

# Technology Advancement Office Clean Fuels Program

## Technology Advancement Plan 2003 Update



# South Coast Air Quality Management District

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## EXECUTIVE SUMMARY

This document represents a plan of action for the South Coast Air Quality Management District (SCAQMD) Clean Fuels Program for 2003. It is a formal plan designed to complement the Clean Fuels Program Annual Report which is required by state law to be adopted by the SCAQMD Governing Board. This update of the Technology Advancement Plan for 2003 (2003 Plan Update) focuses on potential projects for research, development, demonstration, and commercialization of clean fuels technologies and advanced technologies that reduce emissions and help meet the clean air goals of the SCAQMD. This is a planning document, and potential projects represent staff's evaluation of the likelihood of advancing certain new technologies at this point. Each individual project or program will be further developed with further details and funding requests and proposed to the Governing Board for approval. For 2003, there are 11 technical program categories:

- Fuel Cell Technology
- Hydrogen Technology and Infrastructure
- Engine Technology
- Emission Control Technology
- Infrastructure and Fuel Production
- Electric/Hybrid Technologies
- Stationary Clean Fuel Technology
- VOC/Toxics
- Emission Studies
- Outreach and Technology Transfer
- Health Effects

A key area of support for the Clean Fuels Program is the SCAQMD alternative fuels incentives program. The key areas of the Clean Fuels Program and the alternative fuels incentives programs are summarized below.

### **Alternative Fuels Incentives Program**

The California Legislature and Governor have recognized the environmental and societal benefits of the Carl Moyer Memorial Air Quality Standards Attainment Program and have continued funding for a fifth year. In addition, voters passed Proposition 40 in March 2002 to provide another \$50 million statewide to the Carl Moyer Program (20 percent of the funding will be devoted to cleaner school buses). SCAQMD will be administering incentive funds for the replacement of diesel-fueled on- and off- road vehicles including refuse haulers, heavy-duty trucks, transit and school buses, construction equipment, marine and port applications and other vehicles and equipment. New engines, re-powers and retrofits are allowed within the program. This program also helps to commercialize alternative fuel technologies in the real world, addressing a key goal of the AQMP for emission reductions. The Clean Fuels Program will provide matching funds that are required to implement this program at the local level.

As mentioned above, 20 percent of the Carl Moyer Program funds will support the replacement of older diesel-fueled school buses in California. In addition, for 2003, the SCAQMD Governing Board Chairman has proposed that 70 percent of the penalty fees and violation fines be devoted to replacing older diesel school buses with new low-emitting alternative fueled school buses. The health impacts posed by older highly polluting diesel school buses have been well recognized in recent times. This program is designed to support the replacement of older diesel school buses with newer alternative-fueled buses, in addition to support received from other incentives programs. It is necessary for

matching funds to be provided from the Clean Fuels Program to implement the school bus replacement incentive program locally.

### **Engine Technology and Emission Control Technology**

Major emission reductions are required in this area, particularly from heavy-duty vehicles. There are currently 13 open contracts in the area of alternative fuel engine technology development and another six contracts related to emission control technologies. The SCAQMD has initiated projects for the development of heavy-duty natural gas engines that will emit less than 0.5 g/bhp-hr NO<sub>x</sub> and the demonstration of natural gas engines in various vehicle (chassis) platforms to expand the current commercial applications of natural gas engines. Continued efforts will focus on the development of the Next Generation of Natural Gas Vehicles, lower-NO<sub>x</sub> emitting heavy-duty natural gas engines, as well as development and demonstration of alternative fuel school buses and other heavy-duty vehicles. Additionally, plans to demonstrate near-zero and zero-emission technology for idling heavy-duty trucks and trailers are included.

The SCAQMD plans to evaluate various off-road technologies in 2003. Some of these include demonstration of low- and zero-emission locomotives, low-emission alternative fuel off-road engines using technology developed for on-road engines, including retrofit equipment. Another area of focus will be the use of gas-to-liquid fuels, emulsified fuels, bio-diesel, and low-sulfur diesel fuels in construction equipment and other off-road uses. Demonstration of particulate control technologies is a high priority area. The plan also includes projects pertaining to low-emission marine engines, including hybrid-electric technology.

### **Infrastructure and Fuel Production**

In 2002, SCAQMD funded the expansion of compressed natural gas (CNG) and liquefied natural gas (LNG) refueling sites throughout the South Coast Air Basin (Basin), and studies on compressors, meters, and home dispensing and liquefaction equipment. Plans to conduct additional studies to enhance the liquefied natural gas manufacturing, distribution, and detection technologies are contained in this update. Another area of focus will be to develop best practices that can lead to standardization and modularization, as well as develop templates for the design and installation of alternative fuel refueling stations to ensure that natural gas stations continue to operate at a high quality level of service. As part of this effort, work on Codes and Standards development is also proposed.

### **Fuel Cell Technology**

The SCAQMD has cosponsored the development and demonstration of several fuel cell vehicles. One such project is a 30-foot fuel cell hybrid-electric midsize transit bus that will be operated at a local transit agency and fueled by hydrogen generated from a solar- and wind-powered electrolyzer. SCAQMD plans to expand the demonstration of fuel cell vehicles in other conventional and non-conventional fleets. The plan also proposes to co-sponsor studies to develop more realistic demonstration specifications for fuel cell transit buses, specifically to evaluate realistic operational availability, training, on site service, and warranty issues.

### **Hydrogen Technology and Infrastructure**

As part of the overall effort towards zero-emission vehicles, staff will be evaluating potential projects related to the development of hydrogen fueled internal combustion engines for transit buses and the continued development of approaches to increase the hydrogen fuel supply necessary to meet future development of hydrogen and fuel cell vehicles. Natural gas refueling stations that are also capable of refueling hydrogen will be studied. Literature studies on possible station configurations and templates for natural gas and hydrogen refueling stations are contemplated, as well as demonstrating compatible equipment for handling higher pressures. This plan includes development and demonstra-

tion of distributed hydrogen production and refueling stations for fleet and commercial uses, as well as home refueling appliances. Furthermore, the plan includes additional work on cosponsoring studies for certifying hydrogen components and subsystems, as well as the personnel involved in the installation, operation, and maintenance of hydrogen systems. Lastly, the SCAQMD will be seeking partnerships between hydrogen fuel producers and fuel cell vehicle manufacturers to demonstrate vehicles in various locations throughout the Basin.

### **Electric and Hybrid Electric Technologies**

There are currently 16 open contracts in the area of Electric and Hybrid Electric Technologies, including demonstration of light-duty and heavy-duty electric and hybrid-electric vehicles, as well as refinement of charging technologies and advanced energy storage systems. For 2003, the SCAQMD will continue the development and demonstration programs, with focus on a variety of fleets, including transit buses and heavy-duty trucks. There will also be continued focus on advanced energy storage devices such as ultra-capacitors, lithium-technology, and high-speed flywheel battery applications. There are also proposals to upgrade hybrid-electric development and demonstration projects with current, better-performing components resulting in enhanced reliability and lower emissions, as well as plug-in recharging capability.

### **Stationary Clean Fuel Technology and VOC/Toxics**

In 2002, the SCAQMD continued its funding of projects for the use of microturbines for stationary power generation. In 2003, TAO plans to support this effort in assembling and demonstrating portable microturbine technology that utilizes natural gas or propane. Potential demonstration projects include the installation of microturbines at landfill sites using landfill gas as feedstock for the microturbine. Another distributed generation project of interest will be the demonstration of a hybrid fuel cell/microturbine power plant that could provide electricity at much higher efficiencies than conventional generator systems. Another area of focus will be the development and demonstration of emulsified fuel technology for portable power generators.

The 2003 Plan Update also includes projects focusing on technology assessments of future VOC limits in various SCAQMD rules, as well as additional development and demonstration of near-zero or zero-VOC technologies for solvents, coatings, and adhesives.

### **Health Effects and Emissions Studies**

As part of the Chairman's initiatives to form a consortium on asthma research and to further medical research on air pollution related brain cancer, the 2003 Plan Update contains project proposals to examine the potential health impacts from toxic emissions and ultra-fine particles. In addition, proposed studies include the comparison of in-use emission levels from engines powered by various fuels.

# **1. SCAQMD Clean Fuels Program**

## **1.1 Introduction**

This document represents an update of the formal plan required by Health and Safety Code (H&SC) 40448.5.1(a)(1). The South Coast Air Quality Management District (SCAQMD) Governing Board adopted the initial submittal of the plan required by this legislation on March 8, 1996. This initial submittal included background information on the SCAQMD's Technology Advancement Office (TAO) and Clean Fuels Program to provide a basis for the plan. Specifically, the initial plan included the sections describing: (1) background, legislative history, and funding sources; (2) general criteria and methodology used to select specific projects; and (3) proposed projects expected to be funded, including descriptions of expected costs and benefits.

