State of California
AIR RESOURCES BOARD

NOTICE OF PUBLIC MEETING TO CONSIDER A DRAFT REPORT:
PLANNED AIR POLLUTION RESEARCH, FISCAL YEAR 2003-2004

The California Air Resources Board (ARB or Board) will conduct a public meeting at the time and place noted below to consider a draft report, titled *"Planned Air Pollution Research, Fiscal Year 2003-2004."* The Board will meet concurrently with the Research Screening Committee (RSC).

DATE: November 20, 2003

TIME: 9:00 a.m.

PLACE: California Environmental Protection Agency
Air Resources Board
Central Valley Auditorium, Second Floor
1001 I Street
Sacramento, CA 95814

The item will be considered at a two-day meeting of the Board, which will commence at 9:00 a.m., November 20, 2003, and may continue at 8:30 a.m., November 21, 2003. Please note that this item may not be considered until November 21, 2003. Please consult the agenda for the meeting, which will be available at least 10 days before November 20, 2003 to determine the day on which this item will be considered.

If you have special accommodation, language needs or are a person with a disability and desire to obtain this document in an alternative format, please contact ARB's Clerk of the Board at (916) 322-5594 or sdorais@arb.ca.gov as soon as possible. TTY/TDD/Speech-to-Speech users may dial 7-1-1 for the California Relay Service.

OVERVIEW

The California Health and Safety Code (HSC), Sections 39700 and 39703, declares that an effective research program is an integral part of California's broad-based, statewide effort to combat air pollution. It also directs the Board to coordinate and administer all air pollution research that is funded, to any extent, with state funds. To facilitate this process, HSC Section 39705 directs the Board to appoint a screening committee to give advice and recommendations on all air pollution research projects proposed for funding.

The draft report is comprised of research ideas for the current fiscal year. The general public, business and academic communities, and ARB staff submitted the ideas. The research ideas were provided to the RSC for review and comment on August 18, 2003. The RSC met on October 3, 2003 to review the final list of projects.

Consistent with long-established policy, the Board meets annually with the RSC to review and discuss ongoing projects and research proposed for the next fiscal year. At the November 20, 2003 meeting, the RSC and ARB staff will present their report, "*Planned Air Pollution Research, Fiscal Year 2003-2004,*" to the Board for approval. The report describes projected funding allocations and proposed research projects; some recommended for funding and others recommended if funding becomes available.

AVAILABILITY OF DOCUMENTS AND AGENCY CONTACT PERSONS

Copies of the report, *Planned Air Pollution Research Fiscal Year 2003-2004*, will be available for inspection at the Board's Public Information Office, Air Resources Board, Visitors and Environmental Services Center, 1001 I Street, 1st Floor, Sacramento, California 95814, (916) 322-2990, at least 10 days prior to the scheduled meeting.

Inquiries concerning the draft report may be directed to the designated agency contact person, Annmarie Mora, Air Pollution Specialist, at (916) 323-1517 or by email at amora@arb.ca.gov.

This notice and the draft report, when completed, will be available on the ARB's website at http://www.arb.ca.gov/research/apr/apr.htm.

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the hearing, and in writing or by email before the hearing. To be considered by the Board, written submissions must be received **no later than 12:00 noon, November 19, 2003**, and addressed to the following:

Clerk of the Board
Air Resources Board
1001 I Street, 23rd floor
Sacramento, CA 95814

Electronic mail is sent to: rdfy0304@listserv.arb.ca.gov, and received at the ARB **no later than 12:00 noon, November 19, 2003**.

Facsimile submissions are to be transmitted to the Clerk of the Board at (916) 322-3928 and received at the ARB **no later than 12:00 noon, November 19, 2003**.

The Board requests but does not require 30 copies of any written submission. Also, the ARB requests that written and e-mail statements be filed at least 10 days prior to the meeting so that ARB staff and Board Members have time to fully consider each comment. The ARB encourages members of the public to bring any suggestions or comments to the attention of staff in advance of the meeting.

CALIFORNIA AIR RESOURCES BOARD

Catherine Witherspoon
Executive Officer

Date:

California Environmental Protection Agency

Air Resources Board

PLANNED AIR POLLUTION RESEARCH

Fiscal Year 2003-2004

Draft: 10-31-03

November 2003

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Acknowledgments

This report was prepared with the assistance and support of managers and staff from the Research Division, Mobile Source Control Division, Planning and Technical Support Division, and Stationary Source Division of the Air Resources Board. We would also like to acknowledge the members of the academic community, government agencies, private businesses, and the public who submitted research ideas.

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CALIFORNIA AIR RESOURCES BOARD

PLANNED AIR POLLUTION RESEARCH FISCAL YEAR 2003-2004

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Recommended

Investigation of the Relation of Traffic and Ultrafine Particles to Mortality in California 7

To conduct an epidemiological study of the relationship between daily mortality and alternative measures of traffic using the ARB's expanded monitoring network of ultra fine particulate matter and geographical information system software. $220,000

Cardiovascular Disease and Asthma and Exposure to Long-term Air Pollution in California Teachers Study Cohort 8

To examine the long-term exposures to PM or to any of several gaseous pollutants related to cardiovascular disease incidence or mortality and determine if exposure to traffic emissions, measured by residential proximity to busy roads is related to cardiovascular disease incidence or mortality. $220,000

Time-series Study of Mortality/Morbidity from Ambient Woodsmoke 9

To quantify relationships between woodsmoke exposure variables and daily morbidity/mortality over a 12-year period for which data are available. $115,000

Effect of Genetic Variants on Ozone-Induced Allergic Airway Inflammation in Asthmatics 10

To determine whether ozone enhances specific allergic airway inflammatory responses in asthmatics by using the technique of local endobronchial allergen challenge. $500,000

Traffic Pollution and Children's Health: Refining Estimates of Exposure for the East Bay Children's Respiratory Health Study 11
To refine estimates of exposure to traffic-related pollutants in the OEHHA study through the integration of traffic, air pollution and time-activity data, using geographic information (GIS) methods. $240,000

The Use of Multi-Isotope Ratio Measurements as a New and Unique Mechanism to Resolve the Sources of Nitrate to Lake Tahoe..... 12
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Recommended if Funding Available

Health Impacts of Ultrafine Particulate Matter and Associated Air Pollutants in Elderly People with Heart Disease—Monitoring Support and Mechanistic Studies 13
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Recommended

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Relationship of Ventilation and Building Characteristics to Contaminant Levels in California Classrooms..... 18
To review and statistically analyze data that are pertinent to school building performance issues -- especially mechanical and natural ventilation, lighting, and thermal comfort – and their relationships to indoor contaminant levels and environmental conditions. $100,000

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To characterize and quantify the emissions from several types of commonly used office machines, and to examine approaches to reduce emissions and exposures from office machines. $800,000

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To collect and analyze data on indoor air quality, ventilation, air exchange rates, occupant health and comfort, and other factors from a large sample of owner-occupants of new California homes (less than one year old), with and without fresh air ventilators. This project will also examine the relationship between energy factors and indoor air quality, occupant health, and occupant comfort. $1,600,000

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Recommended

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Advanced Collaborative Emissions Study (ACES)..... 23
To produce a high-quality and health-relevant characterization of the emissions from advanced technology heavy-duty, on-highway diesel engines equipped with aftertreatment controls and operating on ULSD fuels. This project will also develop and apply best methods for researching and testing the potential public health implications of those emissions and provide a state-of-the-science commentary evaluating the changes in emissions and potential risks from prototype 2007-2010 diesel engines. $50,000

Recommended if Funding Available

Low-Cost, Easy to Use, Monitoring Technologies 24
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Global Air Pollution

Recommended

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To compare and contrast results from motor vehicle carbon emissions testing/sampling using optical and filter-based sampling techniques, both in laboratory source testing and ambient measurements. This project would also clarify the role of different combustion processes in determining emission rates of BC and OC to the atmosphere including the uncertainty inherent in these factors. $450,000

Summary

This report presents the Air Resources Board's planned air pollution research for the fiscal year 2003-2004. Nineteen projects are proposed. Seventeen are recommended for funding and two are recommended if funding is available. This research portfolio is 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. The proposed budget for the recommended projects is $5,500,000.

