

**STATE OF CALIFORNIA  
AIR RESOURCES BOARD**

**MEETING OF THE  
RESEARCH SCREENING  
COMMITTEE**

**July 8, 2015  
9:00 a.m.**

**Air Resources Board  
Research Division  
Cal/EPA Building  
1001 I Street  
Sacramento, CA 95814  
(916) 445-0753**



**State of California  
AIR RESOURCES BOARD**

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

**July 8, 2015  
9:00 a.m.**

**AGENDA**

- I. Approval of Minutes of Previous Meeting:
  - March 27, 2015 meeting iii-viii
  
- II. Discussion of a Request for Proposals (RFP):
  - 1) "Evaluating Engine and Aftertreatment Performance and Deterioration for Heavy-Duty Engines," \$400,000, RFP No. 15RD006
  
- III. Discussion of a Proposed Contract Augmentation:
  - 1) "Advanced Plug-In Electric Vehicle Travel and Charging Behavior," University of California, Davis, \$442,356, Contract No. 12-319 1
  
- IV. Discussion of New Research Projects:
  - 1) "Heavy-Duty On-Road Vehicle Inspection and Maintenance Program," Foundation for California Community Colleges, \$499,560, Proposal No. 2789-283 7
  - 2) "Designing Vehicle Retirement and Replacement Incentives for Low-Income Households," University of California, Los Angeles, \$483,133, Proposal No. 2790-283 11
  - 3) "Identifying, Evaluating and Selecting Indicators, Indices and Data for Future Monitoring System of the Implementation of Sustainable Communities Strategies," University of California, Los Angeles, \$149,908, Proposal No. 2791-283 15
  - 4) "Assessing the Travel Demand and Co-Benefit Impacts of Affordable TODs," University of California, Berkeley, \$300,000, Proposal No. 2792-283 19

5) “Zero-Carbon Buildings in California: A Feasibility Study,” University of California, Berkeley, \$430,574, Proposal No. 2793-283	23
6) “Characterize Physical and Chemical Properties of Manure in California Dairy Systems to Improve Greenhouse Gas (GHG) Emission Estimates,” University of California, Davis, \$151,423, Proposal No. 2794-283	29
7) “Characterize California-specific Cattle Feed Rations and Improve Modeling of Enteric Fermentation for California's Greenhouse Gas (GHG) Inventory,” University of California, Davis, \$99,964, Proposal No. 2795-283	35
8) “Policy and Scenario Analysis for Managing and Mitigating California’s F-gas Emissions,” University of California, Berkeley, \$318,382, Proposal No. 2796-283	41
9) “Improved Understanding of the Magnitude of Trans-Pacific Long Range Transported Ozone Aloft at California’s Coast,” San José State University, \$281,699, Proposal No. 2797-283	45
10) “LIDAR Profiling of Ozone in the San Joaquin Valley,” National Oceanic and Atmospheric Administration, \$107,639, Proposal No. 2798-283	51
V. Discussion of a Draft Final Report:	
1) “Environmental Fate of Low Vapor Pressure - Volatile Organic Compounds from Consumer Products: A Modeling Approach,” University of California, Davis, \$200,000, Contract No. 13-304	55

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**March 27, 2015  
9:00 a.m.**

**MINUTES**

**RSC Members in Attendance via teleconference**

Harold Cota  
Forman Williams  
Philip Fine  
Alan Vette  
Rashid Shaikh  
Yifang Zhu  
William Eisenstein

The Research Screening Committee (RSC or Committee) convened the meeting at 9:05 a.m. The minutes of the January 30, 2015 meeting were approved.

**I. New Research Projects**

- 1) "Women's Cardiovascular Risk from Particulate Matter Exposure," University of California, Irvine, \$600,000, Proposal No. 2784-282

Staff from Office of Environmental Health Hazard Assessment (OEHHA) and United States Environmental Protection Agency (U.S. EPA) reviewed this proposal. Both OEHHA and U.S. EPA staff found the aim of the study worthwhile, and that the technical plan was reasonable and the proposal suitable for ARB funding. The U.S. EPA reviewer introduced the idea of splitting the project into two phases instead of the current plan of testing all experimental groups concurrently. The two phases would involve investigating the gender and effects of ovariectomization first, and then dependent on the results, proceed to investigate the effect of estrogen replacement on the ovariectomized animals. The Principal Investigator (PI) said that that would add about \$30,000 to the total costs of the project. ARB staff recommended this addition to the project be made. The Committee approved an increase of the budget for the project to \$630,000 with the provision that results will be presented to the Committee members after the first phase of the project before funds could be spent on the second phase of the project.

There were two issues regarding the project which were discussed. A Committee member was concerned about the age of the mice at the beginning of the experiment. His concern was that gender differences might be better observed when the endocrine systems in the mice are more developed as in older animals. Staff, however, noted that having older animals at the start increases the risks of higher atherosclerotic background values for comparisons. The Committee decided not to request the PI change the planned starting age for the mice. The second issue was brought up by another Committee member regarding how the pairing of males and female mice would be based on systolic blood pressure. It was not clear if this pairing will be used for just experimental group assignments or direct comparisons between the pairs during the analysis. Staff agreed to ask the PI to clarify this issue in the revision.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee, with the condition that the results from Phase 1 be brought to the Committee regarding to Phase 2.

The Committee approved the proposal.

- 2) "Are Adverse Health Effects from Air Pollution Exposure Passed on from Mother to Child?" University of Davis, California, \$330,483, Proposal No. 2785-282

Because the proposal was received too late to include staff and outside reviewer comments in the RSC book, staff reported on the comments from ARB staff and the U.S. EPA reviewer. The comments were supportive of the study, and consisted primarily of several questions and requests for clarifications, none requiring the addition of more than a sentence or two. The U.S. EPA reviewer was very enthusiastic about the study. She suggested that the investigator consider looking at antibody production in response to routine vaccinations given to Primate Center animals as an independent means of validating the apparent reduction in immune response in animals that were exposed to high air pollution levels during infancy. The investigator has agreed to add this to the study by measuring serum antibodies to the routine tetanus vaccinations given to Primate Center animals. One Committee member asked that the investigator add an explanation to the proposal describing the blinding procedures that will be followed in performing the analyses. Several Committee members commented on the shortness of the proposal. Staff indicated that all the requisite material was there, but that the background, context, and some technical details were presented in a section at the very end of the proposal that appeared to be an appendix containing supplemental material demonstrating the qualifications of the investigator, rather than the background and context for the project. The investigator will move this section to the front of the proposal to address this confusion.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

- 3) "Greenhouse Gas Measurements (GHG) at Walnut Grove Tower," University of California, Davis, \$200,000, Proposal No. 2786-282

A Committee member noted that the project provides a very cost-effective mechanism to continue important measurements to provide long term trends of GHG emissions.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

- 4) "Certification and In-Use Compliance Testing for Heavy-Duty Diesel Engines to Understand High In-Use NO<sub>x</sub> Emissions," University of California, Riverside, \$500,000, Proposal No. 2787-282

Staff provided general background on the purpose of the project, and why the project is needed. In short, the NO<sub>x</sub> emissions measured from in-use Heavy-Duty (HD) diesel vehicles are not as low as would be expected based on the new low engine emission certification standards implemented in 2010. Part of the discrepancy is that the emission control systems do not perform well during cold start or during other low temperature operations such as transient low load operations. This problem is understood, and there are various studies underway to characterize and address this problem. However, it also observed that NO<sub>x</sub> emissions from in-use HD vehicles are higher than engine certification emissions, even when the vehicles are fully warmed up. The reasons for this are not understood. The purpose of this project is to understand the causes for the discrepancy.

Staff also explained that the "higher-than-certification" emissions measured on chassis dynamometers or on the road do not violate any standards. The engines are in compliance with certification standards and in compliance with in-use standards. In other words, the existing certification and in-use standards do not effectively force in-use emission rates to be near certification levels. In order to design new certification and/or in-use procedures that would better control NO<sub>x</sub> emissions, ARB staff needs to better understand how the discrepancy arises.

The Committee had several questions: Why choose two engines? Would one engine be enough to find the answer? If not, are two engines enough to be representative of the entire engine and all the sources of discrepancy? Will we get all of the information that we need with only two engines?

Staff believes that two engines, from two different manufacturers, provide much more credibility than one engine. Figuring out how and why this discrepancy occurs for even one engine would be meaningful and valuable. But having only one engine would leave questions of it being a fluke and being uncorroborated.

More than two engines would be better, but the program involves pulling engines from vehicles, testing them on an engine dynamometer, and then reinstalling the engines into vehicles, in addition to on-road and on-chassis dynamometer testing. It is time and cost intensive, which is why it has not been done to date. Staff believes that two engines is a reasonable compromise. The results are not intended to be quantitatively representative of the in-use fleet; they are intended to be exploratory and to elucidate mechanisms. If results are useful, ARB could commission additional testing. However, because these data will play into development of new engine certification or new in-use compliance test procedures, staff believes that OEMs will take great interest in the results and will conduct or commission similar testing, so that data from more than two engines will eventually become available.

The Committee asked “how many engines and studies have demonstrated this high emission problem?” A literature search revealed only two studies. How high are the emission rates? Is this problem widespread? Is this problem widely recognized?

Staff stated that laboratory testing studies funded by ARB and South Coast Air Quality Management District (SCAQMD) using different laboratories (ARB, University of California, Riverside (UCR), and West Virginia University (WVU)), as well as on-road PEMS testing by various groups have reported emissions higher than certification test levels by factors of two, three, four or more. The data are available in final reports prepared by UCR and WVU and released by SCAQMD in 2013, in test reports released by ARB in 2013, and in ARB test reports not yet released. All of these data are not yet available in the peer-reviewed literature. Knowledge of this problem is still growing. The existence of the problem has become better documented in recent years, but the reasons for the problem are not known. This problem is now widely acknowledged and was an important topic of discussion at the recent March 2015 CRC Real World Emission Workshop.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

- 5) “Investigative Modeling of PM<sub>2.5</sub> Episodes in the San Joaquin Valley Air Basin during Recent Years,” University of California, Davis, \$199,928, Proposal No. 2788-282

The Committee asked for clarification of several areas in the proposal and that further attention/discussion be placed on a couple of areas of investigation. A summary of their comments follows.

- The first objective – comparison of ambient measurements with simulations – needs a more detailed description. What types of data will be used and how will the comparisons be made? Will data from many different locations be compared, including urban, intermediate distance and rural sites? The grid cells

of NO<sub>x</sub> will be large; this hinders direct comparisons of measured with modeled data. How will this be treated?

- The impact of dry deposition in particle nitrate concentrations should be explored; further discussion of this area of high uncertainty is needed.
- It would be worthwhile to look in more detail at variations in NO<sub>x</sub> emissions (spatial temporal inventory) and the impact on particle nitrate formation.
- Ammonia emissions (spatial/temporal inventory) are highly uncertain; how will this be investigated (Although it is believed that most of the San Joaquin Valley is NH<sub>3</sub> saturated.)? How will the impacts of such uncertainty be evaluated?

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

## II. Draft Final Reports

- 1) "Technical Analysis of Vehicle Load Reduction Potential for Advanced Clean Cars," Control-Tec, \$162,120, Contract No. 13-313

The Committee noted that the project was interesting and carefully done. The Committee noted that the scatter plots shown in Figures 19 and 20 had very large scatter, and the Committee asked for more detail regarding the statistical validity of the trend lines shown in those figures. Staff did not have the technical details at hand. Staff proposed that the contractor would modify the report to include technical descriptions of the statistical methods used to determine the trend lines and used to assess their confidence. The Committee approved the report on that basis.

Motion: Move to accept the report, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the report.

