

**State of California
AIR RESOURCES BOARD**

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

December 11, 2015

9:00 a.m.

ADVANCE AGENDA

I. Approval of Minutes of Previous Meeting:

July 8, 2015

II. Discussion of a New Research Project:

- 1) "Heavy-Duty On-Road Vehicle Inspection and Maintenance Program," University of California, Riverside, \$500,000, Proposal No. 2799-284

Despite substantial reductions in oxides of nitrogen and diesel particulate matter emissions from heavy-duty vehicles (HDVs), 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: 1) identify and evaluate various approaches to HDV I/M and select one or more promising alternatives, 2) demonstrate and evaluate these alternatives in a prototype HDV I/M program, and 3) conduct a 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 or Board).

III. Discussion of Draft Final Reports:

- 1) "Very Low PM Mass Measurements," University of California, Riverside, \$100,000, Contract No. 12-320

ARB's Advanced Clean Car (ACC) regulations adopted in 2012 include particulate matter (PM) emissions standards of 3 and 1 milligrams per mile (mg/mile). Concerns have been raised by auto companies about the repeatability of PM emissions filter measurements made at these low levels. The objective of

this project was to investigate changes to the certification test procedures that could improve the repeatability of PM emissions measurements. Project results indicate that changes can be made to the test procedures to improve measurement repeatability, and this should aid in the implementation of the lower PM emissions standards.

- 2) "Development of a New Methodology to Characterize Truck Body Types Along California Freeways," University of California, Irvine, \$350,000, Contract No. 11-316

California has recently set new, aggressive targets for reducing pollution, including decreasing GHG emissions 40 percent below 1990 levels by 2030 and cutting petroleum use in cars and trucks by up to half from current levels by 2030 as an interim goal on the way to achieving reductions of 80 percent below 1990 levels by 2050. California also needs to meet federal ambient air quality standards for ozone and PM. Further, truck emissions are a major source of air pollution in California and have been linked to adverse health effects such as asthma and cardiovascular disease. To achieve air quality and climate change goals, it is critical to understand the travel characteristics of trucks in California. This study has developed and implemented a new methodology to collect high resolution truck activity data traveling on the California freeway system. The advantage of this methodology is that it uses the existing traffic detector infrastructure such as inductive loop detector (ILD) and weigh-in-motion (WIM) sites. This study has developed a method to provide detailed truck body classification for all vehicle types ranging from two axle pickup trucks to six or more axle semi-tractor trailers. The output from this study can be used to distinguish the proportion of long haul and short haul trips in major corridors and vocation which informs vehicle duty cycle. This can improve the heavy-duty vehicle classifications in ARB's Emission Factor (EMFAC) motor vehicle emissions model and to predict the effectiveness of various emissions control programs. Further, the information from this study can also be used to calibrate and validate the statewide freight-forecasting model and can help inform freight models under development by metropolitan planning organizations (MPOs). The data from this study can be used as a key input to the California Vehicle Activity Database (Cal-VAD) to estimate the truck activities. Ultimately, the results from this study can help to develop strategies to reduce emissions from California's trucks for use in the State Implementation Plan, Scoping Plan, Short Lived Climate Pollutant Plan, and Sustainable Freight Action Plan.

- 3) "New Car Buyers' Valuation of Zero-Emission Vehicles," University of California, Davis, \$358,806, Contract No. 12-332

New car buyers' valuation of zero-emission vehicles (ZEVs) was assessed via on-line survey and in-person interviews with a subset of survey respondents. Questions about ZEV awareness, knowledge, experience, and consideration were asked prior to, and form the set of explanatory variables for, the valuation measure—the drivetrain type selected by each respondent as a plausible next new vehicle in a survey design game. The survey was administered in California and 12 other states, including those adopting California's ZEV rules under

section 177 of the federal Clean Air Act. Even in California, awareness, knowledge, experience and consideration of ZEVs - battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs) - was low by almost every measure. Still, 38 percent of California respondents opted for one of these three ZEV drivetrains in the survey's design game, which reflects current sales availability and pricing of ZEVs as well as current federal and state government incentives. Respondent clusters are identified by motivations for or against designing a ZEV. The most commonly cited motivation for selecting a ZEV was fuel cost savings, while the most common reason for not selecting a ZEV was the limited number of charging/fueling locations away from home. A major finding is that awareness of ZEV technologies and vehicle availability remains low.

- 4) "Analyzing the Economic Benefits and Costs of Smart Growth Strategies," University of California, Berkeley, \$330,000, Contract No. 11-326

California's Senate Bill (SB) 375 (Sustainable Communities and Climate Protection Act of 2008) aims to reduce transportation-related GHG emissions through more efficient patterns of land development. To achieve the regional GHG reduction targets required by SB 375, local governments and landowners must implement smart growth plans developed by regional planning organizations. The success of SB 375 is therefore subject to the decisions of local land use authorities and developers. Advocates claim smart growth policies will reduce vehicle travel while benefitting residents, cities, and regions in the form of more attractive communities, more affordable housing, and healthier municipal finances.

