

**State of California
AIR RESOURCES BOARD**

**Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510, 5th Floor
Sacramento, California 95814
(916) 445-0753**

March 8, 2013

9:00 a.m.

AGENDA

- | | |
|--|---------|
| I. Approval of Minutes of Previous Meeting: | iii-xvi |
| October 26, 2012 meeting | |
| II. Discussion of Draft Final Reports: | |
| 1) "Cardiopulmonary Health Effects: Toxicity of Semi-Volatile and Non-Volatile Components of Ultrafine Particulate Matter," University of California, Irvine, \$501,484, Contract No. 07-307 | 1 |
| 2) "Personal, Indoor, and Outdoor Particulate Air Pollution and Heart Rate Variability in Elderly Subjects with Coronary Artery Disease," University of California, Irvine, \$235,000, Contract No. 08-307 | 7 |
| 3) "Characterization of the Atmospheric Chemistry in the Southern San Joaquin Valley," University of California, Berkeley, \$1,095,000, Contract No. 08-316 | 11 |
| 4) "Characterization of Ambient Aerosol Sources and Processes During CalNex 2010 with Aerosol Mass Spectrometry," University of Colorado at Boulder, \$285,000, Contract No. 08-319 | 19 |
| 5) "Hourly In-Situ Quantitation of Organic Aerosol Marker Compounds During CalNex 2010," University of California, Berkeley, \$249,999, Contract No. 09-316 | 25 |
| 6) "A Field Experiment to Assess the Impact of Information Provision on Household Electricity Consumption," University of California, Los Angeles, \$173,934, Contract No. 08-325 | 31 |

- 7) "Identifying Determinants of Very Low Energy Consumption Rates Observed in Some California Households," University of California, Davis, \$104,911, Contract No. 09-326 37
- 8) "Black Carbon and the Regional Climate of California," University of California, San Diego, \$820,483, Contract No. 08-323 43

III. Discussion of Responses to Requests for Proposals:

- 1) "Technical Analysis of Vehicle Load-Reduction Potential for Advanced Clean Cars," \$250,000, RFP No. 12-311

IV. Other Business:

- 1) Update on a research proposal titled, "Investigating Controls and Measurement Methods for Semi-Volatile Organic Compound Emissions from Light-Duty Vehicles"
- 2) Update on RFP 12-310 titled, "Evaluating Technologies and Methods to Lower Nitrogen Oxide Emissions from Heavy-Duty Vehicles"
- 3) Resolution for Dan Costa

**State of California
AIR RESOURCES BOARD**

**Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510
Sacramento, California 95814
(916) 445-0753**

&

**California State Polytechnic University
Engineering IV, Building 192
Room Number: 206
Street location: Corner of California Blvd. and Highland Drive
San Luis Obispo, California 93407**

**October 26, 2012
9:00 a.m.**

MINUTES

RSC Members in Attendance

Harold Cota
Chung Liu
Tracy Thatcher
Forman Williams
Daniel Costa – via teleconference
Steven Japar – via teleconference
Matthew Kahn – via teleconference
Rachel Morello-Frosch – via teleconference
Suzanne Paulson – via teleconference

The Research Screening Committee (RSC or Committee) convened the meeting at 9:07 a.m. The minutes of the July 11, 2012 meeting were approved.

I. New Research Projects:

- 1) “Measuring Real-World Emissions from the On-Road Heavy-Duty Truck Fleet,” University of California, Berkeley, \$450,000, Proposal No. 2745-275

The Committee had two questions on the proposal. One, the Committee asked how the resulting data will be made available (at least to the California Air Resources Board (ARB or Board). Staff replied that the investigators will generate spreadsheets for each field campaign. The spreadsheet will tabulate

the results for trucks observed; one row for each truck. The fields (columns of the table) will include date and time of measurement, emission factors for each of the pollutants measured (in g-pollutant/kg-fuel or #-particles/kg-fuel), and information about the trucks can be gained from truck license plates. The latter depends on what ARB provides from its truck registry, and ideally will include engine model year and emission control technology. The investigators will deliver this data to ARB on a DVD.

Two, the Committee asked whether the fast mobility particle sizer (FMPS) the investigators plan to borrow from ARB will come from the Southern California mobile monitoring platform (MMP). Their concern was that removing the FMPS from the mobile platform for as much as five months out of the year (including travel time and servicing that may be required after extensive deployment) could have substantial impacts on the MMP research activities. Staff replied that the Research Division was in the process of acquiring two new FMPS instruments. One of them will be made available to the investigators for the sampling campaigns.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the proposal.

- 2) "Evaluating the Benefits of Light Rail Transit," University of California, Irvine, \$200,000, Proposal No. 2746-275

The Committee felt the study was well specified and had a well-designed research protocol. The Committee clarified that proposed ARB funds would support the analysis of Phase 2 data and the collection and analysis of Phase 3 data. The Committee felt the recruitment of new residents to examine self-selection was an important addition and asked that the selection criteria for new residents be clarified. The Committee asked that there be more clarification surrounding the metrics used to measure neighborhood perceptions and cohesiveness (noise, do people want to move out, etc.); the Committee suggested using already-existing survey questions that have been validated and use Likert scales which can be used to derive combined scores of perceived neighborhood quality. The Committee also stated that comparing the demographics of the surrounding neighborhoods with those of the study participants will be key to ensure it is a representative sample that can be generalized. If it is not, more targeted recruiting may be necessary. Lastly, the Committee asked that the characteristics of the "control neighborhoods" be specified, explaining that in addition to distance from transit station, the other characteristics of selecting "control" neighborhoods (demographics or characteristics of the built environment or both) need to be communicated. In conclusion, the Committee felt this study offers an innovative protocol and a good opportunity to better understand how light rail transit investments will help meet Senate Bill (SB) 375 goals.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the proposal.

- 3) "Economic and Operational Considerations in Transitioning to a Zero or Near-Zero Emission Rail System in California," University of Illinois, \$399,889, Proposal No. 2747-275

The Committee as a whole was supportive of the proposal but one of the Committee members raised a number of questions and concerns regarding the proposal as written.

Specific questions raised and ARB staff responses were: 1) Will the contractor (University of Illinois) have access to the proprietary rail operations information needed for the project to be successful? Staff responded that the University of Illinois has standing agreements and past experience working with the rail companies to access and analyze these types of data; 2) How will locomotive manufacturers with an understanding of zero-emissions technology be involved in this project? Staff responded that ARB program staff will consult locomotive manufacturers in developing different zero-emissions technology scenarios that would then be analyzed by the University of Illinois under this contract; 3) Although the University of Illinois has assembled a strong research team, are they familiar with California rail operations? Staff responded that the University of Illinois was selected because it has the best understanding of rail operations nationally, as well as in California. There were no California researchers identified with a comparable level of understanding. Staff also explained that the proposal, as written, includes two tasks (independent expert review; formation of a workgroup) specifically designed to avoid bias in the study methods and results, as well as provide input from other experts with an understanding of California rail operations; and 4) Does the University of Illinois have expertise in zero-emissions rail technology (specifically electrification). Staff responded that the research team has several members with expertise in zero-emissions rail technology, including one researcher with previous experience studying electrification of the Amtrak system in the Northeast.

Prior to voting on the proposal, another Committee member commented that a lot of time and thought had clearly gone into writing the proposal. The Committee recommended moving forward with the proposal with the condition that the peer or expert review process occur early in the project, not just at the end following completion of the draft final report. It was also recommended that the peer reviewer or reviewers selected should have expertise in the technical aspects of the project.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the proposal.

- 4) "Life Cycle Assessment and Co-Benefits of Cool Pavements," Lawrence Berkeley National Laboratory, \$450,000, Proposal No. 2748-275

The Committee thought the research team was strong, the proposal very well-written, and the project well thought-out. The Committee asked what was driving the high cost of the project. Staff explained the project cost is driven by the work hours required for life cycle assessment and Lawrence Berkeley National Laboratory's high overhead rate. The Committee felt that the strong research team was worth the higher cost of the project.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the proposal.

- 5) "Improving Detection of Particulate Matter Emissions for Certification of Advanced Clean Cars (CRC Project E-99, 'Very Low PM Measurement')," University of California, Riverside, \$100,000, Proposal No. 2749-275

The Committee stated that they had no comments beyond those already provided to ARB staff. One member noted that the proposals had been reviewed by the Coordinating Research Council (CRC) that includes particulate matter experts, so he was satisfied with the proposal's review.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the proposal.

- 6) "Investigating Controls and Measurement Methods for Semi-Volatile Organic Compound Emissions from Light-Duty Vehicles," Colorado State University, Fort Collins, \$500,000, Proposal No. 2750-275

A Committee member noted that two of the semi-volatile organic compound measurement technologies discussed in the proposal are cutting edge.

The Committee asked about the emissions contribution since these vehicles are low emitting. Staff responded that directly emitted primary organic aerosol (POA) from gasoline vehicles is relatively low, but that secondary organic aerosol (SOA) exceeded POA by factors of 2 to 10 times, and hence further research is needed to better characterize these emissions. Staff also mentioned that because of climate change mandates, the population of gasoline direct injection (GDI) vehicles has been increasing, and GDI vehicles are known to have higher directly emitted PM than older port fueled injected vehicles, and further study of SOA formation is needed.

A Committee member expressed support for staff comments. Another member asked about the CRC 'Tailpipe to Ambient' project, and if it was complete. Staff responded that the project is still ongoing. Phases 1-3, involving vehicle testing are complete, but Phase 4, being sponsored by the CRC Atmospheric Impacts Committee will begin early in 2013, and should be completed in about a year.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the proposal.

- 7) "Improving Chemical Mechanisms for Ozone and Secondary Organic Carbon," University of California, Davis, \$450,024, Proposal No. 2751-275

The Committee commended the proponents on the technical aspects of the project, and indicated that this project would result in a major update of the photochemical models needed to project California compliance with federal ozone and particulate matter air quality standards. The Committee also encouraged collaboration between the UC Riverside gas-phase mechanism update and UC Davis chemical mechanism improvement research projects.

Motion: Move to accept subject to the inclusion of comments from staff and Committee.

The Committee approved the proposal.

- 8) "Characterizing the Climate Impacts of Brown Carbon," University of California, San Diego," \$530,000, Proposal No. 2752-275

The Committee expressed overall support for the proposal. The Committee recommended that the field studies should include enhanced optical characterization, specifically an aethalometer with two or more wavelengths (e.g., 370, 880 nm), so that the field data would be more comparable to results from other studies. The Committee expressed concern as to whether the source-oriented sampling (SOS) technique for this study would allow for collection of samples that are distinguishable enough to meet research goals. Staff explained that while SOS is a key part of the investigators' ambient air sampling strategy, the investigators actually have a three-pronged approach to ensure that their results will meet research needs. A Committee member asked whether four separate modeling sub-tasks are necessary to examine brown carbon's importance in both regional and global modeling climate forcing. Staff responded that a comprehensive assessment of global regional climate effects of brown carbon will be performed, specifically by three types of model simulations and a column observation-based calculation. The column observational analysis will provide an additional measured constraint on the global and regional modeled values, in order to ensure consistency in the analysis; this will provide an additional "ground-truth" constraint for resolving any potential discrepancies in the modeling results.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the proposal.

