California Environmental Protection Agency

Air Resources Board

PLANNED AIR POLLUTION RESEARCH

Fiscal Year 2001-2002

July 2001

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CALIFORNIA AIR RESOURCES BOARD

PLANNED AIR POLLUTION RESEARCH
FISCAL YEAR 2001-02

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Recommended

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To investigate the cardiopulmonary effects of size-specific ambient PM in human volunteers, sensitive animal models, and cellular assays.

$1,200,000

The Role of Particulate Matter in Asthma and Allergic Disease 8

To evaluate the potential for particulate matter (PM10 and PM2.5) from various sites in California to enhance respiratory allergic responses, including asthma, and to act as an adjuvant in development of new respiratory allergy and asthma.

$350,000

The Impact of Air Pollution on Lake Tahoe and an Assessment of the Effectiveness of Control Measures 9

To determine the atmospheric flux of gas-phase nitrogen and particulate nitrogen, phosphorous, and sediment to Lake Tahoe and the surrounding watershed and assess the effectiveness of pollution control strategies.

$195,000

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$200,000

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$150,000

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$75,000

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$313,000

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$100,000

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$400,000

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$80,000

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$100,000

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$165,000

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$200,000

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$200,000

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$90,000

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$300,000

SUMMARY

This report presents the Air Resources Board's planned air pollution research for the fiscal year 2001-2002. Twenty-four projects are proposed. Twenty-one are recommended for funding and three are recommended if funding is available. This research portfolio is ARB's first annual implementation of its Strategic Plan for Research, which covers the years 2001-2010. The Strategic Plan addresses the science and technology needs for ARB's regulatory priorities over the next decade, organized into four main areas of research – Health and Welfare Effects, Exposure Assessment, Technology Advancement and Pollution Prevention, and Global Air Pollution. This annual plan proposes research in these four areas, with a primary emphasis on particulate matter health effects, and exposure assessment and control of particulate matter and toxic air contaminants. The proposed budget for the recommended projects is $5,571,000.

INTRODUCTION

The Air Resources Board (ARB) sponsors a comprehensive program of research addressing the causes, effects, and possible solutions to air pollution problems in California, and provides support for establishing ambient air quality standards. The Board's research program was established by the Legislature in 1971 (Health and Safety Code Sections 39700 et seq.) to develop a better understanding of the various aspects of air pollution, including air pollution's effects on health and the environment, the atmospheric reactions and transport of pollutants, and the inventory and control of air polluting emissions. In recent years, several legislative mandates have expanded and further defined the scope of the program.

The ARB's mission to protect California's public health, welfare, and ecological resources are supported through a Strategic Plan for Research covering the years 2001-2010. The Strategic Plan is based on the ARB's regulatory priorities for the next decade and provides direction for the ARB's research program. Four main areas of research are identified in the Strategic Plan – Health and Welfare Effects, Exposure Assessment, Technology Advancement and Pollution Prevention, and Global Air Pollution. These areas encompass the comprehensive mission of ARB's air pollution research. A copy of the Strategic Plan can be found at http://www.arb.ca.gov/research/apr/apr.htm.

This report represents the ARB's first annual implementation of the Strategic Plan. It consists of twenty-four projects that match the focus of the Strategic Plan. The proposed research projects are not intended to be exhaustive or exclusive. Unanticipated opportunities, unique or innovative study approaches, or urgency may lead to consideration of other projects.

Objective of the Research Program. The goal of the research program is to provide the timely scientific and technical information that will allow the Board and local districts to make the public policy decisions necessary to implement an effective air pollution control program in California. The relevant problems addressed in these policy decisions are identified by the Legislature, the Board, a Board research advisory committee, ARB staff, local air pollution control districts, the academic community, and the public.

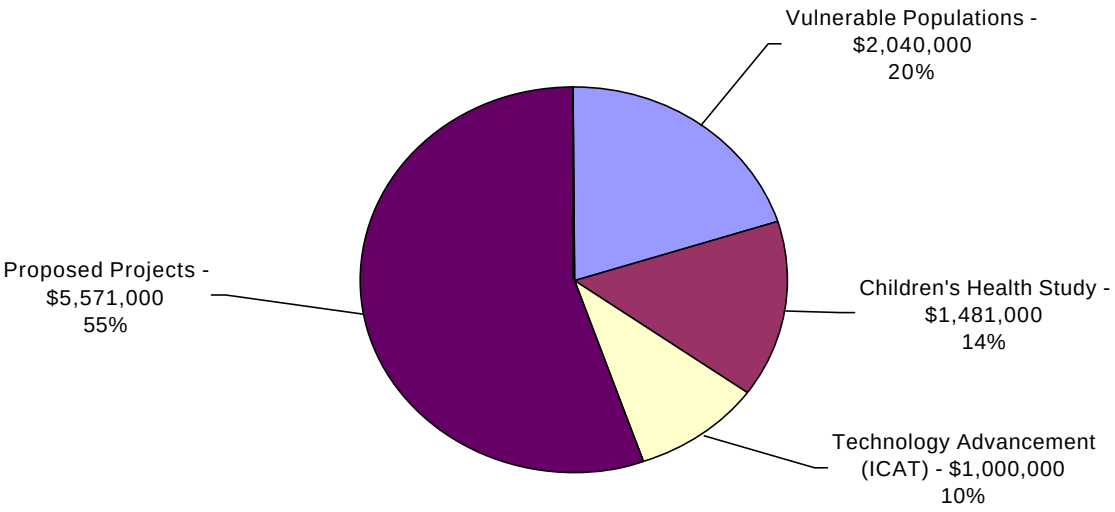
Public Involvement. The Board invites and encourages the public to contribute ideas for project consideration. This year, ninety-three research ideas were submitted. After the ideas were received, a workshop was held on April 6, 2001 to present all the ideas that had been submitted and to solicit public comment.

Planning the Research Program. To aid in planning, the Board's Executive Officer established internal committees to develop and review research ideas. Proposed projects were examined for relevance to regulatory questions facing the Board and modified as necessary. Committee members then prioritized candidate projects in order of urgency and importance. The Research Screening Committee (RSC) reviewed these candidate projects and their priorities. The list of projects, along with comments from

the RSC, were forwarded to the Executive Research Review Committee, whose members are the Executive Officer, his three deputies, and the Chief of the Research Division. The Executive Research Review Committee reviewed all of the proposed projects and established project priorities. Selected projects are then placed into two categories: 1) those that are recommended for funding, and 2) those that are recommended if funding is available. The Research Screening Committee reviewed the selected projects and recommended the Plan to the Board.

Research Budget. The twenty-one recommended projects total $5,571,000 – approximately 55 percent of the research budget (Figure 1). Ten percent of the budget is directed to technology advancement in the Innovative Clean Air Technologies Program. Thirty five percent will support ongoing health studies: The Vulnerable Populations Research Program and the Children's Health Study. The Vulnerable Populations Research Program has a budget allocation of $2,040,000 per year. This program, initiated in the 1999-2000 fiscal year, has funded the Fresno Asthmatic Children's Environment Study for a total of approximately $4,400,000. An external advisory committee is being formed to assist in guiding future projects funded under this program. For the Children's Health Study, a $1,000,000 per year budget proposal for the next four years was recently approved to augment the existing $481,000 per year support for this 10-year study. Another budget proposal, $622,000 per year for two years, will fund research related to air quality issues in the Lake Tahoe Basin. For the first year of funding, $195,000 is allocated to research, with the remainder allocated to monitoring activities.

