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EXECUTIVE SUMMARY

2003 Annual Report

The SCAQMD Governing Board approved 60 new projects, studies or amended contracts during Calendar Year (CY) 2003 to sponsor research, development, and demonstration (RD&D) and commercialization of alternative fuel and clean fuel technologies in Southern California. Tables 2 and 3 list projects which are further described in this report. The SCAQMD contributed more than $11 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 $62 million. These projects addressed a wide range of issues with a diverse mix of advanced technologies. The areas of technology advancement include the following:

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

During CY 2003, 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, 31 research, development, and demonstration projects and 5 technology assessment projects or studies were completed in 2003, as listed in Table 4. Summaries for each technical project completed in 2003 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, 2004, after approval by the SCAQMD Governing Board.

2004 Plan Update

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.

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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 basinwide 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. The NO_x and VOC emission sources of greatest concern are heavy-duty on-road vehicles, light-duty on-road vehicles, and off-road equipment.

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

With the adoption of the 2003 AQMP and the passage of SB 288 in 2003, the content and direction of the Clean Fuels Program needed to be re-examined to determine if the projects were properly aligned with the SCAQMD's mission and the state-of-technologies. Input was garnered from the SCAQMD's Clean Fuels Advisory Group, the Technology Advancement Advisory Group, and other technical experts. During the two-day retreat held in January 2004, participants were grouped into their areas of expertise and interest, reflecting the following six major source categories:

- Light Duty
- Heavy Duty
- Off-Road
- Fuels
- Health and Atmospheric Science
- Stationary and VOCs

In each of these groups, the participants reviewed the current Technology Advancement projects and recommended near-term and long-term projects for consideration. There were 55 near-term and 45 long-term projects suggested by the participants. These project suggestions, where appropriate, are included in this year's Plan Update.

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CLEAN FUELS PROGRAM

Summary

This report summarizes the progress of the South Coast Air Quality Management District (SCAQMD) Clean Fuels Program for Calendar Year (CY) 2003. 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, 2003 and December 31, 2003, the SCAQMD Governing Board approved 60 projects, studies or amended contracts that support clean fuels and advanced technologies. The SCAQMD contribution for these projects was more than $11 million, with total project costs of nearly $62 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.

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

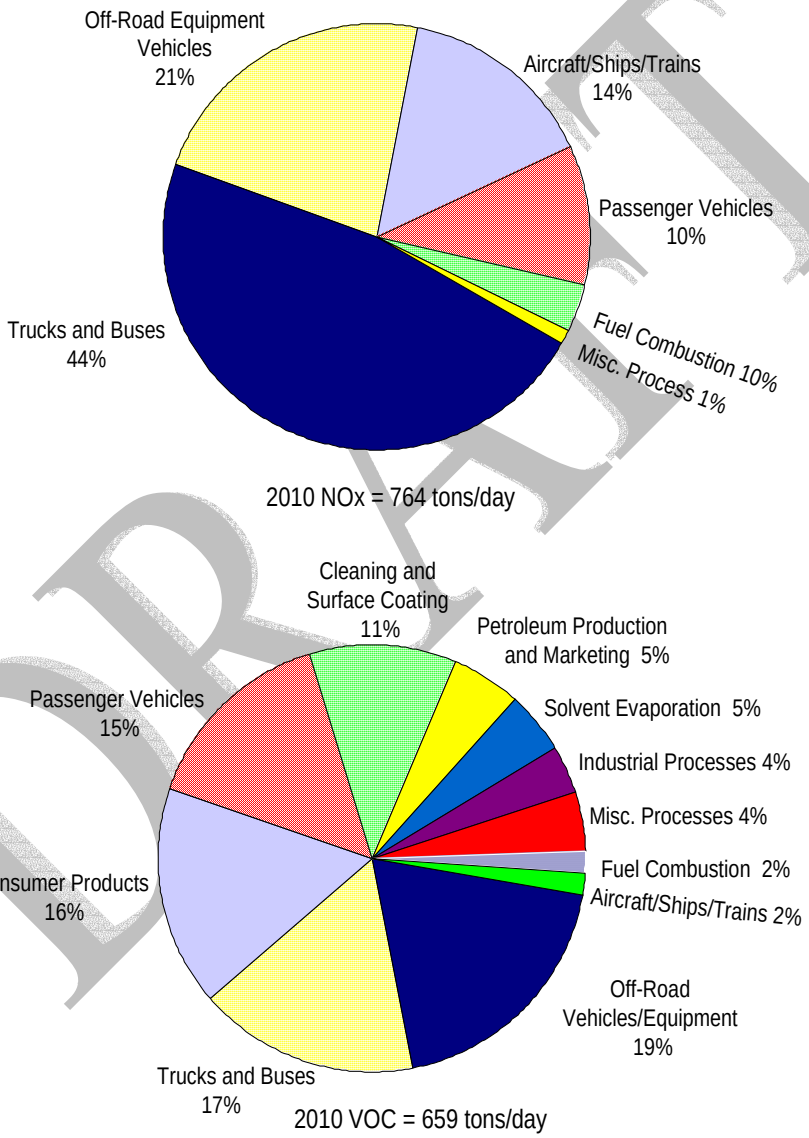

Figure 1. Major Source Contributions (2010)

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

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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 volatile organic compounds (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 in 1998. Subsequently, in 1999, the SCAQMD completed the Multiple Air Toxics Exposure Study (MATES-II) and found that diesel combustion sources (primarily from heavy-duty vehicles) contribute approximately 70% to the estimated potential cancer risk in the Basin.

Advanced clean technologies are, therefore, needed not only for attainment, but also for the health of those that reside within the SCAQMD's jurisdiction. To help meet the need for technologies to address the attainment of clean air standards in the South Coast Air Basin, the SCAQMD 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) Sections 40448.5 and 40512 and Vehicle Code Section 9250.11, establishes mechanisms to collect revenues from mobile and stationary sources to support the program's objectives, 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 hydrogen, fuel cells, liquid petroleum gas, natural gas, combination fuels, synthetic fuels, electricity including electric vehicles, 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. On June 8, 1999, the Clean Fuels Program funding mechanism was extended to January 1, 2005 with the passage of Senate Bill (SB) 98, authored by Senator Richard Alarcon. On September 22, 2003, SB 288 authored by Senator Byron Sher was signed into law, which reauthorized the Clean Fuels Program until January 1, 2010. Annual funds available for Clean Fuels research and development projects from these revenue sources are projected to be as follows:

- Mobile sources (DMV revenues) $ 11,050,000
- Stationary sources (emission fee surcharge) 342,000

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 CARB, the California Energy Commission (CEC), the U.S. EPA, the U.S. Department of Energy (DOE), and the U.S. Department of Transportation (DOT). These supplemental revenues depend in large part on the originating agency, its budgetary and planning cycle, and the specific project or intended use of the revenues.

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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 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
- 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 Section 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.

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Core Technologies

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

1. Low- and zero-emission technologies needed to achieve clean air standards in the Basin.
2. Available funding 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" (i.e., 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., 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 an internal combustion engine (ICE). 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

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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. 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). 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, compressed and liquefied natural gas, and propane. Compressed natural gas (CNG) and liquefied natural gas (LNG) heavy-duty vehicles are finding many applications in urban fleets, such as transit buses, school buses, refuse collection, and delivery vehicles.

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, alcohol-based fuels, propane, hydrogen (as mentioned previously), hydrogen-natural gas mixtures, and even electricity, are much less available or accessible. To realize the emissions reduction benefits, the alternative fuel infrastructure must be developed in tandem with the growth in alternative fueled vehicles. The objectives of the SCAQMD are to 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 2003, the SCAQMD continues to aggressively 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. In addition, as mentioned previously, work continues on implementing a series of hydrogen fueling sites for use by fleets demonstrating fuel cell and hydrogen ICE vehicles.

Emission Control Technology

This broad category refers to technologies that could be deployed on existing mobile sources, especially aircraft, locomotives, marine vessels, farm and construction equipment, industrial equipment, and utility and lawn-and-garden equipment, as well as off-road vehicles. The off-road sources represent about 35 percent of the total NO_x emission inventory and 21 percent of the total VOC inventory in the Basin. Much of the equipment in this source category is either uncontrolled and unregulated, or controlled to a much lesser extent than on-road vehicles. The authority to develop and implement regulations for these off-road mobile sources lies primarily with the U.S. EPA and CARB, and to a lesser extent with the SCAQMD.

Low-emission and clean-fuel technologies that appear promising for on-road mobile sources should also be effective at reducing emissions from a number of off-road sources. Clean fuels such as natural gas, propane, alcohol-based fuels, hydrogen, and hydrogen-natural gas mixtures 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

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conjunction with advanced emission controls—additives, and new engine technologies, appear to have promise. The U.S. EPA and the SCAQMD, for example, have promulgated regulations that lower the sulfur content of diesel fuels in the future. Immediate benefits are also possible from particulate traps, fuel additives, and emulsified fuels that have been developed for diesel applications.

Electric and Hybrid Vehicle Technology

Electric Vehicles (Evs) are powered by an electric motor instead of an ICE. 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 and near-zero emission technologies, including Evs and HEVs, in the Basin to achieve state and federal clean air standards. Although automobile original equipment manufacturers (OEMs) are introducing HEVs such as the Prius (Toyota) and the Civic (Honda), there remains a need to support advancement of technologies to improve marketability and expedite their implementation, especially in the heavy-duty sector. The SCAQMD continues to support projects to develop and demonstrate such advancements in electric drive trains, energy storage devices, charging infrastructure, and related components.

Stationary Source 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, geo-thermal energy, and bio-mass conversion.

Distributed generation with the help of fuel cells 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.

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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 appear to be the most promising approach for this diverse and ubiquitous source category.

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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 CARB; 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
- 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. Such examples are provided in the following sections on Technology Advancement's Research, Development, and Demonstration projects and Technology Commercialization efforts.

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Research, Development, and Demonstration (RD&D)

The development of advanced technology faces increasing challenges in these times of reduced research budgets (especially this year in California), 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-technology knowledge and testing proficiency. Governmental and regulatory agencies can provide guidance in identifying sources with the greatest potential for emissions reduction, assistance in permitting and compliance issues, coordination of infrastructure needs, and facilitation of standards setting and educational outreach. There is also synergy in developing technologies that address multiple goals of public and private bodies regarding the environment, energy, and transportation.

The SCAQMD actively seeks additional partners for the program through participation in various working groups, committees, and task forces. This participation has resulted in coordinating the SCAQMD program with a number of state and federal government organizations, including CARB, CEC, U.S. EPA, and U.S. DOE and several of its national laboratories. Additionally, this list includes the AB 2766 Discretionary Fund Program administered by the Mobile Source Air Pollution Reduction Review Committee (MSRC), various local air districts, National Association of Fleet Administrators (NAFA), major local transit districts, and local gas and electric utilities. The list of organizations with which the SCAQMD coordinates research and development activities also includes the organizations specified in H&SC Section 40448.5.1(a)(2).

In addition, the SCAQMD holds periodic meetings with several organizations specifically to review and coordinate program and project plans. For example, the SCAQMD staff formally meets with CARB staff to review research and development plans, discuss project areas of mutual interest, avoid duplicative efforts, and identify potential opportunities for cost sharing. Periodic meetings are also held with industry-oriented research and development organizations, such as the Manufacturers of Emission Controls Association (MECA), 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 2003, 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 in Table 1. 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.

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Table 1. SCAQMD Funding Partners in CY 2003

Research Funding Organizations	Major Manufacturers
California Air Resources Board	Air Products & Chemicals Inc
California Energy Commission	Cummins Engine Company
Coordinating Research Council	Cummins-Westport
Electric Power Research Institute	Daimler-Chrysler RTNA
Federal Transit Administration	Detroit Diesel Corporation
Gas Technology Institute	Energy Conversion Devices Inc
Los Angeles Department of Water and Power	Engelhard Corp
National Renewable Energy Laboratory	Engine Conversion Systems
Pacific Gas & Electric	Ford Motor Company
Southern California Edison	FuelMaker Corp
Southern California Gas Co.	General Motors
U.S. Department of Energy	Lubrizol Engine Control Systems
U.S. Department of Transportation	Mack Trucks
U.S. Environmental Protection Agency	Quantum Technologies
	Stuart Energy
	Toyota Motor Sales USA Inc

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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 further expansion 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 1.5 g bhp-hr (combined NO_x and VOC). However, additional work is needed to lower the NO_x emissions to 0.5 and ultimately 0.2 g/bhp-hr to meet future heavy-duty vehicle standards which are due to take effect in 2007 and 2010. As such, the SCAQMD is working with the U.S. Department of Energy and the National Renewable Energy Laboratory (NREL) on the Next Generation Natural Gas Vehicle program to develop medium and heavy-duty vehicles to meet these standards before the 2007 timeframe. As part of this program, the SCAQMD is funding Cummins to develop a natural gas

engine using advanced combustion mixing strategies, a three-way catalyst, and exhaust gas recirculation (EGR) to achieve the emissions targets. Cummins is working with Cummins Westport on the modifications to the Cummins Westport C Plus natural gas engine to design, control, and ultimately provide robust operation of the engine system.

Expansion of the Hydrogen Refueling Infrastructure

As part of a larger effort to bring hydrogen vehicles into commercial fruition, the SCAQMD initiated the development of a hydrogen refueling infrastructure for the South Coast Air Basin in 2001. 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. In 2003, the SCAQMD Governing Board approved Phase II of the network with stations at CalState University Los Angeles, Torrance, and Diamond Bar at the SCAQMD Headquarters. The SCAQMD also plans on expanding the network with five additional refueling stations at Burbank, Ontario, Riverside, Santa Ana, and Santa Monica as part of a refueling station and hydrogen ICE vehicle program. Over the next several years, the SCAQMD will seek additional funding to strategically locate hydrogen fueling stations across the Basin in order 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 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 SCAQMD.

The cost-effectiveness of RD&D projects (i.e., dollars spent per ton of pollutant reduced) is difficult to assess since the full benefits of these developing technologies have yet to be realized. The true measure of success for the project lies in whether or not the corresponding 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.

With that qualification, however, the following describes the projects which demonstrate the impact of the SCAQMD program on technology commercialization during the CY 2003 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, school buses, transit buses, shuttle buses, yard tractors at shipping points, and dockside equipment at the ports. Through

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projects directly with OEMs or with intermediate developers such as the Gas Technology Institute, Southern California Gas Company, Acurex Environmental, Tiax LLC (formerly 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)
- Mack E7-400 G (LNG)
- Clean Air Partners/Power Systems (Caterpillar) 3126B (Dual Fuel), C-10 (Dual Fuel), C-12 (Dual Fuel)

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 on-road heavy-duty emissions 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.

Electric Vehicle Application

The SCAQMD continues to support electric and hybrid vehicle technologies as these vehicles provide superior emissions performance as well as fuel economy. Partnering with EPRI and CARB, the SCAQMD is working on "plug-in" hybrid electric vehicles, which couples an ICE with an electric motor but also provides zero emission vehicle (ZEV) miles through the increased use of batteries. In a project started in 2003, with vehicle demonstration from 2005 through 2007, DaimlerChrysler will produce two new gasoline-fueled plug-in hybrid electric Sprinter vans and place them in fleet use for demonstration and evaluation by Southern California Edison and SCAQMD. EPRI will coordinate project participants to evaluate design goals including performance, emissions, fuel economy, and ZEV range while also monitoring market acceptability.

The Sprinter is a popular commercial platform in Europe and can be configured as a panel van, a seven-passenger van or a truck using a variety of alternative propulsion systems and fuels, including natural or liquefied gas, fuel cells, batteries, and hybrid systems by DaimlerChrysler's Competence Center for Low-emission Commercial Vehicles in Manheim, Germany.

For this project, the van will be designed as a plug-in parallel hybrid to provide 20 miles zero emission range on electricity alone, while longer trips can be completed by refueling with gasoline. This hybrid configuration is well suited for urban travel and driving in emission-sensitive areas, such as resorts, residential areas, and around airports. This project represents the impact of the SCAQMD funding toward a near-term technology which couples all of the necessary partners for mass deployment to fully realize the emissions reduction potential, specifically a large automobile OEM, the identified market segment, and the committed partners in a successful pre-commercial demonstration.

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2003 PROJECT EXPENDITURES

The SCAQMD Clean Fuels Program follows a "technology-driven" approach, supporting clean fuels and technologies that appear to offer the most promise in reducing emissions, promoting energy diversity, and, in the long term, providing cost-effective alternatives to current technologies. 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.

As projects are approved by the Governing Board and executed into contracts every month, the finances necessarily change to reflect these projects. As such, the following represents the status of the Clean Fuels Fund as of December 31, 2003.

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, 2003 through December 31, 2003, the SCAQMD Governing Board approved 60 projects, studies or amended contracts that support clean fuels, as shown in Table 2. The funding mechanisms for these programs were described previously in the following areas: fuel cell technology, engine technology, hydrogen technology and infrastructure, electric and hybrid technologies, infrastructure and fuel production, emission studies, emission control technology, health, outreach and technology transfer, VOC and toxics, and stationary source clean fuel technology. These projects are summarized in

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Table 2, and the distribution of funds based on technology area is shown graphically in Figure 2.

Project expenditures for research, development, and demonstration (RD&D) projects that were approved or amended with dollars for the 2003 reporting period were as follows:

Total Cost of Clean Fuels Projects	$ 61,731,577
SCAQMD Clean Fuels Fund Contribution	11,216,254

Each year, the Governing Board approves approximately $400,000 to be transferred to the General Fund Budget for Clean Fuels administration. This includes funding for program operating costs (e.g., postage, supplies, travel costs for special conferences), workshops, conferences and co-sponsorships. Only the funds that are committed by December 31 are included here. Any portion of the Clean Fuels $400,000 that is not spent during the year is returned to the Clean Fuels Fund.

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, 2004.

For the Clean Fuels projects approved by the Governing Board, the average SCAQMD contribution in 2003 was about 18 percent of the total cost of the projects, i.e., each dollar from the SCAQMD was leveraged with more than four dollars of outside investment. This is consistent with the historical average leveraging of four to one.

During 2003, matching funds for the Carl Moyer Program (CMP) were met by using approved "Moyer-like" projects funded with Clean Fuels funds. "Moyer-like" projects are defined as projects that would qualify for funding under CMP Guidelines. Alternative fuel infrastructure projects are eligible. The required local match funding was $3.6 million and was provided from qualified infrastructure projects funded in 2001. This included support for fuel cell technology and alternative fuels infrastructure and production within the SCAQMD's jurisdiction. In 2004, approximately $2,333,000 in Clean Fuels monies will be transferred to the Carl Moyer Program. These funds were originally designated in prior years as part of the Carl Moyer match but were not used because the projects were not realized or companies that were awarded funding returned all of a portion of unused funding.

During 2003, the SCAQMD Governing Board approved Clean Fuels Fund expenditures of nearly $11.2 million for clean fuels projects. The distribution of the Board-approved funding is shown in Figure 2 below.

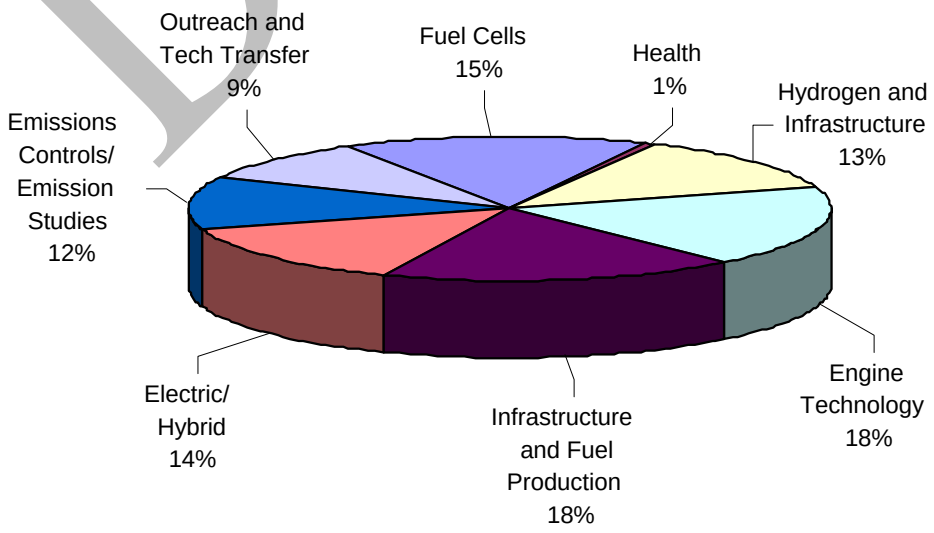

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Figure 2. Distribution of Governing Board Approved Clean Fuels Funds
Calendar Year 2003 ($11.2 million)

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 a comprehensive Annual Financial Report and Single Audit Reports. The firm of Simpson & Simpson conducted the financial audits for the fiscal year that ended June 30, 2003. 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.

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Table 2. Clean Fuels Awards Approved by the Governing Board in CY 2003

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Fuel Cell Technology						
04003	Daimler-Chrysler RTNA	Install & Demonstrate Fuel Cell Vehicle Maintenance Facility	TBD	TBD	$ 253,000	$ 542,000
04004	Daimler-Chrysler RTNA	Demonstrate Two Fuel Cell Vehicles	TBD	12 mos	240,000	1,240,000
TBD	California Cast Metals Association	Install & Demonstrate Molten Carbonate, Stationary Fuel Cells at Local Metal Casting Plants	TBD	TBD	701,000	9,884,448
TBD	UTC Fuel Cells	Install & Demonstrate Proton Exchange Membrane, Stationary Fuel Cells within Disneyland Complex	TBD	TBD	299,000	2,585,852
TBD	Seaworthy Systems	Demonstrate Fuel Cell Water Taxi	TBD	TBD	101,000	781,000
04083	City of Santa Monica	Demonstrate Toyota Fuel Cell Vehicle	TBD	TBD	100,000	300,000
Hydrogen Technology and Infrastructure						
03272	Northern Power Systems	Develop Conceptual Engineering Design for Integrated Hydrogen Energy Demonstration Facility	02/27/03	05/30/03	45,000	45,000
03273	SunLine Services Group	Study & Develop Hydrogen Fueling Station Templates and Future Network in SCAB	07/01/03	02/28/04	68,554	68,554
04011	Air Products & Chemicals, Inc.	Install & Demonstrate an Industrial Pipeline-Supplied Hydrogen Refueling Station	TBD	20 mos	400,000	855,170
04012	Stuart Energy	Install & Demonstrate Electrolyzer-Based Hydrogen Refueling Station Integrated with Stationary Internal Combustion Engine Power Generation Unit	12/05/03	08/05/04	537,000	804,500
04013	California State University, Los Angeles	Install & Demonstrate PEM Electrolyzer, Providing Hydrogen Fueling for Vehicles and Utilizing Technology in the Engineering Curriculum at the University	TBD	24 mos	250,000	600,000
04030	Tank Specialists of California	Removal of Methanol/Gasoline Station at AQMD in Diamond Bar	2/18/04	04/30/04	45,000	45,000
04081	Toyota Motor Sales, U.S.A., Inc.	Cost-Share & Provide Hydrogen Fuel to City of Santa Monica to Support Fell Cell Vehicle	TBD	TBD	30,000	60,000
TBD	Stuart Energy	Maintenance and Data Management of Hydrogen Fueling Station at AQMD Headquarters	TBD	TBD	80,000	80,000
Engine Technology						
03289	Cummins, Inc.	Develop & Demonstrate Next Generation Natural Gas Engine Technology	07/07/03	08/31/05	1,000,000	2,109,203
03427	Mack Trucks Inc.	Integration of Improved Natural Gas Engine into Commercial Chassis	TBD	TBD	600,000	2,475,694

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Table 2. Clean Fuels Awards Approved by the Governing Board in CY 2003 (Continued)

ontract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Engine Technology (Cont'd)						
04046	Evo Transportation, Inc.	Convert Ten Gasoline-Fueled, Full-Length SUVs to CNG	12/23/03	7/31/04	$ 100,000	$ 450,000
04056	Teleflex/GFI Control Systems, Inc.	Develop & Demonstrate 8.1L Natural Gas Engine in Medium-Duty Trucks	TBD	TBD	334,080	2,191,829
Infrastructure and Fuel Production						
03319	FuelMaker Corporation	Upgrade CNG Fueling Systems at School Districts & Municipalities	11/05/03	07/31/04	90,000	180,000
TBD	Pacific Gas & Electric	Demonstrate Small-Scale Natural Gas Liquefaction Plant	TBD	TBD	200,000	6,000,000
04015	WM Energy Solutions, Inc.	Purchase & Install an LNG Production Facility	11/06/3	09/30/09	300,000	5,500,000
TBD	Praxair, Inc.	Purchase & Install an LNG Production Facility	TBD	TBD	750,000	4,000,000
TBD	Cryogenic Equipment & Services LTD	Purchase & Install an LNG Production Facility	TBD	TBD	137,264	2,000,000
TBD	SunLine Services Group	Purchase & Install an LNG Production Facility	TBD	TBD	549,054	9,800,000
Electric/Hybrid Technologies						
04009	Energy Conversion Devices, Inc.	Integrate & Develop Internal Combustion Engine Hybrid Vehicle Utilizing Metal Hydrides for On-Board Hydrogen Storage	TBD	28 mos	200,280	400,561
04027	ISE Research Corporation	Develop & Demonstrate Hydrogen-Internal Combustion Engine Hybrid-Electric Bus	10/29/03	05/31/05	210,000	1,075,000
04032	Electric Power Research Institute	Develop, Demonstrate & Evaluate Plug-In Electric Vans in Fleet Use	11/14/03	08/31/05	475,000	1,525,000
04109	University of California, Davis	Optimize & Demonstrate Plug-In Hybrid Electric Vehicles	TBD	TBD	150,000	458,000
TBD	Clean Fuel Connection, Inc.	Public EV Charging Equipment and Signage Replacement	TBD	TBD	100,000	100,000
TBD	North American Bus Industries	Develop & Demonstrate Two 45-Foot Natural Gas Composite Body Hybrid-Electric Transit Buses	TBD	TBD	400,000	1,400,000
Emission Control Technology						
03467	Cummins Westport Inc.	Aftertreatment Technology for PM & Hydrocarbon Emissions Control of CNG-Fueled Heavy-Duty Engines	TBD	TBD	496,785	656,785
03469	West Virginia University	Emission Testing Heavy-Duty Dedicated Natural Gas and New Diesel Refuse Vehicles	08/26/03	06/30/04	260,000	260,000
04000	Engine, Fuels and Emissions Engineering	Prescreen, Transport & Analyze Heavy-Duty Dedicated Natural Gas and New Diesel Refuse Vehicles	08/12/03	12/31/03	50,000	50,000
TBD	West Virginia University	Transportable Laboratory Testing for Aftertreatment Technology for PM & Hydrocarbon Emissions Control of CNG-Fueled Heavy-Duty Engines	TBD	TBD	83,215	83,215

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Table 2. Clean Fuels Awards Approved by the Governing Board in CY 2003 (Continued)

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Emission Control Technology (Cont'd)						
TBD	Lubrizol Engine Control Systems	Optimize & Demonstrate Oxidation Catalysts to Further Reduce Exhaust Emissions from CNG-Fueled Heavy-Duty Engines	TBD	TBD	$ 364,125	$ 400,000
Emission Studies						
03468	University of California Riverside/CE-CERT	Conduct Reactivity and Availability Studies for VOC Species in Mobile Source Emissions	08/01/03	08/01/04	100,000	100,000
Health						
03358	Jurupa Unified School District	Children's Health Study	06/13/03	05/31/06	25,000	25,000
04073	University of Southern California	Study Effects of Smoke from Recent Wildfires in Cohorts of USC Children's Study	TBD	TBD	49,896	49,896
Outreach and Technology Transfer						
01026	Bevilaqua-Knight Inc.	CY 2003 Membership Participation in California Fuel Cell Partnership	12/18/00	12/31/03	84,000	84,000
02316	California Science Center Foundation	Construct & Install Fuel Cell Exhibit	06/23/03	06/30/04	226,000	276,000
03450	Sawyer Associates	Technical Assistance Pertaining to 2003 Revision & Mobile Source Control Sources	06/26/03	11/30/04	15,000	15,000
03451	TIAX LLC	Technical Assistance Pertaining to 2003 Revision & Mobile Source Control Sources	06/23/03	11/30/04	20,000	20,000
04045	TIAX LLC	Technical Assistance for Development, Outreach & Commercialization of Low-Emission and Alternative Fuel Technologies	11/21/03	12/31/05	30,000	30,000
04048	Cindy Sullivan	Technical Assistance to Develop, Outreach & Commercialize Emission Control Technologies	11/21/03	12/31/05	30,000	30,000
04049	Engine, Fuel and Emissions Engineering, Inc.	Technical Assistance to Develop, Outreach & Commercialize Alternative Fuels Engine Technology	11/21/03	12/31/05	40,000	40,000
04050	Breakthrough Technologies Institute, Inc.	Technical Assistance to Develop, Outreach & Commercialize Fuel Cells and Technical Coordination with Federal Energy & Trans. Depts.	11/21/03	12/31/05	35,000	35,000
04051	Burnett & Burnette	Technical Assistance to Develop, Outreach & Commercialize CNG Engine Technology and CNG Infrastructure	1/19/04	12/31/05	40,000	40,000
04052	USA Pro & Associates	Technical Assistance to Develop, Outreach & Commercialize LNG Infrastructure and Fuel Production	12/19/03	12/31/05	40,000	40,000

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Table 2. Clean Fuels Awards Approved by the Governing Board in CY 2003 (Continued)

Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
Outreach and Technology Transfer (Cont'd)						
04053	Marathon Technical Services	Technical Assistance to Develop, Outreach & Commercialize CNG/LNG Infrastructure	11/21/03	12/31/05	$ 40,000	$ 40,000
TBD	Calstart, Inc.	Operate & Improve Functionality of CleanCarMaps.Com	TBD	TBD	110,000	355,000
TBD	Gladstein & Associates, LLC	Technical & Public Outreach Support for Implementation of Low-Emission, Clean Fuel, Heavy-Duty Vehicles	TBD	TBD	125,000	615,000
Purchase Order	Elmore Toyota Dealership	Purchase of Three 2004 Toyota Prius Hybrid Vehicles	N/A	N/A	79,870	79,870
Various	Various Contractors	Co-Sponsorships: Eight Conferences, Workshops and Events in 2003	Varies	Varies	127,131	850,000

Table 3. Supplemental Grants & Revenues Received in CY 2003

Revenue Agreement	Revenue Source	Project Title	Contractor	AQMD Project	Total
MOU	SoCalGas	Aftertreatment Technology for PM & Hydrocarbon Emissions Control of CNG-Fueled Heavy-Duty Engines	Cummins Westport Inc.	Contract #03467	$ 100,000
MOU	Los Angeles Dept. of Water & Power	Develop & Demonstrate Two 45-Foot Natural Gas Composite Body Hybrid-Electric Transit Buses	North American Bus Industries	Contract #TBD	1,000,000

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Project Summaries

The following presents the summaries of the technology development and demonstration projects and studies awarded in 2003. These new and amended projects are listed in the order found in Table 2, 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 as required by H&SC Section 40448.5.1 (d).

Fuel Cell Technology

04003: Install and Demonstrate Fuel Cell Vehicle Maintenance Facility

Contractor: Daimler-Chrysler RTNA

SCAQMD Cost-share:	$	253,000
Cosponsors:		
Daimler-Chrysler		289,000
Mercedes Benz Test Center		In-kind
Total Cost:	$	542,000

Term: TBD – TBD

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

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

Contractor: Daimler-Chrysler RTNA

SCAQMD Cost-share:	$	240,000
Cosponsors:		
Daimler-Chrysler		500,000
USDOE		500,000
Total Cost:	$	1,240,000

Term: TBD – 12 mos.

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

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TBD: Install & Demonstrate Molten Carbonate, Stationary Fuel Cells at Local Metal Casting Plants

Contractor: California Cast Metals Association	SCAQMD Cost-share:	$ 701,000
	Cosponsors:	
	CCMA	1,203
	Others	9,182,245
Term: TBD – TBD	Total Cost:	$ 9,884,448

In October 2002, to further promote fuel cell deployment, the Board authorized an RFP for installing stationary fuel cells in the South Coast Air Basin in an amount not to exceed $1,000,000. Based on a panel evaluation according to the criteria established in the RFP, two projects were selected for funding. This project represents one of those awards to the California Cast Metals Association (CCMA).

The CCMA proposes to install up to four 250 kW Fuel Cell Energy molten carbonate fuel cells at three of their metal casting facilities within the South Coast Air Basin: Fontana, Carson, and Rancho Dominguez. These high temperature fuel cells will be used for metal pre-heating or other co-generation applications depending on the installation site. CCMA is partnering with Emergent Energy Group, who will own and operate the fuel cell units with guarantees for performance and warrantees from Fuel Cell Energy.

