BOARD MEETING DATE: March 7, 2014 AGENDA NO. 29

PROPOSAL: Approve and Adopt Technology Advancement Office Clean Fuels Program Annual Report and Plan Update, Resolution and Revised Membership of the Clean Fuels Advisory Group

SYNOPSIS: Each year by March 31st the Technology Advancement Office must submit to the California Legislative Analyst of an approved Annual Report for the past year and a Plan Update for the current calendar year. Staff has reviewed the 2013 Clean Fuels Program with the Clean Fuels Advisory Group, the Technology Advancement Advisory Group and other technical experts. Additionally, the 2014 Clean Fuels Program Draft Plan Update was presented to the Board for review and comment at its October 4, 2013 meeting. Staff recommends the Board approve and adopt the final Technology Advancement Clean Fuels Program Annual Report for 2013 and 2014 Plan Update as well as the resolution finding that proposed projects do not duplicate any past or present programs and the revised membership of the Clean Fuels Advisory Group.

COMMITTEE: No Committee Review; the February 21, 2014 Technology Committee meeting was cancelled.

RECOMMENDED ACTIONS:

1. Adopt the attached Technology Advancement Office Clean Fuels Program Plan Update for 2014 and include it in the SCAQMD's Clean Fuels Program;
2. Approve the attached Technology Advancement Office Annual Report for 2013;
3. Approve the attached Resolution finding that the update of the Technology Advancement Office Clean Fuels Program Plan and its proposed projects do not duplicate any past or present programs of specified organizations; and
4. Approve the membership changes to the Clean Fuels Advisory Group and receive and file membership changes to the Technology Advancement Advisory Group.

Barry R. Wallerstein, D.Env.
Executive Officer

MMM:DAH

Background

Achieving federal and state clean air standards in the South Coast Air Basin will require emission reductions from both mobile and stationary sources beyond those available from current technologies. The 2012 Air Quality Management Plan (AQMP) relies on a mix of currently available technology as well as the expedited development and commercialization of cleaner mobile and stationary advanced technologies in the Basin to achieve these standards. Specifically, the 2012 AQMP identifies the need for 200 tons/day NO_x reductions to be adopted by 2020 for full implementation by 2023 and in large part focuses control measures on transportation technologies and cleaner fuels with zero and near-zero emissions in order to achieve these reductions. This will require the SCAQMD Clean Fuels Program, first initiated in 1988 along with establishment of the Technology Advancement Office (TAO), to encourage and accelerate advancement of transformative transportation technologies and commercialization of progressively lower-emitting vehicles and fuels.

The SCAQMD Clean Fuels Program is implemented as a public-private partnership in conjunction with private industry, technology developers, academic institutions, research institutions and government agencies. This public-private partnership has enabled the SCAQMD to historically leverage public funds with outside investment in a ratio of about $3-$4 of outside funding to every dollar of SCAQMD funding.

Health and Safety Code (H&SC) Section 40448.5.1 requires that the SCAQMD adopt a plan that describes the expected cost and benefits of proposed projects prior to any Clean Fuels Program expenditure and find that the proposed projects do not duplicate programs of other organizations specified in the H&SC provision. In 1999 SB 98 amended this provision by requiring annual updates to this Plan and 30-day public notice to specified interested parties and the public prior to the annual public hearing at which the Board takes action on the Clean Fuels Program. SB 98 also requires the preparation of an annual report with specified contents. This annual report requires the review and approval by an advisory group and the Board, prior to submittal to specified offices of the California Legislature by March 31st of each year. This legislation also specifies the make-up of the Clean Fuels Advisory Group (CFAG) and its primary responsibilities to make recommendations regarding the most cost-effective projects that advance and implement clean fuels technology and improve public health. The membership of the CFAG was initially approved by the Board in September 1999. Changes to the composition are reviewed by the Board's Technology Committee on an as-needed basis, and were considered last year, with changes to the membership approved by the Board on May 4, 2012. Prior to formation of the CFAG, the SCAQMD had formed the Technology Advancement Advisory Group (TAAG) to review and assess the Clean Fuels Program. The charter and membership of the TAAG was revisited in 1999 with formation of the CFAG so their function would complement each other. The TAAG's charter specifies membership changes must be approved by the Board's Technology Committee.

Proposal
This package includes an adoption resolution (Attachment A), proposed new advisory group members (Attachment B) and one combined document comprising the TAO Clean Fuels Program 2013 Annual Report and 2014 Plan Update (Attachment C). Staff recommends the Board approve and adopt the TAO Clean Fuels Program Annual Report and Plan Update, and as part of the Board's consideration of the Plan Update, the Board must make a finding that the update to the TAO Clean Fuels Program and its proposed projects do not duplicate any past or present programs of specified organizations. The review process by the two advisory groups helps ensure that SCAQMD efforts do not duplicate projects. The advisory groups meet in-person twice a year and are also emailed the documents to review. The advisors are all experts in different fields and are members of national laboratories, state or federal agencies and academicians. Staff is also intimately involved with specific technologies through efforts at state and federal collaboratives, partnerships and industrial coalitions. Finally, staff also invites technical experts to review the Annual Report and Plan Update. Through this wide network, staff is confident there is no duplication of technology projects represented in the Plan Update as required in the H&SC. Attachment A is an adoption resolution making such a finding. Furthermore, staff recommends the Board approve membership changes, which are necessitated by retirements and departures, to the Clean Fuels Advisory Group and receive and file membership changes to the Technology Advancement Advisory Group.

Clean Fuels Program Annual Report 2013
The Annual Report covers projects and progress of the Program for Calendar Year (CY) 2013. As discussed earlier, this report addresses all of the requirements specified in H&SC 40448.5.1(d). Specifically, the report includes the following required elements:

- 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 commercialization barriers;
- 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 automobile and energy firms, as determined by the SCAQMD;
- A description of projects funded by the SCAQMD, including a list of recipients, subcontractors, co-funders, matching state or federal funds and expected and actual results of each project advancing and implementing clean fuels technology and improving public health;
- 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;
- A summary of the progress made toward the goals of the Clean Fuels Program; and

- Funding priorities identified for the next year and relevant audit information for previous, current and future years covered by the report.

During CY 2013, the Clean Fuels Program executed 45 new projects or studies and modified 3 continuing contracts adding additional dollars to sponsor research, development, demonstration and deployment projects of alternative fuel and clean fuel technologies. The SCAQMD's contribution to these projects was approximately $7.5 million, with total project costs of more than $23 million that includes funding from other governmental agencies, private sector, academia and research institutions. These projects address a wide range of air quality issues with a diverse mix of advanced technologies. Figure 1 shows the distribution of funding committed from the Clean Fuels Program through executed agreements in 2013. It should be noted that the executed agreements typically lag the Board awards due to the time necessary to negotiate contracts. During this phase, project awards may be reduced in scope, encounter delays in execution, or may not be contracted at all due to unforeseen difficulties following Board approval. As such, the funding distribution represents a "snapshot-in-time" of the Clean Fuels Program for the calendar year.

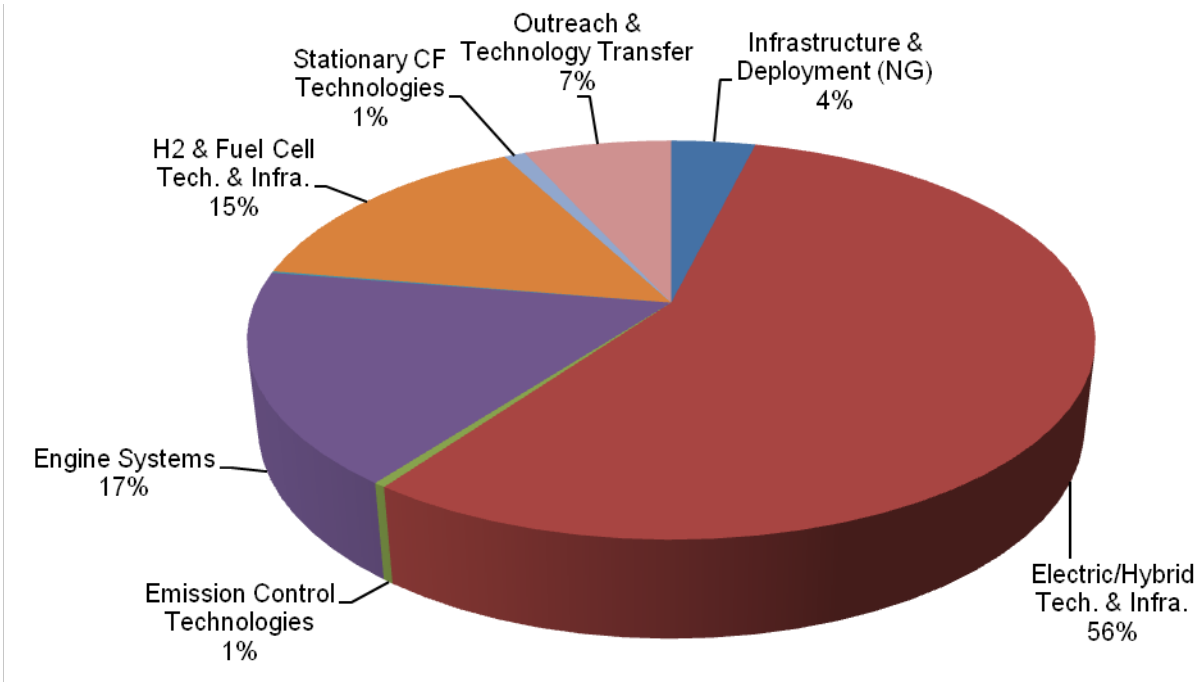

Figure 1: Distribution of Clean Fuels Program Funds in CY 2013 ($7.5 Million)

During CY 2013, 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. Projects in CY 2013 included continued development and

demonstration of electric and hybrid technologies and infrastructure with an emphasis on zero emission goods movement technologies, development and demonstration of heavy-duty natural gas engines and vehicles and development and demonstration of hydrogen technologies and infrastructure.

In addition to the new projects, 24 research, development and demonstration projects or studies and 13 technology assessment and transfer projects were completed in CY 2013. Summaries for each of the technical projects are provided in Appendix C of the Annual Report.

The Clean Fuels Program in CY 2013 has continued to leverage other outside opportunities, with the SCAQMD securing awards totaling more than $15.8 million from federal and state funding. Similar to the nearly $111 million awarded to the SCAQMD between 2009 and 2012 through the American Recovery and Reinvestment Act and other federal and state programs, the $15.8 million awarded in 2013 are for projects that align well with and are complementary to the Clean Fuels Program. Staff will continue to look for and pursue applicable funding opportunities.

Clean Fuels Program Plan Update 2014

Every year TAO staff re-evaluates the Clean Fuels Program to craft a Plan Update which essentially serves to re-calibrate the compass. The attached Plan Update for the Clean Fuels Program identifies potential projects to be considered for funding during 2014 and beyond. The proposed projects reflect promising low and near-zero- or zero emission technologies and applications that are emerging in the different source categories. This Plan Update includes a number of proposed projects, not all of which are expected to be funded in the current calendar year given the available budget. Projects not funded in 2014 may be considered for funding in future years.

In addition to identifying proposed projects to be considered for funding, this Plan Update confirms nine key technical areas of highest priority to the SCAQMD. These high priority areas are listed below based on the proposed funding distribution shown in Figure 2:

- Hybrid and Electric Vehicle Technologies and Related Infrastructure (emphasizing electric and hybrid electric trucks and zero-emission container transport technologies)
- Hydrogen and Mobile Fuel Cell Technologies and Infrastructure
- Engine Systems (emphasizing heavy-duty natural gas engines for truck and rail applications)
- Fueling Infrastructure and Deployment (predominantly compressed and liquid natural gas)
- Fuels and Emission Studies

- Health Impacts Studies
- Stationary Clean Fuels Technologies (including renewables)
- Emission Control Technologies
- Outreach and Technology Transfer

It should be noted that these priorities represent the areas where SCAQMD funding is thought to have the greatest impact. In keeping with the diverse and flexible "technology portfolio" approach, however, these priorities may shift during the year to: (1) capture opportunities such as cost-sharing by the state government, the federal government or other entities, (2) address specific technology issues which affect residents within the SCAQMD jurisdiction; or (3) incorporate findings from studies, such as SCAQMD's MATES IV study results which will be available mid-2014.

These technical priorities will necessarily be balanced by funding availability and the availability of qualified projects. Revenues from several sources support the SCAQMD's Technology Advancement program. The principal revenue source is the Clean Fuels Program, which, under H&SC Section 40448.5 and Vehicle Code Section 9250.11, establishes mechanisms to collect revenues from mobile and stationary sources to support the program's objectives, albeit with constraints on the use of the funds. Grants and cost-sharing revenue contracts from various government agencies, such as the California Air Resources Board, the California Energy Commission, the National Renewable Energy Laboratory and the U.S. Departments of Energy and Transportation, also support technology advancement efforts.

The proposed Plan Update is the result of a comprehensive planning and review process. This process included consideration of the 2012 AQMP control measures which represent new challenges and methodologies from the prior AQMP. It also incorporates coordination activities involving outside organizations including consideration of federal, state and local activities and proposed integrated solutions ranging from CARB's freight strategies to SB 375 requirements which call for sustainable communities. As part of this process, staff hosted two retreats in August 2013 and February 2014 to solicit input from the Clean Fuels Advisory Group, the Technical Advancement Advisory Group and other technical experts. During these retreats, the participants reviewed the current Technology Advancement projects and discussed near-term and long-term technologies as potential projects. In November 2013, the SCAQMD also hosted a technology forum on near road mitigation measures and technologies. Additionally, staff attended meetings with CARB, CEC, the California Fuel Cell Partnership and other entities to solicit and incorporate technical areas for potential leveraged funding and project coordination.

Based on communications with the organizations specified in H&SC Section 40448.5.1 and review of their programs, the projects proposed in this Plan Update do not appear to duplicate any past or present projects. As each individual project is recommended to the

Board for funding, staff will continue to coordinate with these organizations to ensure that duplication is avoided and ensure optimal expenditure of Clean Fuels Program funds.

Finally, staff presented the Draft 2013 Clean Fuels Program Plan Update to the Technology Committee on September 20, 2013, and to the full SCAQMD Board for review and comment at its October 4, 2013 meeting. Feedback from Board Members at the public hearing was used to further refine allocations among the funding priority categories. Figure 2 graphically depicts the potential distribution of SCAQMD Clean Fuels funds, based on projected program costs of $16.4 million, for the nine project areas discussed above.

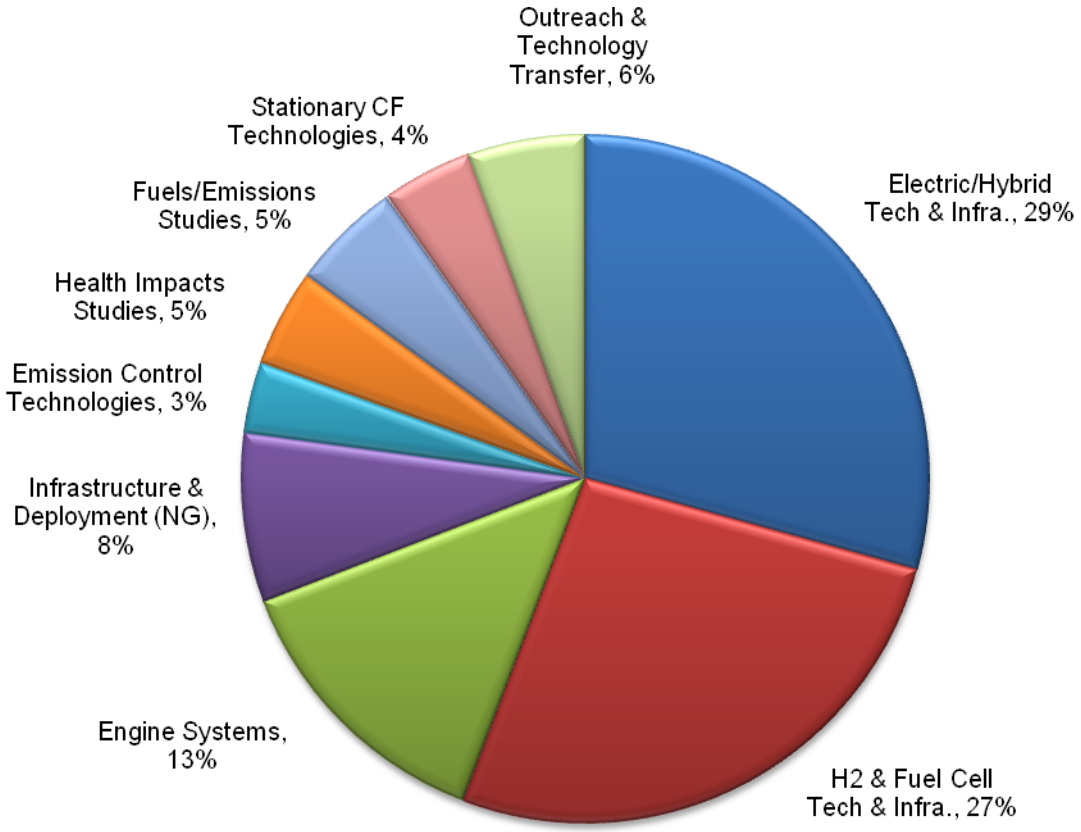

Figure 2: Projected Cost Distribution for Potential Projects in 2014 ($16.4 million)

The expected actual program expenditures for 2014 will be much less than the total 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 2014 will be based on this proposed allocation, the quality of proposals received and evaluation of projects against standardized criteria and, ultimately, the Board's approval. At that time,

additional details will be provided about the technology, its application, the specific scope of work, the project team capabilities and the project cost-sharing.

H&SC Section 40448.5.1 requires the Board approve the Clean Fuels Annual Report for 2013 and adopt the Clean Fuels Plan Update for 2014 as well as find that the proposed projects do not duplicate programs of other organizations specified in the H&SC provision. And as required, the Annual Report and Plan Update have been reviewed and approved by the SB 98 Clean Fuels Advisory Group and is due to the state by March 31, 2014.

Attachments

A. Resolution
B. Qualifications and Expertise of Proposed New Advisory Group Members
C. TAO Clean Fuels Program 2013 Annual Report and 2014 Plan Update

ATTACHMENT A

RESOLUTION NO. 14-

A Resolution of the Governing Board of the South Coast Air Quality Management District (SCAQMD) approving the Technology Advancement Office Clean Fuels Program Annual Report for 2013 and adopting the Clean Fuels Program Plan Update for 2014.

WHEREAS, the Board initiated a Clean Fuels Program in 1988 to expedite the demonstration and commercialization of advanced low emission and zero emission technologies and clean fuels; and,

WHEREAS, Health and Safety Code Sections 40404 and 40448.5 require the SCAQMD to coordinate and manage a Clean Fuels Program to accelerate the utilization of clean-burning fuels within the South Coast Air Basin; and,

WHEREAS, Health and Safety Code Section 40512 and Vehicle Code Section 9250.11 authorize funding for the SCAQMD Clean Fuels Program; and,

WHEREAS, SB 98 (Alarcon), chaptered into state law on June 8, 1999, extended the funding authority for the Clean Fuels Program and added administrative provisions under Health and Safety Code Section 40448.5.1 regarding program planning and reporting, including:

- Providing notice to interested parties and the public at least 30 days prior to the annual public hearing at which the south coast district board or a committee of the board takes action to approve the clean-burning fuels program.
- Consulting with the SB 98 Clean Fuels Advisory Group regarding approval of the required annual report. The results of that consultation shall be provided to the south coast district board prior to its approval of the report.
- Submitting the Clean Fuels Program annual report to the office of the Legislative Analyst and to the committees of the Legislature responsible for improving air quality on or before March 31 of each year that the clean-burning fuels program is in operation.

WHEREAS, SB 1646 (Padilla), chaptered into state law on September 30, 2008, reauthorized the funding authority for the Clean Fuels Program, removed the sunset of January 1, 2010, and reinstated the five percent administrative cap; and,

WHEREAS, the Technology Advancement Office Clean Fuels Program Plan Update has been reviewed and commented on by both the Technology Advancement Advisory Group and the SB 98 Clean Fuels Advisory Group; and,

WHEREAS, Health and Safety Code Section 40448.5.1 requires that the SCAQMD coordinate and ensure non-duplication of clean fuels-related projects with specified organizations, including the: CARB, CEC, California air quality management districts or air pollution control districts, a public transit district or authority within the geographic jurisdiction of the south coast district, San Diego Transit Corporation, North County Transit District, Sacramento Regional Transit District, Alameda-Contra Costa Transit District, San Francisco Bay Area Rapid Transit District, Santa Barbara Metropolitan Transit District, Los Angeles Department of Water and Power, Sacramento Municipal Utility District, Pacific Gas and Electric Company, Southern California Gas Company, Southern California Edison Company, San Diego Gas and Electric Company, or the Office of Mobile Sources within the U.S. Environmental Protection Agency; and

WHEREAS, based on communications with the organizations specified in Health and Safety Code Section 40448.5.1 and review of their programs, the proposed program and projects included in the Technology Advancement Office Clean Fuels Program Plan Update do not duplicate any other past or present program or project funded by those organizations; and,

WHEREAS, notice has been provided to interested parties and the public at least 30 days prior to the annual public hearing at which the south coast district board is to approve the clean-burning fuels program; and,

WHEREAS, the SB 98 Clean Fuels Advisory Group has reviewed the Technology Advancement Office Annual Report.

NOW, THEREFORE, BE IT RESOLVED, that the Board finds the Technology Advancement Office Clean Fuels Program Plan Update does not duplicate any past or present programs or projects funded by the above-specified organizations.

BE IT FURTHER RESOLVED, that the Board approves the Technology Advancement Office Clean Fuels Program Annual Report for 2013.

BE IT FURTHER RESOLVED, that the Board adopts the Technology Advancement Office Clean Fuels Program Plan Update for 2014.

BE IT FURTHER RESOLVED, that the Board hereby directs staff to forward the Technology Advancement Office Clean Fuels Program Annual Report 2013 and Plan Update 2014 to the California Legislature and the Legislative Analyst by March 31, 2014.

_____ _____

Dated: Saundra McDaniel, Clerk of the Board

ATTACHMENT B
Qualifications and Expertise of Proposed New Advisory Group Members

Clean Fuels Advisory Group*

Kevin Walkowicz, NREL	Kevin Walkowicz is the Manager of the Vehicle Testing and Analysis Group within NREL's Transportation and Hydrogen Systems Center. His group primarily supports and manages research projects for the U.S. Department of Energy's Vehicle Technology Office. His group focuses on managing advanced data acquisition efforts, developing data analysis, simulation & visualization tools as well as conducting vehicle and infrastructure testing projects. He is also one of the Principle Investigators for the U.S. Department of Energy's Advanced Vehicle Testing Activity. His primary focus has been on capturing, analyzing and reporting in-use data from advanced technology vehicles and understanding vehicle performance as it relates to usage and duty cycle. Prior to joining NREL in January 2001 he worked at General Motors Corporation to lead fuel system and advanced evaporative emission control system projects in order to meet new stringent EPA emission requirements. He holds a B.S.M.E from Lawrence Technological University and a M.S. in engineering from Rensselaer Polytechnic Institute.

**The charter for the CFAG requires membership changes to be approved by the Board.*

Technology Advancement Advisory Group**

Alberto Ayala, CARB	Alberto Ayala is the Deputy Executive Officer of the California Air Resources Board. In this capacity, Alberto is responsible for the Board's ambient monitoring and laboratory activities and mobile source program. Alberto became a member of CARB's Research staff in 2000 and has since held various management assignments in programs such as Carl Moyer Incentives, AB 32 early actions, mobile refrigerant rules, diesel retrofits, and car, truck, and bus emissions research. Alberto oversees the full range of policy, regulatory, and research efforts of over 400 professionals focused on achieving CARB's goals for clean, zero-emission, and low-carbon transportation; state-of-the-art monitoring for air and climate pollution; and a widely recognized motor vehicle emissions and fuels testing program. He contributed to the first car GHG emissions regulation in 2004 and is now directing one of CARB's most important efforts, the Advanced Clean Cars program.
Patricia Ochoa, Coalition for Clean Air	Patricia Ochoa is the Deputy Policy Director for Coalition for Clean Air which oversees the organization's efforts to improve the air quality in Southern California by working to ensure that the region's freight network is sustainable and cleaner. Prior to joining CCA, Patty worked on developing healthier and equitable land-use policies for the region and spearheaded an effort to improve local auto-dismantler's environmental practices through education and outreach. Patty has a bachelor's degree in English and Chicano/a Studies and a master's degree in Chicano/a Studies from California State University Northridge.
Ed Kjaer, SCE	Edward Kjaer is the Director of SCE's Transportation Electrification program. In his role, Ed is responsible for this broad corporate wide effort supporting transportation connecting to the SCE's electrical system. Ed's responsibilities include; company strategy, external stakeholder engagement, regulatory and legislative strategy, and internal company wide program coordination. Prior to this position, Ed has been a leading proponent of electric transportation at Edison holding key leadership positions since joining the company in 1996. In 2011, Ed received the prestigious "Hall of Fame" award from the Electric Drive Transportation Association and has been named to the Automotive News "Electrifying 100" most influential people leading industry towards a more electric powered transportation future.
WSPA rep	*Appointment Pending*

***The charter of the TAAG requires membership changes to be approved by the Board's Technology Committee.*

ATTACHMENT C

TECHNOLOGY ADVANCEMENT OFFICE
CLEAN FUELS PROGRAM
2013 ANNUAL REPORT AND
2014 PLAN UPDATE

DRAFT

South Coast Air Quality Management District
March 2014

DRAFT

South Coast Air Quality Management District

Governing Board

Chairman

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

County Representatives

Michael D. Antonovich
Supervisor, Los Angeles County

Shawn Nelson
Supervisor, Orange County

Josie Gonzales
Supervisor, San Bernardino County

John J. Benoit**
Supervisor, Riverside County

State Representatives

Dr. Clark E. Parker, Sr.
Senate Rules Committee Appointee

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

Vice Chairman

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

Cities Representatives

Joe Buscaino*
Councilmember, City of Los Angeles
City of Los Angeles

Michael Cacciotti
Councilmember, City of South Pasadena
Los Angeles County, Eastern Region

Judith Mitchell*
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Ben Benoit
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Riverside County Cities

Executive Officer
Barry R. Wallerstein, D.Env.

*Technology Committee Members **Technology Committee Chairman

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Technology Advancement Office

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Henry Hogo, Assistant Deputy Executive Officer, Mobile Sources
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Lourdes Cordova Martinez, Community Relations Manager

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Connie Day, Program Supervisor
Ranji George, Program Supervisor
Joseph Impullitti, Program Supervisor
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EXECUTIVE SUMMARY

The South Coast Air Quality Management District (SCAQMD) is the air pollution control agency for all of Orange County and the urban portions of Los Angeles, Riverside and San Bernardino counties. This region, which encompasses all of the South Coast Air Basin plus small portions of the Mojave Desert and Salton Sea Air Basins, 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, in 1988 the state established the SCAQMD's Clean Fuels Program (along with establishment of the Technology Advancement Office), which affords the SCAQMD the ability to fund the development, demonstration and accelerated deployment of clean technologies. For over 20 years, using funding received through a $1 motor vehicle registration fee, the Clean Fuels Program has encouraged, fostered and supported technologies such as hydrogen and fuel cells, natural gas engines and infrastructure, battery electric vehicles, plug-in hybrid electric vehicles and related 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.

The Clean Fuels Program is implemented as a public-private partnership in conjunction with private industry, technology developers, academic institutions, research institutions and government agencies.

The overall strategy of the SCAQMD's Clean Fuels Program is based in large part on technology needs identified through the Air Quality Management Plan (AQMP) process and the SCAQMD Board's directives to protect the health of residents in Southern California, which encompasses approximately 16.8 million people (nearly half the population of California). 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 2012 AQMP identifies the need for 200 tons/day oxides of nitrogen (NO_x) reductions to be adopted by 2020 for full implementation by 2023 and in large part focuses control measures on transportation technologies and cleaner fuels. Moreover, the SCAQMD is currently only one of two regions in the nation recognized as an extreme ozone nonattainment area (the other is San Joaquin Valley). This is especially noteworthy because the largest contributor to ozone is NO_x emissions, and mobile sources (on- and off-road as well as aircraft and ships) contribute to more than three-fourths of the NO_x emissions in this region. These emission reduction needs are further identified in a joint SCAQMD, California Air Resources Board (CARB) and San Joaquin Air Pollution Control District effort, "Vision for Clean Air: A Framework for Air Quality and Climate Control Planning."[1] The overwhelming hurdles to reduce ozone and NO_x will require the Clean Fuels Program to encourage and accelerate advancement of transformative transportation technologies and commercialization of progressively lower-emitting vehicles and fuels. The Program must also remain flexible to address the needs which will be identified during the current planning process for the 2016 AQMP which will focus on addressing ozone standards. Furthermore, volatile organic compounds (VOCs) and fine particulate matter ($PM_{2.5}$) produced from mobile sources must also be addressed. The NO_x and VOC emission sources of greatest concern to this region are heavy-duty on-road and off-road vehicles as well as to a lesser extent light- and medium-duty on-road vehicles. And while it is anticipated that the

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

2014 standard for $PM_{2.5}$ will be attained for this region, it is contingent upon compliance and implementation of existing and proposed rules and regulations.

In recent years, it has become increasingly clear that the effect of containers 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 to actively develop and demonstrate 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 including catenary technology and heavy-duty technologies.

The prioritization of these types of projects as well as potential technologies which assist with their further development and deployment are emphasized in the 2014 Plan Update portion of the report. The 2013 Annual Report highlights the projects contracted during the previous calendar year and reflects the current status of the program.

2013 Annual Report

During Calendar Year (CY) 2013 the SCAQMD executed 45 new contracts, projects or studies and modified 3 continuing projects adding additional dollars toward research, development, demonstration and deployment (RDD&D) of alternative fuel and clean fuel technologies. Table 2 (page 24) lists these 48 projects or studies, which are further described in this report. The SCAQMD Clean Fuels Program contributed approximately $7.5 million in partnership with other governmental organizations, private industry, academia and research institutes, and interested parties, with total project costs of nearly $23.3 million. Table 3 (page 26) provides information on outside funding received into the Clean Fuels Fund (approximately $2 million in 2013) as cost-share for the contracts executed in CY 2013. Table 4 (page 26) provides a comprehensive summary of federal and state revenue awarded to the SCAQMD during CY 2013 ($15.8 million) for projects to be included within the Clean Fuels Program or which align well with and are complementary to the Clean Fuels Program. Table 5 (page 27) provides a comprehensive summary of federal and state revenue awarded to SCAQMD during CYs 2009 through 2012 (nearly $111 million); some of these projects were undertaken as part of the Clean Fuels Program, while some of the revenue was recognized into other special funds but similar to those reflected in Table 4 align well and are complementary to the Clean Fuels Program.

The projects or studies executed in 2013 addressed a wide range of issues and opportunities with a diverse mix of advanced technologies. The following core areas of technology advancement include:

- Electric and Hybrid Vehicle Technologies and Related Infrastructure (emphasizing electric and hybrid electric trucks and zero emission container transport technologies)
- Hydrogen and Mobile Fuel Cell Technologies and Infrastructure
- Engine Systems (particularly heavy-duty natural gas engines for truck and rail applications)
- Fueling Infrastructure and Deployment (predominantly compressed and liquid natural gas)
- Fuels and Emission Studies
- Health Impacts Studies
- Stationary Clean Fuels Technology (including renewables)
- Emission Control Technologies
- Outreach and Technology Transfer

During CY 2013, 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 2013 included continued development and demonstration of electric and hybrid technologies with an emphasis on zero emission goods movement technologies, development and demonstration of heavy-duty natural gas engines and vehicles and development and demonstration of hydrogen technologies and infrastructure.

As of January 1, 2014, there were 124 open contracts in the Clean Fuels Program; these are summarized in Appendix B.

Twenty four research, development, demonstration and deployment projects or studies and 13 technology assessment and transfer contracts were completed in 2013, as listed in Table 6 (page 51). Appendix C comprises two-page summaries of the technical projects completed in 2013. 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, 2014, after approval by the SCAQMD Governing Board.

2014 Plan Update

Every year TAO staff re-evaluates the Clean Fuels Program (Program) to craft a Plan Update which essentially serves to re-calibrate the compass. The 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 SCAQMD employs a number of outreach and networking activities to overcome this challenge, ranging from intimate involvement with state and federal collaboratives, partnerships and industrial coalitions to issuing Program Opportunity Notices to essentially throw out a wide net to solicit project ideas and concepts and Requests for Information to determine the state of various technologies and what is needed to advance those technologies.

As mentioned, the overall strategy is based in large part on technology needs identified in the SCAQMD's AQMP and the SCAQMD Governing Board's directives to protect the health of residents in the Basin. The NO_x, volatile organic compounds (VOC) and 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 2012 AQMP. 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 of 0.125 ppm by 2022, which must be met as a result of a 2012 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 7 lists the potential projects across the core technologies identified in this report. Potential projects for 2014 total more than $16.4 million, with anticipated leveraging of nearly $76 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
2013 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.

2013 Overview

This report summarizes the progress of the SCAQMD Clean Fuels Program for CY 2013. 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, 2013, the SCAQMD executed 45 new contracts, projects or studies and modified 3 continuing projects adding additional dollars during CY 2013 that support clean fuels and advanced zero, near-zero and low emission technologies. The SCAQMD Clean Fuels Program contribution for these projects was approximately $7.5 million, with total project costs of more than $23 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 (approximately $2 million) as

cost-share for contracts executed in this period as well as funds awarded to the SCAQMD for projects to be included in the Clean Fuels Program or which align well and are complementary to the Clean Fuels Program ($15.8 million in 2013). A comprehensive summary update on the nearly $111 million in federal and state funding awarded to the SCAQMD between 2009 and 2012, again for projects that were included as part of the Clean Fuels Program or which align well and are complementary with the Clean Fuels Program, is also provided. The SCAQMD will continue to pursue federal and state funding opportunities in 2014 to amplify leverage.

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 illustrated by Figure 1 below, which identifies NO_x emissions by category and identifies just how far those emissions must be reduced to meet federal standards by 2023 and 2032.

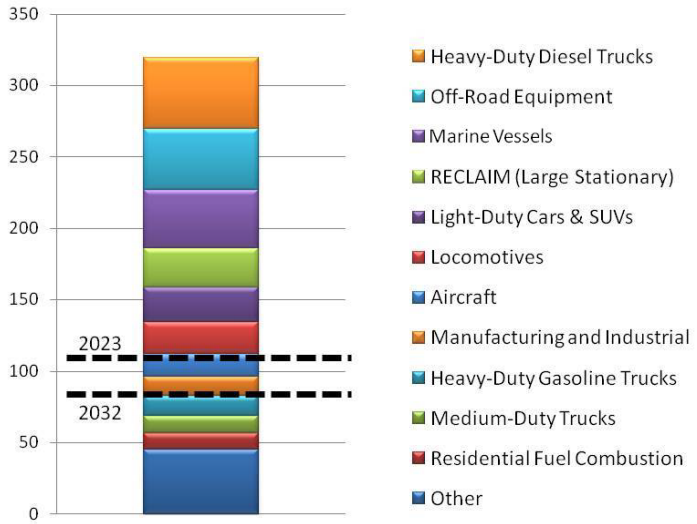


Figure 1: 2023 NO_x Emissions by Category

Additionally, the following piechart reflects NO_x contributors by sector, sharply illustrating the impact of mobile sources on air quality and why the 2012 AQMP calls for the reduction of 200 tons/day of NO_x by 2020 as well as why this region is recognized as an extreme ozone nonattainment area.

