fleet vehicle purchases.

12267: Upgrade CNG Fueling Facility

Contractor: West Covina Unified School District	SCAQMD Cost-Share	$ 60,000
Term: 10/12/12 – 12/31/17	Total Cost:	$ 60,000

At the May 7, 2010 meeting, the Board authorized awards of $40,000 to the West Covina Unified School Districts to upgrade their CNG school bus fueling station. At the time the award was made, the compressors that were quoted were undersized as they did not take into account the school districts expanding natural gas fleet. This contract increased the awards to the school district in an amount not to exceed $20,000 to upgrade the CNG school bus fueling station for a total amount not to exceed $60,000.

12273: Construct LNG Fueling Station

Contractor: Border Valley Trading Ltd.	SCAQMD Cost-Share	$ 251,865
	Cosponsor	
	Border Valley Trading Ltd.	252,165
Term: 02/10/12 – 07/30/13	Total Cost:	$ 504,030

Funding from the CEC AB 118 Alternative and Renewable Fuel and Vehicle Technology Program were awarded to the Clean Fuels Fund in the amount of $2.6 million for 10 natural gas fueling stations. The proposed projects were selected by CEC through a competitive solicitation process. One such project is with Border Valley Trading Ltd. has been operating LNG trucks between the California-Arizona border and the Ports of Los Angeles and Long Beach for several years. Due to a lack of adequate LNG fueling stations in that area, BVT requested funding to offset the cost of constructing a new LNG fueling station in the Palm Springs area.

12386: Demonstrate Natural Gas-Powered Police Vehicle

Contractor: Agility Fuel Systems	SCAQMD Cost-Share	$ 54,000
Term: 06/01/12 – 06/30/13	Total Cost:	$ 54,000

Law enforcement and emergency vehicles are exempt from most tailpipe emission standards and are not subject to the District's Fleet Rules, which require fleets to purchase clean and alternative

fuel vehicles. Many law enforcement agencies deploy the gasoline-powered Ford Crown Victoria vehicle in their fleet. This project specifically funds the purchase of and conversion to dedicated CNG a new 2011 Ford Crown Victoria for demonstration by the City of South Pasadena. This vehicle was upfitted with extra fuel storage capacity to extend both the range and usability of the vehicle.

12851: Construct Two LNG Fueling Stations

Contractor: Clean Energy	SCAQMD Cost-Share	$ 400,000
	Cosponsor	
	Clean Energy	2,618,118
Term: 10/05/12 – 12/31/18	Total Cost:	$ 3,018,118

Funding from the CEC AB 118 Alternative and Renewable Fuel and Vehicle Technology Program were awarded to the Clean Fuels Fund in the amount of $2.6 million for 10 natural gas fueling stations. The proposed projects were selected by CEC through a competitive solicitation process. One such project is with Clean Energy, Inc. They has been actively pursuing the construction of CNG and LNG fueling infrastructure for heavy- and light-duty vehicles. Clean Energy, Inc. has requested funding to offset the cost of constructing the two new LNG fueling stations in an amount not to exceed $400,000.

12852: Construct Public Access CNG Fueling Station

Contractor: City of Covina	SCAQMD Cost-Share	$ 200,000
	Cosponsor	
	City of Covina	418,429
Term: 10/12/12 – 12/31/18	Total Cost:	$ 618,429

Funding from the CEC AB 118 Alternative and Renewable Fuel and Vehicle Technology Program were awarded to the Clean Fuels Fund in the amount of $2.6 million for 10 natural gas fueling stations. The proposed projects were selected by CEC through a competitive solicitation process. One such project is with the City of Covina which had been operating an CNG fueling facility for its fleet for a number of years. As the number of CNG vehicles operated in the area increased, so had the utilization of the station, leading to the ultimate failure of the system and requiring installation of new compressors. The City has requested funding assistance to purchase additional CNG storage tanks, dispensers and compressors in order to meet the growing demand for CNG fueling at their station in an amount not to exceed $200,000.

12854: Upgrade LNG Fueling Station at Baldwin Park Facility

Contractor: Waste Management Inc.	SCAQMD Cost-Share	$ 300,000
	Cosponsor	
	Waste Management Inc.	1,288,100
Term: 08/17/12 – 12/31/18	Total Cost:	$ 1,588,100

Funding from the CEC AB 118 Alternative and Renewable Fuel and Vehicle Technology Program were awarded to the Clean Fuels Fund in the amount of $2.6 million for 10 natural gas fueling stations. The proposed projects were selected by CEC through a competitive solicitation process. One such project is with Waste Management, Inc. which has been operating an LNG

fueling facility for its fleet in the City of Baldwin Park for several years. They are actively pursuing the purchase of additional LNG and CNG heavy- and light-duty vehicles for their fleet, necessitating the expansion of its fueling station to include additional LNG storage and a vaporizer to create CNG. Waste Management has requested funding to offset the cost of constructing the new LNG and CNG storage vessels, compressors, pumps, dispensers, electrical and injection systems, and vaporizers in an amount not to exceed $300,000.

13059: Construct CNG Fast-Fill Station

Contractor: Rim of the World Unified School District	SCAQMD Cost-Share	$ 200,000
	Cosponsor	
	Rim of the World Unified School District	200,000
Term: 10/05/12 – 01/31/18	Total Cost:	$ 400,000

Funding from the CEC AB 118 Alternative and Renewable Fuel and Vehicle Technology Program were awarded to the Clean Fuels Fund in the amount of $2.6 million for 10 natural gas fueling stations. The proposed projects were selected by CEC through a competitive solicitation process. One such project is with Rim of the World USD in Lake Arrowhead. The CNG station is currently a time-fill design and needs increased storage capacity and a dispenser that is approved by the Department of Food and Agriculture in order to provide fueling for waste haulers in the area. This action was to purchase additional CNG storage and a dispenser in an amount not to exceed $200,000.

Fuels/Emissions Studies

11611: In-Use Emissions Testing and Demonstration of Retrofit Technology for On-Road Heavy-Duty Engines

Contractor: West Virginia University Research Corporation	SCAQMD Cost-Share	$ 239,368
	Cosponsors	
	California Air Resources Board	35,000
	West Virginia University Research Corporation	27,975
Term: 07/08/11 – 10/07/12	Total Cost:	$ 302,343

On-road heavy-duty engines are now subject to the 2010 U.S. EPA emissions standards of 0.01 gram per brake-horsepower-hr (g/bhp-hr) PM and 0.20 g/bhp-hr NO_x. Some engine manufacturers are using emissions credits which allow them to produce a mixture of engines certified at, below, or above 0.20 g/bhp-hr NO_x. This mixture of engines allows engine manufacturers to comply with the emissions standards on an average basis. These engines are either stoichiometric engines with three-way catalysts or lean burn engines equipped with exhaust gas recirculation (EGR), selective catalytic reduction (SCR) and/or diesel particulate filter (DPF) technology. While recent limited-scale studies have shown reduced NO_x and PM emissions from trucks powered by compliant engines, other studies indicate a potential increase in some exhaust emissions. In particular, in a recent heavy-duty in-use emissions measurement study conducted by the University of Colorado, ammonia emissions from liquefied natural gas trucks were found to be significantly higher due to the nature of spark-ignited engines. Studies conducted by The

Netherland Organization (TNO) indicated that heavy-duty diesel engines equipped with SCR technologies have higher NO_x exhaust emissions than their certified levels. As such, additional studies are required to assess the impact of the technologies on emissions from engines used in a variety of applications, particularly since the number of these engines will continue to increase in the future. In December 2010, the Board awarded a contract to West Virginia University (WVU) for $734,742 to conduct in-use emissions testing, and if needed, to evaluate emission-reduction potential of retrofit technology on existing and new on-road heavy-duty engines. The Ports of Los Angeles and Long Beach expressed later interest in testing additional heavy-duty drayage vehicles, and in 2012 this project was amended to include an additional $204,368 from the Ports as pass-through revenue into Clean Fuels as well as additional cosponsor funding from CARB and WVU. The additional funds will be to conduct eight additional in-use emissions tests of heavy-duty drayage vehicles and assess in-use emissions from a 2010 U.S. EPA compliant heavy-duty vehicle as the vehicle is driven over a 2,500-mile route between Morgantown, West Virginia, and Riverside, California.

11612: In-Use Emissions Testing and Demonstration of Retrofit Technology for On-Road Heavy-Duty Engines

Contractor: University of California Riverside	SCAQMD Cost-Share	$ 76,638
Term: 08/26/11 – 08/25/13	Total Cost:	$ 76,638

gram per brake-horsepower-hr (g/bhp-hr) PM and 0.20 g/bhp-hr NO_x. Some engine manufacturers are using emissions credits which allow them to produce a mixture of engines certified at, below, or above 0.20 g/bhp-hr NO_x. This mixture of engines allows engine manufacturers to comply with the emissions standards on an average basis. These engines are either stoichiometric engines with three-way catalysts or lean burn engines equipped with exhaust gas recirculation (EGR), selective catalytic reduction (SCR) and/or diesel particulate filter (DPF) technology. While recent limited-scale studies have shown reduced NO_x and PM emissions from trucks powered by compliant engines, other studies indicate a potential increase in some exhaust emissions. In particular, in a recent heavy-duty in-use emissions measurement study conducted by the University of Colorado, ammonia emissions from liquefied natural gas trucks were found to be significantly higher due to the nature of spark-ignited engines. Studies conducted by The Netherland Organization (TNO) indicated that heavy-duty diesel engines equipped with SCR technologies have higher NO_x exhaust emissions than their certified levels. As such, additional studies are required to assess the impact of the technologies on emissions from engines used in a variety of applications, particularly since the number of these engines will continue to increase in the future. In December 2010, the Board awarded a contract to University of California, Riverside (UCR) for $734,742 to conduct in-use emissions testing of existing and new on-road heavy-duty engines. The Ports of Los Angeles and Long Beach later expressed interest in testing additional heavy-duty drayage vehicles, and in 2012 this project was amended to include an additional $76,638 from the Ports as pass-through revenue into Clean Fuels. The additional funds will be used to conduct three additional in-use emissions tests of heavy-duty drayage vehicles.

12154: Cellulosic Biofuel Feedstocks Analysis

Contractor: University of California Riverside/CE-CERT	SCAQMD Cost-Share	$ 235,000
Term: 01/20/12 – 03/31/13	Total Cost:	$ 235,000

The interest in biofuel has increased both at the state and national level as an alternative energy source to reduce petroleum dependency, greenhouse gases and air pollution. However, the use of agricultural products like corns and soybeans hast its limit due to concerns over its sustainability without crowding out food supplies. In order to truly increase biofuel utilization, it is essential to identify feedstocks that can be processed in a more efficient, cost-effective and sustainable manner. Cellulosic biomass is one of the sustainable resources that can potentially support a large-scale and lower-cost biofuel production. Recognizing this potential, the State Alternative Fuels Plan developed by CEC identifies a transition from Midwest corns to regional agricultural, forestry and urban residues as a goal to secure sufficient fuel supplies for future growth. However, cellulosic biomass conversion to liquid fuels is still expensive and technology advances are urgently needed to achieve economical biofuel production from such sources. The objectives of this project are to: 1) identify leading agricultural, forestry, municipal residues that could support large scale production of transportation fuels in California, 2) apply accelerated biomass compositional analysis to measure the cellulose contents in the feedstocks selected, 3) apply a high throughput pretreatment and hydrolysis process to the leading candidates utilizing the UCR's newly-developed robotic system to determine sugar yields that can be used as reactive intermediates for conversion to biofuels, and 4) develop a new high throughput system to handle harsher conditions without using enzymatic hydrolysis for higher yields of reactive intermediates that can be catalytically converted to hydrocarbon biofuels like renewable diesel. The result will facilitate selection of feedstocks and process conditions for making a range of sustainable transportation fuels in California.

Emission Control Technologies

12124: Retrofit Heavy-Duty Diesel Trucks with Diesel Particulate Filters

Contractor: Gaio Trucking, Inc.	SCAQMD Cost-Share	$ (5,000)
	Cosponsor	
	Gaio Trucking, Inc. (in-kind)	(13,408)
Term: 09/28/11 – 03/31/14	Total Cost:	$ (18,408)

The SCAQMD was awarded $1 million from the U.S. EPA under the Diesel Emissions Reductions Act (DERA) program to retrofit heavy-duty diesel trucks with Diesel Particulate Filters (DPFs). These funds were received into and administer under the Clean Fuels Fund. The overall project includes the design, installation and operation of DFP technologies on 200 1998-2006 model year heavy-duty diesel trucks. One of the applications funded was an award to Gaio Trucking, Inc. for DFPs to be installed on nine of the vehicles in their fleet. This modification, executed in 2012, removed one of the vehicles for retrofit, along with the corresponding funding and cofunding, because the same vehicle was funded under the Proposition 1B Program.

12150: Demonstrate NO_x and PM Emission Control Technologies on Diesel-Powered Construction Equipment

Contractor: Puritech US, LLC	SCAQMD Cost-Share	$ 72,000
	Cosponsor	
	Puritech US, LLC (in-kind)	100,000
Term: 02/14/12 – 04/30/13	Total Cost:	$ 172,000

Diesel-powered construction equipment is a significant contributor to NO_x and PM emissions in the South Coast Air Basin. This project is a demonstration of a retrofit system to reduce NO_x

emissions and assist in regeneration of the soot collected in the diesel particulate filter. The system consists of a catalyst, diesel particulate filter, and diesel fuel injection system, system control computer, various sensors and actuators, and a malfunction alarm module. Two off-road construction vehicles are to be retrofitted. The project includes a pre-installation evaluation to confirm that the candidate vehicles are suitable for the test; the design, fabrication, and installation of the systems; and 1000 hours of typical operation to evaluate durability and reliability. Emissions of NO_x before and after the system will be measured during the durability test using electronic sensors.

12186: Retrofit Heavy-Duty Diesel Trucks with Diesel Particulate Filters

Contractor: Pipeline Carriers Inc.	SCAQMD Cost-Share	$ (75,000)
Term: 12/16/11 – 09/30/14	Total Cost:	$ (75,000)

The SCAQMD was awarded $1 million from the U.S. EPA under the Diesel Emissions Reductions Act (DERA) program to retrofit heavy-duty diesel trucks with Diesel Particulate Filters (DPFs). These funds were received into and administer under the Clean Fuels Fund. The overall project includes the design, installation and operation of DFP technologies on 200 1998-2006 model year heavy-duty diesel trucks. One of the applications funded was an award to Pipeline Carriers Inc. for DFPs to be installed on 25 of the vehicles in their fleet. This modification, executed in 2012, removed 15 of the vehicles for retrofit, along with the corresponding funding, at the request of the contractor due to economic reasons.

12485: CSULB CEERS Student Education Study for Development of a Humid-Air System and Exhaust Scrubber for Diesel Engine Emissions Reduction

Contractor: California State University Long Beach Foundation	SCAQMD Cost-Share	$ 28,000
Term: 06/29/12 – 03/31/13	Total Cost:	$ 28,000

Air misting has been used to remove dust particles in the air. In general, fogging and air misting could reduce concentration of large particles of 2-10 microns but not smaller ones. One of the effective methods for removing small particles is an electrostatic scrubber. The goals of this investigation will be focused on the development, assessment and emission testing of the performance improvement of the electrostatic fog system for PM removal. In addition, a study will be conducted to investigate the combined effects of the humid air system and the electrostatic fog for significant reductions in both NO_x and PM emissions from the exhaust of a three-cylinder naturally aspired liquid-cooled diesel engine connected to an electric dynamometer with a maximum output power of 20 BHP.

Electric/Hybrid Technologies & Infrastructure

99109: Lease One Toyota RAV4 Electric Vehicle

Contractor: Toyota	SCAQMD Cost-Share	$ 3,951
Term:	Total Cost:	$ 3,951

The SCAQMD operates a number of alternative fuel vehicles (AFVs), including EVs and 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 AFVs are used to demonstrate new clean-fuel vehicles to public and private organizations so that the potential purchasers may

familiarize themselves with available low-emission technologies. This contract amendment provides for a lease extension and corresponding funding for 2012.

09345: Demonstrate Medium-Speed Electric Vehicles

Contractor: South Bay City Council of Governments	SCAQMD Cost-Share	$ 119,815
	Cosponsor	
	South Bay City Council of Governments (in-kind)	110,663
Term: 06/19/09 – 04/30/13	Total Cost:	$ 230,478

In February 2009, the SCAQMD awarded co-funding to South Bay Cities Council of Governments to demonstrate a Medium Speed Electric Vehicle (MSEV) program in the South Bay. For many residents within the South Coast Air Basin, commutes and short trips can be accomplished solely on residential streets at speeds below 35 mph. This project promotes MSEVs, also called Neighborhood Electric Vehicles, to residents, select businesses, municipalities and government entities and establishes a website with driver's information. This demonstration project was extended for an additional 18 months.

12020: Install Electric Charging Infrastructure

Contractor: Coulomb Technologies	SCAQMD Cost-Share	$ 70,000
Term: 10/05/12 – 04/04/14	Total Cost:	$ 70,000

There are approximately 1,800 PEV chargers in need of upgrading in the South Coast Air Basin. These sites are ideal locations to upgrade EV infrastructure to Level 2 charging at a lower cost than to install PEV infrastructure at new site locations. Leveraging the DOE and/or CEC funding received by the three major EVSE manufacturers—ECOtality, Coulomb Technologies, and Clipper Creek—SCAQMD has executed contracts with these manufacturers to install new or upgraded Level 2 EV infrastructure at high usage site locations identified by SCAQMD and the manufacturers. Coulomb Technologies has received a combination of DOE and CEC funding which will pay for the equipment and partial installation costs for Level 2 infrastructure at 70 site locations. SCAQMD is providing cofunding of $1,000 per charger to offset installation costs at these locations. Data will be collected from these chargers and provided to SCAQMD to assist in SCAQMD's PEV infrastructure planning process for the DOE and CEC PEV infrastructure grants for the South Coast region.

12825: Lease Two BMW ActiveE Electric Vehicles for Two Years

Contractor: BMW of Monrovia	SCAQMD Cost-Share	$ 31,065
Term: 03/23/12 – 03/22/14	Total Cost:	$ 31,065

The SCAQMD is leasing a total of four BMW Active E battery-electric vehicles (BEVs) under two contracts, and will add three of them to its demonstration fleet of advanced technology vehicles, which are operated to increase public awareness of clean vehicle technologies and for display at public outreach events. The fourth vehicle will be used to support an electric vehicle demonstration program being conducted by the South Bay Cities Council of Governments. BEVs are zero-emission vehicles that draw their power from onboard batteries charged with electricity from the grid. The Active E is a limited production model with 700 vehicles deployed in the

United States, and BMW plans to apply knowledge gained from this demonstration to the design and deployment of 2014 retail models i3 and i8.

12889: Lease Two BMW ActiveE Electric Vehicles for Two Years

Contractor: BMW of Monrovia	SCAQMD Cost-Share	$ 31,065
Term: 03/23/12 – 03/22/14	Total Cost:	$ 31,065

The SCAQMD is leasing a total of four BMW Active E battery-electric vehicles (BEVs) under two contracts, and will add three of them to its demonstration fleet of advanced technology vehicles, which are operated to increase public awareness of clean vehicle technologies and for display at public outreach events. The fourth vehicle will be used to support an electric vehicle demonstration program being conducted by the South Bay Cities Council of Governments. BEVs are zero-emission vehicles that draw their power from onboard batteries charged with electricity from the grid. The Active E is a limited production model with 700 vehicles deployed in the United States, and BMW plans to apply knowledge gained from this demonstration to the design and deployment of 2014 retail models i3 and i8.

13042: Demonstrate Battery Electric Vehicle

Contractor: South Bay City Council of Governments	SCAQMD Cost-Share	$ 320,000
	Cosponsor	
	South Bay City Council of Governments (in-kind)	192,545
Term: 11/02/12 – 05/01/15	Total Cost:	$ 528,078

In July, 2012, the SCAQMD awarded co-funding to South Bay Cities Council of Governments to demonstrate Battery Electric Vehicles (BEVs) in the South Bay Cities region where the Local Use Vehicle demonstration project has promoted the use of Neighborhood Electric Vehicles (NEVs) with local residents, select businesses, municipalities and government entities. A demonstration of longer range BEVs will help address some limitations of the previous NEV demonstration project and provide guidance for community planning efforts for new BEV models that have recently become available.

13251: Lease Two 2012 or Newer Chevrolet Volt Extended-Range Electric Vehicles for Three Years

Contractor: Selman Chevrolet Company	SCAQMD Cost-Share	$ 31,375
Term: 11/28/12 – 11/27/15	Total Cost:	$ 31,375

The SCAQMD is leasing two 2013 Chevrolet Volt extended-range electric vehicles (also known as plug-in hybrid electric vehicles or PHEVs) to add to its demonstration fleet of advanced technology vehicles, which are operated to increase public awareness of clean vehicle technologies and for display at public outreach events. PHEVs are vehicles with an all-electric, zero-emission range, followed by an efficient, gasoline-burning hybrid mode. The 2013 Volt has a zero-emission range of 38 miles, which can meet the needs of most trips so that the Volt can operate for extended periods of time without starting the engine. Upon depleting the zero-emission mode, the gasoline-burning "range extending" hybrid mode would allow drivers to take longer trips.

Direct Pay: DMV Title Transfers for 20 Converted MY2010 Ford Escape Hybrid Vehicles to Plug-In Hybrid Electric Vehicles using Advanced Lithium-Ion Battery Systems

Contractor: Dept. of Motor Vehicles	SCAQMD Cost-Share	$ 9,000
Term: 07/13/12 – 07/13/12	Total Cost:	$ 9,000

The SCAQMD demonstrates a number of advanced technology vehicles to help support the development and deployment of cleaner advanced technology and educate consumers at public outreach events. There are currently a variety of plug-in hybrid electric, electric, and fuel cell vehicles in the SCAQMD Alternative Fuel Vehicle Demonstration Program. In 2012, SCAQMD took ownership of 3 Ford Escape Hybrid vehicles, which through a project co-funded through one of our Clean Fuels contracts, had been converted to plug-in hybrid electric vehicles using advanced lithium-ion battery systems and controls. The transfer of title resulted in a charge for California use tax to the DMV.

Direct Pay: Purchase Two 2012 CODA Electric Vehicles

Contractor: Fladeboe CODA	SCAQMD Cost-Share	$ 82,000
Term: 08/31/12 – 08/31/12	Total Cost:	$ 82,000

The CODA Electric, a ZEV which qualifies for carpool lane access, is a four-door five-passenger battery-electric sedan and is powered by a 31 kWh lithium iron phosphate battery with a 10 year, 100,000 mile warranty. The CODA is rated by the U.S. EPA to have a combined highway-city range of 88 miles per charge. Using the SAE J1772 connector and the included portable charging cable on a 120V (Level 1) household outlet requires 36-40 hours to fully charge the battery, and using 220V, 30A Level 2 charging system it will take approximately 6 hours for a full charge. The electric motor of the CODA has a maximum power output of 134 hp, with 221 ft-lbs of torque, allowing it to attain a maximum speed of 85 mph. In 2012 the SCAQMD purchased two of these vehicles to add to its demonstration fleet.

Direct Pay: Purchase Two Toyota Prius Plug-In Hybrid Vehicles

Contractor: Longo Toyota	SCAQMD Cost-Share	$ 88,000
Term:	Total Cost:	$ 88,000

Toyota developed 600 Prius Plug-in Hybrid vehicles as part of a global demonstration program including approximately 160 vehicles for eight regions in the United States, which includes program partners such as the SCAQMD. The program partners operated the demonstration vehicles which transmitted data to Toyota for development purposes. In fact, SCAQMD had three of the demonstration vehicles from February 2011 until the demonstration program ended on April 13, 2012 when the vehicles were returned to Toyota. The Toyota Prius PHV, a PHV which qualifies for carpool lane access, is a full performance five-passenger five-door plug-in hybrid hatchback, based on the third generation Prius. As a plug-in hybrid electric vehicle, the Prius PHV is designed to travel up to 11 miles on battery-electric mode at up to 62 mph before starting the "full-hybrid" mode, helping to avoid pollution caused by the "cold-start" phase primarily caused by short trips. The "full-hybrid mode" has a fuel efficiency of 50 mpg, with an overall fuel efficiency of 95 mpg-equivalent. Energy is stored on board in a 4.4 kWh lithium-ion battery pack, which is capable of taking energy from plugging-in, the on-board generators, or through regenerative braking. The power train consists of an 80 hp electric motor with 153 ft-lbs of torque and a supporting 1.8L, 98 hp four-cylinder gasoline engine with 105 ft-lbs of torque. The battery

fully charges in 3 hours using normal 120V household outlets and in 1.5 hours with 240V Level 2 charging. The Prius PHV uses the SAE J1772 connector, which is the recommended practice for Level 1 and Level 2 charging for passenger vehicles in the US. In 2012 SCAQMD purchased two Toyota Prius PHVs with the premium package including GPS to best showcase the technology in its demonstration fleet..

Direct Pay: Develop Zero Emission Vehicle Demonstration Project and Implementation Plan

Contractor: South Bay Cities Council of Governments	SCAQMD Cost-Share	$ 19,983
Term: 03/30/12 – 09/21/12	Total Cost:	$ 19,983

The South Bay Cities Council of Governments (SBCCOG) conducted a Local Use Vehicle Project. SBCCOG will develop this Plan building on existing policies and programs of SBCCOG and learnings from its Local Use Vehicle Project. The Plan is intended to encourage deployment of range-limited BEVs (including NEVs) as the secondary vehicle in households; provide usage data that will enlighten a number of key policy questions; complement a number of ongoing and planned SBCCOG initiatives including PEV Readiness Planning, Enterprise Rent-A-Car Collaboration, ECOtality EVSE deployment; and include analysis of the transition of long-range primary vehicles to ZEVs and near-ZEVs. The Plan will also provide analysis to help address barriers to ZEV adoption that can be shared with other subregions as each addresses strategies to improve air quality and reduce GHG emissions.