TBD: Install and Demonstrate Proton Exchange Membrane, Stationary Fuel Cells within Disneyland Complex

Contractor: UTC Fuel Cells	SCAQMD Cost-share:	$ 299,000
	Cosponsors:	
	UTC Fuel Cells/Others	2,286,852
Term: TBD - TBD	Total Cost:	$ 2,585,852

This project represents the other project from the October 2002 stationary fuel cell RFP and was awarded in April 2002 to UTC Fuel Cells (UTCFC).

UTCFC is partnering with Southern California Gas Company and Walt Disney Imagineering Research to install 150 kW PEM units at two demonstration sites within the Disneyland complex in Anaheim or possibly elsewhere within the Company territory SCAQMD jurisdiction. The stationary PEM product is seen as the commercial successor to the current PAFC units offered by UTCFC and represents a new technology with faster startup, smaller footprint, and simpler installation than its predecessor. Although the project represents one of the first deployments, and therefore may include higher risks, the proposers offer an innovative mitigation plan by requesting zero funding from the SCAQMD for the first phase of the project. During this phase, the SCAQMD would be actively engaged to help select the final sites and monitor the progress of the prototype testing. Based on the progress of the technology, staff will be able to determine prior to the start of the second phase whether to continue the project and commit the requested funding.

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TBD: Demonstrate Fuel Cell Water Taxi

Contractor: Seaworthy Systems	SCAQMD Cost-share:	$	101,000
	Cosponsors:		
	CCDoT		300,000
	Duffy Boats		380,000
Term: TBD - TBD	Total Cost:	$	781,000

On July 11, 2002, the Governing Board awarded Seaworthy Systems for a Phase II demonstration of a sodium borohydride, fuel cell water taxi, originally funded by the Center for Commercial Deployment of Transportation Technologies.

The team partners and their responsibilities for the Phase II effort are Seaworthy Systems (project management), Millennium Cell (fueling system), and Duffy Boats (vessel builder). The team has purchased the proton exchange membrane (PEM) fuel cell from Anuvu, located in Sacramento, CA. The original scope of the Phase I effort is to build the thirty-foot vessel, integrate the sodium-borohydride fueling system and fuel cell, and demonstrate the water taxi in revenue service for six months at Newport Harbor. The Board approved to extend the demonstration and data collection over a two-year period. This extended demonstration will allow the more detailed investigation of real-world operation, refueling procedures, fueling system design, and fuel cell integrity.

04083: Demonstrate Toyota Fuel Cell Vehicle

Contractor: City of Santa Monica	SCAQMD Cost-share:	$	100,000
	Cosponsors:		
	Toyota		In-Kind
	City of Santa Monica		200,000
Term: TBD - TBD	Total Cost:	$	300,000

Toyota Motor Sales, U.S.A., Inc. (Toyota) will provide a fuel cell vehicle to be incorporated into the City of Santa Monica fleet for a thirty-month demonstration period. This vehicle will be used in general and high-profile applications to test vehicle performance in the context of Santa Monica fleet activities. Service and evaluation of the vehicle will be performed by Toyota staff at their Torrance facility. The fuel cell vehicle provided is highly proprietary with very specific design characteristics and technology. These characteristics will require considerable support from qualified Toyota staff and facilities during the thirty-month demonstration project.

Hydrogen Technology and Infrastructure

03272: Develop Conceptual Engineering Design for Integrated Hydrogen Energy Demonstration Facility

Contractor: Northern Power Systems	SCAQMD Cost	$	45,000
Term: 02/27/03 – 05/30/03	Total Cost:	$	45,000

Northern Power Systems (NPS), a well-established firm specializing in power generation and system integration, was involved in the original installation of the 20 kW solar power array at SCAQMD headquarters in 1993. The Board-approved project will expand the solar generation capability to 100 kW to provide the renewable capacity to power an electrolyzer/compressor unit that will generate hydrogen from water. The hydrogen will be stored to supply fuel upon demand for (1) hydrogen internal combustion and fuel cell vehicles, (2) a fuel cell for back-up or premium power, and (3) a stationary ICE power generator for back-up or peaking power. In addition, an on-site natural gas

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reformer may be included to produce additional hydrogen as required to meet refueling and power generation needs. A possible tie-in to the existing compressed natural gas fueling station will also be considered for supplying Hythane fuel (hydrogen and natural gas) for vehicles. This project is to contract with Northern Power Systems to develop a viable plan for this integrated hydrogen-fuel cell demonstration, including the upgrade to SCAQMD's photovoltaic power generation capability.

The implementation of the study recommendations will further allow the SCAQMD to continue in its historic role as an outreach and educational demonstration site for clean energy. The SCAQMD facility is home to (1) the first-ever commercial fuel cell installation, (2) renewably-powered electric vehicle charging stations, and (3) four microturbine generators, which demonstrate efficient distributed power with heat recovery. Implementation of the integrated hydrogen technologies would allow the SCAQMD to continue in this legacy.

03273: Study and Develop Hydrogen Fueling Station Templates and Future Network in SCAB

Contractor: SunLine Services Group — SCAQMD Cost-share: $ 68,554
Term: 07/01/03 – 02/28/04 — Total Cost: $ 68,554

This award is to develop hydrogen fueling station templates and to conduct an optimization study for siting a hydrogen fueling network. The template(s) include specifications for commercially available, fully demonstrated, and appropriately sized equipment that can be used for hydrogen fueling of fleet vehicles. A summarized consolidated master list that includes but is not limited to these key data will be developed:

- equipment locations;
- schedules and costs;
- development of plot plans and schematics;
- a hydrogen fueling station program reference guide for refueling of vehicles;
- construction guidance with respect to both present and future codes and standards; and
- an optimization study for siting a future hydrogen fueling network in the South Coast Air Basin.

The resulting work products will offer economical and flexible designs with respect to different refueling formats i.e. liquid or gaseous hydrogen storage and dispensing, liquid or gaseous hydrogen stored on board a vehicle and liquid-to-gaseous hydrogen dispensing, etc.

04011: Install and Demonstrate an Industrial Pipeline-Supplied Hydrogen Refueling Station

Contractor: Air Products and Chemicals, Inc. — SCAQMD Cost-share: $ 400,000
Cosponsors:
Air Products 455,170
Term: TBD – 20 mos. — Total Cost: $ 855,170

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

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project are to develop a safety and operational training plan for the station that could be adapted to future sites and to provide increased public awareness of hydrogen as a vehicle fuel.

04012: Install and Demonstrate Electrolyzer-Based Hydrogen Refueling Station Integrated with Stationary Internal Combustion Engine Power Generation Unit

Contractor: Stuart Energy	SCAQMD Cost-share:	$	537,000
	Cosponsors:		
	Stuart Energy		167,500
	California Energy Commission		100,000
Term: 12/05/03 – 08/05/04	Total Cost:	$	804,500

Stuart Energy plans to install and beta test an electrolyzer hydrogen generation and vehicle fueling station integrated with a hydrogen-powered stationary internal combustion engine electricity generator at SCAQMD headquarters. This system will be used to supply fuel cell and other hydrogen powered vehicles with fuel while maintaining the capability to provide auxiliary, peaking or backup power to SCAQMD operations. This system will also be further integrated with a 100 kw photovoltaic array that will be part of the planned SCAQMD Integrated Hydrogen Demonstration Facility currently under development. The hydrogen produced will also be available to support fueling for hydrogen vehicles from other demonstration sites and programs.

04013: Install and Demonstrate PEM Electrolyzer, Providing Hydrogen Fueling for Vehicles and Utilizing Technology in the Engineering Curriculum at the University

Contractor: California State University, Los Angeles	SCAQMD Cost-share:	$	250,000
	Cosponsors:		
	CSULA		350,000
	Quantum Technologies		In-kind
	Proton Energy		In-kind
Term: TBD – 24 mos.	Total Cost:	$	600,000

California State University at Los Angeles in partnership with Quantum Technologies, Proton Energy and other corporate partners will develop and demonstrate a grid-powered Polymer Electrolytic Membrane (PEM) electrolyzer hydrogen refueling station near the Engineering Technology Department. This equipment will be used to provide fuel for fuel cell and other hydrogen-fueled vehicles. The equipment will also be integrated into the Engineering Technology curriculum to expand the current coursework to include clean fuels technologies and hydrogen as a fuel of the future. Power will be supplied by grid electricity and hydrogen will be dispensed to vehicles in a fast-fill mode from a dispenser.

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04030: Removal of Methanol/Gasoline Station

Contractor: Tank Specialists of California	SCAQMD Cost-share:	$	45,000
Term: 2/18/04 – 04/30/04	Total Cost:	$	45,000

To prepare the SCAQMD's Diamond Bar facility for the hydrogen fueling station, the existing methanol/gasoline station must be removed. Tank Specialists of California will undertake this effort and prepare the site for Stuart Energy (Contract #04012) to install an electrolyzer-based hydrogen station.

04081: Cost-Share and Provide Hydrogen Fuel to City of Santa Monica to Support Fuel Cell Vehicle

Contractor: Toyota Motor Sales, U.S.A., Inc.	SCAQMD Cost-share:	$	30,000
	Cosponsors:		
	Toyota Motor Sales		30,000
	City of Santa Monica		In-kind
Term: TBD - TBD	Total Cost:	$	60,000

Toyota Motor Sales, U.S.A., Inc. (Toyota) will provide fuel for a fuel cell vehicle to be incorporated into the City of Santa Monica fleet for a thirty-month demonstration period. This fuel will eventually be displaced by the installation of an electrolyzer hydrogen fueling station currently being planned as part of the SCAQMD's hydrogen refueling infrastructure. Service and fuel delivery as well as all fueling-related support activities will be contracted by Toyota to Air Products and Chemicals, Inc. Due to the commitment of the City of Santa Monica for "green" power, the hydrogen will be generated from renewable energy at the SCAQMD/ISE Research/Wintec Hydrogen Fueling Station in Palm Desert and delivered to Santa Monica.

TBD: Maintenance and Data Management of Hydrogen Fueling Station at SCAQMD Headquarters

Contractor: Stuart Energy	SCAQMD Cost-share:	$	80,000
Term: TBD - TBD	Total Cost:	$	80,000

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

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Engine Technology

03289: Develop and Demonstrate Next Generation Natural Gas Vehicle Engine Technology

Contractor: Cummins, Inc.	SCAQMD Cost-share:	$ 1,000,000
	Cosponsors:	
	Cummins, Inc.	1,109,203
Term: 07/07/03 – 08/31/05	Total Cost:	$ 2,109,203

The National Renewable Energy Laboratory (NREL) issued an RFP in April 2002 to initiate and cosponsor the Phase II development of the Next Generation of Natural Gas Vehicles (NGNGV) in conjunction with funding from the U.S. Department of Energy (DOE). The purpose of NGNGV program is to commercialize new low emission medium- and heavy-duty natural gas vehicles. This particular project is for the development of a medium-duty natural gas engine capable of meeting or exceeding the 2007 EPA standards of 0.2 g/bhp-hr NO_x and 0.01 g/bhp-hr particulate emissions by 2005. The Governing Board approved this contract to co-fund the development of this engine by Cummins for $1M. Cummins will use advanced combustion mixing strategies, a three-way catalyst, and EGR to achieve the emissions targets in conjunction with computer simulations and kinetic modeling of the engine for performance and emissions development. These models will be used to predict and then optimize the engine during the testing phase of the project. Cummins will work with Cummins Westport on the modifications to the Cummins Westport C Plus natural gas engine to design, control, and ultimately provide robust operation of the engine system.

03427: Integration of Improved Natural Gas Engine into Commercial Chassis

Contractor: Mack Trucks Inc.	SCAQMD Cost-share:	$ 600,000
	Cosponsors:	
	NREL	696,991
	Mack Trucks	1,178,703
Term: TBD - TBD	Total Cost:	$ 2,475,694

The National Renewable Energy Laboratory (NREL) issued an RFP in April 2002 to initiate and cosponsor the Phase II development of the Next Generation of Natural Gas Vehicles (NGNGV) in conjunction with funding from the U.S. Department of Energy (DOE). The purpose of NGNGV program is to commercialize new low emission medium- and heavy-duty natural gas vehicles. This particular project is for the development of an integrated heavy-duty, liquid natural gas engine and chassis in a refuse hauler capable of meeting or beating the 2004 EPA standards of standards of 0.5 g/bhp-hr NO_x and 0.01 g/bhp-hr particulate emissions. Mack will modify an existing lean burn, natural gas engine to operate stoichiometrically with a three-way catalyst and exhaust gas recirculation (EGR). Mack will enlist the help of Southwest Research Institute in San Antonio, Texas for the engine modifications. Installation of the EGR system and sensors, optimization of the emissions and performance, and formulations of different catalysts will be conducted to optimize the engine under steady state and transient conditions during the first year of the project. The new engine system will then be integrated into a refuse hauler chassis and demonstrated with Waste Management during the second year.

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04046: Convert Ten Gasoline-Fueled, Full-Length SUVs to CNG

Contractor: EVO Transportation, Inc.	SCAQMD Cost-share:	$	100,000
	Cosponsors:		
	EVO Transportation, Inc.		250,000
	General Motors Corporation		100,000
Term: 12/23/03 – 7/31/04	Total Cost:	$	450,000

EVO transportation, Inc. will retrofit ten gasoline-fueled, full-length, medium duty, 6.0 liter General Motors sport utility vehicles (SUVs) to compressed natural gas (CNG)-fueled Ultra Low Emission Vehicles (ULEV). The retrofit equipment in this project is developed by Baytech Corporation and is CARB certified to ULEV standards on the identified model vehicle. This project will promote the viability of alternative-fueled vehicles through a highly visible medium, a transport chartered party (TCP) company, and facilitate a public outreach of low-emission technologies. The ten retrofitted SUVs will be operated by EVO Transportation, Inc. EVO is a TCP company and an environmentally focused pioneer in the upscale, SUV-class limousine industry, providing service to high profile clientele. Limousines are a highly visible industry in Southern California, and this project can serve as a leader in demonstrating the viability of natural gas-fueled vehicles and the natural gas program for this industry.

04056: Develop and Demonstrate 8.1L Natural Gas Engine in Medium-Duty Trucks

Contractor: Teleflex/GFI Control Systems, Inc.	SCAQMD Cost-share:	$	334,080
	Cosponsors:		
	NREL		1,271,970
	Teleflex/GFI		301,579
	ARBOC Ltd.		138,000
	General Motors		72,500
	Engelhard		73,700
Term: TBD - TBD	Total Cost:	$	2,191,829

The National Renewable Energy Laboratory (NREL) issued an RFP in April 2002 to co-sponsor the Phase II development of the Next Generation of Natural Gas Vehicles (NGNGV) in conjunction with funding from the U.S. Department of Energy. NREL selected a proposed project from Teleflex/GFI for support. The proposed contract with Teleflex/GFI will develop and demonstrate an 8.1-liter natural-gas engine in a heavy-duty commercial chassis.

Infrastructure and Fuel Production

03319: Upgrade CNG Fueling Systems at School Districts and Municipalities

Contractor: FuelMaker Corporation	SCAQMD Cost-share:	$	90,000
	Cosponsors:		
	So Cal Gas		90,000
Term: 11/05/03 – 07/31/04	Total Cost:	$	180,000

The CNG fueling systems installed at school districts and municipalities were designed to meet normal conditions and water content. Due to some very unusual local conditions, the natural gas supplied to some of the SCAQMD sponsored CNG projects contain extremely high water content. Normally, natural gas contains from one-half to six pounds of water per million cubic feet of gas.

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However, some sites have been found to have up to 100 pounds of water per million cubic feet of gas. The existing gas dryers at these sites are inadequate to remove the water from the supplied natural gas at those sites and must be replaced with larger units. As a further step to save expense, regenerative-type dryers are being recommended to allow for the recycling of the molecular sieve desiccant. FuelMaker is a leader in the gas-drying industry and will work with Southern California Gas Company, which will be provide technical and financial assistance with this project.

TBD: Demonstrate Small-Scale Natural Gas Liquefaction Plant

Contractor: Pacific Gas & Electric	SCAQMD Cost-share:	$ 200,000
	Cosponsors:	
	PG&E	2,500,0000
	Southern California Gas Co.	2,150,000
	California Energy Commission	600,000
	New York Electric and Gas Co.	350,000
Term: TBD - TBD	Total Cost:	$ 6,000,000

Implementation of the SCAQMD Clean Fleet Vehicle Rules has increased the demand and need for liquefied natural gas (LNG) fuel in the Basin. The supply of LNG in California is dependent upon LNG production facilities in Arizona, Wyoming and Texas. Associated with this existing supply of LNG is the accompanying transportation cost of the LNG. While there are current plans to build and develop several large stationary liquefaction plants in Southern California utilizing natural gas from existing pipelines, recent advances in liquefaction technologies suggest that a small-scale, mobile liquefaction plant could be built to take advantage of natural gas from stranded wells and possibly landfills. Development of such a technology would provide additional sources of LNG fuel and reduce the region's dependence on LNG pipeline-fed natural gas and out-of-state LNG. This project will design and develop a small-scale liquefaction plant with the capacity of up to 20,000 gpd at a cost estimate of $45,000 (not including installation and storage).

04015: Purchase & Install an LNG Production Facility

Contractor: WM Energy Solutions, Inc.	SCAQMD Cost-share:	$ 300,000
	Cosponsors:	
	WM Energy Solutions	5,200,000
Term: 11/06/03 – 09/30/09	Total Cost:	$ 5,500,000

This project will provide a local supply of LNG fuel, thus reducing the dependency on long-distance, out-of-state supplies of LNG fuel. Producing LNG locally is expected to minimize transportation costs for public and private fleet operators subject to SCAQMD's Clean Fleet Vehicle Rules. In addition to the existing infrastructure network, these new projects are strategically located to help establish an infrastructure backbone that will allow for fueling for both LNG and CNG type vehicles throughout the Basin. WM Energy Solutions, Inc. proposes to build a new gas liquefaction plant using Cryofuel technology at the Bradley Landfill in Sun Valley. This is an innovative process, and this project will be the first commercial installation of this technology.

TBD: Purchase and Install an LNG Production Facility

Contractor: Praxair	SCAQMD Cost-share:	$ 750,000
	Cosponsors:	
	Praxair	3,250,000
Term: TBD - TBD	Total Cost:	$ 4,000,000

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This project will provide a local supply of LNG fuel, thus reducing the dependency on long-distance, out-of-state supplies of LNG fuel. Producing LNG locally is expected to minimize transportation costs for public and private fleet operators subject to SCAQMD's Clean Fleet Vehicle Rules. In addition to the existing infrastructure network, these new projects are strategically located to help establish an infrastructure backbone that will allow for fueling for both LNG and CNG vehicles throughout the Basin. Praxair, Inc. proposes to modify their existing air separation facility, including their liquid nitrogen storage tanks, in Wilmington, California, with a refrigeration and purification system using pipeline natural gas.

TBD: Purchase and Install an LNG Production Facility

Contractor:	Cryogenic Equipment & Services LTD	SCAQMD Cost-share:	$ 137,264
		Cosponsors:	
		Cryogenic Equipment & Services	1,862,736
Term:	TBD - TBD	Total Cost:	$ 2,000,000

This project will provide a local supply of LNG fuel, thus reducing the dependency on long-distance, out-of-state supplies of LNG fuel. Producing LNG locally is expected to minimize transportation costs for public and private fleet operators subject to SCAQMD's Clean Fleet Vehicle Rules. In addition to the existing infrastructure network, these new projects are strategically located to help establish an infrastructure backbone that will allow for fueling for both LNG and CNG vehicles throughout the Basin. Cryogenic Equipment & Services LTD proposes to modify an existing CNG fueling station owned by the Southern California Gas Company with a pressure let-down and gas purification system using pipeline natural gas.

TBD: Purchase and Install an LNG Production Facility

Contractor:	SunLine Services Group	SCAQMD Cost-share:	$ 594,054
		Cosponsors:	
		Praxair	9,205,946
Term:	TBD - TBD	Total Cost:	$ 9,800,000

This project will provide a local supply of LNG fuel, thus reducing the dependency on long-distance, out-of-state supplies of LNG fuel. Producing LNG locally is expected to minimize transportation costs for public and private fleet operators subject to SCAQMD's Clean Fleet Vehicle Rules. In addition to the existing infrastructure network, these new projects are strategically located to help establish an infrastructure backbone that will allow for fueling for both LNG and CNG type vehicles throughout the Basin. SunLine Services, in association with ENRG, Inc. and Cosmodyne, Inc., proposes to build a new natural gas liquefaction plant using traditional technology at SunLine's Thousand Palms transit facility, using pipeline natural gas.

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Electric/Hybrid Technologies

04009: Integrate and Develop Internal Combustion Engine Hybrid Vehicle Utilizing Metal Hydrides for On-Board Hydrogen Storage

Contractor:	Energy Conversion Devices, Inc.	SCAQMD Cost-share:	$ 200,280
		Cosponsors:	
		ECD, Inc.	200,281
		Texaco Ovonics	In-kind
Term:	TBD – 28 mos.	Total Cost:	$ 400,561

Energy Conversion Devices, Inc., in partnership with Texaco Ovonic Hydrogen Systems, will integrate and demonstrate an electric hybrid/hydrogen internal combustion engine vehicle that uses metal hydrides for on-board hydrogen storage. The vehicle used for this demonstration is a gasoline hybrid vehicle converted to run on hydrogen as fuel that also incorporates metal hydrides for fuel storage on the vehicle. The goals of this program are to demonstrate hydrogen internal combustion engine ICE vehicles and to evaluate the viability of using metal hydrides for on-board hydrogen storage. The project will also illustrate the feasibility of converting a stock gasoline electric hybrid vehicle to run on hydrogen. Once fully integrated, the vehicle will be demonstrated at various sites and under various conditions of use throughout the SCAQMD.

04027: Develop & Demonstrate Hydrogen-Internal Combustion Engine Hybrid-Electric Bus

Contractor:	ISE Research Corp.	SCAQMD Cost-share:	$ 210,000
		Cosponsors:	
		California Energy Commission	210,000
		SunLine Transit	290,000
		Natural Resources Canada	56,137
		Province of Manitoba	56,137
		California Air Resources Board	50,000
		ISE Research Corp.	202,726
Term:	10/29/03 - 05/31/05	Total Cost:	$ 1,075,000

As an interim step to zero emission fuel cell buses, which are currently in the early development stage and not commercially viable, hydrogen-powered ICE hybrid-electric vehicles may be a cost-effective option to achieve near-zero emission levels. Additionally, use of hydrogen ICEs would stimulate the development of the hydrogen infrastructure. Hybrid-electric drive systems and hydrogen-ICE technology has matured over the past few years and appears to be to the point of commercialization. CARB has certified a gasoline-powered ICE for hybrid-electric transit use at a 0.5 g/bhp-hr NO_x level. Emissions from an identical hydrogen-ICE are expected to be near zero emissions. ISE Research will develop a hydrogen-ICE hybrid-electric transit bus using deep-cycle batteries in a series hybrid configuration and a variant of Ford Motor Company's (Ford) V10 Triton gasoline engine, which has been used successfully in a gasoline-ICE hybrid-electric bus. ISE Research will assemble and install the hybrid-drive system into a New Flyer transit bus chassis. After the initial testing by ISE Research and Ford, the bus will be demonstrated and tested at various transit districts, including Chula Vista, Winnipeg, and SunLine Transit. CARB will test the bus on the chassis dynamometer to determine the actual emissions under various standard bus cycles. Subsequent to the various demonstrations, the bus will be permanently operated at and owned by SunLine Transit.

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04032: Develop, Demonstrate and Evaluate Plug-In Electric Vans in Fleet Use

Contractor: Electric Power Research Institute	SCAQMD Cost-share:	$ 475,000
	Cosponsors:	
	EPRI	475,000
	DaimlerChrysler (in-kind)	475,000
	Southern California Edison (in-kind)	100,000
Term: 11/14/03 – 08/31/05	Total Cost:	$ 1,525,000

SCAQMD continues to participate in evaluations led by EPRI with CARB on the potential for plug-in hybrid electric vehicles and demonstrations of prototypes with ZEV range. In this project, DaimlerChrysler will produce two new gasoline-fueled plug-in hybrid electric Sprinter vans and place them in fleet use for demonstration and evaluation by Southern California Edison and SCAQMD. EPRI will coordinate project participants to evaluate design goals including performance, emissions, fuel economy, and ZEV range.

04109: Optimize and Demonstrate Plug-In Hybrid Electric Vehicles

Contractor: University of California, Davis	SCAQMD Cost-share:	$ 150,000
	Cosponsors:	
	Electric Power Research Institute	210,000
	Yolo/Solano SCAQMD	10,000
	Ford (in-kind)	40,000
	DOE/Argonne National Lab Future Truck	10,000
	UC (in-kind)	38,000
	Ovonic Battery Company	In-kind
	Southern California Edison	In-kind
Term: TBD - TBD	Total Cost:	$ 458,000

The main objective of this project is to further develop grid-charged, battery dominant hybrid-electric vehicle systems. The commercially available HEVs currently are engine dominant and gasoline fueled. Although they are much more fuel-efficient than traditional vehicles, they have no zero emission range. In this project, the in-line parallel powertrain and control algorithms primarily developed by UC Davis, and supported by the SCAQMD, will be optimized with standard automotive components in a 2002 plug-in Ford Explorer HEV. Design goals include at least twice the fuel economy of the equivalent retail vehicle, compliance with SULEV emission standards, better than stock acceleration and performance, and charge depletion control strategy with 48 miles all electric range. This project is expected to enhance the commercialization potential of plug-in HEVs by analyzing the full fuel cycle emissions and energy impacts, thereby reducing criteria pollutant emissions from the on-road fleet.

TBD: Public EV Charging Equipment and Signage Replacement

Contractor: Clean Fuel Connection, Inc.	SCAQMD Cost-share:	$ 100,000
Term: TBD - TBD	Total Cost:	$ 100,000

Southern California has an established network of public charging stations for electric vehicles. Over time, however, the mix of electric vehicles and their charging needs have evolved. As a result, there is currently a need to replace a portion of the existing chargers to reflect this change. This project will

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replace some of the existing public chargers with new chargers compatible with the electric vehicles currently in Southern California, allowing continued operation of these zero emission vehicles throughout our area.

TBD: Develop and Demonstrate Two 45-Foot Natural Gas Composite Body Hybrid-Electric Transit Buses

Contractor: North American Bus Industries	SCAQMD Cost-share:	$	400,000
	Cosponsors:		
	North American Bus Industries (LADWP Settlement Fund)		1,000,000
Term: TBD - TBD	Total Cost:	$	1,400,000

North American Bus Industries will develop and demonstrate two 45-foot composite structure, heavy-duty transit buses with an Allison parallel-drive hybrid-electric (HE) propulsion system, using a Cummins Westport C8.3 Gas Plus natural gas fueled ICE. The buses will use Allison's proprietary nickel metal hydride battery storage unit capable of being recharged from the electrical grid during non-operational periods or be self-sustaining during operation. The buses will be capable of running on battery-power-only for short durations to mitigate noise and pollution issues. The buses will be constructed based on typical Los Angeles County Metropolitan Transit Authority (MTA) specifications, and will be demonstrated in revenue service by MTA.

Emission Control Technology

03467: Aftertreatment Technology for PM and Hydrocarbon Emissions Control of CNG-Fueled Heavy-Duty Engines

Contractor: Cummins Westport Inc.	SCAQMD Cost-share:	$	496,785
	Cosponsors:		
	SoCalGas		100,000
	DOE/NREL		100,000
Term: TBD - TBD	Total Cost:		$656,785

As part of an effort to compare toxic exhaust emissions from diesel and alternative fuel buses, the Board approved a project to study the emissions of compressed natural gas- (CNG) and diesel-fueled transit buses at its January 19, 2001 meeting. Realizing that the diesel bus would be equipped with particulate trap, the Board expressed an interest in also having a CNG bus equipped with aftertreatment technology for emissions of particulate matter (PM).

The objective of the proposed project is to develop and optimize catalyzed particulate filters to further reduce particulate matter and hydrocarbon emissions by at least 50 percent from current levels, without increasing NO_x, CO, and toxic pollutants emissions from CNG-fueled heavy-duty engines. In addition, Cummins Westport Innovations will investigate the impact of lubricants on emissions from CNG engines and assess emission-reduction potential, performance, and reliability of the catalyzed particulate filters during a six-month in-use demonstration program.

03469: Emission Testing Heavy-Duty Dedicated Natural Gas and New Diesel Refuse Vehicles

Contractor: West Virginia University	SCAQMD Cost-share:	$	260,000
Term: 08/26/03 – 06/30/04	Total Cost:	$	260,000

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In June 2002, the Governing Board directed a study that tested in-use emissions of dual fuel engines compared to their diesel counterparts in refuse collection operations. Staff found that the dual-fueled engines—diesel and natural gas—have about a 20 percent reduction in NO_x emissions compared to diesel engines. Based on certification data for dual fuel engines, they are expected to have about a 35 percent reduction in NO_x emissions.

It was recommended that dedicated natural gas engines be tested. As such, Virginia University (WVU) will conduct in-use emissions evaluation of 12 solid waste collection vehicles from existing fleets operating with the latest dedicated natural gas and certified clean diesel technologies. Emission testing will be conducted using WVU's Transportable Heavy-Duty Vehicle Emissions Laboratory and will use test cycles that most accurately simulate heavy-duty refuse collection.

04000: Prescreen, Transport and Analyze Heavy-Duty Dedicated Natural Gas and New Diesel Refuse Vehicles

Contractor: Engine, Fuels and Emissions Engineering	SCAQMD Cost-share:	$ 50,000
Term: 08/12/03 – 12/31/03	Total Cost:	$ 50,000

Engine, Fuels and Emissions Engineering was selected to perform vehicle prescreening and vehicle transportation operations for West Virginia University's emission testing of solid waste collection vehicles (Contract No. 03469). Test vehicles will be loaned to the SCAQMD by various fleet owners who are subject to Rule 1193. EFEE will analyze potential test vehicles and determine if they comply with OEM specifications. Selected test vehicles will then be transported by EFEE subcontractor to the test site and returned to the fleets upon completion of testing.

TBD: Transportable Laboratory Testing for Aftertreatment Technology for PM and Hydrocarbon Emissions Control of CNG-Fueled Heavy-Duty Engines

Contractor: West Virginia University	SCAQMD Cost-share:	$ 83,215
Term: TBD - TBD	Total Cost:	$ 83,215

This project will provide laboratory testing as part of development, optimization, and demonstration of PM trap and oxidation catalyst for CNG C8.3G Plus Cummins engines program initiated under the above program.

TBD: Optimize and Demonstrate Oxidation Catalysts to Further Reduce Exhaust Emissions from CNG-Fueled Heavy-Duty Engines

Contractor: Lubrizol Engine Control Systems	SCAQMD Cost-share:	$ 364,125
	Cosponsors:	
	Lubrizol	35,875
Term: TBD - TBD	Total Cost:	$ 400,000

Recent studies have shown that oxidation catalysts can reduce formaldehyde and non-methane hydrocarbon emissions by at least 90 and 80 percent, respectively, and also reduce benzene, carbon monoxide (CO), particulate matter (PM), and total hydrocarbon emissions from heavy-duty CNG engines in transit buses. Based on these studies and the proven effectiveness and availability of catalytic technologies, oxidation catalysts offer a unique opportunity for even greater emissions

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reductions from CNG buses. The objective of this project is to optimize catalysts for further emissions reductions from heavy-duty Detroit Diesel Series 50 CNG engines.

Emission Studies

03468: Conduct Reactivity and Availability Studies for VOC Species in Mobile Source Emissions

Contractor: University of California Riverside/CE-CERT
SCAQMD Cost-share: $ 100,000

Term: 08/01/03 -08/01/04
Total Cost: $ 100,000

SCAQMD staff initiated efforts in 1999 to conduct research on reactivity-based control strategy to determine whether it is feasible as an alternative compliance option. If feasible, this optional strategy could allow manufacturers to use greater quantities of less reactive solvents and reduce the quantity of higher reactive solvents. The proposed project will focus on assessing the reactivity of VOC species most commonly found in solvent-based and waterborne architectural coatings and mobile sources, including studying ozone reactivities of low volatility solvents and re-evaluating uncertainties resulting from the current data and modeling. The project will also explore the potential of a new environmental chamber to investigate availability of the low volatility solvents and coordinate the studies with other availability studies sponsored by the Reactivity Research Working Group (RRWG). This project will also evaluate the formation of PM in conjunction with reactivity experiments, including VOC emissions from mobile sources.