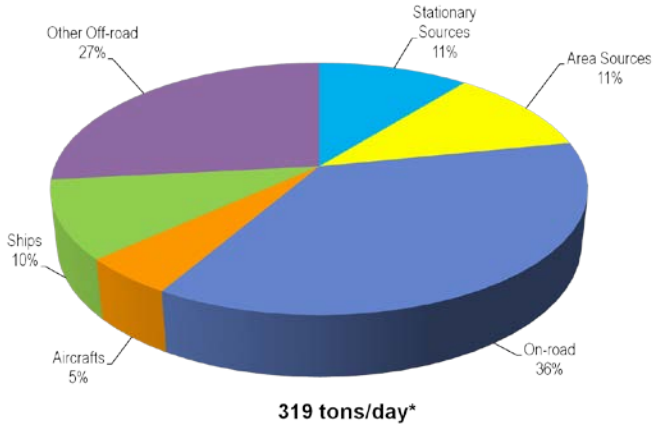


Figure 2: NOx Contributors by Sector

To fulfill long-term emission reduction targets, the 2012 AQMP relies on a mix of currently available technology as well as the expedited development and demonstration of advanced technologies that are not yet ready for commercial use. Significant reductions are anticipated from implementation of advanced control technologies for both on-road and off-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 2012 AQMP's estimate of needed NO_x reductions will require the SCAQMD Clean Fuels Program to encourage and accelerate advancement of cleaner, transformative transportation 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 mid-2014.

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).

The Global Warming Solutions Act of 2006 (AB 32) requires California's greenhouse gas emissions to be capped at 1990 levels by 2020. The 2007 Low-Carbon Fuel Standard (LCFS) for transportation fuels will necessitate increased research into alternatives to oil and traditional fuels. And in September 2008, SB 375 was adopted 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. In 2012 California Governor Brown also set a California target for reductions of GHG emissions from the transportation sector of 80 percent less than 1990 levels by 2050 and called for establishment of benchmarks for the penetration of zero emission vehicles and infrastructure for 2015, 2020 and 2025. Governor Brown's FY 2013-14 state budget also consolidates programs funding bicycle, pedestrian and mitigation projects to fund high-priority projects that reduce GHGs consistent with SB 375 objectives. The 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, in 2012 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 zeroemission 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 its Technology Advancement Office (TAO).

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, SCAQMD's TAO 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 2013 the funds available through each of these mechanisms were as follows:

- Mobile sources (DMV revenues) $12,433,490
- Stationary sources (emission fee surcharge) $275,708

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 26) lists supplemental grants and revenues totaling more than $2 million for contracts executed in CY 2013. Table 4 (page 26) lists federal and state revenue totaling more than $15.8 million awarded to the SCAQMD in 2013 for projects that will be part of the Clean Fuels Program or align well and complement the Clean Fuels Program.

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 2013, 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 2013 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:

- Electric and Hybrid Vehicle Technologies and Infrastructure (emphasizing electric and hybrid electric trucks and zero emission container transport technologies)
- Hydrogen and Fuel Cell Technologies and Infrastructure
- Infrastructure and Deployment (predominantly compressed and liquid natural gas)
- Engine Systems (particularly heavy-duty natural gas engines for truck and rail applications)
- Emission Control Technologies
- 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. While employing a number of creative outreach and networking activities to try to overcome these challenges, SCAQMD's Technology Advancement Office annually develops a comprehensive plan to encourage and accelerate the development and demonstration of cleaner technologies. This comprehensive plan (referred to as the 2014 Plan Update within this document) essentially re-calibrates the Clean Fuels Program for the upcoming year.

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 2012 AQMP needs for achieving clean air are briefly described below.

Electric and Hybrid Vehicle Technologies and Infrastructure

There has been an increased level of activity and attention on electric and hybrid vehicles due to a confluence of factors, including the highly successful commercial introductions of hybrid passenger vehicles and more recently electric 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 electric and 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. However, this category is predominantly targeted at compressed and liquid natural gas infrastructure and deployment, with the related infrastructure for electric and hybrid and hydrogen and fuel cell included within their technology category.

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 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.

In 1999, 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. Also in 1999, in light of the formation of the Clean Fuels Advisory Group, the SCAQMD also revisited the charter and membership of the Technology Advancement Advisory Group to ensure their functions would complement each other.

On an as-needed basis, changes to the composition of the Clean Fuels Advisory Group are reviewed by the SCAQMD Board while changes to the Technology Advancement Advisory Group are reviewed by the SCAQMD Board's Technology Committee. In 2012 membership changes were considered and approved by the SCAQMD Board on May 4, 2012. Subsequent membership changes to both advisory groups will be considered by the SCAQMD Board and its Technology Committee, respectively, as part of consideration of the 2013 Annual Report and 2014 Plan Update. The current proposed members of the SB 98 Clean Fuels Advisory Group and Technology Advancement Advisory Group are listed in Appendix A.

The review process of the Clean Fuels Program now includes at least two full-day retreats of the two Advisory Groups, review by other technical experts, review by the Technology Committee of the SCAQMD Governing Board, a public hearing of the Annual Report and Plan Update before the full SCAQMD Governing Board and finally 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 3 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.

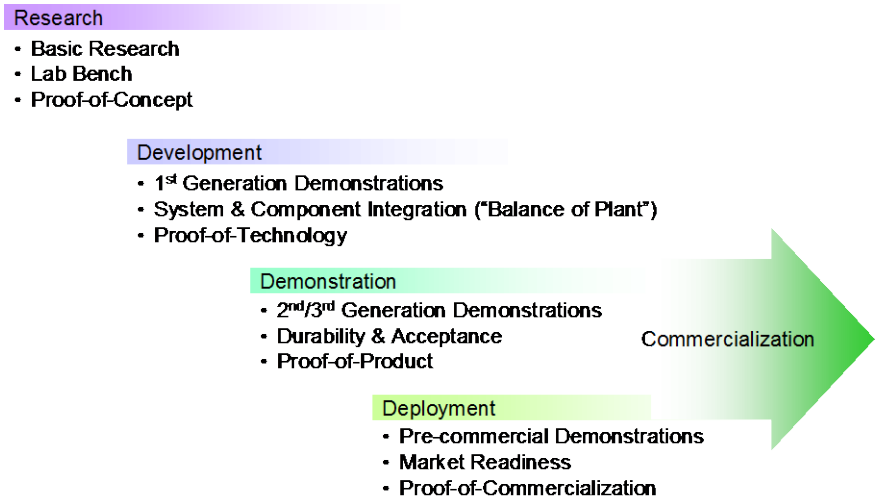


Figure 3: Stages of Clean Fuels Program Projects

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

Project-Specific Issues

- Identifying a committed demonstration site
- Overall project cost and cost-share using public monies
- Securing the fuel

- Fuel availability/convenience issues
- Certification, safety and regulatory barriers
- Quantifying emissions benefits
- Sustainability of market and technology
- 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.

Strategy and Impact

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 2013 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 2013 Project Summaries (beginning page 31) contained within this report.

Table 1: SCAQMD Major Funding Partners in CY 2013

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 2013. 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) development of hybrid system for Class 7 heavy-duty vehicle applications; (b) development and demonstration of catenary Class 8 trucks; and (c) development, integration and demonstration of heavy-duty natural gas engines and vehicles.

Develop Hybrid System for Class 7 Heavy-Duty Vehicle Applications

The Capstone project will develop a Class 7 series hybrid refrigeration truck. The series hybrid refrigeration truck will feature up to ten miles of zero "tailpipe" emissions driving, as well as provide auxiliary electric power to the refrigeration unit; thereafter, switching to ultra-low emission series hybrid drive for full purpose duties after the battery has been depleted. The series hybrid drive system includes a diesel-fueled microturbine which is anticipated to yield emissions that are significantly below CARB 2010 standards.

The technology used on this truck is an electric drive series hybrid truck with a microturbine serving as the range extender or auxiliary power unit. The series hybrid architecture allows the electric motor to provide the full motive propulsion force for the vehicle, using on-board energy stored in a lithium ion battery that will be charged from the grid. The electrical energy stored in the on-board battery will also be used to power the refrigeration system for the box unit that will be installed on the vehicle. Upon breaching the battery's lower state of charge threshold, the microturbine generator will be used to provide power to the vehicle's DC bus to maintain the battery's lower state of charge threshold, which will extend the driving range and refrigeration capabilities of the vehicle. The figure below shows a simplified diagram of the major components.

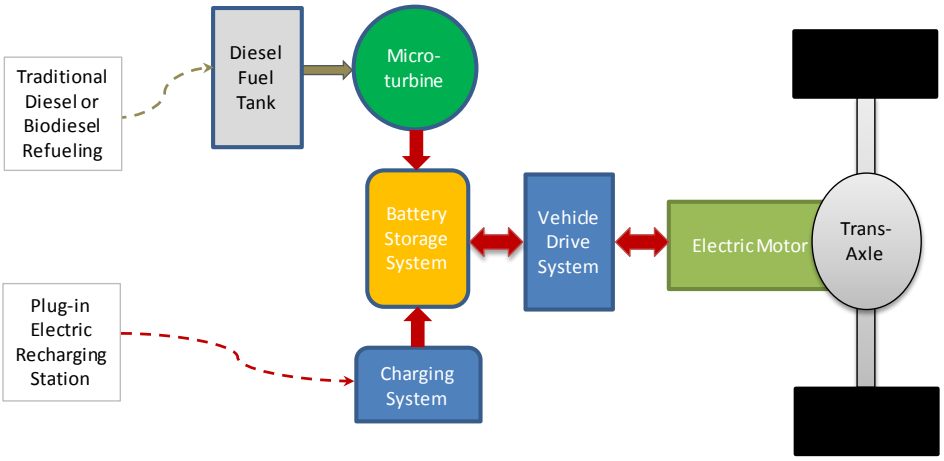


Figure 4: Diagram of the Microturbine Generator's Major Components

The battery storage system in this series hybrid drive system can be recharged or maintained in three ways:

- Utility Power – by plugging the vehicle into the utility grid. The vehicle therefore has some "battery only" range that depends on the size of the battery storage and the drive cycle.
- Microturbine – acting as a range extender, the microturbine can be turned on to recharge the batteries while the vehicle is in use, thereby significantly extending the utilization of the vehicle compared to relying only on the battery storage system.
- Regenerative Braking – the motor and vehicle drive system are able to pass power both to the wheels to propel the truck, but also take power from the wheels to recover a significant amount of the vehicle momentum during braking. Capturing this braking energy can have a significant impact on overall vehicle efficiency, especially in Pickup and Delivery drive cycles that involve a moderate amount of stop and go.

The electric drive system is well suited for trucks with significant auxiliary loads; such as the refrigeration truck being built for this project. The photo below shows the prototype Class 7 hybrid truck with key drive components installed, but prior to the installation of the refrigeration box unit that will be demonstrated as part of this program.

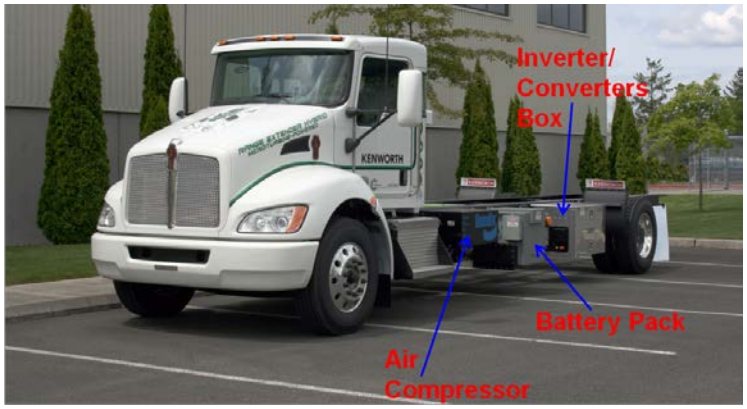


Figure 5: Prototype Class 7 Hybrid Truck

Develop and Demonstrate Catenary Class 8 Trucks

The electrification of transportation technologies has the potential to significantly reduce criteria pollutant and greenhouse gas emissions. This can provide substantial benefits to communities, neighborhoods and school areas where these vehicles operate. The TransPower "ElecTruck" drive system is a zero emission solution that eliminates 100% of the harmful emissions produced by road vehicles, at the point of operation. TransPower has selected port trucks as its initial target market because of the high potential for environmental benefits if these vehicles can be converted to electric propulsion.

TransPower will demonstrate two zero emission battery electric Class 8 truck at the Ports of Los Angeles and Long Beach and intermodal facilities. TransPower will integrate electric drive components into two Class 8 trucks. One truck will be used as a static test vehicle to test new components, and the other will be placed into revenue service carrying cargo containers at the Ports of Los Angeles and Long Beach to intermodal facilities. The battery-electric drive system will utilize high-power drive motors and inverters and energy will be stored in high-energy lithium battery packs. The revenue service vehicle will be operated by a leading drayage firm and closely monitored under real-world operating conditions. In parallel with the initial demonstration, TransPower will work with a subcontractor to develop a power converter using new high-frequency silicon insulated gate bipolar transistors and liquid-cooled heat sinks, leapfrog technologies that offer significant potential benefits including size and weight reductions that will eliminate the need for a separate battery charger.

Figure 6: TransPower Truck at Facility in Poway, CA

The "ElecTruck" project has two overarching objectives: (1) to demonstrate a superior electric drive technology for heavy-duty trucks, and (2) to use this demonstration project as a springboard for rapid commercialization of a modular electric drive system. TransPower's strategy is to develop and demonstrate a reliable electric propulsion system for heavy-duty vehicles and be the first to market with a system sufficiently reliable and cost-effective for everyday use in large trucks. The initial focus will be on the port drayage market, where vehicles have short operating range requirements and where environmental concerns are forcing the ports and others to offer substantial incentives for adoption of clean vehicle technology.

In July 2010, TransPower received a $1 million grant from the California Energy Commission (CEC), which TransPower and its partners will match with $1 million in cash and in-kind contributions. This will enable development of the new integrated converter-charger and a high-energy battery pack, and testing of these components in a static test truck.

Develop, Integrate and Demonstrate Heavy-Duty Natural Gas Engines and Vehicles

The SCAQMD Board adopted a series of clean fuel fleet rules to reduce mobile source emissions within the SCAQMD's regulatory jurisdiction. The fleet rules require certain public entities and special districts, such as air, water, sanitation and school districts, with fifteen or more heavy-duty vehicles to acquire CARB-certified alternative-fueled heavy-duty vehicles when adding new vehicles or forming a new fleet. These rules have helped to advance natural gas engine technology and to expand the natural gas engine market into a wider range of heavy-duty vehicle

applications. Specifically, on-road natural gas engines are now being used on a limited basis as an alternative to diesel engines in transit, refuse and goods movement applications. While the number of natural gas engines has grown, there is still a need to develop natural gas engines in the 11- to 14-liter range to fill the wide array of fleet applications currently served solely by diesel engines. As such, the SCAQMD has been working with NREL, the CEC and Southern California Gas Company (SoCalGas) to accelerate the development, integration and demonstration of natural gas engines ranging in sizes from 11 to 14 liters suitable for transit, refuse and goods movement applications. In 2011, the Board awarded a contract to U.S. DOE's NREL for $3,055,000 to develop, integrate and demonstrate three different heavy-duty natural gas engines. The three engines will be used in refuse, transit and Class 8 heavy-duty truck applications and comply with the U.S. EPA 2010 heavy-duty emissions standards of 0.01 g/bhp-hr PM and 0.2 g/bhp-hr NO_x. The contract, executed in the form of modification to NREL's CRADA, was executed in 2013.

Figure 7: Heavy-Duty Engine

The first project is with Cummins Westport, Inc. (CWI) to develop and optimize a spark-ignited 11.9-liter ISX12 G CNG engine suitable for refuse and Class 8 applications. CWI successfully completed the project, with development of the ISX12 G engine as a spark-ignited, stoichiometric, cooled exhaust gas recirculation (SI-EGR), natural gas engine certified to the EPA/CARB heavy-duty on-highway 2013 emission standards. CWI commercially launched the ISX12 G engine with ratings up to 350 HP and 1450 lb-ft beginning in mid-April 2013, and with ratings up to 400 HP and 1450 lb-ft in August 2013. This engine is targeted at regional haul tractor and vocational (e.g. refuse collection, concrete mixer) truck customers. The ISX12 G engine also meets EPA greenhouse gas legislated requirements and Engine Manufacturer's Diagnostics (EMD+) certification. The ISX12 G engine met final certification (including Deterioration Factor) at:

- 0.15 g/bhp-hr NO_x for both EPA and CARB (vs. 0.20 limit)
- 0.03 g/bhp-hr NMHC for both EPA and CARB (vs. 0.14 limit)
- 8.4 g/bhp-hr (EPA) and 8.7g/bhp-hr (CARB) CO (vs. 15.5 limit)
- 0.001 g/bhp-hr (EPA) and 0.003 g/bhp-hr (CARB) PM (vs. 0.01 limit)

The ISX12 G engine is now available as a factory-installed option in a number of Class 8 truck and tractor models from different OEMs including Autocar, Freightliner, Kenworth, Mack, Peterbilt and Volvo.

The second project is Emissions Solutions, Inc., (ESI) to develop engine hardware and controls to convert a 13-liter Navister diesel engine to a CNG engine. This project has been discontinued because ESI is no longer in business.

Finally, the third project is with Southwest Research Institute (SwRI) to convert an 11-liter Doosan lean-burn engine to a stoichiometric engine and integrate it into a refuse chassis. This project is on-going with an anticipated completion date in 2015.

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 2013 reporting period illustrate the impact of the SCAQMD's technology deployment and commercialization efforts.

California PEV Readiness Planning

DOE's Clean Cities Program awarded California $1 million for PEV infrastructure planning, one of 16 awards nationwide out of a total of $8.5 million made through the Clean Cities' Community Readiness and Planning for PEV and Charging Infrastructure. A statewide partnership with SCAQMD, BAAQMD, PEVC, Clean Cities Coalitions in California and other regional entities enabled the state of California to work together towards PEV readiness, with this joint effort being led by SCAQMD. The statewide partnership consisted of six regional collaborations, many of which also received CEC funding on Regional Plans to Support PEV Readiness, designed to support DOE Clean Cities Program funding for PEV infrastructure planning. The South Coast region received three CEC planning grants to support subregional studies by the Coachella Valley Association of Governments, South Bay Cities Council of Governments, and Western Riverside Council of Governments.

The California PEV Readiness Project advanced the state of PEV readiness in California by creating six regional PEV infrastructure plans for the South Coast, Bay Area, San Diego, Sacramento, Central Coast, and San Joaquin Valley regions, and a statewide PEV readiness guidelines document. The California PEV Readiness Collaborative created a PEV readiness toolkit to assist local government agencies in becoming PEV ready. There were six education outreach workshops to communicate the benefits of PEV readiness to local communities. These project elements helped to ensure a unified statewide approach to planning and implementing critical PEV infrastructure activities to support the California PEV market.

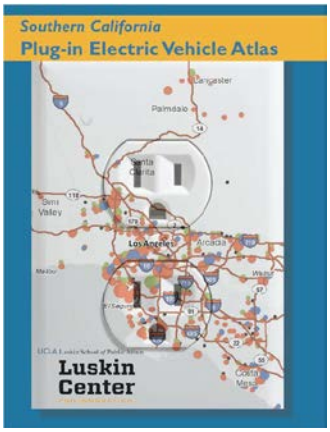


Figure 8: South Coast PEV Atlas of Deployed EV Infrastructure

As part of the California PEV Readiness Project, the UCLA Luskin Center was engaged by SCAG to develop the South Coast PEV readiness plan through a competitive RFP process. The UCLA Luskin Center has significant expertise on PEV readiness issues and has authored several policy documents, including the PEV market in Los Angeles and addressing challenges to installing infrastructure in multi-unit dwellings. The Southern California PEV Readiness Plan was the winner of the 2013 Planning Excellence Award by the Los Angeles section of the American Planning Association. This supplemental project, executed in 2013 at the request of SCAG, was to develop additional PEV readiness elements for the South Coast PEV readiness plan for the DOE Clean Cities grant, including an analysis of barriers of required and optional PEV readiness elements such as permitting and inspection, training and education, workplace and fleet charging, and multi-unit dwelling charging. It also provides a much needed analysis of two challenge areas

identified by the California PEV Collaborative in multi-unit dwelling and workplace charging, for which two new working groups have been created.

Develop Hydrogen Network Investment Plan

California has committed to transition the light-duty vehicle fleet to electric drive, including both "plug-in" battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs), in order to meet long term greenhouse gas, air quality and energy diversity goals. FCEVs, which run on hydrogen gas, are widely accepted as a critical component of this transition. They alone provide the same performance, range and utility as gasoline vehicles, while reducing greenhouse emissions between 50-100 percent, depending on how the hydrogen is made. The leading automakers have committed to fuel cell technology and have announced plans to commercialize FCEVs in the 2015 to 2017 timeframe. The remaining barrier is fueling infrastructure - stations need to be built in advance of the cars to enable automakers to sell the cars to consumers.

State government is providing leadership of the hydrogen transition in many ways, including having provided grants covering 65% of capital costs (up to $1.5 million per station), in the hope that this will be sufficient to attract these investors. Private stakeholders have not responded to the CEC grant program at the scale or timeframe needed to provide sufficient coverage for the early market FCEV launch. The latest grant solicitation was undersubscribed, and previously awarded stations are taking a long time to open. The Hydrogen Network Investment Plan (HNIP) attempts to explain why. The findings are based on 18 months of detailed stakeholder interaction and lessons from a financial model built by Energy Independence Now (EIN) to understand the economic impacts of a variety of incentives under a range of plausible market scenarios and determine what is needed to stimulate investment in the hydrogen network. Discussion with potential investors show that uncertainty remains high and confidence low, and that funding alone cannot compensate for the current uncertainty about when a large scale, FCEV market will emerge. Given the high operating costs of stations, early station investors face possible long, negative financial cash flows as they wait for cars to appear, capital costs-aside. At the same time, automakers fear these stations might close before they have time to get cars to market.

To neutralize both of these risks, the HNIP shows how the government could modify its grant program to share in the financial risk of market delays, including the addition of market assurance grants (MAGs), regular payments that would support operations and maintenance expenses until they can be covered by revenues from hydrogen sales. MAGs can be a difference maker if investors see a credible pathway and plan to reach long-term FCEV success.

Even with significant capital cost-share and downside protection such as MAG grants, it remains unclear if the government can attract appropriate "first-movers" into this sector, namely entities that want to build and operate dozens of stations on a long-term basis. Some investors suggest that this market is one where a "fast-follower" will be more successful, gaining market share by building bigger and better stations with much greater market certainty once cars are on the road. To counter this problem, the state needs to explore what kind of "upside" it can create for early investors, in the form of non-monetary, strategic advantages that come from being a government-backed first mover. Unless the government can bring these investors off the sideline or increase investment of existing participants, early market investment may remain stalled.

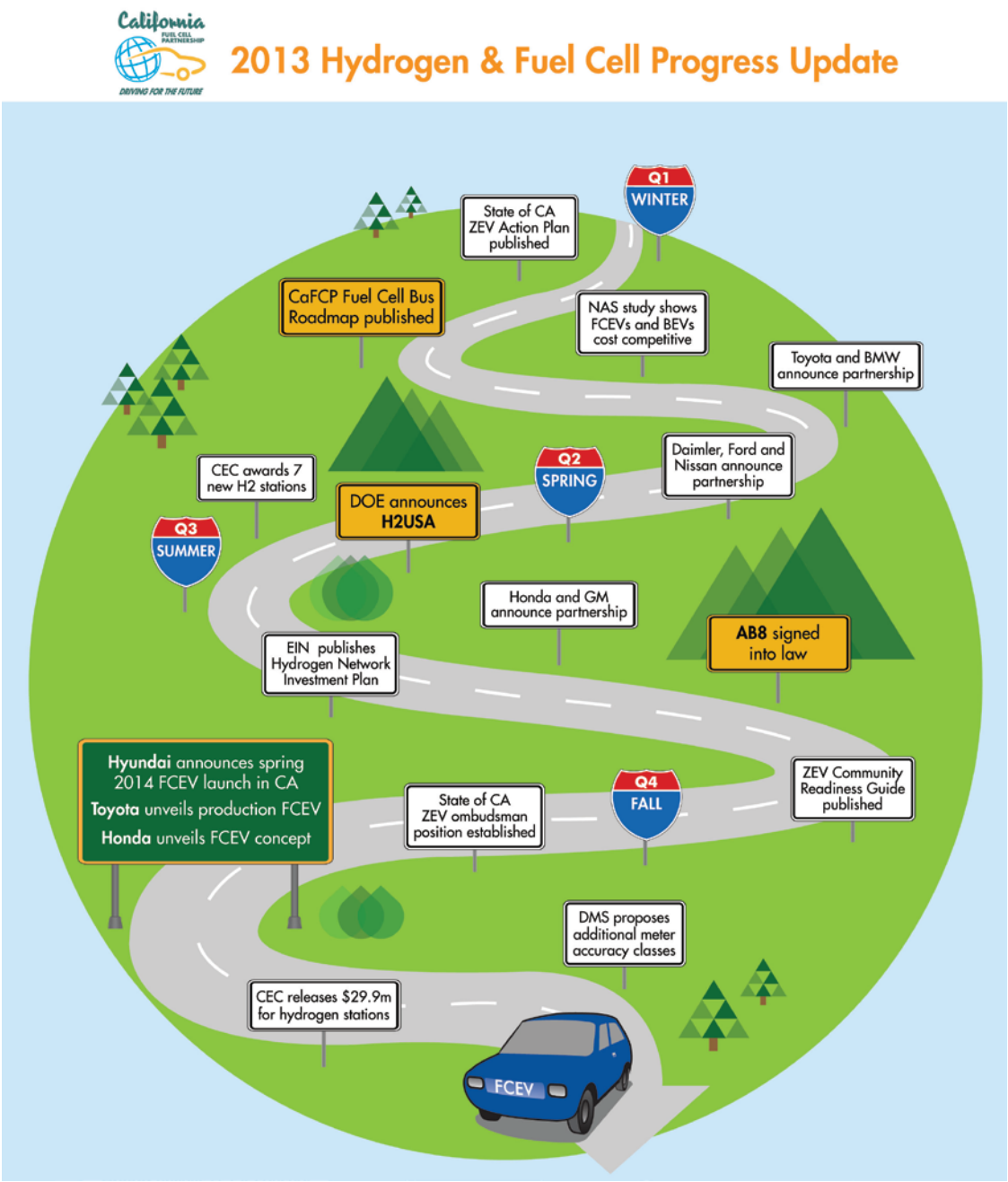


Figure 9: Giant Steps Forward in 2013 for Fuel Cell Electric Vehicles and Hydrogen Stations

It is anticipated that Phase 2 of this effort will begin in 2014. Phase 2 would refine the draft HNIP and coordinate with government and industry to build the hydrogen market and participation and influence hydrogen infrastructure deployment.

2013 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, using revenue from a $1 motor vehicle registration fee (see Program Funding on page 4), 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, 2013.

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, 2013, a total of 48 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 10 (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 2013 reporting period are shown below with the total projected project costs:

- SCAQMD Clean Fuels Fund Contribution $7,542,654
- Total Cost of Clean Fuels Projects $23,263,776

Each year, the SCAQMD Governing Board approves funds to be transferred to the General Fund Budget for Clean Fuels administration. For 2013, the Board transferred $800,000 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, 2013, are included within this report. Any portion of the Clean Fuels Funds not spent by the end of Fiscal Year 2013-14 ending June 30, 2014, 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 for pass-through contracts executed in 2013 totaling $2,040,750 is listed within Table 3 (page 26) for contract.

Appendix B lists the 124 Clean Fuels Fund contracts that were open and active as of January 1, 2014.

For Clean Fuels executed and amended contracts, projects and studies in 2013, the average SCAQMD contribution is approximately 32 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 2013, the distribution of funds for SCAQMD executed contracts, purchases and contract amendments with additional funding for the Clean Fuels Program totaling approximately $7.5 million are shown in Figure 10 below.

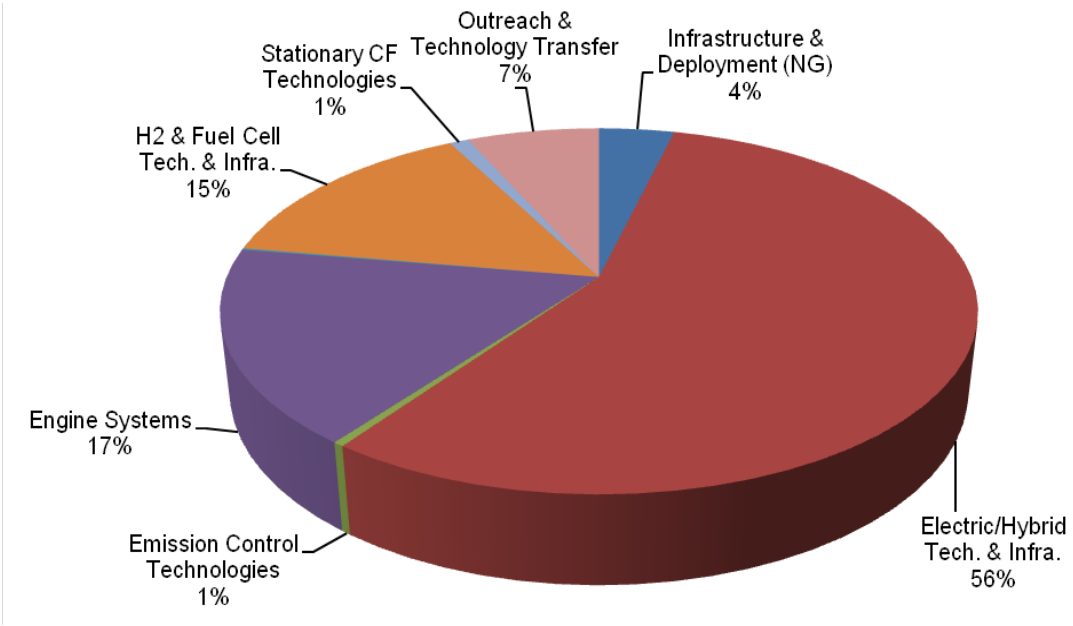


Figure 10: Distribution of Funds for Executed Clean Fuels Projects CY 2013 ($7.5 million)

Table 2 (page 26) provides a breakdown of these $7.5 million awards. Table 3 (page 26) provides information on outside funding recognized and received into the Clean Fuels Fund (approximately $2 million) for contracts executed in CY 2013. Additionally, the SCAQMD continued to seek funding opportunities and Table 4 (page 26) lists the additional $15,810,828 awarded in 2013 for projects that will be implemented as part of the Clean Fuels Program or which align well or are complementary to the Clean Fuels Program. Table 5 (page 27) provides a comprehensive summary and project status of the nearly $111 million in federal and state revenue awarded (including awards made through the American Recovery and Reinvestment Act) to SCAQMD from 2009 and 2012.