In this study, the PI's analyzed the economic impacts of existing smart growth plans similar to those currently being considered and adopted throughout metropolitan California. Through five case studies of neighborhood-level plans already implemented in California, they examined the effects of smart growth interventions on residential development, commercial development, municipal budgets, and vehicle travel. A combination of quantitative and qualitative methods to estimate the net benefits and costs from the regional, municipal, and household perspectives were used.

In most cases, the plans produced net benefits for the stakeholders considered. The benefits emerged from plans that resulted in denser development in relatively central locations with good access to transit. However, in some cases the plans produced costs, and impacts were not evenly distributed. The research suggests smart growth policies can produce benefits, but planners must be aware of potential costs.

- 5) "Reducing In-Home Exposure to Air Pollution," Lawrence Berkeley National Laboratory, \$1,300,863, Contract No. 11-311

Mitigation measures are needed to reduce entry of outdoor pollution into homes in areas that exceed ambient air quality standards and those in close proximity to

vehicle emissions. Investigators tested eight combinations of pollutant removal technologies and mechanical ventilation systems to assess their effectiveness in reducing indoor pollutant levels in homes and the associated energy use. They measured outdoor and indoor air pollutant levels for each system in a modern test house. The primary focus of the pollutant measurements was on PM_{2.5}, ultrafine particles (UFP), and black carbon (BC). Results showed substantial benefits of high efficiency filtration, but with varying energy costs. Use of a high efficiency filter [Minimum Efficiency Reporting Value (MERV) 16] on a supply ventilation system was most effective in reducing indoor concentrations of outdoor particles (97-98 percent reduction) with low energy usage. High efficiency filtration on the central forced air system achieved similar results, but with a greater energy penalty; however, energy use would be lower with a newer technology system. This study provides information that can be used to improve California's building codes and reduce indoor exposures to air pollutants.

- 6) "Atmospheric Measurement and Inverse Modeling to Improve Greenhouse Gas Emission Estimates," Lawrence Berkeley National Laboratory, \$680,000, Contract No. 11-306

The California Global Warming Solutions Act of 2006 (Assembly Bill 32 (AB 32)) requires ARB to reduce statewide greenhouse gas (GHG) emissions to 1990 levels by 2020. This effort relies on accurate accounting of emissions for effective mitigation planning and verification of future emission reductions. Atmospheric GHG measurements from networks of towers, when combined with inverse model estimation techniques, have the potential to accurately quantify current GHG emissions. This project reports on tower measurements and inverse model analyses of emissions for major GHGs which include fossil fuel CO₂ (ffCO₂); methane (CH₄); and nitrous oxide (N₂O); using multi-site and multi-year atmospheric observations. An inverse modeling framework was used to estimate emissions by comparing GHG mixing ratios with an atmospheric transport model (Weather Research and Forecasting and Stochastic Time-Inverted Lagrangian Transport, WRF-STILT) predictions based on high-resolution prior emission models that were evaluated using meteorological predicted and measured carbon monoxide (CO) mixing ratios. Utilizing this technique, the analysis yields state annual anthropogenic CH₄ emissions that are slightly higher (1.2 - 1.8 times) than the anthropogenic emission in ARB's current inventory (1.64 Tg CH₄/yr in 2013), and state annual anthropogenic N₂O emissions of 75 – 97 Gg N₂O/yr, that are 1.5 - 2.5 times larger than the current ARB inventory (44 Gg N₂O/yr in 2013). Assuming the model bias in CO is applicable to CH₄ and N₂O, the estimated emissions drop to 1.0 - 1.6 times the ARB inventory for CH₄, and 1.3 - 2.3 times the ARB inventory for N₂O, if corrected for the 10 percent median emissions. The results also suggest that the livestock sector was likely the major contributor to the state total CH₄ emissions, while agricultural activities are likely a significant source of anthropogenic N₂O emissions in California. The study also noted that a large portion of the increase in global atmospheric N₂O can be attributed to the use of fertilizers.

While the ffCO₂ emission, which accounts for the majority of the total GHG emission in California, is similar to the state inventory in central and southern

California, this study shows that the state inventory underestimates both CH₄ and N₂O emissions, in particular in the Central Valley region. This study's results suggest that while continued effort to reduce ffCO₂ emissions should be the first priority in achieving California's GHG emission goals, mitigation of CH₄ and N₂O emissions from the Central Valley would provide additional benefits.