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. The four main areas of research identified in the Strategic Plan are - Health and Welfare Effects, Exposure Assessment, Technology Advancement and Pollution Prevention, and Global Air Pollution. They are also the categories that guide this plan. 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.

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.

Planning the Research Program. The Board sends out a public solicitation inviting and encouraging the public to contribute ideas for project consideration. Members of the public, the academic community and ARB staff, submit research ideas. To aid in the evaluation, the Board's Executive Officer established internal committees to 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, her 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.

Implementation of the Plan. The next step for projects approved in the plan will be their development into full research projects. The submission and selection of an idea does not guarantee a resulting contract for the submitter. Rather, the ARB is required to first look at

public California universities for expertise to execute these projects. If the universities do not possess the expertise, then a public solicitation is issued or a sole source contract is awarded. There is 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.

Research Budget. The 17 recommended projects total $5,500,000. The allocations for the proposed recommended projects among research categories are as follows:

RESEARCH CATEGORY	BUDGET
Health and Welfare Effects	$1,370,000
Exposure Assessment	$3,080,000*
Technology Advancement and Pollution Prevention	$ 600,000
Global Air Pollution	$ 450,000

$2.5 million from the California Energy Commission

Project Cosponsoships. The Research Division is continually looking for cofunding opportunities and other ways to leverage the state's research dollars. This effort allows the ARB to be part of projects and studies that may otherwise be out of the state's fiscal reach. ARB has had great success in working with other research organizations and has been part of multimillion dollar studies with nominal cash contributions. Several of the projects in this plan have either confirmed or have potential cofunding dollars included in the cost category.

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 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

Investigation of the Relation of Traffic and Ultrafine Particles to Mortality in California... 7

Cardiovascular Disease and Asthma and Exposure to Long-term Air Pollution in California Teachers Study Cohort 8

Time-series Study of Mortality/Morbidity from Ambient Woodsmoke 9

Effect of Genetic Variants on Ozone-Induced Allergic Airway Inflammation in Asthmatics..... 10

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Exposure Assessment

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Relationship of Ventilation and Building Characteristics to Contaminant Levels in California Classrooms 18

Characterization and Quantification of Emissions from Office Machines 19

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Factors Affecting School Bus Cabin Air-Tightness and the Relationship Between Air-Tightness and Bus Self-Pollution 21

Evaluation of the In-Use Not-To-Exceed Requirements for Heavy-Duty Diesel Engines 22

Advanced Collaborative Emissions Study (ACES) 23

Low-Cost, Easy to Use, Monitoring Technologies 24

Global Air Pollution

Climate Change – Characterization of Black Carbon and Organic Carbon Air Pollution Emissions and Evaluation of Measurement 25

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TITLE: Investigation of the Relation of Traffic and Ultrafine Particles to Mortality in California

PROBLEM: Although there are few studies relating adverse health effects to traffic-based pollution, several epidemiological studies suggest that residence near areas of high traffic density may be associated with respiratory symptoms in children, decrements in lung function, cancer, premature birth and mortality. Most studies, however, have relied on crude measures of traffic exposure; few have utilized measurements of localized pollutant concentrations, especially ultrafine particles (UFP or particles less than 0.1 micron). UFP are generated by both gasoline- and diesel-fueled vehicles and are of considerable research interest because of their demonstrated toxicological potential to induce oxidative stress and cause cellular damage. Given the dearth of studies on traffic-specific effects, it is important to undertake new studies examining their health impacts.

PREVIOUS WORK: A few time-series studies have reported associations between ambient PM2.5 and mortality. Several studies have linked UFP to inflammation, asthma exacerbation and other adverse health outcomes. A recent time-series study in Holland indicated that individuals who lived adjacent to a major highway had an increased risk of death associated with exposure to PM10 and Black Smoke. However, the pollution mix, activity patterns and exposures are likely to be quite different in California.

OBJECTIVE: The objective is to conduct an epidemiologic study of the relationship between daily mortality and alternative measures of traffic, including: (1) an exploratory analysis for the years 2001 and 2002 using the ARB's UFP monitoring at the Children's Health Study monitoring stations in southern California; and (2) an analysis of PM2.5-mortality relationships for the years 1999 through 2002 incorporating traffic metrics developed from geographical information system (GIS) software.

DESCRIPTION: This project will focus on the mortality impacts of residential proximity to traffic, based on both GIS-derived measures of traffic and some limited measurement of UFP. We propose to use spatial analysis, meteorological data, and census data to select the population (based on census tracts and block groups) likely to be represented by a given UFP monitor. We will then link these data with existing mortality data and emergency room data from local hospitals. Specifically, we will test whether a stronger association between PM2.5 and mortality exists for those living in census tracts, block groups or zip codes within a given distance (e.g., less than 150 meters from a major roadway). Such a study is now possible due to the existence of: (1) daily PM2.5 data for eight major counties in California for 1999 through 2002, and (2) concurrent mortality data with attributed addresses. Both sets of data have been made available to us for this project.

BENEFITS: This project would represent an important contribution to our understanding of the health impacts of traffic and UFP and will provide methodological insight to inform the design of future epidemiological studies. In addition, successful completion of this project may shed some light on issues of environmental justice, given that low-income and minority groups often live closer to major roadways than much of the population.

COST: $220,000

540

TITLE: Cardiovascular Disease and Asthma and Exposure to Long-term Air Pollution in the California Teachers Study Cohort.

PROBLEM: Short-term ambient air pollution exposure has been implicated as a risk factor for exacerbation of pre-existing illness and for mortality in susceptible individuals. In contrast, much less is known about: (1) the health impacts of longer-term exposure, particularly on the development of cardiac or respiratory diseases; and (2) the roles of specific sources, especially traffic-associated emissions, with respect to the pathogenesis of chronic illness.

PREVIOUS WORK: California Department of Health Services (CDHS) staff members have collaborated with university researchers and the Northern California Cancer Center to establish the California Teachers' Study (CTS), a prospective study of 133,479 current and former female public school teachers and administrators recruited in 1995 from the California State Teachers Retirement System (mean age = 54 years in 1995). Follow-up data on disease incidence and mortality are currently available from 1995 through 2002. CDHS staff members have also developed several traffic exposure metrics using Geographic Information Systems that are considered state-of-the-art.

OBJECTIVE: To determine if long-term exposures to PM or to any of several gaseous pollutants are related to cardiovascular disease incidence or mortality and/or is exposure to traffic emissions, measured by residential proximity to busy roads, related to cardiovascular disease incidence or mortality. This project will also examine pollutant and traffic relationships with other health outcomes, including lung cancer and other respiratory diseases, as well as total mortality.

DESCRIPTION: Three series of detailed mailed questionnaires and computer linkages with California mortality and hospitalization databases will allow for examination of the incidence of mortality from diseases. Addresses of all participants have been geo-coded which will permit a more refined analysis of exposure to air pollution, especially to traffic exposures. Similarly, because prevalence of active smoking in this cohort is low (<5%) and occupational exposures to respiratory irritants almost nonexistent, the database will allow for careful investigation of impacts of air pollution. This analysis would focus on the subset of study participants who live within 20 miles of fixed-site monitors. Multi-year averages of PM10, ozone, nitrogen dioxide, carbon monoxide, and several air toxics will be developed. The investigators will also utilize several years of PM2.5 monitoring and reconstruct additional fine particle data from airport visibility measurement. The primary analysis would also examine several traffic metrics, as well as long-term pollutant averages, as predictors of the health outcomes, using Cox proportionate hazards regression. Controls will include a variety of potential confounders and effect modifiers, including exposure to active and passive cigarette smoke, alcohol consumption, body mass index, and history of hypertension, dietary factors, and exercise.

