BOARD MEETING DATE: November 6, 2015 AGENDA NO. 31

REPORT: Technology Committee

SYNOPSIS: The Technology Committee met on October 16, 2015. Major topics included Technology Advancement items reflected in the regular Board Agenda for the November Board meeting. A summary of these topics with the Committee's comments is provided. The next Technology Committee meeting will be held on November 20, 2015.

RECOMMENDED ACTION:
Receive and file.

John J. Benoit
Technology Committee Chair

MMM:pmk

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**Attendance:** Supervisor John J. Benoit, Councilmember Joseph Buscaino and Mayor Miguel Pulido participated by videoconference. Councilmember Judith Mitchell and Mayor Dennis Yates were in attendance at SCAQMD headquarters. Supervisor Janice Rutherford was absent due to a conflict with her schedule.

**NOVEMBER BOARD AGENDA ITEMS**

1. **Recognize Revenue and Execute Contract for Development, Integration and Demonstration of Ultra-Low-Emission Natural Gas Engine for On-Road Heavy-Duty Vehicles**

   The Board previously awarded contracts to Cummins Westport Inc. (CWI) and Cummins Inc. to develop next generation ultra-low-emission heavy-duty natural gas engines that are 90% cleaner than those meeting the current NOx emission standard. As a follow-on to this development project and given market demand for natural gas engines in the 11- to 13-liter range, the CEC, Southern California Gas Company and Clean Energy have expressed interest in cofunding the advancement of the current 11.9-liter natural gas engine to achieve ultra-low NOx emissions. These actions are to recognize revenues up to $2.5 million and execute a contract with CWI for

development, integration and demonstration of an 11.9-liter ultra-low-emission natural gas engine in an amount not to exceed $4.25 million from the Clean Fuels Fund (31).

*Councilmember Mitchell asked whether the proposed 11.9-liter Cummins Westport, Inc., (CWI) engine is commonly used in freight transportation, and whether the proposed engine will be certified at 0.02g/bhp-hr NOx emissions. Staff responded yes, the 11.9-liter engine is commonly used in drayage trucks. Once the proposed engine is developed and demonstrated, Cummins Westport will submit an application to CARB and U.S. EPA for the engine to be certified at 0.02g/bhp-hr NOx or lower.*

*Supervisor Benoit questioned how further deployment of these 90% cleaner engines will get the South Coast Air Basin closer to federal attainment. Staff showed a scenario analysis indicating that if the new engines are widely deployed for class 8 trucks, we will be able to get very close to the 2023 Federal requirements.*

*Moved by Benoit; seconded by Mitchell; unanimously approved.*

2. **Execute Contract to Cosponsor Study on Opportunities and Benefits of Deploying Next-Generation Heavy-Duty Natural Gas Vehicles Operating on Renewable Natural Gas**

A leading natural gas engine manufacturer is targeting mid-2016 to commercialize the first natural gas engine achieving 90% lower NOx emissions than the current emissions standard. In addition, renewable natural gas (RNG) is currently being produced in large volume for use as a transportation fuel. While the benefits of significantly cleaner combustion engines and the use of renewable fuels have been individually studied, there has been no comprehensive assessment focused specifically on the air quality benefits of having significantly lower NOx combustion engines operating on renewable fuels or the market potential for such deployment. This action is to execute a contract with Gladstein, Neandross & Associates to conduct such a study in an amount not to exceed $100,000, comprised of $50,000 from the Clean Fuels Fund (31) and $50,000 from the Natural Gas Vehicle Partnership Fund (40).

*Moved by Yates; seconded by Mitchell; unanimously approved.*

3. **Execute Contract to Develop Online Application Database for Carl Moyer Program**

The Carl Moyer Program receives several hundred applications for different types of vehicles and equipment during its annual open solicitation period. The projects must be evaluated for eligibility, cost-effectiveness, amount of funding, environmental justice ranking and other applicable factors before they can be considered for award.

Electronic acceptance of the applications will expedite the evaluation and reporting process as well as enhance uploading information into the state's Carl Moyer Program database. This action is to execute a contract with Trinity Technology Group to develop an online application database for the Carl Moyer Program in an amount not to exceed $262,960 from the administrative portion of the Carl Moyer Program AB 923 Fund (80).

*Moved by Yates; seconded by Mitchell; unanimously approved.*

4. **Adopt Resolution Accepting Terms and Conditions for Proposition 1B – Goods Movement Program Grants**

In August 2015, SCAQMD submitted applications to CARB for the Fiscal Year 2015-16 Proposition 1B – Goods Movement Program. This is the last round of funding for this Program with approximately $267 million remaining for eligible projects and local agency administrative costs. Consistent with CARB's funding targets for each trade corridor and upon execution of grant agreements, SCAQMD expects to receive a total of $137.9 million. Eligible projects will include heavy-duty diesel trucks, locomotives, ships at berth, cargo handling equipment and transport refrigeration units. CARB requires a Board resolution to enter into grant agreements for the allocated funds. This action is to adopt a resolution accepting terms and conditions for the Proposition 1B – Goods Movement Program grants and authorize the Executive Officer to enter into grant agreements with CARB.

*Moved by Buscaino; seconded by Mitchell; unanimously approved.*

5. **Clean Fuels Draft Plan Update** ***[Written Report Only]***

Every fall, staff has brought the Clean Fuels Program Draft Plan Update before the Technology Committee to solicit input on the proposed distribution of potential project funds for the upcoming year before requesting final approval for the Plan Update each year in early spring. Staff proposes continued support for a wide portfolio of technologies, but with particular emphasis on heavy-duty truck technologies with zero and near-zero emissions for goods movement applications to create a pathway towards achieving 2023 attainment as well as a continued focus on preparing for hydrogen vehicle deployments. This item was presented at the October 16, 2015 Technology Committee as a written report.

*Staff presented a summary of the Clean Fuels Draft Plan Update. Mayor Yates suggested lowering the proposed funding allocation for electric and hybrid-electric projects and increasing the funding allocation for hydrogen and natural gas, considering the historically limited support from local electric utilities such as Southern California Edison (SCE). Mayor Pulido suggested that electric drivetrain technology can use hydrogen or natural gas and requested staff to clarify. Staff explained that the proposed increase in electric and hybrid-electric funding*

*allocation further provides potential leveraging of greenhouse gas reduction funds available for all-electric-range heavy-duty vehicles. Dr. Wallerstein proposed that based on CARB actions on the use of greenhouse gas funds by March 2016, staff will accordingly revise the funding allocation and proposed a 5% increase in electric and hybrid-electric and the remainder in fuel cells and hydrogen. Supervisor Benoit supported the suggestion made by Dr. Wallerstein. Councilmember Mitchell noted a revised commitment from SCE, based on their recent actions.*

*This is a receive and file item. A copy of the Draft 2016 Plan Update is attached, with revisions relating to the funding allocation for electric and hybrid-electric projects.*

**6. Other Business**

*There was no other business.*

**7. Public Comment Period**

*There was no public comment.*

**Next Meeting: November 20, 2015**

**Attachments**

1. Attendance
2. Clean Fuels Program Draft 2016 Plan Update

## Attachment 1 – Attendance

| | |
|---|---|
| Supervisor John J. Benoit (Videoconference) | SCAQMD Governing Board |
| Councilmember Joseph Buscaino (Videoconference) | SCAQMD Governing Board |
| Councilmember Judith Mitchell | SCAQMD Governing Board |
| Mayor Miguel Pulido (Videoconference) | SCAQMD Governing Board |
| Mayor Dennis Yates | SCAQMD Governing Board |
| Mark Abramowitz | Board Consultant (Lyou) |
| Bob Ulloa | Board Consultant (Yates) |
| Barry Wallerstein, Executive Officer | SCAQMD |
| John Olvera, Principal Deputy District Counsel | SCAQMD |
| Matt Miyasato, STA | SCAQMD |
| Fred Minassian, STA | SCAQMD |
| Laki Tisopulos, STA | SCAQMD |
| Dean Saito, STA | SCAQMD |
| Phil Barroca, STA | SCAQMD |
| Richard Carlson, STA | SCAQMD |
| Connie Day, STA | SCAQMD |
| Lisa Mirisola, STA | SCAQMD |
| Adewale Oshinuga, STA | SCAQMD |
| Mei Wang, STA | SCAQMD |
| Vicki White, STA | SCAQMD |
| Robert Paud, IM | SCAQMD |
| Dominic Tung, IM | SCAQMD |
| Isabel Aguilar, STA | SCAQMD |
| Pat Krayser, STA | SCAQMD |
| Danielle Robinson | CARB |
| Mark Taylor | County of San Bernardino |
| Jon Leonard | GNA |
| Graciela Geyer | Sierra Club |
| Noel Muyco | SoCalGas |
| Susan Stark | Tesoro |

**Attachment 2**

PROPOSAL: Clean Fuels Program Draft 2016 Plan Update

SYNOPSIS: Every fall, staff has brought the Clean Fuels Program Draft Plan Update before the Board Technology Committee to solicit input on the proposed distribution of potential project funds for the upcoming year before requesting final approval for the Plan Update each year in early spring. Staff proposes continued support for a wide portfolio of technologies, but with particular emphasis on heavy-duty truck technologies with zero and near-zero emissions for goods movement applications to create a pathway towards achieving 2023 attainment as well as a continued focus on preparing for hydrogen vehicle deployments. This item was presented at the October 16, 2015 Technology Committee as a written report.

**Background**

Each calendar year, as required by legislation, the Clean Fuels Program Plan Update is revised to reflect technical priorities and proposed project areas for the upcoming year. As part of this process, every fall since 2007 staff has brought the Clean Fuels Program Draft Plan Update before the Board as a separate item to solicit input on the proposed distribution of potential project funds before requesting final approval each year in early spring. This has provided an opportunity for the Board to provide initial input, incorporate Board feedback as well as input from advisory groups, technical experts and other stakeholders and finally return in early spring to seek Board approval of the final Plan Update (concurrent with approval of the Annual Report).

For Calendar Year 2016, staff has prepared a Clean Fuels Program Draft 2016 Plan Update which proposes continued support for a wide portfolio of technologies. However, this Draft Update has particular emphasis on heavy-duty truck technologies with zero and near-zero emissions for goods movement applications to create a pathway towards achieving 2023 attainment, as well as a continued focus on preparing for hydrogen vehicle deployments. This emphasis not only aligns well with the SCAQMD's FY 2015-16 Goals and Priority Objectives, which includes continued development and demonstration of zero-emission goods movement technologies, but also begins to lay a pathway towards implementing the Air Quality Management Plan (AQMP) calling for a 65 percent reduction in NOx emissions by 2031, while leveraging funds from other state programs such as the Greenhouse Gas Reduction Fund Program.

**Proposal**
The attached Clean Fuels Program Draft Plan Update identifies potential projects to be considered for funding during 2016. The proposed projects reflect promising low-, near-zero and zero-emission technologies and applications that are emerging in different source categories. This update includes a number of proposed projects, not all of which are expected to be funded in the current fiscal year given the available budget. Some of the proposed projects for 2016 include but are not limited to: 1) development and demonstration of drayage trucks with all electric range; 2) medium- and heavy-duty fuel cell truck and bus development; 3) development and demonstration of advanced natural gas engines and zero emission technologies for high horsepower applications 4) further evaluation of biofuels including dimethyl ether; 5) partnering with national and university laboratories on in-use testing;; and 6) lease of fuel cell vehicles (FCVs) for use in Technology Advancement's demonstration fleet to promote marketability and demand of FCVs. Projects not funded in 2016 may be considered for funding in subsequent years.

In addition to identifying proposed projects to be considered for funding, this Draft Plan Update confirms nine key technical areas of highest priority to the SCAQMD. These high priority areas are listed below based on the proposed funding distribution shown in Figure 1:

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

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

Staff is developing a rating system or "dashboard" to summarize the viability of technologies and proposed solutions using criteria such as environmental and health benefits, economic sustainability and stakeholder support. The proposed rating system will be evaluated by the Board's Technology Committee, Clean Fuels Advisory Group,

the Technology Advancement Advisory Group and other technical experts and incorporated into the final 2016 Plan Update.

Figure 1 graphically depicts the potential distribution of SCAQMD Clean Fuels funds, based on projected program costs of $16.4 million for the nine project areas discussed previously. The expected actual project expenditures for 2016 will be less than the total projected program cost since not all projects will materialize. The target allocations are based on balancing technology priorities, technical challenges and opportunities discussed previously, and near-term versus long-term benefits with the constraints on available SCAQMD funding. Specific contract awards throughout 2016 will be based on this proposed allocation, the quality of proposals received and evaluation of projects against standardized criteria, and ultimately, the Board's approval. At that time, additional details will be provided about the technology, its application, the specific scope of work, the project team capabilities, and the project cost-sharing.

