

California Environmental Protection Agency



**Air Resources Board**

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**PLANNED AIR POLLUTION  
RESEARCH**

**Fiscal Year 2000-2001**

**July 2000**

This report is available on the World Wide Web at  
[www.arb.ca.gov/research/apr/plan/plan.htm](http://www.arb.ca.gov/research/apr/plan/plan.htm).

# CALIFORNIA AIR RESOURCES BOARD

## PLANNED AIR POLLUTION RESEARCH FISCAL YEAR 2000-01

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## **SUMMARY**

This report presents the Air Resources Board's planned air pollution research for the fiscal year 2000-2001. Sixteen projects are proposed. Nine are recommended for funding and seven are recommended if funding is available. Research this year is focused on improvement of emissions inventories and exposure and health research. One of the studies would measure air pollutants in school buses and at bus stops. Another is a health project that would attempt to identify the mechanisms of the harmful effects of particulate matter. The proposed budget for the recommended projects is \$3,900,000.

# INTRODUCTION

This report presents the Air Resources Board's (Board's) planned air pollution research for fiscal year 2000-2001. 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.

The Board 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.

***Objective of the research program.*** The objective 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, ARB staff, local air pollution control districts, the academic community, Board research advisory committees, and the public.

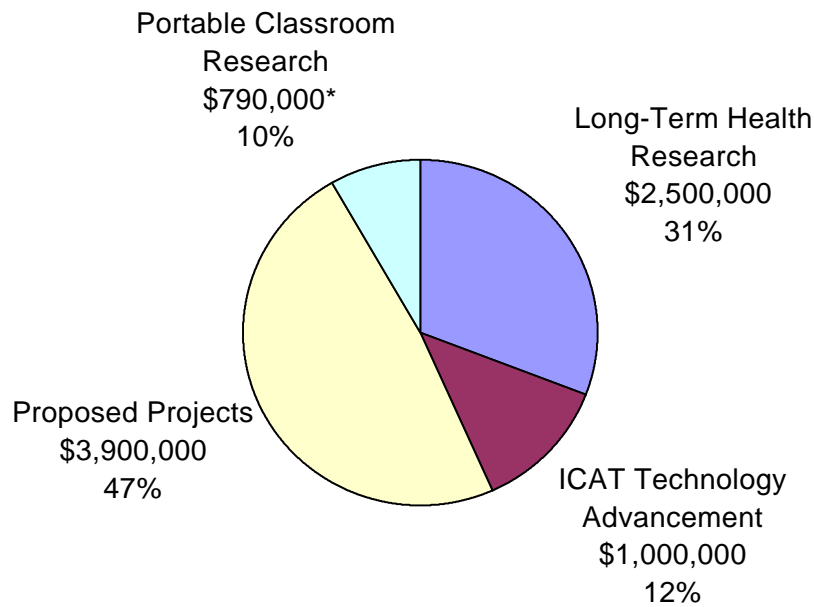
***Public Involvement.*** The Board invites and encourages the public to contribute ideas for project consideration. This year, sixty-five research ideas were submitted. Once the proposals were reviewed, a workshop was held to present the staff project selections and solicit public comment.

***Planning the research program.*** To aid in planning, the Board's Executive Officer has established committees to develop and review research ideas. Proposed projects are examined for relevance to regulatory questions facing the Board and modified as necessary. Committee members then select candidate projects in order of decreasing urgency and importance. Each committee, in consultation with their Deputy Executive Officer, submits a list of projects to the Executive Research Review Committee, whose members are the Executive Officer, his deputies, and the Chief of the Research Division. This Executive Committee reviews all of the proposed projects and establishes project priorities. Selected projects are then placed into two categories: 1) those that are recommended for funding and 2) those recommended if funding is available. The Research Screening Committee reviews the selected projects, considers public comments, and then recommends the plan to the Board. This year's projects are focused on improvement of emissions inventories and exposure and health research.



**Research budget.** The nine recommended projects total \$3,900,000 — 47 percent of the research budget (Figure 1). Twelve percent of the budget is directed to technology advancement in the Innovative Clean Air Technologies Program. Thirty one percent will support ongoing health studies: The Children’s Health Study and the Vulnerable Populations Health Study. The remaining 10 percent of the budget is for a study of indoor environmental problems in portable classrooms, to be conducted jointly with the Department of Health Services.