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, 2013, 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 by Core Technologies

The 48 new and continuing contracts, projects and studies that received SCAQMD funding in 2013 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, 2013

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Deployment						
12853	Rainbow Disposal Company, Inc.	Upgrade CNG Fueling Station	03/08/13	12/31/18	200,000	400,000
13401	Nite-Hawk Sweepers LLC	Demonstrate Natural Gas-Powered Parking Lot Sweepers	08/28/13	12/31/15	90,000	200,000
Fuels/Emissions Studies						
13451	Energy Solutions	Perform Passenger Vehicle Tire Efficiency Study	06/28/13	12/27/13	10,000	16,000
Emission Control Technologies						
13407	Chaffey Joint Union High School District	Demonstrate Diesel Particulate Filter Technology on Two Diesel School Buses	05/18/13	03/31/14	30,000	45,000
Electric/Hybrid Technologies & Infrastructure						
11615	Parker Hannifin	Develop & Demonstrate Up to Four Heavy-Duty Hydraulic Hybrid Vehicles	01/18/13	12/31/14	250,000	2,000,000
13058	Capstone Turbine Corporation	Develop Microturbine Series Hybrid System for Class 7 Heavy-Duty Vehicle Applications	08/12/13	11/30/14	360,000	1,210,000
13149	University of California, Los Angeles	Develop South Coast PEV Readiness Plan	01/18/13	06/30/14	32,000	63,500
13404	Penske Honda of Ontario	Lease Two Honda Fit Electric Vehicles for Three Years	05/02/13	05/01/16	31,307	31,307
13410	Selman Chevrolet Company	Lease Three 2013 Chevrolet Volt Extended-Range Electric Vehicles for Three Years	04/03/13	04/02/16	41,084	41,084
Various	Various	Install & Upgrade EV Charging Infrastructure (Administer SoCalEV Infrastructure Project)	01/01/13	06/30/15	840,750	840,750
13426	Transportation Power, Inc.	Develop & Demonstrate Catenary Class 8 Trucks (1 Electric & 1 CNG Platform)	06/07/13	06/06/16	2,617,887	3,182,795
13429	Longo Toyota	Lease One Toyota RAV4 Electric Vehicle for Three Years	04/19/13	04/18/16	19,618	19,618
13439	City of Carson	MOU for Catenary Zero Emission Goods Movement Project	10/01/13	09/30/16	0	0
Purchase Order	ATVLS, Inc.	Install Electric Vehicle Chargers	02/13/13	02/13/13	19,985	19,985
Purchase Order	Clean Fuel Connection, Inc.	Install Electric Vehicle Chargers	01/29/13	02/20/13	17,389	17,389
Engine Systems						
13168	National Renewable Energy Laboratory	Develop, Integrate & Demonstrate Heavy-Duty Natural Gas Engines and Vehicles	05/22/13	12/31/15	1,300,000	1,300,000
Mobile Fuel Cell Technologies						
10501	American Honda Motor Company, Inc.	Lease One Clarity Fuel Cell Vehicle for Three Years	01/21/10	09/11/13	5,232	5,232

Table 2: Contracts Executed or Amended (w/$) between January 1 & December 31, 2013

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Mobile Fuel Cell Technologies (cont'd)						
13155	Fletcher Jones Motor Cars Inc. (Mercedes-Benz)	Lease Two F-Cell Fuel Fell Vehicles for Two Years	02/08/13	02/08/15	30,397	30,397
14054	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership for Calendar Year 2013 and Provide Support for Regional Coordinator	01/01/13	12/31/13	137,800	1,676,800
14139	Hyundai America Technical Center Inc.	No-Cost Lease of Fuel Cell Vehicle for Two Years	12/13/13	12/12/15	0	0
Hydrogen Technologies & Infrastructure						
10061	Hydrogenics Corporation	Maintenance & Data Management for the SCAQMD Hydrogen Fueling Station	10/30/09	01/31/15	100,000	100,000
11150	Hydrogen Frontier, Inc.	Maintain & Operate City of Burbank Hydrogen Fueling Station	11/24/10	01/23/16	275,000	275,000
13259	Air Products and Chemicals, Inc.	Hydrogen Station Operation & Maintenance for Five Cities Hydrogen Program	03/26/13	09/25/14	300,000	300,000
13400	Energy Independence Now	Develop Hydrogen Network Investment Plan	04/05/13	01/04/15	50,000	130,000
14067	University of California, Irvine	Develop Hydrogen Storage Capability for the Gas-Blending Faciilty	12/31/13	07/16/15	200,000	688,000
Purchase Order	Gas Technology Institute	Hydrogen Quality Sampling Adaptor Repair	04/02/13	04/02/13	1,125	1,125
Stationary Clean Fuel Technologies						
13078	University of California, Riverside	Steam Hydrogasification Reaction Demonstration to Generate Substitute Natural Gas from Biomass Waste	03/07/13	06/07/14	72,916	922,130
Outreach & Technology Transfer						
12486	ICF Resources LLC	Technical Assistance with Goods Movement and Zero Emission Transportation Technologies	09/24/13	09/23/15	50,000	50,000
13256	Three Squares Inc.	Develop, Initiate & Implement Clean Vehicle Outreach Project	01/05/13	12/31/13	21,500	21,500
13408	University of California, Irvine	Demonstrate Building Integration of Electric Vehicles, Photovoltaics and Stationary Fuel Cells	09/30/13	09/29/15	150,000	270,000
Transfer	Transfer from Clean Fuels	Participation in California Natural Gas Vehicle Partnership for Fiscal Years 2012-13 and 2013-14	03/01/13	03/01/13	25,000	160,000
Direct Pay	Transportation Research Board	Participation for CY 2013 Membership in Transportation Research Board and Support Minority Student Fellows Program	01/01/13	12/31/13	37,500	4,000,000
Direct Pay	Various	Cosponsor 15 Conferences, Workshops & Events, plus 1 Membership	Various	Various	226,164	5,246,164

Table 3: Supplemental Revenue Grants Received into Clean Fuels Fund (31)

Revenue Agreement #	Revenue Source	Project Title	Contractor	SCAQMD Contract #	Award Total $
#A00909413 (#13443)	U.S. EPA	Develop & Demonstrate Catenary Class 8 Trucks-1 Electric & 1 CNG Platform	Transportation Power Inc.	#13426	500,000
#5660020940/ #11722	Southern California Gas Company (augments U.S. DOE funding to NREL)	Develop, Integrate & Demonstrate Heavy-Duty Natural Gas Engines and Vehicles	National Renewable Energy Laboratory	#13168	500,000
#12152	CEC AB 118 Program	Upgrade CNG Fueling Station	Rainbow Disposal Company Inc.	#12853	200,000
#13462	CEC ARV-10-045	Install & Upgrade EV Charging Stations (Administer SoCalV Infrastructure Project)	SoCalEV Regional Collaborative Members	#13418-21, et al	840,750
Table 3 lists revenue recognized by SCAQMD into the Clean Fuels Fund (31) only if the pass-through contract was executed during the reporting CY (2013).					**$2,040,750**

Table 4: Summary of Federal & State Funding Awarded between Jan. 1 & Dec. 31, 2013

Awarding Entity or Program	Award Date	Purpose	Contractors	Award Total $/Fund
U.S. EPA A00909413	05/09/13	Develop & Demonstrate Catenary Class 8 Trucks-1 Electric & 1 CNG Platform (Revenue Agreement #13443 - Executed; Project Officer-J.Impullitti) – Project in progress	Transportation Power Inc.	500,000/ Clean Fuels Fund
CEC	04/05/13	Construct One Mile of Catenary System and Develop & Demonstrate Diesel Catenary Hybrid Electric Class 8 Truck ($1.6M Revenue Agreement #14024 - Executed 08/23/13; $1.4M supplemental revenue agreement pending; Project Officer - J.Impullitti) – Contract under negotiation	Siemens Industry Inc.	3,000,000/ Clean Fuels Fund
CEC AB 118 Program	06/07/13	Refurbish & Upgrade Existing, Publicly Accessible Hydrogen Fueling Stations (Revenue Agreement #13468 - Executed 08/08/13; Project Officer – L.Watkins) – Awards pending	TBD	6,690,828/ Fund 63
Bay Area AQMD (thru U.S. DOE/ Clean Cities Program)	09/06/13	Alternative Fuel Infrastructure Planning (Revenue Agreement #14148 – Executed 01/09/14; Project Officer – P.Kwon) – Contracts pending execution	5 Contractors	320,000/ Fund 17
CEC AB 118 Program	09/06/13	Installation of DC Fast Charging Network (Revenue Agreement #14051 – Executed 11/11/13; Project Officer – P.Kwon) – Contracts pending execution	CFCI and Three Squares	300,000/ Clean Fuels Fund
CEC	10/04/13	Develop, Integrate & Demonstrate Ultra-Low Emission Natural Gas Engines for On-Road Heavy-Duty Vehicles (Revenue Agreement – not yet received; Project Officer – J.Cox) – Contracts pending execution	Cummins Westport Inc. and Cummins Inc.	4,000,000/ Clean Fuels Fund
Southern California Gas Company	10/04/13	Develop, Integrate & Demonstrate Ultra-Low Emission Natural Gas Engines for On-Road Heavy-Duty Vehicles (Revenue Agreement #14146 – Pending execution; Project Officer – J.Cox)	Same as above	1,000,000/ Clean Fuels Fund
Table 4 provides a comprehensive summary of revenue awarded to SCAQMD during the reporting CY (2013) if it will be considered part of, or complementary to, the Clean Fuels Program, regardless of whether the pass-through contract has been executed.				**$15,810,828**

Table 5: Update of Federal & State Funding Awarded between Jan. 1, 2009 & Dec. 31, 2012

Awarding Entity or Program	Award Date	Purpose	Contractors	Award Total $
U.S. EPA/DERA Program DE 96085601	02/03/09	Retrofit 200 Heavy-Duty Trucks with Diesel Particulate Filters (Revenue Agreement #09320 – Executed 02/18/09; Project Officer – A.Oshinuga) – All trucks retrofitted	11 Contractors	1,000,000/ Clean Fuels Fund
City of Los Angeles (POLB/POLA)	03/06/09	Install LNG Fueling Station at the Ports (Revenue Agreement #09349 – Executed 01/19/10; Project Officer – L.Watkins) – Station in operation	California Cartage Co.	532,500/ Clean Fuels Fund
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 Officer – J.Cox) – Project complete	Johnson Matthey, Inc.	900,000/ Clean Fuels Fund
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 Officer – R.George) – Project complete	3 School Districts	898,000/ Fund 33
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 Officer – J.Cox) - Project complete	Johnson Matthey Inc.	4,000,000/ Clean Fuels Fund
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; Project Officer – A.Oshinuga) - Project complete	Various	7,500,000/ Fund 81
DOE 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 Officer – J.Cox) – Project in progress	Electric Power Research Institute	45,443,332/ Fund 50
DOE 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 UPS (Revenue Agreement #10467 - Executed 03/04/10; Project Officer – L.Watkins) – Project in progress	4 Contractors	5,591,611/ Fund 51
DOE Clean Cities Program DE-EE0002547	12/18/09	Implement a natural gas drayage truck replacement program (Revenue Agreement #10480 - Executed 1/26/10; Project Officer – V.White) – 219 trucks replaced	Various	9,408,389/ Fund 81
DOE Clean Cities Petroleum Reduction Technologies	12/31/09	Purchase of CNG Taxicabs and Shuttle Vans (Revenue Agreement #10739 – Executed 11/12/10; Project Officer – P.Barroca) – Partially complete	3 Contractors	500,000/ Clean Fuels Fund
CARB AB 118 AQIP Program	02/05/10	Purchase of cordless electric lawn mowers (Revenue Agreement #10592 – Executed 2/4/10; Project Officer – S.Singeetham) – Project complete	Neuton and Black & Decker	816,000/ Fund 27

Table 5: Update of Federal & State Funding Awarded between Jan. 1, 2009 & Dec. 31, 2012 (cont'd)

Awarding Entity or Program	Award Date	Purpose	Contractors	Award Total $/Fund
DOE Clean Cities Program DE-EE0002545	03/12/10	Ontario LNG Station Upgrade (Revenue Agreement #10685 - Executed 05/07/10; Project Officer – L.Watkins) – Pass-through contract pending	UPS	150,000/ Fund 01
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; Project Officer – A.Oshinuga) – Projects in progress	4 Contractors	3,600,000/ Fund 32 & Clean Fuels Fund ($1.4M)
U.S. EPA DE-83468501	06/23/10	Demonstrate Emerging Technologies Advanced Maritime Emissions Controls (Revenue Agreement #11030 – Executed 07/23/10; Project Officer – R.Carlson) – Project complete	ACTI	1,500,000/ Fund 17
U.S. EPA DE 00T37701	06/30/10	National Clean Diesel Program – School Bus Replacement (Revenue Agreement #11029 - Executed 07/16/10; Project Officer – R.George) – Deliverables complete0	11 School Districts	1,065,465/ Fund 33
Southern California Gas Company	07/09/10	Develop Prototype Natural-Gas-Fired, Fan-Type Central Furnaces with Reduced NOx Emissions (Revenue Agreement #11539 – Executed 12/10/10; Project Officer – A.Baez) – Projects partially complete	4 Contractors	447,737/ Fund 27
CEC 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 Officer – J.Cox) – Project in progress	Electric Power Research Institute	5,000,000/ Fund 50
San Joaquin Valley Air Pollution Control District	10/01/10	Develop Prototype Natural-Gas-Fired, Fan-Type Central Furnaces with Reduced NOx Emissions (Revenue Agreement #11195 – Executed 10/29/10; Project Officer – A.Baez) – Projects partially complete	4 Contractors	50,000/ Fund 27
CEC AB118 Program	09/10/10	Alternative and Renewable Fuel and Vehicle Technology Program – Construct & Install 10 NG Fueling Station (Revenue Agreement #12152 –Executed 11/08/11; Project Officer – L.Watkins) – Partially complete	6-7 Contractors	2,600,000/ Clean Fuels Fund
CEC AB118 Program	09/10/10	Alternative and Renewable Fuel and Vehicle Technology Program – Construct & Install One NG Fueling Station (Revenue Agreement #12286 –Executed 02/22/12; Project Officer – L.Watkins) – Pass-through contract pending	UPS	300,000/ Clean Fuels Fund
CEC ARV-09-002	10/07/10	Implement LNG Drayage Truck Replacement Program (Revenue Agreement #11040 - Executed 10/07/10); Project Officer – V.White) – 132 trucks replaced	Various	5,142,000/ Fund 81

Table 5: Update of Federal & State Funding Awarded between Jan. 1, 2009 & Dec. 31, 2012 (cont'd)

Awarding Entity or Program	Award Date	Purpose	Contractors	Award Total $/Fund
CARB AB 118 AQIP Program G10-AQIP-09	04/05/11	Purchase Cordless Electric Lawnmowers (Revenue Agreement #11595 – Executed 04/05/11; Project Officer – S.Singeetham) – Projects complete	4 Contractors	494,314/ Fund 27
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 Officers – J.Impullitti & P.Kwon) – Projects partially complete	TransPower and IQAir North America	400,000/ Fund 17
Southern California Gas Company	04/22/11	Natural Gas-Powered Vehicle Training and Safety and Fuel Cylinder Inspection Program (Revenue Agreement #11617 – Executed 6/23/11; Project Officer – P.Barroca) – Projects in progress	CSA America Inc. and San Diego Community College on behalf of ATTE	67,100/ Clean Fuels Fund
U.S. EPA Targeted Air Shed Grant EM-83493501	07/14/11	Yard Equipment Exchange Program (Residential and Commercial); and Boiler and Process Heater Efficiency Upgrades to Demonstrate Reductions in Ozone and PM2.5 Air Pollution in LA-San Bernardino Nonattainment Areas (Revenue Agreement #11598 – Executed 3/25/11; Project Officer – S.Singeetham) - Projects partially complete	Various	1,270,000/ Fund 17
CEC ARV-10-045	05/20/11	Install & Upgrade EV Charging Infrastructure Stations (Administer the SoCalEV Infrastructure Project to Install Up to 315 EV Chargers throughout Southern California (Revenue Agreement #12295 – Executed 03/22/12; Project Officer – P.Kwon) – Projects in progress	SoCalEV Regional Collaborative Members	840,750/ Clean Fuels Fund
CARB AB 118 AQIP G10-AQIP-10	08/10/11	Demonstrate Combined DPF and SCR Technologies on Marine Vessels (Revenue Agreement #12022 – Executed 08/10/11; Project Officer – R.Carlson) – Project in progress	Hug Engineering	439,000/ Fund 27
U.S. DOE Clean Cities Program E-EE0005588	09/26/11	Plug-In Electric Vehicle Infrastructure Planning (Revenue Agreement #12167 – Executed 11/12/11; Project Officer – P.Kwon) – Projects complete	7 Contractors	1,000,000/ Fund 60
Southern California Gas Company 5660020940 (augmenting U.S.DOE funding to NREL)	06/24/11	Develop, Integrate & Demonstrate Heavy-Duty Natural Gas Engines and Vehicles (Revenue Agreement #11722 – Executed 06/24/11; Project Officer – A.Oshinuga) – Project in progress	National Renewable Energy Laboratory	500,000/ Clean Fuels Fund
California Department of Transportation 07-6373R	06/15/11	Replace Existing Heavy-Duty Diesel Trucks with New Heavy-Duty Natural Gas Trucks (Revenue Agreement #11458 – Executed 07/12/11; Project Officer – A.Oshinuga)- Projects in progress	Various	1,799,612/ Fund 81

Table 5: Update of Federal & State Funding Awarded between Jan. 1, 2009 & Dec. 31, 2012 (cont'd)

Awarding Entity or Program	Award Date	Purpose	Contractors	Award Total $/Fund
Ports of Los Angeles & Long Beach	10/07/11	In-Use Emissions Testing & Demonstration of Retrofit Technology of On-Road Heavy-Duty Engines (Revenue Agreement #12877 – Executed 07/20/12; Project Officer –	WVU and UCR/CE-CERT	281,006/ Clean Fuels Fund
DOE DE-FC26-08NT06812	Orig: 9/30/08 Current: 07/01/12	Plug-In Hybrid Electric Urban Delivery Truck Technology Demonstration (Revenue Agreement #09160 – Executed 10/22/08; Project Officer – J.Cox) – Project in	Volvo Technology of America, Inc.	984,000/ Fund 61
CEC AB 118 Program	07/25/12	Construct CNG Fueling Station I in Murrietta (Revenue Agreement # 13034- Executed 09/09/12; Project Officer – L.Watkins) – Pass-through contract pending	Southern California Gas Company	217,000/ Clean Fuels Fund
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 (Revenue Agreement #13153 – Executed 10/30/12; Project Officer – B.Choe) – Pass-through contract pending	Electric Vehicle International Inc.	1,045,993/ Fund 17
DOE 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; Project Officer – B.Choe) – Project in progress	5 Contractors	4,169,000/ Fund 61
CARB AB 118 AQIP Program	Orig:7/8/11Current: 12/07/12	Demonstrate the commercial use of cordless zero-emission lawn and garden equipment (Revenue Agreement #12018 – Executed 8/10/11; Project Officer – S.Singeetham) –	Mean Green	51,667/ Fund 27
Table 5 provides a comprehensive summary of revenue awarded to SCAQMD during CYs 2009 through 2012, if it is part of, or complementary to, the Clean Fuels Program, regardless of whether the pass-through contract has been executed and regardless of which special fund the revenue was recognized into.				**$110,876,746**

Project Summaries by Core Technologies

The following represents summaries of the contracts, projects and studies executed or amended with additional dollars in 2013. 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

12853: Upgrade CNG Fueling Station

Contractor: Rainbow Disposal Company, Inc.	SCAQMD Cost-Share	$ 200,000
	Cosponsor:	
	Rainbow Disposal Company, Inc.	200,000
Term: 03/08/13 – 12/31/18	Total Cost	$ 400,000

Rainbow Disposal has operated a public access CNG fueling station in Huntington Beach for many years. As the number of CNG vehicles has grown so has the utilization of the station. The ability to adequately service all of the customers from that area has diminished so that there are now waiting lines of up to 30 minutes. To upgrade Rainbow Disposal's existing CNG station, the SCAQMD applied for infrastructure funding through CEC's AB 118 Program and was awarded $200,000, which was recognized into the Clean Fuels Fund, as noted in the incoming revenue table (Table 3). The upgrade includes the addition of a second, larger compressor and dispenser in order to meet the demand of Rainbow Disposal's growing natural gas fleet.

13401: Demonstrate Natural Gas-Powered Parking Lot Sweeper Vehicles

Contractor: Nite-Hawk Sweepers LLC	SCAQMD Cost-Share	$ 90,000
	Cosponsors:	
	Nite-Hawk Sweepers LLC	42,000
	Go Natural CNG	60,000
	ProSales	3,500
	Haaker Equipment	3,500
	Isuzu	1,000
Term: 08/28/13 – 12/31/15	Total Cost	$ 200,000

Parking lot sweeper vehicles are typically classified as medium-duty vehicles (less than 14,000-lbs gross vehicle weight rating or GVWR), and although many parking lot sweepers provide service to public entities, their weight classification and their vocation (non-street sweeping activities), exempts them from SCAQMD Fleet Rule 1186.1 and Rule 1186 (combined, these two Rules ensure that the cleanest vehicles are being used in the SCAQMD for street sweeping activities). The number of parking lot sweepers operating in this region is estimated between 500 to 700 and can accrue as many as 60,000 miles annually, representing a significant amount of emissions in this region. Parking lot sweeper vehicles range from a converted pick-up truck to

more sophisticated chassis conversions and operate on conventional fuel such as gasoline or diesel. This project is to demonstrate a CNG-powered prototype parking lot sweeper that will be built by Nite-Hawk Sweepers LLC based in Seattle, WA, using an Isuzu NPR-HD chassis, powered by a 6.0L GM spark-ignited engine that will be converted to dedicated CNG using a conversion system developed by Go Natural CNG based in Utah that will operate under a CARB Experimental Permit. Demonstration is expected to commence in May 2014. The vehicle will be demonstrated to both public and private parties over a two-year period. The project is expected to result in CARB certification for converting this vehicle to operate on dedicated natural gas as well as commercial availability of a dedicated natural gas powered parking lot sweeper vehicle.

Fuels/Emission Studies

13451: Perform Passenger Vehicle Tire Efficiency Study

Contractor: Energy Solutions	SCAQMD Cost-Share	$ 10,000
	Cosponsor:	
	Energy Solutions	6,000
Term: 06/28/13 – 12/27/13	Total Cost	$ 16,000

This study was to identify how low rolling resistance passenger vehicle replacement tires could provide a significant opportunity to reduce air pollutants and carbon dioxide while saving consumers fuel and money. Across the United States, passenger vehicle tires are being replaced with tires less efficient than those originally installed by the factory. This is, in part, likely due to passenger vehicle tires not having a standardized labeling system that allows consumers to easily identify lower rolling resistance tires, the higher upfront cost of fuel efficient tires and lack of outreach and education on the longer term payback of using more efficient tires. This study would review the air quality and greenhouse gas benefits of increasing the sales of fuel efficient tires. A 4% increase in overall efficiency of the vehicle was used when fuel efficient tires were evaluated over the average replacement tire. Using this efficiency assumption, and applying it to passenger vehicles in the Basin for model year 2010 and older needing replacement tires, the study projected a reduction of 1,500 tons of ozone precursors (612 VOC, 715 NO_x) and a CO_2 reduction of 1.6 million tons. The study also reviewed the cost benefits to consumers and emissions from implementing an incentive program buy down program for purchasing higher efficiency tires.

Emission Control Technologies

13407: Demonstrate Diesel Particulate Filter Technology on Two Diesel School Buses

Contractor: Chaffey Joint Union High School District	SCAQMD Cost-Share	$ 30,000
	Cosponsor	
	Chaffey Joint Union High School District	15,000
Term: 05/28/13 – 03/31/14	Total Cost:	$ 45,000

Chaffey Joint Union High School District (Chaffey) previously received funding to retrofit diesel school buses with Cleaire Horizon diesel particulate filters (DPFs). Within a year of installation,

the buses equipped with hydraulic electronic unit injector (HEUI) engines began to experience higher rates of engine-related problems than normal including fuel injector failures, oil leaks, turbocharger failures and loss of power. These engine problems were attributed to high back pressure caused by plugged Horizon DPFs. The objective of this project was to evaluate two alternate DPF technologies and determine if one would be better suited to the Chaffey buses and provide better bus operation and less maintenance.

Electric/Hybrid Technologies & Infrastructure

11615: Develop & Demonstrate Up to Four Heavy-Duty Hydraulic Hybrid Vehicles

Contractor: Parker Hannifin	SCAQMD Cost-Share	$ 250,000
	Cosponsors:	
	California Energy Commission	750,000
	Parker Hannifin	354,000
	Coca-Cola Company	515,000
	Freightliner	131,000
Term: 01/18/13 – 12/31/14	Total Cost	$ 2,000,000

Parker Hannifin proposes to partner with Coca-Cola, Daimler Trucks North America, Inc., Freightliner Truck Division, Cummins, Inc. and the FEV Group to design, integrate, rollout and field test up to four hybrid hydraulic beverage delivery tractors used by Coca-Cola Enterprises on urban delivery routes within the South Coast Air Basin. The stop-and-go driving associated with urban delivery routes will allow a hydraulic hybrid-equipped vehicle to capture a significant amount of braking energy that would have otherwise been wasted as heat through the vehicles friction brakes. The Parker Hannifin hydraulic hybrid drive system is designed to recover brake energy and store it for later use using hydraulic accumulators instead of chemical energy storage systems used in hybrid electric systems today. Upon braking, the hydraulic hybrid system allows vehicle inertia to be converted and stored as high pressure energy within hydraulic accumulators. Accumulated energy is then made available for use when the vehicle is next accelerated, to supplement or displace the power that would otherwise be supplied by the diesel engine.

13058: Develop Microturbine Series Hybrid System for Class 7 Heavy-Duty Vehicle Applications

Contractor: Capstone Turbine Corporation	SCAQMD Cost-Share	$ 360,000
	Cosponsors:	
	Capstone, Kenworth & Costco	850,000
Term: 08/23/13 – 11/30/14	Total Cost	$ 1,210,000

Kenworth and Capstone Turbine Corporation (Capstone) are working to advance the development of their microtubine generator (MTG) hybrid on a Class 7 refrigeration truck chassis and demonstrate the potential benefits of the drive system architecture in a real-world application. The proposed vehicle will utilize a series hybrid electric drive system that will afford it up to 10 miles of all-electric driving range. After the vehicle breaches the battery's lower state of charge threshold, an on-board MTG will be utilized to provide extended range driving beyond the initial

10 miles. The vehicle is expected to be deployed within Costco's fleet to evaluate its operational and performance benefits.

13149: Develop South Coast PEV Readiness Plan

Contractor: University of California, Los Angeles	SCAQMD Cost-Share	$ 32,000
	Cosponsor:	
	SCAG	$31,500
Term: 01/18/13 – 06/30/14	Total Cost	$ 63,500

As part of a $1,000,000 grant received by SCAQMD from the DOE Clean Cities program for PEV readiness, $200,000 went towards funding the UCLA Luskin Center to create a South Coast PEV Readiness Plan. The UCLA Luskin Center was engaged by SCAG to develop the South Coast PEV Readiness Plan through a competitive RFP process. The UCLA Luskin Center has significant expertise on PEV readiness issues and has authored several policy documents, including one on the PEV market in Los Angeles and addressing challenges to installing infrastructure in multi-unit dwellings. The Southern California PEV Readiness Plan was the winner of the 2013 Planning Excellence Award by the Los Angeles section of the American Planning Association. This project is to develop additional PEV readiness elements for the South Coast PEV Readiness Plan for the DOE Clean Cities grant, including an analysis of barriers of required and optional PEV readiness elements such as permitting and inspection, training and education, workplace and fleet charging, and multi-unit dwelling charging. It will also provide a much needed analysis of two challenge areas identified by the California PEV Collaborative in multi-unit dwelling and workplace charging, for which two new working groups have been created. Using funds from a U.S. DOE grant, SCAG cosponsored the additional elements, along with the SCAQMD.

13404: Lease Two Honda Fit Electric Vehicles for Three Years

Contractor: Penske Honda of Ontario	SCAQMD Cost-Share	$ 31,307
Term: 05/02/13 – 05/01/16	Total Cost	$ 31,307

The SCAQMD leased two Honda Fit EVs from Penske Honda due to limited supply in stock. Honda plans to lease the Fit EV to approximately 1,100 customers over a two-year period to residents of California, Oregon, New York, New Jersey, Connecticut, Massachusetts, Maryland and Rhode Island. The AC induction motor provides 123 hp with a top speed of 90 mph, and there are three drive modes - normal, econ and sport. The U.S. EPA estimated range is 82 miles using a 20 kWh, air-cooled Li-Ion battery pack. The Fit EV is 700 pounds heavier than the gasoline version, and cargo capacity is reduced slightly from 57 to 50 cubic feet in a 5-passenger hatchback.

13410: Lease Three 2013 Chevrolet Volt Extended-Range Electric Vehicles for Three Years

Contractor: Selman Chevrolet Company	SCAQMD Cost-Share	$ 41,084
Term: 04/03/13 – 04/02/16	Total Cost	$ 41,084

The SCAQMD is leasing three additional 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. Previously, SCAQMD leased two 2013 Chevy Volts for $31,373, making the Chevy Volt one of the most cost-effective PEVs.

Various: Install & Upgrade EV Charging Infrastructure (Administer SoCalEV Infrastructure Project)

Contractor: Various	SCAQMD Cost-Share	$ 840,750
Term: 01/01/13 – 06/30/15	Total Cost	$ 840,750

State, federal and local funds are currently being invested to support battery EV, plug-in hybrid EV and charging infrastructure. And while Southern California has an established network of public charging for EVs, the infrastructure is mostly obsolete. Consequently, in 2010, on behalf of the Southern California Electric Vehicle (SoCalEV) Regional Collaborative, the LADWP applied for and was awarded $840,750 by the CEC to install public EV infrastructure at key Southern California locations. LADWP, however, asked the SCAQMD to administer the project. The funds were recognized into the Clean Fuels Fund, as noted in the incoming revenue table (Table 3), and in 2013 the SCAQMD executed the first half dozen of up to 30 agreements with members of the SoCalEV Regional Collaborative to install as well as upgrade existing public EV charging infrastructure at key Southern California locations. Data will also be collected on charger utilization, charging use patterns, operating costs, electricity used and real world electric range of EVs.

13426: Develop & Demonstrate Catenary Class 8 Trucks (1 Electric & 1 CNG Platform)

Contractor: Transportation Power, Inc.	SCAQMD Cost-Share	$ 2,617,887
	Cosponsor:	
	Transportation Power, Inc. (in-kind)	564,908
Term: 06/07/13 – 06/06/16	Total Cost	$ 3,182,795

Transportation Power, Inc. (TransPower) has contracted to deliver two trucks equipped with overhead catenary accessibility. The first truck is an existing vehicle that utilizes a battery electric drive system and will be converted to operate on the catenary system. The second truck will be designed and developed as a purpose built CNG-hybrid electric truck to incorporate TransPower's electric drive system on a major OEM chassis. TransPower will integrate pantographs and associated components into both vehicles. TransPower will perform design, development and testing of new components that enable trucks using their electric drive architecture to acquire and convert power from overhead catenary lines (similar to those used by

metro rail lines). The U.S. EPA also supported this project in the amount of $500,000, with their pass-through funds recognized into the Clean Fuels Fund, as noted in the incoming revenue table (Table 3). The contract with TransPower is part of a larger project being undertaken by the SCAQMD, which will include development and demonstration of additional vehicles and construction of one mile of a catenary system along Alameida to develop and demonstrate a catenary zero emissions goods movement system.

13429: Lease One Toyota RAV4 Electric Vehicle for Three Years

Contractor: Longo Toyota	SCAQMD Cost-Share	$ 19,618
Term: 04/19/13 – 04/18/16	Total Cost	$ 19,618

The SCAQMD leased one Toyota Rav4 EV from Longo Toyota which provided the lowest of three bidders. Toyota plans to produce 2,500 Rav4 EVs for model years 2012, 2013 and 2014, using 41.8 kWh LiIon battery packs with 10 kW onboard chargers provided by Tesla Motors, integrated in Fremont, California. The AC induction motor provides 154 hp at 2,800 rpm. The U.S. EPA estimated range is 103 miles for this EV. There is also an extended charge mode that provides about a 120 mile range and a sport mode that increases torque from 218 lb.-ft to 273 lb.-ft. The Rav4 EV is 470 pounds heavier than the gasoline version but no interior space is lost. It seats 5 adults or provides 73 cubic feet of cargo volume behind the front seat with fold flat rear seats.

13439: MOU for Catenary Zero Emission Goods Movement Project

Contractor: City of Carson	SCAQMD Cost-Share	$ 0
Term: 10/01/13 – 09/30/16	Total Cost	$ 0

Development and demonstration of zero emissions technologies for goods movement is one of SCAQMD's top priorities. In April 2013 the Board approved a project to develop and demonstrate a catenary zero emissions goods movement system. The project includes construction of one mile of catenary system and development and demonstration of diesel and CNG catenary hybrid electric class 8 trucks and integration of a catenary pantograph system on an existing battery electric class 8 truck. The one mile of catenary system will be constructed along Alameda Street from E. Lomita Blvd to the Dominguez channel in Carson, in coordination with the Ports of Los Angeles and Long Beach. This no-cost MOU between the City of Carson and SCAQMD facilitates the City of Carson's participation and assistance with permitting and the CEQA process.

Purchase Order: Install Electric Vehicle Chargers

Contractor: ATVLS, Inc.	SCAQMD Cost-Share	$ 19,985
Term: 02/13/13 – 02/13/13	Total Cost	$ 19,985

This project provided funds for the demonstration of Level 2 electric vehicle charging infrastructure from several manufacturers including Coulomb Technologies, ECOtality and Clipper Creek. Two chargers were installed at the Coachella Valley Association of Governments' facility in Palm Desert as part of SCAQMD's Fleet Demonstration Program.

Purchase Order: Install Electric Vehicle Chargers

Contractor: Clean Fuel Connection,	SCAQMD Cost-Share	$ 17,389

Inc.		
Term: 01/29/13 – 02/20/13	Total Cost	$ 17,389

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 at two SCAQMD Board Member residences as part of SCAQMD's Fleet Demonstration Program.

Engine Systems

13168: Develop, Integrate & Demonstrate Heavy-Duty Natural Gas Engines

Contractor: National Renewable Energy Laboratory	SCAQMD Cost-Share	$ 1,300,000
Term: 05/22/13 – 12/31/15	Total Cost	$ 1,300,000

The SCAQMD Board adopted a series of clean fuel fleet rules to reduce mobile source emissions within the SCAQMD's regulatory jurisdiction. The fleet rules require certain public entities and special districts, such as air, water, sanitation and school districts, with fifteen or more heavy-duty vehicles to acquire CARB-certified alternative-fueled heavy-duty vehicles when adding new vehicles or forming a new fleet. These rules have helped to advance natural gas engine technology and to expand the natural gas engine market into a wider range of heavy-duty vehicle applications. Specifically, on-road natural gas engines are now being used on a limited basis as an alternative to diesel engines in transit, refuse and goods movement applications. While the number of natural gas engines has grown, there is still a need to develop natural gas engines in the 11- to 14-liter range to fill the wide array of fleet applications currently served solely by diesel engines. As such, the SCAQMD has been working with NREL, the CEC and Southern California Gas Company (SoCalGas) to accelerate the development, integration and demonstration of natural gas engines ranging in sizes from 11 to 14 liters suitable for transit, refuse and goods movement applications. In 2011, the Board awarded a contract to U.S. DOE's NREL for $3,055,000 to develop, integrate and demonstrate three different heavy-duty natural gas engines. The three engines will be used in refuse, transit and Class 8 heavy-duty truck applications and comply with the U.S. EPA 2010 heavy-duty emissions standards of 0.01 g/bhp-hr PM and 0.2 g/bhp-hr NO_x. The first project is with Cummins Westport to develop and optimize a spark-ignited 11.9-liter CNG engine suitable for refuse and Class 8 application, and has been fully executed under a Cooperative Research and Development Agreement (CRADA) between SCAQMD and NREL. SoCalGas supported this first project with Cummins Westport in the amount of $500,000, with their pass-through funds recognized into the Clean Fuels Fund, as noted in the incoming revenue table (Table 3). The CRADA will be modified again at a later date to include the remaining two projects.

Mobile Fuel Cell Technologies

10501: Lease One Clarity Fuel Cell Vehicle for Three Years

Contractor: American Honda Motor Company, Inc.	SCAQMD Cost-Share	$ 5,232
Term: 01/21/10 – 09/11/13	Total Cost	$ 5,232

The Executive Officer approved a short-term extension of the lease contract with Honda for the 2009 Honda Clarity FCX. The Clarity has been in the SCAQMD demonstration fleet and is primarily used at outreach events and public meetings to demonstrate state-of-the-art hydrogen fuel cell vehicles.

13155: Lease Two F-Cell Fuel Cell Vehicles for Two Years

Contractor: Fletcher Jones Motor Cars Inc. (Mercedes-Benz)	SCAQMD Cost-Share	$ 30,397
Term: 02/08/13 – 02/08/15	Total Cost	$ 30,397

The SCAQMD leased two Mercedes F-Cell fuel cell vehicles from Fletcher Jones MotorCars which is conveniently located near the UC Irvine hydrogen fueling station. SCAQMD previously demonstrated Mercedes A-class (smaller) F-Cell vehicles from 2005 to 2009. Mercedes plans to demonstrate about 200 F-Cells as part of this pilot program in the US and Europe. This new B-Class F-Cell provides 136 hp and a top speed of 106 mph. Range is improved to about 200 miles compared to the previous A-Class version when refueling at a higher pressure of 700 bar. The vehicle will be placed into our alternative fuel vehicle fleet to demonstrate new clean fuel vehicles to public and private organizations to promote zero- and low-emission technologies.