Figure 1. Tentative Fiscal Year 2001-2002 Budget: $10,092,000



The allocations for the proposed recommended projects among research categories are as follows:

Research Category	
Health and Welfare Effects	$2,095,000
Exposure Assessment	$2,195,000
Technology Advancement and Pollution Prevention	$ 981,000
Global Air Pollution	$ 300,000

Implementation of the Plan. The next step for projects approved in the plan will be their development into full research projects. Contracts are initiated with universities, private entities, and governmental agencies, whose scientists will carry out most of the projects. Contracts are implemented through either interagency agreements or public solicitations. Public solicitations in the form of Request for Proposals (RFP) are posted on the Board's web site at http://www.arb.ca.gov/research/rfp/rfp.htm. There is also a list serve that individuals can subscribe to for receiving updates on research activities. More information on the list serve can be found at http://www.arb.ca.gov/listserv/research/research.htm.

Summaries of Past Research. Ongoing research projects and projects completed since the beginning of 1989 are summarized in the Research Division's publication, *Air Pollution Research,* which is available on the World Wide Web at http://www.arb.ca.gov/research/apr/past/past.htm. For a printed copy of this publication, please contact:

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Electronic copies of all of the Research Division's final reports (over 600) are available for downloading at the same web site.

RESEARCH PROJECT DESCRIPTIONS

One-page summaries of all the research projects for which funding is recommended (or recommended if funding is available) are provided in this section.

Health and Welfare Effects

Inhalation Studies of the Health Effects of Particulate Matter in California Using Ambient Particle Concentrators.....7

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Global Air Pollution

Estimates of Nitrous Oxide and Ammonia Emissions from Motor Vehicles and the Effects of Catalyst Composition and Aging 30

TITLE: Inhalation Studies of the Health Effects of Particulate Matter in California Using Ambient Particle Concentrators

PROBLEM: Particulate matter (PM) has been associated with increased mortality and morbidity, yet little is known of the mechanisms involved in PM toxicity, or the differences in the toxicity of the different size fractions of PM.

PREVIOUS WORK: Under a previous contract with the ARB, the University of California at Los Angeles and the University of Southern California developed a new state-of-the-art technology to concentrate coarse (2.5 – 10 μm), fine (0.15 – 2.5 μm), and ultrafine (0.01 – 0.15 μm) ambient particles by up to a factor of fifty. In coordination with the U.S. EPA-funded Southern California Particle Center and Supersite program, this innovative technology is being used in the study of the effect of ambient particles in human volunteers and animal models. Studies will be conducted in different locations and during different seasons in the South Coast Air Basin. Additional research is needed to investigate the effects of freeway emissions on asthma and allergy, as well as to begin to investigate the cardiopulmonary effects of particle exposures in human volunteers.

OBJECTIVE: The goal of this project is to investigate the cardiopulmonary effects of size-specific ambient PM in human volunteers, sensitive animals (mice and rats), and cellular assays.

DESCRIPTION: In this three-year program, healthy volunteers as well as asthmatics and volunteers with chronic obstructive pulmonary disease will be exposed to concentrated coarse, fine, and ultrafine ambient particles. Before proceeding, the research will need approval by the appropriate human subject review board. Additional studies will be done using sensitive animals and cellular systems. Ovalbumin-sensitized Balb/c mice will be used to study asthma-like responses. These mice exhibit several of the hallmarks of allergic asthma, including increased IgE and IgG1 as well as non-specific airway hyper-responsiveness and eosinophil influx. Brown Norway rats with and without allergic airway disease (ovalbumin-sensitized) will also be used to model allergic responses. Physiological, chemical, and structural endpoints will be studied to assess changes in cardiopulmonary function. Cellular toxicity studies will be conducted by exposing human cell cultures to coarse, fine, and ultrafine ambient particles. Exposures will examine seasonal and site-specific changes in particle toxicity.

BENEFITS: These investigations will result in important new information on the effect of particle exposure on asthma and allergy. The effects of season and site-specific ambient particles on sensitive subpopulations will also be studied. One of the many questions in the regulation of particle pollution has been the relative toxicity of different size fractions and different components of PM, as well as their effects on sensitive subpopulations. The information resulting from these studies is vital to developing future ambient air quality standards and control programs for different size fractions of PM.

COST: $1,200,000 (in coordination with the U.S. EPA-funded Southern California Particle Center and Supersite)

TITLE: The Role of Particulate Matter in Asthma and Allergic Disease

PROBLEM: The incidence of asthma and respiratory allergic disease has increased remarkably in California, the United States, and industrialized countries in recent years. It has been hypothesized that ambient particulate matter (PM) exposure may play a role in the observed increases.

PREVIOUS WORK: Epidemiologic studies have associated ambient PM exposure with exacerbation of asthma and allergies. Research in both animal models and on human subjects has shown that inhalation and tracheal instillation of diesel exhaust particles can induce responses characteristic of asthma, namely airway inflammation and hyper-responsiveness. Evidence for these effects includes changes in the number of goblet cells in lung tissue, altered production of immunoglobulins, influx of inflammatory cells, and enhanced cytokine production. Nasal challenge with diesel particles in allergic and non-allergic human subjects has provided evidence that diesel particles can enhance cytokine production, and induce immunoglobulin production in a pattern similar to that expressed in allergic responses, and can act as an adjuvant in development of new allergy. However, ambient PM typically includes only a small fraction derived from diesel vehicles, with the bulk of ambient PM being from non-diesel sources. These results raise the question as to whether non-diesel derived PM has similar effects.

OBJECTIVE: The goal of this project is to evaluate the potential for ambient-derived particulate matter (PM10 and PM2.5) from various sites in California to enhance respiratory allergic responses, including asthma, and to act as an adjuvant in development of new respiratory allergy and asthma. The overall focus of the project(s) will be on elucidating whether or not PM is a causal factor in the increased rates of allergy and asthma reported in California and other industrialized countries.

DESCRIPTION: Although studies utilizing human subjects are preferred, outstanding proposals utilizing appropriate animal models will be considered. Before proceeding, the research will need approval by the appropriate human subject review board. Subjects will be exposed to PM obtained from the ARB-funded concentrator, or to other well-characterized PM10 and PM2.5 at concentrations that are relevant to actual ambient exposures. The emphasis of the project will be directed to elucidate: 1) mechanisms whereby PM might cause development of new allergy/asthma, 2) mechanisms of PM exacerbation of existing allergy/asthma, and/or 3) whether ambient PM plays a causal role in allergy and/or asthma.

BENEFITS: This research will provide crucial information for determining whether or not ambient PM plays a causal or adjuvant role in two major public health problems, namely the increased rates of asthma and allergic disease reported in California and elsewhere. The results will also be invaluable in ambient air quality standard setting, and in estimating health care costs related to ambient PM pollution.

COST: $350,000

TITLE: The Impact of Air Pollution on Lake Tahoe and an Assessment of the Effectiveness of Control Measures

PROBLEM: Lake Tahoe is known for its exceptional clarity due, in part, to the fact that the surrounding nitrogen-limited forest ecosystem takes up most nutrients (nitrogen and phosphorus) before they reach the lake. Unfortunately the clarity of Lake Tahoe has declined by 30 percent during the past 50 years, which has been attributed to nitrogen, phosphorous, and sediment inputs from both atmospheric and hydrologic sources. Principal sources of air pollutants are motor vehicles, smoke from residential use, wildfires, prescribed forest burns, and air pollutants transported from the western side of the Sierra Nevada, including the San Francisco Bay area and the Sacramento Valley.

PREVIOUS WORK: The recently released Lake Tahoe Watershed Assessment provides a comprehensive summary of the status of our scientific knowledge regarding the factors leading to the observed decline in water quality and steps that can be taken to restore the ecosystem. The report states that atmospheric deposition accounts for approximately 55 percent of the nitrogen and 27 percent of the phosphorous load into the lake but these estimates are highly uncertain. No estimate of atmospheric particulate matter input was presented.