Health

03358: Children's Health Study

Contractor: Jurupa Unified School District
SCAQMD Cost-share: $ 25,000

Term: 06/13/03 – 05/31/06
Total Cost: $ 25,000

This research will study air pollution related health effects in a group of children starting in kindergarten and first grade. Jurupa Unified School District (USD) has participated in previous years in the children's health study being conducted by USC. It is important scientifically for Jurupa USD to continue participation in this study since the Mira Loma area, where Jurupa USD is located, has the highest measured particulate matter and nitrate levels in the Basin. It is anticipated that 500 kindergarten through first grade students at four or five elementary school sites in Mira Loma will be part of this study.

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04073: Study Effects of Smoke from Recent Wildfires in Cohorts of USC Children's Health Study

Contractor: University of Southern California	SCAQMD Cost-share:	$	49,896
Term: TBD - TBD	Total Cost:	$	49,896

This contract will provide study support for materials, supplies, and infrastructure to accommodate rapid assessment of the impact of wildfires on respiratory health of ongoing longitudinal cohort populations, specifically first, second and 12th grade school children in the South Coast Air Basin, which were recruited into the Children's Health Study.

Outreach and Technology Transfer

01026: CY 2003 Membership Participation in California Fuel Cell Partnership

Contractor: Bevilaqua-Knight, Inc.	SCAQMD Cost-share:	$	84,000
Term: 12/18/00 - 12/31/03	Total Cost:	$	84000

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 CaFCP as a full member in March 2000, and this expenditure is to renew the SCAQMD participation for Calendar Year 2003.

02316: Construct and Implement Fuel Cell Exhibit

Contractor: California Science Center	SCAQMD Cost-share:	$	226,000
	Cosponsors:		
	California Air Resources Board		50,000
Term: 06/23/03 – 06/30/04	Total Cost:	$	276,000

This project funds the construction phase of the California Science Center Fuel Cell Exhibit. The Exhibit will incorporate a mock-up fuel cell car as well as other interactive components. The exhibit is a well-designed multi-faceted approach to teach the children about fuel cells, their uses, and operation. The design goals have been met through an interdisciplinary approach that combines sensory, cognitive, aesthetic, social, symbolic and physical elements of the technology in order to effectively communicate with the public.

03450: Technical Assistance Pertaining to 2003 Revision & Mobile Source Control Sources

Contractor: Sawyer Associates	SCAQMD Cost-share:	$	15,000
Term: 06/26/03 – 11/30/04	Total Cost:	$	15,000

This contract provides technical assistance in defining and developing mobile source control measures and "black box" measures (future strategies that have yet to be defined) from outside experts. Dr. Robert Sawyer, prime for Sawyer Associates, will provide technical assistance to further develop and refine the mobile source control measures for the AQMP and for future consultation assistance. Dr. Sawyer will also assist SCAQMD staff in implementing the Clean Fuels Program.

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03451: Technical Assistance Pertaining to 2003 Revision and Mobile Source Control Sources

Contractor: TIAX LLC — SCAQMD Cost-share: $ 20,000
Term: 06/23/03 – 11/30/04 — Total Cost: $ 20,000

This contract provides technical assistance in defining and developing mobile source control measures and "black box" measures from outside experts. Mike Jackson of TIAX LLC will provide technical assistance to further develop and refine the mobile source control measures for the AQMP revision and for future consultation assistance. Mr. Jackson will also assist SCAQMD staff in implementing the clean fleet vehicle rules and the Clean Fuels Program.

04045: Technical Assistance for Development, Outreach and Commercialization of Low-Emission and Alternative Fuel Technologies

Contractor: TIAX LLC — SCAQMD Cost-share: $ 30,000
Term: 11/21/03 – 12/31/05 — Total Cost: $ 30,000

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

04048: Technical Assistance to Develop, Outreach and Commercialize Emission Control Technologies

Contractor: Cindy Sullivan — SCAQMD Cost-share: $ 30,000
Term: 11/21/03 – 12/31/05 — Total Cost: $ 30,000

Cindy Sullivan will provide technical assistance for low-emission and alternative fuels technologies. She will assist TAO staff with expert consultation for emission control technologies and alternative fuels projects such analysis of natural gas vehicle demonstrations and expert consultation for the administration of the Carl Moyer Program.

04049: Technical Assistance to Develop, Outreach and Commercialize Alternative Fuels Engine Technology

Contractor: Engine, Fuel and Emissions Engineering, Inc. — SCAQMD Cost-share: $ 40,000
Term: 11/21/03 – 12/31/05 — Total Cost: $ 40,000

Engine, Fuel, and Emissions Engineering, Inc. (EF&EE) will provide technical expertise for natural gas engine technology in the areas of internal combustion engine technology, fuels, combustion, and emission controls. EF&EE will provide expertise with 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.

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04050: Technical Assistance to Develop, Outreach and Commercialize Fuel Cells and Technical Coordination with Federal Energy & Trans. Depts.

Contractor: Breakthrough Technologies Institute, Inc.
SCAQMD Cost-share: $ 35,000
Term: 11/21/03 – 12/31/05
Total Cost: $ 35,000

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

04051: Technical Assistance to Develop, Outreach and Commercialize CNG Engine Technology and CNG Infrastructure

Contractor: Burnett & Burnette
SCAQMD Cost-share: $ 40,000
Term: 1/19/04 – 12/31/05
Total Cost: $ 40,000

Burnett and Burnette will provide technical assistance with CNG engine technology and the development and commercialization of the CNG. Burnett and Burnette have been involved with internal combustion engines and retail facilities for aviation, marine and vehicular fueling facilities for over 20 years. Burnett and Burnette worked extensively with vehicle manufacturers and conversion companies in the implementation of CNG vehicles.

04052: Technical Assistance to Develop, Outreach and Commercialize LNG Infrastructure and Fuel Production

Contractor: USA Pro & Associates.
SCAQMD Cost-share: $ 40,000
Term: 12/19/03 – 12/31/05
Total Cost: $ 40,000

USA Pro and Associates will provide expert consultation for LNG infrastructure and fuel production. USA Pro and Associates staff has over 35 years of automotive and cryogenic gas experience which includes working with fleet operators with vehicle and refueling station procurement and operation, providing technical assistance to engine/chassis manufacturers and dealers with fleet product and expertise and specifications for engine/chassis development, refueling station design and implementation, site engineering, maintenance facility safety, and alternative fuels.

04053: Technical Assistance to Develop, Outreach and Commercialize CNG/LNG Infrastructure

Contractor: Marathon Technical Services
SCAQMD Cost-share: $ 40,000
Term: 11/21/03 – 12/31/05
Total Cost: $ 40,000

Marathon Technical Services will provide technical expertise for CNG/LNG infrastructure. Technical Services staff have over 19 years of experience in the CNG market in manufacturing and constructing CNG stations. The company is currently involved in CNG station research, design, and design of transit facility garage modifications to accommodate CNG buses.

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TBD: Operate and Improve Functionality of CleanCarMaps.com

Contractor: Calstart, Inc.	SCAQMD Cost-share:	$	110,000
	Cosponsors:		
	FTA		50,000
	Auto Club		30,000
	The Gas Company		30,000
	Clean Energy		30,000
	Pacific Gas & Electric		30,000
	Gladstein & Associates		15,000
	OEMs/Others		60,000
Term: TBD -TBD	Total Cost:	$	355,000

As part of the overall effort to expand deployment of alternative fueled-vehicles in the South Coast Air Basin, the SCAQMD has supported the development of alternative fueling infrastructure in various applications. One aspect of advancing this infrastructure is providing information on fueling station locations and their operating status. The SCAQMD cosponsored the development of an internet website to provide locations, directions, and information on alternative fueling and electric vehicle charging stations. The website, www.cleancarmaps.com, is developed and maintained by CALSTART, Inc. Staff recommends the SCAQMD cofund $110,000 of a $355,000 project over three years for CALSTART, Inc to continue existing operations, enhance "real-time" monitoring of station operational status, and develop a new "on-road" interactive communication feature using AAA's emergency number 1-800-AAA-HELP.

TBD: Technical and Public Outreach Support for Implementation of Low-Emission, Clean Fuel, Heavy-Duty Vehicles

Contractor: Gladstein, Neandross & Associates	SCAQMD Cost-share:	$	125,000
	Cosponsors:		
	SCAQMDs/Transportation Commissions		180,000
	EPA ICTC		99,999
	Others (to be specified)		210,001
Term: TBD - TBD	Total Cost:	$	615,000

Low emission, alternative fuel heavy-duty engines produce half or less NO_x emissions of their diesel counterparts and a fraction of the particulates. SCAQMD is specifically seeking both technical and public outreach support for a public-private effort to implement and increase widespread penetration of these technologies in public, commercial and private fleets. This contract would support continuation of the Interstate Clean Transportation Corridor (ICTC) effort and would develop four public outreach events, such as ride-n-drives, and a one-day alternative fuel expo/conference.

Purchase Order: Purchase of Three 2004 Toyota Prius Hybrid Vehicles

Contractor: Elmore Toyota Dealership	SCAQMD Cost-share:	$	79,870
Term: n/a	Total Cost:	$	79,870

This item is for the purchase of three 2004 Toyota Prius hybrid vehicles. The vehicles are for use in Technology Advancement's Alternative Vehicle Loan Program.

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Various: Co-Sponsorships of Conferences, Workshops and Events

Contractor: Eight Different Contractors	SCAQMD Cost-share:	$	127,131
	Co-Sponsors:		
	Various		722,869
Term: Various	Total Cost:	$	850,000

The SCAQMD regularly participates and sponsors conferences, workshops, and events. These funds provide support for eight such events during 2003.

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PROGRESS IN 2003

Key Projects Completed

A large number of emission sources contribute to the air quality problems in Southern California. Given the diversity of these sources, it is unlikely that a single technology or "silver bullet" will solve all of the region's problems. Accordingly, the SCAQMD continues to support a wide range of advanced technologies addressing not only the diversity of emissions sources, but also the time frame to commercialization of these technologies. Projects co-funded by the SCAQMD's Clean Fuels Program include emission reduction demonstrations for both mobile and stationary sources, although legislative amendments and reduced SCAQMD revenues 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, 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 2003. Summaries of these completed projects are also included in Appendix C. Selected projects which represent a range of key technologies from near-term to long-term are highlighted below.

Fuel Cell Transit Bus

Fuel cell vehicles represent a promising technology especially for transit buses since such buses offer zero tailpipe emissions and therefore large health benefits to passengers and others in the urban environment. At the May 2001 meeting, the Governing Board approved co-funding of $350,000 to develop and demonstrate a fuel cell transit bus, with total project costs of over $2 million. Funding partners included Thor Industries, ISE Research, the U.S. DOT through Sacramento Municipal Utilities District, and Westart-CALSTART. Thor Industries, Inc. teamed with ISE Research-ThunderVolt Inc. (ISE-TVI) under a new entity, ThunderPower L.L.C.. This team developed a midsize, 30-foot fuel cell bus to demonstrate and test the prototype vehicle in a transit operation.

The bus uses a 60 kW fuel cell stack from United Technologies Corporation – Fuel Cells with hydrogen storage capacity of 26 kg of hydrogen at 3,600 psi, providing a range of more than 200 miles. The bus is propelled by two Siemens 67 kW drive motors driving the differential through a combining gearbox. The bus operation and maintenance are monitored using a newly developed remote diagnostic unit.

On February 21, 2003, the bus completed six months of testing and demonstration at SunLine Transit. The bus accumulated over 9,000 miles and accomplished operational availability of over 76%, a remarkable accomplishment for a first-of-a-kind prototype. In addition to producing zero emissions, the bus achieved over 10 miles per gasoline-equivalent gallon which is more the twice the energy efficiency of a similarly-sized CNG bus. Subsequently, the Los Angeles County Metropolitan Transit Authority operated the bus for 30 days, with a remarkable operational availability of 96%, exceeding the current specifications for availability by equivalent CNG buses.

The fuel cell bus produces zero emissions with an increased efficiency provided by the hybrid-electric drive system. This bus demonstrated the potential for fuel cell buses to achieve high efficiency and high reliability. However, the cost of the fuel cell as well as the cost of the hydrogen fuel needs to be significantly reduced to make this type of technology commercially viable. Seven additional 40-foot

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fuel cell transit buses are being developed as part of the California Fuel Cell Partnership effort. The SCAQMD will monitor this project and identify how best the Clean Fuels funding can affect commercialization and development.

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 higher toxicity and criteria pollutants in diesel exhaust, the SCAQMD has adopted initiatives to reduce diesel emissions in the Basin and to promote heavy-duty natural gas vehicles. However, natural gas engines historically suffer from lower power performance, especially in heavy (greater than 80,000 lbs.gross vehicle weight) line-haul truck applications. As a result, 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. Previously approved in 2000, the SCAQMD Governing Board further augmented the project funding in 2001 to achieve an expedited natural gas engine introduction for the 2003 model year. The SCAQMD contribution of over $1 million was matched with co-funding of $2.4 million from CEC, CARB, and DDC.

During this project, DDC developed the Series 50G natural gas engine with an advanced fuel control system to achieve 300 hp and 900 ft-lb torque. This engine achieved 0.9 g/bhp-hr NO_x or a 40 percent reduction over currently available diesel engines. The development efforts for this project enabled DDC to certify its Series 50G natural gas engine at 1.2 g/bhp-hr combined NO_x and VOC for the model years 2003-2004. This 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.

The Tri-Fuel Hybrid Electric Car

Hybrid electric vehicles provide the potential for reducing emissions and increasing fuel economy by combining an ICE with an electric motor. The tri-fuel concept goes one step further by introducing vehicle-to-grid power allowing the vehicle to provide energy while parked.

The VW Jetta is a five-passenger sedan with modifications by AC Propulsion. The Tri-Fuel Hybrid is a series hybrid and uses only electric propulsion to drive the wheels. The lead-acid batteries provide 30-to-40 miles of all-electric range and can be recharged in less than an hour by the onboard 20 kW charger plugged into grid electricity – the first fuel. An onboard low-emission engine-powered generator can sustain battery charge on long trips giving range unconstrained except to stop for gasoline – the second fuel. When the vehicle is parked and plugged in, the generator can send its electrical output back into the grid through the unique AC Propulsion Reductive bi-directional grid interface. To avoid depletion of the gasoline and reduce tailpipe and refueling emissions in this stationary mode, the generator operates on low pressure natural gas from a gas main – the third fuel.

The Tri-Fuel Hybrid accelerates 0 to 60 mph in 8.8 seconds with a top speed limited at 85 mph. By the end of 2003, it had accumulated more than 7,000 miles as a hybrid. Tailpipe emissions were generally measured at the SULEV or better level. Engine cold-starts would benefit from more advanced control strategies and hardware, possibly including an electrically heated catalyst.

By substituting electricity for petroleum, the plug-in hybrid can use significantly less gasoline than commercially available hybrids and travel zero emission miles. The project car can generate electricity with lower emissions than other small generators, and so can help to minimize emissions related to the growth of distributed energy resources over the next decade. The plug-in hybrid concept may also apply to fuel cells. Replacing the ICE in the project car with a fuel cell could demonstrate a more cost effective and efficient alternative by taking advantage of lower cost battery technology.

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The SCAQMD contributed $180,000 of the total project budget of $755,000. Other funding was provided by the CARB through its Innovative Clean Air Technology program ($230,000), Volkswagen of America ($225,000 in-kind), NREL ($40,000 in-kind), and AC Propulsion's cost share ($80,000 in-kind).

Children's Pollutant Exposure During School Bus Commutes

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

Because children's lungs are still developing and children are more susceptible to adverse health effects from air pollution, potentially high pollutant exposures during school bus commutes are of concern. Studies of pollutant concentrations inside vehicles show high exposures are typical, but few studies have attempted to characterize concentrations on-board and near school buses. The primary objective of this study was to determine the range of children's exposures to air pollutants during their bus commutes, with an emphasis on determining the specific factors and conditions leading to high exposures and comparing the effects of different bus and fuel types. The study was conducted by the College of Engineering – Center for Environmental Research and Technology, University of California, Riverside. The SCAQMD contributed $58,992 toward the overall project cost of $580,169.

Real-time and integrated measurements of pollutant concentrations were conducted in the spring of 2002 in instrumented buses while driving school bus routes in Los Angeles, CA. Five conventional diesel school buses, manufactured from 1975 to 1993, a 1998 diesel bus outfitted with a particulate trap, and a 2002 bus powered by natural gas were used for testing. Measurements were taken during 24 bus commutes on a Los Angeles Unified School District bus route from South Central Los Angeles to the west side of LA. Additional runs were made on a second urban route, a rural/suburban route, and to test the effect of window position.

Measurements made during on-board school bus commutes in Los Angeles indicated that higher exposures are occurring during children's commutes than ambient air concentrations would indicate. These exposures resulted primarily from the commute itself and not from loading, unloading, or waiting at bus stops. Exposure factors calculated were as much as two orders of magnitude higher for bus commutes on urban routes than for the bus stop or loading/unloading microenvironments. Overall, children's school bus commutes in Los Angeles appear to expose children to significantly higher concentrations of vehicle-related pollutants than ambient air concentrations and frequently higher concentrations than those measured on roadways. Self-pollution from the bus' own exhaust was found to play a significant role in on-board bus concentrations, especially when windows were closed. This was demonstrated by on-board measurements of an inert tracer gas, SF6, added to each bus's exhaust. Minimizing commute times, using the cleanest buses for the longest bus routes, reducing bus "caravanning," and reducing unnecessary bus idling time would reduce children's exposures to bus-related pollutants. Additional research on methods to reduce self-pollution is recommended.

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Table 4. Projects Completed Between January 1 and December 31, 2003

Contract	Contractor	Project Title	Date
Fuel Cell Technology			
02129	ISE Research Corporation	Develop & Demonstrate Fuel Cell Bus with Major Bus Manufacturer	Oct-03
Hydrogen Technology and Infrastructure			
03272	Northern Power Systems	Perform Conceptual Design Study of Integrated Hydrogen Energy Station	May-03
Engine Technology			
01225	Detroit Diesel Corporation	Develop Very Low-NO_x Heavy-Duty Natural Gas Engine	May-03
02181	Ford Motor Company	Develop & Demonstrate Nine CNG-Powered Mid-Size School Buses	Nov-03
02219	Cummins Westport, Inc.	Develop Technologies for Next Generation Natural Gas Vehicles Class 3-6 CNG Engines	Sep-03
Infrastructure and Fuel Production			
02156	Southern California Gas Company	Upgrade Existing CNG Refueling Stations	Sep-03
03102	USA Waste of California, Inc.	Purchase & Install LNG-L/CNG Refueling System at La Metro Hauling District	Dec-03
03232	FuelMaker Corporation	Develop & Demonstrate Advanced Home Refueling Appliance for CNG Vehicles	Oct-03
Electric/Hybrid			
00020	EV Rental Cars	Demonstrate Electric Vehicle Rental Program	Jun-03
01111	Trojan Battery Company	Develop & Demonstrate Commercial Prototype Advanced Valve Regulated Lead-Acid Batteries	Feb-03
02155	AC Propulsion Inc.	Develop & Evaluate a Tri-Fuel, Plug-In Hybrid Electric Vehicle with Vehicle-to-Grid Power Flow	Dec-03
Emission Control Technology			
04000 †	Engine, Fuel & Emission Engineering, Inc.	Prescreen, Transport & Analyze Heavy-Duty Dedicated Natural Gas and New Diesel Refuse	Dec-03
Emission Studies			
03226 †	West Virginia University Research Corporation	Emission Testing of Natural Gas Refuse Trucks	Mar-03
Health			
01209	University of California Riverside	Study of Children's Pollutant Exposures During School Bus Commutes	Apr-03
VOC/Toxics			
03030 †	Public Health Foundation (Formerly California Public Health Foundation)	Re-Analysis Of Health Effects Of Air Pollution Data In The Coachella Valley	Feb-03

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Table 4. Projects Completed Between January 1 and December 31, 2003 (Continued)

Contract	Contractor	Project Title	Date
Outreach and Technology Transfer			
00078 †	Breakthrough Technologies Institute	Technical Assistance Related to Development & Commercialization of Zero-/Low-Emission Technologies including Fuel Cells	Jan-03
00112 †	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance Regarding Alternative Fuel Engines	Apr-03
00175 †	Burnett & Burnette	Technical Support for Evaluation & Implementation of CNG Refueling Facilities	Dec-03
01026 †	Bevilacqua-Knight Inc.	Program Support for the California Fuel Cell Partnership	Dec-03
01152 †	ENRG, Inc. (formerly Energy/Pickens Fuel Corporation)	Construction Management & Consulting Services for Natural Gas Refueling Station at AQMD Headquarters	Mar-03
01162 †	TIAX, LLC (formerly Arthur D. Little)	Technical & Management Assistance for Carl Moyer & School Bus Programs	Apr-03
02135 †	SunLine Transit Agency	Co-Sponsor Educational Outreach Program	Feb-03
02288 †	FuelMaker Corporation	Technical Consultant Services for Two School Districts	Jul-03
02294 †	Calstart	Membership & Participation in Hybrid Electric Operations Forum	Apr-30
02340 †	Air & Waste Management Association	Co-Sponsor Dedicated Issue of Journal of Air & Waste Management Association	Apr-03
03033 †	Hydrogen 2000 Inc.	Develop Outreach Video on Fuel Cell and Hydrogen Fuel Usage	Mar-03
03180 †	Charles Powars	Technical & Management Assistance for Alternative Fuel Vehicles and Refueling Infrastructure Projects	Jul-03
03206 †	Tred Foundation	Co-Sponsor 4th Bi-Annual World Truck Conference	Oct-03
03256 †	National Hydrogen Association	Co-Sponsor 14th Annual U.S. Hydrogen Conference & Expo	Dec-03
03268 †	Coordinating Research Council Inc.	Co-Sponsor 13th Annual CRC On-Road Vehicle Emissions Workshop	Nov-03
03361 †	SAE International	Co-Sponsor 2003 SAE International Future Transportation Technology Conference	Nov-03

†Summary not required or unavailable.

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FUTURE TECHNOLOGIES

Funding Priorities for 2004

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 basinwide emission reductions needed to achieve ambient air quality standards by 2010, the regulatory measures to achieve those reductions, the timeframes to implement these proposed measures, and the technologies or types of technologies required to meet these future proposed regulations. As previously identified in Figure 1, the NO_x and VOC emission sources of greatest concern are heavy-duty on-road vehicles, light-duty on-road vehicles, and off-road equipment.

In addition to specific control measures based on known technologies and control methods, the Clean Air Act has provisions for more general measures based on future, yet-to-be-developed technologies. These "black box" measures are provided under Section 182(e)(5) of the Clean Air Act for regions that are extreme non-attainment areas, such as the South Coast Air Basin. The Plan Update includes projects to develop, demonstrate, and commercialize a variety of technologies, from near-term to long-term, that are intended to provide solutions to the emission control 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 begin in 2004 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 these efforts, from long-term to near-term, are described below.

- Technology development projects are expected to begin during 2004 with durations of about two years. Additional field demonstrations to gain long-term verification of performance, spanning up to two years, may also be needed prior to commercialization. Certification and ultimate commercialization would be expected to follow. Thus, development projects identified in this plan are expected to result in technologies ready for commercial introduction as soon as 2008. Projects are also proposed that may involve developing emerging technologies that are considered longer term and, perhaps higher risk, but with significant emission reduction potential. Commercial introduction of such long-term technologies would not be expected until 2010 or later.

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- More mature technologies, that is, those ready to begin field demonstration in 2004, are expected to result in a commercial product in 2005-06. 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.

Program Review

With the adoption of the 2003 AQMP and the passage of SB 288 in 2003, the content and direction of the Clean Fuels Program were re-examined to ensure the projects were properly aligned with the SCAQMD's mission and the state-of-technologies. This review took place at a two-day retreat on January 15 and 16, 2004 at the SCAQMD headquarters, where input was garnered from the Clean Fuels Advisory Group, the Technology Advancement Advisory Group, and other technical experts. During the two-day retreat, participants were grouped into their areas of expertise and interest, reflecting the following six major source categories:

- Light Duty
- Heavy Duty
- Off-Road
- Fuels
- Health and Atmospheric Science
- Stationary and VOCs

In each of these groups, the participants reviewed the current Technology Advancement projects and recommended near-term and long-term projects for consideration. There were 55 near-term and 45 long-term projects suggested by the participants. These project suggestions, where appropriate, are included in this year's Plan Update.

The participants also suggested the priority allocation of Clean Fuels resources by emissions source category, which is shown in Figure 3.

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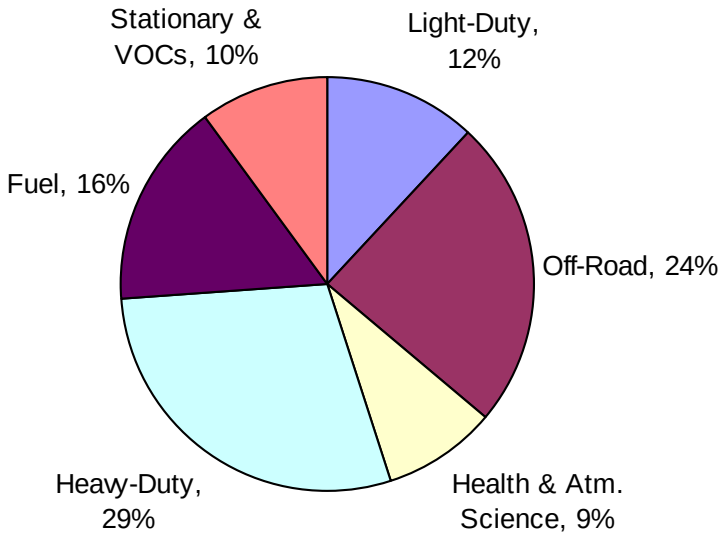

Figure 3. Resource Allocation Proposed by Advisors and Participants at Clean Fuels Program Retreat (January 2004)

Based on this input, the 2004 Plan Update was revised to reflect this approximate allocation except for two notable differences as shown in Figure 4. For the health studies, the advisory group members and retreat participants felt health considerations should be included in all projects and allocated nine percent of the total budget toward those efforts. The Clean Fuels Program Plan Update, however, has only identified five percent support due to other health related programs already underway at the SCAQMD, including the Chairman's Initiatives on Asthma and Brain Cancer, which acquire funding through other sources. As a result, the Plan Update shows less resource allocation through the Clean Fuels Program than recommended by the Advisors and Retreat Participants.

Conversely, for stationary sources, the advisory group members and retreat participants suggested only ten percent allocation of VOC control technologies which account for thirty percent of the basin's inventory (Figure 1). Although these technologies may not be funded through the Clean Fuels Program, the projects represent advanced technologies which represent advanced technologies which require assistance in commercializing so fit within the spirit and scope of the Technology Advancement Office mission.

A major recommendation from the retreat was the need for more near-term projects to reduce the "black box" emissions shortfall identified in the 2003 AQMP. These project topic recommendations were added to the Plan Update for consideration and are included in the following technical priorities for 2004.

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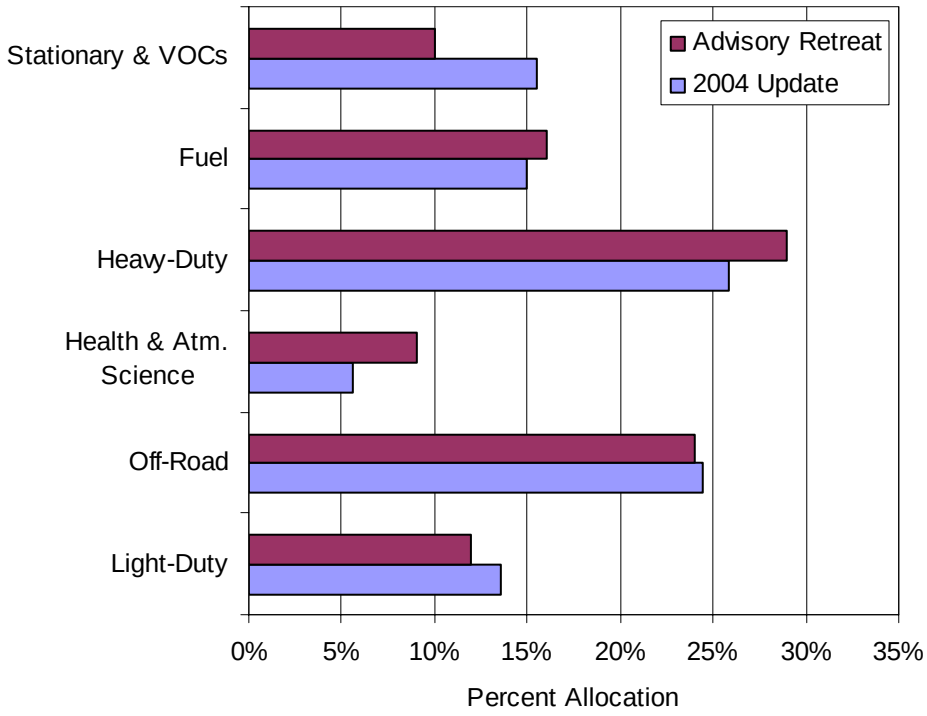

Figure 4. Allocation Comparison of Advisory Input to Plan Technologies Identified

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Summary of Technical Priorities

The SCAQMD program maintains flexibility to address dynamically evolving technologies and the latest progress. The challenge for the SCAQMD is to identify programs where the available funding can make a difference. The major technical program areas are identified below with specific project categories discussed in more detail in the following section.

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

Fuel Cells

Fuel cells are emerging as a leading alternative technology to replace more polluting ICEs 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. Examples are fuel cell vehicles which can put power back into the electrical grid or co-location of the fuel cell DG at fueling stations to provide power for compressors or pumping.

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 2004 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 the following:

- 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
- 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 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 ICE or PEM fuel cell, are also being considered.

Furthermore, as an interim step toward full fuel cell vehicle deployment and as a means to testing and verifying the hydrogen infrastructure, hydrogen ICE vehicles will be developed and demonstrated. Hydrogen ICEs represent the most cost effective alternative to fuel cell vehicles since ICEs are an established technology. The emissions, however, are higher than fuel cell vehicles and development should be pursued to optimize this technology to ensure SULEV or better perfromance. Future projects are expected to include the following:

- Continued development and demonstration of distributed hydrogen production and refueling stations
- Development and demonstration of integrated hydrogen production for refueling and power
- Development and demonstration of hydrogen ICEs for vehicle and power applications

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Engine Technology

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

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

- Continued development and demonstration of alternative fuel medium-duty and heavy-duty engines and vehicles
- Demonstration of low and zero-emission locomotives
- Development and demonstration of clean alternative fuel engines for off-road applications
- Next Generation Natural Gas Vehicle development and deployment
- 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 (PM-Traps) and catalysts, as well as lowering the sulfur content or using additives with diesel fuel. Gas-to-Liquid (GTL) fuels, formed from natural gas or other gas rather than petroleum feedstock, and emulsified diesel provide low-emission fuels for use in diesel engines. And as emissions from engines become lower and lower, the lubricant contributions to VOC and PM emissions become increasingly important. The most promising of these technologies will be considered for funding, specifically:

- Development and demonstration of advanced air pollution control equipment
- Evaluation and demonstration of new emerging liquid fuels, including ultra-low sulfur diesel and GTL fuels
- Evaluation and demonstration of emulsified diesel fuels
- Development and demonstration of advanced after-treatment technologies for mobile applications (including particulate traps and catalysts)
- Development and demonstration of low VOC and PM lubricants for diesel and natural gas engines

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. CNG and LNG refueling stations are being

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positioned to support public and private fleet applications today as funding for purchasing natural gas vehicles is made available to fleet operators.

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

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

Electric and Hybrid Technologies

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

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

- Development and demonstration of cross-cutting applications (e.g., 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
- Upgrade and demonstration of hybrid electric buses

Stationary and VOC/Toxics Technologies

Although progress is being made in the development and commercialization of zero VOC products and processes, the 2003 AQMP 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 stationary power applications. Future priorities will focus on "pollution prevention" technologies which appear 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

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- Technology assessments of future VOC limits in current source specific VOC rules
- Demonstration project for portable liquid petroleum gas (LPG) or propane-powered ICE generators
- Development and demonstration of low-emission emulsified diesel fuel technology for portable power generators

Target Project Allocations

Figure 5 below presents the potential allocation of available funding, based on SCAQMD projected program cost of $29.9 million for all potential projects. The expected actual project expenditures for 2004 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 2004 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.

