Technology Advancement Office

Clean Fuels Program
2005 Annual Report and 2006 Plan Update

South Coast Air Quality Management District

March 2006

Cleaning the air that we breath...™

South Coast Air Quality Management District

Governing Board

Chairman

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

Vice Chairman

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

County Representatives

Michael D. Antonovich
Supervisor, Los Angeles County

James W. Silva
Supervisor, Orange County

Gary Ovitt
Supervisor, San Bernardino County

Cities Representatives

Jan Perry
Councilmember, City of Los Angeles
Los Angeles County, Western Region

Beatrice J.S. LaPisto-Kirtley
Mayor, City of Bradbury
Los Angeles County, Eastern Region

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

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

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

State Representatives

Jane W. Carney
Senate Rules Committee Appointee

Cynthia Verdugo-Peralta*
Governor's Appointee

Executive Officer

Barry R. Wallerstein, D.Env.

*Technology Committee Members **Technology Committee Chairman

South Coast Air Quality Management District
Technology Advancement Office

Chung S. Liu, D.Env., Deputy Executive Officer, Science & Technology Advancement
Henry Hogo, Assistant Deputy Executive Officer, Science & Technology Advancement

Gary Dixon, Special Technologies Project Manager
Larry Kolczak, Community Relations Manager
Fred Minassian, Technology Implementation Manager
Matt Miyasato, Ph.D., Technology Demonstrations Manager
Dean Saito, Mobile Source Strategies Manager
Paul Wuebben, Clean Fuels Officer

Naveen Berry, Program Supervisor
Michael Bogdanoff, Program Supervisor
David Coel, Program Supervisor
Connie Day, Program Supervisor
Ranji George, Program Supervisor
Marty Kay, Program Supervisor
Dipankar Sarkar, Program Supervisor
Larry Watkins, Program Supervisor

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

Phil Barroca, P.E., Air Quality Specialist
Suresh Chaurushiya, Air Quality Specialist
Mark Coleman, Air Quality Specialist
Larry Irwin, Air Quality Specialist
Von Loveland, Air Quality Specialist
Lisa Mirisola, Air Quality Specialist
Adewale Oshinuga, Air Quality Specialist
Shashi Singeetham, Air Quality Specialist
Vicki White, Air Quality Specialist
Vasken Yardemian, Air Quality Specialist

Geri Bowen, Staff Specialist

Dory Kilgour, Senior Administrative Secretary
Drue Ramirez, Senior Administrative Secretary
Penny Shaw Cedillo, Secretary
Majorie Eaton, Secretary
Donna Vernon, Secretary
Lani Montojo, Staff Assistant
Michelle White, Contracts Assistant
Flor Tumambing, Senior Office Assistant

Other Staff Contributors
Jean Ospital, Ph.D., Health Effects Officer, Planning, Rule Development & Area Sources
Joe Cassmassi, Planning & Rules Manager, AQMP/Special Projects

Table of Contents

Appendix A

Appendix B

Appendix C

Figures

Tables

EXECUTIVE SUMMARY

2005 Annual Report

The South Coast Air Quality Management District (SCAQMD) executed 61 new projects, studies or amended contracts during Calendar Year (CY) 2005 to sponsor research, development, demonstration and deployment (RDD&D) and commercialization of alternative fuel and clean fuel technologies in Southern California. Table 2 (page 17) and Table 3 (page 20) list projects which are further described in this report. The SCAQMD contributed $12.7 million towards such projects in partnership with other government organizations, private industry, academia and research institutes, and interested parties, with total project costs of $38.6 million. These projects addressed a wide range of issues and opportunities with a diverse mix of advanced technologies. The areas of technology advancement include the following:

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

During CY 2005, the AQMD supported a variety of projects and technologies, ranging from near-term to longer-term research, development, demonstration, and deployment activities. This "technology portfolio" strategy provides the AQMD the ability and flexibilty to leverage state and federal funding while also addressing the speciic needs of the South Coast Air Basin. Projects in CY 2005 included expansion of the hydrogen re-fueling infrastructure with hydrogen internal combustion engine vehicles, deployment of natural gas vehicles, and the development of plug-in hybrid vehicles. The AQMD also executed two conventional fueled projects to advance low-emission, heavy-duty diesel engines to meet the 2010 federal standards.

Eleven research, development, demonstration and deployment projects or studies, 23 technology assessment or outreach projects, and 4 incentive projects were completed in 2005, as listed in Table 4 (page 43). Summaries for each technical project completed in 2005 are included in Appendix C. 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, 2006, after approval by the SCAQMD Governing Board.

2006 Plan Update

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

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

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

The oxides of nitrogen (NO_x), volatile organic compounds (VOC), and particulate matter (PM) emission sources of greatest concern are heavy-duty on-road vehicles, light-duty on-road vehicles, and off-road equipment. The Plan Update includes projects to develop, demonstrate, and commercialize a variety of technologies, from near term to long term, that are intended to provide solutions to the emission control needs identified in the AQMP.

CLEAN FUELS PROGRAM

Introduction

The Basin, which is comprised of the Los Angeles, Orange, San Bernardino, and Riverside counties, has some of 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:

- 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;
- 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;
- 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;
- 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.

This report summarizes the progress of the SCAQMD Clean Fuels Program for Calendar Year (CY) 2005. This SCAQMD program cosponsors projects to develop, demonstrate, and expedite the implementation and deployment of low-emission clean fuels and advanced 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, 2005, the SCAQMD executed 61 projects or studies and amended contracts that support clean fuels and advanced low-emission technologies. The SCAQMD contribution for these projects was $12.7 million, with total project costs of $38.6 million. These projects address a wide range of issues with a diverse technology mix. This report highlights achievements of the SCAQMD Clean Fuels Program in this period, summarizes project costs, and outlines future plans for the Program.

The Need for Advanced Technologies & Clean Fuels

Achieving federal and state clean air standards in Southern California will require emission reductions from both mobile and stationary sources beyond those expected using current technologies. The need for advanced technologies and clean fuels is best demonstrated by considering the emissions inventory for the Basin and the future emissions levels projected in the 2003 Air Quality Management Plan (AQMP). The baseline 2010 emissions inventory is shown in Figure 1. Based on the 2003 AQMP, significant reductions are necessary to demonstrate attainment with the federal standards.

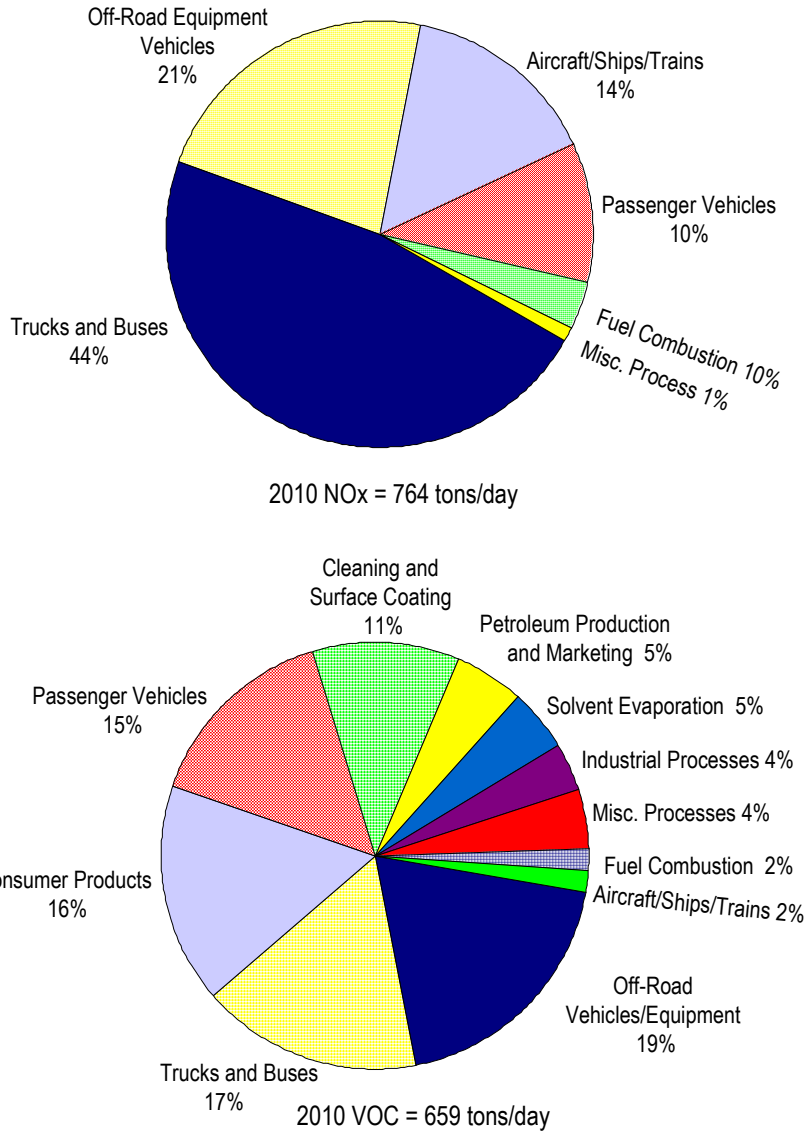


Figure 1: Major Source Contributions (2010)

To fulfill long-term emission reduction measures, the 2003 AQMP relies on advanced technologies that are not yet fully developed for commercial use. Significant reductions are anticipated from implementation of advanced control technologies for both on-road and non-road mobile sources.

In addition, the new air quality standards for ozone (0.08 ppm, 8-hour average) and fine particulate matter, promulgated by the U.S. Environmental Protection Agency (U.S. EPA) in 1997, are projected to require additional long-term controls for both NO_x and VOC.

Recent health studies also indicate a greater need to reduce NO_x emissions and toxic air contaminant emissions. More importantly, the California Air Resources Board (CARB) listed diesel exhaust emissions as a toxic air contaminant in 1998. Subsequently, in 1999, the SCAQMD completed the Multiple Air Toxics Exposure Study (MATES-II) and found that diesel combustion sources (primarily from heavy-duty vehicles) contribute approximately 70 percent to the estimated potential cancer risk from air toxics in the Basin. A follow-on study, (MATES-III), was initiated in Spring 2004 to evaluate air toxic exposure trends, expand the list of known air toxics, and assess local impacts from industrial, commercial and mobile sources. MATES-III was continued through 2005 and is expected to conclude in 2006.

In addition, there are increasing concerns over greenhouse gas emissions and petroleum dependence arising from the heavy use of conventional technologies. In recognition of these concerns, the federal government has 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 (namely hydrogen) technologies. Similarly, the state has adopted goals to reduce long-term dependence on petroleum-based fuels (AB 2076) as well as limit the amount of greenhouse gases emitted from automobiles starting in 2009 (AB 1493). The goals of the federal and state programs will be achieved, in part, through alternative fuels (petroleum displacement) and increased vehicle hybridization (improved efficiency).

It is clear then that clean, 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, reduce long-term dependence on petroleum-based fuels, and support a more sustainable energy future. To help meet this need for advanced, clean technologies, the SCAQMD Governing Board continues to promote the Clean Fuels Program through the Technology Advancement Office. This program is intended to assist in the rapid development and deployment of progressively lower-emitting technologies and fuels through innovative public-private partnership. Since its inception, the SCAQMD Technology Advancement Office has co-funded projects in cooperative partnership with private industry, technology developers, academic and research institutes, and local, state, and federal agencies. Funding for the program and the public-private partnerships are described in the next section.

Program Funding

The Clean Fuels Program, under California Health and Safety Code (H&SC) Sections 40448.5 and 40512 and Vehicle Code Section 9250.11, establishes mechanisms to collect revenues from mobile and stationary sources to support the program's objectives, and identifies the constraints on the use of the funds. In 2003 these funding mechanisms, described below, were reauthorized through January 1, 2010, under SB 288 (Sher). The objective of the Program is to support and promote projects to increase the utilization of clean-burning alternative fuels and related technologies, such as hydrogen, fuel cells, liquid petroleum gas, natural gas, combination fuels, synthetic fuels, electricity including electric and hybrid vehicles, as well as unique applications of conventional fees and other clean alternatives yet to be developed.

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 2005 the funds available through each of these mechanisms were as follows:

- Mobile sources (DMV revenues) $ 11,971,000
- Stationary sources (emission fee surcharge) $ 285,360

The SCAQMD Clean Fuels Program also receives grants and cost-sharing revenue contracts from various agencies, on a project-specific basis, that supplement the SCAQMD program. Historically, such cooperative project funding revenues have been received from CARB, the California Energy Commission (CEC), the U.S. EPA, the U.S. Department of Energy (DOE), and the U.S. Department of Transportation (DOT). These supplemental revenues depend in large part on the originating agency, its budgetary and planning cycle, and the specific project or intended use of the revenues. Table 3 lists the supplemental grants and revenues recognized in 2005.

The final, and perhaps most significant, funding source can best be described as an indirect source, i.e., funding not directly received by the SCAQMD. This indirect source is the cost sharing provided by private industry and other public and private organizations. Historically, the Technology Advancement Office has been successful in leveraging its available public funds with more than $3 of outside funding for each $1 of SCAQMD funding. Through this 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.

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 interests. The Technology Advancement Advisory Group, whose members are listed in Appendix A, serves:

- To coordinate the SCAQMD program with related local, state, and national activities;
- To review and assess the overall direction of the program; and
- To identify new project areas and cost-sharing opportunities.

A second advisory group was formed as required by SB 98 (Alarcon). Under H&SC Section 40448.5.1(c), this advisory group must be comprised of 13 members with expertise in clean fuels technology and policy or public health, appointed from the scientific, academic, entrepreneurial, environmental, and public health communities. This legislation further specified conflict-of-interest guidelines prohibiting members from advocating expenditures towards projects in which they have professional or economic interests. The objectives of the SB 98 Clean Fuels Advisory Group are to make recommendations regarding projects, plans, and reports, including approval of the required annual report prior to submittal to the SCAQMD Governing Board. The members of the SB 98 Clean Fuels Advisory Group are also listed in Appendix A.

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

Core Technologies

The broad technology areas of focus for the Clean Fuels Program are listed below from a near-term to longer-term commercialization perspective:

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

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

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

The SCAQMD strives to maintain a flexible program to address dynamically evolving technologies and the latest progress in the state-of-the-technology. Although the SCAQMD program is significant, especially at a time when both public and private funding available for technology research and development are limited, national and international activities affect the direction of technology trends. As a result, the SCAQMD program must be flexible in order to leverage and accommodate these changes in state, national and international priorities. 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.

Given the diversity of sources that contribute to the air quality problems in the Basin, there is no single technology that can solve all of the problems. Thus, the core technologies represent a variety of applications with full emissions benefit "payoffs," i.e., perceived time to full commercialization and mass deployment, occurring at different times. Historically, mobile source projects have targeted low-emission developments in automobiles, transit buses, medium- and heavy-duty trucks, and non-road applications. These vehicle-related efforts have focused on advancements in engine design, electric power-trains and energy storage/conversion devices (e.g., fuel cells and batteries); and implementation of clean fuels (e.g., natural gas, propane, and hydrogen), including their infrastructure development. Stationary source projects have included a wide array of advanced low NO_x technologies; and clean energy alternatives such as fuel cells, solar power, and other renewable energy systems.

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

Infrastructure and Fuel Production

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

In 2005, the SCAQMD continued to aggressively add and upgrade natural gas fueling facilities to support the need for compressed natural gas (CNG) and liquefied natural gas (LNG) fuel by fleet operators subject to clean-fuel fleet requirements. In addition, work continues on implementing a series of hydrogen fueling sites for use by fleets demonstrating fuel cell and hydrogen ICE vehicles.

Emission Control Technologies

This broad category refers to technologies that could be deployed on existing mobile sources, especially aircraft, locomotives, marine vessels, farm and construction equipment, cargo handling equipment, industrial equipment, and utility and lawn-and-garden equipment. These non-road sources represent about 35 percent of the total NO_x emission inventory and 21 percent of the total VOC inventory in the Basin. Much of the equipment in this source category is either uncontrolled and unregulated, or controlled to a much lesser extent than on-road vehicles. The authority to develop and implement regulations for these 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 also 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 for 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 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 in the future.

Electric and Hybrid Vehicle Technologies

Electric vehicles are powered by an electric motor instead of an internal combustion engine (ICE). The electrical energy is supplied from an onboard energy storage device such as a battery. Hybrid electric vehicles (HEVs) add an engine-alternator system with fuel storage for onboard recharging of the batteries to extend vehicle range, increase fuel efficiency, and minimize emissions compared to conventional vehicles. In HEVs, the engine is typically small and may be powered by gasoline, natural gas, or diesel fuels. Fuel cells may also provide electrical power. Both EVs and HEVs are usually equipped with regenerative braking that reverses the field of the electric motor during vehicle braking so that it functions as a generator to recharge the batteries and extend vehicle range.

Although automobile original equipment manufacturers (OEMs) have introduced HEVs such as the Prius (Toyota) and the Civic (Honda), there remains a need to support advancement of technologies to improve marketability and expedite their implementation, especially in the heavy-duty sector. For example, hybrid technologies using hydraulics (compressed gas) to assist in acceleration are being considered for heavy-duty applications, which may provide significant emissions reductions and fuel

savings. Another exciting hybrid technology is the plug-in hybrid electric vehicle (PHEV) which marries the EV and HEV concepts by incorporating a larger battery pack with a small ICE and allows some operation on batteries alone. The SCAQMD continues to support projects to develop and demonstrate such advancements in electric drive trains, energy storage devices, and related components.

Engine Technologies

Medium and heavy-duty vehicles contribute over 60% of the Basin's NO_x and almost 30% of the VOC emissions. More importantly, heavy-duty diesel engines contribute over 40% of the mobile source particulate emissions, which have known toxic effects. Significant long-term emission reductions will be required from mobile sources, especially from the heavy-duty sector, to attain 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 2.5 g/bhp-hr (combined NO_x and VOC emissions). Natural gas fueled engines with advanced engine controls have demonstrated emissions levels as low as 0.5 g/bhp-hr and is the technology most likely to achieve the federal standard of 0.2 g/bhp-hr emission levels by 2007. The SCAQMD, along with various local, state and federal agencies, are supporting development and demonstration of alternative fueled heavy-duty engine technologies, using CNG and LNG for applications in transit buses, school buses, and refuse collection and delivery vehicles to meet future federal emissions standards.

Mobile Fuel Cell and Hydrogen Technologies

Fuel cells are devices in which chemical energy is converted into electrical energy without combustion. In a proton exchange membrane (PEM) fuel cell, for example, hydrogen reacts with oxygen to produce electrical power and pure water with essentially no emissions. These ultra-clean and high-efficiency electrochemical engines can provide excellent performance for vehicles and have the potential to work in virtually every mobile and stationary application currently powered by an internal combustion engine (ICE). Consequently, fuel cells are specifically identified in the AQMP as "enabling" technologies to help meet long-term control measures in the transportation sector.

Fuel cells are the leading technology to power zero emission vehicles (ZEVs) and near-ZEVs. Despite the considerable amount of work done by nearly all of the major automotive manufacturers, a significant amount of additional development is needed to improve and demonstrate the ultimate commercial viability of fuel cells for transportation. Two of the prime challenges facing the widespread potential usage of fuel cells are the refueling infrastructure development and the relatively high cost of the fuel cells and on-board hydrogen storage. In order to address these issues, the SCAQMD is funding the refueling infrastructure development, vehicles with hydrogen ICEs which are lower in cost than fuel cells, and investigating different on-board storage strategies.

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, and bio-mass conversion.

Although combustion sources are lumped together as stationary, the design and operating principles vary significantly. 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, and alternative fuels and technologies.

PROGRAM IMPACT

Expected 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 can be long and the costs high to address these technical and market barriers, discouraging both manufacturers and end-users from considering advanced technologies. A combination of real-world demonstrations, education, outreach, and regulatory impetus and incentives are necessary to catalyze new, clean technologies. The Clean Fuels Program addresses several of these aspects by co-funding research, development, demonstration, and deployment projects to share the risk of emerging technologies.

Figure 2 provides a conceptual diagram 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 variety of emissions benefit payback timing, but also to proliferate technology choices.

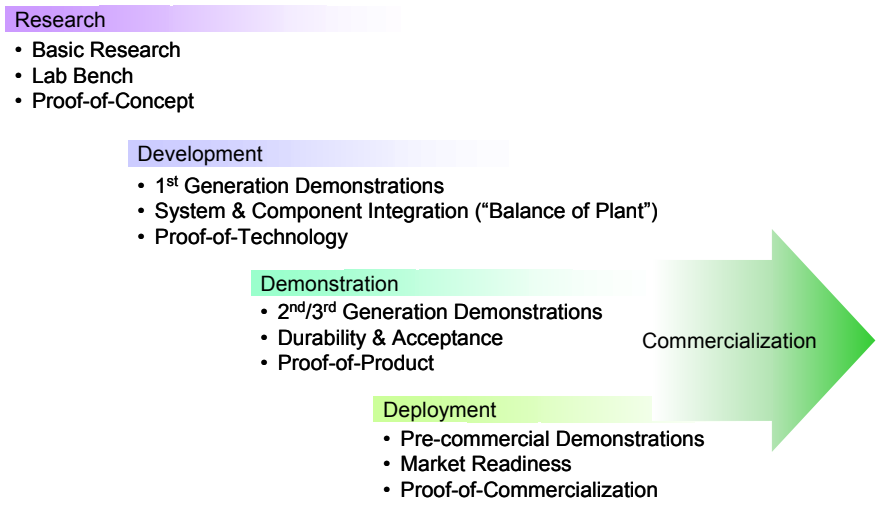


Figure 2: Clean Fuels Program Project Types

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. However, a good indication of the impact and benefits of the Clean Fuels Program overall is provided by a brief list of sponsored projects which have resulted in commercialized products or helped to advance the state-of-the-technology:

- CNG Engine Development for Heavy-Duty Vehicles
  - Cummins: C8.3L (CNG, LNG), B5.9L (CNG), L10 (CNG)
  - Detroit Diesel: Series 60G (CNG/LNG), Series 50G (CNG/LNG)
  - John Deere: 6068 (CNG), 6081 (CNG)
  - Mack: E7-400G (LNG)

  - Clean Air Partners/Power Systems (Catepillar): 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
  - Commercial Stationary Fuel Cell Demonstration with UTC and SoCalGas (first of its kind)
- Electric and Hybrid Electric Vehicle Development and Demonstrations
  - EPRI hybrid vehicle evaluation study
  - Hybrid electric vehicle demonstrations with SCE, UC Davis, and AC Propulsion
  - Electric vehicle demonstrations with Santa Barbara Bus Works, Toyota, and GM
- After-treatment Technologies for Heavy-Duty Vehicles
  - Johnson Matthey and Engelhard trap demonstrations on buses and construction equipment
  - Lubrizol optimization and demonstration of oxidation catalysts on CNG, heavy-duty vehicles

The benefits of these technologies, however, could not have been achieved unless all stakeholders (i.e., manufacturer, end-users, and government) collectively worked 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.

Project-Specific Issues

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

Technology Implementation Issues

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

Other barriers include reduced research budgets, infrastructure and energy uncertainties, sensitivity to multi-media environmental impacts, and the need to find balance between environmental and economic needs. In order to address these barriers, the SCAQMD seeks to establish relationships with the stakeholders through unique public-private partnerships involving industry, end-users, and

other government agencies. 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 institutions 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, coordination of infrastructure needs, and facilitation of standards setting and educational outreach. There is also synergy in developing technologies that address multiple goals of public and private bodies regarding the environment, energy, and transportation.

The SCAQMD actively seeks additional partners for the program through participation in various working groups, committees, and task forces. This participation has resulted in coordinating 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. Additionally, this list 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 the 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 formally 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), California Fuel Cell Partnership, the California Stationary Fuel Cell Collaborative, and the California Natural Gas Vehicle Partnership.

The coordination efforts with these various funding organizations have resulted in a number of cosponsored projects. The descriptions of the projects awarded in CY 2005 are provided in the next section of this report. It is noteworthy that most of the projects are cosponsored by various funding organizations and include the active involvement of manufacturers. Such partnerships are essential to address commercialization barriers and help expedite the implementation of advanced low-emission technologies. Listed in Table 1 are the funding agency partners and major 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, smaller manufacturers, and project participants who make important contributions critical to the success of the SCAQMD program. These partners are identified in the more detailed Project Summaries section.

Table 1: SCAQMD Funding Partners in CY 2005

Research Funding Organizations	Major Manufacturers/Providers
California Air Resources Board	Air Products
California Energy Commission	BAF Technologies
California Public Utilities Commission	Clean Energy Fuels Corp.
National Renewable Energy Laboratory	Cummins Inc.
New York State	Fuel Cell Energy
Pacific Gas & Electric	Plug Power
U.S. Department of Energy	Quantum Technologies
	Teleflex/GFI
	Westport Research

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 2005. 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 SCAQMD research and development coordination efforts are: (a) the continued focus on low-emission alternative fuel heavy-duty engines to replace diesel engines and (b) the further development of plug-in hybrid electric vehicle technologies.

Advanced Heavy Heavy-Duty Natural Gas Engine

The SCAQMD and others have long supported the development and demonstration of natural gas heavy-duty engine technology as the cleanest current alternative to higher-polluting diesel engines. Reducing diesel emissions is even more critical because diesel particulate has been identified as a toxic air contaminant by CARB. The SCAQMD continues to seek applications and platforms where alternatives to diesel may be best applied. One application that currently has no natural gas offering is in the very large, or Class 8, heavy-heavy-duty engines. These engines are typically used for waste transfer, bulk haul, fuel delivery, and regional distribution. The SCAQMD is supporting Westport Research to develop a Class 8, heavy-duty natural gas engine at the 1.2 g/bhp-hr NO_x emissions level. The commercialization of such an engine would help provide cleaner vehicles for fleets in the Basin and throughout California.