This update to the Technology Advancement Plan for the Clean Fuels Program focuses on proposed projects expected to be funded during calendar year 2003 and subsequent years. The background of the program and project selection criteria and methodologies has not changed over the last few years and, thus, are not repeated in this document. That information is still valid and is included herein by reference. As noted in the initial submittal, this plan will continue to be updated periodically to be as responsive as possible to technological advances and the dynamics of a cost-shared public-private partnership.

## **1.1 Overview**

This document serves to update the original plan for the Clean Fuels Program, which cosponsors the development and demonstration of low- and zero-emission clean fuel technologies. This public-private partnership has enabled the SCAQMD to leverage its public funds with outside investment, attracting, on average, about \$4 from outside sources for every dollar contributed by the SCAQMD to fund these technology demonstration projects.

Revenues from several sources support the SCAQMD's Technology Advancement Program. The principal revenue source is the Clean Fuels Program, which, under H&SC 40448.5 and Vehicle Code 9250.11, establishes mechanisms to collect revenues from mobile and stationary sources to support the program's objectives, albeit with constraints on the use of the funds. The objective of this program is to support and promote projects to increase the utilization of clean-burning alternative fuels and related technologies, such as natural gas, methanol, fuel cells, liquid petroleum gas, combination fuels, synthetic fuels, electricity including electric vehicles, hydrogen, and other clean-burning fuels 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 this Clean Fuels Program are imposed on the largest stationary source facilities within the SCAQMD to support related stationary source clean fuel technology developments.

Technology advancement efforts are also supported by grants and cost-sharing revenue contracts from various government agencies such as the California Air Resources Board (CARB), California Energy Commission (CEC), Environmental Protection Agency (EPA), and United States Department of Energy (DOE), on a project specific basis. Another potential source to fund the development and demonstration of advanced clean air technologies is the Advanced Technology Fund. This fund was established primarily as a trust fund for revenues received as a result of fines, penalties, and settlements from air pollution violations. Although not required by legislation, but in an attempt for completeness, the proposed Update to the Technology Advancement Plan includes some projects that may be funded by revenue sources other than the Clean Fuels Program. For example, there are several proposed projects that address the development of technologies that would reduce VOC and PM

emissions from various stationary source applications, including spray booths, coating operations, and solvent cleaning.

The estimated project contract budget available for the SCAQMD Technology Advancement Office programs for the CY 2003 is summarized below:

Clean Fuels Fund balance as of Dec. 31, 2002	\$ 34,271,295
Program Commitments (committed for projects already)	(24,142,657)
Available Balance for New Projects as of Jan. 1, 2003	10,128,638
2003 Clean Fuels Program Revenues Expected (includes \$11,200,000 from motor vehicle registrations and \$400,000 from stationary sources)	11,600,000
Advanced Technology Fund Balance (Fund 17)	188,000
<hr/>	
Total Expected Funds for Projects in 2003	\$ 21,916,638

The Clean Fuels Fund does not expire at the end of fiscal or calendar years and is carried over into the future. This plan includes a number of proposed projects, not all of which are expected to be funded in the current year given the project budget noted above. The projects included reflect the areas identified in Technology Advancement's planning process, along with coordination activities involving outside organizations. The proposed projects are in varying states of development, which may affect the timing of potential co-funding by the SCAQMD. Projects not funded in 2003 may be considered for funding in subsequent years.

Some of the factors that affect the selection and timing of projects include:

- Air quality needs in specific areas -- the urgency for emission reductions in specific categories of the overall plan for attainment of clean air standards and public health protection;
- Future prospects for commercialization or deployment for environmental benefits;
- Maturity of the proposed technology -- the stage of development that the technology has reached, e.g., theory, laboratory, pilot scale, prototype, etc.;
- Availability of prospective contractors with experience in the proposed technology and capabilities to complete a development and demonstration project; and
- Availability of sufficient cost sharing to complete the proposed project and the status of commitments by cosponsors.

## 1.2 Clean Fuel Program Review

In 1990, the SCAQMD initiated an annual review by an external panel of experts. That external review process continues and 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 membership is listed in Appendix A, serves:

- to coordinate the SCAQMD program with related local, state, and national activities;
- to review and assess the overall direction of the program; and
- to identify new project areas and cost-sharing opportunities, including technologies to reduce VOC emissions from stationary and area sources.

A second advisory group was formed in response to requirements specified in Senate Bill (SB) 98 (Alarcon), signed into state law June 8, 1999, that amended and extended the Clean Fuels Program until January 1, 2005. SB 98 specified an advisory group 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 Clean Fuels Advisory Group are listed in Appendix B.

The review process of the Clean Fuel Program now includes several periodic meetings of the two Advisory Groups, the Technology Committee of the SCAQMD Board, public hearing of plans and reports before the SCAQMD Governing Board, and submittal of annual reports to the State Legislature.

### **1.3 Summary of Technical Priorities**

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

Not all project areas will be funded given the funding constraints and the availability of suitable projects. The top priority technical areas identified below are clearly appropriate within the context of the current air quality challenges and opportunities for technology advancement. Within these areas there is significant opportunity for SCAQMD to leverage its funds with other funding to expedite the implementation of cleaner alternative technologies in the Basin.

#### **1.3.1 Incentive Programs**

Incentive programs encourage the immediate use of commercially available, low emission on-road and off-road alternative fuel engines to replace high-polluting diesel engines and to reduce the resulting toxic exposures. In CY 2002, the SCAQMD provided \$531,000 from its Clean Fuels Fund to the State Lower-Emission School Bus Program to purchase alternative fuel school buses as its required local match funding. As for the Carl Moyer Program, the guidelines allow SCAQMD qualified projects to be used as the required local match contribution. The required local match funding was \$3.5 million and was provided from qualified infrastructure projects funded in 2001. In CY 2003, additional Clean Fuels funds may be used as local match funding for some of the Incentive programs as required by the specific program's guidelines. Participation in ARB ZEV Incentive Program does not require matching funds; however additional local funds may be instrumental in placing these vehicles within SCAQMD.

The incentive programs are needed to encourage use of the cleanest technologies sooner rather than later, and establish an early market penetration that would provide manufacturers justification to gear up for mass production. Projects that will be considered for funding will include the expansion of the alternative fuel infrastructure and increased alternative vehicle deployments. It is important to note

that these matching funds from the Clean Fuels Program serve to assist in commercialization of alternate fuel vehicles, which is a goal of the SCAQMD Clean Fuels Program.

### **1.3.2 Fuel Cell Technology**

Fuel cells are emerging as a leading alternative technology to replace more polluting internal combustion engines in vehicle, marine, and stationary distributed energy applications. There are a handful of different fuel cell technologies and fuels being considered for these applications. On the mobile side, the first demonstration vehicles are using proton exchange membrane (PEM) fuel cells and compressed hydrogen as the fuel, but the long-term infrastructure requirements, stack durability, and any synergistic relationship to stationary applications remain uncertain. Considerable research, development, and demonstration efforts are already underway to address these issues by some of the largest automobile manufacturers and fuel suppliers. Yet much work is needed to improve the performance and range of these vehicles, reduce costs, develop a viable fueling infrastructure, and obtain public acceptance for a new technology in everyday applications. On the stationary side, many of the same technology issues exist and can be potentially easier to address due to constant load applications and larger space availability for the stack and balance of plant. It is hoped that cross-cutting advances in the technology can then be transferred and applied to mobile applications or used in concert with mobile and stationary applications, e.g., a fuel-cell vehicle to grid power.

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

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

### **1.3.3 Hydrogen Technology and Infrastructure**

In 2002, the SCAQMD initiated the groundwork for a distributed hydrogen refueling network to allow the limited number of demonstration fuel cell vehicles unhindered access throughout the Basin and reduce the number of obstacles to commercialization of further fuel cell vehicles. Despite the selection of hydrogen as the current fuel of choice for the demonstration vehicles, there are various production, storage, and dispensing strategies still under consideration for the long-term infrastructure solution. As a result, further development of these refueling technologies is planned.

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

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

#### **1.3.4 Engine Technology**

The use of alternative fuels can provide significant reductions in NO<sub>x</sub> and PM emissions. The replacement and further control of heavy-duty diesel engine emissions for on-road, off-road, and marine applications is an important area for the 2003 Technology Advancement Plan Update. Natural gas engines have shown significant promise, with the greatest benefit coming from heavy-duty diesel truck and bus replacement with new natural gas vehicles in urban areas. Hybrid electric technologies and the use of microturbines instead of internal combustion engines have also shown promise for replacing higher polluting diesel engines. All of these options are worth pursuing for cleaner engine technologies and immediate emission reductions.