**Figure 1. Tentative Fiscal Year 2000-2001 Budget: \$8,190,000**



*\*allocation for FY 2000-2001 only*

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

Research Category	Budget
Mobile Sources	\$850,000
Toxic Air Contaminants	\$200,000
Stationary Sources	\$650,000
Regional Air Quality	\$1,050,000
Economic Studies	\$150,000
Health Effects	\$1,000,000

**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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# RESEARCH PROJECT DESCRIPTIONS

The following nine projects are recommended for funding; a summary of the projects for which funding is recommended (or recommended if funding is available) are provided in this section.

Collection and analysis if weekend/weekday activity data in the 1997 Southern California Ozone Study modeling domain .....	6
Analysis of off-road evaporative emissions .....	7
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**TITLE: Collection and Analysis of Weekend/Weekday Activity Data in the 1997 Southern California Ozone Study Modeling Domain**

**PROBLEM:** Both the on- and off-road mobile source emissions inventory models purport to estimate ozone episodic inventories. However, the activity estimates contained in current models are based on either monthly or yearly averages. Ozone episodes in Southern California occur more often on weekends than during the week, but little is known regarding changes in activity that might contribute to these episodes.

**PREVIOUS WORK:** Analyses of weekday versus weekend episodes have been performed by Dr. Winer of UCLA and ARB staff. However, these studies have been limited to the analysis of ambient monitoring station data.

**OBJECTIVE:** To conduct a comprehensive study of the activity changes in the mobile source fleet from weekday to weekend, with emphasis on understanding the relationship between activity and air quality.

**DESCRIPTION:** This study will gather information on the variation in activity occurring in the on-road fleet on weekdays and weekends, such as the number of trips per day, miles per day, and speed of each trip. The off-road fleet will also be monitored to determine the influences of increased activity in such areas as lawn and garden and recreational vehicle usage. The temporal resolution for activity data collection is hourly. The desired modeling domain is the area that includes Ventura and Santa Barbara Counties to the north and San Diego County to the south.

**BENEFITS:** The performance of this study will allow emissions modelers to produce ozone episodic inventories that depict activity more realistically. This approach will improve cost effectiveness analyses of ozone abatement strategies and the estimated results from airshed models. This information will also be used to modify the on- and off-road models to reflect weekend and seasonal variations in activity.

**COST:** \$550,000 (The total cost of the project is \$800,000.)

**TITLE: Analysis of Off-Road Evaporative Emissions**

**PROBLEM:** Evaporative emissions from off-road mobile sources are not included in ARB's emissions inventory models. The availability of emissions test data for developing evaporative emissions estimates on off-road equipment is limited. A baseline emissions inventory is needed to assess the amount of emissions from these sources and determine the effectiveness of control strategies in attaining future State Implementation Plan goals.

**PREVIOUS WORK:** Recent analysis of the evaporative emissions from gas cans yields a statewide inventory estimate of over 85 tons per day. The gasoline powered off-road equipment population is comparable to that of gas cans, both of which act essentially as containers for fuel. Therefore, the evaporative emissions associated with this segment of the motor vehicle population may be comparable and just as significant.

**OBJECTIVE:** To quantify emission rates and the activity associated with various evaporative processes for off-road equipment.

**DESCRIPTION:** Several pieces of off-road equipment (e.g., lawn mowers, personal watercraft) will be tested for diurnal, hot soak, and permeation emissions. In addition, simple control strategies (i.e., retrofit canister, non-vented gas caps) will be assessed to determine their emissions control potential. The OFFROAD model will then use the emission rates and activity to estimate the evaporative emissions inventory of off-road equipment.

**BENEFITS:** This project will aid in estimating the baseline evaporative emissions inventory of off-road equipment. There has never been an accounting for this portion of the emission inventory.

**COST:** \$300,000

**TITLE: Improvement of Emissions Inventory for Particulate Matter from Tire Wear**

**PROBLEM:** Ten percent of all particulate matter is currently attributed to tire wear. However, these estimates have not been updated in many years and may underestimate the overall emissions from this source.

**PREVIOUS WORK:** The current emissions inventory for particulate matter (PM) from tire wear is based on a constant assumption of 0.002 grams per mile per wheel. This estimate is from the U.S. EPA's AP42, which also assumes that 40 percent of the total particulate from tire wear is less than or equal to 10 microns in diameter.

**OBJECTIVE:** To more accurately determine the amount of particulate matter that is attributable to tire wear.

**DESCRIPTION:** In this project, several vehicle/tire combinations will be tested to update the inventory for tire wear. The influences of temperature, vehicle weight, tire type, road surface, tire pressure, and driving cycle will be explored. Measurements of total particulate, PM10, and PM2.5 will be measured.