Purchase Order: Install Electric Vehicle Chargers

Contractor: ATVLS, Inc.	SCAQMD Cost-Share	$ 20,182
Term: 06/26/12 – 09/20/12	Total Cost:	$ 20,182

This project provided funds for the demonstration of Level 2 electric vehicle charging infrastructure from several manufacturers including Coulomb Technologies, ECOtality, and Clipper Creek. Charging infrastructure was placed in the SCAQMD's parking lot for public, employee, and fleet use. The contractor ATVLS installed four Clipper Creek Level 2 chargers at SCAQMD headquarters.

Purchase Order: Install Electric Vehicle Chargers

Contractor: Clean Fuel Connection Inc.	SCAQMD Cost-Share	$ 11,266
Term: 01/01/12 – 08/30/12	Total Cost:	$ 11,266

This project provided funds for the demonstration of Level 2 electric vehicle charging infrastructure from several manufacturers including Coulomb Technologies, ECOtality, and Clipper Creek. Charging infrastructure was placed in SCAQMD's parking lot for public, employee, and fleet use. The contractor Clean Fuel Connection installed six Coulomb Technologies chargers at SCAQMD headquarters.

Purchase Order: Install Electric Vehicle Chargers

Contractor: On Target Electric, Inc.	SCAQMD Cost-Share	$ 28,946
Term: 02/07/12 – 10/03/12	Total Cost:	$ 28,946

This project provided funds for the demonstration of of Level 2 and DC fast charging electric vehicle charging infrastructure from ECOtality. Level 2 charging infrastructure was placed in the SCAQMD's parking lot for public, employee, and fleet use plus a DC fast charger was placed in the fleet parking for public, employee, and fleet use. The contractor On Target Electric installed 12 ECOtality Level 2 chargers and a DC fast charger at SCAQMD headquarters.

Transfer: Insurance Coverage for Hybrid Vehicles in SCAQMD's Demonstration Fleet

Contractor: The Hartford	SCAQMD Cost-Share	$ 12,000
Term: 08/30/12 – 08/30/12	Total Cost:	$ 12,000

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.

Hydrogen Technologies & Infrastructure

07292: Develop Hydrogen Storage Capability for Gas Blending Facility

Contractor: University of California Irvine	SCAQMD Cost-Share	$ 200,000
	Cosponsors	
	U.S. Dept. of Energy	134,000
	California Energy Commission	241,000
	Air Products and Chemicals, Inc.	60,000
	National Fuel Cell Research Center	53,000
Term: 08/31/12 – 06/30/13	Total Cost:	$ 688,000

Hydrogen has garnered much attention as a mobile fuel due to its potential to deliver near-zero emissions in fuel cell vehicles. Hydrogen blended with other fuels, such as natural gas, however, has shown potential promise in mobile and stationary combustion systems. Utilizing hydrogen blends may provide a near-term opportunity to displace fossil fuels while reducing emissions. Testing of distributed generation devices, including microturbines and fuel cells, on different blends of hydrogen is therefore a focus of the U.S. Department of Energy and California Energy Commission. This contract was to develop the hydrogen storage capability at the Advanced Power and Energy Program at UC Irvine for their gas blending facility at a cost not to exceed $200,000.

10061: Maintenance and Data Management for SCAQMD's Hydrogen Station

Contractor: Hydrogenics Corporation	SCAQMD Cost-Share	$ 130,000
Term: 10/30/09 – 12/30/13	Total Cost:	$ 130,000

The SCAQMD, in partnership with Hydrogenics Corporation (formerly Stuart Energy Systems), installed a hydrogen generation and fueling station at SCAQMD Headquarters. This system uses electrolysis of water to produce the hydrogen and includes the capability to produce backup

electrical power using a hydrogen-powered internal combustion engine. This system has been used extensively by the SCAQMD hydrogen-powered vehicle fleet and other hydrogen vehicles for other demonstration programs throughout Southern California. The hydrogen fuel quality has been tested and shown to meet the needs of fuel cell vehicle manufacturers and of the SCAQMD. SCAQMD has become a vital location as part of the California Hydrogen Highway network. In order to continue maintenance and data management of the existing SCAQMD hydrogen station, an amendment of the contract was required with Hydrogenics Corporation. This contract extends beyond the original scope of the project and will ensure the station is maintained while plans are made for the station's upgrade.

11555: Construct Hydrogen Fueling Station

Contractor: University of California Los Angeles	SCAQMD Cost-Share	$ 400,000
	Cosponsors	
	MSRC/AB 2766 Discretionary Fund Program	400,000
	California Air Resources Board	1,700,000
	University of California Los Angeles	489,9990
Term: 12/07/12 – 12/31/19	Total Cost:	$ 2,589,990

The University of California Los Angeles (UCLA) was awarded funding under CARB RFP #08-606 entitled "California Hydrogen Highway Network Modular Fueling Stations" and by the MSRC under program RFP # P2008-12 entitled "Alternative Fuel Infrastructure Funding Opportunities." Both RFPs were issued in 2008. UCLA will demonstrate a new hydrogen refueling station open 24 hours a day 7 days a week which will be accessible to the public and will provide fueling at pressures of both 35 MPa and 70 MPa. The proposed location for this station is at the north-east corner of the UCLA Transit facility (1100 Veteran Avenue, 11075 Kinross Avenue) located within one quarter mile of the San Diego Freeway (Interstate 405) in Westwood. This is a strategic location that will fill a significant gap in the availability of hydrogen in Southern California as part of the California Hydrogen Highway Network. The hydrogen station demonstration project required additional funding in the amount of $400,000 in order to offset capital equipment costs.

12057: Expand Hydrogen Fueling Infrastructure

Contractor: Linde, LLC	SCAQMD Cost-Share	$ 250,000
	Cosponsors	
	California Energy Commission	2,049,134
	Linde, LLC	433,043
Term: 11/02/12 – 11/02/18	Total Cost:	$ 2,732,177

The goal of this project is to successfully provide commercially viable hydrogen fueling to a large FCV population by deploying fueling station technology that represents step change advances in reliability, performance, and speed. Linde will demonstrate that hydrogen fueling can be successfully integrated with retail gasoline fueling stations and provide public hydrogen fueling to promote its viability in the broader marketplace. The station will be located in a heavily traveled area close to main corridors and adjacent to key residential areas considered by OEMs to be FCV early-adopters. Linde will design and build an MF90 Fueling System with a capacity of

up to 240 kg/day with 350 and 700 bar fueling capability that will be fully SAE J2601 compliant. The system will also include high pressure storage to increase peak fueling capacity. The high throughput and redundant design is a major leap forward in hydrogen fueling station technology, and this translates to higher up-front capital costs compared to a system that supplies only 100 kg/day. Approximately 100% of the renewable biogas that Linde will purchase to fulfill SB 1505 requirements will go towards the Laguna Niguel fueling station.

13146: Lease One Toyota Prius Hydrogen-Fueled Vehicle

Contractor: California State University Los Angeles	SCAQMD Cost-Share	$ 0
Term: 11/08/12 – 03/31/14	Total Cost:	$ 0

The SCAQMD demonstrates a number of advanced technology vehicles to help support the development and deployment of cleaner advanced technology and educate consumers at public outreach events. There are currently a variety of plug-in hybrid electric, electric, and fuel cell vehicles in the SCAQMD Alternative Fuel Vehicle Demonstration Program. In 2012, a lease was executed with Cal State LA to add one Toyota Prius hydrogen-fueled vehicle to the SCAQMD's demonstration fleet.

Direct Pay: Hydrogen Fuel Analyses for SCAQMD's Hydrogen Station

Contractor: Smart Chemistry	SCAQMD Cost-Share	$ 4,000
Term: 04/11/12 – 05/20/12	Total Cost:	$ 4,000

The SCAQMD maintains a hydrogen station at its Headquarters in Diamond Bar, and every few years there is a need to conduct sampling and analysis of particulates and gaseous content in the hydrogen fuel. Smart Chemistry is one of the few qualified independent laboratories that can perform sampling and analysis of hydrogen gas streams to the low levels SAE J2719. Smart Chemistry assisted SCAQMD in 2008 with performing gas sampling and chemical analysis of the electrolyzer-based hydrogen fueling station. The work conducted was for determining hydrogen purity in order to present to the various OEMs assuring them the quality met the SAE J2719 standards.

Health Impacts Studies

12197: Health Effects of PM Particles from Heavy-Duty Biodiesel-Fueled Vehicles

Contractor: University of California Riverside/CE-CERT	SCAQMD Cost-Share	$ 207,500
Term: 01/13/12-09/12/13	Total Cost:	$ 207,500

Biodiesel is one of the renewable fuels promoted as a promising alternative to petroleum diesel because it can be substituted for diesel with little or no engine modifications while maintaining the same load capacity and range. Despite recent advancements in toxicological research in the air pollution field and numerous studies on the effects of alternative fuels on vehicular emissions, the relationship between particle chemical composition and health effects is still not completely understood for many alternative fuels, including biodiesel. A study to better understand how the toxicity of PM emissions from heavy-duty vehicles varies with different biodiesel compositions is needed to ensure health benefits are not compromised with the increased use of biodiesel. The objective of this project is to investigate the toxicological potential, and physical and chemical composition of exhaust PM emissions from biodiesel-fueled heavy duty trucks. The test matrix

will include two heavy duty trucks with different exhaust configurations tested over the EPA Urban Dynamometer Driving Schedule (UDDS) cycle, with four test fuels consisting of CARB diesel as a baseline and three biodiesel blends created from soy based, animal fat based, and waste cooking oil biodiesels. The blend levels will be at least 20% or higher by volume to ensure discernible differences in the test results.

12208: Determine the Physical and Chemical Composition and Associated Health Effects of Tailpipe PM Emissions

Contractor: University of California Riverside/CE-CERT	SCAQMD Cost-Share	$ 175,000
	Cosponsor	
	California Energy Commission	1,200,000
Term: 01/21/12 – 07/19/13	Total Cost:	$ 1,375,000

CARB has recently amended the reformulated gasoline regulation allowing the ethanol content to increase from 5.7% to 10% to further promote ethanol use as part of the state's strategy to reduce petroleum dependency and carbon intensity. In addition, with the approval of E15 for sale by U.S. EPA, ethanol use is expected to increase in the future. In order to ensure that such increase in ethanol use does not compromise air quality or public health, it is important to investigate the toxicity and associated health impacts from the use of ethanol-blended fuels. The objective of this project is to characterize the physical and chemical compositions, such as particle size and number distribution, elemental and organic carbon fractions, ions, metals, and polycyclic aromatic hydrocarbons (PAHs), and to evaluate the toxicological properties and associated health risks of tailpipe PM emissions for ethanol and other alcohol-blended fuels. This project will be conducted in conjunction with an emissions testing program funded by CEC to test vehicles, representing current and future California vehicle fleets, with various alcohol and hydrocarbon blends. While the CEC funded project will focus on measurements of emissions for criteria pollutants and other regulated emissions, SCAQMD funding will be used to characterize PM emissions for toxicity and health effects from a subset of the test vehicles. The test matrix will include three light-duty passenger vehicles with four different alcohol fuel blends, mostly ethanol blends, tested over Federal Test Procedure or Unified Cycles. The final test matrix will be developed in consultation with a technical advisory committee.

12865: Develop Quantitative Cellular Assays for Use in Understanding the Chemical Basis of Air Pollutant Toxicity

Contractor: University of California Los Angeles	SCAQMD Cost-Share	$ 368,457
Term: 06/08/12 – 07/07/14	Total Cost:	$ 368,457

The objective of this project is to develop a biological-mechanism-based analytical procedure to characterize the toxicity of air pollutants. The initial phase of the study will be to develop and characterize a standard in quantities sufficient to be employed in subsequent toxicity analyses of vehicle emissions and ambient pollutants. The proposed path is to work with researchers at University of California Riverside's Center for Environmental Research and Technology (CE-CERT) to collect a large quantity of diesel exhaust (including both particulate and vapor phase) from a well-characterized engine using low-sulfur fuel as the standard. Quantitative dose response toxicity assays will then be conducted with emissions from advanced technology engines to compare with results from assays using the standard diesel emissions. This will

provide a measure of the relative toxic potency of vehicle emissions that can be directly compared in standard assays.

Stationary Clean Fuel Technologies

10723: Retrofit Digester Gas Engine with NO_x Tech Aftertreatment Emission Control Technology

Contractor: Eastern Municipal Water District	SCAQMD Cost-Share	$ 85,000
	Cosponsor	
	Eastern Municipal Water District	804,000
Term: 03/16/12 – 03/15/13	Total Cost:	$ 889,000

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 and used primarily to power electrical generators and in some cases blowers. The objective of this contract is to demonstrate the NOxTech aftertreatment emission control technology on an internal combustion engine operating on biogas from a wastewater treatment plant. This project is part of an effort to further demonstrate and identify biogas cleanup and emission control technologies for biogas engines to achieve compliance with the January 2016 emission limits of Rule 1110.2.

13030: Demonstrate 300kW Molten Fuel Cell with Exhaust-Fired Absorption Chiller

Contractor: University of Irvine	SCAQMD Cost-Share	$ 257,500
	Cosponsors	
	Fuel Cell Energy	100,000
	Yazaki	261,000
	Self-Generation Incentive Program	690,000
	Southern California Gas Company	200,000
	Xnergy	988,000
	University of California Irvine	37,000
	California Energy Commission	1,480,000
Term: 10/12/12 – 04/11/15	Total Cost:	$ 4,013,500

UCI proposes a combined cooling, heat and power (CCHP) system that will be installed on the University of California, Irvine campus at the Multipurpose Science and Technology Building. This system integrates a highly efficient, high-temperature molten carbonate fuel cell with an exhaust-fired absorption chiller, which utilizes the exhaust heat from the fuel cell to generate cooling. The system will provide 300 kW of reliable, clean electricity and 40 tons of cooling to the campus building, while producing virtually zero criteria pollutants. Overall the system is expected to achieve an efficiency approaching 70%. The goal of the project is to provide a "showcase" installation that will inform the California architectural and developer communities to the attributes of fuel cell based CCHP technology.

Outreach & Technology Transfer

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

Contractor: TIAX LLC	SCAQMD Cost-Share	$ 70,000
Term: 07/23/10 – 05/31/13	Total Cost:	$ 70,000

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. 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. An additional $70,000 was added to this Contract to provide expertise on mobile and stationary source technology scenarios to achieve ozone attainment in the Basin by 2023 and 2030 time frame.

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

Contractor: Clean Fuel Connection Inc.	SCAQMD Cost-Share	$ 41,000
Term: 09/17/10 – 12/31/12	Total Cost:	$ 41,000

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 was originally executed in September 2010 in the amount of $50,000 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 16 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.

12064: Technical Assistance with Low- and Zero-Emission Vehicles, Technology and Emissions Analysis

Contractor: Joseph C. Calhoun, P.E., Inc.	SCAQMD Cost-Share	$ 20,000
Term: 06/01/12 – 12/31/14	Total Cost:	$ 20,000

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 50 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.

12214: Development, Initiation & Implementation of a Clean Vehicle Outreach Project

Contractor: Calstart	SCAQMD Cost-Share	$ 12,000
Term: 01/27/12 – 10/29/12	Total Cost:	$ 12,000

Through this project, a vehicle comparison calculator for medium- and heavy duty vehicles would be developed. The calculator would compare fuel cost, fuel economy, criteria emissions, and greenhouse gas emissions for gasoline, diesel, advanced technology, and alternative fueled medium- and heavy-duty vehicles. This project was cancelled before the calculator was completed. The in-progress deliverable included estimations of fuel cost, fuel economy, and greenhouse gas emissions for medium- and heavy-duty vehicles.

12309: Technical Assistance with Low- and Zero-Emission Vehicles, Fuel Cells and Fueling Infrastructure

Contractor: TIAX LLC	SCAQMD Cost-Share	$ 75,000
Term: 04/06/12 – 04/05/14	Total Cost:	$ 75,000

Under this Contract, TIAX is providing expert technical assistance to SCAQMD to implement the Clean Fuels Program. Their services will include technical assistance in the areas of low- and zero-emission vehicles, alternative fuels, fueling infrastructure, fuel cells, and goods movement studies. TIAX has previously assisted SCAQMD in these technical areas.

12312: Technical Assistance with Low- and Zero-Emission Technology, Goods Movement, Alternative Fuels, Transit Applications and Fueling Infrastructure

Contractor: Calstart	SCAQMD Cost-Share	$ 12,181
Term: 03/29/12 – 10/29/12	Total Cost:	$ 12,181

There is a need to accelerate the learning process regarding workplace charging by quickly sharing information and enabling employer-to-employer communication and collaboration. CalSTART has been engaged to prepare an analysis of the knowledge and experience of first-mover companies based on the results from their online scoping survey and to present the survey analysis at a Workplace Charging Workshop on July 31, 2012 at Google Headquarters in Mountain View, California.

12313 CNG Fuel System Inspection Certification Courses

Contractor: CSA America Inc.	SCAQMD Cost-Share	$ 14,100
Term: 07/13/12 – 05/31/13	Total Cost:	$ 28,200

This project will provide qualified individuals with an opportunity to participate in a CNG Fuel System Inspector Certification examination. Individuals permitted to participate in this program will have demonstrated completion of a Natural Gas Vehicle Cylinder Inspection training course under a separate project administered through the Advanced Transportation Technology and Energy Network of the California Community Colleges. Individuals completing the Certification course will be qualified to perform inspections of containers, valves, PRDs (including vent system) and other fuel system components of compressed natural gas powered vehicles. The certification complies with the International Organization for Standardization (ISO) 17024 standard for personnel certification programs. CSA Standards is an ANSI Accredited Certifier Accreditation #0779.

12380: Technical Assistance Related to Emissions, Advanced Technologies and Goods Movement

Contractor: The Tioga Group	SCAQMD Cost-Share	$ 25,000
Term: 04/13/12 – 04/30/14	Total Cost:	$ 25,000

Due to the rapid pace at which technologies are evolving, external expertise is needed to augment in-house expertise and assist staff in technical reviews of emissions, advanced technologies, and operations of the goods movement sector. In addition, expert consultants are required to assist staff in establishing the procedures and renewing applications implementing CARB's Carl Moyer and Proposition 1B programs for goods movement applications. This contract provides SCAQMD with emission analysis, advanced technologies, and operations of the goods movement sector on a task order basis. SCAQMD designated staff will define and pre-authorize specific tasks.

12381: Technical Assistance Related to Emission Inventories, Goods Movement and Off-Road Sources

Contractor: Integra Environmental Consulting Inc.	SCAQMD Cost-Share	$ 25,000
Term: 04/06/12 – 04/30/14	Total Cost:	$ 25,000

Due to the rapid pace at which technologies are evolving, external expertise is needed to augment in-house expertise and assist staff in technical reviews of emission inventories, goods movement sector, and off-road sources. In addition, expert consultants are required to assist staff in establishing the procedures and renewing applications implementing CARB's Carl Moyer and Proposition 1B programs for goods movement applications. This contract provides technical assistance to SCAQMD with emission inventories, goods movement sector analysis.

12453: Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis and Aftertreatment Technologies

Contractor: Tech Compass	SCAQMD Cost-Share	$	75,000
Term: 06/21/12 – 05/30/14	Total Cost:	$	75,000

The Air Quality Management Plan (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. To promote, assess, expedite, and deploy the development and demonstration of advanced, low-and zero-emissions mobile and stationary technologies, SCAQMD relies on expert input and consultation. Tech Compass has over 28 years of professional experience in bringing environmental, energy, and alternative propulsion technologies from the laboratory to the market.

13052: Assist with Completing & Publicizing SCAQMD's Clean Air Tips Celebrity Video

Contractor: The Better World Group	SCAQMD Cost-Share	$	11,000
Term: 11/16/12 – 11/30/12	Total Cost:	$	11,000

As a way of promoting actions that can be performed by the general public to clean the air, The Better World Group worked closely with SCAQMD staff on creating the 10 Things You Can Do, which served as a promotional video and as separate PSAs. The video was featured at SCAQMD conferences and events and will be aired on various media outlets. The Better World Group identified and secured celebrities for the video and oversaw production.

13081: Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Technologies

Contractor: Burnett & Burnette	SCAQMD Cost-Share	$	40,000
Term: 11/01/12 – 04/30/14	Total Cost:	$	40,000

Development and demonstration of advanced alternative fuel vehicles that incorporate current state-of-the-art technology including low-emission, high efficiency engines and low-cost alternative fuel chassis technology are encouraged to lower NO_x and PM emissions in the Basin. This contract is being used to leverage staff resources with specialized outside expertise. Burnett & Burnett is a recognized expert in the design, engineering, construction and operation of natural gas fueling systems and has been instrumental in the past in assisting SCAQMD in implementing

and commercializing CNG related vehicles and fueling systems. Burnett & Burnett will continue to provide expertise involving new installations and upgrades of existing alternative fueling infrastructure and will assist in analyzing all data gathered from prospective fleet operators and provide advice on natural gas fuel station construction, operation, and maintenance costs and concerns, supply and demand projections, strategic location, fuel availability and delivery reliability.

13194: Technical Assistance with Alternative Fuels, Renewable Energy and Electric Vehicles

Contractor: Clean Fuel Connection Inc.	SCAQMD Cost-Share	$ 30,000
Term: 12/07/12 – 12/06/14	Total Cost:	$ 30,000

In order to promote the deployment, development and demonstration of advanced, low-and zero-emissions mobile and stationary technologies, Clean Fuel Connection will provide expertise involving PEV technologies. This work will include building upon the previous set of fact sheets on PEVs and PEV infrastructure by developing additional worksheets focusing on education outreach on multi-unit dwellings and workplace charging, with a focus on the South Coast region.

13198: Technical Assistance with Alternative Fuels, Emissions Analysis and On-Road Sources

Contractor: Gladstein, Neandross & Associates, LLC	SCAQMD Cost-Share	$ 75,000
Term: 12/14/12 – 12/31/14	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. Gladstein, Neandross & Associates LLC (GNA) has previously assisted SCAQMD with implementing a wide-array of incentive programs to deploy lower-emitting heavy-duty vehicles and advanced transportation technologies. Under this Contract, GNA will provide technical expertise across a broad spectrum of emission reduction technologies, including alternative fuels, emissions analysis and on-road sources.

Direct Pay: Support National Education Campaign, Participate as 2013 Membership and Cosponsor 2013 Conference

Contractor: Electric Drive Transportation Association	SCAQMD Cost-Share	$ 50,000
	Cosponsors:	
	Over 110 members in public and private agencies	950,000
Term: 10/01/12 – 09/30/13	Total Cost:	$ 1,000,000

The Electric Drive Transportation Association (EDTA), created in 1989, is the preeminent US industry association dedicated to the promotion of electric drive as the best means to achieve the highly efficient and clean use of secure energy in the transportation sector. EDTA brings together 110+ key stakeholders from across the electric vehicle value chain, constituting the most comprehensive manufacturers' and trade association representing transportation electrification. SCAQMD has cosponsored EDTA conferences in the past and joined EDTA membership in 2012. Membership benefits will allow SCAQMD to serve as a member of the GoElectricDrive national education and awareness campaign to accelerate the adoption of PEVs by consumers, fleet operators and other major market segments. Other campaign committee workgroups on public policy and communications are also available for SCAQMD participation. SCAQMD will also be recognized as a cosponsor of the upcoming annual EDTA conference in June 2013 in Washington, D.C.

Direct Pay: Cosponsor 18 Conferences, Workshops & Events plus 3 Memberships

Contractor: Various	SCAQMD Cost-Share	$ 244,516
	Cosponsors	
	Various	2,450,000
Term: 01/01/12 – 12/31/12	Total Cost:	$ 2,694,546

The SCAQMD regularly participates in and hosts or cosponsors conferences, workshops and events. These funds provide support for the 20 conferences, workshops and events sponsored throughout 2012 as follows: UCI's ICEPAG Conference; Verde Xchange Conference; WRCOG's Clean Cities Advancing the Choices Event; UCR's PEMS Conference; CRC's 22nd Real World Vehicle Emissions Workshop; U.S. EPA's West Coast Collaborative 2012 Meeting; EVS26 Conference; ACT Expo Conference & Expo; UCLA's World EV Conference; Cal Poly Pomona's Solar Boat Student Project; Miscellaneous Event Attendance and Exhibit Setup; Women in Green Conference; City of Santa Monica AltCar Expo & Conference; C3VR's California Vehicle Codes & Standards Seminar; Southern California Energy Summit; JPL's Student Climate Day; BreathLA's 4th COPD Conference; and Transportation Research Board's Minority Student Fellows Program. Memberships for the California Plug-In Electric Vehicle Collaborative for both calendar years 2012 & 2013 and the Fuel Cell & Hydrogen Energy Association for calendar year 2013 are also included.

PROGRESS IN 2012

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 7 (page 59) provides a list of 40 projects and contracts completed in 2012. 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.

Convert Light-Duty Vehicle to Plug-In Hybrid Electric

In May 2005, the Board approved the design, implementation, and demonstration of the conversion of a 2005 Toyota Prius hybrid electric vehicle (HEV) to a battery-dominant system that increases vehicle range, decreases fuel consumption, and reduces air pollution through adding all-electric range. In November, 2005, the Board approved additional funding to convert two more Priuses to plug-in, with an option to convert another two with next-generation enhancements.