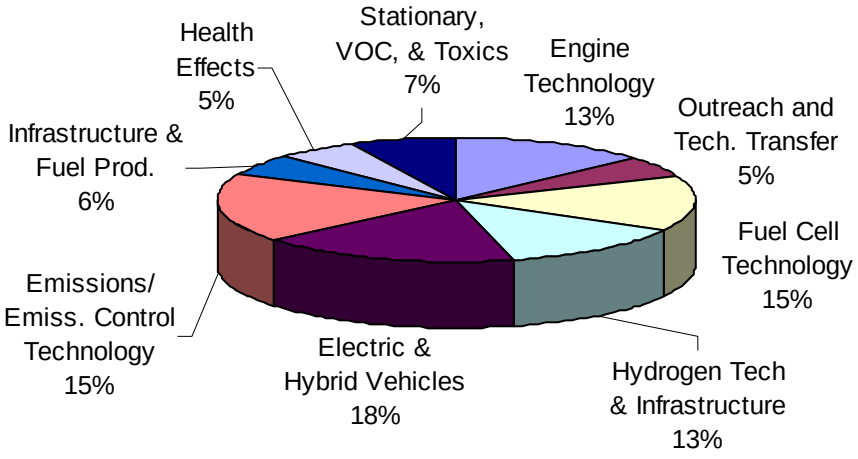

Figure 5. Projected Cost Distribution for Potential SCAQMD Projects 2004 and Beyond ($29.9 million)

Program Plan Update

This section presents the Clean Fuels Program Plan Update for 2004. The proposed projects are organized by program areas and described in further detail, consistent with the SCAQMD budget, priorities, and the best available information. Although not required, this plan also includes proposed projects that may be funded by revenue sources other than the Clean Fuels Program, specifically related to VOC and incentive projects.

Each of the proposed projects described in this plan, once fully developed will be presented to the SCAQMD Governing Board for approval prior to contract initiation. This development reflects the maturity of the proposed technology, identification of contractors to perform the projects, host site participation, securing sufficient cost-sharing to complete the project, and other necessary factors. Recommendations to the Governing Board will include descriptions of the technology to be demonstrated and in what application, the proposed scope of work of the project, and the capabilities of the selected contractor and project team, in addition to the expected costs and expected benefits of the projects as required by H&SC 40448.5.1.(a)(1). Based on communications with all of the organizations specified in H&SC 40448.5.1.(a)(2) and review of their programs, the projects proposed in this plan do not appear to duplicate any past or present projects.

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

Proposed Project: A descriptive title and a designation for future reference.

Expected SCAQMD Cost: The estimated proposed SCAQMD cost share as required by H&SC 40448.5.1.(a)(1).

Expected Total Cost: The estimated total project cost, including the SCAQMD cost share and the cost share of outside organizations expected to be required to complete the proposed project. This is an indication of how much the SCAQMD's public funds are leveraged through its cooperative efforts.

Description of Technology and Application: A brief summary of the proposed technology to be developed and demonstrated, including the expected vehicles, equipment, fuels, or processes that could benefit.

Potential Air Quality Benefits: A brief discussion of the expected benefits of the proposed project, including the expected contribution towards meeting the goals of the AQMP, as required by H&SC 40448.5.1.(a)(1). In general, the most important benefits of any technology research, development, and demonstration program are not necessarily realized in the near-term. Demonstration projects are generally intended to be proof-of-concept for an advanced technology in a real-world application. While emission benefits, for example, will be achieved from the demonstration, the true benefits will be seen over a longer term, as a successfully demonstrated technology is eventually commercialized and implemented on a wide scale.

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Table 5. Summary of Potential Projects

Proposed Project	Expected SCAQMD Cost	Expected Total Cost
Fuel Cell Technology		
Demonstrate Fuel Cell Vehicles	$1,000,000	$5,600,000
Demonstrate Fuel Cell Vehicle with Vehicle to Grid Power	500,000	1,500,000
Develop and Demonstrate Microturbine Fuel Cell Hybrid Technologies	200,000	800,000
Demonstrate Stationary Fuel Cells for Residential, Commercial, and Industrial Applications	2,000,000	5,000,000
Develop and Demonstrate Fuel Cells for Marine Vessels	100,000	1,000,000
Develop and Demonstrate Fuel Cells in Off-Road and Construction/Industrial Applications	250,000	1,000,000
Demonstrate Fuel Cell in Heavy-Duty/Transit Bus Applications	350,000	2,000,000
Subtotal	$4,400,000	$16,900,000
Hydrogen Technology and Infrastructure		
Demonstrate Integrated Hydrogen Production and Power Facility	1,000,000	4,000,000
Develop and Demonstrate Heavy-Duty Truck On-Board Electrolyzer	40,000	200,000
Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations	1,500,000	4,000,000
Develop and Demonstrate Reformer Technology for Hydrogen Production	50,000	250,000
Develop and Demonstrate Hydrogen and Hydrogen-Natural Gas Internal Combustion Engine Vehicles	1,300,000	4,000,000
Subtotal	$3,890,000	$12,450,000
Engine Technology		
Demonstrate Twin-Speed Marine Engines	250,000	500,000
Develop and Demonstrate Advanced Alternative Fuel Heavy-Duty and Medium-Duty Engines and Vehicles	2,000,000	4,000,000
Demonstrate Low- and Zero-Emission Locomotives	1,500,000	7,000,000
Demonstrate On-Board LNG Tank	250,000	500,000
Subtotal	$4,000,000	$12,000,000

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Table 5. Summary of Potential Projects (Continued)

Proposed Project	Expected SCAQMD Cost	Expected Total Cost
Infrastructure and Fuel Production		
Develop Template for Designing, Permitting, and Constructing CNG Fueling Facility	200,000	200,000
Develop and Demonstrate Advanced Natural Gas Systems for Refueling Stations	750,000	4,000,000
Liquefied Natural Gas Manufacturing and Distribution Technologies	750,000	7,000,000
Subtotal	$1,700,000	$11,200,000
Electric/Hybrid Technologies		
Demonstrate Plug-In Hybrid Electric Vehicles	150,000	500,000
Develop and Demonstrate Light- and Medium-Duty Hybrid Electric Vehicles and Systems	750,000	5,000,000
Demonstrate Alternative Energy Storage Systems	700,000	1,400,000
Evaluate and Demonstrate Hybrid Heavy-Duty Vehicles	2,000,000	10,000,000
Upgrade and Demonstrate Hybrid/Electric Technologies for a Variety of Applications	500,000	2,000,000
Develop and Demonstrate High-Capacity, Alternate Fueled Hybrid Electric Transit Buses	750,000	5,000,000
Investigate and Demonstrate Neighborhood Electric Vehicle Applications	150,000	500,000
Investigate and Demonstrate Advanced Emissions Control Technologies for Hybrid Vehicles	100,000	400,000
Demonstrate Advancements In Lithium Ion Battery Technology For Electric or Plug-In Hybrid Electric Vehicle	150,000	600,000
Subtotal	$5,250,000	$25,400,000
Emission Control Technology		
Develop and Demonstrate Advanced Aftertreatment Technologies for Liquid Fuels	800,000	2,600,000
Demonstrate Advanced Alternative Fuels in Off-Road Equipment	1,200,000	2,600,000
Develop and Demonstrate Advanced Aftertreatment Technologies for Natural Gas Emissions	800,000	1,600,000
Develop and Demonstrate Low-VOC and PM Lubricants for Natural Gas Engines	200,000	500,000
Demonstrate NO_x and PM Control Technologies for Off-Road Equipment	750,000	1,500,000
Investigate and Demonstrate Near-term Emissions Control Technologies	1,000,000	4,000,000
Subtotal	$4,750,000	$12,800,000

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Table 5. Summary of Potential Projects (Continued)

Proposed Project	Expected SCAQMD Cost	Expected Total Cost
Emission Studies		
Comparative Emissions of Heavy-Duty Alternative Fuel and Conventional Fuel Engines	$500,000	$1,000,000
Develop Improved Particulate Measurement Procedures	100,000	700,000
Subtotal	$600,000	$1,700,000
Health		
Evaluate Ultrafine Particle Health Effects	500,000	2,000,000
Evaluate Health Impacts from Toxic Emissions	1,000,000	2,500,000
Evaluate Benefits of Emissions Reductions	100,000	310,000
Subtotal	$1,600,000	$4,810,000
Stationary Source Clean Fuel Technology		
Develop and Demonstrate Portable Low Emission Alternative Fuel ICE Generator	100,000	200,000
Demonstrate Emulsified Diesel Fuel Use in Portable Generators	50,000	100,000
Develop and Demonstrate Low-Emission Refinery Flares	100,000	200,000
Develop and Demonstrate Renewable-Based Alternatives	500,000	1,000,000
Develop Next Generation Emission Monitoring Systems	250,000	750,000
Develop and Demonstrate Low Emission, High Efficiency Distributed Generation Technologies	250,000	750,000
Subtotal	$1,250,000	$3,000,000
VOC/Toxics Technologies		
Technology Assessments of Future VOC Limits in SCAQMD VOC Rules	250,000	250,000
Develop and Demonstrate Near-Zero/Zero-VOC Products	500,000	500,000
Evaluate, Develop, and Demonstrate Advanced VOC Control Technologies for Miscellaneous Stationary Sources	200,000	200,000
Subtotal	$950,000	$950,000

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Table 5. Summary of Potential Projects (Continued)

Proposed Project	Expected SCAQMD Cost	Expected Total Cost
Outreach and Technology Transfer		
Technical Assistance in Assembling SAE Standards for LNG Fueling and Dispensing	$150,000	$300,000
Technical Assistance in LNG Fueling for Transit Properties	200,000	200,000
Technical Assistance for Schools' Maintenance Facilities	300,000	300,000
Assessment and Technical Support of Advanced Technologies and Information Dissemination	500,000	500,000
Support for Implementation of Various Clean Fuels Vehicle Incentive Programs	400,000	400,000
Subtotal	$1,550,000	$1,700,000
TOTALS FOR POTENTIAL PROJECTS	**$ 29,940,000**	**$101,010,000**

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Fuel Cell Technology

Proposed Project: Demonstrate Fuel Cell Vehicles

Expected SCAQMD Cost: $ 1,000,000

Expected Total Cost: 5,600,000

Description of Technology and Application:
This project would support the demonstration and deployment of limited number of promising fuel cell vehicles using direct hydrogen, methanol, ethanol or natural gas. Among the fuel cell technologies, PEM technology shows considerable promise for mobile application in the nearer term (3 to 5 years), while direct methanol fuel cell may become competitive in the longer term (over 10 years). Early fleet vehicles are expected to be tested over the 2004-05 timeframe at fleet locations. Expected project areas would include:

- *Fleet demonstration:* Major fuel cell and automobile OEMs are developing PEM fuel cell technology for applications in conventional vehicles, such as passenger cars, light-duty trucks, sport utility vehicles, transit buses including 30 foot and 40 foot buses, and medium to heavy-duty trucks. Pre-production vehicles are planned for demonstration in controlled fleets, such as the California Fuel Cell Partnership program and local transit agencies. Fleets are useful demonstration sites because of economies of scale, centralized fueling, availability of skilled personnel to operate and maintain the vehicles, and ability to monitor and collect data on vehicle performance. These early fuel cell vehicles would likely be compressed hydrogen fueled with on-board hydrogen storage.
- *Specialized applications:* Smaller manufacturers of fuel cell technology will likely focus on niche applications of their fuel cells. These include applications of fuel cells in non-conventional markets such as:
  - neighborhood vehicles
  - off-road vehicles
  - utility maintenance vehicles including city vehicles and lawn and garden equipment
  - airport ground support equipment and airport shuttles
  - off-road equipment including boom lifts and portable power units

Potential Air Quality Benefits:
The AQMP identifies the need to implement zero-emission vehicles. The proposed projects have the potential to accelerate the commercial viability of fuel cell vehicles. Expected immediate benefits include the establishment of zero- and near-zero-emission proof-of-concept vehicles in numerous applications. Over the longer term, the proposed projects could help foster wide-scale implementation of zero-emission fuel cell vehicles in the Basin. This would also lead to significant fuel economy improvements, independence from petroleum imports, manufacturing innovations and the creation of high-tech jobs in Southern California, besides realizing the air quality benefits projected in the AQMP.

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Proposed Project: Demonstrate Fuel Cell Vehicle with Vehicle to Grid Power

Expected SCAQMD Cost: $ 500,000

Expected Total Cost: 1,500,000

Description of Technology and Application:
Major automakers have begun to demonstrate their prototype fuel cell vehicles in a few controlled fleet settings in California and Japan. The vehicle designs and degree and method of electrical energy storage on-board the vehicle varies. Cost reduction, better cold start capability, increased peak power for acceleration and passing, higher system efficiency through braking energy recovery and leveling of the load on the fuel cell, and potential increases in fuel cell life are a few of the major reasons why hybrid fuel cell designs have great potential. Fuel cell vehicle designs with vehicle to grid power (VTGP) may encourage faster commercialization of fuel cell vehicles by enabling further economic value by reducing the payback period through reduced grid charges. These vehicles would allow the operator to produce power from the vehicle while parked, thereby acting as a small DG application. Having this power flexibility provides all of the fuel cell DG benefits, i.e. local, clean, reliable, efficient, and independent power.

Development, demonstration and evaluation of a VTGP fuel cell vehicle in a commercial fleet setting and comparison to other fuel cell and hybrid vehicle designs can provide a greater understanding of advanced vehicle design decisions and the market potential for hybrid fuel cell vehicles. An overall systems analysis, encompassing mobile and stationary benefits, would need to be developed to capture all of the attributes of this technology.

Potential Air Quality Benefits:
The AQMP identifies the need to implement zero emission vehicles. The proposed project has the potential to enable faster commercialization of fuel cell vehicles with greater market potential.

Demonstration of a fuel cell hybrid vehicle with VTGP prototype encourages the deployment of fuel cell vehicles by major automakers.

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Proposed Project: Develop and Demonstrate Microturbine Fuel Cell Hybrid Technologies

Expected SCAQMD Cost: $ 200,000

Expected Total Cost: 800,000

Description of Technology and Application:
With the price and availability of electricity supply from large power providers becoming increasingly uncertain, on-site generation of power, known as distributed generation (DG), is playing a larger role in the power supply infrastructure of southern California. With few exceptions, the DG technology of choice is a diesel-fueled internal combustion engine driving a generator. This technology is harmful to air quality in that diesel generators emit much larger amounts of NO_x, VOC, PM and carcinogens per unit power produced than large power plants.

Two alternative DG technologies that produce relatively low emissions of NO_x, VOC, PM and carcinogens are fuel cells and microturbine generators. These technologies are much cleaner than diesel generators mainly because they operate on clean fuels such as natural gas or propane. The electrical efficiency of these technologies, compared with diesel generators, is respectively better for fuel cells and somewhat poorer for microturbine generators. However, by combining these two technologies in a synergistic arrangement known as a hybrid fuel cell/microturbine generator (HFCMTG), a new technology is created which has a much better electrical efficiency. HFCMTG is therefore not only substantially cleaner than diesel generators in terms of air emissions but also substantially more fuel-efficient.

Development of a successful HFCMTG has been pursued for several years by researchers and commercial entities, and has been brought to the proof-of-concept stage. The next logical step in the development of this technology would be to build and demonstrate a small prototype unit, which is the principal objective of this project. Specific technical objectives include: (1) a full characterization of the emissions as a function of duty cycle; (2) performance evaluation for grid-connected operation; and (3) design and evaluation of integration into buildings to assure maximization of energy utilization and minimization of pollutant emissions.

Potential Air Quality Benefits:
A successful HFCMTG technology may constitute BACT for DG and would thus replace diesel generators in future DG installations in southern California. This technology would represent at least an order-of-magnitude reduction in NO_x, VOC, PM and carcinogens from the emissions that would otherwise have occurred from diesel generators. Furthermore, because of the far superior fuel efficiency of HFCMTG, which is expected to approach 80%, emissions of CO_2 would be less than half those that would be produced by diesel generators for the same amount of power produced. This has the potential to form the next generation of clean and plentiful power source for the Basin and elsewhere, while improving energy security and diversity.

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Proposed Project: Demonstrate Stationary Fuel Cells for Residential, Commercial, and Industrial Applications

Expected SCAQMD Cost: $ 2,000,000

Expected Total Cost: 5,000,000

Description of Technology and Application:
The objective of this proposed program is to support the development and demonstration of clean energy alternatives for stationary power generation. This program to support stationary fuel cell applications is expected to improve performance and efficiency, potentially reduce capital and operating costs, improve reliability and user-friendliness, and identify niche markets that could expedite the implementation of successful technologies.

Fuel cell technologies that will be considered include, but not limited to, proton exchange membrane, solid oxide, direct methanol, phosphoric acid, and molten carbonate. Hybrid systems, integrating fuel cells with gas turbines or energy storage devices, are expected to be the focus of this program area in the future. Peripheral technologies involving fuel infrastructure, fuel storage, hydrogen reformers, and other balance-of-plant issues will be included if they have potential to advance the commercial viability of fuel cell applications. The proposed program will also address all performance codes and standards, state and local building, fire, and safety codes and other permitting issues that may apply.

Potential Air Quality Benefits:
The AQMP identifies the development and implementation of non-polluting power generation as a long-term control measure goal. The AQMP also projects a significant increase in the use of clean electrical technologies to replace fossil fuel-fired equipment. The proposed program is expected to accelerate the implementation of advanced zero-emission energy sources. Expected benefits include the direct reduction of NO_x emissions at electrical power generating stations; proof-of-concept and potential viability for near-zero-emission power generation systems; and increased exposure to and user acceptance of the new technology. If the demonstration is successful, the project will help expedite wide-scale use of environmentally friendly and energy efficient fuel cells in the Basin for multiple applications.

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Proposed Project: Develop and Demonstrate Fuel Cells for Marine Vessels

Expected SCAQMD Cost: $ 100,000

Expected Total Cost: 1,000,000

Description of Technology and Application:
The diesel engines used to power marine vessels are significant sources of NO_x, SO_x, and particulate emissions in the Basin. A previous project co-funded by the EPA and SCAQMD resulted in significant emissions reductions from a tug boat by simply replacing the old diesel engine with a new diesel engine. The proposed project would focus on replacing these conventional diesel engines with near-zero-emission, fuel cell technologies for pleasure craft and other marine applications. The demonstration would be conducted in the Port of Los Angeles, Newport Harbor, or other applicable location. The results from the proposed project will allow early insights into potential candidate technologies for emissions controls on larger ships operating in Basin waters.

Potential Air Quality Benefits:
The 2003 AQMP estimates that ships and commercial boats operating in the Basin contributes approximately than 40 tons per day of NO_x and around 30 tons per day of SO_x. Gasoline-fueled pleasure craft o5erating in the Basin, including recreational boats and personal water craft, contributes approximately 55 tons per day of VOC, around 300 tons per day of CO, and more than 3 tons per day of PM10 emissions. These emissions clearly indicate the need for advanced technologies to reduce emissions from these types of marine vessels.

The potential benefits of the proposed project include proof-of-concept of the new technology, increased exposure and user acceptance, diversification of fuels used to power marine vessels and ships, direct emission reductions in NO_x and PM from the in-Basin demonstrations, and the potential for expedited commercialization. In addition, the successful demonstration of the dual fuel technology with a tug boat or the hybrid electric drive system could assist in developing similar controls for large freighter vessels, which are responsible for the majority of emissions from ships and commercial boats.

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Proposed Project: Develop and Demonstrate Fuel Cells for Off-Road and Construction/Industrial Applications

Expected SCAQMD Cost: $ 250,000

Expected Total Cost: 1,000,000

Description of Technology and Application:
There are many off-road applications that are potential niche markets for fuel cell systems. These applications include recreation vehicles, pleasure boats, camping equipment, lawn and garden equipment, forklifts, boom lifts, portable power units, and construction and industrial vehicles. This project would support the demonstration and deployment of limited number of promising fuel cell systems using direct hydrogen, methanol, ethanol, natural gas or gas-to-liquid fuels derived from natural gas. Among the fuel cell technologies, PEM and direct methanol systems are promising candidates for mobile applications.

Potential Air Quality Benefits:
The AQMP identifies the need to implement zero-emission vehicles. The proposed projects have the potential to accelerate the commercial viability of fuel cell in off-road equipment. Expected immediate benefits include the establishment of zero- and near-zero-emission proof-of-concept vehicles in numerous applications. Over the longer term, the proposed projects could help foster wide-scale implementation of zero-emission fuel cell vehicles in the Basin. This would also lead to significant fuel economy improvements, independence from petroleum imports, manufacturing innovations and the creation of high-tech jobs in Southern California, besides realizing the air quality benefits projected in the AQMP.

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Proposed Project: Demonstrate Fuel Cell in Heavy-Duty/Transit Bus Applications

Expected SCAQMD Cost: $ 350,000

Expected Total Cost: 2,000,000

Description of Technology and Application:

The AQMD has supported numerous fuel cell technologies for stationary and mobile uses. Among the fuel cell technologies, Proton Exchange Membrane (PEM) technology has shown the greatest acceptance for mobile applications. Major fuel cell and automobile OEMs have developed passenger cars, sports-utility vehicles, transit buses (30-foot and 40-foot) using PEM fuel cell technology, and placed a limited number in fleet demonstrations. ARB's Transit Bus regulation requires the use of Zero-Emission Buses to reduce overall emissions from transportation uses. In support of the requirement, a 30-foot fuel cell bus using a PEM fuel cell was successfully developed and demonstrated in revenue service, clearly supporting the viability of this technology. Although fuel cell buses are still in the prototype stage, the use of fuel cells in buses or other heavy-duty uses is one of the most commercially-advanced of all the fuel cell vehicles to date, since these platforms offer a size large enough for system components and fuel storage and can be fueled at a central fueling station with trained personnel for regular maintenance. Seven 40-foot transit buses are currently under development for use in California, as part of the California Fuel Cell Partnership effort to demonstrate these buses in fleet service, of which only one is expected to be in the South Coast. However, the development of fuel cell buses is still somewhat limited due to the high cost of the fuel cell stacks and the limited warranty offered by the fuel cell OEMs. The Department of Defense also supports the development of medium- and heavy-duty trucks using fuel cell stacks.

The objective of this proposed program is to support the development and demonstration of clean energy alternative for heavy-duty mobile sources in the South Coast. Expected participants in this project include CARB, CEC, FTA, local transit authorities, as well as bus and fuel cell OEMs.

Potential Air Quality Benefits:

The AQMP identifies on-road mobile sources as one of the largest contributors of air pollution in the basin, and therefore considers the development and implementation of non-polluting power generation as a long-term control measure goal. Additionally, diesel emissions have been identified as a toxic air contaminant. The proposed program is expected to accelerate the implementation of advanced zero-emission energy sources. Expected benefits include the direct reduction of NOx, CO, VOC, PM, and CO2 emissions, as well as increased exposure and user acceptance of the new technology.

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Hydrogen Technology and Infrastructure

Proposed Project: Demonstrate Integrated Hydrogen Production and Power Facility

Expected SCAQMD Cost: $ 1,000,000

Expected Total Cost: 4,000,000

Description of Technology and Application:
In November 2002, the U.S. Department of Energy (USDOE) unveiled the *National Hydrogen Energy Roadmap* in support of the National Energy Policy to develop a hydrogen economy and resolve growing concerns about America's energy supply, security, air pollution, and greenhouse gas emissions. Similarly, the AQMP identifies the use of alternative clean fuels as a key air quality attainment strategy. In this regard, hydrogen fuel cell vehicles and power generators offer great promise since they are near zero-emission and have the potential to vastly reduce or eliminate VOC, NO_x, CO, toxics, and greenhouse gas emissions. Providing the hydrogen to fuel these technologies to facilitate their demonstration is therefore an integral part of developing the national and local clean air plan.

This project is intended to demonstrate the renewable production, storage, and power generation capabilities of hydrogen in a single facility at the AQMD headquarters. The technologies to be demonstrated include a solar powered electrolyzer, natural gas reformer, advanced hydrogen storage, vehicle fueling, internal combustion engine generator, and proton exchange membrane fuel cell. The project will also include a possible tie-in to the existing natural gas compressor for supplying Hythane (hydrogen and natural gas) for vehicles. The project will not only demonstrate the viability of integrating all of these technologies, it will also provide the required fueling infrastructure for the pending AQMD fuel cell vehicles.

Potential Air Quality Benefits:
The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. The hydrogen demonstration will help address the fuel production and storage issues associated with fuel cell vehicles and, thus, assist in accelerating its acceptance and ultimate commercialization. Further, the co-location of power producing technologies offers hydrogen producers alternatives to consider while fuel cell vehicle numbers and use rise. Widespread adoption of such technologies would lead to direct reductions in NO_x, VOC, CO, PM, toxics and global warming emissions from light-duty and medium-duty vehicles as well as back up and premium power generators.

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Proposed Project: Develop and Demonstrate Heavy-Duty Truck On-Board Electrolyzer

Expected AQMD Cost: $ 40,000

Expected Total Cost: 200,000

Description of Technology and Application:
This proposed project is to produce and store hydrogen on-board heavy-duty vehicles by electrolyzing water. The electrolyzer can be powered through the alternator of the vehicle while the vehicle is being propelled by its engine. Heavy-duty vehicle engines have enough excess power to provide energy for such an application.

The hydrogen that is generated by this electrolysis process can be stored on-board in pressurized containers or metal hydrides, and used to power a fuel cell to provide electrical power for truck cabs (for TVs, radios, microwave ovens, computers, etc.), heating and air conditioning for truck cabs, and other auxiliary power applications without idling the main diesel ICE engine while the vehicle and the driver are at rest. Typically, a truck cab requires about 1.5 – 2kW for this purpose.

AQMD's truck APU project with U.C. Davis has already reached the stage where the PEM fuel cell can provide power to the cab (about 2.5 kW peak load). This fuel system can be used in conjunction with the stored on-board hydrogen in this project.

Potential Air Quality Benefits:

Main engines on trucks are idled to provide electrical power to the cab for the above mentioned purposes. These engines idle at about 5-10% load and diesel ICEs are extremely fuel inefficient at these low load levels. Idling also produces a lot of air pollution and noise pollution.

Currently there are over 350,000 heavy-duty vehicles in California. These vehicles generate an estimated 430 tons of PM annually. Truck idling in California wastes about 800 million gallons of diesel fuel annually. CARB is in the process of developing an air toxic control measure (ATCM) for existing heavy-duty vehicles. This ATCM, which will include limited idling times, truck stop electrification, and cleaner technologies is expected to be adopted by CARB's Board in May 2004. AQMD is working with CARB in developing control strategies for this ATCM.

The National Heavy-Duty Vehicle Idling committee is currently studying emission impacts from idling of trucks, locomotives, and all other heavy-duty vehicle engines. AQMD is a part of this committee. This committee is holding a national conference in May 2004.

AQMD has developed Rules 1633 and 1634, which are pilot credit generation rules, for truck stop and truck electrification which will reduce idling. The AQMP addresses heavy-duty vehicle idling issues in the on-road heavy-duty vehicle section.

DRAFT

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

Expected SCAQMD Cost: $ 1,500,000

Expected Total Cost: 4,000,000

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

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

- *Fleet and Commercial Refueling Stations*. Pre-production hydrogen fuel cell vehicles are being introduced for controlled fleet demonstrations as part of the California Fuel Cell Partnership program, and other OEM programs. In 2002, the SCAQMD Governing Board approved the funding to develop five new hydrogen fueling sites in the District. The objective of this project is to continue to expand the development and demonstrate the distributed production and distribution of hydrogen to support these vehicles in the Basin. Hydrogen refueling stations will be installed at strategic locations within the Basin to enable fuel cell vehicles of various types to travel within the greater Los Angeles metro region. Several hydrogen production technologies are envisioned for these sites. Likely candidates would include electrolysis of water using grid power or renewable sources, steam reforming of methanol or natural gas, and partial oxidation of other liquid fuels such as gasoline. Multiple use energy stations, that can produce hydrogen for fuel cell vehicles or for stationary power generation, are also included in this demonstration project.
- *Home Refueling Appliances*: Home refueling/recharging is among the advantages offered by many alternative clean fuels. A project has already been initiated for demonstrating a natural gas home refueling appliance for personal vehicles. It is anticipated that the appliance will be commercially available by the end of 2003. This project would be extended for hydrogen refueling and these technologies could be evaluated for cost, compactness, performance, durability, emission characteristics, ease of assembly and disassembly, maintenance, and operations. Other issues such as building permits, building code compliance, and UL ratings for safety will also be evaluated.

Potential Air Quality Benefits:
The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. Pursuant to AQMP goals, the SCAQMD recently adopted several fleet rules that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. Fuel cell vehicles constitute the cleanest alternative-fuel vehicles today. Since hydrogen is a key fuel for fuel cell vehicles, this program would address some of the barriers faced by hydrogen as a fuel and, thus, assist in accelerating its acceptance and ultimate commercialization. In addition to supporting the immediate deployment of the demonstration fleet, expanding the hydrogen fuel infrastructure should contribute to the market acceptance of fuel cell technologies in the long run, that lead to substantial reductions in NO_x, VOC, CO, PM, and toxic compound emissions from vehicles.

DRAFT

Proposed Project: Develop and Demonstrate Reformer Technology for Hydrogen Production

Expected AQMD Cost: $ 50,000

Expected Total Cost: 250,000

Description of Technology and Application:
This proposed project is to produce and store hydrogen at existing gas stations and truck stops by reforming liquid fuels (gasoline, diesel) and propane. The infrastructure for gasoline and diesel already exists, and most truck stops in the U.S. sell propane. The hydrogen can be used to refuel ICEs in cars and future hydrogen-powered fuel cell cars. The hydrogen can also be used to provide fuel to reduce heavy-duty vehicle idling as mentioned in the above proposed project, Hydrogen Technology and Infrastructure.

This method of hydrogen production will not necessitate the development of an intricate infrastructure for this fuel. The hydrogen can be stored in pressurized tanks or in metal hydrides. For this application, the weight of metal hydrides to hydrogen absorption is not much of a concern because it is a stationary source application.

ChevronTexaco and other OEMs are currently developing reformers that can be used to produce hydrogen from propane and liquid fossil fuels. These reformers can be used for this application. The ChevronTexaco reformer can currently produce PEM fuel cell quality hydrogen from propane, and they are in the process of technology development to reform gasoline and diesel.

Potential Air Quality Benefits:
The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. The hydrogen demonstration will help address the fuel production and storage issues associated with fuel cell vehicles and, thus, assist in accelerating its acceptance and ultimate commercialization. Further, the co-location of power producing technologies offers hydrogen producers alternatives to consider while fuel cell vehicle numbers and use rise. Widespread adoption of such technologies would lead to direct reductions in NO_x, VOC, CO, PM, toxics and global warming emissions from light-duty and medium-duty vehicles as well as back up and premium power generators.

DRAFT

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

Expected AQMD Cost: $ 1,300,000

Expected Total Cost: 4,000,000

Description of Technology and Application:
Over the past few years, the AQMD has initiated the development of a hydrogen refueling station network across the South Coast. Subsequently, the State of California has recently announced its intent to develop a hydrogen highway, with hydrogen refueling stations expected to be built at an average distance of 20 miles throughout the state. In recognition of these strategically-placed refueling stations, automotive OEMs have initiated limited fleet demonstrations of hydrogen-powered fuel cell vehicles in these areas. However, due to the cost and on-going technology issues, automotive OEMs plan to place a limited number in service (approximately 250 over the next four years). In parallel, there has been a significant amount of technology development for converting existing ICE vehicles to operate on hydrogen in place of gasoline. Automotive OEMs, as well as other smaller firms, have successfully developed prototypes of hydrogen ICE vehicles with near-zero emissions. These hydrogen ICE vehicles can be developed at a fraction of the cost of a fuel cell vehicle and utilize the growing hydrogen infrastructure in the near future, as the fuel cell technology is further refined.

This project is to develop, certify for emissions and safety, and demonstrate hydrogen ICE vehicles for a variety of uses. The goal of the project is to achieve a minimum of SULEV emission certification for the hydrogen ICE vehicles. The expected project partners may include auto OEMs, including small volume manufacturers, conversion firms, hydrogen fueling and certification experts, and local fleets.

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

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

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

DRAFT

Engine Technology

Proposed Project: Demonstrate Twin-Speed Marine Engines

Expected SCAQMD Cost: $ 250,000

Expected Total Cost: 500,000

Description of Technology and Application:
Twin speed marine transmissions reduce engine speed and enhance fuel use and emissions without significantly affecting vessel speed. The technology is applicable to planing hull vessels, e.g., crew, supply, pilot, fishing, recreational boats and possibly barge towing tugs. While twin speed transmissions are commercially available for certain horsepower ranges and duty cycles, virtually all recreational and commercial vessels in the AQMD use single speed transmissions. Based on experience, commercial vessel operators are reluctant to use twin speed transmissions because twin speed transmissions represent a new, untested technology.

The second gear can achieve nearly the same top end vessel speed as a single speed transmission at substantially lower engine RPM and fuel consumption (25% to 30%). Unless the propeller speed is governed (limited), the use of twin speed transmission could result in a substantial increase in vessel fuel consumption. Experimental data indicates that if the propeller speed can be regulated in second gear, it is probable that a twin speed transmission could reduce emissions of all pollutants in the order of 25% to 30% without a significant sacrifice in vessel performance.