Figure 3: Heavy Heavy-Duty Application using Westport Research Natural Gas Engine

Plug-in Hybrid Conversion

The AQMD has also actively sponsored the development of battery-dominant hybrid vehicles, or "plug-in" hybrids electric vehicles (PHEVs). These vehicles utilize larger battery packs and recharge using the grid in order to achieve a portion of their commute on batteries only, thereby achieving true zero-emission miles. For longer trips, the ICE engages and the vehicle performs like a conventional hybrid electric vehicle, therefore eliminating the need for special refueling infrastructure. PHEVs also offer a transition platform for hydrogen vehicles, allowing improved performance using more mature battery technologies in order to improve range and reduce the costly components associated with hydrogen (e.g., storage tank and fuel cell stack). In 2005, the SCAQMD provided support to EnergyCS to convert a Toyota Prius to a PHEV platform. The project will develop, demonstrate, and attempt to commercialize an upfit package for Prius owners to convert their vehicles to PHEVs.

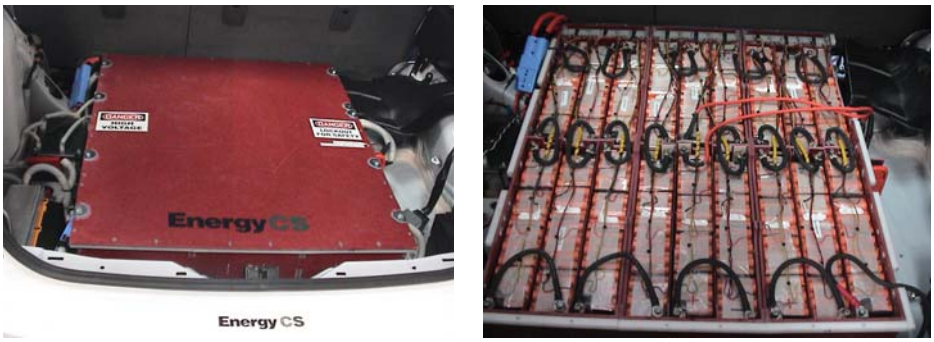


Figure 4: Battery Pack for Plug-in Hybrid Electric Vehicle

Technology Deployment and Commercialization

It is the specific function of the Clean Fuels Program 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. This is accomplished through a unique public-private partnership where the risks and costs of developing and demonstrating promising technologies and clean-burning fuels are shared with industry. 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 describes two projects which demonstrate the impact of the SCAQMD program on technology deployment and commercialization during the CY 2005 reporting period.

Natural Gas Fueling Infrastructure

The development and demonstration of low-emission medium- and heavy-duty engines has been a priority of the SCAQMD Clean Fuels Program since its inception. These engines are used in numerous commercial activities including local pick-up and delivery trucks, heavy-duty truck tractors for pulling trailers and shipping containers both in the Basin and for long-haul, school buses, transit buses, shuttle buses, yard tractors at shipping points, and dockside equipment at the ports. In order to fully commercialize these technologies, the fueling infrastructure must be present to support these applications. As a result, the SCAQMD continues to co-fund CNG and LNG fueling stations to support local fleet operations. To date, there are over 130 natural gas refueling stations in the Basin, some which have been recipients of Clean Fuels Program awards, demonstrating near-commercial success in the heavy-duty niche markets.

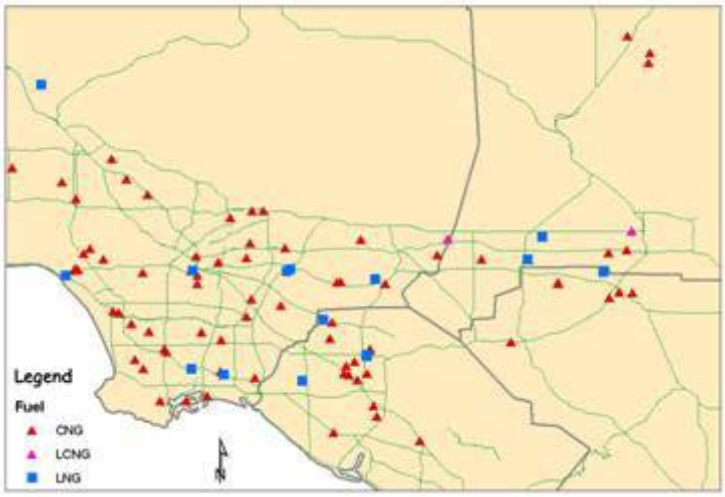


Figure 5: Natural Gas Refueling Infrastructure

Solar Panel Installation

Photovoltaics not only reduce emissions by displacing power generated from fossil fuels, they also provide renewable, sustainable energy. The SCAQMD has an existing 20 kW solar system on a car port, which was used to charge electric vehicles. In order to increase the renewable generation at the SCAQMD headquarters, SolSource Energy was selected through an RFP process to install an additional 80 kW of solar panels on the SCAQMD roof. The system is comprised of RWE Schott Solar ASE 300 semi-crystalline solar panels on an innovative non-penetrating roof mounting system. The CPUC Self-Generation Incentive Program (SGIP) is providing approximately 50% of the cost of the system; the SGIP was created by the California legislature to encourage the installation of renewables and other clean electric generating technologies. The SCAQMD solar system will include flat panel displays in the building lobby to display the real time output of the solar panels.

Figure 6: Solar Panels on SCAQMD Roof

2005 PROJECT EXPENDITURES

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

As projects are approved by the Governing Board and executed into contracts every month, the finances necessarily change to reflect these projects. As such, the following represents the status of the Clean Fuels Fund as of December 31, 2005.

Financial Summary

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, 2005, sixty-one contracts that support clean fuels were executed or amended, as shown in Table 2. The major technology areas summarized are: infrastructure and fuel production, fuels/emission studies, emission control technology, electric and hybrid technologies, engine technology, hydrogen technology and infrastructure, fuel cell technology, health impacts studies, stationary clean fuel technology, and outreach and technology transfer. The distribution of funds based on technology area is shown graphically in Figure 7. This wide array of technology support represents the AQMD's commitment to researching, developing, demonstrating, and deploying potential near-term and longer-term technology solutions.

The project expenditures that were contracted or amended for the 2005 reporting period are shown below with the total project costs:

SCAQMD Clean Fuels Fund Contribution	$ 12,704,346
Total Cost of Clean Fuels Projects	$ 38,594,723

Each year, the Governing Board approves funds to be transferred to the General Fund Budget for Clean Fuels administration. For 2005, the Board transferred $500,000 for workshops, conferences, co-sponsorships and outreach activities as well as postage, supplies, and travel costs for special conferences. Only the funds committed by December 31, 2005, are included within this report. Any portion of the Clean Fuels Funds not spent by the end of Fiscal Year 2005-06, ending June 30, 2006, is returned to the Clean Fuels Fund.

Partially included with the SCAQMD contribution are supplemental sponsorship revenues from various organizations that supported these technology advancement projects. This supplemental revenue is listed in Table 3. Appendix B lists all Clean Fuels Fund contracts that were open and active as of January 1, 2006.

For Clean Fuels executed or amended contracts in 2005, the average SCAQMD contribution was 33 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. The historical average for leveraging dollars has been more than four to one.

During 2005, the SCAQMD executed contracts or amendments with expenditures of nearly $12.7 million for Clean Fuels projects. The distribution of funds for executed contracts is shown in Figure 7 below.

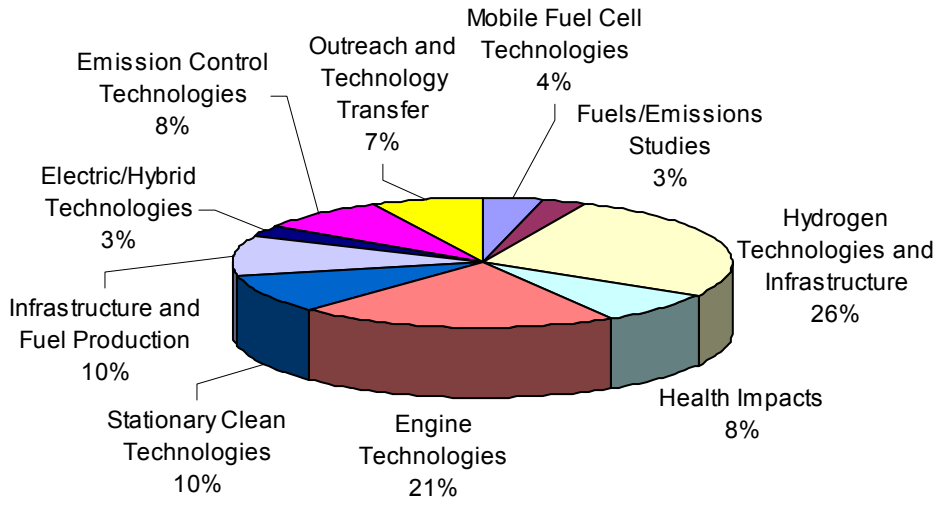


Figure 7: Distribution of Funds for Executed Clean Fuels Projects Calendar Year 2005 ($12.7 million)

Review of Audit Findings

State law requires the SCAQMD to undergo a standard, annual financial audit after the closing of each fiscal year. The financial audit is conducted by an independent accounting firm selected through a competitive bid process. For the fiscal year ended June 30, 2005, the firm of Simpson & Simpson conducted the financial audit. As a result of this financial audit, a Comprehensive Annual Financial Report (CAFR) was issued. The CAFR noted there were no adverse internal control weaknesses with regard to SCAQMD financial statements, which include the Clean Fuels Program revenue and expenditures. Simpson & Simpson gave the SCAQMD an "unqualified opinion," which is the highest financial rating obtainable. Notably, the SCAQMD has achieved this rating on all prior annual financial audits.

Table 2: **Contracts Initiated or Amended Between January 1 and December 31, 2005**

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Fuel Production						
05109	Orange County Sanitation District	Purchase & Install New Dispenser & Credit Card Payment System in Fountain Valley	02/04/05	02/28/10	24,000	80,000
05135	Sysco Food Services of Los Angeles, Inc.	Purchase & Install LNG Fueling System in City of Walnut	05/25/05	03/31/10	250,000	1,102,476
05250	Downs Commercial Fueling	Purchase & Install New L/CNG Fueling System in Temecula	11/04/05	12/31/10	203,137	1,033,137
06017	Fuelmaker Corporation	Incentive Buydown Program for CNG Home Refueling Appliances	09/26/05	06/30/06	100,000	200,000
06018	American Honda Motor Company Inc.	Incentive Buydown Program for CNG Home Refueling Appliances	11/02/05	06/30/07	300,000	600,000
06028	Consolidated Disposal Service	Purchase & Install New LNG Fueling System in Long Beach	11/23/05	12/31/11	222,038	740,127
06029	Clean Energy	Upgrade Existing CNG Fueling Station at SoCalGas Facility in Santa Monica	10/26/05	12/31/11	190,000	634,500
Fuels/Emission Studies						
05069	Automotive Testing and Development Services, Inc	Perform Evaporative Emission Testing on Gasoline Heavy-Duty Hybrid-Electric Bus	02/10/05	06/30/06	260,000	260,000
05195	West Virginia University	Provide Transportable Emissions Testing of CNG Fueled Heavy-Duty Engines	08/18/05	07/31/06	83,215	183,215
Emission Control Technologies						
02293	Automotive Testing Laboratories	Develop & Demonstrate Fischer Tropsch Fueled Heavy-Duty Vehicles with Control Technology to Reduce Exhaust Emissions	08/23/02	06/30/06	15,000	25,000
05067	Cummins Inc.	Demonstrate & Evaluate Performance, Durability and Emission-Reduction Potential of Advanced Diesel Emissions Control System (ADECS) for Low-Sulfur Diesel-Fueled Heavy-Duty Engines	03/09/05	07/28/07	750,000	4,450,000
05161	BAF Technologies	Develop & Certify Retrofit System to Convert Gasoline-Powered Ford Crown Victoria & E-450 Cutaway Van to Compressed Natural Gas	06/03/05	04/30/06	300,000	1,227,660
05196	West Virginia University	Demonstrate & Evaluate Performance, Durability and Emission Reduction Potential of ADECS for Low-Sulfur Diesel-Fueled Heavy-Duty Engines	08/13/05	02/28/07	350,000	750,000
Electric/Hybrid Technologies						
05259	AC Propulsion Inc.	Upgrade & Evaluate Plug-In Hybrid Electric Sedan with Lithium Polymer Batteries	07/25/05	07/24/07	25,300	53,000
05260	EnergyCS	Convert Light-Duty Vehicle to Plug-In Hybrid Electric	09/09/05	09/08/07	130,000	538,464

Table 2: **Contracts Initiated or Amended Between January 1 and December 31, 2005 (Continued)**

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Electric/Hybrid Technologies (cont'd)						
Purchase Orders	Various	Purchase Six 2005 Hybrid Vehicles: Three Toyota Prius, Two Honda Civic & One Ford Escape	03/04/05	03/04/05	162,400	162,400
Purchase Order	Toyota Motor Co.	Purchase One 2005 Toyota Prius Hybrid Vehicle	05/06/05	05/06/05	27,000	27,000
Engine Technologies						
05110	Westport Research, Inc.	Develop & Demonstrate Heavy, Heavy-Duty Natural Gas Engine for Class 8 Trucks	04/01/05	06/30/06	1,944,911	5,583,426
05244	Cummins Westport, Inc.	Develop, Demonstrate & Certify Heavy-Duty Natural Gas Engine to Meet 2010 Emission Standards	08/26/05	07/31/07	690,000	5,943,410
Hydrogen Technologies and Infrastructure						
04011	Air Products and Chemicals, Inc.	Install & Demonstrate Industrial Pipeline-Supplied Hydrogen Refueling Station in Torrance	08/03/05	04/02/07	400,000	855,710
04111	Stuart Energy	Maintenance & Data Management for AQMD Hydrogen Fueling Station	02/16/05	02/16/09	80,000	80,000
05165	Air Products and Chemicals, Inc.	Install & Demonstrate Three Electrolyzers (in Burbank, Riverside & Santa Monica) and Two Mobile Fuelers (in Santa Ana & Ontario), with One Year of Hydrogen Fuel Supply	06/21/05	06/20/07	2,982,000	2,982,000
Mobile Fuel Cell Technologies						
04003	Daimler-Chrysler RTNA	Install & Demonstrate Fuel Cell Vehicle Maintenance Facility in Long Beach	11/21/05	05/21/08	253,000	542,000
04004	Mercedes-Benz USA, LLC	Demonstrate Two Fuel Cell Vehicles at AQMD in Diamond Bar	02/04/05	04/04/06	240,000	1,240,000
Health Impacts Studies						
05172	Desert Research Institute	Conduct Organic Compound Analyses of Particulate Matter Samples Collected under MATES III Program	08/13/05	06/30/06	199,995	199,995
Direct	Transfer from Clean Fuels	MATES III Field Measurement Program	n/a	n/a	835,000	835,000
Stationary Clean Fuels Technologies						
05104	Alliance Power	Demonstrate Two Molten Carbonate Stationary Fuel Cell Systems in Fontana	07/28/05	03/27/08	565,000	4,176,325
05122	Plug Power, Inc.	Demonstrate Three Proton Exchange Membrane Stationary Fuel Cell Systems at UCI	04/29/05	07/28/07	257,500	572,604

Table 2: **Contracts Initiated or Amended Between January 1 and December 31, 2005 (Continued)**

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Stationary Clean Fuels Technologies (cont'd)						
05207	SolSource Energy	Install an 80 kW Solar Panel System at AQMD Headquarters	06/06/05	06/05/11	360,000	693,000
06075	Advanced Engine Technology Corporation	Field Comparison of Portable Electrochemical Analysers to a CEMs for Measurement of NOx and CO Emissions from a Rich-Burn Engine	12/21/05	03/31/06	33,320	67,320
Outreach and Technology Transfer						
05008	Bevilaqua-Knight Inc.	CY 2005 Membership & Participation in California Fuel Cell Partnership	07/07/05	07/06/06	133,800	1,960,000
05101	Calhoun, Joseph	Technical Assistance for Development, Outreach & Commercialization of Advanced, Low-Emission Light- & Heavy-Duty Vehicle Technologies and Coordination with State Agencies	01/07/05	09/31/07	40,000	40,000
05120	Clean Fuels Connection, Inc	Technical Assistance for Technology Incentive Programs to Evaluate Proposals for Compliance with New CARB Guidelines	04/01/05	03/31/07	90,000	90,000
05121	Sullivan, Cindy	Technical Assistance to Coordinate with CARB to Develop, Analyze and Implement New Incentive Program Guidelines	03/14/05	03/31/07	75,000	75,000
05123	TIAX, LLC	Technical Assistance for Development, Outreach & Commercialization of Low-Emission and Alternative Fuels Technologies and Evaluating Project Proposals for Technology Incentive Programs	03/14/05	03/31/07	90,000	90,000
05125	Breakthrough Technologies Institute, Inc	Technical Assistance for Development, Outreach & Commercialization of Fuel Cells and Technical Coordination with Federal Energy & Transportation Departments	03/05/05	03/31/07	40,000	40,000
05126	St. Croix Research	Technical Assistance for Development, Outreach & Commercialization of LNG, CNG and Hydrogen Fuels	03/15/05	03/31/07	25,000	25,000
05127	Protium Energy Technologies	Technical Assistance for Development, Outreach & Commercialization of Hydrogen & Fuel Cell Technologies	03/14/05	03/31/07	40,000	40,000
05128	Mid-Atlantic Research Institute, LLC	Technical Assistance for Development, Outreach & Commercialization of Advanced Heavy-Duty & Off-Road Technologies	08/08/05	03/31/07	40,000	40,000

Table 2: **Contracts Initiated or Amended Between January 1 and December 31, 2005 (Continued)**

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (Cont'd)						
05171	James Hazelton	Technical Assistance for Locomotive Technologies	04/08/05	04/30/06	20,000	20,000
05198	Don Stedman	Technical Assistance for Remote Sensing Programs for Light-Duty Vehicles and Locomotives	05/30/05	11/30/06	25,000	25,000
Direct	Transfer from Clean Fuels	Conduct & Host International Conference on Ultrafine Particles in Spring 2006	12/02/05	12/02/05	78,500	78,500
Various	Various Contractors	Co-Sponsorships of Conferences, Workshops and Events Plus Memberships	Varies	Varies	204,230	941,954

Table 3: Supplemental Grants and Revenue Received Between January 1, 2005 and December 31, 2005

Revenue Agreement	Revenue Source	Project Title	Contractor	SCAQMD Project	Total
Interagency Agreement	California Air Resources Board	Demonstrate & Evaluate Advanced Diesel Emission Control System in Diesel-Fueled Heavy-Duty Engines	West Virginia University	Contract #05196	$50,000
Interagency Agreement	California Air Resources Board	Demonstrate Advanced Diesel Emission Control System in Low-Sulfur Diesel-Fueled Heavy-Duty Engines	Cummins Inc.	Contract #05067	$50,000

Project Summaries

The following represents the summaries of the projects and studies executed in 2005. 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 Fuel Production

05109: Purchase & Install New Dispenser & Credit Card Payment System in Fountain Valley

Contractor:	Orange County Sanitation District	SCAQMD Cost-share:	$	24,000
		Cosponsor:		
		Orange County Sanitation District		56,000
Term:	02/04/05 – 02/18/10	Total Cost:	$	80,000

This project will provide cost-share funds for an existing station to upgrade the fueling dispenser and card reader, providing a significant improvement in the station's ability to service increasing numbers of large fleet vehicles in a timely and convenient manner. The upgrade will enhance station reliability allow public access, improve speed of service and ensure the ability of the station to operate in an efficient manner.

05135: Purchase & Install LNG Fueling System in City of Walnut

Contractor:	SYSCO Food Services of Los Angeles, Inc.	SCAQMD Cost-share:	$	250,000
		Cosponsors:		
		SYSCO		302,476
		MSRC/ AB 2766 Discretionary Fund		200,000
		Carl Moyer Program		200,000
		DOE SEP Grant		150,000
Term:	05/25/05 – 03/31/10	Total Cost:	$	1,102,476

This project will provide cost-share funding for a new publicly accessible LNG station at 20701 Currier Road, Walnut. SYSCO has undertaken an aggressive LNG project having already received partial incremental funding for the purchase of 95 new LNG trucks and this supporting infrastructure. SYSCO is working to ultimately replace its entire fleet of 216 heavy duty trucks with LNG. It will eventually be the largest single private fleet operator of over the road LNG trucks in the United States. The station will be constructed with state of the art equipment and will fill a critical gap in the existing LNG refueling infrastructure in this region. The LNG fuel dispensers will be situated to accommodate traffic flow of several different kinds of heavy-duty trucks.

05250: Purchase & Install New L/CNG Fueling System in Temecula

Contractor: Downs Commercial Fueling	SCAQMD Cost-share:	$	203,137
	Cosponsors:		
	California Energy Commission's Alternative Fuel PON		250,000
	County of Riverside		30,000
	City of Temecula		50,000
	MSRC/ AB 2766 Discretionary Fund		250,000
	AES Settlement Program		250,000
Term: 11/04/05 – 12/31/10	Total Cost:	$	1,033,137

This project will provide a publicly accessible LNG/LCNG station in southwestern Riverside County that will fuel existing natural gas vehicles operating in the area. The station acts as a gap filler in that the nearest natural gas station is 25 miles away. Numerous fueling commitments have been received including Laidlaw Transit, Riverside County, CR&R and Camp Pendleton Marine Corps Bases.

06017: Incentive Buydown Program for CNG Home Refueling Appliances

Contractor: FuelMaker Corporation	AQMD Cost-share:	$	100,000
	Cosponsor:		
	MSRC/ AB 2766 Discretionary Fund		100,000
Term: 09/26/05 – 06/30/06	Total Cost:	$	200,000

Light- and medium-duty natural gas vehicles (NGVs) have been used primarily by centralized fleets, and expanding the use of alternative fuel vehicles to the general consumer market will further reduce air pollution in the Basin. Market research indicates that a major concern of consumers owning alternative fuel vehicles is availability of fueling infrastructure. Similar market research has indicated that availability of a home refueling appliance (HRA) to the vehicle consumer market would broaden the consumer base for NGVs. The AQMD has funded the development and commercialization of a HRA and the appliance is now available to the consumer. Due to the extensive research development efforts, the initial rollout cost of the HRA is significantly more expensive than anticipated. The MSRC through its AB 2766 Discretionary Fund approved a buy-down program for the HRA, and this project provides incentives to match the MSRC's buydown for the HRA to further incentivize consumer interest in alternative fuel vehicles. The contract with Fuelmaker Corporation provides $100,000 to buydown the cost of 100 units. The MSRC's matching incentive is provided through a separate contract between the MSRC and Fuelmaker. Consumers will receive a $2,000 buydown incentive toward the purchase of the HRA.

06018: Incentive Buydown Program for CNG Home Refueling Appliances

Contractor: American Honda Motor Company Inc.	AQMD Cost-share:	$	300,000
	Cosponsor:		
	MSRC/ AB 2766 Discretionary Fund		300,000
Term: 11/02/05 – 06/30/07	Total Cost:	$	600,000

Light- and medium-duty natural gas vehicles (NGVs) have been used primarily by centralized fleets, and expanding the use of alternative fuel vehicles to the general consumer market will further reduce air pollution in the Basin. Market research indicates that a major concern of consumers owning alternative fuel vehicles is availability of fueling infrastructure. Similar market research has indicated that availability of a home refueling appliance (HRA) to the vehicle consumer market would broaden the consumer base for NGVs. The AQMD has funded the development and commercialization of a HRA and the appliance is now available to the consumer. Due to the extensive research development efforts, the initial rollout cost of the HRA is significantly more expensive than anticipated. The MSRC through its AB 2766 Discretionary Fund approved a buy-down program for the HRA, and this project provides incentives to match the MSRC's buydown for the HRA to further incentivize consumer interest in alternative fuel vehicles. The contract with American Honda Motor Company provides $300,000 to buydown the cost of 300 units. The MSRC's matching incentive is provided through a separate contract between the MSRC and Fuelmaker. Consumers will receive a $2,000 buydown incentive toward the purchase of the HRA.

06028: Purchase & Install New LNG Fueling System in Long Beach

Contractor: Consolidated Disposal Service	SCAQMD Cost-share:	$	222,038
	Cosponsors:		
	MSRC/ AB 2766 Discretionary Fund		250,000
	Consolidated Disposal Service		268,089
Term: 11/23/05 – 12/31/11	Total Cost:	$	740,127

This project will provide cost-share funding for a publicly accessible LNG station at the company's transfer station in Long Beach. This planned facility will provide convenient LNG fueling access to more than 125 LNG heavy Duty Refuse trucks to be deployed at company's facility. The LNG fuel dispensers will be situated to accommodate traffic flow of several different kinds of heavy-duty trucks. A universal card reader system will be incorporated to handle fueling and billing transactions.

06029: Upgrade Existing CNG Fueling Station at SoCalGas Facility in Santa Monica

Contractor: Clean Energy	SCAQMD Cost-share:	$	190,000
	Cosponsor:		
	Clean Energy		444,500
Term: 10/26/05 – 12/31/11	Total Cost:	$	634,500

This project will provide cost-share funding for a publicly accessible CNG station at the Southern California Gas Company's Santa Monica Base. The project will completely upgrade first generation equipment commissioned in 1993 and would serve as a crucial fueling stop for the growing number of fleets traveling throughout the Los Angeles Basin, specifically in the west Los Angeles area. The station will benefit numerous taxi and commercial fleets operating in the area. The station will have two compressors to insure efficient refueling of vehicles should one compressor go down, with a total capacity of 700 SCFM. The CNG fuel dispensers will be situated to accommodate traffic flow of several different kinds of heavy-duty trucks. A universal card reader system will be incorporated to handle fueling and billing transactions.

