Research in Review

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Check out other Research Seminars on our webpage at *arb.ca.gov/research/seminars/seminars.htm*

For More Information

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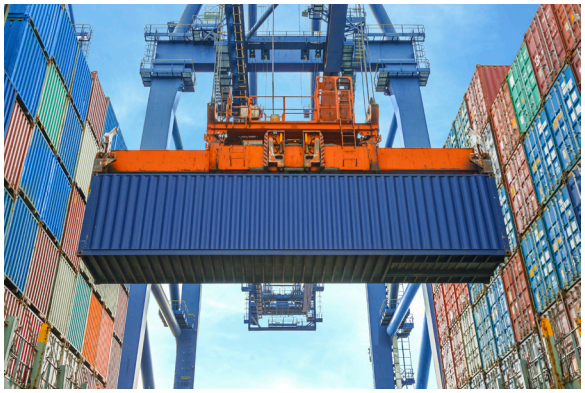
Welcome

We are pleased to present the second issue of Research in Review, a newsletter that will keep you informed about the Air Resources Board's (ARB's) recently completed research projects. The past year's completed research projects cover a range of topics from health effects, emission inventories, emission reduction strategies, effectiveness of current programs, and more.

Each issue of Research in Review presents a brief description of completed projects and results along with the ARB Contract Number that you can use to look up the full project description, final reports, public seminars, articles in scientific journals, and other products at our website *www.arb.ca.gov/research*.

Impacts of the Drayage Truck Regulation at the Port of Oakland



Heavy-duty diesel trucks emit the majority of nitrogen oxides (NO_x) and diesel particulate matter (PM) in urban areas in California. These emissions contribute to exceedances of air quality standards for fine particulate matter (PM2.5) and ozone, and may lead to adverse health effects for exposed individuals. Black carbon (BC), which is a short-lived yet potent climate pollutant, comprises the majority of diesel PM. The *Drayage Truck Regulation* is part of ARB's ongoing effort to reduce PM and NO_x emissions from diesel-fueled engines involved in freight transport. Between 2009 and 2013, the effects of heavy-duty drayage truck fleet modernization and diesel particulate filter (DPF) retrofits were examined through measurements of truck emissions near the Port of Oakland. Results show that Phase 1 of the regulation led to an increase in Port trucks equipped with DPFs from 2 to 99% and a decrease in median engine age from 11 to 6 years. Over the same period, fleet-average emission factors decreased 76 ± 22% and 53 ± 8% for BC and NO_x, respectively. The BC reductions resulted primarily from increased use of DPFs, whereas NO_x reductions were attributed to replacement of the oldest trucks with newer equipment that met more stringent NO_x emission standards. The distributions of emission factors for Port trucks have become increasingly skewed over time, with a minority of trucks now responsible for the majority of emissions of all pollutants—except carbon dioxide—measured in this study.

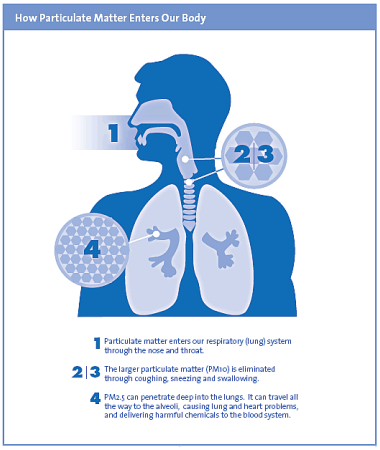
ARB Contract 09-340

Health

Living Near High Traffic Linked to Increased Air Pollution Sensitivity in Asthmatic Children

The relationship between worsening of asthma and exposure to air pollution was studied for over 11,000 asthma-related emergency room visits and hospital admissions made by 8,000 children in Orange County. This is the first study to show increased sensitivity to daily air pollution exposures in asthmatic children living in homes in areas with higher levels of air pollution from traffic, compared to asthmatic children exposed to lower levels of traffic-related pollution. Hispanic and African-American children, as well as those without private insurance, tended to live in areas associated with higher levels of traffic-related air pollution, further increasing their vulnerability. The results provide additional evidence to support ARB's regulations to reduce traffic-related air pollution. *ARB Contract 10-319*

Health Effects of Central Valley Particulate Matter



Numerous studies have investigated the health effects of particulate matter exposure, but because investigators typically measure all endpoints at the same time post-exposure, responses that occur both before and after the measurement time may not be captured. This animal exposure study was undertaken to explore the time-course for development of lung, cardiovascular, and systemic health-related responses to particulate matter exposure. The particulate matter used for the exposures was collected in two Central Valley locations. The results demonstrate that different categories of health effects (cardiovascular vs. systemic vs. pulmonary) follow different time courses for development and resolution. The results suggest that observations should extend for a longer time period after exposure and add new insights for future research study design. *ARB Contract 09-330*