This project will also include vessel performance and emissions testing.

Potential Air Quality Benefits:
It is estimated that the use of a twin speed marine transmission can reduce emissions of NO_x, HC, PM and CO from marine diesel engines used in planing hulls and, possibly, barge towing applications by 25% to 30%. Assuming a planing hull vessel is powered by twin 250 hp diesel engines, that operates 1500 hours per year at a 70% average load, the baseline emission rate of NO_x, HC and PM (combined) is 7.5 grams/bhp-hr, and the technology has a 25%; emission reduction efficiency, emissions of NO_x, HC and PM would be reduced by just over one ton per year (combined).

In addition, each gallon of diesel fuel contains hidden environmental costs. A substantial amount of air pollution and energy is required to explore for, extract, transport and refine crude oil, and ship refined products to market. Any technology that reduces fuel consumption will reduce "up-stream" environmental costs as well.

Assuming a 10 year project life and the use of the CRF method at 5%, cost-effectiveness would be approximately $3,200 per ton of NO_x reduced.

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

Expected SCAQMD Cost: $ 2,000,000

Expected Total Cost: 4,000,000

Description of Technology and Application:
The objective of this proposed program is to support development and certification of near commercial prototype low emission heavy-duty alternative fuel engine technologies and demonstration of these technologies in on-road vehicles. The NO_x emissions target for this program area is 0.5 g/bhp-hr and PM emissions target is below 0.01 g/bhp-hr. This program is expected to result in several projects, including:

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

The program proposes to expand field demonstration of these advanced technologies in various vehicle fleets operating with different classes of vehicles.

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

Potential Air Quality Benefits:

This proposed program supports the 2003 AQMP Mobile Sources Control Measure, On-road Heavy-Duty-3, "Pursue Approaches to Clean-up the Existing and New Truck/Bus Fleet."

This program is intended to expedite the commercialization of low emission alternative fuel heavy-duty engine technology in California, both in the Basin and in intrastate operation. By working cooperatively with other local air districts and the ARB, the SCAQMD can leverage its funds and provide a statewide air quality benefit. The emission reduction benefit of replacing one 4.0 g/bhp-hr heavy-duty engine with a 0.5 g/bhp-hr engine in a vehicle that consumes 10,000 gallons of fuel per year is about 1400 lb/yr of NO_x. Clean alternative fuels, such as natural gas, or natural gas blends with hydrogen can also reduce heavy-duty engine particulate emissions by over 90 percent compared to current diesel technology. This program is expected to lead to increased availability of low emission alternative fuel heavy-duty engines. Fleets can use the engines and vehicles emerging from this program to comply with recently adopted SCAQMD regulations.

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Proposed Project: Demonstrate Low- and Zero-Emission Locomotives

Expected AQMD Cost: $ 1,500,000

Expected Total Cost: 7,000,000

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

The purpose of the proposed project is to support the demonstration of low-emission locomotives in the Basin, either utilizing LNG combustion systems, low-emission engine calibrations, exhaust after-treatment technology, or hybrid-electric technology. Both LNG spark-ignition and compression-ignition technology have been developed and demonstrated for certain locomotive applications. In addition, locomotive engine manufacturers and component suppliers are developing low-emission, Tier-II calibrations for existing base locomotive engines. Such calibrations will allow the Class-1 railroads to meet their emission obligations under the CARB MOU using rebuilt locomotives rather than purchasing new Tier-II locomotives as they have planned. Such technology would also be applicable to Class-2 and -3 railroads and passenger locomotives which operate mainly within the Basin. On-road exhaust after-treatment technology is available for application to locomotive engines, especially for the smaller generator sets found on passenger locomotives (Head-End Power). Finally, locomotive manufacturers have investigated hybrid-electric technology for larger locomotives. Demonstrating such retrofit technology in certain locomotive applications could significantly reduce emissions.
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The purpose of the proposed project is to support the demonstration of clean-burning locomotives in the Basin utilizing low-emission LNG combustion systems. Both LNG spark-ignition and compression ignition technology have been developed for locomotive engines. This project will involve the rebuilding of existing diesel locomotives to LNG. This involves conversion of the engine, the fuel storage system, and for passenger locomotives, the head-end power (electrical generator set).

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

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Proposed Project: Demonstrate On-Board LNG Tank

Expected AQMD Cost: $ 250,000

Expected Total Cost: 500,000

Description of Technology and Application:
During the past five years, fleets have been converting to natural gas medium- and heavy-duty vehicles. Faulty tanks have been a detriment to purchasing more natural gas vehicles due to the increasing down time needed for maintenance. A new on-board LNG tank was developed to address this problem. This project proposes to purchase, install and track the maintenance needed for 50 LNG trucks with the new tanks. The objective of this project is to demonstrate the reliability of these tanks in order that the market can purchase new LNG vehicles that won't cause maintenance problems.

Potential Air Quality Benefits:
This program is intended to continue the commercialization of low emission alternative fuel heavy-duty engine technology in California, both in the Basin and in intrastate operation. By working cooperatively with other local air districts and the ARB, the AQMD can leverage its funds and provide a statewide air quality benefit. The NOx emission reduction benefit of replacing one 4.0 g/bhp-hr heavy-duty engine with a 0.5 g/bhp-hr engine in a vehicle that consumes 10,000 gallons of fuel per year is about 1400 lb/yr. Clean alternative fuels, such as natural gas, or natural gas blends with hydrogen can also reduce heavy-duty engine particulate emissions by over 90 percent compared to current diesel technology. This program is expected to lead to increased availability of low emission alternative fuel heavy-duty engines. Fleets can use the engines and vehicles emerging from this program to comply with recently adopted AQMD regulations.

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Infrastructure and Fuel Production

Proposed Project: Develop Template for Designing, Permitting, and Constructing CNG Fueling Facility

Expected AQMD Cost: $ 200,000

Expected Total Cost: 200,000

Description of Technology and Application:
Refueling station installations consist of loosely organized companies that design and install a wide variety of non-standardized site-specific refueling systems. This system of procurement leaves the design and operational functions of these highly integrated systems to the end user who in essence is a complete novice. This project proposes to design templates for both CNG and LCNG fueling stations to minimize customization and operational parameters to ensure the most reasonable costs and highest performance possible.

Potential Air Quality Benefits:
This program is intended to continue the commercialization of low emission alternative fuel heavy-duty engine technology in California, both in the Basin and in intrastate operation. 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. This project, if successful, would help develop a uniform safety standards and codes for all types of alternative fuel re-fueling equipment as well as have a beneficial consequence to future standardization of vehicle onboard fuel systems. The project would significantly reduce the barriers for installing and operating NGV refueling stations. This would lead to the expansion of the NGV fueling infrastructure and greater consumer acceptance, which in turn, should support expedited commercial implementation of NGVs. The increased exposure and fleet and consumer acceptance of NGVs would lead to significant and direct reductions in NO_x, VOC, CO, PM, and toxic compound emissions from mobile sources.

DRAFT

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

Expected SCAQMD Cost: $ 750,000

Expected Total Cost: 4,000,000

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

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

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

Potential Air Quality Benefits:
The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. The ARB has also passed LEV regulations that require light-duty vehicles to comply with increasingly stringent emission standards. The ARB has passed analogous standards for medium- and heavy-duty vehicles. NGVs have significantly lower emissions than gasoline vehicles and represent the cleanest internal combustion engine powered vehicles available today.

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

DRAFT

Proposed Project: Liquefied Natural Gas Manufacturing and Distribution Technologies

Expected AQMD Cost: $ 750,000

Expected Total Cost: 7,000,000

Description of Technology and Application:
Lack of statewide LNG production results in increased fuel costs. The cost of transporting LNG from production facilities out-of-state increases the fuel cost anywhere from 15 to 20 cents per gallon of LNG. The capital cost to construct a large scale liquefaction facility is high. The capital cost of the distributed small-scale liquefied natural gas (LNG) liquefaction system is about 25% lower than that for conventional technology per gallon of LNG produced. Because these smaller plants can be sited near fleet customers, costs for transporting the LNG produced to the end user are much lower than those for remote larger plants. Beyond these cost reductions, the smaller plant offers the key benefit of requiring a much smaller capital investment than does a larger plant. This smaller price tag greatly reduces investment risk, and can be profitable for relatively small LNG usage. Natural gas, landfill gas and waste gases can be processed to yield LNG. These processes are typically power-intensive, due to the higher energy content of LNG.

Industry and government agree that LNG promises to capture a significant share of the heavy-duty vehicle and engine market. LNG is the preferred for long distance trucking as it provides twice the energy per unit volume as CNG. This translates to longer driving ranges and lower-weight vehicle fuel storage.

The main objectives of this project are to:

- Develop and demonstrate an economic small-scale natural gas liquefaction technology
- Develop and demonstrate LNG manufacturing plants on a small scale from various gaseous feed stocks locally available
- Commercialize incentives for fleets to site, install, and use LNG and L/CNG refueling facilities

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

DRAFT

Electric/Hybrid Technologies

Proposed Project: Demonstrate Plug-In Hybrid Electric Vehicles

Expected AQMD Cost: $ 150,000

Expected Total Cost: 500,000

Description of Technology and Application:
The SCAQMD has been involved in the development and demonstration of energy storage systems for electric and hybrid electric vehicles, mainly lead acid, nickel cadmium, and nickel metal hydride battery packs. Over the past few years, additional technology consisting of nickel sodium chloride and lithium manganese batteries have shown robust performance, especially in heavy-duty uses. Also, other energy storage devices are under development, including flywheels and hydraulic systems, but these storage devices have more potential in medium- and heavy-duty vehicles.

Major auto makers feature nickel metal hydride batteries in their current retail gasoline fueled hybrid electric vehicles and demonstration fuel cell hybrid vehicles, plus a couple examples of ultracapacitors and automotive-sized lithium ion batteries in fuel cell hybrid vehicles. Lithium ion batteries provide performance improvements at reduced weight compared to other battery chemistries. In the consumer electronics market the use of small lithium ion batteries has grown to be a dominant chemistry, with a large variety of competitive manufacturers producing quality product at steadily decreasing prices. Some automakers are encouraged by the continuing advancements in lithium ion batteries, but lithium ion automotive batteries remain costly and are not in mass production, since concerns remain about battery life and other issues in automotive applications.

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

Potential Air Quality Benefits:
The AQMP identifies zero- or near zero-emitting vehicles as a key attainment strategy. HEV technologies have the potential to achieve near-zero emissions but with the range of conventional gasoline-fueled vehicle, a factor expected to enhance consumer acceptance. Plug-in HEVs can increase the zero emission miles traveled in town, and also allow conventional vehicle refueling to enable long trips.

Demonstration of optimized prototypes improves the viability of electric drive vehicle technologies and encourages the deployment of near-ZEV and ZEV technologies by major automakers.

DRAFT

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

Expected SCAQMD Cost: $ 750,000

Expected Total Cost: 5,000,000

Description of Technology and Application:

The objective of this program is to evaluate and compare the impacts and benefits of various types of HEVs, especially plug-in or battery dominant hybrids which are also referred to as "extended range" hybrids, as compared to non plug-in hybrids. Work to be conducted will include: 1) developing various HEV architectures, and modeling their efficiency and environmental performance based on several different driving cycles; 2) determining the anticipated costs and comparing differences for each option; 3) assessing customer interest and preferences for each alternative; 4) evaluating prospective commercialization issues and strategies for various alternatives; and 5) integrating the technologies into prototype vehicles to demonstrate the viability and clean air benefits of these types of vehicles.

Innovative approaches to HEV systems are also under development that could improve performance, fuel efficiency, and reduce emissions relative to the first HEVs commercially introduced. Innovations that may be considered for demonstration include: advancements in the auxiliary power unit, either ICE or other heat engine, especially using alternative fuels including natural gas and hydrogen; battery-dominant hybrid systems utilizing off-peak re-charging; and non-conventional light-duty and medium-duty HEVs including delivery vans, shuttles, and other medium-duty vehicles.

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

Potential Air Quality Benefits:
The AQMP identifies zero- or near zero-emitting vehicles as a key attainment strategy. HEV technologies have the potential to achieve near-zero emissions but with the range of conventional gasoline-fueled vehicle, a factor expected to enhance consumer acceptance. This proposed project will evaluate various HEV systems and their performance and identify the most appropriate protocols with which to test real-world HEVs. Given the variety of HEV systems under development, it is critical to determine the true emissions and performance of HEVs. Demonstration of optimized prototypes would improve the viability of near-ZEV HEV technologies and enhance the deployment of near-ZEV technologies.

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

DRAFT

Proposed Project: Demonstrate Alternative Energy Storage Systems

Expected SCAQMD Cost: $ 700,000

Expected Total Cost: 1,400,000

Description of Technology and Application:
The SCAQMD has been involved in the development and demonstration of energy storage systems for electric and hybrid-electric vehicles, mainly lead acid and nickel-cadmium battery packs. Over the past few years, additional technology consisting of nickel sodium chloride and lithium manganese batteries have shown robust performance, especially in heavy-duty uses. During this time period, other technology manufacturers have further developed other energy storage devices, including flywheels and hydraulic systems. Flywheel systems can draw electrical energy from internal combustion engines, microturbines, and regenerative braking systems, store the energy in kinetic form, and be capable of releasing the energy to provide electric power. Hydraulic energy storage systems are available in various forms. Typically, these systems can storage retardation energy and provide this energy as a secondary source of propulsion, especially during acceleration. Both energy storage systems can be retrofitted into existing platforms to significantly increase fuel economy, especially in medium- and heavy-duty vehicles with frequent stopping in urban environments.

The long-term objective of this program is to decrease the fuel consumption without any changes in their performance compared to conventional diesel and alternative fuel engines. This program will support several projects for development and demonstration of different types of low-emission heavy-duty hybrid vehicles. The types of fuels utilized in these projects would include, but not be limited to LPG, natural gas, combined with high power energy storage systems required for the electric energy. The overall net emissions and fuel consumption of these types of vehicles are expected to be much lower than traditional diesel engine systems.

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

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

DRAFT

Proposed Project: Evaluate and Demonstrate Hybrid Heavy-Duty Vehicles

Expected SCAQMD Cost: $ 2,000,000

Expected Total Cost: 10,000,000

Description of Technology and Application:
The SCAQMD together with the Department of Energy are supporting the development and certification of natural gas heavy-duty engines with maximum NO_x emissions of 0.5 g/bhp-hr and 0.2 g/bhp-hr. This effort sets the stage for the development of other low-emission technologies for heavy-duty applications, including electric hybrids.

The long-term objective of this program is to achieve the emissions limits suggested by the ARB for heavy-duty trucks, without any changes in their performance compared to diesel engines. This program will support several projects for development and demonstration of different types of low-emission heavy-duty hybrid electric vehicles. The types of fuels utilized in these projects would include, but not be limited to LPG, natural gas, combined with high power energy storage systems required for the electric energy. Depending on the system design and specific operational needs of the vehicles, energy storage system of hybrid electric vehicles may be recharged off the electrical grid during non-operational periods or be self-sustaining. Either way, the overall net emissions and fuel consumption of heavy-duty hybrid electric vehicles are expected to be much lower than traditional diesel engine systems.

Potential Air Quality Benefits:
Certification of low-emission vehicles and engines, and their integration into the Basin's transportation sector is a high priority under the AQMP. This program is expected to develop hybrid electric technologies that could be implemented in heavy-duty trucks, buses, and other applications. Benefits will include proof of concept for the new technologies, diversification of transportation fuels, and lower emissions of criteria and toxic pollutants. Specifically, it is expected that heavy-duty hybrid electric technologies could achieve NO_x emissions of 0.5 g/bhp-hr or lower, compared to the 4.0 g/bhp-hr and 2.5 g/bhp-hr (combined NO_x and hydrocarbons) currently produced by heavy-duty diesel engines.

DRAFT

Proposed Project: Upgrade and Demonstrate Hybrid/Electric Technologies for a Variety of Applications

Expected SCAQMD Cost: $ 500,000

Expected Total Cost: 2,000,000

Description of Technology and Application:
Over the past five years, the SCAQMD, together with the California Energy Commission (CEC) and CARB, have funded a variety of light-, medium-, and heavy-duty electric and hybrid electric vehicle projects. The technology utilized in some of those projects has since evolved and enhanced in terms of overall performance. Specifically, significant progress has been made in battery pack design and battery management systems to extend the service period. Additionally, lower-emitting APUs have been successfully demonstrated in subsequent projects, including a microturbine.

This project will seek to upgrade existing electric and hybrid-electric vehicle technology with newer, better performing components, resulting in enhanced reliability and lower emissions, as well as plug-in recharging capability.

Potential Air Quality Benefits:
Certification of low-emission vehicles and engines, and their integration into the Basin's transportation sector is a high priority under the AQMP. This program is expected to upgrade existing hybrid electric vehicles from past projects. Benefits will include proof of concept for the new technologies, diversification of transportation fuels, and lower emissions of criteria and toxic pollutants. Specifically, it is expected that heavy-duty hybrid electric technologies could achieve NO_x emissions of 0.5 g/bhp-hr or lower, compared to 4.0 g/bhp-hr and 2.5 g/bhp-hr (combine NO_x and hydrocarbons) currently produced by heavy-duty diesel engines.

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Proposed Project: Develop and Demonstrate High-Capacity, Alternate Fueled Hybrid Electric Transit Buses

Expected SCAQMD Cost: $ 750,000

Expected Total Cost: 5,000,000

Description of Technology and Application:
The SCAQMD together with the U.S. Department of Energy (DOE) are supporting the development and certification of natural gas heavy-duty engines with maximum NO_x emissions of 0.5 g/bhp-hr and 0.2 g/bhp-hr. This effort sets the stage for the development of other low-emission technologies for transit buses, including electric hybrids.

The long-term objective of this program is to achieve the emissions limits adopted by CARB for transit buses, without any changes in their performance compared to diesel engines. This program will support several projects for development and demonstration of different types of low-emission transit buses with large capacity. Over the past few years, local transit authorities have emphasized a need for higher-capacity buses in support of FTA's Bus Rapid Transit programs. Therefore, the primary focus of these projects will be the development and demonstration of 45-foot or 60-foot buses. The types of fuels utilized in these projects would include, but not be limited to LPG, hydrogen, natural gas, combined with high power energy storage systems required for the electric energy. Depending on the system design and specific operational needs of the vehicles, energy storage system of hybrid electric vehicles may be recharged off the electrical grid during non-operational periods or be self-sustaining. The overall net emissions and fuel consumption of heavy-duty hybrid electric vehicles are expected to be much lower than traditional diesel engine systems.

Potential Air Quality Benefits:
Certification of low-emission vehicles and engines, and their integration into the Basin's transportation sector is a high priority under the AQMP. This program is expected to develop hybrid electric technologies that could be implemented in heavy-duty trucks, buses, and other applications. Benefits will include proof of concept for the new technologies, diversification of transportation fuels, and lower emissions of criteria and toxic pollutants. Specifically, it is expected that heavy-duty hybrid-electric technologies could achieve NO_x emissions of 0.5 g/bhp-hr or lower, compared to 4.0 g/bhp-hr and 2.5 g/bhp-hr (combined NO_x and hydrocarbons) currently produced by heavy-duty diesel engines.

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Proposed Project: Investigate and Demonstrate Neighborhood Electric Vehicle Applications

Expected SCAQMD Cost: $ 150,000

Expected Total Cost: 500,000

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

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

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

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

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Proposed Project: Investigate and Demonstrate Advanced Emissions Control Technologies for Hybrid Vehicles

Expected SCAQMD Cost: $ 100,000

Expected Total Cost: 400,000

Description of Technology and Application:
Commercially available gasoline-fueled internal combustion engines and hybrid electric passenger vehicles are achieving SULEV certifications. Plug-in hybrid electric vehicles can provide additional air quality benefits as zero emission range. However, existing emission test methods may not provide adequate comparisons among hybrid vehicles of varying designs and applications. Also, improvements to control cold start emissions, such as enhanced electronics and electrically heated catalysts, would benefit the overall emissions from plug-in hybrid electric vehicles and may also benefit other vehicles.

The objective of this program area is to optimize control system strategies for a plug-in hybrid electric vehicle to maximize air quality benefits without sacrificing commercial marketability.

Potential Air Quality Benefits:
Plug-in hybrid electric vehicles can increase zero emission miles traveled locally, plus allow conventional vehicles refueling for extended trips. Demonstration of optimized plug-in hybrid electric prototypes improves the commercial potential and encourages deployment, with added benefits for disproportionately impacted urban areas.

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Proposed Project: Demonstrate Advancements In Lithium Ion Battery Technology For Electric or Plug-In Hybrid Electric Vehicle

Expected AQMD Cost: $ 150,000

Expected Total Cost: 600,000

Description of Technology and Application:
The SCAQMD has been involved in the development and demonstration of energy storage systems for electric and hybrid electric vehicles, mainly lead acid, nickel cadmium, and nickel metal hydride battery packs. Over the past few years, additional technology consisting of nickel sodium chloride and lithium manganese batteries have shown robust performance, especially in heavy-duty uses. Also, other energy storage devices are under development, including flywheels and hydraulic systems, but these storage devices have more potential in medium- and heavy-duty vehicles.

Major auto makers feature nickel metal hydride batteries in their current retail gasoline fueled hybrid electric vehicles and demonstration fuel cell hybrid vehicles, plus a couple examples of ultracapacitors and automotive-sized lithium ion batteries in fuel cell hybrid vehicles. Lithium ion batteries provide performance improvements at reduced weight compared to other battery chemistries. In the consumer electronics market the use of small lithium ion batteries has grown to be a dominant chemistry, with a large variety of competitive manufacturers producing quality product at steadily decreasing prices. Some automakers are encouraged by the continuing advancements in lithium ion batteries, but lithium ion automotive batteries remain costly and are not in mass production, since concerns remain about battery life and other issues in automotive applications.

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

Potential Air Quality Benefits:
The AQMP identifies zero- or near zero-emitting vehicles as a key attainment strategy. HEV technologies have the potential to achieve near-zero emissions but with the range of conventional gasoline-fueled vehicle, a factor expected to enhance consumer acceptance. HEVs can increase the zero emission miles traveled in town, and also allow conventional vehicle refueling to enable long trips.

Demonstration of optimized prototypes improves the viability of electric drive vehicle technologies and encourages the deployment of near-ZEV and ZEV technologies by major automakers.

DRAFT

Emission Control Technology

Proposed Project: Develop and Demonstrate Advanced Aftertreatment Technologies for Liquid Fuels

Expected SCAQMD Cost: $ 800,000

Expected Total Cost: 2,600,000

Description of Technology and Application:
The U. S. EPA has recently established a heavy-duty on-highway engine emission standard of 0.01 gram per brake horsepower-hr (g/bhp-hr) PM, effective 2007, and 0.20 g/bhp-hr NO_x to be phased in between 2007 and 2010. In response to these tighter emission standards, engine manufacturers have improved or are improving their engine designs through electronic engine controls, changes in fuel injection systems, handling intake air, combustion chamber modification, exhaust gas recirculation systems, and reducing oil consumption. Although these engine improvements have shown some emission-reduction potential, more work is needed to meet future emission standards. Additionally, several thermal and catalyzed technologies have been developed to control diesel NO_x and PM emissions, but many of these systems are in the early stages of laboratory development and have not been tested in vehicles. Even the potentially promising technologies have development challenges, and require diesel fuel with sulfur content below 10 ppm in general for heavy-duty diesel applications.

The purpose of the proposed program is to explore alternative diesel emission control strategies, which could reduce on-road heavy-duty diesel NO_x and PM emissions by at least 60 and 90 percent, without significantly increasing fuel consumption on an energy equivalent basis. This involves the following:

- developing emissions control strategies that would include advanced alternative fuel enabling the use of advanced emission control technologies that may not otherwise be possible with conventional diesel fuel
- requiring a multi-year demonstration that would include participation and cost-sharing from fleet operators of heavy-duty vehicles, original equipment manufacturers, fuel suppliers, and other agencies.

Potential Air Quality Benefits:
In 1997 AQMP, mobile sources account for the majority of NO_x and VOC emissions in the Basin inventory. The majority of the emissions control strategies that will be proposed under this program are already commercially available and have been shown to reduce emissions from passenger cars, light-duty trucks, and medium-duty vehicles to very low levels, and yielded emissions reduction from buses, trucks, and heavy-duty highway vehicles. Low sulfur diesel and other advanced alternative liquid fuels, further advancements in engine design, and optimization of existing control devices will be necessary for heavy-duty vehicles to comply with future emissions standards. This program in combination with other programs (2003 CFE1-2) could reduce NO_x and PM emissions by over 60 and 90 percent, respectively. The program will ultimately expedite the progress of heavy-duty engine and control device manufacturers to build vehicles that comply with future emissions standards.

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Proposed Project: Demonstrate Advanced Alternative Fuels in Off-Road Equipment

Expected SCAQMD Cost: $ 1,200,000

Expected Total Cost: 2,600,000

Description of Technology and Application:
As on-road emissions continue to be reduced through tight regulation and fleet turnover, the relative emissions contribution of off-road vehicles and equipment will increase. For many off-road equipment applications, gaseous alternative fuels, such as natural gas and LPG, may not be a viable option. However, emerging low-sulfur diesel fuels (LSDF) and additives, such as the 15-ppm sulfur content diesel fuel, Purinox, emulsified diesel fuel, natural gas derived Fischer-Tropsch (F-T) liquids, and other advanced liquid fuels, could offer some emissions benefit. Reformulated diesel fuels can facilitate the use of advanced diesel emission controls, including after-treatment devices, which are susceptible to sulfur poisoning. A comprehensive, long-term demonstration in heavy-duty equipment is an important step toward quantifying viability and emissions benefit.

The purpose of the proposed program is to evaluate the emission-reduction potential of advanced alternative liquid fuels when used in heavy-duty off-road equipment. A secondary consideration is to assess the effect of these fuels on equipment's operational performance in a demonstration study. Majority of the projects under this program will include emission control strategies for reducing engine-out emissions, and require a multi-year demonstration that would include participation and cost-sharing from owners/operators of heavy-duty off-road equipment, original equipment manufacturers, fuel suppliers, and other agencies. Potential applications include: heavy-duty construction equipment, yard hostlers, miscellaneous industrial equipment, airport ground support equipment, and port vehicles.

Potential Air Quality Benefits:
Off-road sources are classified as "Other Mobile" sources in the AQMP. These sources include off-road vehicles (i.e., construction vehicles/equipment), commercial boats, trains, ships, aircraft, utility equipment, and other equipment not considered as on-road sources. Off-road mobile sources are estimated to represent 36, 33, and 53 percent of the entire 2003 Basin mobile source VOC, NO_x, and PM emissions, respectively. Currently, off-road heavy-duty equipment accounts for 32 percent of all PM mobile source emissions; however, its contribution to mobile source emissions inventory is projected to steadily increase over other mobile sources.

This program is expected to demonstrate LSDF, F-T, Purinox, emulsified diesel fuel, and other advanced liquid fuels that could be implemented throughout the heavy-duty off-road equipment population in the Basin thereby resulting in significant emissions reductions in NO_x, VOC, CO, PM, and toxics. Direct benefits will include proof of concept of these fuels and increased experience of end users with the cleaner fuels. In addition, the emissions control strategies that will be proposed under this program are already commercially available, and have been shown to reduce emissions from passenger cars, light-duty trucks, and medium-duty vehicles to very low levels, and yielded significant emissions reduction from buses, trucks, and heavy-duty highway vehicles. The program may ultimately expedite the development and commercialization of heavy-duty off-road equipment equipped with advanced diesel emission controls.

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Proposed Project: Develop and Demonstrate Advanced Aftertreatment Technologies for Natural Gas Emissions

Expected SCAQMD Cost: $ 800,000

Expected Total Cost: 1,600,000

Description of Technology and Application:
Public agencies and private industry have continued to direct considerable efforts and resources to developing strategies that allow an effective use of natural gas as a cleaner-burning alternative to conventional fuel in automotive service. These efforts have resulted in many options available for improving natural gas engine technology and efficiency, and developing exhaust aftertreatment devices to achieve higher reduction of criteria and toxic pollutant emissions. However, little effort has been devoted to specifically address carbonyl (formaldehyde and acetaldehyde) and PM emissions. With tighter regulations, additional work is needed to further reduce all criteria and toxic emissions with emphasis on formaldehyde and PM emission.

The purpose of the proposed program is to develop new or optimize existing emission control strategies capable of significantly reducing engine-out PM, NO_x, CO, carbonyl, and hydrocarbon emissions from CNG heavy-duty vehicles. This requires the participation and cost-sharing from fleet operators of heavy-duty vehicles, original equipment manufacturers, fuel suppliers, and other agencies.

Potential Air Quality Benefits:
The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. The ARB has also passed LEV regulations that require light-duty vehicles to comply with increasingly stringent emission standards. The ARB has passed analogous standards for medium- and heavy-duty vehicles. NGVs have significantly lower emissions than gasoline vehicles and represent the cleanest internal combustion engine powered vehicles available today. These emission levels could be reduced further by control technology enhancement or optimization. Benefits will include direct emission reductions in NO_x, VOC, CO, PM and toxics from in-Basin demonstrations, and expedited commercialization.

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

Expected AQMD Cost: $ 200,000

Expected Total Cost: 500,000

Description of Technology and Application:
Natural gas engine technology is making great advances in lowering emissions to the requisite EPA 2004 and 2007 standards for NO_x, VOC, and PM emissions. The SCAQMD is participating in several joint funding efforts, such as the Next Generation Natural Gas Vehicle (NGNGV) program with the National Renewable Energy Laboratories. As progress in these natural gas engines moves forward, the significance of the lubricating oil contribution to the emissions becomes increasingly important. The objective of this proposed project is to investigate the significance of lubricating oils on natural gas engine emissions and test commercially available and near-commercial lubricating oils on the domestic and international (European) market. The same lubricating oils may also be used for existing diesel engines and concurrent testing on these engines is anticipated. Effects on proposed aftertreatment technologies will also be considered.

Potential Air Quality Benefits:
The 1997 AQMP On-Road Mobile Sources Control Measures included control measures M4: Heavy-Duty Diesel Vehicles- Early Introduction of Low-NO_x Engines, and M5: Heavy Duty Diesel Vehicles - Additional NO_x Reductions in California. Pursuant to these AQMP goals, the SCAQMD adopted several fleet rules that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. One of the acceptable clean-burning alternative-fueled technologies is natural gas engine technology. The use of low-emission lubricating oils in natural gas engines would potentially have a significant reduction on particulate emissions. Clean alternative fuels can reduce heavy-duty engine particulate emissions by over 90 percent compared to current diesel technology. Coupling this with clean lubricating oils can result in higher than 90 percent particulate emission reductions.

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Proposed Project: Demonstrate NO_x and PM Control Technologies for Off-Road Equipment

Expected SCAQMD Cost: $ 750,000

Expected Total Cost: 1,500,000

Description of Technology and Application:
Marine vessels contribute a significant portion of NO_x, PM, greenhouse gas and toxic emissions particularly in coastal regions and in and around shipping ports. These emissions contribute to on-shore air quality problems. In order to continue meeting clean air goals, emission reductions from marine vessels are necessary. Currently, the California Maritime Air Quality Technical Working Group, CARB, U.S. EPA and the AQMD are exploring promising retrofit technologies to be used on marine vessels.

The primary objectives of the marine vessel technology demonstration project are to: identify technologies that are capable of reducing NO_x, PM, and greenhouse gases, identify and demonstrate emission measurement systems capable of accurately measuring pollutant emissions in ship exhaust streams; and install the most promising technology(s) on an in-use vessel(s) for demonstration under real world conditions and establish the emission reduction potential in different modes of operation. These technologies are also being considered as control measures in the AQMD's AQMP. The types of technologies are listed in the following section. Alternative fuels such as emulsified diesel can also be investigated.