**BENEFITS:** Results from this project will more accurately identify PM, especially as it relates to tire wear, for future State Implementation Plans.

**COST:** \$300,000

**TITLE: Comparison of >C<sub>10</sub> Polar Organics in Size-Segregated Particles for Source Apportionment of Diesel and Gasoline Emissions.**

**PROBLEM:** The ARB has classified particulate matter from diesel exhaust as a toxic air contaminant (TAC). Molecular speciation of organics in diesel particles is critical to evaluating the effectiveness of control strategies and investigating whether specific chemicals, or signature patterns of chemicals, can serve as markers of diesel emissions for source apportionment.

**PREVIOUS WORK:** Some studies suggest that the signature of >C<sub>10</sub> hydrocarbons in diesel- and gasoline-derived particles can be used for source apportionment. This project will focus on the oxygenated combustion products found in PM, specifically carbonyls and multi-functional carbonyls. Existing methods can measure gas-phase carbonyls but do not provide information on carbonyls found in the particle phase. In a previous study, carbonyls in particles were measured in the Caldecott tunnel. Preliminary results indicate possible differences between multi-functional carbonyls in PM associated with gasoline and diesel exhaust.

**OBJECTIVE:** To develop the capability to characterize >C<sub>10</sub> carbonyls and multi-functional carbonyls in size-segregated diesel and gasoline particles; measure the composition of >C<sub>10</sub> polar organics in diesel- and gasoline-derived particulate matter; and evaluate whether specific high-molecular weight chemicals, or patterns of specific chemicals, can be used as markers for source apportionment.

**DESCRIPTION:** Impaction substrates and materials to coat the substrate to reduce particle bounce will be evaluated. To test this method of reducing particle bounce, particles segregated into seven different size cuts will be collected in the heavy-duty bore of the Caldecott tunnel. Carbonyls and other polar organics will be measured by using derivatization followed by GC-MS (PFBHA/GC/ITMS) methods. If necessary, experiments will be conducted to refine the method to provide sampling times of ½ hour or less. After development of the method, samples of size-segregated particles will again be collected in the heavy- and light-duty bores of the Caldecott tunnel. The data will be analyzed to determine whether the composition of >C<sub>10</sub> organics on size-segregated particles can be used to differentiate between diesel- and gasoline-derived particles.

**BENEFITS:** This project will develop a method to measure carbonyls and multifunctional carbonyls in PM. It will also examine size-segregated particle-phase samples for compounds, which can serve as markers for diesel exhaust. Information from this study will provide vital corroboration for diesel exhaust risk assessment and diesel and gasoline PM source apportionment. The project will also investigate a possible sampling artifact, which could have an impact on future PM chemical speciation.

**COST:** \$200,000

**TITLE: Improvement of Emissions Inventory for Industrial Coatings and Thinning and Cleanup Solvents**

**PROBLEM:** The existing information used to estimate emissions from industrial coatings, and thinning and cleanup solvents associated with industrial and architectural coatings is outdated and/or incomplete. There have been many changes in these industries, due to improvements in coating technology and rule implementation. Some districts have said that the current emissions inventory does not accurately represent current practices.

**PREVIOUS WORK:** The current emissions inventory for industrial coatings and related solvents usage is based on emission factors derived from results of 1976 and 1977 surveys, conducted by the Stationary Source Division (SSD). The current inventory for thinning and cleanup solvents associated with architectural coatings is calculated based on usage rate, derived from a 1980 Board survey, and an emissions factor derived from a 1975 ARB survey.

**OBJECTIVE:** To quantify the activity and emissions from industrial coatings and thinning and cleanup of industrial and architectural coatings; to determine if current coating technology reduces emissions and the potential for future changes in formulation that might further reduce air pollution emissions; and to determine if thinning and cleanup practices have changed as a result of the introduction of water-based formulations and changes in coating practices.

**DESCRIPTION:** This project will survey the manufacturers and users of industrial coatings and solvents for use rates, formulations, and types of usage. Emission factors for each type of coating and solvent will be calculated. Using the survey data and resulting emission factors, investigators will calculate the 1999 California emissions by air basin, county, and air district.

**BENEFITS:** Information from the survey will be used to determine the current activity and emission factors from formulation data. It will also provide more accurate data for updating the State's emissions inventory, which will assist the Board to better determine future control strategies and help districts meet SIP commitments.