This project converted Toyota Prius HEVs into plug-in hybrid electric vehicles (PHEVs) that can use grid-electricity to provide part of the energy for running the vehicles. These vehicles were used to demonstrate PHEV technology, to gather charging and performance data, and to engage the public about alternative fuel technologies.

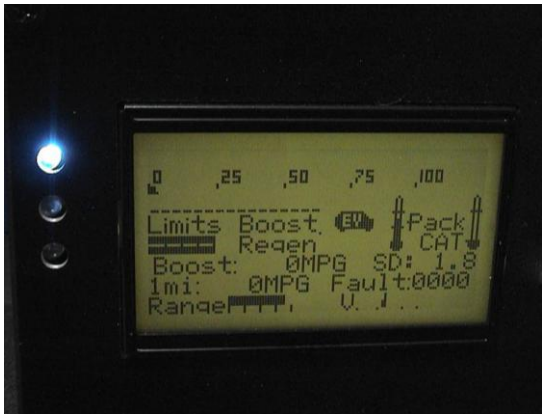


Figure 12: EnergyCS display includes battery voltage and temperature

Figure 13: EnergyCS battery integrated in a passenger vehicle

Major milestones of this project were the refinement of the control system and hardware, procurement of batteries and components, integration of the vehicle systems, optimization of the control system, vehicle completion, testing, demonstration, and analysis.

While EnergyCS will not be commercializing a plug-in hybrid electric passenger vehicle, the battery control technology has found a new, related application. EnergyCS has been acquired by CODA specifically for the battery control system that EnergyCS developed. The CODA Electric automobile is a zero-emission all-electric passenger vehicle now available for retail sale, and CODA Energy is providing battery storage for renewable energy generation.

Sustainable Transportation Energy Pathways (STEPs) Program

In 2007, UC Davis Institute of Transportation Studies instituted the Sustainable Transportation Energy Pathways (STEPS) program to conduct a four-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. STEPS also applied these tools and methods in comparative assessments of four general transportation energy pathways in the areas of hydrogen, biofuels, electricity and fossil fuels.

The focus of the STEPS program is on understanding transitions toward more sustainable transportation fuels and vehicles, understanding how one technology path can enable another, how multiple technologies can be synergistic or competitive and how transitions might occur at lowest cost with maximum public benefits.

STEPS analyses included a focus on Southern California as the early market for alternative fueled vehicles, specifically hydrogen fuel cells, plug-in hybrid and battery electric vehicles. Four specific STEPS projects have direct relevance to AQMD: Hydrogen Infrastructure Transition Analysis – Station Build-out in LA Basin; Electric Vehicle Energy Loads on the Grid - LA Basin Regional Case Study; Plug-in Hybrid Electric Vehicle and Alternative Fueled Vehicle Consumer Survey Research; and Cross-Comparison of Vehicle-Fuel Pathways.

Free electronic copies are available at www.steps.ucdavis.edu/STEPS.Book.

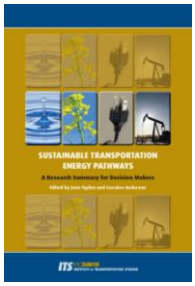


Figure 14: UC Davis IT, STEPs Program Publication

Perhaps the single most important insight from STEPS research is that a portfolio approach combining efficiency, alternative fuels and VMT reduction will give us the best chance of meeting stringent goals for a sustainable transportation future. Given the uncertainties, and the long timelines, it is critical to nurture a portfolio of key technologies toward commercialization and to start now. UC Davis ITS is further developing sustainable transportation energy pathways, including increased analysis of shale oil and gas, in the Next STEPs program through 2014.

Installation of Industrial Pipeline-Supplied Hydrogen Fueling Station

Deployment of zero-emission fuel cell electric vehicles is a key step toward reducing levels of criteria pollutants in the South Coast Air Basin. Manufacturers of fuel cell vehicles have provided survey figures to state agencies indicating their plans to deploy tens of thousands of light-duty cars into the South Coast Air Basin in the 2015-2107 timeframe. In order to meet this goal,

reliable hydrogen fueling stations such as the Torrance pipeline station are needed to provide confidence to automakers and to their potential customers.

As part of an ongoing Cooperative Agreement between Air Products and the U.S. DOE, SCAQMD provided cost-share funding to construct, install and operate a hydrogen fueling station in Torrance, CA. The station is the first in the country to be supplied by an existing, active industrial pipeline system. Delivery of gaseous products such as hydrogen and natural gas via pipeline systems is the lowest-cost means of distribution. The Torrance pipeline station has provided significant learnings into the design and installation of hydrogen fueling stations while providing a platform to demonstrate key new components such as simultaneous refueling from multiple dispensers at two pressure levels. Based on existing technologies, low-cost hydrogen can be delivered and dispensed well below gasoline prices to fueling stations in a fully deployed hydrogen economy.

Operating performance of the hydrogen fueling station has been excellent. Use of the station by automakers in the area has increased since the station was brought online; Toyota and Honda have major facilities within two miles of the station, General Motors and Daimler have operations nearby, and vehicles from Hyundai and Mazda have fueled at the station. On several occasions, station throughput in excess of the rated 48 kilograms per day has been observed, and a total of 2,972 fueling events (both H35 and H70) were completed by the end of March 2012.

Figure 15: Torrance Pipeline Hydrogen Station

Diesel to CNG Repower Project for Solid Waste Collection Trucks

AQMD Rule 1193 requires public and private solid waste collection fleets with more than 15 trucks that provide solid waste collection services for governmental agencies to purchase or replace existing vehicles with alternative-fueled vehicles to reduce air toxic and criteria pollutant emissions. For a more viable and cost-effective solution to comply with this requirement, Waste Management (WM) partnered with Cummins Cal Pacific and AFV Fleet Service to develop a repowered diesel-to-CNG proof-of-concept (POC) vehicle for demonstration in real world solid waste collection services.

This project involves repowering a diesel–fueled 2005 Freightliner Condor refuse truck with the ISL-G natural gas engine that is CARB-certified to meet the federal standards of 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM for heavy duty vehicles. WM also performed the initial Installation Quality Audit on the new cooling system for the POC vehicle. This audit procedure validated the cooling system design and will allow the system to be used with future ISL-G repower packages within WM's fleet and other fleets throughout the nation. WM demonstrated the repowered vehicle for a six-month period at a WM's facility in Moreno Valley. Throughout the six-month demonstration period, WM tested the performance of the vehicle versus a comparable diesel truck under a variety of working conditions including urban pickup cycles, rural higher-speed pickup cycles, freeway driving cycles and grade climbing cycles. WM also tracked and recorded vehicle maintenance requirements. Because the Moreno Valley site primarily has slow-fill CNG

capability, daily fuel measurements were not possible. Thus, the total fuel consumption was calculated based on the engine hours operated per month using an average fuel consumption rate developed by WM in the first month of the demonstration. WM measured the daily fuel consumption over a one-month period by using an on-site fast-fill CNG dispenser for measurements. WM recorded the total fuel consumption and total engine hours of operation since the last fueling event and then used this data to determine the average fuel consumption rate per hour of engine operation. Based on these data, the average diesel gallon equivalent (DGE) per hour for the vehicle tested was 4.02 and the average mile per DGE was 2.60.

WM also hired InfoWedge to conduct emissions tests on the repowered refuse truck and a comparable diesel-fueled refuse truck for NOx, CO, PM, and CO_2 emissions based on AQMD approved protocol and instrumentation. The vehicles were tested while stationary in the following operating modes: idle, high idle, and idle with power take off engaged during a compacting cycle while the truck is at least half full. The testing confirmed the emissions to be significantly lower for the CNG engine.

This diesel to CNG engine repower project was largely successful. WM operators reported that the new engine had similar power to conventional diesel engines. The only notable difference was that the fuel range was not the same as diesel engines, so the vehicle had to be refueled mid-day to ensure that the routes could be finished. The repowered vehicle did not have any major issues other than the radiator at one point being plugged with debris and causing the engine to overheat. Once the radiator was cleaned to correct the problem, no other issues were experienced.

This project was completed with a $75,000 funding from SCAQMD with WM providing the rest of the $331,000 total project cost. The successful completion of this project demonstrates the viability of repowering diesel-fueled solid waste collection trucks with cleaner CNG engines to reduce exhaust emissions as equipment ages, while minimizing the cost. WM estimates there are approximately 3,800 diesel-fueled refuse trucks affected by Rule 1193. With an average fuel consumption of 10,000 gallons of diesel per year for each of these trucks, repowering them would eliminate 38 million gallons of diesel annually.

Figure 16:CNG-powered WM refuse truck

Effects of Natural Gas Fuel Composition on Vehicle Emissions

The objective of this study was to evaluate the impact of natural gas composition on the emissions of natural gas vehicles (NGVs) to confirm the fuel effects of "Hot Gas" with higher Wobbe numbers (WN) and to support CARB in the amendment of fuel standards for natural gas in transportation applications. In this project, two natural gas light-duty vehicles (LDVs) were tested over the Federal Test Procedure and the Unified Cycle on a range of 4 different test gases, and three natural gas buses over the Central Business District cycle and a waste hauler over the

Refuse Truck Cycle were tested on a range of 6 to 7 different test gases for heavy-duty vehicles (HDVs). CE-CERT conducted this study at their chassis dynamometer facility with the total project cost of $729,000 funded by CEC for $400,000, CARB for $279,000, and $50,000 from SCAQMD. Comparisons between test gases were made for regulated exhaust emissions, fuel economy, PM mass, PM number and size distributions, ammonia, carbonyl compounds, and power maps, depending on the phase of the program in this study.

The two LDVs were a SULEV-certified 2006 Honda Civic GX and a ULEV-certified 2002 Ford Crown Victoria and the test gases for LDVs included a baseline gas representative of those typically found in the historical marketplace, an average CARB certification gas, a gas with high Wobbe number (1437), and a modified version of this gas blended down to a 1385 Wobbe number. For heavy-duty vehicles (HDVs), the three transit buses consisted of a bus with a 2009 8.9L stoichiometric spark ignited Cummins ISL-G engine and a 3-way catalyst, a bus with a 2004 8.1L 6081H John Deere lean burn engine with an oxidation catalyst (OC), and a bus with a 2003 C-Gas Plus lean burn engine with an OC. The waste hauler was equipped with a 2002 Cummins 8.3L C-Gas Plus lean burn engine with an OC. The test gases for the heavy-duty testing included gases representative of Texas Pipeline Gas and Rocky Mountain Pipeline Gas; a gas representing Peruvian LNG modified to 1385 WN; a Middle East LNG-untreated; and two gases with high WNs and low methane numbers (MNs), one with a high ethane content and the other with a high propane content as shown in Table 1.

Table 6: HDV Test Fuel Specifications

Gas #	Description	methane	ethane	propane	I-butane	N_2	CO_2	MN	Wobbe #	HHV	H/C ratio
1	Baseline, Texas Pipeline	96	1.8	0.4	0.15	0.7	0.95	99	1339	1021	3.94
2	Baseline, Rocky Mountain Pipeline	94.5	3.5	0.6	0.3	0.35	0.75	95	1361	1046	3.89
3	Peruvian LNG	88.3	10.5	0	0	1.2	0	84	1385	1083	3.81
4	Middle East LNG-Untreated	89.3	6.8	2.6	1.3	0	0	80	1428	1136	3.73
5	High Ethane	83.65	10.75	2.7	0.2	2.7	0	75.3	1385	1115	3.71
6	High Propane	87.2	4.5	4.4	1.2	2.7	0	75.1	1385	1116	3.70
7	L-CNG fuel	98.4	1.2	0.3	0	0	0	103.1	1370	1029	3.96

For modern light-duty NGVs, fuel properties had a clear and direct impact on fuel economy and some emissions components, such as CO_2 and NMHC. The gases with the higher energy content provided better fuel economy on a volumetric basis, and showed higher NMHC and CO_2 emissions in general. The fuel effects were not clear on other emission components, such as THC, NO_x, and CO.

Waste hauler truck emissions were evaluated over a refuse truck cycle that included, transport, compaction, and curbside segments. Overall, the waste hauler showed the strongest fuel effects for most of the pollutants compared to the buses. Almost all the pollutants showed some fuel effects for at least one of the cycle segments. The richer gases with heavier hydrocarbons showed higher NO_x emissions for all three phases of the cycle and showed lower THC, CH4, formaldehyde and acetaldehyde emissions. Fuel economy on a volumetric basis showed increases for the richer gases with higher energy contents for all the phases of the cycle.

For the 2003 Cummins 8.3L C-Gas Plus bus and 2004 John Deere 8.1L bus, which are both equipped with lean burn engines, the fuel effects were similar to those for the waste hauler for NOx and NMHC emissions, and volumetric fuel economy. THC and CH4 emissions were lower for the richer gases in general like in the waste hauler testing. PM emissions were very low, close to the background levels and showed no trends. Also, no significant fuel effects were observed for CO and CO_2 emissions, except CO emissions showing some statistically significant increases

with some of the richer gases for the C-Gas Plus bus. The 2009 Cummins ISL-G bus was the newest technology tested during this program. In general, for this bus, most of the pollutants did not show any specific fuel effects. THC, NMHC, CH4, and formaldehyde emissions for the Cummins ISL-G bus were lower than for the other buses, and NO_x emissions were also considerably lower than those of the John Deere bus. The Cummins ISL-G bus did, however, show higher CO and NH3 emissions compared to the other buses. Some fuel effects were seen for fuel economy, THC, and CH4 emissions, but not for the other pollutants. Richer gases with higher energy contents showed higher fuel economy on both a volumetric and energy equivalent basis. THC and CH4 emissions were higher for the richer gases, which could be due to combustion differences for the stoichiometric vs. the lean burn engines.

Table 7: Projects Completed between January 1 & December 31, 2012

Contract	Contractor	Project Title	Date
Infrastructure and Deployment			
06031	R.F. Dickson	Upgrade CNG Station at Bellflower Facility	Dec-12
06238	Gas Equipment Services, Inc.	Purchase & Install New CNG Fueling System at City of San Fernando Public Works Dept. Yard	Dec-12
07152	Newport-Mesa Unified School District	Purchase & Install New Limited Public Access CNG Fueling Station	Dec-12
09348†	AFV Fleet Services	Demonstrate Two Natural Gas-Powered Police Vehicles	Mar-12
10640	Yellow Cab Company	Convert 45 Taxicabs to Natural Gas Power for Deployment as Airport Ground Transportation	Jun-12
12132†	Lawrence Livermore National Laboratory	Transfer Ownership of Four Toyota Prius Hydrogen-Fueled Vehicles	May-12
Fuels/Emission Studies			
09290	University of California Riverside	Evaluate Emissions Impacts from Natural Gas Blends on Vehicle Emissions	Sep-12
10095	University of California Davis-Intelligent Transportation Studies	Study Sustainable Transportation Energy Pathways	Jul-12
Emission Control Technologies			
08261	Community Recycling and Resource Recovery Inc.	Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment	Mar-12
08318	ServoTech Engineering Inc.	Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment	Dec-12
09000	Shimmick Construction Company	Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment	Mar-12
10112	Sanitation Districts of Los Angeles County	Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment	Feb-12
11136	ServoTech Engineering Inc.	Showcase: Demonstrate NOx & PM Emissions Control Technology on Diesel-Powered Construction Equipment	May-12
Electric/Hybrid Technologies			
05260	Energy Control Systems Engineering, Inc.	Convert Light-Duty Vehicle to Plug-In Hybrid Vehicles	Aug-12
08067	Calstart	Demonstrate Hydraulic-Hybrid Shuttle Bus	Oct-12
09360†	BMW of North America LLC	Lease of Five Mini Cooper Electric Vehicles for CY 2011	Dec-12

Table 7: Projects Completed between January 1 & December 31, 2012

Contract	Contractor	Project Title	Date
Electric/Hybrid Technologies (cont'd)			
11205	Calstart	Implement Hybrid Truck and Bus Voucher Incentive Program	Mar-12
11610†	Balqon Corporation	MOU to Participate in Electric Yard Hostler Loaner Program	Apr-12
Engine Systems			
11485	Waste Management Collection & Recycling Inc.	Demonstrate Refuse Truck Retrofitted with Cummins ISL-G Natural Gas Engine	Apr-12
Hydrogen Technologies and Infrastructure			
04011	Air Products and Chemicals Inc.	Install & Demonstrate Industrial Pipeline-Supplied Hydrogen Fueling Station in Torrance	Jul-12
Outreach and Technology Transfer			
05127†	Protium Energy Technologies	Technical Assistance for Development, Outreach & Commercialization of Hydrogen and Fuel Cell Technologies	Mar-2012
05198†	Don Stedman	Technical Assistance for Remote Sensing Programs for Light-Duty Vehicles and Locomotives	Nov-2012
07059†	Dowling Associates, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods	Nov-2012
08254†	Maria Robles, R.N.	Administrative Assistance in Organizing Two Air Quality & Health-Related Conferences	Jul-2012
08311†	Calstart	Technical Assistance with Development, Outreach and Commercialization of Advanced Technologies to Transit, Port & Other Activities	Oct-2012
09183†	Gary Full	Technical Assistance on Remote Sensing Measurement Technologies as Applied to Auto, Heavy-Duty Diesel and Other Mobile Sources	Jun-2012
09185†	Clean Fuel Connection Inc.	Technical Expertise on the CARB EMFAC Mobile Emissions Model and Other Related Mobile Source Issues	Jun-2012
11117†	Clean Fuel Connection Inc.	Technical Assistance for Alternative Fuels, Renewable Energy and Electric Vehicles	Dec-2012
09253†	Nexant Inc.	Technical Assistance on Alternative Fuels Life-Cycle Analyses	Jun-2012
10062†	TIAX LLC	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile & Stationary Source Technologies	Dec-2012
10663†	Clean Fuel Connection Inc.	Technical Assistance for Implementation of Proposition 1B Goods Movement Program	Dec-2012
11148†	Joseph C. Calhoun, P.E. Inc.	Technical Assistance for Development, Outreach & Commercialization of Advanced Low-Emission Vehicles	Dec-2012

Table 7: Projects Completed between January 1 & December 31, 2012

Contract	Contractor	Project Title	Date
Outreach and Technology Transfer			
12016†	California Hydrogen Business Council	Platinum Membership Renewal in CHBC for 2011	Jun-2012
12104	Three Squares, Inc.	Development, Initiation & Implementation of a Clean Vehicle Outreach Project	Sep-2012
12214†	Calstart	Development, Initiation & Implementation of a Clean Vehicle Outreach Project	Oct-2012
12301†	Gladstein, Neandross & Associates, LLC	Cosponsor the ACT Expo 2012	Aug-2012
12312†	Calstart	Technical Assistance with Low- and Zero-Emission Technology, Goods Movement, Alternative Fuels, Transit Applications and Fueling Infrastructure	Oct-2012
12388†	Electric Drive Transportation Association	Cosponsor EDTA's EVS26: The 26th International Electric Vehicle Symposium "Great Minds Think Electric"	Jul-2012
12891†	Three Squares Inc.	Cosponsor The Women in Green Forum	Nov-2012
13052†	The Better World Group	Assist with Completing & Publicizing SCAQMD's Clean Air Tips Celebrity Video	Nov-2012

†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
2013 PLAN UPDATE

Technology Funding Priorities for 2013

The Clean Fuels Program continually seeks to support the development and deployment of zero and near-zero emission technologies over a broad array of applications and spanning near- and long-term implementation. 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 few years have been especially difficult for technology partnering due to the dramatic global economic downturn, which has shifted national research and development priorities and opportunities. 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, especially in these times of expanding national debt, the continued sluggish economy, and worsening state and local government budget difficulties, all of which affect both public and private investment in technology development and research. Despite these challenges, the SCAQMD's Technology Advancement Office (TAO) has developed this comprehensive plan for accelerating the development and demonstration of cleaner technologies.

The overall strategy of the SCAQMD's Clean Fuels Program is based in large part on technology needs identified through the AQMP process and the SCAQMD Board's directives to protect the health of residents of Southern California, which encompasses approximately 22 million people. 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 federal standards. 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. While it is anticipated that the 2014 standard for PM2.5 will be attained for this region, it is contingent upon compliance and implementation of existing and proposed rules and regulations. With respect to ozone and NO_x, there are overwhelming hurdles which will require even more accelerated technology development, demonstration and deployment. These emission reduction needs were identified in a joint SCAQMD, CARB and San Joaquin Valley Air Pollution Control District effort, "Vision for Clean Air: A Framework for Air Quality and Climate Change Planning."[1]

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. The technologies that are developed and demonstrated in the Clean Fuels Program can serve as control measures for the "black box."

In recent years, it has become increasingly clear that the importation of goods through the Ports of Los Angeles and Long Beach and the subsequent movement of goods throughout the region not only have a dramatic impact on air quality but also the quality of life to the communities along the major goods movement corridors. In recognition of these impacts, the SCAQMD has

[1] http://www.arb.ca.gov/planning/vision/docs/vision_for_clean_air_public_review_draft.pdf

initiated a concerted effort in the last two years on developing zero and near-zero emissions goods movement technologies, such as electric trucks, plug-in hybrid trucks with all-electric range, trucks operating from wayside power and even electric locomotives. The prioritization of these types of projects as well as potential technologies which assist with their further development and deployment remain a strong emphasis of the 2013 Plan Update. This 2013 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 2007 and 2012 AQMPs and to address the increasing challenges this region is facing to meet air quality standards, including new and changing federal requirements, implementation of new technology measures, and the continued development of economically sound compliance approaches. The scope of projects in the 2013 Plan Update also needs to remain sufficiently flexible to address new challenges and proposed methodologies that are identified in the 2012 AQMP. The results of the fourth Multiple Air Toxics Exposure Study (MATES IV) may also affect future funding direction. This follow-up study, the results of which should be available toward the end of 2013, is intended to update emissions inventory of toxic air contaminants and conduct a regional modeling effort to characterize risk across the Basin, including measuring ultrafine particle concentrations.

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 2013 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 2016. Projects are also proposed that may involve the development of 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 2018 or later.

- More mature technologies, those ready to begin field *demonstration* in 2013, are expected to result in a commercial product in the 2014-2015 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 incorporating the latest progress. Over the years, the SCAQMD has provided funding for projects for a wide variety of low- and zero-emission projects. In order to meet the upcoming 2014 $PM_{2.5}$ and 2023 8-hour ozone standards, the areas of zero- and near-zero emission technologies need to be emphasized and this effort can be seen in the following sections and in the proposed funding distribution in Figure 17. The major technical program areas are identified below with specific project categories discussed in more detail in the following sections. The technology areas identified reflect the staff's forecast for upcoming projects and needs within the basin but is not intended to be considered a budget.

Not all project categories 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 SCAQMD historically has leveraged its funds $1 for every $3-$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. The following technical areas are listed by current SCAQMD priorities based on the goals for 2013.

Electric/Hybrid Technologies & Infrastructure

If the region hopes to meet the federal standards for $PM_{2.5}$ and ozone, a primary focus must be on zero- and near-zero emission technologies. A leading strategy to achieve these goals is the wide-scale implementation of electric drive systems for all applicable technologies. With that in mind, 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.

The development and deployment of zero emission goods movement systems remains one of the top priorities for the SCAQMD to support a balanced and sustainable growth in the port complex. The SCAQMD continues to work with our regional partners, in particular the Ports of Los Angeles and Long Beach, SCAG and LACMTA, to identify technologies which could be beneficial to and garner support from all stakeholders. Specific technologies include zero emission trucks (using batteries and/or fuel cells), near-zero emission trucks with all-electric range using wayside power (catenary or roadbed electrification), locomotives with near-zero emissions (e.g., 90% below Tier 4), electric locomotives using battery tender cars and catenary, and linear synchronous motors for locomotives and trucks.

There is a high level of interest from major automobile manufacturers for hybrid-electric technologies in light-, medium- and heavy-duty applications as well as off-road equipment. In particular, there are increasing numbers of diesel- and gasoline-fueled hybrid-electric vehicles and multiple models of light-duty plug-in hybrid and battery electric vehicles (BEVs). 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:

- development and demonstration of hybrid and electric technologies for goods movement, e.g., series hybrids with all electric range, and trolley trucks on catenary wayside power;
- evaluation and demonstration of light-, medium- and heavy-duty plug-in hybrid electric vehicles;
- demonstration of full performance and niche application battery electric vehicles;
- 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 battery electric vehicles;
- demonstration of heavy-duty hybrid vehicles including hydraulic and series hybrid concepts;
- 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, and to reduce cost, improve convenience and integrate with renewable energy and building demand management strategies.

Engine Systems

Natural gas engines are experiencing huge market growth due to the low cost of fuel. In order to achieve the emission reductions required for the South Coast Air Basin, the ICEs used in the heavy-duty sector will require emissions much lower, i.e., 90%, than the 2010 standards. Future projects will support the development, demonstration and certification of engines that can achieve these massive emissions reductions using an optimized systems approach. Specifically, these projects are expected to target the following:

- development of ultra-low emissions natural gas engines for heavy-duty trucks;
- 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;
- 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 & Fuel Cell Technologies & Infrastructure

The SCAQMD supports hydrogen infrastructure and fuel cell technologies as one option in our technology portfolio and is dedicated to assisting federal and state government programs to deploy fuel cell vehicles by supporting the required refueling infrastructure.

SCAQMD has supported many efforts for fuel cell demonstration and deployment in the South Coast district. Stationary fuel cells offer base-load power solutions that can operate on a continuous basis. The SCAQMD has partnered with federal and state agencies, industry and universities to develop and demonstrate a molten carbonate stationary fuel cell system that operates on biogas to produce heat, power and hydrogen. This SCAQMD project is currently in progress at the Orange County Sanitation District wastewater treatment facility located in Fountain Valley. This project could advance SCAQMD's goals for clean distributed generation, hydrogen fueling infrastructure and renewable energy. Going forward the technology is being refined and tested with the goal to apply it to other sites where biogas is a byproduct that can be utilized.