OBJECTIVE: The objective of this study is to determine the atmospheric flux of gas-phase nitrogen and particulate nitrogen, phosphorous, and sediment to Lake Tahoe and the surrounding watershed and assess the effectiveness of pollution control strategies.

DESCRIPTION: The project will measure the concentrations of airborne pollutants at representative sites in the Lake Tahoe Basin, perform measurements during different periods of the year to obtain the seasonal input of pollutants, couple the air quality data with meteorological data to provide an estimate of the contributions from in-basin and out-of-basin sources, integrate the results of this study with other efforts measuring the flow of pollutants into the lake to reduce the uncertainty in the estimates of nutrient and sediment input, and provide a baseline against which implemented control strategies can be evaluated to assess their effectiveness. Additional funding is allocated to expand and support the operation of a multi-agency air monitoring network, equip the sites with state-of-the-art samplers for airborne pollutants, and provide for chemical analyses of samples.

BENEFITS: The results would enable an estimate of the impact of atmospheric sources on declining lake clarity to be determined. This study would also provide an assessment of the effectiveness of implemented control strategies.

COST: $195,000 (year one funding with an additional $370,000 available for monitoring activities; year two funding for a lesser amount will also be available; to be conducted in cooperation with the State Water Resources Control Board, the Tahoe Regional Planning Agency, and the Resources Agency)

TITLE: Health Benefits of Incremental Improvements in Air Quality

PROBLEM: Ambient air quality has improved in southern California, as evidenced by a decrease of 50 percent in ozone, 47 percent in PM10, and 30 percent in toxic air pollutants in the past twenty years. Although the effects of these pollutants on human morbidity and mortality have been documented, no effort has been made to validate the estimated health benefits resulting from this air quality improvement. The accuracy of past benefit estimates has been in question because of: 1) the inability to validate benefit estimates with observed air quality and health data; 2) wide variations in the range of estimates, presumably due to the assumptions made, selection of models, and model specifications; and 3) uncertainties in statistical approaches which may inappropriately force, or by default accept, a linear dose-response relationship between pollutant levels and effects.

PREVIOUS WORK: A prior study showed that regulations to eliminate lead from gasoline resulted in greatly reduced blood lead levels in children. An unpublished analysis from the Southern California Children's Health Study found that children who moved from high pollution to low pollution areas showed increase growth in lung function. Another study looked at the effect of sulfur controls for coal-fired power plants in the East and Midwest on acid deposition and ecosystem effects. To date, no efforts have been made to conduct a comprehensive study of the health benefits of ozone, PM10, and air toxic reductions in California.

OBJECTIVE: The goal of this project is to determine the relative health benefits of incremental air quality improvements in southern California using observed air quality and health data.

DESCRIPTION: The contractor will determine the extent to which air pollution-related mortality and morbidity (e.g., hospital visits and admissions) has changed in the South Coast Air Basin (SoCAB) since 1980. The study design will include a pilot study to determine the roles of various factors (e.g., changes over time in the spatial distribution of ambient air pollution, demographic changes, variability in the availability of health care, and changes in health care entitlement programs) in modifying the magnitude of impact. SoCAB-specific air quality and health data will be used to reduce uncertainties associated with models previously used to derive dose-response functions. The study will take advantage of the ambient pollution data from the network of monitoring stations in the SoCAB, which is more extensive and complete than in any other U.S. urban area.

BENEFITS: Results from this study will provide policy-makers a more accurate assessment of health benefits resulting from improvements in air quality since 1980. Combined with other information, the results can be used to measure the incremental benefits of specific air pollution control programs.

COST: $200,000 (plus possible co-funding from other sponsors)

TITLE: Long-term Benefits of Air Pollution Control Technology Improvements for Air Quality Management

PROBLEM: Air quality regulations take a few years to develop and adopt. Compliance dates are usually set for a few years beyond the adoption date. The cost estimates made during the regulatory development are projections based on assumptions that change by the time of compliance. Technological improvements, integration of compliance requirements into design processes, availability of substitutes, and competition help reduce ultimate compliance costs. At times, a regulation encourages creative talent and thinking that lead to more efficient compliance than envisioned in the adoption stage of a regulation. These are benefits that are unleashed after a regulation is adopted. The problem is that there is no systematic analysis, after the Board's regulations are adopted, of the benefits of technological improvement in air pollution control. Lack of estimation of the technology improvements and their impacts on costs tend to raise cost estimates for proposed regulations, an important consideration in the decision to adopt a regulation.

PREVIOUS WORK: There have been no comprehensive studies of air pollution control technology improvements. A study of the effect of technology improvement on automobile emission control costs of the 1970s and 80s found that the actual implementation costs of regulations were lower than the original estimate when adopted.

OBJECTIVE: The goal of this project is to estimate the benefit of air pollution control technology improvements on compliance costs over the past twenty years.

DESCRIPTION: The contractor will develop a methodology to estimate technology improvements in air pollution control and apply it to the last twenty years of air quality regulations in California. This project will search the literature on control technology, conduct surveys of regulated industries, and study past and proposed innovations, technology investments, and projects that are likely to produce improvements. Using the collected information, the study will estimate technology improvement benefits that can serve as factors to adjust cost estimates of proposed regulations.

BENEFITS: The methodology and its application to several air pollution categories will provide the Board a better understanding of the likely benefit of air pollution control technology improvements on compliance cost estimates during regulatory development and adoption.

COST: $150,000 (including possible cost-sharing with local air districts)

TITLE: Time-Series Study of Mortality and Morbidity from Ambient Woodsmoke

PROBLEM: Wood burning and forest fires emit considerable amounts of particulate matter (PM), carbon monoxide (CO), and a variety of toxic compounds into community air. Woodsmoke can accumulate to high concentrations when temperature inversions occur, as is common during fall and winter periods in the Central Valley and mountain communities of California. Forest fires, either those resulting from accidental events or prescribed biomass reduction, also periodically expose the State's citizens to substantial levels of smoke. The 24-hour-average PM10 levels exceed 100 $\mu g/m^3$ during smoke episodes in California, with shorter-term levels reaching above 1000 $\mu g/m^3$. We know PM increases mortality and morbidity, and that PM and other components of smoke are harmful, but there is little direct evidence about the quantitative nature of smoke exposures or the health impacts.

PREVIOUS WORK: Clinical exposure studies are underway to evaluate how brief exposures to rice smoke impact asthmatics and people with allergies. Smoke has been found to be associated with increases in hospitalization and deaths under very severe conditions in many places in the world, primarily in less developed countries. Very little is known regarding either the exposure conditions experienced by California residents or the health outcomes they suffer.

OBJECTIVE: The goal of this project is to quantify relationships between residential wood burning and wildfire activities, community and individual smoke exposure variables, and daily morbidity and mortality data in various California communities.

DESCRIPTION: Two lines of research are proposed that include both the evaluation of existing data sets as well as the collection of community smoke concentration, exposure, and health impacts data. First, hourly air pollution monitoring (PM10, CO, nitrogen oxides, sulfur dioxide) and meteorological data from various routine air monitoring sites for recent years will be assembled from existing sources. Mortality and hospital admission data for all population groups in the state will be acquired from the Department of Health Services and other record keepers. Statistical analyses will evaluate the nature of health impacts when smoke was present in targeted communities. In a second group of studies, community as well as indoor air pollution levels (PM2.5, PM10, CO, and possibly other harmful agents) will be measured and questionnaires administered in households located closely to a fixed monitoring site during winter and summer. This will be done to assess health impacts. These efforts will be coordinated with state and federal agencies involved in fire suppression.

BENEFITS: The results of this study will provide local and state air quality officials, federal land managers, and the public with information on the health effects associated with wood smoke. This will help to formulate policies to reduce exposures to safe levels.