**COST:** \$350,000



**TITLE: Development of a Test Method to Measure the Emissions from Stationary and Portable Engines**

**PROBLEM:** Engines registered with the Statewide Portable Equipment Registration Program (Program), except for those certified to satisfy a State or federal standard for off-road engines, must satisfy either technology or emissions standards. Compliance is determined by the engine manufacturer's test data. This data is based on measurements of carbon monoxide (CO), hydrocarbon (HC), and nitrogen oxides (NO<sub>x</sub>) taken while a dynamometer simulates load changes on the engine. Current test methods used in the field differ from those employed in the laboratory. Because the laboratory test method is used to determine the emission rates for State or federally certified engines, emission reduction estimates based these rates may not be accurate. As a result, replacement or modification of existing engines to meet new engine standards may not achieve the expected reduction of emissions.

**PREVIOUS WORK:** Historically, stationary source test methods have been used to measure emissions from stationary and portable engines. These methods have not been demonstrated to be equivalent to tests using a dynamometer and it is not practical to take in-use portable engines to a laboratory for testing. In addition, staff are not aware of any portable engines that have been tested in the field.

**OBJECTIVE:** To develop a test method that can be used in the field for stationary and portable engines; is equivalent to tests currently employed for off-road engines, including test methods applicable to newly manufactured portable engines; and can be done at a reasonable cost.

**DESCRIPTION:** This project would first review existing test methods to identify the major issues that need to be considered when developing an in-the-field test method for both stationary and portable engines. Using the results of this review, a proposed test procedure would be developed and tested on a representative sample of stationary and portable engines.

**BENEFITS:** Development of an in-the-field test method for stationary and portable engines will help ensure compliance with the Program's requirements and accurately identify overall emission reductions. Accurate estimates will help achieve and maintain compliance with State and federal ambient air quality standards. Results from this project will also support development of toxics control measures for diesel-fueled engines, the RACT/BARCT program, and the State Implementation Plan.

**COST:** \$300,000

**TITLE: Improvement of Emissions Inventory for Stationary and Portable Engines**

**PROBLEM:** The current emissions inventory does not contain an accurate estimate of the emissions from engines used in stationary and portable applications. Emissions inventories for these engines have been difficult to develop for the following reasons: 1) the large number of sources within this category; 2) the exemption of certain categories of engines from district permit programs, such as emergency standby generators and agricultural irrigation pumps; and 3) until recently, certain classes, such as diesel-fueled engines, have not been targeted for emissions reduction.

**PREVIOUS WORK:** Overall, the 1996 inventory for stationary and portable engines constitutes about 1% of the total inventory for nitrogen oxides (NO<sub>x</sub>). Review of this data established that emissions from stationary and portable engines are under-represented. For example, the emissions inventory for agricultural irrigation pumps contains estimates for only two districts and no estimates for a number of districts with significant irrigated farmland. Staff estimates that the inventory for agricultural irrigation pumps may be understated by 50% or more. Updating of the off-road inventory has resulted in draft estimates that are about 300% higher than those contained in the 1996 emissions inventory, not including certain categories of engines operating within the Statewide Portable Equipment Registration Program.

**OBJECTIVE:** To develop a more accurate emissions inventory of engines used in stationary and portable applications, with the focus on collecting information to improve the weaker aspects of the inventory.

**DESCRIPTION:** The first step of this project is to work with ARB staff to identify the areas of the overall inventory for stationary and portable engines in need of major improvement. Once these areas are identified, the necessary information will be collected from district permit systems and the Statewide Registration Program, including descriptive information of the engine and activity information that describes the engine's operation in the field. Finally, a proposed procedure would be developed to estimate the number, size, and operating characteristics of engines that are not operating under either a district permit or the Statewide Registration Program.

**BENEFITS:** This project is necessary to develop an accurate emissions inventory for stationary and portable engines in support of the development of toxics control measure for diesel-fueled engines, the RACT/BARCT program, and the State Implementation Plan.

**COST:** \$250,000

**TITLE: Children's Pollutant Exposures During School Bus Commutes**

**PROBLEM:** A recent study showed that levels of pollutants inside vehicles traveling on California roadways are much higher--up to ten times higher--than levels found in ambient air, and that roadside pollutant levels are also high. Additionally, real-time measurements showed a direct influence from nearby diesel-fueled vehicles on passenger cabin fine particle levels. Children spend about 1.5 hours in transit each day, and many children travel to and from school in buses. Because most of these buses are diesel-powered, young riders may be exposed to especially high levels of toxic pollutants from diesel engine exhaust. To date, children's in-transit exposures have not been measured or assessed.