SCAQMD is actively working with the California Fuel Cell Partnership to further the commercialization of fuel cells for transportation and install the required hydrogen refueling infrastructure. Calendar Years 2015-2017 are a critical timeframe for the introduction of fuel cell vehicles. Since stations need one to two years lead time for permitting and construction, plans for stations need to be initiated now. In addition, new business models and funding besides grants for construction need to be explored to enable the station operations to remain solvent during the early years until vehicle numbers ramp up.

The 2013 Plan Update identifies key opportunities while clearly leading the way for pre-commercial demonstrations of OEM vehicles. Future projects may include the following:

- development and demonstration of hydrogen-natural gas vehicles for medium- and heavy-duty applications as well as stationary power applications;
- 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;
- 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, locomotive and marine applications; and
- demonstration of fuel cell vehicles in controlled fleet applications in the Basin.

Infrastructure and Deployment (NG)

The importance of refueling infrastructure cannot be overemphasized for the realization of large deployment of alternative fuel technologies. Significant demonstration and commercialization efforts funded by the Clean Fuels Program as well as other local, state and federal agencies are underway to: 1) support the upgrade and buildup of public and private infrastructure projects , 2) expand the network of public-access and fleet fueling stations and charging sites based on the population of existing and anticipated vehicles, and 3) put in place infrastructure that will ultimately be needed to accommodate transportation fuels with very low gaseous emissions.

CNG and LNG refueling stations are being positioned to support public and private fleet applications. 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. Funding has been provided at key refueling points for light-, medium- and heavy-duty natural gas vehicle users traveling from the local ports, along I-15 and the greater Interstate Clean Transportation Corridor network.

Active participation in the development of NFPA fire and safety codes and standards, cost and economics of the new fuels, public education and training and emergency response capability are just a few areas of the funded efforts that have overcome public resistance to these new technologies. Some of the projects expected to be developed and co-funded for infrastructure development are:

- Development and demonstration of renewable natural gas as a vehicle fuel from renewable feedstocks and biowaste;
- Development and demonstration of advanced, cost effective methods for manufacturing synthesis gas for conversionto renewable natural gas;
- Deployment of natural gas home refueling appliances for light-duty vehicles;
- Enhancement of safety and emissions reduction from LNG refueling equipment;
- Expansion of fuel infrastructure, fueling stations, and equipment; and
- Expansion of infrastructure connected with existing fleets, public transit, and transportation corridors.

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 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 and renewable 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.

Emissions, Fuels and Health Impacts Studies

The monitoring of pollutants in the Basin is extremely important, especially when focused on (1) a particular sector of the emissions inventory (to identify the responsible technology) or (2) exposure to 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 resulting from these technologies.

Over the past few years, the SCAQMD has funded emission studies to evaluate the impact of tailpipe emissions of biodiesel and ethanol fueled vehicles mainly focusing on criteria pollutants and greenhouse gas emissions. These studies showed that biofuels, especially biodiesel, contribute to higher NO_x emissions while reducing other criteria pollutant emissions. Furthermore, despite recent advancements in toxicological research related to air pollution, the

relationship between particle chemical composition and health effects is still not completely understood, especially for biofuels. Therefore, the SCAQMD has recently funded studies to investigate the physical and chemical composition and toxicological potential of tailpipe PM emissions from biodiesel and ethanol fueled vehicles to better understand their impact on public health.

In recent years, there has also been an increased interest both at the state and national level on the use of alternative fuels including biofuels to reduce petroleum oil dependency, GHG emissions and air pollution. In order to sustain and increase biofuel utilization, it is essential to identify feedstocks that can be processed in a more efficient, cost-effective and sustainable manner and cellulosic biomass plays an important role in this regard. In this regard, the SCAQMD funded a research project in 2011 to identify regional cellulosic biofuel feedstocks best suited for a large scale production in California. This project utilizes a newly developed robotic system capable of handling a large number of samples to determine their sugar yields and potentials as biofuel feedstocks.

Some areas of focus include:

- demonstration of remote sensing technologies 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 using biofuels;
- in-use emissions studies to determine the impact of new technologies, in particular PEVs 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.

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 ICE 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.

The use of renewable feedstocks for energy production is a viable and necessary strategy to provide sustainable power for future needs while reducing greenhouse gas emissions and achieving domestic energy diversity. One of the projects that the SCAQMD recently supported in this effort was a bench scale demonstration project using steam hydrogasification process to produce natural gas from biomass and biosolid (sewage sludge) feedstocks. Steam Hydrogasification Reaction (SHR) has been developed to produce various forms of energy products from carbonaceous resources. SHR is capable of handling wet feedstocks like sludge, does not require expensive oxygen plants and has been demonstrated to be most efficient and cost-effective compared to other conventional gasification technologies. This project successfully demonstrated that the SHR process coupled with a WGS reactor can produce natural gas containing up to 90% methane.

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);
- exploration of renewables as a source for cleaner stationary technologies; and
- evaluation, development and demonstration of advanced control technologies for stationary sources.

Target Allocations to Core Technology Areas

Figure 17 below presents the potential allocation of available funding, based on SCAQMD projected program costs of nearly $16.2 million for all potential projects. The expected actual project expenditures for 2013 will be 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 2013 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.

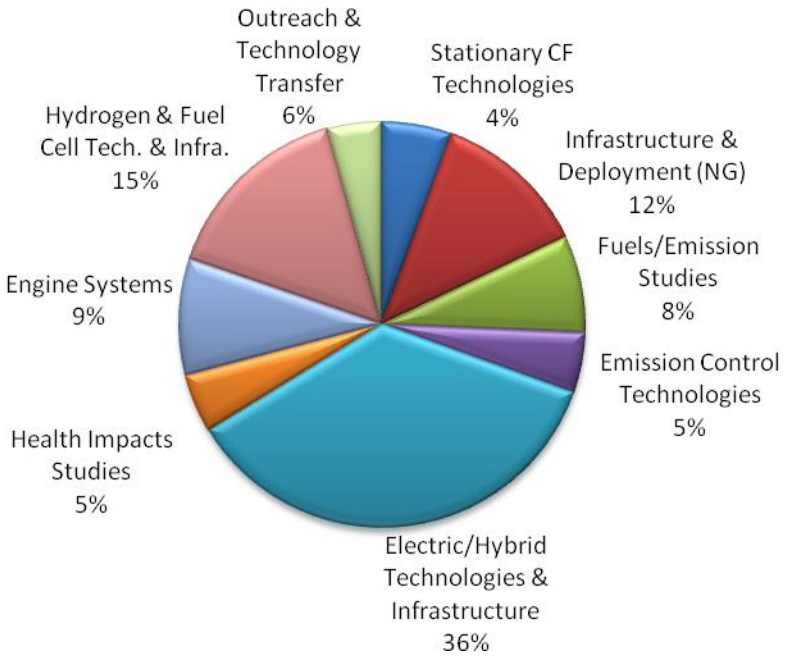


Figure 17: Projected Cost Distribution for Potential SCAQMD Projects 2013 & Beyond ($16.2 Million)

PROGRAM PLAN UPDATE FOR 2013

This section presents the Clean Fuels Program Plan Update for 2013. 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.

Table 8 (page 73) summarizes potential projects for 2013 as well as the redistribution of SCAQMD costs in some areas as compared to 2012. The relative shift in funding allocation is a result of continued but increasing focus on zero- and near-zero emission technologies and also because of state and federal awards received over the last year in some technology areas. For the past two years the SCAQMD has emphasized electric and hybrid-electric technologies and the urgency now is to develop and demonstrate heavy-duty all electric fuel cell, plug-in hybrid and hybrid technologies with all electric range for zero and near-zero emission goods movement applications, including the infrastructure for such technologies. To address this critical need, the 2013 Plan shifts funding of proposed projects in the Electric/Hybrid Technologies and Infrastructure category from light- and medium-duty hybrid vehicles and infrastructure to development and demonstration of electric container transport technologies.

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 8.

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 8: Summary of Potential Projects

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Electric/Hybrid Technologies & Infrastructure		
Demonstrate Light-Duty Plug-In Hybrid & Battery Electric Vehicles and Infrastructure	500,000	1,000,000
Develop and Demonstrate Medium- and Heavy-Duty Hybrid Vehicles and Infrastructure	1,000,000	3,000,000
Demonstrate Alternative Energy Storage	300,000	2,000,000
Develop and Demonstrate Electric Container Transport Technologies	4,000,000	15,000,000
Subtotal	$5,800,000	$21,000,000
Engine Systems		
Develop and Demonstrate Advanced Alternative Fuel Medium- and Heavy-Duty Engines and Vehicles	1,000,000	20,000,000
Develop and Demonstrate Alternative Fuel and Clean Conventional Fueled Light-Duty Vehicles	500,000	1,500,000
Subtotal	$1,500,000	$21,500,000
Hydrogen and Fuel Cell Technologies and Infrastructure		
Develop and Demonstrate Operation and Maintenance Business Case Strategies for Hydrogen Stations	500,000	4,000,000
Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations	1,750,000	6,000,000
Develop and Demonstrate Fuel Cell Vehicles	250,000	4,000,000
Subtotal	$2,500,000	$14,000,000
Infrastructure and Deployment (NG)		
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 Natural Gas Manufacturing and Distribution Technologies Including Renewables	500,000	7,000,000
Subtotal	$2,000,000	$11,000,000
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
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

Table 8: Summary of Potential Projects

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Fuels/Emission Studies (cont'd)		
Identify and Demonstrate In-Use Fleet Emissions Reduction Technologies & Opportunities	400,000	2,000,000
Subtotal	$1,250,000	$4,300,000
Health Impacts Studies		
Evaluate Ultrafine Particle Health Effects	250,000	3,000,000
Conduct Monitoring to Assess Environmental Impacts	250,000	1,000,000
Assess Sources and Health Impacts of Particulate Matter	250,000	300,000
Subtotal	$750,000	$4,300,000
Stationary Clean Fuel Technologies		
Develop and Demonstrate Reliable, Low Emission Monitoring Systems and Test Methods	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	500,000	800,000
Support for Implementation of Various Clean Fuels Vehicle Incentive Programs	400,000	400,000
Subtotal	$900,000	$1,200,000
TOTALS FOR POTENTIAL PROJECTS	**$16,175,000**	**$85,550,000**

Technical Summaries of Potential Projects

Electric/Hybrid Technologies & Infrastructure

Proposed Project: Demonstrate Light-Duty Plug-In Hybrid & Battery Electric Vehicles and Infrastructure

Expected SCAQMD Cost: $500,000

Expected Total Cost: $1,000,000

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 battery power 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) infrastructure (especially in conjunction with the DOE and the Los Angeles Department of Water & Power) 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 and 2012 AQMPs identify 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: $1,000,000

Expected Total Cost: $3,000,000

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 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 has accelerated 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 and 2012 AQMPs identify 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 Lithium ion chemistry battery packs. Over the past few years, additional technology consisting of nickel sodium chloride, lithium-ion and lithium iron phosphate batteries have 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 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 and 2012 AQMPs. 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: $4,000,000

Expected Total Cost: $15,000,000

Description of Technology and Application:

Advanced transportation systems can be used to transfer cargo containers from ports to both local and "distant" intermodal facilities, thereby significantly reducing emissions from on-road trucks and locomotives and also reducing 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 that are electrified with catenary electric lines or linear electric motors to move containers on modified trucks equipped to run on electricity. 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 elevated guideways. These container freight systems are not designed to carry any operators on the guideways, where the over-the-roadway system may require the operator to actively control the transport of the containers.

One of the container transportation concepts the AQMD is considering is the eHighway catenary hybrid truck system by Siemens Mobility. Siemens and their partners have developed a catenary system and hybrid electric trucks to utilize the catenary for zero emission transport of containers. The hybrid drive system will extend the operating range of the truck beyond the all-electric range of the catenary system, thus enabling the truck to perform regional drayage operations and bridge gaps in catenary infrastructure as it is deployed on a regional level. The proposed Siemens pantograph system will allow for seamless connection and disconnection from the catenary wires. When entering the catenary system corridor, the pantograph system will verify the presence of catenary lines and allow the driver to raise the pantograph from within the cab of the truck. Upon leaving the catenary system, the pantograph automatically retracts and the truck switches to on-board power systems. The on-board power systems could be a range of technologies, including batteries, fuel cells, or internal combustion engines. In addition, AQMD is administering a project to develop and demonstrate zero emission drayage trucks for goods movement operations, consisting of three different battery electric truck technologies and a fuel cell hybrid electric truck platform. This project is funded by a $4.2 million award from Department of Energy to promote the deployment of zero emission cargo transport technologies. These trucks can be also upfitted to connect to wayside power via a catenary or LSM system in the future.

In addition to these technologies, there are other options for electric container applications such as dual-mode locomotives, hybrid electric technologies with battery storage, a battery tender car, magnetic levitation, and fuel cell propulsion system. This program will evaluate all available technology options to determine whether their systems can be successfully developed and deployed, financially viable, and reliably operated on a long-term basis.

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 and 2012 AQMPs propose 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: $1,000,000

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), clean diesel, bio-diesel and ultra low-sulfur diesel, and compressed air technologies. 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;
- assessment of "clean diesel" vehicles, including hybrids and their ability to attain SULEV standards; and
- assessment of compressed air technologies.

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

Potential Air Quality Benefits:

The 2007 and 2012 AQMPs identify 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 and Fuel Cell Technologies & Infrastructure

Proposed Project: Develop and Demonstrate Operation and Maintenance Business Case Strategies for Hydrogen Stations

Expected SCAQMD Cost: $500,000

Expected Total Cost: $4,000,000

Description of Technology and Application:

California regulations require automakers to place increasing numbers of zero emission vehicles into service every year. By 2050, CARB projects that 87% of light-duty vehicles on the road will be zero emission battery and fuel cell vehicles with fuel cell electric becoming the dominant powertrain.

The California Fuel Cell Partnership (CaFCP) recently published a roadmap describing the first network of commercial hydrogen stations in California. The roadmap states that by 2015, 68 hydrogen fueling stations in cluster communities and at specific destinations will provide coverage for the first 20,000 FCEV owners in California. Stakeholders estimate 37 stations will be funded and operating in 2015, leaving a gap of 31 needed stations. The cost for these 31 stations is estimated to be approximately $65 million. The cost-estimates for these stations were based on a "cash-flow" analysis whereby the state would ensure the station operators would not be financially penalized for opening a hydrogen station. This model, however, makes assumptions based on a fuel retailers' perspective, including the station operator is able to secure financing, the size of stations, the cost of rent for the land and other factors. The analysis did not identify, however, the implementation of such a system.

This project category would evaluate the actual implementation of a "cash-flow" system, the willingness of banks to grant loans, the strategy to assess the cash-flow "gap", and other implementation challenges for such a system.

Potential Air Quality Benefits:

The 2007 and 2012 AQMPs identify the use of alternative fuels and zero-emission transportation technologies as necessary to meet federal air quality standards. One of the major advantages of Fuel Cell vehicles (FCEVs) is the fact that they use hydrogen, a fuel that can be domestically produced from a variety of resources such as natural gas, solar, wind and biomass. The technology and means to produce hydrogen fuel to support FCEVs are available now. The deployment of large numbers of FCEVs, which is an important strategy to attain air quality goals, requires a well planned and robust hydrogen fueling infrastructure. This AQMD program with additional funding from other entities will provide the hydrogen fueling infrastructure that is necessary in the South Coast Air Basin. The deployment of FCEVs and the development of the necessary fueling infrastructure will lead to substantial reductions in NOx, VOC, CO, PM and toxic air contaminants from vehicles.

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, are 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. It is estimated that approximately 50,000 fuel cell vehicles will be deployed by 2017 in California and the majority of these vehicles will be in the South Coast Air Basin. To provide fuel for these vehicles, the hydrogen fueling infrastructure needs to be significantly increased. SCAQMD will seek additional funding from CEC and CARB to construct and operate hydrogen fueling stations.

Potential Air Quality Benefits:

The 2007 and 2012 AQMPs identify 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.

Proposed Project: Develop and Demonstrate Fuel Cell Vehicles

Expected SCAQMD Cost: $250,000

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)

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

Potential Air Quality Benefits:

The 2007 and 2012 AQMPs identify 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 wide-scale 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.

Infrastructure and Deployment (NG)

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 SCAQMD's 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 and incorporate advancing concepts to increase the overall number of such fueling stations in strategic locations throughout the Basin including the Ports, 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 Natural Gas Manufacturing and Distribution Technologies Including Renewables

Expected SCAQMD Cost: $500,000

Expected Total Cost: $7,000,000

Description of Technology and Application:

Lack of sufficient 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 (e.g., production from biomass);
- 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 a significant increase in the penetration of zero- and low-emission vehicles in the South Coast Basin to attain federal clean air standards by 2014 and 2023. 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.

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. With the increasing focus on zero and near-zero emission goods movement technologies, this category should examine idle reduction concepts and technologies that can be employed at ports and airports.

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 emission 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.

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 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 SCAQMD'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:

The use of biofuels can be an important strategy to reduce petroleum dependency, air pollution and greenhouse gas emissions. Biofuels are in fact receiving increased attention due to national support and state activities resulting from AB 32, AB 1007 and the Low-Carbon Fuel Standard. With an anticipated increase in biofuel use, it is the objective of this program to further analyze these fuels to better understand their benefits and impacts not only on greenhouse gases but also on air pollution and associated health effects.

In various diesel engine studies, replacement of petroleum diesel fuel with biodiesel fuel has demonstrated reduced PM, CO and air toxics emissions. Biodiesel also has the potential to reduce greenhouse gas emissions because it can be made from renewable feedstocks, such as soy and canola. However, certain blends of biodiesel have a tendency to increase NO_x emissions, which exacerbates the ozone and $PM_{2.5}$ challenges faced in the Basin. In addition, despite recent advancements in toxicological research in the air pollution field, the relationship between biodiesel particle composition and associated health effects is still not completely understood.

Ethanol is another biofuel that is gaining increased national media and state regulatory attention. CARB has recently amended the reformulated gasoline regulation to further increase the ethanol content to 10% as a means to increase the amount of renewable fuels in the state. It is projected that the state's ethanol use will increase from 900 million gallons in 2007 to 1.5 billion gallons by 2012 as a result. As in the case of biodiesel, ethanol has demonstrated in various emission studies to reduce PM, CO and toxic emissions; however, the relationship between particle composition and associated health effects from the combustion of ethanol is not well understood either. The impact of natural gas fuel composition on emissions from heavy-duty trucks and transit buses is also being studied.

In order to address these concerns on potential health effects associated with biofuels, namely biodiesel and ethanol blends, this program will investigate the physical and chemical composition and associated health effects of tailpipe PM emissions from light- to heavy-duty vehicles burning biofuels in order to ensure public health is not adversely impacted by broader use of these fuels. This program also supports future studies to identify mitigation measures to reduce NO_x emissions for biofuels. Additionally, a study of emissions from well-to-wheel for the extraction and use of shale gas might be considered.

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.

Health Impacts Studies

Proposed Project: Evaluate Ultrafine Particle Health Effects

Expected SCAQMD Cost: $250,000

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 AQMP 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 and saturation 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.

Proposed Project: Assess Sources and Health Impacts of Particulate Matter

Expected SCAQMD Cost: $250,000

Expected Total Cost: $300,000

Description of Technology and Application:

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

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

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

In mid-2012 the SCAQMD initiated MATES IV which includes an air monitoring program, an updated emissions inventory of toxic air contaminants and a regional modeling effort to characterize risk across the Basin. This follow-on study will continue to focus on the carcinogenic risk from exposure to air toxics, but will not estimate mortality or other health effects from particulate exposures, as in previous studies. Instead, MATES IV will measure ultrafine particle concentrations and assess human exposure to ultrafines and back carbon near sources such as airports, freeways, rail yards, busy intersections and warehouse operations. Additionally, other related studies may be conducted, such as toxicity assessment based on age, source (heavy-duty, light-duty engines) and composition (semi-volatile or non-volatile fractions) to better understand the health effects and potential community exposures.

Potential Air Quality Benefits:

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

Stationary Clean Fuel Technologies

Proposed Project: Develop and Demonstrate Reliable, Low Emission Monitoring Systems and Test Methods

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. Reliable, 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. Another technical approach might be 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:

Stationary engines, boilers, heaters, furnaces and ovens account for approximately 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, 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, enhance the quality of natural gas generated from renewable sources for injection into natural gas pipelines, improve reliability and user friendliness and identify markets that could expedite the implementation of successful technologies.

Potential Air Quality Benefits:

The 2007 and 2012 AQMPs identify 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: $500,000

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

Dr. Chung Liu, Chair	SCAQMD
Luis Cabrales	Coalition for Clean Air
Tom Cackette*	California Air Resources Board
Patrick Davis.	U.S. Department of Energy
Dr. John Froines	Professor Emeritus University of California, Los Angeles
Gretchen Hardison	Los Angeles Department of Water and Power; Chair of Technical Advisory Committee of the Mobile Source Air Pollution Reduction Review Committee
Dr. Mike Hertel	Southern California Edison
Philip J. Hodgetts	Clean Air Now
Randall Lewis	Lewis Group of Companies
Tim Olson	California Energy Commission
James Uihlein	Chevron Corporation
Cherif Youssef	Southern California Gas Company

*Recently retired

SB 98 Clean Fuels Advisory Group

Dr. Chung Liu, Chair	SCAQMD
Robert Bienenfeld	American Honda Motor Company Inc
Dr. Blair Folsom	Independent Consultant in Combustion Technology
Dr. Mridul Gautam	West Virginia University
Dr. Fritz Kalhammer	Independent Consultant in Energy and Process Technology
Dr. Melanie Marty	California Environmental Protection Agency Office of Environmental Health Hazard Assessment
Dr. Wayne Miller	University of California, Riverside Center for Environmental Research and Technology
Dr. Vernon Roan	Professor Emeritus University of Florida
Dr. Scott Samuelsen	University of California, Irvine Combustion Laboratory/National Fuel Cell Research Center
Dr. Robert Sawyer	Sawyer Associates
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

* Currently with GMS Consulting, LLC

Appendix B

Open Clean Fuels Contracts as of January 1, 2013

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment						
05250	Downs Commercial Fueling, Inc.	Purchase & Install New L/CNG Fueling System at Commercial Fueling Station in Temecula	11/04/05	04/30/14	$203,137	$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
06042	University of California Los Angeles	Upgrade Existing CNG Public Access Station with Dispenser & Card Reader	09/05/06	12/31/13	15,921	31,842
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	02/28/16	120,000	400,000
06091	City of Whittier	Purchase & Install New Public Access CNG Fueling Station at City Yard	03/18/06	12/31/13	150,000	450,000
07051	City of Pasadena	Purchase & Install New Public Access CNG Fueling Station	12/28/06	03/01/14	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	12/31/13	164,861	1,399,110
07153	Foothill Transit	Purchase & Install New Public Access CNG Refueling Station in Irwindale	11/02/09	06/30/16	250,000	3,350,000
07243	City of Commerce	Purchase & Install New Public Access L/CNG Station	05/16/07	12/31/15	250,000	1,300,000
07244	SunLine Transit Agency	Upgrade Existing Public Access CNG Stations in Thousand Palms & Indio	04/04/07	04/30/14	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	06/30/17	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	06/30/17	200,000	440,000
07320	Orange County Transportation Authority	Install New CNG Station in the City of Santa Ana	12/21/07	03/31/13	350,000	5,841,729
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
09218	Rim of the World Unified School District	Install Mountain Safety Equipment on Five New CNG School Buses	01/05/10	12/31/16	65,850	65,850

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment (cont'd)						
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
10067	Rim of the World Unified School District	Install Mountain Safety Equipment on Seven New CNG School Buses	12/21/09	12/31/16	92,190	92,190
11548	Mansfield Gas Equipment Systems, Inc.	Buydown Incentive Program for CNG Home Refueling Appliance "Phill"	09/07/12	06/30/14	60,000	356,000
11559	Ace Parking Management	Purchase Six Natural Gas-Powered Cutaway-Type Shuttle Vans	05/06/11	07/31/13	96,200	600,950
11561	Supershuttle International	Purchase and Convert 20 Gasoline-Powered Passenger Vans to CNG-Powered Passenger Shuttle Vans	06/01/11	10/31/14	464,900	1,098,900
12135	Placentia-Yorba Linda Unified School District	Upgrade CNG Fueling Station	11/18/11	11/30/17	60,000	60,000
12259	A-1 Alternative Fuel Systems	Demonstrate Natural Gas-Powered Police Vehicle	04/20/12	10/19/14	65,000	65,000
12267	West Covina Unified School District	Upgrade CNG Fueling Facility	10/12/12	12/31/17	60,000	60,000
12273	Border Valley Trading Ltd.	Construct LNG Fueling Station	02/10/12	07/30/13	251,865	504,030
12386	Agility Fuel Systems	Demonstrate Natural Gas-Powered Police Vehicle	06/01/12	06/30/13	54,000	54,000
12851	Clean Energy	Construct Two LNG Fueling Stations	10/05/12	12/31/18	400,000	3,018,118
12852	City of Covina	Construct Public Access CNG Fueling Stations	10/12/12	12/31/18	200,000	618,429
12854	Waste Management, Inc.	Upgrade LNG Fueling Station at Baldwin Park Facility	08/17/12	12/31/18	300,000	1,588,100
13059	Rim of the World Unified School District	Construct CNG Fast-Fill Station	10/05/12	01/31/18	200,000	400,000
Fuels/Emission Studies						
07236	National Renewable Energy Lab	Investigate the Role of Lubricating Oil on PM Emissions from Vehicles	03/23/07	12/30/15	200,000	446,887
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
10066	National Renewable Energy Laboratory	CRADA – Loan of 70 MPa Hydrogen Quality Sampling Apparatus to AQMD	11/02/09	12/30/15	0	0
10722	University of California Riverside/CE-CERT	Re-Establish Testing Facility & Quantify PM Emission Reductions from Charbroiling Operations	08/06/10	04/30/13	60,000	60,000
11611	West Virginia University Research Corporation	In-Use Emissions Testing and Demonstrate Retrofit Technology of On-Road Heavy-Duty Engines	07/08/11	01/31/13	974,110	1,134,015