14054: Participate in California Fuel Cell Partnership for Calendar Year 2013 and Provide Support for Regional Coordinator

Contractor: Bevilacqua-Knight, Inc.	SCAQMD Cost-Share	$ 137,800
	Cosponsors:	
	8 automakers; 6 government agencies; 1 fuel cell provider; and 19 associate members	1,539,000
Term: 01/01//13 – 12/31/13	Total Cost	$ 1,676,800

The SCAQMD has been a member of the California Fuel Cell Partnership (CaFCP) since 2000. The CaFCP and its members are demonstrating fuel cell passenger cars and transit buses with associated hydrogen fueling infrastructure in California. Since the CaFCP is a voluntary collaboration, each participant contracts with Bevilacqua-Knight, Inc. (BKI) for their portion of CaFCP administration. For Calendar Year 2013 the SCAQMD contributed $87,800 for its membership participation and up to $50,000, along with office space at SCAQMD Headquarters, to provide support for the CaFCP Regional Coordinator.

13059: No-Cost Lease of Fuel Cell Vehicle for Two-Years

Contractor: Hyundai America Technical Center Inc.	SCAQMD Cost-Share	$ 0
Term: 12/13/13 – 12/12/15	Total Cost	$ 0

SCAQMD has been working with Hyundai America Technical Center Inc. to become a partner in their fuel cell vehicle demonstration program. In 2013 Hyundai approached the SCAQMD and requested its participation in the on-road testing of their new fuel cell electric vehicle. The on-road testing program is being funded by a grant from the U.S. DOE. Hyundai provides fuel cell

vehicles in-kind as their cost-share to secure U.S. DOE funding. This no-cost lease with Hyundai will allow the SCAQMD to participate in the development of this technology and demonstrate its effectiveness. The vehicle will be placed into our alternative fuel vehicle fleet to demonstrate new clean fuel vehicles to public and private organizations to promote low-emission technologies.

Hydrogen Technologies & Infrastructure

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

Contractor: Hydrogenics Corporation	SCAQMD Cost-Share	$ 100,000
Term: 10/30/09 – 01/31/15	Total Cost	$ 100,000

The SCAQMD, in partnership with Hydrogenics Corporation, 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 with Hydrogenics Corporation was required. 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.

11150: Maintain & Operate City of Burbank Hydrogen Fueling Station

Contractor: Hydrogen Frontier, Inc.	SCAQMD Cost-Share	$ 275,000
Term: 11/24/10 – 01/23/16	Total Cost	$ 275,000

The City of Burbank hydrogen fueling station was one of the original stations under the Five Cities Hydrogen Program. Pursuant to a DOE Program, the original electrolyzer station was removed and a new steam methane reformer (SMR) based station was installed. When the DOE project was completed, the SCAQMD in partnership with the CARB and NREL funded the ongoing operation of the station. The station has now become an important connector station for all FCVs in Southern California and is now fueling up to 60 kg per day. This amendment provides funding to continue operation and maintenance as well as pay for increased costs associated with utility services (electricity and natural gas) for this station. This contract extends beyond the original scope of the project and will ensure that the station is maintained and will meet the increased demand for hydrogen fuel.

13259: Hydrogen Station Operation & Maintenance for Five Cities Hydrogen Program

Contractor: Air Products and Chemicals, Inc.	SCAQMD Cost-Share	$ 300,000
Term: 03/26/13 – 09/25/14	Total Cost	$ 300,000

Air Products and Chemicals, Inc. (APCI) designed and constructed five hydrogen fueling stations under the Five Cities Hydrogen Program, which included three electrolyzers and two mobile fuelers. APCI has provided operation, repair and general maintenance services for the stations since the program began. This contract is to continue ongoing maintenance and operation including equipment repair or replacement for another two years for electrolyzer stations located in the cities of Santa Monica and Riverside plus a mobile fueler in the City of Santa Ana. The Ontario Station was dismantled and shut down and operation and maintenance of the City of Burbank station was taken over by Hydrogen Frontier, Inc.

13400: Develop Hydrogen Network Investment Plan

Contractor: Energy Independence Now	SCAQMD Cost-Share	$ 50,000
	Cosponsors:	
	Energy Independence Now	15,000
	California Fuel Cell Partnership	25,000
	Daimler	15,000
	Toyota	25,000
Term: 04/05/13 – 01/04/15	Total Cost	$ 130,000

California does not have a clear plan to open and maintain the early commercial hydrogen fueling infrastructure needed to launch the fuel cell electric vehicle (FCEV) market. The CaFCP Roadmap clearly establishes the need for 68 hydrogen stations by the beginning of 2016 to reach California's early market potential for FCEVs. It does not, however, define how to get there. Initially, the success of the Roadmap completely depended upon the CEC's oversubscribed AB 118 Program, which even using optimistic assumptions, would provide for only about half of these stations by 2016. While Assembly Bill 8, which was chaptered in September 2013, dedicates additional funding to build up to 100 hydrogen stations, the Roadmap target can only be achieved with a clear plan on how the additional stations will be financed, including evaluating the evolving market dynamics and potential incentive options. To develop and outline a methodology on how to move forward, Energy Independence Now, in conjunction with the CaFCP and its partners, will develop a Hydrogen Network Investment Plan (HNIP) that will include a pathway for Market Assurance Grant (MAG) implementation, operating guidelines and the next steps for implementation of a proposed funding mechanism to administer these grants, ultimately leading to complement CEC grants.

14067: Develop Hydrogen Storage Capability for the Gas-Blending Facility

Contractor: University of California, Irvine	SCAQMD Cost-Share	$ 200,000
	Cosponsors:	
	U.S. Department of Energy	134,000
	California Energy Commission	241,000
	NFCRC	53,000
	Air Products & Chemicals, Inc.	60,000
Term: 12/31/13 – 07/16/15	Total Cost	$ 688,000

Hydrogen fuel cell vehicles have zero emissions, and hydrogen blended with other fuels, such as natural gas, has shown the potential to reduce emissions in mobile and stationary combustion sources. Hydrogen and natural gas blends may provide a near-term opportunity to displace petroleum-based fuels while reducing emissions. Testing of distributed generation devices, including microturbines and fuel cells, on different blends of hydrogen is a focus of the U.S. DOE and CEC. This project will develop hydrogen storage capability for a gas blending facility at UCI's Advanced Power and Energy Program. It will enable the study of hydrogen and hydrogen/natural gas blends for distributed generation applications. The capacity will be 100,000 cu.ft. of compressed hydrogen stored at 2,200 psi. This capacity will allow the continuous operation of 30 kW of distributed generation devices given a normal hydrogen delivery schedule and intermittent operation of a 250 kW distributed generation on an aggressive delivery schedule.

Purchase Order: Hydrogen Quality Sampling Adaptor Repair

Contractor: Gas Technology Institute	SCAQMD Cost-Share	$ 1,125
Term: 04/02/13 – 04/02/13	Total Cost	$ 1,125

The SCAQMD performs hydrogen quality sampling at demonstration hydrogen stations demonstrated in its jurisdiction including the one maintained at SCAQMD Headquarters. The apparatus used to perform the sampling began leaking, creating a safety hazard and contamination concern. A purchase order was issued for, and payment made to, GTI to repair the sampling apparatus.

Stationary Clean Fuel Technologies

13078: Steam Hydrogasification Reaction Demonstration to Generate Substitute Natural Gas from Biomass Waste

Contractor: University of California, Riverside	SCAQMD Cost-Share	$ 72,916
	Cosponsors:	
	California Energy Commission	649,214
	Synergy, Inc. (in-kind)	200,000
Term: 03/07/13 – 06/07/14	Total Cost	$ 922,130

Utilization of renewable energy sources, including biomass waste, has the potential to make a significant contribution in providing sustainable power and transportation fuel for the future. Steam Hydrogasification Reaction (SHR) is a thermo-chemical process, developed by the University of California, Riverside, to convert carbonaceous matter in biomass waste into methane in a hydrogen rich environment. The SHR process is capable of generating product gas with 90% or higher methane content in a cost effective and efficient manner. It is also capable of handling wet feedstocks without drying, providing an attractive and viable solution to utilize wet sludge and green waste in lieu of landfill disposal. The objectives of this project are to demonstrate the SHR technology in a Process Demonstration Unit using biosolids comingled with food waste and green waste to produce Substitute Natural Gas and to provide preliminary modeling evaluation and design for a five ton-per-day pilot plant for the next phase.

Outreach and Technology Transfer

12486: Technical Assistance with Goods Movement and Zero-Emission Transportation Technologies

Contractor: ICF Resources LLC	SCAQMD Cost-Share	$ 50,000
Term: 09/24/13 – 09/23/15	Total Cost	$ 50,000

The Clean Fuels Program supports projects to research, develop, demonstrate, and deploy technologies to accelerate commercialization of clean, new technologies. Due to constant and rapid changes in technologies and the sheer breadth of the potential projects, staff occasionally requires input from experts and practitioners in the field to aid in selecting and establishing projects for funding through the Clean Fuels Program as well as the many incentive programs the SCAQMD administers. ICF International is a leading technology firm with over 40 years of experience and will provide technical assistance with goods movement technologies, alternative fuels, and zero-emission transportation technologies under this contract. ICF has worked as a prime contractor for local, state and federal agencies and has extensive expertise in the areas of fuels and transportation related issues.

13256: Program and Technical Assistance for Clean Vehicle Outreach and Senior Clean Air Fair

Contractor: Three Squares, Inc.	SCAQMD Cost-Share	$ 21,500
Term: 01/05/13 – 12/31/13	Total Cost:	$ 21,500

Three Square's Inc. (TSI) developed a customized content management system (CMS) for the Clean Air Choices vehicle comparison calculator. The CMS allows SCAQMD staff to update the vehicles by model year, emission factors and vehicle costs. Only the lowest emission vehicles are included in the database. TSI also prepared custom outreach materials to promote the vehicle calculator and staffed three outreach events where the program was highlighted.

13408: Demonstrate Building Integration of Electric Vehicles, Photovoltaics and Stationary Fuel Cells

Contractor: University of California, Irvine	SCAQMD Cost-Share	$ 150,000
	Cosponsor:	
	University of California, Irvine	120,000
Term: 09/30/13 – 09/29/15	Total Cost	$ 270,000

U.C. Irvine's Advanced Power and Energy Program will demonstrate building integration of plug-in electric vehicles, photovoltaics and stationary fuel cells with the electrical grid. The CEC through its AB 118 Program recently awarded U.C. Irvine $120,000 for installation of new Level 2 chargers at multiple locations on campus, and the SCAQMD was asked to partner on this project. Information from these new chargers can be included in this modeling effort, with two to three chargers to be installed near the Multipurpose Science and Technology Building integrated into the building controls. U.C. Irvine will integrate existing computer models for solar photovoltaic, high-temperature fuel cells, electric grid operation and PEV operations, with operational data collected from their existing 95 kW photovoltaic solar system, new and existing

on-campus EVSE and a recently co-funded molten carbonate fuel cell to explore the integration of PEV charging and distributed energy generation.

Transfer: Participate in California Natural Gas Vehicle Partnership

Contractor: Transfer from Clean Fuels	SCAQMD Cost-Share	$ 25,000
	Cosponsors:	
	CNGVP Participating Members	135,000
Term: 03/01/13 – 03/01/13	Total Cost	$ 160,000

The California Natural Gas Vehicle Partnership (CNGVP) was formed to accelerate the development of advanced natural gas vehicle technologies to provide a benchmark for lowering emissions from petroleum-based engines and to provide a pathway to future fuel cell use in the next two decades. The SCAQMD spearheaded the formation of this strategic alliance, which comprises state and federal air quality, transportation and energy agencies, vehicle and engine manufacturers, fuel providers, and transit and refuse hauler organizations. Partnership Steering Committee members contribute monies to fund specific projects intended to achieve the goal of the Partnership. In March 2013 the SCAQMD approved $25,000 for the SCAQMD's participation in the Steering Committee for the next two years.

Direct Pay: Participation for CY 2013 Membership in Transportation Research Board and Support of Minority Student Fellows Program

Contractor: Transportation Research Board	SCAQMD Cost-Share	$ 37,500
	Cosponsors:	
	SCAQMD's Legislative & Public Affairs Office	32,500
	Participating Members	3,930,000
Term: 01/01/13 – 12/31/13	Total Cost	$ 4,000,000

In 2013 the SCAQMD supported the Transportation Research Board (TRB) by participating as a member and sponsoring TRB's 2013 Minority Student Fellowship Program. The mission of the TRB is to promote innovation and progress in transportation through research. In an objective and interdisciplinary setting, TRB facilitates the sharing of information on transportation practice and policy by researchers and practitioners; stimulates research and offers research management services that promote technical excellence; provides expert advice on transportation policy and programs; and disseminates research results broadly and encourages their implementation. TRB's varied activities annually engage more than 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest by participating on TRB committees, panels and task forces. TRB is one of six major divisions of the National Research Council (NRC) - a private, nonprofit institution that is jointly administered by the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine - and is the principal operating agency of the National Academies in providing services to the government, the public and the scientific and engineering communities. The TRB Executive Committee, whose members are appointed by the chairman of NRC, exercises oversight responsibility for the Board's

programs and activities. Members include senior transportation industry executives, top officials of public-sector transportation agencies, and distinguished researchers from academia. Sponsors and affiliates provide support for TRB core programs and activities. Sponsors are the major source of financial support for TRB's core technical activities. Federal, state, and local government agencies and professional societies and organizations that represent industry groups are eligible to be TRB sponsors. TRB's annual expenditures for program activities exceed $90 million.

Direct Pay: Cosponsor 15 Conferences, Workshops & Events plus 1 Membership

Contractor: Various	SCAQMD Cost-Share	$ 226,164
	Cosponsors:	
	Various	5,020,000
Term: 01/01/13 – 12/31/13	Total Cost	$ 5,246,164

The SCAQMD regularly participates in and hosts or cosponsors conferences, workshops and events. These funds provide support for the 15 conferences, workshops and events sponsored throughout 2013 as follows: The Women in Green Forum (Southern California & Washington DC); 2013 Asilomar Conference on Transportation & Energy Policy; Electric Drive Transportation Association Campaign and 2013 Conference; February 2013 Clean Fuel Advisory Group Participation Fees; 2013 Mobile Source Air Toxics Workshop; 2013 Real World Vehicle Emissions Workshop; PEMS Conference; 2013 ICEPAG; Act Expo 2013 Washington DC; 6th Symposium on Global Emerging Environmental Challenges and Government; Plug-In 2013; 2013 SoCal Energy Summit; 2013 Life Cycle Analysis of Transportation Fuels Workshop; 2013 Santa Monica AltCar Expo & Conference; and 2013 LA Auto Show Sponsorship. Membership for 2013 to support the Electric Drive Transportation Association is also included.

PROGRESS AND RESULTS IN 2013

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 6 (page 51) provides a list of 37 projects and contracts completed in 2013. 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.

In-Use Emissions Testing & Demonstration of Retrofit Technology for On-Road Heavy-Duty Engines

On-road heavy-duty engines are now subject to the 2010 U.S. EPA emissions standards of 0.01 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. While recent limited-scale studies have shown reduced NO_x and PM emissions from trucks powered by 2010 compliant engines, other studies indicate a potential increase in some exhaust emissions. 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 and October 2011, the Board awarded contracts to WVU and CE-CERT to conduct in-use emissions testing of 24 MY 2007-2012 heavy-duty vehicles from different vocations and fueling technologies and, if needed, to evaluate emission reduction potential of retrofit technologies for ammonia emission from a heavy-duty natural gas engine. The study also involve the in-use characterization of NO_x and GHG emissions from a MY 2011 heavy-duty MACK diesel vehicle equipped with DPF and SCR during a long-haul operation across the country. The Mack truck was used to transport WVU transportable emissions measurement system across the country while continuously measuring emission through a 40 CFR Part 1065 compliant CVS system for over a 2,500-mile route between Morgantown, WV, and Riverside, CA.

Figure 11: Portable In-Use Emissions Mobile Unit

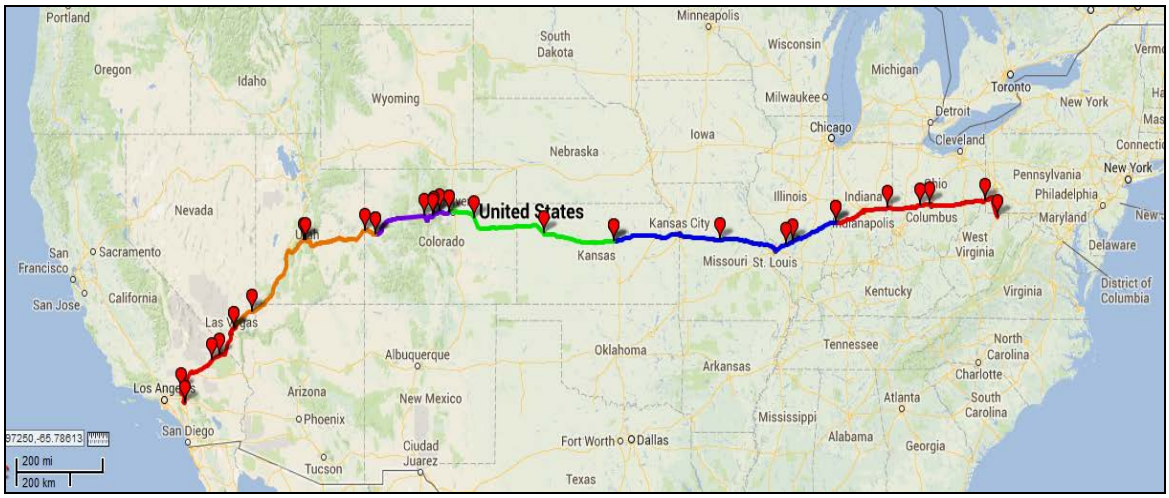


Figure 12: 2,500-Mile Route of In-Use Emissions Study

The test vehicle vocation included goods movement, refuse truck, transit bus and school bus applications. The test matrix involved five natural gas and four dual-fuel (natural gas and diesel) vehicles to be chassis dynamometer tested by WVU, eight diesel and two propane vehicles to be tested by CE-CERT and five diesel vehicles to be tested by both WVU and CE-CERT for inter laboratory comparison. The engine technologies and vocations of vehicles tested by WVU and CE-CERT are shown below.

Figure 13: Vehicle test matrix of engine technologies and vehicle vocations

Engine/Technology		Vehicle Vocation/Number of Vehicle			
		Transit	**School Bus**	**Refuse**	**Goods Movement**
I.	Natural gas engine with three-way catalyst	1[1]	-	1[1]	3[1]
II.	High pressure diesel injection (HPDI) engine with EGR and DPF at 0.8g NOx		-	-	3[1]
III.	HPDI engine with EGR, DPF, and SCR at 0.2g NOx				1[1]
IV.	Diesel engine certified at 1.2g NOx		-	1[2]	1[3]+2[2]
V.	Propane and diesel school bus	-	2[2]	-	-
VI.	Propane engine certified at or below 0.2g NOx			1[2]	
VII.	Diesel Engine certified above 0.2g NOx w/o SCR		-	1[3]+	1[3]+1[2]
VIII.	Diesel Engine certified at or below 0.2g NOx w/SCR		-	1[3]+1[2]	1[3]+2[2]

[1] WVU test vehicles; [2] CE-CERT test vehicles; [3] Round-robin test vehicles

The in-use emissions results showed that the three-way catalyst equipped stoichiometric natural gas vehicles emitted significantly lower distance-specific NO_x emissions than comparable SCR equipped diesel vehicles over all applications. The stoichiometric fuel-air-ratio strategy contributed to a sustained NO_x reduction activity by the three-way catalyst, unlike the SCR technology that is affected by vehicle operation that results in exhaust temperature lower than 250 degrees Celsius. For example, stoichiometric natural gas vehicles emitted 91% lower distance-specific NO_x emissions than a SCR equipped diesel vehicles over a near-dock driving cycle characterized by extended idle and creep operation. The SCR catalyst activity profile suggested

the after-treatment system to be active less than 40% of the time during all types of drayage operations. The dual-fuel natural gas vehicle exhibited a SCR catalyst activity profile similar to that of the diesel technology vehicles. However, the lower in-cylinder NO_x formation due to dual-fuel combustion resulted in an overall reduction in NO_x emissions compared to SCR equipped diesel vehicles. Similarly, the natural gas refuse vehicle emitted 20% lower NO_x emissions than a comparable SCR equipped diesel refuse vehicle. The PM emissions from both natural gas engines and diesel engines equipped with DPF were close to the detection limits of the gravimetric method.

The activity of the three-way catalyst contributes to the formation of ammonia, and as a result, the stoichiometric natural gas vehicles were characterized by ammonia emissions close to 1 g/mi over all driving cycles. N_2O emissions were observed only during the warm-up period of the three-way catalyst. No significant ammonia emissions were detected from SCR equipped diesel vehicles.

In conclusion, emissions comparison between stoichiometric natural gas vehicles and SCR equipped diesel vehicles show the three-way catalyst after-treatment system to be superior in NO_x reduction compared to SCR system. Since, the TWC is dependent on the control of air-fuel ratio close to stoichiometric rather than exhaust temperature characteristics, the activity of the TWC is extended even to idle and creep mode operation. Therefore, natural gas engines can be viewed as better alternatives to modern diesel technology in certain applications such as refuse trucks and port drayage trucks that are characterized by extended idle and creep. The fuel range limitation of stoichiometric natural gas vehicle may limit its operation to smaller geographical coverage. However, the dual-fuel HPDI vehicles with the lean-burn technology provided the same range advantage of a diesel vehicle with a relatively lower NO_x emissions profile.

The cross-country study showed that the NO_x conversion efficiency of the SCR after-treatment system to be on an average 83-88% during the course of the test campaign. Sustained temperatures of greater than 250 Deg C contributed to high SCR activity at highway driving conditions. One of the shortcomings of the cross-country study was the lack of high traffic densities in major sections of the route. Therefore the effect of extended idling and stop-and-go traffic on SCR activity was seldom noticed. A one hour duration of a “high NO_x” event observed in the state of Kansas contributed to close 92% of the total NO_x emitted during a 5 hour duration micro trip. The “high NO_x” event can be attributed to SCR regeneration strategies adopted by OEM to burn adsorbed hydrocarbons and or prevent urea crystallization.

Demonstrate Quick Charge Infrastructure for Electric Buses

Transit buses are ideal applications for advanced, alternative energy technologies that address criteria pollutant and green house gas emissions because they operate in highly visible, congested areas where air quality is a problem. Electric zero emission transit buses address these problems. Traditionally, the range and charging needs of batteries have been barriers to employ battery-powered buses in large-scale applications. Additionally, the weight of traditional buses has made it difficult to feasibly incorporate a battery with sufficient power and energy storage capacity into coach designs. By using a smaller battery that can be charged quickly and repeatedly, the bus weight and cost can be reduced. The keys to quick charge electric bus technology are the utilization of a quick-charge battery and quick-charge infrastructure. The battery must be able to retain its energy reserve and charging profile over many charge-discharge cycles and be quick-charged in ten minutes or less. The quick charge infrastructure must be able to deliver a large amount of energy in a short period of time, and operate safely without human intervention because of the high voltage and associated heavy cables.

Foothill Transit replaced three diesel buses with Ecoliner electric buses with quick-charge capability and quick-charge infrastructure on an existing route from the City of La Verne to the City of Pomona. The 35- foot Ecoliner bus carries 37 passengers and is powered by a 75 kW hr battery. Funding from SCAQMD supported the charging technology, charging station and supplemental charging components associated with the Ecoliner buses. The charging system connects to the bus from overhead. The charging station includes the architectural and engineering design, the installation and construction of the charging station for the three buses. The benefits of this proprietary technology are a safe automated charging system that will perform without human intervention.

Figure 14: Foothill Transit's Electric Bus Charging in Pomona

All three Ecoliner buses are running in daily revenue service on line 291 from La Verne to Pomona. The three buses have accumulated nearly 175,000 in-service miles and Proterra data collection indicates overall energy efficiency is as good as or better than initially expected. Foothill Transit became the first transit agency in the U.S. to use on-route charge electric buses, and they plan to purchase an additional 12 buses from Proterra to completely electrify the 291 route between La Verne and Pomona and use 3 of the 12 in other routes within their territory.

Demonstrate Advanced Fuel Cell Bus

Fuel cell buses have been successfully demonstrated in recent years in California, across the United States and Canada. The SCAQMD has long sponsored the development and deployment of fuel cell bus technologies because these heavy-duty vehicles have zero-tailpipe emissions, help establish hydrogen refueling infrastructure, and operate in congested urban areas providing the greatest outreach potential through ridership. The next step in the development of this clean air technology is commercialization. The intent of American Fuel Cell Bus (AFCB) project was the development of a newly designed fuel cell bus with a North American chassis, as well as domestically sourced fuel cell and drive components.

The AFBC achieved an 83% average availability starting from the clean point established at the beginning of March, 2012 through the end of December, 2012. Following the clean point, bus availability in six out of the ten months was above the target of 85%. During the demonstration phase the American Fuel Cell Bus experienced occasional anomalies which included several component failures. In each case the issues were promptly addressed by the IPT. In general the issues that were encountered were fairly “low-tech” in nature.

Figure 15: American Fuel Cell Bus In Service SunLine Transit

The project brought together a newly formed team of world class companies to apply their products and expertise to develop a first of its kind 40’ heavy duty, zero emissions, fuel cell bus. The American Fuel Cell bus project favorably addressed many of the challenges currently facing the introduction of fuel cell technology

and met the goals for the project that were established at the onset. The project advanced the pathway to commercialization and addressed challenges of cost competitiveness, reliability, durability, integration and manufacturing. With SunLine Transit at both the project leadership and the operational ends of the project, the team forged a blueprint on how to deliver and operate reliable, American built, zero emission technology in the transit world. The project independently verified the frequent claim that Hydrogen powered, fuel cell technology is indeed "proving out". The relatively "low tech" nature of the issues encountered during demonstration period suggest that the major technological hurdles of fuel cell powered transit have been substantially addressed. Additionally key enabling technologies including fully electrified accessories and reliable fueling infrastructure have also been advanced. The average availability of the bus exceeded the availability of the CNG reference fleet and availability is expected to improve as the integration is refined. This suggests that the technology has matured and will continue to mature to a level that supports larger scale deployments. The performance, reliability, maintenance and operating cost of the American Fuel Cell Bus is stable and approaching an affordability point that enables transit properties to consider applying for funds to deploy fuel cell buses or to support a larger centralized deployment.

Natural Gas Infrastructure & Deployment

The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy, and the importance of natural gas refueling infrastructure cannot be overemphasized if the region is to realize large-scale deployment of alternative fuel technologies. Natural gas vehicles have lower emissions than gasoline and significantly lower than their diesel counterparts and represent the cleanest internal combustion engine powered vehicles available in today's market. Consequently, amongst the mixed portfolio of technical priorities within the Clean Fuels Program is the continued emphasis on the installation, maintenance and expansion of natural gas infrastructure throughout the Basin including the Ports. In 2013 three significant natural gas infrastructure contracts, which are representative of the natural gas refueling infrastructure the Clean Fuels Program encourages and supports, were completed and closed as follows:

1) In 2008 the City of San Bernardino built a nearly $2 million LNG-L/CNG station including a 15,000 gallon LNG bulk storage tank at its City municipal service yard. The station has now been operating successfully for five years, fueling their 75 vehicle, and ever growing, natural gas fleet with throughput in 2013 of more than 85,000 gallons of natural gas.

Figure 16: City of San Bernardino's East Valley Regional Fueling Facility

2) Also in 2008 the Los Angeles Unified School District built a $1.3 million time- and fast-fill CNG station at its Sun Valley Bus Garage. The station has now been operating successfully for five years, fueling their 100 plus CNG school bus fleet with throughput in 2012 of nearly one-half million DGE of natural gas.

3) In 2012 Border Valley Trading and its development partner Hey Day Farms, which are exporters of agri-products, built a $2.5 million LNG fueling station including a 6,000 gallon fueling unit in Palm Springs. The station has been operating successfully, fueling their 40 heavy-duty LNG trucks with throughput for the first quarter exceeding 37,000 GGEs. In the near future they plan to expand storage and fueling capabilities at this station.

Recognizing the importance of natural gas infrastructure, the SCAQMD actively pursues outside funding to supplement its own Clean Fuels Program dollars in this core technology. Table 5 is a comprehensive summary of federal and state revenue awarded to the SCAQMD from 2009 to 2012 and includes several natural gas infrastructure projects this agency is administering to fill critical gaps in natural gas infrastructure. One representative example is the DOE Clean Cities award the SCAQMD received to expand the LNG corridor from Ontario to Las Vegas, which included not only the installation of a publicly accessible LNG fueling station in Las Vegas but also the purchase of 48 heavy-duty LNG tractors for operation by UPS. The Clean Fuels Program Plan Update for 2014 continues to emphasize natural gas infrastructure and deployment projects, allocating 8% of the $16.4 million of potential projects.

Table 6: Projects Completed between January 1 & December 31, 2013

Contract	Contractor	Project Title	Date
Infrastructure and Deployment			
07149	City of San Bernardino	Purchase & Install New Public Access LNG-L/CNG Fueling Station at City Municipal Service Yard	Dec-13
08271	Los Angeles Unified School District	Purchase & Install New CNG Fueling Station at Sun Valley Bus Garage	Dec-13
11559	Ace Parking Management	Purchase & Deploy Six CNG Cutaway Shuttle Vans	Jul-13
12273	Border Valley Trading	Construct New LNG Fueling Station in Palm Springs	Jul-13
12386	Agility Fuel Systems	Demonstrate Natural Gas-Powered Police Vehicle	Jun-13
Fuels/Emission Studies			
08320	University of Denver	Remote Sensing Measurements of On-Road Emissions from Heavy-Duty Diesel Vehicles	Dec-13
08321	Environmental Systems Products	Remote Sensing Measurements of On-Road Emissions from Heavy-Duty Diesel Vehicles	Dec-13
11611	West Virginia University Research Corporation	In-Use Emissions Testing & Demonstrate Retrofit Technology for On-Road Heavy-Duty Engines	Oct-13
11612	University of California, Riverside/CE-CERT	In-Use Emissions Testing & Demonstrate Retrofit Technology for On-Road Heavy-Duty Engines	Aug-13
12154	University of California, Riverside	Identify Cellulosic Biomass Feedstocks	Oct-13
13451	Energy Solutions	Passenger Vehicle Tire Replacement Efficiency Study	Dec-13
Emission Control Technologies			
08246	Griffith Construction Company	Showcase: Demonstrate NO_x and PM Emission Control Technology on Diesel-Powered Construction Equipment	Dec-13
10069	Johnson Matthey, Inc.	Develop & Demonstrate Selective Catalytic Regeneration Technology for NO_x and PM Emissions Control on Heavy-Duty Trucks	Oct-13
12485	California State University Long Beach Foundation	CSULB CEERS Student Education Study to Assess the Effects of a Humid Air System with an Exhaust Scrubber on Diesel Emissions	Mar-13
Electric/Hybrid Technologies & Infrastructure			
99109†	Toyota Motor Credit Corporation	Lease Two Toyota RAV4 Electric Vehicles	Feb-13
09345	South Bay Cities Council of Governments	Demonstrate Medium-Speed Neighborhood Electric Vehicles	Apr-13

Table 6: Projects Completed between January 1 & December 31, 2013(cont'd)

Contract	Contractor	Project Title	Date
Electric/Hybrid Technologies & Infrastructure (cont'd)			
10738	Foothill Transit	Demonstrate Quick Charge Infrastructure for Electric Buses	Jun-13
12024	ECOtality North America	Upgrade & Install Electric Charging Infrastructure	May-13
Mobile Fuel Cell Technologies			
10501†	American Honda Motor Company	Lease a Clarity Fuel Vehicle for Three Years	Jul-13
10650	SunLine Transit Agency	Demonstrate Advanced Fuel Cell Bus (American Fuel Cell Bus)	Jun-13
10714	University of California, Irvine	Develop Fuel Cell Gas-Turbine Hybrid System for On-Board Locomotive Applications	Dec-13
13113	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership for Calendar Year 2012 & Provide Support for Regional Coordinator	Jan-13
14054	Bevilacqua-Knight, Inc.	Participate in California Fuel Cell Partnership for Calendar Year 2013 & Provide Support for Regional Coordinator	Dec-13
Health Impacts Studies			
09307†	California Air Resources Board	In-Vehicle Air Pollution Exposure Measurement and Modeling	Jun-13
Outreach and Technology Transfer			
02308†	Sperry Capital, Inc.	Evaluate Financial Stability of Potential Contractors	Dec-13
04049†	Engine, Fuel and Emissions Engineering, Inc.	Technical Assistance for Alternative Fuels Engine Technology	Apr-13
05126†	St. Croix Research	Technical Assistance for Development, Outreach & Commercialization of LNG, CNG and Hydrogen Fuels	Mar-13
07314†	Engine, Fuel and Emissions Engineering, Inc.	Technical Assistance with Advanced Heavy-Duty and Off-Road Technologies	Dec-13
09255†	Stan Lisiewicz	Technical Assistance with Caltrans	Dec-13
10056†	San Diego Miramar College (Advanced Transportation Technology & Energy, San Diego Community College District)	Enhanced Training Technology Program	Dec-13
10662†	Gladstein, Neandross & Associates	Technical Assistance for Implementation of Proposition 1B Goods Movement and Truck Replacement Program	Dec-13
10700†	TIAX LLC	Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Technologies	May-13

Table 6: Projects Completed between January 1 & December 31, 2013 (cont'd)

Contract	Contractor	Project Title	Date
Outreach and Technology Transfer (cont'd)			
12313†	CSA America Inc.	CNG Fuel System Inspection Certification Courses	May-13
13256	Three Squares Inc.	Develop, Initiate and Implement Clean Vehicle Outreach Project	Dec-13
13268†	California Hydrogen Business Council	Platinum Membership Renewal for 2012	Jun-13
13414†	Three Squares Inc.	Cosponsor The Women in Green Forum in Southern California & Washington, D.C.	Nov-13
13415†	University of California, Davis, Office of Research	Cosponsor the Asilomar 2013 Conference on Transportation & Energy Policy	Dec-13

†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
2014 PLAN UPDATE

The Clean Fuels Program, which was first created in 1988, along with establishment of the SCAQMD's Technology Advancement Office (TAO), 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 as well as new research and data. Every year the SCAQMD re-evaluates its Clean Fuels Program and crafts a Plan Update to essentially re-calibrate its compass for the upcoming CY. This comprehensive document is the Plan Update for 2014.

Technology Funding Priorities for 2014

The past few years have been especially difficult for technology partnering due to the dramatic global economic downturn, which shifted national research and development priorities and opportunities. On the other hand, the SCAQMD was able to take advantage of the opportunities presented by the American Recovery and Reinvestment Act (ARRA), securing nearly $111 million in ARRA funds and other federal and state funding opportunities from 2009 to 2012. The SCAQMD continued this trend in 2013 by securing additional federal and state funding totaling $15.8 million. Some of the projects implemented with these funds will be administered as part of the Clean Fuels Program, while others, which align well with and are complementary to the Clean Fuels Program, will be implemented under other SCAQMD programs. Nonetheless, the challenge for the SCAQMD continues to be how to identify project or technology opportunities in which its available funding can encourage and accelerate the commercialization and deployment of progressively cleaner technologies in the Basin.