- 2) "Evaluating the Benefits of Light Rail Transit," University of California, Irvine, \$200,000, Contract No. 12-313

One Committee member stated that it was a great study and well executed. Another Committee member commented that they were concerned that the overall response rate in phase I was only 1.1 percent. They suggested that the Principal Investigator should compare the demographic distribution to ensure the sample of those that responded is representative of the population.

Motion: Move to accept the report, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the report.

The meeting adjourned at 10:17 a.m.

## DISCUSSION OF A PROPOSED CONTRACT AUGMENTATION

ITEM NO.: III.1  
DATE: July 8, 2015  
CONTRACT NO.: 12-319

### STAFF EVALUATION OF A CONTRACT AUGMENTATION

**TITLE:** Advanced Plug-In Vehicle Travel and Charging Behavior

**CONTRACTOR:** University of California, Davis

**PRINCIPAL INVESTIGATORS:** Thomas Turrentine, Ph.D.  
Michael Nicholas, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** Original contract amount: \$649,997  
CEC co-funding: \$442,356  
Total with co-funding: \$1,092,353

**CONTRACT TERM:** 12 Months (56 months total)

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For further information, please contact Dr. Annalisa Schilla at (916) 322-8514.

#### I. SUMMARY

This project was originally approved by the RSC in 2012 to advance the Air Resources Board's (ARB) research related to advanced technology vehicles. A contract augmentation is requested to allow ARB to accept \$442,356<sup>1</sup> of co-funding from the California Energy Commission (CEC) to significantly expand this study. This project's objective is to collect and analyze in-use vehicle data from a variety of plug-in electric vehicle (PEV) types in a household context to improve estimates of emission profiles and consumer benefits, in order to provide insight into the real-world emission benefits of plug-in vehicles. PEVs constitute a growing share of new light-duty vehicle sales; however, their environmental benefits will vary depending on consumer usage and charging behavior. The additional funds will be used to add newer vehicle technologies, additional households, a project manager, and interviews with PEV-owning households, which will improve the robustness and richness of the results.

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<sup>1</sup> CEC is giving ARB an additional \$207,644 to purchase more vehicle loggers for this project so the total project will be augmented by \$650,000.

## **II. TECHNICAL SUMMARY**

### **Objective**

The objective of this research project is to collect and analyze longitudinal and spatial in-use vehicle data from households that own PEVs. A wide array of data will be collected from all vehicles within the households – both PEV and non-PEV – in order to improve emissions estimates at the vehicle, household, and fleet levels. The data will also be used to inform potential demand on the electrical grid as well as the need for potential future supporting infrastructure. This augmentation will allow ARB to accept co-funding from the CEC to significantly expand this study to include newer vehicle technologies, additional households, a project manager, and interviews with PEV-owning households, which will improve the robustness and richness of the results.

### **Background**

This project was originally approved by the RSC in 2012 to address the need to study consumers' actual usage of plug-in electric vehicles, identified during the January 2012 meeting of ARB's Board when the Advanced Clean Car standards were approved. Consumer usage and charging habits of PEV owners remain ambiguous due to limited data availability and the diversity of PEV attributes. However, these behaviors will have significant implications for statewide emissions, energy consumption, and electrical grid management based on the total miles these vehicles travel using electricity (eVMT). As PEVs are expected to become an increasing share of the light-duty fleet, understanding these behaviors will be important for appropriately projecting fleet emissions and estimating consumer impacts as well as efficiently planning future resources.

### **Proposal Summary**

This research will enhance ARB's understanding of PEV-owning households' travel and charging behavior. The additional funds from CEC will be used to add more PEV types to the study, which will include long-range battery electric vehicles (BEV) and range-extended BEV (BEVx) technologies that were either less common or nonexistent when the study was initiated; increase the number of households in the study to improve the robustness of the observations; add interviews with seven households per vehicle type to provide richer insight into vehicle purchase decisions and the motivations that underlie travel and charging behavior; and to add a project manager to assist the

research team with logger installation, trouble-shooting, and other day-to-day project tasks in order to keep the project on schedule.

The primary data collection method will be through instrumentation with a customized data logging device that captures vehicle location, operations, and charging data transmitted to a server via a cellular network. University of California, Davis (UCD) has selected FleetCarma as the vendor for the loggers for the households in the original study scope, and has deployed the loggers in test vehicles with plans for deployment in the first wave of study households in early summer 2015. ARB will issue a request for bids to purchase the additional loggers for the expanded study.

The original study aimed to recruit 108 households to participate, spread over three vehicle types: Nissan Leaf, Chevrolet Volt, and Toyota Prius plug-in hybrid. Ford recently provided supplementary funding directly to UCD to allow inclusion of the Ford Fusion and C-Max plug-in hybrids. This augmentation will increase the number of households to a total of 264 households and will allow inclusion of the BMW i3 Rex (BEVx) and the Tesla Model S (long-range BEV). Data will be collected from all vehicles within the household. There will be four waves of data collection, with each household being monitored for up to twelve months, and with the total data collection period lasting approximately two years. Collecting data over two years has the benefit of correcting for seasonal effects as well as providing insights into how households adapt their travel patterns and vehicle trip assignments as they become more familiar with their PEVs or as public charging infrastructure expands and becomes more congested. The data will be highly resolved – many parameters collected at a frequency as high as one-second intervals – which will provide opportunities for future studies to improve understanding of travel behavior in general and further refine emissions estimates.

The in-use vehicle data will be supplemented with two surveys of the participating households. The first survey was administered to eligible households to gather data on household characteristics, charger availability, important destinations, and expectations about their PEVs. As of mid-May 2015, over 4,000 responses had been received and the survey was closed. The results of this survey are being used to select households along the various dimensions of interest: PEV technology type, access to workplace

charging, geographic diversity, utility service territory, annual miles traveled, etc. The exit survey will be conducted at the conclusion of the household's data collection period to provide context for interpreting the vehicle data and capture relevant changes to the household (e.g. change in workplace location or household structure) and reflections on their experiences with the vehicle and charging infrastructure.

The additional funds will also be used to add interviews with households that own each of the different vehicle types. They will be focused on understanding vehicle allocation, charging patterns, travel routines, owner beliefs about their new technology as well as conventional technology. For example, if a household is using a BEV for more miles of travel than a previous vehicle it replaced in the household, interviewers will seek to understand whether that is driven by costs, values, or opportunities such as free charging at work. Interviews will be conducted in two different regions (Los Angeles and San Francisco Bay Area) to capture variations in infrastructure availability, and there will be seven interviews for each of the six vehicle technology types for a total of 42 interviews.

Given the large volume of data that will be generated from this project, database software and geographic information systems (GIS) are being used to process the data and to describe the current state of PEV household vehicle use dynamics and charging, and the interaction between charging infrastructure and eVMT. A project manager will also be funded by this augmentation, to install and remove logger equipment in vehicles, monitor data collection, trouble-shoot problems with the loggers or data transmission, and provide other project support. The results of this study will inform policymakers on strategies for increasing eVMT and the need for additional public charging infrastructure. The U.S. Department of Energy is also providing an additional \$400,000 directly to UCD for data analysis

### **III. STAFF COMMENTS**

Staff at ARB (Research and Emissions Compliance, Automotive Regulation, and Science (ECARS) Divisions) have worked with CEC and the Public Utilities Commission to ensure that this augmentation meets the needs of all three State agencies. When the RSC approved the original proposal in 2012, the committee recommended that if

additional funding became available, the project should include interviews and a project manager. Other reviewers of the original proposal (which included ARB staff in the Research and Mobile Source Control Divisions, the California and U.S. Environmental Protection Agencies, the CEC, the California Public Utilities Commission, South Coast and Bay Area Air Quality Management Districts, Oak Ridge National Lab, and the U.S. Department of Energy) also recommended the addition of other vehicle types. This augmentation will allow the project to address those comments.

This research team has been investigating consumer behavior related to alternative fuel vehicles for decades and currently serves as the State's research center on plug-in hybrid and electric vehicles. They have led previous vehicle instrumentation research projects and demonstrated the ability to receive and process large volumes of data. In addition, they have conducted extensive research on charging infrastructure that will complement the interpretation of the vehicle and survey data. Additionally, they have demonstrated their ability to leverage existing partnerships with industry and other government agencies, which is expected to enhance the quality of the final deliverables.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this augmentation for a total amount not to exceed \$442,356, subject to inclusion of any changes and additions specified by the Committee.



**DISCUSSION OF A NEW RESEARCH PROJECT**

**ITEM NO.:** IV.1

**DATE:** July 8, 2015

**PROPOSAL NO.:** 2789-283

**STAFF EVALUATION OF A NEW RESEARCH PROJECT:**

**TITLE:** Heavy-Duty On-Road Vehicle Inspection and Maintenance Program

**CONTRACTOR:** Foundation for California Community Colleges  
\$499,560

**SUBCONTRACTORS:** West Virginia University, \$69,080  
Hager Environmental & Atmospheric Technologies, \$49,940  
Robert Harris (economist), \$7,500

**PRINCIPAL INVESTIGATORS:** Mark Carlock, Ph.D.  
Nigel Clark, Ph.D.

**CONTRACT TYPE:** Standard Agreement

**TOTAL AMOUNT:** \$499,560

**CONTRACT TERM:** 30 Months

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For further information, please contact Dr. John Collins at (916) 327-8097.

**I. SUMMARY**

Despite substantial reductions in oxides of nitrogen and diesel particulate matter emissions from heavy-duty vehicles (HDV), these vehicles are still significant contributors to statewide and regional emissions of these pollutants. Because of their long service lives, it is important that HDVs remain in emissions compliance throughout their entire lifetimes, and a HDV inspection and maintenance (I/M) program is one means of trying to ensure this compliance. The objectives of this project are to evaluate various approaches to HD I/M, select one or more promising alternatives, develop and demonstrate a prototype HDV I/M program, and conduct an economic cost analysis for this prototype program. Results from this project will be used to inform the design of an

improved HDV I/M program for consideration by the California Air Resources Board (ARB).

## **II. TECHNICAL SUMMARY**

### **Objective**

The objectives of this project are to evaluate alternatives for and develop a prototype of an Inspection and Maintenance (I/M) program for on-road heavy-duty vehicles (HDVs), and to perform an economic cost analysis of this prototype HDV I/M program. These objectives will be accomplished by conducting four tasks that include literature reviews, HD I/M program development and demonstration, and economic cost analysis.

### **Background**

Over the past twenty years, ARB has reduced on-road HD engine emissions standards for oxides of nitrogen (NO<sub>x</sub>) and diesel particulate matter (PM) by about 97 percent. Despite these significant improvements, HDVs over 8,500 pounds are still responsible for approximately a third of California's total NO<sub>x</sub> emissions and over a quarter of the diesel PM. While new engines employ improved engine designs and exhaust aftertreatment to meet stringent emissions standards, California needs a more comprehensive HDV I/M program to ensure that in-use engines continue to meet emissions performance requirements throughout their useful lives which can include 20 or more years of operation and a nearly a million miles of travel.

### **Proposal Summary**

The proposed principal investigators (PIs) for the project are Dr. Mark Carlock from the Foundation for California Community Colleges (FCCC), and Dr. Nigel Clark from West Virginia University (WVU).

In addition to the co-PIs, the project team would include: Hager Environmental and Atmospheric Technologies (H.E.A.T.) who would provide their LIDAR (Light Detection and Ranging) remote sensing device (RSD); Dr. Robert Harris, an economist; and a repair facility equipped with a chassis dynamometer located in southern California.