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Fuels/Emission Studies (cont'd)						
11612	University of California Riverside	In-Use Emissions Testing and Demonstrate Retrofit Technology of On-Road Heavy-Duty Engines	07/08/11	08/25/13	766,380	785,172
Emission Control Technologies						
08246	Griffith Company	Showcase: Demonstrate NO_x & PM Emissions Control Technology on Diesel-Powered Construction Equipment	5/14/08	12/31/13	191,450	297,450
08321	Environmental Systems Products	Remote Sensing Measurements of On-Road Emissions from Heavy-Duty Diesel Vehicles	08/12/08	01/31/13	38,000	38,000
10069	Johnson Matthey, Inc.	Develop & Demonstrate SCRT for NO_x and PM Emissions Control	06/18/10	10/13/13	300,000	2,818,449
10696	Johnson Matthey, Inc.	Optimize & Demonstrate SCRT for NO_x and PM Emissions Control	07/09/10	12/31/14	300,000	2,818,449
10697	Johnson Matthey, Inc.	Optimize & Demonstrate SCCRT for NO_x and PM Emissions Control	07/09/10	12/31/14	300,000	2,818,449
12113	Southern Counties Terminals dba Griley Air Freight	Retrofit Three Heavy-Duty Diesel Trucks with Diesel Particulate Filters	10/13/11	03/31/14	15,000	45,000
12114	South Bound Express, Inc.	Retrofit Three Heavy-Duty Diesel Trucks with Diesel Particulate Filters	10/13/11	03/31/14	15,000	54,623
12118	National Ready Mixed Concrete	Retrofit 13 Heavy-Duty Diesel Trucks with Diesel Particulate Filters	10/13/11	03/31/14	65,000	239,806
12120	Standard Concrete Products	Retrofit 40 Heavy-Duty Diesel Trucks with Diesel Particulate Filters	10/13/11	03/31/14	200,000	596,665
12121	Challenge Diary Products, Inc.	Retrofit Three Heavy-Duty Diesel Trucks with Diesel Particulate Filters	11/18/11	03/31/14	15,000	46,845
12122	Bear Trucking, Inc.	Retrofit One Heavy-Duty Diesel Truck with Diesel Particulate Filter	10/14/11	03/31/14	5,000	13,555
12123	RRM Properties	Retrofit 107 Heavy-Duty Diesel Trucks with Diesel Particulate Filters	10/06/11	03/31/14	535,000	1,481,067
12124	Gaio Trucking, Inc.	Retrofit Nine Heavy-Duty Diesel Trucks with Diesel Particulate Filters	09/28/11	03/31/14	40,000	147, 261
12125	Spragues Ready Mix	Retrofit Four Heavy-Duty Diesel Trucks with Diesel Particulate Filters	10/14/11	03/31/14	20,000	62,953
12150	Puritech US, LLC	Demonstrate NOx and PM Emission Control Technologies on Diesel-Powered Construction Equipment	02/14/12	04/30/13	72,000	172,000
12175	RRM Properties	Retrofit Seven Heavy-Duty Diesel Trucks with Diesel Particulate Filters	12/08/11	03/31/14	35,000	84,812
12186	Pipeline Carriers Inc.	Retrofit 25 Heavy-Duty Diesel Trucks with Diesel Particulate Filters	12/16/11	03/31/14	50,000	182,300

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Emission Control Technologies (cont'd)						
12485	California State University Long Beach Foundation	CSULB CEERS Student Education Study for Development of a Humid Air System and Exhaust Scrubber for Diesel Engine Emissions Reductions	06/29/12	03/31/13	28,000	28,000
Electric/Hybrid Technologies						
99109	Toyota	Lease Two Toyota RAV4 Electric Vehicles for CY 2011	04/04/99	02/01/13	120,620	120,620
08063	Quantum Fuel Systems Technologies Worldwide, Inc.	Develop & Demonstrate 20 Plug-In Hybrid Electric Vehicles	01/22/08	12/15/14	2,165,613	2,885,266
08219	A123Systems Inc.	Develop & Demonstrate Ten Plug-In Hybrid Electric Vehicles	06/05/09	06/04/15	622,667	962,667
09345	South Bay City Council of Governments	Demonstrate Medium-Speed Electric Vehicles	06/19/09	04/30/13	298,640	298,640
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	06/30/13	300,000	755,767
11606	Odyne Systems, LLC	Develop and Demonstrate Plug-In Hybrid Electric Drive System for Medium- and Heavy-Duty Vehicles	07/08/11	07/07/13	494,000	2,599,000
11614	Transportation Power, Inc.	Demonstrate Battery Electric Heavy-Duty Trucks	07/08/11	11/07/13	496,505	2,616,275
11725	Puente Hills Nissan	Lease of Three Nissan Leaf Vehicles for 39 Months	05/27/11	08/26/14	60,222	82,722
12020	Coulomb Technologies	Install Electric Charging Infrastructure	10/05/12	04/04/14	70,000	70,000
12024	ECOtality North America	Install Electric Charging Infrastructure	11/04/11	05/03/13	70,000	70,000
12028	Electric Vehicle International, Inc.	Demonstrate and Replace UPS Diesel Delivery Trucks with Zero-Emission Medium-Duty Trucks	09/09/11	09/08/17	1,400,000	4,872,000
12825	BMW of Monrovia	Lease Two BMW ActiveE Electric Vehicles for Two Years	03/23/12	03/22/14	31,065	31,065
12862	Volvo Technology of America, Inc.	Develop Class 8 Plug-In Hybrid Heavy-Duty Vehicle	12/07/12	12/31/14	1,200,000	2,400,000
12889	BMW of Monrovia	Lease Two BMW ActiveE Electric Vehicles for Two Years	03/23/12	03/22/14	31,065	31,065
13042	South Bay City Council of Governments	Demonstrate Medium-Speed Electric Vehicles	11/02/12	05/01/15	320,000	528,078
13251	Selman Chevrolet Company	Lease Two 2012 or Newer Chevrolet Volt Extended-Range Electric Vehicles for Three Years	11/28/12	11/27/15	31,375	31,375
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

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Mobile Fuel Cell Technologies (cont'd)						
10714	University of California Irvine	Develop Fuel Cell Gas Turbine Hybrid System for On-Board Locomotive Applications	12/02/11	12/01/13	78,000	156,000
Hydrogen Technologies and Infrastructure						
04185	Quantum Fuel Systems Technologies Worldwide	Develop & Demonstrate Hydrogen Internal Combustion Engine Vehicles	10/18/04	04/30/14	2,353,000	3,328,631
07292	University of California Irvine	Develop Hydrogen Storage Capability for Gas Blending Facility	08/31/12	06/30/13	200,000	688,000
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	12/30/13	368,000	368,000
11150	Hydrogen Frontier, Inc.	Maintenance & Operation of City of Burbank Hydrogen Fueling Station	11/24/10	01/24/15	200,000	1,060,000
10482	California State University Los Angeles	Install and Demonstrate PEM Electrolyzer, Providing Hydrogen Fueling for Vehicles and Utilizing the Technology in the Engineering Technology Curriculum at the University	03/04/11	10/03/17	250,000	1,662,000
11555	University of California Los Angeles	Construct Hydrogen Fueling Infrastructure	12/07/12	12/31/19	400,000	2,589,990
12075	Linde, LLC	Expand Hydrogen Fueling Infrastructure	11/02/12	11/02/18	250,000	2,732,177
13146	California State University Los Angeles	Lease of One Toyota Prius Hydrogen-Fueled Vehicle	11/08/12	03/31/14	0	0
Health Impacts Studies						
09307	California Air Resources Board	In-Vehicle Air Pollution Exposure Measurement & Modeling	09/01/08	06/28/13	250,000	500,000
11527	University of Southern California	Conduct Study on Sources, Composition, Variability and Toxicological Characteristics of Ultrafine Particles in Southern California	07/24/11	07/24/14	470,969	470,969
12197	University of California Riverside/CE-CERT	Health Effects of PM Particles from Heavy-Duty Biodiesel-Fueled Vehicles	01/13/12	09/12/13	207,500	207,500
12208	University of California Riverside/CE-CERT	Determine the Physical and Chemical Composition and Associated Health Effects of Tailpipe PM Emissions	01/21/12	07/19/13	175,000	1,375,000
12865	University of California Los Angeles	Develop Quantitative Cellular Assays for Use in Understanding the Chemical Basis of Air Pollutant Toxicity	06/08/12	07/07/14	368,457	368,457

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Stationary Clean Fuels Technology						
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
10723	Eastern Municipal Water District	Retrofit Digester Gas Engine with NO_x Tech Aftertreatment Emission Control Technology	03/16/12	03/15/13	85,000	889,000
11208	Long Beach Unified School District	Air Filtration MOA	12/02/10	12/01/14	0	0
13030	University of California Irvine	Demonstrate 300 kW Molten Fuel Cell with Exhaust-Fired Absorption Chiller	10/12/12	04/11/15	257,500	257,500
Outreach and Technology Transfer						
00069	Walsh Consulting	Technical Assistance Relating to the Use of Alternative Fuels in Mobile Sources	02/17/00	02/28/14	35,000	35,000
02308	Sperry Capital, Inc.	Evaluate Financial Stability of Potential Contractors	06/25/02	12/31/13	50,000	50,000
04049	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance for Alternative Fuels Engine Technology	11/21/03	04/30/13	120,000	120,000
05126	St. Croix Research	Development, Outreach & Commercialization of LNG, CNG and Hydrogen Fuels	03/15/05	03/31/13	25,000	25,000
05128	Mid-Atlantic Research Institute LLC	Development, Outreach & Commercialization of Advanced Heavy-Duty and Off-Road Technologies	08/08/05	03/31/13	40,000	40,000
07060	Don Breazeale and Associates, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods Movement	11/15/06	11/30/13	58,000	58,000
07062	The Tioga Group, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods	12/19/06	11/30/14	58,000	58,000
07129	Breakthrough Technologies Institute, Inc.	Technical Assistance with Fuel Cell Technology	12/01/06	03/31/14	40,000	40,000
07314	Engine, Fuel and Emissions Engineering, Inc.	Technical Assistance with Advanced Heavy-Duty and Off-Road Technologies	06/25/07	12/31/13	60,000	60,000
08210	Sawyer Associates	Technical Assistance on Mobile Source Control Measures and Future Consultation on TAO Activities	02/22/08	02/28/14	25,000	25,000
09252	JWM Consulting Services	Technical Assistance with Review & Assessment of Advanced Technologies, Heavy-Duty Engines, and Conventional & Alternative Fuels	12/20/08	06/30/14	30,000	30,000
09255	Stan Lisiewicz	Technical Assistance with Caltrans	01/29/09	12/31/13	10,000	10,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (cont'd)						
09337	Mark Weekly, CPA	Follow-Up Assessment of AQMD's Compliance with Special Revenue Funds	03/03/09	01/31/15	35,000	35,000
10056	Advanced Transportation Technology & Energy, San Diego Community College District	Enhanced Training Technology Program	05/27/10	12/31/13	500,000	500,000
10700	TIAX LLC	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile & Stationary Source Technologies	07/23/10	05/31/13	190,000	190,000
10662	Gladstein, Neandross & Associates	Technical Assistance for Implementation of Proposition 1B Goods Movement and Truck Replacement Program	05/12/10	12/31/13	275,000	275,000
10700	TIAX LLC	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Technologies	07/23/10	05/31/13	70,000	70,000
11028	Martin Kay	Technical Assistance on Stationary Source Control Measures & Future Consultation on TAO Activities	08/04/10	12/31/13	40,000	40,000
11144	San Diego Community College District on behalf of Advanced Transportation Technology and Energy	Natural Gas-Powered Vehicle Training and Safety and Fuel Cylinder Inspection Program	12/10/10	05/31/13	130,000	130,000
11182	Tech Compass	Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis & Aftertreatment Technologies	11/19/10	12/31/13	75,000	75,000
11484	Gladstein, Neandross & Associates, LLC	Develop and Implement Two Customer Centers to Provide Education and Outreach to Truck Owners and Operators	01/27/11	11/30/13	150,000	150,000
12064	Joseph C. Calhoun, P.E., Inc.	Technical Assistance with Low- and Zero-Emission Vehicles, Technology and Emissions Analysis	06/01/12	12/31/14	20,000	20,000
12309	TIAX LLC	Technical Assistance with Low and Zero Emission Vehicles, Fuel Cells and Fueling Infrastructure	04/06/12	04/05/14	75,000	75,000
12313	CSA America Inc.	CNG Fuel System Inspection Certification Courses	07/13/12	05/31/13	14,100	28,200
12380	The Tioga Group	Technical Assistance Related to Emissions, Advanced Technologies and Goods Movement	04/13/12	04/30/14	25,000	25,000
12381	Integra Environmental Consulting Inc.	Technical Assistance Related to Emission Inventories, Goods Movement and Off-Road Sources	04/06/12	04/30/14	25,000	25,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (cont'd)						
12453	Tech Compass	Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis and Aftertreatment Technologies	06/21/12	05/30/14	75,000	75,000
13052	The Better World Group	Assist with Completing & Publicizing SCAQMD's Clean Air Tips Celebrity Video	11/16/12	11/30/12	11,000	11,000
13081	Burnett & Burnette	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Technologies	11/01/12	04/30/14	40,000	40,000
13194	Clean Fuel Connection Inc.	Technical Assistance with Alternative Fuels, Renewable Energy and Electric Vehicles	12/07/12	12/06/14	30,000	30,000
13198	Gladstein, Neandross & Associates, LLC	Technical Assistance with Alternative Fuels, Emissions Analysis and On-Road Sources	12/14/12	12/13/14	75,000	75,000

Appendix C

Final Reports for 2012

SCAQMD Contract #06031 **December 2012**

Upgrade CNG Station at Bellflower Facility

Contractor

R.F Dickson Co., Inc. dba California Clean Fuels
Contact: Steve Dickson

Co-Participants

Mobile Source Air Pollution Reduction Review Committee (MSRC)
California Energy Commission

Project Officer

Larry Watkins

Background

California Clean Fuels (CCF), based in Bellflower CA, supports the goal of clean air and a healthier environment through the use of alternative fuel vehicles. Their upgraded station greatly improves fueling support to the growing fleet of regionally operated light-, medium- and heavy-duty compressed natural gas (CNG) vehicles, as school districts, transit fleets and waste collection operators continue to implement fleet conversion to CNG to meet local (SCAQMD) and California Air Resources Board (CARB) fleet rules and regulations. The station expansion specifically supports R.F. Dickson's growing fleet of CNG heavy-duty municipal street sweepers as well as Bellflower Unified School District's (Bellflower USD) CNG school buses and maintenance fleet vehicles.

Project Objective

The objective of this project was implementation of a CNG station upgrade that: 1) helps the station to better meet projected throughput requirements as a function of peak demand over time, 2) meets long-term operational requirements, 3) was designed using state-of-the-art, proven fuel storage, dispensing and compression technologies, 4) is easy to access and operate by a variety of NGV configurations, and 5) is compatible with all applicable industry and public codes and standards (both health and safety) to ensure safe installation and operation.

Technology Description

Under this grant agreement, California Clean Fuels upgraded its regional CNG fueling station, which is strategically located at 15330 South Woodruff Avenue, Bellflower, CA, 90706. This station is near the 91, 5, 605, 710 and 105 freeways, providing excellent public access for the CNG vehicle population operating throughout Southern California.

Equipment specifications that met key project criteria were used to solicit an experienced CNG station contractor to implement the station upgrade. The station upgrade prime contractor selected was AMTEK Construction. CCF will continue to operate and maintain the station. The upgraded station meets all applicable codes/standards for CNG fueling. Steve Dickson was responsible for overall project management and achieved timely completion of the project, once the CEC grant agreement was executed and the compressor equipment and storage vessels were procured and delivered.

Status

The expanded station opened on May 15, 2007. CCF experienced a handful of startup "bugs" including computer software problems and line feed leaks. All hardware issues have now been addressed but software issues continue to need attention. More information on the startup of the station can be found in the Final Report. Fleet customers of the expanded station include the City of Bellflower, the City of Lakewood, R.F. Dickson Co., Inc. (street sweepers), Bellflower USD, Super Shuttle and Express Shuttle, among many others. The station is equipped with a universal card billing system that allows the use of standard Visa/Mastercard-type credit cards.

Upgraded Station in Operation

Results

The completed station upgrade provides a significant improvement in the ability to service increasing numbers of large fleet vehicles in a timely and convenient manner, consistent with preferred fleet operations. The upgrade included the following key elements:

- An additional compressor that increased compression capacity from the previous capacity of 260 scfm to 920 scfm. This additional fuel compressor facilitates movement of more, and larger, vehicles through the station in a timely manner.
- Three additional ASME compressed gas storage vessels, increasing storage from 72,000 to 108,000 scf. This increased storage allows for a significant increase in the number of vehicles that can now be fueled at peak times.
- An added fuel dispenser, integrated in a manner to ensure that larger vehicles may be easily accommodated at this new dispenser. This dispenser is equipped with both a standard NGV1 nozzle and a high-flow transit nozzle (Sherex 5000) in order to better serve the growing transit fleet customer base. The dispenser also includes a credit card system for user-friendly public access.

Since the upgrade, a total of 62,275 GGE were dispensed from the upgraded station; this compares to an average of 53,348 over a similar 2-month period prior to the upgrade. Once all of the upgraded station's operational bugs are fully addressed, CCF anticipates that throughput will grow to an annual average of 400,000 GGE within the next three years.

Benefits

The use of low-emission CNG fueled vehicles and refueling stations is an effective strategy to reduce mobile source emissions and reduce consumption of imported oil imports. The initial throughput load at the station is projected to be 400,000 GGE per year. Each equivalent gallon of CNG dispensed equates to varying degrees of NOx and diesel PM emissions reductions, depending on the age and usage of the CNG vehicles and the diesel vehicles they replaced.

Project Costs

The SCAQMD contributed co-funding in the amount of $211,148 towards this project. California Clean Fuels and its partners contributed $501,247 towards the CNG station expansion for a total cost of $712,395 to date. Projected costs were originally $703,828. Cost increases were a result of the extended amount of time required to execute a contract with project partner CEC; in the added time to initiate the project, costs of raw materials increased dramatically. Please refer to Table One: Project Costs, in the Final Report for a detailed breakdown of planned versus actual costs.

Commercialization and Applications

The use of low-emission alternative fuel vehicles and refueling stations is an effective strategy to reduce mobile source emissions. The purchase of alternative fuel vehicles and construction/expansion of CNG stations are replicable by local agencies and private fleets throughout the SCAQMD's operational jurisdiction and beyond.

SCAQMD Contract #06238 **December 2012**

Purchase & Install New CNG Fueling System at City of San Fernando Public Works Dept. Yard

Contractor

Gas Equipment Systems Inc

Cosponsors

SCAQMD
MSRC
Southern California Gas Company
Southern California Edison
City of San Fernando

Project Officer

Larry Watkins

Background

The City of San Fernando, CA located in the San Fernando Valley, was an early adopter of clean fuel vehicles, specifically CNG.

The City further made commitments to SCAG through an MOU in October of 2003 to implement a long-term plan for cleaner air through the expansion of the City's vehicle fleet with CNG fueled vehicles and the addition of a CNG City commuter Trolley and CNG fueling infrastructure necessary to fuel the expansion of that fleet.

Gas Equipment Systems, Inc. (GESI) has been a long-term partner with the City of San Fernando in the development of their CNG fueling infrastructure, beginning with two vehicles and a small FuelMaker CNG fueling appliance installed by GESI.

Objective

To prepare for growing the City's existing 7 light duty CNG vehicles to 35, to include Trolleys and Paratransit buses, over the next five years, reduce toxic vehicle emissions and improve San Fernando Valley air quality. The City CNG fueling infrastructure development was launched and expanded in three phases over a period of years, beginning in their January 5, 2004 Council approval of Resolution No. 6948 for development of their CNG fueling station Phase III plan, and culminating in the recent construction and opening of the Public Access CNG fueling station at 120 McNeil Street in downtown San Fernando.

In order to implement this CNG infrastructure development plan, GESI made application to the SCAQMD for partial Grant funding with GESI acting as the Station developer and operator and maintenance facilitator. The City of San Fernando agreed to participate as the "CNG anchor tenant" for a period of five years and to commit to assist GESI in attracting CNG fuel clients to achieve maximum CNG throughput during GESI's five-year AQMD contract obligation.

Status

After the CNG infrastructure Grant was officially awarded to GESI by the SCAQMD, the City decided to sell the City owned Corporation Yard originally identified as the station location; GESI therefore requested and was granted an extension for completion of this infrastructure project.

Ultimately the City selected a site directly across the street from the City of San Fernando City Hall. This site was in fact better situated for the CNG infrastructure, being located near downtown, the library, State, County and City agency buildings, other transit venues and parking lots, and easily accessible from major freeways I-5, Hwy118, I-210, Hwy 170, I-405, and arterial streets.

Further time extensions were needed while the City negotiated with the electric utility for adequate electrical supply at the new location.

GESI completed construction and the CNG station went operational in December 2007, followed by a Grand Opening Event on March 28, 2008. The public access CNG station is now open 24 hours daily, 7 days each week.

Public Access CNG Fueling Station

Results

It is anticipated that this project will achieve and or exceed the program objectives as outlined in the original Grant funding request. Un-reconciled throughput as of May 2008 was 1600 gge.

CNG Fueling Station Components

Benefits

Principal benefits include: reduction in fuel costs for the City of San Fernando's existing and future CNG vehicle fleet; introduction and projected expansion of CNG vehicles in the area's commercial vehicle fleets, and reduced emissions in the greater San Fernando Valley area as a result of more CNG vehicles being purchased and driven.

Project Cost

GESI's total project cost was $410,038 for supply and installation.

SCAQMD Contract #07152 **December 2012**

Purchase & Install New Limited Public Access CNG Fueling Station

Contractor

Newport Mesa Unified School District

Cosponsors

SCAQMD
Newport-Mesa Unified School District
MSRC/AB 2766 Discretionary Fund

Project Officer

Larry Watkins

Background

With the help of grant funding from the Department of Energy and SCAQMD, the Newport Mesa Unified School District (NMUSD) has been able to obtain 29 CNG fueled school buses. NMUSD plans to obtain at least 19 more as funding allows, as part of its bus replacement program. Emissions from NMUSD's older diesel bus fleet prior to embarking on this program had significant impact on the environment.

Project Objective

NMUSD proposed to construct, own and operate a new limited public access CNG fueling station on district-owned land located at 2985 Bear Street, Costa Mesa, California, 92626. The total initial estimated budget for the station was $375,000.

The station was intended to include up to 32 slow-fill posts and options for a fast-fill dispenser at a later date. Due to significant increases in cost, the project was reduced in scale to include only 13 slow-fill posts and 26 dispensers. Additional hoses, including fast-fill capability, will not be available until further resources are secured. However, the existing installed design can accommodate later expansion to include fast-fill and additional alternative fuels if appropriate.

Technology Description

The fueling station as installed uses dual Angi 75 scfm (50 Hp) compressors which generate 4500 psi at the outlet with a 15 psi inlet pressure. It also uses a Xebec STV24 gas dryer. The dual compressor design allows for maintenance and anticipated growth. The system feeds 13 dual hose time-fill posts.

Status

The project was completed and the CNG fueling infrastructure became operational on August 24, 2009. All necessary permits and documents are in place. On October 29, 2009, a grand opening event was held. Representatives of the media, district administration, contractors, and dozens of other interested parties attended.

There were no significant unanticipated problems with this project besides the inability to secure less costly equipment and services.

Results

The new fueling station has resulted in significant cost savings in staff time previously expended to fuel CNG-powered school buses, mileage associated with off-site fueling, and the cost of fuel. This information is summarized in the following table.

Expense Item	Prior to Station Install	After Station Install
Annual Driver Labor Expense – Fueling Offsite	$66,000	0
Annual Travel Expense – Fueling Off-site (fuel cost)	$2,711	0
Annual estimated Cost of fuel (diesel vs. on-site CNG)	$97,453	$44,730
Annual fuel related Electrical Cost (diesel vs. on-site CNG)	0	$18,900

Some tradeoffs involved in switching to CNG technology include:

- Additional parts storage and training required for the new technology.
- Availability of service expertise and parts in the future as the engine manufacturer (Deere) is no longer producing CNG bus engines.
- Limited travel range of the buses due to CNG storage limitations on the bus. However, there is an approximate 20% increase in the range of buses that are now slow-filled using the new station over fast-filled CNG buses.
- Several maintenance issues specific to the CNG technology on buses (including the need to replace CNG on-bus storage tanks when they reach their labeled useful life span.)

While the CNG technology provides well documented benefits in terms of emissions reduction, especially over older diesel technology, there are operational expenses inherent in the new technology.

Benefits

The benefits of CNG buses and the on-site fueling station are significant in terms of air pollution and community exposure to toxic diesel particulate. Additionally, on-site CNG fueling provides significant cost savings over on-site diesel fueling.