Fuels/Emission Studies

05069: Perform Evaporative Emission Testing on Gasoline Heavy-Duty Hybrid-Electric Bus

Contractor: Automotive Testing and Development Services, Inc.	SCAQMD Cost-share:	$	260,000
Term: 02/10/05 – 06/30/06	Total Cost:	$	260,000

In 2003, CARB certified the gasoline hybrid-electric drive system manufactured by ISE Research. This drive system has exhaust emissions of 0.4 g/bhp-hr NMHC+NOx, which makes considerable progress toward meeting the future transit bus standards of 0.2 g/bhp-hr NMHC+NOx starting in 2007. Because such drive systems use gasoline, an evaporative control system is used on each vehicle to prevent gasoline vapors in the fuel tank and other components from escaping into the atmosphere. Due to their large size, gasoline heavy-duty vehicles are not physically tested but have their evaporative control systems designed and certified using mathematical models, which are based on light-duty vehicle systems. Without direct test data to verify compliance, however, there is concern that the evaporative emissions could be higher than expected, which would negate the extremely low exhaust emissions of the heavy-duty, gasoline hybrid-electric drive system.

SCAQMD solicited a contractor to perform evaporative emission testing on a gasoline heavy-duty hybrid-electric bus, and ATDS of Ontario, CA, was selected. Under this project, ATDS will be constructing a test vehicle with the evaporative control system of the ISE Research gasoline hybrid electric bus. The test vehicle will then undergo testing to determine the adequacy of the evaporative controls. If emissions are higher than the standards, diagnosis will be undertaken, repairs performed, and testing repeated.

05195: Provide Transportable Emissions Testing of CNG-Fueled Heavy-Duty Engines

Contractor: West Virginia University	SCAQMD Cost-share:	$	83,215
	Cosponsor:		
	National Renewable Energy Lab		100,000
Term: 08/18/05 – 07/31/06	Total Cost:	$	183,215

This project will provide laboratory testing as part of the development, optimization, and demonstration of aftertreatment technologies for PM and hydrocarbon emissions control of CNG-fueled heavy-duty engines.

Emission Control Technologies

02293: Develop & Demonstrate Fischer Tropsch Fueled Heavy-Duty Vehicles with Control Technology to Reduce Exhaust Emissions

Contractor: Automotive Testing Laboratories	SCAQMD Cost-share:	$	15,000
	Cosponsor:		
	National Renewable Energy Lab		10,000
Term: 08/23/02 – 06/30/06	Total Cost:	$	25,000

This modification provided additional funds to cover costs for fuel delivery and storage costs that were higher than projected as well as repairs and diagnostics during the initial demonstration phase for this project.

05067: Demonstrate & Evaluate Performance, Durability and Emission-Reduction Potential of Advanced Diesel Emissions Control System for Low-Sulfur Diesel-Fueled Heavy-Duty Engines

Contractor: Cummins Inc.	SCAQMD Cost-share:	$	700,000
	Cosponsors:		
	U.S. DOE		700,000
	CARB (pass-through funding)		50,000
	Cummins Inc. (In-Kind)		3,000,000
Term: 03/09/05 – 07/28/07	Total Cost:	$	4,450,000

This project is an effort to support the implementation of advanced alternative fuel technology that could potentially reduce NOx and PM emissions from diesel-powered solid waste collection vehicles to the 2010 heavy-duty engine exhaust standards of 0.20 and 0.01 g/bhp-hr, respectively. Under this project, Cummins will use a two-step strategy to achieve the federal 2010 heavy-duty NOx and PM emissions standards. The first step involves using a high-capacity exhaust gas recirculation (EGR) system, a variable geometry turbocharger, high injection pressure, and a robust controls architecture to reduce base engine-out NOx and PM emissions to 1.0 g/bhp-hr or less. In the second stage, the diesel engine will be equipped with a NOx adsorber catalyst and particulate filter to further reduce NOx and PM emissions to the desired targets of 0.2 and 0.01 g/bhp-hr, respectively. Cummins will perform engine dynamometer tests over the U.S. EPA heavy-duty Federal Test Procedure (FTP) and steady-state test cycles to optimize and assess fuel consumption, gaseous emissions, and particulate matter emissions from the ISL engines, with and without the NOx and PM emission control technologies.

05161: Develop & Certify Retrofit System to Convert Gasoline-Powered Ford Crown Victoria & E-450 Cutaway Van to Compressed Natural Gas

Contractor: BAF Technologies	SCAQMD Cost-share:	$	300,000
	Cosponsors:		
	Teleflex/GFI		313,800
	BAF Technologies		213,800
	New York State		300,000
	Clean Energy		100,000
Term: 06/03/05 – 04/30/06	Total Cost:	$	1,227,600

Two major automobile manufacturers have recently ceased production of natural gas-powered vehicles. Ford announced their entire natural gas vehicle product line will be unavailable after the 2004 model-year, and General Motors announced their full size natural gas-powered vans will be similarly unavailable. To ensure the availability of rule compliant natural gas-powered vehicles after the 2004 model-year, BAF Technologies will develop and certify CARB-compliant natural gas conversion systems for the 2005 model-year Ford Crown Victoria and E-450 Cutaway Vehicles. The total cost for this project is estimated to be $1,227,600. SCAQMD's contribution of $300,000 to this project will be leveraged at a ratio of approximately one to four.

05196: Demonstrate & Evaluate Performance, Durability and Emission-Reduction Potential of ADECS for Low-Sulfur Diesel-Fueled Heavy-Duty Engines

Contractor: West Virginia University	SCAQMD Cost-share:	$	300,000
	Cosponsors:		
	CARB (pass-through agreement)		50,000
	West Virginia University/MACK		400,000
Term: 08/13/05 – 02/28/07	Total Cost:	$	750,000

This project is an effort to support the implementation of advanced alternative fuel technology that could potentially reduce NOx and PM emissions from diesel-powered solid waste collection vehicles to the 2010 heavy-duty engine exhaust standards of 0.20 and 0.01 g/bhp-hr, respectively. Under this project, West Virginia University will work with Volvo Powertrain to modify the combustion system of a Volvo MD11 diesel engine equipped with a high-pressure, external, cooled EGR system. The modifications will include changing the original EGR system to accommodate a larger volume of EGR, retrofitting the MD11 engine with a variable geometry turbocharger, and optimizing injection system parameters to yield the lowest engine-out NOx and PM emissions. The MD11 engine will then be equipped with a selective catalytic reduction (SCR) system and diesel particulate filter to further reduce NOx and PM emissions to the desired targets of 0.20 and 0.01 g/bhp-hr, respectively. West Virginia University will perform engine dynamometer tests over the U.S. EPA heavy-duty Federal Test Procedure (FTP) and steady-state test cycles to optimize and assess fuel consumption, ammonia slip, gaseous emissions, and particulate matter emissions from the MD11 engines, with and without the NOx and PM emission control technologies.

Electric/Hybrid Technologies

05259: Upgrade & Evaluate Plug-In Hybrid Electric Sedan with Lithium Polymer Batteries

Contractor: AC Propulsion	SCAQMD Cost-share:	$	25,300
	Cosponsor:		
	AC Propulsion		27,700
Term: 07/25/05 – 07/24/07	Total Cost:	$	53,000

AQMD previously awarded a contract to AC Propulsion for the development and evaluation of a plug-in hybrid electric vehicle with distributed power generation capability using off-board natural gas and Panasonic valve-regulated lead acid batteries. The cost to develop and evaluate the vehicle was $755,000 including contributions from Volkswagen, ARB, AQMD, AC Propulsion, and NREL. This action is to upgrade the vehicle with high power lithium polymer batteries, including the control system, to increase the zero emission range, improve the performance, and reduce the total vehicle weight.

05260: Convert Light-Duty Vehicle to Plug-In Hybrid Electric

Contractor: EnergyCS	SCAQMD Cost-share:	$	130,000
	SCAQMD In-Kind Vehicle:		29,000
	Cosponsors:		0
	EnergyCS		91,027
	Valence		55,788
	Clean-Tech		77,049
	CalCars		58,800
	City of Santa Monica		50,800
	Southern California Edison		25,000
	California Air Resources Board		21,000
Term: 09/09/05 – 09/08/07	Total Cost:	$	538,464

The AQMD has actively sponsored hydrogen infrastructure and vehicle (fuel cell and internal combustion engine) projects to demonstrate their viability and benchmark their performance. One potential barrier to ultimate consumer acceptance is the range achievable by these vehicles. Long-term research is continuing on hydrogen storage solutions but an immediate and attractive solution is utilizing battery-dominant or "plug-in" capability. This solution takes advantage of mature vehicle battery technology and enables zero-emission miles. This action proposes to convert a 2005 Toyota Prius to a plug-in hybrid and demonstrate improved mileage and zero emission range.

Purchase Orders: Purchase Six 2005 Hybrid Vehicles: Three Toyota Prius, Two Honda Civic & One Ford Escape

Contractors: Toyota Motor Company, American Honda Company, & Ford Motor Company	SCAQMD Cost-share:	$	162,400
Term: 03/04/05	Total Cost:	$	162,400

This item is for the purchase of six vehicles, as noted above. The vehicles will be used as part of the AQMD's Clean Air Choice Program which in part promotes alternative fuel vehicles as well as to provide consumer education at public outreach events.

Purchase Order: Purchase One 2005 Toyota Prius Hybrid Vehicle

Contractor: Toyota Motor Company	SCAQMD Cost-share:	$	27,000
Term: 05/06/05	Total Cost:	$	27,000

This item is for the purchase of the vehicle noted above. The vehicles will be used as part of the AQMD's Clean Air Choice Program which in part promotes alternative fuel vehicles as well as to provide consumer education at public outreach events.

Engine Technologies

05110: Develop & Demonstrate Heavy, Heavy-Duty Natural Gas Engine for Class 8 Trucks

Contractor: Westport Research, Inc.	SCAQMD Cost-share:	$ 1,944,911
	Cosponsors:	
	Westport Research, Inc. Sustainable Technology & Development Canada	2,320,612
	DOE/NREL	1,058,803
	Pacific Gas & Electric	259,100
Term: 04/01/05 – 06/30/06	Total Cost:	$ 5,583,426

Class 8 Trucks (Heavy, Heavy-Duty), typically used for waste transfer, bulk haul, fuel delivery, and regional distribution, are some of the highest consumers of diesel fuel, and yet currently there are currently no commercially available alternative fuel engines for this class of vehicles. This action is to award a sole-source contract to Westport Research, Inc. to develop a heavy-duty natural gas engine for Class 8 vehicles that meets 2007 emission standards at a cost not to exceed $1,944,911 from the Clean Fuels Fund. Total funding for this project is $5,583,426. U.S. DOE and Pacific Gas and Electric are cofunding the engine development and demonstration and the engines will be demonstrated with fleets located in Canada and Northern California. Westport Research, Inc. is currently working on identifying a fleet in the Basin that could participate in this demonstration.

05244: Develop, Demonstrate & Certify Heavy-Duty Natural Gas Engine to Meet 2010 Emission Standards

Contractor: Cummins Westport, Inc.	SCAQMD Cost-share:	$ 690,000
	Cosponsors:	
	DOE/NREL	2,048,211
	Cummins Westport, Inc.	3,205,199
	Los Angeles County MTA (In-Kind)	0
Term: 08/26/05 – 07/31/07	Total Cost:	$ 5,943,410

Cummins Westport plans to transfer and implement the technology developed under the earlier Cummins project to the L Gas Plus engine to meet the 2010 Federal standards for heavy-duty engines by 2007. The L Gas Plus is a 8.9L, natural gas stoichiometric engine that has a peak rating of 320 HP and 1,000 lb-ft of torque. They plan to commercialize this engine in 2007, well ahead of the 2010 standards. Commercial availability of a heavy-duty engine at 0.2 g/bhp-hr NOx in 2007 will enable significant mobile source NOx reductions in comparison with model year 2007-2009 diesel engines.

Hydrogen Technologies and Infrastructure

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

Contractor:	Air Products and Chemicals, Inc.	SCAQMD Cost-share:	$	400,000
		Cosponsor:		
		Air Products		455,170
Term: 08/03/05 – 04/02/07		Total Cost:	$	855,170

Air Products and Chemicals, Inc**.** owns and operates 17 miles of pipeline in the industrial/commercial districts of Torrance and Wilmington; the only one of its kind in an urban area in North America. The proposed hydrogen fueling station in Torrance will utilize the pipeline system to deliver hydrogen to the fueling site. This will allow hydrogen fueling in a very cost-effective manner without the need for on-site hydrogen generation or additional truck deliveries of hydrogen. The proposed fueling station will be capable of providing hydrogen based upon demand. As the demand increases, the pipeline is capable of supplying the fuel to meet those needs. Additional goals of this project are to develop a safety and operational training plan for the station that could be adapted to future sites and to provide increased public awareness of hydrogen as a vehicle fuel.

04111: Maintenance & Data Management for AQMD Hydrogen Fueling Station

Contractor: Stuart Energy	SCAQMD Cost-share:	$	80,000
Term: 02/16/05 – 02/16/09	Total Cost:	$	80,000

Stuart Energy will provide maintenance, data acquisition and evaluation, and performance optimization for the hydrogen electrolyzer and fueling station with a stationary ICE power-generation unit at SCAQMD Headquarters. This maintenance and data collection service will support the operation of the hydrogen fueling station and power generation unit and ensure that they are functioning optimally and safely. The goals of this program are to provide hydrogen for hydrogen-fueled vehicles and to demonstrate/evaluate the generation of electric power from electrolyzer hydrogen.

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

Contractor:	Air Products and Chemicals, Inc.	SCAQMD Cost-share:	$	2,982,000
Term: 06/21/05 – 06/20/07		Total Cost:	$	2,982,000

This project, called the "Five Cities" project, is designed to evaluate hydrogen internal combustion engine hydrogen-fueled vehicles at five city fleet sites. This contract is to provide hydrogen fueling stations at each of the five city sites: Santa Monica, Riverside, Burbank, Santa Ana and Ontario and to coordinate with the delivery of the converted fleet vehicles. Funding may come through from the U.S. Department of Energy and/or California Energy Commission; if so, it will be used to reimburse the SCAQMD's expenditure from Clean Fuels.

Mobile Fuel Cell Technologies

04003: Install & Demonstrate Fuel Cell Vehicle Maintenance Facility in Long Beach

Contractor: Daimler-Chrysler RTNA	SCAQMD Cost-share:	$	253,000
	Cosponsors:		
	Daimler-Chrysler		289,000
	Mercedes Benz Test Center		In-kind
Term: 11/21/05 – 05/21/08	Total Cost:	$	542,000

Daimler-Chrysler RNTA has planned a series of fuel cell vehicle demonstrations to be phased over several years. Their plan utilizes an existing Mercedes-Benz emissions testing facility in Long Beach which will be upgraded and modified to evaluate, modify, and service fuel cell vehicles. This facility will serve all of the Daimler-Chrysler fuel cell demonstration fleets in the South Coast Air Basin. One goal of the facility is to provide local, state-of-the-art equipment and qualified staff to ensure optimal vehicle operation with minimal downtime. The proprietary nature and highly specific design characteristics of current fuel cell vehicles requires this type of maintenance and testing facility.

04004: Demonstrate Two Fuel Cell Vehicles at SCAQMD in Diamond Bar

Contractor: Mercedes-Benz USA, LLC	SCAQMD Cost-share:	$	240,000
	Cosponsors:		
	Daimler-Chrysler		500,000
	USDOE		500,000
Term: 02/04/05 – 04/04/06	Total Cost:	$	1,240,000

Daimler-Chrysler RTNA will provide two fuel cell vehicles to be incorporated into the SCAQMD fleet for a two-year demonstration period. These vehicles will be used in general and high-profile applications to test vehicle performance in the context of SCAQMD fleet activities. Service and evaluation of the vehicles will be performed by Daimler-Chrysler staff at the Long Beach test center (see previous project).

Health Impacts Studies

05172: Conduct Organic Compound Analyses of Particulate Matter Samples Collected under MATES III Program

Contractor: Desert Research Institute	SCAQMD Cost-share:	$	199,995
Term: 08/13/05 – 06/30/06	Total Cost:	$	199,995

Under MATES III, particulate matter samples were collected for analysis of elemental carbon and organic carbon. The MATES III Technical Advisory Group recommended that supplemental analysis of organic compounds be conducted on the particulate filter samples to better characterize the sources contributing to ambient particulate matter including diesel particulate matter. Currently the AQMD Laboratory does not have the instrumental methodology or standard components needed for the analyses. Therefore, Desert Research Institute will conduct organic compound analyses of particulate matter samples collected under MATES III. Analysis of particulate bound organic compounds will be utilized as tracers to estimate levels of ambient diesel particulate matter, as well as estimate levels of particulate matter from other major sources. The measurements 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.

Fund Transfer: MATES III Field Measurement Program

Contractor: n/a	SCAQMD Cost-share:	$	835,000
Term: July 1, 2005-June 30, 2006	Total Cost:	$	835,000

Mobile sources, especially diesel emissions, were found to be a significant contributor to potential cancer risk in the MATES-II. This item funds the field measurement activities related to MATES-III to gain further understanding of the air toxics/impacts from mobile source emissions. Services include field instrument set-up and operation, sample collection and delivery. Also, this item funds temporary laboratory staff that prepare sampling media and equipment as well as analyze samples once collected and returned to the laboratory.

Stationary Clean Fuel Technologies

05104: Demonstrate Two Molten Carbonate Stationary Fuel Cell Systems in Fontana

Contractor: Alliance Power	SCAQMD Cost-Share:	$	565,000
	Cosponsors:		
	Alliance Power (In-Kind)		1,305,000
	California Cast Metal Association (In-Kind)		56,325
	Fuel Cell Energy (In-Kind)		1,000,000
	Self-Generation Incentive Program		1,250,000
Term: 07/28/05 – 03/27/08	Total Cost:	$	4,176,325

This is one of two-part fuel cell demonstration study to promote the development, demonstration, and commercialization of near-zero technology; the second part is awarded to Plug Power (described below). Under this project, Alliance Power will install, operate, and maintain two 250kW molten carbonate fuel cell units for combined heat and power at the TST-Timco metal foundry in Fontana, California. The waste heat recovered from the fuel cell units will be used to support the smelting operation at the foundry. These units will provide near-zero emissions and high efficiency power to a real-world, industrial process in an area of environmental justice concern and to an industry sector with high emissions. In addition, this project will demonstrate the commercial viability of fuel cells in metal foundry, but more generally, it will illustrate the validity of clean, distributed generation in industrial applications.

05122: Demonstrate Three Proton Exchange Membrane Stationary Fuel Cell Systems at UCI

Contractor: Plug Power, Inc.	SCAQMD Cost-share:	$	257,500
	Cosponsors:		
	Plug Power (In-Kind)		161,567
	UCI		80,000
	LOGAN Energy		73,537
Term: 04/29/05 – 07/28/07	Total Cost:	$	572,604

This is the second of the two-part fuel cell demonstration study to promote the development, demonstration, and commercialization of near-zero technology. Under this project, Plug Power will install, operate, and maintain three 5kW PEM fuel cell units for combined heat and power at an industrial park building next to the University of California, Irvine (UCI) in collaboration with the National Fuel Cell Research Center (NFCRC). The waste heat generated from the fuel cell units will be used to heat steam for hot-water demands in the building, These units will establish the experience and protocol necessary for integrating fuel cells in the "as built" environment will providing near-zero emissions, reliable baseload power to the building, and critical loads in the event of a grid disruption. In addition, this project is an opportunity to accelerate the cost effectiveness and technology adoption through detailed analysis of integrated fuel cell systems and demonstration of a fuel cell system integrated into commercial and residential buildings.

05207 Install an 80 kW Solar Panel System at AQMD Headquarters

Contractor: SolSource Energy	AQMD Cost-share:	$	360,000
	Cosponsor:		
	CA Public Utilities Commission		333,000
Term: 06/06/05 – 06/05/11	Total Cost:	$	693,000

In December 2004, AQMD issued a RFP soliciting bids to install solar panels on its roof to generate up to 80 kW AC. These panels could ultimately be used to power the electrolyzer that generate hydrogen and/or for reducing peak use electricity during summer months. Five bids were received, which were evaluated by three outside panelists and two AQMD staff. SolSource Energy was the unanimous choice among the panelists. On April 2005, AQMD awarded SolSource Energy to install semi-crystalline RWE Schott Solar ASE 300 series, on an innovative mounting system that doesn't penetrate AQMD roof. AQMD award will not exceed $360,000, with the remaining funds of $338,000 to be provided by CPUC's self-generation incentives (SGIP). The SGIP was created by the California legislature to encourage the installation of renewables and other clean electric generating technologies. The AQMD solar system is expected to be completed by early next year, and would include flat panel displays in AQMD lobby that monitor real time output of the solar panels.

06075 Field Comparison of Portable Electrochemical Analyzers to a CEMS for Measurement of Nox and CO Emissions from a Rich-Burn Engine

Contractor: Advanced Engine Technology Corporation	AQMD Cost-share:	$	33,320
	Cosponsors:		
	SoCalGas (In-Kind)		3,000
	Eastern Municipal Water District (In-Kind)		6,000
	Testo Inc. (In-Kind)		25,000
Term: 12/21/05 – 03/31/06	Total Cost:	$	67,320

As part of the proposed amendments to Rule 1110.2 "Emissions from Gaseous and Liquid-Fueled Internal Combustion Engines," staff is considering requiring additional monitoring, testing, recordkeeping, and reporting to improve compliance with the rule. In an effort to identify and evaluate internal combustion (IC) engine control technology and monitoring technology, staff established an IC Engine Working Group made up of representatives from various stakeholder groups to provide input in the development of proposed amended Rule 1110.2. In the course of these discussions, we were approached about funding a test study to demonstrate lower cost alternatives to

the costly CEMS type-equipment and the effect the introduction of LNG may have on different types of gases. Ultimately it will provide guidance on what emissions monitoring strategies are achievable and practical to ensure compliance with engine permit limits. Partners in the project currently include the Southern California Gas Company, Eastern Municipal Water District (EMWD), Advanced Engine Technology Corporation (AETC), and Testo, Inc. Partners will be providing in-kind support and access to key assets to perform the study. AETC will demonstrate a low-cost electrochemical cell based portable analyzer as a semi-continuous emission monitor for a stationary, non-emergency engine. The portable electrochemical cell based analyzer will record NOx and CO emissions from two engines at least three times per day for 15 minutes while a portable CEMS will concurrently record emissions data. A final report will be prepared documenting the accuracy and benefits of using the analyzer as a semi-continuous emissions monitor.

Outreach and Technology Transfer

05008: CY 2005 Membership & Participation in California Fuel Cell Partnership

Contractor: Bevilaqua-Knight Inc.	SCAQMD Cost-share:	$	133,800
	Cosponsors: eight automakers, four energy companies, two technology providers, seven government agencies, and ten associate members		1,826,200
Term: 07/07/04 - 07/06/06	Total Cost:	$	1,960,000

In April 1999, the California Fuel Cell Partnership (CaFCP) was formed with eight members; SCAQMD joined and has participated since 2000. The CaFCP and its members are demonstrating fuel cell passenger cars and transit buses with associated fueling infrastructure in California. The goals of the CaFCP for 2005 include the following: a) to facilitate members placement of fuel cell vehicles and fueling stations into fleets in California, including fuel cell buses; b) to support the implementation of the California Hydrogen Highway network; c) to promote hydrogen fueling station and vehicle interoperability and accessibility; d) to train First Responder trainers in vehicle and fueling demonstration communities; e) to engage in focused community and stakeholder outreach to disseminate CaFCP learnings and distribute CaFCP Resource documents; f) to coordinate with other fuel cell vehicle programs worldwide; and g) to maintain and expand CaFCP's position as a leading information source for hydrogen and fuel cell vehicles. Since the CaFCP is a voluntary collaboration, each participant contracts with Bevilacqua-Knight, Inc. (BKI) for their portion of CaFCP administration. SCAQMD contributes $83,800 for membership, plus up to $50,000 and an office at SCAQMD to provide 50 percent support for the CaFCP Regional Coordinator. These funds provide continued participation for 2005, and subject to Governing Board annual review and approval of funding, it is expected that SCAQMD will continue its participation through 2007 under this contract.

05101: Technical Assistance for Development, Outreach & Commercialization of Advanced, Low-Emission Light- & Heavy-Duty Vehicle Technologies and Coordination with State Agencies

Contractor: Calhoun, Joseph	SCAQMD Cost-share:	$	40,000
Term: 01/07/05 – 09/31/07	Total Cost:	$	40,000

The major light-duty vehicle manufacturers have improved the natural gas, hydrogen, and electric vehicles used in the marketplace. Due to fluctuating gasoline prices, a more available fueling

infrastructure network, and vehicle reliability and durability, the public and fleet managers are now more receptive to alternative fuel technologies. Hybrid electric technologies in both light- and heavy-duty applications are developing as a major contribution to achieve federal and state ambient air quality standards in the Basin. Hybrid electric technology can be coupled with natural gas engines, microturbines, and fuel cells as well as gasoline and diesel engines. To promote, fund, manage, and expedite the development and demonstration of such advanced technology projects, Mr. Calhoun will work with SCAQMD staff to provide expertise in alternative fuels for light- and heavy-duty vehicles and outreach for dissemination and commercialization of new technologies.

05120: Technical Assistance for Technology Incentive Programs to Evaluate Proposals for Compliance with New CARB Guidelines

Contractor: Clean Fuels Connection, Inc.	SCAQMD Cost-share:	$	90,000
Term: 04/01/05 – 3/31/07	Total Cost:	$	90,000

The SCAQMD receives funding from state agencies to provide incentives for fleet operators to reduce emissions of construction equipment and medium- and heavy-duty vehicles. An important goal is to keep fleet operators, industry groups, and trade organizations apprised of emerging low- and zero-emissions technologies and opportunities to purchase them. Although engine technology research is required to reduce the emissions at the combustion source, combustion cleanup methods are also needed to address the current installed base of on-road and off-road technologies. Clean Fuel Connection will assist staff in project cost-effectiveness calculation and feasibility evaluation.