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

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

#### **1.3.5 Emissions Control Technologies**

Although engine technology research is required to reduce the emissions at the combustion source, post-combustion cleanup methods are also needed to address the current installed base of on-road and off-road technologies. Existing diesel emissions can be greatly reduced with after-treatment controls such as Particulate Matter Traps (P-Traps) and catalysts, as well as lowering the sulfur content or using additives with diesel fuel. Gas-to-Liquid (GTL) fuels, formed from natural gas or other gas rather than petroleum feedstock, and emulsified diesel provide low-emission fuels for use in diesel engines. And as emissions from engines become lower and lower, the lubricant contributions to VOC and PM emissions become increasingly important. The most promising of these technologies will be considered for funding, specifically:

- Development and demonstration of advanced air pollution control equipment;

- Evaluation and demonstration of new emerging liquid fuels, including ultra-low sulfur diesel and Gas-to-Liquid fuels;
- Evaluation and demonstration of emulsified diesel fuels;
- Development and demonstration of advanced after-treatment technologies for mobile applications (including particulate traps and catalysts); and
- Development and demonstration of low VOC and PM lubricants for diesel and natural gas engines.

### **1.3.6 Infrastructure and Fuel Production**

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

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

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

### **1.3.7 Electric and Hybrid Technologies**

Despite the fact that Ford ended sale of its *Th!nk* electric vehicle (EV) unit in September 2002 and in January 2003 Toyota announced that they are discontinuing the RAV4 EV, the state continues to offer buy-down incentives for electric vehicles and the SCAQMD started a program announcement for the buy-down of zero-emission vehicles to fleets. Despite this effort and the greater environmental benefits offered by battery EVs, widespread demand and deployment have been hampered by public concerns over cost, battery lifetime, travel range, and charging station infrastructure. The SCAQMD will continue to consider projects addressing these concerns as well as the use of battery EVs in fleet or niche applications.

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

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

### **1.3.8 Stationary and VOC/Toxics Technologies**

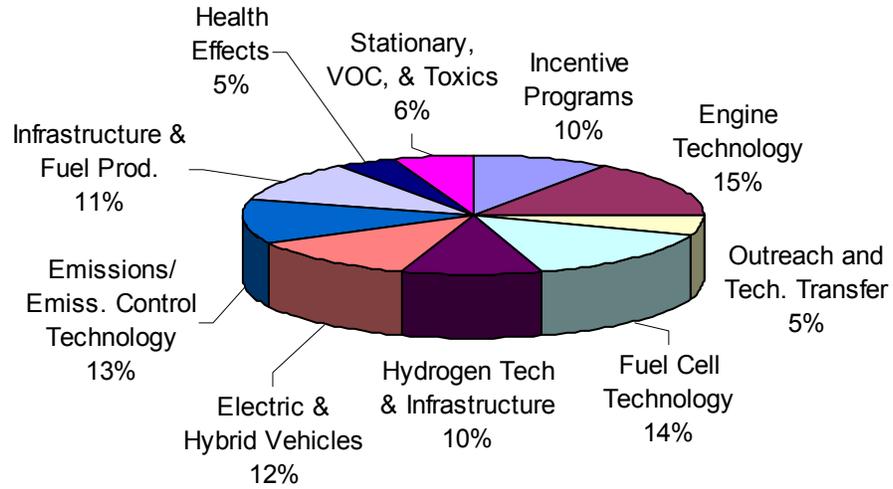
Although progress is being made in the development and commercialization of zero-volatile organic compound (VOC) products and processes, the Draft 2003 Air Quality Management Plan (AQMD) revision identifies further need for VOC and PM emission reductions to achieve the federal clean air standards by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

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

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

### **1.4 Target Project Allocations**

Figure 1 presents the potential distribution of SCAQMD Clean Fuels funds, based on SCAQMD projected program cost of \$ 31.1 million for all potential project areas shown in Table 1. The expected actual project expenditures for 2003 will be much less than the total SCAQMD projected program cost since not all projects will materialize. The target allocations are based on balancing technology priorities, technical challenges and opportunities discussed previously, and near-term versus long-term benefits with the constraints on available SCAQMD funding. Specific contract awards throughout 2003 will be based on this proposed allocation, the quality of proposals received and evaluation of projects against standardized criteria, and, ultimately, SCAQMD Governing Board approval.



**Figure 1: Projected Cost Distribution for Potential Projects in 2003 (\$31.1 million)**

## 2. PROGRAM PLAN

This section presents the Clean Fuels Program Plan Update for 2003, based on the best available information. The proposed projects are organized by program areas and described in further detail, consistent with the SCAQMD budget and priorities. Although not required, this plan also includes proposed projects that may be funded by revenue sources other than the Clean Fuels Program.

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 Section 2 contains the following information for each of the potential projects summarized in Table 1:

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

**Table 1. Summary of Potential Projects in Plan**

Number and Name of Proposed Project	Expected SCAQMD Cost	Expected Total Cost
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**CFM1: Incentive Programs**

2003 CFM1-1, Clean Fuels Program Match for Vehicle and Infrastructure Incentive Programs	\$1,000,000	\$4,000,000
2003 CFM1-2, Infrastructure Incentive Awards for Schools, Including Maintenance Facilities	\$2,000,000	\$11,500,000
Subtotal	\$3,000,000	\$15,500,000

**CFM2: Fuel Cell Technology**

2003 CFM2-1, Demonstrate of Fuel Cell Vehicles	\$1,400,000	\$5,600,000
2003 CFM2-2, Develop Plug-in Fuel Cell Vehicle with Vehicle to Grid Power	\$500,000	\$1,500,000
2003 CFM2-3, Develop and Demonstrate MicroTurbine-Fuel Cell Hybrid Technologies	\$200,000	\$800,000
2003 CFM2-4, Demonstrate Stationary Fuel Cells for Residential, Commercial, and Industrial Applications	\$2,500,000	\$5,000,000
2003 CFM2-5, Develop and Demonstrate Fuel Cells for Marine Vessels	\$100,000	\$1,000,000
Subtotal	\$4,700,000	\$13,900,000

**CFM3: Hydrogen Technology and Infrastructure**

2003 CFM3-1, Demonstrate Integrated Hydrogen Production and Power Facility	\$1,000,000	\$4,000,000
2003 CFM3-2, Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations	\$1,500,000	\$4,000,000
2003 CFM3-3, Demonstrate Hydrogen-Internal Combustion Engine Transit Bus	\$500,000	\$1,000,000
Subtotal	\$3,000,000	\$9,000,000

**CFM4: Engine Technology**

2003 CFM4-1, Demonstrate Twin-Speed Marine Engines	\$250,000	\$500,000
2003 CFM4-2, Develop and Demonstrate Next Generation Natural Gas Vehicles	\$1,000,000	\$3,000,000
2003 CFM4-3, Develop and Demonstrate Advanced Alternative Fuel Heavy Duty and Medium Duty Engines and Vehicles	\$1,500,000	\$3,000,000
2003 CFM4-4, Evaluate and Demonstrate Medium- and Heavy-Duty Alternative Fuel Microturbine Vehicles	\$500,000	\$1,000,000
2003 CFM4-5, Demonstrate Low- and Zero-Emission Locomotives	\$1,000,000	\$4,000,000
Subtotal	\$4,850,000	\$11,500,000

Number and Name of Proposed Project	Expected SCAQMD Cost	Expected Total Cost
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**CFM5: Infrastructure and Fuel Production**

2003 CFM5-1, Demonstrate Solution to Hot Gas Issue Using LNG Blending	\$300,000	\$600,000
2003 CFM5-2, Manual for Designing, Permitting, and Constructing CNG Fueling Facility	\$200,000	\$200,000
2003 CFM5-3, Development and Demonstration of Advanced Natural Gas Systems for Refueling Stations	\$1,000,000	\$4,000,000
2003 CFM5-4, Liquefied Natural Gas Manufacturing and Distribution Technologies	\$1,800,000	\$22,000,000
Subtotal	\$3,300,000	\$26,800,000

**CFM6: Electric and Hybrid Electric Technologies**

2003 CFM6-1, Demonstrate Plug-In Hybrid Electric Vehicle with Vehicle-to-Grid Power	\$150,000	\$500,000
2003 CFM6-2, Develop and Demonstrate Electric Vehicle Charging Equipment	\$200,000	\$300,000
2003 CFM6-3, Develop and Demonstrate Light and Medium Duty Hybrid Electric Vehicles and Systems	\$750,000	\$5,000,000
2003 CFM6-5, Demonstrate Alternative Energy Storage Systems	\$700,000	\$1,400,000
2003 CFM6-6, Evaluate and Demonstrate Hybrid Heavy-Duty Electric Vehicles	\$1,000,000	\$10,000,000
2003 CFM6-7, Upgrade and Demonstrate Hybrid Electric Vehicles	\$250,000	\$2,000,000
2003 CFM6-8, Develop and Demonstrate High-Capacity, Alternate Fueled Hybrid Electric Transit Buses	\$750,000	\$5,000,000
Subtotal	\$3,800,000	\$24,200,000

**CFE1: Emission Control Technology**

2003 CFE1-1, Develop and Demonstrate Advanced Aftertreatment Technologies for Liquid Fuels	\$800,000	\$2,600,000
2003 CFE1-2, Demonstrate Advanced Alternative Liquid Fuels in Heavy-Duty Off-Road Equipment	\$1,200,000	\$2,600,000
2003 CFE1-3, Develop and Demonstrate Advanced Aftertreatment Technologies for Natural Gas Emissions	\$800,000	\$1,600,000
2003 CFM3-4, Develop and Test Low-VOC and PM Lubricants for Natural Gas Engines	\$200,000	\$500,000
2003 CFM3-5, Demonstrate NO <sub>x</sub> and PM Control Technologies for Marine Vessels	\$250,000	\$500,000
Subtotal	\$3,250,000	\$7,600,000