The average price difference for the two fuels is $1.54 per gallon equivalent. However, the true cost difference is somewhat less since diesel buses get more miles / gallon than CNG fueled buses. Project performance statistics show CNG buses use approximately 45% more fuel (5.5 mi./gallon vs. 8.0 mi./gallon.) Additionally, the CNG compressors cost approximately $.30/gallon in electrical fees. Therefore, the true fuel cost difference to operate on-site CNG vs. diesel is $.92/gallon equivalent which is still very significant given the volumes involved.

Implementation of on-site fueling infrastructure also helps reduce 21,000 miles of bus travel that had been necessary to access off-site CNG fueling. Although this benefit is only marginal in terms of emissions reduction, it does offset a significant labor cost that switching to CNG had placed on NMUSD. Existing diesel storage on-site did not require travel for access. The new CNG station mitigated the labor and travel expenses.

Project Costs

Actual project costs totaled $538,997 and were funded as follows:

Infrastructure Funding Sources	**Grant #**	**Funding**
Lower-Emission School Bus Program	G07089	$170,708
Lower-Emission School Bus Program	G05083	$39,947
Clean Fuels Program - Infrastructure	C07152	$150,000
MSRC/AB 2766 Discretionary Fund	MS06048	$50,000
NMUSD Cost-Share		$128,342
Final Actual Costs		**$538,997**

Commercialization and Applications

It is anticipated that, when funding is available, the NMUSD will install additional time filled posts as well as fast fill capability. Once this is achieved it is anticipated other local users will avail themselves of the fueling site.

SCAQMD Contract #10640 **June 2012**

Convert 45 Taxicabs to Natural Gas Power for Deployment as Airport Ground Transportation

Contractor
Yellow Cab Co. of Greater Orange County

Cosponsors
U.S. Department of Energy
Yellow Cab Co. of Greater Orange County
SCAQMD

Project Officer
Philip Barroca

Background
This project was co-funded from the American Recovery and Reinvestment Act (ARRA) through a U.S. DOE Clean Cities ward for Petroleum Reduction Technologies Projects for the Transportation Sector. The project provided buy-down incentive funds for the conversion and deployment of 45 natural gas-powered taxi cabs used in commercial airport ground transportation services in the South Coast Air Basin.

Project Objective
The program was to expand the use of alternative fuel passenger class vehicles and displace the use of conventionally fueled, high-mileage taxi cabs which serve the major commercial airports in the SCAQMD jurisdictional area.

Technology Description
The technology used in this project is a 2009 CARB-certified gasoline to natural gas conversion system manufactured by BAF Technologies, certified to SULEV (Super Ultra Low Emission Vehicle) exhaust emission standards. The CNG conversion system is matched for installation on a 2009 model year Ford Crown Victoria, powered with an OEM-equipped 4.6L gasoline engine. The gasoline version of this vehicle is CARB certified to ULEV (Ultra Low Emission Vehicle) exhaust emission standards.

Status
Forty-five 2009 Ford Crown Victoria vehicles have been successfully converted to operate on dedicated natural gas (CNG) and have been continuously operating in the South Coast Air Basin since the third quarter of 2010.

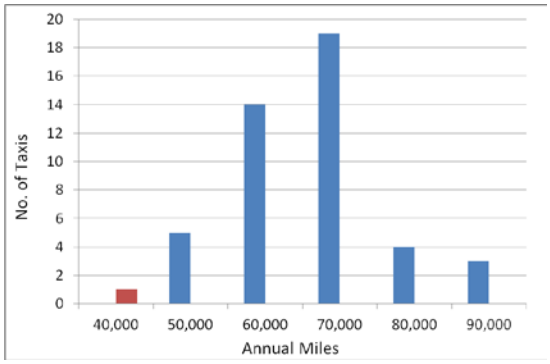
Converted CNG-Fueled Taxicab

This project was intended to provide up to two years of mileage and fuel usage data, and exceeded this goal by producing 2.5 years of data. Additional information on vehicle performance and operator satisfaction is included in the Final Report.

Results
As part of the buy-down incentive program, Yellow Cab Co. of Greater Orange County has provided quarterly data for each vehicle including fuel usage and mileage data. This data comprises 2.5 years or 10 calendar quarter periods for 45 CNG powered taxi cabs starting with the third quarter of 2010 through the fourth quarter of 2012. The following data has been compiled for this 2.5 year period and for the forty-five (45) 2009 CNG Ford Crown Victoria vehicles: Total CNG fuel usage: 408,400 GGE (Gasoline Gallon Equivalents), and total vehicle miles accrued: 6.9 million miles. Per-vehicle average annual fuel consumed: 3,600 GGE; per vehicle average annual miles driven: 61,000 miles. Average vehicle fuel

economy is estimated at 16.6 miles per gallon gas equivalent (GGE).

Preliminary information on annual taxicab mileage indicated a single vehicle can accrue as much as 80,000 miles per year. The following graph depicts the distribution of annual miles traveled for the fleet of 45 vehicles, based on the 2.5 years of data provided by Yellow Cab Co. of Greater Orange County. The distribution bars on the graph are based on 10,000 mile increments. Seven vehicles in this population had annual mileage accrual greater than 70,000 miles but less than 90,000 miles, with the majority of vehicles accruing between 60,000 and 70,000 miles per year.



Based on the U.S. EPA Greenhouse Gas (GHG) Equivalencies Calculator, this project has resulted in reducing 1,083 metric tons of CO_2 equivalent emissions. This total emission reduction is based on 2.5 years of operation of 45 CNG powered taxis and the equivalent displacement of 408,400 gallons of gasoline, and GGE to Therms CNG conversion factor of 1.248 Therms/GGE.

Benefits

The primary objective of the proposed project was to increase the use of alternative-fueled vehicles through the deployment of natural gas fueled vehicles in a high-mileage application such as taxicabs. The vehicles in this project served the six major commercial airports in the SCAQMD jurisdictional area as well as other taxi services. Emissions from conventionally fueled versions of these vehicles contribute to the air quality problem in the region; contribute to greenhouse gas emissions; and reflect dependency on imported petroleum fuel. CNG versions of these vehicles help reduce local air quality impacts, reduce GHG emissions, and use domestically produced natural gas.

Taxicab fleets serving commercial airports within the SCAQMD jurisdictional area represent one of the highest-accumulated-mileage fleets operating in the region. This project demonstrated that these vehicles average more than 60,000 miles per year per vehicle. Considering the high annual mileage and relatively low fuel economy (16 mpg), these vehicles contribute significantly to the ozone air quality problem in the South Coast Air Basin.

A buy-down incentive program for natural gas taxicabs serving commercial airports in the South Coast Air Basin and Coachella Valley will ensure that the pollution contribution from these fleets will be kept to a minimum while concurrently displacing petroleum use. As previously mentioned in this paper, the CNG version of this vehicle is CARB classified as SULEV as compared to its gasoline/E85 counter-part which is CARB classified as ULEV. In addition, the amount of calculated GHG reductions realized over the current life of this project is greater than 1,000 metric tons equivalent of CO_2.

Project Costs

The total cost for the purchase and conversion of the 45 CNG vehicles in this project was $2,129,000. Funding was provided as follows: Yellow Cab Co. of Greater Orange County $1,455,000 (68%); U.S. DOE $337,000 (16%); and SCAQMD $337,000 (16%).

Commercialization and Applications

CNG conversion systems are commercially available for a few vehicles and require CARB certification for specific engines and vehicles. Ford discontinued the production of its Crown Victoria model vehicle following the 2011 model year; however the technology of converting vehicle fueling from gasoline to CNG is well established. Also, CNG-powered vehicles are gaining acceptance with airport ground transportation fleet operators and the taxi service sector in the SCAQMD jurisdictional area. Factors helping to drive this transition to CNG include the lower cost of domestically available natural gas, accessibility to the HOV lane, lower vehicle operating and maintenance cost, and incentive funding for CNG conversion systems.

SCAQMD Contract #09290 **September 2012**

Evaluate Emissions Impacts from Natural Gas Blends on Vehicle Emissions

Contractor

University of California Riverside, Bourns College of Engineering–Center for Environmental Research and Technology (CE-CERT)

Cosponsors

SCAQMD

Project Officer

Brian Choe

Background

CARB is currently in the process of developing an amended set of standards for NG that can be used as a fuel in transportation applications, which will take into account variances in fuel composition. Previous studies of interchangeability, or the impacts of changing NG composition, have been conducted on small stationary source engines, such as compressors, heavy-duty engines, and light-duty NGVs. Some of the previous studies have shown that NG composition can have an impact on emissions, including studies that have shown increases in oxides of nitrogen (NO_x) emissions with increasing Wobbe number (WN), the applicable measure of heating value.

Project Objective

The objective of the present study is to evaluate the impact of NG composition on the performance and emissions of light-duty and heavy-duty vehicles. For this study, two NG LDVs were tested over the Federal Test Procedure (FTP) and the Unified Cycle (UC) on a range of 4 different test gases. Three NG buses were also tested over the Central Business District (CBD) cycle and an NG waste hauler was tested over the Refuse Truck Cycle on a range of 6 to 7 different test gases.

For the testing of the light-duty vehicles, the test gases included a baseline gas representative of those typically found in the historical marketplace, an average CARB certification gas, a gas with high Wobbe number (1437), and a modified version of this gas blended down to a 1385 Wobbe number. The test gases for the heavy-duty testing included gases representative of Texas Pipeline Gas and Rocky Mountain Pipeline Gas; a gas representing Peruvian LNG modified to 1385 WN; a Middle East LNG-Untreated (WN above 1400); and two gases with high WNs and low methane numbers (MNs), one with a high ethane content and the other with a high propane content.

Comparisons between test gases were made for regulated exhaust emissions, fuel economy, PM mass, PM number and size distributions, ammonia, carbonyl compounds, and power maps, depending on the phase of the program. Testing was conducted on CE-CERT's heavy-duty chassis dynamometer.

Technology Description

The two light-duty test vehicles were a SULEV-certified 2006 Honda Civic GX and a ULEV-certified 2002 Ford Crown Victoria. The three transit buses included a bus with a 2009 8.9L stoichiometric spark ignited Cummins ISL-G engine and a three-way catalyst (TWC), a bus with a 2004 8.1L 6081H John Deere lean-burn engine with an oxidation catalyst (OC), and a bus with a 2002 C-Gas Plus lean-burn engine with an OC. The waste hauler was equipped with a 2002 Cummins 8.3L C-Gas Plus lean-burn engine with an OC.

Status

This project was completed in January of 2013. Several publications relating to this work have been submitted and accepted in peer reviewed journals.

Results

Light-Duty Vehicles

For modern light-duty NGVs, fuel properties had a clear and direct impact on fuel economy and some emissions components, such as CO_2 and NMHC, but not for other emission components, such as THC, NO_x, and CO. The gases with higher energy content provided better fuel economy on a volumetric basis and some higher power levels. Changes in CO_2

depended on the fuel/cycle/vehicle, but, generally, blends with heavier hydrocarbons and lower H/C ratios, had higher CO_2 emissions. NMHC emissions were very low, in general, but did increase for the two fuels with the highest levels of heavier hydrocarbons for both vehicles. THC emissions showed higher emissions for the fuel with the higher levels of methane for the Crown Victoria, but no trends for the Honda. CO emissions were higher for the two fuels with the highest Wobbe numbers for the Honda under some test conditions, including the cold-start phases of the driving cycles, but did not show significant fuel differences for the Crown Victoria. NO_x emissions showed only limited fuel effects for the two vehicles.

2002 Cummins 8.3L C-Gas Plus Waste Hauler
Waste hauler truck emissions were evaluated over a refuse truck cycle that included transport, compaction, and curbside segments. Overall, the waste hauler showed the strongest fuel effects for most of the pollutants compared to the buses. Almost all the pollutants showed some fuel effects for at least one of the cycle segments. The richer gases with more heavier hydrocarbons showed higher NO_x emissions for all three phases of the cycle. Gases with more heavier hydrocarbons showed lower THC, CH_4, formaldehyde and acetaldehyde emissions. For the compaction and curbside phases, higher NMHC emissions were seen for the gases with more heavier hydrocarbons, but for the transport phase the opposite trend was observed. Cumulative PM emissions and CO emissions for the compaction cycle showed a trend of lower emissions for the gases with more heavier hydrocarbons. Fuel economy on a volumetric basis showed increases for the richer gases with higher energy contents for all the phases of the cycle.

2004 John Deere 8.1L 6081H transit bus
The post-repair John Deere bus tests showed a number of fuel effects. Fuels with higher methane contents showed higher THC, CH_4, and formaldehyde emissions, but lower NMHC emissions. Richer gases with more heavier hydrocarbons showed higher NO_x emissions, although these increases were not statistically significant for all fuel combinations. Richer gases with higher energy contents showed higher fuel economy on a volumetric basis.

Some fuel effects were also seen for the initial testing of the John Deere bus, at which time a mechanical issue was identified. Trends for THC, CH_4, formaldehyde, and NO_x were consistent with the post-repair results. Higher methane content gases resulted in higher THC, CH_4, and formaldehyde emissions, but lower NMHC and particle number emissions. NO_x emissions showed increases for the highest WN gas compared to the baseline gas. Richer gases with higher energy contents showed higher fuel economy on a volumetric basis.

2003 Cummins 8.3L C-Gas Plus engine transit bus
For the 2003 Cummins 8.3L C-Gas Plus bus, NO_x and NMHC emissions and volumetric fuel economy were higher, and THC and CH_4 emissions were lower for the richer gases containing more higher hydrocarbons. CO emissions showed some statistically significant increases with some of the richer gases with more higher hydrocarbons.

2009 Cummins ISL-G 8.9 L transit bus
The bus with a 2009 Cummins ISL-G stoichiometric engine with a TWC was the newest technology tested during this program. In general, for this bus, most of the pollutants did not show any specific fuel effects. THC, NMHC, CH_4, and formaldehyde emissions for the Cummins ISL-G bus were lower than for the other buses, and NO_x emissions were also considerably lower than those of the John Deere bus. The Cummins ISL-G bus did, however, show higher CO and NH_3 emissions compared to the other buses. Some fuel effects were seen for fuel economy, THC, and CH_4 emissions, but not for the other pollutants. Richer gases with higher energy contents showed higher fuel economy on both a volumetric and energy equivalent basis. THC and CH_4 emissions were higher for the richer gases, which could be due to combustion differences for the stoichiometric vs. the lean-burn engines.

Benefits

The information obtained from this program will be very valuable in providing a standardized set of fuel standards for use in natural gas vehicles to provide optimal performance and emissions outcomes.

Project Costs

Total Funding for this project was $50,000 from the SCAQMD.

Commercialization and Applications

This research will facilitate the development of regulations for the composition of CNG used for transportation applications, that will help ensure NGVs achieve the maximum possible emissions benefits.

SCAQMD Contract #10095 **July 2012**

Study Sustainable Transportation Energy Pathways

Contractor

University of California, Davis, Institute of Transportation Studies

Cosponsors

7 energy providers, 9 automakers, and 6 government agencies including SCAQMD

Project Officer

Lisa Mirisola

Background

In 2007, UC Davis Institute of Transportation Studies instituted the Sustainable Transportation Energy Pathways (STEPS) program to conduct a four-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. STEPS also applied these tools and methods in comparative assessments of four general transportation energy pathways in the areas of hydrogen, biofuels, electricity and fossil fuels.

The focus of the STEPS program is on understanding transitions toward more sustainable transportation fuels and vehicles, understanding how one technology path can enable another, how multiple technologies can be synergistic or competitive, and how transitions might occur at lowest cost with maximum public benefits. Over 75 research publications and reports produced by STEPS researchers are currently available to the public at www.steps.its.ucdavis.edu.

The STEPS program follows previous ITS-Davis consortium-based research programs on Fuel Cell Vehicle Modeling (1998-2002) and Hydrogen Pathways (2003-2006).

Project Objective

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 included a focus on Southern California as the early market for alternative fueled vehicles, specifically hydrogen fuel cells, plug-in hybrid and battery electric vehicles. Under this contract, SCAQMD co-sponsored STEPS program projects in 2009 and 2010 in an amount not to exceed $120,000 from the Clean Fuels Fund.

Four specific STEPS projects are described below that have direct relevance to AQMD.

Hydrogen Infrastructure Transition Analysis – Station Build-out in LA Basin (Project#NS30)

California's ZEV regulation focuses on Southern California as an ideal site for early introduction of hydrogen vehicles. Developing a successful early hydrogen refueling network in Southern California, primarily for passenger vehicles, requires a coordinated strategy. Key concerns include fuel accessibility, customer convenience, the quality of refueling experience, network reliability, cost and technology choice. This study project analyzed a variety of "clustered" scenarios for introducing hydrogen vehicles and refueling infrastructure. AQMD benefits from this study's analysis of station characteristics, placement and fuel transportation and production.

Electric Vehicle Energy Loads on the Grid - LA Basin Regional Case Study (Project#S32)

In a future hydrogen and/or battery electric economy, the supply pathways for electricity and transportation fuels might converge. Interactions between electricity and hydrogen could be crucial issues, but have not been studied extensively. Further analysis is needed to understand the impact of this convergence in terms of emissions, prices, reliability, and resource availability on a regional basis. This project studied statewide and Los Angeles regional implications.

Plug-in Hybrid Electric Vehicle and Alternative Fueled Vehicle Consumer Survey Research (Project#P05)

Included are a variety of investigations into the forces driving markets for alternatively fueled vehicles, such as costs, innovation, and consumer behavior. The plug-in hybrid electric vehicle is an important case study since it provides consumers with a direct choice of two energy sources within their control. Insights were gained about consumer expectations in California especially related to PHEVs from this study that have important implications on the growth of these vehicles in Southern California and throughout the state.

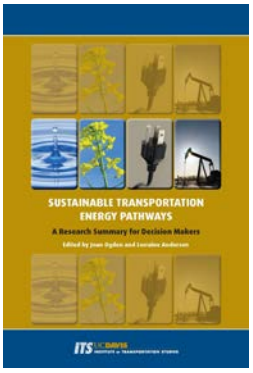
Cross-Comparison of Vehicle-Fuel Pathways (Project#s S10, S40, and NS61; STEPS Book chapters 4 and 6)

This project built on previous analysis conducted by UC Davis for individual fuel pathways and include vehicle technology evaluation and upstream fuel analysis. The change in criteria emissions that result for alternative fuel vehicle operation and fuel production/distribution were characterized, along with other performance metrics.

Status

The STEPS program, including the four projects listed above, was completed on December 31, 2011.

In addition to intended deliverables, the culmination of research findings is presented in a book, Sustainable Transportation Energy Pathways: A Research Summary for Decision Makers. Four print copies of this book were provide in November, 2011. Additional, free electronic copies are available at: www.steps.ucdavis.edu/STEPS.Book.



Results

From 2007 to 2010, STEPS researchers produced over 130 major publications and journal articles as well as numerous research reports (please see the accompanying *STEPS Achievements* document). In addition, the program held twelve symposia, sponsor meetings, and policymaker outreach events in California and Washington D.C. The STEPS website (www.steps.ucdavis.edu) hosts electronic copies of selected publications and other program materials.

STEPS Book Summary:
Perhaps the single most important insight from STEPS research is that a portfolio approach combining efficiency, alternative fuels and VMT reduction will give us the best chance of meeting stringent goals for a sustainable transportation future. Given the uncertainties, and the long timelines, it is critical to nurture a portfolio of key technologies toward commercialization and to start now. All our work in characterizing pathways and comparing them flows toward this conclusion.

Benefits

The STEPS program and especially the four projects highlighted above have a direct relevance to AQMD's priorities in evaluating changes to criteria emission levels and vehicle technology options. In addition, outreach and communication of results from the STEPS program will broaden the public knowledge base and help expedite introduction of zero and near-zero emitting vehicles in the South Coast Basin.

Project Costs

As budgeted, AQMD contributed $120,000 toward the STEPS program in years 2009 and 2010. The STEPS program was supported by other industry and government sponsorships and contracts, and the total support was over $2 million over this period.

SCAQMD Contract #08261 **March 2012**

Showcase: Demonstration of NOx and PM Emission Control Technology on Diesel-Powered Construction Equipment

Contractor
Community Recycling and Resource Recovery Inc

Cosponsors
SCAQMD
Nett Technologies

Project Officer
Richard Carlson

Background
Off-road equipment represents an important source of emissions in the South Coast Air Basin. According to the California Air Resources Board (CARB), there were approximately 68,600 diesel powered construction equipment in the Basin in 2006 which together produced approximately 120 tons per day of NOx and 7.5 tons per day of PM emissions.

The Off-Road Diesel Showcase Project is a cooperative program between the AQMD, MSRC, CARB, participating off-road equipment fleets and control technology providers to demonstrate the effectiveness and durability of emission control technologies for construction equipment. On March 7, 2007, the MSRC issued an RFQ to manufacturers of emission control systems and a Program Announcement for owners of off-road diesel construction equipment. The MSRC subsequently awarded contracts to install non-verified control devices on 198 off-road vehicles. Some quotations were received for NOx and PM control devices which AQMD agreed to fund using Clean Fuel funds.

On October 5, 2007, the AQMD Board awarded a contract to Community Recycling to participate in the "Showcase" demonstration of NOx and PM control technologies. The original award to Community Recycling was $363,250 for nine off-road vehicles. Unfortunately, only two off-road vehicles could be retrofitted with devices due to their mechanical condition, configuration, or the withdrawal of selected device manufacturers from the Showcase.

Project Objective
The objective of this project was to demonstrate after-treatment DPF-SCR emission control systems for off-road construction vehicles; the control system consisted of a diesel particulate filter (DPF) for control of PM emissions and selective catalytic reduction (SCR) system for control of NOx emissions. The demonstration included the following:

- Exhaust temperature measurements to confirm suitable exhaust temperatures.
- No interference with operator visibility, access or safety.
- Equipment performance and functionality equivalent to non-retrofitted configuration.
- Operation for a minimum of 1000 hours with CARB monitoring.

Technology Description
A Caterpillar 330B excavator was equipped with the Nett Technologies BlueMAX 100 PLUS SCR system with a passively regenerated DPF. A Kawasaki 95Z rubber-tired loader was also equipped with a Nett Technologies BlueMAX Plus SCR system with a passively regenerated DPF. The components were the same in both systems and consisted of a urea tank, a urea dosing pump and injection nozzle, an SCR catalyst, silicon carbide DPF coated with proprietary catalyst, sensors for NOx emissions, air flow, exhaust pressure, and exhaust temperature, a proprietary computer, and an auxiliary air pump.

DPF and SCR Catalyst on Loader

DPF/SCR Components on Excavator

Status

The excavator was equipped with the BlueMAX 100 PLUS SCR with passive DPF in December 2008. Over 6,000 hours were accumulated on the system although some components were replaced. At 3,000 hours, the DPF housing and mounting hardware showed fatigue cracking and was replaced. Standard plastic urea and fuel lines were replaced with steel lines after some lines failed during operation.

The rubber-tired loader was equipped with the BlueMAX 100 PLUS SCR with passive DPF in October 2010. Over 2000 hours were accumulated on the system. No significant operational problems have been encountered.

Results

The major components of the system demonstrated durability for considerably more than 1000 hours. However, the demonstration also identified deficiencies in the design of some components that were not rugged enough for off-road service. These design improvements were incorporated in subsequent systems installed in other fleets. No emission measurements were performed on these systems because CARB was unable to provide a portable emission measurement system as originally planned.

Benefits

This project has provided annual emission reductions from the two off-road vehicles of approximately 2 tons/year of NOx and 0.05 ton per year of PM. In addition, valuable design and operating experience was obtained. There are significant potential emission reductions from future applications of these technologies to additional off-road equipment operating in the South Coast Air Basin.

Project Costs

Total Project	AQMD	Nett Technologies
$104,440	$77,550	$26,890

Contract funds were paid by the contractor to the technology provider; no AQMD funds were retained by the contractor. Nett provided a $26,890 discount from commercial pricing. Additional non-monetary cost share was provided by the contractor by providing the equipment used during this demonstration contract and by Nett for maintenance and upgrade of the systems.

Commercialization and Applications

California Air Resources Board verification is required for commercialization. The technology provider is currently pursing CARB verification for off-road equipment and stationary engine applications. A stand along SCR system is verified by EPA for certain off-road engines.

SCAQMD Contract #08318 **December 2012**

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

Contractor
ServoTech Engineering Inc

Cosponsors
SCAQMD
Sanitation Districts of LA County (SDLAC)

Project Officer
Richard Carlson

Background
Off-road equipment represents a significant source of emissions in the South Coast Air Basin. Diesel engines are used in most heavy-duty off-road construction and industrial equipment. Due to the toxicity of diesel exhaust emissions, CARB issued a number of regulations to reduce emissions from diesel engines. One of these regulations required older diesel construction equipment to be replaced, retired, or retrofitted on an accelerated schedule.

Retrofit was viewed as a lower-cost option for certain equipment and fleets than the replacement option. The only devices available for retrofit were diesel particulate filters (DPF) which controlled particulates and carbon soot; however, AQMD needed reductions in NOx emissions for compliance with future air quality attainment deadlines.

On April 4, 2008, the AQMD Board awarded a contract to ServoTech Engineering to develop and demonstrate a combined selective catalytic reduction (SCR) and DPF technology on up to three large off-road construction vehicles for an amount not to exceed $320,000.

Project Objective
The objective was to develop diesel emission control systems (DECS) for heavy-duty diesel-powered construction equipment and to assess their reliability and emission reduction potential. The emission reduction goal was to meet Level III PM (85% reduction) and Mark 5 NOx (85% reduction) for off-road vehicles. The equipment was provided by the Sanitation Districts of Los Angeles County (SDLAC) and operated at the SDLAC landfill in Puente Hills, California.