05121: Technical Assistance to Coordinate with CARB to Develop, Analyze and Implement New Incentive Program Guidelines

Contractor: Sullivan, Cindy	SCAQMD Cost-share:	$	75,000
Term: 03/14/05 – 03/31/07	Total Cost:	$	75,000

With more stringent heavy-duty engine emission standards effective as of October 2002, there is a need to develop cleaner engines. Alternative-fueled engines have inherently been cleaner than conventionally fueled engines. Most alternative-fueled engines have historically met lower optional emission standards and continue to demonstrate the capability of meeting future emission standards. As an incentive to develop new engines to meet future optional emission standards, California and SCAQMD provide incentive funds to help offset the additional costs of these engines. Ms. Cindy Sullivan will provide technical expertise on implementation of incentive program guidelines. Ms. Sullivan's in-depth experience will provide expertise with alternative fuel heavy-duty engine technology. Ms. Sullivan was the Carl Moyer Program manager for SCAQMD and CARB and is very familiar with the program requirements having drafted the original state guidelines for the Moyer Program.

05123: Technical Assistance for Development, Outreach & Commercialization of Low-Emission and Alternative Fuels Technologies and Evaluating Project Proposals for Technology Incentive Programs

Contractor: TIAX, LLC	SCAQMD Cost-share:	$	90,000
Term: 03/14/05 – 03/31/07	Total Cost:	$	90,000

Due to the constant and rapid changes in technologies, and the sheer breadth of the potential projects, TAO staff requires input from experts and practitioners in the field to aid in selecting and establishing projects under the Clean Fuels Program. TIAX, LLC will provide technical assistance for low-emission and alternative fuels technologies such as low- and zero-emission mobile source technologies, emissions testing, and alternative fuel vehicles. TIAX, LLC also provides staff knowledgeable in heavy-duty vehicle control technologies; off-road vehicles and equipment; and state and federal programs, policies, and regulations regarding off-road and alternative vehicles.

05125: Technical Assistance for Development, Outreach & Commercialization of Fuel Cells and Technical Coordination with Federal Energy & Transportation Departments

Contractor: Breakthrough Technologies Institute, Inc.	SCAQMD Cost-share:	$ 40,000
Term: 03/05/05 – 03/31/07	Total Cost:	$ 40,000

Breakthrough Technologies will provide expertise in fuel cell technology and administrative coordination with the U.S. DOE and U.S. Department of Transportation. Breakthrough Technologies will support the SCAQMD with expertise in commercialization of fuel cells and other low- and zero-emission technologies.

05126: Technical Assistance for Development, Outreach & Commercialization of LNG, CNG and Hydrogen Fuels

Contractor: St. Croix Research	SCAQMD Cost-share:	$ 250,000
Term: 03/15/05 – 03/31/07	Total Cost:	$ 25,000

In the AQMP, advanced technologies are required in order to achieve necessary emissions reductions, especially in the area of mobile sources. These are emission reductions that may not be achievable using conventional fuels and technologies. St. Croix Research will provide expertise to evaluate projects relating to the commercialization of LNG, CNG and hydrogen vehicles used in the marketplace. Due to fluctuating gasoline prices, a more available fueling infrastructure network, and vehicle reliability and durability, the public and fleet managers are now more receptive to alternative fuel technologies.

05127: Technical Assistance for Development, Outreach & Commercialization of Hydrogen & Fuel Cell Technologies

Contractor: Protium Energy Technologies	SCAQMD Cost-share:	$ 40,000
Term: 03/14/05 – 03/31/07	Total Cost:	$ 40,000

Fuel cells are emerging as a leading alternative to the internal combustion engines in vehicle, marine and stationary distributed energy applications. The SCAQMD supports development of fuel cell technologies and is currently sponsoring programs focused on advancement of specific fuel cell systems and determining fuel quality issues for fuel cells. The SCAQMD is working with government and industries to further commercialize mobile and stationary fuel cells in stationary and mobile applications. Protium Energy Technologies will provide expertise to evaluate development and commercialization of hydrogen vehicles to be used in the marketplace.

05128: Technical Assistance for Development, Outreach & Commercialization of Advanced Heavy-Duty & Off-Road Technologies

Contractor: Mid-Atlantic Research Institute, LLC.	SCAQMD Cost-share:	$ 40,000
Term: 08/08/05 – 03/31/07	Total Cost:	$ 40,000

The alternative fuel refueling infrastructure has been expanding allowing for greater use of heavy-duty and off-road alternative-fueled vehicles. Mid-Atlantic Research Institute has expertise in the design and development of after-treatment, advanced heavy-duty engine design, and exhaust emission measurement and chemical speciation as these technologies apply to on-highway, off-road, portable engines, stationary engines, locomotives, and marine vessels.

05171: Technical Assistance for Locomotive Technologies

Contractor: James Hazelton	SCAQMD Cost-share:	$ 20,000
Term: 04/08/05 – 04/30/06	Total Cost:	$ 20,000

James Hazelton is a respected expert in locomotives and railroad operations and would be a resource to AQMD staff in evaluating technologies needed to meet future mobile source emission standards and potential AQMD rules, including the possible use of alternative fuels. Proposed railroad legislation also address various locomotive technology capabilities, and expertise to assess the emissions impact of such actions imposed upon railroad operations is necessary. Mr. Hazelton's experience in this field span the spectrum of locomotive research, testing, servicing and railroad operations.

05178: Technical Assistance for Remote Sensing Programs for Light-Duty Vehicles and Locomotives

Contractor: Don Stedman	SCAQMD Cost-share:	$ 25,000
Term: 05/30/05 – 11/30/06	Total Cost:	$ 25,000

Dr. Stedman is renowned in the field of mobile source remote sensing technology, and has extensive academic, technical and practical experience in designing and implementing mobile source remote sensing programs. This provides for staff to utilize his technical assistance on remote sensing to identify high emitting light- and medium-duty vehicles and high emitting locomotives. This effort will be on conjunction with the implementation of two remote sensing programs, one for identifying high emitting light- and medium-duty vehicles and another for identifying high emitting locomotives. Both programs will be developed with AQMD staff to comply with CARB and EPA regulatory requirements for these mobile sources.

Fund Transfer: Conduct & Host International Conference on Ultrafine Particles in Spring 2006

Contractor: n/a	SCAQMD Cost-share:	$ 78,500
Term: 12/02/05	Total Cost:	$ 200,000

Recent findings from studies of ultrafine particles (those less than 0.1 micron in diameter) indicate that these particles may be more potent than either PM10 or PM2.5 at inducing adverse health effects. The Board directed staff to organize a conference to be held in Spring 2006 that will highlight the current state of knowledge of the sources, measurement, ambient levels, health significance,

regulation and control of ultrafine particles. The Board authorized up to $200,000 to organize and conduct the Ultrafine Particle Conference, which will be conducted April 30 through May 2, 2006, in Los Angeles. Since the Clean Fuels Conference Fund already had existing revenue remaining from a previous conference ("Hydrogen-Fueling the Clean Air Future" in August 2004), only an additional $78,500 was required. The monies were simply transferred from the Clean Fuels Fund to this special fund.

Varies: Co-Sponsorships of Conferences, Workshops and Events

Contractor: 19 Different Contractors	SCAQMD Cost-share:	$	204,230
	Cosponsors:		
	Various		737,724
Term: Various	Total Cost:	$	941,954

The SCAQMD regularly participates and sponsors conferences, workshops and events. These funds provide support for 19 such events during 2005, plus three business council memberships.

PROGRESS IN 2005

Key Projects Completed

A large number of emission sources contribute to the air quality problems in Southern California. Given the diversity of these sources, there is no single technology or "silver bullet" that can solve all of the region's problems. Accordingly, the SCAQMD continues to support a wide range of advanced technologies addressing not only the diversity of emissions sources, but also the time frame to commercialization of these technologies. Projects co-funded by the SCAQMD's Clean Fuels Program include emission reduction demonstrations for both mobile and stationary sources, although legislative amendments and reduced SCAQMD revenues limit the use of available funds primarily to 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 advancements in engine design, electric power trains, energy storage/conversion devices (e.g., fuel cells and batteries); and 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 4 provides a list of projects completed in 2005; summaries of these completed projects are included in Appendix C. Selected projects which represent a range of key technologies from near-term to long-term are highlighted below.

Development & Demonstration of Next Generation Natural Gas Engine Technology

This project was part of Department of Energy's (DOE) Next Generation Natural Gas Vehicle (NGNGV II) program to develop and implement a variety of technologies to further lower the emissions from natural gas engines. The goal of this project was to demonstrate technologies that deliver 0.2 g/bhp.hr NOx, 0.01 g/bhp.hr PM, 0.14 g/bhp.hr NMHC, and 0.01 g/bhp.hr formaldehydes emissions at higher brake thermal efficiency and power density than current products. The emissions demonstration was planned over the U.S. EPA Heavy Duty Transient test cycle.

In this project, Cummins integrated cooled exhaust gas re-circulation (EGR), combustion optimization and three way catalysts (TWC) to achieve the desired emission levels, higher power density, and efficiency. Cummins used a technology blend from proven diesel and natural gas systems to meet the project emissions and durability goals; specifically, the Cummins C Plus gas engine was used and EGR components from the diesel ISM and ISB engines were integrated. Target ratings for this engine were 310 HP, 950 lbs-ft torque and 40% brake thermal efficiency.

The work consisted of adapting a C8.3 Gas Plus engine with production available heavy-duty EGR systems, such as EGR cooler, valve and control logic. This work included analysis, models development, simulation, design, installation, modification, testing, optimization and demonstration in a steady state and transient cycle operation.

The target rating (310 BHP) was demonstrated and exceeded in some cases. A final configuration consisting of a high swirl head and fast burn combustion chamber was selected for the transient performance optimization. SI EGR C8.3 engine was optimized for performance and emissions and tested for transient FTP. Results met all emissions targets for this project, as follows:

- BSNOx at 0.15 g/bhp.hr

- BSCO at 4.0 g/bhp.hr
- BSNMHC at 0.0 g/bhp.hr,
- PM at 0.0024 g/bhp.hr.
- Formaldehyde at 0.014 g/bhp-hr

All torque and speed regression parameters required by EPA were met, and the engine followed the transients without any issues. In addition, analysis of the plug up test results indicates that the SI EGR C8.3 engine can result in better transient response than the current lean burn product.

An endurance test of the SI-EGR engine was also completed. The learning goals of the test included EGR tubing durability, EGR cooler effectiveness degradation, power cylinder wear, durability of anti-corrosion coating on intake cover, spark plug life, oil consumption, and oil degradation. The engine has been torn down and overall results have been favorable.

This application of EGR with stoichiometric combustion and a three-way catalyst has the potential to reduce vehicle emissions to the 2010 EPA levels, without significant durability issues. It is estimated that cost of ownership for a natural gas engine with this technology should be competitive, if not better, than the 2010 diesel engine technologies.

This project has demonstrated the capabilities of the cooled EGR technology applied to a SI stoichiometric engine with a three way catalyst. No major limitations have been identified that would restrict this technology from going into a commercial application. As a result, this technology was selected for commercialization and is now under a product development phase for market introduction by Cummins Westport, Inc. by 2007, well ahead of the planned commercialization of diesel engines that meet the same emission standards. This engine is most commonly used in transit bus and refuse collection operations.

A second phase for this technology could include additional studies towards improvements in fuel efficiency. Although a peak break thermal efficiency of 40% was demonstrated, overall efficiency over a real world operating cycle will still be lower than an equivalent diesel engine due to the inefficiencies of the throttled SI engine at part load.

Hydrogen Hybrid Internal Combustion Engine (HHICE) Bus

The AQMP calls for the accelerated introduction of both light- and heavy-duty zero-emission vehicles as an air quality attainment strategy. CARB regulations also require transit authorities to start using Zero Emission Buses. As an interim step to zero emission fuel cell buses, which are currently in the early development stage, hydrogen-powered ICEs used to provide a charge to a battery pack may be a cost-effective option to achieve near-zero emission levels. Additionally, use of hydrogen ICEs would stimulate the development of the hydrogen infrastructure and are highlighted in the California Hydrogen Highway Network Blueprint Plan. Hybrid-electric drive systems and hydrogen-ICE technology have matured over the past few years and appear nearer to commercialization than fuel cell vehicles. CARB has certified a gasoline-powered ICE for hybrid-electric transit use at a 0.6 g/bhp-hr optional NO_x emission standard. Emissions from an identical hydrogen-ICE are expected to be near zero emissions.

Under this project, ISE Research developed a hydrogen hybrid ICE (HHICE) transit bus using deep-cycle batteries in a series hybrid configuration and a variant of Ford Motor Company's (Ford) V10 Triton gasoline engine, which has been used successfully in a gasoline-ICE hybrid-electric bus. ISE Research assembled and installed the hybrid-drive system into a New Flyer transit bus chassis. After the initial testing by ISE Research and Ford, the bus was demonstrated and tested at various transit districts, including Chula Vista, Winnipeg, and SunLine Transit. CARB tested the bus on the chassis dynamometer to determine the actual emissions under various standard bus cycles. Subsequent to the various demonstrations, the bus has been operated by SunLine Transit in Revenue Service.

Figure 8: Hydrogen Hybrid ICE Transit Bus

Except for the hydrogen version of the V10 engine and the fuel storage on the roof, this HHICE bus is similar to the gasoline fueled hybrid electric buses which are certified as an alternative fueled vehicle in California.

The prototype HHICE bus was delivered to the customer, SunLine Transit on November 30, 2004 and put into revenue service. The bus went into service on SunLine's Route 50 in Palm Desert and was in service for three weeks, accumulating over 200 miles in service every day. The only service interruptions were for planned maintenance and upgrades. In January, the bus was shipped to Winnipeg, Manitoba for winter testing with Winnipeg Transit. The bus returned to SunLine Transit at the beginning of April following a series of demonstrations in Michigan, New York, New Jersey and Washington DC. The bus continues in daily service with SunLine Transit.

Key features and feedback include:

- Improved acceleration compared to conventional drive buses,
- Fuel economy of approximately 4-6 MPG (equivalent) with a range of over 200 miles,
- Quiet operation and
- Over 7,000 miles accumulated in the first five months of revenue service.

ISE offers the bus for US and Canadian transit agency service. ISE, along with other project partners, plan to develop technology to lower NO_x levels to light-duty vehice levels using a low-NO_x catalyst, as well as further optimize the engine controller to improve fuel economy. Numerous groups have indicated interest in implementing this technology, including the Los Angeles World Airports as shuttle buses.

Wind/Hydrogen Fueling Station

The wind/hydrogen fueling station funded under this program successfully demonstrated the generation of hydrogen fuel for vehicles from electricity produced at the Wintec wind farm. The hydrogen was used to fuel vehicles operated by SunLine transit. This program was a joint effort of several groups:

- The SCAQMD,
- ISE Corporation, Prime Contractor,
- Wintec Energy provided the wind turbines and space used for the program,
- SunLine Transit, end- user and long-term operator,
- Stuart Energy provided an electrolyser to the program, and

- Quantum Technology supplied the hydrogen storage trailer.

Figure 9: Wintec Hydrogen Generation System

Three 65kW rated Nordtank wind turbines were used to provide power to the hydrogen generation facility. Wintec and ISE developed the site. The electrolyser was lowered into place May 28, 2003 and commissioned in June with filling of the cells with electrolyte. Hydrogen was produced in July and a sample was taken and sent out for analysis. The fuel analysis indicated:

- N2 < 5 ppmv
- CO < 1 ppmv
- Ar < 1 ppmv
- CO_2 ~1.7 ppmv
- HC ~ 0.3 ppmv
- Mercaptans + HS < 0.2 ppmv
- CH4 < 1 ppmv
- Ethane < 1 ppmv
- Ethene < 1 ppmv

The hydrogen was used by SunLine for the HHICE bus (described above).

This project demonstrated the viability of generating hydrogen from a renewable source such as wind. Several key lessons learned from the project, however, were:

- Need to have the hydrogen available in a more convenient fueling location. Due to the remote location of the wind turbines, it was inconvenient for the bus operators to fuel at the hydrogen generation site.
- The intermittency of wind power can be overcome by including solar and conventional backup power to ensure availability.

Although the project has been successfully completed, a follow-on project would be to implement the lessons learned to provide a completely renewable source of hydrogen for mobile use.

Table 4: Projects Completed Between January 1 and December 31, 2005

Contract	Contractor	Project Title	Date
Incentive Programs-Alternative Fuels			
00114†	Alta Loma School District	Purchase 2 CNG School Buses	Jun-05
00116†	Montebello Unified School District	Purchase 2 CNG School Buses	Jun-05
00143†	Los Angeles County, Department of Water & Power	Purchase 25 Electric Buses	Jun-05
01051†	Fabrica International	Purchase 2 Electric Forklifts with Batteries	Dec-05
Infrastructure and Fuel Production			
03468	University of California Riverside	Reactivity & Availability Studies of VOC Species Found in Architectural Coatings and Mobile Sources	Jul-05
04121	Pacific, Gas & Electric	Cost-Share Small-Scale Natural Gas Liquefaction Plant	Dec-05
Fuels/Emission Studies			
04073	University of Southern California	Study Effects of Smoke from Recent Wildfires in Cohorts of USC Children's Health Study	Jun-05
Emission Control Technologies			
03109	West Virginia University	Aftertreatment Technologies for PM Emissions Control of CNG-Fueled Heavy-Duty Engines	Sep-05
Electric/Hybrid Vehicle Technologies			
02116†	Clean Fuel Connection, Inc.	Develop Dual Inductive/Conductive Charger Bracket to Allow Reduction of EV Charging Infrastructure Costs	Mar-05
04027	ISE Research Corporation	Develop & Demonstrate Hydrogen-Internal Combustion Engien for Hybrid-Electric Buses	May-05
Engine Technologies			
00139	Gas Research Institute	Develop & Demonstrate Advanced Safety Inspection Methods for Natural Gas Vehicle Tanks	Aug-05
03289	Cummins Inc.	Develop & Demonstrate Next Generation Natural Gas Engine Technology	Dec-05
03427†	Mack Truck Inc.	Natural Gas Next Generation Vehicle Phase II Integration of Improved Natural Gas Engine into Commercial Chassis	Nov-05
Hydrogen Technologies and Infrastructure			
02189	ISE Research Corporation	Develop & Demonstrate Water Electrolyzer Hydrogen Refueling Station in Coachella Valley	Sep-05
02208	Structural Composites Industries	Develop & Demonstrate Advanced Storage Tanks for Storing CNG/LNG and Compressed and Liquid Hydrogen	Sep-05

Table 4: Projects Completed Between January 1 and December 31, 2005 (Continued)

Contract	Contractor	Project Title	Date
Hydrogen Technologies and Infrastructure (cont'd)			
03200	Sunline Services Group, Inc.	Develop & Demonstrate an Autothermal Reformer Hydrogen Fueling Station	Jul-05
Outreach and Technology Transfer			
01104†	Seaworthy Systems, Inc.	Evaluate Carl Moyer Marine Vessel Proposals	Jan-05
01169†	Clean Fuel Connection, Inc.	Technical & Management Assistance for Carl Moyer School Bus and ZEV Implementation Programs and Infrastructure Scoping	Apr-05
02158†	College of the Desert	Develop Natural Gas School Bus Training Curriculum	Jul-05
03451†	TIAX LLC	Technical Assistance Pertaining to 2003 AQMP Revision & Mobile Source Control Sources	Nov-05
04045†	TIAX LLC	Technical Assistance for Development, Outreach & Commercialization of Low-Emission & Alternative Fuel Technologies	Dec-05
04048†	Cindy Sullivan	Technical Assistance for Emission Control & Alternative Fuels Technologies	Dec-05
04049†	Engine, Fuel, & Emissions Engineering Inc.	Technical Assistance for Alternative Fuels Engine Technology	Dec-05
04050†	Breakthrough Technologies Institute	Technical Assistance for Fuel Cells	Dec-05
04102†	Clean Vehicle Education Foundation	Cosponsor 2004 NGV Conference & CVEG Activities	Jan-05
04183†	Energy Independence Now	Cosponsor EIN 2004 Activities & Support the California Hydrogen Highway Network	Jan-05
04207†	University High School	Cosponsor UHS Solar Racing Project	Sep-05
05040†	Westart-Calstart	Cosponsor 5th Annual Heavy-Duty Vehicle Conference	Sep-05
05053†	Rand Corporation	Cosponsor RAND's Forum on Valuing the Hydrogen Economy	Sep-5
05054†	Westart-Calstart	Cosponsor 2020: California's Transportation Energy Future Conference	Aug-05
05055†	Enterprise for Education	Provide Funding Support to the Clean Air Challenge	Dec-05
05113†	Alternative Fuel Vehicle Institute	Cosponsor the 11th National Clean Cities Conference & Exposition	Aug-05
05129†	Coordinating Research Council Inc.	Cosponsor the 15th Annual CRC On-Road Vehicle Emissions Workshop	Sep-05
05136†	University of California Irvine	Cosponsor Moving Forward: The Transition to Alternative Fuels Conference	Oct-05

Table 4: Projects Completed Between January 1 and December 31, 2005 (Continued)

Contract	Contractor	Project Title	Date
Outreach and Technology Transfer (Cont'd)			
05147†	National Hydrogen Association	Cosponsor the 16th Annual U.S. Hydrogen Conference	Oct-05
05164†	California Climate Action Registry	Cosponsor CaCAR's 3rd Annual Conference	Oct-05
05201†	Clean Air Now	Provide Funding Support to the Clean Air Challenge	Dec-05
05254†	The Partnership	Cosponsor the SCAG Clean Cities Coalition "Advancing the Choice for Alternative Fuel Vehicles" Event	Nov-05
06038†	Occidental College	Cosponsor the Regional Seminar on Professional Wet Cleaning	Dec-05

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

FUTURE TECHNOLOGIES

Funding Priorities for 2006

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

The overall strategy is based in large part on technology needs identified in the AQMP for the Basin and the Governing Board's directives to protect the health of residents of Southern California. The AQMP is the long-term "blueprint" that defines the basin-wide emission reductions needed to achieve ambient air quality standards by 2010, the regulatory measures to achieve those reductions, the timeframes to implement these proposed measures, and the technologies or types of technologies required to meet these future proposed regulations. As previously identified in Figure 1, the NO_x and VOC emission sources of greatest concern are heavy-duty on-road vehicles, light-duty on-road vehicles, and off-road equipment.

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 Basin. This Plan Update includes projects to develop, demonstrate, and commercialize a variety of technologies, from near-term to long-term, that are intended to provide solutions to the emission control measures identified in the AQMP.

Within each technical area, there exist 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, but not 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 2006 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 2009. Projects are also proposed that may involve developing emerging technologies that are considered longer term and, perhaps higher risk, but with significant emission reduction potential. Commercial introduction of such long-term technologies would not be expected until 2010 or later.

- More mature technologies, those ready to begin field demonstration in 2006, are expected to result in a commercial product in the 2007-08 timeframe. Technologies being field demonstrated generally have been certified or 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.

Summary of Technical Priorities

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

Not all project areas will be funded, given the funding constraints 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 to expedite the implementation of cleaner alternative technologies in the Basin.

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

Infrastructure and Fuel Production

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

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

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

Emissions and Health Impacts Studies

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

emissions and health studies to identify the emissions from high polluting sectors as well as the health effects from these technologies:

- Emissions studies for locomotives, port, and marine vessels
- Demonstrate remote sensing to target different high emission applications
- Conduct studies to identify the health risks associated with ultrafines and ambient particulate matter

Emission Control Technologies

Although engine technology research is required to reduce the emissions at the combustion source, post-combustion cleanup methods are also needed to address the current installed base of on-road and off-road technologies. Existing diesel emissions can be greatly reduced with after-treatment controls such as particulate matter traps (PM-traps) and catalysts, as well as lowering the sulfur content or using additives with diesel fuel. Gas-to-Liquid (GTL) fuels, formed from natural gas or other gas rather than petroleum feedstock, and emulsified diesel provide low-emission fuels for use in diesel engines. And 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 ultra-low sulfur diesel and GTL fuels
- Development and demonstration of advanced after-treatment technologies for mobile applications (including particulate traps and catalysts)
- Development and demonstration of low VOC and PM lubricants for diesel and natural gas engines
- Development and demonstration of advanced air pollution control equipment

Electric and Hybrid Technologies

Despite the greater near-term environmental benefits of battery EVs, no major automobile manufacturer is currently producing light-duty passenger EVs. Widespread demand and deployment have also been hampered by public concerns over cost, battery lifetime, travel range, charging station infrastructure and manufacturer commitment. The SCAQMD continues to consider projects addressing these concerns as well as the use of battery EVs in fleet or niche applications.

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

- Upgrade and demonstration of hybrid electric buses
- Demonstration of advanced commercial utility equipment
- Demonstration of advanced energy storage technologies

- Evaluation and demonstration of light and medium-duty, grid-rechargeable, hybrid electric vehicles (e.g., PHEVs)
- Demonstration of heavy-duty hybrid vehicles

Engine Technologies

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

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

- Continued development and demonstration of alternative fuel medium-duty and heavy-duty engines and vehicles
- Demonstration of low and zero-emission locomotives
- Development and demonstration of clean alternative fuel engines for non-road applications

Hydrogen Technologies and Infrastructure

In 2002, the SCAQMD initiated the groundwork for a distributed hydrogen fueling network to allow the limited number of demonstration fuel cell vehicles refueling access throughout the Basin and reduce the number of obstacles to commercialization of additional fuel cell vehicles. Despite the selection of hydrogen as the current fuel of choice for the demonstration vehicles, there are various production, storage, and dispensing strategies still under consideration for the long-term infrastructure solution. As a result, further development of these refueling technologies is planned, especially in areas where our funding can be leveraged with other state or federal programs.