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

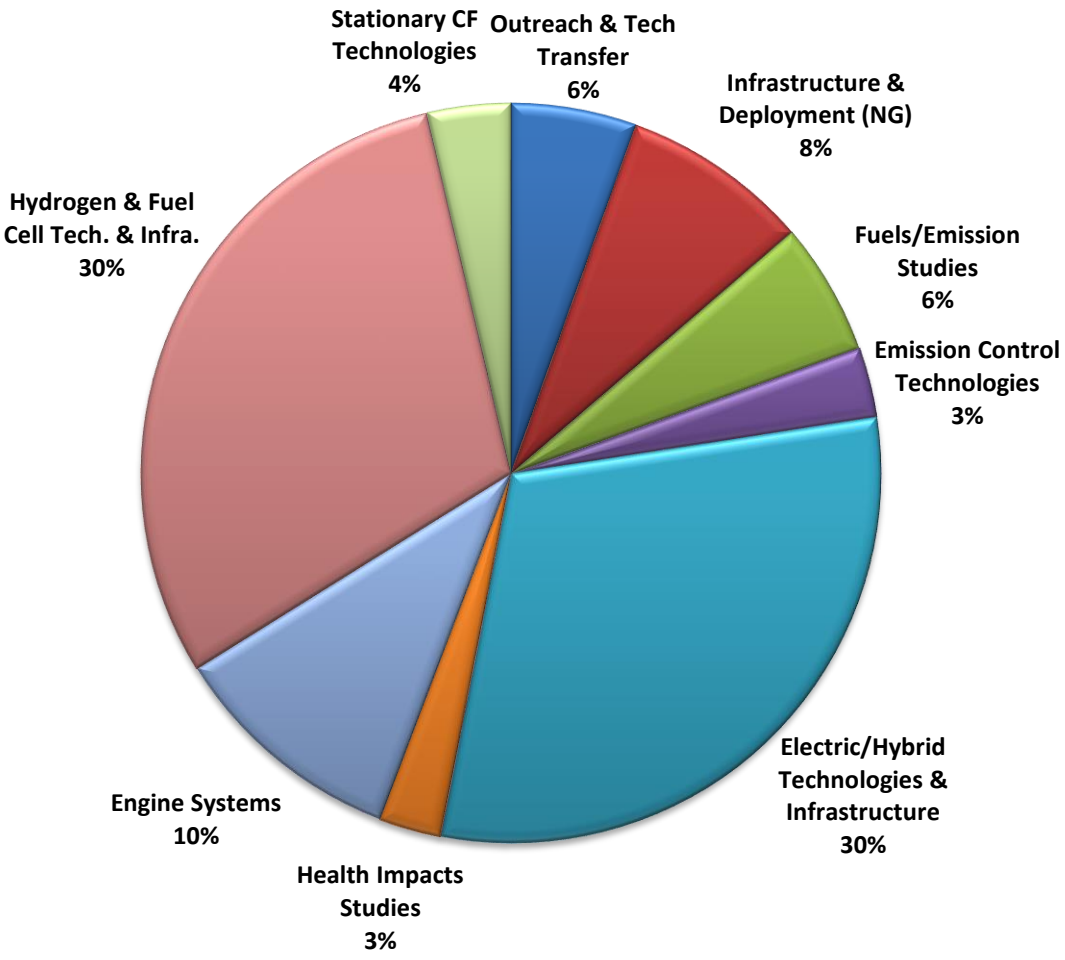


Figure 1: Projected Funding Distribution for Potential Projects in 2016 ($16.4M)

The proposed update has been the result of a comprehensive planning and review process, which will continue over the next few months as it is further refined before the Board considers adoption in early spring. This process includes consideration of the 2012 AQMP and its control measures along with the white papers and preliminary analysis prepared for the Draft 2016 AQMP, as well as CARB's recent draft discussion document "Mobile Source Strategy" (October 2015)[1]. The proposed update also incorporates coordination activities involving outside organizations including consideration of federal, state and local activities and proposed integrated solutions ranging from the Governor's Executive Orders and goals on electricity derived from renewable sources, petroleum reduction use in cars and trucks, and reduction of short-lived climate pollutants to CARB's Sustainable Freight Strategy to AB 32 Scoping Plan updates. As part of this process, staff hosted two advisory group meetings in January 2015 and September 2015 to solicit input from the Clean Fuels Advisory Group, the Technology Advancement Advisory Group and other technical experts. During these

[1] http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc_dd.pdf

advisory meetings, the participants reviewed current and proposed Technology Advancement projects as well as the proposed funding distribution for the Draft 2016 Plan Update and discussed near-term and long-term technologies as potential projects.

Discussions from the review process and advisory meetings, where appropriate, have been and will continue to be fashioned into project areas and included in this year's Plan Update as it is finalized. Additionally, staff regularly interacts with CARB, CEC, DOE, the California Fuel Cell Partnership, and other entities to solicit and incorporate technical areas for potential leveraged funding. Overall, the Draft Plan attempts to maintain flexibility to address dynamically evolving technologies and incorporate new research and data.

The major areas of focus are proposed in the following areas:

- Electric and hybrid technologies and infrastructure
- Hydrogen and fuel cell technology and infrastructure
- Near-zero emission engine systems
- Infrastructure and deployment

The relative changes in funding allocation are a result of opportunities to partner with other agencies on projects and studies, particularly the Greenhouse Gas Reduction Fund (GGRF) Program, to seek cost-sharing for heavy-duty truck projects. However, the Draft Update also continues a significant focus on hydrogen and fuel cell vehicles and infrastructure to meet the anticipated auto manufacturer roll out of fuel cell vehicles in 2016-2017.

Based on feedback from the Technology Committee, if the GGRF program award for zero-emission drayage trucks is not awarded to the SCAQMD, the proposed allocation in Figure 1 above will be revised to reflect a 25% allocation for Electric and Hybrid Technology and Infrastructure and a 35% allocation to Hydrogen and Fuel Cell Technology and Infrastructure.

There remains an urgency, in light of 2023 ambient air quality standards for ozone, on the need to develop and demonstrate heavy-duty all-electric, fuel cell, plug-in hybrid and hybrid technologies with all-electric range for zero and near-zero emission goods movement applications, including the infrastructure for such technologies. Notwithstanding, while this Draft Update reflects a modest decrease in anticipated funding for hydrogen and fuel cells in 2016, the emphasis on heavy-duty truck technologies with zero and near-zero emissions for goods movement applications continues to lay a pathway towards achieving 2023 attainment. Emphasis will be maintained on engine system development and demonstration and natural gas infrastructure and deployment to ensure a broad portfolio of technologies and leverage state and federal efforts.

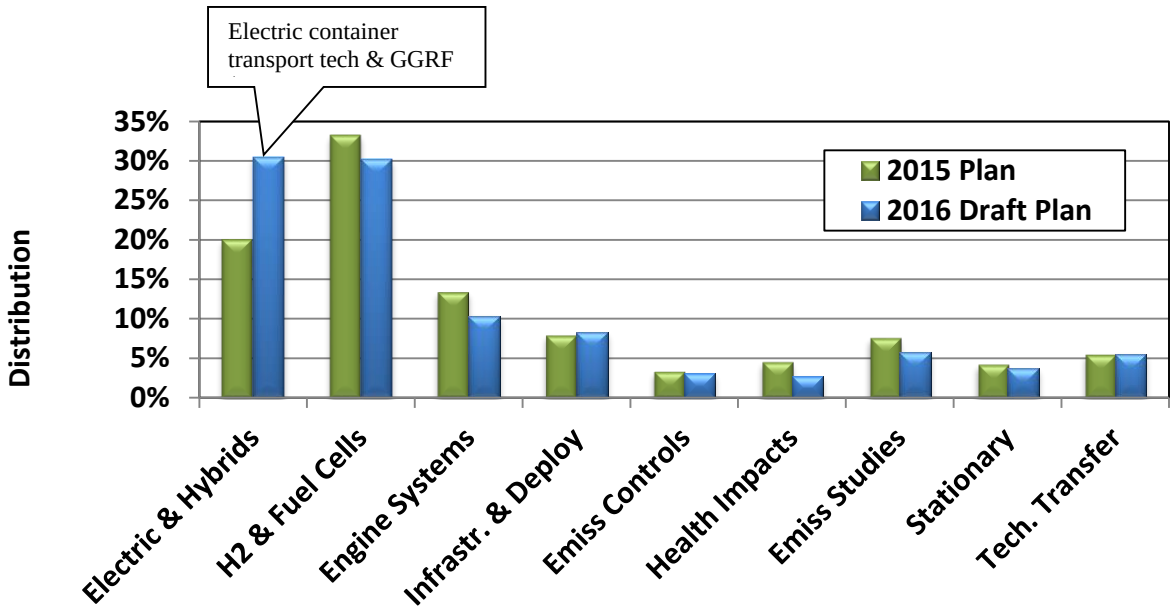


Figure 2: Plan Update Comparison

Based on communications with the organizations specified in H&SC Section 40448.5.1 and review of their programs, the projects proposed in this update do not appear to duplicate any past or present projects. As each individual project is recommended to the Board for funding, staff will continue to coordinate with these organizations to ensure that duplication is avoided and ensure optimal expenditure of Clean Fuels Program funds.

**Attachment**
Clean Fuels Program Draft 2016 Plan Update

# TECHNOLOGY ADVANCEMENT OFFICE
# CLEAN FUELS PROGRAM
# DRAFT 2016 PLAN UPDATE



South Coast Air Quality Management District
November 2015

# EXECUTIVE SUMMARY

## Introduction

The South Coast Air Quality Management District (SCAQMD) is the air pollution control agency for all of Orange County and the urban portions of Los Angeles, Riverside and San Bernardino counties. This region, which encompasses all of the South Coast Air Basin plus small portions of the Mojave Desert and Salton Sea Air Basins, historically experiences the worst air quality in the nation due to the natural geographic and atmospheric conditions of the region coupled with the high population density and associated mobile and stationary source emissions. Recognizing this challenge, in 1988 the state established the SCAQMD's Clean Fuels Program (Program), along with the SCAQMD's Technology Advancement Office (TAO). The Clean Fuels Program affords the SCAQMD the ability to fund the development, demonstration and accelerated deployment of clean fuels and transportation technologies.

For over 20 years, using funding received through a $1 motor vehicle registration fee, the Clean Fuels Program has encouraged, fostered and supported clean fuels and transportation technologies such as hydrogen and fuel cells, natural gas engines and infrastructure, battery electric vehicles, plug-in hybrid electric vehicles and related fueling infrastructure. A key strategy of the Program, which allows significant leveraging of the Clean Fuels funding, is its implementation as a public-private partnership in conjunction with private industry, technology developers, academic institutions, research institutions and government agencies. The SCAQMD Clean Fuels Program has traditionally supported a portfolio of technologies, in different stages of maturity, to provide a continuum of emission reductions and health benefits over time. This approach provides the greatest flexibility and optimizes the region's ability to achieve National Ambient Air Quality Standards (NAAQS).

Health & Safety Code (H&SC) 40448.5.1 requires the SCAQMD to annually prepare, and submit to the Legislative Analyst each year, a Clean Fuels Annual Report and Plan Update. The Clean Fuels Annual Report looks at what the Program accomplished in the prior calendar year (CY) and the Clean Fuels Plan Update looks ahead at proposed expenditures for the next CY, essentially re-calibrating the technical direction of the Program. This document currently comprises the Draft 2016 Plan Update for preliminary review and comment by SCAQMD's Governing Board, advisory groups, technical experts and other interested parties. It will be modified in early 2016 to encompass the 2015 Clean Fuels Annual Report and the final 2016 Plan Update, which are due to the Legislative Analyst by March 1, 2016.

The overall strategy of the SCAQMD's Clean Fuels Program is based in large part on technology needs identified through the Air Quality Management Plan (AQMP) process and the SCAQMD Board's directives to protect the health of residents in Southern California, which encompasses approximately 16.8 million people (nearly half the population of California). The AQMP is the long-term "blueprint" that defines:

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

The 2012 AQMP identified the need for 200 tons/day oxides of nitrogen ($NO_x$) reductions to be adopted by 2020 for full implementation by 2023 and in large part focused control measures on transportation technologies and cleaner fuels. These emission reduction needs are further identified in the California Air Resources Board's (CARB's) recent draft discussion document "Mobile Source Strategy" (October

2015)[1]. Moreover, the SCAQMD is currently only one of two regions in the nation recognized as an extreme ozone nonattainment area (the other is San Joaquin Valley). Ozone (smog) is created by a chemical reaction between $NO_x$ and volatile organic compound (VOC) emissions at ground level. This is especially noteworthy because the largest contributor to ozone is $NO_x$ emissions, and mobile sources (on- and off-road as well as aircraft and ships) contribute approximately 80 percent of the $NO_x$ emissions in this region. Furthermore, $NO_x$ emissions, along with VOC emissions, also lead to the formation of PM2.5 (particulate matter measuring 2.5 microns in size as contained in a cubic meter of air, expressed as micrograms per cubic meter ($\mu g/m^3$).

The 2016 AQMP, which is currently under development, will develop integrated strategies and measures to meet the following NAAQS:

- 8-hour Ozone (75 parts per billion or ppb) by 2032
- Annual PM2.5 (12 $\mu g/m^3$) by 2021-2015
- 8-hour Ozone (80 ppb) by 2024 (updated from the 2007 and 2012 AQMPs)
- 1-hour Ozone (120 ppb) by 2023 (updated from the 2012 AQMP)
- 24-hour PM2.5 (35 $\mu g/m^3$) by 2019 (updated from the 2012 AQMP)

The daunting challenge to reduce $NO_x$ and PM2.5 requires the Clean Fuels Program to encourage and accelerate advancement of transformative fuel and transportation technologies, leading the way for commercialization of progressively lower-emitting fuels and vehicles. It is projected that a 65% reduction in $NO_x$ is required to meet upcoming ozone standard deadlines. Given the relationship between $NO_x$, ozone and $PM_{2.5}$, the 2016 Plan Update must emphasize emission reductions in all these areas. However, the confluence of federal, state and local planning efforts on climate change, greenhouse gases (GHGs), air quality and other environmental areas should provide co-benefits that may help the region.

A few years ago, it became clear that the effect of containers through the Ports of Los Angeles and Long Beach and the subsequent movement of goods throughout the region not only have a dramatic impact on air quality but also the quality of life to the communities along the major goods movement corridors. In recognition of these impacts, the SCAQMD initiated a concerted effort to develop and demonstrate zero and near-zero emissions goods movement technologies, such as electric trucks, plug-in hybrid trucks with all-electric range, zero emission container transport technologies, trucks operating from wayside power including catenary technology and heavy-duty technologies. The prioritization of these types of projects is emphasized in this Draft 2016 Plan Update.

