Technology Advancement Office

Clean Fuels Program

Annual Report 2002

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AQMD

South Coast
Air Quality Management Distirct

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EXECUTIVE SUMMARY

The SCAQMD Governing Board approved 63 new projects or amended contracts during Calendar Year (CY) 2002 to sponsor research, development, and demonstration (RD&D) and commercialization of alternative fuel and clean fuel technologies in Southern California. Tables 1 and 2 list projects which are further described in this report. The SCAQMD contributed more than $7.6 million towards such projects in partnership with other government organizations, private industry, academia and research institutes, and interested parties, with total project costs of nearly $22 million. These projects addressed a wide range of issues with a diverse mix of advanced technologies. The areas of technology advancement, listed below, were expanded from 2001 to emphasize fuel cells and hydrogen technologies:

- Fuel Cell Technology
- Hydrogen Technology and Infrastructure (production, storage, and fueling)
- Engine Technology (particularly in the heavy-duty vehicle sector)
- Emission Control Technology
- Infrastructure and Fuel Production (CNG and LNG)
- Electric and Hybrid Vehicle Technologies
- Stationary Clean Fuel Technology (including renewables)
- VOC and Toxics
- Emissions Analyses
- Outreach and Technology Transfer
- Health Studies

During CY 2002, the SCAQMD continued the advancement of alternative fuel technologies with an emphasis on deployment of natural gas vehicles, expansion of the natural gas refueling infrastructure, and initiation of a hydrogen refueling infrastructure for fuel cell vehicles. The SCAQMD also continued sponsorship in the development of electric and electric-hybrid technologies.

In addition to the new projects, 39 research, development, and demonstration projects and 19 technology assessment projects or studies were completed in 2002, as listed in Table 4. Summaries for each technical project completed in 2002 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, 2003, after approval by the SCAQMD Governing Board.

CLEAN FUELS PROGRAM

An Overview

Summary

This report summarizes the progress of the South Coast Air Quality Management District (SCAQMD) Clean Fuels Program for Calendar Year (CY) 2002. 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.

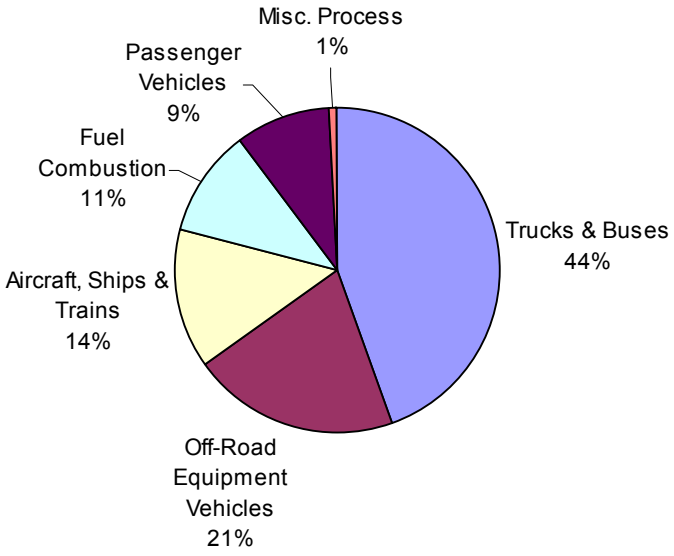
During the period between January 1, 2002 and December 31, 2002, the SCAQMD Governing Board approved 63 projects that support clean fuels and advanced technologies. The SCAQMD contribution for these projects exceeds $7.6 million, with total project cost of nearly $22 million. These projects address a 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 content of this report addresses the requirements set forth in state legislation passed during 1999 that 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:

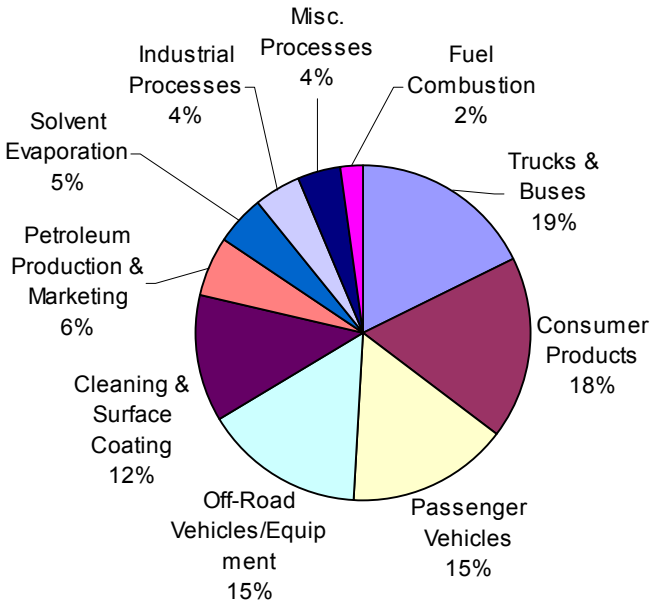
- A description of the core technologies that the SCAQMD considers critical to ensure attainment and maintenance of ambient air quality standards and a description of the efforts made to overcome barriers to commercialization of those technologies;
- An analysis of the impact of the SCAQMD's Clean Fuels Program on the private sector and on research, development, and commercialization efforts by major automobile 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.

The Need for Advanced Technologies

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 South Coast Air Basin (Basin) and the future emissions levels projected in the draft 2003 Air Quality Management Plan (AQMP) revision. The baseline 2010 emissions inventory is shown in Figure 1. Based on the draft 2003 AQMP, significant reductions are necessary to demonstrate attainment with the federal 1-hour ozone standard.



Total NO_x Emissions = 740 tons/day



Total VOC Emissions = 614 tons/day

Figure 1: 2010 Baseline Emissions (1997 Base Year)

The 1997 and draft 2003 AQMP rely on advanced technologies that are not yet fully developed for commercial use to meet long-term emission reduction measures. For the draft 2003 AQMP, significant reductions are anticipated from implementation of advanced control technologies for both on-road and off-road mobile sources.

In addition, new air quality standards for ozone (0.08 ppm, 8-hour average) and fine particulate matter, promulgated by the U.S. Environmental Protection Agency (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 air toxic contaminant emissions. More importantly, the California Air Resources Board (CARB) listed diesel exhaust emissions as an air toxic contaminant. The SCAQMD Multiple Air Toxics Exposure Study (MATES-II) found that diesel combustion sources (primarily from heavy-duty vehicles) contribute on the average 70% to the estimated potential cancer risk in the Basin.

The on-road mobile source inventory for the years 1997 and 2010 is estimated to be:

	1997	2010
VOC [a]	549	208
Carbon Monoxide [b]	4,914	1,771
Oxides of Nitrogen [a]	785	399
PM_{10} [c]	18	19 [d]

[a] summer planning inventory; [b] winter planning inventory; [c] annual average [d] Year 2006

To help meet the need for technology to address the attainment of clean air standards in the South Coast Air Basin, the Governing Board adopted a Clean Fuels Program and established the Technology Advancement Office in 1988. This program is intended to assist in the rapid development and deployment of progressively lower-emitting technologies and fuels through an innovative public-private partnership. Since its inception, the SCAQMD Technology Advancement Office has co-funded projects in a cooperative partnership with private industry, technology developers, academic and research institutes, and local, state, and federal agencies. This public-private partnership has enabled the SCAQMD to leverage its public funds with outside investment.

Program Funding

The Clean Fuels Program, under California Health and Safety Code (H&SC) 40448.5 and 40512 and Vehicle Code 9250.11, establishes mechanisms to collect revenues from mobile and stationary sources to support the program's objectives, albeit with constraints on the use of the funds. The objective of this program is to support and promote projects to increase the utilization of clean-burning alternative fuels and related technologies, such as methanol, fuel cells, liquid petroleum gas, natural gas, combination fuels, synthetic fuels, electricity including electric vehicles, hydrogen, and other clean alternatives yet to be developed.

This program imposes a $1 fee on the renewal of registration of motor vehicles registered in the SCAQMD to fund this effort. Revenues collected from these motor vehicles must be used to support mobile source clean fuel projects. In addition, emission fee surcharges under the Clean Fuels Program are imposed on stationary sources emitting more than 250 tons of pollutants per year within the SCAQMD to support related stationary source clean fuel technology developments. As noted previously, the Clean Fuels Program was amended with the passage of Senate Bill (SB) 98, authored by Senator Richard Alarcon, on June 8, 1999, that extended this funding mechanism until January 1,

2005. Projected funds available annually for related Clean Fuels research and development projects from this revenue source are approximately:

- Mobile sources (DMV revenues) $11,200,000
- Stationary sources (emission fee surcharge) $400,000

The estimated uncommitted balance in the Clean Fuels Fund at the close of 2002 was $10 million. 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 budget. Historically, such cooperative project funding revenues have been received from the ARB, 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.

Another limited revenue source available to fund the development and demonstration of advanced clean air technologies is the Advanced Technology, Outreach and Education Fund. This fund was established as a special revenue fund, separate from the SCAQMD budget, for revenues received as a result of penalties and settlements from violations of air pollution control rules and regulations. In some cases, the revenues from violations may be tied to specific technologies or the development of technologies to address specific industrial needs. In certain enforcement cases, for example, instead of simply paying a fine a company could place the penalty amount into this fund and help develop low-emission processes in its own field of business. The estimated uncommitted balance in this fund at the close of CY 2002 is $188,000.

The final, and perhaps most significant, funding source can best be described as an indirect source, i.e., funding not directly received by the SCAQMD. This indirect source is the cost sharing provided by private industry and other public and private organizations. Historically, the Technology Advancement Office has been successful in leveraging its available public funds with at least $4 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, including technologies to reduce VOC emissions from stationary and area sources.

A second advisory group was formed in response to requirements specified in SB 98 (Alarcon). Under H&SC 40448.5.1(c), this advisory group was specified to 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, the Technology Committee of the SCAQMD Board, public hearing of plans and reports before the full SCAQMD Governing Board, and submittal of annual reports to the Legislature.

Core Technologies

The SCAQMD continually seeks to support the deployment of lower emitting technologies. The technology advancement program is shaped by two basic factors:

- The low- and zero-emission technologies needed to achieve clean air standards in the Basin; and
- The funding available to support technology development within the constraints imposed by that funding.

The SCAQMD program 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 is limited, national and international activities affect the direction of technology trends. As a result, the SCAQMD program must be flexible to accommodate these changes in direction. 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.

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 the common approach of "pollution prevention;" that is, inherently low- or zero-emission technologies rather than after-treatment technologies intended to reduce emissions after they are formed. Historically, mobile source projects have targeted low-emission 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 and energy storage/conversion devices (e.g., fuel cells and batteries); and implementation of clean fuels (e.g., methanol, natural gas, propane, and hydrogen), including their infrastructure development. Stationary source projects have included a wide array of advanced low NO_x technologies, low VOC coatings and processes, and clean energy alternatives, such as fuel cells, solar power, and other renewable energy systems.

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.

Fuel Cell Technology and Hydrogen Infrastructure

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, a fuel, usually 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 along with rapid refueling for vehicles, and have the potential to work in virtually every mobile and stationary application currently powered by internal combustion engines. Consequently, they are specifically identified in the AQMP as "enabling" technologies to help meet long-term control measures in the transportation sector and hold promise as near-zero emission power providers in the stationary sector.

Fuel cells are emerging as a leading alternative technology to power zero emission vehicles (ZEVs) and near-ZEVs. Despite the considerable work done and recent announcements of international joint ventures, a significant amount of additional development is needed to improve and demonstrate the ultimate commercial viability of fuel cells for transportation as well as stationary applications. It appears that cars, buses, and distributed power generation will be the first beneficiaries of this exciting new technology. Two of the prime challenges facing the widespread potential usage of fuel cells are the refueling infrastructure development and the relatively high cost for both mobile and stationary applications.

Engine Technology (Heavy-Duty Vehicles)

Heavy-duty vehicles are significant contributors to the Basin's on-road vehicle emissions inventory, contributing over one-third of the NO_x and two-thirds of the particulate emissions. These heavy-duty vehicles are primarily powered by diesel-fueled compression ignition engines, which in addition to emitting NO_x and PM, produce exhaust pollutants that have known toxic effects. The 1997 AQMP and the draft 2003 AQMP revision both project that significant long-term emission reductions will be required from mobile sources, especially from the heavy-duty sector, to attain 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) for seven of the major engine manufacturers subject to the noncompliance consent decree and 4.0 g/bhp-hr (NO_x only) for the other engine manufacturers not subject to the recent consent decree; whereas natural gas fueled engines with after-controls can potentially achieve emissions as low as 0.5 g/bhp-hr and is the technology most likely to achieve the 0.2 g/bhp-hr emission levels prior to 2007. The SCAQMD, along with various local, state and federal agencies, have supported development and demonstration of alternative fuel heavy-duty engine technologies, including methanol, compressed and liquefied natural gas, and propane. CNG and LNG heavy-duty vehicles are finding many applications in urban fleets, such as transit buses, refuse collection, and delivery vehicles. Micro-turbines are also showing great promise as a low-emission alternative to the internal combustion engines, when powered by natural gas or propane. 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.

Infrastructure and Fuel Production

A key element for the widespread acceptance and resulting increased use of alternative fueled vehicles is the infrastructure to support the refueling of vehicles by the driving public. The refueling infrastructure for gasoline and diesel fuel is well established and accepted by the public. Alternative, clean fuels such as natural gas, methanol, ethanol, propane, hydrogen, Hythane™ , 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 develop enabling technologies for refueling and recharging of alternative fuel vehicles (AFVs) and electric vehicles (EVs) and to expand the infrastructure to support zero and near-zero emission vehicles.

In 2002, the SCAQMD embarked on an aggressive endeavor to add and upgrade natural gas fueling facilities to support the need for CNG and LNG fuel by fleet operators who are subject to clean-fuel fleet requirements. As part of that effort, the SCAQMD released a request for proposals in the fall of

2002 to bring local production of LNG to the Basin. In addition, work has also started in 2002 on implementing a series of hydrogen fueling sites for use by fleets demonstrating fuel cell cars and buses.

Emission Control Technology

This broad category refers to aircraft, locomotives, marine vessels, farm and construction equipment, industrial equipment, and utility and lawn-and-garden equipment, as well as off-road vehicles. These sources represent about 25 percent of the total NO_x emission inventory and 11 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 off-road mobile sources lies primarily with the U.S. EPA and CARB, and to a lesser extent with the SCAQMD.

For example, CARB adopted emission standards for utility and lawn and garden equipment that became effective in 1995, with more stringent standards to have taken effect in 1999. The U.S. EPA has also proposed a national program for such engines. Such standards may eliminate hand-held, two-stroke engines and the associated equipment they power because of the lack of satisfactory, low-cost emission control equipment. The greatest need and opportunity for emission reductions may well lie with off-road sources subject to federal control or international agreements.

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 off-road sources. Clean fuels such as natural gas, propane, methanol, ethanol, hydrogen, and Hythane™ may provide an effective option to reduce emissions from some off-road fleet applications. In addition, reformulated gasoline and diesel fuels have been developed to lower emissions and, when used in conjunction with advanced emission controls, additives, and new engine technologies, appear to have promise. The U.S. EPA and the SCAQMD, for example, has promulgated regulations that lower the sulfur content of diesel fuels in the future. Immediate benefits are also possible from particulate traps, fuel additives and emulsifiers that have been developed for diesel fuel applications.

Electric and Hybrid Vehicle Technology

Electric Vehicles (EVs) are powered by an electric motor instead of an internal combustion engine. The electrical energy is supplied from an on-board 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 fuel cells. 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.

The AQMP projects the need for significant penetration of zero emission technologies, including EVs, in the Basin to achieve state and federal clean air standards. Although original equipment manufacturers (OEMs) are beginning to introduce limited quantities of EVs and HEVs in Southern California to meet the terms of the Memoranda of Agreement with CARB, there remains a need to support advancement of EV technologies to improve marketability and expedite their implementation. The SCAQMD continues to support projects to develop and demonstrate such advancements in electric drive trains, energy storage devices, charging infrastructure, and related components. In addition to passenger vehicles, other applications for EV technologies are evolving slowly.

Stationary Clean Fuel Technology

Given the limited funding available to support low emission stationary source technology development, this technical 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 zero emission technologies, such as:

- Solar, Wind, and Geo-thermal Energy
- Bio-mass Conversion

Distributed generation with the help of fuel cells (mentioned previously) or renewable resources also holds the promise of significant emission reductions by displacing generation from older, higher-polluting central power plants.

Although combustion sources are lumped together as stationary, the design and operating principles vary significantly. Included in the stationary category are continuous combustion devices, such as boilers, heaters, and 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 technology for this category would focus on using advanced combustion processes, development of catalytic add-on controls, and alternative fuels and technologies.

VOC and Toxics

The broad category of VOC reduction technologies is developing and emerging in response to technology-forcing control measures and rules, business demands for clean non-polluting products and processes that reduce toxic exposure risk for their employees, and general public demand for clean air and a clean environment. A few examples from this broad category of low VOC products and processes include:

- Water-based zero-VOC architectural paints;
- Low-VOC and Zero-VOC wood, metal, and plastics coatings, including Ultra-Violet (UV) and Electron Beam (EB) cured products, water-based coatings, and powder coatings. Such coatings are proving to be preferred for a number of reasons including performance, reduction in worker exposure to toxic materials, and easier compliance with air, water, and other regulations; and
- Aqueous cleaning solutions and processes, such as steam cleaning, as alternatives to conventional petroleum solvent cleaning operations.

Although progress is being made in the development and commercialization of zero-VOC products and processes, further technology advancements are needed to achieve the AQMP goals. Future technology priorities will focus on “pollution prevention” technologies, which appears to be the most promising approach for this diverse and ubiquitous source category.

PROGRAM IMPACT

Benefits of the Clean Fuels Program

The SCAQMD Clean Fuels Program continually seeks lower emitting technologies. Overall program direction reflects the technology needs identified in the AQMP; state and federal regulatory developments; annual research and development coordination meetings with the ARB; periodic meetings with various technology, clean fuel, and industry working groups; review of technical papers and scientific journals; participation in technical exchange conferences; and periodic meetings with the Technology Advancement Advisory Group and SB 98 Clean Fuels Advisory Group.

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 possibility, and consistency with program goals and funding constraints.

Commercialization and implementation of advanced technologies come with several real-world challenges and barriers to be overcome. Recurring barriers to the successful commercialization of new technologies include:

- Cost/Economics,
- Real-world demonstration requirements,
- Technical performance,
- Fuel and Support Infrastructure,
- Regulations,
- Safety,
- Certification and liability, and
- Consumer acceptance.

The reluctance of manufacturers as well as end users to invest in advanced technology products must be overcome by a combination of real-world demonstrations, education and outreach, and regulatory mandates and incentives. The SCAQMD's role in technology advancement is to share the risk of emerging technologies by cost-sharing the development and demonstration projects that address these barriers.

One way to assess the impact and benefits of the SCAQMD program is to provide specific examples of accomplishments and commercial, or near-commercial, products supported by the SCAQMD Clean Fuels Program.

Research and Development Programs

The development of advanced technology faces increasing challenges in these times of diminishing resources, infrastructure and energy uncertainties, sensitivity to multi-media environmental impacts, and the need to find balance between the environment and the economy. 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-art 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 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 formally meets with CARB 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), Electric Power Research Institute (EPRI), and Gas Technology Institute (GTI).

The coordination efforts with these various funding organizations have resulted in a number of cosponsored projects. The descriptions of the projects awarded in CY 2002, found in the next section of this report, list the cosponsors and subcontractors for each project. 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 to help expedite the implementation of advanced low-emission technologies. Listed below are the funding agency partners and major manufacturers actively involved in SCAQMD projects for this reporting period. It is also important to note that, although not listed below, the technology developers, smaller manufacturers, and other project participants listed in the project descriptions all make important contributions critical to the success of the SCAQMD program.

Research Funding Organizations	Major Manufacturers
California Air Resources Board	Caterpillar
California Energy Commission	Cummins Engine Company
Coordinating Research Council	Cummins-Westport
Defense Advanced Research Projects Agency	Detroit Diesel Corporation
Electric Power Research Institute	Engine Manufacturers Association
Gas Technology Institute	General Motors
Gas Technology Canada	IMPCO Technologies
Los Angeles Department of Water and Power	John Deere Power Systems
National Renewable Energy Laboratory	Mack Trucks
New York Power Authority	PACCAR
Sacramento Metropolitan AQMD	Siemens-Westinghouse
San Diego APCD	Solar Turbines
Southern California Edison	
Southern California Gas Co.	
U.S. Department of Energy	
U.S. Department of Transportation	
U.S. Environmental Protection Agency	
U.S. Postal Service	

Important examples of the impact of SCAQMD research and development coordination efforts is the continued focus of heavy-duty engine manufacturers and end-users on low-emission alternative fuel engines and the initialization of the hydrogen refueling infrastructure.

Alternative Fuel On-Road Engines

The SCAQMD and others have long supported the development and demonstration of natural gas heavy-duty engine technology. Over the past decade, major U.S. engine manufacturers have developed a first generation of heavy-duty natural gas engines for use in transit buses and heavy-duty commercial trucking. The current generation of natural gas engine technology can achieve emissions below 2.0 g NO_x/bhp-hr. However, additional work is needed to lower the NO_x emissions to 0.5 and ultimately 0.2 g/bhp-hr, and lower the PM emissions to 0.01 g/bhp-hr to meet future heavy-duty vehicle standards.

As a specific example, in 2001, the SCAQMD formally joined with CEC, CARB, and Detroit Diesel Corporation (DDC) to cosponsor a $3.5 million project to develop very low emission heavy-duty natural gas engines. While this project was previously approved in 2000, the SCAQMD Governing Board further augmented the funding in 2001 to achieve an expedited natural gas engine introduction

for the 2003 model year. The SCAQMD contribution of about $1 million is matched by co-funding of about $2.5 million from CEC, CARB, and DDC.

The goal of the DDC project is to develop the Series 50G natural gas engine with an advanced fuel control system to achieve 300 hp and 900 ft-lb torque. This engine is intended to be certified to 0.5 g/bhp-hr NO_x emissions. This development will utilize new engine system design that will run the engine at the leanest possible air-to-fuel ratio under any condition. New technology to optimize the combustion stability and extend the engine's lean misfire limit will be also developed. The DDC Series 50G engine is widely used in the bus market and the technology may also be extended to the Series 60G engine used in heavy-duty trucks. As part of this effort, DDC has certified its Series 50G natural gas engine at 1.2 g/bhp-hr (combined NO_x and VOC) for Model Year 2003.

Initialization of a Hydrogen Refueling Infrastructure

As part of larger effort to bring hydrogen and fuel cell vehicles into commercial fruition, the SCAQMD initiated the development of a hydrogen refueling infrastructure for the South Coast Air Basin. This effort began with initial planning and evaluation of the feasibility of constructing hydrogen refueling stations in the Basin followed by the SCAQMD Governing Board awards to move forward with the construction of five refueling stations located throughout the Basin: one at LAX, two in Orange County; one in Long Beach; and one in the Coachella Valley. Over the next two years, the SCAQMD will be seeking to fund additional refueling sites to create the hydrogen fueling network needed to sustain a modest number of hydrogen and fuel cell vehicles for demonstration purposes. As part of this effort, various means of supplying hydrogen fuel are being evaluated including methane reforming, hydrolysis, and remote transport. The SCAQMD believes that this early expansion will provide the momentum for vehicle manufacturers to continue its research and development of hydrogen and fuel cell vehicles.

Technology Commercialization

It is the specific function of the Clean Fuels Program to help expedite the commercialization of low- and zero-emission technologies and fuels needed to meet the requirements of the long-term 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. When such projects are completed, an assessment is performed to determine the feasibility of incorporating the technology into rule development. If the technology appears feasible, future rule development is recommended to realize the emission reductions associated with the corresponding long-term measure. Thus, the advanced technology projects funded are an important and necessary process towards implementation of the clean air goals of the AQMP.

Projects designed to develop and demonstrate prototype low-emission technologies are inherently difficult to quantify with respect to cost effectiveness, i.e. dollars spent per ton of pollutant reduced. For example, if a project leads to the successful development of a prototype electric vehicle, the avoided emissions from that single vehicle are trivial compared to the overall environmental benefit. The true measure of success for the project lies in whether or not the corresponding ZEV technology has been significantly advanced and/or accelerated towards commercialization. Since commercialization may come years later, after many iterations of technological development, this can be difficult to measure or quantify. Thus, assessing the value of the original project in terms of its cost per ton of emissions reduced is not a true measure of success of the project.

The following examples, however, demonstrate the impact of the SCAQMD program on technology commercialization during the CY 2002 reporting period.

Heavy-Duty Engine Development

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 long-haul, transit buses, shuttle buses, yard tractors at shipping points, and dockside equipment at the ports. Through projects directly with original-equipment manufacturers (OEMs) or with intermediate developers such as the Gas Technology Institute, Southern California Gas Company, Acurex Environmental (A.D. Little, ARCADIS) and others, SCAQMD has supported the ultimate commercialization of the following engines:

- Cummins B5.9G (CNG), B5.9LPG (LPG), L10G (CNG), C8.3G (CNG);
- Detroit Diesel Corporation Series 60G (CNG/LNG), Series 50 G (CNG/LNG);
- Deere 6068 (CNG), 6081 (CNG); and
- Mack E7-400 G (LNG);
- Clean Air Partners/Power Systems (Caterpillar) 3126B (Dual Fuel), C-10 (Dual Fuel), C-12 (Dual Fuel)

These engines are the backbone of the SCAQMD's clean fleet vehicle rules that require specific fleets to purchase alternative fuel vehicles. In 2002, a project with John Deere was completed which supported the development of the next-generation of electronic controls for the natural gas engine used for refuse hauling vehicles. This technology is now being commercialized on new natural gas engines. New projects for 2003 with Cummins and Mack Trucks will look at developing CNG and LNG heavy-duty engines which will meet the 2007 NO_x standard with the 2003 model year natural-gas engines (0.5 g/bhp-hr NO_x). Today, natural gas engines power thousands of transit buses, delivery trucks, refuse trucks, and street sweepers in the Basin, as a result of SCAQMD's support. As part of the efforts to reduce emissions further, in-use emissions testing of CNG engines indicates that further reductions in toxic emissions can be achieved through the use of oxidation catalysts.

The Carl Moyer Program

In early 1999, CARB established the Carl Moyer Memorial Air Quality Standards Attainment Program (Moyer Program) to provide incentives to accelerate the implementation of such low emission heavy-duty vehicles, off-road vehicles and equipment, and for fueling infrastructure support. CARB has established overall program requirements and allocates funds to local air districts, including the SCAQMD, for local program administration. The Moyer Program subsidizes the incremental cost between a low-emission alternative fuel engine and a new diesel engine.

Governor Davis and the Legislature have placed $16 million in CARB's FY 2001-02 budget to continue this incentive program for low-emission heavy-duty vehicles. The SCAQMD released an RFP in December 2001 to solicit projects for FY 2001-02 Moyer Program funding at a cost not to exceed about $ 11.5 million for vehicle and equipment incentives. As a substitute for the local match requirement, SCAQMD has spent $3.5 million on alternative fuel infrastructure development. The RFP solicits projects for on- and off-road vehicles and equipment, including refuse haulers, over-the-road trucks, transit buses, construction equipment, marine vessels and port applications, and other vehicles and equipment. New engines, re-powers, and retrofits are allowed within the program.

The first solicitation in 2002 for the Carl Moyer Program was undersubscribed; as a result a second RFP was released to solicit more proposals. The response was overwhelming. Approximately $29 million in applications were received, almost five times the amount of the RFP. The demand for

alternative fuel engines is still low compared to diesel engines, however, the Carl Moyer Program provides a clear indication to heavy-duty engine and equipment manufacturers that end users are willing to choose competitively priced equipment. Significant numbers of new and upgraded natural gas refueling stations are also being built with SCAQMD support in response to market demand for alternative fuels by fleet operators.

In CY 2002, California voters approved Proposition 40 which provides $50 million statewide to the Carl Moyer Program. As such, the SCAQMD will be soliciting additional projects in CY 2003. In addition, in CY 2003, the SCAQMD will be awarding approximately $9 million for projects from the CY 2002 remaining funds.

Electric Vehicle Application

As with the natural gas engine development, the SCAQMD has long supported the development and demonstration of electric vehicle in the Basin.

For example, in 1999 the United States Postal Service (USPS) initiated the "Electric Carrier Route Vehicle" project in which it planned to deploy up to 6,000 new electric mail delivery vehicles at post offices nationwide over a five year period. Phase 1 called for the deployment of 500 vehicles, with an option to provide an additional 5,500 vehicles pending their satisfactory performance in Phase 1. Ford Motor Company was competitively selected to supply the specialty vehicle based on the Ford Ranger EV light duty truck.

Up to 400 of the first 500 vehicles will be demonstrated within the SCAQMD area. USPS selected Southern California Edison (SCE) to test and evaluate four of the electric mail delivery vehicles funded by the SCAQMD. The evaluation protocol assessed the electric drivetrain, battery pack, and chassis performance based on the DOE "EV America Protocol." In 2002, the USPS held a press event to showcase its new fleet of electric postal vehicles.

The evaluation by SCE has shown that the electric mail delivery vehicles met or exceeded all of the baseline performance standards set by USPS. Accelerated testing, which quickly adds miles to the vehicle over a consistent test route, has provided insight into how the vehicles may perform on a longer term basis and encouraged project participants to proactively address many issues. Improvements made to these specialty vehicles are expected to yield benefits in other electric drivetrain vehicles as well. Many of these technological advances may find application in a variety of hybrid electric vehicles powered by non-internal combustion engines such as microturbines and fuel cells.

2002 PROJECT EXPENDITURE

Description of New Technology Development Projects

A technology-driven approach was continued in 2002, with the SCAQMD 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. Given the evolving nature of technology, such a representation is only a "snapshot-in-time." While the SCAQMD has always sought breadth in its project selection in an attempt to address the myriad of sources that contribute to air pollution in the Basin, such technology distributions have necessarily evolved and changed to reflect progress and market conditions.

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, 2002 through December 31, 2002, the SCAQMD Governing Board approved 63 projects that support clean fuels, Table 1, and advanced technologies, Table 2. The funding mechanisms for these programs were described previously in the *Program Funding* section.

Project expenditures for research, development, and demonstration (RD&D) projects approved or amended with dollars for the 2002 reporting period were:

Total Cost of Clean Fuels Projects	$21,165,204
SCAQMD Clean Fuels Fund Contribution	7,448,352

Partially included with the SCAQMD contribution are supplemental 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 are open and active as of January 1, 2003.

For the Clean Fuels projects approved by the Governing Board, the average SCAQMD contribution was about 36 percent of the total cost of the projects, or each dollar from the SCAQMD was leveraged with more than two dollars of outside investment. Since the inception of the Technology Advancement program, about four dollars of outside funding has been received for every AQMD dollar, historically. For 2002 this ratio was less because of several local infrastructure development projects and technical assessments in which SCAQMD was the sole or major contributor.

During 2002 the SCAQMD Governing Board approved a total expenditure of about $0.5 million from the Clean Fuels Program for alternative fuel incentive programs. The matching funds for incentive programs were reduced in CY 2002 because the Carl Moyer Program guidelines were modified to allow SCAQMD qualified projects to be used instead of cash contributions. The required local match funding was $3.5 million and was provided from qualified infrastructure projects funded in 2001. This included support for fuel cell technology and alternative fuels infrastructure and production in the Basin.

During 2002 the SCAQMD Governing Board also approved expenditure of more than $7.6 million for projects in the following areas: fuel cell technology, engine technology, hydrogen technology and infrastructure, electric and hybrid technologies, infrastructure and fuel production, emissions, emission control technology, health, outreach and technology transfer, VOC and toxics, and

stationary clean fuel technology. The distribution of the Board-approved funding in these areas is shown in Figure 2 below (note that this figure does not include the local matching funds required for state incentive programs).