BENEFITS: This effort would involve analysis of existing datasets and would leverage the infrastructure of an enormous ongoing study. The results would be the first to examine impacts of long-term traffic exposures on incidence and mortality from cardiovascular disease in the U.S., and would also be the first large cohort anywhere to examine the relationship of long-term air pollution exposure on the incidence of new cases of cardiovascular diseases.

COST: $220,000

TITLE: Time-series Study of Mortality/Morbidity from Ambient Woodsmoke.

PROBLEM: The fact that urban particulate matter (PM) increases mortality and morbidity has been documented in many U.S. cities, but in most cases traffic exhaust or industrial air pollution were the dominant emission sources. Wood burning emits PM, carbon monoxide (CO), and a variety of organic compounds, however, there is little direct evidence about the quantitative health impacts of ambient woodsmoke itself.

PREVIOUS WORK: Christchurch, New Zealand, has one of the largest city populations (300,000) in developed countries exposed to high woodsmoke levels. Research by the New Zealand Environmental and Occupational Health Research Center shows woodsmoke makes up 80 – 90% of ambient PM during winter months with PM2.5/PM10 ratio ≈ 0.90. The 24-hour PM10 levels exceed 50 $\mu g/m^3$ about 30 days each winter, while peak levels are above 200.

OBJECTIVE: To quantify relationships between woodsmoke exposure variables and daily morbidity/mortality over a 12-year period for which data are available.

DESCRIPTION: Hourly air pollution monitoring (PM10, CO, NO, NO_2, NOx, SO_2) and meteorological data from a central monitoring site for the years 1988-2000 will be acquired from the regional environmental office. Data from other monitoring sites and emission inventories (already available) will be used to validate the geographic distribution. Multiple regression analyses will be used to identify the conditions in which high woodsmoke air pollution occurs. Indoor/outdoor air pollution levels (PM2.5, PM10, CO) will be measured and questionnaires administered at 40 non-smoking pensioner (age 65-75 years) households located closely to a fixed monitoring site during winter and summer. These results and the fixed outdoor measurements will be compared in order to assess the best estimate of personal exposure (for elderly people) to woodsmoke. The Poisson regression protocol, by Air Pollution and Health: A European Approach, will be used taking into account recent updates of this protocol to determine risk levels. Mortality (all causes) and hospital admission (respiratory and heart disease) data for all population groups in Christchurch for the period 1988 to 1999 will be acquired from the New Zealand Health Information Service. Daily data including age, sex, address (census area), ethnicity and 4-digit ICD-9 code will be used.

The data from this study and previously published reports will be used to prepare a review report on all aspects of human exposure from woodsmoke due to the heating of houses. Chemical composition, particle size distributions, air concentrations, and the influence of climatic conditions will be discussed. Relationship between outdoor levels and indoor levels will be analyzed and compared to those in California.

Epidemiological analyses will be done in direct collaboration with the California Office of Environmental Health Hazard Assessment.

BENEFITS: Residential woodsmoke is responsible for a substantial fraction of ambient PM in many California communities, mostly in winter. The Christchurch dataset offers a unique opportunity to evaluate the risk of nearly pure woodsmoke within a culturally and economically similar population sufficiently large and with the high-quality medical and pollution monitoring needed to produce statistically valid results. No such community is available in California.

COST: $115,000

542

TITLE: Effect of Genetic Variants on Ozone-Induced Allergic Airway Inflammation in Asthmatics

PROBLEM: Ambient ozone levels have been associated with asthma exacerbations in several epidemiological studies, although the mechanism is not known. One possible mechanism is enhancement of allergen-induced airway inflammation.

PREVIOUS WORK: Controlled human exposure studies that have addressed the effect of ozone on subsequent pulmonary function responses to allergen have not consistently found ozone-induced enhancement of bronchoconstriction. This raises the question as to whether the timing of O_3 challenge relative to allergen challenge is a significant factor in explaining the discrepancies in the literature, or alternatively, whether there is more than one sub-population of asthmatics, each with a different response profile. One mechanism by which ozone induces adverse effects is through activation of oxidative stress pathways. The GSTM1 gene regulates a key antioxidant enzyme that is involved in protection from and repair of damage from oxidative stress reactions in the lungs. Several studies also suggest that a common genetic variant that results in the absence of a key antioxidant enzyme, GSTM1, may play a key role in the toxicity of inhaled ozone, and may be a basis for differences between individuals in susceptibility to adverse effects from ozone inhalation.

OBJECTIVES 1) to determine whether ozone enhances specific allergic airway inflammatory responses in asthmatics by using the technique of local endobronchial allergen challenge; 2) to assess the effect of the GSTM1 null genotype on ozone enhancement of allergic airway inflammation; and 3) to assess whether exposure to ozone at the current federal ambient air quality standard (0.08 ppm for 8 hrs) can enhance allergic airway inflammation. 3) to investigate whether the exposure sequence (O_3 – allergen vs. allergen – O_3) explains between subject inconsistencies in the responses to combined O_3/allergen exposures.

DESCRIPTION: Human subjects with asthma who are specifically sensitized to house dust mite will be studied. Screening of potential subjects will be done to ensure that at least 50% of the subjects have the GSTM1 null genotype. Subjects will participate in three exposures, including one to filtered air (FA), and two to 0.16 ppm ozone. They will undergo local endobronchial allergen challenge 18 hrs following the FA and one of the O_3 exposures, with sampling bronchoscopy 6 hours later. Local endobronchial allergen challenge will occur the day before the second O_3 exposure, with the sampling bronchoscopy following the O_3 exposure. All exposures will involve intermittent exercise. Various cellular and biochemical indices of airway inflammation will be assayed in the bronchoscopically obtained samples. Subjects will also be genotyped for several other genes that may be related to susceptibility to adverse effects of O_3 exposure (GSTT1, GSTP1, NQO1, SOD2, GPX1, and catalase). The distribution of variants of these genes in the population is unknown, and consequently these will be exploratory analyses. However, the results from these exploratory analyses will help guide development of future investigations into the biological foundations of susceptibility to O_3 exposure.

BENEFITS: Greater understanding of how ozone might be causing exacerbations of asthma will accrue from this study. In addition, the safety of the current federal standard will be directly studied in a vulnerable population using a relevant outcome (allergic airway inflammation).

COST: $500,000

TITLE: Traffic Pollution and Children's Health: Refining Estimates of Exposure for the East Bay Children's Respiratory Health Study.

PROBLEM: Although epidemiological studies have documented associations between air pollutants and a variety of adverse health outcomes, the impact of exposure to traffic-based pollutants has not been well characterized. Most studies have used pollutant concentrations measured at central monitoring sites and therefore could not examine the impact of residential proximity to major roads. In this light, the Office of Environmental Health Hazard Assessment (OEHHA) is proposing to develop new measures of exposure to traffic and to conduct additional analyses of a dataset developed specifically to examine the influence of tra ffic on children's respiratory health outcomes.

PREVIOUS WORK: OEHHA recently conducted a school-based, epidemiological study to examine respiratory health among children living and attending schools at varying distances from high-traffic roads in Alameda County, CA. OEHHA found that traffic pollutants measured at neighborhood schools were elevated near major roads and were associated with both bronchitis and episodes of asthma.