In the future years, the AQMP and this Plan will also consider the recently adopted lower national ambient air quality 8-hour ozone standard of 70 ppb, creating a greater need for implementation of zero-emission technologies in a broad range of sectors.

# 2016 Plan Update

Every year TAO staff re-evaluates the Clean Fuels Program to craft a Plan Update which essentially serves to re-calibrate the compass. The Program continually seeks to support the deployment of lower-emitting technologies. The design and implementation of the Program Plan must balance the needs in the various technology sectors with technology readiness, emissions reduction potential and co-funding opportunity. As the state and federal governments have turned a great deal of their attention to climate change, the SCAQMD has remained committed to developing, demonstrating and commercializing zero and near-zero emission technologies. Fortunately many, if not the majority, of technology sectors that address our need for $NO_x$ reductions also garner greenhouse gas (GHG) reductions. Due to these

[1] http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc_dd.pdf

"co-benefits," the SCAQMD has been successful in partnering with the state and federal government, which as noted allows the Clean Fuels Program to leverage its funding and achieve more for less.

To identify project or technology opportunities in which its available funding can make a significant difference in deploying progressively cleaner technologies in the Basin, the SCAQMD employs a number of outreach and networking activities. These activities range from intimate involvement with state and federal collaboratives, partnerships and industrial coalitions to issuing Program Opportunity Notices to essentially throw out a wide net to solicit project ideas and concepts and Requests for Information to determine the state of various technologies and what is needed to advance those technologies.

The overall strategy is based in large part on technology needs identified in the SCAQMD's AQMP and the SCAQMD Governing Board's directives to protect the health of residents in the Basin. The $NO_x$, VOC and PM emission sources of greatest concern are heavy-duty on-road vehicles, medium- and light-duty on-road vehicles and off-road equipment.

The Plan Update includes projects to develop, demonstrate and commercialize a variety of technologies, from near term to long term, that are intended to provide solutions to the emission control needs identified in the 2012 AQMP and white papers prepared for the Draft 2016 AQMP. Preliminary 2016 AQMP analysis indicates that a 50 percent reduction in NOx is required by 2023 with an additional 15 percent NOx reduction beyond 2023 levels by 2031. Given the need for these significant reductions over the next 8-16 year timeframe, mid- and longer-term alternative fuels, hybrid, electric and fuel cell based technologies are emphasized. Several of the technology areas of focus include:

- reducing emissions from port-related activities, such as cargo handling equipment and container movement technologies, including demonstration and deployment of zero emission cargo container movement systems;
- mitigating criteria pollutant increases from renewable fuels, such as low-blend ethanol and high-blend biodiesel;
- increased activities in electric, hybrid, battery and plug-in hybrid technologies across light-, medium- and heavy-duty platforms; and
- production of transportation fuels and energy from renewable biowaste sources.

Table 1 lists the potential projects across the nine core technologies identified in this report. Potential projects for 2016 total $16.4 million, with anticipated leveraging of more than $3 for every $1 of Clean Fuels funding for total project costs of more than $66 million. The proposed projects may also be funded by revenue sources other than the Clean Fuels Program, especially VOC and incentive projects.

# CLEAN FUELS PROGRAM
# 2016 PLAN UPDATE

The Clean Fuels Program (Program) was first created in 1988, along with the SCAQMD's Technology Advancement Office (TAO). Funding for the Program is received through a $1 motor vehicle registration fee. The Clean Fuels Program continually seeks to support the development and deployment of zero and near-zero emission technologies over a broad array of applications and spanning near- and long-term implementation. Planning has been and remains an ongoing activity for the Program, which must remain flexible to address evolving technologies as well as the latest progress in the state-of-technologies, new research areas and data.

Every year the SCAQMD re-evaluates the Clean Fuels Program based on the region's ongoing need for emissions reductions and develops a Plan Update for the upcoming calendar year (CY) targeting near-term projects to help achieve those reductions.

## Overall Strategy

The overall strategy of the SCAQMD's Clean Fuels Program is based primarily on technology needs identified through the AQMP process and the SCAQMD Board's directives to protect the health of residents in Southern California, which encompasses approximately 16.8 million people (nearly half the population of California). The AQMP is the long-term "blueprint" that defines:

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

The 2012 AQMP identified the need for 200 tons/day oxides of nitrogen ($NO_x$) reductions to be adopted by 2020 for full implementation by 2023 and in large part focuses control measures on transportation technologies and cleaner fuels. These emission reduction needs are further identified in CARB's recent draft discussion document "Mobile Source Strategy" (October 2015)Moreover, the SCAQMD is currently only one of two regions in the nation recognized as an extreme ozone nonattainment area (the other is San Joaquin Valley). Ozone (smog) is created by a chemical reaction between $NO_x$ and VOCs emissions at ground level. This is especially noteworthy because the largest contributor to ozone is $NO_x$ emissions, and mobile sources (on- and off-road as well as aircraft and ships) contribute to more than three-fourths of the $NO_x$ emissions in this region. Furthermore, $NO_x$ and VOC emissions also lead to the formation of PM2.5, particulate matter measuring 2.5 microns in size as contained in a cubic meter of air, expressed as micrograms per cubic meter ($\mu g/m^3$).

The 2016 AQMP, which is currently under development, will develop integrated strategies and measures to meet the following NAAQS:

- 8-hour Ozone (75 parts per billion or ppb) by 2032
- Annual PM2.5 (12 $\mu g/m^3$) by 2021-2015
- 8-hour Ozone (80 ppb) by 2024 (updated from the 2007 and 2012 AQMPs)
- 1-hour Ozone (120 ppb) by 2023 (updated from the 2012 AQMP)
- 24-hour PM2.5 (35 $\mu g/m^3$) by 2019 (updated from the 2012 AQMP)

The daunting challenge to reduce $NO_x$ and PM2.5 require the Clean Fuels Program to encourage and accelerate advancement of transformative fuel and transportation technologies, leading the way for

commercialization of progressively lower-emitting fuels and vehicles. It is projected that a 65% reduction in $NO_x$ is required. The $NO_x$ and VOC emission sources of greatest concern to this region are heavy-duty on-road and off-road vehicles as well as to a lesser extent light- and medium-duty on-road vehicles. To underscore this concern, the 2013 Vehicle Technologies Market Report[2], released in early 2014 by the Oak Ridge National Laboratory for the Department of Energy, and corroborated by EMFAC 2011 projections, notes that Class 8 trucks comprise 41% of the medium- and heavy-duty truck fleet but consume 78% of the fuel use in this sector. This is especially significant since the report also notes that Class 8 truck sales have continued to increase significantly since 2009. Given the relationship between $NO_x$, ozone and $PM_{2.5}$, the Draft 2016 Plan Update must emphasize emission reductions in all these areas.

A few years ago, it became increasingly clear that the effect of containers being moved through the Ports of Los Angeles and Long Beach and the subsequent movement of goods throughout the region not only have a dramatic impact on air quality but also the quality of life to the communities along the major goods movement corridors. In recognition of these impacts, the SCAQMD initiated a concerted effort to develop and demonstrate zero and near-zero emissions' goods movement technologies, such as electric trucks, plug-in hybrid trucks with all-electric range, zero emission container transport technologies, trucks operating from wayside power including catenary technology and heavy-duty technologies. The preliminary findings from the Multiple Air Toxics Exposure Study (MATES) IV[3], which included local scale studies near large sources such as ports and freeways, reinforce the importance of these impacts and the need for transformative transportation technologies, especially near the ports and goods movement corridor.

For over 20 years, a key strategy of the Clean Fuels Program has been its implementation as a public-private partnership in conjunction with private industry, technology developers, academic institutions, research institutions and government agencies. This public-private partnership has allowed the Program to leverage its funding with $3-$4 of spending on R&D projects to every $1 of SCAQMD funds.

As the state and federal governments have turned a great deal of their attention to climate change, the SCAQMD has remained committed to developing, demonstrating and commercializing zero and near-zero emission technologies. Fortunately many, if not the majority, of technology sectors that address our need for $NO_x$ reductions also garner greenhouse gas (GHG) reductions. Due to these "co-benefits," we have been successful in partnering with the state and federal grants.

# Funding Scope

This 2016 Plan Update includes projects to develop, demonstrate and commercialize a variety of technologies, from near-term to long-term, that are intended to provide solutions to the emission control measures identified in the 2012 AQMP and in white papers and preliminary analysis prepared for the Draft 2016 AQMP and to address the increasing challenges this region is facing to meet air quality standards, including:

1) new and changing federal requirements, such as the recently adopted lower federal 8-hour ozone standard of 70 ppb;
2) implementation of new technology measures; and
3) continued development of economically sound compliance approaches.

The scope of projects in the Draft 2016 Plan Update also needs to remain sufficiently flexible to address new challenges and proposed methodologies that are identified in the 2012 AQMP and Draft 2016

[2] http://cta.ornl.gov/vtmarketreport/index.shtml

[3] http://www.aqmd.gov/home/library/air-quality-data-studies/health-studies/mates-iv

AQMP, consider dynamically evolving technologies, and incorporate new research and data. The latter, for example, includes the findings from the MATES IV study, which was undertaken to update the emissions inventory of toxic air contaminants, measure the concentration of ultrafine particles and black carbon (an indicator of diesel particulate emissions), and conduct a regional modeling effort to characterize risk to health across the Basin.

Finally, the co-benefits of technologies should also be considered in light of the increasing call for action by the federal government and California's Governor to reduce carbon and greenhouse gases. These actions include President Obama's Climate Action Plan released in June 2013. But more recently and significantly to this region are Governor Brown's actions including: 1) his Executive Order issued this spring setting a new interim goal to reduce GHGs 40 percent below 1990 levels by 2030, the most ambitious target in North America; 2) his recent remarks outlining goals to reduce black carbon by 50 percent (and methane and hydrofluorocarbons or HFCs by 40 percent) below current levels by 2030; and 3) his state-of-the-state address in January this year which included increasing the amount of electricity generated from renewable sources from 33 to 50 percent as well as reducing the use of petroleum in cars and trucks by up to 50 percent from today's levels. Notably, SB 350 (De León), which is pending signature by the Governor, would have codified the Governor's goals outlined in his January 2015 inaugural address, but was amended to remove the 50 percent reduction of petroleum use in cars and trucks. The bill, if signed into law, will still dramatically reshape California's energy economy, and the Governor has noted his office still has the authority to reduce oil use in vehicles without the bill.

The Clean Air Act, in addition to providing for specific control measures based on known technologies and control methods, has provisions for more general measures based on future, yet-to-be-developed technologies. These "black box" measures are provided under Section 182(e)(5) of the Clean Air Act for regions that are extreme non-attainment areas, such as the South Coast Basin. In the past, some of the technologies that have been developed and demonstrated in the Clean Fuels Program may have served as control measures for the "black box." However, the Draft 2016 AQMP calls for elimination on the reliance of these "black box" (future technologies) to the maximum extent possible.

Within the core technology areas defined later in this section, there exists a range of projects that represent near-term to long-term efforts. The SCAQMD Clean Fuels Program tends to support development, demonstration and technology commercialization efforts, or deployment, rather than fundamental research. The general time-to-product for these efforts, from long-term to near-term, is described below.

- Most technology *development* projects are expected to begin during 2016 with durations of about two years. Additional field demonstrations to gain long-term verification of performance, spanning up to two years, may also be needed prior to commercialization. Certification and ultimate commercialization would be expected to follow. Thus, development projects identified in this plan are expected to result in technologies ready for commercial introduction as soon as 2018. Projects are also proposed that may involve the development of emerging technologies that are considered longer term and, perhaps higher risk, but with significant emission reduction potential. Commercial introduction of such long-term technologies would not be expected until 2020 or later.

- More mature technologies, those ready to begin field *demonstration* in 2016, are expected to result in a commercial product in the 2017-2018 timeframe. Technologies being field demonstrated generally are in the process of being certified. The field demonstrations provide a controlled environment for manufacturers to gain real-world experience and address any end-user issues that may arise prior to the commercial introduction of the technology. Field demonstrations provide real-world evidence of a technology's performance to help allay any concerns by potential early adopters.

- *Deployment* or technology commercialization efforts focus on increasing the utilization of clean technologies in conventional applications. It is often difficult to transition users to a non-traditional technology or fuel, even if such a technology or fuel offers significant societal benefits.

As a result, in addition to government's role to reduce risk by funding technology development and testing, one of government's roles is to support and offset any incremental cost through incentives to help accelerate the transition and use of the cleaner technology. The increased use and proliferation of these cleaner technologies often depends on this initial support and funding as well as efforts intended to increase confidence of stakeholders that these technologies are real, cost-effective in the long term and will remain applicable.

# Core Technologies

As previously noted, the SCAQMD Clean Fuels Program maintains flexibility to address dynamically evolving technologies incorporating the latest state-of-the-technology progress. Over the years, the SCAQMD has provided funding for projects for a wide variety of low and zero emission projects. In order to meet the upcoming 2023 8-hour ozone standard, the areas of zero and near-zero emission technologies need to be emphasized. The working definition of "near-zero" is an order of magnitude lower than the existing 0.2 g/bhp-hr $NO_x$ or 0.02 g/bhp-hr $NO_x$, close to a combined cycle powerplant emissions rate. This effort can be seen in the following sections and in the proposed funding distribution in Figure 1 (page 10). The major core technology areas are identified below with specific project categories discussed in more detail in the following sections. The core technology areas identified reflect the staff's forecast for upcoming projects and needs within the basin but is not intended to be considered a budget.