The economical production of hydrogen for these vehicles and, to the extent necessary, for stationary applications, is also a key area in need of development and demonstration. In particular, the production of hydrogen from renewable sources is of interest, either using photovoltaics and electrolyzer technologies or biomass feedstocks and reformation technologies due to the potential for higher lifecycle efficiencies and lower greenhouse gas emissions compared to conventional fuels. Such renewable energy projects would provide data to help understand and benchmark critical parameters for enabling these technologies.

Furthermore, as an interim step toward full fuel cell vehicle deployment and as a means to testing and verifying the hydrogen infrastructure, hydrogen ICE and hydrogen-CNG (HCNG) blended fuel vehicles will be developed and demonstrated. Hydrogen ICE and HCNG vehicles, which utilize conventional engine technologies, represent potentially cost effective hydrogen vehicle options. The emissions, although higher than those of fuel cell vehicles, can be optimized for emissions lower than dedicated CNG vehicles. Future projects are expected to include the following:

- Development and demonstration of hydrogen ICEs for vehicle and power applications
- Development and demonstration of hydrogen HCNG vehicles for medium and heavy-duty applications

- Continued development and demonstration of distributed hydrogen production and refueling stations, including energy stations with electricity and hydrogen co-production

Mobile Fuel Cell Technologies

Fuel cells are emerging as a leading alternative technology to replace more polluting ICEs. The first demonstration vehicles are using PEM fuel cells and compressed hydrogen as the fuel, but the long-term infrastructure requirements, stack durability, and any synergistic relationship to stationary applications remain uncertain. Considerable research, development, and demonstration efforts are already underway to address these issues by some of the largest automobile manufacturers and fuel suppliers. Yet, much work is needed to improve the performance and range of these vehicles, reduce costs, develop a viable fueling infrastructure, and obtain public acceptance for a new technology in everyday applications.

The SCAQMD is also actively working with the California Fuel Cell Partnership and the California Hydrogen Highway Network to further the commercialization of mobile fuel cells. The 2006 Plan Update identifies key opportunities consistent with both organizations while clearly leading the way for the development and demonstration of both mobile applications. Future projects may include the following:

- Development and demonstration of cross-cutting fuel cell applications (e.g. plug-in vehicle to grid power and fuel cell auxiliary power units)
- Development and demonstration of fuel cells in off-road and marine applications
- Demonstration of fuel cell vehicles in controlled fleet applications in the Basin

Stationary Technologies

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

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

Target Project Allocations

Figure 10 below presents the potential allocation of available funding, based on SCAQMD projected program cost of nearly $23 million for all potential projects. The expected actual project expenditures for 2006 will be much less than the total SCAQMD projected program cost since not all projects will materialize. The target allocations are based on balancing technology priorities, technical challenges and opportunities discussed previously, and near-term versus long-term benefits with the constraints on available SCAQMD funding. Specific contract awards throughout 2006 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.

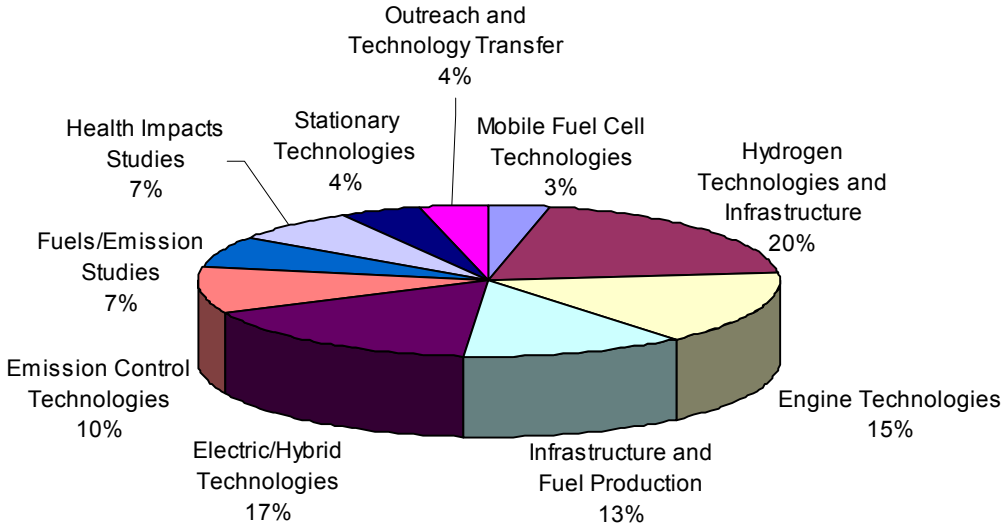


Figure 10: Projected Cost Distribution for Potential SCAQMD Projects 2006 and Beyond ($23 million)

PROGRAM PLAN UPDATE

This section presents the Clean Fuels Program Plan Update for 2006. 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.

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 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.

The remainder of this section contains the following information for each of the potential projects summarized in Table 5.

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 5: Summary of Potential Projects

Proposed Project	Expected SCAQMD Cost	Expected Total Cost
Infrastructure and Fuel Production		
Develop and Demonstrate Biofuels in Vehicles	1,000,000	5,000,000
Demonstrate Equipment to Reduce Fugitive Fueling Emissions	100,000	400,000
Upgrade of Existing Natural Gas Infrastructure	250,000	1,000,000
Develop and Demonstrate Advanced Natural Gas Systems for Refueling Stations	750,000	4,000,000
Demonstrate LNG Manufacturing and Distribution Technologies	750,000	7,000,000
Subtotal	$2,850,000	$17,400,000
Fuels/Emission Studies		
Conduct Studies to Develop More Accurate Emissions Inventories	800,000	1,300,000
Identify and Demonstrate In-Use Fleet Emissions Reductions	500,000	2,000,000
Perform Study of Comparative Emissions of Alternative Fuel and Conventional Fuel Engines	250,000	1,000,000
Subtotal	$1,550,000	$4,300,000
Emission Control Technologies		
Develop and Demonstrate Advanced Aftertreatment Technologies	2,000,000	5,200,000
Develop and Demonstrate Low-Emission Lubricants for Natural Gas Engines	250,000	1,000,000
Subtotal	$2,250,000	$6,200,000
Electric/Hybrid Technologies		
Demonstrate Light Duty Plug-In Hybrid Electric Vehicles	1,000,000	5,000,000
Develop and Demonstrate Medium- and Heavy-Duty Hybrid Vehicles and Systems	1,500,000	5,000,000
Demonstrate Alternative Energy Storage Systems	1,100,000	2,600,000
Investigate and Demonstrate Small Urban Electric Vehicle Applications	150,000	500,000
Subtotal	$3,750,000	$13,100,000
Engine Technologies		
Develop and Demonstrate Advanced Alternative Fuel Medium- and Heavy-Duty Engines and Vehicles	1,000,000	4,000,000
Demonstrate Lower Emission Locomotives	1,500,000	7,000,000
Develop and Demonstrate Alternative Fuel and Clean Conventional Fueled Light-Duty Vehicles	1,000,000	5,000,000
Subtotal	$3,500,000	$16,000,000

Table 5: Summary of Potential Projects (Continued)

Proposed Project	Expected SCAQMD Cost	Expected Total Cost
Hydrogen Technologies and Infrastructure		
Develop and Demonstrate Hydrogen Storage Technologies	$500,000	$1,500,000
Develop and Demonstrate Hydrogen Vehicles	1,000,000	5,000,000
Develop and Demonstrate Hydrogen-Natural Gas Internal Combustion Engines	500,000	3,000,000
Demonstrate Hydrogen-CNG Compatibility	300,000	1,400,000
Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations	2,250,000	9,000,000
Subtotal	$4,550,000	$19,900,000
Mobile Fuel Cell Technologies		
Develop and Demonstrate Fuel Cells in Vehicle Applications	750,000	3,500,000
Subtotal	$750,000	$3,500,000
Health Impacts Studies		
Evaluate Ultrafine Particle Health Effects	$750,000	$3,000,000
Conduct Monitoring to Assess Environmental Impacts	500,000	1,000,000
Assess Sources and Health Impact of Ambient Particulate Matter	300,000	300,000
Subtotal	$1,550,000	$4,300,000
Stationary Clean Fuel Technologies		
Develop and Demonstrate Low-Cost Emission Monitoring Systems	$250,000	$500,000
Develop and Demonstrate Clean Stationary Technologies	250,000	750,000
Develop and Demonstrate Renewable-Based Energy Generation Alternatives	500,000	1,000,000
Subtotal	$1,000,000	$2,250,000
Outreach and Technology Transfer		
Assessment and Technical Support of Advanced Technologies and Information Dissemination	500,000	500,000
Support for Implementation of Various Clean Fuels Vehicle Incentive Programs	400,000	400,000
Subtotal	$900,000	$900,000
TOTALS FOR POTENTIAL PROJECTS	**$22,650,000**	**$87,850,000**

Infrastructure and Fuel Production

Proposed Project: Develop and Demonstrate Biofuels in Vehicles

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

The use of biological feedstocks for fuels, e.g., waste products (biomass), cellulosic biomass (ethanol), and organically derived oils (biodiesel), is a continuing goal due to their renewable and sustainable potential. Such fuels, however, must also provide prospective economic production, seamless integration with current vehicle technologies, and low emissions in order to be competitive in the marketplace. This project category is to demonstrate biofuels in vehicles in order to investigate these challenges. Existing and advancing technologies may be used in concert with the fuels to enable lower production costs, maintain vehicle performance, and reduce emissions to the lowest possible levels. Potential feedstock candidates include refuse sites, water reclamation facilities, diaries, and greenwaste collection facilities. Conversion processes may include gasification, celluosic, or photobiological.

The resulting alternative fuels to be demonstrated under this project category include methane (CNG), hydrogen, ethanol, Fischer-Tropsch, and biodiesel.

Potential Air Quality Benefits:

This project category is to ensure that renewable transportation fuels do not adversely affect air quality for the sake of sustainability. For example, although biodiesel and ethanol have been supported at the federal level, these fuels have potentially adverse air quality issues in the South Coast Air Basin. Biodiesel has lower PM but higher NO_x emissions than conventional diesel, and ethanol at low concentrations has potentially higher VOC emissions but does not meet SULEV NO_x emissions. This project category would investigate technologies to enable these fuels to provide both the lowest possible emissions with the renewable and petroleum reduction benefits.

Proposed Project: Demonstrate Equipment to Reduce Fugitive Fueling Emissions

Expected SCAQMD Cost: $100,000

Expected Total Cost: $400,000

Description of Technology and Application:

Fugitive emissions are difficult to identify, quantify, and capture. For example, propane emissions from BBQ, residential, forklift, automotive, commercial, industrial, etc. are estimated to leak approximately 7 tons of VOC emissions per day into the atmosphere within the South Coast Basin. This project category is to identify and develop equipment to reduce the fugitive emissions from a variety of refueling and storage equipment (e.g., above-ground tanks and under-ground tanks); processing and transfer (e.g., valves, pumps, compressors, etc.) of chemicals and petroleum products; and gasoline dispensing facilities. Projects in this category will focus on new technologies to detect and repair frequent and big leaks, develop leakless valves, and enhance vapor recovery devices to broaden their applications and/or to improve control efficiency.

Potential Air Quality Benefits:

VOC emission reductions are required in the Basin to attain federal Clean Air Standards. Projects in this category will target long-term technologies and processes that, if successful, will result in direct VOC emissions reductions at the demonstration sites, followed by broader applications that can deliver major VOC reductions throughout the Basin from the emission sources listed above.

Proposed Project: Upgrade of Existing Natural Gas Infrastructure

Expected SCAQMD Cost: $250,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

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

Potential Air Quality Benefits:

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

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

Expected SCAQMD Cost: $750,000

Expected Total Cost: $4,000,000

Description of Technology and Application:

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

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

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

Potential Air Quality Benefits:

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

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

Proposed Project: Demonstrate LNG Manufacturing and Distribution Technologies

Expected SCAQMD Cost: $750,000

Expected Total Cost: $7,000,000

Description of Technology and Application:

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

Industry and government agree that LNG promises to capture a significant share of the heavy-duty vehicle and engine market. LNG is the 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

- Economic small-scale natural gas liquefaction technologies;
- Utilization of various gaseous feed stocks locally available;
- Commercialize incentives for fleets to site, install, and use LNG and L/CNG refueling facilities; and
- Strategic placement of LNG storage capacity sufficient to provide supply to users in the event of a production outage.

Potential Air Quality Benefits:

The SCAQMD relies on the significant penetration of zero- and low-emission vehicles in the South Coast Basin to attain federal clean air standards by 2010. This project would help develop a number of small-scale liquefaction technologies that can reduce LNG costs to be competitive with diesel fuel. Such advances are expected to lead to greater infrastructure development. This would make LNG fueled heavy-duty vehicles more available to the commercial market leading to direct reductions in NO_x, PM, and toxic compound emissions.

Fuels/Emission Studies

Proposed Project: Conduct Studies to Develop More Accurate Emissions Inventories

Expected SCAQMD Cost: $800,000

Expected Total Cost: $1,300,000

Description of Technology and Application:

In order to develop more accurate predictive models, the SCAQMD regularly sponsors studies to help upgrade the emissions inventory of various mobile sources. For example, a study was cosponsored with CARB in 1990 to update the emission inventory from locomotives for development of the 1994 AQMP. Similarly, in 1999 a study was sponsored to update the marine vessels emissions inventories for the 2003 AQMP. Both studies provided emissions inventories for various categories of locomotives and marine vessels (ocean-going vessels and harbor craft) for the 1994 and 1997 base years and forecast years (2000, 2010, and 2020). The emissions inventories presented a significant improvement compared to the inventories previously developed.

Current information indicates significant increases beyond previous projections in many different sectors, particularly marine vessels, locomotives, cargo handling equipment, and other non-road applications. This new information needs to be analyzed and integrated into new emission inventory projections.

Potential Air Quality Benefits:

Updated emissions inventories in the Basin are necessary for the purpose of planning and development of the 2007 AQMP Revision. Further improvements to the existing emissions inventories and future growth projections are critical to accurately assess the air quality impacts from the ports as well as planning future controls necessary to demonstrate attainment of the 8-hour ozone and PM2.5 national ambient air quality standards.

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

Expected SCAQMD Cost: $500,000

Expected Total Cost: $2,000,000

Description of Technology and Application:

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

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

- Remote sensing for heavy-duty vehicles
- Annual testing for high mileage vehicles (>100,000 miles)
- Replace or upgrade emissions control systems at 100,000 mile intervals
- On board diagnostics with remote notification
- Low cost test equipment for monitoring and identifying high emitters
- Test cycle development for different class vehicles (e.g. four wheel drive SUVs)
- Electrical auxiliary power unit replacements

The second phase of the project is to then 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 high emitting vehicles, 5 percent in the existing fleets account for up to 80 percent of the emissions. Identification of higher emitting vehicles would assist with demand-side strategies, where higher emitting vehicles have correspondingly higher registration charges, which is included in Chapter 4 of the AQMP as a potential control strategy.

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

Expected SCAQMD Cost: $250,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

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

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

Potential Air Quality Benefits:

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

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

Emission Control Technologies

Proposed Project: Develop and Demonstrate Advanced Aftertreatment Technologies

Expected SCAQMD Cost: $2,000,000

Expected Total Cost: $5,200,000

Description of Technology and Application:

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

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

Potential Air Quality Benefits:

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

Proposed Project: Develop and Demonstrate Low-Emission Lubricants for Natural Gas Engines

Expected SCAQMD Cost: $250,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

There are data indicating that engine lubrication oil affects exhaust emissions. With properly formulated lube oil, emission benefits are available from both petroleum-based and synthetic lube oils. A lube oil reformulation has recently taken place for new heavy-duty diesel engines with exhaust gas recirculation (EGR). In addition, such a reformulation process is currently underway for 2007 and newer heavy-duty diesel engines in order to improve the effectiveness of future exhaust emission controls.

It is proposed that heavy-duty lube oils be directly investigated to reduce PM emissions (ultrafine particles and nanoparticles) on both new and older heavy-duty natural gas and diesel engines. This will involve investigating the specific parameters that affect emissions, securing specific commercial lube oils or preparing specially formulated lube oils, conducting engine and/or vehicle emission testing, and demonstrating such oils in fleet vehicles. Further efforts may also be required to gain industry certifications of such oils for new and older engines.

Potential Air Quality Benefits:

Up to 20 percent reductions in PM and toxic compounds are possible with lower NO_x reductions. Besides their use in new engines, such reformulated oils could be used in older diesel and natural gas engines expanding such benefits to the entire fleet in a relatively short period of time. A nominal 10 percent PM (ultrafine particles, nanoparticles) benefit and 5 percent NO_x benefit to the 2007 heavy duty on-road fleet could be expected. Emission toxicity of PM, ultrafine particles and nanoparticles, and hydrocarbons can also be improved. Finally, fuel consumption is expected to be reduced potentially offsetting the increased cost of such improved lube oils. These benefits could also be expanded to off-road heavy-duty engines.

Electric/Hybrid Technologies

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

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

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

The AQMD has long supported the concept of using increased batteries to allow a portion of the driving cycle to occur in all electric mode for true zero emission miles. This battery dominant strategy is accomplished by incorporating an advanced battery pack initially recharged from the household grid or EV chargers. This "plug-in" hybrid electric vehicle (PHEV) strategy allows reduced emissions and improved fuel economy. Unfortunately, no automobile manufacturer is openly pursing this strategy.

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

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

Potential Air Quality Benefits:

The 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 conventional gasoline-fueled vehicle, a factor expected to enhance consumer acceptance. This proposed project will evaluate various HEV systems and their performance and identify the most appropriate protocols with which to test real-world HEVs. Given the variety of HEV systems under development, it is critical to determine the true emissions and performance of HEVs. Demonstration of optimized prototypes would improve the viability of near-ZEV HEV technologies and enhance the deployment of near-ZEV technologies.

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

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

Expected SCAQMD Cost: $1,500,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

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

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

Potential Air Quality Benefits:

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

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

Proposed Project: Demonstrate Advanced Energy Storage Systems

Expected SCAQMD Cost: $1,100,000

Expected Total Cost: $2,600,000

Description of Technology and Application:

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

The long-term objective of this program is to decrease the fuel consumption without any changes in performance compared to conventional diesel and alternative fuel engines. This program will support several projects for development and demonstration of different types of low-emission hybrid vehicles. The types of fuels utilized in these projects would include, but not be limited to LPG, natural gas, combined with high power energy storage systems required for the electric energy. The overall net emissions and fuel consumption of these types of vehicles are expected to be much lower than traditional diesel engine systems. Both new and retroffitable 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 AQMP. This program is expected to develop hybrid technologies that could be implemented in medium- and heavy-duty trucks, buses, and other applications. Benefits will include proof of concept for the new technologies, diversification of transportation fuels, and lower emissions of criteria and toxic pollutants.

Proposed Project: Investigate and Demonstrate Small Urban Electric Vehicle Applications

Expected SCAQMD Cost: $150,000

Expected Total Cost: $500,000

Description of Technology and Application:

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

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

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

Potential Air Quality Benefits:

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

Engine Technologies

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

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $4,000,000

Description of Technology and Application:

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

- Demonstration of advanced engines in medium-duty and heavy-duty vehicles; and
- Development of durable and reliable retrofit technologies to convert engines and vehicles from petroleum fuels to alternative fuels.

Anticipated fuels for these projects include, but are not limited to, CNG, LNG, LPG, emulsified diesel, and gas-to-liquid (GTL) fuels. The program proposes to expand field demonstration of these advanced technologies in various vehicle fleets operating with different classes of vehicles.

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

Potential Air Quality Benefits:

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

Proposed Project: Demonstrate Lower Emission Locomotives

Expected SCAQMD Cost: $1,500,000

Expected Total Cost: $7,000,000

Description of Technology and Application:

SCAQMD has previously supported the GasRail USA program which has successfully led to the development of LNG combustion technology capable of reducing locomotive NO_x emissions by 75 percent or more compared to conventional diesel technology. Unfortunately, the OEM involved in GasRail, GM-Electromotive Division (EMD), withdrew from the consortium and has chosen not to participate in a field demonstration. The CARB has also entered into a Memorandum of Understanding (MOU) with the Class-1 railroads who operate in the Basin (Burlington Northern Santa Fe and Union Pacific). By 2010, these railroads have agreed to meet the tightest adopted Tier-II standards, on average, with their locomotives operating in the Basin. Hybrid locomotives have been commercialized for switching applications. These units have lower emissions because they rely upon a large battery pack to supply peak locomotive power instead of a large diesel engine; the battery pack is recharged by a smaller diesel generator set.

The purpose of the proposed project is to support the demonstration of low-emission locomotives in the Basin, either utilizing LNG combustion systems, low-emission engine calibrations, exhaust after-treatment technology, zero-emission electrics or hybrid-electric technology. Both LNG spark-ignition and diesel-pilot compression ignition technology have been developed and demonstrated for certain locomotive applications. In addition, locomotive engine manufacturers and component suppliers are developing low-emission Tier-II calibrations for existing base locomotive engines. Such calibrations will allow the Class-1 railroads to meet their emission obligations under the CARB MOU using rebuilt locomotives rather than purchasing new Tier-II locomotives as they have planned. Such technology would also be applicable to Class-2 and 3 railroads and passenger locomotives which operate mainly within the Basin. On-road exhaust after-treatment technology is available for application to locomotive engines, especially for the smaller generator sets found on passenger locomotives (Head-End Power). Zero-emission electric and dual-mode (electric & diesel) locomotives are currently used at selected locations in the U.S. to match available infrastructure or to meet local environmental needs. Such locomotives could also be demonstrated for selective applications such as the Alameda Corridor or for steep rail grades within the Basin. Finally, locomotive manufacturers have investigated hybrid electric for larger locomotives. Demonstrating such retrofit technology in certain locomotive applications could significantly reduce emissions.

Potential Air Quality Benefits:

The AQMP emissions inventory shows that about 35 tons/day of NO_x emissions come from locomotives. The U.S. EPA and CARB have agreed to a program that will reduce emissions from these sources by about 65 percent by 2010. However, sooner reductions are necessary to provide additional NO_x benefits for the Basin to achieve federal PM10 air quality standards by 2006. As proven in the GasRail USA program, natural gas combustion systems can meet and exceed these NO_x emission reductions while also achieving significant reductions of PM compared to conventional diesel technology. This project will continue development and demonstration of low-emission LNG technology. This has the potential to NO_x and PM emissions by more than 75 percent.

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

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

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

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

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

Potential Air Quality Benefits:

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

Hydrogen Technologies and Infrastructure

Proposed Project: Develop and Demonstrate Hydrogen Storage Technologies

Expected SCAQMD Cost: $500,000

Expected Total Cost: $1,500,000

Description of Technology and Application:

One of the critical barriers for fuel cell and hydrogen vehicle commercialization is the need for increased on-board hydrogen storage. The complexity and safety issues associated with storing hydrogen in large enough quantities to provide sufficient vehicle range is the subject of a national effort through the DOE. Projects under this category may include joint efforts with the DOE and other stakeholders to develop and demonstrate hydrogen storage technologies such as metal hydrides, higher pressure tanks, and additional hydrogen storage tank options. Increased hybridization and battery capacity may also be considered.

Potential Air Quality Benefits:

The AQMP identifies the need to implement zero-emission vehicles. SCAQMD adopted fleet regulations requiring 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 and near-zero emission ICE vehicles operating on hydrogen fuel. The proposed projects have the potential to accelerate the commercial viability of fuel cell and hydrogen 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.

Proposed Project: Develop and Demonstrate Hydrogen Vehicles

Expected SCAQMD Cost: $1,000,000

Expected Total Cost: $5,000,000

Description of Technology and Application:

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

Potential Air Quality Benefits:

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

Proposed Project: Develop and Demonstrate Hydrogen-Natural Gas Internal Combustion Engines

Expected SCAQMD Cost: $500,000

Expected Total Cost: $3,000,000

Description of Technology and Application:

The transition to hydrogen fuel will require bridging technologies to utilize the hydrogen infrastructure while fuel cell vehicles are being developed and deployed. One such bridging technology is hydrogen-compressed natural gas (HCNG) mixture ICE vehicles. These vehicles will be able to use conventional engine technology and optimize the performance and emissions to operate on hydrogen and natural gas fueling blends. ICEs converted to run on hydrogen and natural gas are optimized to operate on very lean fuel mixtures, reducing peak combustion temperatures, which can result in very low exhaust emissions. Such vehicles will help in the transition to hydrogen as well as utilize the existing, well-developed natural gas infrastructure.

This project will seek to convert existing natural gas or gasoline vehicles to allow the use of hydrogen and natural gas mixtures to demonstrate the technology in a variety of applications.

Potential Air Quality Benefits:

The AQMP identifies on-road mobile sources as one of the largest contributors of air pollution in the basin, and therefore considers the development and implementation of non-polluting power generation as a long-term control measure goal. Certification of low-emission vehicles and engines, and their integration into the Basin's transportation sector is a high priority under the AQMP. This program is expected to further develop and validate new technologies, diversification of transportation fuels, and low emissions of criteria and toxic pollutants.

Proposed Project: Demonstrate Hydrogen-CNG Compatibility

Expected SCAQMD Cost: $300,000

Expected Total Cost: $1,400,000

Description of Technology and Application:

Natural gas promises to be a potential bridge to hydrogen fueling for vehicles. Hydrogen, however, will not replace natural gas in the near future, and it anticipated that both fuels will co-exist as pure fuels and as blends (HCNG). This potential project is to develop and demonstrate a hydrogen-CNG refueling station that can provide hydrogen, CNG, and a blended fuel both as a new installation and as a retrofit of an existing CNG station.

Potential Air Quality Benefits:

Natural gas and hydrogen fuels offer reduced emissions compared to similar, conventional gasoline powered vehicles. Hydrogen when used in a fuel cell has near-zero emissions. Preliminary results from HCNG blended fuels also indicate reduced emissions compared to natural gas vehicles in heavy-duty applications.