OBJECTIVE: The objective is to refine estimates of exposure to traffic-related pollutants in the OEHHA study through the integration of traffic, air pollution and time-activity data, using geographic information (GIS) methods.

DESCRIPTION: In a previous study, OEHHA related traffic-based air pollution monitored at schools to bronchitis and asthma episodes in children. School pollutant concentrations were used as surrogates for children's overall exposure to traffic emissions. The proponent will refine these measures to better reflect exposures at both residences and schools. By reducing exposure measurement error, they will obtain a better quantitative assessment of the health impacts of traffic on a vulnerable population. The study population is 85% non-white and generally of lower socioeconomic status, making this study a good opportunity to examine the effects of traffic on a low income and primarily non-white population. For this project, there is good coverage from CalTrans traffic data and only a few major highways, making it easier to model traffic exposures. Ultimately, these factors make it easier to isolate the effect of traffic on respiratory health, particularly among a sub-population where the issue of environmental justice is relevant.

BENEFITS: Results will be used to determine the relation of traffic exposure to health outcomes among a vulnerable population of children. It will evaluate the relative importance of different approaches to refining exposure estimates and will provide methodological guidance for future traffic studies. Finally, it will address issues of environmental justice for subpopulations who are often highly exposed to traffic, but whose pollutant exposures are not routinely monitored.

COST: $284,000

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TITLE: The Use of Multi-Isotope Ratio Measurements as a New and Unique Mechanism to Resolve the Sources of Nitrate to Lake Tahoe.

PROBLEM: The world-famous clarity of Lake Tahoe declined over 30% since the mid-1960s. The cause is directly related to elevating levels of nitrate. One of the most important unresolved issues is identifying the source of nitrate to the Lake. Agricultural and soil run off, groundwater, and transport and injection to the Lake by aerosols and wet deposition are potential culprits.

PREVIOUS WORK: The UCSD laboratory recently developed techniques to measure all isotopes of oxygen and nitrogen in aerosol and aqueous nitrate. These isotope signals have been instrumental in resolving a variety of long-standing issues. For example, measurement of Chilean nitrate deposits has shown quite clearly that they arise from atmospheric long-range transport. Aerosol and soil nitrate samples from the Antarctic have also furthered understanding of the source and transport of nitrate. From aerosol nitrate measurements of samples obtained in central California, it was uniquely shown that there are two distinct nitrate sources, one from *in situ* atmospheric oxidation and a second from entrainment of soil nitrate, in particular fertilizer. It has been shown from the central California aerosol measurements, that not only does the technique allow for resolution of the sources, it also allows for quantification of the individual sources.

OBJECTIVE: The objective is to quantify the sources of nitrate in Lake Tahoe, separating atmospheric and water sources.

DESCRIPTION: This project will perform nitrate isotope measurements on both aerosol and Lake water nitrates to identify and quantify the sources and variability of nitrate in the region and to the Lake. Measurements of rain and snow samples can also quantify their potential role in the region for the delivery of nitrates. This new technique has been demonstrated already to be unique in its ability to provide this information and would be a powerful complement to other measurement techniques done at the same time and place.

BENEFITS: The ARB is working with the Lahonton Regional Water Quality Control Board and the Tahoe Regional Planning Agency to develop atmospheric deposition estimates of nitrate and other pollutants to Lake Tahoe. These proposed measurements provide a unique, relatively low-cost opportunity to verify estimates of nitrate from both atmospheric and water sources, resolving potential conflicts in the attribution of water clarity loss.

COST: $75,000 (potential funding by U.S. EPA. This project will support work already sponsored by other research organizations in the Lake Tahoe Basin to develop a Total Maximum Daily Load (TMDL) for Lake Tahoe.

TITLE: Health Impacts of Ultrafine Particulate Matter and Associated Air Pollutants in Elderly People with Heart Disease—Mechanistic Studies and Exposure Assessment

PROBLEM: The elderly, especially those with cardiovascular disease, have been identified as especially vulnerable to the effects of air pollution. A major study is about to begin in southern California to study the impacts of air pollution on this group . The three-year study is funded by the National Institute of Environmental Health Sciences (NIEHS) at a cost of $3.3 million. PM air pollution, in particular the ultrafine size fraction, is of special interest. The study has limited air monitoring and does not include health-related assays that could provide mechanistic linkages between health outcomes and PM.

PREVIOUS WORK: Cardiovascular health impacts of ambient air pollution have been observed in several epidemiological studies. These studies find that PM, or some component, may cause changes in blood, in cardiac function, and may be associated with mortality in people with cardiovascular disease. Controlled animal and human exposure studies have been conducted which suggest mechanistic explanations for these findings. Recent studies suggest that the ultrafine fraction (diameter less than 0.1μm) may have a special potential for harm.

OBJECTIVE: This study would provide comprehensive, time-resolved air monitoring data for use in epidemiological analyses. It would also provide information on biological markers of effects that are related to possible mechanisms of cardiac injury.

DESCRIPTION: The NIEHS-funded health study will collect health outcome data from elderly people who reside at sheltered living facilities in southern California. The study will use data from existing routine air monitoring stations, personal and indoor monitoring, as well as ultrafine PM counts and activity records as exposure predictors.

The current proposal would provide funds and monitoring resources to expand the nature of air pollution data as well as to add collection and evaluation of the chemical and biological characteristics of PM samples. A mobile monitoring trailer, provided by ARB, would report ultrafine particle counts, NOx, CO, ozone, PM mass, carbon, nitrate, and sulfate. Indoor air monitoring efforts would also be enhanced. Mechanistic studies related to reactive oxygen species (ROS) are included. The ROS assays reflect cellular level toxicity of particles that may explain how PM can harm people.

BENEFITS: This study would address important questions of which chemical or size fractions of PM are most harmful, and what biological mechanisms underlie harmful effects. The funds requested would be heavily leveraged against a federally sponsored study with approximately $1/10^{th}$ of the total from ARB. The findings of this study would have direct application to our Vulnerable Populations Research Program, to evaluations of air quality standards for PM, and increase our level of understanding regarding important air pollution exposures experienced by the elderly, a group of special concern for adverse impacts from ambient PM. The nature of the overall study, with the proposed additional monitoring, may provide findings regarding the short-term health consequences of PM exposure.

COST: $175,000 ARB (plus equipment/support), $750,000 SCAQMD, $3.3 million NIEHS

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TITLE: Hourly, In-situ Quantitation of Organic Aerosol Marker Compounds.

PROBLEM: Regulatory efforts to conform to PM2.5 standards require improvements in our knowledge of the factors controlling the concentration, size and chemical composition of PM2.5. While many advances have been made in measuring and modeling the inorganic ionic species that are found in PM2.5, much less is known about the organic fraction. Yet organic matter is a major constituent of airborne particles, comprising 20-40% of the PM2.5 mass in many regions. Quantitative, time-resolved knowledge of composition of PM2.5 organic matter is key to tracing its sources and understanding its formation and transformation processes.

PREVIOUS WORK: Generally, the most complete identification has been by gas chromatography followed by mass spectrometry (GC/MS). These methods have provided valuable insight and guidance in our understanding of airborne organic matter. While the identified compounds comprise only a fraction of the total organic mass, those that are quantified serve as valuable tracers for sources, and have been used to determine the relative contribution of various source types to primary ambient organic matter. However, analyses are costly, and generally the time resolution is poor. Needed is routine, time-resolved quantification of these organic marker compounds.

OBJECTIVE: To identify the origins of PM2.5 organic matter within a region in California that is currently out of compliance with PM air quality standards utilizing hourly, in-situ measurements of organic marker compounds.