The FCCC proposal concludes that some methods such as remote sensing devices (RSDs) using the non-dispersive infrared (NDIR) technique have been in service long enough to permit an assessment and recommendations, even at the proposal stage

(e.g., NDIR RSD was invented about 25 years ago and has been used in numerous LD and HD sampling campaigns over the years). Hence, the FCCC proposal made some preliminary assessments based on existing data, and proposed to focus on the most promising methods and technologies in terms of the collection of new data. Thus, the FCCC team would evaluate more mature potential I/M methods (like NDIR RSD) based on existing data collected in other research projects, and would reserve HD I/M project resources to focus on newer technologies such as RSD that uses the LIDAR technique. Vehicle on-board diagnostics would be evaluated as a means of detecting high emitters, both on-site interrogation of the vehicle, as well as remotely, using cellular technology.

Because of the high cost associated with emissions testing HDVs, FCCC proposes to utilize repair-grade chassis dynamometer for all emissions testing. FCCC proposes to procure and test 50 HDVs during the demonstration phase of the project. Selection of specific test vehicles and diagnosis and repairs of high emitters could include vehicles identified by HDV repair shops, and/or engine problems induced by the investigators; determination of specific methods to be utilized will be made as additional information is collected during the project execution. Subsequent to the HD I/M prototype demonstration, FCCC would conduct an economic analysis of the costs associated with establishing and implementing a statewide HD I/M program.

### **III. STAFF COMMENTS**

The proposal was reviewed and evaluated by ARB staff from the Research, Mobile Source Control, and the Industrial Strategies Divisions, and included both engineers/scientists and economists. The proposal before the RSC reflects input and guidance from ARB staff.

The proposed project PIs are well qualified to conduct this project - Dr. Carlock possesses extensive experience with I/M program development and emissions modeling, and Dr. Clark is a recognized expert in HDV emissions testing and HDV diagnosis and repairs. The FCCC proposal demonstrated a good understanding of the problem, including both HD I/M program development as well as vehicle diagnosis and repairs. The proposed methods will present a variety of possible options that could be evaluated to determine the best method(s) for a HD I/M program.

ARB staff agree with the proposal's conclusion that for some technologies such as NDIR RSD, there is sufficient existing data to permit a preliminary evaluation of this technology, even at the proposal stage. Making these assessments at the proposal stage permitted FCCC to propose a fewer number of possible I/M methods to evaluate during the project, and to direct project resources elsewhere, such as vehicle emissions testing. The existing technologies such as NDIR RSD will still be evaluated during the literature review part of the project, but as noted, this will be accomplished using existing data, some of which is currently being collected in other ARB and other agency (e.g., U.S. EPA) HDV research projects.

The proposed use of a 'repair grade' chassis dynamometer to verify high emissions is considered by ARB staff to be a satisfactory alternative to much more expensive 'research grade' dynamometer testing (about \$250/test versus \$10,000-\$20,000/test). While research-grade chassis dynamometers are clearly superior in terms of simulating the entire domain of real-world vehicle operation, that is not the goal for this project. Instead, the goal is to correctly identify both complying and non-complying engines, and verify that the field test (e.g., verify that RSD correctly passed or failed the engine when operated under enforceable in-use engine operating conditions). For this purpose, a repair grade dynamometer appears to be sufficient to adequately exercise the engine/vehicle to determine compliance under field-test conditions. Data can also be collected under lighter load conditions to help evaluate possible modifications to in-use compliance and/or certification procedures and methods.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$499,560, subject to any changes and additions specified by the Committee.

**DISCUSSION OF A NEW RESEARCH PROJECT**

**ITEM NO.:** IV.2

**DATE:** July 8, 2015

**PROPOSAL NO.:** 2790-283

**STAFF EVALUATION OF A NEW RESEARCH PROJECT**

**TITLE:** Designing Vehicle Retirement and Replacement Incentives for Low-Income Households

**CONTRACTOR:** University of California, Los Angeles

**PRINCIPAL INVESTIGATORS:** George M. DeShazo, Ph.D.  
Evelyn A. Blumenberg, Ph.D.  
Paul M. Ong, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$483,133

**CONTRACT TERM:** 24 Months

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For further information, please contact Dr. Annalisa Schilla at (916) 322-8514.

**I. SUMMARY**

In order to meet air quality and climate change goals in California, a transformation of the light-duty vehicle fleet will be necessary. Incentives play an important role by accelerating the retirement and replacement of older, high-polluting vehicles and to increase adoption of advanced clean vehicles. This project will provide insight into vehicle retirement and replacement motivations and patterns of low and moderate income households, and will assess the effectiveness and cost-effectiveness of different policies and financial incentive program structures for optimizing adoption of advanced technology vehicles or other travel options (such as transit or car- or ride-sharing), particularly among low and moderate income households. The results of the research will be used to evaluate the light-duty vehicle market and inform ARB decision makers about the potential options for modifying ARB's incentive programs to ensure they make the best use of limited State resources, as well as provide benefits to underserved populations and disadvantaged communities.

## II. TECHNICAL SUMMARY

### **Objective**

The objectives of this project are to understand the demographics and vehicle retirement and replacement motivations and patterns of low and moderate income households, and to assess the effectiveness and cost-effectiveness of different policies and financial incentive program structures for optimizing adoption of advanced technology vehicles or other travel options (such as transit or car- or ride-sharing), particularly among low and moderate income households.

### **Background**

ARB has been providing incentives to California consumers to encourage the retirement of high-polluting vehicles and to support the purchase of new near-zero and zero-emission vehicles, through the Enhanced Fleet Modernization Program (EFMP) and the Clean Vehicle Rebate Project (CVRP), respectively. ARB is currently funding several research projects to analyze the market for ZEVs, and the role that financial incentives, charging infrastructure, and other benefits (e.g., high-occupancy vehicle lane access, free parking or charging for ZEVs) play in driving the market. Additional research is needed to understand how financial incentives motivate purchase decisions in low and moderate income households, and to provide insight into the role of various market factors and how financial incentives types and/or amounts may need to be adjusted as the market for clean vehicles grows and technologies are improved. This research will help ensure that limited incentive funding makes the best use of resources while remaining effective in supporting air quality improvement, particularly in disadvantaged communities.

EFMP is a vehicle retirement and replacement program that aims to retire functional, high-polluting passenger vehicles and light-duty and medium-duty trucks by voluntary means. Statute directs that the program should be focused on the areas with the greatest air quality impact and considers cost-effectiveness and impacts on disadvantaged and lower-income populations (defined as 225 percent of the federal poverty level). Although the retirement-only element of the EFMP is very popular, some evidence suggests that consumers participating in vehicle retirement-only element intended to scrap their vehicles even without the EFMP incentive. And the retirement and replacement element of EFMP has very limited participation. Additional incentives

for replacing older, inherently higher-emitting vehicles with near-zero and zero emission replacement vehicles can provide additional air quality benefits, reduce fuel costs, and help to transition consumers into advanced technology vehicles.

CVRP, also established under Assembly Bill 118 as part of the Air Quality Improvement Program, offers vehicle rebates on a first-come, first-served basis for new light-duty zero emission vehicles (ZEVs), and plug-in hybrid electric vehicles (PHEVs), zero emission motorcycles, and neighborhood electric vehicles. As the market for advanced clean vehicles grow and technologies improve, the structure and incentive amounts need to be re-evaluated in order to ensure that they make the best use of limited State funds while remaining effective in supporting clean vehicle purchases.

### **Proposal Summary**

The results of the research will be used to evaluate the light-duty vehicle market and inform ARB decision makers about the potential options for modifying ARB's incentive programs to ensure they make the best use of limited State resources, as well as provide benefits to underserved populations and disadvantaged communities.

The first task of this research is to conduct focus groups in the South Coast and San Joaquin Valley Air Districts, targeting households that have participated in the EFMP retirement program. Next, the research team will administer a survey to over 1,400 low income households who intend to purchase a vehicle within the next two years. The survey will evaluate the most effective policy and program structures to encourage retirement of high-polluting vehicles and adoption of advanced technology vehicles or lower-emission vehicle alternatives such as transit, car- or ride-sharing programs. The survey results will then be evaluated with a consumer choice model that simulates survey respondents' demand and willingness to pay for conventional and advanced technology vehicles. This model will be used to simulate the effect of alternative incentive program structures on demand for clean vehicles. Based on these results, the research team will then work with ARB and other stakeholders in the Los Angeles region to leverage or expand pilot programs that seek to increase fleet turnover. And finally, the research team will build upon other ARB-funded research, being conducted by members of the team for this project and others, to identify and evaluate indicators of self-sustaining markets for plug-in vehicles.

### **III. STAFF COMMENTS**

This proposal and a prior draft have been reviewed by ARB staff in the Chair's Office, and the Research, Industrial Strategies, Mobile Source Control, and Emissions Compliance, Automotive Regulation, and Science Divisions. The reviewers were generally supportive of the proposal for EFMP, but want the scope to expand beyond low income households to incorporate moderate income households as well, and to provide additional detail on the methods, data, and analysis for Task 6 (indicators of self-sustaining vehicle market). Staff recommends that the research team evaluate the development of the market for hybrid electric vehicles as an analog for the development of the market for ZEVs. ARB staff and the research team are also actively pursuing opportunities for this project to leverage ARB-funded "pilot" programs that are in the early stages and will serve to market EFMP in the South Coast Air District, and will seek opportunities to leverage CVRP pilots as well. However, reviewers were satisfied that the tasks in the proposal would be valuable even if these leveraging opportunities are not possible (and if the leveraging is unsuccessful, the total project budget will be decreased accordingly).

The research team, led by Dr. J.R. DeShazo, Dr. Evelyn Blumenberg, and Dr. Paul Ong from University of California, Los Angeles (UCLA), has a strong research record on related projects, and has demonstrated success in delivering on other ARB-funded projects. Professor Blumenberg's research has focused on auto ownership and use among low income households, and Professor Ong has done complementary research on minority vehicle ownership and use, and analysis of low income households' access to credit. Professor J.R. DeShazo brings expertise with survey design and implementation and large statistical data analysis, which is complemented by his familiarity with advanced and low emission vehicles which has been demonstrated through another ARB-funded project that is nearly complete.

### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$483,133, subject to inclusion of any changes and additions specified by the Committee.

**DISCUSSION OF A NEW RESEARCH PROJECT**

**ITEM NO.:** IV.3

**DATE:** July 8, 2015

**PROPOSAL NO.:** 2791-283

**STAFF EVALUATION OF A NEW RESEARCH PROJECT**

**TITLE:** Identifying, Evaluating and Selecting Indicators, Indices and Data for Future Monitoring System of the Implementation of Sustainable Communities Strategies

**CONTRACTOR:** University of California, Los Angeles

**PRINCIPAL INVESTIGATOR:** Paul Ong, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$149,908

**CONTRACT TERM:** 18 Months

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For further information, please contact Dr. Annalisa Schilla at (916) 322-8514.

**I. SUMMARY**

In 2008, the Sustainable Communities and Climate Protection Act (Senate Bill 375) requires Metropolitan Planning Organizations (MPOs) to do more integrated land use, transportation, and housing planning, through development of Sustainable Communities Strategies (SCS). These regional planning elements show that, if implemented, the major regions of California can reduce transportation-related greenhouse gas (GHG) emissions compared to 2005 levels. In the 2014 Scoping Plan Update, one of the recommended actions to achieve the State’s post-2020 climate goals is to “ensure GHG emission reductions from approved SCSs are achieved or exceeded through coordinated planning.” In order to track and monitor the progress in achieving the goals of SB 375, a framework must be established that identifies the key indicators of progress, such as vehicle miles traveled (VMT) and fuel usage data, as well as tracking the effectiveness of land use policies. In particular, there is a need to understand the extent to which shifts in regional and local planning are resulting in actual changes in land use and transit-oriented development patterns, and resulting in reduced VMT across the State through time. This project will develop a framework and baseline to

enable future tracking and evaluation of land use, development, and other indicators that reflect progress toward the goals of SB 375 over time.