Not all project categories will be funded due to cost-share constraints, and focus will be on the control measures identified in the 2012 AQMP and potentially the Draft 2016 AQMP, with consideration for availability of suitable projects. The technical areas identified below are clearly appropriate within the context of the current air quality challenges and opportunities for technology advancement. Within these areas there is significant opportunity for SCAQMD to leverage its funds with other funding agencies to expedite the implementation of cleaner alternative technologies in the Basin. A concerted effort is continually made to form private partnerships to leverage Clean Fuels funds. For example, staff anticipates there will be upcoming opportunities to leverage state funding through the California Clean Truck, Bus and Off-Road Vehicle and Equipment Technology Program (created by SB 1204, chaptered in September 2014), which designates money from the state's cap-and-trade program for development, demonstration and early commercialization of zero and near-zero emission truck, bus and off-road vehicles, and the Low Carbon Transportation Greenhouse Gas Emission Reduction Fund, which includes funding for zero-emission drayage trucks and truck and bus pilot projects, especially in disadvantaged communities.

It should be noted, therefore, that these priorities may shift during the year in keeping with the diverse and flexible "technology portfolio" approach. Changes in priority may occur to: (1) capture opportunities such as cost-sharing by the state government, the federal government, or other entities; or (2) address specific technology issues which affect residents within the SCAQMD's jurisdiction.

The following nine core technology areas are listed by current SCAQMD priorities based on the goals for 2016.

## *Electric/Hybrid Technologies & Infrastructure*

If the region hopes to meet the federal standards for $PM_{2.5}$ and ozone, a primary focus must be on zero and near-zero emission technologies. A leading strategy to achieve these goals is the wide-scale implementation of electric drive systems for all applicable technologies. With that in mind, the SCAQMD seeks to support projects to address the main concerns regarding cost, battery lifetime, travel range, charging station infrastructure and manufacturer commitment. Integrated transportation systems can encourage further reduction of emissions by matching the features of electric vehicles (zero emissions, zero start-up emissions, modest range) to typical consumer demands for mobility by linking them to transit. Additionally, the impact of fast charging on battery life and infrastructure costs is still evolving.

The development and deployment of zero emission goods movement systems remains one of the top priorities for the SCAQMD to support a balanced and sustainable growth in the port complex. The SCAQMD continues to work with our regional partners, in particular the Ports of Los Angeles and Long Beach, the Southern California Association of Governments (SCAG) and Los Angeles County Metropolitan Transportation Association (LACMTA) to identify technologies which could be beneficial to and garner support from all stakeholders. Specific technologies include zero emission trucks (using batteries and/or fuel cells), near-zero emission trucks with all-electric range using wayside power (catenary or roadbed electrification) or with plug-in hybrid powertrains, locomotives with near-zero emissions (e.g., 90% below Tier 4), electric locomotives using battery tender cars and catenary, and linear synchronous motors for locomotives and trucks. In fact, last year, the California Cleaner Freight Coalition, in a report entitled *Moving California Forward: Zero and Low-Emissions Freight Pathways*[4] pointed out that the short distances between freight hubs make electrification a viable option for local freight haul heavy-duty trucks, and in some cases, for on-dock rail which could eliminate some local freight truck trips altogether.

There is a high level of interest from major automobile manufacturers for hybrid-electric technologies in light-, medium- and heavy-duty applications as well as off-road equipment. In particular, there are increasing numbers of diesel- and gasoline-fueled hybrid-electric vehicles and multiple models of light-duty plug-in hybrid and battery electric vehicles (BEVs). Such vehicles offer the benefits of higher fuel economy and range, as well as lower emissions. Hybrid electric technology is not limited to gasoline and diesel engines and can be coupled with natural gas engines (including natural gas engines operating on renewable natural gas), microturbines and fuel cells for further emission benefits. Additionally, continued advancements in the light-duty arena which, while there is commercially available product, is not yet mainstream technology, may have applications for medium- and heavy-duty vehicles. In fact, the goal of SB 1275 (de León), chaptered in September 2014 establishing the Charge Ahead California Initiative, is to bring one million zero and near-zero emission electric vehicles to California by 2023 as well as to ensure that disproportionally impacted communities benefit from this transition toward cleaner transportation.

Opportunities to develop and demonstrate technologies that could enable expedited widespread use of electric and hybrid-electric vehicles in the Basin include the following:

- development and demonstration of hybrid and electric technologies for goods movement, e.g., series hybrids with all electric range or plug-in hybrid powertrains and trolley trucks on catenary wayside power;
- evaluation and demonstration of light-, medium- and heavy-duty plug-in hybrid electric vehicles;
- development and demonstration of CNG hybrid vehicle;
- demonstration of full performance and niche application battery electric vehicles;
- demonstration of integrated programs that make best use of electric drive vehicles through interconnectivity between fleets of electric vehicles and mass transit, and web-based reservation systems that allow multiple users;
- demonstration of heavy-duty battery electric vehicles;
- demonstration of heavy-duty hybrid vehicles including hydraulic and series hybrid concepts;
- development of streamlined implementation procedures to prepare and accelerate EV market penetration and commercialization; and
- demonstration and installation of EV infrastructure to support the electric and hybrid-electric vehicle fleets currently on the roads or soon entering the market, and to reduce cost, improve convenience and integrate with renewable energy and building demand management strategies (e.g., vehicle-to-grid or vehicle-to-building functionality).

[4] http://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_vehicles/Moving-California-Forward-Executive-Summary.pdf

## *Hydrogen & Fuel Cell Technologies & Infrastructure*

The SCAQMD supports hydrogen infrastructure and fuel cell technologies as one option in our technology portfolio and is dedicated to assisting federal and state government programs to deploy fuel cell vehicles (FCVs) by supporting the required refueling infrastructure.

In mid-2014 the California Fuel Cell Partnership (CaFCP), with which the SCAQMD works closely as a participating member to further commercialization of fuels cells for transportation and install the required infrastructure, published the Hydrogen Progress, Priorities and Opportunities (HyPPO)[5]. The HyPPO builds upon CaFCP's 2012 roadmap describing the first network of commercial hydrogen stations in California, which calls for 68 hydrogen fueling stations in cluster communities at specific destinations by 2016. Using $20 million annual funding established by AB 8, CEC funding awards over the last three years, along with support from SCAQMD, have made significant inroads to creating a growth path to 100 hydrogen stations, the state's current goal for launching a commercially self-sustaining network to support a growing number of fuel cell vehicles to implement the state's ZEV Action Plan. Additional support to encourage renewable hydrogen will be needed. For 2015-2016 the CaFCP is developing a medium-/heavy-duty action plan in coordination with multiple members.

Calendar Years 2015-2017 are a critical timeframe for the introduction of FCVs. In fact, several automakers (e.g., Toyota and Honda) are scheduled to release products in 2015-2016, with Hyundai being the first to already offer a FCV for lease in 2014. Since stations need 18-36 month lead times for permitting, construction and commissioning, plans for stations need to be implemented now. While coordination efforts with the Division of Measurement Standards to establish standardized measurements for hydrogen fueling started in 2014, additional efforts to offer hydrogen for sale to general consumers are still needed. In addition, new business models and funding besides grants for construction need to be explored to enable the station operations to remain solvent during the early years until vehicle numbers ramp up.

Commencing late 2012, the CEC, which based its AB 118 hydrogen funding strategy on CaFCP's roadmap and the University of California, Irvine's Advanced Power and Energy Program, has issued multiple Program Opportunity Notices for hydrogen fuel infrastructure and to date has awarded funding for 48 new hydrogen fueling stations plus operation and maintenance grants for a few of the original older stations. Additionally, the SCAQMD is currently implementing a $6.7 million CEC grant awarded in 2013 to upgrade and refurbish four of the existing hydrogen fueling stations to ensure legacy stations continue operation as FCVs become available in the market. In 2014 the SCAQMD also received an award of $300,000 from CEC to implement a plan for hydrogen readiness in early market communities and that effort is currently underway. The SCAQMD will work closely with state agencies to implement these programs and continue efforts to upgrade and refurbish existing hydrogen infrastructure.

The 2016 Plan Update identifies key opportunities while clearly leading the way for pre-commercial demonstrations of original equipment manufacturer (OEM) vehicles. Future projects may include the following:

- continued development and demonstration of distributed hydrogen production and fueling stations, including energy stations with electricity and hydrogen co-production and higher pressure (10,000 psi) hydrogen dispensing;
- development and demonstration of cross-cutting fuel cell applications (e.g. plug-in hybrid fuel cell vehicles);
- development and demonstration of fuel cells in off-road, locomotive and marine applications;
- demonstration of fuel cell vehicles in controlled fleet applications in the Basin; and

[5] http://cafcp.org/sites/default/modules/pubdlcnt/pubdlcnt.php?file=http://cafcp.org/sites/files/Roadmap-Progress-Report2014-FINAL.pdf&nid=2560

- development and implementation of strategies with government and industry to build participation in the hydrogen market including certification and testing of hydrogen as a commercial fuel to create a business case for investing.

## *Engine Systems*

Natural gas engines are experiencing huge market growth due to the low cost of fuel. In order to achieve the emission reductions required for the South Coast Air Basin, the internal combustion engines (ICEs) used in the heavy-duty sector will require emissions of 90% lower than the 2010 standards. Future projects will support the development, demonstration and certification of engines that can achieve these massive emissions reductions using an optimized systems approach. Specifically, these projects are expected to target the following:

- development of ultra-low emissions natural gas engines for heavy-duty vehicles and high horsepower applications;
- continued development and demonstration of alternative fuel medium-duty and heavy-duty engines and vehicles;
- development and demonstration of alternative fuel engines for off-road applications;
- evaluation of alternative engine systems such as opposed piston ICEs and hydraulic plug-in hybrid vehicles; and
- development and demonstration of engine systems that employ advance fuel or alternative fuels, engine design features, improved exhaust or recirculation systems, and aftertreatment devices.

## *Infrastructure and Deployment (Natural Gas)*

The importance of natural gas and related refueling infrastructure cannot be overemphasized for the realization of large deployment of alternative fuel technologies. Significant demonstration and commercialization efforts funded by the Clean Fuels Program as well as other local, state and federal agencies are underway to: 1) support the upgrade and buildup of public and private infrastructure projects, 2) expand the network of public-access and fleet fueling stations based on the population of existing and anticipated vehicles, and 3) put in place infrastructure that will ultimately be needed to accommodate transportation fuels with very low gaseous emissions.

Compressed and liquefied natural gas (CNG and LNG) refueling stations are being positioned to support both public and private fleet applications. Upgrades and expansions are also needed to refurbish or increase capacity for some of the stations installed five or more years ago as well as standardize fueling station design, especially to ensure growth of alternative fuels throughout the South Coast Air Basin and beyond. Funding has been provided at key refueling points for light-, medium- and heavy-duty natural gas vehicle users traveling from the local ports, along I-15 and The Greater Interstate Clean Transportation Corridor (ICTC) Network. If signed into law, SB 350 (De León) would establish a target to double the energy efficiency in electricity and natural gas end uses by 2030.

Active participation in the development of National Fire Protection Association (NFPA) fire and safety codes and standards, evaluation of the cost and economics of the new fuels, public education and training and emergency response capability are just a few areas of the funded efforts that have overcome public resistance to these new technologies. Some of the projects expected to be developed and co-funded for infrastructure development are:

- development and demonstration of renewable natural gas as a vehicle fuel from renewable feedstocks and biowaste;
- development and demonstration of advanced, cost effective methods for manufacturing synthesis gas for conversion to renewable natural gas;
- enhancement of safety and emissions reduction from LNG refueling equipment;
- expansion of fuel infrastructure, fueling stations, and equipment; and

- expansion of infrastructure connected with existing fleets, public transit, and transportation corridors.

## *Emissions, Fuels and Health Impacts Studies*

The monitoring of pollutants in the Basin is extremely important, especially when focused on (1) a particular sector of the emissions inventory (to identify the responsible technology) or (2) exposure to pollution (to assess the potential health risks). Recent studies indicate that smoggy areas can produce irreversible damage to children's lungs. This information highlights the need for further emissions and health studies to identify the emissions from high polluting sectors as well as the health effects resulting from these technologies.

Over the past few years, the SCAQMD has funded emission studies to evaluate the impact of tailpipe emissions of biodiesel and ethanol fueled vehicles mainly focusing on criteria pollutants and greenhouse gas (GHG) emissions. These studies showed that biofuels, especially biodiesel, can contribute to higher $NO_x$ emissions while reducing other criteria pollutant emissions. Furthermore, despite recent advancements in toxicological research related to air pollution, the relationship between particle chemical composition and health effects is still not completely understood, especially for biofuels. Therefore, a couple of years ago the SCAQMD funded studies to investigate the physical and chemical composition and toxicological potential of tailpipe PM emissions from biodiesel and ethanol fueled vehicles to better understand their impact on public health. Studies have continued in 2014 to further investigate the toxicological potential of emissions, such as ultrafine particles and vapor phase substances, and to determine whether or not other substances such as volatile or semi-volatile organic compounds are being emitted in lower mass emissions that could pose harmful health effects.

In recent years, there has also been an increased interest both at the state and national level on the use of alternative fuels including biofuels to reduce petroleum oil dependency, GHG emissions and air pollution. In order to sustain and increase biofuel utilization, it is essential to identify feedstocks that can be processed in a more efficient, cost-effective and sustainable manner. One such fuel that the Clean Fuels Program is interested in pursuing is dimethyl ether (DME). This synthetic fuel can be made from renewable natural gas resources and has characteristics similar to gas-to-liquids fuels, i.e., high cetane, zero aromatics and negligible emissions of particulate matter. Volvo has announced they will commercialize class 8 trucks using DME in 2015, and staff would like to ensure these trucks have lower $NO_x$ than the existing standard. A study in 2015-2016 timeframe on DME is being proposed.