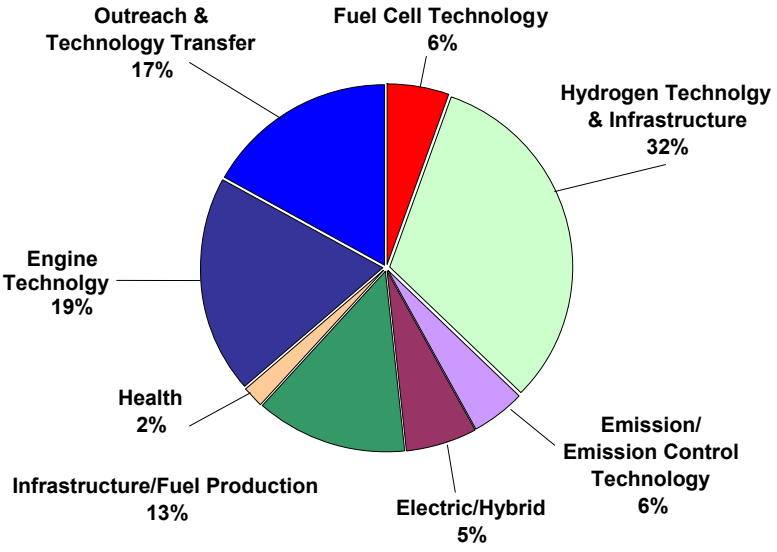


Figure 2: Distribution of Governing Board Approved Clean Fuels Funds in Calendar Year 2002 ($7.45 million)

Table 1*:* Clean Fuels Awards Made by the Governing Board in CY 2002

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM1: Fuel Cell Technology						
03095	Fuel Cell Technologies	Demonstrate Natural Gas Fueled Solid Oxide Fuel Cell Technology at Residences	TBD	06/30/03	$ 16,149	$ 982,300
TBD	California Air Resources Board	Develop Integrated Autothermal Cyclic Reformer and PEM Fuel Cell	TBD	TBD	100,000	800,000
TBD	University of California, Davis	Truck Fuel Cell Auxiliary Power Unit Development, Demonstration and Evaluation	TBD	TBD	300,000	1,200,000
CFM2: Hydrogen Technology and Infrastructure						
02312	SunLine Services Group, Inc.	Determine Feasibility and Steps to Design Conversion of CNG Fueling Station into a Hydrogen Fueling Station	07/26/02	12/31/02	51,680	51,680
03167	SunLine Services Group, Inc.	Develop & Demonstrate Hydrogen CNG Blend Transit Buses	11/01/02	10/31/03	238,000	476,000
03198	Praxair Inc.	Demonstrate & Develop Electrolyzer-Based Hydrogen Fueling Station Near the LAX	09/13/02	02/01/04	351,000	1,451,000
03200	SunLine Services Group, Inc.	Develop & Demonstrate an Autothermal Reformer Hydrogen Fueling Station	09/13/02	07/31/04	350,000	1,075,000
03201	University of California, Irvine	Demonstrate & Develop Hydrogen Fueling Stations in Orange County	9/13/02	01/31/06	863,400	983,400
TBD	BP Corporation	Install and Demonstrate a Hydrogen Refueling Station in Long Beach	TBD	TBD	500,000	2,375,000
CFM3: Engine Technology						
02181	Ford Motor Company	Develop & Demonstrate Two CNG-Powered Midsize School Buses and Demonstrate Two Smaller CNG Buses	07/26/02	07/01/03	600,000	1,688,000
02293	Automotive Testing Laboratories	Develop & Demonstrate Fischer-Tropsch Fueled Heavy-Duty Vehicles with Control Technology to Reduce Exhaust Emissions	08/23/02	03/31/04	750,000	1,300,000
TBD	National Renewable Energy Laboratory	Laboratory Testing for Fischer-Tropsch Fueled Heavy-Duty Vehicles Project	TBD	TBD	100,000	100,000
CFM4: Infrastructure and Fuel Production						
02320	USA Pro & Associates	Develop Odorant for Liquefied Natural Gas	08/02/02	12/31/03	123,835	418,320
03232	Fuelmaker Corporation	Develop & Demonstrate Advanced Home Refueling Appliance for CNG Vehicles	TBD	12/31/03	550,000	1,341,000
TBD	Orange County Transportation Authority	Upgrade & Expand Existing LNG Fueling Infrastructure at OCTA	TBD	TBD	314,000	1,800,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM5: Electric/Hybrid						
02326	Electric Power Research Institute	Study for Commercialization of Advanced HEVs	10/18/02	02/28/04	$ 250,000	$ 1,300,000
TBD	University of California, Riverside/CE-CERT	Develop & Evaluate Multiple Vehicle Type Expansion of Shared Electric Vehicle System	TBD	TBD	95,336	522,094
CFE1: Emission Control Technology						
03109	West Virginia University Research Corporation	Aftertreatment Technologies for PM Emissions Control of CNG-Fueled Heavy-Duty Engine	11/07/02	03/31/04	450,000	550,000
CFE2: Emission						
02289	University of California, Riverside	Boiler Hot Gas Emission Testing	05/31/02	12/31/02	30,752	30,752
CFE3: Health						
02300	University of California Riverside/CE-CERT	Conduct Indoor & Outdoor Air Quality Study in Mira Loma	06/13/02	08/30/02	35,000	360,000
03030	Public Health Foundation	Reanalysis of Health Effects of Air Pollution Data in the Coachella Valley	09/19/02	02/28/03	9,122	9,122
03225	California Air Resources Board	Quantify Health Benefits of Incremental Improvements in Air Quality in the SCAB	10/01/02	12/30/04	100,000	306,261
CFT: Outreach and Technology Transfer						
00175	Burnett & Burnette	Evaluate & Implement CNG Fueling Stations	05/31/00	12/31/03	60,000	60,000
01026	Bevilaqua-Knight Inc.	CY2002 Membership Participation in California Fuel Cell Partnership	12/18/00	12/31/03	84,000	84,000
01190	USA Pro & Associates	Infrastructure Scoping Support	06/04/01	06/30/03	265,000	265,000
02162	California Natural Gas Vehicle Coalition	Develop Natural Gas Fueling Station Directory	04/03/02	10/31/02	25,000	25,000
02240	Cindy Sullivan	Technical Assistance for Development, Outreach and Commercialization of Heavy-Duty Engine Technologies	04/11/02	05/31/03	45,000	45,000
02288	FuelMaker Corporation	Technical Consultant Services for Two School Districts	05/23/02	07/30/03	41,198	82,395
02294	Calstart	Membership and Participation in Hybrid Electric Operations Forum	06/21/02	04/15/03	25,000	405,000
02295	SynchroEnergies	Technical Assistance on Lubricants, Fuels, Combustion, Alt. Energy Sources & High Performance Fluid Technologies	05/23/02	06/30/04	25,000	25,000
02308	Sperry Capital, Inc.	Evaluate Financial Stability of Potential Contractors	05/26/02	08/30/02	5,000	5,000
02311	Jerald A. Cole	Technical Assistance for Development/Outreach/ Commercialization of H2 Infrastructure & Reforming Technology	06/09/02	06/30/04	30,000	30,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFT: Outreach and Technology Transfer (cont'd)						
02316	California Science Center Foundation	Fuel Cell Exhibit and Amend Children's Museum	TBD	06/30/03	$ 225,000	$ 275,00
02333	University of California at Riverside	Technical Assistance for Development, Outreach and Commercialization of Clean Fuels Technologies, Hydrogen & Fuel Cell Technologies	11/01/02	06/30/04	30,000	30,000
02334	Engine, Fuel & Emissions Engineering, Inc.	Technical Assistance on Natural Gas Engine Technology	07/31/02	06/30/04	30,000	30,000
02335	Neil C. Otto	Technical Assistance on Fuel Cell Technology	08/09/02	06/30/04	30,000	30,000
03033	Hydrogen 2000 Inc.	Develop Outreach Video on Fuel Cell and Hydrogen Fuel Usage	08/23/02	03/01/03	45,000	240,000
03180	Charles Powars	Technical & Management Assistance for Alt. Vehicle and Fueling Infrastructure Projects	11/14/02	07/31/03	25,000	25,000
03181	USA Pro & Associates	Support, Training and Guidance Toward Purchase of New Fleet and On-Board LNG Fueling Systems	11/20/02	11/19/03	50,000	50,000
03202	Nissan North America	Lease One 2002 Nissan Altra Electric Vehicle	12/31/02	12/31/05	12,000	21,000
TBD	Ford Th!nk	Two-Year Lease for One 2002 City Electric Demonstration Vehicle with Fast Charging Capability	TBD	TBD	6,000	6,000
TBD	Rose Communications	Technical Assistance for Development, Outreach & Commercialization of Fuel Cells	TBD	TBD	25,000	25,000
TBD	Honda Motor Company	Purchase Three Honda 2003 Civic Hybrid Gasoline-Electric Vehicles	TBD	TBD	63,030	63,030
TBD	TBD (potentially multiple contractors)	Technical Assistance for Developing Alt. Fuel Vehicles and Refueling Infrastructure	TBD	TBD	50,000	50,000
n/a	Fund Transfer from Clean Fuels	Two-Year Participation in the Natural Gas Vehicle Partnership	n/a	n/a	25,000	375,000
Various	10 Contractors	Co-Sponsors: Conferences, Workshops and Events in 2002	Varies	Varies	48,850	48,850

Table 2: Advanced Technology Awards Made by the Governing Board in CY 2002

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFS1: Stationary Clean Fuel Technology						
02322	Colmac Energy Inc.	Agricultural Biomass-to-Energy Conversion in Basin	07/01/02	07/01/02	$ 38,000	$ 38,000
CFS2: VOC/Toxics						
TBD	California Air Resources Board	High-Performance Low-VOC Waterborne Coatings	TBD	TBD	20,000	436,872
TBD	California Air Resources Board	Alternatives to Automotive Consumer Products that Use VOCs and/or Chlorinated Organic Compound Solvents	TBD	TBD	50,000	189,966
CFT: Outreach and Technology Transfer						
Purchase Order	Eco-Soul, Inc.	HOPE Fuel Cell Curriculum Packages for High School Science Programs	04/05/02	n/a	20,000	20,000
01105	Children's Museum of Los Angeles	Implement Children's Air Quality Initiative	04/11/02	04/10/03	1,500	1,500
03197	SunLine Transit Agency	Develop a "Child Friendly" Educational Brochure Discussing Particulate Matter Pollution	TBD	01/31/03	10,000	12,500
03203	Palm Springs Desert Museum	Develop and Implement "Blow Out! Meet the Science Power Standards" Education Program	TBD	08/31/03	21,907	21,907
011081	Riverside Municipal Museum	Implement Children's Air Quality Initiative: Partners Against Pollution	06/15/02	06/14/23	2,994	2,994

Table 3: Supplemental Grants & Revenues Received in CY 2002

Revenue Agreement	Revenue Source	Project Title	Contractor	AQMD Project	Total
02176	California Energy Commission	Fischer-Tropsch Fueled Heavy-Duty Vehicles	Automotive Testing Laboratories	Contract #02293	$ 400,000
02276	California Energy Commission	Public Access Fast-Fill CNG Station in Diamond Bar	Pinnacle CNG Company	Contract #02127	169,500
02321	California Technology, Trade & Commerce Agency	Agricultural Biomass-to-Energy Conversion	Colmac Energy	Contract #02322	42,105
TBD	California Air Resources Board	Develop & Demonstrate Advanced Home Refueling Appliance for CNG Vehicles	Fuelmaker Corporation	Contract #03232	50,000

Review of Audit Findings

The SCAQMD undergoes regular financial audits required by state law, as well as special audits periodically requested by the state. This subsection briefly summarizes recent audits of the SCAQMD that included the Clean Fuels Program.

Financial Audits

The regular financial audits are conducted annually at the close of the SCAQMD fiscal year by an independent accounting firm. The financial audits include an Annual Financial Report and Single Audit Reports. The firm of Simpson & Simpson conducted the financial audits for the fiscal year that ended June 30, 2002. There were no findings and recommendations with regard to SCAQMD financial statements, which include Clean Fuels Program revenues and expenditures. Simpson & Simpson gave the SCAQMD an "unqualified opinion," which is the highest financial rating obtainable. This has consistently been the result of prior annual financial audits of the SCAQMD.

Project Summaries

The following presents the summaries of the technology development and demonstration projects awarded in 2002. These new and amended projects are listed in the order found in the previous tables, i.e., by category and contract number (where applicable). 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.

Clean Fuels Fund

CFM1: Fuel Cell Technology

03095: Demonstrate Natural Gas Fueled Solid Oxide Fuel Cell Technology at Residences

Contractor: Fuel Cell Technologies	AQMD Cost-share:	$	16,149
	Cosponsors:		
	AES Settlement Fund		350,000
	Fuel Cell Technologies		616,151
Term: TBD – 06/30/03	Total Cost:	$	982,300

Fuel cells are near-zero emission and energy efficient sources of electricity. The promise of fuel cells to clean the air is only hampered by their high cost and sparse operational experience. This project helps on both counts by providing the funding to install ten, 5 kW residential solid oxide fuel cell units throughout the South Coast Air Basin. The solid oxide technology allows internal conversion of natural gas to hydrogen to power the fuel cell. The program will monitor and report on the fuel cells' performance over a period of two years.

TBD: Develop Integrated Autothermal Cyclic Reformer and PEM Fuel Cell

Contractor: California Air Resources Board	AQMD Cost-share:	$	100,000
	Cosponsors:		
	CARB		100,000
	GE EER		600,000
Term: TBD – TBD	Total Cost:	$	800,000

This project co-funds with the California Air Resources Board and General Electric Energy and Environmental Research (GE EER) to develop and demonstrate an integrated autothermal cyclic reformer (ACR) and proton exchange membrane (PEM) fuel cell system. The ACR can produce hydrogen from many fuels including natural gas, diesel fuel, coal and renewable feedstocks. For this project, the system goals are 10 kW of electric power, greater than 90 percent system availability, greater than 40 percent overall thermal efficiency, and NO_x emissions less than 1 ppm.

TBD: Truck Fuel Cell Auxiliary Power Unit Development, Demonstration and Evaluation

Contractor: University of California, Davis	AQMD Cost-share:	$	300,000
	Cosponsors:		
	UC Davis, CARB, DOE, Carrier, and the American Trucking Assoc.		900,000
Term: TBD – TBD	Total Cost:	$	1,200,000

Diesel-fueled truck engine idling provides non-driving electrical energy for refrigeration, cab power for heaters and air conditioners, and hotelling operations. The idling of diesel truck main engines is only 5 to 10% efficient and produce significant emissions of NO_x, PM, toxics, and greenhouse gases.

It is estimated that truck engine idling consumes between 840 million to two billion gallons of diesel fuel annually. This project funds the development and demonstration of a diesel-fueled, fuel cell auxiliary power unit to replace main engine idling for non-driving cab power for a typical Class 8 truck (5 to 25 kW).

CFM2: Hydrogen Technology and Infrastructure

02312: Determine Feasibility and Steps to Design Conversion of CNG Fueling Station into a Hydrogen Fueling Station

Contractor: SunLine Servics Group, Inc.	AQMD Cost-share:	$	51,680
	Cosponsors:		
	USDOE		In-kind
Term: 07/26/02 – 12/31/02	Total Cost:	$	51,680

SunLine Transit Agency will conduct a feasibility study to outline the steps required to convert a CNG fueling station into a fast fill hydrogen fueling station and further develop a conversion package template that can be used to facilitate these conversions. The template will provide a step-by-step process, incorporating performance and safety testing procedures. The final template will define design criteria and specifications, compare parameters for natural gas and hydrogen, determine design phase steps, and provide a final report. SunLine will also include public education and technology transfer to ensure adequate public outreach.

03167: Develop & Demonstrate Hydrogen CNG Blend Transit Buses

Contractor: SunLine Services Group, Inc.	AQMD Cost-share:	$	238,000
	Cosponsors:		
	NREL (Center for Trans.Tech.)		238,000
	Cummins Westport, SunLine Transit, Hydrogen Components, Inc.		In-Kind
Term: 11/01/02 – 10/31/03	Total Cost:	$	476,000

SunLine Services Group, in cooperation with Cummins Westport, NREL and Hydrogen Components, Inc., will develop and demonstrate two hydrogen/CNG fueled transit buses, testing them for durability, performance and pollutant emissions. This project will provide data and demonstrated experience that can be used in the certification and commercialization of hydrogen-CNG fuel blends in transit buses and other vehicles. The project will utilize four transit buses equipped with Cummins 5.9L B+ engines. Two of them will operate on CNG and will serve as controls. The other two buses will use the hydrogen/CNG fuel blend. The engines will be installed, calibrated and optimized for the three month/24,000 mile test interval. The engines, as well as critical components, will then be thoroughly inspected and evaluated resulting in the production and presentation of a detailed engine inspection report.

03198: Demonstrate & Develop Electrolyzer-Based Hydrogen Fueling

Contractor: Praxair Inc.	AQMD Cost-share:	$	351,000
	Cosponsors:		
	USDOE		500,000
	Praxiar		550,000
	Los Angeles International Airport		50,000
	BP		In-Kind
Term: 09/13/02 – 02/01/04	Total Cost:	$	1,451,000

By the middle of this decade, an initial network of compressed hydrogen fueling stations will be needed in the South Coast Air Basin for the early surge of fuel cell demonstration vehicles that are expected to be introduced by major auto manufacturers. Praxair, in partnership with the USDOE, Los Angeles International Airport (LAX), and BP will develop and demonstrate a grid-powered hydrogen generation and refueling station near LAX on World Way West. The station will utilize an electrolyzer to convert water into hydrogen which will then be compressed and stored on site. The fast-fill system will produce one kilogram of hydrogen per hour with the capacity to store up to 25 kilograms of hydrogen on site.

03200: Develop & Demonstrate an Autothermal Reformer Hydrogen Fueling Station

Contractor: SunLine Servics Group, Inc.	AQMD Cost-share:	$	350,000
	Cosponsors:		
	USDOE		125,000
	SunLine Transit		300,000
	UOP		300,000
Term: 09/13/02 – 07/31/04	Total Cost:	$	1,075,000

Hydrogen refueling stations are necessary to facilitate the introduction of fuel cell vehicles and the development of an extensive hydrogen refueling network to support those vehicles. SunLine Services Group will partner with UOP, a large, well-established firm specializing in refinery equipment, and the United States Department of Energy to develop and demonstrate an autothermal natural gas reformer (ATR). The main goal of this project is to provide hydrogen to the fuel cell transit buses operated by SunLine and hydrogen fuel cell cars that are expected to be demonstrated in the future. This system will be capable of producing 3 kilograms of hydrogen per hour which will be stored and dispensed on site.

03201: Demonstrate & Develop Hydrogen Fueling Stations in Orange County

Contractor: University of California, Irvine	AQMD Cost-share:	$	863,400
	Cosponsors:		
	UC Irvine		120,000
	USDOE, APCI, Irvine, Anaheim		In-kind
Term: 09/13/02 – 01/31/06	Total Cost:	$	983,400

The National Fuel Cell Research Center in conjunction with the Advanced Power and Energy Program of the University of California at Irvine (UCI) is actively involved with the ZEV-NET Program in Orange County. Air Products and Chemicals (APCI) are partnering in this project to provide fueling infrastructure and technical expertise. This project will provide two hydrogen fueling

demonstration sites (with an additional site to be added in Huntington Beach next year). The primary station location will be at the City of Irvine maintenance facility with a second (transportable) station to be placed at the City of Anaheim maintenance facility. As additional vehicles are added to the demonstration fleets, the need for the third site will be considered.

TBD: Install and Demonstrate a Hydrogen Refueling Station in Long Beach

Contractor: BP Corporation	AQMD Cost-share:	$	500,000
	Cosponsors:		
	BP Corp		1,875,000
Term: TBD – TBD	Total Cost:	$	2,375,000

BP in partnership with Daimler-Chrysler Corporation (DCC) has planned a series of fuel cell vehicle demonstrations phased in over several years. Their plan utilizes small vehicle fleets clustered around fueling facilities centrally located for each fleet. These fueling stations will use a steam/methane reformer (SMR) hydrogen generation system supported by bulk hydrogen deliveries as needed. Starting with a single station in Long Beach (an alternative site may be chosen if the first fleet is located elsewhere), additional sites may be requested as the fleet demonstrations increase.

CFM3: Engine Technology

02181: Develop & Demonstrate Two CNG-Powered Midsize School Buses and Demonstrate Two Smaller CNG Buses

Contractor: Ford Motor Company	AQMD Cost-share:	$	600,000
	Cosponsor:		
	Ford Motor Company ($248,000 In-Kind)		553,000
	ARBOC, Ltd. (In-Kind)		110,000
	ENRG Inc.		300,000
	Collins Bus		125,000
Term: 07/26/02 – 07/01/03	Total Cost:	$	1,688,000

Under this project, Ford will develop one low-floor midsize (approximately 30-foot) natural gas bus using the E-550 chassis with a 6.8-liter engine. The low-floor bus design will eliminate the need for a wheel chair lift and will comply with the Special Education Program through the use of a ramp. Ford will also provide funding for the acquisition of two smaller natural gas buses using the E-450 chassis with a 5.4 liter engine that utilizes the same drivetrain, fueling system, and other components to be used in the larger E-550 bus. One of the E-450 buses will be configured as a certified school bus and the other will be configured as a shuttle bus, and will be used by the District to highlight available technology at various outreach events, including conferences and meetings.

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

Contractor: Automotive Testing Laboratories	AQMD Cost-share:	$	750,000
	Cosponsors:		
	Dept. of Energy/NREL ($150,000 In-Kind)		450,000
Term: 08/23/02 – 03/31/04	Total Cost:	$	1,300,000

The SCAQMD, U.S. DOE National Renewable Laboratory (NREL), and California Energy Commission (CEC) are exploring an alternative diesel emission control strategies, which could reduce on-road heavy-duty diesel NO_x and PM emissions by 60 and 90 percent or more, to meet the new federal emissions standards, respectively. One such strategy uses Fischer-Tropsch (F-T) synthetic diesel fuel, which has excellent ignition properties, is sulfur free, and may enable the use of advanced emission control technologies that many not otherwise be possible with conventional diesel fuels. This project will evaluate the emission-reduction potential of a low emission technology involving F-T fuel, a modified combustion system, and advanced emission control systems. Additionally, this project will demonstrate and assess the operational performance and reliability of the low emission technology in two prototype heavy-duty highway vehicles powered by Cummins ISM engines. The emission targets for this project are 1.2, 0.01, 1.3, and 15.5, 0.4 g/bhp-hr NO_x, PM, HC, CO, NO2 emissions, respectively.

TBD: Laboratory Testing for Fischer-Tropsch Fueled Heavy-Duty Vehicles Project

Contractor: National Renewable Energy Laboratory	AQMD Cost-share:	$	100,000
Term: TBD – TBD	Total Cost:	$	100,000

This project will provide laboratory testing as part of the development and demonstration of Fischer-Tropsch fueled heavy-duty vehicles with control technologies for reduced diesel exhaust emissions program initiated under AQMD Contract No. 02293.

CFM4: Infrastructure and Fuel Production

02320: Develop Odorant for Liquefied Natural Gas

Contractor: USA Pro & Associates	AQMD Cost-share:	$	123,835
	Cosponsors:		
	USA Pro		170,650
	Gas Research Institute		123,835
Term: 8/2/02 – 12/31/03	Total Cost:	$	418,320

Liquefied natural gas (LNG) has become the alternative fuel of choice for natural-gas heavy-duty vehicles because they have greater range than compressed natural gas (CNG) vehicles. However, LNG is a cryogenic liquid in which the natural-gas odorants added to CNG are not compatible because these odorants freeze and separate out. As such, LNG vehicles are required to have on-board gas detectors for leakage warning. Under this project, USA Pro & Associates will develop a viable

LNG odorant package and mixing system for the cryogenic LNG fuel. This involves investigating odorant and blending compounds, investigating mixing systems, and demonstrating a candidate odorant blend. Ultimately, an odorant blend and LNG mixing system will be recommended for commercialization.

03232: Develop & Demonstrate Advanced Home Refueling Appliance for CNG Vehicles

Contractor: Fuelmaker Corporation	AQMD Cost-share:	$	550,000
	Cosponsors:		
	Technology Partnerships Canada		375,000
	USDOE		416,000
Term: TBD – 12/31/03	Total Cost:	$	1,341,000

FuelMaker Corporation will develop and demonstrate an advanced home refueling appliance for CNG vehicles in two phases. The first phase has been completed and consisted of initial development and limited testing of the device. This second phase will incorporate improvements indicated by the results of the first phase, the development of beta prototype units and extensive home testing of the units. The test user comments and observations on the performance of the beta prototype units during field testing will allow FuelMaker engineering staff to pursue certification of the home refueling appliance and to include any upgrades to the beta units necessary to resolve user-based issues or observed deficiencies.

TBD: OCTA LNG Fueling

Contractor: Orange County Transit Authority	AQMD Cost-share:	$	314,000
	Cosponsors:		
	AQMD - Other Funds		686,000
	OCTA		800,000
Term: TBD – 12/31/04	Total Cost:	$	1,800,000

In the past several years, the Board has recognized the need for additional fueling infrastructure, and has awarded funding for several alternative fueling infrastructure projects through the Clean Fuel Funds, the AES Settlement Fund, and from the Rule 1309.1 Priority Reserve Funds. While these actions have resulted in the establishment of over 30 new fueling stations and the upgrade of an additional 27 stations, a few of the proposed projects that were awarded funding could not be completed due to a variety of reasons. Funding from those projects was re-allocated to upgrade and expand the existing Liquefied Natural Gas (LNG) fueling infrastructure at Orange County Transportation Agency's Garden Grove location. The existing LNG fueling infrastructure is inadequate to meet current as well as future LNG bus fueling demands. This additional fueling capacity is needed to address the current and future needs of OCTA's fleet of LNG transit buses.

CFM5: Electric/Hybrid

02326: Study for Commercialization of Advanced HEVs

Contractor: EPRI	AQMD Cost-share:	$	250,000
	Cosponsors:		
	California Air Resources Board		250,000
	Department of Transportation		150,000
	EPRI		650,000
Term: 10/18/02 – 02/28/04	Total Cost:	$	1,300,000

The Electric Power Research Institute (EPRI) assembled a working group that compared the impacts and benefits of various hybrid electric vehicle options for light and medium-duty vehicles. Technology developments in the areas of fuel cell hybrid electric vehicles, plug-in hybrid electric vehicles with vehicle-to-grid power capability and other advancements have enhanced the paths to commercialization.

TBD: Develop & Expand Multiple Vehicle Type Evaluation of Shared Electric Vehicle System

Contractor: UCR CE-CERT	AQMD Cost-share:	$	95,336
	Cosponsors:		
	American Honda		146,270
	Daimler Chrysler GEM		90,000
	Riverside County		110,000
	UC Digital Media		80,488
Term: TBD – 07/30/04	Total Cost:	$	522,094

Recent research has shown that in order to maximize the overall effectiveness of shared vehicle systems, multiple vehicle types should be used to capture the widest range of possible travel demand. This project will expand the UCR Intellishare system beyond its current vehicle fleet of 15 homogenous electric vehicles to integrate additional vehicles and vehicle types. This adds complexity, but will be necessary to effectively manage large commercial vehicle allocation systems. Valuable operational data is collected daily on system operation, users, and vehicles.

CFE1: Emission Control Technology

03109: Aftertreatment Technologies for PM Emissions Control of CNG-Fueled Heavy-Duty Engine

Contractor: West Virginia University Research Corporation	AQMD Cost-share:	$	450,000
	Cosponsors:		
	WVU and Partners		100,000
Term: 11/07/02 – 03/31/04	Total Cost:	$	550,000

Many demonstration programs are now showing that PM emissions from some diesel engines can be significantly reduced with particulate traps. This project will develop and demonstrate a catalyzed trap capable of reducing PM by at least 50%, and also reduce NO_x, CO, and hydrocarbon emissions

from CNG engines. This project will also demonstrate and assess the operational performance and reliability of the catalyzed trap on an Orion bus powered by a Cummins C8.3G plus engine.

CFE2: Emission

02289: Boiler Hot Gas Emission Testing

Contractor: University of California, Riverside	AQMD Cost-share:		$	30,752
Term: 05/31/02 – 12/31/02	Total Cost:		$	30,752

The purpose of the contract is to determine the impact on emissions from burning hot gas in a boiler. Hot gas is natural gas with elevated levels of ethane and propane. Hot gas, which has an increased heating value compared to normal natural gas, is produced and used in some parts of California. The contractor will test NO_x and CO emissions from small commercial hot water boiler, rated at 250,000 Btu per hour while burning normal natural gas and hot gases produced by enriching the natural gas with blends of ethane, propane, and inert gases.

CFE3: Health

02300: Conduct Indoor & Outdoor Air Quality Study in Mira Loma

Contractor: University of California, Riverside/CE-CERT	AQMD Cost-share:		$	35,000
	Cosponsors:			
		County of Riverside		310,000
		AQMD Analysis Support		15,000
Term: 06/13/02 - 08/30/02		Total Cost:	$	360,000

A special PM2.5 program is being conducted by the University of California at Riverside's College of Engineering - Center for Environmental Research and Technology (CE-CERT). The study includes chemical characterization of PM2.5 outdoors and within 20 homes and a school in the Mira Loma area. Mira Loma has been identified as the area with the highest ambient (outdoor) PM2.5 mass concentrations in the Basin. Results from this project will provide a clearer picture of the potential impacts to health from alterations in air quality related to land use and diesel fuel combustion.

03030: Reanalysis of Health Effects of Air Pollution Data in the Coachella Valley

Contractor: Public Health Foundation	AQMD Cost-share:		$	9,122
Term: 09/19/02 - 12/28/03		Total Cost:	$	9,122

Under a previous contract to AQMD, the Public Health Institute conducted analyses of the correlation between air pollutants and health effects in the Coachella Valley. A recently discovered problem in the application of the statistical software package used (S-Plus) necessitates a re-analysis of the data to determine if the results could be affected by the software flaw. This action is to execute a contract with the Public Health Institute for the statistical reanalysis. Total project cost is $9,122.

03225: Quantify Health Benefits of Incremental Improvements in Air Quality in the SCAB

Contractor: California Air Resources Board	AQMD Cost-share:	$	100,000
	Cosponsors:		
	California Air Resources Board		206,261
Term: 10/01/02 - 12/30/04	Total Cost:	$	306,261

Significant improvements in air quality have been made over the past 20 years in the South Coast Air Basin (SCAB). These include a 50 percent reduction in peak ozone levels and a 47 percent reduction in annual-average PM10 at some sites. The University of California, Berkeley will investigate the relation of health changes in residents to air quality improvements in the SCAB. Health measures investigated will include changes in mortality and morbidity from respiratory and cardiovascular diseases that can be associated with changes in air quality over the period 1980 to 2000. This project will provide an analysis of the association between long-term changes in air quality and health benefits due to these changes. In addition, an analysis will be conducted to estimate the economic benefits of reducing air pollution in the SCAB.

CFT: Outreach and Technology Transfer

00175: Evaluate & Implement CNG Fueling Stations

Contractor: Burnett & Burnette	AQMD Cost-share:	$	60,000
Term: 05/30/00 - 12/31/03	Total Cost:	$	60,000

The AQMD fleet rules have resulted in increased construction and installation of alternative fuel refueling infrastructure throughout the AQMD. It is essential to the successful implementation of the clean fleet rules that the alternative fuel refueling infrastructure be installed in a cost-effective and expeditious manner. In order to assist in these efforts, the Board awarded contracts to consultants to augment staff resources to provide technical and management assistance in the development of alternative fuel refueling infrastructure. These consulting services have proven to be critical for implementing alternative fuel infrastructure projects and supporting the clean fleet rules in a prompt and timely manner. Burnett & Burnette provide technical assistance for developing alternative fuel refueling infrastructure, specifically in the areas relating to CNG engine and fueling station components as well as providing preliminary specifications for fueling systems.

01026: CY 2002 Membership Participation in California Fuel Cell Partnership

Contractor: Bevilaqua-Knight, Inc.	AQMD Cost-share:	$	84,000
Term: 12/18/00 - 12/31/03	Total Cost:	$	84,000

The California Fuel Cell Partnership (CaFCP) was formally initiated in April of 1999 as a public/private effort to demonstrate fuel cell vehicles in order to validate the technology, initiate the fueling infrastructure, and hasten their commercialization. The CaFCP members include automobile companies, technology providers, fuel suppliers, and government agencies. The Board approved joining the California Fuel Cell Partnership (CaFCP) as a full member in March 2000, and this expenditure is to renew the AQMD participation.

01190: Infrastructure Scoping Support

Contractor: USA Pro & Associates	AQMD Cost-share:	$	265,000
Term: 06/04/01 - 06/30/03	Total Cost:	$	265,000

The AQMD fleet rules have resulted in increased construction and installation of alternative fuel refueling infrastructure throughout the AQMD. It is essential to the successful implementation of the clean fleet rules that the alternative fuel refueling infrastructure be installed in a cost-effective and expeditious manner. In order to assist in these efforts, the Board awarded contracts to consultants to augment staff resources to provide technical and management assistance to fleets in the development of alternative fuel refueling infrastructure in support of the AQMD's fleet rules. These consulting services have proven to be critical for implementing alternative fuel infrastructure projects and supporting the clean fleet rules in a prompt and timely manner. USA Pro & Associates have been retained to help implement liquefied natural gas (LNG) infrastructure projects.

02162: Develop Natural Gas Fueling Station Directory

Contractor: California Natural Gas Vehicle Coalition	AQMD Cost-share:	$	25,000
Term: 04/03/02 - 10/31/02	Total Cost:	$	25,000

The Natural Gas Vehicle (NGV) Coalition has published the Natural Gas Fueling Station Directory for a number of years. The directory is designed for use by natural gas vehicle users to assist them in locating and using public natural gas fueling sites throughout California. The directory is distributed to members of the NGV Coalition including natural gas local distribution companies, NGV automobile manufacturers, NGV fleet users, and regulatory agencies. It includes station locations, street addresses, telephone contact numbers and driving directions. Due to budget shortfalls, the NGV Coalition required subsidies to defray the cost of publishing.

02240: Technical Assistance for Development, Outreach and Commercialization of Heavy-Duty Engine Technologies

Contractor: Cindy Sullivan	AQMD Cost-share:	$	45,000
Term: 04/11/02 - 05/31/03	Total Cost:	$	45,000

The broad range of technologies being developed, from alternative fuel cars to fuel cells, requires that the AQMD have access to specific expertise on an as-needed basis. This expertise provides technical consultation for demonstration programs related to heavy-duty vehicle control technologies and off-road vehicles and equipment. Technical assistance and outreach is provided for the Governing Board Chairman's Strategic Alliance Initiative No. 3, Natural Gas Vehicle Partnership, to provide technical assistance for natural gas vehicles and assistance for administration of the Carl Moyer Program. Additional expertise includes clean fuels control technologies and off-road vehicles and equipment.

02288: Technical Consultant Services for Two School Districts

Contractor: FuelMaker Corporation	AQMD Cost-share:	$	41,198
Term: 05/231/02 - 07/30/03	Total Cost:	$	41,198

School Districts and Municipalities have received funding awards to purchase natural gas vehicles and to install refueling stations. It has been discovered that the natural gas supply in the San Gabriel Valley area has an unusually high water content which can lead to vehicle and refueling equipment breakdowns. To reduce the water content in the natural gas supplied to the vehicles, high-capacity, regenerative dryers must be installed to upgrade and replace existing dryers not capable of removing the excess water found at these sites. This project is to upgrade the dryers installed at Mountain View and El Monte Union High School Districts in El Monte to alleviate the high water content problem and its impacts.

02294: Membership and Participation in Hybrid Electric Truck Users Forum

Contractor: Calstart	AQMD Cost-share:	$	25,000
	Cosponsors:		380,000
Term: 06/21/02 - 04/15/03	Total Cost:	$	405,000

CALSTART, in conjunction with the National Automotive Center, has developed the Hybrid Electric Truck Users Forum (H-TUF). The primary goal of the H-TUF is to reduce criteria pollutants by speeding the development and deployment of commercially viable heavy-duty hybrid electric drivetrains utilizing conventional and alternative fuels. The H-TUF will encourage joint development of hybrid-electric technology and will consolidate future projects thus minimizing the costs on individual developers. For this project, AQMD will support bringing together truck fleet operators, truck manufacturers, technology developers, and other stakeholders located in the South Coast Air Basin.

02295: Technical Assistance on Lubricants, Fuels, Combustion, Alternative Energy Sources & High Performance Fluid Technologies

Contractor: SynchroEnergies	AQMD Cost-share:	$	25,000
Term: 05/23/02 - 06/30/04	Total Cost:	$	25,000

The broad range of technologies being developed, from alternative fuel cars to fuel cells, requires that the AQMD have access to specific expertise on an as-needed basis. Expertise in lubricant technologies, with funding in an amount not to exceed $25,000. Mr. Tom Sheahan worked for the Lubrizol Corporation for 38 years; his last position held at Lubrizol was Managing Director, Legislative and Regulatory. Mr. Sheahan will provide in-depth knowledge in the areas of fuels and lubricants, combustion, alternative energy sources, and high performance technologies.