**PREVIOUS WORK:** A recent study, co-sponsored by the ARB and the South Coast Air Quality Management District, demonstrated the feasibility of sampling pollutant levels in the small, mobile environment of in-use vehicles, and provided the first in-vehicle particle data useful for assessing Californians' in-transit exposures. A single diesel-powered school bus was monitored during two simulated driving trips in that study, for a subset of pollutants. The bus findings were not instructive because of test limitations; real-time measurements of fine particles and black carbon were not obtained.

**OBJECTIVES:** To refine and adapt the sampling methods for the pollutants of interest for use in buses and, using the refined methods, measure pollutant levels inside school buses during driving trips and at associated bus stops, under a range of conditions.

**DESCRIPTION:** The researchers will first refine and improve sampling methods to make them suitable for use inside buses; then conduct a pilot study in unoccupied buses. Following satisfactory completion of the pilot study, the researchers will measure a variety of volatile organic compounds (e.g., formaldehyde, benzene), PM<sub>2.5</sub>, PM<sub>10</sub>, black carbon, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, and other pollutants inside diesel-fueled, gasoline-fueled, and alternatively fueled school buses during normal usage. Field work will be conducted during two seasons. Air samples will also be taken at sites along the bus routes (e.g., bus stops) and at congested school bus drop-off areas.

**BENEFITS:** This project will obtain critical data needed to more accurately estimate children's exposure to toxic air contaminants (such as diesel exhaust particles, benzene, and formaldehyde) and criteria pollutants during bus travel. The results will identify the range of exposures experienced by children in buses; contribution of children's transit exposures to their total exposures; and improved risk management actions that may need to be taken.

**COST:** \$450,000

**TITLE: Detailed Characterization of Personal, Indoor, and Outdoor Particle Exposure**

**PROBLEM:** Exposure to particulate matter (PM) is a major concern because of its serious acute and chronic health effects. Elevated outdoor PM levels measured at ambient monitoring sites have been consistently associated with increased acute morbidity and mortality. However, there are major uncertainties in our understanding of the contributions of outdoor and indoor sources to actual PM exposures.

**PREVIOUS WORK:** PM10 exposure studies indicate that personal daytime PM exposures greatly exceed concurrent outdoor levels, and were moderately correlated with outdoor levels. Harvard University recently conducted pilot studies of personal particle exposures of individuals with pre-existing lung disease in Boston and Nashville. Using an improved study design, the investigators found stronger outdoor-personal PM2.5 correlations than those found in earlier PM exposure studies. They also confirmed that indoor activities such as cooking can be major contributors to exposures. As a follow-up, the U.S. EPA has recently funded Harvard to conduct studies of PM exposure in sensitive population groups in Los Angeles, Boston, and Atlanta. ARB has recently co-funded additional chemical speciation and statistical analyses of personal, indoor, and outdoor PM for the Los Angeles portion of this study.

**OBJECTIVE:** To characterize in detail the levels and chemical composition of personal exposure to PM in the general population; quantify the actual contribution of outdoor PM to personal PM exposures; examine the penetration, transport, and deposition of outdoor PM in southern California homes; and characterize the relationships and contributing factors among personal, indoor, and outdoor particle concentrations, components, and source contributions.

**DESCRIPTION:** Investigators would measure personal, indoor and outdoor PM and gaseous pollutants (PM10, PM2.5, elements of PM2.5, elemental and organic carbon, nitrates, ozone, nitrogen dioxide, carbon monoxide, and sulfur dioxide) in sixteen homes in the Los Angeles area. In addition, short-term indoor and outdoor continuous measurements of elemental carbon and nitrate and hourly PM2.5 would be made. Measurements would be made in homes for seven consecutive days in both the winter and summer. Data would also be collected on home air exchange rates, house dust, housing characteristics, and daily activities.

**BENEFITS:** Results from this study will improve our understanding of the contribution of outdoor (and indoor) sources of particles to Californians' personal exposures and resultant health impacts. The component data will expand our knowledge of exposures to toxic air contaminants, such as metal compounds and diesel exhaust. The study will provide information on the movement of outdoor particles to indoor spaces and particle deposition and resuspension indoors. The results can help focus risk management actions on those sources that contribute most to personal exposures.