To overcome these challenges, the SCAQMD continued to expand its outreach and networking activities. These efforts not only include continued participation on numerous and varied collaborative and working groups, reaching out to technology developers as well as other funding agencies, and releasing Program Opportunity Notices to essentially throw out a wide net to solicit project ideas and concepts, but over the last few years the SCAQMD has also hosted a variety of technology forums, such as the one in November 2013 on near-road mitigation measures and technologies, and released Requests for Information to determine the state of various technologies. As a result, the SCAQMD's Technology Advancement Office has developed this comprehensive plan for accelerating the development, demonstration and deployment 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 16.8 million people (nearly half the population of California). The AQMP is the long-term "blueprint" that defines the basin-wide emission reductions needed to achieve ambient air quality standards by 2014, 2023 and 2032, 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.

The 2012 AQMP identifies the need for 200 tons/day NO_x reductions to be adopted by 2020 for full implementation by 2023 and in large part focuses control measures on transportation

technologies and cleaner fuels. Moreover, the SCAQMD is currently only one of two regions in the nation recognized as an extreme ozone nonattainment area (the other is San Joaquin Valley). This is especially noteworthy because the largest contributor to ozone is NO_x emissions, and mobile sources (on- and off-road as well as aircraft and ships) contribute to more than three-fourths of NO_x emissions in this region. These emission reduction needs are further identified in a joint SCAQMD, California Air Resources Board (CARB) and San Joaquin Valley Air Pollution Control District effort, "Vision for Clean Air: A Framework for Air Quality and Climate Change Planning."[2] The overwhelming hurdles to reduce ozone and NO_x will require the Clean Fuels Program to encourage and accelerate advancement of transformative technologies and commercialization of progressively lower-emitting vehicles and fuels. The Program must also remain flexible to address the needs which will be identified in the current planning process for the 2016 AQMP which will focus on addressing ozone standards. Furthermore, volatile organic compounds (VOCs) and fine particulate matter ($PM_{2.5}$) produced from mobile sources must also be addressed. The NO_x and VOC emission sources of greatest concern to this region are heavy-duty on-road and off-road vehicles as well as to a lesser extent light- and medium-duty on-road vehicles. And while it is anticipated that the 2014 standard for $PM_{2.5}$ will be attained for this region, it is contingent upon compliance and implementation of existing and proposed rules and regulations.

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 effect of containers 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 few years to actively pursue development of 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 including overhead catenary technology and near-zero heavy-duty technologies. 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 2014 Plan Update.

This 2014 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 2012 AQMP and to address the increasing challenges this region is facing to meet air quality standards, including new and changing federal requirements such as a the new 2032 ozone standard in addition to the current 2023 standard, implementation of new technology measures, and the continued development of economically sound compliance approaches. The scope of projects in the 2014 Plan Update also needs to remain sufficiently flexible to address new challenges and proposed methodologies that are identified in the 2012 AQMP as well as the upcoming 2016 AQMP. The results of the fourth Multiple Air Toxics Exposure Study (MATES IV), which should be available mid-2014, may also affect future funding direction. This follow-up study 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 and black carbon concentrations. Finally, given the

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

increasing call for action by the federal government to reduce carbon and greenhouse gases (e.g., President Obama's Climate Action Plan released in June 2013), the co-benefits of technologies should also be considered.

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 2014 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 2017. 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 2019 or later.
- More mature technologies, those ready to begin field *demonstration* in 2014, are expected to result in a commercial product in the 2015-2016 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 (Core Technologies)

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 2012 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. A concerted effort is also made to form private partnerships to further leverage funds. 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 2014.

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, the Southern California Association of Governments (SCAG) and Los Angeles County Metropolitan Transportation Association (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. Additionally, continued advancements in the light-duty arena, which while there are commercially available product is not yet mainstream technology, may have applications for medium- and heavy-duty vehicles. 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;
- development and demonstration of CNG hybrid vehicle;
- 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 and 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 (e.g., vehicle-to-grid or vehicle-to-building functionality).

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 internal combustion engines (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 vehicles;
- 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 (FCVs) by supporting the required refueling infrastructure.

SCAQMD works closely with the California Fuel Cell Partnership (CaFCP) to further the commercialization of fuel cells for transportation and install the required hydrogen refueling infrastructure. In mid-2012 the CaFCP published a roadmap describing the first network of commercial hydrogen stations in California, calling for 68 hydrogen fueling stations in cluster communities at specific destinations by 2016. Calendar Years 2015-2017 are a critical timeframe for the introduction of FCVs. Since stations need one to two years lead time for permitting and construction, plans for stations need to be initiated now. Coordination with the Division of Measurement Standards also needs to occur to establish standardized measurements for hydrogen refueling. 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 California Energy Commission (CEC) based its recent AB 118 hydrogen funding strategy on CaFCP's roadmap as well as the University of California, Irvine's Advanced Power and Energy

Program. In late 2012 the CEC issued a $28.6 million Program Opportunity Notice for hydrogen fuel infrastructure, and in mid-2013 SCAQMD was awarded a $6.7 million award to implement the upgrade and refurbishment of existing hydrogen fueling stations to ensure legacy stations continue operation as FCVs become available in the market. Additionally, in September 2013 the Governor signed Assembly Bill 8 providing significant funding for hydrogen stations, which will greatly assist in making further inroads toward expanding the hydrogen infrastructure network in California. The SCAQMD will work closely with state agencies to implement these programs and continue efforts to upgrade and refurbish existing hydrogen infrastructure.

The 2014 Plan Update identifies key opportunities while clearly leading the way for pre-commercial demonstrations of original equipment manufacturer (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;
- demonstration of fuel cell vehicles in controlled fleet applications in the Basin; and
- develop and implement strategies with government and industry to build participation in the hydrogen market including certification and testing of hydrogen as a commercial fuel to create a business case for investing.

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 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.

Compressed and liquefied natural gas (CNG and LNG) refueling stations are being positioned to support both 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 (ICTC) 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 conversion to 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 (PM) traps and catalysts, as well as lowering the sulfur content or using additives with diesel fuel. Gas-to-Liquid (GTL) fuels, formed from natural gas or other hydrocarbons 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 diesel particulate traps and selective catalytic reduction catalysts);
- development and demonstration of low-VOC and PM lubricants for diesel and natural gas engines; and

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 (GHG) emissions. These studies showed that biofuels, especially biodiesel, can 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. Studies will continue in 2014 to further investigate the toxicological potential of emissions, such as ultrafines and vapor phase substances, and to determine whether other substances such as volatile or semi-volatile organic compounds are being emitted in lower mass emissions that could pose harmful health effects.

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. One such fuel staff is interested in pursuing is dimethyl ether (DME). This synthetic fuel can be made from renewable natural gas resources and has characteristics similar to gas-to-liquids fuels, i.e., high cetane, zero aromatics and negligible particulate matter. Volvo has announced they will commercialize class 8 trucks using DME in 2015, and staff would like to ensure these trucks have lower NO_x than the existing standard.

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 including DME to evaluate in-use emission composition;
- 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 a 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 water-gas shift (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 $16.4 million for all potential projects. The expected actual project expenditures for 2014 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 2014 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.

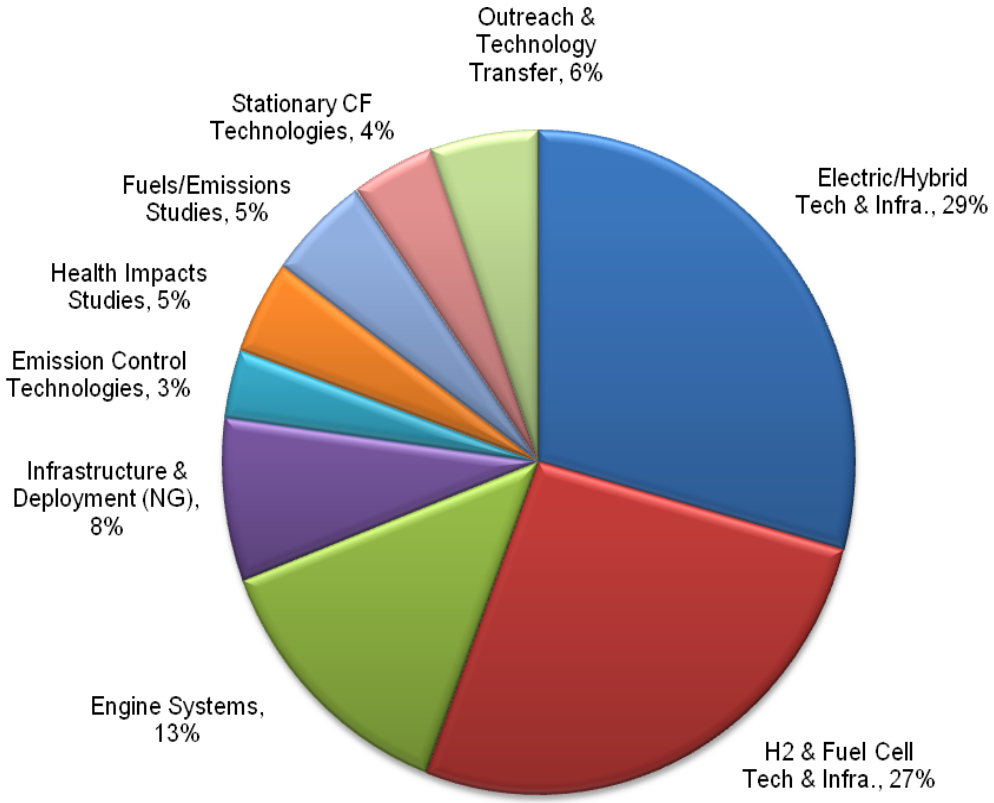


Figure 17: Projected Cost Distribution for Potential SCAQMD Projects 2014 & Beyond ($16.4M)

PROGRAM PLAN UPDATE FOR 2014

This section presents the Clean Fuels Program Plan Update for 2014. 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 7 summarizes potential projects for 2014 as well as the redistribution of SCAQMD costs in some areas as compared to 2013. The funding allocation continues the focus toward development and demonstration of zero and near-zero emission technologies including the infrastructure for such technologies. However, while the SCAQMD had over the last couple of years emphasized electric and hybrid-electric technologies, the intent is to allow the projects in this core technology area to achieve some progress while the Program is slightly re-calibrated to focus on the current federal and state activity in hydrogen and fuel cells and the anticipated roll out of fuel cell vehicles in the next couple of years. Additionally, a significant heavy-duty engine project was recently funded so some emphasis has been adjusted in light of that project currently getting underway as well as awards over the last couple of years in other technology areas, both those made by SCAQMD as well as state and federal awards. The funding allocations continue to align well with the SCAQMD's FY 2013-14 Goals and Priority Objectives. Overall, the Program is designed ensure a broad portfolio of technologies and leverage state and federal efforts.

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 7.

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 7: Summary of Potential Projects for 2014

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	3,000,000	5,000,000
Subtotal	$4,800,000	$11,000,000
Engine Systems		
Develop and Demonstrate Advanced Alternative Fuel Medium- and Heavy-Duty Engines and Vehicles	2,000,000	20,000,000
Develop and Demonstrate Alternative Fuel and Clean Conventional Fueled Light-Duty Vehicles	200,000	1,500,000
Subtotal	$2,200,000	$21,500,000
Hydrogen and Fuel Cell Technologies and Infrastructure		
Develop and Demonstrate Operation and Maintenance Business Case Strategies for Hydrogen Stations	350,000	4,000,000
Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations	2,000,000	6,000,000
Develop and Demonstrate Fuel Cell Vehicles	2,000,000	6,000,000
Subtotal	$4,350,000	$16,000,000
Infrastructure and Deployment (NG)		
Deploy Natural Gas Vehicles in Various Applications	500,000	2,000,000
Develop, Maintain & Expand Natural Gas Infrastructure	300,000	2,000,000
Demonstrate Natural Gas Manufacturing and Distribution Technologies Including Renewables	500,000	7,000,000
Subtotal	$1,300,000	$11,000,000
Emission Control Technologies		
Develop and Demonstrate Advanced Aftertreatment Technologies	300,000	5,000,000
Demonstrate On-Road Technologies in Off-Road and Retrofit Applications	250,000	1,000,000
Subtotal	$550,000	$6,000,000
Fuels/Emission Studies		
In-Use Emissions Studies for Advanced Technology Vehicle Demonstrations	500,000	1,000,000
Conduct Emissions Studies on Biofuels and Alternative Fuels	100,000	1,300,000

Table 7: Summary of Potential Projects for 2014 (cont'd)

Proposed Project	Expected SCAQMD Cost $	Expected Total Cost $
Fuels/Emission Studies (cont'd)		
Identify and Demonstrate In-Use Fleet Emissions Reduction Technologies & Opportunities	250,000	2,000,000
Subtotal	$850,000	$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	**$16,400,000**	**$77,550,000**

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 smaller internal combustion engine, battery pack and electric drive motors to improve fuel economy (e.g., Chevy Volt) 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 2012 AQMP identifies zero- or near-zero emitting vehicles as a key attainment strategy. HEV technologies have the potential to achieve near-zero emissions but with the range of a conventional gasoline-fueled vehicle, a factor expected to enhance consumer acceptance. Given the variety of PEV systems under development, it is critical to determine the true emissions and performance of PEVs. Demonstration of optimized prototypes would enhance the deployment of near-ZEV and ZEV technologies.

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

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

Expected SCAQMD Cost: $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 2012 AQMP identifies zero- or near-zero emitting vehicles as a key attainment strategy. Hybrid technologies have the potential to redirect previously wasted kinetic energy into useable vehicle power. This proposed project category will evaluate various hybrid systems and fuel combinations to identify their performance and emissions benefits. Given the variety of hybrid systems under development, it is critical to determine the true emissions and performance of these prototypes, especially if both emissions and fuel economy advantages are achieved.

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

Proposed Project: Demonstrate Alternative Energy Storage

Expected SCAQMD Cost: $300,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

The SCAQMD has been involved in the development and demonstration of energy storage systems for electric and hybrid-electric vehicles, mainly 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 2012 AQMP. This program is expected to develop alternative energy storage 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: $3,000,000

Expected Total Cost: $5,000,000

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 SCAQMD is actively pursuing 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, SCAQMD 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 2012 AQMP proposes to reduce emissions from this

activity by modernizing the fleet and retrofitting NO_x and PM emission controls on older trucks. An alternative approach, especially for local drayage to the nearby intermodal facilities, is to use advanced container transport systems that use electric propulsion for the containers on fixed guideways or modified trucks able to operate on electricity which will eliminate local diesel truck emissions. The emission benefits have not yet been estimated because the fate of the displaced trucks has not been determined.

Engine Systems

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

Expected SCAQMD Cost: $2,000,000

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: $200,000

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, 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 2012 AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. Pursuant to AQMP goals, the SCAQMD has in effect several fleet rules that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. This program is expected to lead to increased availability of low emission alternative-and conventional-fueled vehicles for fleets as well as consumer purchase.

Hydrogen and Fuel Cell Technologies & Infrastructure

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

Expected SCAQMD Cost: $350,000

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.

In mid-2012 the CaFCP published a roadmap describing the first network of commercial hydrogen stations in California. The roadmap states that by 2016, 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 2012 AQMP identifies 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 SCAQMD 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: $2,000,000

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, adoption of standardized measurements for hydrogen refueling, 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 2012 AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. Pursuant to AQMP goals, the SCAQMD has in effect several fleet rules that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. Fuel cell vehicles constitute the cleanest alternative-fuel vehicles today. Since hydrogen is a key fuel for fuel cell vehicles, this program would address some of the barriers faced by hydrogen as a fuel and thus assist in accelerating its acceptance and ultimate commercialization. In addition to supporting the immediate deployment of the demonstration fleet, expanding the hydrogen fuel infrastructure should contribute to the

market acceptance of fuel cell technologies in the long run, leading to substantial reductions in NO_x, VOC, CO, PM and toxic compound emissions from vehicles.

Proposed Project: Develop and Demonstrate Fuel Cell Vehicles

Expected SCAQMD Cost: $2,000,000

Expected Total Cost: $6,000,000

Description of Technology and Application:

This proposed project would support the demonstration of promising fuel cell technologies for applications using direct hydrogen with proton exchange membrane (PEM) fuel cell technology. 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- & Heavy-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 2012 AQMP identifies the need to implement zero emission vehicles. SCAQMD adopted fleet regulations require public and some private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. In the future, such vehicles could be powered by zero emission fuel cells operating on hydrogen fuel. The proposed projects have the potential to accelerate the commercial viability of fuel cell vehicles. Expected immediate benefits include the establishment of zero- and near-zero emission proof-of-concept vehicles in numerous applications. Over the longer term, the proposed projects could help foster 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 AB 1007 (Pavley).

Proposed Project: Develop, Maintain & Expand Natural Gas Infrastructure

Expected SCAQMD Cost: $300,000

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, 2023 and 2032. 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: $300,000

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: $500,000

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.

DME is another fuel which requires evaluation of in-use emissions, especially NO_x, in light of Volvo's announcement that they will commercialize class 8 trucks using DME in 2015.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 SCAQMD 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: $250,000

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.

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 areas of interest and conduct ambient air monitoring, conduct 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, for which results should be available mid-2014, continues 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. This project category would include other related studies, 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 2012 AQMP identifies the development and ultimately the implementation of non-polluting power generation. To gain the maximum air quality benefit, polluting fossil fuel-fired electric power generation needs to be replaced with clean renewable energy resources or other advanced zero emission technologies, such as hydrogen fuel cells, particularly in a distributed generation context.

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

Outreach and Technology Transfer

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

Expected SCAQMD Cost: $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 Office 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 incentive programs, 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. Matt Miyasato, Chair	SCAQMD
*Patricia Ochoa	Coalition for Clean Air
*Alberto Ayala	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
*Ed Kjaer	Southern California Edison
Philip J. Hodgetts	Clean Air Now
Randall Lewis	Lewis Group of Companies
Tim Olson	California Energy Commission
**Pending*	Western States Petroleum Association
Cherif Youssef	Southern California Gas Company

*Newly appointed members

SB 98 Clean Fuels Advisory Group

*Dr. Matt Miyasato, Chair	SCAQMD
Robert Bienenfeld	American Honda Motor Company Inc
Dr. Blair Folsom	Independent Consultant in Combustion Technology
Dr. Mridul Gautam	West Virginia University, Adjunct Professor, & University of Nevada-Reno
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, College of Engineering, Center for Environmental Research and Technology
Dr. Vernon Roan	University of Florida, Professor Emeritus
Dr. Scott Samuelsen	University of California, Irvine, Combustion Laboratory/National Fuel Cell Research Center
Dr. Robert Sawyer	Sawyer Associates
*Kevin Walkowicz	National Renewable Energy Laboratory
Dr. Nicholas Vanderborgh	Independent Consultant in Fuel Cell Technologies
Michael Walsh	Independent Consultant in Motor Vehicle Pollution Control

*Newly appointed members

Appendix B

Open Clean Fuels Contracts as of January 1, 2014

Contract	Contractor	Project Title	Start Term	End Term	SCAQMD $	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	12/31/16	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	12/31/16	150,000	450,000
07051	City of Pasadena	Purchase & Install New Public Access CNG Fueling Station	12/28/06	09/01/14	165,000	550,000
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	12/31/14	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	03/31/16	350,000	5,841,729
08043	University of California Los Angeles	Public Access CNG Refueling Station Upgrade for UCLA Transportation	05/02/08	12/31/16	140,000	350,000
08044	Beaumont Unified School District	Install Limited Access CNG Refueling Station	03/05/09	12/31/16	288,000	615,994
08098	Redlands Unified School District	Purchase & Install New CNG Refueling Station	01/25/08	04/30/17	525,000	700,000
08101	Pupil Transportation Cooperative	Upgrade Existing Public Access CNG Station	01/04/08	06/30/14	187,154	300,000
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
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

Contract	Contractor	Project Title	Start Term	End Term	SCAQMD $	Project Total $
Infrastructure and Deployment (cont'd)						
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 "Phil"	09/07/12	06/30/14	60,000	356,000
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	954,600
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
12851	Clean Energy	Construct Two LNG Fueling Stations	10/05/12	12/31/18	400,000	3,018,118
12852	City of Corona	Construct Public Access CNG Fueling Stations	10/12/12	12/31/18	200,000	618,429
12853	Rainbow Disposal Company, Inc.	Upgrade CNG Fueling Station	03/08/13	12/31/18	200,000	400,000
12854	Waste Management, Inc.	Upgrade LNG Fueling Station at Baldwin Park Facility	08/17/12	12/31/18	300,000	1,588,100
13401	Nite-Hawk Sweepers LLC	Demonstrate Natural Gas-Powered Parking Lot Sweepers	08/28/13	12/31/15	90,000	200,000
Fuels/Emission Studies						
07236	National Renewable Energy Laboratory	Investigate the Role of Lubricating Oil on PM Emissions from Vehicles	03/23/07	12/30/15	200,000	446,887
10066	National Renewable Energy Laboratory	CRADA – Loan of 70 MPa Hydrogen Quality Sampling Apparatus to SCAQMD	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	04/30/14	60,000	276,000
Emission Control Technologies						
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

Contract	Contractor	Project Title	Start Term	End Term	SCAQMD $	Project Total $
Emission Control Technologies (cont'd)						
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	Retrofit Four Heavy-Duty Diesel Trucks with Diesel Particulate Filters	02/14/12	06/30/14	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
13407	Chaffey Joint Union High School District	Demonstrate Diesel Particulate Filter Technology on Two Diesel School Buses	05/18/13	03/31/14	30,000	45,000
Electric/Hybrid Technologies & Infrastructure						
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
11204	AC Propulsion	Develop & Demonstrate Electric Drive Conversion for Fleet Vehicles	12/24/10	11/30/14	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	09/30/15	494,000	2,599,000
11614	Transportation Power, Inc.	Demonstrate Battery Electric Heavy-Duty Trucks	07/08/11	09/30/14	196,505	2,616,275
11615	Parker Hannifin Corporation	Develop & Demonstrate Up to Four Heavy-Duty Hydraulic Hybrid Vehicles	01/18/13	12/13/14	250,000	2,000,000
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
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
13058	Capstone Turbine Corporation	Develop Microturbine Series Hybrid System for Class 7 Heavy-Duty Vehicle Applications	08/12/13	11/30/14	360,000	1,210,000

Contract	Contractor	Project Title	Start Term	End Term	SCAQMD $	Project Total $
Electric/Hybrid Technologies & Infrastructure (cont'd)						
13149	University of California, Los Angeles	Develop South Coast PEV Readiness Plan	01/18/13	06/30/14	32,000	63,500
13251	Selman Chevrolet Company	Lease Two 2012 or Newer Chevrolet Volt Extended-Range Electric Vehicles for Three Years	11/28/12	05/01/15	31,375	31,375
13404	Penske Honda of Ontario	Lease Two Honda Fit Electric Vehicles for Three Years	05/02/13	05/01/16	31,307	31,207
13410	Selman Chevrolet Company	Lease Three 2013 Chevrolet Volt Extended-Range Electric Vehicles for Three Years	04/03/13	04/02/16	41,084	41,084
13418	City of Claremont	SoCalEV Infrastructure MOA to Install & Upgrade EV Charging Infrastructure	08/29/13	12/15/14	0	0
13419	California State University, Los Angeles	SoCalEV Infrastructure MOA to Install & Upgrade EV Charging Infrastructure	08/05/13	12/15/14	0	0
13420	University of California, Irvine	SoCalEV Infrastructure MOA to Install & Upgrade EV Charging Infrastructure	08/28/13	12/15/14	0	0
13421	County of Los Angeles	SoCalEV Infrastructure MOA to Install & Upgrade EV Charging Infrastructure	09/06/13	12/15/14	0	0
13426	Transportation Power, Inc.	Develop & Demonstrate Catenary Class 8 Trucks (1 Electric & 1 CNG Platform)	06/07/13	06/06/16	2,617,887	3,182,795
13429	Longo Toyota	Lease One Toyota RAV4 Electric Vehicle for Three Years	04/19/13	04/18/16	19,618	19,618
13439	City of Carson	MOU for Catenary Zero Emission Goods Movement Project	10/01/13	09/30/16	0	0
Engine Systems						
13168	National Renewable Energy Laboratory	Develop, Integrate & Demonstrate Heavy-Duty Natural Gas Engines and Vehicles	05/22/13	12/31/15	1,300,000	1,300,000
Mobile Fuel Cell Technologies						
13155	Fletcher Jones Motor Cars Inc. (Mercedes-Benz)	Lease Two F-Cell Fuel Fell Vehicles for Two Years	02/08/13	02/08/15	30,397	30,397
14139	Hyundai America Technical Center Inc.	No-Cost Lease of Fuel Cell Vehicle for Two Years	12/13/13	12/12/15	0	0
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
10046	Air Products and Chemicals Inc.	Develop & Demonstrate Renewable Hydrogen Energy and Refueling Station	12/21/09	11/21/14	750,000	8,436,735
10061	Hydrogenics Corporation	Maintenance & Data Management for the AQMD Hydrogen Refueling Station	10/30/09	1/31/15	468,000	468,000

Contract	Contractor	Project Title	Start Term	End Term	SCAQMD $	Project Total $
Hydrogen Technologies and Infrastructure (cont'd)						
11150	Hydrogen Frontier, Inc.	Maintain & Operate City of Burbank Hydrogen Fueling Station	11/24/10	01/23/16	475,000	1,635,000
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
13259	Air Products and Chemicals, Inc.	Hydrogen Station Operation & Maintenance for Five Cities Hydrogen Program	03/26/13	09/25/14	300,000	300,000
13400	Energy Independence Now	Develop Hydrogen Station Investment Plan	04/05/13	01/04/15	50,000	130,000
14067	University of California, Irvine	Develop Hydrogen Storage Capability for the Gas-Blending Faciilty	12/31/13	07/16/15	200,000	688,000
Health Impacts Studies						
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	03/31/14	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	07/19/14	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 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	06/15/15	85,000	889,000
11208	Long Beach Unified School District	Air Filtration MOA	12/02/10	12/01/14	0	0

Contract	Contractor	Project Title	Start Term	End Term	SCAQMD $	Project Total $
Stationary Clean Fuels Technology (cont'd)						
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
13078	University of California, Riverside	Steam Hydrogasification Reaction Demonstration to Generate Substitute Natural Gas from Biomass Waste	03/07/13	06/07/14	72,916	922,130
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
05128	Mid-Atlantic Research Institute LLC	Development, Outreach & Commercialization of Advanced Heavy-Duty and Off-Road Technologies	08/08/05	03/31/15	40,000	40,000
07060	Don Breazeale and Associates, Inc.	Technical Assistance Related to Air Quality Impacts of Regional Goods Movement	11/15/06	05/31/14	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
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
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
11028	Martin Kay	Technical Assistance on Stationary Source Control Measures & Future Consultation on TAO Activities	08/04/10	12/31/15	40,000	40,000
11182	Tech Compass	Technical Assistance with Alternative Fuels, Fuel Cells, Emissions Analysis & Aftertreatment Technologies	11/19/10	12/31/14	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	01/31/15	150,000	150,000
12093	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
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	SCAQMD $	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
12486	ICF Resources LLC	Technical Assistance with Goods Movement and Zero Emission Transportation Technologies	09/24/13	09/23/15	50,000	50,000
12604	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
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
13256	Three Squares Inc.	Develop, Initiate & Implement Clean Vehicle Outreach Project	01/05/13	12/31/13	21,500	21,500
13408	University of California, Irvine	Demonstrate Building Integration of Electric Vehicles, Photovoltaics and Stationary Fuel Cells	09/30/13	09/29/15	150,000	270,000
13414	Three Squares Inc.	Cosponsor 2013 The Women in Green Forum (Southern California & Wash DC)	05/27/13	11/30/13	25,000	400,000
13415	University of California Davis, Office of Research	Cosponsor the 2013 Asilomar Conference on Transportation & Energy Policy	06/28/13	12/31/13	30,000	100,000

Appendix C

Final Reports for 2013

SCAQMD Contract #07149 **December 2013**

Purchase & Install New Public Access LNG-L/CNG Fueling Station at City Municipal Service Yard

Contractor

City of San Bernardino

Cosponsors

City of San Bernardino
MSRC/AB 2766 Discretionary Fund
SANBAG
SCAQMD

Project Officer

Larry Watkins

Background

The SCAQMD has adopted various rules and regulations requiring municipalities that operate fleets of medium and heavy-duty trucks to purchase less polluting vehicles that operate on alternative fuels such as CNG and LNG. Thus, the City of San Bernardino (City) began purchasing LNG and CNG vehicles when fleet expansion vehicles were needed. After an analysis of labor and fuel expended driving to offsite fueling locations, it became apparent that the City needed to build a local LNG-CNG fueling station. Consequently, the City applied for and received funding assistance from the SCAQMD to build one.

Project Objectives

The objectives of this project were to:

- Establish an initial regional fueling station capable of meeting the short-term fueling needs of LNG-CNG vehicles operating under the fleet rules within the metro San Bernardino area; and
- Develop a fueling facility to support the City's planned deployment of LNG refuse trucks.

Technology Description

The LNG-L/CNG fueling station was built based on proven technology. The project included installation of a 15,000 gallon LNG bulk storage tank, a single dispenser with a submerged multi-function pump and CNG ground storage containers with 36,000 standard cubic feet capacity.

Figure 1: East Valley Regional Fueling Facility

Status

EFS West was awarded the contract for the construction, start-up and commissioning of the LNG-L/CNG fueling station. On October 23, 2006, EFS West ordered the major equipment considering the long lead time for the LNG tank. The contractor also provided final site and mechanical design engineering. Final plans and calculations were submitted to the City Building Department for plan check and in May 2007 the plans were approved.

On June 6, 2007, EFS West mobilized the field crew and began site clearing. The foundation were complete on June 26.On July 23 the 15,000 gallon LNG tank, the three CNG tanks and the mechanical equipment arrived and were set in place. During the next month the multifunction pump and CNG pump skids were installed, the piping was welded and other related components were installed.

Preparing for the first testing, on September 24, 2007, the LNG tank was filled with liquid nitrogen for cooling and testing purposes. The system was pressure tested and inspected by the Fire Engineering consultant. Tests continued and during the month of October the manufacturer programming and station specific mechanical

engineering was done. The first load of LNG was delivered in November and the station was able to pump LNG and produce CNG but the system was not automatic. The City's subcontractor made adjustments and reprogrammed the controller. The system was improved and on November 30 the City and its consultant reviewed the station, approving all but a few items. The remaining items were tested in December and the station was placed into full operation.

The Notice of Completion for the City of San Bernardino East Valley Regional LNG-L/CNG Fueling Facility was filed on March 27, 2008. While the station was commissioned in March 2008, the City had to provide five years of annual reporting including throughput to the SCAQMD under this contract.

Results

The development of this LNG-L/CNG infrastructure has achieved the following:

- Reduced air pollution emissions.
- Reduced diesel consumption
- Provided a vital LNG infrastructure link along the ICTC
- Provided a City LNG fueling site to operate its heavy-duty trucks
- Allowed for the expanded market penetration of additional clean fuel, natural gas vehicles along the ICTC and
- Allowed CNG users an additional location where they can fuel their vehicles

The City's fleet has increased to 26 LNG heavy-duty refuse trucks and 21 CNG vehicles. This displaced more than 75,000 gallons of diesel fuel in the first six months of station use.

Benefits

In one year the City of San Bernardino's initial 20 LNG waste hauling trucks reduced an estimated 18,110 pounds of PM and NO_x emissions annually and displaced consumption of diesel by more than 130,000 gallons a year. The City plans to purchase additional natural gas vehicles through the normal replacement cycle and by 2012 the City plans to have 43 LNG trucks and 32 CNG vehicles in its fleet.

Issues

There was a prolonged problem with false alarms that stopped station operation and an ongoing problem with the multi-function pump that disables the CNG production. The multi-function pump problem is related to fine tuning, according to EFS West; Nexgen/Chart the mechanical subcontractor is continuing to make adjustments to the station's controller and multi-function pump. The false alarms have been addressed. The City and EFS West have decided to handle this as a warranty issue because the City has had beneficial use of the station for some time.

Project Costs

The cost of the project was $1,919,912, more than $550,000 over the original projected cost, due mainly to the increase in world materials costs. The City was able to secure additional CMAQ funding of $91,186 from SANBAG and utilize some of the City's Sewer and Refuse funds. Cost-share for this project was as follows:

SANBAG CMAQ Funds	$1,003,859
City of San Bernardino	531,192
SCAQMD Contract #07149 (CF$)	164,861
SCAQMD Contract #03100 (R1309.1)	143,208
MSRC/AB 2766 Discretionary Fund	76,792
Final Project Total	**$1,919,912**

Commercialization and Application

The LNG-L/CNG fueling station process is an available, proven technology. There are many installations in California, and 12 stations in the Los Angeles Metropolitan Area alone. These installations are typically for specific fleet owners, some allowing public use and others remaining private. With pressure from government agencies, environmental groups and the relative cost of diesel fuel, the use of LNG fuel will likely increase dramatically in the future.

Summary and Conclusions

With the construction of the City of San Bernardino LNG-L/CNG Fueling Station, the City and the larger community will benefit greatly from the availability of alternative fuels. The San Bernardino Valley area now has a location to fuel both LNG and CNG vehicles.

Initial fuel use is estimated to be approximately 275,000 LNG gallons per year. Once the City operates a full complement of natural gas vehicles, the City's fleet alone will require a minimum of 1.8 million LNG gallons annually.

SCAQMD Contract # 08271 **December 2013**

Purchase & Install New CNG Fueling Station at Sun Valley Bus Garage

Contractor

Los Angeles Unified School District (LAUSD)

Cosponsors

LAUSD
SCAQMD

Project Officer

Larry Watkins

Background

CARB has identified diesel exhaust particulates and over 40 chemical components associated with particulates as human carcinogens and toxic air contaminants. In 1998 CARB adopted a resolution identifying replacement of all pre-1977 diesel school buses with alternative fuel buses. Additionally, the 2007 AQMP relies on the expedited implementation of advanced technologies and clean-burning fuels in Southern California to achieve air quality standards. In light of these facts, coupled with LAUSD's growing natural gas fleet, LAUSD applied for and received funding assistance from the SCAQMD to build a new time- and fast-fill CNG station.

Project Objective

LAUSD's project objective was installation of facilities for CNG fueling and maintenance and the expansion of the natural gas fueling infrastructure needed to support LAUSD'S school bus fleet fueling needs. Specifically, this contract provided funding assistance to construct and operate a new time- and fast-fill CNG station at LAUSD's Sun Valley Bus Garage, located at 11247 Sherman Way, Sun Valley, California.

The successful implementation of LAUSD's school bus replacement program will provide less polluting and safer school transportation for school children. In addition, the program maximizes potential emission benefits in high diesel and high PM10 exposure areas, thus also enhancing the objectives of the Environmental Justice and Children's Health Initiatives adopted by the LAUSD Board. Without the use and expansion of clean fuel CNG buses by local school districts, the economic burden may severely increase the risk and exposure of children to toxic diesel particulate matter and smog-forming pollutants.

The new station will provide fuel for LAUSD's existing CNG fleet as well as the 40 CNG buses on order plus an additional 30 buses to be purchased over the next three years.