02308: Evaluate Financial Stability of Potential Contractors

Contractor: Sperry Capital, Inc.	AQMD Cost-share:	$	5,000
Term: 05/26/02 - 08/30/02	Total Cost:	$	5,000

With the increasing number of contract for various Clean Fuels and Technology Advancement program, it is necessary to obtain an advisor on the financial stability of potential contractors. An independent financial advisory firm provides independent consulting services on the evaluation of new and small technology innovation companies.

02311: Technical Assistance for Development/Outreach/Commercialization of H2 Infrastructure & Reforming Technology

Contractor: Jerald A. Cole	AQMD Cost-share:	$	30,000
Term: 08/09/02 - 06/30/02	Total Cost:	$	30,000

Expertise provides consultation on demonstrations for hydrogen infrastructure and reforming technology of nearly-commercial technologies as well as support for research studies of technologies to be developed which includes.

02316: Fuel Cell Exhibit and Amend Children's Museum

Contractor: California Science Center Foundation	AQMD Cost-share:	$	225,000
	Cosponsors:		
	California Air Resources Board		50,000
Term: TBD - 06/30/03	Total Cost:	$	275,000

The Children's Air Quality Agenda Initiative No. 8 directs staff to work with local museums to develop programs to teach children about air pollution and air quality issues. This project is for the development of a fuel cell demonstration exhibit in the Transportation Gallery of the Creative World Exhibition at the California Science Center. The exhibit will be centered on an actual car body with simulated components representing those that will be found in fuel cell vehicles. It will also have an interactive video with questions and answers regarding fuel cells. It will also contain an interactive mechanical model showing how fuel cells work and links to fuel cell internet sites and information.

02333: Technical Assistance for Development, Outreach and Commercialization of Clean Fuels Technologies, Hydrogen & Fuel Cell Technologies

Contractor: University of California, Riverside/CE-CERT	AQMD Cost-share:	$	30,000
Term: 11/01/02 - 06/30/04	Total Cost:	$	30,000

The scope of the Technology Advancement (TA) program considers all potential sources of air pollution emissions in the Basin, including both stationary and mobile sources. Expert technical assistance is provided in various research areas. Technical expertise includes areas such as advanced vehicle/transportation technologies and systems, atmospheric measurement and modeling, and renewable energy.

02334: Technical Assistance on Natural Gas Engine Technology

Contractor: Engine, Fuel & Emissions Engineering, Inc.	AQMD Cost-share:	30,000
Term: 007/31/02 - 06/30/04	Total Cost:	30,000

The Technology Advancement (TA) program is a far-reaching effort, incorporating a mix of short-, medium-, and long-term goals, representing a three-tiered approach to achieve clean air in the Basin. As a result, the breadth of the TA program includes demonstrations of nearly commercial technologies as well as support for research studies of technologies to be developed. This expert consultation provides technical knowledge on natural gas engine technology including the measurement and control of fine particulate emissions from diesel vehicles; emission measurements and control technology for trucks, buses, railway locomotives, and other heavy-duty diesel vehicles; natural gas, and other "clean" fuels for vehicles

02335: Technical Assistance on Fuel Cell Technology

Contractor: Neil C. Otto	AQMD Cost-share:	$	30,000
Term: 08/09/02 - 06/30/04	Total Cost:	$	30,000

The broad range of technologies being developed, from alternative fuel cars to fuel cells, requires that the AQMD have access to specific expertise on an as-needed basis. Consultation is provided for expertise on fuel cell development and technologies, technical knowledge on hydrogen infrastructure development, and technical expertise on fuel processing and reformation.

03033: Development of Outreach Video on Fuel Cell & Hydrogen Fuel Usage

Contractor: Hydrogen 2000 Inc.	AQMD Cost-share:	$	45,000
	Cosponsors:		
	U.S. DOE/NREL		96,000
	Natural Resources Canada		49,953
	ENAA/MITI		37,000
Term: 08/23/02 - 03/01/03	Total Cost:	$	227,953

Under this project, Hydrogen 2000 Inc., a non-profit corporation, will develop a 26 minute video entitled Hydrogen Safety Video – Hydrogen Energy: The Safe and Clean Alternative, as well as a safety booklet to provide information on the latest hydrogen refueling; fuel cell, and safety technologies. The video and booklet will cover relevant safety issues and compare hydrogen's safety and handling characteristics to those of other fuels. The video will demonstrate fueling infrastructure in commercial and residential environments. The video is expected to have a shelf life of 5 years. The video will be distributed through schools, libraries, and broadcasted on public broadcasting stations.

03180: Technical & Management Assistance for Alternative Fueled Vehicle and Fueling Infrastructure Projects

Contractor: Charles Powars	AQMD Cost-share:	$	25,000
Term: 11/14/02 - 07/31/03	Total Cost:	$	25,000

In the past three years, the Board has approved significant incentive funding for alternative-fueling stations in the Basin to support the fleet rules. In response to requests for technical and management assistance for developing alternative fuel vehicles and refueling infrastructure projects from fleet owners, additional alternative fuel infrastructure technical assistance was needed. The AQMD entered into new contract agreements with contractors to increase the level of technical assistance and expertise that are offered by them to help implement alternative fuel infrastructure projects. Charles Powars is an expert in the areas of natural gas vehicles and infrastructure with extensive experience in advanced transportation technologies and alternative fuels and will provide timely consultation and assistance to clean fleet and infrastructure owners.

03181: Support, Training and Guidance Toward Purchase of New Fleet and On-Board LNG Fueling Systems

Contractor: USA Pro & Associates	AQMD Cost-share:	$	50,000
Term: 11/20/02 - 11/19/03	Total Cost:	$	50,000

The successful implementation of the AQMD's clean fleet rules depends on the ability to build an alternative fuel refueling infrastructure in a cost-effective and expeditious manner. To accomplish this, the Board retained outside technical experts to provide technical assistance for developing this infrastructure and resolving technical and or vehicle performance related issues. Specifically, OCTA needs continued technical assistance from an expert in natural gas engines and vehicles and the design of LNG fueling systems, including cryogenic on-board fuel storage / delivery systems. USA Pro & Associates has such expertise and has been contracted for providing such services to OCTA as well as other fleets operating in the Basin. Training and guidance would include necessary certifications, regulatory approvals and engineering analysis in the area of CNG, hydrogen and liquefied natural gas for both current and new user fleets.

03202: Lease One 2002 Nissan Altra Electric Vehicle

Contractor: Nissan North America	AQMD Cost-share:	$	12,000
	Cosponsors:		
	State ZEV Incentive		9,000
Term: 12/31/02 - 12/31/05	Total Cost:	$	21,000

This item was for the lease of one Nissan 2002 Altra Electric vehicle. The vehicle is for use in Technology Advancement's Alternative Vehicle Loan Program.

TBD: Two-Year Lease for One 2002 City Electric Demonstration Vehicle with Fast Charging Capability

Contractor: Ford Th!nk	AQMD Cost-share:	$	6,000
Term: TBD - TBD	Total Cost:	$	6,000

This item was for the lease of one Ford Th!nk City Electric demonstration vehicle. The vehicle is for use in Technology Advancement's Alternative Vehicle Loan Program.

TBD: Technical Assistance for Development, Outreach & Commercialization of Fuel Cells

Contractor: Rose Communications	AQMD Cost-share:	$	25,000
Term: TBD - TBD	Total Cost:	$	25,000

The scope of the Technology Advancement (TA) program considers all potential sources of air pollution emissions in the Basin, including both stationary and mobile sources. The expertise in fuel cell technology provided through this project results in specialized support for the SCAQMD's TA program to assist with commercialization of fuel cells, other low- and zero-emission technologies, as well as administrative coordination with the U.S. Department of Energy and U.S. Department of Transportation.

TBD: Purchase Three Honda 2003 Civic Hybrid Gasoline-Electric Vehicles

Contractor: Honda Motor Company	AQMD Cost-share:	$	63,030
Term: TBD - TBD	Total Cost:	$	63,030

This item was for the purchase of three Honda 2003 Civic hybrid gasoline-electric vehicles with continuously variable transmissions. The vehicles are for use in Technology Advancement's Alternative Vehicle Loan Program.

TBD: Technical Assistance for Developing Alternative Fueled Vehicles and Refueling Infrastructure

Contractor: potentially multiple contractors	AQMD Cost-share:	$	50,000
Term: TBD - TBD	Total Cost:	$	50,000

This item provides $50,000 for the Executive Officer to award additional contracts to consultants in order to provide technical and management assistance for developing alternative fuel vehicles and refueling infrastructure projects on an expeditious basis. It could potentially result in multiple contractors.

Fund Transfer: Participation in the Natural Gas Vehicle Partnership

Contractor: California Natural Gas Vehicle Partnership	AQMD Cost-share:	$	25,000
	Cosponsors:		
	Other Paying Partners		$350,000
Term: two years	Total Cost:	$	375,000

The California Natural Gas Vehicle Partnership (CNGVP) was established with the initiative of the AQMD Chairman Glover and approved by the Governing Board in February 2002. It is an alliance of state and federal air quality, transportation and energy agencies, together with vehicle and engine manufacturers, fuel and infrastructure providers, and fleet operators. The CNGVP seeks to increase and strengthen the deployment of low-emission natural gas vehicles throughout California, as a strategy transferable to many other major metropolitan areas. The CNGVP is led by a Steering Committee comprised of sixteen Voting and seventeen Associate members. The Voting members, excluding an environmental representative group pay $25,000 for a two-year membership fee, and Associate members participate without cash contribution and play a supporting role by providing specific expertise and input to the activities of the CNGVP. The AQMD is a voting member of the Partnership.

Varies: Co-Sponsorships of Conferences, Workshops and Events

Contractor: Ten Different Contractors	AQMD Cost-share:	$	48,850
Term: Various	Total Cost:	$	48,850

The AQMD regularly participates and sponsors conferences, workshops, and events. These funds provide support for ten such events during 2002.

Advanced Technology, Outreach & Education Fund

CFS1: Stationary Clean Fuel Technology

02322: Agricultural Biomass-to-Energy Conversion in Basin

Contractor: Colmac Energy Inc.	AQMD Cost-share:	$	38,000
Term: 07/01/02 - 07/01/02	Total Cost:	$	38,000

California agriculture produces substantial quantities of residual materials from farming practices, including orchard and vineyard pruning and removals that are disposed of primarily by open field burning, resulting in air emissions that would be substantially reduced if the residual materials instead were converted into energy at a biomass-to-energy facility. California established an agricultural biomass-to-energy incentive grant program to provide incentives to reduce open field burning of agricultural residual materials that degrade air quality, to produce electrical power from a renewable source, and to foster and sustain the biomass industry, including collection, hauling, and processing infrastructure. Facilities that convert qualified agricultural biomass to energy between July 1, 2001 and June 30, 2002 can receive a rate of $10 per every ton of qualified agricultural biomass that is converted to electricity. Colmac Energy in Riverside County is a qualified 47 Megawatt biomass-to-

energy plant located in Cabazon. It annually converts approximately 250,000 bone-dry tons of wood and agricultural waste. It voluntarily agreed to comply with stringent air quality emissions control regulations. It is eligible to receive about $33,000 for converting about 3,000 tons of qualified agricultural biomass, primarily orchard trimmings and removals, for a period from February 2002 to June 2002.

CFS2: VOC/Toxics

TBD: Development & Demonstration of Alternatives to Automotive Consumer Products

Contractor: California Air Resources Board	AQMD Cost-share:	$	50,000
Term: TBD - TBD	Total Cost:	$	189,966

About 4.5 million aerosol spray cans and spray bottles of automotive cleaning and degreasing products are currently sold annually in California. Virtually all of these products are based on VOC and chlorinated solvents and emissions from automotive cleaning operations amount to more than 21 tons per day. CARB has adopted a ban on the use of chlorinated automotive products that become effective after December 31, 2002. Although CARB has also established VOC limits for these products, emissions are still high. The objective of this project is to identify, test, and demonstrate low-VOC, low toxicity, water-based aerosol automotive cleaners that can replace chlorinated high-VOC products currently used as brake cleaners, engine degreasers, carburetor and fuel injection cleaners and general purpose cleaners. The low-VOC products thus developed will be tested 10 to 15 auto repair facilities such as dedicated brake cleaning shops, service stations, general automotive repair facilities and dealerships. The performance and cost of the water-based cleaners will be compared with the performance and cost of the solvent aerosol products used currently.

TBD: Development & Demonstration of High-Performance Low-VOC Waterborne Coatings

Contractor: California Air Resources Board	AQMD Cost-share:	$	20,000
Term: TBD - TBD	Total Cost:	$	436,872

Southwest Texas State University (STSU) has developed high performance hyperbranched phosphate ester polyol resin technology for reducing VOC in alkyd and other coatings. The resins are based on vegetable oil phosphate ester polyol (POLYOL). STSU's previous research discovered outstanding properties of POLYOL, which include better adhesion to substrates, corrosion resistance and increased durability. Under this project, STSU will produce and demonstrate low-VOC (100 grams per liter or less), high-performance prototype waterborne drum and wood coatings using the POLYOL technology. The performance of the new low-VOC coatings will be compared with that of higher-VOC coatings currently used by the industry. It is expected that the use of POLYO will also reduce the raw material cost of coatings.

CFT: Outreach and Technology Transfer

Purchase Order: HOPE Fuel Cell Curriculum Packages for High School Science Program

Contractor: Eco-Soul, Inc.	AQMD Cost-share:	$	20,000
Term: 04/05/02 – 04/05/04	Total Cost:	$	20,000

This project was initiated to purchase fuel cell demonstration/learning kits for the high school classes participating in the Los Angeles City Mayor's Office, Bureau of Engineering "Design a Hydrogen Fueling Station" contest. Additional kits will be provided to high school classes representing other areas in the AQMD through collaboration with the California Regional Environmental Education Community (CREEC) Network and the National Environmental Science Teachers (NEST) Group. The kits consist of a fuel cell demonstration module, instructional videos and a seven module Hydrogen Outreach Program for Education (HOPE) curriculum developed under contract with the USDOE. These twenty kits will be distributed to high schools throughout the Basin to be incorporated into their classroom activities.

01105: Implement Children's Air Quality Initiatives

Contractor: Children's Museum of Los Angeles	AQMD Cost-share:	$	1,500
Term: 04/11/02 – 04/10/03	Total Cost:	$	1,500

This project was to provide supplemental funding to a previously funded project, "Storytelling in Theater Format". This project was the adaptation of a children's book about air pollution, "Larue and the Brown Sky" into a theater presentation to be presented at various schools. The supplemental funding was necessary to reimburse the museum for negotiated copyright releases to allow the project and presentations to proceed.

03197: Develop a "Child Friendly" Educational Brochure Discussing Particulate Matter Pollution

Contractor: SunLine Transit Agency	AQMD Cost-share:	$	10,000
	Cosponsors:		
	SunLine Transit Agency		2,500
Term: TBD – 08/31/03	Total Cost:	$	12,500

The Children's Air Quality Initiative # 8 directs staff to work with local museums and educational institutions to develop programs to teach children about air pollution and air quality issues. This project is to develop a "child friendly" educational brochure to be distributed through the museums in Coachella Valley (and other areas within the AQMD). This brochure will present information related to particulate matter pollution and health in a format that is interesting and understandable for school children. It will also provide an action plan for pre-teens and their families to follow to become part of the environmental/public health solution to the particulate problem in the Coachella Valley.

03203: Develop and Implement "Blow Out! Meet the Science Power Standards" Education Program

Contractor: Palm Springs Desert Museum	AQMD Cost-share:	$	21,907
Term: TBD – 08/31/03	Total Cost:	$	21,907

The Children's Air Quality Initiative # 8 directs staff to work with local museums and educational institutions to develop programs to teach children about air pollution and air quality issues. This project is to develop "Blow Out! Meet the Science Power Standards". This program is designed for fourth grade level students to teach them about particulate matter, its role in Coachella Valley air quality and related health effects. A large scale-model of the Coachella Valley will be used to demonstrate the generation and transport of particulate matter (particularly PM10) throughout the region. The lesson will further discuss the impacts that these particulates will have on the region, its plants, animals and human inhabitants. Included in the lesson will be discussions of the various sources of particulates and applicable regulatory standards.

011081: Implement Children's Air Quality Initiative "Partners against Pollution" Supplemental Funding

Contractor: Riverside Municipal Museum	AQMD Cost-share:	$	2,994
Term: 06/15/02 – 06/14/03	Total Cost:	$	2,994

The Children's Air Quality Initiative # 8 directs staff to work with local museums and educational institutions to develop programs to teach children about air pollution and air quality issues. This project is to supplement the funding already allocated to the "Partners Against Pollution" museum project. This additional funding will allow the purchase of additional pollutant monitoring badges, cameras and film to be used in the project. This program is conducted in partnership with the Children's National Forest in Sky Forest.

PROGRESS IN 2002

Key Projects Completed

A large number of emission sources contribute to the remaining air quality problems in Southern California. Given the diversity of these sources, it is unlikely that a single technology will solve these problems. As a result, the SCAQMD continues to support a wide range of advanced technologies to address this diversity. Projects co-funded by the SCAQMD's Clean Fuels Program have included emission reduction demonstrations for both mobile and stationary sources of air pollution, although legislative amendments and reduced SCAQMD revenues now 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, 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 infrastructures. Stationary source projects have included a wide array of advanced low NO_x technologies, low VOC coatings and processes, and clean energy alternatives, such as fuel cells, solar power, and other renewable energy systems.

Table 4 provides a list of projects completed in 2002. Summaries of these completed projects are included in Appendix C, as available. These summaries describe the progress achieved toward SCAQMD and Clean Fuels Program goals by each completed project.

Selected projects, from the list of projects completed in 2002 representing a range of key technologies from near-term to long-term, are highlighted below.

The First Hybrid Solid Oxide Fuel Cell

Fuel cells emit the lowest level of urban air pollutants of all fossil-fueled, electrical generation systems, with emissions less than 1.0 ppm NO_x, below detection levels for other criteria pollutants, and reduced global warming pollutants –such as carbon dioxide and methane.

The hybrid demonstration combines a Siemens-Westinghouse solid oxide fuel cell and an Ingersoll-Rand micro-turbine generator (MTG) to produce a total capacity of 220 kW. These two technologies, when coupled together, provide combined higher efficiency electrical generation than when independently operated. The increase in efficiency results by using the solid oxide fuel cell exhaust, which is at high temperature and pressure, to drive the MTG, and using the MTG power to pressurize the fuel cell stack. These synergies, combined with the electrical generation of both technologies, promise efficiencies approaching 60%, which is nearly a 10% improvement over non-hybrid fuel cell power plants and over 30% increase over traditional combustion power plants. The increased efficiency translates directly into a decrease in CO_2 emissions. The SCAQMD contributed $200,000 toward the total project costs of $17 million.

The hybrid unit was designed and constructed by Siemens-Westinghouse as a proof-of-concept demonstration to assess power output and efficiency as well as operational and safety procedures. The unit experienced "first-of-its-kind" problems, but no significant technology challenges were identified. For example, after 150 hours of operation, the unit experienced automatic shut-down when a power lead cable overheated. Despite these upsets, the unit achieved 193 kW of power with an overall efficiency of 53%, which is notable for a "first-ever" type design without optimization.

Follow-on projects being pursued by the manufacturers include system optimization and lower production costs.

Heavy-Duty Natural Gas Engine Development

Heavy-duty, diesel-fueled trucks contribute significantly to the emissions inventory of the South Coast Air Basin. Due to the increased toxicity and criteria pollutants in diesel exhaust, the AQMD has adopted initiatives to reduce diesel emissions in the Basin and to promote clean-fuel vehicles like heavy-duty natural-gas vehicles. However, natural gas engines historically suffer from lower power performance, especially in heavy (80,000 lb Gross Vehicle Weight) line-haul truck applications. As a result, the SCAQMD entered into this project with the Gas Technology Institute (GTI), Mack Trucks, and Southwest Research Institute to achieve significant power enhancements in heavy-duty natural-gas engines while retaining low emissions characteristics. The SCAQMD contributed $400,000 toward a total project cost of $2,756,000.

The objective of the program was to up-rate the Mack Trucks E7G-325 natural gas fueled engine, rated at 325 bhp and 1180 lb-ft torque, to 400 bhp and 1440 ft-lb torque, while maintaining emissions at 2.5 g/bhp-hr NO_x + NMHC or less. The project team was able to exceed the power goal by 6%, achieving 425 bhp, and slightly improving on the torque goal of 1450 ft-lbs. Emissions calibration and testing were also successfully conducted and demonstrated the ability to achieve certification at 2.5 g/bhp-hr NO_x + NMHC.

Field demonstration of these engines and trucks will be completed prior to commercial introduction of the technology. The field demonstration is planned to start during the first half of 2003 with four additional vehicles by the end of the year. Commercial availability is planned for late 2004 or early 2005. The commercial deployment of these vehicles promises large air quality benefits since these high power low emission engines were previously unavailable.

Air Pollution Health Impacts in Lower-Income, Ethnic Community

The emission of air pollution in different segments of the population, and the resulting exposure of the inhabitants, is of great concern to the SCAQMD. Of particular interest is the most vulnerable portion of the population, namely asthmatic children.

This study was initiated to help understand the respiratory health risks (particularly asthma in children) from volatile organic compounds (VOC) air pollutants in lower-income ethnic-minority urban populations who may have unusually high exposure rates. The study's goal was to determine whether day-to-day changes in children's asthma status tracked personal VOC exposures and/or ambient background pollution levels over a period of weeks. The research was conducted in Huntington Park, a city southeast of central Los Angeles with a predominantly Hispanic population. Huntington Park has a high density of motor vehicle traffic and industry, resulting in the region's highest level of VOC pollution. The SCAQMD contributed $129,878 toward the total study costs of $329,069.

The study was conducted by the Los Amigos Research and Education Institute, Research Triangle Institute, and the University of California, Irvine. Twenty six volunteers with asthma, ages 10 – 16, were followed in the study for 12 weeks to observe asthma episodes in relation to pollution levels. The study concluded that concurrent measurement of respiratory health and pollution exposure is feasible and informative in low-income minority asthmatic children. Further, there was a clear association of VOC with asthma symptoms, but the results could not distinguish effects specific to VOC or from other pollutants. Recommendations for future work include a larger-scale study with electronic data acquisition and a field-based manager to coordinate the diverse investigative and administrative activities.

Table 4: Projects Completed Between January 1 and December 31, 2002

CONTRACT	CONTRACTOR	PROJECT TITLE	DATE
CFM1: Fuel Cell Technology			
98091	Honeywell	Fuel-Flexible Proton Exchange Membrane Fuel Cell Power System for Vehicle Applications	Jun-02
00053	Southern California Edison Company	Develop & Demonstrate a 250kW Hybrid Fuel Cell-Micro Turbine Powerplant	Oct-02
CFM2: Hydrogen Technology and Infrastructure			
00135	SunLine Services Group, Inc.	Relocate Hydrogen Facility	May-02
02029	ENRG, Inc.	Develop & Demonstrate a Universal Card Reader System	Sep-02
CFM3: Engine Technology			
99157	Clean Air Partners	Develop &Pre-Commercial Demonstrate a CAT C-12 Natural Gas Engine	Feb-02
99158	Gas Research Institute	Develop & Demonstrate MACK E7G Natural Gas Engine @ 400 HP	Dec-02
02161	GFI Control Systems Inc.	Develop Low-NO_x 6.0 Liter Natural Gas Engine and Chassis	Dec-02
CFM4: Infrastructure and Fuel Production			
99064 †	Hydrogen Burner Technology Inc.	Thermal Partial Oxidation Unit to Reform Methanol Fuel & Simulated Landfill Gas	Mar-02
99118	Ocean Air Environmental, LLC	Advanced Fast-Fill Natural Gas Compressor to Refuel Natural Gas Vehicles	Sep-02
00071	IMPCO Technologies Inc.	Develop & Demonstrate an Advanced High Capacity, High Performance NGV Storage Tank	Jan-02
00193	Transportation Foundation of Los Angeles	Evaluate Alternative Fuel Transit Bus Maintenance Practices & Design Training Curriculum for Maintenance &Repair of Alt. Fuel Transit Buses	Nov-02
02080	FuelMaker Corporation	Develop & Demonstrate Advanced Home Refueling Appliance for CNG Vehicles	Oct-02
02127	Pinnacle CNG Systems LLC	Construct Fast-Fill CNG Fueling Station at AQMD Headquarters	Oct-02
02172	Energy International Inc.	Evaluate Variances Between Utility Gas Feed Meter & Compressed Gas Dispenser Meter Readings	Sep-02
02186	Jurupa Unified School District	Supplemental Funding to Construct CNG Fueling Station	Dec-02
CFM5: Electric/Hybrid			
99068	California Air Resources Board	Establish Electric Vehicle Loan Program for Government Agencies	May-02
00164	Electric Power Research Institute	Evaluate Hybrid Electric Vehicles	Feb-02
00192	Southern California Edison Company	Demonstrate & Evaluate U.S. Postal Service Electric Mail Delivery Vehicles	Mar-02

CONTRACT	CONTRACTOR	PROJECT TITLE	DATE
CFM5: Electric/Hybrid (cont'd)			
01022	University of California, Davis	Develop & Evaluate Battery Dominant Hybrid Electric Vehicle Systems	Sep-02
CFE1: Emission Control Technology			
99121	University of Southern California	Demonstrate Reduced Vehicular Emissions through Throttleless Engines Using Alt. Fuels	Aug-02
00170	Southern California Gas	Demonstrate an Increased Horsepower Natural Gas Engine in On-Road Delivery Trucks	Mar-02
01032	Johnson Matthey	Demonstrate School Buses Retrofitted with PM Reduction Technologies	Feb-02
01036	Los Angeles Unified School District	Demonstrate School Buses Retrofitted with PM Reduction Technologies	Feb-02
01048	Hemet Unified School District	Demonstrate School Buses Retrofitted with PM Reduction Technologies	Feb-02
01057	Engelhard Corporation	Demonstrate School Buses Retrofitted with PM Reduction Technologies	Feb-02
CFE2: Emission			
99038	Coordinating Research Council Inc.	Evaluate Diesel Particulate Sampling Methodology & Determine Zone of Influence of Ultrafine Particle Fraction of On-Road Emissions	Apr-02
01029	California Air Resources Board	Determine Non-Registration Rates of On-Road Vehicles	Apr-02
01140 †	West Virginia University Research Corporation	Analyze Exhaust from CNG-Fueled Buses	Sep-02
01141 †	Desert Research Institute	Chemical Analysis of Exhaust Samples from CNG Buses	Feb-02
01144 †	University of California, Davis	Ames Bioassays on Diesel & CNG Fueled Bus Exhaust Samples	Aug-02
01166 †	Los Angeles Unified School District	Evaluate Durability of PM Retrofit Trap on a School Bus	Feb-02
02289	University of California, Riverside/CE-CERT	Boiler Hot Gas Emission Testing	Dec-02
CFE3: Health			
96081 †	Public Health Foundation	Health Effects of PM10 in the Coachella Valley	May-02
99099	Rancho Los Amigos Research & Education Institute Inc.	Evaluate Health Impacts of Multiple Toxic Air Pollutants in a Community	Sep-02
02300	University of California, Riverside	Conduct Indoor & Outdoor Air Quality Study in Mira Loma Area	Aug-02
CFS1: Stationary Clean Fuel Technology			
98028	Bergquam Energy Systems	High-Efficiency, Solar Energy-Based Air Conditioning Technology	Dec-02

CONTRACT	CONTRACTOR	PROJECT TITLE	DATE
CFT: Outreach and Technology Transfer			
96058 †	Moore Consulting	Technical Support, Alternative Fuels and PM Issues, Non-Registration Options	Jan-02
97061 †	Rose Communications Inc.	Technical Support, Policy Support & Information, Fuel Cell Task Force Implementation	Jan-02
00045 †	Dr. Adi Arieli	Technical Assistance in ATTB & Fuel Cell Technology	Oct-02
00079 †	USA Pro & Associates	Technical Assistance Relating to Development & Commercialization of NG Engines, Vehicles and Fueling Facilities	Jan-02
01104 †	Seaworthy Systems, Inc.	Evaluate Carl Moyer Marine Vessel Proposals	Jan-02
01158 †	University of California, Riverside	Evaluate School Bus Retrofit with Exhaust After Treatment Devices	May-02
01189 †	Natural Gas Vehicle Coalition	Co-Sponsor the 19th National NGV Conference & Exhibition	Jan-02
01197 †	Fritz Kalhammer	Clean Fuels Advisory Group Member Expenses	Feb-02
01199 †	Vernon Road	Clean Fuels Advisory Group Member Expenses	Feb-02
01200 †	Brian Runkel	Clean Fuels Advisory Group Member Expenses	Feb-02
01201 †	Nicholas Vanderborgh	Clean Fuels Advisory Group Member Expenses	Feb-02
02118 †	Weststart-Calstart	Co-Sponsor the 2nd Annual Clean Heavy-Duty Vehicles for the 21st Century	Aug-02
02135 †	SunLine Transit Agency	Co-Sponsor Educational Outreach	Dec-02
02162	California Natural Gas Vehicle Coalition	Develop Natural Gas Fueling Station Directory	Oct-02
02174 †	Coordinating Research Council Inc.	Co-Sponsor 12th CRC On-Road Vehicle Emissions Workshop	Dec-02
02227 †	National Hydrogen Association	Co-Sponsor NHA's 14th Annual Work Hydrogen Energy Conference	Dec-02
02297 †	SAE International	Co-Sponsor 2002 Future Car Congress	Aug-02
02311 †	Jerald A. Cole	Technical Assistance for Development/Outreach/ Commercialization of H2 Infrastructure & Reforming Technology	Jun-02
03018 †	Electric Vehicle Association of Americas	Co-Sponsorship of Electric & Hybrid Electric Buses Workshop	Sep-02

†Summary not available.

FUTURE TECHNOLOGIES

Funding Priorities for 2003

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-art. 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 Air Quality Management Plan (AQMP) for the South Coast Air 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.

Technology-based mobile source control measures in the 1997 AQMP and the Draft 2003 AQMP revision address heavy-duty on-road vehicles, light-duty on-road vehicles, and off-road equipment.

Specifically from the 1997 AQMP:

- Measures M4, M5, and M6 reference a heavy-duty engine NO_x emission standard of 2.0 g/bhp-hr, to be implemented between 1997 and 2002. The cost effectiveness projected for these measures is $3,120 – 8,990/ton of NO_x removed. Estimated emission reductions from these measures are projected to be about 62 tons NO_x/day. Since 1997, significant progress has been made in the development and commercialization of heavy-duty alternative fuel engines that meet that standard. The Moyer Program, as implemented in the SCAQMD, demonstrates that there is considerable demand for these engines if they are cost competitive and that the cost effectiveness of these technologies for emission reductions is reasonable. More recently, the ARB has identified heavy-duty engines for further regulation and reduction in standards, targeting NO_x emissions of 0.5 g/bhp-hr in 2004 and 0.2 g/bhp-hr in 2007.
- Measure ATT-03 references zero emission light-duty vehicles and related infrastructure to be implemented between 1997 and 2010. The major automobile manufacturers have introduced a limited number of electric vehicles into the marketplace with what can best be characterized as mixed commercial success. Key challenges for electric vehicles to gain greater market share include first costs, limited range, and limited, although growing, recharging infrastructure. Advanced batteries that provide extended range and that may allow some cost reduction appear needed. A promising zero emission technology being actively pursued by automobile makers is fuel cell technology. Although automobile makers have announced intentions to introduce fuel cell vehicles in the 2004-05 timeframe, key challenges that

remain are the cost of the fuel cells and the infrastructure to refuel early introduction fuel cell vehicles, likely to be fueled by hydrogen or methanol.

- Off-road vehicles and equipment are targeted by several AQMP control measures. Measures M9 and M10 target off-road diesel equipment with a proposed NO_x standard of 2.5 g/bhp-hr by 2005. The estimated benefit is a 46 tons/day reduction in NO_x emissions. Industrial equipment, such as forklifts, fueled by gasoline and propane are targeted by measures M11 and M12 for control by three-way catalysts, a transfer of successful automotive technology, by 2000-04. Expected emission reductions for M11 and M12 are NO_x (17 tons/day), VOC (32 tons/day), and CO (1038 tons/day).
- Off-road equipment under the jurisdiction of the US Environmental Protection Agency is also targeted in the 1997 AQMP as requiring controls. Measure M13 targets marine vessel for control in 1998-2001 for 30 percent reduction in NOx for a projected benefit of 15 tons/day. Locomotives are targeted in M14 for a 67 percent NO_x reduction in 2000-10, which should provide a reduction of 17 tons/day. Aircraft are targeted for 30 percent reduction of VOC and NO_x by measure M15, which is expected to reduce VOC by 3 tons/day and NO_x by 5 tons/day.

The primary challenges with respect to stationary sources are related to VOC emissions, in large part to the relatively small contribution stationary sources make to the NO_x inventory. The 1997 AQMP identifies several long-term measures to reduce VOC emissions from a number of applications in the 2006-10 timeframe, including:

- Consumer products - 43 tons/day;
- Architectural coatings – 20 tons/day;
- Solvent cleaning and degreasing – 19 tons/day;
- Industrial coating and solvent use – 20 tons/day;
- Fugitive emission – 18 tons/day; and
- Industrial process operations – 8 tons/day.

In addition to 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 so-called “black box” measures are provided under Section 182(e)(5) of the Clean Air Act for regions that are extreme non-attainment areas, such as the South Coast Air Basin. This Technology Advancement Plan 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. With respect to timeframes, all future projects are expected to have begun in 2002 with the time-to-product dependent on the technology maturity and market forces. The SCAQMD Clean Fuels Program tends to support development, demonstration, and technology commercialization efforts, but not fundamental research. The general time-to-product for those efforts, from long-term to near-term, are described below:

- Technology development projects included in the 1997 AQMP are to begin during 2002 with expected completion in about two years. Additional field demonstrations to gain long-term verification of performance, spanning up to two years, may 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 2007. 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 2009 or later.

- More mature technologies, that is, those ready to begin field demonstration in 2002, are expected to result in a commercial product in 2004-05. 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 also help alleviate future purchasers of concerns with being the first user "guinea pig" by providing real-world evidence of a technology's performance.
- Commercialization-ready technologies, that is, those that have been successfully developed, demonstrated, and certified, are included in this plan through incentive programs established to offset higher first costs due to their as yet limited production. The incentive programs are needed to encourage use of the cleanest technologies sooner rather than later, and establish an early market penetration that would provide manufacturers justification to gear up for mass production that would ultimately reduce the costs of these new technologies.