Some areas of focus include:

- demonstration of remote sensing technologies to target different high emission applications and sources;
- studies to identify the health risks associated with ultrafine and ambient particulate matter including their composition to characterize their toxicity and determine specific combustion sources;
- in-use emissions studies using biofuels including DME to evaluate in-use emission composition;
- in-use emissions studies to determine the impact of new technologies, in particular PEVs on local air quality as well as the benefit of telematics on emissions reduction strategies;
- lifecycle energy and emissions analyses to evaluate conventional and alternative fuels; and
- analysis of fleet composition and their associated impacts.

## *Stationary Clean Fuel Technologies*

Although stationary source emissions are small compared to mobile sources in the South Coast Air Basin, there are areas where cleaner fuel technology can be applied to reduce $NO_x$, VOC and PM emissions. For example, inspections suggest there is a large population of small ICE generators within the Basin that are operating outside their permit limits due to poor maintenance, deliberate tuning for

different performance, operation outside equipment design or changes in fuel quality. Cleaner, more robust distributed generation technologies exist that could be applied to not only improve air quality, but enhance power quality and reduce electricity distribution congestion.

The use of renewable feedstocks for energy production is a viable and necessary strategy to provide sustainable power for future needs while reducing greenhouse gas emissions and achieving domestic energy diversity. One of the projects that the SCAQMD recently supported in this effort was a bench scale demonstration project using a steam hydrogasification process to produce natural gas from biomass and biosolid (sewage sludge) feedstocks. Steam Hydrogasification Reaction (SHR) has been developed to produce various forms of energy products from carbonaceous resources. SHR is capable of handling wet feedstocks like sludge, does not require expensive oxygen plants and has been demonstrated to be most efficient and cost-effective compared to other conventional gasification technologies. This project successfully demonstrated that the SHR process coupled with a water-gas shift (WGS) reactor can produce natural gas containing up to 90% methane.

Additionally, alternative energy storage could be achieved through vehicle to grid or vehicle to building technologies. The University of California Riverside's Sustainable Integrated Grid Iniitiative, funded in part by the SCAQMD and launched in 2014, for example could assist in the evaluation of these technologies. Projects conducted under this category may include:

- development and demonstration of reliable, low emission stationary technologies (e.g., low $NO_x$ burners, fuel cells or microturbines);
- exploration of renewables as a source for cleaner stationary technologies;
- evaluation, development and demonstration of advanced control technologies for stationary sources; and
- vehicle-to-grid or vehicle-to-building demonstration projects to develop sustainable, low emission energy storage alternatives

## *Emission Control Technologies*

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

- evaluation and demonstration of new emerging liquid fuels, including alternative and renewable diesel and GTL fuels;
- development and demonstration of advanced aftertreatment technologies for mobile applications (including diesel particulate traps and selective catalytic reduction catalysts);
- development and demonstration of low-VOC and PM lubricants for diesel and natural gas engines; and

## *Outreach and Technology Transfer*

Since the value of the Clean Fuels Program depends on the deployment and adoption of the demonstrated technologies, outreach and technology transfer efforts are essential to its success. This core area encompasses assessment of advanced technologies, including retaining outside technical assistance as needed, efforts to expedite the implementation of low emission and clean fuels technologies, coordination of these activities with other organizations and information dissemination

to educate the end user. Technology transfer efforts include support for various clean fuel vehicle incentive programs as well.

# Target Allocations to Core Technology Areas

Figure 1 below presents the potential allocation of available funding, based on SCAQMD projected program costs of $16.4 million for all potential projects. The expected actual project expenditures for 2016 will be less than the total SCAQMD projected program cost since not all projects will materialize. The target allocations are based on balancing technology priorities, technical challenges and opportunities discussed previously and near-term versus long-term benefits with the constraints on available SCAQMD funding. Specific contract awards throughout 2016 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.

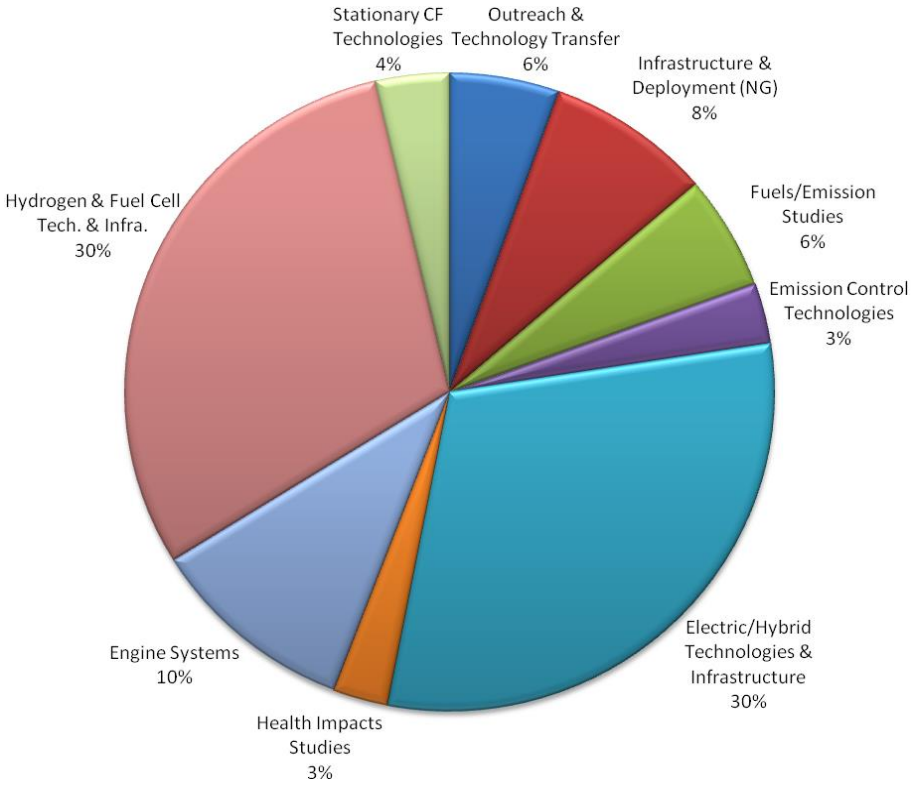


**Figure 1: Projected Cost Distribution for Potential SCAQMD Projects in 2016 ($16.4M)**

# PROGRAM PLAN UPDATE FOR 2016

This section presents the Clean Fuels Program Plan Update for 2016. The proposed projects are organized by program areas and described in further detail, consistent with the SCAQMD budget, priorities and the best available information on the state-of-the-technology. Although not required, this Plan also includes proposed projects that may be funded by revenue sources other than the Clean Fuels Program, specifically related to VOC and incentive projects.

Table 1 summarizes potential projects for 2016 as well as the distribution of SCAQMD costs in some areas as compared to 2015. The funding allocation continues the focus toward development and demonstration of zero and near-zero emission technologies including the infrastructure for such technologies. For the Draft 2016 Plan, the SCAQMD returns to an emphasis on electric and hybrid-electric technologies in order to take advantage of funding opportunities afforded by the Greenhouse Gas Reduction Fund Program and the need to continue electrifying goods movement technologies. Focus will continue concurrently on hydrogen and fuel cells given sustained activities by federal and state government and the anticipated roll out of fuel cell vehicles in 2016-2017. A small funding shift to Infrastructure and Deployment is also recommended, with modest decreases in other areas given awards over the last year or two. As in prior years, the funding allocations again align well with the SCAQMD's FY 2015-16 Goals and Priority Objectives. Overall, the Program is designed to ensure a broad portfolio of technologies and leverage state and federal efforts.

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

## Funding Summary of Potential Projects

The remainder of this section contains the following information for each of the potential projects summarized in Table 1 (page 13).

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

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

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

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

**Potential Air Quality Benefits:** A brief discussion of the expected benefits of the proposed project, including the expected contribution towards meeting the goals of the AQMP, as required by H&SC 40448.5.1.(a)(1). In general, the most important benefits of any technology research, development and demonstration program are not necessarily realized in the near term. Demonstration projects are

generally intended to be proof-of-concept for an advanced technology in a real-world application. While emission benefits, for example, will be achieved from the demonstration, the true benefits will be seen over a longer term, as a successfully demonstrated technology is eventually commercialized and implemented on a wide scale.

**Table 1: Summary of Potential Projects for 2016**

| Proposed Project | Expected SCAQMD Cost $ | Expected Total Cost $ |
|---|---|---|
| **Electric/Hybrid Technologies & Infrastructure** | | |
| Demonstrate Light-Duty Plug-In Hybrid & Battery Electric Vehicles and Infrastructure | 700,000 | 1,500,000 |
| Develop and Demonstrate Medium- and Heavy-Duty Hybrid Vehicles and Infrastructure | 2,000,000 | 6,000,000 |
| Demonstrate Alternative Energy Storage | 300,000 | 2,000,000 |
| Develop and Demonstrate Electric Container Transport Technologies | 2,000,000 | 6,000,000 |
| Subtotal | $5,000,000 | $15,500,000 |
| **Hydrogen and Fuel Cell Technologies and Infrastructure** | | |
| Develop and Demonstrate Operation and Maintenance Business Case Strategies for Hydrogen Stations | 350,000 | 4,000,000 |
| Develop and Demonstrate Distributed Hydrogen Production and Fueling Stations | 1,500,000 | 5,000,000 |
| Develop and Demonstrate Medium- and Heavy-Duty Fuel Cell Vehicles | 3,000,000 | 10,000,000 |
| Demonstrate Light-Duty Fuel Cell Vehicles | 100,000 | 100,000 |
| Subtotal | $4,950,000 | $19,100,000 |
| **Engine Systems** | | |
| Develop and Demonstrate Advanced Alternative Fuel Medium- and Heavy-Duty Engines and Vehicles | 1,500,000 | 3,000,000 |
| Develop and Demonstrate Alternative Fuel and Clean Conventional Fueled Light-Duty Vehicles | 200,000 | 1,500,000 |
| Subtotal | $1,700,000 | $4,500,000 |
| **Infrastructure and Deployment (NG)** | | |
| Deploy Natural Gas Vehicles in Various Applications | 500,000 | 2,000,000 |
| Develop, Maintain & Expand Natural Gas Infrastructure | 350,000 | 2,000,000 |
| Demonstrate Natural Gas Manufacturing and Distribution Technologies Including Renewables | 500,000 | 7,000,000 |
| Subtotal | $1,350,000 | $11,000,000 |
| **Fuels/Emission Studies** | | |
| In-Use Emissions Studies for Advanced Technology Vehicle Demonstrations | 300,000 | 800,000 |
| Conduct Emissions Studies on Biofuels and Alternative Fuels | 400,000 | 1,000,000 |

Table 1: Summary of Potential Projects for 2016 **(cont'd)**

| Proposed Project | Expected SCAQMD Cost $ | Expected Total Cost $ |
|---|---|---|
| **Fuels/Emission Studies (cont'd)** | | |
| Identify and Demonstrate In-Use Fleet Emissions Reduction Technologies & Opportunities | 250,000 | 2,000,000 |
| Subtotal | $950,000 | $3,800,000 |
| **Stationary Clean Fuel Technologies** | | |
| Develop and Demonstrate Reliable, Low Emission Monitoring Systems and Test Methods | 150,000 | 500,000 |
| Develop and Demonstrate Clean Stationary Technologies | 250,000 | 750,000 |
| Develop and Demonstrate Renewables-Based Energy Generation Alternatives | 200,000 | 1,000,000 |
| Subtotal | $600,000 | $2,250,000 |
| **Emission Control Technologies** | | |
| Develop and Demonstrate Advanced Aftertreatment Technologies | 300,000 | 5,000,000 |
| Demonstrate On-Road Technologies in Off-Road and Retrofit Applications | 250,000 | 1,000,000 |
| Subtotal | $550,000 | $6,000,000 |
| **Health Impacts Studies** | | |
| Evaluate Ultrafine Particle Health Effects | 150,000 | 2,000,000 |
| Conduct Monitoring to Assess Environmental Impacts | 150,000 | 500,000 |
| Assess Sources and Health Impacts of Particulate Matter | 150,000 | 300,000 |
| Subtotal | $450,000 | $2,800,000 |
| **Outreach and Technology Transfer** | | |
| Assessment and Technical Support of Advanced Technologies and Information Dissemination | 500,000 | 800,000 |
| Support for Implementation of Various Clean Fuels Vehicle Incentive Programs | 400,000 | 400,000 |
| Subtotal | $900,000 | $1,200,000 |
| **TOTALS FOR POTENTIAL PROJECTS** | **$16,400,000** | **$66,150,000** |

# Technical Summaries of Potential Projects

## *Electric/Hybrid Technologies & Infrastructure*

**Proposed Project:** Demonstrate Light-Duty Plug-In Hybrid & Battery Electric Vehicles and Infrastructure

**Expected SCAQMD Cost:** $700,000

**Expected Total Cost:** $1,500,000

**Description of Technology and Application:**

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

The SCAQMD has long supported the concept of using increased battery power to allow a portion of the driving cycle to occur in all-electric mode for true zero emission miles. This battery dominant strategy is accomplished by incorporating an advanced battery pack initially recharged from the household grid or EV chargers. This "plug-in" hybrid EV strategy allows reduced emissions and improved fuel economy. In 2009, CARB adopted Plug-In Hybrid Electric Vehicle Test Procedure Amendments and Aftermarket Parts Certification and several automobile manufacturers have announced demonstration or early production plans of "blended" plug-in hybrid electric, extended-range electric vehicles (E-rEV), or highway capable battery electric vehicles (BEVs). Electric utilities refer to PHEVs, E-rEVs and BEVs as plug-in electric drive vehicles (PEVs) and are working with automakers to support PEVs. The recent adoption of revised recommended practice SAE J1772 enables passenger vehicles to charge from 110/120V AC (Level 1), 220/240V AC (Level 2), and faster 440/480V DC charging using a common conductive connector in 30 minutes or less in the U.S. and Europe. The impact of fast charging on battery life and infrastructure costs is not well understood and will be evolving as three fast DC systems (SAE combo, CHAdeMO and Tesla) compete for international market share.