COST: $150,000 (plus possible co-funding or in-kind contributions from other sponsors)

TITLE: Ambient Ozone and Pine Tree Injury in the Sierra Nevada

PROBLEM: Exposure to ambient ozone has been identified as a factor contributing to the loss of sensitive pine species in southern California. Evidence of ozone injury to pines on the western slope of the Sierra Nevada (2,000-6,000 feet elevation) has also been reported, but a systematic effort to evaluate changes over time has not been undertaken. In future decades, ambient ozone in Sierran forests is expected to rise due to local population growth and associated increases in motor vehicle emissions.

PREVIOUS WORK: A number of surveys and special studies have been conducted in Sierran forests since the 1970s. The USDA Forest Service and USDI National Park Service have surveyed ozone injury to pines in National Forests and National Parks, respectively. These efforts lacked site-specific ozone data, but documented the presence of injury on the western slope of the Sierra Nevada. In 1999, a cooperative study involving the ARB and USDA Forest Service was undertaken that utilized passive ozone samplers and ozone injury analyses of tree plots established in the early 1990s. A final report, containing GIS-based maps of ozone air quality and tree injury for the western Sierra, will be completed in summer 2001.

OBJECTIVE: The goal of this project is to perform a retrospective, GIS-based analysis of ozone air quality and pine injury in the Sierra Nevada and to conduct fieldwork to supplement the cooperative ARB/USDA Forest Service study completed in 1999.

DESCRIPTION: Air quality and tree injury data from the literature and other sources will be secured and subject to spatial analyses using GIS techniques. Maps of air quality and tree injury will be compared over the past 25 years to identify trends along the western slope of the Sierra Nevada. The fieldwork will consist of deploying a denser network of passive ozone samplers and more extensive surveys of tree injury in a subset of forest sites examined in 1999. Efforts will target sites where data gaps exist or where previous results are inconclusive.

BENEFITS: The health of California's forests is critical for the amenities and essential services they provide (e.g., wood products, water storage, and recreation). Air pollution is known to adversely impact native pine species across the state, and the gradual deterioration of forest-lands is inevitable unless action is taken to reduce ozone exposures. Through this study, changes in ozone air quality and tree damage in the western Sierra Nevada over the past 25 years will be characterized for consideration in future land-use decision-making efforts.

COST: $75,000 (in coordination with the USDA Forest Service)

TITLE: Chemical and Physical Transformation of Pollutants in Indoor Air

PROBLEM: Recent, limited research conducted in locations such as offices, communications facilities, and research chambers indicates that indoor chemical reactivity, surface reactivity, and removal and re-emission processes can have a major impact on the indoor concentrations of both indoor gases and particles. Toxic chemicals and particles are formed indoors when common pollutants such as ozone and some volatile organic compounds (VOCs) are present. It has become clear that indoor chemistry plays a critical role in determining human exposures to air pollutants. However, the extent to which harmful chemicals and particles are formed indoors has not been quantified, especially in common indoor environments such as homes and schools.

PREVIOUS WORK: Investigators examining VOCs and ozone indoors have identified substantial indoor transformation, removal, and re-emission processes in several studies. Carpets have been identified as substantial "sinks" for some toxic VOCs. The VOCs emitted during activities such as painting and remodeling are adsorbed, and later re-emitted from the carpet surface over time. One investigator has shown conclusively that indoor VOC-ozone reactions can result in the formation of elevated levels of fine particles indoors; earlier investigators found that toxic compounds such as formaldehyde can result from elevated indoor ozone concentrations.

OBJECTIVE: The goal of this project is to quantify indoor ozone and VOC reactivity, removal, formation, and re-emission in homes and schools under typical indoor conditions; identify conditions in which such processes result in potentially harmful levels of pollutants; quantify the resultant levels of harmful pollutants; and estimate the quantities available for emission to the outdoors.

DESCRIPTION: Investigators will utilize a test chamber, test home, and/or various indoor environments to examine and measure chemical and physical transformation processes in common indoor environments.

BENEFITS: Results will be used to improve estimates of indoor pollutant levels, to better understand their inter-relationships, and to more accurately quantify exposures to ozone, particles, and toxic VOCs both indoors and outdoors. This information can be used to develop more effective approaches to reduce exposure and risk. Results will also help improve the VOC emission inventory.

COST: $400,000

TITLE: Polybrominated Diphenyl Ethers (PBDEs) Exposure Assessment

PROBLEM: Since the 1960s, polybrominated diphenyl ethers have been used as flame retardant additives in electronic appliances, paints, and textiles. Due to widespread exposure to PBDEs, concentrations in human tissue have been found to be increasing exponentially, and may pose a serious public health threat. Recent health studies indicate that PBDEs bioaccumulate and are linked to neurodevelopmental toxicity and thyroid cancer. The potential health risk of PBDEs warrants an evaluation to determine if PBDEs should be considered for identification and regulation as toxic air contaminants. However, currently, there is insufficient information to adequately characterize exposure to these substances in California.

PREVIOUS WORK: There are several recently published health studies indicating that PBDEs can cause neurodevelopmental toxicity. There are also studies indicating that these substances bioaccumulate and persist in the environment. However, only limited studies exist which evaluate human exposure to PBDEs or their atmospheric chemistry.

OBJECTIVE: The goal of this project is to obtain data needed for an exposure assessment that will serve as the basis for formal identification and control of PBDEs as toxic air contaminants, if warranted.

DESCRIPTION: This research project will obtain measurements of indoor and ambient concentrations of PBDEs, and identify indoor and outdoor sources of PBDEs.

BENEFITS: The data obtained will help us to decide if this class of compounds should be formally identified as toxic air contaminants by the ARB. If PBDEs are formally identified as toxic air contaminants, this research will provide a sound foundation for that decision, and will also help characterize exposure for control purposes.

COST: $100,000

TITLE: **Exposure Assessment of Use of Janitorial and Institutional Cleaning Products**

PROBLEM: Many janitorial cleaning products on the market such as general purpose cleaners, general purpose degreasers, and glass cleaners contain solvents. Some commonly used compounds include glycol ethers, terpenes, and alcohols. These products are used in institutional settings, as well as in the home, to clean floors, walls, windows, and bathrooms. Concern has been raised that solvents used in these cleaning products may pose a health threat, especially those containing 2-butoxyethanol.

PREVIOUS WORK: The U.S. EPA conducted a study that focused on some of the components that were toxic in janitorial products. The toxic components were identified and alternative janitorial products that were not as toxic were suggested.

OBJECTIVE: The goal of this project is to conduct an exposure assessment using cleaning products that will comply with the future regulation for a four-percent-by-weight limit for non-aerosol general purpose cleaners, degreasers, and non-aerosol glass cleaners.

DESCRIPTION: This project will consist of five tasks. Task 1 will be to develop typical parameters and conditions to be used to generate data for the exposure assessment. This plan will be reviewed by ARB staff. In task 2, ARB staff will work with the contractor to determine appropriate cleaning products to be tested. Task 3 will be to generate data to determine typical air concentrations from using the cleaning products as directed. In task 4, the data generated from task 3 will be modeled to determine overall exposure. Task 5 will be to determine irritation and odor thresholds, using available data, for these compounds. Task 6 will be to prepare the final report.

BENEFITS: This project will provide data needed to determine if further control of cleaning products is warranted to reduce worker exposure.

COST: $125,000

TITLE: Source Apportionment of Fine and Ultrafine Particulate Matter

PROBLEM: Reducing fine particulate matter (PM2.5) is one of the most difficult environmental challenges facing California because of the great diversity of sources and chemical species involved. Linking sources to measured air quality uses a statistical method termed "source apportionment". Perhaps the greatest uncertainties in source apportionment calculations for PM2.5 are the relative contributions made by heavy-duty diesel and light-duty gasoline engines. An evaluation of the sources of ultrafine particles is also needed to better understand where these tiny particles are coming from and how they impact health.