- 9) "Advanced Plug-in Electric Vehicle Travel and Charging Behavior," University of California, Davis, \$650,000, Proposal No. 2753-275

Staff provided an update indicating the recruitment process for this project was more expensive than originally anticipated, which will reduce the number of households that can be included in the study.

The Committee asked about recruiting households, and commented that a contingency plan is needed for recruiting households if mailings do not yield sufficient response. In addition, a minimum number of households should be required for the project to proceed. Staff clarified the current recruitment process, which has some follow-up provisions, and the number of households that would need to participate relative to the total plug-in electric vehicle (PEV) population. Staff will ask researchers to explore additional recruitment strategies as well.

The Committee asked about the potential for co-funding from other government agencies, non-profit organizations, and/or industry partners. Staff responded that they are actively seeking co-funding and described the potential sources.

A Committee member commented that qualitative information gathered from interviews is essential for interpreting the data, and that given the large volume of data and logistics of deploying loggers to households, a project manager seems critical to ensure the success of the project. Staff responded that they will note the high priority for interviews and a project manager should additional funding become available.

A Committee member asked about plan B if the GPS signal acquisition issues cannot be resolved. Staff responded that they will ask researchers to address this issue in a revised proposal.

A Committee member asked that the plan explicitly address how and when data from this project would be available for use by outside researchers. Staff responded that only some data will be available to outside researchers due to privacy concerns. If additional co-funding becomes available, more data could be processed to mask sensitive information and be made available through the National Renewable Energy Laboratory's Secure Transportation Data Center portal. Alternatively, researchers would need to go to the University and apply for access to the data.

A Committee member asked for clarification on who would be doing the analysis, as the current proposal does not include a programmer. Staff responded that the three postdoctoral researchers would be responsible for analyzing the data; a programmer will be added if additional funding becomes available.

A Committee member asked about the timeliness of the project and representativeness of the sample given the lag in when results would be available and the current flux of the PEV market. Staff responded that this project originated due to a Board resolution that does not require a report to the Board until 2016. Additionally, staff commented that changes in the market are important to monitor for informing future regulations.

A Committee member noted the total budget request and asked for clarification on the project deliverables and decision points. Another Committee member asked whether vehicle owners could give permission to release their vehicle's data in lieu of installing the data logger. Staff clarified the project costs and the opportunities to collaborate with researchers and manufacturers on an ongoing basis to ensure a useful end product.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the proposal.

- 10) "New Car Buyers' Valuation of Zero-Emission Vehicles," University of California, Davis, \$250,000, Proposal No. 2744-275

Staff indicated that a number of states that have adopted California's vehicle regulations have indicated an interest in providing co-funding to administer the same survey and/or conduct similar interviews in their State. Staff therefore requested approval for a total budget of up to \$575,000.

A Committee member asked for more detail on the selection criteria for interviews and that the interview protocol be piloted with at least five households. Staff responded that they will ask researchers to address this issue in the revised proposal.

A Committee member asked for the section related to regional sampling to be clarified. Staff responded that they will ask researchers to address this in the revised proposal.

A Committee member asked for clarification on the different issues and parameters to be explored or measured in the interviews and the survey. Additionally, the Committee member suggested the survey include questions regarding consumer habits related to emerging technologies and information sources on vehicle purchases. Staff responded that attitudes towards new technologies and consumer information are included as areas of interest, and they will ask researchers to clarify in the revised proposal.

A Committee member asked for clarification regarding relevance of the mobility package game shown in the Appendix. Staff responded that this game was included only as an example for the type of game that could be created for this project.

A Committee member asked whether the survey could be designed to allow for completion on smartphones thereby potentially increasing response rates. Staff responded that the survey will be compatible with various operating systems but due to display sizes may not be compatible with smartphones.

A Committee member asked whether this project could be coordinated with outside experts on consumer issues. Staff responded that they will inquire about potential interest.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the proposal.

- 11) "Identifying Urban Designs and Traffic Management Strategies that Reduce Air Pollution Exposure," University of California, Los Angeles, \$388,001, Proposal No. 2754-275

Overall, the Committee was supportive of the measurement proposed.

The Committee was concerned about the success of the modeling and if the study could still give useful results if the modeling failed. One Committee member suggested funding only the measurement part of the proposal and suggesting putting remaining funds toward studying other important microenvironments such as indoors. Another Committee member suggested the modeling could be done by ARB's modelers and another member recommended outside review prior to model development. Response by staff and management highlighted the usefulness of the measurements themselves and also stressed the importance of personal exposures in the transit environment. In addition, the investigator leading the modeling portion is well qualified to do the work. A Committee member mentioned he is currently doing modeling work for South Coast Air Quality Management District (SCAQMD). However, outside review will be pursued given the complexity of the modeling.

One Committee member was concerned about generalizing the model to other locations besides Los Angeles and suggested changing the title to reflect this potential limitation. Another questioned how useful the model would be. Staff responded that it is unknown how robust the model will be and if it could be applied to other locations. However, as the modeling is experimental, it will be useful to try and move forward. The final model would be able to provide practical guidance for implementing SB 375.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the proposal. Suzanne Paulson recused herself and was not present for this item.

II. Draft Final Reports:

- 1) "Mobile Platform III: Characterizing Spatially Inhomogeneous Non-Criteria Pollutants in the Los Angeles Air Basin," University of California, Los Angeles, \$290,000, Contract No. 09-357

Overall, Committee members thought the report was well done with a few minor formatting suggestions.

One Committee member commented there was not much discussion about the implications of elevation, but that the research was targeted and well done. In addition, it was asked if there were any additional plans or next steps for the data. Staff responded that no additional steps were planned at this stage, although there is potential for use in future modeling studies.

One Committee member commented on the simplicity of the model and minor formatting details such as using larger font on figures. Another Committee member also asked if comments had been made by other ARB Divisions. Staff responded that the Planning and Technical Support Division had commented and had also noted the simplistic nature of the model. However, further development of the model is not feasible given resources and time available.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the report.

- 2) "Measuring the Climate Impact of Residential Buildings: Greenpoint Rated Climate Calculator Version 2," University of California, Berkeley, \$101,575, Contract No. 09-344

A Committee member stated that the value of the tool depends on how widely it is used. The Committee member recommended that ARB staff identify alternatives to reaching builders and developers to let them know the tool is available for use. For example, ARB staff could work with trade association newsletters for targeted outreach. ARB staff agreed that this was a good recommendation. Another Committee member asked what users think about the tool. ARB staff explained that there has been limited user feedback since the contractor is still working on the on-line version of the tool. ARB staff will work directly with the contractors to make sure the final version of the tool is user friendly. ARB staff have previewed the wire frame version of the tool and stated that it looks straightforward and easy to use.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the report.

- 3) "Measurement of Diesel Solid Nanoparticle Emissions Using a Catalytic Stripper for Comparison to Europe's Particle Measurement Programme Protocol," University of California, Riverside, \$170,000, Contract No. 08-302

The Committee recommended clarifying the importance of the results by improving descriptions and providing more explanation of the figures, especially in Chapter 7. The figures are cryptic and it is difficult to figure out the importance of the results and the meanings of the figures. Staff responded that running nine instruments simultaneously with complex test sequences made it very complex to deliver the results effectively. Staff will work with the contractor to improve descriptions of the figures.

The Committee asked for additional background on motivation for the Particle Measurement Programme (PMP) measurement itself. Staff responded that the motivation for this study was to evaluate the PMP method. Staff agreed to work with the contractor to include motivation for the PMP and motivation for this study into the Executive Summary. Staff also responded that we had observed solid sub-nano particles less than 23nm downstream of Europe's PMP system and staff wanted to better understand if the particles were artifacts formed through the PMP system.

The Committee noted that the on-road truck test results in Executive Summary section were misleading. The truck test results would not be fleet representative. Staff responded that the purpose of the on-road truck testing was to investigate whether the laboratory findings that the apparently-solid particles were actually artifact particles also remained true under real-world driving conditions. Staff proposed to work with the contractor to improve the executive summary by reducing the focus on the on-road testing results and further focusing on importance and implication of research findings.

The Committee noted that particles measured by scanning mobility particle sizer include particles and agglomerates of various shapes and lengths, and asked why any special treatment was not made for the particle measurement by size. Staff responded that the main focus of the particle measurement was on nucleation mode particles in the ten nanometer or smaller range rather than large agglomerates.

Motion: Move to accept with revisions.

The Committee approved the report.

- 4) "Are There Any Counteracting Effects that Reduce the Global Warming Benefits Attributed to Black Carbon Controls: Assessment of Cloud Drop Number Concentration Changes and its Importance in Modeling Cloud Albedo Effects on Climate," University of California, San Diego, \$114,751, Contract No. 09-337

The Committee requested explanation of how this work plays to the larger global impact of black carbon. For example, if California is able to resolve some of this problem, is it transferable outside of California? Staff explained that the policies in California can be implemented outside of the State, including other countries. The prevention of warming by the direct effects of black carbon would be shared

by other states and countries. Some of this would be visible from satellite imagery in the long term, if California solves the problem before others. Furthermore, if we improve the representation of black carbon's indirect effects in global models, then we and other states and countries will be able to design more effective control strategies to minimize climate change and its impacts.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the report.

- 5) "Inverse Modeling to Verify California's Greenhouse Gas (GHG) Emission Inventory," California State University, East Bay, \$150,000, Contract No. 09-348

The Committee asked for several changes to the draft final report in addition to those requested by staff. The Committee agreed that the substance of the research was good, but that the draft final report needed more detail and a clear description of the methodology, results, and recommendations. The committee commented that the draft final report was written like a journal article and suggested staff work with the principal investigator to improve the final report and submit it to the Committee in the future.

Motion: Tabled.

The Committee tabled the report.

III. Response to a Request for Proposals

- 1) "Measuring Real-World Emissions from the On-Road Passenger Fleet," University of Denver, Colorado, \$75,000, Proposal No. 2755-275, RFP No. 12-303

Motion: Move to accept the proposal.

The Committee approved the proposal.

IV. Discussion of Request for Proposals (RFP)

- 1) "Technical Analysis of Vehicle Load-Reduction Potential for Advanced Clean Cars," \$250,000, RFP No. 12-311

A Committee member asked for additional discussion of the relationship between vehicle mass and greenhouse gas emissions as well as the potential impacts on vehicle safety. Staff responded that they will revise the RFP accordingly.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the RFP.

- 2) "Evaluating Technologies and Methods to Lower Nitrogen Oxide Emissions from Heavy-Duty Vehicles," \$1,000,000, RFP No. 12-310

The Committee expressed that the RFP was well-written and very ambitious, and asked staff which contractors would respond to the RFP. Staff responded that they expected at least two universities and four private engineering/research companies capable of doing the work to be interested in submitting proposals.

The Committee asked what would be achieved by this project. Staff responded that the ultimate goal of this project is to demonstrate the feasibility of lowering the current heavy duty nitrogen oxides (NO_x) emission standard to 0.02 g/bhp-hr, which is 90 percent lower than the existing 2010 emission standard. The study calls for proof of concept rather than commercialization, but staff expects the project to demonstrate technologies that are reasonably close to commercialization by optimizing and modifying existing technologies, rather than by developing completely new technologies.