## **II. TECHNICAL SUMMARY**

### **Objective**

The main objective of this research is to support the evaluation of progress toward the goals of SB 375. The project will identify key indicators and accessibility indices and consider the advantages and disadvantages of various methodologies for assessing land use change and other indicators of SB 375 progress in California through time.

### **Background**

SB 375 requires Metropolitan Planning Organizations to do more integrated land use, transportation, and housing planning. The program, now in its sixth year of implementation, has resulted in the development of Sustainable Communities Strategies, which show that, if implemented, the major regions of California can reduce transportation-related GHG emissions compared to 2005 levels. As of February 2015, all MPOs have adopted their first SCS and several are already undergoing their second round of SCS planning as part of their Regional Transportation Planning effort.

Although several years have passed since the inception of SB 375, land use and development changes take time and detectable changes in land use from business as usual may not be apparent for several more years. This is particularly true when factoring in likely impacts of the recent recession. However, this project will develop a framework and baseline to enable future tracking and evaluation of how land use, development, and other indicators that impact reduced VMT change over time.

### **Proposal Summary**

The proposed research would examine elements of a broad framework that are relevant to monitoring and assessing land use developments and changes relevant to SB 375 and SCS over time. This project will lay the groundwork for the development of a SCS monitoring system for the State.

The first task in this project is to establish an Advisory Committee comprised of state agencies, MPOs and other stakeholders to provide recommendations on SCS

indicators, accessibility indices, and analytical methods. Input from the Advisory Committee will be complemented with a literature and practice review of potential indicators, based on a review of publications and governmental documents on SCS indicators and accessibility indices, their construction, analytical uses, and relationship to travel and GHGs. This will include an examination of current professional practices as they relate to SCS indicators and accessibility indices, and to affiliated fields. The research team will then consult with MPOs and State agencies regarding availability of data, analytical capacity, and monitoring of SCS activities. This task also involves development of an assessment tool to evaluate SCS elements in selected general plans for a small representative sample of cities and counties. The researchers will then develop a list of desirable and potential SCS indicators and accessibility indices; develop a list of possible data sets for the construction of SCS indicators and accessibility indices; conduct an assessment of the data set as it relates to the pilot SCS monitoring system; and select data sets based on benefits and cost, and on stakeholder priorities. Finally, based on input, findings and results from previous tasks, the research team will develop recommendations on the best use and recommendations for development of a prototype SCS monitoring system.

### **III. STAFF COMMENTS**

While MPOs collect data and information related to land use and other indicators of SB 375 progress, to date no consistent framework exists for monitoring and tracking such progress statewide, nor is it clearly understood what data and indicators will best measure SB 375 progress and/or their availability. This project addresses the research need to track and monitor changes over time to demonstrate achievement of the goals of SB 375 throughout California.

This proposal reflects input from staff members of the Research and Air Quality Planning and Support Divisions within ARB and from two regional Metropolitan Planning Organizations (Southern California Association of Governments and the Bay Area Metropolitan Transportation Commission), as well as staff from various other state agencies, such as the Governor's Office of Planning and Research, California State Transportation Agency, California Department of Transportation, Department of

Housing and Community Development, and the Business, Consumer Services and Housing Agency.

While overall support for the project was received from all parties reviewing the proposal, the initial proposal focused much more specifically on land use, and reviewers requested the project include a broader scope of commonly agreed upon, and widely available indicators of SB 375 progress. ARB staff recommended that the proposal include more information on the types of VMT related indicators that would be sought in order to monitor how progress would be tracked for the transportation sector.

Additionally, reviewers felt that the initial proposal sought to accomplish too much given the project's budget allocation. It was agreed upon that this research is extremely important and should provide a solid foundation for future SCS and SB 375 related work, and that additional funding support from partnering state agencies could be sought to enhance the project scope or provide follow-up research opportunities as recommended upon completion of this work. Changes were recommended to the proposal to reduce the number of tasks and identify recommendations as part of the final report for additional follow-up tasks or research that could be pursued.

Staff is confident that the research team will meet expectations. This project brings together the expertise of three researchers with extensive knowledge and experience related to the tasks listed in this proposal. Dr. Paul Ong has a Ph.D. in Economics from University of California, Berkeley (UCB) and will be the project leader. Dr. Michael Lens, who has a Ph.D. in Public Administration from New York University, and Dr. Paavo Monkkonen, who has a Ph.D. in City and Regional Planning from UCB, are co-Principal Investigators. They are all professors in University of California, Los Angeles's Department of Urban Planning in the Luskin School of Public Affairs.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$149,908, subject to inclusion of any changes and additions specified by the Committee.

**DISCUSSION OF A NEW RESEARCH PROJECT**

**ITEM NO.:** IV.4

**DATE:** July 8, 2015

**PROPOSAL NO.:** 2792-283

**STAFF EVALUATION OF A NEW RESEARCH PROJECT**

**TITLE:** Assessing the Travel Demand and Co-Benefit Impacts of Affordable TODs

**CONTRACTOR:** University of California, Berkeley

**PRINCIPAL INVESTIGATOR:** Karen Chapple, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$300,000

**CONTRACT TERM:** 30 Months

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For further information, please contact Dr. Annalisa Schilla at (916) 322-8514.

**I. SUMMARY**

Senate Bill 375 (SB 375) requires Metropolitan Planning Organizations (MPOs) in California to develop a Sustainable Communities Strategy (SCS) as part of their federally mandated Regional Transportation Plan (RTP), to demonstrate how, largely through reduced travel demand and vehicle miles traveled; they will meet regional passenger vehicle greenhouse gas reduction (GHG) targets set by ARB. Affordable housing in transit-oriented developments has been recognized as a potential travel demand reduction strategy. However, to date very limited empirical, peer-reviewed research has evaluated the impact of preserving or building affordable housing on travel behavior and associated GHG emissions. The objectives of the research project are to evaluate the impact that preserving and building affordable housing in transit-oriented areas has on travel demand and vehicle miles traveled (VMT), and to assess the economic, health, and well-being impacts on the associated residents.

## II. TECHNICAL SUMMARY

### **Objective**

The objectives of this research project are to provide an empirical, quantitative analysis of the impact of preserving and building transit-oriented affordable housing on VMT in California, and to qualitatively assess the health, economic, and well-being impacts of affordable housing.

### **Background**

The preservation and development of affordable housing opportunities near public transit is a land use planning strategy that is thought to increase viability of the public transit system, and provide mobility options to populations with the greatest need. Affordable housing is also thought to reduce vehicle travel demand. The California State Budget allocated \$130 million of the 2014/2015 proceeds from Cap and Trade to support an Affordable Housing and Sustainable Communities Program, part of which will fund affordable housing projects near transit stations in order to reduce GHG emissions.

While there is a general understanding that income and socioeconomic characteristics influence vehicle ownership and VMT, there has been limited research to confirm whether increasing affordable housing in transit-oriented areas actually reduces VMT. A few attempts to understand the impacts of affordable housing on VMT have relied on cross-sectional analysis of household travel survey data and smog check odometer readings from the Department of Motor Vehicles. Additionally, a Caltrans-funded project that aims to develop a trip generation methodology for multifamily housing proposes to survey travel behavior of subsidized housing dwellers; however, this project is not designed to assess the effectiveness of affordable housing as a VMT reduction strategy (i.e., does not use a control/counterfactual) nor will it assess the potential for co-benefits of affordable housing.

### **Proposal Summary**

The results of this research will provide data and information to metropolitan planning organizations, county and local city planning departments, housing agencies, and local climate action planning efforts on the efficacy of transit-oriented affordable housing as a

VMT and GHG reduction strategy. In addition, the results are expected to aid in the evaluation of affordable housing projects funded by the Cap and Trade auction proceeds, and to inform future Cap and Trade proceeds investment plans.

The project will begin with a literature review on land use, urban form, and VMTs to identify the key variables associated with VMT reductions in affordable transit-oriented developments (TODs), and on the impact of residence in a TOD on public health, economics, and well-being. The research team will work with ARB and other appropriate agencies to select appropriate study sites for case-control surveys. The sites selected will address the need for diversity of geography, affordable housing type (e.g., multi-family, special needs, senior residence), neighborhood accessibility (e.g., proximity to destinations and transit characteristics), and other factors, plus the selection of appropriate counterfactual sites. Once the sites are selected, approximately 200 households will be recruited for travel diary data collection, and a subset of those will also have their travel tracked through smart phone-based GPS data collection to ground-truth the travel diaries. Researchers will provide smart phones to participants that do not own them, and will provide materials in either English or Spanish as appropriate. In order to assess the health, economic, and well-being impacts of affordable housing, the researchers will conduct focus groups.

### **III. STAFF COMMENTS**

This proposal reflects input from staff at a variety of State agencies, including ARB (Research and Air Quality, Planning, and Science Divisions), the Department of Housing and Community Development, California Business, Consumer Services, and Housing Agency, Caltrans, the State Transportation Agency (CalSTA), the Governor's Office of Planning and Research, as well from two metropolitan planning organizations: the Bay Area's Metropolitan Transportation Commission (MTC) and the Southern California Association of Governments (SCAG).

The proposal demonstrates the research team's knowledge and experience in the subject area and in translating academic work into decision-making tools for policymakers. The research team has past experience working with both MTC/ABAG and SCAG on their RTP/SCS, providing important knowledge of the context through which this research will be applied.

Dr. Karen Chapple, the principal investigator, is also the principal investigator of another ARB-funded research project focusing on displacement associated with transit-oriented development, has conducted pioneering research on gentrification and affordable housing transit-oriented development for the San Francisco Foundation, the Association of Bay Area Governments, the University of California Transportation Center, and Center for Housing Policy. She has advised MTC/ABAG on the affordable housing allocation for their Sustainable Communities Strategy and as part of the Great Communities Collaborative, has provided technical assistance on linking affordable housing and transit to over twenty cities in the Bay Area.

#### **IV. STAFF RECOMMENDATION**

Staff recommend the Research Screening Committee approve this proposal for a total amount not to exceed \$300,000, subject to any changes and additions specified by the Committee.

**DISCUSSION OF A NEW RESEARCH PROJECT**

**ITEM NO.:** IV.5

**DATE:** July 8, 2015

**PROPOSAL NO.:** 2793-283

**STAFF EVALUATION OF A NEW RESEARCH PROJECT**

**TITLE:** Zero-Carbon Buildings in California:  
A Feasibility Study

**CONTRACTOR:** University of California, Berkeley

**PRINCIPAL INVESTIGATOR:** Louise A. Mozingo, M.L.A.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$430,574

**CONTRACT TERM:** 24 Months

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For further information, please contact Dr. Annalisa Schilla at (916) 322-8514.

**I. SUMMARY**

California is on track to achieving the 2020 greenhouse gas (GHG) target, however much more must be done long-term to ratchet down emissions to a level needed for climate stabilization. The First Update to the Scoping Plan identified future actions and policies that can help California achieve our post-2020 climate goals, including advancing Zero Net Energy (ZNE) buildings to be Zero Carbon Buildings. A zero or near-zero carbon building is a Zero Net Energy building that would generate nearly no GHG emissions from the energy, water, waste, and transportation use associated with the building. Zero carbon buildings will utilize high performance design solutions, generate renewable energy on-site, and employ other techniques to eliminate or offset these GHG emissions. To date, almost no research has been conducted on Zero Carbon Buildings, and additional research is needed to explore the technical feasibility of zero or near-zero carbon building for both residential and commercial buildings.

**II. TECHNICAL SUMMARY**

**Objective**

The main objective of this research is to assess the technical feasibility of zero or near-zero carbon buildings.