Potential Air Quality Benefits:
The technologies that can be investigated and the associated emission reductions, from industrial and OEM surveys, are as follows:

Type of Control Details	Emission Reductions		
	PM	NO_x	Other
DFT #1500 Diesel Fuel Conditioner	90%	90%	90% CO
Organo-metallic combustion catalysts dosed into fuel supply	40-60%		
Catalytic Vapor Injection (CVI)	25%	15%	25% CO 5% HC 7% NO_2
Fitch Fuel Catalyst: fuel flows through catalyst prior to ignition	18-20%	15-20%	17-20% HC
CRT System: also filters reducing PM emissions	85%	90%	90% CO
MES Eco-Silencer : exhaust gas mixes with sea water solution	80%	0%	90% SO_2
Munters H.A.M. System: humidification of air		90%	75% HC
Munters SCR Converter System		90%	75% HC
DX Systems, DXX Systems, DXXX Systems Emission Capture & Exhaust Reduction/Catalytic Seperation Units	70%	50%	23% HC 38% CO
SCR catalyst w/ urea dosing system	85%	90%	90% CO
Ceramic coatings, water-emulsified fuel oil, intake-air fumigation/temperature control, fuel injection optimization combination system	52%	26%	

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Proposed Project: Investigate and Demonstrate Near-Term Emissions Control Technologies

Expected SCAQMD Cost: $ 1,000,000

Expected Total Cost: 4,000,000

Description of Technology and Application:

This category of projects includes control technologies that can be readily applied to assist in reducing emissions in the near-term. Such projects include the evaluation and demonstration of technologies such as

- On-Board Diagnostics (OBD) with remote notification
- Telematics for reduced congestion
- Remote Sensing
- Low cost test equipment for monitoring and identifying high emitters
- Test cycle development for different class vehicles
- Global positioning satellite (GPS) for potential high emitters
- Auxiliary power unit replacements
- Electrification where feasible

Most of these technologies have been proven in concept but not practice, so projects would need to develop these as feasible control strategies.

Potential Air Quality Benefits:

Many of the technologies identified can be applied to light-duty and heavy-duty vehicles to identify and subsequently remedy high emitting vehicles in the current fleet inventory. Estimates suggest that high emitting vehicles, 5% in the existing fleets account for up to 80% of the emissions. Identification of higher emitting vehicles would assist with demand-side strategies, where higher emitting vehicles have correspondingly higher registration charges, which is included in Chapter 4 of the AQMP as a potential control strategy.

DRAFT

Emission Studies

Proposed Project: Comparative Emissions of Heavy-Duty Alternative Fuel and Conventional Fuel Engines

Expected SCAQMD Cost: $ 500,000

Expected Total Cost: 1,000,000

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

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

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

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

DRAFT

Proposed Project: Develop Improved Particulate Measurement Procedures

Expected AQMD Cost: $ 100,000

Expected Total Cost: 700,000

Description of Technology and Application:
Reducing particulate emissions has become a high priority in the South Coast Air Basin since the ARB identified the particulate phase of diesel exhaust as a surrogate for all of the toxic air contaminant emitted from diesel exhaust. In addition, the ARB and EPA have adopted very stringent particulate standards for heavy-duty engines and vehicles. As the particulate emissions have been reduced, the specified gravemetric technique for measuring particulate mass has been approaching the limit of its sensitivity, especially with regards to natural gas engines. In addition, with the new standards, the characteristics of the particulate is changing due to various forms of particulate control.

In this program, important parameters related to assessing PM mass emissions will performed. This includes investigating different particulate sampling techniques, simulated ambient temperatures and dilution ratios, various filter media, and particulate physical and chemical composition. In addition to developing techniques for better particulate measurement on the Federal Test Procedure, a simple alternate particulate measurement will be developed on a 1-second to 1-minute time scale rather than a multi-hour scale. This will enable engine developers to quickly assess control system changes. These improved techniques will be applicable to heavy-duty diesel, natural-gas and other alternative-fuel engines.

Potential Air Quality Benefits:
The AQMP relies on the significant penetration of low-emission vehicles in the South Coast Air Basin to attain federal clean air standards. This project would help understand and improve the characterization and measurement of particulate emissions. This will allow particulate emissions to be accurately measured and their contribution to emission inventory properly understood.

DRAFT

Health

Proposed Project: Evaluate Ultrafine Particle Health Effects

Expected SCAQMD Cost: $ 500,000

Expected Total Cost: 2,000,000

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

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

Potential Air Quality Benefits:
The AQMP relies on the significant penetration of low-emission vehicles in the South Coast Basin to attain federal clean air standards by 2010. Reduction of diesel fuel consumption is a major priority in achieving these standards. This project would help better understand the nature and amount of toxic and criteria pollutants generated by different types of fuels. Such an understanding is important to assess the emission reduction potentials of these technologies upon commercialization. This will in turn have a direct effect on the policy and regulatory actions for commercial implementation of alternative fuel vehicles in the Basin.

DRAFT

Proposed Project: Evaluate Health Impacts from Toxic Emissions

Expected SCAQMD Cost: $ 1,000,000

Expected Total Cost: 2,500,000

Description of Technology and Application:
The objective of this proposed project is to determine whether some communities in the Basin are indeed at increased risk from emissions from multiple sources located in close proximity, and whether impacts have been reduced to the same extent in those communities as compared to the rest of the Basin.

In recent years, a consistent improvement in the ambient air quality of the Basin has been observed and is attributable to a reduction of emissions from both stationary and mobile sources. The ambient levels of both criteria pollutants and air toxic compounds measured have shown decreases in recent years. However, data on air toxics is very limited due to low frequency of ambient monitoring as well as a limited number of toxics monitoring sites.

In addition, some environmental and community groups have voiced their concerns about communities impacted by toxic emissions from multiple sources because of an increase in health complaints (nausea, vomiting, upper respiratory symptoms and asthma attacks) by the residents. Neither the current risk assessment methods, nor health effects studies conducted to date, have evaluated acute or chronic impacts to a community from multiple emission sources in close proximity. Thus, it is possible that the risk in some local communities impacted by multiple toxic emissions sources may not be declining as rapidly as the Basin as a whole.

Adding to the complexity of the problems is the fact that the socioeconomic status of a community may play both contributory and modifying roles affecting cancer risk and other effects from ambient exposures to air toxic compounds.

The proposed studies will include the following:

- Exposure characterization for both toxics and criteria pollutants at a community level
- Evaluation of hospital admissions database or other sources of health status to determine the correlation between exposure and health effects
- Comparison between communities having similar ethnicity and socioeconomic status but different exposure profiles

Potential Air Quality Benefits:
The proposed project will assist in evaluation of adverse public health impacts associated with simultaneous exposure to current ambient levels of criteria pollutants as well as toxics. The information will be useful in: a) determining whether areas impacted with multiple nearby emission sources have a relatively higher impact on residents living in close proximity to the sources; and b) providing guidance to develop some area specific control strategies in the future should it be necessary.

DRAFT

Proposed Project: Evaluate Benefits of Emissions Reductions

Expected SCAQMD Cost: $ 100,000

Expected Total Cost: 310,000

Description of Technology and Application:
The objective of this proposed program is to evaluate the health benefits of advanced mobile source control technologies that have potential to reduce criteria and toxic compound emissions. Projects in these areas may include the following:

- Development, demonstration, and evaluation of advanced remote sensing technologies to detect and quantify emissions from high emitting vehicles
- Demonstration and assessment of advanced catalysts and other after-treatment devices
- Evaluation of in-use vehicle emissions and resulting benefits from alternative and reformulated fuels
- Comparative assessment of baseline and reformulated fuels composition and resulting emissions
- Evaluation of emissions benefits of advanced transportation systems
- Assessment of health benefits and economic estimates related to improved air quality, clean fuels, and implementation of advanced technologies

Other related evaluations may also be conducted on the effects of air quality on health of residents of the Basin.

Potential Air Quality Benefits:
Mobile sources contribute the bulk of the VOC and NO_x emissions in the Basin. As a result, the AQMP relies on significant reductions of emissions from the transportation sector. In large part, these reductions are to be achieved through the implementation of advanced technologies.

This program is expected to assess the benefits of new, advanced technology options to cost-effectively reduce emissions from the transportation sector. Benefits will include qualitative or quantitative assessment of the health impacts or emission impacts from the implementation of clean fuels and clean technologies. Such assessment is important from the policy and planning perspective for commercialization and regulatory acceptance.

DRAFT

Stationary Source Clean Fuel Technology

Proposed Project: Develop And Demonstrate Portable Low Emission Alternative Fuel ICE Generator

Expected AQMD Cost: $ 100,000

Expected Total Cost: $ 200,000

Description of Technology and Application:

Portable engines are commonly used for a variety of purposes, e.g., generators, compressors, tree chippers, concrete pumpers, lights, etc. Diesel engines are currently used to power portable equipment and are classified by the U.S. EPA as non-road diesels, which have emissions standards that are much less stringent than on-road diesel engines. Current standards range from NOx levels of 6.9 g/bhp-hr and hydrocarbon (HC) levels of 1.0 g/bhp-hr to combined NOx + HC of 4.5 g/bhp-hr.

The objective of this proposed project is to assemble and demonstrate a portable low-emission generator technology capable of operating on liquefied petroleum gas (LPG), i.e. propane, that can compete with portable diesel generators over a range of useful sizes and applications. LPG-fired, spark-ignition engines could be used in their place with much lower emissions levels. Rich-burn engines could be equipped with a 3-way catalyst, achieving emissions levels equal to or near to stationary engines (0.15 g/bhp-hr NO_x and 0.15 g/bhp-hr of HC). Alternatively, lean-burn engines with combustion modifications and an oxidation catalyst could achieve 1.5 g/bhp-hr NOx and 0.15 g/bhp-hr HC.

Potential Air Quality Benefits:

CARB has recently adopted regulatory standards for distributed power generation sources, based on BACT for large stationary sources and the state of available technology. A portable, low emissions LPG generator technology can be expected to become BACT for portable generators in the future. Air quality would benefit from the availability of this technology as future portable diesel generators that would otherwise have been placed in service are replaced by portable, low emissions, generators operating on propane and emitting less NOx, VOC, PM and carcinogens per unit power produced.

DRAFT

Proposed Project: Demonstrate Emulsified Diesel Fuel Use in Portable Generators

Expected SCAQMD Cost: $ 50,000

Expected Total Cost: 100,000

Description of Technology and Application:
The objective of this proposed project is the development and demonstration of low-emission emulsified diesel fuel technology for portable power generators. Portable generators are used to power equipment at work sites, by film crews working on remote locations, and by highway construction companies to provide light at night, etc. The technology currently available to drive portable generators is the diesel-fueled internal combustion engine, which is a high polluting technology in terms of NO_x, VOC, PM and carcinogen compound emissions.

Emulsified diesel fuel is a blend of diesel fuel, water, and additives. This fuel has been demonstrated to reduce NO_x and PM emissions by approximately 15% and 50% respectively from on-road mobile sources. This low-emission fuel technology, which is promising for on-road mobile sources, should also be effective at reducing emissions from portable power generators.

One of the issues that will be addressed in this project is the stratification of the fuel for long term storage. It has been reported that this fuel tends to stratify when stored in tanks for a relatively long period of time without any agitation. The problem of stratification is not encountered in on-road mobile source applications due to more frequent filling of fuel tanks.

Engine durability and warranty issues will also be studied, particularly for older existing diesel engines.

Potential Air Quality Benefits:
The authority to develop and implement regulations for portable power generators lies primarily with CARB, and to a lesser extent with the SCAQMD. Some of the portable power generators require SCAQMD permits and need to comply with the Best Available Control Technology emission limits. The current AQMP does not have any control measures to reduce emissions from portable power generators, however, significant reductions in diesel toxic exposures may be expected from the reduction of emissions from such engines in urban areas.

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Proposed Project: Develop And Demonstrate Low-Emission Refinery Flares

Expected AQMD Cost: $ 100,000

Expected Total Cost: 200,000

Description of Technology and Application:
Refinery waste gases are currently flared and create substantial emissions while producing no useful energy or power. This program supports the development and demonstration of low-emission stationary combustion technologies. The objective of this program is the advancement of technologies that will reduce emissions from the combustion of refinery waste gases.

This program could result in the demonstration of a pre-mixed, surface-combustion flare system in development or similar technologies that have the potential to reduce unburned hydrocarbon and NO_x emissions from existing flares.

Potential Air Quality Benefits:
The 2003 AQMP includes the stationary source control measure CMB-07 Emission Reductions from Petroleum Refinery Flares. This measure consists of a two-step approach. In step I, data collected from implementing Rule 1118 has been received and is being evaluated to determine the source of emissions and to develop an emissions inventory. If flare operations are determined to represent a significant source of emissions, step II will be implemented. Step II will consist of a thorough investigation of control options to identify the most feasible and cost effective control strategies available to reduce emissions from refinery flares.

Expected benefits of this proposed project include directly reducing the emissions from the demonstration site; proof-of-concept; increased exposure and user acceptance of the new technology; and once successfully demonstrated, the potential for increased use, with resulting emission benefits through expedited implementation. If the technologies are successfully demonstrated, expected results from this program include the commercialization of cost-effective control technologies and providing a basis to proceed with rulemaking to require reductions in refinery flare emissions.

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Proposed Project: Develop and Demonstrate Renewable-Based Alternatives

Expected SCAQMD Cost: $ 500,000

Expected Total Cost: 1,000,000

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

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

Potential Air Quality Benefits:
The AQMP identifies the development and, ultimately, the implementation of non-polluting power generation. To gain the maximum air quality benefit, polluting fossil fuel-fired electric power generation needs to be replaced with clean renewable energy resources or other advanced zero emission technologies, such as hydrogen fuel cells, particularly in a distributed generation context.

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

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Proposed Project: Develop Next Generation Emission Monitoring Systems

Expected AQMD Cost: $ 250,000

Expected Total Cost: 750,000

Description of Technology and Application:
Low-cost emission monitoring systems are needed for small-to-intermediate size combustion devices, including, stationary engines, boilers, heaters, furnaces and ovens, that are not large enough to justify a continuous emission monitoring system (CEMS). This class of combustion devices is permitted on the basis of a single demonstration or periodic demonstrations of NO_x and CO emissions meeting AQMD rule requirements or a RECLAIM concentration limit. Emission spot checks, for example AQMD unannounced tests, on engines and boilers have found that in many cases NO_x and/or CO levels have increased significantly above levels that have been initially or periodically demonstrated due to equipment malfunction and/or inadequate operator attention. It is suspected that the same may be true of heaters, furnaces and ovens.

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

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

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Proposed Project: Develop and Demonstrate Low Emission, High Efficiency Distributed Generation Technologies

Expected AQMD Cost: $ 250,000

Expected Total Cost: 750,000

Description of Technology and Application:

Distributed generation (DG) is the placement of small power units near the point-of-use to provide enhanced reliability and power quality. The need for such technologies is made more evident in the wake of the California energy crisis in the early 2000s and the Northeastern U.S. power blackout in 2003. Such technologies, however, need to be clean and efficient in order to be successful, especially in the South Boast Basin. Combined cooling, heat, and power DG using advanced technologies such as fuel cells, microturbines, and absorption cooling may provide the balance necessary for improved power reliability, quality, emissions benefits, and energy efficiency.

This project will investigate the integration of these various technologies including fuel cells, microturbines, and absorption cooling. The design features, load following, market acceptability, and emissions performance will be monitored, analyzed, and optimized.

Potential Air Quality Benefits:

The clean DG technologies, using fuel cells or microturbines, will result in reduced NO_x, VOCs, and PM-10 emissions. Such advanced technologies are identified in Chapter 4 of the AQMP as part of the long-term control strategy.

The need for advanced, energy efficient technologies will also satisfy the reduction of greenhouse gas emissions and reduced fossil fuel dependence, in line with the state efforts in AB 1493 and AB 2076.

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VOC/Toxics Technologies

Proposed Project: Technology Assessments of Future VOC Limits in SCAQMD Rules

Expected SCAQMD Cost: $ 250,000

Expected Total Cost: 250,000

Description of Technology and Application:
Currently, SCAQMD Rule 1113 (Architectural Coatings), Rule 1122 (Solvent Degreasers), Rule 1136 (Wood Products Coatings), and Rule 1168 (Adhesive and Sealant Applications) contain technology-forcing VOC limits which will become effective in future years. These rules also contain provisions that require the Executive Officer to conduct assessment of low-VOC technologies relative to the technology-forcing limits in these rules. Specifically, the technology assessments required under various rules are as follows:

Rule 1113: Technology Assessments for the future VOC limits for flat and nonflat coatings; lacquers; primers, sealers, and undercoaters; quick-dry primers, sealers, and undercoaters; quick-dry enamels; waterproofing wood sealers; stains floor, rust preventive, and industrial coatings.

Rule 1122: Technology Assessment for cleaning of film resistors and the future VOC limit for cleaning satellite components.

Rule 1136: Technology Assessment for the future VOC limits for clear sealers; clear topcoats; pigmented primers, sealers, and undercoats; pigmented topcoats, barrier coat – plastic components; composite wood edge filler; extreme performance coatings; fillers; high-solid stains; inks; mold-seal coatings; multi-colored coatings; low-solid barrier coats – plastic components; and low-solid stains, toners, and washcoats.

Rule 1168: Technology Assessment for the future VOC limits for PVC welding, CPVC welding, plastic cement welding, and adhesive primer for plastic.

Assessments of these technologies are required to decide on a regulatory course of action to reduce the VOC emissions from these sources. If the technology is available then affected companies may be asked to utilize these new products and processes, otherwise additional work may be required to reduce such emissions.

Potential Air Quality Benefits:
VOC emission reductions are required in the Basin to attain federal Clean Air Standards and pursuant to the AQMP and SIP control measures for the sources listed above.

The future technology-forcing VOC limits in these rules were added to achieve the VOC emission reductions required under various 2003 AQMP control measures. If the future VOC limits are determined to be feasible, the application of materials complying with these limits will result in direct VOC emissions reductions in the Basin.

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Proposed Project: Develop and Demonstrate Near-Zero/Zero-VOC Products

Expected SCAQMD Cost: $ 500,000

Expected Total Cost: 500,000

Description of Technology and Application:
VOC emissions from stationary sources result primarily from the use of VOC products such as coatings, inks, adhesives, polyester resin materials, cleaning solvents, lubricating oils and mold release agents. These VOC products are used in a wide variety of industries which include: manufacturing and coating of metal, wood, plastic, and other products; printing operations such as lithography, flexography, screen printing, gravure and letterpress; cleaning operations at repair and maintenance facilities; numerous industries where adhesives are used; and manufacturing of boats, tubs, pools, showers, etc.

The proposed projects under this broad category would support the development and demonstration of near-zero- and zero-VOC products. Traditionally, these products contained high content of VOC. However, waterborne, high-solids, radiation-curing and powder coating technologies have been developed to reduce VOC emissions from these products. These technologies will be utilized to further reduce VOC emissions from these products. Due to a very large number of products and technologies covered under this broad category, multiple projects are anticipated to reduce VOC emissions from these sources. Some of the potential projects are: development and demonstration of near-zero or zero-VOC lubricating oils, mold release agents, gel coats and polymer resins.

Potential Air Quality Benefits:
The 2003 AQMP includes control measure CM #2003CTS-10: Miscellaneous Industrial Coatings and Solvent Operations. This control measure seeks to reduce VOC emissions from all industrial coating and solvent operations covered under the AQMD regulations as well as other categories which are not yet regulated. The control measure will be implemented in two steps. The first step involves the emission inventory and technology assessment of the available technology. The second step involves development and demonstration of near-zero or zero-VOC products. The projects under this category, if successful, will develop low-VOC products which, when used in the South Coast Basin, will reduce the VOC emissions and thus help achieve the goals of the AQMP and Clean Air Act.

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Proposed Project: Evaluate, Develop, and Demonstrate Advanced VOC Control Technologies for Miscellaneous Stationary Sources

Expected SCAQMD Cost: $ 200,000

Expected Total Cost: 200,000

Description of Technology and Application:
The objective of projects in this category is to evaluate, develop, and demonstrate advanced VOC control technologies for miscellaneous stationary sources. This program area will focus on the following source categories:

- Fugitive VOC emissions from organic liquid storage containers (e.g., above-ground tanks and under-ground tanks); processing and transfer (e.g., valves, pumps, compressors, etc.) of chemicals and petroleum products; and gasoline dispensing facilities. Projects in this category will focus on new technologies to detect and repair frequent and big leaks, develop leakless valves, and enhance vapor recovery devices to broaden their applications and/or to improve control efficiency.
- Manufacturing and fabrication of rubber, plastic, polystyrene foam, fiberglass and chemical products. Emissions are primarily generated from material handling, use of chemicals in different chemical processes, and storage of volatile chemicals.
- VOC emissions can be reduced by the use of control equipment such as carbon adsorption, thermal and catalytic oxidation, and bio-filtration. Projects under this category could include development and demonstration of innovative control technologies for coating, solvent, and printing industries.

Multiple projects are anticipated from this broad category. Since some of the source categories targeted by this measure are not permitted or regulated, it is necessary to first identify and refine the emission inventory, sources of emissions, and industry operations and practices. Based on the findings, appropriate control methods can then be conceptualized and developed, including technological solutions such as development of enclosures that could reduce process-related fugitive emissions.

Potential Air Quality Benefits:
Fugitive emissions are currently regulated under Rule 1173, Rule 1176, Rule 461, Rule 462, and Rule 463. The 2003 AQMP includes control measure CM#2003FUG-05: Emission Reductions from Fugitive Resources. Rubber and plastic product manufacturing operations, and fiberglass fabrication and impregnation processes are not currently regulated under a source-specific SCAQMD VOC rule. The 2003 AQMP targets VOC emission reductions from these operations in control measure CM #2003PRC-07: Industrial Process Operations. This control measure would also include bakeries, breweries, and other sources under chemical, food, and agricultural products processing sources categories. Projects in this category will target long-term technologies and processes that, if successful, will result in direct VOC emissions reductions at the demonstration sites, followed by broader applications that can deliver major VOC reductions throughout the Basin from the emission sources listed above.

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Outreach and Technology Transfer

Proposed Project: Technical Assistance in Assembling SAE Standards for LNG Fueling and Dispensing

Expected AQMD Cost: $ 150,000

Expected Total Cost: 300,000

Description of Technology and Application:
The alternative fuel re-fueling industry consists of numerous companies that design and install a wide variety of non-standardized, application-specific refueling systems. Virtually all hydrogen, CNG or LNG-L/CNG stations are custom built to match site parameters, often resulting in unnecessarily costly facilities. These factors all contribute to the high cost of alternative fuel re-fueling stations compared to conventional petroleum stations, and present major barriers to expansion of the NGV refueling infrastructure.

Efforts must be undertaken to reduce capital costs at alternative fuel re-fueling stations by standardizing station designs and components. For instance, dispensers are second only to compression equipment as the most expensive part of a CNG fueling station, with gas flow meters accounting for much of the high cost. Part of the problem is that CNG dispensers intended for public-access stations must meet challenging and expensive Weights and Measures regulations that are not optimized for gaseous fuels.

Card lock systems that control dispenser access and record and process NGV fueling transactions are available with many levels of sophistication. Presently, however, NGV users are unable to use a NGV credit card from one system to another unless the purveyor has an agreement in place to share credit and billing information. Very few of these types of agreements exist leading to the very real possibility of the motorist being stranded with no way to fuel their vehicle if they don't possess the right type of CNG fueling card. Software development must be done in order for the different card readers on the different CNG systems. Efforts such as the FuelNet pilot program are underway to develop a national networked system with card reader commonality among CNG stations.

The main objectives of this project are:

- Developing and implementing various code changes that will decrease unnecessary costs associated with building alternative fuel re-fueling stations.
- Demonstrate the cost, performance and safety parameters for all alternative fuel re-fueling equipment.

Potential Air Quality 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. This project, if successful, would help develop a uniform safety standards and codes for all types of alternative fuel re-fueling equipment. It will also help decrease the cost of alternative fuel re-fueling equipment installation and expedite the introduction of alternative fuels, including hydrogen, into the Basin. This increased convenience and lower cost equipment.

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Proposed Project: Technical Assistance in LNG Fueling for Transit Properties

Expected SCAQMD Cost: $ 200,000

Expected Total Cost: 200,000

Description of Project:
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 SCAQMD entered into 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. Experts in the areas of natural gas vehicles and infrastructure with extensive experience in advanced transportation technologies and alternative fuels will provide timely consultation and assistance to clean fleet and infrastructure owners.

Potential Air Quality 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. This technical assistance provides the needed resources for the implementation of alternative fuel infrastructure projects and thus their wider and expedited use.

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Proposed Project: Technical Assistance for Schools' Maintenance Facilities

Expected SCAQMD Cost: $ 300,000

Expected Total Cost: 300,000

Description of Project:
As school districts convert their bus fleets from diesel to natural gas, they must renovate their maintenance facilities to supply the NGVs. Cost, regulation requirements, and equipment safety are major issues during the transition. Addressing the garage modification issues will require more study and evaluation as each district is hiring architects and consultants with a host of high cost compliance solutions. These architects and consultants should be encouraged to develop options for compliance with NFPA 88 B rather than conveniently taking the worst case scenario. The approximate costs of repair garage modifications could be significant depending on the garage configuration and appurtenances, and Fire Department code interpretations.

The scope of work would include developing a California-wide school bus user group with the major school bus vendors. Formation of the user group will allow discussions of NGV performance, operational requirements, and safety standards. The process will enhance the implementation of a continuous improvement design and equipment modifications that will result in NGVs becoming more competitive and cost effective. Through this process, the user group may be able to speed up the commercialization process for NGVs. The user group will also provide complete basic standard turnkey designs, construct engineering drawings, and compile specifications packages for new NGVs stations and modifications to existing CNG stations at school districts. Areas that should be included are plans, flow schematics, fueling curves, and performance specifications, and basic construction specifications.

Potential Air Quality Benefits:
The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. The ARB has also passed standards for medium- and heavy-duty vehicles. NGVs have significantly lower emissions than gasoline vehicles and represent the cleanest internal combustion engine powered vehicles available today. This technical assistance provides the needed resources for the implementation of alternative fuel infrastructure projects and thus their wider and expedited use.

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

Expected SCAQMD Cost: $ 500,000

Expected Total Cost: 500,000

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

This program may include the following:

- Technical review and assessment of technologies, projects, and proposals
- Alternative fuel refueling and EV charging site information support
- Advanced technology curriculum development, mentoring, and outreach to local schools
- Emissions studies and assessments of zero-emission alternatives
- Alternative Fuel Vehicle Lease Program
- Preparation of reports, presentations at conferences, improved public relations and public communications of successful demonstrations of clean technologies
- Participation in and coordination of workshops and various meetings
- Support for training programs related to fleet operation, maintenance, and refueling of alternative fuel vehicles
- Publication of technical papers, reports, and bulletins
- Production and dissemination of information, including web sites

These objectives will be achieved by consulting with industry, scientific, health, medical, and regulatory experts and co-sponsoring related conferences and organizations, resulting in multiple contracts. In addition, an ongoing outreach campaign will be conducted to encourage decision-makers to voluntarily switch to alternatively fueled vehicles, and train operators to purchase, operate and maintain these vehicles, and its associated infrastructure.

Potential Air Quality Benefits:
SCAQMD recently adopted fleet regulations requiring public and private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. Expected benefits of highlighting success stories in the use of advanced alternatively fueled vehicles could potentially expedite the acceptance and commercialization of advanced technologies by operators seeking to comply with the provisions of the recently adopted SCAQMD fleet rules. The resulting future emissions benefits will contribute to the goals of the AQMP.

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

Expected SCAQMD Cost: $ 400,000

Expected Total Cost: 400,000

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

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

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APPENDIX A

SCAQMD Advisory Groups

Technology Advancement Advisory Group

Tom Cackette	California Air Resources Board
Tim Carmichael	Coalition for Clean Air
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
Scott Matthews	California Energy Commission
Dan Moran	Quality Body Works
Gary Stafford	Terra Furniture
Lee Wallace	Sempra Energy
William R. West	Southern California Edison

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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

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APPENDIX B

Open Clean Fuels Contracts as of January 1, 2004

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Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM1: Fuel Cell Technology						
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
03095	Fuel Cell Technologies Ltd.	Pilot Demonstration of Residential Fuel Cell	02/10/03	02/28/06	16,149	1,964,600
03269	University of California Davis	Develop, Demonstrate & Evaluate Truck Fuel Cell Auxiliary Power Unit	05/23/03	03/31/05	300,000	1,200,000
03287	California Air Resources Board	Develop & Demonstrate Integrated Autothermal Cyclic Reformer and PEM Fuel Cell	09/01/02	09/30/05	100,000	800,000
CFM2: Hydrogen Technology and Infrastructure						
02189	ISE Research Corp	Develop & Demonstrate Water Electrolyzer Hydrogen Refueling Station in Coachella Valley	05/23/02	09/30/04	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	10/31/04	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	02/10/03	07/31/04	350,000	1,075,000
03201	University of California, Irvine	Demonstrate & Develop Hydrogen Fueling Stations in Orange County	10/16/03	04/16/06	863,400	983,400
03273	SunLine Services Group, Inc.	Develop Hydrogen Fueling Station Templates	07/01/03	02/28/04	68,554	68,554
04012	Stuart Energy	Install & Demonstrate Electrolyzer-Based Hydrogen Refueling Station Integrated with Stationary Internal Combustion Engine Power Generation Unit	12/05/03	08/05/04	537,000	849,500
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
01137	R.F. Dickson Company, Inc.	Repower Ten & Purchase Four PM10-Efficient CNG Street Sweepers	04/17/01	12/31/06	1,010,000	1,010,000
01160	Waste Management of the Desert	Repower Seven Roll-Off Refuse Trucks LNG	10/03/01	06/30/08	75,221	1,053,094

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Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM3: Engine Technology (Cont'd)						
01178	CalMet Services Inc.	Repower 27 Waste Collection Trucks with CNG	09/19/01	06/30/07	$ 343,000	$ 1,323,000
02218	Cummins Westport, Inc.	Preliminary Vehicle Design Development for NGNGV	06/02/02	06/30/04	297,396	396,528
02269	University of California, Berkeley	Develop & Demonstrate Natural Gas HCCI Engine	12/03/02	05/30/04	300,000	665,900
03289	Cummins Engine Co. Inc.	Develop & Demonstrate Next Generation Natural Gas Vehicle (NGNGV) Engine Technology	07/07/03	08/31/05	999,769	1,999,546
04046	EVO Transportation Corporation	Demonstrate Program to Convert Ten Gasoline-Fueled SUVs to CNG-Fueled ULEVs	12/23/03	07/31/04	100,000	450,000
CFM4: Infrastructure and Fuel Production						
01154	R.F. Dickson Company, Inc.	Cost-Share Installation of CNG Fueling Facility	08/04/01	07/31/06	180,000	180,000
01165	ENRG, Inc. (formerly Pickens Fuel Corp.)	Construct & Operate One LNG & Four CNG Fueling Stations within SCAQMD Basin	05/07/01	03/30/06	288,800	1,577,600
02157	ENRG, Inc. (formerly Pickens Fuel Corp.)	Upgrade Existing CNG Fueling Stations	01/17/02	05/31/04	823,199	1,375,696
02320	USA Pro & Associates	Develop Odorant for Liquefied Natural Gas	08/02/02	02/28/04	123,835	40,888
03099	Sanitation Districts of Los Angeles County	Purchase & Install LNG-L/CNG Fueling Station at Puente Hills Landfill Facility	02/10/03	07/31/08	560,000	560,000
03102	USA Waste of California, Inc.	Purchase & Install LNG-L/CNG Fueling Station at LA Metro Hauling District	06/26/03	06/30/08	400,000	400,000
03103	Waste Management Recycling & Disposal Services	Develop LNG-L/CNG Fueling Station	10/23/03	12/31/08	400,000	400,000
03319	FuelMaker Corporation	Upgrade CNG Fueling Stations at Various School Districts and Municipalities	11/05/03	07/31/04	90,000	180,000
04015	WM Energy Solutions, Inc.	LNG Production at Bradley Landfill	11/06/03	09/30/09	300,000	5,277,000
CFM5: Electric/Hybrid Technologies						
99109	Toyota Motor Corporation	Three-Year Lease of One RAV4 Electric Vehicle	04/04/99	11/22/04	61,895	61,895
00051	Santa Barbara Electric Bus Works Inc.	Develop & Demonstrate an Electric School Bus	11/23/99	06/30/04	100,000	400,000
00105	Avery-Dennison Office Products North America	Purchase Nine Electric Forklifts	06/20/00	03/15/06	10,000	277,452
00107	Harbor Distributing, LLC	Purchase 32 Electric Forklifts	05/16/00	03/15/06	20,000	923,732

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Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFM5: Electric/Hybrid (Cont'd)						
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
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	01/31/04	266,348	532,695
01336	Chroma Systems	Purchase Electric Forklift w/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	12/31/01	03/31/04	47,815	95,694
02326	Electric Power Research Institute	Study for Commercialization of Advanced HEVs	10/18/02	02/28/04	250,000	250,000
03275	University of California, Riverside	Develop & Evaluate Multiple Vehicle Type Expansion of Shared Electric Vehicle System	05/12/03	10/31/04	95,336	522,094
04027	ISE Research Corporation	Develop & Demonstrate Hydrogen-Internal Combustion Engine for Hybrid-Electric Buses	10/29/03	05/31/05	210,000	1,075,000
04032	Electric Power Research Institute	Develop, Demonstrate & Evaluate Plug-In Hybrid Electric Vans in Fleet Use	11/14/03	08/31/05	475,000	1,525,000
CFE1: Emission Control Technology						
01173	National Renewable Energy Laboratory	Demonstrate Fischer-Tropsch Synthetic Fuel in Heavy- & Medium-Duty Vehicles	06/11/01	04/30/04	178,001	737,855
02119	Booz-Allen Hamilton Inc.	Demonstrate Particulate Trap Technologies	12/21/01	02/29/04	489,143	910,000
02292	West Virginia University Research Corporation	Demonstrate Fischer-Tropsch Synthetic Fuel in Heavy-Duty Vehicles	11/01/02	04/30/04	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	726,850	1,670,976
03109	West Virginia University Research Corporation	Aftertreatment Technologies for PM Emissions Control of CNG-Fueled Heavy-Duty Engine	11/07/02	03/31/04	447,042	547,042