The Committee observed that including original equipment manufacturers (OEM) in the RFP is essential to achieving commercialization. Staff responded that they are in contact with the Engine Manufacturers Association (EMA), and while the EMA are not expected to be part of the RFP itself, they have expressed interest and will most likely participate in the effort with in kind contribution and possibly by funding additional work. Staff also noted that the Manufacturers of Emission Controls Association, who represent emission control manufacturers, is willing to participate by providing in-kind support and possibly funding. Staff also responded that the RFP rating criteria would be changed by adding higher ratings for bidders with OEM partnerships.

The Committee asked if other agencies, including the South Coast Air Quality Management District and California Energy Commission, would participate as co-funding agencies. Staff responded that over the last several months ARB has worked with those agencies and found mutual interests. This project will be coordinated with and add to similar efforts underway by those agencies, but direct co-funding is not expected.. Staff recommended moving forward with this RFP to meet ARB's planning targets, but to remain open to potential co-funding agencies.

Motion: Move to accept subject to the inclusion of comments from the Committee.

The Committee approved the RFP.

V. Other Business

- 1) Update on the 2013-2014 Research Solicitation

Staff corrected the agenda: this is an update on the 2013-2014 Research Solicitation (not 2012-2013).

Staff updated the Committee on changes to the research plan development process.

Goals of new process: 1) better focus on priority program needs, and 2) utilize the full three year life of State research funds.

Overview of new process:

- Staff gathered input from across ARB's divisions to identify where research was most needed
- Prioritized research to meet three goals: meeting more stringent air quality standards, achieving climate goals, and supporting Advanced Clean Cars
- Staff are now consulting with other ARB divisions to develop scopes of work
- Staff will request comments on the scopes of work from Committee members with expertise on the topics (staff will email to Committee members the week following the meeting); comments will be needed two weeks later
- Scopes of work will be sent out as a UC/CSU call for proposals in late November or early December
- Submitters will have eight weeks from release of solicitation until draft proposals are due (anticipated late January, 2013)
- Technical review teams will review proposals in February
- Proposals will be summarized in the 2013-2014 Annual Research Plan which will go to ARB's Board in March 2013
- Full proposals will be reviewed by the Research Screening Committee in April
- Proposals will go back to the Board for formal approval in April or May
- Contracts will be executed after June 30, 2013

Comments from the Committee:

- One Committee member pointed out that ARB's proposal requirements are labor-intensive and requested that the first round for developing draft proposals be simplified (e.g., provide a template and allow less budget detail and more abbreviated task description) and requested that ARB provide guidance on developing overall project budgets.
- One Committee member asked how comprehensive ARB's UC/CSU distribution list is and suggested that it should be expanded, and also that

ARB notify research offices in advance of the release of the solicitation so that prospective submitters can plan for the short turnaround time for submitting proposals.

- One Committee member requested that ARB spell out the proposal process in an email to Committee members so that they can comment further and to notify those absent from the meeting that their input is requested on the scopes of work within the next few weeks.

The meeting adjourned at 1:29 p.m.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: II.I

DATE: March 8, 2013

CONTRACT NO.: 07-307

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: Cardiopulmonary Health Effects: Toxicity of Semi-Volatile and Non-Volatile Components of Ultrafine Particulate Matter

CONTRACTOR: University of California, Irvine

PRINCIPAL INVESTIGATOR: Michael Kleinman, Ph.D.

TOTAL AMOUNT: \$501,484

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 60 Months

For further information, please contact Dr. Alvaro Alvarado at (916) 445-4843.

I. SUMMARY

The objective of this project was to determine the relative contributions of the semi-volatile and non-volatile fractions of ultrafine particles (UFP) to health outcomes. Epidemiological and animal studies have shown associations between exposure to near-roadway particulate matter (PM) and adverse health impacts, including cardiovascular morbidity and mortality and pro-inflammatory effects. However, little is known about the role of the semi-volatile constituents of PM in generating these negative outcomes. Therefore, the current project studied the cardiopulmonary effects of exposure to UFP, with and without semi-volatile components, in an atherosclerotic mouse model. Results of this study showed that exposure to UFP's semi-volatile constituents accelerated the development of atherosclerotic plaque and decreased heart rate variability in mice. These findings provide evidence that the semi-volatile constituents of ambient PM may be causally related to cardiopulmonary health effects. These results also suggest that emission control measures that remove organic

constituents of combustion-generated aerosols could benefit public health because coronary artery disease is a leading contributor to heart-related deaths in California.

II. TECHNICAL SUMMARY

Objective

The objective of this study was to determine how the toxicity of ultrafine particles depends on the concentration and characteristics of semi-volatile and non-volatile fractions of PM emitted from vehicles and other sources.

Background

The specific mechanisms by which PM exposure disrupts cardiac function and worsens cardiovascular disease (CVD) are not well understood. Research findings suggest that PM exposure can induce inflammatory changes in blood vessels and lead to the development of atherosclerotic plaques and lesions. Preliminary findings from the current researchers demonstrated that if the particles were stripped of most of their organic constituents they also lost substantial ability to elicit free radicals and their oxidant potential. Therefore, this study was designed to test the hypothesis that removal of organic constituents of PM would reduce PM's ability to induce or accelerate atherosclerosis.

Project Summary

The goal of this project was to determine whether the toxicity of ultrafine particles (UFP, particles $\leq 0.18 \mu\text{m}$ aerodynamic diameter) depends on the concentration and composition of semi-volatile and non-volatile fractions of the PM. A unique mobile in-vivo rodent exposure system was used in combination with a particle concentrator and thermal denuder to study the cardiopulmonary effects of UFP, before and after the removal of the semi-volatile components. The study used genetically modified (apoE^{-/-}) mice that had impaired lipid metabolism and were therefore predisposed to the development of atherosclerotic-like plaques. Exposures were 6 hr/day, 4 days per week for 8 weeks and were conducted near the University of Southern California campus in central Los Angeles.

Detailed chemical and physical characterization was performed on the concentrated ambient UFP (CAPs) and thermally denuded CAPs. The thermal denuder removed more than 60 percent of the particle-associated organic compounds (OC) but did not remove the non-volatile components such as elemental carbon (EC) or trace metals. Exposure to whole CAPs accelerated the development of atherosclerotic plaque in the apoE^{-/-} mice, characterized by decreased arterial lumen diameters and increased incorporation of lipids in arterial walls. The lumen diameters and arterial wall lipid contents in mice exposed to thermally denuded CAPs suggested significantly less plaque development than in the mice exposed to undenuded CAPs and were not different from plaque levels in mice exposed to purified air, as controls. In addition, heart rate variability was decreased in the mice exposed to undenuded CAPs but not in the mice exposed to either air or denuded CAPs. In a separate experiment mice were exposed to air, undenuded CAPs, and the particle-free organic compounds (PFO) that were stripped from the CAPs in the thermodenuder and delivered to the exposure system.

This study demonstrated that the organic compounds, independent of the presence of particles, played an active role in the acceleration of plaque development. Cholesterol and low density lipoprotein-cholesterol (LDL) levels were relatively high in the apoE^{-/-} mice, as would be expected. Exposure to undenuded CAPs, denuded CAPs and PFO all induced increased levels of both cholesterol and LDL in the serum of these mice, but only the undenuded CAPs and the PFO caused significant serum lipid peroxidation, which is a known contributor to plaque formation. The researchers concluded that the organic constituents of UFP contribute to the accelerated development of atherosclerotic plaque in arteries, lipid oxidation is an important mechanism of action in PM-induced coronary artery disease, and that removal of the organic compounds from PM greatly ameliorates plaque development associated with air pollutant exposure.

III. STAFF COMMENTS

This draft final report provides important insights into the differential health impacts of exposure to the semi-volatile versus the non-volatile components of PM. The findings

were fairly striking, and should provide a strong background for further research into PM-related cardiopulmonary health endpoints.

Staff from the Research Division had the opportunity to review the initially submitted draft report, and they felt that the information contained in this report was well presented. Staff was satisfied that the main objectives of the contract had been met. However, staff suggested a number of revisions to increase the clarity of the final report. The draft report was also sent to an outside reviewer (from the Office of Environmental Health Hazard Assessment). Any additional suggestions from this reviewer will be presented at the meeting of the Research Screening Committee.

A revised draft final report was subsequently submitted. The revised report was much improved compared to the initial draft, and the main concerns raised about the initial draft had been successfully addressed. Additional minor details, such as typographical errors, were conveyed directly to the PI for revision in the final report. A few minor concerns remained, as listed below; however, it was felt that the revised report was well written overall.

- Additional reference citations should be added to the Conclusions section (as indicated by comments provided directly to the PI). Staff felt that several statements were not adequately substantiated and that the addition of background literature would be helpful.
- It would be helpful to provide the readers with a clearer view of the overall study design. This could be accomplished by providing figures and/or tables that allow for easier visualization of the procedures carried out in the project. Although these details may have been provided in the original research proposal, readers should be able to discern how the project was run without referring to the proposal. For example, a table listing the samples that were collected and subsequent analyses that were carried out, as well as a timeline outlining exposure/non-exposure periods, transport, and time of animal sacrifice after the last exposure would be helpful. Also, there was some confusion regarding Table 4 and Figures 9 and 10, with respect to

the two “air” and “undenuded” categories. Perhaps this can be cleared up with a diagram of the overall study design.

- Additional details in the figure and table legends/captions would add clarity to the presentation. More information about the statistical analyses (e.g. p-values or symbols indicating significant differences, and labels explaining the error bars) would assist readers greatly.
- In order to remove the semi-volatile component of PM, it was necessary for the particles to be heated. Is it possible that heating elicited changes in addition to simply removing semi-volatiles? The author should address this possibility, and how it might have affected the results.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: II.2

DATE: March 8, 2013

CONTRACT NO.: 08-307

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: Personal, Indoor, and Outdoor Particulate Air Pollution and Heart Rate Variability in Elderly Subjects with Coronary Artery Disease

CONTRACTOR: University of California, Irvine

PRINCIPAL INVESTIGATORS: Ralph J. Delfino, M.D., Ph.D.
Scott Bartell, Ph.D.

TOTAL AMOUNT: \$235,000

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 48 Months

For further information, please contact Dr. Alvaro Alvarado at (916) 445-4843.

I. SUMMARY

This study evaluated the relationships of heart rate variability (HRV) and cardiac arrhythmias to particulate matter (PM) exposures. Decreased HRV is a marker of autonomic dysfunction and has been associated with future cardiac morbidity and mortality. However, HRV has been inconsistently associated with exposure to PM air pollution. Furthermore, few studies have examined whether air pollution exposure is a risk factor for cardiac arrhythmias. Results from this study support the hypothesis that exposure to PM and ozone increases the risk of one specific type of cardiac arrhythmia, ventricular tachycardia, among elderly subjects with coronary artery disease. The present findings enhance our current understanding of the health impacts associated with exposure to the air pollutant components of traffic emissions. The relationship between pollution exposure and normal cardiac function are a major concern in California, especially near roadways; thus, efforts to decrease traffic emissions are likely to have an impact on adverse cardiovascular events, including arrhythmias that have been linked to sudden cardiac death.