Technology Description

The new CNG fueling station included installation of a compressor skid (280 SCFM or equivalent) with 150 HP electric motor; storage vessels with 20,000 SCF at 4000 PSI capacity; 20-dual hose time-fill posts; 40 hoses and nozzles capable of fueling vehicles at 3,600 PSI; and a single Xebec gas dryer.

Status

The fueling station became operational on August 11, 2008. Throughput for the first three quarters of operation exceeded 90,000 gasoline gallon equivalents. Unanticipated issues that arose during construction included:

1. Weaver Electric refusing to agree to the Project Stabilization Agreement to employ union labor with the use of union funds; the outcome of this issue involved Weaver Electric being assessed a $51,000 fine and having to use LAUSD employees and funds for the project.
2. Gas service that should have remained at 20-22 psi on the compressor was 33 psi; the increased gas pressure required the purchase and installation of a high volume gas regulator to reduce pressure to normal.

Once commissioned, LAUSD had to provide the SCAQMD five years of annual reporting including throughput through 2013 under this Contract.

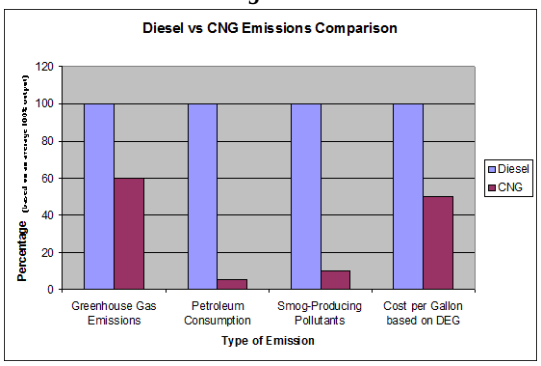
Figure 1: CNG Compressor

Results

As a result of the installation of the new CNG fueling station, several positive results occurred.

- A decrease in emissions including greenhouse gases, carbon dioxide, nitrogen oxides, particulate matter, and toxic and carcinogenic pollutants.
- Imported diesel fuel will not be consumed and an equivalent number of cleaner CNG gallons, which are locally produced, will be consumed.
- Operation and maintenance requirements of the new technology will decrease by over 50% based on fewer carbon emissions from bus fleets. CNG engines last longer, produce less carbon emissions and require less frequent maintenance.

Figure 2



Benefits

In addition to increased efficiency of fueling LAUSD's CNG fleet, project benefits include (based on research assumptions): 30-40% less greenhouse gas emissions (greenhouse gas carbon dioxide); natural gas provides a reduction in petroleum consumption by almost 100% from the level of gasoline; 60-90% less smog-producing pollutants including nitrogen oxides, particulate matter and toxic and carcinogenic pollutants; over 85% of natural gas is domestically produce and the cost of natural gas is over 30% less than the cost of diesel fuel (per gallon, based on a diesel equivalent gallon).

Diesel fuel consumption compared to CNG consumption for the number of gallons per year shows that an average savings of 2 million gallons of imported diesel fuel is saved per year with the use of CNG, which also increases savings by an estimated $12 million plus annually over the cost of diesel fuel.

Project Costs

The initial budget for this project was estimated at a total of $1,747,000 but actual project costs came under budget at $1,342,119. The final project cost-share was as follows:

SCAQMD Contract #08271	$380,203
SCAQMD's Lower-Emission School Bus Replacement Program	$536,520
LAUSD	$425,396
Total Project Costs	**$1,342,119**

Commercialization and Applications

Anticipated and potential applications of the CNG fuel station includes saving money, a decrease in the carbon footprint from the bus fleet from diesel fuel and a decrease in many other major air pollutants.

Projects to further improve the CNG fuel station are Phase II of the project which includes the purchase of a minimum of 60 CNG buses, but potentially over 100 buses total, and construction of more CNG fuel stations district-wide.

The cost of compressed natural gas should remain table due to local production.

SCAQMD Contract #11559 **July 2013**

Purchase & Deploy Six CNG Cutaway Shuttle Vans

Contractor
Ace Parking Management

Cosponsors
Ace Parking Management
SCAQMD
U.S. Dept. of Energy

Project Officer
Phil Barroca

Background
In 2009, the SCAQMD Board recognized funding from the U.S. Department of Energy Clean Cities Petroleum Reduction Technologies for the Transportation Sector, and also provided match funds of $750,000 from the Clean Fuels Fund for alternative fuel-powered airport ground transportation projects.

Project Objective
The project objective was to increase the use of alternative-fuel and reduce petroleum dependency in the on-road transportation sector through the deployment of natural gas fueled airport ground transportation vehicles operating in the South Coast Air Basin. This project, which increased co-funding from Ace Parking Management, was to purchase and deploy (for a minimum of two years) six Ford E-450 cutaway passenger vehicles converted to operate exclusively on CNG.

Technology Description
The project involves the purchase of six new 2011 model year Ford E-450 cutaway vehicles, equipped with OEM installed gasoline-powered engines. The Ford engine has 6.8L of displacement and a V-10 cylinder configuration. The vehicle has a gross vehicle weight rating (GVWR) of 14,500-lbs. The engine is converted to dedicated CNG-power with a CARB-certified conversion system manufactured by BAF Technologies. The vehicle is fitted with 29 gasoline gallon equivalents (GGE) of fuel capacity, comprised of two 14.5 GGE CNG tanks that are positioned in the rear of the vehicle and replacing the OEM gasoline tank.

Status
All six Ford E-450 Cutaway vehicles were purchased and converted to dedicated CNG with the CARB certified BAF conversion system. The vehicles were deployed to the Los Angeles area to provide ground transportation shuttle service between Los Angeles International Airport and remote parking structures and commenced operation in the fourth quarter of 2011. Per DOE requirements, the project required quarterly reports on both fuel usage and mileage for each vehicle. All six vehicles reported usage for four consecutive quarters (one year), and four vehicles provided usage data for a total of seven consecutive quarters. Two vehicles were removed from service in the fourth quarter of 2012, and all six vehicles were removed from operation at, or near the end of, the second quarter of 2013. The company was contacted to provide an explanation for discontinued use of the vehicles and they explained the company had to cease operating at the existing parking facility in the Los Angeles area, but is expected to resume operation in the second quarter of 2014 at a new location servicing the Los Angeles Airport.

Figure 1: Ford E-450 Cutaway with 6.8L V-10

Results

During the seven quarter period in which all or most of the vehicles were in continuous operation, the vehicles collectively amassed 511,000 miles and displaced more than 102,000 gallons of gasoline. The vehicles averaged 2,600 miles per quarter and consumed an average of 520 GGE of fuel, resulting in a fuel consumption rate of 5 miles per gallon.

The 2011 Ford E-450 cutaway is classified as a heavy-duty vehicle with a GVWR greater than 14,000-lbs. Based on CARB Executive Orders and the certified emissions for both the Ford OEM version of this vehicle and the BAF CNG version of this vehicle, the CNG-powered vehicle emits 35% less emissions in terms of hydrocarbon and NO_x emissions.

Benefits

Relative to its gasoline-powered counterpart, the CNG version of this vehicle is 35% cleaner in hydrocarbon and NO_x emissions. The vehicles are also helping to displace the use of petroleum based fuels. The full benefits of this program are yet to be determined as the project was unexpectedly halted at the end of the second quarter of 2013 but is expected to produce increased benefits over the full life of these vehicles. Based on full-life projections of 200,000 to 300,000 miles per vehicle, these six vehicles collectively will displace the use of 240,000 to 360,000 gallons of gasoline over the lifetime.

Project Costs

The total project cost for vehicle purchase and conversion to dedicated CNG was $501,350. The total funding award to this project was $96,200, comprising $25,500 from the DOE and $70,700 from the SCAQMD.

Commercialization and Applications

The technology utilized in this project has been successfully demonstrated. The expected outcome of this project is to increase awareness and viability of using alternative fuel vehicles and to promote the use of non-petroleum based fuel sources.

SCAQMD Contract #12273 **July 2013**

Construct New LNG Fueling Station in Palm Springs

Contractor

Border Valley Trading

Cosponsors

Border Valley Trading
California Energy Commission
MSRC/AB 2766 Discretionary Fund
SCAQMD

Project Officer

Larry Watkins

Background

Border Valley Trading (BVT) and its development partner, Hay Day Farms (HDF), are exporters of agri-products with daily round trips originating in Brawley and Blythe, with deliveries to the Ports of Los Angeles and Long Beach.

In 2008, in response to the local air district directives and San Pedro Port's clean truck program, both companies began transitioning their fleet operations from diesel to LNG.

Because SunLine's Thousand Palms LNG facility closed soon after BVT and HDF converted their fleets, they decided to construct LNG fueling infrastructure to support their own fleet needs (Phase 1), with the goal of expanding the facility (phase 2).

Project Objective

The project objective was to construct a new LNG fueling station in Palm Springs. The site, located at 670 West Garnet Road in the City of Palm Springs, was chosen because it was a logistically key location on the I-10.

With financial assistance from the SCAQMD and CEC, BVT initiated phase 1, which included site acquisition and grading, paving, wall and fencing construction, laying concrete, and installing electric control and security lighting as well as drainage and installation of a 6,000 gallon "Quick Response Station" (QRS) LNG fueling unit including associated controls and appurtenances.

Phase 2 incorporated forward planning and phased development to provide for expanded fueling infrastructure in support of other truck operators seeking LNG fueling alternatives along the east-west Phoenix to LA and the south-north Imperial County to LA trips.

Technology Description

The technology used for this station was a 6,000 gallon QRS LNG portable fueling unit. The station saturates the entire contents of the storage tank immediately upon refill. This automatically occurs when the offload operator changes the selector switch from "offload" to "dispense" and variable saturation set points between 25 and 100 psig can be selected. Saturation is accomplished by circulating LNG through an ambient vaporizer and back into the tank. Once saturated, LNG is dispensed via a suitable cryogenic pump.

Status

BVT has completed the phase 1 site development and installation of the QRS fueling unit in early 2012. An operational permit was issued on March 20, 2012. Fueling capability was initially limited to a manual mode at the start of operation. An initial challenge included data connectivity of a point-of-sale (POS) system to the fuel flow metering system included with the QRS unit. After several months of diagnostics, GreenFIX America completed the installation and connection of a state-of-the art POS system that auto logs throughput and allows truck operators to purchase fuel through the use of special purchase cards (BVT and HDF) or credit cards. Working with GreenFIX America, and the support of USLandLink and the other subcontractors, BVT successfully installed the LNG fueling unit to support 40 clean burning trucks. Phase 2, which includes expanded storage and fueling capabilities, is scheduled to begin in 2013.

Throughput measured at the Palm Springs site for the first four months of operation is as follows:

Actual LNG Throughput		
Year	***LNG Gallons Dispensed***	***Gasoline Gallon Equivalents***
*June 2012**	*7,500*	*5,035*
*July 2012**	*10,000*	*6,715*
August 2012	*19, 300*	*12,950*
September 2012	*19,300*	*12,950*
TOTAL	***57,100***	***37,650***

Recent work has also included vapor recovery systems to capture methane blow-off or "boil-off" which will be collected and pressurized for CNG use at 3,600 psi. Several loads of CNG have been dispensed at this location to a local CNG operator (CV Ice) making deliveries to the Yucca and Morongo basin areas.

Figure 1: LNG Storage Tank

Results

BVT is now successfully operating an LNG fueling facility in support of 40 LNG trucks. The direct and immediate benefit is the reduction of NO_x, PM and GHG emissions. The attached table provides a representation of the reductions:

	Border Valley		**HayDay**		**TOTAL**	
Criteria Pollutant Emission Reduction Calculation	NO_x	PM	NO_x	PM	NO_x	PM
Annual Fuel Consumption (LNG gallons)	40,040	40,040	41,470	41,470	81,470	81,470
Annual Fuel Consumption (dge)	23,553	23,553	24,394	24,394		
Annual Emission Reductions (tons/year)	**1.83**	**0.037**	**1.895**	**0.038**	**3.73**	**0.75**

Benefits

The conversion of 40 heavy-duty trucks from diesel to LNG is achieving a significant reduction of emissions within the SCAQMD's jurisdiction as well as the Greater Southern California area.

The Palm Springs facility has the opportunity to bridge one small gap; however, continued support of clean energy programs and infrastructure remains essential to help stimulate the industry. Affordable fueling opportunities remain limited along the interstates resulting in reluctance in the private sector to convert diesel to natural gas.

Project Costs

The actual costs for phase 1 were about 10-15% higher than estimated. These costs included fire and gas detection as well as integrating a POS system with the data collector on the QRS fueling unit. BVT and its partner HDF made significant business investments in developing the Palm Springs LNG fueling facility. A summary of final project costs is as follows:

Phase 1	
BVT	$472,570
HDF	$472,565
SCAQMD	$251,865
Phase 2	
BVT	$325,000
HDF	$325,000
CEC	$500,000
MSRC/AB Discretionary Fund	$150,000
Total Project Costs	**$2,497,000**

This investment was made both as a commitment to cleaner burning fuel and the environment, but also as an opportunity to reduce long-term operational costs through fuel savings. The SCAQMD's support to help pay for site development costs has been critical to the project.

Commercialization and Applications

Phase 1 of the Palm Springs site will support 40 heavy-duty trucks making round trips from Imperial County and east Riverside County to the Ports of Los Angeles and Long Beach. This initial investment provided a strategic location to provide LNG fuel where very limited and difficult to access options existed. It will provide a return on cost (key to any private business activity) through the cost savings of fuel and re-fuel efficiencies based on location. This return, roughly 7 years, is based on the cost of LNG fuel at roughly 60% the price of diesel. The commitment by BVT and HDF to cleaner burning fuels was not only a business investment but an investment towards a cleaner, greener future for everyone.

SCAQMD Contract #12386 **June 2013**

Demonstrate Natural Gas-Powered Police Vehicle

Contractor
Agility Fuel Systems

Cosponsor
SCAQMD

Project Officer
Phil Barroca

Background
Mobile source emissions continue to be a major contributor to air pollution in the South Coast Air Basin. The SCAQMD's Fleet Rules provide a mandate for public fleets to purchase clean, alternative fuel vehicles when replacing or adding to their fleets; however, law enforcement and emergency vehicles are exempt from these rules and, collectively, law enforcement vehicles represent a significant amount of mobile source emissions in the basin.

Project Objective
The objective of this project was to increase awareness and use of alternative fuel vehicles in the law enforcement vehicle sector. This program was intended to demonstrate the use of a clean, natural gas-powered vehicle in a law enforcement vehicle and deploy this vehicle into daily police vehicle activities. This demonstration program is exclusive with the City of South Pasadena which will provide annual vehicle performance information and vehicle operator feedback for a period of two years.

When this project was initially approved by the SCAQMD Governing Board in 2009, the Ford Crown Victoria was the most widely deployed vehicle in law enforcement agencies in the country. This project specifically funded the purchase of a new 2011 FCV, the conversion to dedicated CNG, and a two-year demonstration of this vehicle by the City of South Pasadena. The program commenced with contract execution in the second quarter of 2012.

Technology Description
The technology in this project involves the conversion of a new gas-powered 2011 Ford Crown Victoria Police Pursuit Vehicle (PPV) to dedicated CNG. The PPV is powered by a 4.6 liter, V-8 engine. The CNG conversion is an EPA approved system by EvoTek LLC, a subsidiary of Impco Technologies, Inc. The vehicle's CNG fuel storage consists of five high pressure CNG fuel storage tanks comprising a total of 16.9 gasoline gallon equivalents (GGE) of CNG fuel. Four tanks, or 12.4 GGE are Type 1 steel tanks; the vehicle was subsequently upgraded with a 4.5 GGE Type 3 CNG fuel tank to provide the vehicle with extended range and usability. The CNG conversion and tank installations were performed under subcontract by A-1 Alternative Fuel Systems located in Fresno, CA.

Figure 1: City of South Pasadena CNG 2011 PPV

Figure 2: Type 3 CNG Fuel Tank upgrade installed in trunk of PPV; 4.5 GGE of fuel capacity.

Status

The City of South Pasadena has been operating the CNG PPV since the second quarter of 2012, primarily as a K-9 unit. The vehicle has amassed 35,000 miles to date and based on conservative estimates displaced the use of more than 2300 gallons of gasoline. The City recently reported that the engine dies on occasion when the vehicle is idling at a stop; this problem is currently under review.

Benefits

Relative to its gas-powered counterpart, the CNG version of this vehicle is at least 70% cleaner in hydrocarbon plus NO_x emissions. As mentioned above, the vehicle is also displacing the use of petroleum-based fuels. Based on full-life projections of 300,000 miles for this vehicle vocation, a CNG-powered Ford Crown Victoria would displace the use of 20,000 gallons of gasoline.

Project Costs

The total amount awarded to this project was $54,000 for the purchase of a new 2011 Ford Crown Victoria with the factory-equipped PPV package, the installation of the CNG conversion system and four CNG fuel storage vessels. An additional $3,145 was approved for this project to purchase and install one 4.5 GGE Type 3 CNG fuel storage tank to increase the vehicle's fuel storage capacity to 16.9 GGE.

Commercialization and Applications

The technology utilized in this project has been successfully demonstrated and increased awareness to cities and municipalities and law enforcement jurisdictions on both the environmental benefits and cost benefits of using CNG in high fuel consuming vehicles.

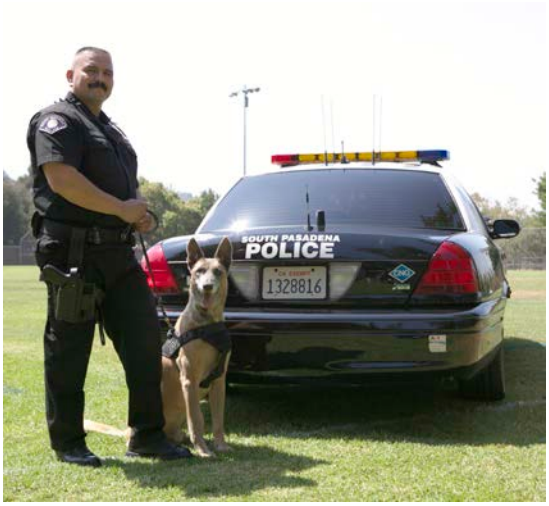


Figure 3: City of South Pasadena CNG-powered K9 unit

SCAQMD Contract #08320 / 08321 **January 2013**

Remote Sensing Measurements of On-Road Emissions from Heavy-Duty Diesel Vehicles

Contractor

University of Denver and Environmental Systems Products (now Envirotest Systems Corporation)

Cosponsors

NREL
SCAQMD

Project Officer

Wei Li

Background

It is important to determine and monitor the benefits of CARB regulations in comparison to the large sums of public funds devoted to heavy-duty vehicle (HDV) diesel emission reductions. To properly gauge the effectiveness of HOV regulations, it was deemed necessary to conduct a study to develop a database of on-road emissions from HDVs operating near ports.

Project Objective

The study was intended to update on-road HDV fleet emissions data to better characterize in-use on-road heavy-duty vehicle emissions in the South Coast Air Basin and evaluate the impact of CARB's Drayage Truck Regulation and In-Use On-Road Heavy Duty Diesel Vehicle Regulation and San Pedro Bay Ports Clean Air Action Plan (CAAP). A subsidiary goal was to compare results from two different measurement systems.

Technology Description

Two sets of remote sensing equipment were used, a University of Denver developed FEAT 3002, used for research studies, and a commercial product, the RSD 4600, made by Environmental Systems Products (ESP), now Envirotest Systems Corporation.

Remote sensing is an inexpensive method of measuring on-road CO, CO_2, HC and NO (both instruments); and NO_2, SO_2 and NH_3 (FEAT 3002 only) gaseous emissions; and UV(RSD 4600 only) and IR opacity (both instruments) from a large number of vehicles without inconveniencing vehicle operation.

Status

Four field campaigns conducted over five years, 2008, 2009, 2010 and 2012, resulted in license plate matched records for 7078 trucks at the Port of Los Angeles Water Street exit (shown below in Figure 1) and 9189 trucks at the Peralta Weigh Station on SR91. Each campaign operated for one week at each of the two locations.

This study was successfully completed in December 2013.

Figure 1: Port of Los Angeles Weigh Station

Results

Peralta: The heavy-duty California fleet observed at Peralta continues to age and over the five year span has increased in average age by about 0.9 model years. Since 2008 the average model year of just the California fleet has gone from 2000.2 (8.1 years old) to 2003.8 (9 years old).

FEAT reported NO_x ($NO+NO_2$) emissions have decreased by 27% from 2008 to 2012 with the largest drop (more than 60% of the total) occurring since the 2010 measurements. For the 2008 to 2010 period, the RSD 4600 reported 11% of NO reductions compared to 13% reductions in NO reported by FEAT over the same period. RSD 4600 was not used at Peralta in 2012.

The overall trend for FEAT IR %opacity at Peralta showed no statistical change since 2008, though a closer examination by chassis model year shows that the DPF equipped trucks (chassis models 2008 and newer) have similar IR %opacity reductions as those seen at the Port though their fraction of the fleet at Peralta was still too small to reduce the overall mean. The RSD 4600 UV channel reported a 7% reduction between 2008 and 2010.

Port of Los Angeles: The fleet age at the Port changed dramatically between the sampling campaigns in 2008 and 2012, averaging almost 14 model years newer. In 2008 the average model year was 1995.6 (~12 years old) and in 2012 the average model year was 2009.3 (~ 3 years old).

FEAT reported NO_x emissions reductions of 55%, with the decrease slowing as expected since 2010 when the CAAP truck replacement was completed. The RSD 4600 observed a 56% reduction in NO compared with the FEAT instruments NO reduction of 50%.

A 54% reduction in FEAT IR %opacity was observed from 2008-2010 with no significant change during the last 2 year interval. The RSD 4600 IR and UV smoke channels reported reductions of 64% and 76% respectively, from 2008 to 2012, with most of the reduction occurring from 2008 to 2010.

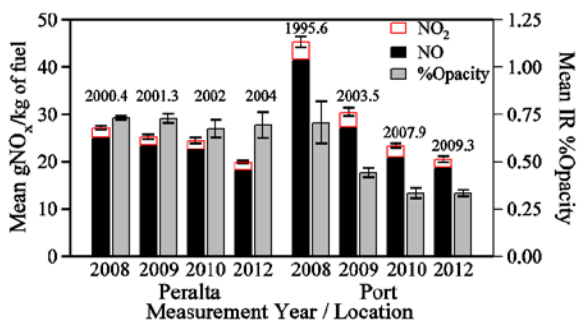


Figure 2: FEAT 3002 Mean Grams of NO and NO2 per kg of fuel (left axis) and IR %Opacity (right axis) versus measurement year.

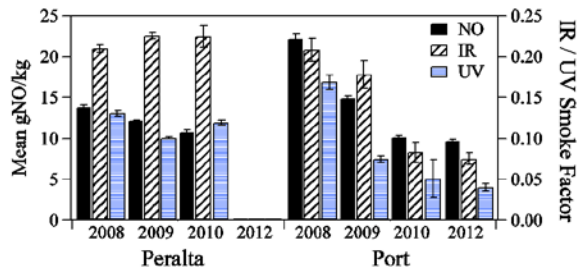


Figure 3: RSD 4600 mean Grams of NO per kg of fuel (left axis) and IR and UV Smoke Factor (right axis) versus measurement year.

Comparison of FEAT 3002and ESP 4600 Results

FEAT 3002 and RSD 4600 emission measurements were binned by model year for each campaign and results compared. Results for NO showed good correlation while the correlations for other pollutants were variable.

Benefits

The remote sensing technology is uniquely able to inexpensively monitor the heavy-duty fleet and ensure emission reduction benefits are being achieved and maintained. The technology is able to measure and compare emissions from differently fueled vehicles. These capabilities allow public agencies to make regulatory decisions with better information and with greater confidence.

Project Costs

	SCAQMD	NREL	Total
DU FEAT Measurements and Reporting	$161,041	$161,041	$322,082
ESP RSD Measurements	$ 38,000	-	$ 38,000
Total	$199,041	$161,041	$360,082

Commercialization and Applications

Both FEAT 3002 and RSD 4600 systems reported similar trends and both are well suited for monitoring progress in HDV on-road emissions that are otherwise expensive and difficult to monitor. The FEAT unit has the advantage of measuring NO_2 as well as NO and of measuring SO_2, and ammonia (NH_3). The RSD 4600 UV smoke channel was more sensitive to particulate emissions than the IR channels of either system. The addition of an NO_2 channel to the RSD 4600 would be beneficial and is being undertaken by the manufacturer.

SCAQMD Contract #11611 **October 2013**

In-Use Emissions Testing & Demonstrate Retrofit Technology for On-Road Heavy-Duty Engines

Contractor

West Virginia University Research Corp

Cosponsors

CARB
Ports of Los Angeles and Long Beach
SCAQMD
West Virginia University

Project Officer

Adewale Oshinuga

Background

On-road heavy-duty engines are now subject to the 2010 U.S. EPA emissions standards of 0.01 g/bhp-hr PM and 0.20 g/bhp-hr NO_x. Some engine manufacturers are using emission credits which allow them to produce a mixture of engines certified at, below, or above 0.20 g/bhp-hr NO_x. While recent limited-scale studies have shown reduced NO_x and PM emissions from trucks powered by 2010 compliant engines, other studies indicate a potential increase in some exhaust emissions. 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 SCAQMD awarded contracts to West Virginia University (WVU) and University of Riverside, California (CE-CERT) 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. In 2011 the emission testing study was amended to include additional funds from the Ports of Los Angeles and Long Beach to conduct 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, WV, and Riverside, CA.

Project Objective

The primary objective of this study was to evaluate the emissions rates of regulated pollutants from current model year heavy-duty diesel, natural gas and dual-fueled vehicles operating under different vocations. Specifically:

1. Assessment of emissions rates of CO, CO_2, NMHC, CH4, NO_x and PM emissions from vehicles operating as port drayage application, transit buses and refuse trucks.
2. Characterize ammonia emission rates from stoichiometric-fueled natural gas vehicles and urea-SCR diesel vehicles.
3. Characterize PM number concentrations and formaldehyde, benzene, toluene, ethyl benzene and o-p xylene emissions.
4. Develop a retrofit strategy for reduction of ammonia emissions from natural gas engines.
5. 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 WV and CA.

Project Description

WVU and CE-CERT were contracted by SCAQMD to conduct heavy-duty chassis dynamometer testing to achieve the above-mentioned objectives. The test matrix included vehicles from eight engine technology categories distributed among four different vocations. A total of 24 heavy-duty vehicles were tested as part of this study. WVU used the transportable heavy-duty chassis dynamometer stationed at Ralph's Distribution Center at Riverside for this study as shown below in Figure 1.

Figure 1: Test Vehicle during chassis dynamometer testing

As part of the in-use emissions testing study, WVU was contracted to collect data during a cross-country truck operation for over 2,500 miles from Morgantown, WV to Riverside, CA. Figure 2 shows the test vehicle in Denver, CO, during the cross-country study.

Figure 2: Test Vehicle set up for the cross-country data collection

Status

The testing phase of the project was completed in February 2013.

Results

First, the in-use emissions testing study showed that NO_x emissions from natural gas vehicles with TWC and the dual-fuel HPDI equipped with DPF and SCR to be lower 2010 compliant diesel engines both in term of distance-specific and brake-specific emissions. Sustained activity of the TWC under all operating conditions contributed to orders of magnitude lower NO_x emissions. The overall lower engine out NO_x emissions from the dual-fuel HPDI engine reduced the effect of SCR inactivity on the NO_x emissions from this engine. Second, exhaust temperature characteristics over the drayage cycle did not support sustained SCR activity for the diesel with SCR, while the stoichiometric natural gas with TWC exhibit orders of magnitude lower NO_x emissions over all three drayage activity. Third, the dual-fuel HPDI vehicles also exhibited lower NO_x even during periods of no SCR activity. From a perspective of port drayage application the natural gas fueled vehicles will contribute to lower NO_x emissions during activities inside the port and local urban type operation. Fourth, diesel vehicles with SCR require sustained vehicle speeds and higher operating loads to achieve lower NO_x emissions. Fifth, stoichiometric natural gas engines were characterized by orders of magnitude higher ammonia emissions than diesel vehicles equipped with SCR. Sixth, N2O emissions from natural gas engines were observed only during the warm-up phase of the three-way catalyst. No significant N2O emissions were detected from any diesel technology vehicles. Finally, particle size distribution analysis showed particle emissions from stoichiometric natural gas engines and DPF equipped diesels to be of the same order of magnitude as ambient air concentrations. The results also indicated the impact of engine component ageing on ultrafine particle emissions.

Results of the cross-country study showed that the NO_x conversion efficiency of the SCR after-treatment system to be on an average 83-88% during the course of the test campaign. Sustained temperatures of greater than 250 Deg C contributed to high SCR activity at highway driving conditions. One of the shortcomings of the cross-country study was the lack of high traffic densities in major sections of the route. Figure 3 shows the SCR after-treatment efficiency and the measured SCR intake exhaust gas temperatures during the entire cross-country test campaign.

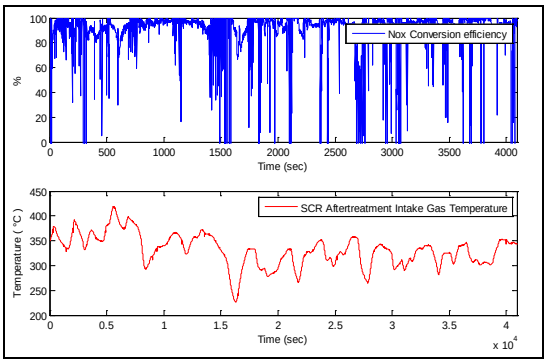


Figure 3: NO_x conversion efficiency of SCR and exhaust gas temperatures during cross-country study

Benefits

The study provided a comprehensive understanding of emission rates of current technology heavy-duty diesel and alternative fueled engines operating in Southern California. In addition, the study provided a reference for updating federal, state and local in-use emissions inventories.

Project Costs

The total project cost was $1,982,162, of which SCAQMD's cost was $1,459,484. CARB, POLA, POLB, WVU and UCR provided the remaining $522,678 in direct and in-kind contributions.

SCAQMD Contract #11612 **August 2013**

In-Use Emissions Testing & Demonstrate Retrofit Technology for On-Road Heavy-Duty Engines

Contractor

University of California, Riverside

Cosponsors

CARB
Ports of Los Angeles and Long Beach
SCAQMD
University of California, Riverside

Project Officer

Adewale Oshinuga

Background

On-road heavy-duty engines are now subject to the 2010 U.S. EPA emissions standards of 0.01 g/bhp-hr PM and 0.20 g/bhp-hr NO_x. Some engine manufacturers are using emission credits which allow them to produce a mixture of engines certified at, below, or above 0.20 g/bhp-hr NO_x. While recent limited-scale studies have shown reduced NO_x and PM emissions from trucks powered by 2010 compliant engines, other studies indicate a potential increase in some exhaust emissions. 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 SCAQMD awarded contracts to West Virginia University (WVU) and University of Riverside, California (CE-CERT) 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. In 2011 the emission testing study was amended to include additional funds from the Ports of Los Angeles and Long Beach to conduct 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, WV, and Riverside, CA.

Project Objective

The objectives of this study were to conduct in-use testing of heavy-duty natural gas and diesel vehicles while measuring: 1) regulated emissions; 2) unregulated emissions such as ammonia and formaldehyde; 3) greenhouse gas levels of CO_2 and N2O; and 4) ultrafine PM emissions.

Project Description

WVU and CE-CERT were contracted by SCAQMD to conduct heavy-duty chassis dynamometer testing to achieve the above-mentioned objectives. The test matrix included vehicles from eight engine technology categories distributed among four different vocations. A total of 24 heavy-duty vehicles were tested as part of this study. The testing protocol involved measuring emissions while the vehicles followed driving cycles that were better at representing the in-use emissions than those used for certification. All testing was carried out on a chassis dynamometer with measurements being made with a laboratory meeting 40 CFR Part 1065 specifications.

Figure 1: Truck being tested on chassis dynamometer

Status

The testing phase of the project was completed in May 2013.

Results

Emissions of PM and NOx

- PM emissions from all diesel vehicles and driving cycles met the 10mg per bk-hp-hr

certification limit. For inventory purposes, the measured value on a per-mile basis was ≤2 mg/mi. PM emissions for the single LPG vehicle found in the South Coast Air Basin was ~140mg/bk-hp-hr on the UDDS cycle.

- NO_x emissions depended on the certification value, application/driving cycle and the manufacturer. With diesel engines used for goods movement, emissions were lowest with installed SCR technology; however, increases up to 500% were measured when the temperature of the SCR was <325ºC. Vehicles using only cooled EGR were certified to higher levels and surprisingly showed emissions for near-port operations that were 250% higher than for service to regional distribution centers. An overall lower average exhaust temperature is typical of vehicles operating close to port where a significant amount of queuing takes place.
- Navistar engines all had emissions exceeding the compliance level. News in May 2013 indicated that Navistar exceeded the limit established for engines certified under the EPA nonconformance penalty (NCP) rule, thus resulting in a recall of the Navistar engines. Other news indicated Navistar's approach to use EGR and pay fines as the NO_x emission solution was abandoned in favor of adopting SCR technology like the other engine manufacturers. Navistar's technology change to SCR will allow them to comply with the strict NO_x certification levels.
- NO_x emissions from diesel refuse haulers using SCRs showed most of the NO_x was produced during the compaction portion of the in-use cycle as exhaust temperatures were relatively low when compared with exhaust temperature during the transit portion of the cycle
- An important finding was the percentage of NO_x as NO_2 ranged from 10% to near 90% with most of the data showing high levels of NO_2, especially with an SCR. These values can be compared with the retrofit rule where the NO_2 levels were limited to 20% above the baseline levels.

NH_3, Hydrocarbons, Toxics and Fine PM

- NH_3 emissions were very low; ranging from about 10 to 100 mg/mi over the range of vehicle/cycle combinations. All vehicles showed cycle averaged raw NH_3 emission concentrations <10ppm.
- The emission factors for the THC, CH_4, NMHC and toxics were very low for all vehicle/cycle combinations with a DOC/DPF installed as expected from the ACES project that showed a 98% reduction from diesel engines without DPFs. THC, NMHC, and CH_4 emissions were at or below 0.45 g/mi, 0.30 g/mi, and 0.20 g/mi, respectively.
- Real-time PM measurements suggest the reported reference PM emission rate may be lower due to low filter weights for DPF equipped vehicles.
- Fine particles show higher concentrations during the first 200 seconds of a cold start. Hot stabilized engines show similar results between test cycles. The fine particles appear to be higher for the regional port cycle where extended high loads were experienced by the after treatment systems.

Greenhouse Gas & Fuel Economy

- For engines burning diesel fuel, the GHG and fuel economy are represented by CO_2 since the very low methane emissions do not measurably contribute to GHG. However with LPG, methane emissions represented ~8% of the GHG. Fuel economy ranged from 2.6 to 7.6 mpg for the range of vehicles and cycles, with goods movement vehicles having the highest fuel economy for the regional cycle. The refuse trucks showed slightly higher fuel economy values for the RTC compared to the UDDS.
- The project measured N_2O, another greenhouse gas, and levels were very low for all vehicles and were about one to two standard deviations above ambient concentrations, as expected.