The further benefits of reduced petroleum use, greenhouse gas emissions, and energy diversity may also be realized through the use of hydrogen and natural gas.

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

Expected SCAQMD Cost: $2,250,000

Expected Total Cost: $9,000,000

Description of Technology and Application:

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

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

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

Potential Air Quality Benefits:

The 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, that lead to substantial reductions in NO_x, VOC, CO, PM, and toxic compound emissions from vehicles.

Mobile Fuel Cell Technologies

Proposed Project: Develop and Demonstrate Fuel Cells in Vehicle Applications

Expected SCAQMD Cost: $750,000

Expected Total Cost: $3,500,000

Description of Technology and Application:

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

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

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

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

Potential Air Quality Benefits:

The AQMP identifies the need to implement zero-emission vehicles. SCAQMD adopted fleet regulations requiring 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.

Health Impacts Studies

Proposed Project: Evaluate Ultrafine Particle Health Effects

Expected SCAQMD Cost: $750,000

Expected Total Cost: $3,000,000

Description of Technology and Application:

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

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

Potential Air Quality Benefits:

The AQMP relies on the significant penetration of low-emission vehicles in the South Coast Basin to attain federal clean air standards by 2010. Reduction of particulate emissions from the use of diesel fuel is a major priority in achieving these standards. This project would help to better understand the nature and amount of ultrafine particulates generated by different types of fuels and advanced control technologies, as well as provide information on potential health effects of ultrafine particles. . Such an understanding is important to assess the emission reduction potentials and health benefits of these technologies. This will in turn 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: $500,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

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

Potential Air Quality Benefits:

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

Proposed Project: Assess Sources and Health Impacts of Particulate Matter

Expected SCAQMD Cost: $300,000

Expected Total Cost: $300,000

Description of Technology and Application:

Previous studies of ambient levels of toxic air contaminants, such as the MATES II study, have found that diesel exhaust is the major contributor to health risk from air toxics. Analyses of diesel particulate matter in ambient samples has 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 is collecting particulate samples at ten locations in the South Coast Air Basin. Analysis of particulate bound organic compounds will be 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 may be 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 can be used to determine contributing sources.

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

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

Potential Air Quality Benefits:

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

Stationary Clean Fuel Technologies

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

Expected SCAQMD Cost: $250,000

Expected Total Cost: $500,000

Description of Technology and Application:

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 devices is 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. Emission spot checks, for example 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.

Manufacturers of flue gas analyzers have, in recent years, developed low-cost multi-gas analyzers suitable for portable or stack-mounted use. Installation of stack-mounted emission monitoring systems on combustion devices would provide guidance to owners/operators in keeping the emission control features in good condition and proper adjustment and would enhance SCAQMD's ability to enforce full-time compliance.

Potential Air Quality Benefits:

The 2003 AQMP indicates that in 2010 stationary sources, i.e., stationary engines, boilers, heaters, furnaces and ovens, will account for about 11 percent of total NO_x emissions and about 6 percent of total CO emissions. As mentioned above, evidence indicates that many of these devices are operating with NO_x and/or CO emissions above levels required in their permits. Installation of stack monitors would enable continuous compliance to be more closely approximated on these devices, thus reducing a significant class of NO_x and CO emissions that is in excess of the assumptions in the AQMP.

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 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

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 AQMD has a substantial number of older, small, stationary source technologies within its jurisdiction. Since these devices are not subject to continuous emissions monitoring system (CEMS) 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.

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

Expected SCAQMD Cost: $500,000

Expected Total Cost: $1,000,000

Description of Technology and Application:

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

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

Potential Air Quality Benefits:

The 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: $500,000

Description of Project:

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

This program may include the following:

- Technical review and assessment of technologies, projects, and proposals
- Support for Alternative fuel refueling and infrastructure
- Advanced technology curriculum development, mentoring, and outreach to local schools
- Emissions studies and assessments of zero-emission alternatives
- Advanced Technology Vehicle Demonstrations
- Preparation of reports, presentations at conferences, improved public relations and public communications of successful demonstrations of clean technologies
- Participation in and coordination of workshops and various meetings
- Support for training programs related to fleet operation, maintenance, and refueling of alternative fuel vehicles
- Publication of technical papers, reports, and bulletins
- 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 its associated infrastructure.

Potential Air Quality Benefits:

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 success stories in the use of advanced alternatively fueled vehicles could potentially expedite the acceptance and commercialization of advanced technologies by operators seeking to comply with the provisions of the recently adopted SCAQMD fleet rules. The resulting future emissions benefits will contribute to the goals of the AQMP.

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

Expected SCAQMD Cost: $400,000

Expected Total Cost: $400,000

Description of Project:

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

Potential Air Quality Benefits:

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

Appendix A

SCAQMD Advisory Groups

Technology Advancement Advisory Group

Tom Cackette	California Air Resources Board
Tim Carmichael	Coalition for Clean Air
Dr. Blair Folsom	GE Energy &Environmental Research Corp.
James Uihlein	BP
John D. Harper, Jr.	Small Business Coalition
Philip J. Hodgetts	Clean Air Now
Shang Hsiung	U.S. Department of Transportation
Dr. Sigmund Gronich.	U.S. Department of Energy
Michael La Cavera	Westway Terminals
Charles Mizutani	California Energy Commission
Dan Moran	Quality Body Works
Lee Wallace	Sempra Energy
William R. West	Southern California Edison

SB 98 Clean Fuels Advisory Group

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

Appendix B

Open Clean Fuels Contracts as of January 1, 2006

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Incentive Programs-Alternative Fuels						
00105	Avery-Dennison Office Products North America	Purchase Nine Electric Forklifts	06/20/00	03/15/06	10,000	277,452
00107	Harbor Distributing, LLC	Purchase 32 Electric Forklifts	05/16/00	03/15/06	20,000	923,732
00113	Lowes Home Improvement Warehouse Inc.	Purchase 40 Electric Forklifts	05/24/00	03/15/06	80,000	921,595
00131	HomeBase Inc.	Purchase 20 Forklifts	06/07/00	03/15/06	40,000	700,000
01137	R.F. Dickson Company, Inc.	Repower Ten & Purchase Four PM10-Efficient CNG Street Sweepers	04/17/01	12/31/06	1,010,000	1,010,000
01138	Hayward Pool Products, Inc.	Purchase Two Electric Forklifts w/Batteries	05/02/01	06/15/06	20,200	20,200
01151	Vicro Manufacturing	Purchase 30 Electric Forklifts with 2 Battery Packs	11/26/01	12/31/07	424,190	424,190
01157	Waste Management of Los Angeles	Purchase 20 Natural Gas Refuse Trucks	02/27/02	06/30/08	394,278	829,200
01159	Waste Management of San Gabriel	Purchase 20 CNG Refuse Collection Trucks	07/31/02	06/30/08	829,200	829,200
01160	Waste Management of the Desert	Repower Seven Roll-Off Refuse Trucks LNG	10/03/01	06/30/08	75,221	526,547
01178	CalMet Services Inc.	Repower 27 Waste Collection Trucks with CNG	09/19/01	06/30/07	343,000	1,323,000
01336	Chroma Systems	Purchase Electric Forklift w/Battery	04/11/01	06/30/06	4,734	4,734
04167	Foothill Transit	Purchase 75 CNG Transit Buses	05/25/05	01/31/10	727,500	727,500
04169	City of Santa Monica	Purchase 52 New LNG Transit Buses	08/04/04	09/30/10	407,732	407,732
04170	Mellon Grading, Inc.	Repower One Each of Diesel Water Hauler, Diesel Crawler Tractor, Diesel Crawler Tractor Loader	10/01/04	12/31/10	140,450	140,450
04171	Santa Clarita Transit	Purchase 12 New CNG Transit Buses	07/28/04	07/31/10	126,000	4,203,432
Infrastructure and Fuel Production						
01154	R.F. Dickson Company, Inc.	Cost-Share Installation of CNG Fueling Facility	08/04/01	07/31/06	180,000	180,000
01165	ENRG, Inc. (formerly Pickens Fuel Corp.)	Construct & Operate One LNG & Four CNG Fueling Stations within SCAQMD Basin	05/07/01	03/30/06	288,800	788,800
02113	Gas Research Institute	Enhance L/CNG Fueling Station Evaluation & Upgrade	12/03/02	12/31/06	35,000	35,000
02157	ENRG, Inc. (formerly Pickens Fuel Corp.)	Upgrade Existing CNG Fueling Stations	01/17/02	02/28/07	$ 892,615	$ 1,445,112

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Infrastructure and Fuel Production (Cont'd)						
03099	Sanitation Districts of Los Angeles County	Purchase & Install LNG-L/CNG Fueling Station at Puente Hills Landfill Facility	02/10/03	07/31/08	560,000	560,000
03102	USA Waste of California, Inc.	Purchase & Install LNG-L/CNG Fueling Station at LA Metro Hauling District	06/26/03	06/30/08	400,000	400,000
03103	Waste Management Recycling & Disposal Services	Develop LNG-L/CNG Fueling Station	10/23/03	12/31/08	400,000	400,000
04015	WM Energy Solutions, Inc.	LNG Production at Bradley Landfill	11/06/03	09/30/09	300,000	5,277,000
04085	City of Banning	Construct Natural Gas Fueling Station in Banning	03/26/04	08/31/09	140,000	725,000
05109	Orange County Sanitation District	Purchase & Install New Dispenser & Credit Card Payment System in Fountain Valley	02/04/05	02/28/10	24,000	80,000
05135	Sysco Food Services of Los Angeles, Inc.	Purchase & Install LNG Fueling System in City of Walnut	05/25/05	03/31/10	250,000	1,102,476
05250	Downs Commercial Fueling	Purchase & Install New L/CNG Fueling System in Temecula	11/04/05	12/31/10	203,137	1,033,137
06017	Fuelmaker Corporation	Incentive Buydown Program for CNG Home Refueling Appliances	09/26/05	06/30/06	100,000	200,000
06018	American Honda Motor Company Inc.	Incentive Buydown Program for CNG Home Refueling Appliances	11/02/05	06/30/07	300,000	600,000
06028	Consolidated Disposal Service	Purchase & Install New LNG Fueling System in Long Beach	11/23/05	12/31/11	222,038	740,127
06029	Clean Energy	Upgrade Existing CNG Fueling Station at SoCalGas Facility in Santa Monica	10/26/05	12/31/11	190,000	634,500
Fuels/Emission Studies						
00188	University of California, Riverside	Testing Support & Emissions Assessment	07/17/00	07/01/06	100,000	100,000
05069	Automotive Testing and Development Services, Inc.	Perform Evaporative Emission Testing on Gasoline Heavy-Duty Hybrid-Electric Bus	02/10/05	06/30/06	260,000	260,000
05195	West Virginia University	Provide Transportable Emissions Testing of CNG Fueled Heavy-Duty Engines	08/18/05	07/31/06	83,215	183,215
Emission Control Technologies						
01173	National Renewable Energy Laboratory	Demonstrate Fischer-Tropsch Synthetic Fuel in Heavy- & Medium-Duty Vehicles	06/11/01	08/31/07	738,001	1,920,435
02293	Automotive Testing Laboratories	Develop & Demonstrate Fischer-Tropsch Fueled Heavy-Duty Vehicles with Control Technology to Reduce Exhaust Emissions	08/23/02	06/30/06	$ 741,850	$ 1,695,976

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Emission Control Technologies (cont'd)						
03467	Cummins Westport, Inc.	Aftertreatment Technology for PM & Hydrocarbon Emissions Control of CNG-Fueled Heavy-Duty Engines	04/08/04	01/31/06	496,785	740,000
04155	Lubrizol Engine Control Systems	Optimize & Demonstrate Oxidation Catalysts to Reduce Emissions from CNG-Fueled Heavy-Duty Vehicles	06/25/04	06/24/06	340,900	412,650
05161	BAF Technologies	Develop & Certify Retrofit System to Convert Gasoline-Powered Ford Crown Victoria & E-450 Cutaway Van to Compressed Natural Gas	06/03/05	04/30/06	300,000	1,227,660
Electric/Hybrid Technologies						
99109	Toyota Motor Corporation	Three-Year Lease of One RAV4 Electric Vehicle	04/04/99	12/01/06	77,483	77,483
00051	Santa Barbara Electric Bus Works Inc.	Develop & Demonstrate an Electric School Bus	11/23/99	02/28/06	100,000	400,000
02116	Clean Fuels Connection	Develop Dual Inductive/Conductive Charger Bracket to Allow Reduction of EV Charging Infrastructure Costs	12/31/01	03/31/05	47,815	95,694
04019	University of California, Davis	Optimize & Demonstrate Plug-In Hybrid Electric Vehicles	04/27/04	07/31/06	150,000	458,000
04027	ISE Research Corporation	Develop & Demonstrate Hydrogen-Internal Combustion Engine for Hybrid-Electric Buses	10/29/03	05/31/05	210,000	1,075,000
04032	Electric Power Research Institute	Develop, Demonstrate & Evaluate Plug-In Hybrid Electric Vans in Fleet Use	11/14/03	03/31/10	475,000	1,525,000
04143	Clean Fuels Connection	Public EV Charging Equipment & Signage Replacement	07/09/04	07/07/06	100,000	100,000
05003	Calstart	Develop & Demonstrate Hydraulic-Hybrid System for Heavy-Duty Vehicles	01/13/05	12/16/06	250,000	1,358,476
05259	AC Propulsion Inc.	Upgrade & Evaluate Plug-In Hybrid Electric Sedan with Lithium Polymer Batteries	07/25/05	07/24/07	25,300	53,000
05260	EnergyCS	Convert Light-Duty Vehicle to Plug-In Hybrid Electric	09/09/05	09/08/07	130,000	539,000
Engine Technologies						
03427	Mack Truck Inc.	Develop & Demonstrate Next Generation Natural Gas Vehicle Phase II Integration of Improved Natural Gas Engine into Commercial Chassis	07/13/04	11/30/06	583,651	2,334,998
04046	EVO Transportation Corporation	Demonstrate Program to Convert Ten Gasoline-Fueled SUVs to CNG-Fueled ULEVs	12/23/03	02/28/06	100,000	450,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Engine Technologies (Cont'd)						
05067	Cummins Inc.	Demonstrate & Evaluate Performance, Durability and Emission-Reduction Potential of Advanced Diesel Emissions Control System (ADECS) for Low-Sulfur Diesel-Fueled Heavy-Duty Engines	03/09/05	07/28/07	750,000	4,450,000
05110	Westport Research, Inc.	Develop & Demonstrate Heavy, Heavy-Duty Natural Gas Engine for Glass 8 Trucks	04/01/05	06/30/06	1,935,727	5,653,262
05196	West Virginia University	Demonstrate & Evaluate Performance, Durability and Emission-Reduction Potential of ADECS for Low-Sulfur Diesel-Fueled Heavy-Duty Engines	08/13/05	02/28/07	350,000	750,000
05244	Cummins Westport, Inc.	Develop, Demonstrate & Certify Heavy-Duty Natural Gas Engine to Meet 2010 Emission Standards	08/26/05	07/31/07	690,000	5,943,410
Hydrogen Technologies and Infrastructure						
03198	Praxair Inc.	Demonstrate & Develop Electrolyzer-Based Hydrogen Fueling Station Near LAX	10/16/03	10/16/05	351,000	1,451,000
03201	University of California, Irvine	Demonstrate & Develop Hydrogen Fueling Stations in Orange County	10/16/03	04/16/06	863,400	983,400
04009	Energy Conversion Devices Inc.	Integrate & Develop an ICE Hybrid Vehicle Utilizing Metal Hydrides for On-Board Hydrogen Storage	03/12/04	07/12/06	200,280	400,561
04011	Air Products and Chemicals, Inc.	Install & Demonstrate Industrial Pipeline Supplied Hydrogen Refueling Station in Torrance	08/03/05	04/02/07	400,000	855,710
04012	Stuart Energy	Install & Demonstrate Electrolyzer-Based Hydrogen Refueling Station Integrated with Stationary Internal Combustion Engine Power Generation Unit	12/05/03	04/30/06	637,000	849,500
04111	Stuart Energy	Maintenance & Data Management for AQMD Hydrogen Fueling Station	02/16/05	02/16/09	80,000	80,000
04185	Quantum Fuel Systems Technologies Worldwide Inc.	Develop & Demonstrate Hydrogen Internal Combustion Engine Vehicles	10/18/04	08/31/10	2,109,851	3,255,631
05165	Air Products and Chemicals, Inc.	Install & Demonstrate Three Electrolyzers (in Burbank, Riverside & Santa Monica) and Two Mobile Fuelers (in Santa Ana & Ontario), with One Year of Hydrogen Fuel Supply	06/21/05	06/20/07	2,280,000	2,982,000
Mobile Fuel Cell Technologies						
03095	Fuel Cell Technologies Ltd.	Pilot Demonstration of Residential Fuel Cell	02/10/03	02/28/06	16,149	982,300

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Mobile Fuel Cell Technologies (cont'd)						
03269	University of California Davis	Develop, Demonstrate & Evaluate Truck Fuel Cell Auxiliary Power Unit	05/23/03	07/31/06	300,000	1,200,000
03287	California Air Resources Board	Develop & Demonstrate Integrated Autothermal Cyclic Reformer and Proton Exchange Membrane Fuel Cell	09/01/02	05/15/06	100,000	800,00
04003	Daimler-Chrysler RTNA	Install & Demonstrate Fuel Cell Vehicle Maintenance Facilities in Long Beach	11/21/05	05/21/08	253,000	542,000
04004	Mercedes-Benz USA, LLC	Demonstrate Two Fuel Cell Vehicles at AQMD in Diamond Bar	02/04/05	04/04/06	240,000	1,240,000
04120	Seaworthy Systems, Inc.	Demonstrate a Fuel Cell Water Taxi	07/13/04	09/12/06	101,000	781,000
05104	Alliance Power Inc.	Demonstrate Two Molton Carbonate Stationary Fuel Cell Systems in Fontana	07/28/05	03/27/08	565,000	4,176,325
05122	Plug Power, Inc.	Demonstrate Three Proton Exchange Membrane Stationary Fuel Cell Systems at UCI	04/29/05	07/28/07	257,500	572,604
Health Impacts Studies						
03225	California Air Resources Board	Quantify Health Benefits of Incremental Improvements in Air Quality in the SCAB	10/01/02	05/15/06	100,000	306,261
03358	Jurupa Unified School District	Children's Health Study	06/13/03	05/31/06	25,000	25,000
05037	California Air Resources Board	Co-Fund Ultrafine Particulate Matter Health Effects Study	06/28/04	10/31/07	501,814	4,392,814
05172	Desert Research Institute	Conduct Organic Compound Analyses of Particulate Matter Samples Collected under MATES III Program	08/13/05	06/30/06	199,995	199,995
Stationary Clean Fuel Technologies						
99046	Engelhard Corporation	Field Evaluation of PremAir Ozone Catalyst Technology on AC Units	10/06/98	12/31/10	0	0
03292	Occidental College	Professional Wet Cleaning Technology Demonstration & Pilot Incentive Program	06/23/03	02/28/07	16,000	391,000
05207	SolSource Energy	Install n 80 kW Solar Panel System at AQMD Headquarters	06/06/05	06/05/11	360,000	693,000
06075	Advanced Engine Technology Corporation	Field Comparison of Portable Electrochemical Analysers to a CEMS for Measurement of NOx and CO Emissions from a Rich-Burn Engine	12/21/05	03/31/06	33,320	33,320
Outreach and Technology Transfer						
97110	Burke, Andrew	Review & Assessment of Technical Proposal re: ATTB Ultracapacitor System	06/04/97	08/30/07	15,000	15,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (cont'd)						
97113	JME Inc.	Review & Assessment of Technical Proposal re: ATTB Ultracapacitor	05/08/97	08/30/07	15,000	15,000
00069	Walsh Consulting	Technical Assistance Relating to the Use of Alternative Fuels in Mobile Sources	02/17/00	02/28/06	35,000	35,000
00098	Katz, Murray	Technical Assistance Pertaining to Fuel Cell Development & Commercialization	02/25/00	02/28/06	$ 20,000	$ 20,000
02114	Gladstein & Associates	Outreach Support for Low-Emission Clean Fuel Heavy-Duty Vehicles	02/22/02	02/28/06	250,000	250,000
02295	SynchroEnergies LLC	Technical Assistance on Lubricants, Fuels, Combustion, Alternative Energy Sources & High Performance Fluid Technologies	05/23/02	06/30/07	25,000	25,000
02308	Sperry Capital, Inc.	Evaluate Financial Stability of Potential Contractors	06/25/02	12/31/07	20,000	20,000
02311	Cole, Jerald A.	Technical Assistance for Development ,Outreach & Commercialization of H2 Infrastructure and Reforming Technology	08/09/02	06/30/07	30,000	30,000
02333	University of California, Riverside	Technical Assistance on Clean Fuels Technology, Hydrogen, Fuel Cell Technology and Natural Gas Technology	11/01/02	06/30/07	30,000	30,000
02335	Otto, Neil C.	Technical Assistance on Fuel Cell Technology	08/09/02	06/30/07	30,000	30,000
03450	Sawyer Associates	Technical Assistance Pertaining to 2003 Revision and Mobile Source Control Sources	06/26/03	11/30/06	15,000	15,000
03451	TIAX LLC	Technical Assistance Pertaining to 2003 Revision and Mobile Source Control Sources	06/23/03	11/30/06	20,000	20,000
04051	Burnett & Burnette	Technical Assistance for Alternative Fuels Engine Technology & Infrastructure	01/19/04	07/31/06	40,000	40,000
04052	USA Pro & Associates	Technical Assistance for Alternative Fuels Infrastructure	12/19/03	12/31/06	40,000	40,000
04053	Marathon Technical Services	Technical Assistance for Alternative Fuels Infrastructure	11/21/03	12/31/07	40,000	40,000
04097	Calstart	Ongoing Operation & Improved Functionality of Clean Car Maps Internet Website	06/15/04	01/31/07	110,000	355,000
04115	Los Altos High School	Cosponsor the LAAE Ultra-Light Single Passenger Fuel Cell/Electric Power Vehicle Project	05/05/04	05/31/06	10,000	91,500

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (Cont'd)						
04123	Gladstein, Neandross & Associates LLC	Demonstrate Low-Emission, Alternative Fuel Heavy-Duty Vehicles within SCAB & Public Awareness Program	06/04/04	12/03/07	125,000	615,000
04146	Gross, Tom	Tech Assistance for Hydrogen & Fuel Cell Technologies	06/23/04	05/31/07	25,000	25,000
04168	Regulus Associates Inc.	Technical Assistance with Contract-Related Services	06/23/04	06/30/06	40,000	40,000
05008	Bevilacqua-Knight Inc.	CY 2004 Membership & Participation in California Fuel Cell Partnership	07/07/04	07/06/06	267,600	1,960,000
05101	Joseph Calhoun	Tech Assistance for Development, Outreach & Commercialization of Advanced, Low-Emission Light- & Heavy-Duty Vehicle Technologies and Coordination with State Agencies	01/07/05	01/31/07	40,000	40,000
05120	Clean Fuels Connection, Inc.	Tech Assistance for Technology Incentive Programs to Evaluate Proposals for Compliance with New CARB Guidelines	04/01/05	03/31/07	90,000	90,000
05121	Sullivan, Cindy	Tech Assistance to Coordinate with CARB to Develop, Analyze and Implement New Incentive Program Guidelines	03/14/05	03/31/07	75,000	75,000
05123	TIAX, LLC	Tech Assistance for Development, Outreach & Commercialization of Low-Emission and Alternative Fuels Technologies and Evaluating Project Proposals for Technology Incentive Programs	03/14/05	03/31/07	90,000	90,000
05125	Breakthrough Technologies Institute, Inc.	Tech Assistance for Development, Outreach & Commercialization of Fuel Cells and Technical Coordination with Federal Energy & Transportation Departments	03/05/05	03/31/07	40,000	40,000
05126	St. Croix Research	Tech Assistance for Development, Outreach & Commercialization of LNG, CNG and Hydrogen Fuels	03/15/05	03/31/07	25,000	25,000
05127	Protium Energy Technologies	Tech Assistance for Development, Outreach & Commercialization of Hydrogen & Fuel Cell Technologies	03/14/05	03/31/07	40,000	40,000
05128	Mid-Atlantic Research Institute, LLC	Tech Assistance for Development, Outreach & Commercialization of Advanced Heavy-Duty & Off-Road Technologies	08/08/05	03/31/07	40,000	40,000
05137	City of Sierra Madre	Cosponsor the Solar Pool Heating System Demonstration Project	03/11/05	03/10/06	5,000	28,592
05149	Clean Vehicle Education Foundation	Cosponsor 2005 CVEF Activities	04/08/05	04/07/06	15,000	100,000
05171	James Hazelton	Tech Assistance for Locomotive Technologies	04/08/05	04/30/06	20,000	20,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (Cont'd)						
05190	Walnut High School	Cosponsor the Walnut High School Solar Car Project	06/17/05	03/31/06	5,000	25,000
05198	Don Stedman	Tech Assistance for Remote Sensing Programs for Light-Duty Vehicles and Locomotives	05/30/05	11/30/06	25,000	25,000
06020	Gladstein, Neandross & Associates, LLC (GNA)	Co-Host 2nd Faster Freight-Cleaner Air 2006 Conference	10/07/05	09/30/06	25,000	25,000
06051	National Hydrogen Association	Cosponsor 17th Annual U.S. Hydrogen Conference	12/16/05	10/30/06	20,000	100,000

APPENDIX C

Final Reports for 2005

AQMD Contract # 03468 **July 2005**

Reactivity & Availability Studies of VOC Species Found in Architectural Coatings and Mobile Sources

Contractor

William P. L. Carter
College of Engineering Center for Environmental Research and Technology
University of California Riverside

Cosponsors

California Air Resources Board

Project Officer

Naveen Berry

Background

Gas-phase reactions of volatile organic compounds (VOCs) emitted from architectural coatings use and mobile sources are major sources of ozone and secondary organic aerosol (SOA) pollution in the South Coast Air Basin. In order to develop effective control strategies to achieve ambient air quality standards it is necessary to be able to quantify and predictively model the relative effects of the different types of VOCs on formation of ozone and secondary PM. VOCs differ significantly in their effects on ozone and SOA formation, and significant uncertainties remain.