II. TECHNICAL SUMMARY

Objective

The objectives of the study were to examine relationships between cardiovascular autonomic function as measured by HRV and exposures to air pollutants measured at retirement community sites of study subjects with diagnosed coronary artery disease.

Background

HRV and arrhythmias are associated with future cardiac morbidity and mortality. Decreased HRV is considered to be a marker of autonomic dysfunction and has been inconsistently associated with exposure to PM air pollution. Also, few studies have examined whether air pollution exposure is a risk factor for cardiac arrhythmia. The focus of this project was to use repeated daily ambulatory electrocardiogram (ECG) data to investigate HRV and arrhythmias in elderly subjects.

Project Summary

To evaluate acute cardiovascular health effects from exposure to air pollution, home air pollution and ambulatory ECG data were collected for 50 elderly subjects with a history of coronary artery disease living in four retirement communities in the Los Angeles Air Basin. Relationships between HRV and arrhythmias and air pollution exposure were analyzed. Daily 24-hr quasi-ultrafine (PM_{0.25}), accumulation (PM_{0.25-2.5}), and coarse mode (PM_{2.5-10}) particulate matter mass were collected on Sioutas impactors. Hourly pollutant data included criteria gases, particulate matter (PM_{2.5}), total particle number, black carbon (BC), and PM_{2.5} elemental and organic carbon (EC, OC). Outdoor concentrations of primary and secondary OC were estimated. Multiple regression analyses of HRV and arrhythmias using generalized estimating equations were conducted to account for within-subject correlations. Associations were adjusted for physical activity and heart rate, temperature, day of week, season, and community location. Subject susceptibility to decreased HRV and increased arrhythmias with increasing air pollutant exposures, including medication use (e.g., beta-blockers), sex, self-reported co-morbidities, and genotypes (GSTM1 and GSTT1) also were assessed.

Previous work had shown only limited or weak epidemiological and mechanistic evidence linking air pollution exposure with risk of arrhythmias. The results of the current study showed that risk of ventricular tachycardia was significantly increased with higher exposure to markers of traffic-related particles, secondary organic carbon, and ozone. Stronger associations of ventricular tachycardia with OC and both its primary and secondary OC fractions were found among subjects who had the GSTM1 null genotype. Few consistent associations were observed for supraventricular tachycardia. PM exposure was significantly associated with decreased heart rate variability only in the 20 subjects using ACE inhibitors and in those with glutathione S-transferase M1 non-null (lower risk) genotype.

This study's findings support the hypothesis that exposure to PM and ozone increases the risk of ventricular tachycardia among elderly subjects with coronary artery disease. These results are consistent with previous findings in this cohort for adverse effects of air pollution on systemic inflammation, blood pressure and electrocardiographic evidence of ischemia. The information presented in this study will help the Air Resources Board (ARB or Board) in the overall assessment of California health risks associated with exposure to components of air pollution from traffic emissions.

III. STAFF COMMENTS

This draft final report from Drs. Delfino, Bartell, and Longhurst offers a comprehensive and well written summary of the work performed under the contract. Although the investigators did not observe the anticipated strong relationships between smaller fractions of PM_{2.5} and heart rate variability, they did find consistent relationships between ventricular tachycardia and a number of the air pollutant metrics they examined.

Three ARB staff members and one staff member from the Office of Environmental Health Hazard Assessment had the opportunity to review the first draft of this report, and these staff members had a number of questions and comments about the report. In response to staff comments, the researchers revised the draft report, and submitted a second version. Staff comments are summarized below.

Staff agreed that the main objectives of the contract, which involved the evaluation of the relationships between heart rate variability and cardiac arrhythmias and air pollutant exposures, had been met successfully. Additionally, staff felt that the concerns and questions they had about the initial draft report were adequately addressed in the revised report, and felt that the final product was very well written.

Staff had only minor comments on the second draft, which are summarized below:

- Several minor typographical, formatting, and grammatical errors were found in the revised report. A list of these was sent to the PIs so that the errors could be corrected in the final submitted report.
- On page 63, the authors refer to subjects with GSTM1 and GSTT1 “wild-type” or “non-null” genotypes. It would be helpful for readers if the terminology could be kept consistent throughout the report.
- On page 64, the authors state that “The less common GSTT1 null genotype did show the anticipated inverse association of decreased SDNN with air pollutant exposure, primarily traffic-related pollutants.” There were only four subjects with this genotype, so the authors might want to word this sentence a little more cautiously.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: II.3

DATE: March 8, 2013

CONTRACT NO.: 08-316

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: Characterization of the Atmospheric Chemistry in the Southern San Joaquin Valley

CONTRACTOR: University of California, Berkeley

PRINCIPAL INVESTIGATORS: Ronald Cohen, Ph.D.
Allen Goldstein, Ph.D.

TOTAL AMOUNT: \$1,095,000

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 47 Months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

Concentrations of ozone (O₃) and PM_{2.5} in the San Joaquin Valley (SJV) continue to frequently exceed ambient air quality standards. In fact, the southern Valley experiences the worst air quality in the nation. Air quality progress has occurred more slowly in the Valley than in the more populated South Coast Air Basin (SoCAB) despite relatively similar control efforts. The objectives of this project were to coordinate measurements with the large CalNex 2010 field study (research in California at the nexus of air quality and climate change) to investigate the atmospheric chemistry occurring within the SJV. The investigators made a wide range of gaseous and some aerosol (primarily nitrate) measurements at a monitoring site just southeast of the Bakersfield urban area. The investigators found that NO_x controls are important for improving air quality in the SJV. Although the NO_x reductions have been marginally effective in the past in reducing peak ozone concentrations, the changing balance of ozone precursors in the Valley indicated that NO_x reductions are poised to cause substantial reductions in ozone concentrations. In addition, the investigators found that NO_x emissions contribute to the aerosol problem via the production of organic nitrate

aerosols and that continued NO_x reductions will also improve PM_{2.5} air quality. The project results also indicated that diesel emissions are a major contributor to secondary organic aerosols (SOA) at this location. This extensive research project confirmed ARB's strategy of aggressively reducing emissions of both NO_x and volatile organic compounds.

II. TECHNICAL SUMMARY

Objective

The primary objective of this project was to make air quality measurements at a site in the southern SJV in coordination with other researchers participating in the CalNex (research in California at the nexus of air quality and climate change) field study, which was conducted for six weeks in the spring of 2010. These air quality measurements were planned to better elucidate the chemical reactions involving volatile organic compounds (VOC) and NO_x that contribute to the unhealthy O₃ and PM_{2.5} concentrations that occur in the southern SJV and that have not declined as rapidly as desired.

Background

The San Joaquin Valley Air Basin (SJVAB) does not attain federal O₃ and PM_{2.5} ambient air quality standards (classified as an Extreme non-attainment area for O₃). The central and southern portions of the SJVAB experience some of the poorest air quality in the nation and the improvement has been slow. Most of the emission control regulations for vehicles and fuels apply Statewide and the fact that air quality has improved more dramatically in Southern California than in the SJV prompts the question as to why. A number of factors could be responsible for the slower improvement in the SJVAB and this detailed chemical measurement project was developed to investigate a likely major factor: that atmospheric conditions and the photochemical reactions in the SJVAB are different from those in Southern California.

Project Summary

As part of the CalNex study sponsored by the National Oceanic and Atmospheric Administration and ARB, the University of California, Berkeley (UCB) organized a field

site in Bakersfield, California to improve our understanding of the atmospheric chemistry in the SJVAB.

A wide suite of organic molecules (hydrocarbons, oxygenates, peroxides, organic acids, aldehydes-including primary emissions and secondary oxidation products), nitrogen oxides (NO, NO₂, total and speciated peroxy nitrates, total organic nitrates (RONO₂), HNO₃), hydrogen oxides (OH, HO₂), O₃, carbon monoxide (CO), carbon dioxide (CO₂), H₂O, and meteorological parameters were measured at this site in the southern SJVAB from May 18–June 29, 2010. Additional measurements by UCB researchers included aerosol organic nitrate, ozone production rates, and total OH loss rates while other CalNex collaborators measured a wide suite of additional gas and aerosol properties at the site. The six-week measurement program provided a sampling of atmospheric variations in response to meteorological fluctuations and to systematic variations in emissions associated with day-of-week and time-of-day activities. The observations formed the basis for analyses aimed at understanding the atmospheric chemistry controlling ozone and PM_{2.5} production in the study region.

The project tasks were to:

- 1) Collaborate with ARB and other CalNex sponsors on site selection. Assist with recruiting other experimenters to make measurements at one or both of the CalNex supersites in the SJV and SoCABs.
- 2) Prepare analyses of prior observations in the region of the chosen site.
- 3) Prepare instrumentation for deployment at chosen site.
- 4) Deploy, test, and operate instrumentation for six weeks at the chosen site. Help as possible within available resources to insure that all CalNex data sets are accurate and referenced to common calibration standards. Remove instrumentation and complete post-mission calibration.
- 5) Report preliminary data to a community archive during or immediately following the observing period.
- 6) Report final data to a community archive upon completion of the measurements, calibration, validation, and data reduction to final form.

- 7) Summarize and analyze the observations to identify how they support or contradict current understanding (e.g., modeling results) of O₃ and PM_{2.5} formation at the chosen site.
- 8) Prepare at least one manuscript summarizing findings during the research and analysis and submit to a peer-reviewed scientific journal.
- 9) Prepare a final report that responds to comments and suggestions made by staff and the RSC on a draft report.
- 10) Present a seminar summarizing the research for the air pollution community at ARB headquarters.
- 11) Cooperate with CalNex 2010 sponsors and researchers to integrate the various measurements into a coherent understanding of the atmospheric chemistry in the southern SJV regarding the formation of secondary pollutants.

The data analyses conducted by the UCB researchers indicated that emission controls on sources of VOCs, with the goal of reducing O₃ concentrations, have been ineffective at high temperatures in the southern SJV, but that they have been effective at moderate temperatures and in central and northern locations. NO_x controls have recently become effective at reducing the frequency of high ozone days under some conditions in the SJVAB and they are poised to become even more effective in the future. The observations also provided insight into some of the sources of VOC and the extent to which those sources might be controllable.

The aerosol measurements show that nitrate (NO₃) chemistry is an important source of aerosol growth at night. The data analysis indicated that particulate alkyl nitrates form at night as a consequence of chemical reactions involving the nitrate radical and thus these nitrate aerosols can serve as a tracer of secondary organic aerosol formation from gaseous anthropogenic emissions. Further, in combination with aerosol mass spectrometry by other CalNex collaborators, the data demonstrated that about 20 percent of the individual molecules in SOA are chemicals indicative of RONO₂. One of the more interesting findings of this research effort was that diesel emissions (particularly unburned diesel fuel) are a major source of SOAs in the Bakersfield area.