**COST:** \$600,000

**TITLE: Real-time Measurement of Particulate Matter**

**PROBLEM:** PM<sub>2.5</sub> and PM<sub>10</sub> have been suspected of causing significant adverse health effects. Due to a lack of routine particle composition data, this relationship has not been extended to specific compounds. The low concentration/long-term epidemiological methods needed to evaluate these compounds require an extensive exposure database detailing the size and composition of ambient PM. The development of a near-real-time analyzer would provide such a database. Real-time or high-time-resolution measurement is also desirable to assess acute effects and minimize collection artifacts.

**PREVIOUS WORK:** Near-real-time analyzers have been developed for measuring specific species such as nitrate, sulfate, and carbon. These usually involve short-term collection on a filter or impactor, followed by heating the sample to decomposition to evolve NO<sub>x</sub>, SO<sub>2</sub>, or CO<sub>2</sub>, which is then quantified by ambient air analyzers for these compounds. Controlled and rapid heating is difficult to adapt to a low-cost commercial instrument that can be operated with minimum supervision and maintenance.

**OBJECTIVE:** To build and evaluate a real-time particle composition analyzer that would be readily adaptable for carbon, nitrate, and sulfate measurements and would reduce the cost and increase the reliability of the monitor.

**DESCRIPTION:** A real-time PM analyzer would consist of a filter collection/thermal desorption system that simultaneously directs the effluent to commercial NO<sub>x</sub>, SO<sub>2</sub>, and CO<sub>2</sub> analyzers. The ceramic filter is formulated to absorb microwave radiation at 2450 MHz, thus allowing it to be heated by microwave ovens. The rate of temperature rise and ultimate temperature is easily controlled remotely by varying the power setting and operating time of the oven. After optimizing the temperature programming, the unit would be tested by collocating with routinely used PM samplers. A cyclone or impactor could be used to provide the desired cut-point. To minimize collection artifacts, nitric acid would be removed from the sampling stream prior to filtration. The ceramic filter medium is currently being evaluated by researchers at UC Riverside for its ability to collect and thermally evolve nitric acid.

**BENEFITS:** This project would develop a method that would allow for a relatively inexpensive approach to determine the composition of PM for nitrate, sulfate, and carbon in real time. This measurement approach would provide higher temporal resolution and potentially lower costs than current methods. The increase of temporal resolution and decrease of costs would be very useful in assessing potential health affects of PM.

**COST:** \$150,000

**TITLE: Aerosol Time of Flight Mass Spectrometry (ATOFMS): Field Sampling, Laboratory Experiments, and Development of a Compact ATOFMS for Sampling Ultrafine Particles.**

**PROBLEM:** California needs to develop controls for reducing ambient concentrations of aerosols to attain the federal ambient air quality standards for particulate matter (PM). Developing a scientific foundation for future PM controls requires research on two fronts: characterizing directly emitted “primary” aerosols in sufficient detail to link them to particular sources, and determining the dynamics of “secondary” particles formed from gaseous precursors in direct gas-to-particle, droplet, and condensation processes.

**PREVIOUS WORK:** Dr. Kimberly Prather’s previous work has demonstrated that this technology can overcome many of the limitations of conventional aerosol analysis. Existing ATOFMS provides real-time data, while eliminating problems of long sample items, lags between sampling and data availability, and chemical artifacts. It also provides unprecedented specificity of particle size and composition within a heterogeneous mix of particles in ambient air.

**OBJECTIVE:** To bring ATOFMS technology up to a level of quantification that eliminates the need for “side-by-side” bulk sampling; applies ATOFMS to artificial and “real” aerosols in experimental chambers and ambient air; refines understanding of the processes by which aerosols form, grow, and age; and supports construction of “third-generation” ATOFMS instruments capable of real-time analysis of ultrafine (10-100 nm diameter) particles.

**BENEFITS:** ATOFMS development has direct bearing on major ARB programs. Building and applying ATOFMS gives ARB a substantial leap forward in the aerosol measurement capabilities necessary to develop the scientific basis for regulatory action. The availability of ATOFMS real-time data will reduce field study costs and the richness of single-particle data will allow much greater freedom of analysis, so a shorter field experiment gives a more robust and useful data set. Single-particle analysis is the only means of resolving crucial questions regarding health effects (e.g., which chemical components cause the observed health impacts, resolving the mass vs. particle number controversy). Finally, this cutting-edge research will attract cost participation from other agencies. This is evidenced by support from U.S. EPA (partial funding toward the “Mini” prototypes) and NSF (funding basic aerosol science), based on previous work with this technology.