DESCRIPTION: Currently a field-portable, semi-continuous instrument for the quantitative, time-resolved measurement of the ambient concentration of specific organic compounds in PM2.5 is being developed and will be tested in a field study next summer. The collection and analysis steps will be automated, yielding around the clock speciation with hourly time resolution. Following successful completion of the field study, the instrument will be deployed for one winter month and one summer month at a site in California. This instrument will measure the chemical signatures for important organic aerosol sources such as, biomass burning, to identify marker compounds that should be measurable in ambient air samples. The field measurements in the Central Valley will provide comprehensive data sets suitable for interpreting diurnal patterns, and determining sources of organic species.

BENEFITS: This work addresses the critical need for on-line, time-resolved, quantitative measurement of atmospheric PM2.5 organics at the molecular level. Marker compounds unique to specific source types provide a means of determining the relative contribution of primary sources. Data at the compound level are also needed for understanding the chemical formation and transformation mechanisms leading to secondary organic aerosol formation. This research will provide useful new data of immediate value for air quality attainment strategies for the Central Valley and the development of the State Implementation Plan. The placement of an enhanced air monitoring site in Fresno provides a unique opportunity for complementary research.

COST: $260,000

TITLE: Polycyclic Aromatic Hydrocarbons (PAH) Sources of Ambient Quinones.

PROBLEM: It has been hypothesized that much of the high morbidity and mortality associated with fine particulate matter (PM) is due to quinones and their reduction products, adsorbed to the particulate core (e.g., "Role of Quinones in Toxicology", J. Bolton et al., *Chem. Res. Toxicol.*, 13, p. 135-160, 2000; J. Froines, ARB Chairman's seminar, June 18, 2003). Although quinones are toxic through their direct reaction with DNA, they also enter into oxidation-reduction (redox) reactions. Through redox reactions, one equivalent of quinone can generate multiple equivalents of toxic 'reactive oxygen species', and thereby overwhelm the protective effects of cellular enzymes and reducing agents. PAH-quinones, which are formed from atmospheric reactions of semi-volatile PAHs present in diesel and gasoline vehicle exhaust, may have potentially significant consequences for the health of California's residents. It is therefore important to understand the extent of PAH-quinone formation in ambient air.

PREVIOUS WORK: Dimethyl-naphthalenes (DMNs), along with naphthalene and methyl-naphthalenes, are generally the most abundant PAHs in ambient air, and are largely derived from volatilized diesel fuel. We have shown that DMNs react rapidly in the air (via both OH radical- and nitrate radical-initiated reactions) to form dimethyl-nitro-naphthalenes (nitro-DMNs). Nitro-DMNs have been found in ambient air, but our results suggest that they photolyze rapidly. Moreover, we have shown that nitro-naphthalenes photolyze to yield significant amounts of naphtho-quinones. Therefore, the photolysis of nitro-PAHs (such as nitro-DMNs) may be an important source of ambient PAH-quinones. Once formed, PAH-quinones are likely to be quite stable in the ambient air, certainly compared to their PAH precursors.

OBJECTIVES: Identify the nitro-DMNs formed from atmospheric reactions of selected dimethyl-naphthalenes and study their photolysis reactions and products, which are expected to include quinones.

DESCRIPTION: Radical-initiated (OH and NO_3) environmental chamber reactions of specific DMNs, chosen based upon their abundance in ambient air, will be conducted. The chamber reaction products on adsorbent materials, extracting, subjecting to HPLC fractionation and analysis by GC/MS will be collected. Products using Solid Phase Micro-Extraction (SPME), including sampling with on-fiber derivatization to analyze carbonyl products, with GC/MS analysis will also be collected. Specific nitro-DMNs, either after *in-situ* formation from the NO_3 radical reaction of a DMN or after synthesis by nitration of the DMN with N_2O_5 in CCl_4 solution will be photolyzed and products with an emphasis on quinones will be analyzed.

BENEFITS: PAH-quinones formed via atmospheric reactions of PAHs emitted in vehicle exhaust may cause serious morbidity/mortality of Californians. This pilot study will provide data needed for future assessments of the human health risk associated with atmospheric reactions of traffic-derived PAHs.

COST: $120,000

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TITLE: Identification and Atmospheric Reactions of Polar Products of Selected Aromatic Hydrocarbons

PROBLEM: The polar, oxygenated and nitrated, photooxidation products of aromatic hydrocarbons are poorly understood. While aromatics are known to be significant precursors to secondary organic aerosols, their reaction products in many cases have not been identified, and their toxicity and subsequent fate in the atmosphere are unknown.

PREVIOUS WORK: Using Solid Phase MicroExtraction (SPME) techniques, the formation of hydroxycarbonyl products from two biogenic alcohols and a series of *n*-alkanes has been investigated. Additionally, the formation and reaction of an unsaturated di-aldehyde, $HOCH_2CH=CHCHO$, from the OH radical-initiated reaction of 1,3-butadiene has also been investigated. From its time-dependent concentration, a formation yield of ~22% and a rate constant for its reaction with OH radicals of $\sim 5.3 \times 10^{-11}$ cm^3 $molecule^{-1}$ s^{-1} (which is 80% of its parent, 1,3-butadiene) has been derived.

OBJECTIVES: To identify and, whenever possible, quantify dicarbonyl and hydroxycarbonyl products formed from the atmospheric reactions of selected aromatic hydrocarbons (including polycyclic aromatic hydrocarbons, PAH). The reaction rates of these carbonyl-containing products with hydroxyl radicals and their photolysis rates will be measured, as will the products of these processes.

DESCRIPTION: SPME fibers pre-coated with PFBHA [*O*-(2,3,4,5,6-pentafluoro-benzyl)hydroxyl-amine hydrochloride] will be used to allow on-fiber derivatization of carbonyl-containing compounds with subsequent thermal desorption and gas chromatographic analysis of these carbonyl compounds as their oximes. Identification will be made by GC-MS and analysis by GC-FID during OH + aromatic reactions will provide the time-concentration behavior of the carbonyl product(s). These data allow the rate constants for reaction (with OH radicals and/or photolysis) of the product(s) to be determined. This approach will allow the investigation into the formation and reactions of carbonyl-containing products (unsaturated 1,4-dicarbonyls such as C(O)CH=CHCH=CHCHO and possibly di-unsaturated dicarbonyls and unsaturated epoxy-1,6-dicarbonyls) from the OH radical-initiated reactions of aromatic hydrocarbons such as toluene and xylenes and selected PAHs. Many of these compounds are not commercially available and cannot be analyzed by gas chromatographic methods without prior derivatization.

BENEFITS: This project will provide data needed for assessments of the human health risk associated with sources of aromatic hydrocarbons, such as gasoline and diesel fuels, as well as provide atmospheric chemistry data needed to formulate more scientifically accurate computer models of air pollution, including the formation of secondary organic aerosols.

COST: $50,000

TITLE: Updated Chemical Mechanisms for Airshed Model Applications.

PROBLEM: For maximum accuracy in predictions of effects of control strategies on air quality, models must use the most up-to-date mechanisms available to represent formation of secondary air pollutants such as O_3 and secondary PM or air toxics. The most up-to-date California regulatory modeling uses the SAPRC-99 mechanism, which reflects the state of the science of the late 90s. However, important uncertainties remain and research yielding new information is continuing. For example, recent environmental chamber and other data indicate that this mechanism has significant errors in simulating effects of aromatics on O_3 and radical formation, and may underpredict O_3 formation rates in the high NO_x, low VOC/NO_x conditions representative of many source areas. (Older mechanisms, such as CB4, are probably even worse in this regard.) In addition, prediction of secondary PM is becoming important, but existing gas-phase mechanisms were not designed for this purpose. Because of this ad-hoc parameterized approaches are used to append PM-forming processes to such mechanisms. Continued reliance on SAPRC-99 or older mechanisms in regulatory models without at least some ongoing mechanism development research will leave California unprepared for the more accurate and scientifically-based modeling demands to support the more difficult control strategies required to ultimately achieve mandated clean air standards.