Number and Name of Proposed Project	Expected SCAQMD Cost	Expected Total Cost
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**CFE2: Emissions**

2003 CFE2-1, Comparative Emissions of Heavy Duty Alternative Fuel and Conventional Fuel Engines	\$500,000	\$1,000,000
Subtotal	\$500,000	\$1,000,000

**CFH: Health Impact Analyses**

2003 CFH-1, Evaluate Ultrafine Particle Health Effects	\$1,000,000	\$2,000,000
2003 CFH-2, Evaluate Health Impacts from Toxic Emissions	\$300,000	\$600,000
2003 CFH-3, Benefits of Emissions Reductions	\$100,000	\$310,000
Subtotal	\$1,400,000	\$2,910,000

**CFS1: Stationary Source Clean Fuel Technology**

2003 CFS1-1, Development and Demonstration of a Portable Low Emission LPG ICE Generator	\$100,000	\$200,000
2003 CFS1-2, Demonstration of Emulsified Diesel Fuel Use in Portable Generators	\$50,000	\$100,000
2003 CFS1-3, Demonstration of Landfill Gas to Electricity Microturbine	\$250,000	\$500,000
2003 CFS1-4, Development and Demonstration of Low-Emission Refinery Flares	\$100,000	\$200,000
2003 CFS1-5, Develop and Demonstrate Renewable-Based Alternatives	\$300,000	\$1,000,000
Subtotal	\$800,000	\$2,000,000

**CFS2: VOC and Toxics Technologies**

2003 CFS2-1, Technology Assessments of future VOC limits in SCAQMD VOC Rules	\$250,000	\$250,000
2003 CFS2-2, Develop and Demonstrate Near-Zero/Zero-VOC Products	\$500,000	\$500,000
2003 CFS2-3, Evaluate, Develop, and Demonstrate Advanced VOC Control Technologies for Miscellaneous Stationary Sources	\$200,000	\$200,000
Subtotal	\$950,000	\$950,000

Number and Name of Proposed Project	Expected SCAQMD Cost	Expected Total Cost
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**CFT: Outreach and Technology Transfer**

2003 CFT-1, Technical Assistance in Assembling SAE Standards for LNG Fueling and Dispensing	\$150,000	\$150,000
2003 CFT-2, Technical Assistance in LNG Fueling for Transit Properties	\$200,000	\$200,000
2003 CFT-3, Technical Assistance for Schools Maintenance Facilities	\$300,000	\$300,000
2003 CFT-4, Assessment and Technical Support of Advanced Technologies and Information Dissemination	\$500,000	\$500,000
2003 CFT-5, Support for Implementation of Various Clean Fuels Vehicle Incentive Programs	\$400,000	\$400,000
Subtotal	\$1,550,000	\$1,550,000

<b>TOTALS FOR POTENTIAL PROJECTS</b>	<b>\$31,100,000</b>	<b>\$122,910,000</b>
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## 2.1 Incentive Programs

**Proposed Project:** 2003 CFM1-1, Clean Fuels Program Match for Vehicle and Infrastructure Incentive Programs

**Expected SCAQMD Cost:** \$1,000,000

**Expected Total Cost:** \$ 4,000,000

### **Description of Technology and Application:**

Incentive programs encourage the immediate use of commercially available, low emission on-road and off-road alternative fuel engines to replace high-polluting diesel engines and to reduce the resulting toxic exposures. In CY 2003, additional Clean Fuels funds may be used as local match funding for some of the Incentive programs as required by the specific program's guidelines. Participation in ARB ZEV Incentive Program does not require matching funds; however additional local funds may be instrumental in placing these vehicles within SCAQMD.

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

### **Potential Air Quality Benefits:**

In 1998, diesel exhaust emission was identified as a toxic air contaminant based on its potential human cancer risk. The majority of heavy-duty vehicles in the Basin are powered by diesel engines, which contribute significantly to the Basin's emissions of NO<sub>x</sub> and particulates. The use of Clean Fuels Program funds for incentivizing alternative fuel vehicles will result in the direct replacement of diesel engines with low emission engines. Potential benefits include direct NO<sub>x</sub> emissions reductions due to introduction of cleaner engines, increased exposure to clean engine alternatives by end users, accelerated commercialization of advanced technologies due to market demand, and expansion of alternative fuel infrastructure in the Basin.

**Proposed Project:** 2003 CFM1-2, Infrastructure Incentive Awards for Schools, Including Maintenance Facilities

**Expected SCAQMD Cost:** \$2,000,000

**Expected Total Cost:** \$11,500,000

**Description of Technology and Application:**

Implementation of clean, alternative fuel vehicles provides an opportunity to significantly reduce the emission inventory. Adopting natural gas fueled school buses requires additional training of maintenance personnel and potential modification to maintenance facilities in order to observe codes, regulations and safety practices. The cost associated with the additional training and facility modification can potentially be significant and, with potential school district budget cuts, financial assistance is required in order to implement their clean fuels programs. Current incentive award programs including the Carl Moyer Program and the MSRC program have not allowed awards to be used for facility upgrades or training of personnel. Clean Fuels Program funds can be used as incentive awards for these much needed upgrades and training. The school districts awarded funding will be encouraged to evaluate their current maintenance and repair practices as well as facility modifications that may be needed, and determine how to best use incentive funds. Upon completion of this evaluation, a customized alternative fuels training curriculum for bus maintenance employees will be designed and necessary facility upgrades made.

**Potential Air Quality Benefits:**

The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. The California Air Resources Board (CARB) has also passed standards for medium- and heavy-duty vehicles. Natural gas vehicles (NGVs) have significantly lower emissions than gasoline vehicles and represent the cleanest internal combustion engine powered vehicles available today.

The project, if successful, would significantly increase students and school maintenance personnel knowledge about natural gas fueling stations, help reduce the installation and operating costs of NGV refueling stations and improve refueling time. There would also potentially be a much larger number of natural gas fueling stations throughout the Basin as schools could offer public access to their fueling facility. This would lead to the expansion of the NGV for CNG and LNG-L/CNG 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<sub>x</sub>, VOC, CO, PM, and toxic compound emissions from mobile sources.

## 2.2 Fuel Cell Technology

**Proposed Project:** 2003 CFM2-1, Demonstrate Fuel Cell Vehicles

**Expected SCAQMD Cost:** \$2,000,000

**Expected Total Cost:** \$ 8,000,000

### **Description of Technology and Application:**

This 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 2002-05 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, sports 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, ability to monitor and collect data on vehicle performance, and due to greater technical and customer support. 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; and
  - off-road equipment, including boom lifts and portable power units.

### **Potential Air Quality Benefits:**

The AQMP identifies the need to implement zero-emission vehicles. SCAQMD recently adopted fleet regulations requiring public and private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. In the future, such vehicles could be powered by zero-emission fuel cells among other technologies. 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.

**Proposed Project:** 2003 CFM2-2, Develop Plug-In 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. Plug-in fuel cell vehicle designs enhance many of these features and may encourage faster commercialization of fuel cell vehicles by enabling inexpensive overnight recharging at home to extend the vehicle range between hydrogen or other refueling. Vehicle-to-grid power flow capability would provide the same type of benefits with fuel cell hybrid vehicles as with ICE hybrid vehicles as discussed under proposed project CFM5-1.

Development, demonstration and evaluation of a plug-in hybrid 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 plug-in hybrid fuel cell vehicles.

**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 plug-in fuel cell hybrid vehicle prototype encourages the deployment of fuel cell vehicles by major automakers.

**Proposed Project:** 2003 CFM2-3, Develop and Demonstrate MicroTurbine Fuel Cell Hybrid Technologies

**Expected SCAQMD Cost:** \$500,000

**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<sub>x</sub>, VOC, PM and carcinogens per unit power produced than large power plants.

Two alternative DG technologies that produce relatively low emissions of NO<sub>x</sub>, 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<sub>x</sub>, 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<sub>2</sub> 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.

**Proposed Project:** 2003 CFM2-4, Demonstrate Stationary Fuel Cells for Residential, Commercial, and Industrial Applications

**Expected SCAQMD Cost:** \$2,500,000

**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<sub>x</sub> 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.

**Proposed Project:** 2003 CFM2-5, 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<sub>x</sub>, SO<sub>x</sub>, 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 1997 AQMP estimates that in 1993 ships and commercial boats operating in the Basin contributed more than 40 tons per day of NO<sub>x</sub> and around 25 tons per day of SO<sub>x</sub>. The 1997 AQMP also estimates that in 1993, gasoline-fueled pleasure craft operating in the Basin, including recreational boats and personal water craft, contributed more than 28 tons per day of VOC, around 145 tons per day of CO, and more than 1 ton per day of PM10 emissions. AQMP Control Measure MOF-07, "Credits for the Replacement of Existing Pleasure Craft Engines with New Lower-Polluting Engines," proposes development of an emission reduction credit rule to accelerate replacement of pleasure craft engines with new lower-polluting engines.