Benefits

The project met the intended goals and provided direct information on the difference between in-use and certification emission levels for trucks operating in the Basin. The results point to a need to lower the emissions from HDDT even with the current strict emission standards, especially when the trucks are operating outside the not-to-exceed zones. Otherwise, this region will not make the planned progress towards cleaner air.

Project Costs

The total project cost was $1,982,162, of which SCAQMD's cost was $1,459,484. CARB, POLA, POLB, WVU and UCR provided the remaining $522,678 in direct and in-kind contributions.

SCAQMD Contract #12154 **October 2013**

Identify Cellulosic Biomass Feedstocks

Contractor

University of California, Riverside / CE-CERT

Cosponsors

Ford Motor Company Endowed Chair
SCAQMD

Project Officer

Brian Choe

Background

California consumes more transportation fuel than any other state, with gasoline alone responsible for 14.6 billion gallons in 2011. High fuel use produces high greenhouse gas (GHG) emissions that feed global climate change. The national Renewable Fuel Standard (RFS2) mandates alternative fuels with lower GHG emissions than motor gasoline, and State Low Carbon Fuel Standards (LCFS) require carbon intensity to drop 10% by 2020. The California Air Resources Board and California Energy Commission note that biofuels from non-edible abundant lignocellulosic biomass in the state can reduce GHG emissions by as much as 75% over conventional fuels.

Project Objective

The objective was to identify state lignocellulosic residues and wastes with favorable characteristics for conversion into biofuels using University of California, Riverside (UCR) high throughput (HT) systems through four main tasks: (1) select promising cellulosic biomass, (2) analyze their sugar content, (3) evaluate their recalcitrance, and (4) design a HT hydrolysis and dehydration reaction system.

Technology Description

Four parameters, adapted from the 2011 National Renewable Energy Laboratory (NREL) technoeconomic report, defined the criteria for promising biorefinery feedstocks: (a) potential availability of at least 773,000 dry tons/year, (b) distribution density over 98.5 dry tons/mi^2, (c) minimum structural carbohydrate content of 59%, and (d) a sugar yield at or above 90% (wt/wt). Two national and two regional studies were utilized to estimate the availabilities and county level distribution densities of biomass types and allow selection of biomass materials satisfying the criteria. Next, the UCR downscaled HT system was applied to simultaneously determine sugar contents of up to 16 leading biomass candidates with 3 replicates of each. UCR's HT pretreatment and enzymatic hydrolysis (HTPH) device shown in Figure 1 was then applied to measure actual sugar release from biomass types that possessed more than 59% sugar by weight based on one pretreatment with just hot water at 180°C and another with 0.5% dilute sulfuric acid at 160°C followed by enzymatic hydrolysis with a high loadings of Spezyme® CP cellulase and Multifect® Xylanase xylanase. Biomass that released more than 90% of total sugar content was deemed most promising. Finally, a high-pressure steam chamber was designed and fabricated to operate at up to 260°C and 665 psig, thereby allowing future screening for production of reactive intermediates (RIs) that can be converted into hydrocarbon fuels.

Figure 1: UCR's HTPH device

Status

The project was completed in November 2013. The report contains details of the four tasks outlined in this summary. All tasks needed to identify promising sources of biomass in California were completed. The kinetic modeling study originally planned was not undertaken as selection of promising candidates was possible without this additional information.

Results

Of the more than 60 biomass types evaluated, 9 cleared the first threshold for availability in excess of 773,000 dry tons/year: municipal solid wastes (MSW) as mixed paper with mixed cardboard and processed wood wastes; agricultural residues of rice straw, heifer, and dairy cattle manures; and logging, thinning, and primary and secondary mill residues from forestry. Together, these made up more than two-thirds or 68% of the state's 23 million dry tons of cellulosic residues and wastes.

Out of these 9 biomass types, rice straw qualified as the most promising single biomass feedstock candidate. Field and seed crop rice straw had an average potential availability approaching 1 million dry tons/year and a distribution density ranging from a low of 110 dry tons/mi^2 to a high of 131 dry tons/mi^2 concentrated in small clusters of 6-7 contiguous rice producing counties (i.e., Glenn, Butte, Colusa, Sutter, Yolo, Yuba, and Placer Counties) in the Central Valley. Rice straw also showed a total glucan, xylan, mannan, galactan, and arabinan sugar content that exceeded 59% (wt/wt). Furthermore, yields of the dominant sugars of glucose, xylose, galactose, and mannose was as high as ~92% (wt/wt) when subjected to dilute sulfuric acid HTPH at 160°C.

Another promising feedstock is MSW mixed paper. Although sugar yields were limited to 60-70% (wt/wt), such sugar yields were possible without pretreatment, the single most expensive step in bioethanol production from cellulosic biomass.

The remaining biomass types did not meet criteria for adequate distribution density (i.e., heifer manure, MSW processed wood wastes, secondary mill residues, logging slash, and thinnings), sugar content (i.e., dairy cattle), and sugar yields (i.e., MSW mixed cardboard and primary mill residue).

It is important to note that the study had some limitations that deserve more attention. First, combining several of the biomass types that are available in particular areas would likely result in the total availability meeting the selection criteria. In addition, although the assessment took into account sustainability and handling losses, it did not include the impact of current consumptions in other non-biofuel sectors or the costs of gathering biomass from the source, which could alter availability. Also, the biomass evaluation depended on the particular samples that could be obtained, and more extensive sampling could ensure that the results are more representative at the state level. And energy crops could greatly increase the impact. However, more extensive studies of this nature were beyond the scope of this project.

Benefits

Assuming a 76% of theoretical conversion of biomass to ethanol, rice straw, which constitutes 4.3% (wt/wt) of cellulosic biomass now available in California, would generate 77 million gallons/year of bioethanol, equal to 5.9% (vol/vol) of the 1.3 billion gallons of ethanol consumed by the state in 2010. If processes were available to release sugars from the more recalcitrant lignocellulosic materials in California, softwoods of Douglas fir and redwood primary mill residues, along with MSW mixed papers and cardboards, as much as 351 million gallons or 27% of the state's 2010 ethanol consumption could be generated. Thus, even though, such materials did not satisfy all four criteria, it is important not to ignore them in light of such considerations.

Project Costs

The project was completed at a cost of $250,000, of which SCAQMD provided $235,000 and the Ford Motor Company Endowed Chair provided $15,000.

Commercialization and Applications

This study shows lignocellulosic biomass could contribute substantially to meeting California GHG reduction targets. In addition, even greater impact would likely be possible through deconstruction of more recalcitrant materials to the RIs furfural, levulinic acid, and 5-hydroxy-methylfurfural (5-HMF) for conversion into infrastructure compatible fuels. The HTHD system developed in this project is a valuable tool for efficient screening of multiple materials at favorable conditions for RI formation.

SCAQMD #13451 **December 2013**

Passenger Vehicle Replacement Tire Efficiency Study

Contractor

Energy Solutions

Cosponsors

Energy Solutions
SCAQMD

Project Officer

Aaron Katzenstein

Background

Passenger vehicle low-rolling resistance replacement tires (herein referred to as "fuel efficient tires") provide significant opportunities to reduce air pollutants and carbon dioxide while saving consumers fuel and money. Fuel efficient tires are technically feasible and common for new vehicles (due to environmental regulations) with a very high benefit/cost ratio and rapid payback. However, they face significant market barriers in the replacement market. This is because manufacturers face a modest cost increase, tire retailers lack a significant incentive to stock and promote fuel efficient tires and consumers have limited resources to identify these tires.

Project Objective

The objective of this study was intended to:

- Quantify environmental benefits of fuel efficient tires, including expected fuel savings and air quality and greenhouse gas (GHG) benefits;
- Define fuel efficient tire characteristics; and
- Evaluate a fuel efficient tire incentive program design.

Technology

Rolling resistance refers to the force needed to move a tire forward and overcome internal deformations and friction with the road. Rolling resistance co-efficient (RRC) is a common benchmark and is determined by the force needed to overcome rolling resistance divided by the load on the tire. Technologies to reduce rolling resistance without sacrificing traction include increasing the use of natural rubber with dispersed silica. Low-rolling resistance tires are widely deployed on new vehicles by Original Equipment Manufacturers (OEMs) and U.S. EPA predicts a further 10% improvement in this market by 2015. Thus a 25% per vehicle reduction in replacement market tire rolling resistance is technically feasible as shown in Figure 1 from the study. A 20% overall reduction is feasible including vehicles with specialty tires.

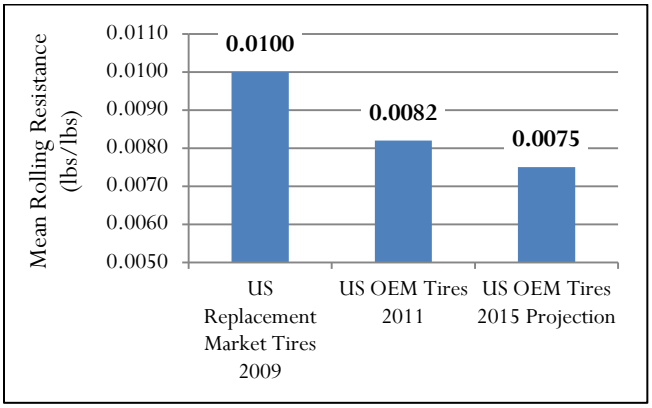


Figure 1: Replacement Market Passenger Vehicle Tire Rolling Resistance Coefficient (RRC) Compared to OEM Median RRC

Sources: RMA 2009, Lutsey 2012, Energy Solutions Calculation

Status

The study was completed in October 2013, and successfully achieved all objectives.

Results

An overall 4% fuel economy benefit can be achieved for the fleet of vehicles operating on replacement tires. Estimated air quality benefits from one year of full deployment include 1,500 tons of ozone precursor reductions and 1.6 million tons of greenhouse gas (GHG) reductions. Manufacturers are not expected to trade-off rolling resistance for other attributes (safety/traction and durability) and appropriate program design can discourage trade-offs.

An incentive and education program can achieve benefits that are proportional to participation rates. Retailers will play a key role due to customer interactions and stocking decisions. An electronic

processing system, with purchase data submitted by retailers, will also play an important role.

Benefits

Expected benefits far exceed costs under a wide range of scenarios. For instance, a hypothetical one year program with a 10% penetration rate at a cost of $12.50/tire ($50/vehicle) would cost about $9 million (this example is not intended to predict actual participation rates). This hypothetical program would achieve net lifetime benefits of $50-$64 million at a benefit/cost ratio of about 7:1 due to fuel savings, GHG reductions and criteria pollutant benefits. Air quality benefits alone (including GHG), using the lower of two valuation methods in the study, would roughly equal costs. Net benefits would scale up with higher penetration rates, even if somewhat higher costs per vehicle were necessary. This extremely high benefit/cost ratio exceeded initial expectations.

Project Cost

SCAQMD project cost was $10,000. Energy Solutions provided a $6,000 cost-sharing contribution in recognition of the importance of this project.

Commercialization and Application

Fuel efficient tires are ready for commercial deployment in the replacement market and regulators in the European Union, Japan and South Korea have set a precedent with policies to overcome market barriers in overseas markets. An SCAQMD incentive and education program would help overcome market barriers locally and the following implementation steps are recommended:

1. Determine incentive levels and structure based on available funding levels and further retailer engagement.
2. Test tires for rolling resistance to support program design and prepare an initial list of eligible products and allow manufacturers to submit data for additional products.
3. Evaluate potential designs for an on-line system that accepts retailer sales data, validates qualifying product purchases and processes rebate applications.
4. Support state efforts to promote fuel efficient tires and federal efforts to develop a customer information and labeling program. In the meanwhile, the SCAQMD can consider the development of educational materials to complement a potential local incentive program.

SCAQMD Contract #08246 **December 2013**

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

Contractor

Griffith Construction Company

Cosponsors

Griffith Construction Company
Nett Technologies Inc
Puritech GmbH
SCAQMD

Project Officer

Richard Carlson

Background

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

The Showcase was 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 SCAQMD awarded a contract to Griffith Construction to participate in the Showcase Program to demonstrate NO_x and particulate matter (PM) control technologies on five off-road vehicles.

Project Objective

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

- No interference with operator visibility, access or safety.
- Equipment performance and functionality equivalent to non-retrofitted configuration.
- Operation for a minimum of 1,000 hours with CARB monitoring.

Technology Description

Two technologies were selected: 1) a combined DPF and SCR technology from Nett Technologies and 2) a DPF technology which included fuel injected in front of an oxidation catalyst from Puritech.

The Nett BlueMAX Ultra system uses a fuel burner to raise the exhaust gas temperature high enough during normal operation to continuously regenerate the DPF. Regeneration is initiated automatically based on exhaust pressure, flow rate and temperature. The Nett BlueMAX Plus SCR system uses a passive continuously regenerated DPF while the excavator is operating normally and is intended for units with higher exhaust gas temperatures. The SCR system is the same on both systems and injects urea in front of an SCR catalyst based on NO_x concentration, exhaust temperature and exhaust flow. Emission reductions up to 90% for NO_x and PM are claimed by Nett.

The PURImax includes a DPF preceded by an oxidation catalyst and a diesel fuel injection system. Diesel fuel is injected to maintain the exhaust temperature high enough for passive DPF regeneration and also to reduce NO_x, particularly NO2. Fuel is automatically injected according to exhaust temperature and exhaust flow rate while the equipment is operating normally. Puritech claims 90% PM reduction and 30% NO_x reduction.

Figure 1: DPF/SCR Catalyst on Loader

Status

The five retrofit systems were installed on the off-road equipment. The Nett BlueMAX Ultra SCR system with actively regenerated DPF was installed on two Tier 1 Caterpillar TH103 rough terrain forklifts in 2009 and 2010. However, the systems were removed in 2011 because rough terrain forklifts were not well suited for the Nett retrofit system due to the system's high electrical demand when running, the intermittent/short run time duty cycle of the forklifts, and their low average engine power. The result was that the forklift batteries frequently ran down and the power demand for battery charging and operation of the retrofit system exceeded the capacity of the alternators. The two forklift systems only accumulated a few hundred hours.

The Nett BlueMAX Plus SCR system with passively regenerated DPF was installed on a Tier 3 Caterpillar 330DL excavator in 2013 and has accumulated approximately 600 hours. A low NO_x efficiency alarm for the SCR system was reported several times but has been corrected by a software change. There were no problems with the DPF.

The Puritech PURImax DPF was installed on one Tier 1 Caterpillar 988G rubber-tired loader and one Tier 3 Caterpillar 950H rubber-tired loader in 2012. The Tier 1 loader has accumulated nearly 3,000 hours and the Tier 3 loader has accumulated over 1,800 hours. Both have operated without problems and DPF cleaning has not been required.

Results

No emission measurements were performed on these systems because CARB was unable to provide a portable emission measurement system as originally planned. The demonstration showed that off-road equipment can be successfully retrofitted with retrofit devices that reduce both PM and NO_x provided they are compatible with the specific equipment duty cycle and configuration.

Benefits

The benefits of this demonstration are mainly qualitative since emission measurements were not performed. The project demonstrated that retrofit systems that reduce both NO_x and PM can be installed and operated successfully on off-road equipment. As a result, retrofit can remain an option for future emission reductions.

Project Costs

Total Project	SCAQMD	Griffith
$191,450	$92,750	$98,750

Additional non-monetary cost-share was provided by Nett and Puritech for maintenance of their systems.

Commercialization and Applications

CARB verification is required for commercialization in California. The technology providers are currently pursuing CARB verification for off-road engine applications. The Nett SCR system is verified by EPA for off-road mobile applications. A Nett DPF is verified by CARB for stationary engines. The PURImax system is verified in Europe. The systems demonstrated in the project are commercially available outside California.

SCAQMD Contract #10069 **October 2013**

Develop & Demonstrate Selective Catalytic Regeneration Technology for NO_x and PM Emissions Control on Heavy-Duty Trucks

Contractor
Johnson Matthey Inc

Cosponsors
SCAQMD
U.S. EPA

Project Officer
Jeff Cox

Background

There is a great deal of test data and field experience that demonstrate the performance and reliability of passive technologies for the reduction of PM. There has been little data collected that demonstrates the performance and impact on fleet operations of the newer retrofit NO_x reduction technologies using SCR. A demonstration of the emission reduction and the impact on fleet operations of these new technologies is necessary to evaluate the potential impact of the retrofit technology.

Project Objective

This project was undertaken to demonstrate the emission reduction potential with a retrofit 4-way emission control technology on 35 heavy-duty diesel trucks operating in the South Coast Air Basin. Since SCR based NO_x reduction is effected by the exhaust temperature profile of the application, special attention was paid to the relationship between system performance and exhaust temperature. Of secondary concern is the impact that such a technology will have on a fleet from an operation and maintenance standpoint.

Technology Description

Johnson Matthey (JM) has developed a product that combines their continuously regenerating technology (CRT) with urea-based selective catalytic reduction (SCR) to retrofit on heavy-duty diesel vehicles. The SCRT consists of several subsystems; CRT, SCR catalyst module and urea dosing system.

The CRT was previously verified by CARB as a level 3 PM control device (>85% reduction) that also meets the 20% NO2 requirement for 1998-2002 MY heavy-duty diesel engines. The SCR system uses NH3, carried on the vehicle as urea, to reduce NO_x over a vanadium-based catalyst. The precise air assisted injection of urea is performed using an OE dosing pump controlled by an ECU developed by JM.

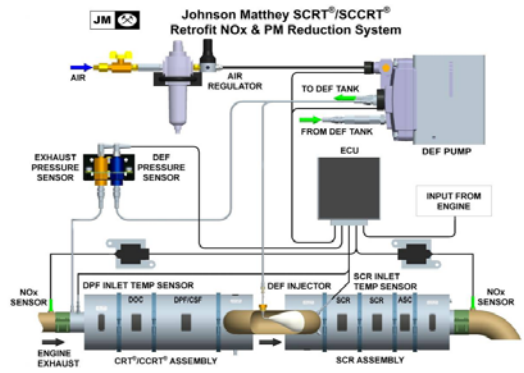


Figure 1: System Schematic

Status

The phases of this project were:

- CARB test plan was completed and submitted on September 15, 2010, for vanadium. There was an SCR catalyst formulation change that occurred during the program. All program field installations were vanadium SCR.
- 25 systems were installed and operated on trucks within 5 fleets. The trucks were equipped with Caterpillar C12, Cummins ISM, Mack E7 or MBE OM906LA engines built between 1999 and 2003.
- Chassis dyno emissions testing that was originally part of the program was cancelled.

Figure 2: Universal Application Mounted System

Changes to the CARB On-Highway Truck and Bus 2010 Regulation occurred during this program. The previous interim 2007 NO_x standard was dropped and instead required a direct transition to a 2010 NO_x standard.

Potential program participating fleets dropped out with the consideration of installing a retrofit PM device only as a route to rule compliance with less complexity than the JM SCRT system with post program upgrade costs. The balances of system installations against the program were not complete because the SCRT CARB experimental operational permit expiration date and the CARB verification timing were not aligned, requiring system removals.

Results

Emissions data was gathered using NO_x sensors to compare system out and engine out NO_x levels during actual operation. The daily operational NO_x reduction was as high as 85% as seen below.

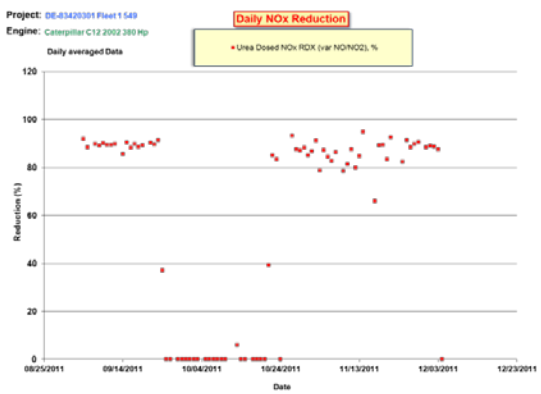


Figure 3: Daily NO_x reduction during SCRT durability trial

Other information generated by the project included:

- Verification that 70% NO_x reduction can be achieved with a CRT inlet temperature over 240°C for 40% of the operating time.
- A universal Class 7/8 system bracket design was integrated on the majority of participating vehicles.
- Bracket system durability failures were observed in a challenging bulk hauling application that experienced some off-highway unpaved surfaces when g loads exceed 7g's.
- Wire splices in the electrical harness had failure issues during installation where harness routing had aggressive bend radius during installation.

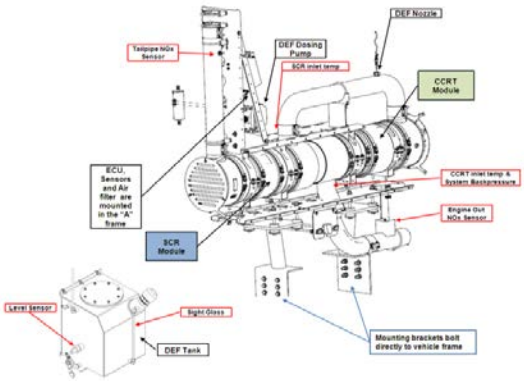


Figure 4: Vehicle Integration Application Schematic

- DEF connections (flareless tube, pipe and JIC fittings) from tank to pump proved to be a challenge at initial system commissioning requiring some post installation service downtime.
- The installation location and orientation of the tailpipe NO_x sensor was demonstrated as unreliable in some installations.

Benefits

Besides the percentage of NO_x reduction shown, the data gathered during this program was able to show that some applications with 15 hour shifts could remove as much as 13 lbs. of NO_x per daily average.

Project Costs

Total project cost was $1,200,000, of which SCAQMD contributed $300,000 along with pass-thru funding provided by U.S. EPA in the amount of $900,000.

Commercialization and Applications

This demonstration program identified areas in the system that needed improvement like the wiring harness, DEF line connection methods and tailpipe NO_x sensor orientation to increase the system reliability. The universal class 7/8 bracket design system behind the vehicle cab integrated well with various over-the-road applications for bulk goods delivery. Certain vehicle applications with excessive operational g loadings challenged the bracket systems where improvements are required before commercialization. The universal bracket design allowed for the system to be assembled with common parts and the price of the system to be lowered because of better volume purchasing.

SCAQMD Contract #12485 **March 2013**

CSULB CEERS Student Education Study to Assess the Effects of a Humid Air System with an Exhaust Scrubber on Diesel Emissions

Contractor

CSULB Foundation

Cosponsor

SCAQMD

Project Officer

Alfonso Baez

Background

Humid air system or fumigation is an effective approach in reducing diesel NO_x emissions. In this method, water vapor is injected in the intake air supplied to the engine cylinders. The process reduces the local temperature in the cylinder and raises the specific heat of the air-fuel mixture which also contributes to the elimination of the hot spots in the engine cylinder. With decreased temperature, NO_x reduction is achieved. With an optimized system, fumigation can reduce NO_x emission without significant increases in hydrocarbon emissions. Other benefits of the process include longer life of the engine components due to reduced cycle temperature and reductions in carbon deposits.

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 the smaller ones. One of the effective methods for removing small particles is the use of an electrostatic scrubber. In this method, the droplets entering the scrubber region are electrically charged which results in attraction of the particles to the droplets and their sedimentations.

Project Objective

The objective of the project was to investigate the combined effects of the humid air system and an exhaust fog scrubber or an electrostatic fog for significant reductions in both NO_x and PM emissions of diesel engines.

Technology Description

The experiments were performed in the diesel engine laboratory of the CEERS/Mechanical and Aerospace Engineering Department. A Vanguard 3-cylinder naturally aspired liquid-cooled diesel engine connected to an electric dynamometer with a maximum output power of 20 brake horse power (BHP) at 3600 rpm was used for the investigations. The experiments were performed at two different BHP of 5.3 and 8.8. Due to the high freestanding resistance by the dynamometer, it was not possible to run the experiments at a higher load.

The gaseous emissions were measured with a Horiba PG-250 emission analyzer. The exhaust PM measurements were performed in two different methods. The first was a direct measurement with a TSI DusTrak aerosol monitor (Model 8520). The unit is supplied with three different inlet nozzles for different size particle measurements. For the present investigations, the 2.5 µm inlet nozzle was used.

The second method for PM measurements was using a dilution tunnel connected to a cyclone with a Teflo filter (Figure 1). The raw exhaust gas was transferred via the sampling pilot tube to the dilution tunnel via a heated transfer tube. The dilution tunnel was also supplied with filtered dry air equipped with temperature, pressure, and flow control sensors. Two stainless steel tubes of 0.635 cm ID were used for sampling the diluted flow downstream of the venturi. One tube was connected to the Horiba PG-250, and another to the cyclone. 47 mm Teflo filters as recommended in 40 CFR 1065 were used. The Teflo filters were conditioned (dried) in a uniform temperature at 72F inside a class 10,000 clean room for at least 24 hours both prior to and after the experiments before weight measurements. Weight measurements were performed with a Mettler-Toledo MT5 analytical microbalance, provided by the UCI laser center.

Figure 1. Dilution Tunnel and Horiba 250 Emission Analyzer

The humid air intake was generated using a Sunpentown humidifier (Model SU-2000) which injected mist to the intake air of the engine at a rate of 6.05 cm3/min at 70 F. The level of humidity at the engine air intake was measured with an Omega RH 32, temperature/humidity meter. A 60% relative humidity for the intake air could be maintained.

The electrostatic fog was produced with a newly designed L-shaped static generator rod connected to a variable voltage AC generator. Figure 2 shows the experimental set-up.

Figure 2. Mixing box

Status

The project has been completed in March 2013.

Results

Tables 1 and 2 show exhaust emissions and percent changes of NO_x and PM for the highest BHP with two different methods of PM measurements. These cases are:

C1. Raw exhaust (Exh),
C2. Exhaust with humid air system (Exh&Hum),
C3. Exhaust with exhaust fog scrubber (Exh&Fog),
C4. Humid air intake and exhaust fog scrubber (Exh&Hum&Fog),
C5. Exhaust with electrostatic fog scrubber (Exh&Fog&Elec), and finally
C6. Exhaust with humid air intake and electrostatic fog scrubber (Exh&Hum&Fog&Elec)

In table 1, the reduction in NO_x for C2, when humid air system was used was in excess of 24%, the highest among all cases studies. At this power, the combustion temperature was high and the humid air was effective in reducing the temperature, resulting in substantial reduction in the NO_x emission. Injecting fog into the exhaust resulted in nearly 20% NO_x reduction, followed by C5 at nearly 17%, C4 at about 13%, and finally C6 at slightly higher than 12%.

C2 was the only case with substantial reduction in PM (at slightly higher than 34%), when the humid air system was used. All the other cases showed increases in PM, even in the C3 experiment when fog was injected into the exhaust.

	rpm	Torque (N.m)	mf (lb/hr)	BHP (hp)	BSFC (lb/ hr-hp)	PM/ BSFC	NOx/ BSFC	% ΔPM/ Exh	% ΔNOx/ Exh
Exh	1754	20	3.31	8.77	0.38	113.20	259.07		
Exh&Hum	1758	20	3.97	8.79	0.45	74.30	196.28	-34.36	-24.24
Exh&Fog	1765	20	3.31	8.83	0.37	116.17	207.54	2.62	-19.89
Exh&Hum&Fog	1768	20	3.17	8.84	0.36	121.48	224.61	7.31	-13.30
Exh&Fog&Elec	1767	20	3.17	8.84	0.36	123.25	215.37	8.88	-16.87
Exh&Hum&Fog& Elec	1767	20	3.17	8.84	0.36	136.62	227.55	20.69	-12.17

Table 1. % Change in Emissions with Direct PM Measurements

In table 2, except for C2, all cases showed increases in PM emission with the highest being for C6, followed by C4, C3, and C5 respectively. For C2, there was substantial reduction in PM emission at nearly 40% which also corresponds to the highest rate of NO_x reduction at slightly higher than 51%. All other cases also displayed NO_x reduction with C3 being the next highest followed by the C6, C4, and C5 respectively. These trends were similar with the previous results when PM was measured directly with a TSI unit.

	rpm	Torque (N.m)	mf (lb/hr)	BHP (hp)	BSFC (lb/ hr-hp)	PM/ BSFC	NOx/ BSFC	% ΔPM/ Exh	% ΔNOx/ Exh
Exh	1754	20	3.31	8.77	0.38	232.42	114.72		
Exh&Hum	1758	20	3.97	8.79	0.45	139.76	55.78	-39.87	-51.38
Exh&Fog	1765	20	3.31	8.83	0.37	266.52	86.98	14.67	-24.18
Exh&Hum&Fog	1768	20	3.17	8.84	0.36	270.28	95.04	16.29	-17.15
Exh&Fog&Elec	1767	20	3.17	8.84	0.36	250.31	98.78	7.70	-13.89
Exh&Hum&Fog& Elec	1767	20	3.17	8.84	0.36	302.18	94.31	30.01	-17.79

Table 2. % Change in Emissions using Dilution Tunnel for PM Measurements

Benefits

Results of the present experiments have shown that the humid air system and exhaust fog scrubber with distilled water as the working fluid are viable options for reducing both NO_x and PM emissions in diesel engines.

Project Costs

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

Commercialization and Applications

Further steps are required for development of a portable adaptive system that can be incorporated in the existing and new diesel trucks for reducing NO_x and PM emissions.

SCAQMD Contract #09345 **April 2013**

Demonstrate Medium-Speed Neighborhood Electric Vehicles

Contractor

South Bay Cities Council of Governments (SBCCOG)

Cosponsor

SCAQMD

Project Officer

Lisa Mirisola

Background

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. Passenger cars and light trucks account for most of these emissions. In addition, there are increasing concerns over GHG emissions from these vehicles and petroleum dependence from the heavy use of conventional technologies. For many residents within the geographic boundaries of the SCAQMD, commutes and other daily trips can be accomplished solely on residential streets at speeds below 35 MPH.

Project Objective

This program was intended to promote neighborhood electric vehicles (NEVs) to residents, businesses and municipalities in the South Bay sub-region. The project objective was to answer these three questions:

1. Will South Bay residents drive NEVs to satisfy a portion of their travel needs without the infrastructure changes and driving culture that have provided support in the most successful NEV communities elsewhere?
2. Does the usage have the potential to produce significant environmental and economic benefits?
3. Is large scale deployment of NEVs (or LUVs) feasible?

Technology Description

A NEV is a zero emission vehicle that can be driven on public streets subject to being registered, having a Vehicle Identification Number (VIN), being insured and adhering to vehicle safety standards. In 1998, the National Highway Traffic Safety Administration (NHTSA) of the Federal Department of Transportation defined a street-legal Low Speed Vehicle (LSV) in the Code of Federal Regulations (Rule FMVSS 500). NEVs are recognized as a sub-class of LSVs, limited to a maximum speed of 25 MPH and restricted to streets with speed zones of 35 MPH or less. The "advancement" involved is learning how to stimulate a stalled market place for a technology that was originally commercialized about 20 years ago.

Figure 1: NEV Used in Study

Status

The active demonstration phase of the project was completed in December 2012. There were four main activities: 1) preparation (leasing vehicles, arranging insurance; acquiring and installing GPS, recruiting, and selecting and training participants); 2) active demonstration (51 households drove a NEV for 2 to 4 months each); 3) data processing and analysis (GPS generated a data point every minute each vehicle was "on" creating millions of geo-data points that were mapped, summarized in tables, and interpreted); and 4) reporting. Unanticipated problems included occasional

unreliability of the NEVs which led to a change in fleet composition about half way through the active demonstration; poorly maintained driver logs which required additional staff time to call drivers for interpretation; and more complex travel patterns and destinations which required more staff time to interpret and analyze.

Results

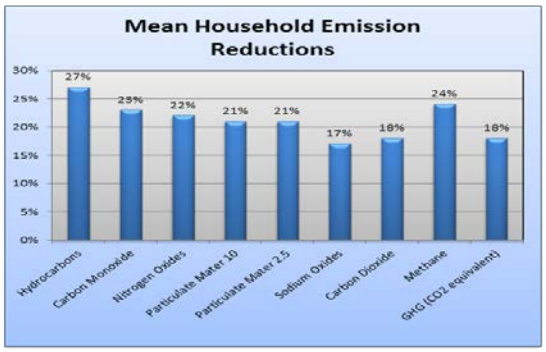


Figure 2: Mean Household Emission Reduction

The objectives did not involve any specific emissions reduction targets. Emissions reduction per household is one outcome the project sought to measure. However, the average household reductions in criteria pollutants and GHG emissions were surprisingly high compared to reasonable expectations.

Another of the objectives was to verify that drivers routinely used a NEV and accessed a wide range of destinations. NEV miles on average made up 19% of total household VMT. There were no performance tradeoffs. More NEV use resulted in greater reductions in criteria pollutants and GHG emissions reductions.

Benefits

The immediate benefits included giving a specialized, zero emission neighborhood vehicle a high level of public exposure, while producing environmental impacts that can help make the vehicle attractive to manufacturers and policy makers.

Potential benefits include the pollution reductions that are possible if all South Bay residents "right sized" their vehicles to suit their travel needs. That is assuming all trip segments less than 5 miles long, driven by South Bay residents in a zero emission neighborhood vehicle (approximately 1.7 billion of 43% of the VMT driven by South Bay residents) could be shifted from gasoline to EV propulsion technology. That is approximately 1 billion annual trip segments or 82% of all trip segments. That equates to a 59% reduction in private vehicle hydrocarbons, 52% reduction in carbon monoxide, 51% reduction nitrogen dioxide, 48% reduction in all particulate matter, 47% reduction in sodium oxides, and a 56% reduction in methane emissions. Overall, battery recycling will improve the net gains from widespread NEV use, although NEVs use relatively small onboard battery packs.

Project Costs

	Actual Cost (Including in-kind by SBCCOG)	**SCAQMD Project Budget**
Total	$311,807.02	$298,640.00
Labor	$175,757.74	$158,805.00
GPS	$10,497.19	$10,435.89
Insurance	$10,491.39	$11,336.11
Vehicle Acquisition	$105,517.52	$118,063.00
Vehicle Unplanned	$6,527.79	$ -
Other Expenses	$3,015.39	$ -

Commercialization and Applications

The South Bay Cities Council of Governments is planning a presentation specifically for the auto manufacturing industry to share the data that essentially establishes the existence of a short range, slow speed vehicle market in mature, compact suburbs such as the South Bay cities. Lessons learned about product quality and price will also be presented.

There are about 275,000 "secondary" vehicles driven by South Bay residents. Replacing them with NEVs and other ZEVs is the market target. The primary barrier to reaching that target is the public education to guide residents and businesses toward the ability to "right size" their vehicle choices. Most residents currently use too much automotive technology to make the 1-, 2-, and 3-mile trips that make up the majority of their average travel behavior.