PREVIOUS WORK: California supported the development of the SAPRC-99 mechanism for O_3 reactivity scales for VOC regulations. A project to evaluate and adapt the mechanism for low NO_x conditions is underway, but this does not cover the effort required for major mechanism updates and making needed improvements to the aromatic mechanisms. Work is underway elsewhere in the U.S. to develop improved condensed mechanisms, but efforts to relate these to the detailed, fundamental chemistry of organics is limited. Detailed mechanism development efforts are underway in Europe, but their evaluations against chamber data are not yet comprehensive and the formulations of most of the European mechanisms are not yet suitable for use in models used in California.

OBJECTIVE: Develop and comprehensively evaluate an updated detailed mechanism that incorporates new data, improves representations for aromatics and PM precursors, and reduces uncertainties in estimated mechanisms for species where no data are available. Obtain environmental chamber data most needed to support this objective.

DESCRIPTION: The SAPRC-99 detailed mechanism and its associated mechanism generation system will be revised and extended to incorporate the above objectives. This will involve major changes to the aromatics mechanisms, adding lumped intermediate and species to appropriately represent PM precursors, and conducting new chamber experiments, most with PM data, most needed for its evaluation. The predictions of the mechanism will be comprehensively evaluated against existing and new chamber data.

BENEFITS: Regulatory agencies and researchers will be able to incorporate a detailed and scientifically based mechanism in their models for predictions of O_3, PM, air toxics, and VOC reactivity that represent the current state-of-the art and that is not inconsistent with new environmental chamber data. This support is also needed to assure a continuation of a mechanism development effort in California that otherwise may be lost.

COST: $150,000

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TITLE: Relationship of Ventilation and Building Characteristics to Contaminant Levels in California Classrooms

PROBLEM: A wealth of data was collected in the California Portable Classrooms Study (PCS) on classroom characteristics; ventilation system type, operation, and maintenance; contaminant levels in indoor air and in floor dust; and other factors. These data have not been fully analyzed: only basic frequency distributions and very limited ANOVA modeling have been completed to date, due to the time constraints related to public review and delivery of the Report to the Legislature, and collection of more data than was originally budgeted. The PCS is unique in its breadth and representativeness. Further analysis of the more detailed information included in the data, especially to further examine relationships between ventilation / building characteristics and contaminant levels in the floor dust, would provide data useful to the California Energy Commission for refinement of school ventilation standards, and to the Division of the State Architect, and other state agencies to further improve classroom specifications and operation and maintenance practices.

PREVIOUS WORK: The PCS examined kindergarten through 12th grade portable and traditional classrooms throughout California. The results of the PCS indicated numerous, widespread environmental health problems in both portable and traditional classrooms. Most classrooms exceeded acceptable noise levels (primarily from ventilation systems) and formaldehyde levels. Many also did not meet acceptable guidelines or standards for temperature, humidity, lighting, and ventilation. Additionally, many classrooms had numerous pesticides, polycyclic aromatic hydrocarbons, and metals in the floor dust, some of which may pose a serious health risk.

OBJECTIVES: To review and statistically analyze data that are pertinent to school building performance issues – especially mechanical and natural ventilation, lighting, and thermal comfort – and their relationships to indoor contaminant levels and environmental conditions.

DESCRIPTION: The Contractor will: 1) Complete the statistical analysis of energy-related characteristics of portable and traditional classrooms from the PCS. 2. Complete the floor dust laboratory analyses. 3. Examine the relationships among key building performance variables, contaminants in indoor air and floor dust, and indoor environmental conditions.

BENEFITS: The data will be used by the California Energy Commission to assess possible changes to the energy efficiency/ventilation standards for California's school buildings; by the Division of the State Architect and other state agencies to revise portable classroom specifications, school operation and maintenance practices, and building design and construction; and by ARB, DHS, and others to better estimate the potential risk to students and teachers from floor dust and air contaminants.

COST: $100,000 (funded by CEC)

TITLE: Characterization and Quantification of Emissions from Office Machines

PROBLEM: Office machines such as photocopiers, printers, FAX machines, and computer terminals emit a variety of toxic pollutants as part of their normal operation. These pollutants can include volatile organic compounds, formaldehyde, particles, ozone, PAHs and nitrogen dioxide. The machines are operated in enclosed spaces and often with inadequate ventilation, which may lead to elevated levels of pollutants in the office environment. Office workers have complained of odors associated with these machines, and have reported health symptoms such as headache, mucous membrane irritation, and eye irritation that may be linked to pollutants associated with these machines. Voluntary industry effort has focused on reducing emissions, but it is not known how effective that effort has been.

PREVIOUS WORK: In 1998, the U.S. EPA published a report entitled *Indoor Air Emissions from Office Equipment: Test Method Development and Pollution Prevention Opportunities*. The authors concluded that there is a general lack of published emissions data on office machines. The report contains a draft test method compiled by a committee of EPA, industry, and Research Triangle Institute representatives. The report also discusses opportunities for pollution prevention associated with office machines. In addition to the EPA report, studies of office machine emissions have been conducted outside the U.S. over the last decade, in Australia and Denmark. More recently, Syracuse University in New York has established a new research center that is conducting emissions research with funding from U.S.EPA.

OBJECTIVES: To characterize and quantify the emissions from several types of commonly used office machines, and to examine approaches to reduce emissions and exposures from office machines. Pollutants will be identified and measured while the equipment is idle (standby mode), while operating under typical conditions, and while operating under purposely-varied conditions anticipated to result in reduced emissions or exposure.

DESCRIPTION: Investigators will select office machines for emission testing based on California markets, state purchasing practices, and other criteria. The machines will be monitored in different operating modes in a controlled-environment large chamber, so that emissions can be accurately characterized under variable conditions. Work will complement related research.

BENEFITS: Characterization of the pollutants emitted by office machines will allow ARB and California Energy Commission staff to determine user exposures to a variety of Toxic Air Contaminants and criteria pollutants. Knowledge gained in the study can be used to reduce emissions and exposures, assess ventilation needs, and direct educational efforts for improving indoor air quality.

COST: $800,000 (to be funded by CEC)

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TITLE: Energy Efficiency, Indoor Air Quality, and Human Health in New Homes

PROBLEM: New California homes are built using materials that can emit formaldehyde and a variety of volatile organic chemicals (VOCs) and semi-volatiles listed as California Toxic Air Contaminants. They are also built to meet California's stringent energy efficiency regulations, which have reduced the natural air exchange between indoor and outdoor air. Concerns have been raised regarding whether current energy-efficiency requirements result in insufficient fresh outdoor air to dilute indoor contaminants and moisture. CEC is considering the need to require mechanical ventilation to assure a minimal level of fresh outdoor air exchange in new homes.

PREVIOUS WORK: Building materials are known sources of VOCs and semi-volatile contaminants, including some that can cause cancer and other serious health effects, and many that can irritate mucous membranes and the lungs. Large, residential indoor air quality studies that include VOCs and semi-volatiles have been conducted previously in California, but the most recent study was in 1989-1990, and no study has focused strictly on new homes. Since then, many new chemicals have been developed, and construction materials such as paints and caulking have been re-formulated. Additionally, new residential energy efficiency standards have been developed and approved by the California Energy Commission, and implemented throughout the state. These include requirements for ventilation, heating and cooling, insulation, appliances, and other factors that affect energy usage. These changes have resulted in a reduction in outdoor air exchange and triggered concerns regarding the impact of the energy requirements on indoor air quality and occupant health and comfort.