Integrated programs can interconnect fleets of electric drive vehicles with mass transit via web-based reservation systems that allow multiple users. These integrated programs can match the features of EVs (zero emissions, zero start-up emissions, short range) to typical consumer demands for mobility in a way that significantly reduces emissions of pollutants and greenhouse gases.

At recent auto shows, automakers have displayed concept plug-in fuel cell vehicles. Development and demonstration of dual fuel, zero emission vehicles could expand the acceptance of battery electric vehicles and accelerate the introduction of fuel cells in vehicle propulsion.

The SCAQMD has long been a leader in promoting early demonstrations of next generation light-duty vehicle propulsion technologies (and fuels). However, given the current and planned market offerings in this category, priorities have shifted. Nevertheless, the SCAQMD will continue to evaluate market offerings and proposed technologies in light-duty vehicles to determine if any future support is required.

This project category is to develop and demonstrate: 1) various PEV architectures; 2) anticipated costs for such architectures; 3) customer interest and preferences for each alternative; 4) prospective commercialization issues and strategies for various alternatives; 5) integration of the technologies into prototype vehicles and fleets; 6) infrastructure (especially in conjunction with the DOE and the Los Angeles Department of Water & Power) to demonstrate the potential clean air benefits of these types of vehicles; 7) support for local government outreach and charging installation permit

streamlining; and 8) evaluation of any new promising light-duty vehicle propulsion technologies or fuels.

**Potential Air Quality Benefits:**

The 2012 AQMP identifies zero or near-zero emitting vehicles as a key attainment strategy. HEV technologies have the potential to achieve near-zero emissions but with the range of a conventional gasoline-fueled vehicle, a factor expected to enhance consumer acceptance. Given the variety of PEV systems under development, it is critical to determine the true emissions and performance of PEVs. Demonstration of optimized prototypes would enhance the deployment of near-ZEV and ZEV technologies.

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

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

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

**Expected Total Cost:** $6,000,000

**Description of Technology and Application:**

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

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

Federal Recovery Act funding combined with state and local support has accelerated the development and demonstration of medium-duty plug-in hybrid electric truck platforms. Analysis of project data and use profiles will help optimize drive systems, target applications for early commercialization and fill gaps in product offerings.

**Potential Air Quality Benefits:**

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

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

**Proposed Project:** Demonstrate Alternative Energy Storage

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

**Expected Total Cost:** $2,000,000

**Description of Technology and Application:**

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

The long-term objective of this program is to decrease fuel consumption and resulting emissions without any changes in performance compared to conventional vehicles. This program will support several projects for development and demonstration of different types of low emission hybrid vehicles using advanced energy strategies and conventional or alternative fuels. The overall net emissions and fuel consumption of these types of vehicles are expected to be much lower than traditional engine systems. Both new and retrofit technologies will be considered.

**Potential Air Quality Benefits:**

Certification of low emission vehicles and engines and their integration into the Basin's transportation sector is a high priority under the 2012 AQMP. This program is expected to develop alternative energy storage technologies that could be implemented in medium- and heavy-duty trucks, buses and other applications. Benefits will include proof of concept for the new technologies, diversification of transportation fuels and lower emissions of criteria, toxic pollutants and greenhouse gases.

**Proposed Project:** Develop and Demonstrate Electric Container Transport Technologies

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

**Expected Total Cost:** $6,000,000

**Description of Technology and Application:**

Advanced transportation systems can be used to transfer cargo containers from ports to both local and "distant" intermodal facilities, thereby significantly reducing emissions from on-road trucks and locomotives and also reducing traffic congestion in local transportation corridors. Such systems could be stand-alone systems that use magnetic levitation (maglev), linear synchronous motors or linear induction motors on dedicated guideways. A more near-term design could use existing roadways that are electrified with catenary electric lines or linear electric motors to move containers on modified trucks equipped to run on electricity. In both scenarios, containers are transported relatively quietly and without direct emissions. The footprints for such systems are similar to conventional rail systems but have reduced impact on adjacent property owners including noise and fugitive dust. These systems can even be built above or adjacent to freeways or on elevated guideways. These container freight systems are not designed to carry any operators on the guideways, where the over-the-roadway system may require the operator to actively control the transport of the containers.

One of the container transportation concepts the SCAQMD is actively pursuing is the eHighway catenary hybrid truck system by Siemens Mobility. Siemens and their partners have developed a catenary system and hybrid electric trucks to utilize the catenary for zero emission transport of containers. The hybrid drive system will extend the operating range of the truck beyond the all-electric range of the catenary system, thus enabling the truck to perform regional drayage operations and bridge gaps in catenary infrastructure as it is deployed on a regional level. The proposed Siemens pantograph system will allow for seamless connection and disconnection from the catenary wires. When entering the catenary system corridor, the pantograph system will verify the presence of catenary lines and allow the driver to raise the pantograph from within the cab of the truck. Upon leaving the catenary system, the pantograph automatically retracts and the truck switches to on-board power systems. The on-board power systems could be a range of technologies, including batteries, fuel cells, or internal combustion engines. In addition, SCAQMD is administering a project to develop and demonstrate zero emission drayage trucks for goods movement operations, consisting of three different battery electric truck technologies and a fuel cell hybrid electric truck platform. This project is funded by a $4.2 million award from Department of Energy to promote the deployment of zero emission cargo transport technologies. These trucks can be also upfitted to connect to wayside power via a catenary or LSM system in the future.

In addition to these technologies, there are other options for electric container applications such as dual-mode locomotives, hybrid electric technologies with battery storage, a battery tender car, magnetic levitation, fuel cell propulsion systems and other wayside power alternatives. This program will evaluate all available technology options to determine whether their systems can be successfully developed and deployed, financially viable, and reliably operated on a long-term basis.

**Potential Air Quality Benefits:**

On-road heavy-duty diesel truck travel is an integral part of operations at the ports moving cargo containers into the Basin and beyond. The 2012 AQMP proposes to reduce emissions from this activity by modernizing the fleet and retrofitting $NO_x$ and PM emission controls on older trucks. An alternative approach, especially for local drayage to the nearby intermodal facilities, is to use advanced container transport systems that use electric propulsion for the containers on fixed

guideways or modified trucks able to operate on electricity which will eliminate local diesel truck emissions. The emission benefits have not yet been estimated because the fate of the displaced trucks has not been determined.

## *Hydrogen and Fuel Cell Technologies & Infrastructure*

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

**Expected SCAQMD Cost:** $350,000

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

**Description of Technology and Application:**

California regulations require automakers to place increasing numbers of zero emission vehicles into service every year. By 2050, CARB projects that 87% of light-duty vehicles on the road will be zero emission battery and fuel cell vehicles with fuel cell electric becoming the dominant powertrain.

In 2013, cash-flow analysis resulting in a Hydrogen Network Investment Plan and fuel cell vehicle development partnership announcements by major automakers enabled the passage of AB 8 which provides $20 million per year for hydrogen infrastructure cofunding through the CEC. This resulted in limited fuel cell vehicle production announcements by Hyundai, Toyota and Honda for 2014-2015.

In mid-2014 the CaFCP published the *Hydrogen Progress, Priorities and Opportunities* (HyPPO) report, an update of their roadmap describing the first network of commercial hydrogen stations in California.

Additional work in this project category would develop a plan to secure long-term funding to complete the hydrogen fueling network build-out, provide details how funding can be invested, assess alternative revenue streams such as renewable incentives, propose alternative financing structures to leverage/extend CEC funding, and support station operation during the transition to commercial viability.

**Potential Air Quality Benefits:**

The 2012 AQMP identifies the use of alternative fuels and zero emission transportation technologies as necessary to meet federal air quality standards. One of the major advantages of Fuel Cell vehicles (FCEVs) is the fact that they use hydrogen, a fuel that can be domestically produced from a variety of resources such as natural gas, solar, wind and biomass. The technology and means to produce hydrogen fuel to support FCEVs are available now. The deployment of large numbers of FCEVs, which is an important strategy to attain air quality goals, requires a well planned and robust hydrogen fueling infrastructure. This SCAQMD program with additional funding from other entities will provide the hydrogen fueling infrastructure that is necessary in the South Coast Air Basin. The deployment of FCEVs and the development of the necessary fueling infrastructure will lead to substantial reductions in NOx, VOC, CO, PM and toxic air contaminants from vehicles.

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

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

**Expected Total Cost:** $5,000,000

**Description of Technology and Application:**

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

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

- *Fleet and Commercial Refueling Stations:* Further expansion of the hydrogen fueling network based on retail models, providing renewable generation, adoption of standardized measurements for hydrogen refueling, other strategic refueling locations and increased dispensing pressure of 10,000 psi and compatibility with existing CNG stations may be considered.
- *Energy Stations*: Multiple-use energy stations that can produce hydrogen for fuel cell vehicles or for stationary power generation are considered an enabling technology with the potential for costs competitive with large-scale reforming. System efficiency, emissions, hydrogen throughput, hydrogen purity and system economics will be monitored to determine the viability of this strategy for hydrogen fueling infrastructure deployment and as a means to produce power and hydrogen from renewable feedstocks (biomass, digester gas, etc.).

*Home Refueling Appliances*: Home refueling/recharging is an attractive advancement for alternative clean fuels due to the limited conventional refueling infrastructure. Similar to the natural gas home refueling appliance currently commercially available, this project would evaluate a hydrogen home refueler for cost, compactness, performance, durability, emission characteristics, ease of assembly and disassembly, maintenance and operations. Other issues such as building permits, building code compliance and UL ratings for safety would also be evaluated.
It is estimated that approximately 50,000 fuel cell vehicles will be deployed by 2017 in California and the majority of these vehicles will be in the South Coast Air Basin. To provide fuel for these vehicles, the hydrogen fueling infrastructure needs to be significantly increased. SCAQMD will seek additional funding from CEC and CARB to construct and operate hydrogen fueling stations.

**Potential Air Quality Benefits:**

The 2012 AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. Pursuant to AQMP goals, the SCAQMD has in effect several fleet rules that require public and certain private fleets to purchase clean-burning alternative-fueled vehicles when adding or replacing vehicles to their vehicle fleets. Fuel cell vehicles constitute the cleanest alternative-fuel vehicles today. Since hydrogen is a key fuel for fuel cell vehicles, this program would address some of the barriers faced by hydrogen as a fuel and thus assist in accelerating its acceptance and ultimate commercialization. In addition to supporting the immediate deployment of the demonstration fleet, expanding the hydrogen fuel infrastructure should contribute to the market acceptance of fuel cell technologies in the long run, leading to substantial reductions in $NO_x$, VOC, CO, PM and toxic compound emissions from vehicles.

**Proposed Project:** Develop and Demonstrate Medium- and Heavy-Duty Fuel Cell Vehicles

**Expected SCAQMD Cost:** $3,000,000

**Expected Total Cost:** $10,000,000

**Description of Technology and Application:**

This proposed project would support evaluation including demonstration of promising fuel cell technologies for applications using direct hydrogen with proton exchange membrane (PEM) fuel cell technology. Battery fuel cell hybrids are another potential technology being mentioned by battery experts as a way of reducing costs and enhancing performance of fuel cell vehicles.

The California ZEV Action Plan specifies actions to help deploy an increasing number of zero emission vehicles, including medium- and heavy-duty ZEVs. Fleets are useful demonstration sites because economies of scale exist in central refueling, in training skilled personnel to operate and maintain the vehicles, in the ability to monitor and collect data on vehicle performance and for manufacturer technical and customer support. In some cases, medium- and heavy-duty fuel cell vehicles could leverage the growing network of hydrogen stations, providing an early base load of fuel consumption until the number of passenger vehicles grows. These vehicles could include hybrid-electric vehicles powered by fuel cells and equipped with batteries capable of being charged from the grid and even supplying power to the grid.

In 2012 SCAQMD launched demonstrations of Zero Emission Container Transport (ZECT) technologies. This project included development and demonstration of a fuel cell hybrid electric truck platform. In 2015 staff proposes to launch ZECT II to develop and demonstrate additional fuel cell truck platforms and vehicles.

This category may include projects in the following applications:

On-Road:
- Transit Buses
- Shuttle Buses
- Medium- & Heavy-Duty Trucks

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

**Potential Air Quality Benefits:**

The 2012 AQMP identifies the need to implement zero emission vehicles. SCAQMD adopted fleet regulations require public and some private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. In the future, such vehicles could be powered by zero emission fuel cells operating on hydrogen fuel. The proposed projects have the potential to accelerate the commercial viability of fuel cell vehicles. Expected immediate benefits include the establishment of zero- and near-zero emission proof-of-concept vehicles in numerous applications. Over the longer term, the proposed projects could help foster wide-scale implementation of zero emission fuel cell vehicles in the Basin. The proposed projects could also lead to significant fuel economy improvements, manufacturing innovations and the creation of high-tech jobs in Southern California, besides realizing the air quality benefits projected in the AQMP.

**Proposed Project:** Demonstrate Light-Duty Fuel Cell Vehicles

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

**Expected Total Cost:** $100,000

**Description of Technology and Application:**

This proposed project would support the demonstration of limited production and early commercial fuel cell passenger vehicles using gaseous hydrogen with proton exchange membrane (PEM) fuel cell technology. Recent designs of light-duty fuel cell vehicles include hybrid batteries to recapture regenerative braking and improve overall system efficiency.