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Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFE2: Emission Studies						
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
03468	University of California, Riverside	Reactivity & Availability Studies of VOC Species Found in Architectural Coatings and Mobile Sources	08/01/03	08/01/04	200,000	200,000
03469	West Virginia University Research Corporation	Emissions Testing & Analysis of Dedicated NG and Diesel Solid Waste Collection Vehicles	08/26/03	06/30/04	255,000	255,000
CFH: Health						
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
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
03358	Jurupa Unified School District	Children's Health Study	06/13/03	05/31/06	25,000	25,000
CFS1: Stationary Source 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	12/31/04	95,000	95,000
03287	California Air Resources Board	Develop & Demonstrate Integrated Autothermal Cyclic Reformer and PEM Fuel Cell	09/01/02	09/30/05	100,000	800,000
CFS2: VOC/Toxics Technologies						
03286	California Air Resources Board	Develop & Demonstrate High Performance Low-VOC Waterborne Coatings	10/01/02	07/31/05	20,000	436,872
CFT: Outreach and Technology Transfer						
97110	Burke, Andrew	Review & Assessment of Technical Proposal re: ATTB Ultracapacitor System	06/04/97	08/15/05	15,000	15,000
97113	JME Inc.	Review & Assessment of Technical Proposal re: ATTB Ultracapacitor	05/08/97	08/15/05	15,000	15,000
00069	Walsh Consulting	Technical Assistance Relating to the Use of Alternative Fuels in Mobile Sources	02/17/00	02/28/04	35,000	35,000

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Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFT: Outreach and Technology Transfer (Cont'd)						
00098	Murray Katz	Technical Assistance Pertaining to Fuel Cell Development & Commercialization	02/25/00	02/28/04	$ 20,000	$ 20,000
01104	Seaworthy Systems, Inc.	Evaluate Carl Moyer Marine Vessel Proposals	01/19/01	01/31/04	50,000	50,000
01169	Clean Fuels Connection	Technical & Management Assistance for Carl Moyer, School Bus and ZEV Implementation Programs and Infrastructure Scoping	04/20/01	04/19/04	225,000	225,000
01190	USA Pro & Associates	Technical & Management Assistance for Infrastructure	06/04/01	06/30/04	365,000	365,000
02114	Gladstein & Associates	Outreach Support for Low-Emission Clean Fuel Heavy-Duty Vehicles	02/22/02	02/28/04	250,000	250,000
02158	College of the Desert	Develop Natural Gas School Bus Training Curriculum	11/05/02	11/30/04	233,609	233,609
02240	Cindy Sullivan	Technical Assistance & Expert Consultation	04/11/02	06/30/04	45,000	45,000
02295	SynchroEnergies LLC	Technical Assistance on Lubricants, Fuels, Combustion, Alternative 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	12/31/05	20,000	20,000
02311	Jerald A. Cole	Technical Assistance for Development ,Outreach & Commercialization of H2 Infrastructure and Reforming Technology	08/09/02	06/30/04	30,000	30,000
02316	California Science Center Foundation	Construct & Implement Fuel Cell Exhibit at California Science Center	06/23/03	06/30/04	226,000	325,000
02333	University of California, Riverside	Technical Assistance on Clean Fuels Technology, Hydrogen, Fuel Cell Technology and Natural Gas Technology	11/01/02	06/30/04	30,000	30,000
02334	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance on Natural Gas Engine Technology	07/31/02	06/30/04	65,000	65,000
02335	Neil C. Otto	Technical Assistance on Fuel Cell Technology	08/09/02	06/30/04	30,000	30,000
03181	USA Pro & Associates	Support, Training & Guidance Toward Purchase of New Fleet and On-Board LNG Fueling Systems	11/20/02	10/16/04	50,000	50,000
03203	Palm Springs Desert	Develop & Implement "Blow Out!" Meet the Science Power Standards Education Program	08/01/03	08/30/04	21,907	21,907
03271	Northwest Riverside County Clean Cities Coalition	Co-Sponsor 9th Annual National Clean Cities Conference & Expo	03/19/03	01/31/04	15,000	100,000
03276	Rose Communications Inc.	Technical Assistance for Development, Outreach & Commercialization of Fuel Cells	03/24/03	03/31/04	25,000	25,000

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Contract	Contractor	Project Title	Start Term	End Term	AQMD $	Project Total $
CFT: Outreach and Technology Transfer (Cont'd)						
03424	WestStart-CalStart	Co-Sponsor 4th Annual Heavy-Duty Vehicle Conference	06/26/03	08/31/04	$ 25,000	$ 25,000
03450	Sawyer Associates	Technical Assistance Pertaining to 2003 Revision and Mobile Source Control Sources	06/26/03	11/30/04	15,000	15,000
03451	TIAX LLC	Technical Assistance Pertaining to 2003 Revision and Mobile Source Control Sources	06/23/03	11/30/04	20,000	20,000
03466	Electric Drive Transportation Association (EDTA)	Co-Sponsor 20th International Electric Vehicle Symposium & Expo	06/24/03	05/31/04	25,000	25,000
04040	University of California, Irvine	Co-Sponsor Transition from Fossil Fuels Conference	11/12/03	05/31/04	7,500	100,000
04045	TIAX LLC	Technical Assistance for Development, Outreach & Commercialization of Low-Emission and Alternative Fuel Technologies	11/21/03	12/31/05	30,000	30,000
04048	Cindy Sullivan	Technical Assistance for Emission Control & Alternative Fuel Technologies	11/21/03	12/31/05	30,000	30,000
04049	Engine, Fuel & Emissions Engineering Inc.	Technical Assistance for Alternative Fuels Engine Technology	11/21/03	12/31/05	40,000	40,000
04050	Breakthrough Technologies Institute	Technical Assistance for Fuel Cells	11/21/03	12/31/05	40,000	40,000
04052	USA Pro & Associates	Technical Assistance for Alternative Fuels Infrastructure	12/19/03	12/31/05	40,000	40,000
04053	Marathon Technical Services	Technical Assistance for Alternative Fuels Infrastructure	11/21/03	12/31/05	15,000	15,000

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APPENDIX C

Final Reports for 2003

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AQMD Contract # 02129 *October 2003*

Develop & Demonstrate Fuel Cell Bus With Major Bus Manufacturer

ISE Research Corporation
Thor
ThunderPower.

Cosponsors

South Coast Air Quality Management District
Sacramento Municipal Utility District
Calstart.
US DOT-FTA

Project Officer

Naveen Berry

Background

In this day and age, our society depends heavily on fossil fuels for energy. About 26% of the world's CO_2 emissions from fuel combustion are from an integral part of our everyday lives, transportation. Fuel cell buses hold new promise for cities with air quality problems, as they do not produce any harmful emissions. Fuel cell buses also operate quieter and achieve better fuel efficiency than their internal combustion engine counterparts.

Project Objective

The project objective was to develop and manufacture a fuel cell powered hybrid electric bus, refine and test the bus under a variety of operating conditions, train operators and maintenance technicians on the new technology, and introduce the bus to the public through a public outreach program.

Technology Description

The Thor/ISE fuel cell bus utilizes a hybrid drive system with energy provided by a fuel cell operating on gaseous hydrogen and a set of batteries. The hybrid powertrain allows the use of a much smaller fuel cell as peak power demands are supplied by the batteries. Utilizing a hybrid drive system has the secondary effect of reducing the cost by allowing the use of a substantially smaller fuel cell.

The fuel cell utilized was a 60kW PEM fuel cell manufactured by UTC Fuel Cells. This fuel cell was selected due to its high efficiency and ability to operate at ambient pressure. Hydrogen is stored on the bus in eight 3600 psi tanks produced by Quantum which hold about 26kg of fuel. This is about equivalent to 26 gallons of gasoline, yet provides the bus well over 200 miles in range.

To propel the bus, the ThunderVolt TB30FC drive system utilizes two Siemens 67kW drive motors driving the differential through a combining gearbox. A Siemens Duo inverter powers the motors while a second is used as a DC-DC converter to boost the fuel cell voltage up to that desired by the drive system. The drive system also has independent permanent magnet motors driving an air compressor for braking and a hydraulic pump for steering. Finally, this drive system incorporates ISE's new Remote Diagnostics Unit (RDU), which allows authorizes users to monitor vehicle status and obtain maintenance and operating information in near real time over the internet.

Status

The project was completed on September 1, 2003. The fuel cell bus completed a 6-month demonstration at the SunLine Transit Agency, with three months in daily revenue service. This represented the first extended use of a hybrid fuel cell bus in regular revenue service in the U.S.. After SunLine, the bus concluded a demonstration on the urban inner-city routes of Los Angeles. During the demonstrations the bus was presented at a number of trade shows and special events. The

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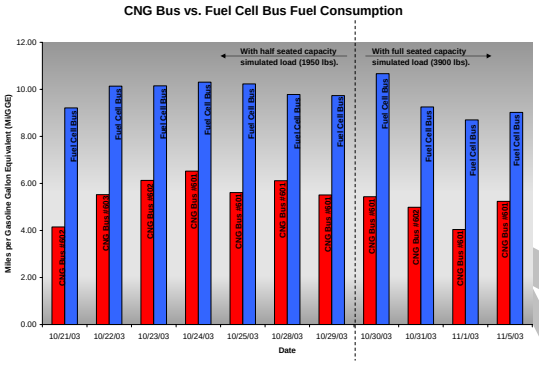
bus was exhibited at several high profile locations, including Las Vegas and Washington, DC, displaying the new technology and offering riders a glimpse of the future in transportation.

Results

Due to the efficiency of the fuel cell and the ISE hybrid drive system, the bus offered an average 110% increase in fuel efficiency over a 30' compressed natural gas (CNG) bus on the SunLine route and an average 160% increase over a CNG bus in fuel efficiency in the stop-and-go traffic of Los Angeles. Reliability of the bus was defined by the availability rate: the percentage of the number of days the bus was in service divided by the total



number of days of service possible. The prototype bus achieved a 76% availability rate while at Sunline and a 96% availability rate while as the Los Angeles Metropolitan Transportation Authority (LAMTA). A chart comparing the fuel efficiency of the fuel cell bus versus a 30' SunLine CNG bus can be found below. This chart was produced by "shadowing" the CNG bus with the fuel cell bus using sand bags as a simulated load.

Benefits

The ThunderPower fuel cell bus produces zero emissions and it does this with a drive system operating at unparalleled efficiency. As shown in the chart above, the ThunderPower bus achieves more than double the economy of conventionally powered buses. No secondary pollutants are produced in the operation of the bus. The bus was primarily fueled by an electrolyser at SunLine Transit and AC Transit to also ensure a source of environmentally clean hydrogen. ISE is also conducting a parallel program to install a wind powered hydrogen station in Palm Desert. This will enable the demonstration of a completely emission free, renewable transportation system. Each new diesel transit bus today produces approximately 2200 lbs of NOx per year. With many thousands of these buses in operation in California, and thousands in the South Coast Basin alone, the potential to reduce emissions is tremendous.

Project Costs

The actual cost of the entire project (Phase 1 & 2) was $2,232,157. Of the $2,232,157 of costs incurred, AQMD provided a funding contribution of $350,000 or about 16%. Overall, ISE Research, Thor and Thunderpower provided $1,214,367 of cost share funds, which represented 54% of the total costs incurred. The project overran the original budget by $75,840, mainly due to the six month schedule delay.

Commercialization and Applications

The ThunderPower fuel cell bus demonstrates the potential for fuel cell buses to achieve unprecedented efficiency with high reliability. The remarkably smooth and quiet operation of the fuel cell bus is appreciated by operators and riders alike. With the performance levels exhibited by the fuel cell bus, operators and riders can also be assured that the bus will be able to keep time on their route. Running on clean, renewable hydrogen, the bus exhausts only water and offers promise to urban cities with air quality problems.

Some major hurdles still need to be overcome before fuel cell vehicles can be become a mass-market reality. Fuel cell cost is one of the chief concerns. While hybridization reduces the system cost while adding efficiency, fuel cell costs will still have to be reduced by an order of magnitude before sizeable orders can be realized. Additionally, long term fuel cell durability still remains to be demonstrated.

Even with these obstacles, the road to fuel cell buses looks very promising. The ThunderPower 30 foot fuel cell bus has inspired strong interest, generating commitments to provide similar 40' fuel cell buses for other transit agencies over the next two years. The ThunderPower fuel cell bus project is testimony to that zero emission transit buses can be built now, that fuel cells offer unparalleled efficiency, that reasonable reliability can be achieved now, and that there is strong interest in these vehicles. The remaining hurdle is increasing the volume of these systems to enable fuel cell producers to lower their cost.

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AQMD Contract # 03272 *May 30, 2003*

Perform Conceptual Design Study of Integrated Hydrogen Energy Station

Contractor

Northern Power Systems

Cosponsors

None

Project Officer

Matt Miyasato

Background

This project began with the vision of the South Coast Air Quality District (SCAQMD) for a hydrogen system at their facility to serve as a demonstration system, provide real world economic and environmental benefits, and to advance the development of this important technology area.

Project Objective

The objectives of this feasibility study were to compile an equipment review including costing, complete a preliminary system design with several performance options, and perform operational modeling including a cost of energy analysis.

Technology Description

The major components in the Base Case are a 340,000 kWh/year (209 kW) photovoltaic (PV) solar array, a 70 kW electrolyser, 141 kg of pressurized hydrogen (H2) storage, a 120 kW H2 internal combustion engine (ICE), a 60 kW fuel cell (FC), and a H2 fuel dispenser. The system can provide 120 kW of back–up power for a demonstration load for a minimum of 4 hours. The hydrogen-fueled generators (ICE and FC) can provide peak shaving to avoid 100 kW of demand charges per month. The system can support six hydrogen-fueled vehicles driving an average of fifty miles per day for four days per week.

Also presented are three options that may be desirable to include with the Base Case in order to enhance system performance. The options are: Premium Power enhancement, addition of reformer for increased hydrogen production, and H2/CNG blend fueling capabilities.

Status

The conceptual design was completed and presented to the AQMD in May 2003. A major concern was the effect the changing electric rate structure would have on the estimated savings for each scenario. Further analyses would need to be conducted to incorporate the new rates into the model, but the reduced rates would also reduce the net savings from the distributed power.

Another issue was the need for fine control and dispatch of the power generation sources to avoid the demand charge increment (15 minute intervals). The control system would rely on historical demand data as well as real-time monitoring to effectively dispatch the genset.

Results

Below are the budgetary estimates that Northern recommends allocating for equipment, engineering, and installation of the Base Case and the various options:

	Range, $	
Base Case	**$3,287,000**	**$4,823,000**
PV Array* (340,000 kWh, 209 kW)	$625,000	$796,000
Integration	$1,850,000	$3,100,000
Hydrogen System**	$637,000	$637,000
Testing	$175,000	$290,000
Options		
Premium Power Option	**$272,000**	**$452,000**
Reformer Option	**$525,000**	**$875,000**
Hythane Fueling Option	**$45,000**	**$110,000**
Additional H2 Storage, 125 kg	**$108,000**	**$132,000**

* After incentives

** Based on Stuart quote

Key Results from the Study:

- The various roofs at the Diamond Bar Facility can accommodate a maximum of 340,000 kWh/yr (209 kW) of PV. Avoided utility charges will be $45,000 - $60,000 per year.
- The energy required for hydrogen production is completely off set by the energy produced from the PV array.

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- The FC/ICE combination can be operated in a peak shaving mode to significantly reduce the cost of energy by eliminating 100 kW – 180 kW of peak demand per month throughout the year.
- Coupled with adequate storage, the electrolyser actually has annual production capacity to support the operation of twelve H2 vehicles, supply the peak shaving and back-up power needs for up to 180 kW of stationary power, **and** supply hydrogen for an 8% H2/CNG blend for the entire fleet of CNG vehicles at the Diamond Bar facility.
- The 60kW PEM fuel cell offered by Hydrogenics is currently the only commercially available product in the size range appropriate for this project.
- Primarily because of product life issues, today's PEM products are best suited for intermittent use and not for base load applications.

Benefits

The benefits from implementing the Base Case are:

- Produce 4.5 % of SCAQMD energy needs from a renewable source.
- 120 kW of back–up power for a demonstration load for a minimum of 4 hours
- Save $27,000 per year of demand charges & $45,000 per year of consumption charges
- Produce 1881 kg of renewable H2 @ $6/kg (considering electricity costs only)
- Support 6 H2-fueled vehicles driving an average of 50 miles per day for 4 days per week
- The electrolyser has capacity to produce enough hydrogen so that the entire fleet of compressed natural gas (CNG) vehicles at Diamond Bar could be run on 4% H2/CNG blend. Several studies have shown that a low percentage H2/CNG blend mixture can actually reduce NOx and CO emissions by 40% - 50% compared to running with pure natural gas.

Project Costs

The total project costs were $42,000.

Commercialization and Applications

This projects demonstrates the following technology application:

- Peak shaving using both a fuel cell and H2 ICE in concert with PV
- Hydrogen as an energy carrier for both power generation and transportation
- A control system allowing operation of all equipment in the highest efficiency and economic modes. It will allow hydrogen generation scenarios to maximize hydrogen production, minimize costs, or maximize renewable production
- Backup or peak shaving power generation using fuel cells and ICE engines
- Incorporating hydrogen and compressed natural gas (CNG)for Hythane® use in current CNG vehicle fleet

This project will be conducted using near-term, available technologies. In the case of the electrolyser, ICE, hydrogen storage and fueling dispenser Stuart Energy Systems has the only commercially available unit. The PV array can be composer of a fully mature and proven technology. The component that has less maturity is the PEM fuel cell as proposed by Hydrogenics. The recommended component of 60 kW is made up of a commercially available 20 kW module. The first 60 kW module will be installed this summer. The control system development and integration while using mature technical components represents a challenge in integration, allowing multiple power generation technologies to be used in multiple modes of operation.

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AQMD Contract # 01225 *December 2003*

Develop Very Low NOx Detroit Diesel Heavy-Duty Natural Gas Engine

Contractor

Detroit Diesel Corporation

Cosponsors

California Air Resources Board
California Energy Commission
AQMD

Project Officer

Michael Bogdanoff

Background

The majority of heavy-duty vehicles in the South Coast Air Basin are powered by diesel engines that contribute significant NOx and particulate matter emissions. With an increasing number of trucks and other heavy-duty vehicles, the need for reducing emissions from these sources is critically important in meeting clean air goals. The AQMD has long recognized the adverse air quality and health impacts of diesel exhaust and has adopted several measures to promote the use of low-emission natural-gas vehicles.

Several heavy-duty engine manufacturers currently offer natural gas engines at NO_x emission levels of 2.5 to 4.0 g/bhp-hr. The ARB has proposed that transit bus engines be certified with NO_x emissions of 0.5 g/bhp-hr in 2004 and 0.2 g/bhp-hr in 2007.

In accordance with these goals, the AQMD released a Request for Proposals (RFP) to develop heavy-duty natural gas engines with NO_x emissions of 0.5 g/bhp-hr. The California Energy Commission (CEC), the California Air Resources Board (CARB), and the National Renewable Energy Laboratory (NREL) participated in the award selection process for this RFP.

Project Objective

Under this solicitation, Detroit Diesel Corporation (DDC) was selected to further develop its Series 50G engine using an Advanced Fuel Control System. The objective of this development work was to produce a 300 bhp, 900 ft-lbs. S50G engine certified to 0.5 g/bhp-hr NOx and ≤ 0.01 g/bhp-hr PM. Additionally, a target was to achieve equivalent or better engine efficiency compared to current production on-road heavy-duty natural gas engines.

Technology Description

The original Detroit Diesel proposal for the Series 50 Gas engine included a new combustion system, new cylinder head, new intake manifold, trimming gaseous injectors, ionization current feedback (misfire detection), auxiliary electronic controller (used for gaseous injector control and misfire detection control) and electronic turbocharger wastegate control.

Due to technical hurdles that were insurmountable within the scope of this program, a number of hardware items were changed. These included itens that were dropped from the original proposal along with new hardware items being added. The hardware items that were retained were the combustion system, cylinder head, intake manifold (improved) and electronic wastegate turbocharger.

Hardware deletions include trimming gaseous injectors, the ionization current feedback system and the auxiliary electronic controller. The trimming gaseous injectors were removed due to their inability to handle LNG. LNG, being a dry gas, does not offer any form of lubrication for the injectors. The ionization current feedback system was removed due to its inability to function on a lean burn combustion system application. Through testing of the prototype system, it was determined that a clear signal was not capable of being produced. The auxiliary electronic controller was removed because it was the controlling unit for the two previous hardware items.

The hardware additions were a humidity sensor and catalytic converter. The humidity sensor was added to allow leaner air-fuel calibration and lower NOx emissions. The oxidation catalytic converter was added for formaldehyde control, and also provided some PM control.

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Results

Emissions

The official test results on the Federal Test Procedure are listed below.

	NOx g/bhp-hr	NMHC g/bhp-hr	PM g/bhp-hr
Testing w/o deterioration	0.851	0.09	0.003
EPA/CARB certification	0.86	0.09	0.01

Performance

The final engine rating is 275 Hp @ 2100 Rpm and 900ft-lbs @ 1200 Rpm. This includes a catalyst (California) and non-catalyst version (49 State). Both of these versions will operate on CNG or LNG.

Heat Rejection

There was a decrease in coolant heat rejection of 2% and an increase of 50% in air heat rejection. The increase in air heat rejection is due to the increase in boost pressure required to run the engine at leaner air/fuel ratios. The increase in heat rejection in the charge air cooler is not an issue for OEM vehicle manufacturers.

Vehicle Performance/Fuel Economy

Improved Series 50 Gas engines were installed in 25 heavy-duty transit coaches. Vehicle acceleration performance improved by 1 to 3 seconds depending on the transit coach power train configuration. In all cases fuel economy remained the same as the previous version of the Series 50 Gas engine.

Benefits

It is estimated that 1000 of the new Series 50 Gas engines will be implemented on buses within the South Coast Air Basin between 2004 and 2007. The emission benefits of this new engine over the previous engine are estimated be 1.3 tons per day NOx.

Project Costs

The project was completed on time and within the cosponsor's budget. A summary of the costs incurred over the course of the project are as follows:

performance improved by 1 to 3 seconds depending on the transit coach power train configuration. In all cases fuel economy remained the same as the previous version of the Series 50 Gas engine.

Benefits

It is estimated that 1000 of the new Series 50 Gas engines will be implemented on buses within the South Coast Air Basin between 2004 and 2007. The emission benefits of this new engine over the previous engine are estimated be 1.3 tons per day NOx.

Project Costs

The project was completed on time and within the cosponsor's budget. A summary of the costs incurred over the course of the project are as follows:

	Actual	*Budget*
Project expenditure	*$3,561,795*	*$3,458,150*
CARB Funding	*$ 100,000*	*100,000*
CEC Funding	*$ 700,000*	*700,000*
AQMD Funding	*$1,030,966*	*1,030,966*
DDC Match Funding	*$1,730,829*	*1,627,184*

Commercialization and Applications

Current Application: Transit Buses

Potential Applications: Refuse Haulers

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AQMD Contract # 02181 *January 2004*

Develop and Demonstrate Nine CNG-Powered Mid-Size School Buses

Contractor

Ford Motor Co.

Cosponsors

Ford Motor Co.
South Coast AQMD
Clean Energy

Project Officer

Naveen Berry

Background

Develop an Alternative Fuel (CNG), Low Floor, Midsize demonstration school bus that is accessible by persons with disabilities, as well as ambulatory passengers. Vehicles of this type have been available for urban paratransit use for some time, but have not been available in the school bus market.

Project Objective

Develop and demonstrate one midsize (30 foot, E-550) school bus and demonstrate two (22 foot, E-450) with a compressed natural gas (CNG) powertrain. The bus should provide wheel chair access, meet ULEV II standards, and meet school district performance characteristics.

Technology Description

Prototype 6.8L V-10 CNG engine

Drop E-550 floor from 28" down to 17"

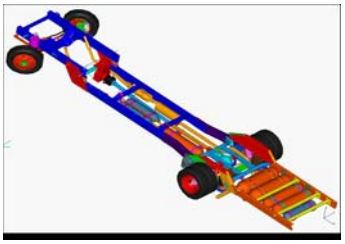
Collins School Bus Body

Kneeling air suspension

Status

This E-550 Low Floor CNG bus project has been completed on Nov. 15 2003. The "Draft" final report is on file with complete technical details of the project. The two smaller (E-450) buses have been delivered to AQMD for additional demonstration and outreach of the natural gas buses

Accomplished Tasks	***Completion date***
- Initial package design	*25-May-02*
- Complete package design	*10-Aug-02*
- Driveline components MRD	*15-Aug-02*
- Emissions tests	*10-Aug-2002*
- In-vehicle calibration	*25-Aug-2002*
- Chassis build completion	*30-Aug-2002*
- Demonstration bus body build and installation (U.S. Bus)	*15-Dec-2002*
- Vehicle commissioning (U.S. Bus)	*5-Dec-2002*
- Low Floor Demonstration bus Milestone review	*17-Dec-2002*
- Performance testing	*17-Jan-2003*
- Performance and Fuel Economy evaluation	*17-Jan-2003*
- Heat management	*17-Jan-2003*
- Drivability and Noise, Vibration, Harshness (NVH) testing	*17-Jan-2003*
- Evaluation / Durability / Mileage accumulation	*23-Jan-2003*
- Transport vehicle to AQMD / Demo period begins	*19-Feb-2003*
- Deliver production E-450 CNG Shuttle Bus	*30-Jun-2003*
- Demonstration period ends	*23-Sept-2003*
- Submit "Draft" Final report	*1-Oct-2003*
- Submit Final report	*TBD*
- Deliver production E-450 CNG School Bus	*15-Nov-2003*



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Results

Demonstration Vehicle Completed and Tested Description/Specifications:

- Chassis: Low Floor Dedicated CNG E-550 Bus
- Engine: 6.8L CNG
- Transmission: 4R100
- Weight class: 19,000 lbs
- Meets California Optional 0.5 g/bhp-hr NOx Standard (Actual → 0.3 g/bhp-hr NOx)

Other Key Emission Results:
CO → 1.44
NMHC → 0.048
NMHC + NOx → 0.35

Preliminary Engine Dyno Testing indicates an overall ULEVII Emission Capability

The achieved engine performance:

Net Peak Power: 248 HP @ 4320 RPM
Net Peak Torque: 244 ft-lb @ 3250 RPM
Max Engine Speed: 5000 RPM

School District evaluation indicates comparable performance to similar diesel buses, with superior ride and handling characteristics. The only limitation was the prototype wheelchair ramp that was too narrow and unreliable.

Benefits

The results of this Demonstration project clearly show that it is feasible from an engineering standpoint to develop a clean, ULEV-II capable, mid size CNG School bus that meets the short turning radius and other key performance characteristics of a midsize school bus, as desired by school districts.

Unfortunately, due to the reasons stated below under "Commercialization and Applications", Ford will not be able to consider possible side-crash testing required for all school buses by the California Highway Patrol nor production of the product.

Project Costs

Description	***Total Cost***
EMISSIONS TEST COMPLETION	*$263,750.00*
COMPLETE PACKAGE DESIGN	*$460,000.00*
DRIVELINE COMPONENT MRD	*$130,000.00*
IN VEHICLE CALIBRATION COMPLETION	*$60,000.00*
CHASSIS BUILD COMPLETION	*$185,000.00*
E-550 DEMO UNIT BODY BUILD	*$35,618.00*
VERIFY BUS PERFORMANCE TWO E-450 PRODUCTION UNITS	*$151,000.00*
E-550 DEMO PROJECT COMPLETION	*$50,000.00*
TOTAL:	***$1,335,368.00***

Commercialization and Applications

Ford Motor Company decided to discontinue of the E-550 base vehicle platform.

The decision made by Ford Motor Company to discontinue the E-550 base vehicle platform had no impact on our ability to complete the deliverables outlined in Contract No. 02181. However, it will result in our not being able to support any future low floor/CNG projects, and/or consideration of possible production programs, using the E-550 platform.

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AQMD Contract # 02219 *November 2003*

Develop Technologies for Next Generation Natural Gas Vehicle Class 306 CNG Engines

Contractor

Cummins Westport Inc.
EmeraChem LLC.

Cosponsors

California Energy Commission
South Coast AQMD

Project Officer

Michael Bogdanoff

Background

The majority of heavy-duty vehicles in the South Coast Air Basin are powered by diesel engines that contribute significant NOx and particulate matter emissions. With an increasing number of trucks and other heavy-duty vehicles, the need for reducing emissions from these sources is critically important in meeting clean air goals. The AQMD has long recognized the adverse air quality and health impacts of diesel exhaust and has adopted several measures to promote the use of low-emission natural-gas vehicles.

The U.S. Department of Energy's Office of Heavy Duty Vehicle Technologies and the National Renewable Energy Laboratory initiated a program called the Next Generation Natural Gas Vehicle (NGNGV). The NGNGV program sponsors the development of heavy-duty natural-gas vehicles.

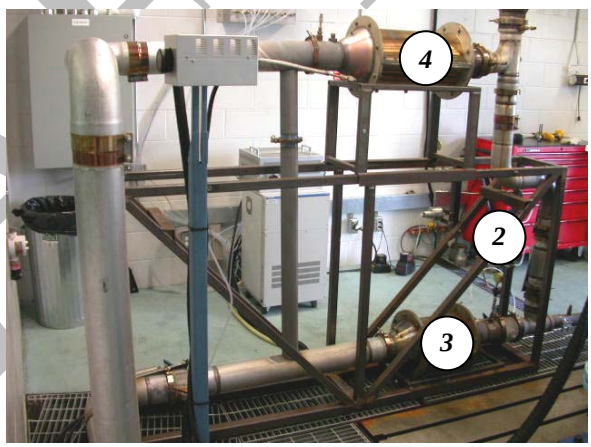
Project Objective

As part of the NGNGV program, the goal was to demonstrate 0.5 grams per brake-horsepower-hour (g/bhp-hr) NOx and 0.01 g/bhp-hr PM emissions from a lean-burn spark-ignition natura- gas engine. This would be achieved by reduction of in-cylinder NOx formation followed by conversion of NOx in an exhaust aftertreatment system. The program reviewed the potential of this approach and others to reduce NOx emissions toward 0.2 g/bhp-hr, improve full load performance, and increase overall system efficiency.

Technology Description

Targeting 0.5 g/bhp-hr NOx emissions

The 5.9 liter Cummins Westport B Gas Plus engine was developed to meet 1.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM engine-out emissions. A NOx Storage and Reduction (NSR) system with by-pass flow during regeneration was identified as the emission control system best suited to achieve the program NOx targets. NSR systems work by first storing NOx in the catalyst. Once the NSR catalyst capacity is reached, it is regenerated by generating suitable conditions in the exhaust to release and reduce the NOx to nitrogen. In this case, the reformation of natural gas within the exhaust flow was developed as a novel method to regenerate the NSR catalysts.



The final prototype NSR emission control system hardware shown under test above included:

1. *Single bed NSR system with a by-pass route,*
2. *Two by-pass flow control valves,*
3. *14 liters of reformer catalysts, and*
4. *21 liters of NSR catalyst.*

The system components are identified by number in the picture above. Regeneration strategies were developed to work over the entire engine operating range.

Targeting 0.2 g/bhp-hr NOx emissions

Available technologies were screened in order to produce a manageable number of combinations. Three combustion types with appropriate emission controls were considered with three transmission types, as shown in the table below. Baseline vehicle simulation models were built and validated against published data and the nine selected system combinations compared. The systems were assessed on

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economical merit for transit bus and delivery van applications

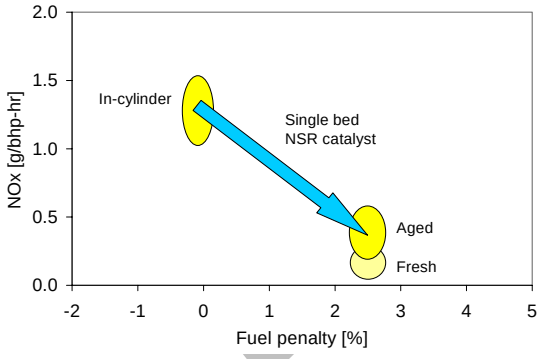
Combustion Type	+	*Aftertreatment*	*Transmission Options*
Lean-Burn SI (Spark Ignition)	+	NOx Storage & Reduction	Conventional
Stoichiometric SI with EGR	+	Three Way Catalyst	Continuously Variable Transmission
Direct Injection with Hot Surface Ignition	+	Selective Catalytic Reduction	Hybrid Electric Vehicle

Status

A prototype NSR system was commissioned in a test cell in November, 2002. Based on lessons learned while working with the prototype system, refinements were made. The modified system was optimized and demonstrated by the end of July, 2003. All work was completed to schedule and on budget. The final report is on file with complete technical details.