OBJECTIVES: To: 1) Collect and analyze data on indoor air quality, ventilation, air exchange rates, occupant health and comfort, and other factors from a large sample of owner-occupants of new California homes (less than one year old), with and without fresh air ventilators. 2) Examine the relationship between energy factors and indoor air quality, occupant health, and occupant comfort.

DESCRIPTION: Work will be conducted in two studies. First, investigators will conduct a mail survey of a large sample of new home owner-occupants to obtain information on building characteristics, ventilation, and occupant activities, and occupant comfort and satisfaction. Then, a field study (including a pilot study) will be conducted in a sub-sample of homes to obtain measurements of indoor air contaminants, energy efficiency characteristics and other factors. Homes from several climate zones will be studied in at least two seasons. Data will be analyzed and a final report prepared.

BENEFITS: This study will provide data on Californians' exposures to indoor contaminants in new homes, filling an important data gap for estimating Californians' indoor exposures to toxic air contaminants as required by HSC 39660.5. It also will provide information needed by the CEC to assess the impact of current energy efficiency standards and help determine the need for mechanical ventilators in new homes.

COST: Mail survey $650,000; Field study $950,000 (to be funded by CEC).

TITLE: Factors Affecting School Bus Cabin Air-Tightness and the Relationship Between Air-Tightness and Bus Self-Pollution.

PROBLEM: Recent tests of in-cabin air pollution concentrations on board school buses indicate a bus's own exhaust may be infiltrating into the bus cabin in significant quantities under some conditions. To better be able to understand this self-pollution effect and what factors are involved, more study is needed of how and when bus exhaust infiltrates into the cabin, and what factors lead to bus cabins being vulnerable to self-pollution. Measures to reduce bus cabin infiltration (e.g., sealants, maintenance practices, raising the exhaust outlet) may turn out to be a cost-effective means of reducing children's exposures during bus commutes.

PREVIOUS WORK: The recent Children's School Bus Exposure Study (Fitz et al., 2003) found some buses to contribute significantly to their own on-board pollution concentrations. This was determined through the use of SF_6 tracer gas added to each bus's exhaust. The extent of the self-pollution appeared to be a function of the bus's own emission rate and the infiltration rate of the bus cabin, although the bus emissions rates were only indirectly measured, so this relationship could not be well quantified. Infiltration rates appeared to increase with bus age and mileage, but bus-to-bus variability was large. The Children's School Bus Exposure Study as well as other in-vehicle studies has also shown closed-window air exchange rates are a strong function of vehicle speed (or air speed).

OBJECTIVE: To better understand the self-pollution effect in school buses by examining what affects bus exhaust infiltration into the cabin and what measures can be used to reduce cabin infiltration.

DESCRIPTION: A representative sample of school buses will be tested for leaks under slight positive pressure to identify the locations, visual conditions, and related characteristics of likely points of exhaust intrusion. The same bus will also have closed-window air exchange rate tests performed at low and zero wind speeds to test the relationship between closed-window air exchange rates and leaks.

A subset of the buses will have exhaust intrusion tests performed using a tracer gas added to the exhaust to see how well self-pollution is related to leak tests and air exchange rates, and to see under what conditions self-pollution seems to be occurring, such as low or zero speeds, sudden decelerations, when bus doors open, or during certain wind directions relative to the bus. A small subset of the buses showing significant infiltration effects will, where practical, be modified in an attempt to reduce infiltration, and have leak testing and air exchange rate tests repeated. These measures might include new sealing around windows and emergency doors, repair of window latch mechanisms, and raising the exhaust outlet (if safety concerns can be overcome).

BENEFITS: Many school districts cannot afford new buses or particulate trap retrofits. If simple maintenance, specific repairs, or avoidance of certain operating conditions can reduce infiltration of a bus's exhaust and its self-pollution, exposures for children riding older and dirtier buses might be able to be significantly reduced at little or no cost.

COST: $300,000 ($150,000 from ARB and matching funds from other sponsors)

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TITLE: Evaluation of the In-Use Not-To-Exceed Requirements for Heavy-Duty Diesel Engines

PROBLEM: Heavy-duty diesel engines/vehicles (HDDEs/HDDVs) are substantial contributors to the motor vehicle emissions inventory for NO_x and particulate matter (PM). In the 1990s it was found that seven of the largest HDDE manufacturers violated certification regulations by defeating emissions controls during in-use highway driving. As a consequence of these violations, the USEPA, and ARB negotiated the Consent Decree (CD) and Settlement Agreement (SA), respectively with these HDDE manufacturers. The CD and SA stipulate the implementation of in-use Not-To-Exceed (NTE) requirements. The NTE requirements call for the HDDE manufacturers to perform in-use emissions measurements and report results to the USEPA and ARB. The CD and SA NTE requirements have been carried over into the upcoming 2007 HDDE emissions standards, and the ARB has also adopted NTE requirements for 2005-06. The NTE requirements are expected to result in compliant in-use HDDEs, but this has not been independently verified.

PREVIOUS WORK: The USEPA/Engine Manufacturers Association (EMA) Calibration Standards Task Force and NTE in-use Measurement Workgroup have been working to implement the 2007 emissions standards, including the NTE requirements for HDDEs.

OBJECTIVE: The objective of this project would be to perform in-use HDDE/HDDV testing to verify the in-use emissions performance of post-1998 HDDEs complying with the NTE requirements.

DESCRIPTION: A small fleet of in-use HDDVs would be emissions tested, including over-the-road testing, and dynamometer testing. On-board emissions measurement instrumentation would be utilized as part of all emissions testing, including dynamometer testing. The over-the-road NTE testing would include typical HDDV in-use operation, while dynamometer testing would include the HDDE Federal Test Procedure (engine testing), and transient and steady-state test cycles. The emphasis of the project would be on NO_x plus non-methane hydrocarbons, but consideration would also be given to PM measurements.

BENEFITS: The results from this project would permit a rigorous and systematic comparison of on-board, over-the-road emissions measurements against laboratory emissions measurements to permit an evaluation of the NTE requirements as a means of ensuring in-use compliance for HDDEs.

COST: $400,000

TITLE: Advanced Collaborative Emissions Study (ACES).

PROBLEM: Many of the most significant adverse health effects that are ascribed to exposures to diesel engine exhaust – including potentially increased risks for lung cancer – are premised on studies that relied on estimated exposures to diesel engine products from previous decades, specifically the 1960s and 1970s. The relevance of those studies and conclusions is becoming increasingly questionable, especially in light of the advanced diesel engines, aftertreatment systems, and ultra-low sulfur diesel (ULSD) fuels that will be entering the on-highway diesel vehicle market by 2007. Thus, there is a critical need for new emissions characterization and health studies of the exhaust from prototype 2007-2010 diesel engines equipped with advanced aftertreatment systems and operating on ULSD fuels.

PREVIOUS WORK: The Health Effects Institute (HEI) and the Coordinating Research Council (CRC) have been working in tandem to develop a detailed outline for the ACES program. HEI will be responsible for overseeing the health testing development, implementation and overall reporting of results. CRC will be responsible for overseeing the emissions characterization work of the ACES project.

OBJECTIVE: There are three principal objectives to the ACES initiative: (1) to produce a high-quality and health-relevant characterization of the emissions from advanced technology heavy-duty, on-highway diesel engines equipped with aftertreatment controls and operating on ULSD fuels; (2) to develop and apply best methods for researching and testing the potential public health implications of those emissions; and (3) to provide a state-of-the-science commentary evaluating the changes in emissions and potential risks from prototype 2007-2010 diesel engines.