Technology Description
The ServoTech Engineering design for retrofit Diesel Emission Control Systems (DECS) included urea-based SCR integrated with a DPF. The DPF technology uses active regeneration by periodic injection of diesel fuel in front of the DPF module. A catalyst in front of the DPF substrate oxidizes the diesel fuel, raising the exhaust temperature entering the DPF to burn off the accumulated carbon soot. Injection is initiated using pressure differential across the DPF. The SCR system injects urea in front of the SCR catalyst in proportion to the engine-out NOx emissions measured by the controller using data from NOx, temperature and pressure sensors.

Status
Two ServoTech retrofit DECS were designed, one for an excavator and another for a bulldozer. The project included inspection of the subject vehicles, measurement, baseline testing, design, fabrication, installation, and in-field demonstration of the retrofit emissions control designs. In-field testing during 2009 with fresh catalysts showed the expected reduction of particulate matter and NOx. However, after installation on the first vehicle, an engine injector malfunction caused excess smoke and high temperatures to enter and destroy the DPF and SCR. The engine was repaired and the DECS components were replaced. Particulate and NOx reduction were again demonstrated.

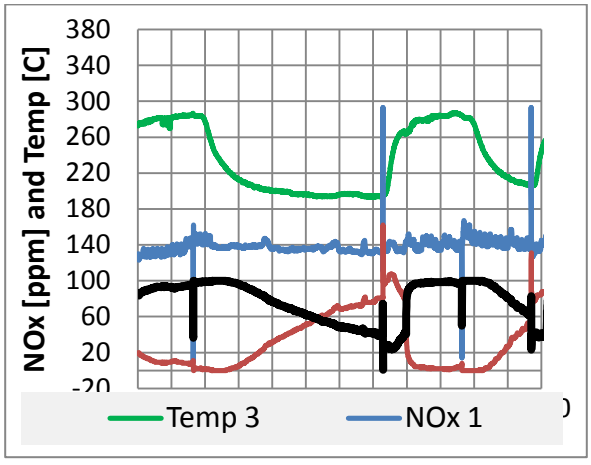
ServoTech DECS Mounted in Place Above Engine on Excavator Vehicle

Engine injector malfunctions reoccurred and the project was not carried out to 1100 hours for final evaluation of the retrofit DECS effectiveness. Additionally, in 2010, the Air Resources Board delayed implementation and relaxed the requirements for retrofitting off-road vehicles in California. Subsequent work to demonstrate the system on the other vehicles was suspended and a final report was submitted to AQMD in October 2012.

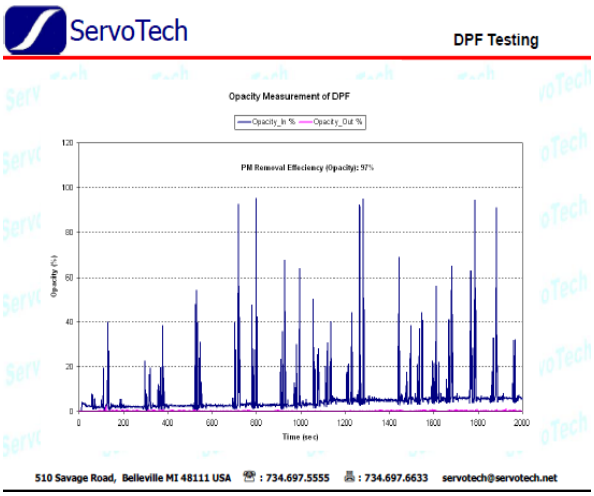
Results

The ServoTech Engineering DECS with integrated urea-based SCR and DPF demonstrated CARB Level III particulate control and Mark 5 NOx control with new catalyst components. Fully automatic control was achieved for transient vehicle operations for normal vehicle use in the landfill facility. The vehicle performance was not deteriorated due to operation of the emission control system. However, during engine fuel injector failures, soot emissions increased dramatically. The increased soot loading exceeded the regeneration capacity of the system causing the DPF to plug on two occasions.

The following graph shows NOx emissions during prototype tests of at least 85% efficiency during loaded operation.



The following graph shows opacity measurements during prototype tests showing >85% collection efficiency.



Benefits

The data recorded during this project demonstrate emission control for off-road diesel vehicles, by applying an integrated urea-based SCR and actively regenerated DPF with real-time control of urea flow rate based on measured engine parameters. This system is expected to achieve 85% PM reduction and at least 55% NOx reduction during verification testing.

Project Costs

The original cost estimate was $990,420. AQMD provided $320,000. ServoTech Engineering provided $540,000 for in-kind expense for engineering and development. An additional $130,420 for in-kind expense was provided by CSDLAC for operating and maintaining the equipment during the project. Since the project was not completed, the actual costs to AQMD were $140,000.

Commercialization and Applications

An application for verification of the combined SCR and DPF technology used in this contract was submitted to CARB.

The ServoTech Engineering diesel emission controller, control technology, and software utilized for this project have been commercialized since 2002, and are currently available for diesel-powered stationary generator sets and locomotives with large diesel engines. Systems have been installed on several diesel generator sets and facility emission control systems outside California.

SCAQMD Contract #09000 **March 2012**

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

Contractor

Shimmick Construction Company

Cosponsors

SCAQMD
NETT Technologies Inc

Project Officer

Richard Carlson

Background

Off-road equipment represents a significant source of emissions in the South Coast Air Basin. Diesel engines are used in heavy-duty off-road construction and industrial equipment. Due to the toxicity of diesel exhaust emissions, CARB issued a number of regulations to reduce emissions from diesel engines. One of these regulations required older diesel construction equipment to be replaced, retired, or retrofitted on an accelerated schedule.

Retrofit was viewed as a lower-cost option for certain equipment and fleets than the replacement option. The Showcase is a cooperative program between the SCAQMD, MSRC, CARB, participating off-road equipment fleets and control technology providers to demonstrate the effectiveness and durability of emission control technologies for off-road construction equipment.

The only retrofit devices available for retrofit were diesel particulate filters (DPF) which controlled particulates and carbon soot. However, SCAQMD needed reductions in NOx emissions for compliance with future air quality standards. A few technology providers offered combined selective catalytic reduction (SCR) and DPF technology capable of reducing both NOx and PM emissions.

On October 5, 2007, the SCAQMD Board awarded a contract to Shimmick Construction Company to demonstrate a combined SCR and DPF system from NETT Technologies, Inc (NETT) on one large off-road construction vehicle in an amount of $38,900.

Project Objective

The objective of this project was to demonstrate after-treatment DPF-SCR emission control systems for off-road construction vehicles. The demonstration included the following:

- Inspection and measurement of exhaust temperatures to confirm the equipment was suitable for the technology.
- No interference of the installed system with operator visibility, access or safety.
- Equipment performance and functionality equivalent to non-retrofitted configuration.
- Operation for a minimum of 1000 hours.

Technology Description

A 2004 Caterpillar 966G rubber tired loader with Tier 2 235hp engine was equipped with a NETT BlueMAXTM 100 PLUS SCR system including a passively regenerated DPF. The passive DPF was selected because the measured temperature distribution was 51% of operation >300C and NETT's criteria for passively regenerated filters was at least 25% of operation >300C.

The system components consisted of a urea tank, a urea dosing pump and injection nozzle, a SCR catalyst, silicon carbide DPF coated with proprietary catalyst, sensors for NOx emissions, air flow, exhaust pressure, and exhaust temperature, a proprietary computer, an auxiliary air pump, and an operator warning module.

DPF and SCR in Engine Compartment

Status

The loader was data logged to measure and record the temperature, pressure, and other parameters necessary to design and fabricate the SCR/DPF system.

The NETT DPF/SCR retrofit system was installed on the loader on December 1, 2009. Since that time, the loader has been operated on construction jobs in Southern California. The loader is used to load materials into a portable batch concrete plant. The system has operated generally without problems, accumulating 3,625 operating hours. The system remains installed and continues to be used.

Of the 3,625 hours accumulated, about 1,700 hours were accumulated without urea injection due to urea line failures, an oil fire that damaged wiring and tubing of the system, air pump failure, and replacing exhaust tubing between the DPF and SCR catalyst to fix a urea leak. The urea delivery hose needed to be made more durable for the harsh off-road environment and there were some early incidents when plastic hoses failed causing the system to shut down. NETT replaced plastic hoses with stainless steel tubing and made other repairs as required to upgrade the system. The fire was unrelated to the NETT system and damaged tubing and wiring was not considered a system failure.

The loader performed satisfactorily when loading the batch concrete plant due to working hard with high exhaust system temperature. It did not work as well when the exhaust temperatures stayed low for several hours. However, performance recovered almost immediately after the loader was again run under high load conditions

The DPF/SCR substrates and sensors were mounted entirely within the OEM engine compartment in place of the muffler. The control module, urea tank, computer, urea dosing pump and air pump were mounted on the side or rear of the operator's cab. As a result, the system did not obstruct visibility or operator access to the machine.

Results

The NETT system operated successfully for approximately 1925 hours. An additional 1,700 hours was operated without urea injection but with the DPF and other system components installed. The system demonstrated satisfactory operation except as noted above for extended low exhaust temperature conditions which are probably due to soot buildup in the DPF.

Benefits

The project was to include in-field emission measurements by CARB staff. However, the portable emission measuring equipment needed for these tests was not available. As a result, baseline emission results were estimated from the engine certification data, the operational hours, and Carl Moyer Program calculations. Emission reductions were based on NETT's published reduction percentages for their SCR and DPF systems (NOx = 65-90%; PM = 85%).

On this basis, the NOx emission reduction during the program was between 1,025 and 1,420 pounds and PM emission reduction was 63 pounds. On an annualized basis, the estimated reduction was 0.4-0.5 ton per year NOx and 0.012 ton per year PM. Fuel consumption and CO2 emissions were not measured.

Project Costs

Total Project	SCAQMD	Nett Technologies
$50,290	$38,900	$11,390

Contract funds from SCAQMD were paid directly to NETT at the request of the contractor. NETT provided a $11,390 discount from commercial pricing and additional in-kind for maintenance, warranty repairs, and upgrade of the system. Additional non-monetary cost share was provided by the contractor for use of the loader and operating personnel for inspection, installation, demonstration and maintenance.

Commercialization and Applications

California Air Resources Board verification is required for commercialization. The technology provider is currently pursing CARB verification for off-road equipment and stationary engine applications. A stand-alone SCR system is verified by U.S. EPA for certain off-road engines.

SCAQMD Contract #10112 **February 2012**

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

Contractor
Sanitation Districts of Los Angeles County

Cosponsors
SCAQMD

Project Officer
Richard Carlson

Background

The County Sanitation Districts of Los Angeles County (Sanitation Districts) have been in the forefront of implementing advanced technology for improving air quality relating to their solid waste and wastewater operations. Starting in early 2002, the Sanitation Districts pioneered a program with California Air Resources Board (CARB) and SCAQMD to demonstrate the use of diesel particulate filters (DPF) to reduce the particulate emissions from off-road equipment and the use of SCR technology coupled with DPF to reduce emissions of NO_x and particulate from on-road vehicles. This Showcase Program demonstrates the continued effort of the Sanitation Districts to further develop emission reduction technologies in the off-road vehicle operations.

Project Objective

This Project is part of the Showcase Program (funded under the Clean Fuels Program), which aims to assess the reliability and emission-reduction potential of DPF combined with SCR technology as an emission control system on off-road construction equipment. The goal of this Program is to accumulate at least 700 hours of operation, and data collected will help CARB to expedite the much-needed verification status of the control system as well as achieve significant near-term emission reductions from off-road construction equipment.

Technology Description

NETT Technologies' BlueMAX Plus control system uses cordierite or silicon carbide all-flow monoliths filters to control the particulate emissions, coupled with the urea-SCR technology to control the NO_x emissions from diesel engines. The DPF is coated with a proprietary catalyst which lowers the soot combustion temperature allowing the filter to regenerate. The accumulated soot is oxidized in the filter during regular operation of the engine. An exhaust temperature of 325-400^oC periodically is required to effectively achieve the proper filter regeneration.

NO_x is reduced over the SCR catalyst through chemical reactions with a reducing agent (urea). Based on the NO_x sensor signal, in combination with an engine mass air flow and temperature sensors, the necessary urea dosing rate is calculated by the control software. Urea consumption can vary from 1-5% (by vol.) relative to the diesel fuel consumption.

The BlueMAX Plus control system typically provides greater than 85% reduction in particulate emissions; and a reduction in NO_x emissions in the range of 65 to 90% under transient diesel engine conditions and over 90% in steady-state operation.

Loader Retrofitted in March 2011

Status

The contract for the retrofit using NETT Technologies' SCR/DPF system was executed in February 2010. Three Caterpillar wheel loaders (966F and 966G) were selected for the retrofit. However, one of the three wheel loaders (#6799, a 966G) was not retrofitted due to some engine problems and contract schedule constraint.

Both 966F wheel loaders (#6705 and #6783) at the Downey Area Recycling & Transfer (DART) Facility, located in the City of Downey, were retrofitted. Both loaders are equipped with the Tier 1 Caterpillar 3306 diesel engines. The machines were data logged to measure and record the temperature, pressure, and other parameters necessary to design and fabricate the SCR/DPF system. Also, a mock-up system was fabricated and installed in September 2010 to make sure that the system has no line-of-sight interference.

The design of the control system was finalized and approved by CARB in December 2010 and installation was completed in March 2011.

Since March 2011, both loaders have been in service continuously. There were minor problems with urea leakage from the pipe elbow delivering urea to the combustion chamber. This problem was addressed by welding the pipe to the elbow. Just recently, the data is showing that the back pressure is running high, over 120 in. H20, which indicated filter cleaning is required. Both filters were cleaned in February 2012.

Results

Both loaders have been in service continuously since the installation in March 2011. As of the end of June 2012, loader #6705 and loader #6783 accumulated 1,207 hours and 2,480 hours, respectively, which are well above the required 700 hours.

Benefits

The objectives of the Program are to assess the feasibility and reliability of the SCR/DPF technology on off-road equipment and to determine emissions reduced. This Program achieved both since the loaders were in use continuously without any major problems. However, during the course of the demonstration, no on-board emission testing was conducted. Therefore, the emission benefits from the Program were estimated using the manufacturer's pilot testing data of 85% particulates and 65-90% NOx removal efficiency. The total amount of particulate emissions reduced during the demonstration period was 70 lbs, and NOx emissions reduced was between 2,930 and 4,060 lbs., corresponding to the removal efficiency of 65-90%, respectively.

Project Costs

The total fixed price of this contract is $116,450 which is for retrofitting three pieces of equipment at $38,817 each. However, since the third loader was not retrofitted, a total cost of $77,634 was reimbursed from this contract.

SCAQMD Contract #11136 **May 2012**

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

Contractor
ServoTech Engineering Inc

Cosponsors
SCAQMD
Community Recycling and Resource Recovery Inc

Project Officer
Richard Carlson

Background
Off-road equipment represents a significant source of emissions in the South Coast Air Basin. Diesel engines are used in most heavy-duty off-road construction and industrial equipment. Due to the toxicity of diesel exhaust emissions, CARB issued a number of regulations to reduce emissions from diesel engines. One of these regulations required older diesel construction equipment to be replaced, retired, or retrofitted on an accelerated schedule.

Retrofit was viewed as a lower-cost option for certain equipment and fleets than the replacement option. The only devices available for retrofit were diesel particulate filters (DPF) which controlled particulates and carbon soot; however, AQMD needed reductions in NOx emissions for compliance with future air quality standards.

On March 6, 2009, the AQMD Board awarded a contract to ServoTech Engineering to develop and demonstrate a combined selective catalytic reduction (SCR) and DPF technology on up to two large off-road construction vehicles. The amount awarded was $132,000.

Project Objective
The objective was to develop diesel emission control systems (DECS) for heavy-duty diesel-powered construction equipment and to assess their reliability and emission reduction potential. The emission reduction goal was to meet Level III PM (85% reduction) and Mark 5 NOx (85% reduction) for off-road vehicles. Off-road vehicles were provided by Community Recycling and Resource Recovery, Inc. (CR&RR) at their recycling yard in Sun Valley, California.

Technology Description
The ServoTech Engineering design for retrofit DECS included urea-based SCR integrated with a DPF. The DPF technology uses active regeneration by periodic injection of diesel fuel in front of the DPF module. A catalyst in front of the DPF substrate oxidizes the diesel fuel, raising the exhaust temperature entering the DPF to burn off the accumulated carbon soot. Injection is initiated using pressure differential across the DPF. The SCR system injects urea in front of the SCR catalyst in proportion to the engine-out NOx emissions measured by the controller using data from NOx, temperature and pressure sensors.

Status
The project included inspection of the subject vehicles, measurement, baseline testing, design, fabrication, installation, and in-field demonstration of the retrofit emissions control designs. Two ServoTech Engineering retrofit DECS were designed, one for an excavator and one for a rubber-tired loader. The system for the excavator was installed in 2011. However, the engine was operating at a high soot level and the retrofit system was not able to adequately regenerate the DPF. The system was removed from the excavator pending repair of the engine. The rubber-tired loader was initially considered to be in poor mechanical condition due to high opacity and was not retrofitted. ServoTech Engineering developed a preliminary design for the loader assuming it would be repaired. Unfortunately, the contract ended before CR&RR repaired the engines and no further work was performed on the contract.

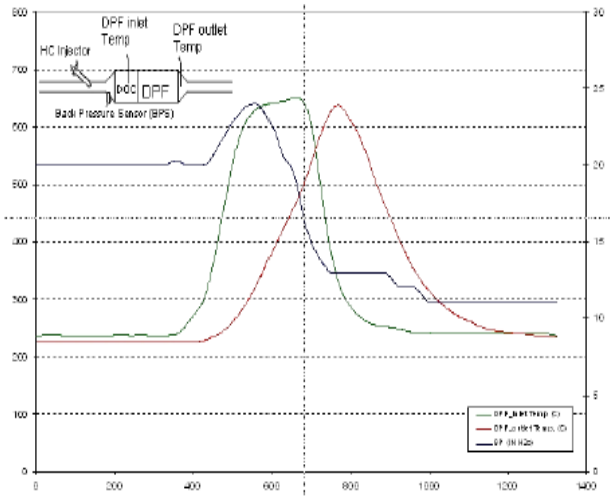
Retrofit System Mounted on Excavator

Additionally, in 2010, the Air Resources Board delayed implementation and relaxed the requirements for reducing emissions from off-road vehicles. A final report was submitted to AQMD on November 1, 2012.

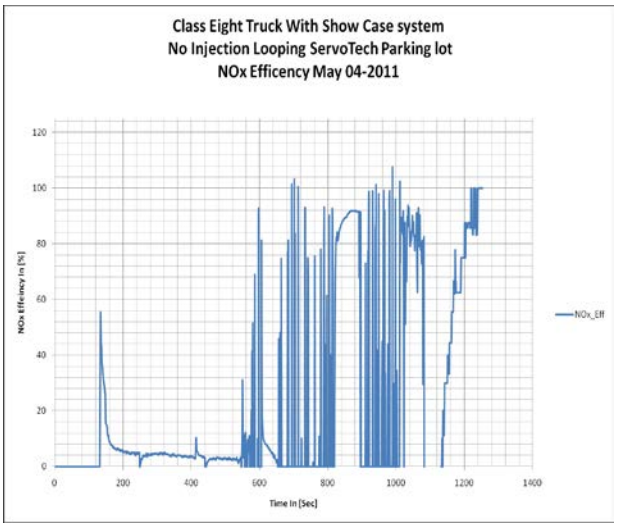
Results

The ServoTech Engineering DECS with integrated urea-based SCR and DPF was designed for two heavy-duty off-road vehicles. One system was fabricated, tested at Servotech, and installed and determined to be functional. Although not demonstrated on the off-road vehicle due to an engine malfunction, the tests at Servotech demonstrated the potential for CARB Level III (85%) particulate reduction and Mark 5 (85%) NOx reduction.

The following graph shows a typical regeneration event during prototype tests of the system. Fuel injected in front of the DPF increases exhaust temperatures (green and red lines) high enough to cause rapid oxidation of the collected soot. Backpressure (black line) was reduced from 20 to 10 inches of water during a 5 minute regeneration cycle. Unfortunately, high soot emissions from the excavator engine overwhelmed the regeneration capability of the system during initial operation.



The following graph shows NOx efficiency during prototype tests of the system. At sustained power levels, these data show NOx reduction efficiency exceeding 85%.



Benefits

The study resulted in a retrofit system design suitable for properly maintained off-road equipment. The vehicle evaluation and system design process for a successful retrofit project was documented. The vehicles in this project were not suitable for retrofit due to their poor mechanical condition and the demonstration project was not completed.

Project Costs

The original cost estimate was $432,000 of which $132,000 was provided by SCAQMD. ServoTech Engineering provided $300,000 in in-kind expenses. Since the full project was not completed, the actual costs to SCAQMD were $59,500.

Commercialization and Applications

An application for verification of the DECS developed in this contract was submitted to CARB for off-road equipment.

The ServoTech Engineering diesel emission controller, control technology, and software utilized for this project have been commercialized since 2002, and are currently available for diesel-powered stationary generator sets and locomotives with large diesel engines. Systems have been installed on several diesel generator sets and facility emission control systems outside California.

SCAQMD Contract #05260 **August 2012**

Convert Light-Duty Vehicle to Plug-In Hybrid Vehicles

Contractor

Energy Control Systems Engineering Inc dba EnergyCS

Cosponsors

City of Santa Monica, Cal Cars, Sacramento Municipal Utility District, Manitoba Hydro, and SCAQMD

Project Officer

Lisa Mirisola

Background

On May 6, 2005, the Board approved the design, implementation, and demonstration of the conversion of a 2005 Toyota Prius hybrid electric vehicle (HEV) to a battery-dominant system that increases vehicle range, decreases fuel consumption, and reduces air pollution through adding all-electric range. In November, 2005, the Board approved an additional $130,000 to convert two more Priuses to plug-in, with an option to convert another two with next-generation enhancements.

Interest in Plug-in Hybrid Electric Hybrid (PHEV) technology was growing, but the technology was not commercially available in the U.S. at the time. Additional vehicle testing data, driver feedback, and outreach events were still needed before commercialization.

Project Objective

This project converted Toyota Prius HEV's into PHEV's that can use grid-electricity to provide part of the energy for running the vehicles. These vehicles were used to demonstrate PHEV technology, to gather charging and performance data, and to engage the public about alternative fuel technologies. The project emphasized commercialization of the conversion product and increased public interest in PHEV technology.

Technology Description

PHEV technology builds upon the fuel-efficiency of an HEV through adding an all-electric, zero-emission mode. The all-electric range is made possible through installing a Valence 8.5kWh lithium-ion battery pack, a charger with 120V connection, and additional control system software to monitor the state of charge, control battery charging and discharging, and activate the EV operating mode. The battery pack, seven times as powerful as the original nickel metal hydride pack, can power the vehicle for up to 40 miles of zero-emission travel, up to 34 mph on city streets with the internal combustion engine off. The base model shuts off the engine only when stopped.

Status

Three 2005 Toyota Prius HEVs were successfully converted and operated as PHEVs by SCAQMD from 2006 - 2012. After the three PHEVs were returned to original hybrid configuration, the contract concluded August 31, 2012.

Major milestones of this project were the refinement of the control system and hardware, procurement of batteries and components, integration of the vehicle systems, optimization of the control system, vehicle completion, testing, demonstration, and analysis.

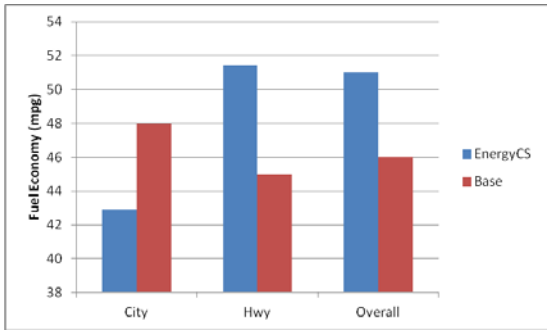
2005 Toyota Prius HEV Converted to PHEV

Results

After implementation of the new control system and battery packs, the converted vehicles were returned to SCAQMD for testing and demonstration.

The final report is on file, with technical details and data analyses prepared by Idaho National Lab as part of the U.S. Department of Energy (DOE) Advanced Vehicle Testing Activities study. The final report includes information on "real world" driver behavior as well as energy consumption by mode (charge-depleting, charge depleting/charge sustaining, charge sustaining).

Based on the final report, the vehicles had an average overall fuel economy of 51mpg, and accrued over 22% of the total miles travelled with the internal combustion engine off, reducing gasoline consumption and emissions.



Since the control system was designed to have the engine on in the beginning to warm the catalyst, the first several miles travelled have a lower fuel economy. Because most city driving trips performed by the drivers in this study were, on average, less than two miles in length, the full benefits of the conversion system were not realized in the city portion. Nevertheless, for trips that were longer in length, the battery power augmented the fuel economy, as shown in the chart above.

There were minimal tradeoffs in the design of this vehicle, with the most significant impact being the removal of the spare tire to make room for the battery pack.

Benefits

Initial emissions testing indicated that with careful control, the converted vehicles could achieve CARB's SULEV emissions rating. The conversions further improved upon the base model by increasing zero-emission EV operation, which accounted for 22% of total miles travelled as reported by the Idaho National Labs Advanced Vehicle Testing Activities study. Altogether, the converted vehicles average fuel economy of 51 mpg was an improvement by 5mpg over the already fuel-efficient base model. Because the technology helps increase the efficiency of the vehicle and reduces the amount of fuel consumed, it reduces air pollutants and the amount of greenhouse gas released. With both economy and environmental benefits, PHEV technology is capable of market penetration, as shown by interest from major manufacturers such as GM and Toyota.