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<sub>x</sub> 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.

### 2.3 Hydrogen Technology and Infrastructure

**Proposed Project:** 2003 CFM3-1, 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<sub>x</sub>, 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<sub>x</sub>, VOC, CO, PM, toxics and global warming emissions from light-duty and medium-duty vehicles as well as back up and premium power generators.

**Proposed Project:** 2003 CFM3-2, Develop and Demonstrate Distributed Hydrogen Production and Fuel 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 barrier 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<sub>x</sub>, VOC, CO, PM, and toxic compound emissions from vehicles.

**Proposed Project:** 2003 CFM3-3, Demonstrate Hydrogen-Internal Combustion Engine Transit Bus  
**Expected SCAQMD Cost:** \$500,000

**Expected Total Cost:** \$1,000,000

**Description of Technology and Application:**

Present commercial transit bus technology does not meet the CARB 2007 guidelines for criteria pollutant emissions. There are a variety of technologies being evaluated to meet the future standards, including battery electric buses, CNG hybrid buses, fuel cell buses, hydrogen, hydrogen-enriched natural gas (HCNG) engines, and various diesel engine cleanup technologies. Each technology has advantages (lower emissions than the standards) and drawbacks (cost, durability, etc.). It appears that internal combustion engines (ICEs) modified for hydrogen or HCNG technology may be the most cost-effective means to satisfactorily meet the requirements for California transit agencies. The use of hydrogen or HCNG allows the ICE to be able to run on very lean fuel mixtures, reducing peak combustion temperatures, resulting in significantly lower exhaust emissions.

This project will seek to retrofit existing natural gas transit buses with technology to allow the use of hydrogen or HCNG and demonstrate this technology in revenue service. The overall goal of the project is to validate clean, advanced H<sub>2</sub> fuel technologies in transit bus applications.

**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 and validate the new technologies, diversification of transportation fuels, and lower emissions of criteria and toxic pollutants. Specifically, it is expected that transit buses could achieve NO<sub>x</sub> emissions of 0.2 g/bhp-hr or lower, compared to 2.5 g/bhp-hr currently produced by the cleanest natural gas transit buses.

## 2.4 Engine Technology

**Proposed Project:** 2003 CFM4-1, Demonstrate Twin-Speed Marine Engines

**Expected SCAQMD Cost:** \$125,000

**Expected Total Cost:** \$300,000

### **Description of Technology and Application:**

Twin speed marine transmissions reduce engine speed and hence 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<sub>x</sub>, 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<sub>x</sub>, HC and PM (combined) is 7.5 grams/bhp-hr, and the technology has a 25% emission reduction efficiency, emissions of NO<sub>x</sub>, 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<sub>x</sub> reduced.

**Proposed Project:** 2003 CFM4-2, Develop and Demonstrate Next Generation Natural Gas Vehicles

**Expected SCAQMD Cost:** \$1,600,000

**Expected Total Cost:** \$3,000,000

**Description of Technology and Application:**

The objective of this program is to support the development of the Next Generation Natural Gas Vehicles or NGNGV. This is a four-year US Department of Energy program. Many technologies for heavy-duty natural gas vehicles have been under development for several years including: low-emission engines, electronic controls, ported fuel injection systems, recommended practices for building CNG and LNG vehicles, composite storage tanks, various refueling systems, and aerodynamic chassis. There is a need to demonstrate natural gas engines in a wider variety of applications and make these vehicles commercially available.

This program is intended to support the development and demonstration of advanced natural gas vehicles that incorporate current state-of-the-art technology including low-emission, high efficiency engines and low-cost natural gas chassis technology. These vehicles are expected to be local pick-up and delivery trucks and truck tractors for local freight hauling (“day trippers”) that will compete with equivalent diesel vehicles under life-cycle costs and performance. Emissions are expected to be lower than 0.5 g/bhp-hr NO<sub>x</sub> and 0.01 g/bhp-hr PM.

Co-sponsorship for NGNGV is expected to include the US Department of Energy and manufacturers of heavy-duty engines and chassis. The SCAQMD Governing Board has already approved the first phase of this effort for funding in 2001. Significant cost sharing is expected from private and public partners for these projects, which tend to be multi-year in duration.

**Potential Air Quality Benefits:**

This program supports several On-Road Mobile Sources Control Measures in the 1999 Ozone SIP, including M4, “Heavy-Duty Diesel Vehicles; Early Introduction of Low-NO<sub>x</sub> Engines,” and M5, “Heavy-Duty Diesel Vehicles; Additional NO<sub>x</sub> Reductions in California.” Certification of low-emission engines, and their integration into the Basin’s transportation sector, is a high priority under the AQMP and the SIP. In addition, with the identification of diesel exhaust particulate as a toxic air contaminant by CARB, there is a need to expedite the implementation of clean alternatives to diesel engines to protect health.

This program is intended to expedite the commercialization of low emission alternative fuel heavy-duty vehicles in the Basin and in other US urban areas. The NO<sub>x</sub> emission reduction benefit of replacing a 4.0g/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 1,400 lb/yr per vehicle. Clean alternative fuels, such as natural gas, can also reduce heavy-duty engine particulate emissions by over 90 percent compared to current diesel technology and lead to significant reductions in diesel toxic compound emissions. This program is expected to lead to increased commercial availability of low emission alternative fuel heavy-duty vehicles, with significant reductions in NO<sub>x</sub>, PM, and toxic air contaminants.

**Proposed Project:** 2003 CFM4-3, Develop and Demonstrate Advanced Alternative Fuel Heavy-Duty and Medium-Duty Engines and Vehicles

**Expected SCAQMD Cost:** \$1,500,000

**Expected Total Cost:** \$3,000,000

**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<sub>x</sub> 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; and
- 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 several 1997 AQMP On-Road Mobile Sources Control Measures, including M4, "Heavy-Duty Diesel Vehicles; Early Introduction of Low-NO<sub>x</sub> Engines" and M5, "Heavy-Duty Diesel Vehicles; Additional NO<sub>x</sub> Reductions in California."

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 NO<sub>x</sub> 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 SCAQMD regulations.

**Proposed Project:** 2003 CFM4-4, Evaluate and Demonstrate Medium- and Heavy-Duty Alternative Fuel Microturbine Vehicles

**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 certification of low emission, alternative fueled microturbine hybrid vehicles for on-road medium- and heavy-duty applications. Microturbines are internal, continuous combustion devices based on similar technology as jet engines. These devices show the potential for low vibrations, fuel flexibility, reduced vibration, and ultra-low emissions. Microturbine hybrids use the generator to replenish the vehicle's batteries, thereby extending range, and adding power for air conditioning and acceleration. This project would support the development and demonstration of the microturbine hybrids on clean fuels, including but not limited, to CNG, LNG, or fuels with blends of natural gas and hydrogen.

**Potential Air Quality Benefits:**

This proposed program supports several 1997 AQMP On-Road Mobile Sources Control Measures, including M4, "Heavy-Duty Diesel Vehicles; Early Introduction of Low-NO<sub>x</sub> Engines" and M5, "Heavy-Duty Diesel Vehicles; Additional NO<sub>x</sub> 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.

**Proposed Project:** 2003 CFM4-5, Demonstrate Low- and Zero-Emission Locomotives

**Expected SCAQMD Cost:** \$1,000,000

**Expected Total Cost:** \$4,000,000

**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<sub>x</sub> emissions by 75% or more compared to conventional diesel technology. Unfortunately, the OEM involved in GasRail, GM-Electromotive Division withdrew from the consortium and has chosen not to participate in a field demonstration.

The purpose of the proposed project is to support the demonstration of clean-burning locomotives in the Basin, utilizing a low-emission LNG combustion system. This first involves development of a low-emission LNG Head End Power (HEP) unit for a passenger locomotive. The HEP supplies electric power for passenger heating, lighting, and air conditioning. The second step involves developing a full LNG propulsion system for a passenger locomotive along with the LNG HEP, developing an LNG storage system, and demonstrating the unit in Metrolink passenger service. In addition, the proposed project would seek to expand the fueling infrastructures for LNG locomotives.

**Potential Air Quality Benefits:**

The AQMP emissions inventory shows that 35 tons/day of NO<sub>x</sub> 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 NO<sub>x</sub> benefits for the Basin to achieve the federal PM<sub>10</sub> air quality standards by 2006. As proven in the GasRail USA program, natural gas combustion systems can meet and exceed these NO<sub>x</sub> emission reductions while also achieving significant reductions of PM compared to conventional diesel technology. This project will continue development and demonstration of the low-emission locomotive technology started by GasRail. This has the potential to reduce NO<sub>x</sub> and particulate emissions by more than 75%. Other expected benefits include the advancement of low-emission technology for locomotives with potential for wide-scale application to both passenger and freight rail, the expansion of a LNG fueling infrastructure, and diversification of fuels within the transportation sector.