Summary of Technical Priorities

The SCAQMD program maintains flexibility to address dynamically evolving technologies and the latest progress in the state-of-art. The challenge for SCAQMD is identification of programs in which the available funding can make a difference. Major technical program areas are identified below and specific project categories are discussed in more detail.

Not all project areas will be funded, given the funding constraints and the availability of suitable projects. The top priority 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.

Incentive Programs

Incentive programs encourage the immediate use of commercially available, low emission on- and off-road alternative fuel engines to replace high-polluting diesel engines and to reduce the resulting toxic exposures. Among the incentive programs administered by the SCAQMD, the State Lower-Emission School Bus and Carl Moyer programs require local matching funds. In year 2002, the SCAQMD provided $531,000 from its Clean Fuels Fund to the State Lower-Emission School Bus Program to purchase alternative fuel school buses as its required local match funding. As for the Carl Moyer Program, the guidelines allow SCAQMD qualified projects to be used as the required local match contribution. The required local match funding was $3.5 million and was provided from qualified infrastructure projects funded in 2001. Participation in the CARB ZEV Incentive Program and the State Emissions Mitigation Program does not require matching funds.

The incentive programs are needed to encourage use of the cleanest technologies sooner rather than later, and establish an early market penetration that would provide manufacturers justification to gear up for mass production. Projects that will be considered for funding will include the expansion of the alternative fuel infrastructure and increased alternative vehicle deployments. It is important to note that these matching funds from the Clean Fuels Program serve to assist in commercialization of alternate fuel vehicles, which is a goal of the SCAQMD Clean Fuels Program.

Fuel Cells Vehicles and Hydrogen

Fuel cells are emerging as a leading alternative technology to replace more polluting internal combustion engines in vehicle, marine, and stationary distributed energy applications. There are a handful of different fuel cell technologies and fuels being considered for these applications. On the mobile side, the first demonstration vehicles are using proton exchange membrane (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. On the stationary side, many of the same technology issues exist and can be potentially easier to address due to constant load applications and larger space availability for the stack and balance of plant. It is hoped that cross-cutting advances in the technology can then be transferred and applied to mobile applications or used in concert with mobile and stationary applications, e.g., a fuel-cell vehicle to grid power.

The SCAQMD is actively working with two state–industry entities to further the commercialization of mobile and stationary fuel cells, the California Fuel Cell Partnership and the California Stationary Fuel Cell Collaborative, respectively. The 2003 Plan Update identifies key opportunities consistent with both organizations while clearly leading the way for the development and demonstration of both mobile and stationary applications. The specific future projects are expected to include:

- Demonstration of Fuel Cell Vehicles in controlled fleet applications in the Basin;
- Development and demonstration of fuel cells for marine applications;
- Development and demonstration of fuel cells for residential, commercial, and industrial applications;
- Development and demonstration of microturbine-fuel cell hybrid technologies; and
- Development and demonstration of cross-cutting fuel cell applications (e.g. plug-in vehicle to grid power and fuel cell auxiliary power units).

Hydrogen Technology and Infrastructure

In 2002, the SCAQMD initiated the groundwork for a distributed hydrogen refueling network to allow the limited number of demonstration fuel cell vehicles unhindered access throughout the Basin and reduce the number of obstacles to commercialization of further 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.

The economic 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 agreement with the *National Hydrogen Energy Roadmap* (USDOE, November 2002), the renewable generation of hydrogen through photovoltaics and electrolyzer technologies will be demonstrated as well as reformer technology to produce hydrogen from natural gas. The integrated generation and use of the hydrogen for vehicle fueling and stationary backup or premium power, using a hydrogen internal combustion engine or PEM fuel cell, are also being considered. Future projects are expected to include:

- Continued development and demonstration of distributed hydrogen production and refueling stations;
- Development and demonstration of integrated hydrogen production for refueling and power; and
- Development and demonstration of hydrogen internal combustion engines for vehicle and power applications.

Engine Technology

The use of alternative fuels can provide significant reductions in NO_x and PM emissions. The replacement and further control of heavy-duty diesel engine emissions for on-road, off-road, and marine applications is an important area for the 2003 Technology Advancement Plan Update. 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. Hybrid electric technologies and the use of microturbines instead of internal combustion engines have also shown promise for replacing higher polluting diesel engines. All of these options are worth pursuing for cleaner engine technologies and immediate emission reductions.

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:

- Continued development and demonstration of alternative fuel medium-duty and heavy-duty engines and vehicles;
- Evaluation and demonstration of alternative fuel medium-duty and heavy-duty microturbine vehicles;
- Demonstration of low and zero-emission locomotives;
- Development and demonstration of clean alternative fuel engines for off-road applications;
- Next Generation Natural Gas Vehicle development and deployment; and
- Demonstration of alternative fuel technologies in marine applications.

Emissions 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 (P-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:

- Development and demonstration of advanced air pollution control equipment;
- Evaluation and demonstration of new emerging liquid fuels, including ultra-low sulfur diesel and Gas-to-Liquid fuels;

- Evaluation and demonstration of emulsified diesel fuels;
- Development and demonstration of advanced after-treatment technologies for mobile applications (including particulate traps and catalysts); and
- Development and demonstration of low VOC and PM lubricants for diesel and natural gas engines.

Infrastructure and Fuel Production

The importance of refueling infrastructure cannot be overemphasized for the realization of on-road alternative fuel technologies. Significant demonstration and commercialization efforts are underway to support the deployment of natural gas vehicles. SCAQMD fleet rules already require certain types of fleets to purchase and operate clean fuel vehicles in the Basin, and many types of vehicles are being introduced in response. Compressed natural gas (CNG) and liquefied natural gas (LNG) refueling stations are being positioned to support these fleet and private applications today.

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 advanced, cost effective CNG and LNG stations;
- Development of standards, certifications and codes for new clean fuels;
- Investigation of LNG manufacturing and distribution technologies; and
- Demonstration of LNG fuel blending to resolve "hot gas" issues and fuel composition variability.

Electric and Hybrid Technologies

Despite the fact that Ford ended sale of its *Th!nk* electric vehicle (EV) unit in September 2002 and in January 2003 Toyota announced that they are discontinuing the RAV4 EV, the state continues to offer buy-down incentives for electric vehicles and the SCAQMD started a program announcement for the buy-down of zero-emission vehicles to fleets. Despite this effort and the greater environmental benefits offered by battery EVs, widespread demand and deployment have been hampered by public concerns over cost, battery lifetime, travel range, and charging station infrastructure. The SCAQMD will continue 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 in future. As mentioned for fuel cells, there is also the potential for cross-platform hybrid development for vehicle to grid power. Opportunities to develop and demonstrate technologies that could enable expedited widespread use of electric and hybrid electric vehicles in the Basin, include:

- Development and demonstration of cross-cutting applications (e.g., plug-in vehicle to grid power);
- Demonstration of advanced energy storage technologies in transit engines;
- Evaluation and demonstration of light and medium-duty hybrid electric vehicle systems;
- Demonstration of heavy-duty hybrid electric vehicles; and
- Upgrade and demonstration of hybrid electric buses.

Stationary and VOC/Toxics Technologies

Although progress is being made in the development and commercialization of zero-volatile organic compound (VOC) products and processes, the Draft 2003Air Quality Management Plan (AQMD) revision identifies further need for VOC and PM emission reductions to achieve the federal clean air standards by 2010. As such, low-VOC solvents and coatings research will continue, as well as diesel alternative technologies for portable power applications.

Future priorities will focus on "pollution prevention" technologies, which appears to be the most promising approach for this diverse source category, including:

- Development and demonstration of near-zero or zero-VOC products;
- Evaluation, development, and demonstration of advanced VOC control technologies for miscellaneous stationary sources;
- Technology assessments of future VOC limits in current source specific VOC rules;
- Demonstration project for portable liquid petroleum gas (LPG) or propane-powered internal combustion engine generators;
- Demonstration of microturbine generators with low heat content (e.g. landfill) gases; and
- Development and demonstration of low-emission emulsified diesel fuel technology for portable power generators.

Target Project Allocations

Figure 3 presents the potential allocation of available funding, based on SCAQMD projected program cost of $31.1 million for all potential projects. The expected actual project expenditures for 2003 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 2003 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.

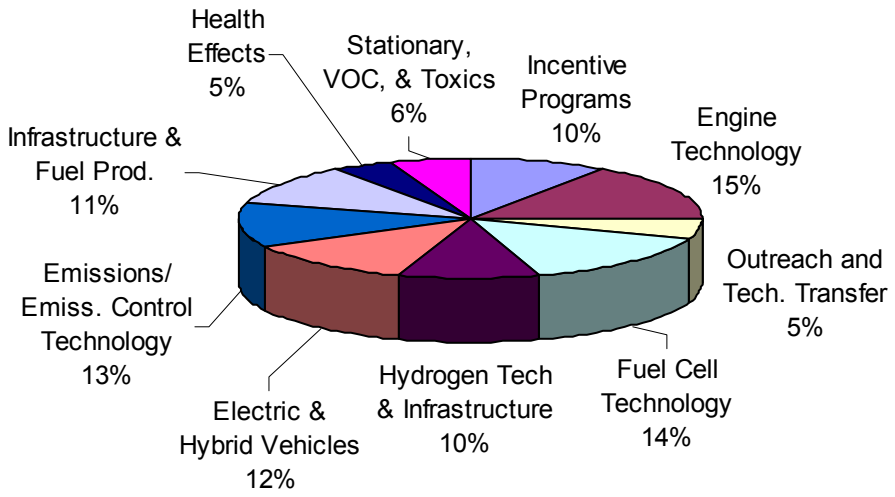


Figure 3: Projected Cost Distribution for Potential SCAQMD Projects in 2003 ($31.1 million)

APPENDIX A

SCAQMD ADVISORY GROUPS

Technology Advancement Advisory Group

Tom Cackette	California Air Resources Board
Tim Carmichael	Coalition for Clean Air
Nancy Deller	California Energy Commission
Blair Folsom, Ph.D.	GE Energy &Environmental Research Corp
John Freel	Chevron Products Company
Henry Gong, M.D.	Rancho Los Amigos Hospital
John D. Harper, Jr.	Small Business Coalition
Philip J. Hodgetts	Clean Air Now
Shang Hsiung	U.S. Department of Transportation
Robert S. Kirk, Ph.D.	U.S. Department of Energy
Michael La Cavera	Westway Terminals
Dan Moran	Quality Body Works
Gary Stafford	Terra Furniture
Lee Wallace	Sempra Energy
William R. West	Southern California Edison

SB 98 Clean Fuels Advisory Group

Todd Campbell	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	Blue Star Industries Corporation
Michael Walsh	Independent Consultant in Motor Vehicle Pollution Control

APPENDIX B

OPEN CLEAN FUELS CONTRACTS AS OF JANUARY 1, 2003

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM1: Fuel Cell Technology						
02129	ISE Research Corporation	Develop & Demonstrate Fuel Cell Bus with Major Bus Manufacturer	01/17/02	05/31/03	$ 350,000	$ 2,150,300
02136	University of California, Irvine	Renew Participation for Three Years in National Fuel Cell Research Center at UCI	07/26/02	10/31/04	90,000	1,250,000
CFM2: Hydrogen Technology and Infrastructure						
02189	ISE Research Corp	Develop & Demonstrate Water Electrolyzer Hydrogen Refueling Station in Coachella Valley	05/23/02	03/30/04	389,882	1,177,205
02312	SunLine Services Group, Inc.	Determine Feasibility & Steps for Design Conversion of CNG Fueling Station into a Hydrogen Fueling Station	07/26/02	03/30/04	51,680	51,680
03167	SunLine Services Group, Inc.	Develop & Demonstrate Hydrogen CNG Blend Transit Buses	11/01/02	10/31/03	238,000	476,000
03198	Praxair Inc.	Demonstrate & Develop Electrolyzer-Based Hydrogen Fueling Station Near the LAX	09/13/02	02/01/04	351,000	1,451,000
03200	SunLine Services Group, Inc.	Develop & Demonstrate an Autothermal Reformer Hydrogen Fueling Station	09/13/02	07/31/04	350,000	1,075,000
03201	University of California, Irvine	Demonstrate & Develop Hydrogen Fueling Stations in Orange County	9/13/02	01/31/06	863,400	983,400
CFM3: Engine Technology						
00114	Alta Loma School District	Purchase Two CNG School Buses	03/22/00	06/01/05	119,608	464,000
00116	Montebello Unified School District	Purchase Two CNG School Buses	06/07/00	06/01/05	119,608	464,000
01035	Baytech Corporation	Develop Ultra-Low Emission Natural Gas Vehicle for Use in Shuttle and Package Delivery Applications	12/18/00	04/15/03	186,211	398,729
01111	Trojan Battery Company	Develop & Demonstrate Commercial Prototype Advanced Valve Regulated Lead-Acid Batteries	02/22/01	02/28/03	150,000	391,000
01137	R.F. Dickson Company, Inc.	Repower 10 & Purchase 4 PM10-Efficient CNG Street Sweepers	04/17/01	12/31/06	1,010,000	1,010,000
01160	Waste Management of the Desert	Repower 7 Roll-Off Refuse Trucks LNG	10/03/01	06/30/08	75,221	1,053,094
01178	CalMet Services Inc.	Repower 27 Waste Collection Trucks with CNG	09/19/01	06/30/07	2,646,000	2,646,000
01205	TEC of California	Loan and Maintenance of One LNG Frontloader Refuse Truck	12/31/01	07/31/03	50,000	50,000
01225	Detroit Diesel Corporation	Development of Very Low-NOx Heavy-Duty Natural Gas Engine	04/20/01	05/30/03	1,830,966	3,758,150

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM3: Engine Technology (cont'd)						
02181	Ford Motor Company	Develop & Demonstrate Two CNG-Powered Midsize School Buses and Demonstrate Two Smaller CNG Buses	07/26/02	07/01/03	$ 600,000	$ 1,688,000
02207	NGV Ecotrans Group LLC	Develop Low-NOx Heavy-Duty Natural Gas Engine & Vehicle Platforms	06/07/02	07/31/03	800,000	2,651,000
02218	Cummins Westport, Inc.	Preliminary Vehicle Design Development for NGNGV	06/02/02	07/31/03	378,715	504,954
02219	Cummins Westport, Inc.	Develop Technologies for NGVGV Class 3-6 CNG Engines	08/02/02	07/31/03	400,000	2,036,000
CFM4: Infrastructure and Fuel Production						
01152	ENRG, Inc.	Construction, Management and Consulting Services for NG Fueling Station at AQMD Headquarters	03/19/01	03/31/03	26,415	26,415
01154	R.F. Dickson Company	Cost-Share Installation of CNG Fueling Facility	08/04/01	07/31/06	180,000	180,000
01165	ENRG, Inc.	Construct & Operate One LNG & Four CNG Refueling Stations within SCAQMD Basin	05/07/01	03/30/06	288,800	1,577,600
01217	ENRG, Inc.	Construct/Upgrade Seven Natural Gas Refueling Stations	09/17/01	06/15/06	1,000,000	4,270,700
02156	Southern California Gas Company	Upgrade Existing CNG Fueling Stations	02/19/02	04/30/03	448,900	641,280
02157	ENRG, Inc.	Upgrade Existing CNG Fueling Stations	01/17/02	04/30/03	892,615	1,445,112
02320	USA Pro & Associates	Develop Odorant for Liquefied Natural Gas	08/02/02	12/31/03	123,835	418,320
CFM5: Electric/Hybrid						
99109	Toyota Motor Corporation	Three-Year Lease of One RAV4 Electric Vehicle	04/04/99	11/30/03	54,101	54,101
00020	EV Rental Cars	Demonstrate Electric Vehicle Rental Program	09/08/99	06/30/03	300,000	1,175,755
00051	Santa Barbara Electric Bus Works Inc.	Develop & Demonstrate an Electric School Bus	11/23/99	03/31/03	100,000	400,000
00105	Avery-Dennison Office Products North America	Purchase 9 Electric Forklifts	06/20/00	03/15/06	10,000	277,452
00107	Harbor Distributing, LLC	Purchase 321 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

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM5: Electric/Hybrid (cont'd)						
00143	Los Angeles Department of Water & Power	Purchase 25 Electric Buses	06/28/00	06/01/05	$ 450,000	$ 5,511,944
01051	Fabrica Int'l	Purchase 2 Electric Forklifts w/Batteries	10/11/01	12/31/05	25,598	25,598
01138	Hayward Pool Products, Inc.	Purchase 2 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
01208	Southern California Edison Company	Develop & Demonstrate Grid-Rechargeable Hybrid Electric Utility Service Truck & Mobile Electric Power Supply	08/10/01	05/31/03	266,348	532,695
01336	Chroma Systems	Purchase Electric Forklift with Battery	04/11/01	06/30/06	4,734	4,734
02116	Clean Fuels Connection	Develop Dual Inductive/Conductive Charger Bracket to Allow Reduction of EV Charging Infrastructure Costs	12/31/02	03/28/03	47,815	95,694
02155	AC Propulsion Inc.	Develop & Evaluate a Tri-Fuel, Plug-In Hybrid Electric Vehicle with Vehicle-to-Grid Power Flow	01/23/02	09/30/03	180,000	755,000
02326	Electric Power Research Institute	Study for Commercialization of Advanced HEVs	10/18/02	02/28/04	250,000	1,300,000
CFE1: Emission Control Technology						
01173	National Renewable Energy Laboratory	Demonstrate Fischer-Tropsch Synthetic Fuel in Heavy- & Medium-Duty Vehicles	06/11/01	07/31/03	178,001	737,855
011731	National Renewable Energy Laboratory	Advanced Diesel Fuels, Engines, NOx Absorber Catalyst & Diesel Particulate Filter Project	08/01/01	07/31/03	200,000	400,000
02119	Booz-Allen Hamilton Inc.	Demonstrate Particulate Trap Technologies	12/21/01	01/21/03	489,143	910,000
02292	West Virginia University Research Corporation	Demonstrate Fischer-Tropsch Synthetic Fuel in Heavy-Duty Vehicles	11/01/02	08/30/03	189,854	737,855
02293	Automotive Testing Laboratories	Develop & Demonstrate Fischer-Tropsch Fueled Heavy-Duty Vehicles with Control Technology to Reduce Exhaust Emissions	08/23/02	03/31/04	750,000	1,300,000
03109	West Virginia University Research Corporation	Aftertreatment Technologies for PM Emissions Control of CNG-Fueled Heavy-Duty Engine	11/07/02	03/31/04	450,000	550,000
CFE2: Emission						
00188	University of California, Riverside	Testing Support & Emissions Assessment	07/17/00	07/01/04	100,000	100,000
02231	Coordinating Research Council Inc.	Heavy-Duty Vehicle Chassis Dynamometer Testing for Emissions Inventory, etc.	06/07/02	04/30/04	200,000	1,500,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFE3: Health						
01209	University of California, Riverside	Study of Children's Pollutant Exposures During School Bus Commutes	06/25/01	04/30/03	$ 58,992	$ 509,000
02117	University of Southern California	Deploy & Operate Scanning Mobility Particle Sizers & Low Temperature Tapered Element Oscillating Microbalance in Children Health Study Communities	11/29/01	10/31/04	120,000	194,649
03030	Public Health Foundation	Reanalysis of Health Effects of Air Pollution Data in the Coachella Valley	09/19/02	02/28/03	9,122	9,122
03225	California Air Resources Board	Quantify Health Benefits of Incremental Improvements in Air Quality in the SCAB	10/01/02	12/30/04	100,000	306,261
CFS1: Stationary Clean Fuel Technology						
99046	Engelhard Corporation	Field Evaluation of PremAir Ozone Catalyst Technology on AC Units	10/06/98	12/31/10	0	0
02089	University of California, Irvine	Monitor Power Production by Microturbine Generators	03/26/02	03/15/03	75,000	75,000
CFS2: VOC/Toxics						
02307	Gregg Industries, Inc.	Demonstrate Integrated Technology for Control of Odors & VOCs from Metal Casting Operations	06/26/02	05/31/03	300,000	600,000
CFT: Outreach and Technology Transfer						
97110	Burke, Andrew	Review & Assessment of Technical Proposal re: ATTB Ultracapacitor System	06/04/97	08/15/03	15,000	15,000
97113	JME Inc.	Review & Assessment of Technical Proposal re: ATTB Ultracapacitor	05/08/97	08/15/03	15,000	15,000
00069	Walsh Consulting	Technical Assistance Relating to the Use of Alternative Fuels in Mobile Sources	02/17/00	02/28/03	35,000	35,000
00078	Breakthrough Technologies Institute	Technical Assistance Related to Development and Commercialization of Zero- & Low-Emission Technologies Including Fuel Cells	01/28/00	01/31/03	50,000	50,000
00098	Murray Katz	Technical Assistance Pertaining to Fuel Cell Development & Commercialization	02/25/00	02/24/03	20,000	20,000
00112	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance Regarding Alternative Fuel Engines	04/13/00	04/12/03	35,000	35,000
00175	Burnett & Burnette	Evaluate & Implement CNG Fueling Stations	05/31/00	12/31/03	60,000	60,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFT: Outreach and Technology Transfer (cont'd)						
01026	Bevilaqua-Knight Inc.	CY 2002 Membership Participation in California Fuel Cell Partnership	12/18/00	12/31/03	$ 167,600	$ 167,600
01162	Arthur D. Little Inc.	Technical & Management Assistance for Carl Moyer & School Bus Programs	04/20/01	04/19/03	150,000	150,000
01169	Clean Fuels Connection	Technical & Management Assistance for Carl Moyer, School Bus & ZEV Implementation Programs and Infrastructure Scoping	04/20/01	04/20/03	225,000	225,000
01190	USA Pro & Associates	Infrastructure Scoping Support	06/04/01	06/30/03	265,000	265,000
02114	Gladstein & Associates	Outreach Support of Low-Emission Clean Fuel Heavy-Duty Vehicles	02/22/02	05/31/03	250,000	250,000
02240	Cindy Sullivan	Technical Assistance for Development, Outreach and Commercialization of Heavy-Duty Engine Technologies	04/11/02	05/31/03	45,000	45,000
02288	FuelMaker Corporation	Technical Consultant Services for Two School Districts	05/23/02	07/30/03	41,198	82,395
02294	Calstart	Membership and Participation in Hybrid Electric Operations Forum	06/21/02	04/15/03	25,000	405,000
02295	SynchroEnergies	Technical Assistance on Lubricants, Fuels, Combustion, Alt. Energy Sources & High Performance Fluid Technologies	05/23/02	06/30/04	25,000	25,000
02308	Sperry Capital Inc.	Evaluate Financial Stability of Potential Contractors	06/25/02	12/31/03	20,000	20,000
02311	Jerald A. Cole	Technical Assistance for Development/Outreach/ Commercialization of H2 Infrastructure & Reforming Technology	06/09/02	06/30/04	30,000	30,000
02316	California Science Center Foundation	Fuel Cell Exhibit and Amend Children's Museum	TBD	06/30/03	225,000	275,00
02333	University of California at Riverside	Technical Assistance for Development, Outreach and Commercialization of Clean Fuels Technologies, Hydrogen & Fuel Cell Technologies	11/01/02	06/30/04	30,000	30,000
02334	Engine, Fuel & Emissions Engineering, Inc.	Technical Assistance on Natural Gas Engine Technology	07/31/02	06/30/04	30,000	30,000
02335	Neil C. Otto	Technical Assistance on Fuel Cell Technology	08/09/02	06/30/04	30,000	30,000
02340	Air & Waste Management Association	Co-Sponsor the Dedicated Issue of Journal of the Air & Waste Management Association	06/28/02	04/30/03	5,000	5,000
03033	Hydrogen 2000 Inc.	Develop Outreach Video on Fuel Cell and Hydrogen Fuel Usage	08/23/02	03/01/03	45,000	240,000
03180	Charles Powars	Technical & Management Assistance for Alt. Vehicle and Fueling Infrastructure Projects	11/14/02	07/31/03	25,000	25,000

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFT: Outreach and Technology Transfer (cont'd)						
03181	USA Pro & Associates	Support, Training and Guidance Toward Purchase of New Fleet and On-Board LNG Fueling Systems	11/20/02	11/19/03	$ 50,000	$ 50,000
03202	Nissan North America	Lease One 2002 Nissan Altra Electric Vehicle	12/31/02	12/31/05	12,000	21,000

APPENDIX C

FINAL REPORTS FOR 2002

FUEL CELL TECHNOLOGY

AQMD Contract # 98091 *November 2002*

R&D of a 50-kW High-Efficiency, High-Power-Density, CO-Tolerant PEM Fuel Cell Stack System

Contractor

Honeywell Engines & Systems.

Cosponsors

Department of Energy
Honeywell
General Electric Power Systems

Project Officer

Adewale Oshinuga

Background

Fuel cell power plants will become viable substitutes for the internal combustion engine (ICE) in automotive applications only when their benefits of increased fuel efficiency and reduced emissions are accompanied by performance and cost comparable to the ICE. Meeting these requirements is a significant technical challenge that requires an integrated systems approach. This effort encompasses the technical and developmental activities required to incorporate innovations necessary to develop a 50 kW fuel cell stack system to meet the requirements set forth by the SCAQMD and the DOE.

Project Objective

The objective of this project was to research, develop, assemble, and test a 50 kW net Polymer Electrolyte Membrane (PEM) fuel cell stack system comprised of a PEM fuel cell stack and the supporting gas, thermal, and water management subsystems. The PEM fuel cell stack system is capable of integration with at least one of the fuel processors currently under development by Hydrogen Burner Technology (HBT) and Arthur D. Little, Inc.

Technology Description

The electric energy of the 50kW System is provided by a set of six PEM fuel cell stacks that were developed under this program. Special emphasis was given to low cost manufacturing of fuel cells by introducing compression molded bipolar plates. The fuel cell stack system operates under variable pressure (up to 3 atm) by using a turbocompressor for air delivery to the fuel cell. The exhaust gas from the fuel cell is expanded through the turbine section of the turbocompressor, which increases the overall efficiency of the system. A high CO tolerance of the PEM fuel cell (up to 200 ppm) is achieved by using air bleed.

Status

This project was completed by September 30, 2002. The final report is on file with complete technical details of the project. The project ended with the development of a 50-kW size PEMFC brassboard system. The system was tested at Honeywell using simulated reformate. Additional system testing will be performed at the Argonne National Laboratories at the beginning of 2003.

Results

The main objectives of this project was to demonstrate the feasibility of a high-efficient, low-cost PEM fuel cell system A conceptual design was developed to show existing technology gaps. The technical performance of various components required in the conceptual design exceeds that which is currently available. This is especially so for the PEM fuel cell stack, where significant improvements in polarization curve performance are needed under high fuel utilization (low stoichiometry) operating conditions. Specifically, in order for all of the goals of this program to be simultaneously met, the PEM fuel cell stack must

simultaneously have a power density of 1.8 kW/liter and 1.1 kW/kg and a cost of $29/kW, all at a single cell potential of 0.86V.

Subsequent to the development of the conceptual design a brassboard system was developed and demonstrated. To demonstrate the technical feasibility of the conceptual PEM system design new fuel cell stacks were developed. For the development of the final PEMFC stack, three design iterations were undertaken in this program. In each design, the most current development efforts on the MEA, the bipolar plate material, and flow field were leveraged. Additionally, in each of the design iterations, efforts were made to reduce stack size and weight to improve the power density metrics of the stack. The power density achieved in the last (3^{rd}) iteration reached 1.6 kW/liter and 0.9 kW/kg at absolute peak power. In addition, the 10-kW size stack demonstrated operation at 1.25 anode stoichs and 2 cathode stoichs for all designed operating points of the brassboard system.

The final stack was integrated into the brassboard system and tested. Table 1 shows the final test results achieved in comparison with the original goals.

Metric	Goal	Result
High-Volume Production Cost	$100/kW	$100/kW if MEA<$5/kW
Power density	0.35kW/L	0.17kW/L
Specific Power	0.35kW/kg	0.13kW/kg
Efficiency@12.5kW	55%	42%
CO Tolerance	>>10ppm	>100ppm

Table 1.: Performance goals and results.

Technologically, much work remains before the goal of 55% can be accomplished. Further advances in stack fuel utilization are needed. In this program, substantial progress was made and an anode stoichiometry of 1.35x was demonstrated in the system. Further effort is needed to better engineer electrode structure and flow fields to improve the anode stoichiometry to less than 1.2x. This improvement alone could increase system efficiency by nearly 13%. While this potential gain is substantial, the goal cannot be met through *engineering* advances alone, technological gains in key materials are also needed. The single largest loss in the system is cathode overpotential. In order to reach the goal of 55%, it will be necessary to improve cathode electrode performance in order to reduce the cathode overpotential and allow the fuel cell to operate at potentials in the neighborhood of 0.85 Volts at appreciable current densities. The conceptual design polarization curves can only be accomplished through improvements in catalyst performance and Honeywell recommends that the DoE and SCAQMD make substantial investment in oxygen reduction electrocatalysts to enable the cathode overpotential to be reduced and to enable the program goal of 55% to be accomplished. In addition to the necessary performance improvements it will be essential to significantly reduce the cost for bipolar plates and MEA in order to make PEM fuel cells commercially viable in automotive applications.

Benefits

The PEM system developed on this program demonstrated an efficiency of 42%. When integrated with a fuel processor, the system is projected to have an efficiency of about 31%, an efficiency improvement of 25-40% over conventional internal combustion engines, offering the potential to reduce CO_2 emissions by a commensurate amount. While the efficiency of the system was less than originally targeted, material reductions in emissions are accomplishable with the technology developed on this program.

Project Costs

The overall cost of the program was $10.9M. The majority of the funding ($7.2M) was provided by the DOE. The SCAQMD portion was $500k and the cost share by Honeywell and GE was $3.2M. The originally estimated cost was $10.5M. The difference was covered by GE Power Systems.

Commercialization and Applications

The technology developed in this program, while integrated and demonstrated in a system, remains too immature for commercialization in light duty vehicles. As can be seen in the photograph above, the system is too large for light-duty vehicles, and too costly. Both size and cost of the system are best mitigated by improving the performance of the PEM cathode—such performance improvements will simultaneously reduce the cost and size of the overall system.

AQMD Contract # 00053 ***November 2002***

Develop and Demonstrate a 250kW Hybrid Fuel Cell-Micro Turbine Powerplant

Contractor
Southern California Edison Company (SCE*)*

Cosponsors
Department of Energy (DOE), Edison International (SCE & EIX), California Energy Commission, and EPRI

Project Officer
Ranji George

Background
Fuel cells are known to emit the lowest level of urban air pollutants of all electrical generation systems that use fossil fuels with emissions less than 1.0 ppm for NOx, below detection levels for other criteria pollutants and reduced global warming pollutants –such as carbon dioxide and methane.

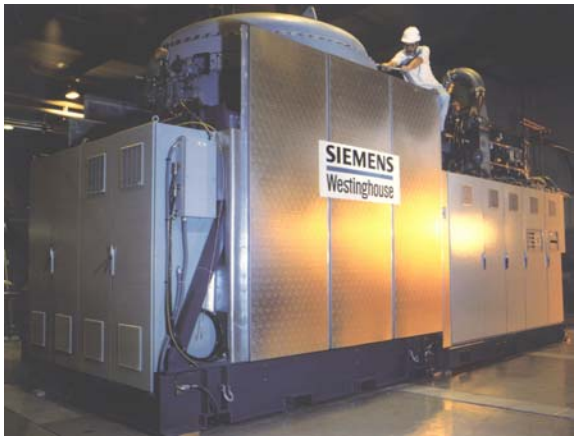
The hybrid fuel cell combines fuel cell technology with micro-turbine generator (MTG) technology to achieve a combined higher efficiency electrical generation. Higher efficiency results in less fuel consumption per kW-hr produced, and less CO2 production. Efficiencies approaching 60% are expected to be achieved, nearly a 10% improvement above a non-hybrid fuel cell power plant.

Project Objective
The project objective is to "prove the concept" of the hybrid fuel cell/MTG power plant. To prove the concept, this project includes:

1. Design, construction and installation of a 200 kW pressurized solid oxide fuel cell (PSOFC) combined with 75 kW.
2. Development and demonstration of startup and shutdown procedures, and
3. Development and demonstration of automatic safe shutdown for upset conditions.

Design and construction is by Siemens Westinghouse Power Corporation (SWPC) in Pittsburgh, PA – the world's leading manufacturer of Solid oxide fuel cells (SOFCs). A 100 hour Factory Acceptance Test (FAT) followed construction. On completion of the FAT, the hybrid fuel cell was installed at the Southern California Edison test site located at the University of California in Irvine, CA (UCI). Following installation at the test site, a 100 hour Site Acceptance Test (SAT) was conducted. Following the SAT, the hybrid fuel cell was to be operated for 3000 hours. During the 3000 hours of "proof of concept" operation, an assessment of gross power, net power and net efficiency was planned.

Technology Description



Fuel cells produce electric power without combustion. Fuel and air are combined electrochemically, like a battery, but the reactants (natural gas and air) are continuously replenished. Non-hybrid fuel cells have an air mover, such as a blower, to provide the air reactant. The blower is a parasitic load, reducing net power. The hybrid fuel cell uses the compressor of a MTG for the air mover. The fuel cell exhaust thermal energy supplants the MTG combustor, and provides the energy to drive the turbine. The turbine provides sufficient power to drive the compressor with excess to drive an electric generator. The elimination of a combustor for the MTG, during steady state operations, results in MTG power production without creation of pollutants. Emissions less than 1.0 ppm for NOx and below detection levels for other criteria pollutants was measured during the factory testing.

Status
The hybrid unit was assembled and tested at the Siemens/Westinghouse factory. The unit

experienced several 'first of a kind' problems, but no significant technology challenges were identified. For example, after 150 hours of operation, the unit experienced automatic shut-down when a power lead cable overheated. The unit was shipped back to the factory, where it was repaired. Since then the unit has operated off and on. Each time it failed, unit was repaired at the manufacturing site, and shipped back to UC Irvine, CA.

Results
The unit achieved 193 kW of power with an overall efficiency of 53%. The project is scheduled to conclude the 3,000 hr. testing in January 2003.

Benefits
The system has provided preliminary evidence that very high electrical efficiencies can be achieved for a small generating unit (units under several MW's). In addition, this high efficiency can be achieved without combustion at very low air emissions.

Project Costs
The overall project budget is approximately $17 million with SCAQMD providing $200,000.