Environmental chamber data provide a necessary means to develop and test predictive models for the effects of various types of VOCs on ozone and secondary PM. The California Air Resources Board (CARB) funded the contractors to utilize a newly developed state-of-the art environmental chamber to study effects of architectural coatings VOCs on ozone formation. However, that project did not include studies of all the major types of coatings VOCs, or of the effects of the VOCs on SOA.

Project Objectives

The primary objective of this project is to conduct environmental chamber experiments to assess ozone and SOA formation potentials of various types of VOCs in architectural coatings. In addition to the four VOCs most commonly found in waterborne coatings, specifically ethylene and propylene glycols, 2-(2-butoxyethoxy)-ethanol (DGBE), and benzyl alcohol, this project included assessing SOA formation in the CARB-funded chamber experiments on the water-based coatings solvent Texanol® and various types of hydrocarbon solvents used in solvent-based coatings

An additional objective of this project as proposed was to conduct experiments with updated ambient reactive organic gas (ROG) surrogate mixtures that represent current emissions from mobile and other sources. However, they could not be carried out because of a lack of time and resources to derive a target composition for a new ROG surrogate within the timescale needed for this project. Instead, more types of water-based coatings VOCs were studied than initially planned.

A final objective of this and the related CARB study is to evaluate and where appropriate improve the predictive capabilities of the SAPRC-99 mechanism, used in current airshed model and to develop ozone reactivity scales, and assess needs for additional research.

Technology Description

This project is not directly applicable to pollution control technology as such. Instead, it is applicable to the modeling technology used to predict effects of ozone and PM control strategies. This is discussed in the "Applications" section.

Status

This project is now complete. The objectives of providing useful environmental chamber data on architectural coatings VOCs, and of evaluating the ozone predictions of the SAPRC-99 mechanism were attained. Additional funding will be needed to use the data to evaluate PM models and to evaluate updated ROG surrogates of mobile and other emissions.

Results

Most of the experiments consisted of environmental chamber irradiations to determine effects of adding the VOCs on ozone and PM formation in chamber irradiations of ambient ROG surrogate - NO_x experiments at two ROG/NO_x rations, representing maximum incremental reactivity (MIR) and NO_x-limited conditions. The state of the art "UCR EPA" chamber, developed under EPA funding, was employed. The results were used to evaluate the predictions of the SAPRC-99 mechanism.

The existing mechanism for DGBE was found to simulate the ozone reactivity data adequately, and a new mechanism for benzyl alcohol was developed that simulated the chamber data as well as mechanisms for other aromatics. The existing mechanisms for ethylene and propylene glycols were found to underpredict their ozone impacts by ~20% and 25-30% in some, but not all, experiments, but no reasonable basis was found to modify the mechanisms to improve these predictions. It is possible that that this is due to problems with the mechanisms for the aromatics present in the ambient ROG.

In terms of relative PM impacts in the experiments, the relative ordering was found to be benzyl alcohol >> DGBE > petroleum distillates > a synthetic hydrocarbon solvent consisting mainly of branched alkanes ≈ Texanol® > ethylene and propylene glycols. The benzyl alcohol was found to have a surprisingly high PM impact compared to other aromatics, and the glycols were found to actually reduce PM levels in the experiments, probably due to reducing rates of reactions of other VOCs present in the incremental reactivity experiment.

No clear correlation between aromatic content and PM formation potential in the hydrocarbon solvents was seen. Background PM formation was observed in the chamber that will need to be characterized before these data can be used for PM model evaluation. Exploratory availability experiments were carried out to assess whether the presence of $(NH_4)2SO_4$ and NH_4HSO_4 seed aerosol at levels up to ~10 $\mu g/m^3$ and humidity up to ~10% RH affected the gas-phase loss rates or ozone formation potentials of ethylene and propylene glycol, but effects were not seen.

Benefits

As a result of this and the associated CARB project, uncertainties in ozone predictions of ozone impacts of important types of coatings VOCs have been reduced, and data needed to further reduce these uncertainties have been obtained. This should result in increased confidence of applications of reactivity-based VOC control strategies to this important VOC source, which has the potential for much more cost-effective ozone control. Uncertainties still remain concerning some aspects of the mechanisms, particularly for aromatic compounds, and the data obtained will be useful in the evaluations of future and improved mechanisms.

Although additional studies are needed before predictive models for SOA formation can be fully evaluated, the SOA formation data obtained for this project provide an important start in obtaining the database needed for this purpose. This will be needed for developing and evaluating cost-effective strategies for SOA formation.

Project Costs

The total cost of this project to the SCAQMD was $200,000. This projected benefited from the CARB coatings project, whose total cost to the CARB was $240,100, and from the EPA project to construct the environmental chamber used for this project, whose total cost was around $3 million.

Applications

The primary application of the experimental data and mechanism evaluation related to ozone formation from this project is the chemical mechanisms used in air quality models for research and regulatory applications. The SAPRC-99 chemical mechanism that was evaluated for this project is already implemented in airshed models. It is also used to calculate the MIR and other ozone reactivity scales that is used, or being considered, for regulatory applications in California and elsewhere.

The applications for the SOA data obtained for this project include evaluating mechanisms for SOA formation and also serving as a basis for more comprehensive experimental and modeling studies of SOA. Although current SOA models were not evaluated using these data, such evaluations need to be included in future projects.

AQMD Contract # 04121 **December 2005**

Demonstrate Small Scale Natural Gas Liquefaction Plant

Contractor
Pacific Gas and Electric Company (PG&E)

Cosponsors
Southern California Gas Company
Idaho National Laboratory (INL)
California Energy Commission
Enbridge Gas Distribution, Inc.

Project Officer
Larry Watkins

Background
Costs of liquefied natural gas (LNG) vehicle ownership and operation have presented barriers to adoption of such vehicles. In the late nineties PG&E investigated one cost area for improvement: fuel production and distribution. This area presented opportunities for improvement because, for the most part, LNG was produced out-of-state and so bore significant delivery costs. Additionally, pre-liquefaction gas clean-up typically required by liquefaction technologies added significant cost to product LNG. Lowering production and delivery costs of LNG would facilitate implementation of the California Air Resources Board's Diesel Risk Reduction Plan as well as the South Coast Air Quality Management District's (SCAQMD's) Clean Fleet Vehicle Rules.

Project Objective
The objective of the project was to field test a prototype low-cost liquefaction system developed by INL. Additionally, specific project objectives included: implementing modifications to prevent the system's compressor from entering surge conditions, implementing modifications to prevent carbon dioxide (CO2) build-up in the system's secondary heat exchanger, verifying that control software worked as intended, and taking any additional steps to allow the system to maintain full liquefaction capacity and reliable performance as available funding and operational success allowed.

Technology Description
The liquefaction system developed by INL included several features intended to reduce overall LNG fuel cost. The system was designed to: have a minimal plant 'footprint' to allow siting close to fleets (reducing fuel delivery costs); make use of pipeline pressure differentials to power production of LNG (reducing the need for combustion-derived power); remove non-methane components of feedstock gas (such as water and CO2) after liquefaction has been accomplished. Most liquefaction systems employ expensive, large, pre-liquefaction gas clean-up processes.

Status
The SCAQMD-sponsored *Demonstration* project has been completed as of September 2005; a final report on the project with complete technical details is on file with SCAQMD. Specifically, PG&E implemented effective improvements to provide effective surge protection for the compressor, implemented somewhat effective improvements to prevent CO2 build-up within the secondary heat exchanger, and verified that the system control software functioned as intended. Additionally, PG&E has resolved a long-standing issue with turboexpander stability which had prevented its operation at design rotation speed. While the remaining issue of CO2 build-up within the secondary heat exchanger will eventually halt

LNG production, INL is currently working to modify certain system components to allow for its effective removal. Apart from this matter, the system has been run stably at the turboexpander's design rotational speed and INL's carbon dioxide stripping technology has been proven to work. PG&E plans a lengthy run of the system in January 2006 to determine the liquefaction capacity of the prototype system with its fully operational turboexpander component.

Results

1. Modifications to prevent the system's compressor from surging have proven very effective: initial system cool-down prior to the modifications took nearly 6 hours due to the danger of compressor surge during this process state. After the modifications, cool-down could be achieved in as little as 3 hours.

2. Several improvements were made in an effort to prevent CO2 build-up within the system's secondary heat exchanger: while these improved a necessary temporary gradient within the heat exchanger, the current temperature gradient does not allow for continuous sublimation of CO2 within the exchanger.

3. The system control software has been found to function as intended.

4. A major barrier to operation of the liquefier at design capacity of 10,000 gallons per day (gpd) had for a great period been performance of the system's turboexpander. The turbo-expander was once limited to operating at near 50,000 revolutions per minute (RPM) due to its becoming unstable when operated with magnetic bearings. After much effort to improve stability while still using the magnetic bearings, ultimately these were replaced with gas bearings. A test run in September 2005 verified that the turboexpander operation maintained stability at design rotation speed of 85,000 RPM. Since a full, sustained run at this rotation speed has not yet been undertaken, the ultimate liquefaction capacity of the system in its current configuration is not yet known. However, the last full run at 68,000 RPM produced LNG at a rate of about 2000-3000 gpd. Operation with the turboexpander rotating at design speed is expected to result in at least a doubling of capacity output per day. With additional modifications, the system's output could possibly reach 20,000 gpd.

Benefits

An implementation of a liquefier of INL's design, designed to 30,000 gpd output, might output 10,200,000 gallons of LNG per year. Thus each implementation of such a liquefier might result in avoidance of 122 tons of NOx and 11,851 tons of carbon dioxide emissions when product LNG is used instead of diesel to fuel vehicles over 30,000 lbs. gvwr having a fuel economy of 3 mpg (assuming emission rates contained within Carl Moyer Program guidelines, 2005 revision). If one twentieth of the approximately 200,000 vehicles greater than 26,000 gvwr estimated to operate in California in 2002 operate within the SCAQMD jurisdiction, and each travels an average of 25,000 miles per year with 3 mile per diesel gallon fuel economy, this would result use of more than 300 million gallons of diesel fuel per year in SCAQMD's jurisdiction, or potential for use of more than 500 million gallons of LNG yearly assuming 1.7 gallons of LNG are required to replace one diesel gallon.

If a liquefier implementation were limited to 2500 gpd output (approximate output achieved to date by the demonstration project), this would result in about 8% of the emissions impact of a 30,000 gpd implementation.

Project Costs

Total project costs to PG&E for work sponsored by SCAQMD totaled about $1.1 million. These costs were well above the sponsorship consideration of $200,000 generously provided by SCAQMD.

Commercialization and Applications

Southwest Transportation Agency recently received funding to implement a commercial installation of the liquefier technology at Harris Ranch near Coalinga in California. PG&E now plans to test improvements to components intended to resolve the issue of carbon dioxide build-up within the secondary heat exchanger.

AQMD Contract #04073 **June 2005**

Study Effects of Smoke from Recent Wildfires in Cohorts of USC Children's Health Study

Contractor
Dr. John Peters, Division of Environmental Health; Keck School of Medicine University of Southern California, USC

Cosponsors
NIEHS; Hastings Foundation

Project Officer
Dr. Jean Ospital, Health Effects Officer

Background

In October 2003, a series of devastating wild fires challenged Southern California. Local air quality monitors recorded hourly particulate matter concentrations approaching 1,000 $\mu g/m^3$ particulate matter (as PM_{10}); these levels were 10 to 20 times the typical observed ambient levels. Several thousand schoolchildren across the region were already enrolled and participating in a long-term respiratory health development study (the Southern California Children's Health Study, or CHS), when the fires erupted. These children thus became the subject of an investigation, to assess the acute effects of the fire smoke on respiratory health, superimposed onto an existing investigation of longer-term respiratory health.

Project Objective

To assess the health effects of the wildfires, two studies were initiated immediately after the fires. First, a questionnaire-based investigation of fire smoke exposure and symptoms among two of the existing schoolchildren study cohorts (Cohort D, consisting of twelfth-grade high school students; Cohort E, consisting of first and second-grade elementary school students) was performed. Second, high school students from three Southern California communities – two directly impacted by the fire, one removed from the fire area – were visited at their respective schools to measure lung function in addition to completing a Fire Study Questionnaire.

Initial questionnaire response rates were unsatisfactory among those approached by conventional mail (in three attempts) immediately following the October 2003 fires. The deployment of questionnaires was therefore extended through the first half year of 2004. AQMD funds were allocated to the questionnaire-based study while other funding sources were used to support the lung function testing component. The lung function data are currently in data analysis phase.

This Final Report presents questionnaire-based effects of the October 2003 Southern California wild fires on children's health.

Technology Description

A questionnaire was designed to collect specific information about exposure to fire smoke and occurrence of symptoms during the fire period. The health questions were assembled in a manner to be directly comparable with those collected annually in the multi-year Children's Health Study.

Status

The study was completed in November 2005. Low participation rates in some communities led to an extension of data collection in all communities until mid-2004. Collection of objective measures of fire smoke (PM_{10}) faced major challenges due to fire-related shut-down of several monitoring sites. To fill these gaps, collaboration with A. Winer and J. Wu (UCLA) to provide developed estimates of fire-related PM_{10} levels (AQMD project #04182; PI: R. Delfino) was arranged. The use of these data greatly improved the ability to validate the reported fire smoke in the current study and to corroborate the questionnaire-based study results.

Results

Participation during the first 8 weeks after the fire (2003) varied largely across the 16 communities involved in this investigation (21 to 78%). The extension of the data collection into 2004 led to more acceptable questionnaire participation rates, averaging 71% (60% to 84%).

Among responders (N=4,609) all symptoms (nose, eye, and throat irritations; cough; bronchitis; cold; wheezing; asthma attacks), medications, and doctors' visits were significantly

associated with individually reported exposure (*within-community effects*). Risks increased monotonically with the number of reported smoky days. As compared to no-fire-smoke exposures, having "fire smoke smell indoors" during 6 or more days was associated with more than four-fold higher rates of eye symptoms, approximately three-fold higher rates of dry cough and sneezing, and more than two-fold higher rates of cold, sore throat, wet cough, medication use, doctors' visits, and missed school due to symptoms. The three types of wheezing (general, sleep disturbing, and speech limiting wheeze) occurred 3.5, 4.9 and 5.5 times more often, respectively, among those with six or more days of fire smell indoors. Asthma attacks increased 1.6 fold.

Reporting rates *between communities* tended to be associated with the fire-related PM_{10} levels too, although statistical significance was reached for only eight outcomes: communities with the highest smoke levels had two to three fold higher rates of sneezing, eye symptoms, or dry cough (all three questions). Sore throat (OR=1.79) and medication use due to these symptoms (1.38) were also significantly associated with the highest levels of fire related PM_{10} (compared to no fire smoke).

These strong associations were not driven by those with preexisting asthma. In fact, associations tended to be weaker among the latter. Asthmatics were more likely to take preventive action such as wearing masks or staying indoors during the fire. As expected, independent of the fire, asthmatics were much more likely to report symptoms.

Findings were similar in both the elementary-school-aged and high-school-aged cohorts. Results were suggestive for health benefits of simple preventive strategies such as spending less time outdoors, wearing a mask, or the use of air conditioners during the fire period.

Benefits

After incorporating the extended data collection period, the project was very successful. The Children's Health Study offered a unique resource to understanding and quantifying the effects of wild fire smoke on children's health. This is relevant for the planning of future emergencies due to wild fires.

The study also provides highly relevant information for the ongoing CHS investigations. The individual data on fire smoke and symptoms will be integrated in future analyses of the association between ambient urban air pollution and the development of children's respiratory health. This allows controlling of potential confounding effects given that the fire smoke affected particular symptoms that are also a main focus of the hypotheses tested in the CHS.

Project Costs

AQMD contributed with $49,896 to the fire investigations. The fire study incurred total costs of at least $300,000, supported in part by other sources (see above).

Commercialization and Applications

The study does not lead to commercialization. The questionnaire will be made available to the scientific community and may be of use to future investigations. The data may be used in future analyses.

AQMD Contract #03109 **September 2005**

Develop and Demonstrate Aftertreatment Technologies for PM Emissions Control of CNG-Fueled Heavy-Duty Engines

Contractor
West Virginia University (WVU)

Cosponsors
South Coast Air Quality Management District
The Gas Company
Engine Control Systems (ECS)
Sunline

Project Officer
Adewale Oshinuga

Background
Increase in urban vehicular population has warranted the local air control boards to impose stringent emissions regulations on heavy duty engine manufacturers and even more demanding regulations on transit bus fleet operators in order to attain the state ambient air quality standards. This trend has made natural gas a promising fuel in reducing oxides of nitrogen (NOx) and predominantly particulate (PM) emissions under the current mass based emission regulations.

Project Objective
The objective of this study was to develop and test an effective exhaust aftertreatment system comprising a particulate trap and an oxidation catalyst to reduce the emissions of toxic hydrocarbons and nanoparticles from a transit bus powered by natural gas fueled-engines.

Technology Description
The novel aftertreatment device designed for the Cummins C8.3G+ engine powered transit bus, by WVU and ECS, consists of a catalyzed particulate trap (PurifilterTM) followed by an oxidation catalyst. The particulate trap was a Pt/Base metal catalyst proprietary washcoat system supported on a silicon carbide diesel particulate substrate with a cell density of 200 CPI for a passive regeneration. The oxidation catalyst used a loading of 1:3 Platinum and Palladium oxidation catalyst with a proprietary washcoat system supported on a cordierite monolith with a cell density of 400 CPI.

Status
The project is completed. The draft final report has been submitted.

Experimental Setup
All the testing was done on WVU's transportable chassis dynamometer (Figure 1). The emissions characterization was done using a clean dilution tunnel built exclusively to test natural gas engines to reduce the effect of background contributions from previous deposits and avoid fuel crossover effects. The entire study was divided into three phases. During Phase I complete chemical speciation of the exhaust was done for "baseline" configuration, without any exhaust aftertreatment system and "vehicle as is" configuration which was with the OEM catalyst. In Phase II the emissions were sampled from the novel aftertreatment system, designed based on the Phase I emissions result. After Phase II the new aftertreatment system was subjected to in-use demonstration and was tested again after six months in Phase III to evaluate any deterioration in the performance. All the exhaust samples were collected by operating the vehicle on the CBD cycle.

Figure 1 Transit Bus on WVU Transportable Heavy-duty Chassis Dynamometer

Results

The carbon monoxide, and total hydrocarbon emissions were reduced to almost zero, and there was a significant reduction in the total PM emissions with the use of the new exhaust aftertreatment system when compared to baseline emissions (Figure 2)

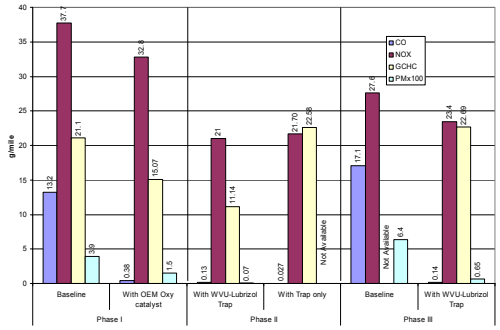


Figure 2 Regulated Emissions from 3 Phases

Toxic gas emissions which include benzene, toluene, xylene and butadiene were reduced by 54% when compared to baseline emissions. Figure 3 shows that toxic emissions were further reduced by 38% in Phase III when compared to Phase II results.

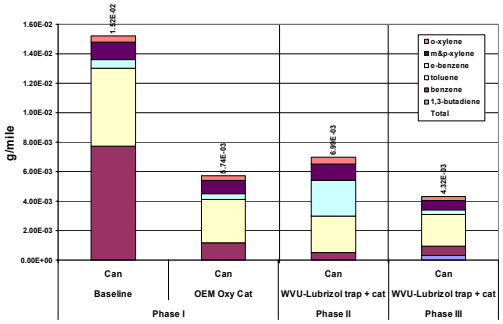


Figure 3 Toxic Gas Emissions

Figure 4 shows that the particle size distribution and concentrations for a number of steady state tests. PM concentrations were reduced to the background levels. Reduction of nanoparticles was one of the major design objectives of the WVU-ECS system.

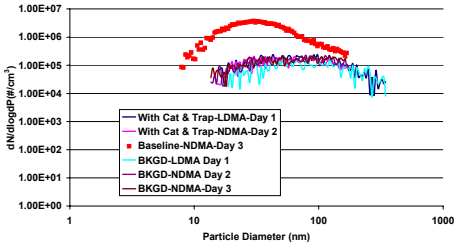


Figure 4 Particle Concentrations and Size Distributions

The Figure 5 shows that carbonyl emissions were reduced by 99% compared to the baseline, and no deterioration was after six months of in-use demonstration.

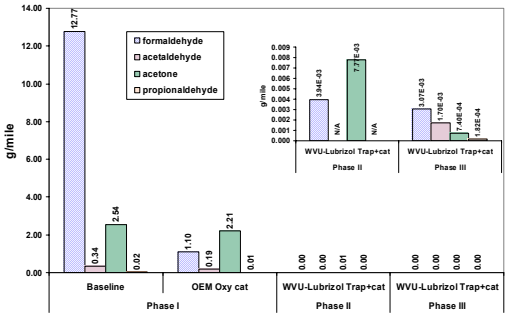


Figure 5 Carbonyl Emissions

Additionally, lube oil emissions were also reduced to non-detectable levels. While organic carbon emissions were reduced by nearly 70%, no elemental carbon was measured in the exhaust stream.

Benefits

This study showed that natural gas fueled heavy-duty engines with well designed exhaust aftertreatment systems can yield significant reductions in nanoparticles, and toxic gas emissions from transit buses. The WVU-ECS system highlighted the benefits.

Project Costs

The project was completed in the funds allocated for this study. No additional funds were requested. ECS donated the exhaust aftertreatment system for the study. The Gas Company provided co-funding.

Commercialization and Applications

After years of concern over nanoparticle, and toxic emissions from natural gas fueled heavy-duty vehicles, this study showed that a well-designed exhaust aftertreatment system can eliminate such emissions. Industry leaders, such as ECS can integrate the functions of a catalyzed trap and an oxidation catalyst into a single unit, and market such devices to the CNG heavy-duty engine industry. The units will find applications not only in the on-highway vehicles, but also in the stationary applications.

AQMD Contract #04027 **May 2005**

Develop & Demonstrate Hydrogen Internal Combustion Engine for Hybrid-Electric Buses

Contractor
ISE Research Corporation

Partners
Ford Motor Company, SunLine Transit

Cosponsors
California Energy Commission, USDOT Federal Transit Administration, Natural Resources Canada, CALSTART

Project Officer
Naveen Berry

Background
The program objective is the development of a hydrogen fueled hybrid electric transit bus.

For environmental and national security reasons, hydrogen fueled vehicles offer unique advantages and have thus become a focal point of long range development attention in industry as well as government. The SCAQMD was an early leader in these developments, noting not only the hydrogen advantages but how bus vehicles would yield the most "bang for the buck" in offering clean transport to large numbers of riders. The SCAQMD not only funded the early development of fuel cell buses, but was a leader in supporting hydrogen engine and vehicle development starting some eleven to twelve years ago.

More recently, the District participated in funding[1] the first hybrid electric fuel cell bus, which successfully demonstrated these new technologies at several sites over the past three years.

Technical Description
In the subject contract (04027) the hybrid electric hydrogen bus technologies have been implemented with a hydrogen-fueled internal combustion engine (HICE). The resulting bus has been termed HHICE, for its Hybrid Hydrogen ICE drive system. ISE serves as systems integrator and prime contractor for the HHICE program.

But for the hydrogen version of the V10 engine and the fuel storage on the roof, this HHICE bus is similar to gasoline fueled hybrid electric buses produced by ISE2. Hydrogen vehicles offer the best opportunity for supplying clean, competitively priced ZEV or near-ZEV vehicles, as with zero-carbon fuel the carbon oxides and hydrocarbon emissions are virtually eliminated. This hydrogen fueled bus, although it has no exhaust gas treatment, will have less toxic emissions than the gasoline fueled hybrid-electric bus, which was recently certified as an alternative fueled bus.

The addition of emissions controls (e.g., NOx Absorption) will further reduce emissions that can meet NZEV expectations.

Status
The prototype HHICE bus was delivered to the customer, SunLine Transit, (on November 30,

[1] With ISE as prime contractor.

[2] The gasoline fueled hybrid electric is certified in California as an alternative (to diesel) fuel vehicle, and is being produced at the rate of over 100 hybrid electric buses per year.

2004) and put into revenue service December 16 following a "rollout" ceremony. The bus was in service from dawn through the evening for the following three weeks, accumulating over 200 miles in service every day, with service interruptions only for planned maintenance and upgrades.

In January the revenue service at SunLine was interrupted to ship the bus to Winnipeg, Manitoba, such that winter testing of the bus could be done in partnership with Winnipeg Transit. The bus returned to SunLine Transit at the beginning of April following a series of demonstrations in Michigan, New York, New Jersey and Washington DC, and is now in daily service again with SunLine Transit.

Performance

Performance of the bus has met and exceeded expectations:

- Drivers appreciate the improved acceleration, as compared to conventional drive buses,
- Fuel consumption has been 4-6 mpeg, with a range of well over 200 miles,
- Passengers note the bus is exceptionally quiet, and appreciate the environmental advantages of use of hydrogen fuel.
- Despite the interruptions for travel and shows, the bus has accumulated over 7,000 miles in the first five months of revenue service. SunLine Transit is an enthusiastic customer, and has indicated interest in adding to its hydrogen fleet.