III. STAFF COMMENTS

Various ARB staffers in the Research, Planning and Technical Support, Monitoring and Laboratory, and Mobile Source Control Divisions as well as staff from the SJV Unified Air Pollution Control District and the National Oceanic and Atmospheric Administration were asked to review the draft report. Reviewers were given until the end of January to provide comments due to holiday schedules and the number and complexity of reports needing review. Consequently, not everyone has been able to respond yet with comments. Any major comments and suggestions that arrive after this evaluation will be presented to the RSC members at the meeting.

Some of the initial staff comments indicate the need for better documentation of the CalNex-Bakersfield monitoring site and quality assurance procedures as well as the desire for better organization of the material around the project objectives and tasks.

Based on previous pollutant measurements and analyses (including photochemical modeling), the investigators began this project with the following hypothesis:

The SJV of California is a region where secondary pollutants will respond weakly or not at all to continued anthropogenic VOC controls while NO_x controls will be effective.

The general objective of this project was to test the ideas underlying the hypothesis with additional detailed chemical measurements, modeling, and data analysis. A full suite of coordinated measurements of primary and secondary atmospheric trace species were made by the two Principal Investigators (PIs) and four sub-contractors. These measurements included organic molecules (hydrocarbons, oxygenates, peroxides, organic acids, aldehydes-including primary emissions and secondary oxidation products), nitrogen oxides (NO, NO₂, total and speciated peroxy nitrates, total RONO₂, HO₂NO₂, HNO₃), OH, HO₂, O₃, CO, H₂O, and meteorological parameters. The measurements included organics emitted directly by anthropogenic and biogenic processes and organics that are unique markers of oxidation. This combination of measurements provided a level of detail never before achieved in the SJVAB and

enabled the critical findings of the role of NO_x and diesel emissions in contributing to the air quality problems of the southern SJV.

The PIs have successfully performed all of the project tasks that could be completed to date and are committed to fulfilling the on-going tasks. When the planned ARB study site became unavailable, the PIs quickly and efficiently secured an acceptable replacement site that ARB staff would have been unable to secure in time for the CalNex field study. In addition, the PIs successfully attracted several other researchers to make critical measurements at the site at no expense to ARB. The PIs successfully coordinated the power, space, and calibration gas needs of the researchers at the supersite. The PIs coordinated the establishment of a common repository for the measurements that were made at the site. The data analyses resulted in the publication of several papers in peer-reviewed journals (e.g., Proceedings of the National Academy of Sciences, Journal of Geophysical Research, Science, Atmospheric Chemistry and Physics) and many posters/presentations at various meetings and workshops (e.g., CalNex Data Analysis, AGU Fall Meetings, ACAST#4 Meeting). These findings are pertinent to ARB's emission control efforts as they reinforce the current strategies and can guide refinements. The PIs will summarize their research for ARB staff (and other interested parties on-line) at a Chair's Seminar scheduled for Monday, April 22, 2013.

Although the staff finds the independent journal publication style of the report less than ideal, the breadth (number of investigators and measurements) makes creating a detailed integrated style of report very challenging. The reviews of the draft final report received thus far indicate general satisfaction with the content and quality of the report. The reviewers have suggested additional documentation of the monitoring site and equipment layout as well as additional quality assurance discussion and analysis. For example, multiple measurements of CO and HNO₃ were made at the site and the comparison of methods needs to be more thorough. In addition, the context of the gaseous measurements (e.g., NO_x and O₃) and meteorological conditions at the supersite needs to be established with concurrent data from the long-term downtown (California St.) and downwind (Arvin) sites. Although reviewers did not dispute the

findings and conclusions, multiple reviewers expressed the need for the basis of some conclusions to be developed in more detail.

For example, one of the findings of this research effort was that diesel emissions (particularly unburned diesel fuel) are a major source of SOA in the Bakersfield area. Because diesel fuel usage is greater in rural than in urban counties and because the site was located near roadways with high proportions of diesel traffic, a concern exists as to how spatially representative across California the result might be. This CalNex result for Bakersfield is in contrast to a separate CalNex research finding that implicated gasoline fuel as the overwhelming contributor to SOA in the Los Angeles area. Although these results appear to be contradictory, the relative contribution of diesel and gasoline sources to ambient SOA is expected to vary depending on local and regional sources. New on-road diesel vehicles with particle filters (DPFs) have very low SOA formation and so the diesel contribution to PM_{2.5} will decrease as the diesel fleet turns over.

The reviewer comments and suggestions as of the end of January were submitted to the PIs. Any late reviewer comments will be transmitted to the PIs along with the comments and concerns of the RSC.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: II.4

DATE: March 8, 2013

CONTRACT NO.: 08-319

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: Characterization of Ambient Aerosol Sources and Processes During CalNex 2010 with Aerosol Mass Spectrometry

CONTRACTOR: University of Colorado at Boulder

PRINCIPAL INVESTIGATOR: Jose-Luis Jimenez, Ph.D.

TOTAL AMOUNT: \$285,000

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 36 Months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

Fine particle air pollution is a persistent problem in many urban areas of California, with organic species often dominating the submicron portion. The sources and processing of this organic aerosol (OA), however, are highly uncertain. This project carried out a detailed characterization of submicron organic aerosols in the Los Angeles area during the 2010 California Research at the Nexus of Air Quality and Climate Change (CalNex 2010) field campaign. A suite of instruments, including high-resolution aerosol mass spectrometry (HR-AMS) and co-located gaseous and particle instruments at the Pasadena site, were utilized to determine sources, composition and atmospheric processing of aerosols. Five OA components were identified using HR-AMS data and organic tracers; secondary organic aerosol (SOA) accounted for the majority of OA mass with smaller contributions from primary combustion emissions and cooking-influenced particulate matter (PM). The ratio of the production rates of SOA to odd oxygen (O_x) was similar to those from other urban studies, which indicates a similar formation chemistry that is independent of location. Lack of a weekend-weekday (WE/WD) effect in SOA formation suggests that gasoline vehicles were the dominant

contributor to SOA, under the assumption that most SOA precursors are from motor vehicles. The results from this work have several possible regulatory implications; e.g., a significant portion of PM_{2.5} mass is composed of SOA, the precursors of which are not adequately regulated.

II. TECHNICAL SUMMARY

Objective

The objective of this research was to provide an improved characterization of the sources and atmospheric processing of organic aerosols in Southern California during the field study CalNex 2010 using an Aerodyne High Resolution Time-of-Flight Aerosol Mass Spectrometer (AMS) and other aerosol instruments.

Background

Despite improvements in emission control technologies, fine particles remain a serious pollution problem in urban areas of California. Both the South Coast Air Basin (SoCAB) and the SJV frequently exceed national air quality standards for particle concentrations. In addition, aerosols significantly impact climate and visibility, increase cardiac and respiratory disease in humans, and deposit toxics to the ground. A recent study organized by Prof. Jimenez in the eastern SoCAB – 2005 Study of Organic Aerosols at Riverside (SOAR-1 July-Aug. 2005, and SOAR-2 in Oct.-Nov. 2005) - indicated that the total organic aerosol comprised approximately 40 percent of the total PM_{2.5}, and more significantly, that SOA was the dominant component of OA. In that work, five independent estimates of SOA for PM_{2.5} during the summer gave similar values: SOA comprised approximately 70 percent of the OA during the summer. AMS measurements near downtown Los Angeles show that this high level of SOA was not limited to the eastern side of the air basin, but likely extended to the western side as well.

These recent SOA estimates differ significantly from older estimates, in which POA is the dominant contributor to OA (typically over 50 percent). Although several explanations for this discrepancy have been proposed, the high level of uncertainty in changes in atmospheric composition (SOA precursors), biases of older SOA estimates, and scaling methods prevent an unambiguous conclusion regarding its origin from being reached.

Compared with model results, these measurements indicate that a few SOA aerosol precursors are not sufficient to describe ambient concentrations; instead, a broader characterization of SOA precursors and aerosol components is needed to accurately model ambient PM concentrations.

Project Summary

This project focused on OA and determined the contributions from various sources to ambient submicron aerosol mass concentrations and evaluated the formation and processing of SOA at the Pasadena ground site during the CalNex 2010 field campaign. An Aerodyne Time-of-Flight HR-AMS provided the principal aerosol composition measurements; a suite of supporting state-of-the-art instruments supplied further gas- and aerosol parameters.

The results from this work may be broadly classified into three studies. The first study included the quantification of aerosol composition, size distributions and daily cycles. A clear diurnal cycle was observed for most aerosol species; this followed the predominant wind pattern in the South Coast – a sea breeze during the day and a weak southwest or southeast wind during the night. Maxima in combustion tracers, such as elemental carbon (EC) and CO, occurred much later than the local rush hour, 12:00-13:00 PDT, indicating that the air masses were transported to Pasadena from downtown LA and the Ports of LA (from their morning rush hour). In contrast to these primary emissions, OA concentrations peaked later, ~15:00 PDT, when air masses transported to Pasadena were the most photochemically processed. The second study comprised the identification of dominant components of submicron OA sources by Positive Matrix Factorization of HR-AMS measurements and identification of these components using correlation analysis with organic tracer species and elemental composition. Five positive matrix factorization (PMF) components of the OA mass were distinguished: 1) hydrocarbon-like OA (HOA), from primary emissions (combustion sources – strong correlation with EC and total chemically reactive nitrogen (NO_y)); 2) cooking-influenced OA (CI-OA), from residential and commercial cooking; 3) local organic aerosol (LOA), whose source is uncertain; 4) semi-volatile oxygenated OA (SV-OOA), from in-basin production of SOA; and 5) low-volatility oxygenated OA

(LV-OOA), from an extremely aged SOA (highest O:C ratio; strong correlation with sulfate). The third study involved comparisons of the evolution of OA composition and of time scales and efficiency of SOA formation against previous measurements. The time series for SOA (SV-OOA + LV-OOA) was correlated with that of odd oxygen, O_x , which is associated with the extent of photochemical oxidation in an air mass. A regression of OOA against O_x gave a slope close to that found in Mexico City and in Riverside; this indicates that different sites have similar SOA and O_x formation chemical dynamics and mechanisms. HOA and EC exhibited strong weekend effects – significantly reduced concentrations - that are associated with decreased diesel vehicle activity. In contrast CO and OOA did not show significantly different concentrations on the weekends versus weekdays. Analysis of the weekend to weekday concentrations of OOA/ Δ CO for different photochemical ages yielded an estimate of the relative contributions of diesel and gasoline vehicle emissions to SOA: gasoline vehicle emissions were significantly more important than diesel vehicle emissions to the formation of SOA in the LA basin (upper estimates of diesel contributions were ~ 16-29 percent). In addition, the OA/ Δ CO ratio increased with photochemical age and fell in the upper limit of similar plots for Mexico City and the northeastern United States, indicating that OA production per CO in Pasadena was slightly more efficient than in other locations.

III. STAFF COMMENTS

Staff from the Planning and Technical Support and Research Divisions reviewed the draft version of the Final Report and are very satisfied with the quality of work performed and with the presentation of results in the Final Report. Staff from NOAA and SCAQMD have been asked to comment on the report. Any major comments and suggestions that arrive after this evaluation will be presented to the RSC members at the meeting.