Commercialization and Applications
As this is a "Proof of Concept" demonstration project, follow-on projects will be required. Follow-on projects will optimize the integrated hybrid fuel cell power plant design and incorporate lessons learned from this research/demonstration project. Siemens recently completed a commercial fuel cell manufacturing facility near Pittsburgh, PA. The fuel cell manufacturing facility will result in lower cost systems moving the technology closer to the goal of becoming competitive with other electric generation technologies. This technology, if successfully developed, could have potential commercial distributed generation applications sized between 250 kW and 1 MW. The first commercial units will be 250 kW atmospheric systems with or without combined heat and power. These could be followed by hybrid units in the 500 kW range.

HYDROGEN TECHNOLOGY AND INFRASTRUCTURE

AQMD Contract # 00135 *April 2002*

Relocation of Solar Hydrogen Facility from Xerox to SunLine

Contractor

SunLine Services Group and Stuart Energy.

Cosponsors

Imperial Irrigation District, SCAQMD and USDOE

Project Officer

Gary Dixon

Background

Air pollution and the need to reduce emissions in Southern California have been driving forces in funding being made available for research, development and demonstrations of renewable energy technology and zero emissions vehicles.

Clean Air Now originally built a solar generated hydrogen production system at the Xerox facility in El Segundo, Ca. After successfully completing its contract with the USDOE, Clean Air Now had to relocate the project. Clean Air Now and SunLine agreed to integrate this project into SunLine Transit Agency's hydrogen complex.

Project Objective

The objectives of this project were: to successfully transport, set up and commission the hydrogen generation system from the Xerox facility to SunLine Transit Agency; to produce a safety assessment relating to the production, storage, transportation and use of hydrogen; and, to include in the assessment an evaluation of the maintenance facilities for hydrogen fueled vehicles involving a variety of technologies.

Technology Description

The hydrogen generation system consists of: 168 Siemens solar flat plate panels, 144 PVI solar tracking panels, a Stuart Energy P3 1400 SCFH electrolyzer, a S.E.R.C. 40 SCFH electrolyzer, a tube trailer with a capacity of 108000 SCF rated at 3130 PSIG, tow ASME hydrogen storage cylinders with a capacity of 10800 SCF rated at 4200 PSIG, a public-access hydrogen dispenser capable of dispensing hydrogen at 3600 PSIG and a public-access hythane (mixture of 80% compressed natural gas and 20% hydrogen) dispenser rated at 3600 PSIG. These components were fully integrated into a functional, operating system.

Status

As the owner of the only hydrogen generation system with public access for fueling hydrogen, SunLine continues to be involved in codes, standards and safety discussions on an on-going basis. SunLine has been involved in discussion throughout this past year regarding the setting of codes and standards for the hydrogen industry in the United States. All code and safety issues received immediate attention by SunLine upon review of the Safety Assessment.

SunLine continues to operate and maintain the integrated equipment successfully, in addition to acquiring data on the project.

Results

The operation and use of the hydrogen facility by SunLine has resulted in the accumulation of information regarding many technologies that is being shared with anyone that asks. SunLine personnel have traveled worldwide by invitation to present this information to a variety of groups.

In connection with the safety assessment of the facility, a non-compliance report was presented to SunLine. Issues were identified and direct reference made to the applicable code/standard followed by a physical description of the non-compliance issue and the recommended action. Most deficiencies have been addressed, with exceptions pending subject to funding.

This project effected or helped in the development of the following actions:

- The construction of hydrogen and Hythane™ fueling infrastructure.

- Operation of (1) a fuel cell bus in association with the Xcellsis Fuel Cell Engine Company for a period of 13 months, ending on September 1, 2001, and (2) two transit buses fueled with Hythane™.

- The operation and maintenance of four hydrogen fuel cell vehicles.

- Hydrogen production facilities including two electrolyzers and a methane reformer.

- A fixed and a tracking solar array for on-site electric power generation for hydrogen production.

Benefits

The use of hydrogen as a transportation fuel is in its infancy. Codes and standards are limited and safety is paramount. This assessment allowed SunLine to address and improve its facilities and to fully comply with existing codes and standards.

The benefits to the environment and the people from a zero emission fuel produced by renewable energy are well documented.

Another benefit of this project has been the education of thousands of people almost on a daily basis. SunLine has had more than 5,000 visitors since 2000, including visitors from 23 countries. Tours and presentation are available by a variety of personnel at SunLine, depending on the group and their area of interest.

Project Costs

South Coast Air Quality Management District contracted with SunLine in the amount of $55,000 for a portion of the work to relocate the Clean Air Now solar hydrogen project from Xerox to SunLine. South Coast and the USDOE contracted with Clean Air Now for work prior to the project coming to SunLine. The Department of Energy also contracted with Stuart Energy USA for the placement of the P3 electrolyzer at SunLine. Imperial Irrigation District contributed $60,000 toward the purchase of the PVI solar tracking panels and USDOE paid for the installation of the support structure of these panels. SunLine has provided project and contract management and labor to complete the integration and re-design of the layout of this project. SunLine also contributed equipment in excess of $138,000 for storage tanks, transformers and an inverter as well as the purchase of a Ford Ranger truck with a hydrogen internal combustion engine.

Commercialization and Applications

Codes and standards for hydrogen production, distribution and storage continue to evolve. The commercialization of hydrogen generation and production from renewable energy sources is ust beginning. SunLine is involved in the California Fuel Cell Partnership, Hydrogen Technical Advisory Panel, National Hydrogen Association and the California Hydrogen Business Council, all of which are participating in discussions regarding the setting of codes and standards for the hydrogen industry in the United States.

The technology has been developed to the point that sufficient hydrogen can be produced to fuel a small fleet of vehicles on a regular basis. As the technology continues to be refined, it will become a viable option for the production of hydrogen, a zero emission fuel.

AQMD Contract No. 020291 *January 2003*

DEVELOP AND DEMONSTRATE A UNIVERSAL CARD READER SYSTEM

Contractor
ENRG Inc., formerly Pickens Fuel Corp.

Cosponsors
Multiforce Systems Corporation

Project Officer
Larry Watkins

Background

Historically, a natural gas vehicle owner would be required to carry numerous proprietary fueling cards in order to fuel their vehicle(s). Equipment at existing natural gas fueling stations is, in most cases, first generation technology. ENRG, owner and operator of the majority of natural gas fueling stations in the South Coast Air Quality Management District (SCAQMD), has partnered with the SCAQMD and Multiforce Systems Corporation (Multiforce) for the purpose of cost-sharing in equipment and technology upgrades.

Project Objective

To develop a fueling card system that is simple, reliable and able to accept multiple credit, fleet and proprietary fueling cards.

Technology Description

The fueling dispenser at the beta test site is a key component to a successful fueling transaction. Due to a change in dispenser selection, Multiforce was required to revise the software programming that had been initially developed and proven for use in another dispenser. It was also necessary to develop technology that would provide on-site fueling training. The fuel training process is demonstrated using a video. A financial network and software provider were selected. Multiforce provided programming and logic including development of code and communication algorithms. Testing was conducted at the beta test site during the months of May and June 2002.

Status

This project has been successfully completed. The system was tested by inserting individual credit cards. After positive acknowledgement of the fueling process, the authorized credit card enabled fueling to commence.

Results

Emission reductions resulting from the project are derived by a fueling convenience factor. The incorporation of using credit cards to purchase fuel mirrors the traditional fueling options at retail gasoline/diesel stations. Individuals who purchase natural gas vehicles will be able to purchase fuel at stations where this technology has been incorporated with a major credit card eliminating the necessity of completing an application for a proprietary fueling card. This convenience will assist in the marketing efforts to expand the use of natural gas vehicles by taxis, shuttles, and private consumers.

Benefits

Taxi owner and operators will derive a direct benefit by being able to use a major credit card to fuel their vehicles. Station owners will no longer be required to bear the financial risk associated with issuing proprietary cards to natural gas vehicle owners that may be a credit risk. Completing fueling applications will no longer be required to purchase natural gas at public access stations.

Having the capability for customers to receive on-site training to fuel their vehicles is a direct benefit of this new technology. Prior to the implementation of the technology, the only way to be trained to fuel your natural gas vehicle was by arranging a face-to-face training session.

Project Costs

The actual costs of this project were higher than originally budgeted. The initial budget for this project was estimated to be $130,000. This project has incurred expenses of approximately $300,000 (Attachment 2). As improvements and enhancements to the system are made and implemented, cost will be borne by ENRG and its subcontractors.

The 2001 portion of the project was executed within schedule and budget objectives with confirmed success. 2002 activities represent budget overruns. These have been conducted, as the result of new requirements.

Specifically, cost escalation for this project stemmed from two causes: (1) *New dispenser with proprietary interfacing technology (rather than industry-standard protocols); and (2) Migration of the project algorithm from the "Have you been trained (Yes/No)?" question to a full-featured verification and training capability.*

Each of the two causes brought significantly more cost to the project than the original retail card network adaptations. The second requirement forced migration to a new product platform and a new operating system.

The initial and revised budgets are included on Attachments 2, California Universal NGV Fueling Card Program (Multiforce Systems Corporation Contribution). Based on the final cost of this project, the SCAQMD's cost share is 10%.

Commercialization and Applications

The initial demonstration proved that credit cards could be successfully authorized with fueling commenced after acknowledgement of training by the user. After authorization for fueling and conclusion of the transaction, payment was successfully transmitted from the financial network to the proper banking institution.

There are incidental improvements to the system, described below, for which ENRG plans to continue its development and system verification as an on-going improvement:

1. Receipt printing functionality.
2. Confirmation that current embedded Windows OS will bring long-term success.

ENGINE TECHNOLOGY

AQMD Contract # 99157 *Date of Publication: October 2001*

On-Road Development of Enhanced Caterpillar® C-12 Dual-Fuel™ Truck Engine

Contractor
Clean Air Partners, Inc.

Cosponsors
National Renewable Energy Laboratory (NREL), Jack B. Kelley Trucking, Caterpillar Engine Company, Gas Research Institute, Power Systems Associates, Clean Air Partners, AQMD

Project Officer
Michael Bogdanoff

Background

The Dual-Fuel engine (natural gas with diesel pilot injection) provides the low NOx emissions of a spark-ignited, lean-burn natural gas engine, with the high efficiency and power output of a diesel engine. The base Cat® C-12 Dual-Fuel engine is rated 410-hp and 1250 lb-ft of peak torque. It has the highest rating of any natural gas on-highway engine manufactured. However, a study of fleet operators indicates that 425-hp and 1450 ft-lb of torque are the minimum performance preferred by the majority of commercial fleets. Therefore, with a slight increase in horsepower and torque and a potential for reduction in particulate matter emissions, the C-12 Dual-Fuel engine could satisfy fleet users as well as reduce emissions.

Project Objective

The goal of this project was to develop an enhanced version of Caterpillar® C-12 on-highway, heavy-duty, Dual-Fuel truck engine with increased rated power and peak torque and the following specifics:

- 425 hp at 1800 rpm and 1450 lb-ft at 1200 rpm
- California low NOx of ___ g/bhp-hr and LEV emission standards
-
- Higher natural gas substitution rate
- Fuel economy of the base C-12 Dual-Fuel engine
- Reduced particulate matter emissions compared to the base C-12 Dual-Fuel engine.

A pre-commercial demonstration in the South Coast Air Basin would be conducted with 5 trucks.

Technology Description

Both CNG and LNG are known to be vulnerable to fuel quality deterioration. Measures to increase the engine output usually result in an increased tendency to engine knock. An effective anti-knock control system can protect against this event and provide the opportunity to reduce knock safety margins incorporated in the base C-12 Dual-Fuel engine software.

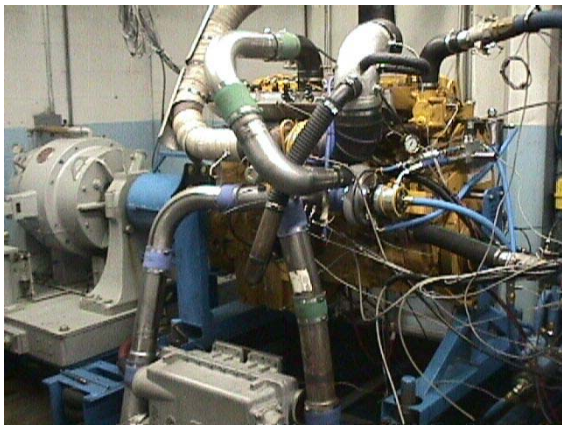
To achieve the LEV rating without compromising efficiency, performance, or other emissions commonly associated with retarded timing for NOx reduction, an alternative method is required. The effect of air charge temperature (ACT) is well published that lower ACT yields lower NOx emissions. Lower ACT also reduces knock tendency in Dual-Fuel engines. Cooler air intake temperature, therefore, allows the brake mean effective pressure to be increased without the risk of knock.

The following technologies were investigated during this project:

1. Knock detection and control
2. Turbo expansion to lower ACT
3. Air pressure booster in addition to the *stock* turbocharger

Figure 1 shows the installation of the hydraulic supercharger on the test engine.

Figure 1



Status

These technologies were investigated during this project. Due to the announcement made by Caterpillar on March 6, 2001, that all Cat® truck engines including C-12 will employ the new engine technology called ACERT™. The MEUI fuel system currently employed on the C-12 engine will be replaced with the next generation HEUI™ fuel system which requires engine design change. The technologies developed during this project becomes inappropriate. It was determined by all parties concerned that this project should be terminated at the end of March 2001.

Results

The hydraulic supercharger (HS) has its merit on boosting air mass flow required by the enhanced C-12 Dual-Fuel engine at engine speeds below 1400 rpm. The HS has also proven to be a suitable and valuable device in identifying the turbocharger performance characteristics required by the enhanced C-12 Dual-Fuel engine. Figure 2 shows the NOx emissions at various hydraulic pressures supplied to the HS turbine. NOx emission decreases as hydraulic turbine pressure increases. This is due to the leaner air and gas mixture at higher hydraulic turbine pressure. Figure 3 shows maximum torque output at 1100 ~ 1400 rpm while HS hydraulic turbine inlet pressure was modulated between the maximum and minimum pressures by the HS electronic pressure regulator.

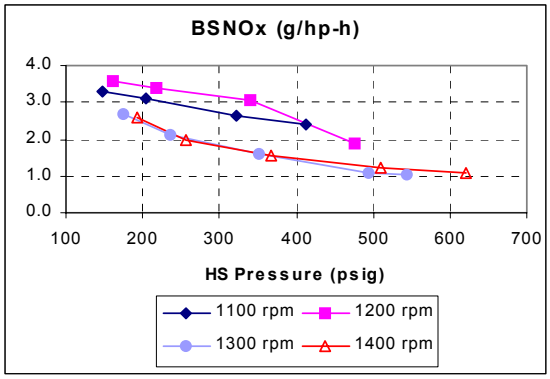


Figure 2

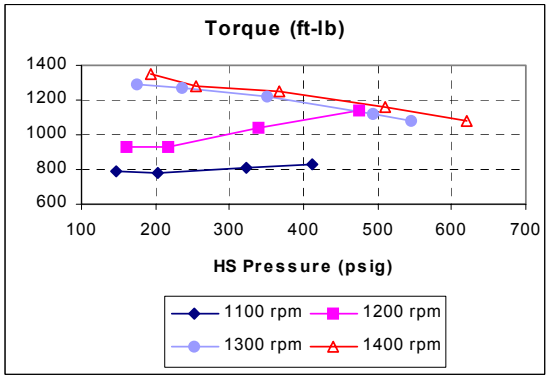


Figure 3

Benefits

The base Cat C-12 Dual-Fuel engine has the highest rating of any natural gas on-highway engine manufactured. The technical investigation and development conducted in the project indicates the enhanced version of C-12 Dual-Fuel engine will produce 425 hp and 1450 lb-ft torque, which will satisfy fleet users as well as air quality advocates.

Project Costs

The actual costs and originally allocated costs of the project are tabulated below:

Funder	Allocated	Actual
Caterpillar	$274,000	$274,000
Power System Associates	$ 75,000	
Gas Research Institute (GRI)	$163,094	$163,094
Jack B. Kelley	$625,000	
NREL	$617,705	$291,000
AQMD	$492,453	

Fundings from Caterpillar and GRI were directed to the completion of laboratory base engine development.

Commercialization and Applications

Due to the unforeseen adaptation of the ACERT™ technology on the C-12 truck engines by Caterpillar, the technologies developed during this project become inappropriate. Commercialization of these technologies as originally envisioned is, therefore, not possible.

The selected knock sensor will require less effort to integrate the sensor's electronic to the Dual-Fuel truck engine's electronic control module. Knock detection and control strategies were developed in this project, were not thoroughly evaluated and tested, however.

There are concerns on commercial viability of the enhanced C-12 Dual-Fuel engine having the hydraulic supercharging system incorporated. A single variable geometry turbocharger optimized for Dual-Fuel engine will be the best solution.

AQMD Contract #99158

Develop and Demonstrate Low-Emission Mack E7G Natural Gas Engine

Contractor

Gas Research Institute, Mack Trucks and Southwest Research Institute

Cosponsors

U.S. Department of Energy, Mack Trucks, Gas Research Institute, AQMD

Project Officer

Mike Bogdanoff

Background

Heavy-duty, diesel-fueled trucks contribute significantly to the emissions inventory of the South Coast Air Basin. Diesel exhaust has also been identified as a Toxic Air Contaminant by the California Air Resources Board. In recognition of these, the AQMD has adopted initiatives to reduce diesel exhaust in the Basin and to promote clean-fuel vehicles like heavy-duty natural-gas vehicles.

The AQMD and others have supported the development and demonstration of natural-gas engine technology. However, a higher-power low-emission natural gas engine was required for heavy (80,000 lb Gross Vehicle Weight) line-haul truck applications.

In 1999, the AQMD in cooperation with the US Department of Energy (DOE) and Gas Research Institute (GRI) entered into a program to achieve significant power enhancements in heavy-duty natural-gas engines while retaining low emissions characteristics.

Technology Description

The E7G engine will be used in a truck with a manual transmission and a gross vehicle weight rating of 36,288 kg (80,000 lbs). This engine produces low emissions while still providing excellent driveability for a natural gas engine. To achieve the low emissions and excellent driveability, an air-assisted turbocharger and humidity compensation were incorporated into the engine. The air-assisted turbocharger significantly improves the transient response of the engine while still allowing for low emissions, and the humidity compensation allows the engine to reduce emissions even further by operating closer to the lean misfire limit.

Other items incorporated into the engine to up rate it include the following. Fuel injectors with larger flow rate capacity were incorporated to handle the higher fuel flows from the higher power rating. A boost recirculation valve was installed to prevent turbocharger surge from the higher boost pressures and rapid throttle closings that occur with a manual transmission. Knock detection was added due to the increased tendency to knock at the higher power rating.

Since this engine will go into a highway truck, an engine brake would be desirable. Engine braking tests were performed.

Project Objective

The objective of the program was to up-rate the Mack Trucks E7G-325 natural gas fueled engine, rated at 325 bhp and 1180 lb-ft torque, to 400 bhp and 1440 lb-ft torque. The engine was to be initially calibrated to achieve emissions certification of 2.5 g/bhp-hr NOx + NMHC or less. This initial engine calibration would be field demonstrated. Additional engine development would be undertaken to further reduce emissions to certify the engine at 2.0 g/bhp-hr NOx + NMHC, or less.

Status

The program was completed on December 1, 2002. The final report is on file. The program exceeded its objectives by achieving greater engine power and torque than originally proposed. The engine is rated at 425 bhp and 1450 lb-ft. Three demonstration vehicles were built, and are available for field demonstration, but the field demonstration could not be conducted within the timeframe of the project.

Result

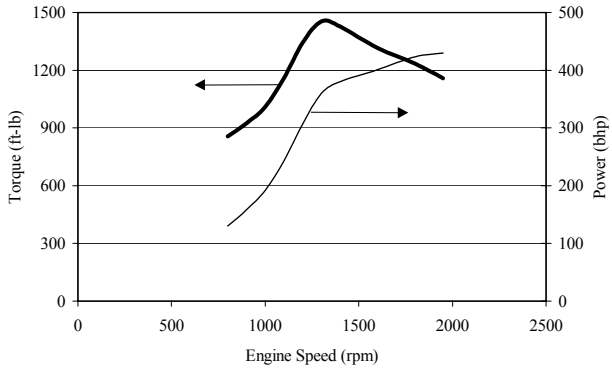
To achieve the low emissions and excellent driveability, several technologies were successfully integrated into the final engine package. These technologies include:

- Air-Assisted Turbocharger
- Humidity Compensation
- Large Flow Rate Capacity Fuel Injectors
- Boost Recirculation Valve
- Knock Detection

Since this engine will go into a highway truck, an engine brake would be desirable. Engine braking tests were performed, but retarding power was low because of the engine's lower compression ratio relative to diesel. For this reason, an engine brake was not incorporated into the demonstration vehicles.

With the incorporation of these technologies, the engines was calibrated to achieve torque and power levels in excess of the program goals, as shown in the following table and power / torque curve.

	Objective	Result
Power (bhp @ rpm)	400 @ 1800	425 @ 1950
Torque (ft-lb @ rpm)	1440 @ 1250	1450 @ 1300



Emissions calibration and testing were successfully conducted and demonstrated the ability to achieve certification at 2.5 g/bhp-hr NOx + NMHC. The results of these tests, with applied deterioration factors are:

g/bhp-hr	NOx + NMHC	PM (Particulate Matter)
Standard	2.5	0.05
Result	1.99	0.010

Further emission calibration resulted in successful calibration to the lower emission goal of 2.0 g/bhp-hr NOx + NMHC, as shown below:

g/bhp-hr	NOx + NMHC	PM (Particulate Matter)
Standard	2.0	0.05
Result	1.79	0.008

Benefits

The benefits of this program are the low emissions option for this high power application, previously unavailable. The up-rate of the engine to 425 bhp and 1450 lb-ft of torque while achieving an emissions certification of less than 2.0 g/bhp-hr NOx + NMHC and 0.05 g/bhp-hr particulate provides a cleaner option to diesel engines in this application.

Commercialization Issues and Applications

Field demonstration of these engines and trucks will be completed prior to commercial introduction of the technology. The field demonstration is planned to start during the first half of 2003 with four additional vehicles by the end of that year. Commercial availability is planned for late 2004 or early 2005.

AQMD Contract #02161 *December 2002*

Develop Low-NOx 6.0L Natural Gas Engine and Chassis

Contractor
TeleflexGFI Control Systems L.P.
Bodycote Material Systems Inc. (subcontractor)
Englehard Corporation (subcontractor)
General Motors Corporation (subcontractor)

Cosponsors
Bodycote Material Systems Inc. (subcontractor)
Englehard Corporation (subcontractor)
General Motors Corporation (subcontractor)

Project Officer
Mike Bogdanoff

Background

The need for medium and heavy duty vehicles for small transit, delivery vehicles and shuttle services is increasing. CNG vehicles have demonstrated low emissions but have had the potential for even lowe emissions, particularly Nitrogen Oxides (NOx). The emissions standards for smaller vehicles are ever decreasing, and the intention is for larger vehicles (particularly SUV's and larger passenger vehicles) to follow suit.

The Department of Energy (DOE)/National Renewables Energy Laboratory (NREL) has initiated a program called the "Next Generation of Natural Gas Vehicles" (NGNGV). One of the purposes of this program is to develop a new medium duty compressed natural gas (CNG) vehicle with potential for early commercialization starting in 2004, and having NOx emissions at or below 0.5g/bhp-hr and PM emissions at or below 0.1g/bhp-hr. In 2007, the goal is to have NOx emissions below 0.2g/bhp-hr in order to meet the EPA's standards.

Project Objective

The project objective is to develop a low-NOx General Motors (GM) CNG medium duty engine which will have NOx emissions at or below 0.5 g/bhp-hr. The goal is to be achieved primarily through improved catalyst technology.

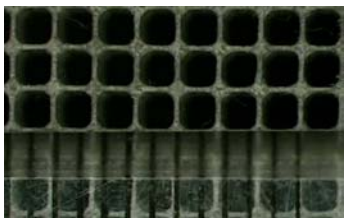
Technology Description

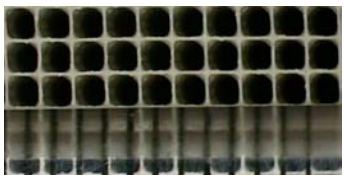
After completion of baseline emissions testing, several options for advanced catalyst designs have been conceived:

1. Substrate cell density change on under-floor (U/F) catalysts, which will provide enhanced residence time needed for conversion.
2. Wash-coat technology upgrade – tri-metal with low and high Palladium (Pd) to enhance low temperature performance.
3. Move the catalysts closer to the exhaust manifolds to allow for quicker heat up.
4. Addition of close-coupled catalysts to existing catalyst setup, with upgraded substrate cell density.

After extensive discussion between GFI and the Englehard Corporation, Englehard developed three different catalyst models for evaluation:

1. 600cpsi/3.5 mil wall "NEX 311H1" with 30g/ft^3 Pt/Pd/Rh in a 3/0/1 ratio. (Current catalyst cell density is 350 cpsi/5.5 mil wall)
2. 600cpsi/3.5 mil wall "OEX-101B" with 30g/ft^3 Pt/Pd/Rh in a 1/2/1 ratio.
3. 600cpsi/3.5 mil wall "OEX-101B" with a 45g/ft^3 Pt/Pd/Rh in a 1/2/1 ratio.


Standard 350 cpsi


New 650 cpsi

Catalyst Sections (cpsi: cells per square inch)

Status

TeleflexGFI Control Systems L.P. has completed all emissions testing and driveability evaluations. Due to very low baseline emissions results, the goal of

achieving 0.5 g/bhp-hr NOx was lowered to 0.2 g/bhp-hr and attained. The final selected catalyst underwent a driveability evaluation on a vehicle without any problems.

Results

The emissions tests that were conducted include Heavy Duty Transient (HDT) cycles recorded on a second-by-second basis for emissions components at the entrance and exit of the catalysts, catalyst temperature traces, air fuel ratios, and exhaust flow rates as well as a number of other engine and performance parameters. In addition, catalyst efficiency tests were conducted to determine the engine conditions in which the catalysts perform best, and raw emissions were recorded at several different steady state conditions**.**

The best performing catalyst was the NEX311H1 catalyst, with average NOx values of 0.078 g/bhp-hr over the hot HDT cycle, and a low single run of 0.057 g/bhp-hr. Another benefit of the advanced NEX311H1 catalyst is the greatly reduced Total Hydrocarbon (THC) emissions. While the production catalyst emitted 0.360 g/bhp-hr of THC, the NEX catalyst reduced that number to an average of 0.135g/bhp-hr.

With regards to particulate matter (PM), the goal of this project was to ensure that PM emissions were below 0.01 g/bhp-hr. During the final transient tests of the NEX catalysts, the PM levels measured were 0.0015 g/bhp-hr during the hot runs, and 0.007 g/bhp-hr during the cold runs, easily below the target levels.

Benefits

The benefit of this project is reduced NOx emissions. By simply increasing the cell density of the catalyst substrate of the base gasoline catalysts (thus greatly increasing surface area), it has shown an 85% reduction in NOx. Future projects using even higher cell-density substrates are planned that may further reduce NOx emissions.

Since the majority of heavy duty vehicles in the South Coast Air Basin are powered by diesel engines which produce higher NOx levels and particulate matter, the introduction of this very low NOx CNG engine would greatly reduce overall emissions for this vehicle type. Although it may be possible for diesel NOx emissions to be reduced to the levels currently achieved by CNG engines, their increased cost and reduced fuel economy will lessen the marketability of such a diesel engine. The immediate implementation of low NOx CNG engines is clearly the simplest means of achieving clean air goals.

Project Costs

The total project cost was $233,730US. This includes emissions testing by Bodycote Materials Testing Inc, and labor, travel and administration costs by GFI. AQMD contributed $140,000US to this project.

Commercialization and Applications

The intended application of this engine technology is for medium duty vehicles such as airport shuttle vans, rental car and hotel shuttle vehicles, and small delivery vehicles. With the increasing CNG distribution infrastructure, the viability and practicality of a low NOx CNG engine increases, as do its commercial benefits. With respect to the clean air goals of the South Coast Air Basin, such low emission vehicles are more environmentally attractive than any other commercially viable vehicle on the market today. Further discussions between TeleflexGFI and GM will need to be conducted before additional commercial and costing analysis can be performed.

INFRASTRUCTURE AND FUEL PRODUCTION

AQMD Contract # 99118 *November 2002*

Development and Demonstration of all Hydraulic NGV Compressor

Contractor

OceanAir Environmental, 4220 Donlon Road, Somis, CA 93066

Cosponsors

South Coast Air Quality Management District, cities of Calabasas, Malibu, Agoura, Westlake and Hidden Hills

Project Officer

Gary Dixon

Background

A major barrier to the market penetration of NGVs is the high cost faced by public and private fleets to purchase, install and operate NGV refueling stations. AQMD has recognized the need to demonstrate low cost, reliable NGV fueling technologies. An innovative, all-hydraulic NGV compressor with potentially lower capital and operating costs than conventional compressor systems will help meet that goal.

Project Objective

The advanced compressor refueling station will refuel NGVs owned and operated by the other participants in the project, namely the cities of Calabasas, Malibu, Agoura, Westlake and Hidden Hills with those cities paying for the natural gas used.

Technology Description

The NGV fueling system is based on OceanAir's Green Compressor (patent pending) including Green's "rest and compress" process, incorporating high pressure hydraulics to compress gases to extreme pressures with high efficiencies. Using Green's polished hard chrome process compression chambers, and graphite impregnated solid rings, coupled with Green's low rpm, friction is virtually eliminated. Blowby is totally eliminated by Green's working fluid becoming a solid barrier between the piston and the gas. Also differential pressure on rings is reduced from as much as 5000 psi in conventional compressors to a maximum of 12 psi in all Green compressors operating above 200 psi. All interior and exterior components of Green compressors are liquid cooled. Compression gas is maintained at temperatures near ambient during all stages of compression.

When used to compress potentially dangerous gases the power source (electric or gas drive motor) can easily be isolated 20 or more feet from the compressor, making it very safe and quiet. Lubrication is eliminated since the working fluid provides all of the necessary lubrication. Low temperatures and low rpm virtually eliminate wear. No maximum inlet pressure is required for this compressor, higher inlet pressures result in greater output.

Conventional compressors are based upon the design of internal combustion engines with rods, pistons, bearings, crankshafts, seals, steel piston rings, unavoidable blowby and high temperature operation. Air cooled compressors and intercoolers require major rebuild every 1500 to 3000 hours of operation.

Status

This project was completed on November 27, 2002 and the final report is on file with complete technical details of the project. Problems encountered during the demonstration included the lack of commercially available components for the following equipment:

1) Reliable 5,000 psi and hydraulic pumps. In reality almost all of the pumps that are rated for high pressure or intermittent high pressure have a degraded lifecycle proportionate to the amount of high pressure use. We developed a hydraulic intensifier that allows the system to keep maximum pump pressures below 2000 psi and still have output hydraulic pressures above 5000 psi;

2) 5000 psi pneumatic valves that are bubble tight and in direct proximity to the compression chambers. The manner in which our compressor operates, slow rpms and low velocity creates a problem of not seating the valves. High presure pneumatic valves were used and incorporated in to the compressor head designs. The use of twelve of these valves in each machine adds to the safety redundancy between the high pressure and the supply;

3) Hydraulic control valves first stage. Due to violent oscillation and vibration when the cycle reversed, we used an accumulator in conjunction with the

conventional valves. The net result of that installation was a softening of the impact at the end of each stroke. Used with a four-way valve the problems were addressed;

4) Hydraulic control valves second and third stages. The only practical commercial control valves were solenoid operated pilot valves to control specially designed valves handling hydraulic fluid;

5) Hydraulic self-centering 3-axis piston retract valve. This valve is fully submerged in the working fluid. This valve had to be designed to center itself within the compression cylinder to less than 0.001 centricity with no outside influence;

6) Hydraulic/pneumatic rings and seals. In these stages there is a direct piston barrier between the working fluid and the compressed gas(CNG);

7) Heat exchanger and related components. The system needed a large unit that would be placed outside requiring specially fabricated housings and mountings;

8) Electronic control package.

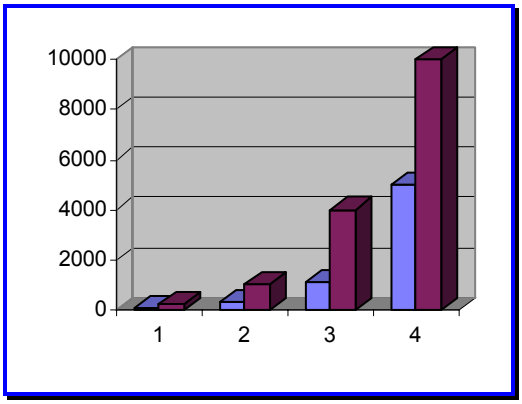
This had to be developed from scratch and is an analog CMOS circuit with a PLC backup for the larger units but the CMOS circuit remains the most promising at the present time.

Results

The compressor system was successfully deployed in operation at Mac Chevron gasoline station in Calabasas, CA. The site was an existing CNG station using a conventional Norwalk 125 scfm compressor. The hydraulic system pumps and control system were installed inside of an explosion proof building enclosure. The compressor module was immersed in a tank of hydraulic fluid for heat transfer purposes and was placed outside of the building. An air cooled unit was installed with a recirculation pump to cool the hydraulic fluid inside the tank.

The unit was supplied with inlet natural gas taken downstream from the filters and the output was sent to the existing coalescing filters which feed into the CNG storage tanks. During initial testing of the system the cooling system proved to be inadequate and was replaced by a water cooled plate exchanger. The noise level of the system was estimated to be 20 db. Cooling was adequate for outlet pressure of 3600 psi. Supplied gas was free from entrained oil. Gas delivery temperature was within acceptable limits.

Comparison of Green Vs. Conventional



X-axis-Compression, Y-axis-Pressure psia

Benefits

Capital cost savings are realized by the siting flexibility inherent in the hydraulic compressor. The hydraulic drive unit may be physically isolated from the actual compressor module, thus avoiding the expense of an explosion proof drive motor. This siting flexibility allows the placing of hydraulic compressor based NGV refueling stations into irregular shaped areas, thus increasing siting flexibility.

Conventional compressors require frequent oil changes and replacement of intended wear parts due to high operating speed. Slow speed operation of the hydraulic compressor is projected to virtually eliminate wear part replacement. The hydraulic compressor does not require periodic oil changes and relies on hydraulic fluid from the drive unit for lubrication. As a result of smooth operation, reliability and availability will be enhanced.

We estimate that the cost of compression will be reduced by 30%, cost of maintenance will be reduced

by 70%, and the capital cost will be 40-50% of a conventional unit. Additionally, the benefits of a hydraulic unit will include easier permitting due to less noise and smaller footprint as well as improved safety (no high speed or high temperature parts). The environmental and cost benefits will make this unit attractive to potential customers.