Results

The target of the program was to develop a system capable of delivering an aged composite NOx value of 0.5 g/bhp-hr over the AVL 8 mode cycle. An AVL 8 Mode composite 0.15 g/bhp-hr NOx level was demonstrated. Total hydrocarbon emissions were essentially unchanged and the fuel consumption increased by 2.5%.



NOx emissions of 0.15 g/bhp-hr were demonstrated with catalysts aged 60 hours; upon aging the same catalysts an additional 50 hours, the NOx system out increased to 0.30 g/bhp-hr. Although natural gas is an ultra-low-sulfur fuel, high temperature desulphations are required causing deterioration in NSR catalyst performance. Deterioration factor estimates indicate that the single bed system NOx levels should stabilize at approximately 0.6g/bhp-hr.

Benefits

It is estimated that around 1300 Cummins Westport lean-burn SI engines will be implemented within the South Coast Air Basin between 2004 and 2007. In total, the installation of the single bed NSR system would reduce the NOx emissions by two thirds or 2,264 tons over a 10-year lifetime. The average amortized cost of the NSR system is estimated as $14,864, giving a NOx cost effectiveness of $8,700 per ton. As the NSR technology matures the cost may be reduced, further increasing cost effectiveness.

Project Costs

The project was completed on time and within budget. A summary of the costs incurred over the course of the project are as follows:

	Actual	*Budget*
Project expenditure	$718,208	$707,000
CEC Funding	$374,174	374,174
SCAQMD Funding	$52,816	52,816
Match Funding	$318,208	307,000

Commercialization and Applications

Targeting 0.5 g/bhp-hr NOx emissions

The commercialization of the NSR system for heavy-duty applications is somewhat dependant on improving the catalyst durability. Further development such as control strategies for transient operation, system packaging and complexity reduction is also required.

Targeting 0.2 g/bhp-hr NOx emissions

The stoichiometric SI with EGR and a three-way catalyst in combination is best suited to meet the 0.2 g/bhp-hr NOx targets for transit bus and delivery van applications. Given a longer timeframe for development, the direct injection of natural gas with hot surface ignition (HSI) and SCR is competitive with the stoichiometric SI option. The benefits of the HSI system include increased part load efficiency, the potential to achieve higher BMEP, improved efficiency and reduced Green House Gas (GHG) emissions.

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AQMD Cntract # 02156 *o* *November 2003*

Upgrade Existing CNG Refueling Stations

Contractor

Southern California Gas Company.

Cosponsors

None

Project Officer

Larry Watkins

Background

The existing CNG fueling infrastructure network is established strategically at several locations within the South Coast Air Basin to provide fueling for natural gas vehicles, and to meet the needs of public and private fleet operators in the areas of their operations. SoCalGas (Contractor) submitted a proposal to upgrade ten (10) existing CNG fueling stations to further enhance public access.

Project Objective

The objective of this project was to, install new fuel dispensers, card readers, training videos, credit card fuel transaction controllers and a host database. The upgrade of the equipment has significantly enhanced the ability of users to successfully fuel their vehicles. This upgrade, has given users the choice of six credit cards for fueling at each station, compared to the single option, which they had before. In the past, users had to apply for a fueling card from the Gas Company to fuel at Company facilities. The process generally took five days before the user received their fueling card and was able to fuel. The current system allows the user to immediately access the system once they have one of the following credit cards: MasterCard, Visa, American Express, Discover, Wright Express or Voyager.

Technology Description

The existing dispensers were replaced with newer ones which have more updated technology. This newer technology provides an Info Screen which allows customers to be trained electronically onsite by viewing a training video which is built into the dispenser. The improvement also allows all major credit cards and the Voyager and Wright Express fleet cards to be used to receive fuel. This new system provides greater reliability and provides instant access to NGV fueling by means of a major credit card or a fleet card. This new installation utilizes technology, which allowed the dispenser and card reader to be a single unit instead of separate units as before.

Status

The project was completed on August 8, 2003 with all ten of the site upgraded with new Greenfield dispensers and Multiforce credit card controller and training display. The project encountered several difficulties. The credit card control and training video display were developed specifically for this project and the natural Gas fueling industry for the first time.

The development encountered many setbacks in the beta testing, therefore, installation had to be delayed, and a project extension was requested and received for the project. Project installation went smoothly after, even though there were several Multiforce software problems, which prevented customers from receiving gas at times, early after the initial installations.

Several software upgrades had to be done to correct problems as customers first tried to use the system. The Multiforce company was very responsive to the problems and resolved them very quickly. Today the system is operating problem free, and customers are finding it easier to use the new equipment, compared to the previous system. A final draft report was submitted on August 27, 2003, and no comments were received from the AQMD.

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Greenfield NGV Dispenser/Card Reader

Results

The installation of these new dispensers/card readers have resulted in more user friendly equipment, and as a result, a wider acceptance of NGVs. By accepting major credit cards, these dispensers allow users to carry fewer cards for fueling. Prior to the installation of these dispensers, customers had to carry several fueling cards to make sure that they could get gas at different fuel suppliers. Now, the customer only needs to have a major credit card to get gas. This new equipment also eliminates the need for scheduled training. Customers now show up at the fueling dispenser, and insert their credit card, and if they have never used the system before, the system will allow them to watch a 90 seconds video for training. Gains were also achieved in terms of greater reliability and performance of equipment. There were no trade offs because of installation of the new equipment.

Benefits

The results achieved above have translated into benefits such as greater potential emissions reduction from more users because of a more reliable and user-friendly system. This new system of dispenser and credit card acceptance will allow more fuel service providers to install public access natural gas fueling stations, because obstacles such as billing of customers would be solved by using major credit cards. With credit card usage, fuel service providers do not have to set up billing systems. The billing, and risk-taking, are done by the credit card companies.

Project Costs

Total actual project cost exceeded the original projections. The original project cost was estimated at $64,128 per site for a total of $641,280 for all ten sites. The AQMD proposed funding level was 70% at $44,890 per site.The final total cost for all stations was $905,210 for equipment and installation. The final funding by the AQMD is $44.890 per site, a 50% funding level.

Cost Per Site:

Item	***Estimated Cost ($)***	***Actual Cost***	***AQMD Share***
Dispenser/ Cardreader	*45,234*	*56,742*	
Multiforce Controller	*0*	*10,260*	
Shipping	*255*	*1,216*	
Tax	*3,639*	*5,527*	
Design	*0*	*7,350*	
Installation	*15,000*	*10,642*	
Total	***64,128***	***90,521***	***44,890***

Commercialization and Applications

The applicable technology can be used widely throughout the natural gas vehicle industry. The technology can also be used in different alternative fuel application wherever credit card billing and training identification is required. The training identification and authorization of credit cards can also be installed off site at car dealers if it is so desired. Natural gas vehicle users can be trained at the car dealer immediately after they purchase, rather than have to wait until they visit the fueling station. The card once assigned a pin can be used at any other alternative fueling station which recognizes the card and the pin.

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AQMD Contract No. 03102 *July 30, 2003*

Purchase & Install LNG-L/CNG Refueling System at LA Metro Hauling District

Contractor:
Waste Management – L.A. Metro

Sponsor:
South Coast Air Quality Management District

Project Officer:

Larry Watkins

Background:

Waste Management has started the process of replacing the older diesel powered collection trucks in our fleet located in Long Beach with low emission trucks powered by LNG. LNG fueling infrastructure was not previously available in Long Beach.

Project Objective:

Waste Management submitted a proposal for construction and operation of an LNG station in response to RFP No. 2002-19 on December 4, 2001. AQMD Contract No. 03102 provided Carl Moyer funding in the amount of $400,000.00. That station was completed on October 20, 2002 and is in operation. Waste Management's fleet of 22 new Mack collection trucks with Mack E7G 325HP LNG engines refuel at the station daily.

Project Description:

The new LNG station has a storage capacity of 16,000 LNG gallons, which permits the efficient delivery of a full tanker load of fuel. The station now has a single dispenser but Waste Management will add a second dispenser if needed.

Status:

The project was completed on October 20, 2002 and a final report has been submitted to the SCAQMD.

LNG Fuel Station and Storage Tank

Results:

The station was completed on October 20, 2002 and has operated satisfactorily since completion. Fuel usage is currently about 40,000 gallons per month. This throughput will increase significantly as Waste Management continues the replacement of older diesel trucks with LNG powered vehicles and as other refuse or industrial fleets in the area choose to refuel at this station.

LNG Station Control Panel and Dispenser

Costs:

Waste Management's original estimate of costs associated with this project was $600,000.00. The actual completed cost including construction, excavation, design, permitting and other related cost was $541,725.91. This savings resulted from Waste Management's contracting with North Star, Inc. for the construction of a series of LNG stations.

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AQMD Contract #03232 *December 30, 2003*

Develop & Demonstrate Advanced Home Refueling Appliance for CNG Vehicles

Contractor

FuelMaker Corporation

Cosponsors

Technology Partnerships Canada
California Air Resources Board

Project Officer

Gary Dixon

Background

Natural Gas Vehicles (NGVs) represent some of the cleanest vehicles available. Despite their 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. Availability of a safe and cost effective standardized home refueling appliance for compressed natural gas (CNG) is 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 from a 110 volt electric outlet,
- commercializing the in-home refueling system with an expected cost of under $1,000, and an intended life equal to or longer than the vehicle's.

Technology Description

The overall project consists of two phases with the duration of 18 months for each phase. The goal of Phase A, which was completed in 2002, was to develop and produce a working Alpha-unit prototype. Phase B upgraded and refined the Alpha unit into a Beta unit prototype that is being used in the final product commercialization.

Some of the features of this device are:

- 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 refueling to be done overnight when the vehicle is not in use.

Status

Over 30 Beta prototypes have been assembled and are being tested both in FuelMaker test cells, at Honda R&D in California, and at field test sites. The individual component status is as follows:

Compression Module and Controls Module - The design is complete -- all components have been tested for functionality and performance.

Electronics Module – The design of the electronics is nearly complete – final adjustments are being made to achieve the EMI (Electromagnetic Interference) profiles required by certification standards in North America and Europe.

Dryer - The second generation single column regenerative Dryer design was prototyped and its functionality verified (dries and regenerates within specifications).

Housing Design - Considerable effort is being expended to incorporate a larger cooling air fan and optimize the air flow providing better cooling and longer life for the Compression Module.

Field test certification has been provided by the CSA to permit field testing in the USA and Canada. Full certification testing will be completed in 2004.

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FuelMaker has completed an FMEA (Failure Modes and Effects Analysis) and is using it as a tool in confirming the safety of the design. A DOE sponsored safety study is nearing completion by TIAX. It includes Fault Tree Analysis and simulation of worst case leakage scenarios (though not yet complete, it is apparent that the technology has an inherent high level of safety).

Results

Over 30 Beta prototypes have been built and are currently being tested – 4 are shown in the picture above, undergoing durability testing. The prototypes demonstrate that the project objectives and design specifications for the HRA have been met. The next steps will be the full commercialization of the product.

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.

Benefits

The AQMD 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 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. 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 developed and demonstrated the Advanced Home Refueling Appliance for CNG Vehicles in two phases. Initial development and limited testing was conducted in the first phase; more extensive prototype testing was carried out in the second phase. For the two phases, DOE allocated $100,000; ARB allocated $250,000, for the first phase and $50,000 for the second phase; and Technology Partners Canada (TPC) provided $375,000 in each of the 2 phases. AQMD funding was $500,000 for each phase. Total project cost is $2,150,000 for both phases.

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, during the last quarter of 2004, following the completion of the Beta Testing Phase.

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AQMD Contract # 00020 *Date of Publication-July 2003*

Demonstrate Electric Vehicle Rental Program

Contractor

EV Rental Cars, LLC

Cosponsors

California Air Resources Board
CALSTART
City of Burbank
Los Angeles Dept. of Water & Power

Project Officer

Lisa Mirisola

Background

According to the AQMP, a significant portion of the basin's emissions inventory is attributed to on-road mobile sources. The AQMD, through its Clean Fuels Program, seeks to develop, demonstrate and commercialize zero- and low-emission technologies in the transportation sector to meet federal and state air quality standards. The successful commercialization of electric vehicles and the ultimate satisfaction of end users is an important part of this program. In order to accomplish this, visibility and convenient availability of these vehicles are necessary. An electric vehicle rental program is a positive outreach tool to achieve these goals.

Project Objective

The Electric Vehicle Demonstration is intended to stimulate the market for electric vehicles by creating a commercial enterprise that purchases EVs and provides first-hand experience at low risk to prospective EV owners. It demonstrates the viability and practicality of EVs as a personal vehicle and as a commercial industry.

Technology Description

Electric Vehicles are classified as zero emission vehicles (ZEV) and are superior for clean air over conventional vehicles because ZEVs have no tailpipe exhaust, no evaporative emissions from fuel systems, no emissions from refining of fuel and distribution of fuel to service stations, no emission control systems that can degrade or fail with time-for example, a conventional vehicle in failure mode puts out more emissions in two weeks than a ZEV will in 100,000 miles. Even when taking into account power plant emissions, ZEVs will be 95% cleaner than even the lowest emitting conventional vehicle. The electric vehicles in EV Rental Cars fleet included the General Motors EV-1, Toyota RAV-4 EV, Nissan Altra EV, Ford Ranger EV, Honda EV Plus, and GEM.

Status

The project was completed in June 2003 and the final report is on file with complete technical details of the project. The EV Rental Demonstration was subject to an availability constraint. The automakers did not have electric vehicles available for delivery. As the electric vehicles become available, they were added to the fleet. The lack of availability only enabled EV to lease an additional 31 out of 39 electric vehicles for its fleet. However, in addition to these electric vehicles, EV Rental Cars is operating 10 GEM neighborhood electric vehicles at Playa Vista in Los Angeles. These electric vehicles demonstrate non-polluting advanced mobility solutions for a planned community.

Due to the delay in obtaining additional electric vehicles, EV Rental Cars has also purchased natural gas and electric hybrid vehicles so that it may achieve its goal of providing zero and super low emission vehicles to its customers. These vehicles are now being rented at the same locations as the electric vehicles. EV Rental Cars is continuing to operate as the only rental car company solely devoted to environmental vehicles.

Results

The Electrical Vehicle Demonstration met its stated purpose and advanced its goal by directly reducing mobile emissions while also developing the market for electric and other environmental vehicles.

The Demonstration directly substituted miles traveled in gasoline-only-powered cars with miles traveled in clean fuel cars.

The success of EV Rental Cars is pioneering a new market for environmental vehicles and

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proving to consumers that the cars are a practical solution for personal use.

For two reasons, EV Rental Cars is widely regarded as one of the best marketing programs in the world for alternative fuel vehicles. First, its customers test-drive the vehicles in real world application, proving that the technology is a viable option for their personal use. Second, working with Budget Rent a Car staff, EV Rental Cars pitches the values of environmental cars to Budget's tens of thousands of renters monthly.

Some corporate accounts and travel agents are working directly with EV Rental Cars, including the State of California and American Lung Association. The management also regularly makes presentations at trade shows and conferences.

Benefits

EV Rental Cars has prevented more than 30 tons of air pollution by renting to more than 45,000 consumers and accumulating more than 8.5 million miles on its environmental fleet. In the process, it has left 330,000 gallons of gasoline unused that would have been guzzled by conventional vehicles.

Already, the company's customers have saved more than $500,000 in fuel costs by acting environmentally.

Project Costs

The total in-cash project costs of the program including AQMD's funding contribution were in line with the original projections of $552,000. EV Rental Cars and all the cosponsors made contributions to the demonstration.

Commercialization and Applications

EV Rental Cars is still the only environmental vehicle rental car company in the United States and will continue to lead the rental car industry by offering vehicles with environment friendly high-technology drive trains. In addition to reducing emissions, its rental vehicles achieve the benefits of lower fuel cost and environmental corporate social responsibility.

The auto rental market is a perfect outlet for automakers to market their vehicles and reduce the risk of introducing new technologies. Competition is fierce in the industry, but EV Rental Cars has established a unique niche in which it can successfully compete

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AQMD Contract # 01111 *April 2003*

DEVELOP & DEMONSTRATE COMMERCIAL PROTOTYPE ADVANCED VALVE-REGULATED LEAD-ACID BATTERIES

Contractor

Trojan Battery Company

Cosponsors

Trojan Battery Company

Project Officer

Lisa Mirisola

Background

The advanced lead acid battery proposed for use in electric and hybrid electric vehicles is a totally maintenance free design using the valve regulated lead acid battery (VRLA) technology. The strong economic advantage in using advanced lead acid batteries in these applications is that these batteries can be manufactured using existing commercial battery manufacturing equipment , without the need for substantial capital investment. A full recycling infrastructure is also in place for lead acid batteries.

For EV and hybrid EV applications, the challenges are in maximizing lead acid battery performance to increase the specific energy i.e. vehicle range. In an earlier ALABC co-funded program, Trojan Battery Company and ENSCI Inc. had demonstrated the unique use of additives to improve specific energy, capacity and cycle life of a 2V VRLA cell. The increase in specific energy and overall capacity was achieved through the use of additives incorporated in the active material of the battery plates.

Project Objective

The objective of this project was to build and demonstrate performance in 12V battery modules using the additives evaluated earlier in 2V cells. The planned approach was to build commercial prototype 12V battery modules using plates incorporating the different additives and demonstrate performance of these modules individually and as part of full scale electric vehicle battery packs.

Technology Description

Separate additives were proposed for evaluation in the positive and negative plates. In a VRLA battery, improvement in porosity of the positive active material allows for increased acid availability and enhanced positive active material utilization. The porosity additives evaluated in the positive paste were the ES-60 (inorganic based, primarily silica) and the ES-100 (organic, porous polypropylene particles, less than 125 microns).

In VRLA batteries, the negative plates can be effected by metallic impurities, resulting inperformance degradation (i.e. increased self discharge rate, hydrogen evolution, poor oxygen recombination and increased water loss). The use of ES-A4 metal control additive (which irreversibly bind trace metal contaminants like antimony, and iron) had been found to be beneficial in earlier studies and this was incorporated into the evaluation test matrix. The effect of this additive in negative plates was evaluated both by itself and also in conjunction with the ES-60 porosity additive.

Status

Test Plan

The test plan called for the assembly of a full matrix of batteries with plates incorporating multiple additive formulations with initial testing at the 12V module level and continuing through battery pack assembly and testing along with post mortem analysis. Utilizing the services of the National Renewable Energy Laboratory, the plan called for analyzing battery modules and battery packs for thermal management and performance during cycling tests simulating electric vehicle operation.

Plates containing different additive combinations would be thoroughly characterized using X-Ray diffraction analysis, scanning electron microscopy, surface area and porosity measurement techniques. These plates would be assembled into 12V battery modules and fully characterized at the module level. This series of

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tests would include initial capacity and constant power testing, along with life tests leading into USABC electric vehicle duty cycle simulation testing and the determination of peak power and specific energy at the module level under these test regimes.

Based on initial module level tests with the performance enhancing additives, 12V battery configurations demonstrating a minimum 15% improvement over base line designs would be identified. These modules would be incorporated in full size electric vehicle packs for characterization of performance in a large battery pack configuration on static tests. These enhanced performance battery packs would then be demonstrated in real life electric vehicle application.

Battery Build

A total of approximately 24,000 positive and negative grids were made using high purity proprietary Trojan lead tin calcium alloys. The grids were controlled to uniform thickness to ensure uniform compression in the VRLA assembled battery. The positive and negative grids from these controlled batches were used for pasting plates containing the different porosity enhancing additives. Following curing and drying, these plates were processed through our dry charge process and plate samples were again analyzed to verify that the lead dioxide and free lead levels met Trojan specifications and to measure the porosity levels in the formed active material. Measurable porosity difference was found between formed plates with the additives as compared to the control plates.

Using these plates, a total of one hundred and eleven batteries were built, 56 batteries in the VRLA gel configuration and 55 batteries in the VRLA AGM configuration.

Results

Based on 12V battery level testing, use of the porosity additive in positive plates yielded an improvement in positive paste utilization of 10% in both the gel and AGM batteries. With a combination of the porosity additive ES-100 in the positive and the metal control additive ESA-4 in the negative plates, active material utilization was improved 14% in gel batteries and up to 20% in AGM batteries, in early cycling.

Batteries were shipped to NREL for thermal characterization. However, since the batteries had not been cycled to peak capacity, testing was discontinued by NREL after the first 12 cycles, due to equipment limitations. Testing at Trojan Battery Company was discontinued from March 2002 due to changes in personnel and business strategy realignment.

Conclusions

Although lead acid batteries are still lower cost than other battery chemistries, decreasing cost, longer life and increasing reliability of other battery chemistries have lead to a shift by automakers to NiMH and increasingly LiIon chemistries in light duty automotive products. Lead acid technology still dominates products where weight and packaging are minor issues and low initial cost is the driving factor such as in electric forklifts where weight provides a counterbalance benefit for heavy lifting.

Project Costs

The total project cost was $197,590 as shown:

Trojan Battery Company	$109,931
South Coast AQMD	87,659

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AQMD Contract #02155 *December 2003*

Develop & Evaluate a Tri-Fuel, Plug-in Hybrid Electric Vehicle with Vehicle-to-Grid Power Flow

Contractor

AC Propulsion, Inc.

Cosponsors

CARB/ICAT
Volkswagen of America
SCAQMD
NREL.

Project Officer

Lisa Mirisola

Background

Zero emission vehicles operate without tailpipe and refueling emissions, but they have not yet been commercialized. Battery powered ZEVs have limited range, and fuel cell ZEVs are still in development. Plug-in hybrid vehicles connect to the power grid while parked so they can operate on batteries for local driving and then use a low-emission petroleum-fueled engine for longer trips. This distinguishes them in a fundamental way from the plugless hybrid vehicles currently produced by automakers which rely 100% on gasoline. The low emission capabilities of ULEV and SULEV automobile engines means that the onboard hybrid generator can generate electricity with very low emissions. The plug-in hybrid can reduce emissions three ways, zero-emission driving, elimination of cold starts, and clean generation of electricity. The plug-in hybrid can reduce petroleum consumption by substituting grid electricity for petroleum.

Project Objective

The project objective was to build, develop, and demonstrate a grid-connected hybrid vehicle with more than 30 mile all-electric range, unconstrained highway range, bi-directional power interface, clean stationary generation using gasoline or natural gas fuel, and commercial potential based on driving performance and desirable features.

Technology Description

A battery and electric drive system allows the hybrid vehicle to operate on battery energy only. Battery-only performance provides easy cruising at freeway speeds. The range on one charge is 35 miles. Charging during the day, daily range of 70 or more miles is possible. The variable-rate charger can plug in anywhere and can charge the battery in less than one hour. The charger can operate in reverse and send power from the vehicle back into the grid or to stand-alone loads. The reverse power flow can be controlled remotely. When grid-connected, the charger senses the presence of the grid and shuts off immediately upon loss of grid.

A gasoline-fueled generator (APU) mounted in the rear of the vehicle delivers DC electricity directly to the battery. When turned on, the APU operates automatically to keep the battery charged allowing sustained cruising at speed up to 80 mph indefinitely except for gas stops. The APU operates at SULEV emission levels. When the car is parked, it can generate electricity with low emissions using either gasoline or natural gas.

Status

Project work was completed November 19, 2003. A Final Report including complete technical details and test results was submitted December 17, 2003. The vehicle was driven as a hybrid for the first time in March, 2003 and made a round-trip from Los Angeles to Sacramento that month. In September, 2003, the project vehicle competed in the 2003 Michelin Challenge Bibendum and received trophies in the acceleration, braking, and emissions

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categories. It has now accumulated more than 7000 miles as a hybrid.

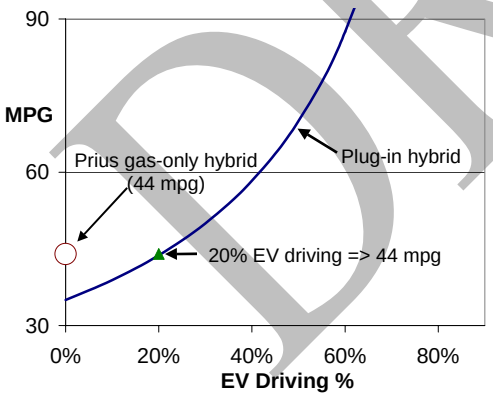
Results

The project vehicle achieves objectives for operating functions, energy consumption, and emissions.

Performance and Emissions Comparison.

Performance	**Project Vehicle**	***Jetta base***	
0-60 mph secs	*8.7*	*12.0*	
Top Speed mph	*85*	*110*	
MPG city/hiway	*27/34*	*23/29*	
Miles elec/gaso	*35/500*	*0/450*	
Stationary Emissions gm/kWh	***NMHC***	***CO***	***NOx***
Project APU	*0.003*	*0.232*	*0.048*
Capstone	*0.078*	*0.603*	*0.223*
CA gen. avg.	*na*	*na*	*0.23*
CA DG std 2003	*0.45*	*2.7*	*0.23*
CA DG std 2007	*0.009*	*0.045*	*0.03*

By substituting electricity for petroleum, the plug-in hybrid can use significantly less gasoline than plugless hybrids even though the plugless hybrid achieves higher fuel economy.



Vehicle weight increased by about 700 pounds as a result of the conversion.

Benefits

The project vehicle demonstrates the potential to operate at SULEV levels and reduce emissions below those from SULEVs by reducing the number of cold starts significantly. Also, by substituting electricity for gasoline, gasoline refueling emissions are reduced. The fuel substitution is also an effective means of reducing petroleum consumption, a stated goal of US energy policy. The overall air quality and global warming benefits depend on the source of electricity. Plug-in cars can make good use of wind energy which often peaks at night. Over the longer term, plug-in cars can provide grid support functions by interacting with the grid. The project car can generate electricity with lower emissions than other small generators, and so can help to minimize emissions related to the growth of distributed energy resources over the next decade.

The benefits anticipated for this project have been realized in the demonstration vehicle. As important, is that the vehicle provides desirable performance and features that are necessary for successful commercialization.

Project Costs

The project was completed on budget. AQMD contributed $180,000 of the $755,000 project budget total. Other funding was provided by the CARB ICAT program ($230,000), Volkswagen of America ($225,000), NREL ($40,000), and AC Propulsion's cost share ($80,000).

Commercialization and Applications

Comparisons with the Toyota Prius suggest that a plug-in hybrid with the features of the project car need not cost more than a plugless hybrid. Battery improvements would allow increased EV range and improved packaging, allowing for restoration of storage capacity. The plug-in hybrid concept also applies to fuel cells, and replacing the ICE in the project car with a fuel cell would demonstrate how hybridization can reduce cost and increase efficiency of the fuel cell installation.

Over the coming decade, the sources and uses of energy in cars will assume increasing importance in vehicle powertrain design. Among alternatives that offer equivalent emissions performance, those that reduce petroleum consumption and offer efficient use of other energy sources will gain both regulatory support and market acceptance.

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AQMD Contract # 01209 *Date of Publication: October 2003*

Study of Children's Pollutant Exposures During School Bus Commutes

Contractor

College of Engineering-Center for Environmental Research and Technology, University of California, Riverside

Cosponsors

California Air Resources Board
U.S. Environmental Protection Agency

Project Officer

Jean Ospital

Background

Because children's lungs are still developing and children are more susceptible to adverse health effects from air pollution, potentially high pollutant exposures during school bus commutes are of concern. Studies of pollutant concentrations inside vehicles show high exposures are typical, but few studies have attempted to characterize concentrations on-board and near school buses.

Project Objective

The primary object was to determine the range of children's exposures to air pollutants during their bus commutes, with an emphasis on determining the specific factors and conditions leading to high exposures and comparing the effects of different bus and fuel types.

Technology Description

Real-time and integrated measurements of pollutant concentrations were conducted in the spring of 2002 in instrumented buses while driving school bus routes in Los Angeles (LA) with five conventional diesel school buses, manufactured from 1975 to 1993, a 1998 diesel bus outfitted with a particulate trap, and a 2002 bus powered by natural gas.

Status

This project was completed and the final report is available as an ARB document released in October 2003. The report can be downloaded from the following location:

http://www.arb.ca.gov/research/schoolbus/schoolbus.htm

Measurements were made during 24 bus commutes on a Los Angeles Unified School District bus route from South Central Los Angeles to the west side of LA, with additional runs on a second urban route, a rural/suburban route, and to test the effect of window position..

Interior of an instrumented bus

Results

Bus stop and bus loading/unloading activities were shown to make small contributions to overall commute-related exposures due to the low concentrations found there and the short lengths of time involved in those activities. Exposure factors calculated were as much as two orders of magnitude higher for bus commutes on urban routes than for the bus stop or loading/unloading microenvironments.

Overall, children's school bus commutes in Los Angeles appear to expose them to significantly higher concentrations of vehicle-related pollutants than ambient air concentrations and frequently higher concentrations than those measured on roadways.

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Self-pollution from the bus's own exhaust was found to play a significant role in on-board bus concentrations, especially when windows were closed, as was demonstrated by on-board measurements of an inert tracer gas, SF_6, added to each bus's exhaust. Older buses showed higher rates of exhaust intrusion, but intrusion was detected in all buses. With closed windows, mean concentrations of diesel vehicle-related pollutants such as black carbon and particle-bound PAHs on board conventional diesel buses were more than double the mean concentrations with windows open.

Under closed window conditions, diesel vehicle-related pollutants were also significantly higher on-board the conventional diesel buses as compared to the single CNG-powered bus, while the trap-equipped bus had concentrations between the two (although diesel-related pollutant concentrations on board this specific trap-outfitted bus appeared to be higher than expected based on emissions data reported for other trap-equipped diesel vehicles). In contrast, natural gas-related pollutants such as formaldehyde were higher aboard the CNG bus.

With closed windows, concentrations were also somewhat higher in the rear of the bus, but front/rear differences were generally smaller than the bus-to-bus concentration differences. When windows were open, the resulting high ventilation rates appeared to strongly reduce the amount of self-pollution, while the influence of following individual vehicles became more pronounced, and high transient concentrations of diesel vehicle-related pollutants were associated with proximity to other diesel vehicles.

On-board concentrations were also strongly influenced by other traffic sources. The table presents the mean pollutant concentrations by run type for the urban and rural/suburban routes, under open and closed window conditions. Both window position and surrounding traffic density can be seen to have strongly affected on-board concentrations for vehicle-related pollutants, but for pollutants with a strong background component, such as $PM_{2.5}$ and fine particle counts (0.3-0.5 µm), differences between routes and differences due to window position were less distinct.

Benefits

Measurements made on-board school buses in Los Angeles indicated higher exposures are occurring during children's commutes than ambient air concentrations would indicate. These exposures resulted primarily from the commute itself, and not from loading, unloading, or waiting at bus stops. Minimizing commute times, using the cleanest buses for the longest bus routes, and reducing bus "caravanning" and unnecessary idling time would reduce children's exposures to bus-related pollutants.

Pollutant	Urban Route[1]				Rural/Suburban	
	Windows Closed (a.m.)[2]		Windows Open (p.m.)[2]		Windows Open (p.m.)[2]	
	Mean	Range of Means	Mean	Range of Means	Mean	Range of Means
Black Carbon (µg/m³)	10	2.5 – 19	5.2	2.9 – 9.1	2.7	0.9 – 4.8
PM-bound PAH (ng/m³)	198	64 – 400	96	33 – 147	36	14 – 66
NO_2 (ppb)	64	34 – 110	73	39 – 120	45	23 – 68
Formaldehyde (µg/m³)	2.1	0.89 – 4.8	1.1	0.55 – 2.1	0.93	0.34 – 2.0
Particle Counts (#/cm³)	113	51 – 235	96	19 – 276	159	29 – 253
Carbon Monoxide (ppm)	5.1	3.7 – 6.4	2.4	1.9 – 2.9	na[3]	na[3]

[1] Includes commutes on urban route one only.
[2] Windows closed in morning and open in afternoon.
[3] No measurements conducted.

Project Costs

The overall cost of the project was $580,169, the amount originally projected. The AQMD's contribution was $58,992.

Commercialization and Applications

Additional research on methods to reduce self-pollution would be desirable. Such a study would cost approximately $300,000.

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