Project Costs

The total project cost was $985,000, including conversion of additional prototypes for the City of Santa Monica, Cal Cars, SMUD, Manitoba Hydro (cold-weather testing), and others. SCAQMD's co-funding was $215,000 plus the base cost of SCAQMD vehicles.

Commercialization and Applications

The PHEV technology developed in this project can be directly applied to similarly converting other Toyota Priuses to provide the same benefits over the base model. Further refinements in the control system could lead to additional increases in performance. However, automaker optimization and economies of scale have since outpaced conversion efforts.

Issues still being overcome are the relatively high price of the batteries and the need to improve battery capacity. Control system optimization and engine start and catalyst warm-up procedures by Toyota and other automakers with changes to CARB emission certification procedures now enable PHEVs to travel 10 – 40 miles before the engine starts, further reducing emissions. These issues continue to be addressed today and as breakthroughs are made, prices will continue to fall even as performance improves.

While EnergyCS will not be commercializing the PHEV technology developed in this project, the technology has found a new, related application. EnergyCS has been acquired by battery-electric car manufacturer CODA specifically for the control system that EnergyCS developed. The CODA Electric automobile is a zero-emission all-electric vehicle now available for retail sale.

SCAQMD Contract #08067 **October 2012**

Demonstrate a Hydraulic Hybrid Shuttle Bus

Contractor
CALSTART

Cosponsors
Eaton
Complete Coach Works
CALSTART/Federal Transit Administration
SCAQMD
Riverside Transit Authority

Project Officer
Jeff Cox

Background
Shuttle buses present an excellent opportunity to integrate hybrid technologies due to the inertial intensity of their drive cycles that are typified by their start-and-stop driving behavior. This type of start-and-stop driving provides an opportunity to capture a significant portion of braking energy to displace a meaningful amount of fossil fuel derived energy that would otherwise be used to generate tractive power. The fuel displacement potential has the potential to achieve co-benefits of reducing criteria pollutant emissions along with reducing consumption of fossil fuel.

Project Objective
CALSTART, in association with Eaton Corporation, Complete Coach Works, and Riverside Transit Authority (RTA), undertook a project to develop a hydraulic hybrid shuttle bus, quantify the emission reductions and fuel economy improvement potential of the system, and finally, place the vehicle in revenue service with RTA.

Technology Description
Hybrid technologies present the opportunity to concurrently reduce criteria pollutant emissions and improve the fuel economy of the vehicle. These potential gains are a result of the ability of the hybrid system to recover braking energy that would otherwise be dissipated as heat. This also allows for the potential downsizing of the IC engine due to the supplemental power provided by the hybrid system, and the ability to optimize the operation of the IC engine over a narrower spectrum.

The hybrid system chosen for this program incorporates the use of hydraulic accumulators to store energy. These accumulators store energy by utilizing a hydraulic fluid to compress nitrogen. The compressed nitrogen can later be expanded to force the hydraulic fluid through a pump motor that provides tractive force to accelerate the vehicle. During a braking event, the hydraulic pump motor will return fluid to the high pressure accumulator and store energy by compressing nitrogen. This compression process results in the application of a retarding force to the vehicle that will also displace the use of the friction brakes.

Status
The program completed the prototype build of the vehicle, emissions and fuel economy testing on a chassis dynamometer, and served time in revenue service with RTA.

Hydraulic Hybrid Shuttle Bus

Results
The University of California, Riverside performed chassis dynamometer emissions testing on a UDDS drive cycle. This testing demonstrated a reduction in NOx emissions of 69% with a corresponding improvement in fuel economy of 58% in a laboratory setting. While these lab test results show the potential of the system, the in-use demonstration of the system proved more challenging. The prototype nature of the vehicle resulted in significant vehicle downtime that

prevented the ability to provide an accurate assessment of the operational benefits of the system in the field. Further refinement of the system would need to be undertaken to properly evaluate the potential benefits of the system in full service operation.

Project Costs

The total project costs were approximately $1,100,000 with the SCAQMD providing $140,167 towards the project. Cost-share for this project was anticipated as follows:

Eaton Corporation	$300,000
Complete Coach Works	$327,500
CALSTART/	
Federal Transit Administration	$290,000
SCAQMD	$140,167
Riverside Transit Agency	$42,500

Commercialization and Applications

The hybrid technology demonstrated as part of this project could have broad applications reaching beyond the shuttle bus. Any vehicle that is subject to a high level of start-and-stop driving behavior could benefit from a power-dense hydraulic hybrid system that was demonstrated as part of this program. However, the significant vehicle downtime that the program experienced highlights that there are still system refinements that need to be implemented before the product would be ready for commercial deployment.

SCAQMD Contract #11205 **March 2012**

Implement Hybrid Truck and Bus Voucher Incentive Program

Contractor
CALSTART Inc

Cosponsors
SCAQMD

Project Officer
Brian Choe

Background

The purpose of the South Coast Air Quality Management District's Hybrid Truck and Bus Voucher Incentive Project (HVIP) is to help commercialize hybrid medium- and heavy-duty vehicle technologies and support a critical ramp-up in production, with the specific target of the South Coast Basin. This production increase is necessary to boost deployment of these lower emission vehicles, which will assist the South Coast in meeting its clean air goals.

Following the format of the CARB HVIP, the SCAQMD's HVIP provided financial incentives to fleet purchasers after the FY2010 CARB HVIP funds had been exhausted and before the FY2011 CARB HVIP funding had launched. Eligible recipients were required to domicile and operate trucks exclusively in the South Coast jurisdiction. The project was managed separately from the existing CARB HVIP, but used the same rules.

Project Objective

The core objective was to further extend the deployment of early-production hybrid trucks into the Basin. These deployments were deemed important for several reasons: 1) they speed the introduction of zero-emission enabling and pathway technology; 2) they speed the early deployment of lower-emitting medium-duty vehicles into the region in advance of requirements; and 3) they allow the SCAQMD to leverage an existing state program and infrastructure to extend additional clean air benefits to the South Coast Basin.

The HVIP provides vouchers of up to $45,000 per vehicle on a first-come, first-served basis for the purchase of eligible new hybrid trucks and buses. CALSTART's role was to administer and implement the HVIP, with assistance by its subcontractor TIAX LLC, 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 would be operated in the geographical boundaries of the SCAQMD. CALSTART was responsible for conducting public outreach to vehicle dealers and fleets to solicit interest in the program within the SCAQMD's geographical boundaries.

Technology Description

The technologies utilized in this project were hybrid-electric drivelines for diesel medium- and heavy-duty trucks. Hybrid-electric trucks reduce the consumption of diesel fuel while lowering the emissions of criteria pollutants, and are also a critical enabling technology and market for future zero-emission vehicles.

Status

The project launched on December 1, 2010. CALSTART issued the vouchers for the purchase of these hybrid-electric trucks on February 15, 2011, and finished voucher redemptions by November 30, 2011. The final voucher checks were delivered to the vehicle dealer on February 8, 2012 and the project was completed on March 31, 2012.

The project operated as expected and new vouchers were requested and redeemed for the purchase of 41 new hybrid-electric trucks, which are running in the field. The 41 vouchers met the expected number of funded vehicles. The vehicles that were funded were in the heaviest weight class currently served by hybrids, that of Class 8 regional tractors. These vehicles can provide the greatest fuel savings and emission reductions because of the volume of fuel burned. The final report, including the complete technical details, is on file.

A Coca-Cola Hybrid Delivery Truck

Results

The vouchers were subscribed by BCI Coca-Cola Bottling Company. Freightliner manufactured 28 of the vehicles, and Kenworth manufactured 13. Eaton supplied the hybrid systems. All of the vehicles are used for regional and urban delivery applications.

Benefits

This project did not include vehicle testing or emission goals. However, from experiences with similar urban/regional delivery vehicles that it is testing, CALSTART found that vehicles with similar duty cycles can expect an average fuel use reduction of approximately 18 percent. With targeted driver training and route selection, some of the trucks in this category can achieve over 30 percent in fuel use reduction. Criteria emission reductions are expected to be proportional to fuel use reductions.

Under the CARB FY2010 HVIP, 313 medium- and heavy-duty hybrids were deployed in the Basin, representing 47 percent of the total vehicles placed under that effort. With the additional vehicles deployed using the SCAQMD HVIP funding, the Basin placed a total of 354 hybrid trucks in service in one year, amounting to roughly eight percent of all hybrid trucks currently on the road in the United States today.

Although the technology is still in the early commercialization phase, we do not expect any issues with availability or reliability. In similar drivelines tested by CALSTART's HTUF program, the vehicles have demonstrated that they are available and able to perform their daily duties from 97 to 99 percent of the time.

Project Costs

SCAQMD provided $1,500,000 toward this project. The voucher funding totaled $1,430,000. CALSTART's administrative costs were $70,000 to administer the SCAQMD HVIP.

Commercialization and Applications

While the HVIP has continued to increase the breadth and range of the eligible vehicles, the largest obstacles for the purchase and deployment of these vehicles remain the up-front incremental costs, particularly with fleets still feeling the constraints of the recession. There continues to be a strong need to decrease the incremental cost for early-adoption vehicles, especially for electric vehicles. The HVIP has successfully overcome these obstacles.

Improving the Program

SCAQMD can continue to build on the success of this initial HVIP through targeted investments in programs for those vehicles most in need of financial incentives, and most needed to meet South Coast clean air requirements and technology objectives. Hybrid trucks represent a critical enabling technology pathway to zero emissions, and battery electric trucks are now following them into the market.

Electric trucks are currently eligible for CARB HVIP funding, but the provided level of incentives offsets a much smaller fraction of the incremental cost than the level of incentives for hybrid trucks. A recent report from CALSTART's E-Truck Task Force verified this specific need, which would entail roughly doubling the current CARB voucher amounts for electric vehicles. A highly useful future SCAQMD program could provide additional incentive funding for electric trucks deployed in the SCAQMD jurisdiction. The SCAQMD incentive could be added to the CARB HVIP incentive to provide a level of financial incentive that would more readily overcome the incremental cost. A similar approach is underway in the San Joaquin Valley APCD. Similarly, because hybrid-electric trucks are a core enabling technology for all-electric trucks, a small "plus up" for hybrids is justified as well to help spur additional SCAQMD deployments.

SCAQMD Contract #11485 **April 2012**

Demonstrate Refuse Truck Retrofitted with Cummins ISL-G Natural Gas Engine

Contractor
Waste Management Collection and Recycling Inc

Cosponsors
SCAQMD

Project Officer
Brian Choe

Background
Waste Management (WM) partnered with Cummins Cal Pacific (CCP) and AFV Fleet Services (AFV) to engineer a diesel-to-CNG proof-of-concept (POC) vehicle. The successful demonstration of the POC vehicle will have the potential to reduce emissions significantly from approximately 3,800 diesel-fueled refuse collection trucks affected by SCAQMD Rule 1193.

Project Objective
WM sought to demonstrate the repowered diesel-to-CNG refuse collection truck for a six-month period. Throughout the six-month demonstration period, WM tracked and recorded the vehicle's maintenance requirements, which included scheduled and unscheduled servicing of vehicle, engine and fuel system (e.g. oil changes, exhaust stack replacement, fuel system repairs, tank repairs, etc.). In addition, WM logged fuel used and designated fueling units (e.g. diesel equivalent gallon (DGE), miles travelled, engine hours). For one month during the six-month demonstration, WM measured fuel consumption by using the on-site fast-fill CNG dispenser. For the remainder of the six-month demonstration, WM operated the vehicle at the Moreno Valley location using the slow-fill CNG capability.

Prior to beginning the demonstration, WM also performed operator training to instruct fleet and vehicle operators on fueling, engine and transmission performance characteristics, safety and any characteristics which distinguish the repowered vehicle from its diesel-fueled equivalent.

Technology Description
This project involves repowering a diesel-fueled 2005/2006 Freightliner Condor refuse collection truck with the CARB certified Cummins ISL-G natural gas engine certified to 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM.

Repowered Vehicle Undergoing Emissions Testing

Status
WM completed the following tasks during the course of this project:

Task 1 Proof-of-Concept Vehicle Design
- 1.1 Engineering and Analytical Work (Vehicle Systems Engineering, Removal of Existing Vehicle System, CNG Vehicle System Installation, Fuel Storage System Installation, Installation Quality Audit)
- 1.2 Vehicle Modifications Analysis
- 1.3 Equipment Procurement
- 1.4 AQMD Approval

Task 2 Demonstration Program
- 2.1 Six-Month Demonstration
- 2.2 Operating Log Maintenance
- 2.3 Performance Testing

2.4 Emission Testing

The findings and the results of each task are provided in the form of the fast-fill fuel data, emissions benefits based on the fuel-usage reduction, and the emission testing results provided in the final report.

Results

WM tested the performance vehicle versus a comparable diesel truck under a variety of working conditions including urban pickup cycles, rural higher-speed pickup cycles, freeway driving cycles and grade climbing cycles. It was fueled at the Moreno Valley site using the slow-fill CNG fueling capability. Because the Moreno Valley site primarily has slow-fill CNG capability, daily fuel measurements were not possible. Thus, instead WM measured the daily fuel consumption over a one-month period by using the on-site fast-fill CNG dispenser for measurements.

WM recorded the total fuel consumption and total engine hours of operation since the last fueling event and then used this data to determine the average fuel consumption per hour of engine operation. For the remainder of the six-month period, then, the total fuel consumption was calculated based on the engine hours operated per month.

	208315 Hours	Fuel Usage	Mileage
(8) January 2012	252	1,013	2,633
(7) December 2011	276	1,110	2,884
(6) November 2011	231	929	2,414
(5) October 2011	247	993	2,581
(4) September 2011	279	1,122	2,916
(3) August 2011	247	993	2,581
(2) July 2011	251	1,009	2,623
(1) June 2011	78	314	815
TOTAL	1,861	7,481	19,447

Six-Month Fuel and Mileage Projections

WM additionally conducted emissions tests on the repowered refuse truck and a comparable diesel-fueled refuse truck for NOx, CO, PM, and CO2 emissions. WM used SCAQMD-approved testing protocols and instrumentation, and consulted with the SCAQMD to secure a qualified testing entity to perform the emission testing and ensure that each vehicle was tested while stationary in the following operating modes: idle, high idle, and idle with power take off (PTO) engaged during a compacting cycle while the truck is at least half full.

In general, emissions from the CNG engine are lower than from the diesel engine.

Benefits

The successful demonstration of this project will have the potential to reduce emissions significantly from approximately 3,800 diesel-fueled refuse trucks affected by Rule 1193. With each diesel-fueled truck using approximately 10,000 gallons of diesel fuel every year, this project has the potential to displace 38 million gallons of diesel annually.

Project Costs

A total of $75,000 was awarded by the SCAQMD for this project. WM, CCP and AFV provided $231,364 of direct and in-kind co-funding. The total project cost will be $306,364.

Commercialization and Applications

This project demonstrated the viability of repowering a heavy-duty diesel engine with newer and cleaner alternative-fuel technology. Repower projects like this demonstrate the viability of cleaner engine replacement policies to reduce exhaust emissions as equipment ages, while minimizing cost.

This project will especially benefit those vehicles subject to Rule 1193, which requires public and private solid waste collection fleets having exclusive contracts with public entities and greater than 15 trucks to purchase or replace existing vehicles with alternative-fuel vehicles.

SCAQMD Contract #04011 **July 2012**

Install & Demonstrate Industrial Pipeline-Supplied Hydrogen Fueling Station in Torrance

Contractor

Air Products and Chemicals Inc

Cosponsors

US Department of Energy
Shell Hydrogen
SCAQMD
Toyota

Project Officer

Larry Watkins

Background

The implementation of zero-emission vehicles is a key component in the effort to achieve air quality attainment in the South Coast Air Basin. Fuel cell vehicle technology is emerging at an accelerated pace and may play a crucial role in this effort.

Project Objective

As part of an ongoing Cooperative Agreement between Air Products and the U.S. DOE, SCAQMD provided cost-share funding to construct, install and operate a hydrogen fueling station in Torrance, CA. The station would be the first in the country to be supplied by an existing, active industrial pipeline system.

Technology Description

Hydrogen from the pipeline system is fed to a membrane purifier that removes carbon monoxide from the parts-per-million (volume) (ppmv) concentrations specified in typical industrial applications to less than 0.2 ppmv as currently required for use in fuel cell vehicles. Compression and storage systems sized for 48 kilograms per day (which can serve 10 to 15 cars per day) are provided. Air Products' proprietary fueling protocol (of which four patents are cited in the SAE hydrogen fueling TIR J-2601) is utilized to cascade fill from the storage tubes to the vehicles. The station utilizes four dispenser hoses (two at H35 or 5,000 psi pressure level and two at H70 or 10,000 psi pressure level) and is the first in the country that can fill four fuel cell vehicles simultaneously. The H70 gas is cooled to temperatures approaching -40 deg C so that refueling times of 3 to 4 minutes can be achieved.

Status

Following execution of agreements with U.S. DOE and SCAQMD, Air Products began negotiations regarding the lease of equipment and sale of hydrogen to Shell Hydrogen (who would act as operator of the fueling station). A Shell-branded retail gasoline station at the intersection of 190th and Normandie in Torrance, CA (near the Air Products pipeline) was initially selected as the host location. However, Shell was unable to negotiate a lease for a parcel of adjacent property to site the purification, compression and storage equipment; in addition, the gasoline station was ultimately sold by Shell, and the new owners were unwilling to consider the addition of hydrogen fueling equipment. Activities related to the site at 190th and Normandie were terminated in mid-2007.

Shell Hydrogen then began discussions for lease of greenfield property at the intersection of 190th and Gramercy in Torrance, CA (adjacent to I-405), also along the Air Products hydrogen pipeline. Air Products and Shell Hydrogen also resumed negotiations regarding the equipment lease and hydrogen supply agreement. A delay in the negotiations for the equipment lease and hydrogen supply agreement occurred in late 2007, and these issues were resolved in mid-2008. Detailed design of the fueling equipment at the Gramercy location was initiated by Air Products at the direction of Shell Hydrogen. Negotiations on the land lease by Shell Hydrogen were completed in early March 2009. Air Products and Shell Hydrogen then executed the equipment lease and hydrogen supply agreement on March 27, 2009.

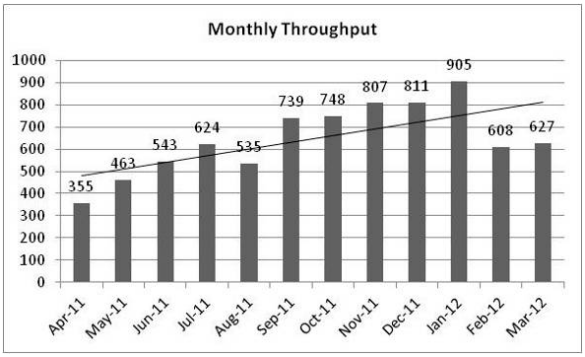
Shell received a conditional use permit from the City of Torrance on August 19, 2009. Construction work was started by Shell Hydrogen in February 2010 and was completed nine months later. Following completion of commissioning activities, station operation commenced on March

1, 2011. The scope of work under the SCAQMD's contract was completed on February 29, 2012, and the final report is on file with results from the project.

Torrance Pipeline Hydrogen Station

Results

Operating performance of the hydrogen fueling station has been excellent. Use of the station by automakers in the area has increased since the station was brought online; Toyota and Honda have major facilities within two miles of the station, General Motors and Daimler have operations nearby, and vehicles from Hyundai and Mazda have fueled at the station. On several occasions, station throughput in excess of the rated 48 kilograms per day has been observed, and a total of 2,972 fueling events (both H35 and H70) were completed by the end of March 2012.



Benefits

Deployment of zero-emission fuel cell electric vehicles is a key step toward reducing levels of criteria pollutants in the South Coast Air Basin. Manufacturers of fuel cell vehicles have provided survey figures to state agencies indicating their plans to deploy tens of thousands of light-duty cars into the South Coast Air Basin in the 2015-2107 timeframe. In order to meet this goal, reliable hydrogen fueling stations such as the Torrance pipeline station are needed to provide confidence to automakers and to their potential customers.

Hydrogen is produced today at pricing that is attractive for use in today's transportation market; oil refineries use hydrogen to meet their needs to process crude oil to the various grades of gasoline products. Delivery of gaseous products such as hydrogen and natural gas via pipeline systems is the lowest-cost means of distribution. The Torrance pipeline station has provided significant learnings into the design and installation of hydrogen fueling stations while providing a platform to demonstrate key new components such as simultaneous refueling from multiple dispensers at two pressure levels. Based on existing technologies, low-cost hydrogen can be delivered and dispensed well below gasoline prices to fueling stations in a fully deployed hydrogen economy.

Project Costs

The total cost of the Air Products' program with the U.S. DOE was $10,922,086 (DOE $5,526,000, Air Products $5,396,096), which included deployment of three permanent hydrogen fueling stations and several mobile refueling systems. The spending for Air Products' scope of work under the DOE program for the Torrance hydrogen pipeline station (excluding program management and contract negotiating costs) exceeded $3 million. SCAQMD provided an initial $400,000 in cost share to the Air Products program, later awarding an additional $89,051 to add equipment for purification of hydrogen from pipeline to fuel cell specifications. Shell leased property from Toyota and was responsible for the balance of the station.

Commercialization and Applications

Demonstration testing of fueling station equipment at relevant usage rates is critical to gain the learnings necessary for rollout of hydrogen refueling infrastructure to the general public. Although pipeline supply of hydrogen to fueling stations during the early phases of fuel cell vehicle deployment will be limited, the use of existing, low-cost sources of hydrogen with delivery to stations as a compressed gas will be a key component of the early station network. SCAQMD and Air Products will be working on a project to deploy low-cost hydrogen fueling stations to eight locations (including six retail sites) beginning in late 2012.

SCAQMD Contract #12104 **September 2012**

Development, Initiation & Implementation of a Clean Vehicle Outreach Project

Contractor
Three Squares Inc

Cosponsor
SCAQMD

Project Officers
Lisa Mirisola
Lourdes Cordova Martinez

Background
The SCAQMD has long supported plug-in electric vehicles - ranging from light-duty battery electric vehicles to heavy-duty plug-in hybrid electric vehicles - due to the clean air benefits associated with electrifying the transportation sector. With the commercialization this year of plug-in vehicles (PEVs) by Nissan, GM and Ford, the SCAQMD Board expressed concerns that only the early-adopters and PEV advocates would know the true value associated with these technologies; whereas the general public may be insufficiently educated and often times misinformed about the costs and benefits of such vehicles.

Project Objective
Three Squares Inc (TSI) was contracted to coordinate an outreach campaign that retools existing SCAQMD programs to focus aspects of consumer messaging, where appropriate, on near-term benefits of clean and high-efficiency vehicles. These efforts will be included under a newly badged Clean Air Choices (CAC) program, an umbrella platform to promote the broad array of lower-polluting consumer options included in SCAQMD clean air technology activities, such as low-VOC paints and solvents, electric lawn and garden equipment, air filters, low-NOx boiler and aftertreatment technologies, as well as clean vehicles.

Technology Description
After several meetings with SCAQMD staff discussing the vision for the Clean Air Vehicle Calculator, defining the audience (consumers in the South Coast Air Basin), and working through the technical specifications so that the calculator would function across digital platforms (desktop, iPhone, iPad, Android, BlackBerry), TSI developed the site map below for the "Clean Air Vehicle Calculator."

Mobile Home Page:

• Two drop-down fields where users select vehicles to compare to the U.S.EPA average gasoline-powered vehicle (users can compare up to 2 vehicles but may choose only one if desired):

> Choose Car 1: -- Choose a Car -- Select Year Vehicle Make Model
> Choose Car 2: -- Choose a Car -- Select Year Vehicle Make Model

Results show comparison of two vehicles with attributes below:

• Vehicle photo
• Make • model• year• sticker price
• Incentives/rebates (link through to incentives page)
• $ saved/year
• C02 saved/year
• Oil saved/year
• Smog score
• Dealer test drive locations (link to page of locations for test driving the vehicle)

Clean Air Vehicle Calculator Home Page

Status

The Clean Air Vehicle Calculator is available online at http://www.cleancarchoices.org and is also available via a click-through link on the Clean Air Choices program website located at http://www.cleanairchoices.org, also accessible from within the AQMD.gov site.

Results

The Google Analytics report (attached to the project final report) demonstrates that even from a "soft launch" of the calculator at the EVS26 event impressions were acquired from countries across the globe, including the U.S., India, United Kingdom, Canada, Germany, Australia, South Africa, France, Japan, Malaysia, the Netherlands, Philippines and many others. With an official launch and press announcement, the calculator should be able to expand its reach and impact.

Benefits

The Clean Air Vehicle Calculator allows interested car shoppers to view easy, quick comparisons of environmental and economic benefits of selecting a clean vehicle, connect directly with a local dealer and phone the dealer to schedule a test drive.

Project Costs

The Clean Air Vehicle Calculator was the result of a rebranding campaign for the Clean Air Choices program. The following costs were associated with the program:

Task 1 – Rebranding	$5,000
Task 2 – Mobile Web Site	$26,000
Task 3 – Clean Vehicle Calculator	$19,000
Task 4 – Social Media	$16,000
Task 5 – Fast Charging Analysis	$24,000
Task 6 – - Assessment	$10,000
Project Total	$100,000

Commercialization and Applications

The rebranded Clean Air Choices Program web site will become a venue to feature a variety of programs focused on promoting clean air vehicles and clean air consumer choices to residents in the South Coast Air Basin.

The Clean Air Vehicle Calculator will continue to be updated with new vehicle models as they are added to the SCAQMD Clean Air Vehicle Lists and featured at local dealerships. The Content Management System will allow SCAQMD staff easy access to make updates via a web interface and the ability to add vehicles, dealerships and edit vehicle data such as smog scores.

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