## **Background**

The First Update to the Scoping Plan calls for ARB and stakeholder agencies to, “establish target dates and pathways toward transitioning to zero net carbon buildings that expand upon and complement ZNE goals” by 2017. Currently, the state’s ZNE goals established by both the California Public Utility Commission and the California Energy Commission are to have all new low-rise residential buildings be ZNE by 2020 and all new commercial buildings to be ZNE by 2030. In addition, the Governor has made a commitment that all new state buildings beginning design in 2025 shall be ZNE. To build upon these targets, ARB and state agency stakeholders must chart a path for expanding these goals to focus on GHG emissions, and as a result, consider water, waste, and transportation impacts of a building.

## **Proposal Summary**

This project will inform ARB decision makers about the practicality and appropriate timeframe for development of a zero carbon building State policy or program. The research team will begin by conducting an inventory of zero carbon building strategies, spanning transportation, water, and waste, and will identify the building types to be studied in subsequent tasks. They will then establish future building performance baselines for each building type in the study, and perform a wedge analysis to evaluate how each of the zero carbon building strategies can reduce building emissions to achieve zero carbon new construction. They will also identify and discuss the potential for retrofit of existing buildings to the various tiers of zero carbon status. GHG abatement strategies will be sorted into three groups: 1) those that can be implemented individually without a major property renovation; 2) those that can only be implemented as part of a major property renovation; 3) strategies with prohibitive installation costs in existing buildings. Finally, the research team will make recommendations to ARB on appropriate targets for zero carbon building for both new construction and retrofit.

## **III. STAFF COMMENTS**

This study will provide the technical foundation needed to chart a path for a zero carbon building program and to set aggressive, yet achievable statewide zero carbon building goals. The research will focus on strategies to reduce the carbon associated with building-level water, waste, and transportation impacts, but will consider energy to the extent renewables could be used to offset GHG emissions associated with water,

waste, or transportation impacts. Research is needed to evaluate the technical feasibility of achieving zero or near-zero carbon buildings for new residential and commercial buildings before the state adopts a zero carbon building definition and associated metrics.

The draft proposal was reviewed by ARB staff in the Research Division, Transportation and Toxics Division, and Industrial Strategies Division. The peer review panel also consisted of staff from several state agencies including the California Energy Commission, the California Public Utilities Commission, Department of Water Resources, California Department of Transportation, and Cal Recycle. The peer review panel stated that the draft proposal clearly describes the technical approach to complete a zero carbon building strategy inventory, feasibility analysis, retrofit potential for existing buildings, and setting targets for an appropriate policy framework. The draft proposal is efficient and provides a reliable approach to support the development of state goals and a path towards transitioning to zero carbon building. The peer review panel also noted that the research team is extremely knowledgeable and has strong insight as a result of conducting past research in the areas of building-level waste, water and transportation.

One of the main comments suggested that the research team update the proposal to include a comparison of the GHG benefits and cost effectiveness of zero carbon versus zero net energy. The peer review panel suggested that the proposal be updated to better explain how the new information on waste, water, transportation will be layered on existing ZNE high performance building data and information. They suggested that there needs to be a clear description of a life-cycle cost (or benefit/cost) analysis related to this task.

Since plug-in electric vehicles (PEVs) are not part of the “building load” that is accounted for in the CEC definition of zero net energy buildings, the peer review panel suggested that the proposal be updated to include PEVs as part of the evaluation of the transportation wedge. The updated proposal should evaluate the associated use of PV to offset the electricity use and associated GHG emissions for charging PEVs.

The peer review panel provided several other suggestions to update the water, waste, and existing building sections of the proposal. For example, the peer review team requested that the proposal be updated to expand on the waste management strategies and include a focus on organic waste generation and reduction.

Advanced solutions were missing in the draft proposal. The peer review panel suggested updating the proposal to further assess other new innovative design solutions, technologies, and building operation strategies in water, waste, and transportation sectors beyond what is currently listed or identified in the proposal. For example, the project could evaluate more innovative strategies like Über/car-share. Some people in San Francisco are using this program to get to work on a daily basis. Additionally, the water area did not mention greywater collection and reuse or composting toilets, which could be used to reduce water related GHG emissions. Perhaps there are other innovative strategies out there that cut across all the sectors. The peer review panel requested the research team update the proposal to analyze leading edge technologies.

Research team members are among the most expert in the field, and have direct experience doing high quality work on closely related research and analysis. The team is led by strong researchers from academia but includes a strong private sector policy firm (Fehr and Peers) with additional “real world” experience and context. Professor Louise Mozingo, Principal Investigator, serves as the Director of the Center for Resource Efficient Communities and the Chair of the Department of Landscape Architecture and Environmental Planning. Professor Mozingo and one of the project team researchers (Dr. William Eisenstein) have worked on a related research project to analyze the GHG co-benefits of green buildings. The research team is extremely knowledgeable and has strong insight as a result of conducting past research in the areas of waste, water and transportation.

This project addresses the research need to explore the technical feasibility of zero or near-zero carbon building for both residential and commercial buildings. It will assess the practicality and appropriate timeframe for a zero or near-zero carbon building State policy or program, which can put California on track to achieve long-term climate goals.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$430,574, subject to any changes and additions specified by the Committee.



## DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: IV.6

DATE: July 8, 2015

PROPOSAL NO.: 2794-283

### STAFF EVALUATION OF A NEW RESEARCH PROJECT

**TITLE:** Characterize Physical and Chemical Properties of Manure in California Dairy Systems to Improve Greenhouse Gas (GHG) Emission Estimates

**CONTRACTOR:** University of California, Davis

**PRINCIPAL INVESTIGATOR:** Deanne Meyer, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$151,423

**CONTRACT TERM:** 24 Months

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For further information, please contact Dr. Dongmin Luo at (916) 324-8496.

#### I. SUMMARY

When manure is stored anaerobically (i.e. without oxygen, in facilities such as lagoons and deep pits), bacteria break down manure volatile solids (VS) and generate methane. California's greenhouse gas (GHG) inventory cites United States Environmental Protection Agency (U.S. EPA) modeling to quantify the methane emitted from manure storage, though CA lacks real world data to substantiate the modeling assumptions such as the amount of VS stored in lagoons. The majority of manure from California's 1.8 million milking cows is assumed to be stored anaerobically, with lagoons being the largest manure methane emitter (nearly 9 million metric tons of CO<sub>2</sub> equivalent emitted in 2012). Real world surveying of manure management pathways (including VS at each stage of management) is necessary to substantiate or refute modeling assumptions. Other factors such as nitrogen (N) will also be tracked and measured with the intent to better inform the N<sub>2</sub>O inventory. Dairy farms will be selected to represent the various types of manure management systems, including scraping, flushing, solids separation, lagoon storage, covered lagoon digestion, and solids digestion, etc. Representative samples of manure will be taken from each manure pathway to determine the nutrient

flow at each stage of management. Results will be compared to U.S. EPA assumptions about VS in manure management systems modeled according to farm-size, temperature, and other modeled factors related to methane production. If current assumptions used by ARB for GHG inventory purposes do not reflect industry practices or the physical/chemical environment in which the manure is residing, alternative values or ranges of values will be suggested. If manure methane is shown to be larger or smaller than the existing U.S. EPA modeling, then ARB will be better able to prioritize dairy manure methane mitigation concepts as well as better calculate the costs and benefits of methane capture or abatement.

## **II. TECHNICAL SUMMARY**

### **Objective**

The objectives are to evaluate existing information on dairy practices as they may relate to GHG production, and to develop and deploy field data collection to estimate VS and N excretion from animals and flow of VS and N through dairy production facilities on up to six commercial dairies. The outcome of this research will identify if the current assumptions used for ARB inventory for manure emissions are reasonable and provide values or ranges of values for ARB consideration if current methods do not represent industry practices.

### **Background**

Methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) are important greenhouse gases produced by dairy production systems. Current inventory by ARB calculates that more CH<sub>4</sub> is emitted through manure processes than enteric emissions. Key assumptions used by U.S. EPA to estimate GHG inventory include: 1) bacteria generate methane at 75 percent of maximal optimum conditions (on average, year round); 2) 59 percent of CA milking cow VS go to anaerobic lagoons and 20 percent to “liquid/slurry” where 33 percent of optimal methane generation is realized. Animal housing dictates to a large extent the potential manure collection and animal welfare options available to dairy managers. A number of key parameters were evaluated prior to building each existing facility: number of animals at the facility (initially and at expansions), labor available to move cattle into and out of the milk parlor, climate (temperature, precipitation, wind), animal welfare concerns, and land available for the production area footprint. Once housing is in place,

modification of manure collection, storage and treatment practices can be incredibly expensive to fit into the existing physical footprint of the operation. Some studies have surveyed dairy producers in the Central Valley to identify manure management practices. Manure flow charts were developed for dry lot and free stall dairy operations. To date, the number of facilities or cattle with manure collected in freestall or drylot systems has not been analyzed. Although spreadsheets exist to estimate VS flows through dairies for purposes of designing anaerobic digesters, no actual data have been collected to validate VS flow assumptions for California.

It is likely that conditions in anaerobic lagoons are not consistent year-round. The quantity of VS in lagoons is likely greatest during cooler weather when methanogenesis is lowest. Under normal water years, the VS percent in lagoons is likely smallest during conditions most favorable to methanogenesis. The amount of VS collected in lagoons likely varies from winter to summer due to animal and management preferences. Previous studies on dairy lagoons indicated that “anaerobic” lagoons varied in their oxidative reduction (redox) potential, thus affecting methane generation.

## **Proposal Summary**

### Task 1: Evaluate the existing information on dairy practices and air emissions calculations in California.

Discussion with San Joaquin Air Pollution Control District (District) staff will occur to obtain and analyze available District data to determine how many animals are housed in freestalls. A summary of information will be prepared including District data on number of animal equivalents housed with solid, liquid or slurry collection systems; identifying current ARB methods for calculating GHG emissions and an evaluation of those methods as applied to the diversity of manure collection systems located on California dairies. The report will identify potential additional parameters requiring data for inclusion in GHG inventory modeling efforts and the results derived will inform selection of facility type for Task 2.

### Task 2: Develop and deploy a comprehensive survey and analysis of confinement open lot and freestall facilities to quantify total and volatile solids (TS, VS) and nitrogen (N) flows from excretion through storage using existing information on dietary composition and digestibility, dairy housing design, and facility manure flow.

Numerous dairies will be visited, and up to six dairies will be selected, based on Task 1 results. Detailed information will be collected on estimated TS, VS, pH, redox, temperature, organic N, ammonium N and nitrate N excreted from animals or in liquid waste stream and traversing the solid and liquid manure collection, treatment and storage systems.

Facilities enrolled in the project will undergo a thorough analysis of feed and diet information to estimate excretion of TS, VS and N. Animal management will be observed monthly. Manure deposition in various housing areas (on surfaces with liquid or slurry manure collection versus dry manure collection) will be estimated. Quarterly analysis of waste stream flows will be utilized to estimate volume and chemical and physical concentrations of TS, VS, and N flows into and through the system for liquid/slurry components. Analysis of solid manure will be conducted when solid manure is removed from the production facility.

Quarterly analysis of waste stream flows (all facilities) will include detailed lagoon monitoring at a minimum of three dairies. Length and width measurements of lagoons will be used to identify 6 sampling locations. A non-motorized 10ft. or 8ft. flat bottom boat (Classic Craft/Keaton Boats) is used and secured via rope from the banks of the lagoon to maintain location during sampling. Liquid manure samples are obtained at various depths using an 8 ounce. stainless steel bomb sampler (Koehler Petroleum Bacon Bomb Sampler). The sampling device is lowered to the appropriate depth and opened to replace air with sample contents. Samples are taken from the shallowest to the deepest depths within a sampling location to avoid unnecessary mixing of water. The contents of the bomb sampler are split into two pre-labelled containers with one set immediately preserved on ice for ammoniacal analyses and the other set used for remaining chemical and physical analyses.