- 7) "Source Speciation of Central Valley GHG Emissions Using In-Situ Measurements of Volatile Organic Compounds," University of California, Berkeley, \$360,000, Contract No. 11-315

To guide development of greenhouse gases (GHGs) reduction strategies, California has developed state-wide GHGs emission inventories (EI). ARB has supported research to improve our GHGs EI, developing regional and source specific information for some GHGs. For example, the Board has supported methane and N₂O research programs including measurements at towers and inverse modeling. In this project, the principal investigators (PIs) used proton transfer mass spectrometry (PTR-MS) to continuously measure a suite of volatile organic carbon species (VOCs), at five elevations on a tall tower in Walnut Grove from summer 2012 through early fall 2013. The VOC data and continuous CO₂, CH₄, and CO measurements were analyzed by the PIs to develop source apportionments for CH₄ and N₂O. Their results confirm that dairies and livestock are the largest regional sources contributing to CH₄ emissions, accounting for 55-90 percent of total emissions over different seasons. N₂O agriculture emissions accounted for about 80 – 90 percent of the observed enhancements during fertilizer use in the spring and summer but declined to about 20 percent of the observed enhancements in late fall season when crops are harvested. In contrast, N₂O emission from the dairy and livestock source were relatively constant across seasons, accounting for > 80 percent of the total enhancements in fall and winter. and fractionally less when agricultural emissions were larger. The role of motor vehicle and hydrocarbon extraction emissions was not significant in the regional inventory and which differs from the state wide GHGs EI. Study findings highlight the importance of long-term measurements to validate the inventory of non-CO₂ GHG sources.

- 8) "Evaluating Mitigation Options of Nitrous Oxide Emissions in California Cropping Systems," University of California, Davis, \$400,000, Contact No. 11-313

Agricultural soils are a major source of the GHG nitrous oxide (N₂O) in California, contributing 53 percent of the State's total N₂O emissions. Production of N₂O in soil is mainly a microbial process involving transformation of various nitrogen (N) species, which can be affected by many soil variables governing soil microbial activities. It is possible, therefore, to minimize N₂O emissions from soil through proper management practices that would shun soil conditions known or suspected to stimulate N₂O emissions. This project examined effects of different N fertilizer types and placements, use of nitrification inhibitors (NIs), subsurface drip irrigation (SDI), and organic management on N₂O emissions from crops of tomato, corn, and lettuce. Overall, the use of NIs, SDI instead of furrow irrigation (FI), and incorporation of N fertilizer into two instead of one band most consistently reduced N₂O emissions in tomato or corn. SDI effects in lettuce

were inconclusive. Organic management in tomato showed slightly higher direct N₂O emissions than conventional management, due to the FI associated with organic systems. N₂O emissions in different fertilizer sources were in order of ammonium N > mixed ammonium and nitrate N > nitrate N, indicating that nitrification contributed more N₂O than denitrification in the systems tested. The results of this study provided experimental evidence for mitigating N₂O emissions from California cropping systems. More analyses, however, would be required to assess the economic and other environmental impacts as well as the total carbon footprint of the management options before ARB can make any policy recommendations.

- 9) "Modeling the Formation and Evolution of Secondary Organic Aerosol during CalNex 2010," University of Colorado, \$350,000, Contract No. 11-305

Secondary organic aerosols (SOA) formed from oxidation of gaseous precursors can constitute a large fraction of the submicron particulate mass and are responsible for significant health and climate effects. Despite their importance, a substantial gap remains between model predictions and field measurements of SOA concentrations. The objective of this project is to improve modeling of the concentration, composition and evolution of SOA in California by using measurements from the CalNex 2010 field campaign to optimize and constrain recent SOA models. Results from this study show that volatile organic compounds (VOCs) alone are insufficient to account for the observed SOA and that primary semi-volatile and intermediate volatility organic compounds (P-S/IVOCs) are needed in models explain ambient concentrations. Several different parameterizations of P S/IVOCs were investigated; these showed large differences in SOA production, which underscores the need to better constrain these species. The dominant contributors to SOA formation in the South Coast are emissions from gasoline and diesel vehicles and cooking. At long photochemical ages (~3 days), all recent parameterizations of SOA formation over predict urban SOA. Heterogeneous oxidation and fragmentation of SOA are likely to play major roles at the highest photochemical ages. Results from this project provide important model parameterization comparisons and constraints on SOA formation and aging rates for regulatory models such as CMAQ; these advances will help improve ARB's modeling basis for SIP development.

- 10) "Probing the Intrinsic Ability of Particles to Generate Reactive Oxygen Species and the Effect of Physiologically Relevant Solutes," \$301,039, University of California, Los Angeles, Contract No. 10-314

Determining the 'causative agents' in particulate matter (PM) that are responsible for damaging health is the subject of increasing research activity but many questions remain. A scientific consensus has emerged that oxidative stress mediated by reactive oxygen species (ROS) is a major mechanism by which PM contributes to illnesses and mortality. Freshly collected ambient particles are able to generate significant amounts of ROS. This work was aimed at understanding the components in PM responsible for ROS formation under physiological conditions and the role of two important ROS: hydrogen peroxide (H₂O₂) and hydroxyl radical (•OH). Measurements of aerosols in the field were

complemented by laboratory studies of ROS generation by metals and organics in PM. The detailed analysis of organics and metals from field samples identified the attribution of those components and sources most responsible for ROS activity to their sources, particularly copper from motor-vehicle braking and humic-like substances from biomass-burning. The results are expected to enable the development of PM controls that target the sources that are most responsible for the toxicity of PM.