PREVIOUS WORK: The source apportionment of fine carbonaceous particles in the South Coast Air Basin (SoCAB) was the first to employ detailed organic compound speciation to distinguish sources of particle carbon. During the SCOS97-NARSTO field study, a Caltech research group deployed filter-based and impactor samplers at several sites in the SoCAB in 1997. To develop size distributions and composition profiles of fine particles emitted by gasoline- and diesel-fueled vehicles, measurements were also made in the Caldecott Tunnel in northern California in November 1997. A source apportionment of ultrafine particles has not been undertaken previously.

OBJECTIVE: The goal of this project is to determine the size distribution of organic tracers using previously collected source and ambient samples, and to perform a source apportionment analysis of fine and ultrafine particles.

DESCRIPTION: The chemical profiles of the emission sources will be developed from the Caldecott Tunnel study and previous studies. Size-resolved source extractions collected from diesel and gasoline vehicles, wood burning, meat cooking, and cigarette smoke will be analyzed for the concentration of the organic tracers. Size-resolved samples of ambient PM will also be extracted and analyzed for the concentration of the same organic tracers. Through an evaluation of fine particles collected from ambient air and sources, fingerprints for the sources of fine particles will be developed. A source apportionment calculation will then be undertaken to determine how much of the ambient fine particle signal is explained by known sources.

BENEFITS: Developing a technically defensible PM control program requires identifying the contribution of each source type to the measured PM concentrations and then estimating the air quality benefits associated with implementing a suite of emission controls. This project will perform the source apportionment of fine particles, including ultrafine particles. Fine and ultrafine particles have been implicated in serious health effects, and so a better understanding of source contributions to PM2.5 concentrations will enable decision-makers to formulate effective control strategies to protect public health.

COST: $313,000

TITLE: **Determination of Particulate Matter Emissions from On-road Tire and Brake Wear, and Asbestos Emissions from Use of Automotive Friction Products**

PROBLEM: The tire wear particulate matter (PM) emissions factor in ARB's emissions model was last updated several years ago. The elimination of bias-ply tires may have significantly altered the total PM emissions from these sources. In addition, there is an area of concern regarding automotive friction products (e.g., brakes, clutch facings, and some automatic transmission components). Many of these parts contain asbestos, a known carcinogen. Brake wear emissions accounted for approximately 23 percent of the total 2000 statewide on-road emissions of motor vehicle PM10, but associated asbestos emissions are currently unknown.

PREVIOUS WORK: Although several studies have been conducted on tire and brake wear emissions, little information is available on the effects of vehicle load and driving cycle. Also, the proportion of automotive brakes containing asbestos, as well as the compositional proportion of asbestos within the brake material, is unknown.

OBJECTIVE: The goal of this project is to improve emission rates for tire and brake wear, and determine the asbestos content of automotive friction products.

DESCRIPTION: A literature search will be performed to determine what test procedures and test data are available regarding the measurement and analysis of PM emissions from tire and brake lining wear. In addition, the contractor will conduct a literature review of the amount of asbestos contained in samples of each friction product such as brakes, clutch facings, and some automatic transmission components, and their frequency of use by vehicle class. A distinction will be made between original engine manufacturer and aftermarket parts. Brakes will be categorized by front or rear, and by material type (asbestos, metallic, etc.). If sufficient funds are available from other sponsors, tire and brake lining wear measurements will be conducted.

BENEFITS: The ARB will acquire useful information on the use of automotive emission products containing asbestos, and thereby determine the need for regulatory control in order to protect public health. Also, the ARB will obtain a better estimate of the PM10 inventory contribution from tire and brake wear emissions.

COST: $100,000 (plus possible co-funding from other sponsors)

TITLE: Dioxin Emissions from Heavy-duty Diesel Vehicles

PROBLEM: Dioxins and dioxin-like compounds include polychlorinated dibenzo-*p*-dioxins, dibenzofurans, and polychlorinated biphenyls (PCBs), and are referred to here as dioxins. The U.S. EPA recently reassessed the issue of dioxin toxicity and exposure. They concluded that dioxins cause adverse health effects at common ambient levels, with exposure due primarily to releases into air from combustion processes. The concentration of dioxins emitted from diesel vehicles is uncertain. This is largely due to the lack of a suitable method to sample dioxins from mobile sources. In view of the identification of particulate matter from diesel exhaust as a toxic air contaminant by the ARB, and the known toxic effects of dioxins, further study of dioxins in heavy-duty diesel emissions is warranted.

PREVIOUS WORK: Dynamometer studies, roadway tunnel studies, and direct on-road sampling have been conducted to estimate dioxin emissions from motor vehicles. Data indicate that dioxin emissions from diesel vehicles are greater than from gasoline-powered vehicles equipped with catalytic converters. Dioxin emissions from a diesel engine were sampled for an ARB-sponsored study titled "Evaluation of Factors that Affect Diesel Exhaust Toxicity" (1998). Relatively low dioxin levels were reported, but the investigators believed this was due to losses of dioxins in the dilution tunnel system used to sample emissions. A recent draft U.S. EPA document cited a roadway tunnel study (Gertler, et al. 1996) as the basis for its estimate of the contribution of diesel emissions to total "releases to air", although the emission factor from this study was assigned a "low confidence" rating.

OBJECTIVE: The goal of this project to determine the total emissions of dioxins from heavy-duty diesel vehicles in California, and, if possible, the effect of control technologies and variations in chlorine levels in the fuel, oil, and ambient air entering the engine.

DESCRIPTION: Possible sampling methods to measure dioxins in heavy-duty diesel emissions will be reviewed. After developing and validating the optimal method, dioxins will be measured from heavy-duty diesel vehicles in “real-world” or controlled settings (e.g., tunnel roadway, on-road, or dynamometer) in order to estimate the total emissions of dioxins from heavy-duty diesel vehicles in California. If funds permit, the levels of chlorine entering the engine through the fuel, oil, and ambient air will be varied to investigate the effect of chlorine content on dioxin production. In addition, the tests will be conducted using various control technologies (e.g., catalyzed diesel particulate filters, diesel oxidation catalysts) to measure their effectiveness in reducing dioxin emissions.

BENEFITS: The method developed in this study will enable accurate quantification of dioxins in motor vehicle emissions, and produce data on emissions of dioxins from typical California heavy-duty diesel vehicles necessary for possible control decisions.

COST: $400,000 (This is a carry-over project for the previous fiscal year. The total funds available, including the prior year, is $720,000)

TITLE: **Impact of NO_X Surface Reactions on the Formation of Particles and Ozone, and Control Strategy Implications**

PROBLEM: Nitrous acid (HONO) is a major source of the hydroxyl radical (OH) in polluted urban areas, initiating the formation of ozone and particles. While HONO is known from laboratory studies to be formed in heterogeneous processes involving particle and other surfaces, these reactions are not sufficiently well understood to be quantified in current air quality models. In addition, under low hydrocarbon to nitrogen oxide (NO_X) conditions, ozone formation is limited by OH scavenging with nitrogen dioxide (NO_2) to form nitric acid (HNO_3); however, initial studies at the University of California at Irvine have shown that there may be mechanisms of recycling HNO_3 back into NO_X. Again, the chemistry is not sufficiently well understood to test whether this "renoxification" of HNO_3 alters the predicted dependence of ozone and particles on the precursor hydrocarbon and NO_X emissions.