**COST:** \$725,000

**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 away from home 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 12 office buildings in the San Francisco 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:** 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 particulate pollutants 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: Indoor Air Pollutant Chemistry and Sinks**

**PROBLEM:** The field of indoor air pollution chemistry is virtually in its infancy. Limited research conducted in locations such as offices, communications facilities, and research chambers seems to indicate that indoor reactivity, removal and re-emission/re-suspension processes can have a major impact on the resulting indoor concentrations of both indoor gases and aerosols. It has become clear that indoor chemistry plays an important role in determining human exposures to air pollutants. However, we know little about processes such as indoor chemical reactivity, surface reactivity, absorption/adsorption, deposition, and other "sink" effects and quantitative data, especially from common indoor environments such as homes, is lacking.

**PREVIOUS WORK:** Investigators examining volatile organic compounds (VOCs) and ozone, have identified substantial indoor sinks in several studies. Carpets have been identified as substantial sinks for toxic VOCs (absorbing VOCs emitted during activities such as painting and remodeling, and re-emitting the VOCs 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 identified toxic compounds that result from elevated indoor ozone concentrations. Recently, investigators have begun to examine in detail the differences in indoor deposition and re-suspension of particles based on size; however, the relationships are not always as anticipated.

**OBJECTIVE:** To quantify indoor pollutant reactivity, removal, formation, re-emission, and re-suspension in homes and schools under common indoor conditions; identify conditions in which such processes may result in potentially harmful levels of pollutants; and quantify the resultant levels of harmful pollutants.

**DESCRIPTION:** Investigators will sponsor a workshop to obtain input from knowledgeable scientists to prioritize the most critical questions and data gaps and study recent findings on gas and particle formation indoors by chemical reaction and re-emission and the effects of factors such as surface type, humidity, and electrostatic charge. The contractor may utilize a test chamber, test home, or actual indoor environments.

**BENEFITS:** Results will be used to improve estimates of indoor pollutant levels and their interrelationships, and our understanding of people's exposures to toxic air pollutants.

**COST:** \$500,000



**TITLE: Benefits of Air Pollution Control Investments to the California Economy**

**PROBLEM:** California businesses invest in equipment and hire labor to clean the air and help meet ambient air quality standards. These investments affect other businesses in ways that could be beneficial to specific sectors of the California economy. Traditionally, the economic analyses of regulations have focused on costs imposed on the regulated business. However, these costs are expenditures on items from other industries whose sales may be enhanced because of the regulation. For example, the manufacturers of the emission control equipment, goods, and services see an increase in their economic activity when a business complies with a regulation. Further, the manufacturer may hire employees to produce and deliver the equipment. The business complying with the regulation may hire employees to operate and maintain the equipment. These job creations are a part of the benefits of the air quality regulations. The problem is that the estimation of such benefits to the California economy is data intensive and there are no updated data sources available. Data and information are needed to not only estimate the benefits of the regulations, but also to comply with legislative requirements of assessing impacts of proposed regulations on business and job creations and competitiveness of California businesses.

**PREVIOUS WORK:** In the early 1980s, the Board conducted a survey of the air pollution control industry (APCI) in California. Since then, studies have been done on the impacts of regulations on parts of the APCI, but not a comprehensive study. In 1993, Cal/EPA formed the California Environmental Technology Partnership, which has focused on promoting environmental businesses. However, there are no updated data studies of the benefits, economic importance, or contributions of the industry to the California economy.

**OBJECTIVE:** To estimate the economic benefits of air quality regulations, from compliance expenditures in the last fifteen years with a focus on jobs, businesses, and growth.

**DESCRIPTION:** The contractor will use ARB documents to list all regulations that affected air quality management expenditures during the last fifteen years. The contractor will also identify and collect data from all relevant sources, such as the California Environmental Technology Center at UC San Diego and the California Business Council, conduct review of existing information, and summarize what is already known about the industry. Where a data gap exists, the contractor will develop and survey firms in California who are engaged in activities attributed to APCI. The collected data will then be analyzed to estimate the benefits of the regulatory expenditures in the last fifteen years on jobs, income, business expansion, and growth.

**BENEFITS:** This study will enhance our understanding of the impacts that air quality management has on the California economy. This knowledge will allow the Board to consider all economic aspects of the regulations, not just costs.