With the implementation of the California ZEV Action Plan, supplemented by the existing and planned hydrogen refueling stations in the Southern California area, light-duty fuel cell limited-production vehicles are planned for retail deployment in early commercial markets near hydrogen stations by several automakers. Fleets are useful demonstration sites because economies of scale exist in central refueling, in training skilled personnel to operate and maintain the vehicles, in the ability to monitor and collect data on vehicle performance and for manufacturer technical and customer support. SCAQMD has included fuel cell vehicles as part of its demonstration fleet since our first hydrogen station began operation in 2005; strengthening support, education, and outreach regarding fuel cell vehicle technology on an on-going basis. In addition, demonstration vehicles could include hybrid-electric vehicles powered by fuel cells and equipped with larger batteries capable of being charged from the grid and even supplying power to the grid.

**Potential Air Quality Benefits:**

The 2012 AQMP identifies the need to implement zero emission vehicles. SCAQMD adopted fleet regulations require public and some private fleets within the Basin to acquire alternatively fueled vehicles when making new purchases. In the future, such vehicles could be powered by zero emission fuel cells operating on hydrogen fuel. The proposed projects have the potential to accelerate the commercial viability of fuel cell vehicles. Expected immediate benefits include the deployment of zero- emission vehicles in SCAQMD's demonstration fleet. Over the longer term, the proposed projects could help foster wide-scale implementation of zero emission fuel cell vehicles in the Basin. The proposed projects could also lead to significant fuel economy improvements, manufacturing innovations and the creation of high-tech jobs in Southern California, besides realizing the air quality benefits projected in the AQMP.

## *Engine Systems*

**Proposed Project**: Develop and Demonstrate Advanced Alternative Fuel Medium- and Heavy-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 $NO_x$ emissions target for this program area is 0.02 g/bhp-hr and lower and the PM emissions target is below 0.01 g/bhp-hr. To achieve these targets, an effective emission control strategy must employ advance fuel or alternative fuels, engine design features, improved exhaust or recirculation systems, and aftertreatment devices that are optimized using a system approach. This program is expected to result in several projects, including:

- demonstration of advanced engines in medium- and heavy-duty vehicles and high horsepower applications;
- development of durable and reliable retrofit technologies to convert engines and vehicles from petroleum fuels to alternative fuels; and
- anticipated fuels for these projects include but are not limited to CNG, LNG, LPG, emulsified diesel and GTL fuels. The program proposes to expand field demonstration of these advanced technologies in various vehicle fleets operating with different classes of vehicles.

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

**Potential Air Quality Benefits:**

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

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

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

**Expected Total Cost:** $1,500,000

**Description of Technology and Application:**

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

- certification of CNG light-duty sedans and pickup trucks used in fleet services;
- resolution of higher concentration ethanol (E-85) affect on vehicle fueling system ("permeation issue");
- certification of E85 vehicles to SULEV standards;
- assessment of "clean diesel" vehicles, including hybrids and their ability to attain SULEV standards; and
- assessment of compressed air technologies.

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

**Potential Air Quality Benefits:**

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

## *Infrastructure and Deployment (NG)*

**Proposed Project:** Deploy Natural Gas Vehicles in Various Applications

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

**Expected Total Cost:** $2,000,000

**Description of Technology and Application:**

Natural gas vehicles (NGVs) have been very successful in reducing emissions in the South Coast Air Basin due to the deployment of fleets and heavy-duty vehicles utilizing this clean fuel. In order to maintain the throughput, utility and commercial potential of the natural gas infrastructure and the corresponding clean air benefits, deploying additional models of NGVs in existing applications are needed. This technology category seeks to support the implementation of early-commercial vehicles in a wide variety of applications, such as taxis, law enforcement vehicles, shuttle buses, delivery vans, transit buses, waste haulers, class 8 tractors and off-road equipment such as construction vehicles and yard hostlers.

**Potential Air Quality Benefits:**

Natural gas vehicles have inherently lower engine criteria pollutant emissions than conventional vehicles, especially in the heavy-duty applications where older diesel engines are being replaced. Incentivizing these vehicles in city fleets, goods movement applications and transit bus routes help to reduce the local emissions and exposure to nearby residents. Natural gas vehicles also can have lower greenhouse gas emissions and increase energy diversity depending on the feedstock and vehicle class. Deployment of additional NGVs is in agreement with SCAQMD's AQMP as well as the state's Alternative Fuels Plan as part of AB 1007 (Pavley).

**Proposed Project:** Develop, Maintain & Expand Natural Gas Infrastructure

**Expected SCAQMD Cost:** $350,000

**Expected Total Cost:** $2,000,000

**Description of Technology and Application**:

This program would support the development, maintenance and expansion of natural gas fueling station technologies and incorporate advancing concepts to increase the overall number of such fueling stations in strategic locations throughout the Basin including the Ports, reduce the cost of natural gas equipment, standardize fueling station design and construction and help with the implementation of SCAQMD's fleet rules. As natural gas fueling equipment begins to age or has been placed in demanding usage, components begin to age and deteriorate. This program offers an incentive to facilities to replace worn-out equipment or to upgrade existing fueling and/or garage and maintenance equipment to offer increased fueling capacity to public agencies, private fleets and school districts.

**Potential Air Quality Benefits**:

The AQMP identifies the use of alternative clean fuels in mobile sources as a key attainment strategy. NGVs have significantly lower emissions than gasoline vehicles and represent the cleanest internal combustion engine powered vehicles available today. The project has the potential to significantly reduce the installation and operating costs of NGV refueling stations, besides improving the refueling time. While new or improved NGV stations have an indirect emissions reduction benefit, they help facilitate the introduction of low emission, NGVs in private and public fleets in the area, which have a direct emissions reduction benefit. The increased exposure and fleet and consumer acceptance of NGVs would lead to significant and direct reductions in NOx, VOC, CO, PM and toxic compound emissions from mobile sources. Such increased penetration of NGVs will provide direct emissions reductions of $NO_x$, VOC, CO, PM and air toxic compounds throughout the Basin.

**Proposed Project:** Demonstrate Natural Gas Manufacturing and Distribution Technologies Including Renewables

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

**Expected Total Cost:** $7,000,000

**Description of Technology and Application:**

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

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

The main objectives of this project are to investigate, develop and demonstrate:

- commercially viable methods for converting renewable feed stocks into CNG or LNG (e.g., production from biomass);
- economic small-scale natural gas liquefaction technologies;
- utilization of various gaseous feed stocks locally available;
- commercialize incentives for fleets to site, install and use LNG and L/CNG refueling facilities; and
- strategic placement of LNG storage capacity sufficient to provide supply to users in the event of a production outage.

**Potential Air Quality Benefits:**

The SCAQMD relies on a significant increase in the penetration of zero- and low emission vehicles in the South Coast Basin to attain federal clean air standards by 2014, 2023 and 2032. This project would help develop a number of small-scale liquefaction technologies that can reduce LNG costs to be competitive with diesel fuel. Such advances are expected to lead to greater infrastructure development. This would make LNG fueled heavy-duty vehicles more available to the commercial market leading to direct reductions in $NO_x$, PM and toxic compound emissions.

## *Fuels/Emission Studies*

**Proposed Project:** In-Use Emissions Studies for Advanced Technology Vehicle Demonstrations

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

**Expected Total Cost:** $800,000

**Description of Technology and Application:**

Hybrid electric, hybrid hydraulic, plug-in electric hybrid and pure EVs will all play a unique role in the future of transportation. Each of these transportation technologies has attributes that could provide unique benefits to different transportation sectors. Identifying the optimal placement of each transportation technology will provide the co-benefits of maximizing the environmental benefit and return on investment for the operator.

The environmental benefit for each technology class will be highly duty-cycle and application specific. Identifying the attributes of a specific application or drive cycle that would take best advantage of a specific transportation technology would speed the adoption and make optimal use of financial resources in the demonstration and deployment of a technology. The adoption rates would be accelerated since the intelligent deployment of a certain technology would ensure that a high percentage of the demonstration vehicles showed positive results. These positive results would spur the adoption of this technology in similar applications, as opposed to negative results derailing the further development or deployment of a certain technology.

The proposed project would conduct a characterization of application specific drive cycles to best match different transportation technologies to specific applications. The potential emissions reductions and fossil fuel displacement for each technology in a specific application would be quantified on a full-cycle basis. This information could be used to develop a theoretical database of potential environmental benefits of different transportation technologies when deployed in specific applications.

**Potential Air Quality Benefits:**

The development of an emissions reduction database, for various application specific transportation technologies, would assist in the targeted deployment of new transportation technologies. This database coupled with application specific vehicle miles traveled and population data would assist in intelligently deploying advanced technology vehicles to attain the maximum environmental benefit. These two data streams would allow vehicle technologies to be matched to an application that is best suited to the specific technology, as well as selecting applications that are substantial enough to provide a significant environmental benefit. The demonstration of a quantifiable reduction in operating cost through the intelligent deployment of vehicles will also accelerate the commercial adoption of the various technologies. The accelerated adoption of lower emitting vehicles will further assist in attaining SCAQMD's air quality goals.

**Proposed Project:** Conduct Emissions Studies on Biofuels and Alternative Fuels

**Expected SCAQMD Cost:** $400,000

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

**Description of Technology and Application:**

The use of biofuels can be an important strategy to reduce petroleum dependency, air pollution and greenhouse gas emissions. Biofuels are in fact receiving increased attention due to national support and state activities resulting from AB 32, AB 1007 and the Low-Carbon Fuel Standard. It's noteworthy to mention that in 2013 the Low-Carbon Fuel Standard was upheld by the U.S. Court of Appeals for the Ninth Circuit and subsequently in June 2014 opponents were denied further appeal by the Supreme Court. With an anticipated increase in biofuel use, it is the objective of this project to further analyze these fuels to better understand their benefits and impacts not only on greenhouse gases but also on air pollution and associated health effects.

In various diesel engine studies, replacement of petroleum diesel fuel with biodiesel fuel has demonstrated reduced PM, CO and air toxics emissions. Biodiesel also has the potential to reduce greenhouse gas emissions because it can be made from renewable feedstocks, such as soy and canola. However, certain blends of biodiesel have a tendency to increase $NO_x$ emissions, which exacerbates the ozone and $PM_{2.5}$ challenges faced in the Basin. In addition, despite recent advancements in toxicological research in the air pollution field, the relationship between biodiesel particle composition and associated health effects is still not completely understood.

Ethanol is another biofuel that is gaining increased national media and state regulatory attention. CARB has recently amended the reformulated gasoline regulation to further increase the ethanol content to 10% as a means to increase the amount of renewable fuels in the state. It is projected that the state's ethanol use will increase from 900 million gallons in 2007 to 1.5 billion gallons by 2012 as a result. As in the case of biodiesel, ethanol has demonstrated in various emission studies to reduce PM, CO and toxic emissions; however, the relationship between particle composition and associated health effects from the combustion of ethanol is not well understood either.

DME is another fuel which requires evaluation of in-use emissions, especially $NO_x$, in light of Volvo's announcement that they will commercialize class 8 trucks using DME in 2015. Furthermore, CARB recently proposed a regulation on the commercialization of alternative diesel fuels, including biodiesel and renewable diesel, while noting that biodiesel in older heavy-duty vehicles can increase $NO_x$ and the need for emerging alternative diesel fuels to have clear ground rules for commercialization. The impact of natural gas fuel composition on emissions from heavy-duty trucks and transit buses is also being studied.

In order to address these concerns on potential health effects associated with biofuels, namely biodiesel and ethanol blends, this program will investigate the physical and chemical composition and associated health effects of tailpipe PM emissions from light- to heavy-duty vehicles burning biofuels in order to ensure public health is not adversely impacted by broader use of these fuels. This program also supports future studies to identify mitigation measures to reduce $NO_x$ emissions for biofuels. Additionally, a study of emissions from well-to-wheel for the extraction and use of shale gas might be considered.

**Potential Air Quality Benefits:**

If biodiesel and biodiesel blends can be demonstrated to reduce air pollutant emissions with the ability to mitigate any $NO_x$ impact, this technology will become a viable strategy to assist in meeting air pollutant standards as well as the goals of AB 32 and the Low-Carbon Fuel Standard. The use of biodiesel is an important effort for a sustainable energy future. Emission studies are critical to understanding the emission benefits and any tradeoffs ($NO_x$ impact) that may result from using this

alternative fuel. With reliable information on the emissions from using biodiesel and biodiesel blends, the SCAQMD can take actions to ensure the use of biodiesel will obtain air pollutant reductions without creating additional $NO_x$ emissions that may exacerbate the Basin's ozone problem.

**Proposed Project:** Identify and Demonstrate In-Use Fleet Emissions Reduction Technologies and Opportunities

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

**Expected Total Cost:** $2,000,000

**Description of Technology and Application:**

New technologies, such as alternative fueled heavy-duty engines, are extremely effective at reducing emissions because they are designed to meet the most stringent emissions standards while maintaining vehicle performance. In addition, many new vehicles are now equipped with telematics enabling motorists to obtain transportation information such as road conditions to avoid excessive idling and track information about the vehicle maintenance needs, repair history, tire pressure and fuel economy. Telematics have been shown to reduce emissions from new vehicles. Unfortunately, the in-use fleet lacks telematic systems--particularly heavy-duty engines in trucks, buses, construction equipment, locomotives, marine vessels and cargo handling equipment--have fairly long working lifetimes (up to 20 years due to remanufacturing in some cases). Even light-duty vehicles routinely have lifetimes exceeding 200,000 miles and 10 years. And it is the in-use fleet, especially the oldest vehicles, which are responsible for the majority of emissions.