PREVIOUS WORK: A major source of HONO is believed to be the heterogeneous reaction of NO_2 on wet surfaces. Recent work has established that the reaction of gaseous nitric oxide (NO) with HNO_3 on wet surfaces also generates HONO, and may rival the NO_2–water reaction as a source in polluted urban areas. The HNO_3-NO reaction also "renoxifies" HNO_3 back into photochemically active NO_2, generating more ozone and particle nitrate than would otherwise be the case.

OBJECTIVES: The goal of this project is to determine the sources of HONO in polluted urban atmospheres; whether there are other reactions on surfaces besides the reaction with NO that can convert HNO_3 back into NO_2; if these reactions are photo-enhanced; and the atmospheric importance of these reactions for the formation of ozone and particles.

DESCRIPTION: The proposed research is comprised of fundamental laboratory studies combined with development of a box model. Fourier transform infrared spectrometry combined with long pathlength cells, transmission cells containing environmentally relevant surfaces which promote the heterogeneous chemistry, and an attenuated total reflectance cell to follow reactions in thin water films on these surfaces will be used to elucidate the fundamental kinetics and mechanisms of heterogeneous NO_X reactions. The results will be used to develop a comprehensive box model for heterogeneous NO_X chemistry in polluted urban atmospheres. This will be introduced into an airshed model for southern California, so that the impact on ozone and particle levels can be assessed.

BENEFITS: The results of this research are critical to the development of accurate airshed models and their application to the development of cost-effective control strategies, in particular, the issue of the relative effectiveness of hydrocarbon and NO_X controls.

COST: $400,000

TITLE: Maximum Incremental Reactivities (MIRs) for Volatile Organic Compounds Used in Architectural Coatings

PROBLEM: Emissions of architectural coatings contribute a significant portion of the daily volatile organic compound (VOC) emissions in California. Control strategies that encourage the use of less photochemically reactive VOCs may be an economical means to achieve ozone reductions, but to do so requires data quantifying ozone-forming potentials of the most common VOCs used in architectural coatings. The ARB recently approved the 2000 Suggested Control Measure (SCM) for Architectural Coatings that will be used by local districts to amend their architectural coating rules. The resolution approving the SCM directs staff to report to the Board by December 2002 with an update on the development of a reactivity-based control strategy for architectural coatings.

PREVIOUS WORK: Until recently, the only speciation profiles for architectural coatings were those provided in an ARB-contracted study in 1996. In the 1998 ARB Architectural Coatings Survey, manufacturers quantified VOCs used in their coatings. The ARB has sponsored several recent studies to investigate the reactivities of compounds used in the ARB's consumer products regulations, and MIR-based standards have recently been adopted for aerosol paints.

OBJECTIVE: The goal of this project is to determine the MIR and the degree of uncertainty associated with each value for any compounds identified in the 1998 Architectural Coatings Survey that have not already been studied or for which there is a large degree of uncertainty in the MIR values.

DESCRIPTION: The contractor will utilize the 1998 Architectural Coatings Survey and any other relevant data to identify the most commonly used solvents used in architectural coatings that do not already have MIR values. The contractor will then determine the estimated MIR and the degree of uncertainty in the MIR values. The estimates of uncertainty, which quantify the degree of confidence with the predictive modeling data and the chemical mechanism, will be used to develop adjustment factors to modify the estimated MIR value in the regulation.

BENEFITS: The study results will be used to support possible reactivity-based standards in the ARB's SCM, and ultimately, architectural coating rules of the local air districts. Manufacturers will gain compliance flexibility by using solvents with low MIR values, and have information about the lowest reactivity solvents to be used when reformulating products.

COST: $240,000 (including possible cost–sharing with the Reactivity Research Working Group)

TITLE: **Evaluation of SAPRC Mechanisms at Low-NO_X Conditions Using Existing Smog Chamber Data**

PROBLEM: The atmospheric chemical mechanisms developed by Dr. William Carter at the Statewide Air Pollution Control Center (SAPRC) are constantly being updated and are considered state-of-the-science mechanisms. The SAPRC mechanism was used in developing the reactivity scales for California's Low-Emission Vehicles and Clean Fuels regulations. However, the mechanisms have been developed and tested under high-NO_X conditions and they have not been evaluated under low-NO_X conditions. There are low-NO_X chamber results currently available from the Tennessee Valley Authority (TVA) smog chamber, and from the CSIRO smog chamber in Australia that can be used to evaluate the SAPRC mechanism. Tighter NO_X regulations are expected to further decrease urban and rural NO_X concentrations in the future, and there is no assurance that the model will perform satisfactorily when simulating low-NO_X atmospheres. There are few environmental chambers in the world with the capacity to conduct experiments under low-NO_X conditions. A new experimental chamber is being developed at the University of California at Riverside, under U.S. EPA funding, that has the capability of performing low-NO_X experiments.

PREVIOUS WORK: The SAPRC mechanisms have been developed and tested under conditions of high NO_X typical of urban areas, but not under low-NO_X conditions. For example, the TVA and CIRO chamber experiments have been used to partially evaluate the performance of the Carbon Bond mechanism (CB4), with the result that the CB4 mechanism significantly underpredicts ozone and other pollutants when NO_X availability is low. Similar studies for other mechanisms have not been conducted.

OBJECTIVE: The goal of this project is to evaluate the performance of the SAPRC mechanism under low-NO_X conditions using currently available low-NO_X smog chamber results from the TVA and CSIRO chambers.

DESCRIPTION: The project will identify low-NO_X experiments where the mechanism is below acceptable performance, suggest improvements to the chemical mechanism and recommend future low-NO_X experiments needed for mechanism performance evaluation when the new environmental chamber in Riverside has been built and evaluated. A limited number of low-NO_X smog chamber experiments will also be conducted in existing chambers at Riverside since it may be determined that insufficient experimental data at low NO_X is available.

BENEFITS: The results of this project will identify potential improvements in the chemical mechanism and recommend future low-NO_X experiments when the chamber at Riverside is operational. A better representation of the processes leading to ozone will ensure that the mechanism used in models for State Implementation Plans is providing the "right answers for the right reasons".

COST: $80,000

TITLE: Correlation Between Solids Content and Hiding as it Relates to Calculation of VOC Content in Architectural Coatings

PROBLEM: Since the 1970s, the U.S. EPA has required that volatile organic compound (VOC) content of architectural coatings be expressed in units of mass of VOC per unit volume of coating, less water and exempt solvents. Traditional thinking is that the "less water and exempts" calculation provides an equivalent basis for comparing the polluting portion of solvent-based and water-based coatings, i.e., on a solvent-to-solids ratio. The justification for this calculation is that it prevents a manufacturer from simply watering down paints to meet the VOC limit. However, this assumes that the higher the solids content, the better the coating coverage and "hiding". If a particular coating "covers" but does not "hide" sufficiently, the consumer will repeat the application with additional paint. Because many waterborne coatings contain at least 50 percent water, the labeled VOC content of waterborne coatings is inflated by at least two times compared to solvent-borne coatings. Manufacturers state that the type of solids used in the coating is also very important in coverage and hiding. Manufacturers also indicate that the labeling requirement "penalizes" them for formulating coatings with water. The Board, during its approval of the 2000 Suggested Control Measure for Architectural Coatings, directed ARB staff to evaluate this issue after an evaluation of the "less water and exempts" calculation.

PREVIOUS WORK: No formal studies have been done to validate the "less water and exempts" calculation.

OBJECTIVE: The goal of this project is to determine the effect of volume and type of solids on surface coverage and hiding for water-based architectural coatings, and evaluate the validity of the "less water and exempts" calculation.