DESCRIPTION: CRC will oversee a series of detailed studies to characterize and speciate prototype diesel engine exhaust, with special emphasis on ambient exhaust characteristics as may be experienced by a near-source receptor. HEI will oversee a series of health studies, including acute and chronic toxicity/inhalation studies, of the relevant prototype exhaust samples to assess both short and longer term potential effects of exposure, focusing on inflammation, asthma, allergic response, lung cancer and other key end-points. A synthesized commentary that can be used to inform public policy decisions pertaining to advanced technology diesel engines will be the final work product of the ACES program.

BENEFITS: The ACES program may provide useful, policy-relevant new information and background for an informed assessment of the technological advantages of advanced prototype diesel engines – greater fuel efficiency and reduced CO_2 emissions to help address climate change concerns.

COSTS: The overall cost estimate for the ACES program is approximately $5MM-$7MM over a five-year period. It is envisioned that multiple stakeholders from the private and public sectors will help to sponsor and underwrite the ACES initiative. The ARB's contribution may be up to $50,000.

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TITLE: Low-Cost, Easy to Use, Monitoring Technologies.

PROBLEM: More and better air quality data are needed for power plant siting cases, to evaluate the air quality impacts of distributed generation, and to address environmental justice concerns. These limitations hinder the ability to identify areas disproportionately affected by air pollution and to determine the air quality impacts of new sources (e.g. power plants) – particularly for distributed generation technologies.

PREVIOUS WORK: A report by Clarkson University, which was sponsored, by the California Energy Commission (CEC) and the New York State Energy Research and Development Authority, surveyed available monitoring methods and those in development. Investigators identified instruments and technologies suitable for use in ambient and indoor air monitoring. The focus was on measurement of particulate matter, mass and constituents, gaseous nitrate, nitrogen dioxide and gaseous NO_y, particle size distributions, particulate carbon species and volatile organic compounds. The pollutants of concern included those on the Photochemical Assessment Monitoring Stations list, toxic air contaminants, particle-bound elemental carbon and organic carbon; and other particulate matter components. The investigators found that there are important problems with monitoring systems – particularly with respect to cost, sensitivity and selectivity.

Under the Innovative Clean Air Technologies Program, the CEC and ARB are currently funding two projects in this area, entitled, "Development of a Low-Cost Particulate Matter Monitor", and "A Simple, Low-Cost Beta Attenuation Monitor (BAM) for Continuous Measurement of PM10, PM2.5, or Ultrafine Particle Counter."

OBJECTIVE: To further develop inexpensive portable instruments that can provide location specific ambient and indoor air monitoring.

DESCRIPTION: The CEC and the ARB will provide funding to contractors who demonstrate the ability to develop new technologies for measuring air pollution in the ambient or indoor air. The focus is developing low-cost, easily operated, air-monitoring technologies that are suitable for wide deployment.

BENEFITS: The use of portable monitors may improve the data available for power plant siting cases, environmental justice concerns, local community monitoring, and indoor/personal exposures, while significantly reducing the cost of obtaining monitoring data.

COSTS: The CEC and the ARB will each provide $282,585.

TITLE: Climate Change - Characterization of Black Carbon and Organic Carbon Air Pollution Emissions and Evaluation of Measurement Method

PROBLEM: In contrast to greenhouse gases, which have a warming effect, aerosols can influence both sides of the energy balance. Sub-micron aerosol particles (less than 1 μm) are highly effective at scattering solar radiation, sending a substantial portion of that scattered radiation back to space, and consequently cooling the Earth. While particles of any composition can reflect light back to outer space, only a few can absorb light. These include black carbon (BC) or "soot", desert dust, and some organic carbon (OC) species. Of these, BC is thought to dominate light absorption by aerosols in many regions, and it is the most efficient at absorbing visible light. It has been proposed that reductions of BC particles may slow the rate of global warming. However, BC is emitted simultaneously with OC, which has a net negative climate forcing. Hence, the net climatic effect of reducing emissions of fine particles is ambiguous until, at least, the relative amounts of BC and OC are known.

For the purposes of climate change emissions inventories, BC is defined as the carbon component of particulate matter that absorbs light. However, this specific component of particulate matter is difficult, if not impossible, to measure. Methods that measure light absorption in particulate matter assume that BC is the only light absorbing component present; however, some components of OC may also be light-absorbing; in this case, inventories of BC and OC may have overlapping impacts

PREVIOUS WORK: Emissions inventories of BC developed to date have focused on industrial, utility, and residential combustion sources. On a global basis, residential emissions represent the largest source of BC. In the U.S., however, Battye et al. (2002) estimated that off-road and on-road diesel sources are the major BC sources (36% of total BC emissions), based on the National Emissions Inventory (NEI) and BC speciation factors. Gasoline vehicles represent a smaller (8%), but non-negligible source of BC emissions. Due to the abundance of these sources in California, on-road and off-road mobile sources likely contribute to significant BC emissions in this state as well.

Most source-characterization studies do not measure BC, but rather so-called "elemental" carbon (EC). This type of measurement is widely used in air-quality and source-characterization applications. Even the results of similar methods may differ based on the procedure used. Future work should include a treatment of the relationship between each measurement method and the quantity of interest—i.e., light absorption. Further, carbon that absorbs light may not be black, and its molecular form may differ from that of BC [Bond, 2001]; these differences are implicitly ignored in most, if not all, studies.

OBJECTIVE: This project would compare and contrast results from laboratory and an ambient air field study of particulate carbon testing/sampling using optical and filter-based sampling techniques, both in laboratory source testing and ambient measurements. This project would also clarify the role of different combustion processes in determining emission rates of BC and OC to the atmosphere including the uncertainty inherent in these factors. A comprehensive review of literature on combustion processes and source characterization would be included to support the selected emission factors.

DESCRIPTION: This project would have two main components: 1) measurement method evaluation and 2) determination of emission rates of BC and OC. Measurement method evaluation would involve A) a laboratory comparison of EC/OC fractions and a comparison of EC results versus BC results using currently accepted analytical method, and B) an ambient

sampling comparison of EC/OC fractions and comparison of EC versus BC using currently accreted sampling methods. For part A, methods evaluation need to be implemented on a small set of collocated laboratory instruments that can be calibrated with the same standards, use the same gases, and that have demonstrated cross-comparability. For part B, ambient sampling would be conducted at locations known to have different carbon contributions from motor vehicle exhaust, wood burning, cooking, etc.

Previous "bottom-up" inventories of BC and OC have assigned emission factors based on fuel type and economic growth factor alone. Because emission rates are highly dependent on the actual process used to determine them, this research project will consider the effects of fuel type, combustion process type, emission control, and their prevalence on a regional basis, with special attention to the residential and transportation sectors. A comprehensive literature review and limited source tests of the most critical sources will be conducted. Specific tasks could include: 1) particulate matter emission factors for technologies that have not been well studied (residential combustion sources, traditional industry, super-emitters); (2) speciation of PM (in particular from high-emitting technologies) into BC and OC and comparison of the results with ambient measurement; this especially affects BC emissions, and involves measurement uncertainties as well as population variability; and (3) analysis of technology divisions in sectors that contain even a small fraction of highly-polluting devices.

BENEFITS: Most studies have treated measurements of EC as equivalent to BC, introducing a substantial uncertainty. The scientific and regulatory communities would both benefit from a better understanding of how EC compares against BC. This project will also result in a quantitative understanding of the effect of different combustion sources and their particle emissions, in particular BC and OC, on air pollution and climate change. Particulate emissions are believed to play a significant role in global warming. Furthermore, unlike the benefits associated with reductions in greenhouse gas emissions which take decades to fully realize, reductions in particulate matter emissions yield immediate improvements due to their short atmospheric lifetime. Therefore, efforts to better characterize and subsequently control particulate matter can have an immediate and potentially profound impact on addressing global warming.

COST: $400,000. Potential co-funding sources include U.S. EPA, EPRI, CRC, SCAQMD, etc