### **III. STAFF COMMENTS**

Dr. Deanne Meyer is a good choice for PI because she has worked for decades with dairy manure pathways from a scientific perspective including multiple publications as well as via UC Davis Cooperative Extension. She is familiar with sampling protocols and dairy farm operations, an important combination for on-farm research. Previous proposal drafts were reviewed by staff from ARB's Air Quality Planning and Science

Division and Research Division, and the California Department of Food and Agriculture. Further collaboration will be necessary between ARB/District and the PI to select appropriate dairies for sampling, and should ensure at least one of the dairies has a mechanically mixed lagoon (to reduce the impact of non-representative samples). This research will further ARB understanding of GHG emissions from dairy systems and set the stage for a future study involving actual emissions measurement which will complement the newly gained understanding of nutrient flow from this research project results.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$151,423 subject to inclusion of any changes and additions specified by the Committee



## DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: IV.7

DATE: July 8, 2015

PROPOSAL NO.: 2795-283

### STAFF EVALUATION OF NEW RESEARCH PROJECT

**TITLE:** Characterize California-specific Cattle Feed Rations and Improve Modeling of Enteric Fermentation for California's Greenhouse Gas (GHG) Inventory

**CONTRACTOR:** University of California, Davis

**PRINCIPAL INVESTIGATOR:** Ermias Kebreab, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$99,964

**CONTRACT TERM:** 18 Months

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For further information, please contact Dr. Dongmin Luo at (916) 324-8496.

#### I. SUMMARY

Enteric emissions comprise the largest known source (30 percent) of methane (CH<sub>4</sub>) in California. Enteric fermentation is a microbial fermentation process that occurs in the digestive tract that produces CH<sub>4</sub> as a byproduct and mostly eructated by ruminant animals such as cattle. The amount of CH<sub>4</sub> produced from enteric fermentation depends primarily on feed intake and diet composition, which can vary widely across the state depending on feed availability and cost. Although emissions from a small number of animals under controlled conditions can be measured, it is not practical to sample large numbers of ruminant animals. Therefore, enteric CH<sub>4</sub> emission estimates for greenhouse gas inventories must rely on mathematical models. The U.S. EPA uses Cattle Enteric Fermentation Model (CEFM), which is a spreadsheet-based mathematical model and the basis of California's inventory, to estimate enteric methane emissions from cattle. However, some values that the model assigns are single values applied nationwide and thus do not represent the variability by state or region for estimating the enteric CH<sub>4</sub> emissions. This study is intended to develop a set of empirical mathematical models for estimating enteric CH<sub>4</sub> emissions from California's cattle using

California-specific inputs. Moreover, the improved CH<sub>4</sub> emissions estimate will better reflect on-farm realities, allow better tracking of other feed-related issues such as nitrogen, and better inform policy decisions for focusing sectorial greenhouse gas (GHG) goals and development of short-lived climate pollutant reduction strategies.

## **II. TECHNICAL SUMMARY**

### **Objective**

The purpose of this study is to improve the modeling methodology for estimating cattle enteric fermentation emissions in the California GHG Emission Inventory by collecting and modeling California-specific feed data. The specific objectives are to collect data on California cattle pertaining to animal and diet characteristics, to develop and evaluate a set of models for estimating enteric methane emissions using data representative of California cattle and diet characteristics, and to apply the evaluated models on distinct groups and obtain improved total enteric CH<sub>4</sub> emission estimates for California cattle.

### **Background**

California cattle operations, primarily dairies, are a significant source of GHGs. Enteric fermentation (bacterial decomposition of feed in ruminant stomachs) emits GHGs, most notably methane in eructation (burping). Enteric fermentation from cattle contributes nearly 30 percent of the statewide methane emission inventory, currently the largest inventoried source of methane statewide. 95 percent of California's enteric methane emissions come from cattle, approximately 3/4 of which are from dairy cows. These estimates rely on mathematical models developed to estimate emissions based on various factors. Because enteric methane emissions are highly influenced by diet, the models need to incorporate the effect of various diets or feed ingredients. Total mixed rations fed to California cows have not been widely surveyed. To improve the accuracy of the inventory and determine the level of uncertainty, California-specific feed data must first be collected and used in the emissions model.

The methodologies to estimate methane emissions from enteric fermentation developed by the U.S. EPA for the U.S. GHG Emissions Inventory form the basis of California's inventory. Dairy feed formulation has changed in the past decade as a consequence of changes in feed price, including the rising price of corn grain due to the large amount of

corn used to produce ethanol. California-specific data are especially important when feed compositions are changing with economic conditions.

A significant amount of enteric fermentation research exists, from methanogenic bacterial studies and modeling to diet and breed effects. This proposal focuses on modeling California-specific data and scenarios, which does not currently exist. This research does not collect emissions samples from enteric fermentation in part because many animals have already been directly measured in other studies, and the limited budget and scope of this work precludes measurements of a sufficient number of ruminant animals. Obtaining California-specific feed data is a key to leveraging existing modeling work and tailoring models to California scenarios.

With approximately 1.8 million milking head, California has the highest number of milking cows in the nation. Due to the large dairy population in the state, feed and enteric methane emissions from dairy cows will be the focus of this research (with beef cattle feed also examined and modeled, though to a lesser degree).

## **Proposal Summary**

The proposed project consists of the following tasks:

### Task 1: Data Sources and Data Collection

The major input to this project will be data on enteric methane emission measurements, dry matter intake, and dietary nutrient composition and corresponding production (e.g. milk yield and milk fat content), and animal characteristics (e.g. body weight). The sources and a brief description of the data accessible to us, including both experimental data as well as literature data, are summarized in the proposal. The Principal Investigator's laboratory at UCD has an extensive database containing over 1,000 individual measurements of lactating and dry cows that include methane emissions among many variables, as well as over 1,000 measurements of dry cows, dairy heifers, and beef steers collected from 62 respiration calorimetry experiments. These datasets are the major data sources that will be used in this project.

### Tasks 2 and 3: Model Development and Evaluation

Since the U.S. EPA's Cattle Enteric Fermentation Model (CFEM) assigns single values applied nationwide, which do not represent the variability by state or region for estimating the enteric CH<sub>4</sub> emissions, a set of empirical models will be developed to predict enteric methane emissions from California cattle groups using data representative of California cattle and diet characteristics. The primary focus will be developing a model for lactating cows since they contribute to the majority of methane emissions from livestock in California, followed by separate prediction models for non-lactating cows, dairy heifers and beef cattle. Dietary nutrient composition and dry matter intake (DMI) will be the primary variables driving methane production. The statistical software R will be used in the model development.

The models developed will then be compared with data compiled under Task 1, with a focus on prediction accuracy and precision, and model efficiency (model estimates vs. average measured value). Several model statistics such as mean square prediction error, and correlation coefficient will be used to assess these parameters.

### Tasks 4 and 5: Estimating California Emissions

A number of inputs the models need for California conditions will be collected from major counties in California that significantly contribute to the enteric methane emission inventory. These data include ingredients commonly used in each production system, nutrient composition, and the herd data. The models developed and evaluated above will be applied on DMI (kg/cow/d), milk yield (kg/cow/d), and dietary nutrient composition data (percent of dry matter of the diet) to calculate methane emissions at animal level (g/cow/d) and a population matrix will be developed using current cattle herd data of California. Then, the animal level enteric methane emission rate and the population matrix will be used to estimate enteric methane emission from total dairy cow population as well as other cattle populations in California.

## **III. STAFF COMMENTS**

Staff from ARB's Air Quality Planning and Science Division and Research Division, and the California Energy Commission, and the California Department Food and Agriculture reviewed earlier versions of the proposal and agree that this proposal is technically

sound and meets a critical need to develop a set of empirical models to estimate enteric methane emissions from cattle. UCD is uniquely capable to perform this research, given previous experience of its researchers and the database and resources they hold. Dr. Kebreab is a well-established animal scientist at the Department of Animal Science and Deputy Director of the Agricultural Sustainability Institute at UCD. His team is well-positioned to carry out the research tasks, having authored over 50 peer-reviewed publications on animal nutrients since 2011. The team possesses a broad expertise in systematic approach to quantifying greenhouse gas emissions in agriculture, and mathematical modeling and mitigation of emissions from animals, manure and soil. The project is particularly cost effective as it will build upon previous projects, funded by the U.S. Department of Agriculture, and other federal and state agencies.

#### **IV. STAFF RECOMMENDATION**

Staff recommends that the Research Screening Committee approve this proposal for a total amount not to exceed \$99,964, subject to inclusion of any changes and additions specified by the Committee.



## DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: IV.8

DATE: July 8, 2015

PROPOSAL NO.: 2796-283

### STAFF EVALUATION OF NEW RESEARCH PROJECT

**TITLE:** Policy and Scenario Analysis for Managing and Mitigating California's F-gas Emissions

**CONTRACTOR:** University of California, Berkeley

**PRINCIPAL INVESTIGATORS:** Daniel Kammen, Ph.D.  
Max Auffhammer, Ph.D.  
Max Wei, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$318,382

**CONTRACT TERM:** 24 Months

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For further information, please contact Fereidun Feizollahi at (916) 323-1509.

#### I. SUMMARY

A majority of future high global warming potential (high-GWP) emissions in California will be comprised of fluorinated gases (F-gases), which are used primarily in refrigeration, air conditioning, insulation and pesticide applications. This project specifies a recommended policy or combination of policies needed to achieve targeted 2030 and 2050 reductions of F-gas emissions in California. To ensure that future F-gas control programs achieve reductions in the most reliable and cost-effective manner, relevant regulatory experience will be reviewed and its lessons applied to a systematic comparative analysis of potential F-gas emission reduction strategies. The design of a recommended F-gas fee program will be specified, and emission reduction strategies other than fees will also be evaluated and compared across multiple criteria including cost-effectiveness, feasibility, economic impacts, and interaction with other emission control programs. Project results will inform the design of ARB's medium and long-term F-gas emission control programs.

## II. TECHNICAL SUMMARY

### Objective

The objective of this project is to identify and describe recommended policy options needed to achieve targeted 2030 and 2050 reductions of F-gas emissions in California. The potential design of an F-gas fee program, including distribution of fee revenues, will be specified in light of comparable regulatory experience. Emission reduction strategies other than fees will also be examined and compared according to their feasibility, estimated economic impacts, and interaction with other emission control programs. Project results will inform the design of ARB's medium and long-term F-gas emission control programs.

### Background

High-GWP gases contribute to global warming at levels hundreds to thousands of times greater than carbon dioxide. A majority of future high-GWP emissions in California will be comprised of F-gases, which are used primarily in refrigeration, air conditioning, insulation and pesticide applications.

High-GWP gases are the fastest growing GHG source in California because F-gases, such as HFCs, are replacing ozone-depleting substances in response to Montreal Protocol mandates. Even with ARB Scoping Plan regulations already in place, annual F-gas emissions in California are projected to increase by about 40 percent (from 18 to 25 MMTCO<sub>2</sub>e) between 2012 and 2020, and more than double by 2050, to 43 MMTCO<sub>2</sub>e. At this level, the F-gas sector alone would represent 50 percent of the total ARB 2050 GHG emission goal of 86 MMTCO<sub>2</sub>e in 2050, and would make it extremely difficult for the state to meet the 2050 goal. Thus, there is a high degree of urgency to identify reliable, long-term solutions for reduction and control of this GHG source.

### Proposal Summary

This project identifies, compares and evaluates policy options for reducing F-gas emissions in the state from 2018 to 2050 and specifies a recommended regulatory design and two "next-best" alternative control programs. The work will comprise four

primary tasks: information collection; F-gas fee program analysis; F-gas emission reduction policy analysis; and the final report and recommendations.