## 2.5 Infrastructure and Fuel Production

**Proposed Project:** 2003 CFM5-1, Demonstrate Solution to Hot Gas Issue Using LNG Blending

**Expected SCAQMD Cost:** \$300,000

**Expected Total Cost:** \$600,000

**Description of Technology and Application:**

The success of the California CNG program is highly dependent upon the gas pipelines and distribution network that so conveniently provide natural gas throughout the State. However, in some portions of the San Joaquin Valley and Ventura-Santa Barbara Counties of California there are exceptions to the availability of high-quality pipeline gas; these areas are subject to higher hydrocarbon loading, i.e., “hot gas”, within the pipeline. The compressed natural gas available to these stranded CNG locations is supplied through a combination of imported trailer loads of CNG or the mixing local poor-quality natural gas with truckloads of much purer gas in order to meet the CARB specifications for automotive grade compressed natural gas.

Operation of CNG refueling stations in this region is dependent on the availability of high-quality pipeline gas, or the ability to access another source of methane gas. This project proposes to demonstrate a practice to ensure that a high quality natural gas supply is available for natural gas vehicle refueling through the blending of liquefied natural gas (LNG) with the “hot gas”.

**Potential Air Quality Benefits:**

The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. CARB has also passed LEV regulations that require light-duty vehicles to comply with increasingly stringent emission standards. CARB 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.

This project would reduce the potential for higher hydrocarbon natural gas and the resulting potential for higher NO<sub>x</sub> emissions from CNG vehicles.

**Proposed Project:** 2003 CFM5-2, Manual for Designing, Permitting and Constructing CNG Fueling Facility

**Expected SCAQMD Cost:** \$200,000

**Expected Total Cost:** \$200,000

**Description of Technology and Application:**

With the continued expansion of the natural gas refueling stations, there is a need to develop manuals for designing, permitting, and constructing natural gas refueling stations that are more “turn-key” in nature, for both CNG and LNG-L/CNG dispensing. This program would also 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, do not have in-house expertise or financial resources to design or install a fueling station, and may be unaware of governing codes or standards affecting such an installation. Providing outreach, 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.* The project is intended to provide outreach, 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. CARB has also passed LEV regulations that require light-duty vehicles to comply with increasingly stringent emission standards. CARB 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 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<sub>x</sub>, VOC, CO, PM, and toxic compound emissions from mobile sources.

**Proposed Project:** 2003 CFM5-3, Development and Demonstration of Advanced Natural Gas Systems for Refueling Stations

**Expected SCAQMD Cost:** \$1,000,000

**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<sub>x</sub>, VOC, CO, PM, and toxic compound emissions from mobile sources.

**Proposed Project:** 2003 CFM5-4, Liquefied Natural Gas Manufacturing and Distribution Technologies

**Expected SCAQMD Cost:** \$1,800,000

**Expected Total Cost:** \$22,000,000

**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:

- Developing and demonstrating an economic small-scale natural gas liquefaction technology;
- Developing and demonstrating LNG manufacturing plants on a small scale from various gaseous feed stocks locally available; and
- Commercialization 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<sub>x</sub>, PM, and toxic compound emissions.

## 2.6 Electric/Hybrid Technologies

**Proposed Project:** 2003 CFM6-1, Demonstrate Plug-in Hybrid Electric Vehicle with Vehicle to Grid Power

**Expected SCAQMD Cost:** \$150,000

**Expected Total Cost:** \$500,000

### **Description of Technology and Application:**

Hybrid electric systems can vary significantly in their design configurations as well as components. Hybrid electric vehicles (HEVs) can be either parallel or serial systems. Engines of various sizes can either drive a generator to charge the batteries or provide power directly to the wheels or both. The batteries can provide primary power to the traction drive motor or supplement the internal combustion engine (ICE). Some HEV designs can plug in to recharge the batteries, operate on the battery only for several miles with the engine coming on just as needed to sustain the batteries. This type of “plug-in” battery dominant HEV can make extended trips by refueling quickly with gasoline or other fuel.

Control algorithms optimized for a plug-in HEV with vehicle-to-grid power flow are very different than algorithms in use for commercially available HEVs. Vehicles with vehicle-to-grid power flow could be used to provide emergency back-up power or valuable ancillary power services which could create market demand and help justify higher initial vehicle cost. Demonstration of a plug-in hybrid sports utility vehicle with vehicle-to-grid power flow using standard automotive components and evaluation of the full fuel cycle emissions and energy impacts will build on previous AQMD cosponsored projects with UC Davis, EPRI, and AC Propulsion. The design criteria for this vehicle position it as a premium sport utility vehicle with great market potential.

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 near-ZEV HEV technologies and encourages the deployment of near-ZEV technologies by major automakers.

**Proposed Project:** 2003 CFM6-2, Develop and Demonstrate Electric Vehicle Charging Equipment

**Expected SCAQMD Cost:** \$200,000

**Expected Total Cost:** \$300,000

**Description of Technology and Application:**

Southern California has an established network of public charging stations for electric vehicles. Over time, the mix of commercially manufactured electric vehicles in use and their charging needs have evolved. In order to match the charging needs of the drivers and vehicles in use, one project in this category will provide for some of the existing public chargers to be replaced with new compatible charging technology. Signage to direct drivers to nearby charging may also need replacement at a few key sites, since charging locations are not usually as visible as corner gasoline service stations. Continued support for our electric vehicle charging network can encourage future plug-in hybrid electric vehicles and enable additional zero emission miles traveled.

Electric forklifts and airport ground support equipment (GSE) are a growing portion of their market. One way to encourage the continued growth of the market for these vehicles is optimization of their charging systems and infrastructure. Most of these vehicles in use today do not have the kind of sophisticated battery and energy management systems that have been demonstrated in passenger electric vehicles and the batteries are frequently overcharged or improperly attended. One potential project would develop a cost-effective battery/energy management system that could be retrofitted to existing forklifts or GSE, increasing energy efficiency and enhancing vehicle maintenance and use.

Another issue of concern is the aging of passenger electric vehicle charging infrastructure. As chargers reach the end of their manufacturers' warranty, there is a need for an inspection and maintenance program to ensure that the public and fleet charging remains operational so that the vehicles are used. It is not clear that the host sites will be willing or able to shoulder the cost for such a program or for repairs or retrofits to the chargers. A demonstration program could develop a cost effective way of maintaining and repairing the infrastructure such as an extended warranty program. Enhancement of public charging station database, mapping functions, and real-time information availability would also enable more zero emission miles traveled.

**Potential Air Quality Benefits:**

Maintaining a compatible, reliable electric vehicle charging network will encourage drivers and automakers to keep battery electric vehicles in operation in the district and can enable the development of future plug-in hybrid electric vehicles. Optimization of battery management and charging systems for electric forklifts and ground support equipment can enhance the market for zero emission off-road vehicles.

**Proposed Project:** 2003 CFM6-3, 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 major automobile manufacturers are actively developing hybrid-electric vehicles with the objective of meeting the CARB LEV II regulations, which provide mechanisms for technologies other than battery electric and hydrogen fuel cells to earn ZEV credits. Hybrid electric vehicles are vehicles with drivetrains that integrate a small internal combustion engine or fuel cell alternator/generator, battery pack, and electric drive motors. Battery fuel cell hybrids are another potential technology being mentioned by battery experts as a way of reducing costs and enhancing performance of fuel cell vehicles.

Hybrid electric systems can vary significantly in their design configurations as well as components. HEVs can be either parallel or serial systems. Engine sizes can vary. The engines can either drive a generator to charge the batteries or provide power directly to the wheels or both. The batteries can provide primary power to the traction drive motor or supplement the ICE. Some HEVs can operate with the battery only with the engine coming on only as needed to recharge the batteries. There is also a trend towards charging the battery systems overnight by connecting to the grid. The HEV hardware variations are numerous and the resulting vehicle and emissions performance can be expected to vary correspondingly.

The objective of this program is to evaluate and compare the impacts and benefits of various types of light-duty, and medium-duty hybrid electric vehicles (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.

**Proposed Project:** 2003 CFM6-4, 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.

**Proposed Project:** 2003 CFM6-5, Demonstrate Heavy-Duty Hybrid Electric Vehicles

**Expected SCAQMD Cost:** \$1,000,000

**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<sub>x</sub> 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.

This program is expected to result in two or more demonstration projects. Given the number of developments underway, the projects are likely to be selected using a competitive procurement.

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 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<sub>x</sub> 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<sub>x</sub> and hydrocarbons) currently produced by heavy-duty diesel engines.

**Proposed Project:** 2003 CFM6-6, Upgrade of Hybrid Electric Vehicles

**Expected SCAQMD Cost:** \$250,000

**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<sub>x</sub> emissions of 0.5 g/bhp-hr or lower, compared to 4.0 g/bhp-hr and 2.5 g/bhp-hr (combine NO<sub>x</sub> and hydrocarbons) currently produced by heavy-duty diesel engines.