Staff would like to note the critical role Professor Jimenez played in helping to coordinate many research groups and making the field study CalNex 2010 an outstanding success. Professor Jimenez and his group organized many web-based meetings prior to the campaign and set up a Wiki-site to collect scientific information and links for the Los Angeles CalNex supersites ([CalNex-LA](http://cires.colorado.edu/~jimenez-group/wiki/index.php/CalNex-LA) <http://cires.colorado.edu/~jimenez-group/wiki/index.php/CalNex-LA>). His and Professor

Stutz's efforts produced an ideal scientific venue for the study of multifaceted problems in atmospheric chemistry, aerosols and climate science by the many research groups who participated in the study. These additional datasets and studies provide an unprecedented picture of and insights into urban atmospheres of California.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: II.5

DATE: March 8, 2013

CONTRACT NO.: 09-316

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: Hourly In-Situ Quantitation of Organic Aerosol Marker Compounds During CalNex 2010

CONTRACTOR: University of California, Berkeley

PRINCIPAL INVESTIGATOR: Allen Goldstein, Ph.D.

TOTAL AMOUNT: \$249,999

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 36 Months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

Many urban and rural air quality districts are out of compliance with California and federal ambient air quality standards for particulate matter less than 2.5 microns in diameter (PM_{2.5}). While many advances have been made in measuring and modeling the inorganic ionic species that are found in PM, much less is known about the organic fraction. Yet organic matter can be a major constituent of aerosols. Quantitative, time-resolved knowledge of the composition of organic aerosols is critical to identifying its sources, to understanding its formation and transformation processes, and to evaluating its roles in PM air quality and in global climate change. This project used thermal desorption aerosol gas chromatography/mass spectrometry (TAG) to better characterize the composition of ambient aerosols less than 1 micron in diameter (PM₁). These data were analyzed by Positive Matrix Factorization (PMF) to characterize the nature and sources of the PM₁. The results indicate that the PM₁ in the southern San Joaquin Valley (SJV) is a mixture of primary and secondary aerosols associated with mobile sources, natural and agricultural biogenic sources, sources associated with the oil and gas industry, and upwind sources via transport. The on-going reduction in

emissions from motor vehicles should continue to reduce not only primary emissions but also the formation of secondary aerosols. This project helped to refine the relative roles of biogenic emissions and ammonia in aerosol formation in the southern SJV.

II. TECHNICAL SUMMARY

Objective

The primary objective of this project was to identify the origins of the organic matter in ambient aerosol samples collected in the SJV during the CalNex 2010 field study. Hourly in-situ measurements were made for four weeks (~June 2010) during the CalNex field study at a “supersite” established just southeast (typically downwind) of Bakersfield. These data provided a rich and comprehensive basis for identification of aerosol origins through Positive Matrix Factorization (PMF) analysis. The investigators identified links between some of the secondary aerosol constituents and their likely precursors.

Background

Many urban and rural air quality districts in California exceed State and federal ambient air quality standards for particulate matter. Regulatory efforts to comply with PM_{2.5} standards require improvements in our knowledge of the factors controlling the concentration, size and chemical composition of fine particulate matter. While many advances have been made in measuring and modeling the inorganic ionic species that are found in particulate matter, much less is known about the organic fraction. Yet organic matter can be a major constituent of airborne particles in many regions. Quantitative, time-resolved knowledge of the composition of atmospheric particulate organic matter is critical for identifying its sources, to understanding its formation and transformation processes, and to evaluating its roles in air quality and in global climate change. The chemical composition of organic aerosols is complex. Many hundreds of organic compounds have been identified through chromatography and mass spectrometry techniques. Some organic compounds are markers for primary emissions, such as combustion sources, while others are secondary products formed from anthropogenic or biogenic precursors. This project used a TAG instrument to identify organic compounds and PMF to improve our understanding of the sources and processes generating the high PM concentrations observed.

Project Summary

This project used a novel instrument designed for measuring quantitative, time-resolved concentrations of specific organic compounds in atmospheric particulate matter. The fundamental measurement principle is collection of ambient aerosols by means of impaction, followed by thermal desorption onto a GC column, with subsequent GC/MS analysis (TAG). The collection and analysis steps were automated, yielding around the clock speciation with approximately hourly time resolution. This approach provides a time-resolution not possible through traditional filter sampling, while avoiding many of the well-documented artifacts and losses associated with filter collection and sample storage and transport.

Marker compounds, unique to specific source types, provide a means of determining the relative contribution of emission sources. Data at the compound level are also needed for understanding the chemical formation and transformation mechanisms leading to secondary organic aerosol formation.

The specific objectives of the project were to:

- Deploy the TAG system as part of the CalNex field study at the supersite in the southern SJV to provide hourly, ambient concentrations of organic compounds in particulate matter;
- Create timelines of organic marker compounds for this study period;
- Identify the relative contributions from different source categories through Positive Matrix Factorization of selected specific organic aerosols (30 were chosen based on the field measurement results), which served as marker compounds for various aerosol sources.

The investigators made hourly in-situ measurements of speciated organic compounds (more than 100 organic compounds in each sample) in aerosols collected in the SJV Air Basin during the CalNex 2010 field studies. The measurements were made over a 4-week period (May 31 – June 27, 2010) to provide a statistical sampling of the ambient variations that occur in response to fluctuations in meteorological conditions and to systematic variations in emissions. These measurements were the basis of a subsequent PMF analysis aimed at better understanding the sources and

photochemistry influencing PM concentrations in the southern portion of the SJV Air Basin. The PMF analysis identified six predominant aerosol types/sources contributing to the organic aerosols (in the PM1 size fraction) in the Bakersfield area: local primary organic aerosols (~15 percent, likely from motor vehicles), a mixture of primary and SOAs (~13 percent), and four types of SOAs (cumulatively comprising ~72 percent of the total PM1). This knowledge is helpful for designing efficient PM control strategies. For example, it is increasingly apparent that controls of precursor gases to secondary aerosols is as important as controlling the primary aerosol emissions. This becomes even more critical with the recent tightening of the annual federal PM2.5 standard from 15 to 12 ug/m³.

III. STAFF COMMENTS

ARB staff from the Research, Planning and Technical Support, Monitoring and Laboratory, and Mobile Source Control Divisions, as well as staff from the SJV Unified Air Pollution Control District and the National Oceanic and Atmospheric Administration were asked to review this draft final report. A summary of the comments received thus far (reviewers were given until the end of January to respond) has been forwarded to the Principal Investigator for incorporation into the final report. Any major reviewer comments and suggestions received after this staff evaluation was prepared will be provided to the RSC members at the meeting.

This project provided useful new data for air quality attainment strategies in the SJV where the highest annual PM2.5 concentrations in the United States occur. The analysis of these data will inform the development of the next State Implementation Plan for the SJV and increase our understanding of the pathways leading to SOAs. Because of the uncertain radiative roles of organic aerosols, these results are also important in climate change research.

These measurements and observations are continuing to be a valuable resource to the entire CalNex team as the various investigators continue analyzing the data and comparing the SJVAB measurements with those from the other CalNex supersite in Pasadena.

Staff offered a number of editorial suggestions to improve the format and clarity of the material presented. For example, the “independent” section style (essentially comprised of scientific papers with specific foci) interrupts the flow, creates some redundancy, and makes the report more challenging for the reader to find specific topics. Furthermore, the condensed “paper” style forces the reader to go elsewhere (e.g., the References) to investigate details. Additional effort will be made to provide more site, methodology, and quality assurance documentation in the Introduction and Background chapter. This chapter should also include some contextual discussion of how PM during the June study period “fit” with historical data as well as with the intra-annual variations in PM concentrations. In addition, the basis for some statements and conclusions need to be more thoroughly developed.

The current version of the report includes some significant results in the appendices (e.g., Appendix C) that should be incorporated or summarized in the main body of the report. Some of the technical details need to be “tightened up” and the significance or implications of the results highlighted. For example, the current version creates ambiguity regarding the size of the aerosols studied (PM₁ vs. PM_{2.5}) and needs to better relate the significance of the results to the current ambient air quality standards for PM_{2.5}. The report reasonably portrays the large contribution of SOA to organic mass but its contribution to total PM_{2.5} during the study needs to also be expressed. The PMF analysis highlights the importance of SOA but does a limited job of guiding regulators toward the emission sources (other than motor vehicles) needing controls to reduce PM_{2.5} concentrations. Although not explicitly required in the contract, some additional analyses constrained by wind direction or relative humidity as well as case studies of specific days corresponding to the various PMF factors might have been informative for guiding future control efforts.

Overall, this project advanced monitoring and analytical methods to improve our understanding of emissions and atmospheric processes impacting aerosol concentrations in the Bakersfield area. With some reorganization and tightening up of the material presented and with the incorporation of some additional contextual analyses, this report will be more user-friendly and beneficial to air quality analysts and planners.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to inclusion of appropriate additions and revisions in response to the staff comments and any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: II.6

DATE: March 8, 2013

CONTRACT NO.: 08-325

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: A Field Experiment to Assess the Impact of Information Provision on Household Electricity Consumption

CONTRACTOR: University of California, Los Angeles

PRINCIPAL INVESTIGATOR: Mathew Kahn, Ph.D.

TOTAL AMOUNT: \$173,934

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 48 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Household energy consumers face a complex non-linear pricing tariff and many households are unaware of how energy management actions affect their electricity consumption. This project examined the impact of providing current information on a household's electricity consuming actions on how that household responds to a nonlinear retail price schedule for electricity. Over 2,000 households, from two different utilities, participated in a customized on-line interactive educational program that taught them how their monthly electricity bill was determined from a nonlinear retail pricing scheme they face. Households were shown how changes in their major electricity-consuming activities would affect their monthly bill under the nonlinear pricing scheme. Using data from before and after this intervention for households that took the educational program and a randomly selected set of control households who did not take the treatment, the researchers assessed the impact of the information intervention on a household's monthly electricity consumption. For both utilities, households that learned they faced a high marginal price for consuming electricity reduced their electricity consumption relative to the control group. Households that learned they faced

a low marginal price increased their electricity consumption relative to the control group. These results suggest that an intervention that targets educating households with customized information can help them become more sophisticated energy consumers and in aggregate help California to achieve its Assembly Bill (AB) 32 goals of reducing greenhouse gas emissions.

II. TECHNICAL SUMMARY

Objective

The objective of this project was to assess the direct impacts of household-specific information treatments on monthly residential electricity consumption.

Background

Reductions in aggregate electricity through successful and cost-effective behavioral change interventions can help California reach its near- and long-term climate change goals. The direct results of the proposed work, as well as the dataset, methodological findings, and establishment of working relationships between agencies and utilities charged with residential behavioral change, will be extremely valuable in helping California reduce its energy use and associated greenhouse gas emissions.

The residential sector is a major electricity consumer in California. Household consumers face a complex non-linear pricing tariff and many households are unaware of how actions such as setting the thermostat at 72 degrees affects their electricity consumption. These facts suggest that an intervention that educates households by providing customized energy use information can help them reduce their energy consumption and in aggregate help California to achieve its AB 32 goals.