Project Costs

The seven tasks established for this project were funded by the AQMD as follows:

Task 1 - Complete scale up design. $20,000

Task 2 - Complete fabrication and testing of compressor. $75,000

Task 3 - Complete NGV station site analysis, deisgn and equipment selection $40,000

Task 4 - Complete procurement of all NGV station components $20,000

Task 5 - Complete permitting, field installation and commissioning of station $15,000

Task 6 - Complete field evaluation and monitoring of station performance & reliability $10,000

Task 7 - Reporting $20,000

Total AQMD cost **$200,000**

Commercialization and Applications

The limited field testing to date has shown excellent working of the compression system design. However, before full commercial success can be claimed, the unit must accumulate substantial run time, trouble free, in the field. The commercial testing at the Chevron revenue station will continue and additional data will be accumulated. We anticipate the commercial demonstration to be complete in 120 days, following which, the unit should be available for commercial sale in revenue service NGV installations.

AQMD Contract # 00071 ***December, 2001***

Develop and Demonstrate Advanced High Capacity, High Performance NGV Storage Tank

Contractor
QUANTUM Technologies, Inc.
(subsidiary of IMPCO Technologies, Inc.)

Cosponsors
N/A

Project Officer
Mr. Gary Dixon, AQMD Program Manager

Background

Natural Gas (Methane) fuel offers very low emissions of ozone-forming hydrocarbons and carbon monoxide, when compared to conventional liquid fuels. It can be produced economically from a variety of feed stocks, including renewables, and represents an excellent fuel medium for fleet vehicles.

Utilization of Natural Gas fuel is an effective way to achieve LEV, ULEV, or lower emission levels. Currently, Natural Gas Vehicles (NGV's) have not been marketed in significant volumes due to increased cost and decreased range. The primary opportunity to reduce cost and improve range is in the on board fuel storage area. On-board fuel storage remains a major issue for NGV's for two primary reasons: (1) high pressure tanks are expensive, (2) large volume tanks are unavailable.

Manifolding of a number of smaller tanks is expensive and there are weight penalties and safety issues. Economic, high volume, lightweight, gaseous fuel storage systems are urgently needed to improve the business case for a number of dedicated natural gas vehicle applications.

Project Objective

The objective of this project is to reduce cost and improve reliability of natural gas powered pickup trucks and medium/heavy duty vehicles, thereby improving their market appeal. This objective is in line with the 1994 Air Quality Management Plan, which emphasizes the use of alternative fuels throughout the transportation sector as an air quality management strategy.

The program consists of the pilot, prototype validation and application demonstration stages, leading to commercial production.
Utilizing the IMPCO "TriShield" © fuel tank design provides the benefits of cost, performance and reliability while reducing fuel system emissions.

Reduction in storage system weight translates directly into improved load capacity and fuel economy.

It is expected that commercialization of a reliable, light-weight, and cost-effective fuel storage tank will help accelerate the penetration of heavy duty NGVs' and thus, cleaner vehicles.

Technology Description

QUANTUM has developed lightweight, high volume fuel storage tanks that are specifically designed for enhanced on-board storage in NGV's. The critical design features of the QUANTUM design are:

- **Cost:**
Utilization of a low cost manufacturing approach that offers selling price comparable to, or lower than that of steel tanks, depending on purchase quantity.

- **Performance**:
Burst pressure of 11,000 psi (37% improvement over the current standard of 8,100 psi).
Weight optimized (70% weight reduction compared to steel design).

- **Reliability:**
Designed, manufactured and tested in an ISO 9001 compliant facility to stringent automotive OEM standards (QS 9000/APQP). "TriShield" design offers (1) a polymer liner for extreme temperature performance and two independent gas seals, (2) a carbon fiber structural shell to minimize corrosion and fatigue degradation, and (3) a tough external husk to protect from impact, abrasion and gouge damage.

Status

Task 1 "Pilot Equipment Adaptation" was successfully completed, with the completion of PFMEA (process failure modes and effects analysis) to minimize process risks. Pilot equipment was adapted to volume production through equipment optimization and implementation of systematic procedures, leading to a successful ISO 9001 registration.

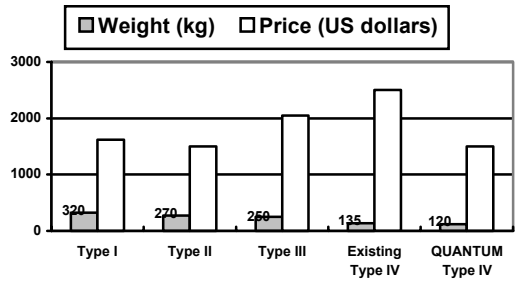
Task 2 "Prototype Build and Validation" is now in progress. Two different sizes are being addressed: (a) 20-gallon size (b) 14-gallon size (bus market).

Based on already proven QUANTUM design philosophies, prototypes have been built and development and validation tests have been successfully completed.

Task 3 "Application Demonstration: Vehicle Testing" was completed. The 20-gallon tank was installed on a GM pickup truck while the 14-gallon tanks were installed on a SunLine Transit "Hythane" bus.

Results

As indicated in the following chart, which compares the weights and costs of various CNG storage options (20-gallon storage), the new tank is lightweight and cost-competitive.



Type I: All Steel

Type II: Steel/Glass or Steel/Carbon Hoop Wrap

Type III: Aluminum/Full Wrap

Type IV: All-Composite Hybrid

Type IV: QUANTUM "TriShield"

Shown in the following table are some relative advantages of the "TriShield" tanks.

Fuel Storage: TriShield Tanks

	Type I	Type II	Type III	Type IV (Existing)	QUANTUM "TriShield"
Mechanical Durability	++	+			+
Environmental Durability		+ (Carbon Wrap)			++
Design Redundancy		+			+
Size (20" Dia.)					+
Weight				+	++
Lead-Time					+
Price	+ (Dia. <16")				+

A (+) sign indicates an inherent advantage of one technology over alternatives.

The tanks are designed to meet the performance requirements of: (a) DOT FMVSS 304; (b) ANSI/AGA NGV2 – 1998; (c) NGV2-2000; (d) Automotive OEM validation criteria

The project objectives in terms of cost and performance have been achieved. Reliability has been fully established.

Tests completed include:

Validation Requirement	Status
Pressure Cycling #1 (Amb Temp)	100,000 Life Cycles Complete
Pressure Cycling #2 (Amb Temp)	Passed
Hydro Burst #1	11,375psi (8,100psi Reqd.)
Hydro Burst #2	Passed
Hydro Burst #3	Passed
Penetration	Passed
Accelerated Stress Rupture	Passed
Bonfire w/ Dual PRD's	Passed
Drop Test followed by Cycling	Passed
Extreme Temperature Cycling	Passed
Corrosion Exposure	Passed
Flaw Tolerance	Passed
Vibration/Shock	Passed
OEM Crash Tests	Passed
OEM Durability Tests	Passed

Benefits

Replacement of gasoline or diesel with natural gas provides significant emissions reductions. For example, it is estimated that during the lifecycle of 3000 ULEV certified 6.0L trucks will lead to the prevention of

approximately 200 tons of NMOG, 1500 tons of CO and 450 tons of NO_x.

Project Costs

The total actual cost for this project was $1,508,300, including $317,300 in cost-share by the AQMD. The original estimated budget was $1,420,000, with $320,000 awarded by the AQMD. The balance was funded by QUANTUM.

Commercialization and Applications

The alternative fuel transportation market is large and growing. Concerns over the pollutants released by gasoline and diesel-fueled vehicles has helped Alternative Fuel Vehicles (AFV) gain momentum, and many of the new emissions standards that have recently been enacted in the United States, Canada, and Europe may increase the penetration of AFVs.

According to the World LP Gas Association and the European Natural Gas Association, there are over 5.6 million gaseous fuel vehicles worldwide, consisting of approximately 4.1 million propane vehicles and approximately 1.5 million natural gas vehicles. Frost & Sullivan estimates that the number of propane vehicles in the United States will continue to grow at the historical rate of 1.7% to 1.9% per year and that the number of natural gas vehicles in the United States will grow at a compounded annual growth rate of 14.6% per year.

In its International Energy Outlook 2001, the Energy Information Administration of the U.S. Department of Energy has found that interest in expanding the use of AFVs is growing in many parts of the world. Over 2 million more AFVs are projected to be on the road worldwide by 2010.

As a result of this cost-shared project, this technology is now commercially available for today's market. The core technology optimized in this project is applicable to future hydrogen fuel cell vehicles, a market which is expected develop into over 2 million units by 2010.

QUANTUM TriShield tanks are now internationally recognized for their hydrogen storage efficiency, and are being used in a number of fuel cell vehicle applications by OEMs around the world.

AQMD Contract # 00193 *November 2002*

Evaluate Alternative Fuel Bus Maintenance Practices and Design Training Curriculum for Maintenance and Repair of Alternative Fuel Transit Buses

Contractor
Transportation Foundation of Los Angeles

Cosponsors
N/A

Project Officer
Connie Day

Background

In 2000, to reduce air toxic and criteria pollutant emissions in the South Coast Air Basin, the South Coast Air Quality Management District (AQMD) enacted a number of fleet rules. Rule 1192 requires public transit fleet operators with fifteen or more vehicles to acquire alternative fuel heavy-duty vehicles when procuring or leasing these vehicles.

Project Objective

The objective of this study is to evaluate existing alternative fueled vehicle maintenance and training practices in transit agencies and to develop a best practice manual to provide such information to the transit industry.

Technology Description

The Best Practices manual is a compilation of the training, maintenance, safety and shop standards of transit properties. The manual evaluates key issues and provides recommendations from experienced agencies and maintenance personnel regarding the implementation of an alternative fueled vehicle maintenance plan in transit operations.

Through sharing information between agencies and distributing illustrations of the best practices it is intended that all transit agencies may benefit from the experience of others. Additionally, identification of technologies and sharing bid costs may create financial benefits so that additional funds can be directed at further improving the alternative fuel transit fleets.

The Alternative Fuels Best Practices Manual for the Transit Industry will be made available to all transit agencies thought the Transportation Foundation of Los Angeles's web site. Use of this format will allow for quick access and the opportunity to update the manual on a continuing basis as new and better information becomes available.

Status

This project is complete. The final report was submitted to AQMD on October 30, 2002

Results

Based largely on case studies and input from the project's Task Force, the Alternative Fuels Best Practices Manual for the Transit Industry provides an evaluation of key issues and recommendations from experienced agencies and maintenance personnel regarding the implementation of an alternative fueled vehicles (AFV) maintenance plan in transit operations.

Benefits

The creation of the project Task Force provided the means for transit agencies, original equipment manufacturers (OEMs), and educators to exchange various levels of information on operation and maintenance.

Through this dialogue process, the Task Force participants began to realize that it is to the benefit of the industry that the information and resource sharing process is continued. In May 2002 initial meeting to discuss the formation of a Regional Transit Training Consortium was held with approximately 40 individuals representing 16 organizations in the transit industry, government agencies, and educators attending, many who had been participants of the Best Practices Task Force. To date, two additional meetings have been held.

Through a consortium transit agencies can share/develop curriculum and instructor resources, save on procurement. By negotiating as regional agencies with OEMs they can greatly increase the agencies ability to meet the necessary training and other requirements at the same time reducing the overall operating cost for all agencies

Project Costs

The total cost of this project was $250,000, with the AQMD contribution not to exceed $200,000. The contractor was to provide $50,000 in-kind services. The actual expense to AQMD was
$175, 513

Commercialization and Applications

The Alternative Fuels Best Practices Manual for the Transit Industry is a useful tool to insure a successful transition from the utilization of diesel fueled vehicles to alternative fuels. The best techniques and current practices provides a guide to the successful implementation, installation and maintenance of alternatively fueled buses, fueling facilities and service faculties.

The Alternative Fuels Best Practices Manual for the Transit Industry has served as a catalyst to the creation of a transit industry consortium. It is anticipated that the consortium will develop training curriculum, share resources, and coordinate the implementation of a successful transition from the utilization of diesel fueled vehicles to alternative fuels in the transportation and related industries.

AQMD Contract #02080 *October 2002*

Develop and Demonstrate Advanced Home Refueling Appliance for CNG Vehicles

Contractor

FuelMaker Corporation

Cosponsors

California Air Resources Board

Project Officer

Gary Dixon

Background

Natural Gas Vehicles (NGVs) represent one of the cleanest combustion powered vehicles on the market. Despite this performance and competitive pricing, NGVs have not penetrated beyond the fleet market.

One of the key barriers to consumer acceptance of NGVs as personal cars is the very limited publicly accessible refueling infrastructure. Fuel retailers cannot justify the capital expenditure to install alternative fuel refueling stations due to the limited number of vehicles.

Since natural gas is available in most homes, home refueling of NGVs appears to be a reasonable option. Availability of a safe and cost effective standardized home refueling appliance for compressed natural gas (CNG) can be an important step in successful commercialization of non-fleet light-duty vehicles operating on CNG.

Project Objective

The main objectives of this project are:

- Developing and demonstrating a small sized in-home CNG vehicle refueling device with no maintenance or installation requirements.
- Providing the convenience of incremental fueling with the small dryer equipped device operating on 110 volt electric outlet.
- Commercializing the in-home refueling system with an expected cost of under $1,000, and an intended life of equal to or longer than the vehicle.

Technology Description

The overall project will consist of two phases with the duration of 18 months for each phase. The goal of Phase A is to develop and produce a working Alpha-unit prototype that is ready for consumer/user testing. Phase B will implement that testing while upgrading and refining the alpha unit into a Beta-unit prototype that will be used in the final product commercialization.

Some of the features of this device will be:

- Home-based refueling using domestic natural gas and 110-volt power
- Inexpensive ($1,000) and designed to be maintenance free
- Installation can be either inside (the garage) or outside
- Provide AFV (1/10 ULEV emissions) within reach of retail market with reliable, accessible fueling
- 32% reduction in greenhouse gas emissions, 38% reduction in CO_2 emissions
- Slow-fill design allows for refueling to be done overnight when vehicle is not in use.

Status

Durability testing of two pre-Alpha prototypes is underway - the first prototype reached 550 hours, the second, 780 hours. The first Alpha prototype was successfully assembled and readied for testing. The individual component status is as follows:

Compression Module - The design is complete -- all components have been tested for functionality and performance. The flowrate and power consumption targets have been achieved. Motor selection has been confirmed.

Controls Module - The decision was taken to locate the controls internally (within the Motor End Cap) to avoid the risk of nuisance service calls as a result of minor leakage. All of the controls components have been evaluated and tested for functionality and performance. Ongoing testing is focused on durability under extreme conditions.

Electronics Module - Four discrete circuit boards are being used:

User Interface/Main Controller -- Prototypes have been built and tested. Software has been written to the point of demonstrating full functionality (stop, start, temperature pressure compensation, Dryer control, motor control, LED control, etc.).

Dryer Controller -- Prototypes have been tested.

Power Supply -- Several prototypes were built - an acceptable design was achieved. Further effort will be made to ensure that the hardware is immune to electrical spikes and other forms of interference.

Motor Controller -- Prototypes have been built and considerable debugging and redesign was necessary until a suitable design was achieved (considerable problems with component failure). Further work will be done to enhance durability and ensure that the design does not generate electrical noise.

Dryer - The single column regenerative Dryer design has been prototyped and its functionality verified (dries and regenerates within specifications). Ongoing development work is being carried out to fine-tune the regeneration components, particularly the heat exchanger, condenser and membrane. Dryer testing is ongoing to optimize timing of the drying and regeneration cycles and the operation of the individual heaters

Housing Design - Considerable effort is being expended on noise and vibration reduction through in-house modeling, prototype testing, and consultants. Design targets should be achievable as the HRA moves into the beta tooling phase.

The HRA project is proceeding according to schedule as the alpha prototypes are assembled and ready for testing. The critical path is completion of the housing design so that the injection moulded plastic components can be ordered. Finalization of noise and vibration performance is critical for completion of the design.

Discussions have been held with CSA to determine the key steps in the HRA certification. Some changes or clarifications are required to the NFPA 52 and the B108 installation codes to allow indoor installation -- at this stage these appear to be readily achievable. Further work will be required, however, to permit the use of an onboard gas detector in the HRA as a replacement for a separate gas detector installed at the "highest point in the room" -- preparatory work is underway.

FuelMaker has completed the first draft of its own FMEA and is using it as a tool in assessing the software requirements. A contract has been placed with Ryerson University to carry out a safety study including fault tree analysis.

Discussions were held with NREL and St. Croix Research regarding the DOE sponsored safety study. Non disclosure agreements were put into place. E-mails have been exchanged detailing materials to be provided by FuelMaker (training manuals, and earlier safety studies).

Results

Several pre-Alpha prototypes have been built and are currently being tested. In addition, one complete Alpha prototype (shown in the picture above) has been built and initial testing is underway. The prototypes demonstrate that the project objectives and design specifications for the HRA have been met. It is expected that the next phase of the project, the Beta prototype development, will demonstrate that the technology can be commercialized.

The possibility of increasing the flowrate from about .33 GGE per hour up to .42 GGE per hour is being evaluated. It is felt that this will better meet the expectations of owners of small commuter vehicles. A reduction in the overall service life may be necessary at the higher flowrate but the target will be to deliver the same amount of fuel and hence the same number of vehicle miles.

Benefits

The AQMP relies on the significant penetration of zero- and low-emission vehicles in the South Coast Basin to attain federal clean air standards by 2010. While not providing any direct emission reductions,

the proposed station enhancements will assist in the commercialization of natural gas light-duty private vehicles by providing a reliable source of fuel. For the Carl Moyer Program and other programs to be successful, fleets and other vehicle users must be able to rely on reliable and efficient refueling facilities. The utilization of home refueling for private vehicles will ensure a convenient, available source for overnight refueling for these vehicles at home rather than forcing the user to rely on the existing commercial infrastructure. The primary benefit of this project will be to help resolve these refueling station challenges.

The HRA is unique in that it will be the smallest VRA ever developed, ideally suited for a small commuter vehicle, such as the Honda Civic GX which uses only natural gas as its fuel and is specifically targeted at the commuter market. The Civic GX has achieved an emission level of 1/10th of ULEV, and has done so when tested for 100,000 miles. The emissions of the Civic GX, fueled by the HRA, were modeled on a "Wellhead to Wheels" basis, using the DOE's GREET Model 1.4, and compared to conventional NGV, using gasoline as a base line. It indicated a 32% reduction in greenhouse gases and a 38% reduction in CO2. Honda is supporting FuelMaker's development efforts by committing to promote the Civic GX and HRA in the consumer market. This will greatly enhance the HRA's chances for market acceptance by increasing the customers' confidence in natural gas vehicles and by creating a synergistic need for the home fueling system.

Project Costs

FuelMaker Corporation will develop and demonstrate an advanced home refueling appliance for CNG vehicles in two phases. Initial development and limited testing will be conducted in the first phase; while more extensive prototype testing is proposed for the second phase. For the first phase, DOE has allocated $100,000, ARB has allocated $250,000, and Technology Partners Canada (TPC) will provide $375,000. AQMD funding for the first phase is proposed not to exceed $500,000. Funding for the second phase, for 2002-2003, is expected at the same level from the present partners, with additional funding anticipated from DOE and CEC. Total project cost for the first phase is $1,225,000 and approximately the same for the second phase.

Commercialization and Applications

FuelMaker has designed, developed, manufactured, sold, distributed and serviced over 8000 VRAs in NGV service since it began operations in 1989. With the HRA, FuelMaker will transfer the design into commercial production following the completion of the Beta Testing Phase. FuelMaker will expand its existing production and service facilities to accommodate the increased production level expected once the HRA is fully commercialized. On the sales side, FuelMaker will make use of its existing distribution channels particularly in the first years of product introduction. As volume builds the number of distributors will be expanded. National distributors, such as Sears will be added to increase coverage particularly as consumer awareness of home fueling builds. On the international front FuelMaker will again use its existing distributor network to reach markets in Europe Asia and South America.

FuelMaker will work with American Honda to prepare marketing plans and sales campaigns for the Honda Civic GX and the HRA. This will include targeted promotions in selected geographic areas, special incentives, and coordination with state agencies. FuelMaker will work on an equal basis with other vehicle OEMs recognizing that it is necessary to reach a critical mass for the NGV industry to succeed.

FuelMaker has prepared a preliminary Business Plan showing the impact of successful exploitation of the HRA technology. The HRA market estimates are based on current sales of;

small commuter vehicles,

in non-attainment areas,

with available off-road parking,

assuming owner occupied homes,

2 vehicle families,

natural gas on-site,

local driving of 10,000 to 15,000 miles per year.

This target market represents about 160,000 vehicles per year. The Business Plan currently projects sales to reach 20,000 per year by 2007.

AQMD CONTRACT #02127 *October 17, 2002*

CONSTRUCTION OF AQMD CNG FUELING FACILITY

Contractor
Pinnacle CNG Company

Cosponsors
California Energy Commission (CEC)

Project Officer
Gary Dixon

Abstract

The South Coast Air Quality Management District (AQMD) has the responsibility to meet the requirements specified in the Clean Air Act throughout the South Coast Air Basin. A significant part of this strategy is the displacement of gasoline- and diesel-fueled vehicles with clean fueled vehicles. Implementation of this type of vehicles requires the construction of fueling infrastructure to support these vehicles. This project was initiated to provide a modern, state-of-the-art CNG fueling station at AQMD headquarters to provide fuel for AQMD as well as third-party vehicles.

AQMD operates a fleet of approximately 80 vehicles with plans to expand the CNG fleet to 160 vehicles over the next 5 years.

Background

Air Quality and health impacts of diesel exhaust have led the AQMD and others to focus attention on reducing diesel exhaust emissions from heavy-duty vehicles. The Air Quality Management Plan has identified the use of low-emission alternative-fuel engines in these vehicles as a control strategy. Alternative fuel vehicles, such as natural gas vehicles (NGVs) have demonstrated significantly lower NOx, PM and toxic emissions than diesel and gasoline vehicles. AQMD Rules 1192, 1193, 1194, 1195 and 1186.1 require the introduction of low emission, alternative fueled transit buses, shuttles, refuse trucks and street sweepers.

While these important programs have set the stage for broader use of clean fuel, low emission technologies, a major challenge to the entry of NGVs is the need for increased availability of NGV refueling stations. Currently, AQMD's compressed natural gas fleet is in critical need of adequate CNG refueling capability; in addition, there is a need for additional publicly accessible CNG fueling infrastructure in the eastern Los Angeles County region near the 60 and 57 Freeway corridors. Introducing hundreds of natural gas vehicles in the near future will require establishing fueling facilities in this and other areas to support these vehicles.

AQMD will build and operate a new natural gas fueling station at its Diamond Bar facility. This station will be designed to incorporate advanced gas metering technology as it is proven in the field. The project will provide a turnkey fast fill compressed natural gas fueling station. AQMD has filed an application and received notification of award of $169,560 from CEC under its Public Alternative Fuel Infrastructure Funding Program. Proposals from an Invitation to Bid (ITB), issued in April 2001, were reviewed by an evaluation panel and the qualified low bidder was selected for recommendation.

Proposal

At the bid closing date of June 1, 2001, AQMD received five bids. The in-house evaluation panel, consisting of the Plant Engineer; Assistant DEO of Planning, Rules and Stationary Sources; a Manager for Special Assignments with the Office of Science and Technology and a Program Supervisor in the Technology Advancement group evaluated the five proposals and based upon submitted cost, selected three of the proposals as being the most cost effective (all five submitted proposals were considered technically viable). From those three lowest bids, the lowest bid ($704,800), from Pinnacle CNG Company, was selected. In addition, Pinnacle also submitted a lower cost option ($565,200) that would result in significant savings to the AQMD. This lower cost option incorporates advanced technology that Pinnacle has patented and is unique in the industry. This system has proven its reliability in the field and was selected as a sole source offering under AQMD's Procurement Policy, Section VI B4.

The contractor was completely responsible for the turn-key installation of the CNG fueling station based on the performance specifications, project conditions

and scoping documents listed within the ITB. The nine-month project cycle has produced an operational station with the official opening ceremony planned for December 6th, 2002. The fast-fill station will be accessible during AQMD business hours (7:00 a.m. - 5:30 p.m., Tuesday through Friday except official holidays) with the option of expanding the service at some future date. Access will be gained by a card reader system designed to accept multiple credit cards. Metering design will accommodate the tie-in of advanced metering systems in parallel with the commercial system employed by the AQMD.

The new CNG fueling station is located in the lower parking/maintenance yard of the AQMD Diamond Bar facility and features drive-through access to the fueling dispensers, on-site training video and 24-hour help line, written operating instructions and emergency shut down buttons at each dispenser, security fencing around the storage tanks, and safety bollards around all equipment and dispensers. The storage vessels meet ASME specifications and the controls include a dial-out modem, computer controlled monitors and sensors, a priority/sequential panel and electrical switchgear.

The project followed the six phases listed below:

- Site assessment, project planning and design development documents
- Detailed engineering drawings and specifications
- Equipment specification, listings and acquisition
- Permit submittal and acquisition
- Field construction and installation
- Final inspection, startup and begin the operations

During the course of construction the chronological sequence of these phases required some overlap to maximize efficiency and minimize delays.

Project Objective

The purpose of this project was to provide a safe, efficient, and reliable fueling source for the growing AQMD CNG fleet of cars trucks and vans. AQMD shall operate the station for at least five (5) years after installation facilities and commencement of fuel dispensing. This station will also provide fuel to the public for non-AQMD CNG users.

CNG Technology

The specific technology utilized in the AQMD CNG station relies on a dual compressor system and a storage tank with associated smaller buffer tank. A reciprocal compressor provides the initial compression of the natural gas with a hydraulic intensifier system being used during fueling to boost the storage pressure and ensure that the vehicle tank is filled to pressure. An interactive computer/control system monitors parameters and operations and maintains system integrity.

The picture above shows inside the compressor skid including the lubricating oil reservoir, pump, reciprocal compressor and cooling fan.

Status

The AQMD CNG facility is operative (one of the three dispensers is not currently operational and is being replaced) and only the completion the final cosmetic site improvements and the decommissioning of the old CNG system are outstanding.

The facilities will not be accepted by AQMD and all payments made, until the above items have been remedied by the contractor. Nonetheless, the unofficial date of completion may be identified as the date that the Los Angeles County Fire Department

signed off on permits for the station on October 10, 2002.

Results

The new CNG station will greatly enhance the CNG vehicle network within the AQMD. It will allow expansion of our existing fleet and convenient, efficient fueling for vehicles in an area not currently covered by existing CNG fueling stations. The design of this station is also amenable to future accommodation with hydrogen fueling to produce fuel blends such as Hythane™ that can be used as bridge technologies to hydrogen fueled vehicles.

Benefits

This project is included in the March 2001 update of the Technology Advancement Plan under Project 2001 CFM3-1, entitled, "Development and Demonstration of Advanced Natural Gas Systems for Refueling Stations." The Air Quality Management Plan relies on the expedited implementation of advanced technologies and clean-burning fuels in Southern California to achieve air quality standards. The use of this station will assist in the commercialization of natural gas light- and heavy-duty vehicles by providing a reliable source of fuel. For the Carl Moyer Program, and other programs to be successful, fleets and other vehicle users must be able to rely on dependable and efficient refueling facilities.

This CNG fueling station will replace existing fueling equipment installed on-site in 1992 but has proven problematic in reliability and repairs. This slow-fill system is incapable of supporting our existing CNG fleet or the opening of our facility to third-party CNG users. The AQMD decision to upgrade our CNG fueling capability with a new CNG station was pursued independently from the CEC PON but it was, in reality, contingent upon receiving the CEC Grant. Without the CEC Grant, the AQMD would not have pursued the CNG station upgrade at this time.

The upgrade allows the AQMD to increase its CNG vehicle fleet, thereby displacing gasoline vehicles and it will also allow third-party users to fuel at our facility. This will improve the basin-wide implementation of CNG vehicles through the strengthening of the CNG infrastructure network. Over the next three years, our CNG usage with the new facility will increase by 13,300 Gasoline Gallon Equivalents (GEG) each year for a total of 79,800 GEG additional CNG pumped. AQMD estimated cost for CNG at the pump is about $1.12 per GEG; with gasoline prices estimated to be $1.75 (or higher) over the next three years, this results in direct savings of $50,274 for this cost alone. The emissions reductions resulting form the replacement of gasoline vehicles with CNG vehicles is significant and consistent with the mission of the AQMD.

Moreover, operations costs are reduced on a smaller scale, as a result of the faster throughput of the upgraded CNG facilities. For example, the fill rate for a mid-size car utilizing the displaced CNG facility was 25 minutes to 2 hours, depending upon the number of vehicles connected to the system, while the fill rate for the same vehicle using the new L/CNG facilities is about 1 1/2 minutes.

Project Costs

On September 21, 2001, the AQMD Governing Board authorized the Chairman to execute a contract to Pinnacle CNG Company for the design, construction and turn-key installation of CNG Fueling Facilities for AQMD Diamond Bar facility in an amount of $565,200 with an additional $50,000 to be added to cover change orders and modifications.

Landscaping and esthetic changes required by the Gateway Corporation (Administrators of the Gateway Corporate Center of which AQMD is a part) as well as design changes to allow for "drive through" fueling, additional security fencing, accommodations made for unforeseen charges and needs from the Southern California gas Company and electrical utility installation charges are the major additional costs for this project and will cost approximately $45,000. The total contract cost for the construction of both facilities, exclusive of the management and maintenance agreement, will be $610,200.

Various agencies provided funding for the project. The SCAQMD provided direct funding for the project and administered funding through the California Energy Commission in an amount of $610,200. Of this amount, $169,560 was provided through a grant from the California Energy Commission. The AQMD Building Corporation and General Operating Budget also paid for various permit fees and utility charges as well as providing in-kind staff labor and logistical support.

Issues Encountered

An issue that was encountered and resolved during the course of the project was the need to install a new natural gas supply line. Originally the Southern California Gas Company had assured AQMD that the existing supply line would be adequate to meet our needs for the new CNG station. However, they were unable to guarantee the service pressure originally promised (25-30 psi) and finally stated that the pressure of the gas in that line could drop below 10 psi during the winter months. After several weeks of discussions with the gas company, an alternative approach was adopted, to install a new four-inch gas supply line from a larger supply line. This required the use of a directional borer and the installation of a much larger MSA (meter set apparatus) by the gas company. This process delayed the project for about three months. The AQMD also faced a challenge in developing administrative and financial procedures that would allow the opening of the facility to third-party customers. This will be accomplished through the establishment of an Enterprise Fund to handle the fueling transactions and station overhead costs. Nonetheless, the contractor met and/or exceeded all existing *and proposed* regulatory requirements by working closely with local and state regulatory agencies. This facility represents the state-of-the-art in safety and alternative fuel technology for industrial CNG fueling applications.

Commercialization and Applications

This project provides other public and private entities with an example of high volume, state-of-the-art natural gas fueling facility. It also provides a much-needed fueling location for third-party customers operating in the Diamond Bar area which includes eastern Los Angeles County, northern Orange County and western portions of Riverside and San Bernardino Counties.

AQMD Contract #02172 ***June 2002***

Consistent Fuel Use Accounting at CNG Fueling Stations

Contractor

Energy International, Inc. (prime contractor)
Architectural Energy Corporation
Burnett and Burnette

Cosponsors

Gas Technology Institute
South Coast Air Quality Management District

Project Officer

Larry Watkins

Background

For many compressed natural gas (CNG) stations, it is common to encounter discrepancies between the amount of natural gas delivered to the station and the amount of CNG dispensed. In some cases, these differences can range from 5-20%. Discrepancies usually reveal that less fuel is dispensed than enters the station.

Fuel use accounting discrepancies impact the profitable operation of CNG stations. As a result, the growth of the CNG infrastructure can be inhibited if CNG station operators are unwilling, or unable, to accept risks associated with uncertain fuel use.

Project Objective

The objectives of this project were twofold. First, determine why discrepancies exist between the metered amount of natural gas entering a CNG fueling station and the metered amount of CNG leaving the station. Second, provide recommendations that will mitigate fuel measurement differences.

A CNG station was selected for evaluation. The station (referred to as Station A) served primarily taxis and small buses and had a natural gas throughput of 3-5 million scf/month. Records indicated that the station had a historical fuel variance of approximately 10% "lost" fuel per month.

The station had a pressure corrected displacement meter to measure fuel entering the station. A temperature correcting device and a mass flow meter were added at the inlet to provide three measurements of the natural gas entering the station: 1) displacement meter with pressure correction only, 2) displacement meter with both pressure and temperature correction, and 3) mass flow meter.

The fuel, at up to 3,000 psig, was dispensed from a single island with two hoses. Each of the two dispensers used a Micro Motion DH-25 mass flow meter to measure flow.

Status

The project is complete and a non-confidential final report, dated June 2002, is on file with complete technical details.

Host CNG Station

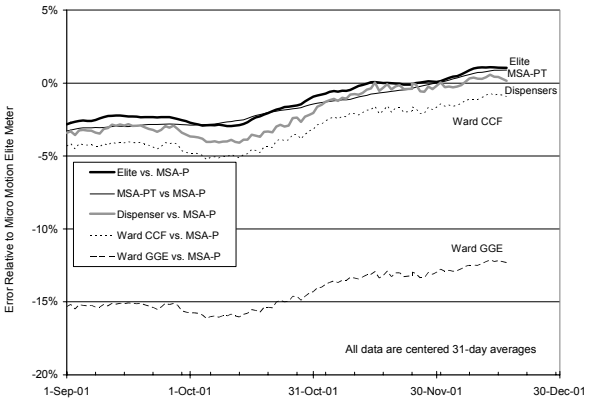
Results

The data acquisition hardware and metering equipment were first installed and then checked for proper operation. A total of five months of data was then collected and analyzed.

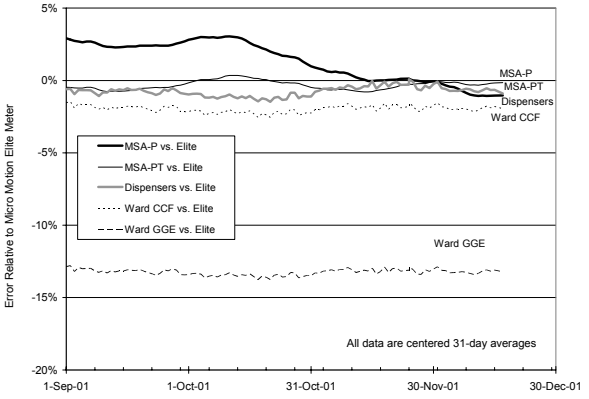
The results of showed that for this particular CNG station the following factors contributed to the fuel use discrepancies:

- Pressure corrected displacement meter did not account for temperature variations
- Data handling introduced errors

After correcting these errors, the fuel use discrepancy for this particular CNG station was reduced from a range of 10-15% to approximately 1%.