**Proposed Project:** 2003 CFM6-7, Develop and Demonstrate High-Capacity 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<sub>x</sub> 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. 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.

This program is expected to result in two or more demonstration projects. Given the number of developments underway, the projects are likely to be selected using a competitive procurement.

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 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<sub>x</sub> emissions of 0.5 g/bhp-hr or lower, compared to 4.0 g/bhp-hr and 2.5 g/bhp-hr (combined NO<sub>x</sub> and hydrocarbons) currently produced by heavy-duty diesel engines.

## 2.7 Emission Control Technology

**Proposed Project:** 2003 CFE1-1, Develop and Demonstrate Advanced Aftertreatment Technologies for Alternative 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<sub>x</sub> 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<sub>x</sub> 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<sub>x</sub> and PM emissions by at least 60 and 90 percent, without significantly increasing fuel consumption on an energy equivalent basis. This involves: (1) 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; and (2) requires 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 are estimated to represent approximately 64, 87, and 10 percent of the entire 1993 Basin VOC, NO<sub>x</sub>, and PM emissions, respectively. The on-road heavy-duty diesel trucks and urban buses contribute about 4, 25, and 68 percent of the entire 1993 on-road mobile VOC, NO<sub>x</sub>, and PM emissions, respectively. 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<sub>x</sub> 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.

**Proposed Project:** 2003 CFE1-2, Demonstrate Advanced Alternative Liquid Fuels in Heavy-Duty 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. In 1997 AQMP, off-road mobile sources are estimated to represent 14, 24, and 34 percent of the entire 1993 Basin mobile source VOC, NO<sub>x</sub>, and PM emissions, respectively. Currently, off-road heavy-duty equipment accounts for 15 percent of all PM 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<sub>x</sub>, 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.

**Proposed Project:** 2003 CFE1-3, 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<sub>x</sub>, 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<sub>x</sub>, VOC, CO, PM and toxics from in-Basin demonstrations, and expedited commercialization.

**Proposed Project:** 2003 CFE1-4, Develop and Demonstrate Low-VOC and PM Lubricants for Natural Gas Engines

**Expected SCAQMD 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<sub>x</sub>, 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:**

This proposed program supports several 1997 AQMP On-Road Mobile Sources Control Measures, including M4, "Heavy-Duty Diesel Vehicles; Early Introduction of Low-NO<sub>x</sub> Engines" and M5, "Heavy-Duty Diesel Vehicles; Additional NO<sub>x</sub> Reductions in California." The use of low-emission lubricating oils for clean, alternative fuel engines, such as natural gas and controlled diesel engines would have a large impact on the air quality. 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.

**Proposed Project:** 2003 CFE1-5, Demonstrate NO<sub>x</sub> and PM Control Technologies for Marine Vessels

**Expected SCAQMD Cost:** \$200,000

**Expected Total Cost:** \$500,000

**Description of Technology and Application:**

Marine vessels contribute a significant portion of NO<sub>x</sub>, 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<sub>x</sub>, 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 <sub>x</sub>	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 25% HC 7% NO <sub>2</sub>
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%	20%	90% SO <sub>2</sub>
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 Separation 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%	

## 2.8 Emissions Studies

**Proposed Project:** 2003 CFE2-1, Compare 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 performed in a laboratory estimated their emissions performance as well as those of conventional heavy-duty diesel engines. From time to time, it is important to assess the emissions performance of these engines 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 1997 AQMP On-Road Mobile Sources Control Measures, including M4, "Heavy-Duty Diesel Vehicles; Early Introduction of Low-NO<sub>x</sub> Engines" and M5, "Heavy-Duty Diesel Vehicles; Additional NO<sub>x</sub> 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.

## 2.9 Health Impact Analyses

**Proposed Project:** 2003 CFH-1, Evaluate Ultrafine Particle Health Effects

**Expected SCAQMD Cost:** \$1,000,000

**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. 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, 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.

### **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.

**Proposed Project:** 2003 CFH-2, Evaluate Health Impacts from Toxic Emissions

**Expected SCAQMD Cost:** \$300,000

**Expected Total Cost:** \$300,000

**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:

- 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; and
- 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.

**Proposed Project:** 2003 CFH-3, Evaluate Benefits of Emissions Reductions

**Expected SCAQMD Cost:** \$100,000

**Expected Total Cost:** \$200,000

**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:

- 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; and
- 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 about 56 percent of the VOC and 83 percent of the NO<sub>x</sub> 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.

## 2.10 Stationary Source Clean Fuel Technology

**Proposed Project:** 2003 CFS1-1, Develop and Demonstrate Portable Low Emission LPG ICE Generator

**Expected SCAQMD Cost:** \$100,000

**Expected Total Cost:** \$200,000

### **Description of Technology and Application:**

Portable electricity generators 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 NO<sub>x</sub> levels of 6.9 g/bhp-hr and hydrocarbon (HC) levels of 1.0 g/bhp-hr to combined NO<sub>x</sub> + 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<sub>x</sub> 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 NO<sub>x</sub> 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 NO<sub>x</sub>, VOC, PM and carcinogens per unit power produced.

**Proposed Project:** 2003 CFS1-2, 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<sub>x</sub>, 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<sub>x</sub> 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.

**Proposed Project:** 2003 CFS1-3, Demonstrate Landfill Gas to Electricity MicroTurbine

**Expected SCAQMD Cost:** \$250,000

**Expected Total Cost:** \$500,000

**Description of Technology and Application:**

This project will demonstrate the use of a Flex-Microturbine to consume gases generated from composting of livestock manure while at the same time generate electrical power. This 30-kW power plant is the next generation Capstone microturbine specially modified with a catalytic combustor to operate at full power on low btu gases with no more than 1.5% methane by volume. Such fuels are well below the threshold of traditional combustion.

Composting is a beneficial reuse of materials that can no longer be directly applied to the soil due to regulations. However, the composting process itself, the bacterial breakdown of substrates, also produces various organic and inorganic gases that can contribute to several different air pollution problems. Outdoor composting represents a significant source of uncontrolled emissions of ammonia and volatile organic compounds. Ammonia is a precursor to particulate nitrates which make up a substantial portion of PM10 emissions.

**Potential Air Quality Benefits:**

The Flex-Microturbine power plant will result in reduced NO<sub>x</sub>, PM-10 (precursors such as ammonia and VOC's), and fugitive methane emissions.

This system will also provide an economic benefit to the site by providing clean inexpensive electrical power. Another potential benefit would be the destruction of odors emanating from the compost.

This technology could play a key role in implementing the requirements of SCAQMD's recently adopted Rule 1133 – "Emission Reductions from Composting."

**Proposed Project:** 2003 CFS1-4, Develop and Demonstrate Low Emission Refinery Flares

**Expected SCAQMD 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 developed in Europe or similar technologies that have the potential to reduce unburned hydrocarbon and NO<sub>x</sub> emissions from existing flares.

**Potential Air Quality Benefits:**

The 1997 AQMP includes the stationary source control measure CMB-07 Emission Reductions from Petroleum Refinery Flares. It proposed a two-step process, namely to monitor flare gas emissions and, if appropriate, implement control measures to reduce such emissions. This control measure resulted in SCAQMD Rule 1118, adopted in 1998, which require the refineries to monitor the quantity of gas flared and its sulfur content starting in 1999. The next step has not commenced.

The control measure did not estimate the potential emission reduction or even target particular pollutants. However, better management and utilization of waste gases, sulfur removal equipment and better flaring methods is expected to reduce VOC, CO, NO<sub>x</sub>, SO<sub>x</sub>, and PM emissions.

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.

**Proposed Project:** 2003 CFS1-5, Develop and Demonstrate Renewable-Based Alternatives

**Expected SCAQMD Cost:** \$300,000

**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 once successfully demonstrated, the potential for increased use, with resulting emission benefits, through expedited implementation. These technologies would, also, have a substantial influence in reducing global warming emissions.

## 2.11 VOC/Toxics Technologies

**Proposed Project:** 2003 CFS2-1, Technology Assessment 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 1997 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.

**Proposed Project:** 2003 CFS2-2, Develop and Demonstrate Near-Zero/Zero-VOC Products

**Expected SCAQMD Cost:** \$500,000

**Expected Total Cost:** \$500,000

**Description of Technology and Application:**

The objective of the project is to advance the state-of-art in low-VOC product formulations. The proposed projects would support the development and demonstration of near-zero- and zero-VOC products and processes for Miscellaneous Industrial Coating Operations. Miscellaneous Industrial Coating Operations is a generic category that represents a wide range of industrial coating and solvent operations. Emissions are categorized as Miscellaneous Industrial Coating Operations when there is insufficient information to place the emissions in an existing source category or the source category is so unique that a source category does not currently exist. The projects may include, but are not limited to the development and demonstration of near-zero and zero-VOC coatings, solvents, adhesives, and inks. Multiple projects are anticipated to reduce VOC emissions from these sources.