Project Summary

In a partnership with two major California electric utilities, over 2000 households who live in single family homes were enrolled in a 30 minute customized education program that took place on the Internet. This group of “treated households” was enrolled through a field experiment research design. Starting with a population sample of households who live in a single family home, a subset of households was drawn at random. This subset was then randomly assigned to the control group and to the “invite for treatment

group.” The latter subset of households was then randomly assigned a dollar amount of an Amazon Gift card to reward them for participating in this field experiment. Each household in the “invite for treatment group” was sent an invitation letter (or email) that briefly explained why the household was receiving the letter, the likely benefits from participating in the educational program and that listed the Amazon Gift card amount that the household would receive once it had completed the educational experience.

For those households who were invited to participate and chose to do so, they logged in to an Internet website and over the course of a 30 minute interactive session were educated about their electric utility’s non-linear pricing system for electricity. Using household specific data on past electricity consumption, the household learned exactly where its recent consumption placed it on the pricing schedule and how changes in its consumption behavior would affect its monthly bill. Based on information that the household provides concerning the home’s physical attributes and appliances, the household received customized advice for how it could reduce its monthly electricity bill.

In a unique data partnership, the two electric utilities provided the contractors with months of household specific electric utility consumption data both before and after the treatment date to allow the researchers to conduct a “before/after” comparison of changes in electricity consumption for both the treatment group, the invite to treatment group and the control group. The longitudinal household data from both utilities was used to estimate econometric models that allow us to test a number of hypotheses related to how new information about the marginal price of electricity affects household electricity consumption.

When households learn that the marginal price of electricity is high, they choose to reduce their consumption. The estimated effects are large. Conversely, when households learn that the marginal price of electricity is low, they chose to increase their consumption. These estimates are insensitive to the size of the Amazon Gift card that households were offered. These results suggest that a potentially cost-effective strategy for ARB to achieve its AB 32 goals would be to target educational treatments such as the one piloted in this study to households who are high baseline consumers.

III. STAFF COMMENTS

This report explored the potential of Internet education courses on energy pricing and energy reduction tips to achieve GHG reductions. Staff at ARB (Stationary Source and Research Division), the CPUC and the Energy Commission reviewed and provided comments on this report. In this thorough analysis of two California utilities, the researchers demonstrated that targeting high marginal price consumers with pricing education could induce a significant (5-10 percent) decline in electricity consumption. These results have important implications for California because it highlights the potential of behavior outreach campaigns to reduce energy consumption. This report suggests that resources that are invested in educating high marginal price consumers about the pricing schedule they face and offering specific advice for how to reduce their consumption will likely result in reductions in energy consumption.

Previous energy customer outreach campaigns have successfully reduced energy use by comparing user consumption to the use of peers (e.g., Opower) and providing incentives for energy efficient technologies. Therefore, in addition to verifying the fact that consumers will change their energy consumption behavior when educated on energy pricing, this report also illustrates a unique approach to affecting consumer behavior. This report provides insight for future outreach campaigns, but also highlights the importance of supporting future behavioral research projects to maximize these proven benefits in reducing residential energy use and the effectiveness of applying multiple outreach campaigns that target pricing education, peer-comparisons and incentives in combination should be explored.

In order to increase outreach on the results of this and other ARB funded research projects on energy use and behavior, staff at ARB are coordinating with staff at the CPUC to host a workshop for IOU representatives. In addition to inspiring IOUs to implement educational campaigns to reducing energy use, we hope to use these workshops to identify additional knowledge gaps in behavioral research to help guide ARB's future research initiatives.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: II.7

DATE: March 8, 2013

CONTRACT NO.: 09-326

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: Identifying Determinants of Very Low Energy Consumption Rates Observed in Some California Households

CONTRACTOR: University of California, Davis

PRINCIPAL INVESTIGATOR: Alan K. Meier, Ph.D.

TOTAL AMOUNT: \$104,911

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 36 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Strategies for pursuing California's ambitious greenhouse gas (GHG) policies generally focus on technology upgrades familiar from the energy efficiency sector, but very little attention is paid to the social dynamics surrounding energy consumption. Observed residential electricity usage falls within a wide range of values, even for populations living in the same climate. This study investigated the circumstances corresponding to electricity consumption levels in a sample of urban California households in the lowest decile of energy use. Primary data were generated through mailed surveys, telephone interviews, and a detailed customer dataset supplied by the partnering electric utility. The survey focused on appliance ownership and use, building characteristics, demographics, attitudes about energy, energy-relevant behaviors, participation in incentive programs, and air conditioning. This study found that very low consumption rates are real and that the distribution of low usage includes a broad cross section of the population quite similar to the general population (as measured by age, income, education, race, and household size). Thermal management strategies ranked high among the behavior trends of the lowest energy users. The researchers found a

diversity of cooling strategies, tolerance for and definition of what is too hot. The researchers also generated several user profile types that capture different dimensions of the low user population this research and identified key characteristics that combine low usage, diverse cooling strategies, an interest in energy upgrades, and high quality of life in multiple different ways.

II. TECHNICAL SUMMARY

Objective

The primary objective of this research project was to acquire a detailed understanding of the characteristics and behaviors which coincide with and contribute to the very low electricity usage found in a subset of California households.

Background

Both past and current policies targeting residential energy consumption are premised on the assumption that residential electricity usage is broadly similar across populations, implicitly referencing a *normal* level of consumption. The focus is on distributing hardware upgrades and knowledge from experts to the public. No effort is made to learn from the public that is already using very little energy or to incorporate their insights into policy. Although some studies have noted that residential energy usage is a function of climate, appliances, number of people, square footage, etc., the larger variation across households within a given jurisdiction is not explained by those factors, and remains essentially invisible. Significant reductions (>50 percent) in electricity consumption are rarely advocated or pursued, and when they are mentioned they are understood to be difficult, expensive, or associated with unacceptable declines in wellbeing. Studying very low electricity consuming households as this study has done helps to fill this gap in knowledge and can inform policies that address these topics.

Project Summary

To examine the behavior of low energy using households, several samples were selected from the general population using a master list of utility billing data. The households included in the initial sample were those falling between the 0-25th percentiles (bottom quartile) of electricity consumption based on average monthly usage from 2008-2010. Using the information in the billing data, summary descriptive statistics

were calculated to identify trends in technical and socioeconomic variables within different subsets of households. Truncated regression was used to examine the relationships between these variables and energy consumption in the general population.

In addition to the statistical analysis of the billing data, in-depth surveys and phone interviews were used to gain insights into the specific circumstances and behaviors that result in very low energy usage. To accomplish these goals, separate random subsamples of renters and owners falling in the 0-10th percentiles (lowest decile) were extracted from the initial sample. Electronic surveys were sent out to 2,910 renters and 500 owners via email, while 1,030 renters and 130 owners were mailed hard copies of the survey. Phone interviews were conducted with a subset of owners who completed the survey and indicated they would be willing to participate in an interview. The surveys and interviews were designed specifically to elicit information regarding behaviors and characteristics of households that were not available from billing data.

The residential population whose consumption of electricity places them in the lowest decile exhibits a substantial degree of variation in how they accomplish their low usage. The strategies, behaviors, attitudes, knowledge, habits, and values that inform and shape their electricity consumption are heterogeneous. The degree to which these electricity customers are aware of their low consumption varies, as does their view of the relationship between energy consumption and their quality of life. Some (a minority) have taken advantage of energy efficiency programs, while others (a majority) claim to think about their energy use regularly or very often, and many of the actions taken to lower their energy consumption include a high degree of specificity. This diversity in approach, circumstances, and attitude also reappears in the demographic profile of the population of low electricity customers, which is quite similar to the general population across income, age, education, and race.

The researchers discovered that there is a very large—perhaps an infinite—number of different pathways to low usage. While some surveyed households don't have any compressor-based air conditioning in their residence, a portion of households with air conditioning use it very little or not at all, and this last, somewhat unexpected, approach

spans all income classes. A second explanation for low usage is a conscious approach to energy practices which includes unplugging devices not in use, and substituting away from electricity for certain tasks (hand washing dishes, line drying clothes, no TV, turning pilot lights off in summer, using natural light, etc.). The third set of strategies involves physical upgrades to the house or appliances (ENERGY STAR appliances, window replacements, LED lights, programmable thermostat, insulation, etc.).

This study has several implications for regulatory programs, and addresses several misconceptions that have arisen around the topic of low energy use in the absence of a careful study. The low users who were studied are not, typically, in that tier because they are never home, or poor and therefore lack a choice about energy matters, or live in cramped quarters, or substitute gas appliances for electricity. The fact that low users and the general population are as demographically similar as they are suggests that the findings about what is involved in producing low usage should have broad applicability.

III. STAFF COMMENTS

Staff at ARB and the Energy Commission reviewed and provided comments on this report. This study has determined that California's 2050 GHG target is found in the lowest decile of the population studied and that these energy users are demographically similar to average Sacramento residents. Hopefully, through the insights in this study, the pathway to compliance with the State's GHG reduction goals can be partially attainable through the reduction of residential energy use through increased outreach on energy-saving behavior.

This research project made gains in demystifying the behavioral and demographic profile of low-energy residents in Sacramento. Not only does this study show that these low-energy residents are similar to average Sacramento residents, it shows that the insights into their habits, attitudes, and values reflect a conscious approach to energy conservation. These results negate the common misconception that low energy users are predominantly poor or have unoccupied homes. Instead, the study found that energy usage and poverty are related in ways that are more complex than suggested by a simple assertion that very low energy users are likely poor.

It is important to recognize that since this study only focused on Sacramento residents, the results are likely to only be applicable to homes with a similar climate zone. Residents in the lowest energy use decile in other California climate zones may have significantly different strategies to attain low energy consumption. Given the insightful results from this project, future research should investigate the characteristics and behaviors of very low electricity usage found in other climate zones in California.

The insights presented in this report could provide valuable information to an outreach campaign or state or federal policies related to voluntary or mandated residential energy conservation. For example, the study found that a majority of the strategies listed were categorized as thermal management related to summer heat. The tips and tricks that low energy users have developed should be shared through outreach. The fact that energy use does not necessitate a lower quality of life should be emphasized.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to any changes and additions specified by the Committee.

DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: III.8

DATE: March 8, 2013

CONTRACT NO.: 08-323

[Link to Report](#)

STAFF EVALUATION OF A DRAFT FINAL REPORT

TITLE: Black Carbon and the Regional Climate of California

CONTRACTOR: University of California, San Diego

PRINCIPAL INVESTIGATOR: Professor V. Ramanathan

TOTAL AMOUNT: \$820,483

CONTRACT TYPE: Interagency Agreement

CONTRACT TERM: 42 Months

For further information, please contact Dr. Dongmin Luo at (916) 324-8495.