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

- remote sensing for heavy-duty vehicles;
- annual testing for high mileage vehicles (>100,000 miles);
- replace or upgrade emissions control systems at 100,000 mile intervals;
- on-board emission diagnostics with remote notification;
- low-cost test equipment for monitoring and identifying high emitters;
- test cycle development for different class vehicles (e.g. four wheel drive SUVs);
- electrical auxiliary power unit replacements; and
- development, deployment and demonstration of smart vehicle telematic systems

The second phase of the project is to validate the technology or strategy on a larger demonstration project over a longer period of time.

**Potential Air Quality Benefits:**

Many of the technologies identified can be applied to light-duty and heavy-duty vehicles to identify and subsequently remedy high-emitting vehicles in the current fleet inventory. Estimates suggest that 5 percent of existing fleets account for up to 80 percent of the emissions. Identification of higher emitting vehicles would assist with demand-side strategies, where higher emitting vehicles have correspondingly higher registration charges.

## *Stationary Clean Fuel Technologies*

**Proposed Project:** Develop and Demonstrate Reliable, Low Emission Monitoring Systems and Test Methods

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

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

**Description of Technology and Application:**

Currently, the inability of air/fuel ratio control (AFRC) systems to keep rich-burn engines in compliance contributes significantly to air pollution in the basin. Reliable, low-cost emission monitoring systems are needed for small-to-intermediate size combustion devices, including stationary engines, boilers, heaters, furnaces and ovens that are not large enough to justify a continuous emission monitoring system (CEMS). This class of combustion device is often permitted on the basis of a single demonstration or periodic demonstrations of $NO_x$ and CO emissions meeting SCAQMD rule requirements or a RECLAIM concentration limit. However, SCAQMD-unannounced tests on engines and boilers have found that in many cases $NO_x$ and/or CO levels have increased significantly above levels that have been initially or periodically demonstrated due to equipment malfunction and/or inadequate operator attention. It is suspected that the same may be true of heaters, furnaces and ovens.

Demonstrations of newer technologies in recent years could result in a commercially viable alternative to CEMs that is both reliable and feasible in terms of lower costs. For example, manufacturers of flue gas analyzers have, in recent years, developed low-cost multi-gas analyzers suitable for portable or stack-mounted use. Some preliminary testing of a new type of AFRC, which uses a different type of O2 sensor known as a wide-band O2 sensor, is another alternative that can be analyzed. Another technical approach might be to deploy technology utilizing the O2 signature of a post-catalyst O2 sensor and additional control concepts being developed by manufacturers. Since an underlying problem has been that engine, catalyst and AFRC manufacturers have developed systems independently, a system being co-developed to perform continuous diagnostics to assist operators in keeping rich-burn engines in compliance is possibly another alternative for demonstration.

**Potential Air Quality Benefits:**

Stationary engines, boilers, heaters, furnaces and ovens account for approximately 11 percent of total $NO_x$ emissions and about 6 percent of total CO emissions. There has been a long-standing compliance problem with rich-burn IC engines in the basin and evidence indicates that many of these devices are operating with $NO_x$ and/or CO emissions above levels required in their permits. Projects could potentially reduce a significant class of $NO_x$ and CO emissions that are in excess of the assumptions in the AQMP and further enhance SCAQMD's ability to enforce full-time compliance.

**Proposed Project:** Develop and Demonstrate Clean Stationary Technologies

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

**Expected Total Cost:** $750,000

**Description of Technology and Application:**

Stationary sources, including VOC sources such as large printing facilities and furniture manufacturers, have become cleaner and cleaner due to the regulatory requirements for low emissions and the advancements in technology to meet those requirements. Best Available Control Technology (BACT) regulations, however, are only required for new, modified, or relocated sources. This project category is to develop and demonstrate new technologies that can provide emissions reductions in new installations or as retrofit modifications. Possible technology examples include:

- low $NO_x$ technologies (burners and ICEs);
- low-Btu gas technologies (e.g., digester, landfill, or diary gases);
- alternative fuels and hydrogen blends;
- alternative diesel fuels (emulsified, gas-to-liquids, biodiesel with aftertreatment);
- low emission refinery flares;
- catalytic combustion;
- cost-effective fuel cell and fuel cell hybrid distributed generation;
- fumes-to-fuel technology to replace thermal oxidizers and capture VOC emissions for electricity generation while ensuring no emission of air toxics; and
- boiler optimization design and strategies to improve efficiencies.

Depending on the technology, a proof-of-concept project, demonstration, or pre-commercial deployment would be considered to garner further information on the technology. Issues to investigate include viability (reliability, maintainability and durability) of the technology, cost-effectiveness and operator ease-of-use in order to assess commercialization.

**Potential Air Quality Benefits:**

The SCAQMD has a substantial number of older, small, stationary source technologies within its jurisdiction. Since these devices are not subject to continuous emissions monitoring system requirements, evidence suggests that these devices may not be operating at their permitted $NO_x$, CO, hydrocarbon and PM emissions levels. Replacing these devices with cleaner and more reliable technologies or technology/fuel combinations can have dramatic reductions in all of these criteria pollutants. VOC emission reductions may also be achieved at larger stationary VOC sources to achieve the new federal ozone and $PM_{2.5}$ standards.

**Proposed Project:** Develop and Demonstrate Renewables-Based Energy Generation Alternatives

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

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

**Description of Technology and Application:**

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

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

**Potential Air Quality Benefits:**

The 2012 AQMP identifies the development and ultimately the implementation of non-polluting power generation. To gain the maximum air quality benefit, polluting fossil fuel-fired electric power generation needs to be replaced with clean renewable energy resources or other advanced zero emission technologies, such as hydrogen fuel cells, particularly in a distributed generation context.

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

## *Emission Control Technologies*

**Proposed Project:** Develop and Demonstrate Advanced Aftertreatment Technologies

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

**Expected Total Cost:** $5,000,000

**Description of Technology and Application**:

There are a number of aftertreatment technologies which have shown substantial emission reductions in diesel engines. These technologies include diesel particulate filters (DPFs), oxidation catalysts, selective catalytic reduction (SCR) systems and $NO_x$ adsorbers. This project category is to develop and demonstrate these aftertreatment technologies alone or in tandem with an alternative fuel to produce the lowest possible PM, ultrafine particles, nanoparticles, $NO_x$, CO, carbonyl and hydrocarbon emissions in retrofit and new applications. With the increasing focus on zero- and near-zero emission goods movement technologies, this category should examine idle reduction concepts and technologies that can be employed at ports and airports.

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

**Potential Air Quality Benefits:**

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

**Proposed Project:** Demonstrate On-Road Technologies in Off-Road and Retrofit Applications

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

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

**Description of Technology and Application:**

Heavy-duty on-road engines have demonstrated progress in meeting increasingly stringent Federal and state requirements. New heavy-duty engines have progressed from 2 g/bhp-hr $NO_x$ in 2004 to 0.2 g/bhp-hr $NO_x$ in 2010, which is an order of magnitude decrease in just six years. Off-road engines, however, have considerably higher emissions limits depending on the engine size. For example, Tier-3 standards for heavy-duty engines require only 3 g/bhp-hr $NO_x$. There are apparent opportunities to implement cleaner on-road technologies in off-road applications. There is also an opportunity to replace existing engines in both on-road and off-road applications with the cleanest available technology. Current regulations require a repower (engine exchange) to only meet the same emissions standards as the engine being retired. Unfortunately, this does not take advantage of recently developed clean technologies.

Exhaust gas cleanup strategies, such as SCR, electrostatic precipitators, baghouses and scrubbers, have been used successfully for many years on stationary sources. The exhaust from the combustion source is routed to the cleaning technology, which typically requires a large footprint for implementation. This large footprint has made installation of such technologies on some mobile sources prohibitive. However, in cases where the mobile source is required to idle for long periods of time, it may be more effective to route the emissions from the mobile source to a stationary device to clean the exhaust stream.

Projects in this category will include utilizing proven clean technologies in novel applications, such as:

- demonstrating certified LNG and CNG on-road engines in off-road applications including yard hostlers, switcher locomotives, gantry cranes, waste haulers and construction equipment;
- implementing lower emission engines in repower applications for both on-road and off-road applications; and
- application of stationary best available control technologies, such as SCR, scrubbers, baghouses and electrostatic precipitators, to appropriate on- and off-road applications, such as idling locomotives, marine vessels at dock and heavy-duty line-haul trucks at weigh stations.

**Potential Air Quality Benefits:**

The transfer of mature emission control technologies, such as certified engines and SCR, to the non-road and retrofit sectors offers high potential for immediate emissions reductions. Further development and demonstration of these technologies will assist in the regulatory efforts which could require such technologies and retrofits.

## *Health Impacts Studies*

**Proposed Project:** Evaluate Ultrafine Particle Health Effects

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

**Expected Total Cost:** $2,000,000

**Description of Technology and Application:**

Reducing diesel exhaust from vehicles has become a high priority in the South Coast Air Basin since CARB identified the particulate phase of diesel exhaust as a surrogate for all of the toxic air contaminant emitted from diesel exhaust. Additionally, recent health studies indicate that the ultrafine portion of particulate matter may be more toxic on a per-mass basis than other fractions. Several technologies have been introduced and others are under development to reduce diesel emissions. These include among others low-sulfur diesel fuel, particulate matter traps and heavy-duty engines operating on alternative fuel such as CNG and LNG. Recent studies have shown that control technologies applied to mobile sources have been effective in reducing the mass of particulates emitted. However, there is also evidence that the number of ultrafine particles on and near roadways has increased, even while the mass of particulates has decreased. To have a better understanding of changes in ultrafine particulate emissions from the application of the new technologies and the health effects of these emissions, an evaluation and comparison of ultrafine particulate matter and the potential impacts on community exposures are necessary.

In this project, measurements and chemical composition of ultrafine particulates will be done, as well as studies conducted to characterize their toxicity. The composition of the particulates can further be used to determine the contribution from specific combustion sources. Additionally, engine or chassis dynamometer testing may be conducted on heavy-duty vehicles to measure, evaluate and compare ultrafine particulate matter, PAH and other relevant toxic emissions from different types of fuels such as CNG, low-sulfur diesel, biofuels and others. This project needs to be closely coordinated with the development of technologies for alternative fuels, aftertreatment and new engines in order to determine the health benefits of such technologies.

**Potential Air Quality Benefits:**

The AQMP for the South Coast Basin relies on significant penetration of low emission vehicles to attain federal clean air standards. Reduction of particulate emissions from the combustion of diesel and other fuels is a major priority in achieving these standards. This project would help to better understand the nature and amount of ultrafine particulates generated by different types of fuels and advanced control technologies as well as provide information on potential health effects of ultrafine particles. Such an understanding is important to assess the emission reduction potentials and health benefits of these technologies. In turn, this will have a direct effect on the policy and regulatory actions for commercial implementation of alternative fuel vehicles in the Basin.

**Proposed Project:** Conduct Monitoring to Assess Environmental Impacts

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

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

**Description of Technology and Application:**

Facilities, buildings, structures, or highways which attract mobile sources of pollution are considered "indirect" sources. Ambient and saturation air monitoring near sources such as ports, airports, rail yards, distribution centers and freeways is important to identify the emissions exposure to the surrounding communities and provide the data to then conduct the health impacts due to these sources. This project category would identify areas of interest and conduct ambient air monitoring, conduct emissions monitoring, analyze the data and assess the potential health impacts from mobile sources. The projects would need to be at least one year in duration in order to properly assess the air quality impacts in the area.

**Potential Air Quality Benefits:**

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

**Proposed Project:** Assess Sources and Health Impacts of Particulate Matter

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

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

**Description of Technology and Application:**

Previous studies of ambient levels of toxic air contaminants, such as the MATES series of studies, have found that diesel exhaust is the major contributor to health risk from air toxics. Analyses of diesel particulate matter in ambient samples have been based on measurements of elemental carbon. While the bulk of particulate elemental carbon in the South Coast Air Basin is thought to be from combustion of diesel fuels, it is not a unique tracer for diesel exhaust.

The MATES III study collected particulate samples at ten locations in the South Coast Air Basin. Analysis of particulate bound organic compounds was utilized as tracers to estimate levels of ambient diesel particulate matter as well as estimate levels of particulate matter from other major sources. Other major sources that were taken into consideration include automobile exhaust, meat charbroiling, road dust, wood smoke and fuel oil combustion. Analyzing for organic compounds and metals in conjunction with elemental carbon upon collected particulate samples was used to determine contributing sources.

MATES IV was initiated in mid-2012 and includes an air monitoring program, an updated emissions inventory of toxic air contaminants and a regional modeling effort to characterize risk across the Basin. The draft report was released for public review in October 2014. In addition to air toxics, MATES IV also measured ultrafine particle concentrations and black carbon at the monitoring sites as well as near sources such as airports, freeways, rail yards, busy intersections and warehouse operations.

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

**Potential Air Quality Benefits:**

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

## *Outreach and Technology Transfer*

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

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

**Expected Total Cost:** $800,000

**Description of Project:**

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

This program may include the following:

- technical review and assessment of technologies, projects and proposals;
- support for alternative fuel refueling and infrastructure;
- advanced technology curriculum development, mentoring and outreach to local schools;
- emissions studies and assessments of zero emission alternatives;
- advanced technology vehicle demonstrations;
- preparation of reports, presentations at conferences, improved public relations and public communications of successful demonstrations of clean technologies;
- participation in and coordination of workshops and various meetings;
- support for training programs related to fleet operation, maintenance and refueling of alternative fuel vehicles;
- publication of technical papers, reports and bulletins; and
- production and dissemination of information, including web sites.

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

**Potential Air Quality Benefits:**

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

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

**Expected SCAQMD Cost:** $400,000

**Expected Total Cost:** $400,000

**Description of Project:**

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

**Potential Air Quality Benefits**:

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