Meter Discrepancies Relative to Pressure-compensated Displacement Meter



Meter Discrepancies Relative to Micro Motion Elite Mass Flow Meter

Benefits

The results of this project are expected to help CNG station operators identify specific causes for fuel use imbalances and then take steps to mitigate problems. The results should help both CNG station operators and fuel providers gain confidence in obtaining accurate meter readings.

Project Costs

The total cost of the project was $220,000. The Gas Research Institute provided $200,000 and the South Coast Air Quality Management District provided $20,000.

Commercialization and Application

This project covered the evaluation of a moderate capacity public access CNG station. However, there are many station designs and unique vehicle fueling patterns in the CNG industry, and the results of this project may not apply universally for all CNG stations. Therefore, it would be beneficial to analyze a different type of station (e.g., a high capacity transit facility) to ensure that the results of this project can be used broadly within the CNG industry.

AQMD Contract # 02186 *December 30, 2002*

Construction Of Jurupa Unified School District CNG Fueling Facility

Contractor

Weaver Electric

Cosponsors

County Of Riverside

Project Officer

Gary Dixon

Background

Air Quality and health impact studies of diesel exhaust for children on school buses have led the Jurupa Unified School District to look at providing a cleaner way to transport their students. The Jurupa Unified School District has recognized the use of low-emission alternative-fuel engines such as Compressed Natural Gas to accomplish this goal. South Coast Air Quality Management District Rule 1195 require the introduction of low emission, alternative fueled school buses which paved the way for the Jurupa Unified School District and the SCAQMD to provide cleaner running school buses for our district. With the change from old diesel school buses to new CNG school buses the district has a need to provide a fueling source near by. Because the closest CNG fueling station is approximately 5 miles away, Jurupa Unified School District's need for an adequate CNG fueling infrastructure is critical.

We also have a desire to help in the crucial need of CNG fueling stations to the public. At this time we will open semi publicly to other government agencies. We are located off the 60 freeway at Pedley Road with easy access to the 15 freeway.

Jurupa Unified School District has filed an application and received notification of award of $125,000 for the fueling facility and $109,826 for Storage Tanks from the South Coast Air Quality Management District.

Project Objective

The purpose of this project is to provide a safe, efficient, and reliable fueling source for the growing Jurupa Unified School District's CNG fleet of school buses. Jurupa Unified School District shall operate the station for at least five (5) years after installation facilities and commencement of fuel dispensing. This station will also provide fuel to other government agencies for CNG users.

Status

The Jurupa Unified School District's CNG facility is operative. The CNG fueling facility was operative on 12-18-01 (at which time it was inspected and signed off on permits). The Storage Tanks were operative and inspected on 10-9-02.

Results

The Jurupa Unified School District's CNG station will greatly enhance the CNG vehicle network within the AQMD. It will allow expansion of our existing fleet and convenient, efficient fueling for vehicles in an area not currently covered by existing CNG fueling stations.

Benefits

The use of this station will assist in the commercialization of natural gas light- and heavy-duty vehicles by providing a reliable source of fuel.

The new facility allows the Jurupa Unified School District to increase its CNG vehicle fleet, thereby displacing diesel vehicles and it will also allow third-party users to fuel at our facility. This will improve the basin-wide implementation of CNG vehicles through the strengthening of the CNG infrastructure network. The emissions reductions resulting form the replacement of diesel vehicles with CNG vehicles is significant and consistent with the mission of the AQMD.

Project Costs

On May 21, 2001, the Jurupa Unified School District awarded a contract to Weaver Electric, Inc for Design, Permitting, Equipment Procurement and Installation, and Construction of a Compressed Natural Gas (CNG) Fueling Station at JUSD Transportation facility. In May 7, 2002 the Jurupa Unified School District awarded a contract to Weaver Electric, Inc for Design, Permitting, and Installation of Storage Vessels for Compressed Natural Gas (CNG) Fueling station at the JUSD Transportation facility. Total cost for both projects is $504,435.

Commercialization and Applications

This project provides other public entities with an example of high volume, state-of-the-art natural gas fueling facility. It also provides a much-needed fueling location for third-party customers operating in the Riverside area, which includes eastern Los Angeles County, western portions of San Bernardino Counties.

ELECTRIC/HYBRID

AQMD Contract # 99068 *August 2002*

Establish Electric Vehicle Loan Program for Government Agencies

Contractor

California Air Resources Board (ARB) with the Sacramento Municipal Utility District as the subcontractor.

Cosponsor

Contributions were made by the United States Environmental Protection Agency (U.S. EPA) and the Office of Fleet Management, California Department of General Services (DGS).

Project Officer

Lisa Mirisola

Background

Many public agencies and fleets may have heard about electric vehicles (EVs), but few have driven them. To encourage EV leases and to expose government representatives, public agencies and fleets to EV technology, the short-term ev Loan Program was launched in 1998. Through the ev Loan Program, State and local governmental agencies can experience the many benefits of EVs.

Project Objective

ARB's zero emission vehicle (ZEV) program is a critical part of achieving California's health-based air quality standards. The ev Loan Program helps increase awareness of new advanced vehicle technologies such as battery electric vehicles.

The objectives of the ev Loan Program are to provide public agencies with:

- A no-risk opportunity to experience the many benefits of electric vehicles.
- The ability to gain "real-world" experience with electric vehicles.
- The opportunity to develop a good understanding of vehicle range, reliability, and operating costs.
- The ability to determine if these vehicles meet their needs.
- The chance to make an informed decision on whether to lease an electric vehicle.
- The ability to showcase the agency's concern about environmental issues.

At no cost to program participants, the *ev* Loan Program provides:

- An electric vehicle for one to two months.
- Temporary installation of any charging infrastructure that is needed.
- A toll-free phone number for program and vehicle questions.

ARB staff would deliver the vehicle to the participating agency and train staff in the use of the EV. After the loan, agencies had the opportunity to evaluate the vehicle and describe their experiences. If they decided that EVs would make a good addition to their fleet, ARB and DGS would help them lease a vehicle and arrange for installation of charging equipment.

Technology Description

The ev Loan Program made use of different EV technologies. Lead Acid battery vehicles such as the EV1 and Nickel Metal Hydride technology in the RAV4, Honda EV Plus and Ford Ranger. All vehicles performed well for this program. At the completion of the project, 8 EVs were being used in the program. They included 2 Honda EV Pluses, 3 RAV4 EVs, 1 GM EV1 and 2 Ford Ranger EVs.

Status

The South Coast ev Loan Program was completed in May 2002. The ARB alone is continuing the program in the South Coast Region as part of the statewide ev Loan Program.

Results

The ev Loan Program allowed 40 agencies in the South Coast Air Basin to participate in over 120 loans. This is because, many agencies tried several different EVs that were available through the program. Of these 40 agencies, 5 agencies leased approximately 10 electric vehicles.

As stated earlier, the initial goal of the program was to increase EV leases. However, from 1999-2001, the EVs offered through the ev Loan Program were not available for lease. Therefore, this is not an

adequate measure of the success of the program. The program success is based on the fact that most people that tried one EV continued to participate in the program and exposed its employees and customers to this technology.

Benefits

The ev Loan program resulted in many benefits to EV technology and air quality. The program exposed many public agencies, fleet managers and government representatives to new electric vehicle technologies. Increasing awareness and exposure to EVs is critical to the success of EVs and the ARB's ZEV program. In addition, 25% of the participating agencies used the EV for outreach and public education. This was not a requirement of the loan, however was an added benefit of the Program.

Project Costs

The South Coast AQMD contributed $80,000 for temporary infrastructure installations.

The U.S. EPA contributed $250,000 for procuring electric vehicles.

The ARB contributed $205,000 for vehicles and $98,000 for infrastructure funding.

The DGS provided $16,000 for infrastructure funding.

AQMD Contract # 00164 *March, 2001*

Evaluate Hybrid Electric Vehicles

Contractor

Electric Power Research Institute

Cosponsors

Electric Power Research Institute
California Air Resources Board
Sacramento Municipal Utilities District
General Motors Corporation
US Department of Energy

Project Officer

Lisa Mirisola

Background

The Electric Power Research Institute (EPRI) has brought together a diverse group of stakeholders to study the energy efficiency, environmental impact, performance, cost, and market potential of different hybrid electric vehicle (HEV) configurations. HEV technologies have tremendous potential to reduce the environmental impacts of transportation and are just beginning to enter the marketplace.

In 1998, and subsequently in 2001, the ARB modified the ZEV Mandate to incorporate HEVs as an optional technology to satisfy up to 60% of a manufacturer's ZEV requirement. There are a number of different applicable HEV designs, each with different benefits and impacts.

Project Objective

The objective of this work is to develop a thorough methodology for the evaluation and comparison of HEVs. This project analyzed the technical, economic, environmental, and customer preference aspects of HEVs, including:

- Development of various HEV architectures and modeling their efficiencies and environmental performance based on different driving cycles.
- Determination of the anticipated component and vehicle costs and for each configuration.
- Assessment of customer acceptance and preferences for each alternative.
- Evaluation of commercialization issues and strategies.

Technology Description

The hybrid vehicles currently entering the marketplace are "fuel-only" HEVs and are not capable of "plugging-in" for recharging. This study compares conventional vehicles, fuel-only hybrids, and "plug-in" hybrids, vehicles that are capable of grid-charging and of operating in all-electric mode, using only onboard energy storage for between 20 and 60 miles of driving.

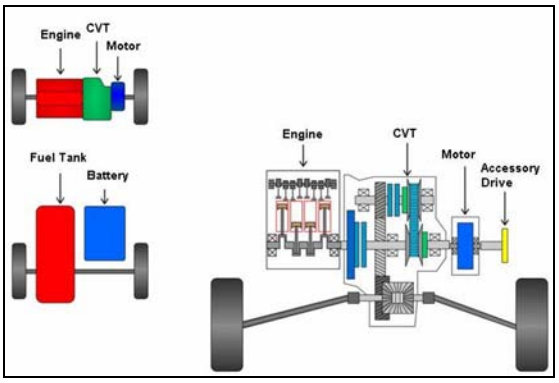


Figure 1. Powertrain layout of an HEV.

Status

This project is complete. EPRI has issued two technical reports that are on file at AQMD, free to the public, and can be downloaded over the internet. The first report, *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options* (EPRI ID #1000349, July 2001), explains the development of EPRI's methodology and applies it to a midsize passenger sedan. The report details performance, efficiency, emissions, cost, and customer preference data for four vehicle configurations, a conventional production sedan, a HEV with zero electric range (HEV0), and plug-in

HEVs with 20 miles and 60 miles of electric range (HEV20 and HEV60, respectively).

The second report, *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options for Compact Sedans and Sport Utility Vehicles* (EPRI ID # 1006892, July 2002), expands the study to include a total of four common vehicle platforms, from small cars to fullsize sport utility vehicles.

Results and Benefits

The main findings and conclusions from this study were the following:

- HEVs with zero to 60 miles of electric range can be designed on a variety of vehicle platforms from compact sedan to fullsize SUV to have performance and operation comparable to conventional vehicles.
- All HEV designs offer major efficiency and emissions benefits over conventional vehicles, will be more expensive to manufacture, and will have lower operating costs.
- All HEV designs reduce full fuel cycle smog precursor emissions. Assuming that all vehicles meet the SULEV PZEV emissions standard, Figure 2 shows the total per mile NO_x and HC including tailpipe, evaporative, power plant, and refinery emissions.

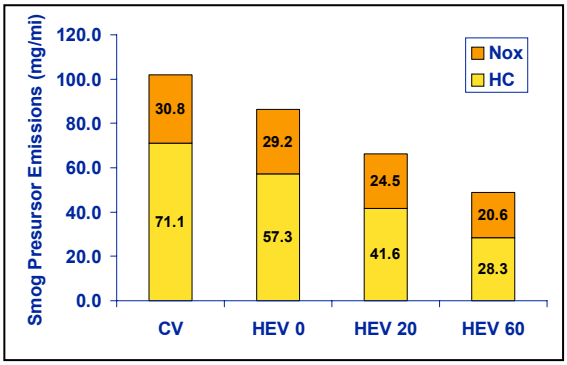


Figure 2. Midsize vehicle emissions.

- The efficiency and environmental benefits increase with HEV electric range capability. For midsize vehicles, a HEV 0 can reduce smog precursor emissions by up to 15% and petroleum consumption and CO_2 emissions by 25%. An HEV 60 can reduce smog precursors and CO_2 emissions by 50% and petroleum consumption by over 75%.
- These benefits also increase with increasing vehicle size. A full-size SUV HEV 60 can reduce emissions by 55%, CO_2 emissions by 60%, and petroleum consumption by 85%.

Project Costs

The table below shows the contributions of each project participant.

Participant	Funding
South Coast AQMD	$ 300,000
California Air Resources Board	$ 300,000
EPRI (including member utilities)	$ 814,194
Sacramento Municipal Utility Dist.	$ 75,000
Total	**$1,489,194**

In addition, General Motors provided an estimated $300,000 of in-kind support and the University of California, Davis and the U.S. DOE provided significant in-kind analysis and modeling support.

Commercialization and Applications

The market assessment phase of the study show significant levels of customer interest in HEVs, even at higher cost. For midsize vehicles 35% to 46% of the respondents would choose an HEV 0 over a conventional vehicle, 35% to 47% would choose an HEV 20 over a conventional vehicle, and 17% to 33% would choose an HEV 60 over a conventional vehicle.

Plug-in hybrid electric vehicle technology is an evolutionary step in automotive development. The electric drive systems, power electronics, charging systems, and energy storage technologies required by these vehicles have already been demonstrated in production electric vehicles and charge-sustaining hybrid vehicles (Prius, Insight, etc). Advancements in battery performance and cycle life will improve the case for plug-in HEVs, but the there are no major technological hurdles in the way of commercialization.

Considering current automotive product development cycles alongside the continuous improvement cost reduction of battery and electric drive technologies, plug-in HEVs could enter the market as early as 2007.

EPRI, with co-funding by SCAQMD and CARB and participation by major auto manufacturers, is engaged in the next phase of this work, which will seek to strengthen the technical and business case for plug-in HEVs, expand their range of benefits, incorporate advanced technologies such as fuel cells and vehicle-to-grid power, and demonstrate these technologies with prototype vehicles.

AQMD Contract # 00192 *December 2001*

Demonstrate and Evaluate U.S. Postal Service Electric Carrier Route Vehicles

Contractor
So. California Edison Co.
Electric Vehicle Technical Center

Cosponsors
USPS
DOE

Project Officer
Lisa H. Mirisola

Background

In December 1998 the United States Postal Service (USPS) issued Specification USPS-E-PURC for the procurement of six Pilot Model Electric Carrier Route Vehicles (ECRVs) "for examination and testing…to prove that the production methods will produce vehicles that meet the requirements specified herein". A year later the USPS announced that Ford Motor Company had been selected to build the first 500 units of a demonstration program aimed at a nationwide deployment of ECRVs. Subsequently, in April 2000, the USPS and South Coast Air Quality Management District (SCAQMD) selected Southern California Edison (SCE) to perform Baseline Performance and Accelerated Reliability Tests at the Electric Vehicle Technical Center (EVTC) in Pomona, California, with oversight of the Department of Energy (DOE) Field Operations Program.

Project Objectives

The following objectives were set at the beginning of the project:

- Understand USPS Mission Requirements
- Review USPS ECRV Characteristics
- Review Existing Field Operations Test Procedures
- Confirm Relevant Existing Procedures
- Propose USPS Specific Procedures
- Finalize Alternate Procedures
- Conduct Tests
- Prepare Test Reports

And the following tasks were included in the contract:

- Task 1: Baseline Test Procedure Evaluation and Modification
- Task 2: Accelerated Reliability Test Procedure Evaluation and Modification
- Task 3: Baseline Test Two EVs
  - 2 Months, 10 Tests
- Task 4: Accelerated Reliability Test Two EVs
  - 1 Year, 20,000 Miles Minimum

Technology Description

Manufacturer: Ford Motor Company
CARB Certification: Zero-Emission Vehicle
Curb Weight: 4,950 lbs
Payload: 1,250 lbs
Range: 50 miles
Maximum Speed: 60 mph

Traction Motor Type: AC Induction
Traction Motor Power: 90 HP
Transaxle: Single speed – rear wheels

Battery Type: Lead-Acid
Battery Voltage: 39 modules X 8 Volts = 312 Volts
Battery Weight: 2,000 lbs

Charging System Type: Conductive
Charging System Voltage: 240 Volts
Charging System Current: 24 Amperes
Charging System Location: On-board
Charging Time: 5 hrs

Status

As of December 2001, all the project objectives had been met and all the tasks of the contract had been completed.

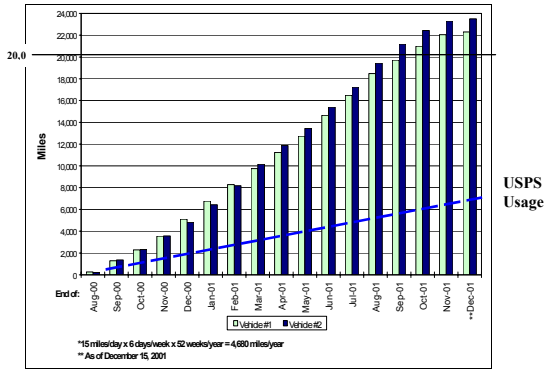
Results

The following Baseline Tests were performed and produced the results tabulated in the "Requirements" column:

Test	Requirements	
	Met	Exceeded
Acceleration		✓
Maximum Speed		✓
Braking	✓	
Gradeability	✓	
Road Handling	✓	
Water Test	✓	
Dynamometer Range	*	*
Road Range	*	*
Battery Charging	✓	
Sound Levels		✓
EMF Levels	NA	NA
Compatibility with Electrical Devices	✓	

*USPS required 50 miles on UDDS cycle. Tests were performed with UDS/HWFET on the dynamometer.
N/A: Measurements only – no required value.

The Reliability Tests met the 20,000-mile goal as seen below:



Vehicle Component Reliability was tracked and is summarized as follows:

Component	Number of Incidents	
	Vehicle No. 1	Vehicle No. 2
Traction Battery	5	2
Charging System	2	2
DC/DC Converter	1	
Battery Control Module	1	
Power Steering		1
Shift Indicator		1

Baseline performance testing determined that the vehicles met all the USPS requirements tested except range on a dynamometer with the UDDS driving cycle (only the UDS/HWFET cycle could be tested). During Accelerated Reliability testing, the long-term suitability of ECRVs for USPS was assessed by driving as many miles as reasonably possible with two vehicles during the test period. From August 2000 to December 2001, a combined total of 45,813 miles had been logged with the two vehicles. Vehicle operation, efficiency, and reliability were carefully documented by these tests. One vehicle recorded 97.5% availability during the period. The other achieved 98.6% availability. Some concerns were raised regarding the management (battery charging and maintenance software) of the traction batteries and its impact on battery life and vehicle efficiency (AC kWh/mile).

Benefits

The ECRVs tested are zero-emission vehicles and are replacing gasoline-powered mail carriers driven approximately 5,000 miles per year. SCE assumes that each EV of its fleet eliminates 0.24 lbs of pollutants per mile driven. Therefore, a fleet of 500 ECRVs, as current USPS plans call for in their first phase of deployment, driven 5,000 miles per year would eliminate 0.24 X 500 X 5,000 = 600,000 lbs or 300 tons of pollutants per year.

Project Costs

SCE met its schedule and cost targets, and at the completion of the project, all billing was conducted in accordance with the original contract and the authorized budget of $399,617.

Commercialization and Applications

At the end of the project, ECRVs were being deployed by the USPS in Southern California and other parts of the U.S. User feedback was good and the vehicles were meeting their mission requirements. The photograph below shows the ECRVs operated at the Fountain Valley USPS site and being charged at their charging stations.

AQMD Contract # 01022 *September, 2002*

Develop and Evaluate Battery Dominant Hybrid Electric Vehicle Systems

Contractor

University of California at Davis - Office of Research UC Davis Hybrid Electric Vehicle Research Center, Dept. of Mechanical and Aeronautical Engineering

Cosponsors

Defense Advanced Research Projects Agency
Sacramento Municipal Utilities District
South Coast Air Quality Management District

Project Officer

Lisa Mirisola

Background

Transportation is the largest and fastest growing sector of energy use in California and automobiles consume a majority of this energy in the form of petroleum products. By displacing energy from mobile petroleum combustion with grid-electrical energy, Battery Dominant Hybrid Electric Vehicles (BDHEVs) have the possibility to dramatically change the way that transportation energy is consumed in California, with benefits in terms of reductions in petroleum use, criteria pollutants, greenhouse gases and other factors.

Figure 4. *Sequoia,* Experimental BDHEV Suburban #1

Project Objective

At present, battery dominant HEVs exist only in an experimental stage of development. Further development of the BDHEV requires validated vehicle simulations, highly optimized experimental vehicles and accurate, repeatable testing and evaluation of the vehicle performance. To those ends, the global objectives of this research project consist of:

1. Further development of light-duty in-line parallel HEV powertrain technology in an effort to achieve 3x fuel economy in a five-passenger sedan.
2. Development and fabrication of a medium duty-in-line parallel HEV powertrain system and controls, integration of the powertrain and control systems into a Chevrolet Suburban and optimization of the powertrain for reliability and test durability.
3. Testing and evaluation of the overall performance of the light and medium duty parallel HEV powertrain systems and vehicles by obtaining component and system test data in the laboratory and from real-life driving conditions.

Technology Description

A BDHEV can accept off-board electricity to recharge the vehicle's battery pack. This allows the powertrain control strategy to utilize energy from two sources: utility grid electricity and a liquid or gaseous fuel such as gasoline, diesel or natural gas.

By using electricity as the primary fuel source, a well-designed battery dominant vehicle can realize gains in vehicle purchase price, overall vehicle operating costs, all-electric range capability, tailpipe emissions, total "upstream" emissions, greenhouse gas emissions, power plant emissions, total "upstream" energy use, energy use at the refueling point, or reduction in petroleum usage, over conventional vehicles.

To capitalize on the advantages of grid electricity, a BDHEV is designed with a substantial amount of battery energy storage, and "plugs-in" to the grid. A large battery pack provides greater electric power capability and a substantial energy buffer that allows the electric motor to assist a reduced-sized engine during high-load driving. In BDHEV designs with adequately sized electric motors, the vehicle can operate all-electrically for a significant portion of its total operation.

A BDHEV has much of the benefit of an electric vehicle, yet does not have the issue of limited driving range since the engine may be used for extended trips.

In addition, the BDHEV requires less battery capacity (and thus has a lower-cost battery) than an electric vehicle, since the BDHEV's battery can be sized for typical daily driving instead of attempting to match the refueling range of a conventional vehicle.

Status

This project has been successfully completed, and the final report is on file with SCAQMD and the UC Davis HEV Center.

Task 1 - Light-Duty Powertrain Systems Development was completed in part in May 2001. Additional testing in support of Task 1.1 was performed up until November 2001. Modeling and simulation was completed using both PSAT and Advisor modeling tools in November 2001.

Task 2.1 - Fabrication, Testing and Evaluation of Suburban #1 was accomplished in November 2001. Testing was first performed at General Motors Milford Proving Grounds in June 2001. Testing was competed at the California Air Resources Board Haagen-Smit Laboratory in El Monte, California in October 2001.

Task 3 - HEV Systems Evaluation and Final Report is complete for September, 2002.

Results

The results of the development and testing of the light duty BDHEV include:

- Development of the Ideal Operating Line (IOL) control strategy for hybrid electric vehicles, resulting in approximately a 10 % improvement in vehicle fuel economy.
- A measured 87% reduction in vehicle petroleum consumption on the city cycle and an 83% reduction in vehicle petroleum consumption on the highway cycle.
- 49 mile all-electric city cycle range.

Results of the development and testing of the medium-duty BDHEV include:

- A measured 84% reduction in vehicle petroleum consumption on the city cycle and an 80% reduction in vehicle petroleum consumption on the highway cycle.
- 64 mile all-electric city cycle range.
- 74% reduction in greenhouse gas emissions over combined cycles
- Below California SULEV emissions over combined cycles

Benefits

Overall, the primary advantages of BDHEVs include:

- Significant all-electric range as a zero-emissions vehicle (ZEV)
- Charge-depleting hybrid mode capability, which can increase efficiency in certain conditions
- In general, the use of grid electricity as an energy source for the vehicle reduces total energy consumption (particularly petroleum consumption), the total emissions (power plant emissions included), and overall CO_2 emissions
- The reduction in engine size increases hybrid-mode fuel economy, which leads to an associated reduction in petroleum consumption and CO_2 emissions
- Since electric motors have high torque capability at low rotational speeds and the electric motor typically provides a significant portion of the powertrain's total output, BDHEVs generally feature high vehicle performance.

Project Costs

Costs associated with all tasks of this project is $5.8 M. SCAQMD has provided $400,000 to this project to support testing and evaluation of two experimental BDHEVs.

Commercialization and Applications

BDHEV technologies are applicable to a great majority of passenger and commercial vehicles on the road. All performance metrics for conventional vehicles are shown to be achievable with BDHEV technology including range, acceleration, consumer acceptability and SULEV emissions targets. The market potential and air quality benefits in the South Coast Air Basin are substantial.

EMISSION CONTROL TECHNOLOGY

AQMD Contract # 99121 *August 2002*

Demonstrate Reduced Vehicular Emissions through Throttleless Engines Using Alternative Fuels

Contractor

Paul D. Ronney, Principal Investigator
University of Southern California
Dept. of Aerospace and Mechanical Engineering

Cosponsors

USC School of Engineering
National Center for Metropolitan Transportation Research (METRANS)

Project Officer

Michael Bogdanoff

Background

A typical Otto-cycle engine employs a throttle in order to provide an adequate range of output power. The disadvantage of the throttling process is that the power required to pull the pistons down against the sub-atmospheric manifold pressure cannot be recovered elsewhere in the cycle. With the Throttleless Premixed Charged Engine (TPCE) concept the throttling losses are nearly eliminated without a decrease in the maximum torque and power output of the engine.

Project Objective

The purpose of this project is to study the effects of preheating and lean mixture on engine performance. The main objectives are the following:

- Design and fabricate TPCE components and install on test engine capable of running on alternative liquid and gaseous fuels, specifically natural gas, methanol and ethanol
- Map TPCE performance, emissions and thermal efficiency running on these fuels
- Determine dynamic response of TPCE running on these fuels
- Determine optimum operating conditions and advantages
- Assess TPCE design and commercialization potential

Technology Description

In a conventional Otto cycle engine, the reduction in torque is achieved by decreasing the air/fuel mixture density at nearly constant temperature through throttling; which results in the aforementioned throttling loss. The reduction in torque in the TPCE is achieved by adding exhaust heat, which would otherwise be wasted, to decrease the intake mixture density (at nearly constant pressure) and by increasing the air/fuel ratio. The intake duct branches into preheated and non-preheated sections. The amount of preheat is controlled by a diverter valve in the intake manifold. Both air/fuel ratio and intake preheat are variable and both produce a change in engine torque.

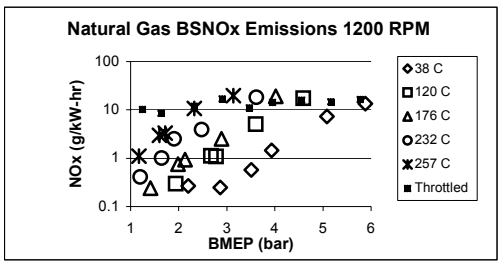
Status

The project was completed on August 3, 2002. A copy of the final report is on file at AQMD with complete technical details and results. Testing was successfully completed using natural gas, methanol and ethanol

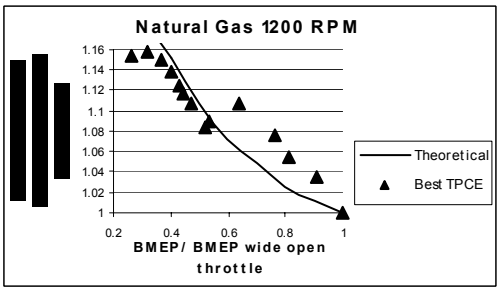
Results

One of the most important findings of the TPCE work was the substantial reduction in untreated NOx emissions attainable with the TPCE system on natural gas. At the same Brake Mean Effective Pressure (BMEP), NOx levels were as much as 25 times lower with the TPCE system than with a conventional throttled engine. The figure below shows the brake specific NOx for natural gas versus the brake mean effective pressure for

various intake temperatures and for the throttled engine.



The data below shows the improvement in fuel efficiency and emissions performance obtainable with the throttleless engine system. This improvement is as much as 15% at light engine load as shown in the following plot.



The results for TPCE systems running on methanol and ethanol (not shown) are similar to those of natural gas.

One performance tradeoff of the TPCE design is a slight delay or lag time encountered when changing torque output. This lag time was found to be 1-2 seconds when changing from maximum to minimum torque output or vice versa. Optimizing the heat exchanger design and fuel delivery strategy could reduce this lag time considerably.

Benefits

As previously stated the two major benefits of the TPCE Engine system are the increased fuel economy (as high as 15%) and reduction in NOx emissions (up to 25 times). On alternative fuel powered vehicles, where fuel storage and range are major issues, the increase in fuel economy is particularly advantageous.

If natural gas TPCE systems were implemented on all the urban and school buses within the Los Angeles air basin NOx production could be reduced by 46 tons per year (assuming an average 10x reduction in NOx on natural gas powered vehicles operating at

lowest intake temperature producing minimum NOx emissions). In addition, if just ten percent of light duty passenger cars in the Los Angeles air basin employed TPCE, NOx production could be reduced by an additional 151 tons per year[i]. These benefits are realized without any considerable increase in greenhouse gases or other major environmental pollutants.

Project Costs

The total cost of this project was $190,138. AQMD contributed $82,800, USC $57,338, and METRANS $50,000. The hydrogen fuel testing planned for this project was not completed due to time constraints. Therefore, $2.500 of AQMD's funding allocation of $85,300 was not spent.

Commercialization and Applications

All three alternative fuels tested could be effectively used in a TPCE engine with similar improvements in efficiency. The optimum fuel of choice would be dependent on the particular vehicle application. Larger vehicles such as city buses would be the best candidates for a natural gas powered TPCE system because they can easily store larger volumes of fuel and typically have shorter-range requirements. Methanol and ethanol would be better suited for smaller vehicles such as passenger cars where fuel storage capacity is limited.

The TPCE apparatus used in these laboratory experiments was fairly large because there were no space-limiting constraints. If the TPCE were to go into commercial production the heat exchanger and packaging would have to be optimized for each application. The ignition timing maps, intake temperature control and fuel delivery strategy required to operate a TPCE engine could easily be programmed into existing ECU (electronic control unit) technology.

The current primary markets for TPCE technology are return-to-base applications such as taxicabs, police cars, city buses, delivery trucks, etc. The market will expand to other applications as alternative fuels become more readily available.

[i] Based on 2001 statistics from California Air Resources Board Website: http://www.arb.ca.gov/homepage.htm

AQMD Contract # 00170 *December 2002*

Increased Horsepower Natural Gas Engine for Freight Delivery Trucks

Contractor

Southern California Gas Company (prime)
Cummins Engine Company (subcontractor)
Viking Freight Incorporated (subcontractor).

Cosponsors

AQMD
Viking Freight Incorporated
Cummins Engine Company
Southern California Gas Company

Project Officer

Mike Bogdanoff

Background

Alternative fuel engines have been shown to provide significant emissions reductions over diesel engines. Natural gas engines for urban transit applications are commercially available products, and natural gas engines are also available for trucking applications but with limited power options. Cummins Engine Company (Cummins) has initiated the development of spark-ignited natural gas heavy-duty engines. The Cummins 8.3-liter C8.3G natural gas engine at 250 horsepower (hp) is certified for both transit and truck applications at the ARB optional low-NO_X standard of 2.5 g/bhp-hr.

Project Objective

Cummins has developed a higher-horsepower (280 hp), higher-torque (850 ft-lb) version of the C8.3G engine to meet medium, heavy-duty trucking applications. This new engine is now called the C Gas Plus engine. Southern California Gas Company (SCG) proposed to demonstrate this higher-horsepower Cummins engine in trucks operated by Viking Freight Incorporated in Whittier. Cummins provided the two pre-production engines. These engines along with CNG fuel systems were installed into two Viking trucks by NGV Ecotrans in Los Angeles. These replaced the existing diesel engines. The compressed natural gas (CNG) trucks were then demonstrated in normal freight pick-up and delivery in southern California.

Refueling was performed at the Puente Hills landfill with natural gas produced from landfill gas and at other public CNG fueling sites in the basin. Following the demonstration period, SCG will have the trucks emission tested at an ARB-certified emission laboratory.

Technology Description

The C Gas Plus engine incorporates many improvements over the C8.3G including a new control module with increased memory, speed and features; elimination of separate non-engine mounted governor control module; state-of-the-art electronic engine management with full control air/fuel handling; and drive-by-wire function.

The C Gas Plus engine is Cummins' so-called "world" natural gas engine. It designed to operate on varying compositions of natural gas found throughout the world where the methane content of natural gas can vary from 78 percent to 98 percent and include other contaminants. Cummins needs to test this engine in an on-road application before full commercial release and assess its operation with real-world natural gases fuels. Cummins selected SCG to provide management responsibilities for this project.

The two truck tractors used for the C Gas Plus engines were 1994 Ford L8000's with Eaton/Fuller T8607B seven-speed transmissions. Two 1997 Freightliner FL-70's with 1997 Cummins C8.3-275 diesel engines were use for control vehicles. These diesel trucks were equipped with Eaton/Fuller RT8609 nine-speed transmissions. All four engines were equipped with oxidation catalysts, Nelson catalysts for the natural gas and Donaldson catalysts for the diesel.

Status

The project was completed in March 2002, and the final report is on file with complete technical details of the project.

Four truck tractors from Viking Freight were selected for the project. The two 1994 Ford L8000's were converted to compressed natural gas by NGV Ecotrans of Los Angeles, while the two 1997 Freightliner FL-70's were used for diesel control vehicles. The vehicles were put into service for the demonstration program in the first quarter of 2001. One of the natural gas trucks was instrumented with a data logger to measure duty cycle information.