The study team will review the relevant literature, consult with F-gas technology and policy experts and collect technical and market data needed to systematically assess emission reduction policy options. Information will be collected on: technical specifications of emerging and existing low-GWP systems and barriers to their adoption; the design and effectiveness of existing GHG and high-GWP regulatory policies and programs; and the size, cost, feasibility and potential economic impacts of F-gas emission reduction opportunities in California through 2050.

Potential designs for an F-gas fee program and other F-gas emission reduction policy options will be specified, compared and evaluated across multiple criteria including: emission reductions; cost-effectiveness; administrative and technological feasibility; enforceability, economic impacts and interaction with other (state, federal, international) regulatory programs. The team will evaluate an inclusive menu of policy options to determine the recommended mix of policies that can achieve 2030 and 2050 F-gas emission reductions, including sector-specific prohibitions, cap and trade variants, performance standards, deposit-refund schemes, targeted abatement and mitigation programs, as well as the fee program option.

### **III. STAFF COMMENTS**

Staff at ARB's Research Division, Industrial Strategies Division and Legal Office as well as the Economic Advisor to ARB's Executive Office reviewed and provided comments on this proposal. Three versions of the technical agreement were submitted, reviewed and revised.

The Scoping Plan update of 2014 outlines several potential approaches to further reduce high-GWP F-gases, including an upstream fee that would complement rather than replace existing downstream high-GWP regulations. The proposed research would satisfy the need for in-depth comparative evaluation of these and other policy options for reducing F-gas emissions in California.

The proposed study team includes: a PI, (Daniel Kammen, UC Berkeley), with expertise and experience in climate change and energy policy analysis; an economist (Maximilian Auffhammer, UC Berkeley), with expertise and experience in resource economics, energy economics and applied econometrics; and an engineer (Max Wei, Lawrence Berkeley National Laboratory) with expertise and experience in techno-economic analysis, modeling and life-cycle cost analysis of existing and emerging technology applications, including HVAC systems.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$318,382, subject to inclusion of any changes and additions specified by the Committee.

## DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: IV.9

DATE: July 8, 2015

PROPOSAL NO.: 2797-283

### STAFF EVALUATION OF NEW RESEARCH PROJECT

**TITLE:** Improved Understanding of the Magnitude of Trans-Pacific Long Range Transported Ozone Aloft at California's Coast

**CONTRACTOR:** San Jose State University

**PRINCIPAL INVESTIGATOR:** Sen Chiao, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$281,699

**CONTRACT TERM:** 36 Months

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

#### I. SUMMARY

Despite very dramatic improvements in air quality in the State, California must continue to achieve significant new reductions in ozone precursor emissions. For non-attainment areas, the SIP must demonstrate how new controls will reduce ground-level ambient ozone to levels below the health-based standards. While recent health research has led to the United States Environmental Protection Agency (U.S. EPA) to propose a new, lower ozone standard, increasing industrialization in Asia have led to increased baseline ozone concentrations entering the State from the west. Short term field studies have documented instances of elevated ozone concentrations aloft that could potentially be relevant to ground level exceedances. While these measurements have provided infrequent information about ozone aloft, these isolated efforts do not provide sufficient information to fully understand the spatial and temporal variations in baseline ozone concentrations entering California. The proposed research will launch ozonesondes from a California coastal site on a near daily basis and collect ozone vertical profiles from the late spring to summer in 2016. The upper air ozone data collected from this project will help us to better quantify the magnitude and temporal variations in baseline

ozone concentrations entering California, particularly on high ozone days in the San Joaquin Valley (SJV). The data are also critically important for evaluating and improving the boundary conditions generated from the global transport models used in our ozone SIP modeling.

## **II. TECHNICAL SUMMARY**

### **Objective**

The overall objective of this project is to collect vertical profiles of ozone concentrations from a California coastal site once a day to quantify the magnitude and temporal variations in baseline ozone entering California.

### **Background**

Increasing global industrialization and development have contributed to increases in background ozone over the eastern Pacific and western United States. Intermittent field studies have documented instances of elevated ozone concentrations aloft (associated with global, regional, and local sources) that could potentially be relevant to ground level exceedances in California. There have been limited, episodic campaigns of instrumented aircraft flights sponsored by federal, state, and regional groups (e.g., the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the San Joaquin Valley Air Pollution Control District, and ARB) as well as weekly ozonesonde launches on the north coast of the State (sponsored by NOAA) to investigate ozone events and processes. But these isolated efforts do not provide sufficient information to fully understand the spatial and temporal variations in baseline ozone concentrations entering California. Currently, global modeling results from the National Center for Atmospheric Research (NCAR) are used to generate California's boundary conditions for SIP modeling. However, there are relatively large uncertainties in the global modeling results and therefore continuous evaluation and improvement of modeled boundary conditions using the measurement data is critically important. This project is designed to collect ozone vertical profiles from a California coastal site on near daily basis during the ozone season of 2016. The data and information collected in this project will help to assess the ability of global models to simulate the vertical and temporal variability of incoming air masses and as such lead to improvements in regional air quality simulations for SIP purposes. The daily

measurements will give great insight into the daily variability and the frequency of incoming high pollution events and greatly enhance the characterization of long-range pollution transport. This research project is a necessary first step toward understanding the difficult policy relevant question of what is the contribution of Pacific long-range transported ozone to surface sites in the state.

### **Proposal Summary**

The proposed work by researchers in San Jose State University includes measurements of ozone vertical profiles during the late spring and summer of 2016 for about three months at the Bodega Bay site. The major tasks include:

- 1) Launch ozonesondes from the University of California, Davis (UCD) Bodega Marine Laboratory once a day to collect the vertical profiles of ozone concentrations.
- 2) Data will be processed and fully screened and validated for quality assurance and quality control.
- 3) Draft data will be submitted to ARB on a monthly basis.
- 4) The full QA'ed database will be submitted to ARB at the end of the deployment.
- 5) Prepare and submit a final report to ARB for approval.

The ozone vertical profiles collected at the coast by this project provide the first opportunity to evaluate daily variations in baseline ozone entering California, which will provide critical information for future State Implementation Plans (SIPs). ARB's air quality modeling to evaluate proposed control strategies benefits for SIPs needs to input atmospheric concentrations of species of interest at the State's "boundary conditions." To the west, this represents air parcels which have crossed the Pacific Ocean. Northern hemisphere baseline ozone concentrations have increased over the past several decades, while controls have reduced the anthropogenic contribution so the baseline represents a larger fraction of the total ozone. For these western boundary conditions, ARB uses the output from National Center for Atmospheric Research (NCAR) global atmospheric models. Up to the present, there is relatively sparse ozone data available to compare with the global model outputs. The

ozone data collected by this project will be a unique set of daily vertical ozone profiles which will allow NCAR's modelers to evaluate the performance of the global model at California's coast. NCAR modelers have expressed strong support for this project. This project will ensure that the boundary conditions used in ARB's SIP modeling have benefited from expanded data sources.

### **III. STAFF COMMENTS**

Staff from ARB's Air Quality Planning and Science Division and Research Division, the San Joaquin Valley Air Pollution Control District, Drs. David Parrish and Owen Cooper from the NOAA, and Professor Michael Kleeman from UCD reviewed the proposal. The review team agreed that Dr. Sen Chiao's proposal provided adequate information on the data collection work, and the selection of the Bodega Marine Laboratory as the primary site is excellent. The project will provide useful information for evaluating, and when possible, improving the ozone boundary conditions used in ARB's photochemical modeling. In responding to ARB's proposed scope of work, Dr. Chiao also proposed ozonesonde launching once or twice a week based on weather conditions from a secondary site at Moss Landing. The review team questioned the usefulness of this site because previous work suggested that ozone profiles at these two locations could be very similar, and the Moss Landing site may be impacted by emissions from the Bay area and not representing the baseline conditions. In addition, the review team suggested that the proposal should include some more references on previous ozonesonde research, and describe in more detail on how this project will improve upon prior work and how data collected may be utilized by SIP models or how it will improve upon current boundary condition specification in the models. The review team also believed that one of the goals - analyze and quantify the contributions of long-range transport and locally generated ozone in coastal areas – included in the draft proposal was beyond the scope of this project. Some specific comments/edits on the preparation and launching of the ozonesondes and the QA/QC of the data were also received from the review team and forwarded to the PI for revisions.

Based on the review comments on the draft proposal, staff discussed with Dr. Chiao and decided that ozonsondes will only be launched from the Bodega bay site. The goal number three, "analyze and quantify the contributions of long-range transport and locally generated ozone in coastal areas," is removed from the proposal and the project

is focused on data collection. The technical plan is revised to include more specific information regarding the preparation and launching of the ozonsondes, and the processing and QA/QC of the data. The revised final proposal includes some more detailed description on what additional information this project will provide and how it may help to improve our understanding of the ozone boundary conditions in California. The data collected from this project will be very valuable to the global modeling community for evaluating the modeled boundary conditions in California, as demonstrated by a letter of support from Dr. Gabriele Pfister of the National Center for Atmospheric Research, and help to improve the performance of ARB's SIP photochemical modeling. The baseline ozone measurements at the coastal area, together with the ozone LIDAR measurements in the SJV (described next in this report as a proposal from NOAA), provide key data to begin to look into any contribution of baseline ozone aloft to surface ozone exceedances in the SJV.

The research team from San Jose State University has strong experience in working on field campaigns including launching radiosondes.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$281,699, subject to inclusion of any changes and additions specified by the Committee.



## DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: IV.10

DATE: July 8, 2015

PROPOSAL NO.: 2798-283

### STAFF EVALUATION OF NEW RESEARCH PROJECT

**TITLE:** LIDAR Profiling of Ozone in the San Joaquin Valley

**CONTRACTOR:** National Oceanic and Atmospheric Administration (NOAA)

**PRINCIPAL INVESTIGATOR:** Andrew O. Langford, Ph.D.

**CONTRACT TYPE:** Standard Agreement

**TOTAL AMOUNT:** \$107,639

**CONTRACT TERM:** 24 Months

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

#### I. SUMMARY

Because health effects research has consistently led to lower ambient air quality standards for ozone, the Air Resources Board (ARB) needs to continue to reduce ozone precursor emissions in California. While state/local control strategies have resulted in significant decreases in locally produced ozone in California, baseline ozone concentrations in the air entering the State have been increasing. Increasing out-of-state contributions are making attainment of the more stringent ozone standards increasingly difficult. Intermittent field studies have documented instances of elevated ozone concentrations aloft (associated with global, regional, and local sources) that could potentially be relevant to ground level exceedances. Modeling exercises focused on the contributions of long-range transport and the stratosphere to ozone in the western United States (including California) have also suggested that baseline ozone aloft may contribute to surface ozone exceedances in California, especially at the high elevation sites. However, at present, there remains a great deal of uncertainty about the contributions of stratospheric and transported ozone to surface concentrations in the San Joaquin Valley (SJV). Intermittent measurements by ozonesondes or aircraft do not

provide the temporal coverage needed to evaluate how well models (such as WRF-Chem) can estimate the contribution of background ozone to surface concentrations in the SJV during these transport regimes. This project will use a surface based ozone LIDAR to provide quasi-continuous ozone profiles up to 2 – 3 kilometre (km) above ground level in the SJV for 6 weeks during the spring and summer (ozone season) of 2016. The data will help us to better characterize the ozone vertical profile and its temporal variation in the SJV, and understand the vertical mixing of ozone aloft down to the surface. It will provide key data to begin to look into any contribution of baseline ozone aloft to surface ozone exceedances in the SJV.