**COST:** \$150,000

**TITLE: Studies of Particulate Matter Toxicity in Controlled Laboratory and Ambient California Settings**

**PROBLEM:** Particulate matter (PM), a complex air pollutant made up of many different kinds and sizes of particles, is a major component of air pollution in indoor and outdoor environments. PM exposure has been associated with numerous adverse health effects, including premature death. The biological mechanisms to explain how PM causes or worsens these health effects remain unknown. Sensitive individuals, such as people with asthma or bronchitis, children, and the elderly may be more susceptible to these effects, but the mechanisms associated with this increased sensitivity have not been explained.

**PREVIOUS WORK:** PM exposure has been linked, via epidemiologic evidence, to premature death in older people who have pre-existing heart and/or lung disease; measures of heart function in humans, dogs, and rodents; and effects to the immune system. Few studies have examined the effects of PM exposure in asthmatic or bronchitic individuals and none have examined, at the biochemical level, the effects on lung development in growing animals (a model in growing children). Studies of PM components from outside California have identified novel markers of PM action that can be used to further address this problem. New technologies have also been developed that allow the use of concentrated ambient particles in controlled exposure studies.

**OBJECTIVE:** To determine the mechanisms by which the components of PM air pollution found in ambient air in California cause or worsen adverse health effects in sensitive individuals.

**DESCRIPTION:** Controlled human clinical exposure and laboratory animal studies would be conducted to identify mechanisms, components, and characteristics of PM that may cause or contribute to adverse health effects. Research would be done to identify levels of toxicity and other effects associated with varying PM concentrations, exposures, composition, and potential confounding with other pollutants, such as ozone (O<sub>3</sub>) and oxides of nitrogen (NO<sub>x</sub>). Work would also be conducted to apply markers of PM effect to ambient particles collected in different seasons, on site and in different parts of California. Other factors, such as variable combinations or components, particle size, and varying responses in humans and animals of varying age and health status would also be addressed. The project duration is four years.

**BENEFITS:** This study would clarify the nature of health impacts from PM by providing information on the mechanisms of effects. It would also provide information that may allow the toxicity of California PM to be compared to PM from other states. This work could be instrumental in helping to explain the health effects seen in epidemiology studies.

**COST:** \$1,000,000

**TITLE: Effect of NO<sub>2</sub> on the Airway Inflammation Response to Inhaled Allergen in Asthmatic Subjects**

**PROBLEM:** Epidemiological evidence, including new data from the Southern California Children's Study, suggests exposure to high ambient NO<sub>2</sub> is associated with worsening of asthma and may be associated with other adverse health effects. These effects appear to occur at levels significantly below both federal and state air quality standards. As a result, some sensitive members of the general population may not be adequately protected.

**PREVIOUS WORK:** Data from several controlled human exposure studies indicate that short-term exposure of allergic asthmatic subjects to relatively high concentrations of NO<sub>2</sub> can lead to enhanced bronchoconstrictor responses to subsequent allergen inhalation challenges (i.e., these individuals show increased sensitivity to allergens), but the mechanisms involved have not been identified. To date, no studies of the effect of NO<sub>2</sub> on airway inflammatory responses to inhaled allergen have been reported. However, animal toxicological studies have shown enhancement by NO<sub>2</sub> to be inflammatory, and evidence of physiologic responses to allergen challenge. In addition, ARB funded two relevant studies, conducted at UC San Francisco. In one study that looked at the effects of high concentrations of NO<sub>2</sub> on T-lymphocytes (white blood cells), airway inflammation was observed. In another, the effects of ozone on the responses of allergic asthmatics showed enhanced early bronchoconstriction and late airway inflammation.

**OBJECTIVE:** The objective of this study is to determine whether exposure to ambient NO<sub>2</sub> enhances the inflammatory response to inhaled allergen in asthmatics.

**DESCRIPTION:** Fifteen subjects with asthma, who are sensitized to house dust mite, would either be exposed to 0.5 parts per million NO<sub>2</sub> or to filtered air alone, on separate days for 2 hours, during intermittent exercise. After each exposure, the subjects would undergo inhalation challenge with house dust mite antigen until their forced expiratory lung volume is measurably decreased. Eighteen hours after antigen exposure, individuals would undergo sputum induction. The induced sputum would be collected and analyzed for cellular and biochemical markers of airway inflammation that might be associated with NO<sub>2</sub> exposure.

**BENEFITS:** This study will increase our understanding of potential mechanisms by which NO<sub>2</sub> exposure may cause or worsen asthma. It would also be helpful in assessing the effectiveness of air quality standards, which are designed to protect sensitive members of our population.

**COST:** \$380,000