**Potential Air Quality Benefits:**

The 1999 amendment to the 1997 AQMP contains a control measure CM# 99ADV-CTS: Long Term Control Measure for Miscellaneous Industrial Coating and Solvent Operations. By focusing on the development of advanced near-zero- and zero-VOC products, projects in this category, if successful, will result in direct VOC emissions reductions at the demonstration sites. More importantly, once developed and successfully demonstrated, the newly developed products could be commercialized for widespread application in the Basin.

**Proposed Project:** 2003 CFS2-3, 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:

- Sources of fugitive VOC emissions that are targeted under this area include organic liquid storage containers (e.g., above-ground tanks and under-ground tanks), chemicals and petroleum products processing and transfer (e.g., valves, pumps, compressors, etc.), and gasoline dispensing facilities. Projects in this category will focus on new technologies to detect and repair frequent and high leakers, develop leakless valves, and enhance vapor recovery devices to broaden their applications and/or to improve control efficiency.
- Small and/or unpermitted facilities that are involved in manufacturing or fabrication of rubber, plastic, or fiberglass products. Sources of emissions are primarily generated from material handling, use of chemicals, volatile liquids during reaction, emissions of solvents during storage, handling, and processing of resins, or the drying/cooling of finished products.
- Many VOC sources can be reduced by the use of control equipment such as carbon adsorption, thermal or catalytic oxidation, or bio-filtration. Projects under this category could include development and demonstration of bio-filtration and other innovative control technologies for coating, solvent, and printing industries.

One or more projects may be implemented with potential to reduce VOC emissions from these sources. Since most 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:**

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. Fugitive emissions are currently regulated under Rule 1173, Rule 1176, Rule 461, Rule 462, and Rule 463. The 1999 amendment to the 1997 AQMP calls for additional short- and intermediate-term measures, followed by a long-term control measure CM #99ADV-FUG: Long Term Control Measure for Fugitive Emissions. Rubber product and plastic product manufacturing operations, and fiberglass fabrication and impregnation processes are not currently regulated for under a source-specific SCAQMD VOC rule. The 1999 AQMP targets VOC emission reductions from these operations in CM #99ADV-PRC: Long Term Control Measure for Industrial Process Operations.

## 2.12 Outreach and Technology Transfer

**Proposed Project:** 2003 CFT-1, Technical Assistance in Assembling SAE Standards for LNG Fueling and Dispensing

**Expected SCAQMD Cost:** \$150,000

**Expected Total Cost:** \$150,000

### **Description of Project:**

As of this date there are no standards for LNG automotive fuel. The alternative fuel refueling 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 and equipment that may not meet safety standards. These factors all contribute to the higher cost of alternative fuel refueling stations compared to conventional petroleum stations.

Efforts must be undertaken to reduce capital costs at alternative fuel refueling 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 Weights and Measures regulations that are not optimized for gaseous fuels.

The main objectives of this project are:

- Developing and implementing various code changes that will decrease unnecessary costs associated with building alternative fuel refueling stations through the following committees:
  - LNG Fuel Quality;
  - LNG Fuel Connectors; and
  - LNG measurement.
- Developing templates for the design and installation of alternative fuel refueling stations.
- Developing a compendium of best practices that will lead to standardization and modularization for alternative fuel re-fueling stations and equipment.
- Demonstrate the cost, performance and safety parameters for all alternative fuel refueling equipment.

### **Potential Air Quality Benefits:**

The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. CARB has also passed LEV regulations that require light-duty vehicles to comply with increasingly stringent emission standards. CARB 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 hurdles 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<sub>x</sub>, VOC, CO, PM, and toxic compound emissions from mobile sources.

**Proposed Project:** 2003 CFT-2, Technical Assistance in LNG Fueling

**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.

**Proposed Project:** 2003 CFT-3, Technical Assistance for Schools Maintenance Facilities

**Expected SCAQMD Cost:** \$300,000

**Expected Total Cost:** \$300,000

**Description of Project:**

Addressing the garage modification issue will require more study and evaluation as each district is hiring individual 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 attending to discuss CNG performance, operating, and safety issues. This process will allow the vendors to get direct feedback and implement continuous improvement design and equipment changes making CNG more competitive and cost effective. A critical mass price equivalent number of buses must be determined by the vendors to eventually eliminate the increased purchase price. Complete basic standard turnkey design and construct engineering drawings and specifications packages for new CNG stations and expansion of 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.

**Proposed Project:** 2003 CFT-4, 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:

- 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; and
- Production and dissemination of information, including web sites.

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

**Potential Air Quality Benefits:**

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

**Proposed Project:** 2003 CFT-5, 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<sub>x</sub> and PM emissions in the basin, besides reducing toxic air contaminants.

## **Section 3**

### **Comments and Responses**

The following comments were received from the SB-98 Clean Fuels Advisory Group members at program review meetings. Also included are brief staff responses and acknowledgements.

**Comment:** The funding secured by TAO is substantial. Due to the magnitude and number of projects, a roadmap of how the projects fit into the AQMP or overall TAO goals would be useful. Projects should also incorporate a “lessons learned” audit when completed.

*Response:* Staff agrees with the comments but it is sometimes difficult to directly link projects to the AQMP as funds are directed toward the projects with the highest potential for air quality benefits. These projects thus may incorporate several AQMP objectives.

*The final reports and two-page summaries required by contractors should encompass the lessons learned from the project. Staff will strive to make these more evident in the future.*

**Comment:** It may be useful to identify near-term, mid-term, and long-term goals and how the projects fit within these goals. Also, TAO should be cautious about using diesel as viable fuel source. Diesel will not be a viable, long-term clean fuel choice.

*Response:* Staff provides an annual Technology Advancement Plan Update and a longer term, 3 year, Advanced Air Pollution Research Plan to address near-term and mid-term goals. These Plans are used to guide the TAO research in order to attain the goals of the Air Quality Management Plan, which has longer-term goals of achieving the Ambient Air Quality Standards by 2010.

*Staff is in agreement with respect to diesel fuel and is pushing for the implementation of clean fuel alternatives where possible. However, some applications are not readily amenable to natural gas or alternative fuel use, so other technologies may be needed in these areas (e.g., off-road heavy-lifting vehicles).*

**Comment:** TAO should identify the critical needs for each technology considered for funding and ask whether the program addresses those needs. Commercialization and technical risk assessment should be identified as part of this assessment.

*Response:* Projects are awarded based on rigorous evaluation by Staff and often outside experts from other government agencies. Proposals are scored according to the criteria established in the AQMD’s Procurement Policy and Procedure as well as commercialization potential, likelihood of success, and cost effectiveness.

**Comment:** During presentations, it would be helpful to present the air quality goals and how the projects relate to these goals. Is the AQMD conducting any projects on home hydrogen refueling, computer modeling, renewable technologies, or traffic congestion?

*Response:* The comments were duly noted regarding presentations.

*The AQMD is actively working on the hydrogen infrastructure for fuel cell vehicle refueling and will consider home refueling if the market and manufacturers have an interest.*

*TAO does limited modeling, and the Clean Fuels Program addresses demonstrations and commercialization projects. Most of the computer modeling, and specifically the air quality modeling, is done in a different group.*

*Renewable technologies are considered when they fit within the scope of the Clean Fuels Program. Most of the funding is legislatively required to be used for transportation and vehicle-related projects.*

*Traffic congestion is more appropriately addressed by the AQMP.*

**Comment:** It is difficult to comprehend the wide array of programs in such a short time (one day); it may be more useful to cover only a few areas in more depth. Cost comparisons of emissions reductions technologies would also be useful as well as assessments over time to evaluate effectiveness of technologies.

**Response:** *Staff will consider the suggestions for presenting the information to the Advisory Groups. Technology costs and benefits are addressed in the AQMP. Staff is working on providing more up-to-date monitoring of projects and will consider releasing regular progress on the AQMD website.*

**Comment:** Conservation is a good project area to pursue in order to evaluate the impact of overall energy use. Consideration should also be given to funding of new research areas, even though these may have inherently higher risks.

**Response:** *TAO has a program opportunity notice (PON) process which solicits pre-proposals on new ideas, but Staff will consider a separate, more research-oriented solicitation.*  
*The environmental impact of the projects is being addressed.*

**Comment:** Most of projects are being conducted to bring emissions down, however, there is great value in also considering projects which “set the bar” to demonstrate the possibilities.

**Response:** *Staff absolutely agrees with the comment. The funded projects are intended to provide the framework for initial deployment; market forces and competition are left to drive the technology.*

**Comment:** Concern was expressed about the effect of California’s budget crisis on projects. Interest was also expressed in hybrid automobile safety, size, and model offerings. Another area of focus could be clean motor oils and their impact on emissions.

**Response:** *R&D budget for the Clean Fuels Program is stable as mandated by state law. The current funding mechanism sunsets in 2005.*  
*Staff believes that there will be a strong market for hybrid vehicles; as a result, size, style variations, and safety will increase with this demand.*  
*Staff is currently considering a project examining the exhaust from synthetic motor oils.*

## **Appendix A**

### **Technology Advancement Advisory Group**

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

## **Appendix B**

### **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 Samuelson .....	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