SCAQMD Contract #10738 **June 2013**

Demonstrate Quick Charge Infrastructure for Electric Buses

Contractor
Foothill Transit

Cosponsors
ARRA (via FTA)
SCAQMD

Project Officer
Joseph Impullitti

Background
Transit buses are ideal applications for advanced, alternative energy technologies that address criteria pollutant and greenhouse gas emissions because they operate in highly visible, congested areas where air quality is a problem. Electric zero emission transit buses address these problems. Traditionally, the range and charging needs of batteries have been barriers to employ battery-powered buses in large scale applications. Additionally, the weight of traditional buses has made it difficult to feasibly incorporate a battery with sufficient power and energy storage capacity into coach designs. By using a smaller battery that can be charged quickly and repeatedly, the bus weight and cost can be reduced. The keys to quick charge electric bus technology are the utilization of a quick charge battery and quick charge infrastructure. The battery must be able to retain its energy reserve and charging profile over many charge-discharge cycles and be quick charged in ten minutes or less. The quick charge infrastructure must be able to deliver a large amount of energy in a short period of time and operate safely without human intervention because of the high voltage and associated heavy cables.

Project Objective
The objective of this demonstration is to determine the feasibility of quick charge electric buses and associated infrastructure in an established urban route. Foothill Transit replaced three diesel buses with Ecoliner electric buses with quick charge capability and quick charge infrastructure on an existing route from the City of La Verne to the City of Pomona.

Technology Description
Each 35-foot Proterra Ecoliner quick-charge electric bus can carry 37 passengers and were built with the following features:

- Composite body: lighter weight, longer life, less cost to maintain
- Battery (74 kWh): <10 minute recharge time, safe chemistry, tested>10,000 cycles
- Drive System: improved fuel economy, reduced noise, low maintenance, lower operating costs

The charging infrastructure was designed and built by AeroVironment with the following features:

- 500KW charger can rapid charge the battery from 10% to 95% in 10 minutes or less
- Unique architecture allows for lower cost and lower impact grid connections while maintaining high charge rates
- Safe overhead charge connection, no operator contact with charger

Status
The three buses are currently operating in revenue service on Foothill's 291 lines from La Verne to Pomona.

Figure 1: Ecoliner Bus Being Charged at Foothill Transit's Pomona Station

Results

All three Ecoliner buses are running in daily revenue service on line 291 from La Verne to Pomona. The three buses have accumulated nearly 175,000 in-service miles and Proterra data collection indicates overall energy efficiency is as good as or better than initially expected. The following characterizes the performance results of the demonstration:

- Total battery charge/discharge cycles: 22,406
- Battery capacity loss over 3 years: <2%
- Maintenance and Repair issues:
  - No propulsion or charging issues
  - Borg Warner transmission issue, replaced with Eaton transmission
  - Non power-train issues with fit & finish, doors and wheel chair lift
- Maintenance Cost Savings Over Diesel: Approximately $40K/year for 3 buses
- Fuel Economy Vs. Diesel:
  - Altoona test results: 17.5 to 29.2 mpg diesel equivalent
  - Fuel Economy: 1.5 – 2.0 kWh/mile
  - 40 foot diesel bus averages 3.8 mpg
  - Cost for 120 mile daily usage:
    - Ecoliner - $36 ($0.15/kWh)
    - Diesel - $126 ($4.00/gal)

Benefits

Foothill Transit believes that quick charge battery electric vehicles will be a solution that will create a paradigm shift for transit fleets because:

- Ability to use battery-electric vehicles as a one-to-one replacement of a conventionally driven vehicle
- Lower energy requirements – smaller battery means lower cost lower weight, improved efficiency, and the battery can accept a high rate of charge so regeneration from braking is increased.

According to CARB, a reduction of 0.47 tons of criteria pollutants and 77.3 tons of GHG's per bus per year is realized. If Foothill Transit were to meet the ZBUS regulation with 15% of their fleet converted to electric, the benefits would be 22.4 tons of criteria pollutants and 3,600 tons of GHG emission reductions.

Project Costs

SOURCE	CONTRIBUTION	PERCENT
ARRA (via FTA)	$4,770,000	94%
SCAQMD	$290,000	6%
TOTAL	$5,060,000	100%

Commercialization and Applications

Foothill Transit became the first transit agency in the U.S. to use on-route charge electric buses. The Proterra buses are 72% plus Buy America content and qualify for FTA funding. The agency is purchasing an additional 12 buses from Proterra to completely electrify its 291 route between La Verne and Pomona. Cost per bus is $990K which is a 25% reduction compared to the first three buses that cost $1.2M per bus. The new buses will have improvements to Fit & Finish, new doors, new seating layout and the same power-train and batteries which have performed well for Foothill. Nine of the twelve buses will be assigned to the 291 Route and 3 buses will be assigned to other routes in Foothill Transit's territory.

SCAQMD Contract #12024 **May 2013**

Upgrade & Install Electric Charging Infrastructure

Contractor
ECOtality

Cosponsor
SCAQMD

Project Officer
Patricia Kwon

Background

There are approximately 1,800 PEV chargers in need of upgrading in the South Coast Air Basin. These sites are ideal locations to upgrade electrical vehicle service equipment (EVSE) for Level 2 charging at a lower cost than to install EVSE at new site locations. Leveraging the DOE and/or CEC funding, SCAQMD executed a contract with ECOtality to install new or upgraded Level 2 EVSE at high usage site locations identified by SCAQMD and ECOtality. ECOtality received DOE and CEC funding to pay for hardware and partial installation costs for Level 2 EVSE 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.

Project Objective

SCAQMD executed a contract with ECOtality to leverage DOE and CEC support for installation of Level 2 EVSE as part of The EV Project, a national project for installation of EVSE in key markets. ECOtality upgraded existing EVSE which were obsolete and installed new EVSE. ECOtality submitted a list of approved sites. As part of the SCAQMD program, ECOtality dedicated full time resources to identify potential site hosts eligible for replacement of obsolete units.

ECOtality completed installation 47 of the planned 70 EVSE. Some costs are in excess of $1,000, with those costs were supplemented by The EV Project funding and/or the site hosts. Using the approved site list for sites with obsolete equipment proved challenging. For a three month period, ECOtality had a full-time staff person contact site hosts and owners of obsolete EVSE to assess replacement opportunities. With little progress, ECOtality assigned additional staff and regional management to make contact to a larger approved list. From January 2011 to March 2012, these employees were largely unable to secure approval for replacement of obsolete EVSEs. Some significant challenges encountered were:

- Site hosts did not understand or recognize that the site had EVSE
- Site hosts felt the new EVSE was another passing fad
- Site hosts felt obsolete equipment was not used and new EVSE would be under utilized
- Site hosts felt the EVSEs offered little benefit to their business
- Site hosts did not believe enough PEVs existed to support the replacement of EVSE
- Site hosts did not want to enter into business agreements

After attempting to improve contact and replacement of obsolete EVSE through the use of experienced skilled sales and support staff, ECOtality approached SCAQMD to request approval of funds to contribute to new sites. By agreement, ECOtality followed the same procedures for submission to SCAQMD and provided site locations for approval or denial. These new installations accounted for 68% of the replacements and contributed to additional EVSE installations. Some prominent locations included LA Live Staples Center, Loyola Marymount University, University of Southern California, and Fox Studios. Other sites who received SCAQMD funding included local small businesses, hotels, marketplaces, and commercial developments. All sites are publicly accessible during business hours. For instance, Staples Center EVSEs may only be available during official events.

Technology Description

Level 2 EVSE with J1772 connectors were installed. The largest challenge for construction of ground-mount EVSE units included the style of EVSE. Because the Blink EVSE utilizes a concrete base; post-mounted EVSE and foundations were not compatible with the Blink unit. This typically required additional construction to facilitate the installation of the new EVSE. As a requirement for new construction and electrical work, permits were required and obtained for projects. There were no significant issues presented with permitting of replacement units.

Status

ECOtality declared bankruptcy in late 2013 and was unable to complete all 70 Level 2 EVSE installations. CarCharging Group assumed control of ECOtality's assets in late 2013 and is the process of communicating with site hosts in The EV Project to determine their future status starting in 2014. The EV Project has been recently extended by DOE to April 2014.

Figure 1: Blink EVSE

Results

ECOtality's Level 2 EVSE installations are shown in the following map:

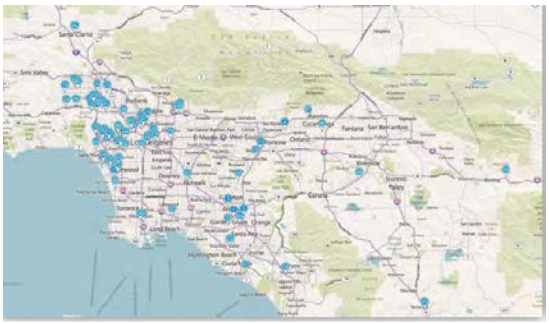


Figure 2: Ecotality's Level 2 EVSE Installations

Source: http://prod.blinknetwork.com/blinkMap.html

Benefits

This project will assist in advancing PEV readiness in California by creating additional public access charging that is convenient and affordable for PEV drivers.

Project Costs

EV infrastructure hardware and installation costs were through DOE and CEC funding from The EV Project, and remaining installation costs were cost shared between The EV Project and the site owner. SCAQMD funding provided $1,000 per EVSE towards installation costs for a total of $70,000.

Commercialization and Applications

Level 2 EVSE is currently commercially available, with installations worldwide. The EV Project installed about 370 Level 2 EVSE in the greater Los Angeles region, with SCAQMD funding contributing towards 70 of those installations.

SCAQMD Contract #10650 **June 2013**

Demonstrate Advanced Fuel Cell Bus (American Fuel Cell Bus)

Contractor

SunLine Transit Agency

Cosponsors

Dept. of Transportation/FTA
CARB
SCAQMD

Project Officer

Joseph Impullitti

Background

FTA's National Fuel Cell Bus Program (NFCBP) includes an international network of technology developers, suppliers and experts in the area of zero emission buses and enabling technology. Periodic reviews and reports on the status of the NFCBP will provide the SCAQMD with available data that may reflect on the commercial readiness of ZBuses and enabling technology.

Project Objective

The intent of this project is the development of a new design fuel cell bus with a North American chassis as well as domestically sourced fuel cell and drive components. Success in this program will ensure availability of a U.S. built product that can offer transit properties the opportunity to buy buses through the FTA capital program. Specifically, the program commercial focus anticipates that the resulting fuel cell bus product would be built and sold profitably at a price of under $2 million. Also, there is an expectation that extended warranties for the fuel cell and battery pack can be attained, further driving down the warranty costs through significantly longer operating lives than the 2005 generation fuel cells and batteries. Body / chassis weight and noise reductions will maximize the number of passengers each fuel cell bus can accommodate while also maximizing the passengers' level of comfort. Packaging the latest generation fuel cell-hybrid drive system into a physically attractive bus with contemporary styling, and which features sufficient U.S. derived content to meet FTA "Buy-America" provisions is very important. Finally, the vehicle will include new power electronics, advanced energy storage and a unique hi-efficiency accessory electronics package.

Technology Description

BAE Systems based the American Fuel Cell Bus (AFCB) propulsion system on its commercial hybrid electric transit bus product, which is operating in buses around the world. For the AFCB, the system was modified to provide power with the Ballard fuel cell system in place of a diesel engine/generator. Ballard's 150 kW fuel cell incorporates the latest advances for durability and efficiency based on numerous field demonstrations of Ballard fuel cell powered buses. The AFCB also incorporates a suite of electric accessories powered by BAE Systems' Accessory Power System.

Status

In accordance with the project plan, the vehicle entered revenue service on December 7, 2011 and completed the one year demonstration phase on December 6, 2012. The bus is continuing in daily revenue service and data provided in this report will be through the end of December 2012. Over the one-year demonstration period, the bus amassed over 36,000 miles and nearly 40,000 miles by the end of December 2012.

Figure 1: AFCB

Results and Benefits

During the evaluation period, the AFCB has achieved exceptional availability, averaging 85 percent. The issues causing downtime were most often related to general bus system items rather than the advanced technologies that were the focus of the demonstration. These issues were generally of a "low tech" nature and consistent with the type of issues that would be expected when introducing a new configuration in a prototype bus model. Overall, the AFCB averaged 6.54 miles per kilogram of hydrogen, which equates to 7.39 miles per diesel gallon equivalent (DGE). Using the gasoline gallon equivalent (GGE) fuel economy of the CNG buses as a baseline, the AFCB had a fuel economy 2.4 times higher than that of the CNG buses.

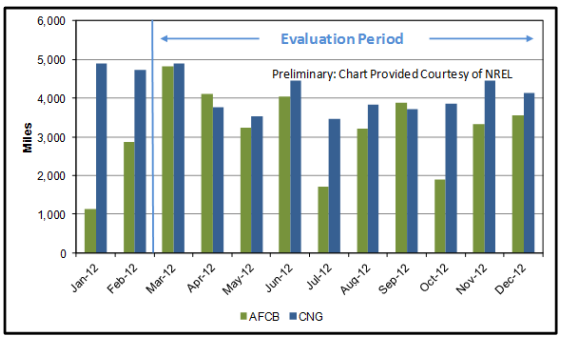


Chart 1: Fuel Cell Bus Miles compared to CNG Reference Fleet

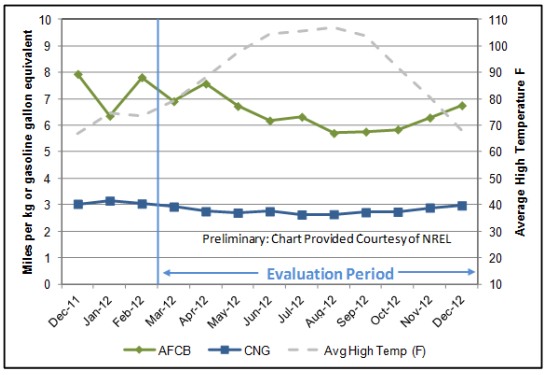


Chart 2: Fuel Economy Summary

Each of the project team members report that the demonstration has gone well and all are pleased with the performance of the AFCB. BAE Systems reports that the performance of the bus matched or exceeded their expectations. SunLine notes that the bus procurement and development process went well and the AFCB start-up issues were much fewer than with previous fuel cell electric buses.

Project Costs

The total project cost was $10,214,877, as follows:

- FTA/CalStart ($4,197,955)
- CARB ($800,000)
- SCAQMD ($400,000)
- BAE ($4,152,450) - in-kind
- SunLine/ElDorado ($664,438) - in-kind

Commercialization and Applications

For fuel cell electric buses to be fully commercialized, the fuel cell hybrid propulsion system needs to be an option offered by the bus OEM in response to increased market demand, as is the case with current diesel hybrid systems. Hybrid buses are currently offered by most OEMs, which order and install the propulsion system at the bus manufacturing plant. BAE Systems' role is as supplier and integrator of propulsion and electric power systems that enable the capability offered by the OEM. In the case of the AFCB project, the integrator and transit agency have taken the lead role in developing the bus. This role needs to transition to the bus OEM for the technology to be fully adopted.

SCAQMD Contract #10714 **December 2013**

Develop Fuel Cell Gas-Turbine Hybrid System for On-Board Locomotive Applications

Contractor

University of California, Irvine

Cosponsors

CARB
SCAQMD

Project Officer

Dipankar Sarkar

Background

Transportation of freight via rail is ubiquitous within the logistics system of both California and the United States. While the system provides a necessary service and has a major positive effect on the economy, its benefits are coupled to serious environmental and health concerns due to the combustion of diesel fuel in conventional locomotives. The burden of these negative effects is disproportionately placed on those who live closest to operational centers for the locomotives. Thus, there exists a need to develop a power system for the locomotives (and in the long-term, other diesel-burning vehicles) that avoids a major portion of the emission of deleterious CO_2, NO_x, and diesel particulate matter. While major development has been underway to develop reciprocating engines or post-combustion technologies to address the issue, it may be an advantage to utilize a fundamentally more efficient and cleaner prime mover technology. The Solid Oxide Fuel Cell-Gas Turbine (SOFC-GT) is proposed as a candidate for this purpose. The SOFC-GT, though still in the early stages of development, has proven to have high-efficiency operation with exceedingly low emissions of CO_2 and NO_x. This work evaluates the system's capability to satisfy the requirements of the locomotive application and the rail industry's expectations.

Project Objectives

The objectives of the project are to (1) develop and implement a proof-of-concept system analysis for a SOFC-GT hybrid power block for long-haul locomotive applications, and (2) establish a conceptual design for a real world demonstration.

Technology Description

In this work, the system is based on the recuperated Brayton cycle, with the SOFC and turbine in the topping cycle configuration. Just as in the recuperated Brayton cycle, the heat exchanger in this work's baseline serves to preheat the air prior to entry to fuel cell, with the intent of supporting a high fuel cell operating temperature so that high power densities can be maintained and losses are at a minimum. In addition, it is assumed that the outlet temperature of the fuel cell will not be high enough to support the turbine inlet temperature requirements. Moreover, control of the turbine's operating temperature is necessary for overall system control. Thus, the system also includes a combustor between the fuel cell and turbine to meet both these needs. The system has a single turbine.

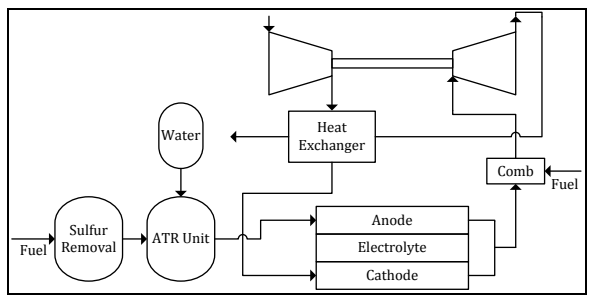


Figure 1: SOFC-GT Baseline System Layout

Status

This project has been completed including the submission of a final report. The project has resulted in the successful development and execution of the simulation model for the SOFC-GT locomotive. The analysis, executed to assess performance when operating on hydrogen, liquefied natural gas and diesel fuels along a representative route through the Cajon Pass, demonstrates the viability of the technology and establishes a conceptual design for a real world demonstration.

Results

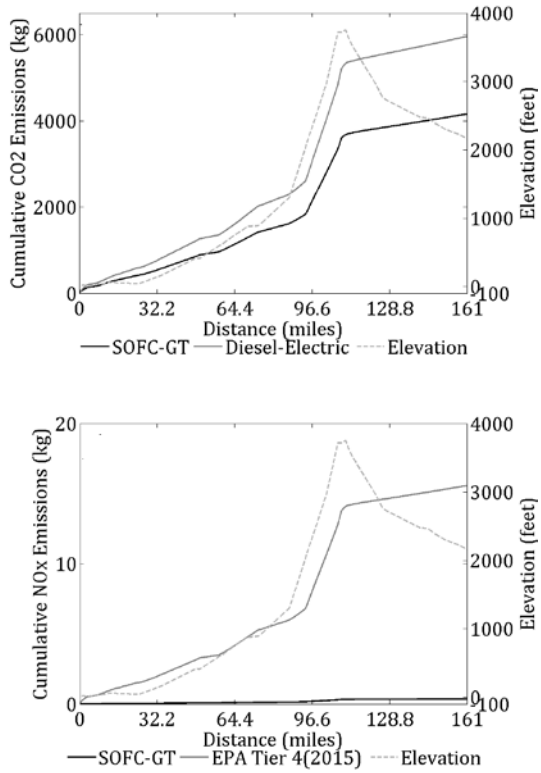


Figure 2: Emissions Comparison between SOFC-GT and Diesel-Electric Systems

Along a typical operating route, an SOFC-GT locomotive fueled by diesel fuel can experience average system efficiency of 52.2%, thereby saving 30.3% of CO_2, and 97.7% of NO_x emissions; a natural gas-fueled system offers average system efficiency of 60%, CO_2 savings of 53.8%, and NO_x savings of 97.7%. For these systems, the integration of the reformer onboard provided an increase in efficiency over the option of offboard reformation; a 7-point gain was observed for diesel and a 12-point gain observed for natural gas. In terms of durability, it was observed that constant rated-power operation could induce a degradation rate of 0.75% per hour, much too high for commercial viability as full deactivation of the SOFC would occur in only 300 hours. However, degradation over a typical route was small enough to be reversible. Furthermore, with a carbon mitigation strategy such as an anode barrier layer applied to only half of the cell, degradation rates could be as low as 0.02% to 0.05% per hour, approaching viability if regenerative cycles are considered a regular part of system maintenance.

It was concluded that the SOFC-GT system is capable of replacing the conventional diesel engine. Adoption of a system operating on diesel would be relatively difficult due to limitations of durability and space available onboard for storing of the water required for reformation. In addition, the degradation issue may be avoided with as little as 100 anode oxidation regenerative cycles over a prime mover lifetime of 100,000 hours of operation. Reformates generated off-board, natural gas reformed onboard and humidified hydrogen were established as viable fuel options, all of which provided even greater efficiency and emissions benefits than the diesel case. The natural gas-fueled system with the fuel reformed onboard proved to be the most efficient option. The hydrogen case would provide for zero emission operation at the locomotive but life-cycle emission dependent on the hydrogen source.

Benefits

The SOFC-GT system has the potential to all but eliminate locomotive NO_x emissions, reduce CO_2 emissions between 30% and 60% based on fuel choice, correspondingly increase fuel efficiency and thereby substantially reduce operating costs, and reduce local noise levels and deleterious air quality impacts in areas of high rail activity.

Project Costs

The cost of the project was $156,000, co-funded by CARB at $78,000 and the SCAQMD at $78,000. The project was completed within budget.

Commercialization and Applications

It was determined that the space (footprint and volume) allocated today for the diesel engine on conventional locomotives is sufficient, and the dynamic response for the proposed SOFC-GT system is satisfactory. The next step is to design and conduct a demonstration of the SOFC-GT power block on an experimental rail platform. The advent of domestically sourced natural gas and the growing interest of railroad companies to transition from diesel to natural gas suggest an implementation strategy with natural gas, circumventing altogether the exploration of fueling the SOFC-GT power block with diesel.

SCAQMD Contract #13113 **January 2013**

Participate in California Fuel Cell Partnership for CY 2012 & Provide Support for Regional Coordinator

Contractor

Bevilacqua-Knight Inc

Cosponsors

8 automakers; 2 energy providers; 6 government agencies; 1 technology provider; and 17 associate members

Project Officer

Lisa Mirisola

Background

Established with eight members in 1999, the California Fuel Cell Partnership (CaFCP) is a collaboration in which private and public entities are independent participants. It is not a joint venture, legal partnership or unincorporated association. Therefore, each participant contracts with Bevilacqua-Knight, Inc. for their portion of CaFCP administration. SCAQMD joined the CaFCP in April 2000, and the CaFCP currently includes 34 organizations interested in demonstrating fuel cell vehicle and fueling infrastructure technology.

Project Objective

There were several goals for 2012:

- Establish and maintain a common vision for the market transition of FCVs in California;
- Facilitate the deployment of commercial fueling stations and coordinate with OEM vehicle plans;
- Support practical codes and standards development;
- Prepare communities for vehicles and fueling stations, and train first responders;
- Coordinate with other fuel cell vehicle demonstration programs worldwide; and
- Enhance public awareness and understanding through technology demonstrations and outreach.

Status

The members of the CaFCP intend to continue their cooperative demonstration efforts and have set goals through 2012, subject to a budget approved annually. This final report covers the SCAQMD Contract #11656 for 2012 membership. This contract was completed on schedule.

Figure 1: Fuel Cell Vehicles on Display at Local Event

Technology Description

The CaFCP members together or individually are demonstrating fuel cell passenger cars and transit buses and associated fueling infrastructure in California. The passenger cars include Daimler's B Class F-CELL, GM's Chevy Fuel Cell Vehicle, Honda's FCX Clarity, Hyundai's Tucson, Nissan's XTrail, and Toyota's FCHV-*adv*. The fuel cell transit buses include 12 placed at AC Transit (Van Hool buses with UTC fuel cells) and 3 placed at Sunline Transit (1 UTC/ISE, and 1 Ballard/New Flyer, and 1Ballard/BAE). Proterra has also placed a battery dominant FC hybrid bus at the City of Burbank and Hydrogenics/BAE has placed one bus with SF MTA.

Results

Specific accomplishments include:

- Automotive members placed over 400 fuel cell passenger vehicles on California roads from 1999 through 2012, including the first retail customers starting in 2005;

- Transit agency members have demonstrated 20 fuel cell buses since 1999, with 15 currently in operation (see technology description);
- There are eight public hydrogen fueling stations in operation in California. There are also 15 additional private stations clustered in regional networks in northern and southern California;
- CaFCP staff and members continue to train local fire departments and work with emergency response organizations to coordinate with state and national efforts;
- CaFCP organized or participated in several ride & drive events, notably Santa Monica AltCar Expo.
- CaFCP continued to upgrade its comprehensive up-to-date website focusing on efforts in California, participated in technical and educational conferences, and helped prepare for hydrogen station openings.

Benefits

Compared to conventional vehicles, fuel cell vehicles can offer zero or near-zero smog-forming emissions, reduced water pollution from oil leaks, higher efficiency and much quieter and smoother operation. If alternative or renewable fuels are used as a source for hydrogen, fuel cell vehicles will also encourage greater energy diversity and lower greenhouse gas emissions (CO_2).

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

Project Costs

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

Commercialization and Applications

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

From 2010 to 2012, CaFCP's goals relate to Building Market Foundations through coordinated individual and collective effort. In 2013, CaFCP will start its fourth phase with activities to launch the commercial market. During this phase, CaFCP members, individually or in groups, will focus on important goals.

- Prepare for larger-scale manufacturing, which encompasses cost reduction, supply chain and production.
- Work on the customer channel, including identifying and training dealers and service technicians.
- Reduce costs of station equipment, increase supply of renewable hydrogen at lower cost, and develop new retail station approaches.
- Support cost reduction through incentives and targeted RD&D projects
- Continue research, development and demonstration of advanced concepts in renewable and other low-carbon hydrogen.
- Provide education and outreach to the public and community stakeholders on the role of FCEVs and hydrogen in the evolution to electric drive.

SCAQMD Contract #14054 **December 2013**

Participate in California Fuel Cell Partnership for CY 2013 & Provide Support for Regional Coordinator

Contractor

Bevilacqua-Knight Inc

Cosponsors

8 automakers; 6 government agencies; 1 technology provider; and 19 associate members

Project Officer

Lisa Mirisola

Background

Established with eight members in 1999, the California Fuel Cell Partnership (CaFCP) is a collaboration in which private and public entities are independent participants. It is not a joint venture, legal partnership or unincorporated association. Therefore, each participant contracts with Bevilacqua-Knight, Inc. for their portion of CaFCP administration. SCAQMD joined the CaFCP in April 2000, and the CaFCP currently includes 34 organizations interested in demonstrating fuel cell vehicle and fueling infrastructure technology.

Project Objective

There were several goals for 2013:

- Establish and maintain a common vision for the market transition of FCVs in California;
- Facilitate the deployment of commercial fueling stations and coordinate with OEM vehicle plans;
- Support practical codes and standards development;
- Prepare communities for vehicles and fueling stations, and train first responders;
- Coordinate with other fuel cell vehicle demonstration programs worldwide; and
- Enhance public awareness and understanding through technology demonstrations and outreach.

Status

The members of the CaFCP intend to continue their cooperative demonstration efforts and have set goals through 2016, subject to a budget approved annually. This final report covers the SCAQMD Contract #14054 for 2013 membership. This contract was completed on schedule.

Figure 1: DOE Solar Decathlon, Irvine CA

Technology Description

The CaFCP members together or individually are demonstrating fuel cell passenger cars and transit buses and associated fueling infrastructure in California. The passenger cars include Daimler's B Class F-CELL, GM's Chevy Fuel Cell Vehicle, Honda's FCX Clarity, Hyundai's Tucson, Nissan's XTrail, and Toyota's FCHV-*adv*. The fuel cell transit buses include 12 placed at AC Transit (Van Hool buses with UTC fuel cells) and 3 placed at Sunline Transit (1 UTC/ISE, and 1 Ballard/New Flyer, and 1Ballard/BAE).

Results

Specific accomplishments include:

- Automotive members placed over 500 fuel cell passenger vehicles on California roads from 1999 through 2013, including the first retail customers starting in 2005;
- Transit agency members have demonstrated 24 fuel cell buses since 1999, with 15 currently in operation (see technology description);
- There are ten public hydrogen fueling stations in operation in California. There

are also 15 additional private stations clustered in regional networks in northern and southern California;

- CaFCP staff and members continue to train local fire departments and work with emergency response organizations to coordinate with state and national efforts;
- CaFCP organized or participated in several ride & drive events, notably Santa Monica AltCar Expo.
- CaFCP continued to upgrade its comprehensive up-to-date website focusing on efforts in California, participated in technical and educational conferences and helped prepare for hydrogen station openings.

Benefits

Compared to conventional vehicles, fuel cell vehicles can offer zero or near-zero smog-forming emissions, reduced water pollution from oil leaks, higher efficiency and much quieter and smoother operation. If alternative or renewable fuels are used as a source for hydrogen, fuel cell vehicles will also encourage greater energy diversity and lower greenhouse gas emissions (CO_2).

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

Project Costs

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

Commercialization and Applications

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

From 2013 to 2016, CaFCP's goals relate to Preparing for Market Launch through coordinated individual and collective effort. During this fourth phase, CaFCP members, individually or in groups, will focus on important goals.

- Prepare for larger-scale manufacturing, which encompasses cost reduction, supply chain and production.
- Work on the customer channel, including identifying and training dealers and service technicians.
- Reduce costs of station equipment, increase supply of renewable hydrogen at lower cost, and develop new retail station approaches.
- Support cost reduction through incentives and targeted RD&D projects
- Continue research, development and demonstration of advanced concepts in renewable and other low-carbon hydrogen.
- Provide education and outreach to the public and community stakeholders on the role of FCEVs and hydrogen in the evolution to electric drive.

SCAQMD Contract #13256 **December 2013**

Develop, Initiate and Implement Clean Vehicle Outreach Project

Contractor

Three Squares, Inc. (TSI)

Cosponsor

SCAQMD

Project Officer

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 is insufficiently educated and often times misinformed about the costs and benefits of such vehicles.

Project Objective

TSI was contracted to coordinate an outreach campaign designed to retool existing SCAQMD programs to include and expand the current efforts to focus some or all of the messaging aspects, where appropriate, in the near-term on clean and high efficiency vehicles. These efforts will be included under a newly badged Clean Air Choices (CAC) program, which will provide an umbrella platform to promote all of the SCAQMD clean air technology activities in the future, such as low-VOC paints and solvents, electric lawn and garden equipment, air filters, low NO_x boiler and aftertreatment technologies, as well as clean vehicles.

Analyzing the list of current clean vehicle outreach events in the South Coast Air Basin, the project team selected several events to conduct in person outreach and live demonstrations of the Clean Vehicle Calculator. TSI also coordinated displays with iPads and custom branded handouts featuring the Clean Air Choices Program Logo.

Technology Description

After several meetings with SCAQMD staff discussing the vision for the 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, Droid, BlackBerry), TSI developed the "Clean Vehicle Calculator" and launched the site http://www.cleancarchoices.org.

In order to facilitate ease of use and updating of the calculator data (new vehicle models, smog scores, MSRP, and dealer assignments), TSI developed a Content Management System (CMS) to allow SCAQMD staff to make updates directly via a web-based portal. SCAQMD staff was briefed and trained on using the CMS.

Figure 1: Image of Calculator CMS Interface

Status

The Clean 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 web site located at http://www.cleanairchoices.org. The CMS is fully functional via a web-based portal and SCAQMD staff have user logins and passwords.

TSI conducted outreach activities at the following events located in the South Coast Air Basin:

- September 20, 2012
  Senior Clean Air Fair - Los Angeles, CA
  September 20, 2013
  AltCar Expo – Santa Monica, CA
- September 28, 2013
  Plug-In Day at the SCAQMD – Diamond Bar, CA

Figure 2: Clean Vehicle Calculator iPad demonstration at AltCar Expo

Results

The CMS was launched prior to the AltCar Expo which allowed updating of the calculator to include the new 2013 clean vehicle models. SCAQMD staff has been trained and will be able to enter the new 2014 clean vehicle models as soon as the vehicle list is available.

TSI staff interacted with attendees both as they visited the SCAQMD booth and while roaming around the event venues. Because of the portability of the handheld iPad, outreach staff was able to interact with attendees waiting in line for the ride and drive and demonstrate the Clean Vehicle Calculator. In addition, TSI staff visited with other exhibitors to inform them about the free online calculator and walk them through a live demonstration.

Benefits

The Clean 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 following costs were associated with the tasks outlined in the scope of work:

Task 1 – Customized Content Management System = $9,500

Task 2 – Clean Air Choices Outreach = $12,000

The total contract award was $21,500; however, the final budget was $16,901.

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 vehicles and clean home choices to residents in the South Coast Air Basin.

The Clean Vehicle Calculator will continue to be updated with new vehicle models as they are added to the SCAQMD Clean 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 like 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
CE-CERT—College of Engineering – Center for Environmental Research and Technology
CEMS—continuous emission monitoring system
CFD—computational fluid dynamic
CNG—compressed natural gas
CO_2—carbon dioxide
CO—carbon monoxide
CRT—continuously regenerating technology
DC—direct connection
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
EGR—exhaust gas recirculation
EPRI—Electric Power Research Institute
ESD—emergency shut down
EV—electric vehicle
FCV—fuel cell vehicle
FTA—Federal Transit Administration
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)
HDDT—highway dynamometer driving schedule
HDV—heavy-duty vehicle
HEV—Hybrid electric vehicle
HPDI—High Pressure Diesel Injection
HT—high throughput
HTPH—high throughput pretreatment and enzymatic hydrolysis
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
LSV—low-speed vehicle
MATES—Multiple Air Toxics Exposure Study
MECA—Manufacturers of Emission Controls Association
MPFI—Multi-Port Fuel Injection
MPG—miles per gallon
MSRC—Mobile Source Air Pollution Reduction Review Committee
MSW—municipal solid wastes
MY—model year
MTA—Metropolitan Transportation Authority (Los Angeles County "Metro")
NAFA—National Association of Fleet Administrators
NCP—nonconformance penalty
NEV—neighborhood electric vehicles
NGV—natural gas vehicle
NHTSA—Natural Highway Traffic Safety Administration
NMHC—non-methane hydrocarbon
NO—nitrogen monoxide
NO_2—nitrogen dioxide
NO + NO_2—nitrous oxide
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

LIST OF ACRONYMS (cont'd)

PPM—parts per million
RDD&D—research, development, demonstration, and deployment
RFS—renewable fuel standards
RI—reactive intermediates
RRC—rolling resistance co-efficient
RTA—Riverside Transit Agency
SBCCOG— South Bay Cities Council of Governments
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
SoCalGas—Southern California Gas Company (A Sempra Energy Utility)
SULEV—super ultra-low emission vehicle
TC—total carbon
THC—total hydrocarbons
TO—task order
UDDS—urban dynamometer driving schedule
U.S.EPA—United States Environmental Protection Agency
ULEV—ultra low emission vehicle
VMT—vehicle miles traveled
VOC—volatile organic compounds
WVU—West Virginia University
ZEV—zero emission vehicle