## **II. TECHNICAL SUMMARY**

### **Objective**

The primary objective of the study is to investigate the variability of ozone in the lowest 2 km above a fixed location in the SJV during the late spring (May-June) and summer (July-August) of 2016. This will be accomplished by using the mobile NOAA Earth Systems Research Laboratory (ESRL) TOPAZ ozone LIDAR, which will be operated continuously (weather permitting) for periods of 4 to 8 hours on a daily basis, and for longer periods on an infrequent basis to collect vertical profiles of ozone concentrations. The data will help us to better characterize the vertical structure and mixing of ozone in the SJV.

### **Background**

The SJV is classified as an extreme ozone nonattainment area for the 8-hour ozone National Ambient Air Quality Standard (NAAQS). To attain the NAAQS, it is important to better understand how the various sources of ozone contribute to the high ozone concentrations. Some recent episodic field studies and modeling work suggest that baseline ozone over California may be increasing and it may contribute to ozone exceedances in the SJV under certain meteorological conditions. However, there is a lack of direct and continuous measurements of the evolution of the ozone vertical profiles in the SJV which are needed to better characterize the ozone layers aloft and how they may be mixed down to the surface. To better understand the contributions of the external pollution sources and atmospheric processes to ozone exceedances in the San Joaquin Valley, a surface ozone LIDAR will be used to measure ozone vertical

profiles continuously for about 4-8 hours per day during the 2016 ozone season. The data will help us to better understand if and how the baseline ozone aloft may impact surface air quality in the SJV.

### **Proposal Summary**

The proposed work by researchers in NOAA includes the deployment and operation of a truck-mounted TOPAZ (Tunable Optical Profiler for Aerosols and ozone) differential absorption LIDAR (DIAL) system to an appropriate secure location in the San Joaquin Valley. Details about the performance and data analysis of this instrument have been published in the overview of the Las Vegas Ozone Study which is included in the proposal package. Preliminary discussions of the site for the LIDAR have selected the airport in Visalia, due to the presence of a NOAA profiler at that location. The LIDAR will measure ozone vertical profiles for a total of 6 weeks in 2016, three weeks in the late spring, the high trans-Pacific transport season, and 3 weeks in the late summer, the high ozone season in the SJV. The LIDAR will be operated quasi-continuously for periods of 4-8 hours each day as weather permits during these deployments over intervals chosen by consultation with ARB. This effort will be coordinated with the launch of ozonesondes at the coast. The ozone profiles will be analyzed routinely and posted daily to a web site for access by ARB staff. At the end of the study, the profile data will be fully screened and validated for quality assurance and quality control, and then submitted to ARB.

### **III. STAFF COMMENTS**

Staff from ARB's Air Quality Planning and Science Division and Research Division, and Dr. Ian Faloon from UC Davis reviewed the proposal. The review team agreed that Dr. Andrew Langford's proposal provided adequate information on the ozone LIDAR measurements in the SJV. The project will provide ARB with ~6 weeks of ozone vertical profile data to better quantify the ozone vertical profile and its temporal variation in the SJV, and understand the vertical mixing of ozone aloft down to the surface during the high ozone season. Some general and specific comments/edits on the LIDAR measurements and the QA/QC of the data were received from the review team and forwarded to the Principal Investigator (PI) for revisions.

Based on the review comments on the draft proposal, the PI revised the proposal. The revised final proposal added some more specific information on the LIDAR operation and data management and QA/QC plan. The ozone LIDAR measurements in SJV, together with the baseline ozone measurements at the coastal area (described also in this report as a proposal from San Jose State University), will provide key data to begin to look into any contribution of baseline ozone aloft to surface ozone exceedances in the SJV. ARB staff will take the lead in developing a combined ozonesonde and LIDAR data analysis plan.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$107,639, subject to inclusion any changes and additions specified by the Committee.

## DISCUSSION OF A DRAFT FINAL REPORT

ITEM NO.: V.1

DATE: July 8, 2015

CONTRACT NO.: 13-304

[Link to Report](#)

### STAFF EVALUATION OF A DRAFT FINAL REPORT

**TITLE:** Environmental Fate of Low Vapor Pressure – Volatile Organic Compounds from Consumer Products: A Modeling Approach

**CONTRACTOR:** University of California, Davis

**PRINCIPAL INVESTIGATOR:** Deborah H. Bennett, Ph.D.

**CONTRACT TYPE:** Interagency Agreement

**TOTAL AMOUNT:** \$200,000

**CONTRACT TERM:** 24 Months

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

### I. SUMMARY

Low vapor pressure-volatile organic compounds (LVP-VOCs) are exempt from the VOC content limits for consumer products and are defined in the California Code of Regulations. To evaluate the availability of LVP-VOCs that may contribute to ozone formation from the use of consumer products, modeling tools were evaluated and developed for two modes of releases during the use of consumer products (i.e., direct release to the outdoor air and disposal down the drain). For the fate of LVP-VOCs found in some consumer products used in down-the-drain applications (e.g., laundry detergents, fabric softeners, dishwashing detergents, and other laundry products), a wastewater treatment plant (WWTP) fate model was applied to predict the fraction of LVP-VOCs that may volatilize at WWTPs. For the portion of the LVP-VOCs volatilized to air during product use, a multi-compartment mass-balance model was used to track the fate of LVP-VOCs in a multimedia urban environment. Based on the modeling results for the selected LVP-VOCs, loss by volatilization in a WWTP is negligible for most compounds, suggesting that most of the LVP-VOCs will not be available for ozone

formation reactions once they are disposed down the drain. In contrast, for the LVP-VOCs in a consumer product that is volatilized from the surface to which it has been applied, greater than 90 percent will remain in the air and may participate in photochemical reactions either at the source location or in the downwind areas. Comparing results from these two modes of releases emphasizes the importance of determining the fraction of LVP-VOCs volatilized versus the fraction disposed down the drain when a product is used by consumers. The results from this study can provide important information and modeling tools to evaluate the impact of LVP-VOCs on air quality.

## **II. TECHNICAL SUMMARY**

### **Objective**

The overall objective of this study is to develop and evaluate environmental modeling tools to determine (i) what portion of a LVP-VOC volatilized to air from the use of consumer products will remain in the urban air gas phase to form ozone and (ii) what portion of a LVP-VOC disposed down the drain from consumer product use will be emitted to air and subsequently form ozone. Comparing results (i.e., the overall fraction available for ozone formation) from these two modes of releases (i.e., direct release to outdoor air and disposed down the drain) allows air-quality researchers to understand the importance of determining the fraction of LVP-VOCs volatilized or disposed down the drain when the product is used by consumers.

### **Background**

The amounts of low vapor pressure-volatile organic compounds (LVP-VOCs) in some consumer products are not currently included in determining compliance with the VOC limits in the California Air Resources Board's (ARB) Consumer Products Regulations. ARB's LVP-VOC exemption was designed to account for the fact that in some product formulations, under certain conditions of use, some LVP-VOCs will evaporate very slowly or not at all due to low vapor pressures. However, some LVP-VOCs have been found to evaporate nearly as rapidly as the traditional high-volatility solvents and thus can be additional contributors to ozone formation depending on their emission rate, the portion remaining in the gas phase, and their reactivity. To help evaluate the availability

of LVP-VOCs that may contribute towards ozone formation, environmental fate modeling tools were developed and applied to select LVP-VOCs. The modeling tools and results from this project can help ARB to better understand the impact of the emissions of LVP-VOCs on ozone formation, thus improving ARB's understanding of the role of consumer products in California's air quality.

### **Project Summary**

This study calculated and compared the fraction of consumer product LVP-VOCs available for ozone formation as a result of (i) volatilization to air during product use and (ii) down-the-drain disposal. The study also investigated the impact of different modes of releases on the overall fraction available in ambient air for ozone formation. For the portion of the LVP-VOCs volatilized to air during product use, a multi-compartment mass-balance model was applied to track the fate of emitted LVP-VOCs in a multimedia urban environment. For the portion of the LVP-VOCs disposed down the drain during product use, a WWTP fate model was selected and used to predict the emission rates of LVP-VOCs to air at WWTPs or at the discharge zone of the plants.

Various models that describe the fate of chemicals in a WWTP or in an ambient environment system have been developed with different features (e.g., biodegradation, volatilization, etc.) and different model compartments (e.g., air, water, urban film, etc.). As part of this study, several models that are suitable for simulating the fate and transport of LVP-VOCs in an urban multimedia environment and a typical WWTP were reviewed. Based on the model comparison results, one representative model was selected as optimum for each mode of release (i.e., disposed down the drain and direct release to outdoor air). The necessity of a two-box regional airshed model and inclusion of dynamic conditions in the multi-compartment models were also evaluated. Based on the modeling results, in a WWTP, the LVP-VOCs selected in this study are primarily either biodegraded or removed via sorption to sludge depending on the magnitude of the biodegradation half-life and the octanol-water partition coefficient ( $K_{ow}$ ). Specifically, once LVP-VOCs are disposed down the drain, then the majority of selected compounds (28/33) had no evaporation from a WWTP and for the other five compounds/mixtures studied less than 11 percent are volatilized and may participate in ozone formation

reactions in the atmosphere. LVP-VOCs discharged to surface water from a WWTP are also not likely to be volatilized to air, but rather are biodegraded in water or sediment. In contrast, for the LVP-VOC in a consumer product that is volatilized from the surface to which it has been applied, greater than 90 percent is available for photochemical reactions either at the source location or in the downwind areas. In addition, for LVP-VOCs with small Henry's law constant and high  $K_{ow}$ , model conditions such as rain events and the composition of a model compartment influence the mass distribution among environmental compartments. Loss by reaction in other compartments such as soil and vegetation is negligible for most compounds, confirming that losses by reaction due to OH radicals or by air advection are the main loss mechanisms. In other words, once LVP-VOCs are in the outdoor air, then more than 90 percent is available for ozone forming reactions during the day either in the air basin that has releases or in the adjacent air basin which receives advective flows. Compared to daytime, the fraction of the compound degraded in all compartments can be ignored during nighttime due to small OH radical concentrations and low temperature. This fraction will be available for ozone formation the next day.

Because of the extreme differences between the predicted portion of the compounds available for ozone forming reactions from emissions to air during product use and that from down-the-drain disposal leading to a WWTP, reliable prediction of the fraction of compounds volatilized to air during the use of consumer products becomes critical for determining the fraction of LVP-VOCs available for ozone forming reactions in many product classes. The modeling effort in this study allows air-quality researchers to understand the importance of determining the fraction of LVP-VOCs volatilized or disposed down the drain when the product is used by consumers.

### **III. STAFF COMMENTS**

The first version of the draft final report (DFR) was submitted by the PI on March 23, 2015. The DFR was sent to staff in ARB's Air Quality Planning and Science Division and Research Division, South Coast Air Quality Management District (SCAQMD), Sanitation Districts of Los Angeles County, State Water Resources Control Board, and the consumer products industry groups for comments. Some major general

and specific comments and suggested revisions/edits were received from the reviewers, and sent back to the PI. The revised DFR report was received on May 15, 2015. Staff from ARB's Air Quality Planning and Science Division and Research Division reviewed the DFR again and provided additional comments to the PI for further improvement of the report. Staff believes that the PI took significant efforts to revise the report, and added additional discussions/descriptions to address the major issues/concerns raised by the reviewers. Additional explanations were added to more explicitly explain how this project fits into the whole scientific issue of the air quality impacts of the LVP-VOCs, and suggestions were given for future research needs to address the additional issues. The limitations and uncertainties associated with the environmental fate modeling were discussed in more detail. Some modeling results were also updated using the measured chemical and physical properties instead of the simulated values from the United States Environmental Protection Agency Estimation Program Interface Suite. Overall, staff believes that the results described in this report accomplished the major objectives stated in the proposal. One peer-reviewed scientific publication to date has been published as part of this project.

#### **IV. STAFF RECOMMENDATION**

Staff recommends the Research Screening Committee approve 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.