The winter testing included a survey of riders done by the University of Manitoba Vehicle Technology Centre.

The HHICE bus was run in scheduled for-fare service on a route running approximately 30 kilometers, from the Red River College campus in Northwest Winnipeg to the Southeast parts of Winnipeg at temperatures as low as -27 C (-17 oF). The objective of the study was to obtain rider-level feedback regarding the HHICE bus "experience". Riders reported significant advantages of the bus: Its quiet operation was appreciated, 69% of the respondents reported improved temperature comfort, and 80% of respondents considered the HHICE bus to be superior in terms of smooth acceleration

Applications

ISE offers the bus for US and Canadian transit agency service.

AQMD Contract # 00139 **August 2005**

Develop and Demonstrate Advanced Safety Inspection Methods for NGV Tanks

Contractor
Gas Technology Institute (with Battelle)

Cosponsors
Gas Technology Institute and
U.S. Department of Energy, Office of Transportation Technology
Lincoln Composites
Dynetek Industries

Project Officer
Ranji George

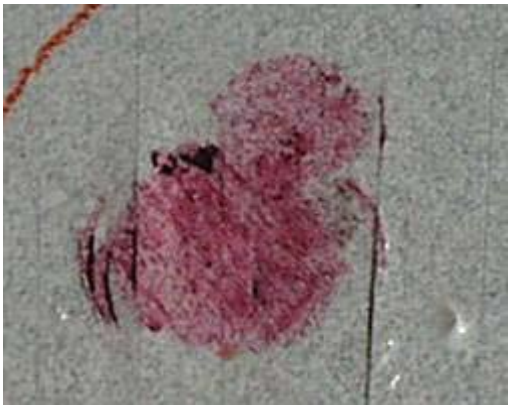
Background
Composite materials provide a strong, durable and lightweight material for construction of compressed natural gas (CNG) fuel cylinders for natural gas vehicles (NGVs). While these cylinders are rugged, impacts such as dropping the cylinders from an excessive height or high velocity impact by moderate sized rocks and debris may induce delamination and other structural damage to the composite materials. Such impacts are unique compared to other forms of cylinder damage, because they can cause damage within the composite wall that is not visible on the outer surface.

Damage caused by impact is not always easily detected. In the worst case scenario, significant damage that is undetected may grow during service until it becomes large enough to cause rupture of the fuel cylinder. Hence, cost-effective methods for detecting damage before failure could enhance the safety and service of composite NGV fuel cylinders. Two such systems are in development: damage indicator coatings and acousto-ultrasonic inspection.

Damage indicator coatings provide a brightly colored indicator that is easy to see and easy to identify when potentially threatening impacts have occurred. Such an indicator can permit simple and reliable visual checks of the cylinder condition prior to refueling without removal of the vehicle from service and or affecting normal operations.

Acousto-ultrasonic inspection is an electronic means of actively monitoring the physical condition of NGV fuel containers. In practice this type of system could activate a warning light to alert drivers and maintenance personnel of the possibility of a damaged cylinder onboard and allow remedial action to be taken before serious failure occurs.

Example of Damage Indicator Coating With Red



(Damaged) And White (Undamaged) Coating On Cylinder.

Project Objective
In this investigation the damage indicator coating developed for Type 4 (all composite) NGV fuel cylinders in previous work was implemented on Type 3 (metal lined) NGV cylinders to demonstrate its technical and economic feasibility. Following this laboratory evaluation, the coating was field demonstrated on Type 4 cylinders.

In addition to the development work on damage indicator coatings, the team was demonstrated and evaluated acousto-ultrasonic technology in the laboratory on full-scale Type 4 NGV cylinders to evaluate cylinder integrity and performance.

Technology Description
A damage indicator coating is a simple concept of a durable and cost-effective coating for the

exterior of an NGV fuel cylinder that changes color when impacted to help locate areas where damage may have occurred. While simple in concept, significant efforts have been necessary to develop a coating system that can withstand the rigors of NGV service.

Based upon experience and a review of the literature, the team adopted a development approach based upon microencapsulated beads. Microencapsulated beads are a two-component system in which a solid, liquid, or gas core material is coated with an encapsulant. These microcapsules rupture when impacted, releasing their contents, which react and change to a contrasting color. Microcapsules typically range in size from microns to millimeters. Common examples where microencapsulation is used include carbonless copy paper and "scratch-n-sniff" perfume samples.

In acousto-ultrasonic testing (AUT), thin piezo-electric transducers, similar to those used for acoustic emission evaluation, are used to actively transmit signals from one transducer to another, evaluating the structural condition of the cylinder through measuring changes in signal amplitude and frequency content. The AUT method is a rich technique which can potentially capture more information on cylinder integrity than conventional acoustic emission methods. It is also an active system which can continuously scan cylinder integrity, rather than a passive system which can only evaluate integrity during refueling.

Status

This program was completed on May 2, 2005 with the completion of the Field Demonstration and Evaluation of the Damage Indicator Coating Technology. The report on this work, as well as the reports on the laboratory demonstration of the Damage Indicator Coating System and the laboratory evaluation of Acousto-Ultrasonic Inspection Methods, is on file, with complete technical detail.

Results

The results of full-scale demonstration experiments on Type 4 NGV cylinders clearly show that the damage-indicator coating increases the visibility of impacted areas on the cylinder and can provide additional information that may be useful to the cylinder inspector and to the cylinder manufacturer in determining the condition of the cylinder. The results show that the force and energy of impact of blunt objects on the sidewall or dome can be can be estimated from the contact blush area. The field demonstration the coating system maintained its integrity, showed no visible signs of degradation, and performed its intended purpose without interfering with normal vehicle operation and maintenance.

The acousto-ultrasonic inspection work provided empirical demonstration of the potential capabilities of the method. The method shows promise for detection and discrimination of damage, although further work is needed in refining the analyses and validation on a series of containers with well characterized damage.

Benefits

Damage indicators coatings and acousto-ultrasonic inspection methods are expected to significantly enhance the safety of NGV cylinders by:

- Simplifying the inspection process
- Encouraging more frequent inspections
- Making it easy for untrained personnel to identify a potential problem
- Increasing the likelihood that a damaged cylinder will be identified and removed from service before failure can occur.

Project Costs

The total estimated cost of conducting the effort for SCAQMD is approximately $300,000. GTI, Lincoln Composites and the U.S. Department of Energy have invested approximately $1,130,000 in the related advanced composite cylinder technology development program.

Commercialization and Applications

Because of the significant safety benefits and potential low cost of these systems, it is anticipated that they will be implemented broadly on Type 3 and Type 4 composite reinforced NGV fuel cylinders. Further development is required prior to the commercial introduction of these technologies.

AQMD Contract # 03289 **December 2005**

Develop & Demonstrate Next Generation Natural Gas Engine Technology

Contractor
Cummins Inc.

Cosponsors
AQMD, Cummins

Project Officer
Naveen Berry

Background

The 2002 update of the Technology Advancement Plan for the Clean Fuels Program calls for significant emission reductions through the commercialization of 0.2 g/bhp.hr NOx natural gas engines. This project is part of Department of Energy's (DOE) Next Generation Natural Gas Vehicle ((NGNGV II) program to develop and implement a variety of technologies to further lower the emissions from natural gas engines. Previously, Cummins has successfully developed and commercialized lean burn spark ignition combustion concepts, closed-loop air/fuel control and electronic controls that have many competitive advantages over traditional stoichiometric engines.

Project Objective

The goal was to demonstrate technologies that deliver 0.2 g/bhp.hr NOx, 0.01 g/bhp.hr PM, 0.14 g/bhp.hr NMHC, and 0.01 g/bhp.hr formaldehydes emissions at higher brake thermal efficiency and power density than current products. The emissions demonstration was planned over the U.S. EPA Heavy Duty Transient test cycle.

Additionally, such an engine configuration was required to survive a steady-state endurance test. These two deliverables demonstrated the emissions and durability capability of the technology.

Technology Description

In this project, Cummins integrated exhaust gas re-circulation, combustion optimization and three way catalysts (TWC) and achieved the desired emission levels, higher power density, and efficiency. Cooled EGR results in lower NOx, suppresses knock and allows higher power density. This technology blend of previously proven diesel and natural gas systems enabled meeting the project emissions and durability goals. The natural gas systems and diesel systems included in the Cummins C Plus gas engine and EGR components from the diesel ISM and ISB engines. Target ratings for this engine were 310 HP, 950 lbs-ft torque and 40% brake thermal efficiency.

Status

The project has been completed and a final report has been submitted to the SCAQMD. The work consisted of adapting a C8.3 Gas Plus engine with production available Heavy Duty EGR systems, such as EGR cooler, valve and control logic. See Figure 1 below.

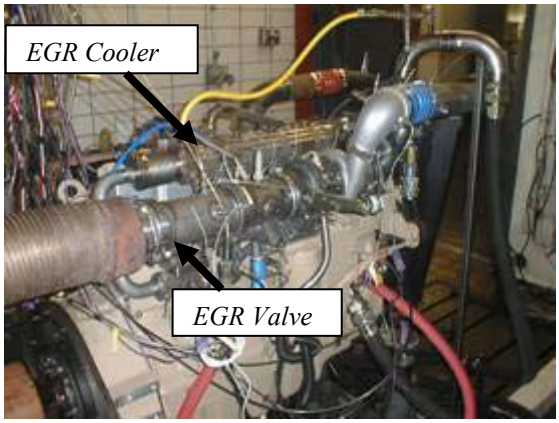


Figure 1: Engine Layout

This work included analysis, models development, simulation, design, installation, modification, testing, optimization and demonstration in a steady state and transient cycle operation. Figure 1

Results

The target rating (310 BHP) was demonstrated and exceeded in some cases. A final configuration consisting of a high swirl head and fast burn combustion chamber was selected for the transient performance optimization. SI EGR C8.3 engine was optimized for performance and emissions and tested for transient FTP (Figure 2). Results met all emissions targets for this project, as follows:

- BSNOx at 0.15 g/bhp.hr
- BSCO at 4.0 g/bhp.hr
- BSNMHC at 0.0 g/bhp.hr,
- PM at 0.0024 g/bhp.hr.
- Formaldehyde at 0.014 g/bhp.hr

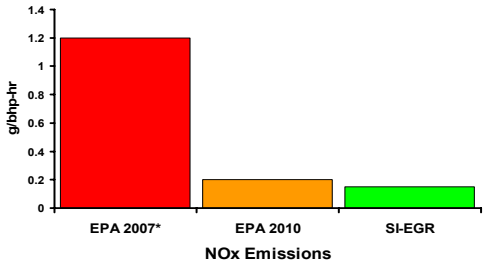


Figure 2: NOx emissions results

All torque and speed regression parameters required by EPA were met, and the engine followed the transients without any issues. In addition, analysis of the lug up test results indicate that the SI EGR C8.3 engine can result in better transient response than the current lean burn product.

An endurance test of the SI-EGR engine was completed. The learning goals of the test included EGR tubing durability, EGR cooler effectiveness degradation, power cylinder wear, durability of anti-corrosion coating on intake cover, spark plug life, oil consumption, and oil degradation. The engine has been torn down and overall results have been favorable.

Benefits

This application of EGR with stoichiometric combustion and a three-way catalyst has the potential to reduce vehicle emissions to the 2010 EPA levels, without significant durability issues. It is estimated that cost of ownership for a natural gas engine with this technology should be competitive, if not better, than the 2010 diesel engine technologies.

Project Costs

The total project cost was $2,349,058. The cost sharing was: Cummins $1,349,289. AQMD $999,769.

Commercialization and Applications

This project has demonstrated the capabilities of the cooled EGR technology applied to a SI stoichiometric engine with a three way catalyst. No major limitations have been identified that would restrict this technology from going into a commercial application.

As a result, this technology was selected for commercialization and is now under a product development phase for market introduction by Cummins Westport, Inc. by the middle of 2007, well ahead of the planned commercialization of diesel engines that meet the same emission standards.

A second phase for this technology could include additional studies towards improvements in fuel efficiency. Although a peak break thermal efficiency of 40% was demonstrated, overall efficiency over a real world operating cycle will still be lower than an equivalent diesel engine due to the inefficiencies of the throttled SI engine at part load conditions.

AQMD Contract #02189 **September 2005**

Develop & Demonstrate Water Electrolyzer Hydrogen Refueling Station in Coachella Valley

Contractor
ISE Research Corporation

Cosponsors
SunLine Services-$16,000; ISC Corp.-$20,000; Quantum Technologies-$130,000; Wintec-$226,000; & U.S. DOE-$200,000

Project Officer
Gary Dixon

Background

Hydrogen used as fuel avoids the primary source of vehicle produced carbon monoxide and hydrocarbons – the use of hydrocarbon fuel. Further, hydrogen as fuel provides a clear path both to renewably sourced fuel and to energy independence. The statement of work for this contract made specific note that "use of renewable sources for fuel generation renders the entire fuel cycle safe and free of climate change potential".

One of the major advantages of hydrogen fuel is that it can come from a variety of sources, from solar powered electrolysis The use of wind to produce fuel has – before this program – been done only in small laboratory scale (5kw, yielding less than a kilogram of fuel in a typical day) demonstrations.

In recognition of the public value of renewable hydrogen, the legislature has recently (in SB76, providing limited hydrogen highway funds) specifically required the use of renewable energy for hydrogen fueling stations.

Project Objective

This project provided for the on-site generation of fuel grade hydrogen from wind sourced electricity and for compression and storage of the fuel. Fuel was to be available to trained personnel at the site, and for storage and transport for dispensing and use at the SunLine public fueling station.

Technology Description

Wind driven turbines of multi-megawatt capability are now installed in sites world over. In this program electrical power produced by the wind is used to power an electrolyser which in turn breaks down water into hydrogen and oxygen. The system compresses the hydrogen to 5800 psi and the fuel grade hydrogen is stored in high pressure containers mounted in a trailer (see photo). That fuel is then available for fueling vehicles. The electrolyser capability of over 2 kg hydrogen per hour allows production (on windy days) of more fuel than our hydrogen fueled buses can use per day.

The use of wind power to generate fuel allows a totally zero carbon system, environmentally ideal in that there are no toxic criteria emissions and no global warming effects.

Status

The Wind Hydrogen system was commissioned in January 2004 and wind generated hydrogen has been available on site since. The photo shows the SunLine Hydrogen fueled Hybrid electric Internal Combustion Engine bus in position for fueling at the wind site. The electrolyser was leased, with intention of the owner quit-claiming or replacing it with new hardware at the end of the lease, but the electrolyser was recently removed from the site (in November, 2005) and reclaimed to be used elsewhere.

AQMD Contract # 02208 **September 2005**

Develop & Demonstrate Advanced Storage Tanks for Storing CNG/LNG and Compressed and Liquid Hydrogen

Contractor

Structural Composites Industries (SCI)
(with Lawrence Livermore National Laboratory and SunLine Transit)

Cosponsors

Department of Energy (DOE)

Project Officer

Gary Dixon

Background

Hydrogen (H2) differs from other fuels in that it can be produced (and used) without releasing the potent greenhouse gas CO2, by simple decomposition of water (H2O) using electricity and/or heat from solar, wind, fission, or fusion power sources. As a versatile and universal carbonless energy carrier, H2 is a necessary element for future energy systems aimed at being free of air pollution, CO2, and other greenhouse gases. If generated from renewable energy, H2 becomes the crucial link in an inexhaustible global fuel cycle based on the cleanest, most abundant, natural, and elementary substances: H2, O2, and H2O.

The physical and chemical properties of hydrogen make its utilization superior to fossil fuels. H2 is a simple, non-toxic molecule that generates power cleanly and efficiently, even silently and without combustion, if desired. Widespread use of H2 has been challenging, however, because of its low energy density relative to conventional (hydrocarbon) fuels. Energy density fundamentally drives the feasibility of H2–fueled transportation by determining the capital, materials, volume, and energy needed for onboard storage.

Project Objective

Considering the importance of storage in achieving a smooth transition to the H2 economy, and the serious technical challenges associated with H2 storage, we have demonstrated the applicability of an alternative approach for vehicular H2 storage: insulated pressure vessels. In this work we have designed and built an insulated pressure vessel, developed a draft set of certification standards for insulated pressure vessels, and demonstrated the technology on a hydrogen fueled pickup truck and tested extensively by fueling it multiple times with liquid and compressed hydrogen and by driving the vehicle..

Technology Description

The proposed alternative to vehicular hydrogen storage consists of storing fuel in an insulated pressure vessel that has the capability to operate at cryogenic temperature (20 K), and at high pressure (240 atm or higher). This vessel can be fueled exclusively with LH2, or it can be fueled flexibly with LH2, cryogenic GH2, or ambient temperature GH2. In both modes of operation insulated pressure vessels present advantages with respect to conventional LH2 and GH2 vessels.

If the insulated pressure vessel is always fueled with LH2, it becomes a compact vessel that goes a long way toward solving most of the problems associated with LH2 tanks: evaporative losses after a short period of inactivity, high evaporative losses for short daily driving distances, danger of being stranded due to fuel evaporation and need for considerable (10-20%) ullage space.

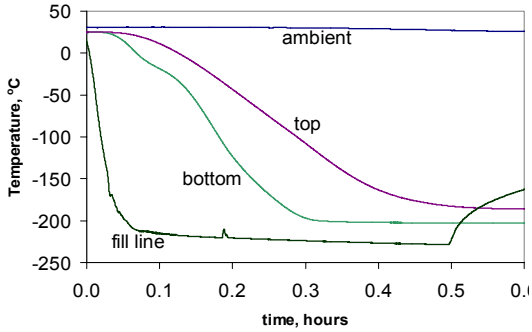
Compressed H2 heats up considerably as it is pumped into a storage vessel, reducing the density of storage. At high pressure, H2 is not an ideal gas, considerably reducing the increase in density that can be obtained by increasing the pressure. Insulated pressure vessels have the advantage with respect to compressed hydrogen of delivering a long vehicle range and no compression heating if fueled with liquid hydrogen.

Status

The project has been successfully completed. The insulated pressure vessel was built in March of 2004, installed in the pickup truck in June of 2004, tested at LLNL in July of 2004, and delivered to SunLine in August of 2004. The truck was tested in SunLine for 6 months. The test was successfully completed and the final report was written in September of 2005.

Results

In this project we have demonstrated the possibility of flexibly refueling an insulated pressure vessel. The insulated pressure vessel was refueled multiple times with no physical damage to the vessel. The figure shows temperature in the pressure vessel during the liquid hydrogen fill operation. The figure shows that the vessel cools down from ambient temperature in approximately 0.3 hours (18 minutes). The fill line is in direct contact with liquid hydrogen and therefore cools down very quickly. The other two thermocouples are located outside the vessel, and therefore take more time to cool down due to thermal lag through the vessel wall. The thermocouple located at the bottom of the vessel cools down faster, since the liquid accumulates there first. The thermocouple at the top is not in direct contact with liquid hydrogen until the vessel is completely full, and therefore remains warmer.



Benefits

This project has demonstrated the benefits of insulated pressure vessels and their advantages with respect to LH2 and GH2 tanks. Insulated pressure vessels offer flexibility and savings, both in terms of energy and cost. From engineering and economic perspectives, insulated pressure vessels strike a versatile balance between the cost and bulk of ambient temperature compressed fuel storage, and the energy efficiency, thermal insulation and evaporative losses of cryogenic storage.

Project Costs

The AQMD contribution for this project was $350,000. The cost share was $200,000 from DOE and $100,000 from SCI. Total cost of the project was $650,000.

Commercialization and Applications

This technology applies to vehicular hydrogen storage, for automobiles as well as buses and trucks. In the near future we will further develop this technology and demonstrate it in another vehicle (a Toyota Prius), and develop cryogenic compatible vessels for hydrogen delivery trucks (with DOE funding).
Commercialization beyond demonstration projects will take some time, due to the futuristic nature of this project and of the hydrogen economy. However, we anticipate that this technology has a good future as a potential solution to the very challenging technical issues of hydrogen storage.

AQMD Contract # 03200 **July 2005**

Develop and Demonstrate an Autothermal Reformer Based Hydrogen Fueling Station

Contractor
SunLine Service Group (with Hyradix)

Project Officer
Gary Dixon

Background

The purpose of this project was to provide a turn key hydrogen station in the Coachella Valley optimizing the use of a hydrogen reformer generation unit. The reformer incorporated a purification system and was integrated into the compression, storage and dispensing system. The reformer was designed to meet ISO 14687 purity standards during operation. Significant cost savings on hydrogen use were made using on-site hydrogen production.

Project Objective

The primary objective of this project was to fill hydrogen vehicles storage tanks to 5000 psig and or up to 5 kg per fill for 6- to 8 vehicles. The majority of the fuel was used on a blended H/CNG application as well as an HHICE bus in service in the Coachella Valley. A portion of the fuel was used to fill outside agency vehicles such as Honda, Toyota, or Ford during demonstrations in and or use near the Coachella Valley.
All of the requirements set in the project agreement have been met. HyRadix and SunLine have demonstrated the viability of producing fuel grade and fuel cell grade hydrogen from a commercial natural gas feedstock and dispensing it to fuel cell vehicles and alternative fuel vehicles.

Technology Description

Commercial hydrogen production facilities are very large in comparison to a small scale hydrogen reformer. The HyRadix AdéoTM On-site Hydrogen Fuel Generator incorporates auto-thermal reforming on bi-functional, monolithic catalysts and CO shift reaction to produce a hydrogen-rich reformate. When coupled with Pressure Swing Adsorption (PSA), the system produces 100 nm3/h of 99.95 vol% hydrogen product with less than 1 vppm carbon monoxide at 90 psig from 52 nm3/h of natural gas feedstock. The hydrogen product from the PSA is subsequently compressed and delivered to storage. The waste gas from the PSA is sent to an onboard Waste Gas Burner to recover heat.

Status

The detail design for the Adéo HFG unit was completed in March, 2003. The design package included a Process Specification, detailed hydraulic calculations, Piping and Instrumentation Diagram, Mechanical Flow Diagram, equipment, control and instrumentation specifications and fabrication drawings. A thorough hazards and operability analysis (HAZOP) was part of the design package, as well, and its recommendations were included in the design.

Fabrication of the Adéo HFG was started in early April, 2003 and was completed in June, 2003. The fabrication was performed in an Illinois fabrication shop under HyRadix guidance.

The Adéo HFG arrived on site on 22 July 2003. All of the catalysts and adsorbents were shipped uninstalled to prevent damage during shipping. The catalyst inventory consisted of monolithic catalyst for the ATR, Shift Reactor and Waste Gas Burner. Pelletized adsorbent was supplied for the sulfur removal system and the PSA. Catalyst and adsorbent loading began on 6 August and was completed the next day.

In early September modifications to improve the heat exchangers on the AdéoTM unit were implemented and completed by the first week of October, 2003.

First gas to the unit occurred on 9 October 2003. For the next month, the Adéo HFG was continuously operated and all systems were tuned to optimize performance. The PSA was commissioned and the unit consistently produced hydrogen product with a purity of 99.95 vol%. The Adéo HFG and hydrogen product compressor integration logic was tested for the first time on 4 November 2004.

The October-November testing produced data that was used to further upgrade the performance of the heat exchange design. The new modifications were completed by the end of March, 2004. The Adéo HFG was started up on 6 April 2004 and successful pre-demonstration run testing was performed through 16 April 2004.

Results

One goal of the demonstration run was to operate the Adéo HFG at 90% of its rated capacity (90 nm3/h) for ten consecutive days within a 30 day period. A product hydrogen purity greater than 99.5 vol% and carbon monoxide concentration less than 1 vppm was to be maintained during the run. SunLine and HyRadix continued to operate and monitor the unit for an additional period of 12 months. During this time, long-term data was collected to verify maintenance requirements and costs, system performance, hydrogen production costs and on-stream availability
The ten day (240 hour) demonstration run was successfully completed at 1800 hrs on 30 April 2004. During the run the average product hydrogen purity was 99.68 vol% and the carbon monoxide concentration was less than 1 vppm. The average feed and product flow rates were 47.0 nm3/h and 91.7 nm3/h, respectively.

From 7 May 2004, when the product compressor was first commissioned, through the end of the one year demonstration run the Adéo was the sole source of hydrogen for SunLine operations.

Benefits

Having on site hydrogen generation is a great benefit to the Coachella Valley. SunLine is able to fuel hydrogen cars or buses from various manufactures to advance the hydrogen fuel cell technology. SunLine continues to be an integral part of hydrogen validation through the efforts in operating hydrogen buses and vehicles everyday in revenue service with the hydrogen produce from this equipment. The hydrogen production cost, on a direct operating cost basis, for the AdéoTM HFG is $2.06 USD per kg. of hydrogen product ($0.94 USD/lb.).

This includes the cost of natural gas feed (at $0.71 USD/therm), cooling and process water, and the electricity required to operate the Adéo HFG as well as the compression, storage and dispensing equipment. Assuming a 90% on-stream factor, a ten year life expectancy, annual maintenance and consumable costs of 5% of capital and combined with the current pricing for a 100 Nm3/h Adéo HFG, the calculated fully loaded cost of hydrogen, with the utility prices in is $4.27 USD/kg ($1.94 USD/lb). If the historical natural gas price of $0.50/therm is used, the calculated hydrogen production cost drops to $3.82/kg ($1.73 USD/lb).

Project Costs

The cost to complete this project was $350,000. In-kind contribution reached over $500,000 and is ongoing to continue to support the hydrogen station.

Commercialization and Applications

From the experience and lessons learned from this project commercialization of the technology has been achieved. It is anticipated that the new units will be ready for market within in the 3rd quarter 2005. All problems that were solved have been incorporated into the commercial unit. American markets as well as Asian markets are being targeted for this technology. Currently the most interest has been from overseas for food processing and alloy annealing manufacturing plants.