The two natural gas trucks initially experienced low-power complaints from the drivers. Cummins diagnosed these problems to the fuel calibration and reprogrammed the engine controller software to resolve the problems. Also, high lubrication oil consumption was experienced with these engines. This was caused by improperly calibrated oil dipsticks which caused overfilling of the crankcase. The problem was corrected by using properly calibrated dipsticks.

Early in the project, refueling was performed at the Puente Hills landfill. During the third quarter of 2001, an on-site timed-fill CNG station was installed at Viking Freight which reduced refueling travel time and cost.

Emission testing was performed by West Virginia University using their Transportable Heavy-Duty Emissions Testing Laboratory set up in Riverside, CA. Testing was performed on all four demonstration vehicles using a "modified heavy-duty Urban Dynamometer Driving Schedule" (UDDS) and a newly created "Viking cycle" derived from data from the data logger.

Results

The emission testing yielded substantial reductions with the natural gas trucks (See Table 1). NOx emissions were 27-45% lower than the diesel trucks while PM and CO were 92-94% and 48-95% lower, respectively. Only the hydrocarbons (Total versus Non-Methane) did not show a clear benefit (58% increase and 19% reduction).

The fuel costs for the demonstration vehicle in freight service depended upon the fueling source. The fuel cost for the diesel trucks averaged $0.16 per mile ($1.07 per gallon). For the natural gas trucks, the cost was $0.29-0.30 per mile for the Puente Hills commercial fueling ($1.06 per diesel gallon equivalent, dge). However, for the timed fill at Viking Freight the cost was $0.12 per mile ($0.62 per dge).

Modified UDDS	NOx g/mi	PM g/mi	HC g/mi	CO g/mi
Diesel	14.1	0.24	0.33	0.84
CNG	10.3	0.015	0.52	0.044
Change	-27%	-93%	+58%	-95%
Viking Cycle				
Diesel	10.7	0.20	0.26	0.49
CNG	5.89	0.016	0.21	0.033
Change	-45%	-92%	-19%	-48%

Table 1. Average Emission Comparisons between Diesel and CNG Demonstration Trucks

Benefits

This project indicated that natural gas freight delivery trucks can have substantially lower emissions than diesel trucks in freight operation. Depending upon the natural gas refueling systems, the natural gas fuel costs can be the same or lower as diesel trucks. The vehicle road performance is not sacrificed with a natural gas truck.

Project Costs

This project had a total cost of $292, 200. Viking Freight, Cummins, and Southern California Gas Company contributed a total of $186,400 to the project while AQMD contributed $105,800.

Commercialization and Applications

Due to this successful demonstration and others, the C Gas Plus engine was launched into production in the third quarter of 2001. This engine has the capability of providing urban

freight service with substantially lower emissions. Fuel costs will depend upon the refueling system employed, but using an on-site time fill system can provide fuel costs that are the same or less than an equivalent diesel engine.

AQMD Contracts # 01032, 01036, 01048, 01057, 01166

Demonstrate School Buses Retrofitted with PM Reduction Technologies

Contractor

Coordinated by SCAQMD

Cosponsors

Engelhard, Johnson Matthey, Los Angeles Unified School District, Hemet Unified School District, CARB, SCAQMD

Project Officer

Fred Minassian

Background

There are approximately 8,600 school buses in the South Coast Air Basin. The use of low-sulfur diesel fuel in combination with recently developed retrofit technologies is one possible method for reducing large amounts of particulate matter (PM) emissions from school buses in the near future.

Project Objective

The main objective of this project was to retrofit a representative number of diesel fueled school buses with different types of engines and model years with regenerative particulate filter traps, and evaluate the PM emissions reduction benefits. The results of the demonstration project were also to help CARB with their efforts in verifying the traps for certain engine families.

Technology Description

The diesel particulate trap is a technology that is employed to reduce particulate matter emissions from vehicles operating on diesel fuel. For the proper operation of this technology low-sulfur diesel is used. The installation of the trap does not require any engine modification. The system operates in a manner that particulate matter is collected on a filter. In the meantime, a portion of the NO present in the exhaust is oxidized to NO2, which is then utilized to combust soot collected on the particulate filter. This allows the continuous combustion of soot.

Status

This project has been completed. The SCAQMD led and coordinated work among all the participating entities. CARB provided its emission testing facility to conduct chassis dynamometer testing of the retrofitted buses before and after installation of the traps. The Los Angeles and Hemet unified school districts provided a representative number of school buses with a variety of engine makes and model years. Johnson Matthey and Engelhard installed their filter traps on the selected school buses for testing and evaluation. In addition, one school bus retrofitted with Engelhard's filter accumulated approximately 50,000 miles on an accelerated schedule to evaluate changes in emissions reductions.

Results

The matrix of the selected engine models for retrofit was:

Engine Models	Model Year
Detroit 671	77, 82, 89
Detroit 6V92	90, 93
Caterpillar 3208	78
Caterpillar 3116	95
Navistar 466	86, 95
Cummins 8.3	98, 99, 00

The Detroit 671 and 6V92 engines were 2-stroke, and the others were 4-stroke engines. In general, the particulate traps manufactured by both Johnson Matthey and Engelhard performed very well on

newer 4-stroke engines, and they either failed or the manufacturer didn't find it feasible to install on the older 4-stroke and the 2-stroke engines. The newer 4-stroke engines were tested on UDDS, CBD, and NY Bus Cycle and they showed particulate matter reductions of around 90%. The bus selected for accelerated mileage accumulation was a 1986 school bus with a Navistar 466 engine retrofitted with Engelhard trap, and showed no deterioration after approximately 50,000 miles.

Benefits

The major benefit of this project was to find out the applicability and performance of particulate traps on different types of engines and model years. The results of this project together with additional data provided by Johnson Matthey and Engelhard were used by the Air Resources Board to verify particulate traps for most of 1994 and newer engine families.

Project Costs

SCAQMD sponsored this project with $261,497. CARB provided in-kind contribution by testing the buses at its emissions testing facility. Johnson Matthey and Engelhard provided in-kind contributions of $89,000 and $72,500, respectively. The Los Angeles and Hemet unified school districts provided in-kind contribution by making their school buses available for testing and evaluation.

EMISSION

AQMD Contract # 99038 *August 2002*

Diesel Aerosol Sampling Methodology

Contractor

Coordinating Research Council (prime) Project E-43
University of Minnesota (prime subcontractor)
West Virginia University
Carnegie Mellon University
Tampere University
Paul Scherrer Institute
University of California at Riverside
Caterpillar, Inc.
Cummins, Inc.

Cosponsors

U.S. Department of Energy through NREL
Coordinating Research Council, Inc.
California Air Resources Board
Engine Manufacturers Association

Project Officer

Mike Bogdanoff

Background

Particulate emissions from internal combustion engines have traditionally been regulated solely on the basis of total particulate mass emissions. No reference is made to either the size or number concentrations of emitted particles. Improved characterization of in-use diesel particulate emissions is needed, including particles less than 30 nm in diameter (nuclei mode). The University of Minnesota and partners under contract to the Coordinating Research Council, Inc. undertook a study to sample, characterize, and quantify nuclei mode in diesel exhaust.

Project Objective

The objective of this project is to develop diesel aerosol sampling methods for the laboratory that produce results similar to those obtained under actual roadway conditions.

Technology Description

To accomplish the goals of the project, a fundamental investigation is required to understand the physical processes that affect aerosol formation, transformation, measurement, and the resulting aerosol size distribution. These processes include dilution, nucleation, condensation, adsorption, and coagulation. In addition to the physical processes, the nature of the particulate matter emitted in exhaust is affected by the engine condition, fuel, lube oil, exhaust system, sampling system, and other factors. The results of this study lead to an approach for obtaining realistic aerosol samples in the laboratory beyond the conventional mass measurement techniques now in use.

Status

This project was completed in August 2002. The final report is on file at AQMD and at the Coordinating Research Council, Inc. The project included on-road chase and wind tunnel experiments to determine the actual particle size distribution and particle number concentration in the exhaust plume from heavy-duty diesel vehicles operated on the road and in the wind tunnel. Laboratory tests were conducted to compare on-road aerosol data with that generated in conventional emission test facilities. Particle transformations were examined as the plume disperses downwind of the roadway in a typical urban situation through modeling studies. The chemical composition of diesel particulate matter including nuclei mode fractions was characterized.

Figure 1
Mobile emission lab developed in this project

Results

Nuclei mode particles measured on-road ranged in diameter from the 3 nm lower detection limit to 30 nm. These nuclei mode particles are primarily volatile and consist of hydrocarbon or sulfur compounds that condense to the particle phase as their temperature decreases following release from the combustion process, cooling, and dilution with ambient air. A small amount of these nuclei mode particles contain solid ash from lube oil or wear metals; however, more research is needed to clearly determine their nature and quantities.

Typically, 0.1-10% of the particle mass and up to 90% or more of the particle number are found in the nuclei mode. Nuclei mode particles are a subset of

the recently popular nanoparticle designation, which consists of particles smaller than 50 nm in diameter. Accumulation mode particles are 30 to 500 nm in diameter and are composed primarily of carbon agglomerates and nuclei mode particles that have collided with accumulation mode particles and contributed to their size.

The nuclei mode is much more sensitive to engine operation, dilution, and sampling conditions than is the accumulation mode. The size distributions formed during on-road operation depend not only upon engine, fuel, lube oil, and exhaust systems design, but also upon many other factors including instantaneous operating conditions, operating history, and environmental conditions.

Particle loss in sampling lines and instruments is an inherent characteristic of aerosol measurement, and a primary goal of aerosol research is to minimize loss, but these data are often not reported. This research team departed from tradition by reporting particle number count loss results as approximately 50% at 10 nm, 20% at 20 nm and 3% at 60 nm.

To address the above observations and concerns, the best sampling strategy for measuring engine exhaust size distributions is to apply good particle technology principles in the laboratory. These principles include using a standard set of sampling and dilution conditions that are reproducible, are sensitive to sampling the broad range of particle sizes known to exist in engine aerosols, and minimize sampling artifacts. Well-designed two-stage dilution systems operating at constant first stage dilution ratio offer the most current promise.

Benefits

The results of this project apply immediately to understanding impacts of in-use vehicle technologies on aerosol emissions, including those from clean fuels. The science and technology developed in this study will also apply to development of future engine and emission control technologies with respect to characterizing and controlling fine particle emissions.

Project Costs

The contract cost of the project was $2.5 million with AQMD contributing $100,000 of the total. The total project cost including in-kind cost-sharing from the University of Minnesota; Caterpillar, Inc.; Cummins, Inc.; Volvo; the National Institute of Occupational Health and Safety; and the Environmental Protection Agency is estimated to be over $3.5 million.

Commercialization and Applications

Much was learned from this research, but further work remains to clarify the character of the particulate matter inventory. More information on roadside and on-road particle concentrations is needed so that critical conditions can be identified. The advanced combined physical chemical characterization methods developed in this project and other related projects should be applied to ultra low emission engines and their associated emission control systems.

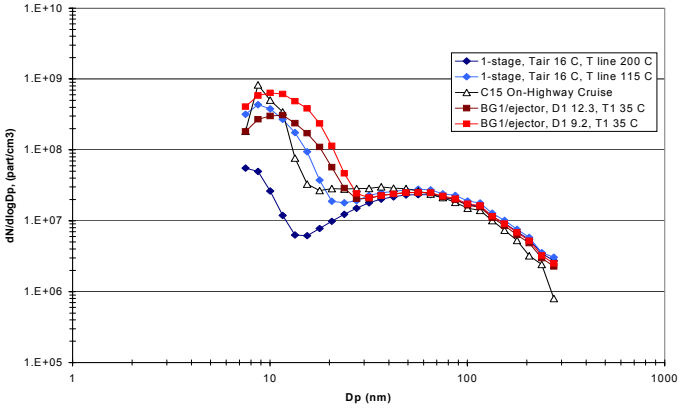


Figure 2. ***PARTICLE DIAMETER***
Size Distributions Obtained with 1-stage Dilutor and BG1/ejector Dilutor for C12 Engine at 1530 rpm, 700 N-m torque and from On-Road Measurements with C15 Engine under Highway Cruise Conditions.

AQMD Contract # 01029 *April 2002*

Determination of Non-Registration Rates for On-Road Vehicles in California

Contractor

California Air Resources Board
University of California, Riverside, Bourns College of Engineering,-Center for Environmental Research and Technology

Cosponsors

California Air Resources Board

Project Officer

Mike Bogdanoff

Background

Development of regional air pollution control strategies requires accurate estimation of the regional emissions inventory. Understanding and accurately portraying the in-use vehicle population is one of the most important aspects of obtaining accurate emission inventory estimates. Mobile sources, by their nature, are difficult to accurately account for in emissions inventories. The registered vehicle population will account for a majority of the vehicles on the road. However, unregistered vehicles and out-of-state vehicles represent an important proportion of the total inventory as well.

Project Objective

The objective of this program was to obtain a better understanding of the population and use characteristics of unregistered vehicles. The primary component of this study was a statewide field survey conducted to provide an estimate of the State of California unregistered vehicle population. In total, photographic records were obtained for over 120,000 vehicles, including vehicles in every county in the state. After elimination of partial plates, out-of-focus plates, and obstructed plates, a database of more than 98,000 vehicles license plates. This represents the most comprehensive study of vehicle non-registration rates to date and encompasses all regions of the state. In addition to the total non-registration rate, the following information was also sought:

- A breakdown of the time period of non-registration status into instantaneous (less than 3 months), prolonged (3 months to 2 years) and chronic (more than 2 years) categories by county for California.
- Characteristics of unregistered vehicles including, but not limited to, model year and make by region or county for California.
- The percentage and identity in each county of non-California vehicles or vehicles which originated out of county.

Technology Description

The results of this study will have an impact on the determination of emissions inventories and the corresponding technologies needed to achieve air quality goals. Although no product was directly developed under this contract for commercialization, the information obtained will assist in evaluating what new technologies will be the most effective in reducing emissions inventories.

Status

The project was completed in March of 2002. No significant problems were encountered during the course of the project

Results

An estimated vehicle non-registration rate of approximately 3.38% was obtained based on analysis of more than 98,817 vehicle records collected in a field study in California. This included vehicles unregistered for a period of less than 3 months (2.41% of total), vehicles unregistered between 3 months and 2 years (0.95% of total), and vehicles unregistered for more than 2 years (0.03% of total). These rates are somewhat lower than the rates used in the current version of EMFAC.

About half of the counties had non-registration rates between 2% and 4%, with most counties having non-registration rates below 5% (see Table 1). In general, the more populous counties (population greater than 300,000) had a tendency toward higher non-registration rates, with non-registration rates in larger counties generally ranging from about 2% to 5%.

In general, the percentage of out-of-state vehicles observed in this study was less than 5%, with the higher concentrations near the state border and near tourist attractions. The percentage of out-of-state and out-of-country vehicles was more than 10% for only 5 counties on the state border.

Demographic analysis was conducted at the county level of aggregation as well as at the individual ZIP code level. At the county level significant regressions of percentage of unregistered vehicles were found for median household income. Home ownership and population percentages were not correlated with vehicle registration rates. At the ZIP code level no significant regressions were found between demographic variables and vehicle registration rates.

The analysis of BAR Smog Check results for the California registered vehicles found several points of interest. The majority of the vehicles, even the chronic unregistered vehicles, passed their last Smog Check test. Of the 13 chronic (more than 2 years) unregistered vehicles, 11 (84.6%) had passed their last Smog Check test. However, the percentage of vehicles passing their last Smog Check test decreased with increasing time since last current registration.

Analysis of the VIN decoded data showed that the unregistered vehicles identified in this study were typically 1984 and new model years. In comparison with the registered vehicle fleet, the unregistered population was more heavily weighted to older model years. These results are consistent with unregistered vehicle being older and potentially higher emitters that would make a disproportionate contribution to the emissions inventory.

Benefits

An important component of improving the air quality in the SCAQMD is understanding the relative important of different sources to the total emissions inventory. To date, limited data has been available to quantify the number of unregistered vehicles in the in-use fleet. Obtaining accurate estimates of the contribution of unregistered vehicles is a critical component of reducing the emissions inventory contribution from this segment

Project Costs

Total funding of $210,000 was provided for this project. The California Air Resources Board provided $160,000 with SCAQMD providing $50,000 for this project.

Commercialization and Applications

This contract did not result in the development of a new technology. The information obtained will be useful in understanding the impact of commercialization of other emerging technologies on improved air quality, however.

Table 1. Non-registration by County.

County	*Total*	*% Unregistered*
San Diego	*9584*	*4.99*
San Francisco	*2840*	*4.37*
Riverside	*4262*	*4.41**
Los Angeles	*25835*	*3.53**
San Bernardino	*4417*	*3.52**
Orange	*9468*	*3.20**
Sacramento	*3337*	*3.31*
Santa Clara	*4109*	*2.80*
Alameda	*3529*	*2.56*
All Counties	*82413*	3.38

*South Coast Air Basin

.AQMD Contract #02289 *Date of Publication December 2002*

Boiler Hot Gas Emission Testing

Contractor
University of California
Riverside, CA

Cosponsor
N/A

Project Officer
Martin Kay

Background
The California Air Resources Board (CARB)is considering amending the State specifications (Title 13, California Code of Regulations, Sections 2290 et seq.) for compressed natural gas (CNG) used in alternative fueled vehicles. The proposed amendment would replace specifications on methane, ethane and C3+ concentrations with a single specification that requires only a minimum Methane Number (MN) of 73. This would have the effects of allowing higher concentrations of ethane and propane in natural gas (NG), and as a result, increases in the heating value of NG to over 1150 Btu per standard cubic foot.
Increasing the heating value of NG could affect the emissions from stationary combustion sources.

Project Objective
The purpose of this project was to determine the emissions impacts of burning NG with higher heating values in stationary combustion equipment.

Project Description
This project was carried out at the facilities of the College of Engineering - Center for Environmental Research and Technology (CECERT) at the University of California, Riverside.

The CECERT staff acquired an Ajax boiler rated at a maximum heat input of 250,000 Btu/hour. The Ajax boiler is a small, locally-manufactured, natural-draft, hot water heater. It is typical of small boilers found in thousands of locations in SCAQMD, including laundries, schools, apartment buildings and commercial buildings.

The boiler was tested with four different NG gas mixtures, with characteristics as shown in Table 1.

Table 1- NG Fuel Specifications

	Baseline MN 91	MN 80	MN 73, hi-inerts	MN73, low-inerts
% CH4	92.35	88.0	79.99	84.63
% C2H6	4.16	7.25	9.98	10.21
% C3H8	0.81	2.79	3.73	3.80
%C4+	0.39	0.31	0.22	0.44
% N2	1.04	0.70	1.47	0.46
% CO2	1.06	0.72	4.42	0.26
HHV Btu/scf	1044	1103	1091	1153

Note: All percentages are by volume.

The baseline fuel is a MN 91 natural gas. This is the normal pipeline NG supplied by the local gas utility to the college. It is a high-quality NG with 92.35 % methane by volume, small amounts of higher hydrocarbons and inerts, and 1044 Btu/scf higher heating value (HHV).

The three other fuels tested were created by mixing ethane, propane, nitrogen and carbon dioxide with the pipeline NG to achieve the desired mixture. The three fuels included one with a nominal MN of 80 and two with a nominal MN of 73.

A MN 80 fuel was selected because: 1) CARB is proposing to limit MN to a minimum of 80 in certain parts of California; and 2) current California CNG regulations result in a minimum MN close to 80. After adding ethane and propane to the pipeline NG to reduce the MN, the 80 MN fuel had a HHV of 1103 Btu/scf.

The proposed amendments to the California CNG regulations would reduce the minimum MN to 73 in the San Joaquin Valley, Santa Barbara and Ventura County areas. Therefore two of the tested fuels duplicate this proposed new minimum MN requirement. One of the 73 MN fuels was prepared by mixing only ethane and propane with the pipeline NG gas to achieve 73 MN, resulting in a fuel with a HHV of 1153 Btu/scf. The other 73

MN fuel was prepared by adding ethane, propane, carbon dioxide and nitrogen to pipeline NG. Although this fuel has the same MN as the other 73 MN fuel, it has a much higher concentration of inert compounds (5.89%) and a HHV of only 1091 Btu/scf. It also matches very closely a 73 MN fuel used by CARB in tests of internal combustion engines. Based on these tests of high-inert, 73 MN NG, CARB concluded there were no adverse affects with 73 MN NG in many engines.

The boiler was first set up and adjusted for proper operation with the baseline, MN 91 NG. NOx and CO emissions tests were run in duplicate at 100% load and 66% load with all four fuels. The boiler operated satisfactorily with all four fuels without making any boiler adjustments. The three fuels with the higher HHVs had the effect increasing the heat input to the boiler.

NG users generally have no way of knowing what is the HHV of their NG. NG users also are not in the habit of getting periodic tune ups of their combustion equipment. They tend to call for service of their equipment only when there is a breakdown. Therefore, if the HHV of their NG increases due to the lower CNG standards, the heat input rates to their combustion equipment would be increased. This is the scenario duplicated by the tests.

Status

This project was completed in December 2002, and the final report is on file with complete technical details of the project. The main problem encountered during the tests was getting the correct mixtures of gases. Initially, the MNs of the gas mixtures were not close to the desired values. However, this was solved by recalibrating the flow meters and using a gas chromatograph to check the fuel composition before conducting the tests.

Results

The results of the emission testing are shown in Table 2 and Figure 1. Averages of the duplicate tests are shown. All measured CO values were less than 1 ppmvd and are not shown.

Table 2- NOx Emission Results

	Baseline MN 91	MN 80	MN 73, hi-inerts	MN73, low-inerts
100% Load lb/mmBtu	0.165	0.194	0.166	0.201
100% Load, % change	NA	+17.6%	+0.6%	+22.6%
66% Load lb/mmBtu	0.159	.170	.160	.180
100% Load, % change	NA	+6.9%	+0.6%	+13.2%

Note: All concentrations are dry and corrected to 3% O2.

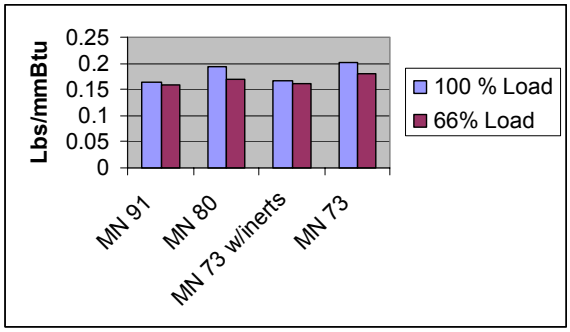


Figure 1 - NOx versus MN

The results show that NOx emissions do increase significantly as MN is reduced (and HHV increases.) Only the MN 73 NG with high levels of inerts (5.89%) has NOx emissions comparable to the baseline MN 91 NG. These results are intuitively logical. Fuels with higher heating values will burn hotter, producing more NOx. The presence of high levels of inert compounds such as CO2 and N2 not only reduce the heating value, but also act as diluents to reduce combustion temperatures, in the same manner as flue gas recirculation.

Benefits

The benefit of this study is that it determined the emission impact of burning natural gas with high heating values in small boilers.

Project Costs

The total cost of this project was $30,752

Commercialization and Applications

There are no application or commercialization opportunities based on the results of this study.

HEALTH

AQMD Contract # 99099 *September 2002*

Rancho Los Amigos Research & Educations Institute Inc.

Contractor

Los Amigos Research and Education Institute (LAREI)

Cosponsors

Research Triangle Institute (RTI)
University of California, Irvine (UCI)

Project Officer

Jean Ospital

Background

This pilot project was intended to help understand respiratory health risks from volatile organics compound (VOC) air pollutants to lower-income ethnic-minority urban populations who may have unusually high exposures.

Project Objective

Our operational goal was to demonstrate feasibility of concurrent exposure and health measurements in asthmatic children, who are suspected to be especially at risk from VOC exposure.

Technology Description

Our scientific goal was to find out whether day-to-day changes in children's asthma status tracked personal VOC exposures and/or ambient background pollution levels, over a period of weeks. If asthmas tended to worsen when VOCs were high (or soon afterward), that would increase suspicion that current VOC pollution levels are harmful to asthmatics. The LAREI participants recruited and screened asthmatic children, performed actual field work, shipped samples and data to the other investigators, and helped to interpret their analytical results, under support from this SCAQMD contract. The remainder of the project was supported by California Air Resources Board Contract 99-302.

Status

The research was performed November 1999-January 2000 in Huntington Park, a nearly all-Hispanic city southeast of central Los Angeles, where a high density of motor vehicle traffic and industry result in the region's highest levels of VOC pollution. With the cooperation of local schools, we reviewed student health records to find potential volunteers, and sent them and their parents invitations to participate. We recruited 26 volunteers with asthma, ages 10 to 16, all Hispanics. Volunteers and parents gave informed consent, and volunteers were paid for participation. We followed each child for 12 weeks (rather that the 8 weeks originally intended) to observe enough asthma episodes for meaningful analysis.

Each volunteer filled out fairies to record time-activity patterns, asthma symptoms, and asthma medication use, and measured his/her own peak expiratory flow (PEF) twice daily. On any day that a new asthma episode began, and on a similar number of days free of asthma symptoms, the volunteer collected a sample of exhaled breath in an evacuated canister. Concurrently, SCAQMD staff operated a central monitoring station to measure VOCs as well as the usual "criteria" pollutants. To further study the ambient pollution/personal exposure/breath VOC relationship, four selected volunteers repeatedly wore personal VOC monitoring badges and placed similar badges in their homes. Badges and canisters were chemically analyzed at RTI; statistical analyses were performed at UCI.

After dropouts and exclusions of suspected invalid diary data, 20 subjects (1035 person-days of asthma and pollution observations) remained for analysis, of whom 19 had analyzable breath samples from asthma and non-asthma days. For the 5 subjects with badges, personal exposures correlated with indoor exposure but not with outdoor measurements of most VOCs; breath VOC concentrations appeared lower than indoor

concentrations. For all usable subjects, asthma symptoms correlated with benzene in exhaled breath, but nor with other breath VOC levels. Outdoor pollutions levels measured at the central station were more closely related to asthma symptoms than were breath VOC levels. Eleven different ambient VOC (including benzene), as well as nitrogen dioxide, sulfur dioxide, and ozone, were associated with asthma symptoms, in statistical analyses allowing for effects of time, weather, and respiratory infections. Particulate air pollution (organic carbon, elemental carbon, and PM10) measurements, though not available for all study days, also showed associations with symptoms. Changes in PEF were not clearly associated with outdoor pollution measurements.

Results

We conclude that concurrent measurement of respiratory health and pollution (including VOC) exposure is feasible and informative in low-income minority asthmatic children. We clearly associated VOC with asthma symptoms, but could not distinguish effects specific to VOC from effects due to other species or to "air pollution in general". A larger-scale investigation might overcome that limitation. To be more cost-effective, any such effort should incorporate electronic recording of health data, more intensive efforts to identify and contact every potential volunteer, and a field-based manager to coordinate the diverse investigative and administrative activities.

Benefits

This section crystallizes the above-noted performance characteristics into project benefits, e.g., reduced emissions, increased efficiency, reduced global warming gases, or other environmental benefits. The potential emissions inventory impact of this technology applied in the South Coast Air Basin must be estimated based on performance results of this project and some estimate of market penetration (concisely state assumptions).

It clearly describes how those actual benefits compare with the benefits that were anticipated at the project's start. Be as detailed as possible, including discussion of overall environmental impacts and benefits. Address the question of whether the technology may reduce an air pollutant while improving (or worsening) problems with water pollution, solid waste, global warming, toxic emissions, etc.

Project Costs

This brief section describes the actual costs of the program (AQMD's funding contribution as well as the overall cost sharing) and how they compare with the originally projected costs of the project as stated in the Board (or EO) letter. Cost information can be presented graphically, in a table, or in paragraph form. This section does not address cost effectiveness or cost of commercialization.

Commercialization and Applications

This section describes the anticipated or potential applications of the demonstrated technology and/or clean fuel. If applicable, discuss follow on projects to further improve the technology. If available or applicable, discuss expected costs of control and cost-effectiveness in the context of currently available technologies. Cost data should be noted as estimates or projections, especially since TA projects are often "first of a kind."

Prospects for commercialization should include a discussion of the potential size of the target or primary market, and if there is another market segment or application that could use the technology. Discussion of the commercial status of the technology should address questions such as: (1) how close to a commercial product is it; (2) what work remains to bring it to market; (3) when could it be made commercially available and competitive; and (4) what barriers remain before the technology can be commercialized.

AQMD Contract # 02300

Conduct Indoor and Outdoor Air Quality Study in Mira Loma

Contractor

UC Riverside - College of Engineering Center for Environmental Research and Engineering (CE-CERT)

Cosponsors

County of Riverside

Project Officer

Rudy Eden

Background

Results from the ongoing Children's Health Study (CHS) sponsored by CARB suggest that exposure to increased levels of particulates, NO_2, and acid aerosols can lead to retarded lung function growth and other adverse health consequences in children. Air monitoring studies in the Mira Loma area indicate that the area has the highest particulate levels measured in the Basin.

Additionally, community members have voiced concerns about the increased number of warehouses in the area and the associated increase in diesel truck traffic and emissions. Diesel exhaust has been identified as a toxic contaminant by the CARB.

Evaluations of health impacts in the Children's Health Study were based exclusively on outdoor pollution measurements. An evaluation of time spent both indoors and outdoors shows that children typically spend less than 3 hours a day outdoors. Therefore, the majority of their exposure is to indoor air. However, no studies existed in the Mira Loma area which have concurrently characterized both indoor and outdoor air.

To assess the air quality in the Mira Loma area, the County of Riverside funded such a study, which was conducted by CE-CERT. The study will took concurrent ambient air samples both indoors and outdoors at 20 homes and a number of classrooms in the Mira Loma area. The data was used to provide an indication of the relationships between indoor and outdoor air quality.

Project Objective

This project will provide a clearer picture of the potential impacts to health from alterations in air quality related to land use and diesel fuel combustion. In addition, the data will provide an indication of the relationships between indoor and outdoor air quality.

Technology Description

The study was conducted using well know sampling and analytical procedures. The unique part of this study was the incorporation of both an indoor and outdoor component. Further, the integration of traffic count, life style, and emissions inventory element was novel.

Status

The project was successfully completed and a final report dated November 4, 2002 was issued. A copy of the final report is on file complete with detailed technical appendices. As anticipated 20 homes, 13 outdoor sites, and a school represented the sampling locations. Within the report authors provided several recommendations, and provided an indication of the relationships between indoor and outdoor air quality.

Results

Within the report authors provided several recommendations, and provided an indication of the relationships between indoor and outdoor air.

Benefits

This project did provide a clearer picture of the potential impacts to health from alterations in air quality related to land use and diesel fuel combustion. This is especially true when taken in conjunction with the AQMD modeling efforts in the area as a part of localized (mini) AQMD. In addition, the data does provide an indication of the relationships between indoor and outdoor air quality.

Project Costs

The total cost of the study was $360,000. The County of Riverside committed $310,000. The AQMD portion of the funding was in the form of a $35,000 grant, and $15,000 in-kind AQMD support in the form of metals analysis of collected particulate filters. These figures were as anticipated at the beginning of the project.

Commercialization and Applications

There are no commercialization benefits from this study. However, the methodologies used to study this area may well be applicable to other geographical areas.

STATIONARY
CLEAN FUEL TECHNOLOGY

AQMD Contract # 980281 ***December 2002***

Develop and Demonstrate High Efficiency, Solar Energy Based Air Conditioning and Heating (solar-HVAC)

Contractor

Bergquam Energy

Cosponsors

California Energy Commission $303,000, SMUD $75,000, NREL $50,000, SCAQMD: $45,000

Project Officer

Ranji S. George

Background

The HVAC technology which is supported by this project involves the use of solar energy to provide air conditioning for commercial buildings. This is a clean fuel technology that addresses the peak load problem that many electric utilities in California encounter during the cooling season. The contractor, Bergquam Energy, has worked on the development of this technology for the past 18 years and has been involved in the design, installation, operation and maintenance of solar absorption chillers ad solar HVAC systems.

Project Objective

This project is concerned with the commercialization of solar energy based absorption air conditioning technology.

- The primary objectives of the project are to:
  design, install and test a solar HVAC system on an 8,000 sq. ft. building in Sacramento, CA.
- select and evaluate suitable sites for a demonstration project in the South Coast Air BasinTechnology Description

The principle of operation of solar driven absorption chillers is that they use heat from an array of solar collectors to produce chilled water that is used to air condition commercial buildings. The technology uses a clean, renewable solar based fuel to cool buildings.

The main advantages of solar HVAC systems are that they:

- displace electrically driven, compression air conditioners, which require approximately 1.5 kW per ton of electric utility provided power
- operate during the cooling season when many electric utilities experience their peak demand for power.
- use a working fluid such as lithium bromide and water (with water as the refrigerant) rather than the CFC's used by conventional chillers.

Status

During the course of this project, a complete solar HVAC system was designed and installed on an 8,000 sq. ft. commercial building in Sacramento. The equipment includes an array of Integrated Compound Parabolic Concentrator (ICPC), evacuated tube type collectors and a nominal 20 ton solar driven, double effect absorption chiller.

The major project events completed to date include:

- Modifying a 20 ton, gas fired, double effect absorption chiller to operate on hot water from an array of vacuum tube solar collectors.

- fabricating a 336 tube array of ICPC evacuated tube solar collectors.
- installing the chillers and the collector array and the balance of a complete solar HVAC system on an 8,000 sq. ft. commercial building.
- testing the operating solar HVAC system and using our data acquisition system to obtain performance data. The system was operated and data were recorded and evaluated from 1998 through the summer of 2001.
- demonstrating that an array of vacuum solar collector tubes can provide the entire cooling load of an 8,000 sq.ft. commercial building using solar energy
- demonstrating that solar collector efficiency can reach efficiencies of up to 65%.
- selecting two potential sites for demonstration projects in the Los Angeles Basin. demonstrating that an array of vacuum solar collector tubes can provide the entire cooling load of an 8,000 sq.ft. commercial building using solar energy
- demonstrating that solar collector efficiency can reach efficiencies of up to 65%.
- selecting two potential sites for demonstration projects in the Los Angeles Basin.

Commercialization and Application

Potential projects are as follows:

- 100 ton system installed at the City of Palm Springs Co-Generation facility. Most of the design and layout work for this project has been completed. Funding issues have caused delays. The Facilities people have expressed strong support for the project.
- 10 ton system for the Audubon Nature Center in Los Angeles that will be under construction in 2003. Bergquam Energy was awarded a sole source design-build contract for the solar HVAC system. The preliminary design work for this project has started and should be complete in mid 2003. AQMD funds would be used to install a state of the art data acquisition and demonstration system for the project.