DESCRIPTION: Three coating categories will be chosen for the study for evaluation of the following variables: level of coating solids content, type of solids (i.e., calcium carbonate, silicates, titanium dioxide), and coverage (both area covered and the coating's ability to hide the substrate). Paint formulations with various solids levels will be used, keeping other formulation properties the same, to perform application tests. The American Society of Testing and Materials tests will be used in many cases to evaluate the effect of the amount and type of solids on coating coverage. These methods may include coverage area, dry film thickness, contrast ratio (hiding), gloss, and a measure of durability (e.g., scrub resistance).

BENEFITS: This project will evaluate the basic assumption used in the "less water and exempts" calculation. With this knowledge, the ARB can work with U.S. EPA to find alternative ways to express VOC content such as VOC including water and exempts and VOC percent by weight. If VOC content can be expressed in a way that includes water and the exempts, an improved VOC test method (i.e., Method 24) may not be needed. The biggest source of errors in the method, measuring water and exempt solvents, will be removed from the calculation. Enforcement will be easier since the test method will be more straightforward.

COST: $100,000

TITLE: California Public and Commercial Building Data for Indoor Exposure Modeling

PROBLEM: ARB is required to estimate indoor and total air exposures for particulate matter (PM) and particulate toxic air contaminants, such as metals and diesel PM (HSC 39660.5). Although there are indoor PM data for residential buildings, little data exists for public and commercial structures. Indoor PM levels of non-residential buildings can be estimated, using a mass balance model. However, to use this model, ARB needs representative input data on the penetration of outdoor PM into non-residential buildings and its removal by air filtration systems.

PREVIOUS WORK: Adults in California spend about 25 percent of their time in public and commercial buildings. Most of these buildings have mechanical ventilation systems, with air filtration systems that remove some PM. However, studies of the prevalence and effectiveness of these systems are very limited. The California Energy Commission funded a survey of 88 California public buildings and their ventilation systems and the Lawrence Berkeley National Laboratory characterized the ventilation of twelve office buildings in the San Francisco Bay area. Periodic surveys of building characteristics related to energy usage have also been conducted in California. However, none of these studies provide the information needed to determine particle penetration and air filtration systems for non-residential structures.

OBJECTIVE: The goal of this project is to obtain representative information on the relationship of PM levels and building ventilation, air filtration systems, and other variables in California's public and commercial buildings.

DESCRIPTION: The investigators will compile information on air handling and filtration systems, building use and occupancy characteristics, maintenance practices, and related information for public and commercial buildings. They will identify the areas where additional data is needed and, in consultation with ARB, conduct a survey of selected buildings to fill some of the critical data gaps. A database of building characteristics will be constructed, using data from previous studies and ARB's targeted survey, in a common coding format. The database will provide inputs for modeling indoor levels of PM in public and commercial buildings.

BENEFITS: The results from this study will improve ARB's ability to estimate Californians' indoor and total air exposures to PM and its toxic components. This representative data will also enable ARB to more accurately estimate the exposure reduction that may be achieved through changes in the design and operation of building ventilation and filtration systems.

COST: $350,000

TITLE: **Vehicle-to-Grid Demonstration Project: Grid Regulation Ancillary Service with a Battery Electric Vehicle**

PROBLEM: In the near-term, electric vehicles (i.e., battery, hybrid, or fuel cell) will cost more than conventional vehicles to manufacture. This reduces the near-term quantities sold and the corresponding air quality benefits that could be obtained from large-scale introduction.

PREVIOUS WORK: ARB and the Los Angeles Department of Water and Power funded a preliminary study entitled "Feasibility of Electric Drive Vehicles—Battery, Hybrid, and Fuel Cell—as Distributed Power Generation Assets in California". The study concluded that economics were favorable for: 1) battery electric vehicles (BEVs) and grid-hybrid electric vehicles (HEVs) providing ancillary services (grid regulation and spinning reserves) and peak power, and 2) other electric drive vehicles, including fuel cell and hybrid electric vehicles, for peak-power production.

OBJECTIVE: The goal of this project is to demonstrate the feasibility of BEVs as grid regulation assets under real-time California Independent Service Operators control, and identify remaining technical, legal, and regulatory challenges for use of BEVs to provide ancillary grid services (grid regulation and spinning reserves) as well as peak power generation.

DESCRIPTION: This project will design, fabricate, and demonstrate a BEV capable of providing electric power grid regulation using real-time control via remote signal from the California ISO. This project will examine existing standards and regulations that apply, identify obstacles to EV-based ancillary services and power generation, and quantify potential benefits of regulation and energy storage using BEVs.

BENEFITS: This project will improve the operation of the electric power grid and the economic attractiveness of EVs by enabling owners to sell grid support services in order to offset the higher cost of EVs relative to conventional vehicles. It will also improves air-quality by improving the affordability of EVs. Since there will be more consumers who can afford them and more of them placed in service, there will be a decrease in vehicle emissions as the vehicle miles traveled increases for zero-emission vehicles.

COST: $165,000 (including possible co-funding from other sponsors)

TITLE: Assessment of Toxic Substances Produced by Diesel Emission Controls

PROBLEM: Efforts to reduce diesel exhaust emissions have resulted in the development of varied control technologies, such as catalyzed diesel particulate filters (DPFs), diesel oxidation catalysts, lean-NO_X catalysts, and NO_X adsorbers. However, their use may lead to the formation of toxic substances. For example, under some engine operating conditions, noble metal catalysts can lead to increased emissions of carcinogenic nitro-polycyclic aromatic hydrocarbons (nitro-PAH). We should determine the extent of adverse health impacts from use of these technologies.

PREVIOUS WORK: DPFs and oxidation catalysts have been shown to increase the mutagenic potency of diesel emissions, likely resulting from the formation of nitro-PAH. The use of fuel-borne catalysts (such as cerium and copper) has been shown to increase particle number, unless used in conjunction with a DPF. Copper as a fuel-borne catalyst led to increased dioxin emissions in a DPF-equipped diesel engine, and copper is used as the catalyst for lean-NO_X technology. Decreased levels of fuel sulfur may also increase dioxin emissions. Recent research has highlighted health concerns from several nitro-PAHs derived from diesel exhaust. For example, 2-nitro-dibenzopyranone is highly mutagenic in human cells, and 3-nitro-benzanthrone is an extremely potent bacterial mutagen. Diesel oxidation catalysts can increase the mutagenicity of diesel exhaust, and recently were found to produce a dramatic increase in nitro-PAH under some conditions.

OBJECTIVE: The goal of this project is to evaluate the potential health impacts posed by the deployment of diesel emission control technologies.

DESCRIPTION: This project will assess emissions from diesel emission control technologies likely to become widespread in the near future. This will include both retrofitted and original engine manufacturer DPFs, and NO_X control devices. Emission parameters of concern include toxic VOC species, PAHs and nitro-PAHs, particle number, and particle size distribution. For each control technology assessed, a net risk analysis will be conducted. Each emission control technology will be compared to the baseline technology and baseline fuel as appropriate. Finally, residue from a catalyst-based DPF will be analyzed for ash and soot components.

BENEFITS: Significant health impacts could arise from the introduction of diesel exhaust control systems. This study will provide data on emissions of toxic substances from diesel exhaust control systems, determine whether DPF residues are toxic, and find ways to control toxic exposure before widespread introduction of these systems. The information obtained from this study will allow us to analyze the health impacts of diesel emission control technologies, and will lead to the use of technologies that provide the greatest health protection.

COST: $326,000 (including possible co-funding from other sponsors)

TITLE: Incidence and Severity of Component Malfunction and Tampering for In-use Heavy-duty Diesel Vehicles

PROBLEM: There is insufficient data on the number of component malfunctions or tampering with in-use heavy-duty diesel vehicles. These data are needed to estimate the in-use fleet emissions and to identify the most significant occurrences. These vehicles will be included in a future heavy-duty diesel inspection and maintenance program (i.e., State Implementation Plan Measure 17).