I. SUMMARY

Black carbon (BC) is the most strongly light-absorbing component of particulate matter (PM), and is formed by the incomplete combustion of fossil fuels, bio-fuels, and biomass. BC has been tied to regional climate change by its contribution to global warming and the suppression of precipitation. Unlike other greenhouse gases (GHG), BC has a short atmospheric lifetime resulting in a strong correlation to regional emission sources. This report provides an assessment of the impact of BC on the regional radiative forcing and climate trends of California. This regional integrated assessment is the first such attempt to estimate the radiative forcing of BC for California, both from a bottom-up approach (starting with the emission inventory as input to aerosol-transport models) and a top-down approach (utilizing satellite data in conjunction with ground-based column-averaged aerosol optical properties). This balanced approach enabled the investigators to uncover three unanticipated major findings. The first finding concerns the large decadal trends in decreasing BC concentrations that have occurred largely in response to policies enacted to decrease PM emissions from diesel combustion. The second is the discovery of the large effect of brown carbon (a form of organic carbon aerosols) on radiative forcing. And the third is the large discrepancy

between the top-down and the bottom-up approaches of estimating radiative forcing. It was speculated that the discrepancy is due to a combination of emission inventory bias and neglect of organic carbon (OC) absorption in the model. The results of this research project provide valuable insights regarding the role of BC aerosols on California's climate.

II. TECHNICAL SUMMARY

Objective

The primary objective of this research study was to assess the impact of BC on California's climate by utilizing a balanced approach featuring observations, data analyses, and modeling studies. The tasks included in this study fell under two broad categories: observational estimates and regional modeling studies.

Background

BC, the main light-absorbing component of soot is the principal absorber of visible solar radiation in the atmosphere. Several studies have concluded that BC, which originates from both natural and anthropogenic sources, is the second largest contributor to global warming, next to CO₂. At current concentrations, Ramanathan and Carmichael estimated a direct forcing of 0.9 watts per square meter ($W m^{-2}$) for BC compared to 1.6 $W m^{-2}$ for CO₂. This study integrated aerosol data from satellites, a surface network of remote sensing instruments, and in-situ field measurements supporting an aerosol-transport-chemical model and a radiative transfer model to obtain the forcing. This study's conclusion that BC is the second largest contributor to warming was debated because most estimates of BC radiative forcing from models were a factor of two to three lower. A major landmark study of the BC forcing problem was published this year (Bond et al, 2013; Journal of Geophysical Research-Atmospheres) by a large group of researchers from nine countries in a range of disciplines that included many modeling groups, and their estimate of 0.88 $W m^{-2}$ for the BC direct forcing (due to all BC sources) is nearly identical to Ramanathan and Carmichael's estimate of 0.9 $W m^{-2}$.

Because of its short atmospheric lifetime of a few weeks, BC concentrations are higher near its sources and hence a regional evaluation is critical for a better understanding of its global effects. Reducing BC emissions has been proposed as a control strategy to

offset short-term climate changes. BC particles also impact climate in a series of feedbacks through their interaction with clouds that can result in both warming and cooling effects. In contrast to the direct aerosol effect of absorbing sunlight and warming the atmosphere, the net climate forcing due to these cloud feedbacks and semi-direct effects are highly uncertain. A recent international assessment by the United Nations Environment Program (UNEP) and World Meteorological Organization (WMO) has estimated that the two indirect effects nearly offset each other leaving the direct forcing as the dominant effect.

California's regional climates may be especially sensitive to these radiative effects of BC. Summer water supplies in California rely predominantly on runoff from mountain snow packs located within the State as well as from the Rocky Mountains via the Colorado River. Agriculture, which represents a large fraction of California's economy, suffers during water shortages. The potential impact of aerosols, including BC, on precipitation and freshwater availability has received increasing attention in California. Furthermore, a warmer atmosphere over already dry regions, combined with less mountain runoff during the summer months, would enhance conditions conducive for wildfires. A recent study tied an observed increase in the frequency and duration of wildfires in the Western United States to warmer temperatures, earlier snowmelt, and drier summers. This increase in wildfires adds to the number of light-absorbing carbon particles with attendant climate impacts on California.

Project Summary

For this research project, a team of scientists from the University of California, Berkeley, the Lawrence Berkeley National Laboratory, and the Pacific Northwest National Lab worked closely together to bring the extensive experience and resources (including instrumentation and models) needed to meet the project goals. They developed a balanced approach between observations, data analyses, and modeling studies, using measurements conducted by ground-based network, aircraft, and satellite instruments. The full climate impact of BC on the regional climate of California was evaluated by using regional climate models in a series of numerical experiments with varying BC emissions to determine changes in the surface temperature and hydrology. The regional climate models used to evaluate the climatic impacts of BC were also applied to

estimate the BC climate forcing. Furthermore, their modeling uncertainties were assessed by comparing their estimated BC forcing with the observation based estimates. Statewide temporally and spatially resolved BC concentrations were estimated from coefficient of haze (COH) data, which are highly correlated with the BC data, from 100 locations throughout California. The study consisted of four primary components:

1. Analysis of multi-decadal BC trends constrained by field measurements

Trends in BC concentrations were determined from assimilation of mass-based measurements from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network that typically samples remote areas, and from analysis of the large set of available COH measurements (which typically sample urban areas). The IMPROVE data showed that the annual average BC concentrations in California have decreased by about 50 percent from $0.46 \mu\text{g m}^{-3}$ in 1989 to $0.24 \mu\text{g m}^{-3}$ in 2008. This trend was found to be consistent in Northern, Central, and Southern California. The COH data revealed that BC concentrations in California decreased markedly from about $3.9 \mu\text{g m}^{-3}$ in 1966 to $2.3 \mu\text{g m}^{-3}$ in 1980 to $1.1 \mu\text{g m}^{-3}$ in 2000, agreeing with the trends reported from the IMPROVE data sets. It was concluded that reduction in diesel emissions is the primary cause of the observed BC reduction, which is also substantiated by a significant decrease in the ratio of BC to non-BC aerosols. Other contributing factors include BC emissions reductions from other sources in the transport sector, the cleanup of BC emissions in the industrial sector, and decreasing wood and waste burning since 1990.

2. Estimation of the direct aerosol forcing due to BC and BrC using integrated observations as well as models

The investigator estimated the radiative forcing using a top-down approach that relies on NASA's ground based Aerosol Robotic Network (AERONET) data and assimilated satellite measurements of aerosol optical properties. This observationally constrained top-down estimate includes solar absorption by brown carbon (BrC) (a form of organic carbon aerosols) while the emission inventory based bottom-up estimates included in this study do not account for BrC.

For the annual mean, the current top-of-atmosphere (TOA) forcing of BC+OC varies from about 0.2 W m^{-2} over Northern California to as large as 1.9 W m^{-2} over Southern California. The implication is that, in the 1980s when BC concentrations were higher by about 100 percent, the TOA forcing for BC+OC could have been as large as 0.4 to 3.8 W m^{-2} . Overall it was concluded that the large negative trend in BC radiative forcing and the lack of corresponding negative trends in OC, confirms the assessment of some other recent studies that diesel-related BC emission reductions would lead to global cooling. BrC absorption has a major impact on the direct forcing due to OC aerosols. Without BrC absorption, models estimate direct forcing due to OC to be between -0.30 and -0.15 W m^{-2} (depending on the location and region), whereas inclusion of BrC brings the net cooling down to between 0.00 and -0.10 W m^{-2} . Thus, models that neglect BrC severely overestimate the OC cooling effects.

3. Source apportionment based upon chemical mixing state

Major differences exist in the PM sources in Northern and Southern California. In-situ measurements of optical properties and chemical mixing state reveal that fossil fuel sources contribute most strongly in Southern California, whereas biomass burning and biogenic sources dominate in Northern California. Using optical properties for estimating aerosol speciation based on satellites or ground-based networks (e.g., AERONET) has the potential to provide extensive input into global climate and air pollution studies. Speciation of dust, BC, and BrC are well classified by optical data, but the separation between fossil fuel and biomass burning sources has limitations because of their overlapping optical properties. Despite these limitations, a detailed comparison reveals the significance of aerosol absorption due to secondary organic aerosol which is currently underestimated in climate models, in addition to the BC underestimation. BrC and SOAs impact many absorption events, indicating that these processes must be given consideration when developing future climate mitigation policies.

4. Estimating the climate impact of BC emissions under various mitigation scenarios

WRF-Chem is the Weather Research and Forecasting (WRF) model coupled with an atmospheric chemistry module. The model simulates the emission, transport, mixing, and chemical transformation of trace gases and aerosols simultaneously with the meteorology. A comparison between the simulated BC concentration and measurements at over 30 sites in California revealed that WRF-Chem under-predicted BC by nearly a factor of two, which indicates that the emission inventory (developed in the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites, also known as ARCTAS-CA campaign), is under-representing BC emissions. The climate impact of BC was evaluated by changing the emissions by factors of 10, 5, and 2. The factor of 2 case approximates the conditions for the present day emissions; the factor of 5 and the factor of 10 cases approximate the emissions during the 1980s and the 1960s, respectively. The comparison indicates that about a third of this difference between the models and the observationally constrained approach is due to the fact that the models ignore BrC.

The results of the regional climate modeling results indicate that reduction of BC from the 1960s to 2000s produced a cooling of the lower atmosphere, accompanied by a statistically insignificant temperature change at the surface. Winds at the 10 meter height generally became weaker over California but were stronger offshore in Southern California. Finally, changes in surface hydrology were small because the BC effects were generally small during winter. Finally, the indirect and semi-direct forcing changes due to the observed decrease in BC is expected to be much smaller than the direct forcing changes given above because the negative indirect forcing is largely due to OC and the study did not observe statistically significant changes in OC concentrations (as expected for diesel-related BC changes). The above finding, while it is the most important scientific aspect of the results, needs to be validated by conducting similar analyses for other States in the United States (U.S.) that have also experienced strong reductions in BC.

In order to most accurately estimate global warming and mitigation impacts, there is a need to account for not only the direct radiative forcing due to BC but also BrC

absorption, the indirect effects of BC and OC, the cloud-inclusion effects of BC and BrC, and the semi-direct effects of BC and BrC.

III. STAFF COMMENTS

Staff from ARB's Planning & Technical Support and Research Divisions and experts from the International Council on Clean Transportation and the U.S. Environmental Protection Agency reviewed an earlier version of the draft report and the current version has incorporated staff comments to improve its clarity. The draft final report accurately describes the completed work and its implications, and identifies future research needs. The reviewers' comments generally recognized the quality of the research effort and the practical importance of the results. The project successfully completed the stated objectives and the report does an excellent job of documenting the findings. The investigators also prepared a "Response to Comments" file that addresses comments made by the review team. In addition to preparing this final report, the investigators have published the results of their work in six peer-reviewed journals and three additional papers are currently in preparation. The response document and the published papers were sent to the RSC members along with the draft final report.

The report contains new results that integrate both the bottom-up and top-down approaches and appears to be the best available science on BC and its influence on the regional climate of California. While the scope of this work was limited to determining the impact of BC, the investigators discovered that BrC is also a significant absorber of radiation, particularly at short wavelengths and may serve as an extra warming agent due to its typically higher concentrations. This opens up a whole new avenue of research as the sources, chemistry, and optical properties of brown carbon are less well understood. This study also pointed out the large uncertainties in existing data sets and resources that are currently used by climate scientists, such as in the solar flux measurements and the BC emission inventory. Lastly, the report recommends that model biases and uncertainties in the model formulations and parameterizations, particularly related to clouds and aerosol-cloud interactions, should be addressed in the future to provide more robust simulations of BC climate effects.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to any changes and additions specified by the Committee.