PREVIOUS WORK: In 1988, the ARB sponsored a heavy-duty diesel inspection and maintenance study which collected data that estimated the incidence and severity of component malfunctions. This study highlighted the most common malfunctions in heavy-duty diesel vehicles. More recently, the U. S. EPA updated the findings of the 1988 study. They collected emission deterioration rates on a limited number of vehicles for particulate matter emissions. The ARB adjusted these deterioration rates to fit the conditions of California's heavy-duty diesel vehicle fleet. These updates incorporated emission test data, but have not generated newer real-world incidence rates. The limited data available on the incidence of component malfunction includes technologies more than a decade old.

OBJECTIVE: The goal of this project is to estimate the failure and tampering rates of the components of in-use heavy-duty diesel vehicles; estimate the benefits of repairing such failures and malfunctions and preventing tampering; and identify the most significant occurrences and include them in a heavy-duty diesel inspection and maintenance program.

DESCRIPTION: This research focuses on estimating the malfunctions and tampering of components in heavy-duty diesel vehicles, and includes three basic elements: 1) surveying repair shops registries, 2) surveying fleet records, and 3) assessing the malfunctions and tampering on random roadside surveys. The combination of these approaches will identify, by class of heavy-duty diesel vehicles, the components most likely to malfunction or be tampered with.

BENEFITS: The State will be able to better estimate the emission inventory and the benefits of the implementation of various levels of mandatory inspection and maintenance programs for heavy-duty diesel vehicles. This will facilitate the implementation of control actions, such as SIP Measure 17, by providing critical information to target the most significant malfunctions and tampering in engine components.

COST: $200,000

TITLE: Alternatives to Aerosol Automotive Products that Use Solvents Containing VOCs and Chlorinated Organic Compounds

PROBLEM: Aerosol products used by auto repair facilities contain VOCs and chlorinated organic compounds. An ARB regulation restricts the VOC content of some aerosol automotive products to 40 percent. In December 2002, another ARB regulation will ban the use of chlorinated solvents for automotive products. To comply with that ban, formulators may use non-chlorinated toxic compounds for their products.

PREVIOUS WORK: The U.S. EPA sponsored a project to identify, test, evaluate, and implement water-based cleaning alternatives to perchloroethylene aerosol brake cleaning products. This project was conducted in partnership with several wastewater discharge agencies, SCAQMD, and Cal/EPA's Department of Toxic Substances Control, and yielded promising results.

OBJECTIVE: The goal of this project is to develop, demonstrate, and evaluate water-based cleaning alternatives for automotive aerosol cleaning products.

DESCRIPTION: Water-based formulations for cleaning engines, brakes, carburetors, fuel injectors, and other parts will be developed and tested in the lab. Irritation and odor thresholds, using available data, will be to determined for these compounds. Auto repair shops, including small shops, chains, service stations, and dealerships, will be converted to the water-based alternatives that worked best for their applications. A cost/benefit analysis will be conducted comparing the new water-based cleaners with currently used aerosol cleaners. Finally, a workshop for the auto repair industry will be held to disseminate the results of the study.

BENEFITS: The project will lead to reduced emissions of VOCs and toxic air pollutants.

COST: $200,000

TITLE: Evaluation of Revegetation Practices in the Antelope Valley for Particulate Matter Control

PROBLEM: The Antelope Valley in northern Los Angeles County experiences severe PM10 episodes when fugitive dust from the bare soil of fallow or abandoned farmlands is raised by the high winds common in this area in spring and early summer. Since the natural desert vegetation does not readily re-colonize these lands, they tend to remain barren or become infested with pest species (e.g., tumbleweeds), which provide little dust suppression

PREVIOUS WORK: Previous research in the Antelope Valley demonstrated that revegetation works for long-term stabilization, but that plant establishment is unreliable in any one year. Continued work is needed to identify the determinants of revegetation success.

OBJECTIVE: The goal of this project is to develop well-defined cost-effective control for dust emissions from abandoned and overgrazed farmlands, construction sites, burns and other disturbed areas in arid and semi-arid regions, emphasizing re-establishing native vegetation.

DESCRIPTION: In cooperation with other groups, the current plant-based research in the Antelope Valley seeks to understand the environmental factors (e.g., soil moisture and temperature) and the physiological responses of selected plant species. Continuous monitoring of microenvironmental parameters and physiological function is essential to this evaluation.

BENEFITS: Management practices and revegetation techniques evaluated in this research may have broad applicability in many semi-arid areas of California and the western United States where cultivated lands are cyclically or permanently abandoned due to changing water supply and price, soil degradation, commodity prices, and land economics. The protocols, under development with stakeholder input, will provide cost-effective best management practices for land managers to stabilize the surface prior to abandonment. In addition to revegetation, evaluations are being conducted of environmentally friendly physical methods such as mulches (e.g., wood chips), “green” chemical suppressants, and wind fences, as well as development of early detection methods for identifying dust prone areas. For these reasons, this research program is enjoying broad support from other agencies and the Southern California Edison Company.

COST: $30,000 per year for three years [plus co-funding from the Antelope Valley Air Pollution Control District ($25,000 annually), the Los Angeles Department of Airports ($35,000 annually), and the Southern California Edison Company ($75,000 annually)].

TITLE: Estimates of Nitrous Oxide and Ammonia Emissions from Motor Vehicles and the Effects of Catalyst Composition and Aging

PROBLEM: Catalytic converters play an important role in controlling vehicle emissions. However, an unforeseen consequence of catalytic control has been increased emissions of nitrous oxide (N_2O) and ammonia (NH_3). Nitrous oxide is a greenhouse gas over 300 times more potent than carbon dioxide on an equal weight basis. Motor vehicles, the fastest growing source of N_2O emissions, account for approximately 15 percent of the total U.S. inventory. Essentially all nitrous oxide generated from motor vehicles is formed within the catalytic converter. Ammonia reacts in the atmosphere to produce ammonium nitrate and sulfate salts, which are forms of PM2.5 and contribute significantly to visibility problems.

PREVIOUS WORK: Nitrous oxide and ammonia emissions from motor vehicles have been measured by several dynamometer, tunnel, and remote sensing studies. Both the Intergovernmental Panel of Climate Change (IPCC) and the U.S. EPA have calculated emission inventories. Catalytic converters generate nitrous oxide and aged converters generally create more than new ones. Catalyst-equipped vehicles can also generate high emissions of ammonia under certain operating conditions. Limited remote sensing studies have found a gamma distribution in emissions rates (i.e., a minority of the vehicles are responsible for the majority of the emissions), but it is not known what factors contribute to these “high emitters”. Limited studies have found that catalyst composition and age play some role in emissions of nitrous oxide and ammonia.

OBJECTIVE: The goal of this project is to measure exhaust emissions of ammonia and nitrous oxide in order to accurately characterize California motor vehicle emissions of these compounds and to investigate the effects of catalyst composition and aging on emissions.

DESCRIPTION: In-use tailpipe testing will be performed on a representative fleet of vehicles, being sure to include late model, low-emission vehicles tested with low-sulfur fuel. Possible options include analysis of existing data, dynamometer testing incorporating real-world driving cycles, and remote sensing studies. The dynamometer testing will be done modally, using various compositions and ages of catalysts.

BENEFITS: Nitrous oxide is a potent greenhouse gas and ammonia is a major contributor to PM2.5 formation. This study will help develop a nitrous oxide and ammonia inventory for motor vehicles. It will help pinpoint types of vehicles, catalyst, and operating conditions of highest concern. It will help the ARB discern if controls are needed for these pollutants. Finally, it will aid in PM2.5 modeling efforts.

COST: $300,000 (including possible co-funding from other sponsors)