Indoor Air Quality

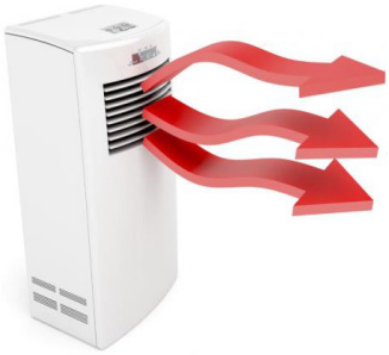
Reducing Air Pollution Exposure in Passenger Vehicles and School Buses

Exposures to vehicle-emitted particle pollutants have been associated with adverse health effects. As a potential strategy to mitigate in-cabin exposure, this "proof-of-concept" study showed that, for both passenger vehicles and school buses, the use of high efficiency cabin air (HECA) filtration was effective in reducing in-cabin ultrafine particles (UFPs) by 82-98%, black carbon (BC) by 66-96%, and PM2.5 by 30-75%, on average, under different driving conditions. These results suggest that HECA filters are especially useful for reducing in-vehicle levels of diesel exhaust particles. *ARB Contract 11-310*

Pollutant Emissions from Portable Air Cleaners

ARB's *Air Cleaner Regulation*, adopted in September 2007, is designed to protect public health by limiting the ozone emitted from indoor air cleaning devices. All air cleaning devices sold in California must meet the regulation requirements. A new generation of portable, stand-alone air cleaners relies on technologies that can generate potentially harmful by-products, including volatile organic compounds (VOCs), ultrafine particles (UFP), and/or reactive oxygen species. Emissions originating from six portable air cleaners were measured, and

results reveal that, rather than removing pollutants, some devices (using ozone-generating ultraviolet bulbs, plasma generation, photocatalytic oxidation, or ceramic heating with ionization) actually produced or had net emissions of VOCs. Some emissions were estimated to produce room concentrations that would exceed California health-based standard levels for ozone, formaldehyde, and benzene under realistic scenarios. The study's results show a need for improved designs for certain types of air cleaners to prevent harmful pollutant emissions and to improve pollutant removal rates, and for standard test methods to measure air pollution other than ozone (e.g., formaldehyde) produced by air cleaners. *ARB Contract 10-320*



Atmospheric Monitoring

Remote Sensing of Ozone Precursor and Greenhouse Gas Emissions in the Los Angeles Air Basin

Accurate quantification of atmospheric trace gas levels, their spatial distribution, and their emissions are crucial to support the development of air pollution and climate change mitigation strategies. The current approach to monitoring air pollutants relies on fixed surface monitoring sites, which limits spatial information. This project developed and deployed two novel remote sensing methods from a mountaintop overlooking the Los Angeles Air Basin to provide a more complete picture of the spatial distribution of several ozone precursors (nitrogen dioxide and formaldehyde) and greenhouse gases (carbon dioxide and methane) for three years. The observations provide novel maps of the seasonal variation of greenhouse gas emissions, which show higher methane emissions in the eastern basin, and markers for the sensitivity of ozone formation to VOC vs. NO_x, which indicate that ozone is increasingly NO_x sensitive on weekends. These and other results from this work improve the geographic resolution of the ozone precursor and greenhouse gas emissions inventories, which in turn will support ARB's ability to strategically target mitigation efforts for air quality and climate change. *ARB Contract 09-318*

Consumer Products Modeling Tools to Evaluate the Availability of LVP-VOCs for Ozone Formation

Low vapor pressure-volatile organic compounds (LVP-VOCs) used in consumer products are exempt from VOC limits in *ARB's Consumer Product Regulations*. LVP-VOCs are found in some consumer products used in down-the-drain applications (e.g., laundry detergents, fabric softeners, dishwashing detergents, and other laundry products). Environmental modeling tools were developed and evaluated to determine what portion of a LVP-VOC volatilizes to air during use of the products (which may lead to ozone formation) as well as what portion of a LVP-VOC disposed down the drain during use will be emitted to air and subsequently form ozone. Researchers used conditions representative of Southern California, an area with extreme ozone non-attainment. Based on the modeling results for the 33 selected LVP-VOCs, loss by volatilization at a wastewater treatment plant was negligible for most compounds, suggesting that a majority of the LVP-VOCs will not contribute to ozone formation once they are disposed down the drain. In contrast, when a consumer product is volatilized to air during use, greater than 90% will remain in the air and may participate in photochemical reactions, either at the source location or in the downwind areas. The study provides important information and modeling tools to evaluate the role that consumer products play in affecting California's air quality. *ARB Contract 13-304*

Sustainable Communities

The CoolCalifornia.org Challenge: A Pilot Inter-City Household Carbon Footprint Reduction Competition

The *CoolCalifornia.org* City Challenge engaged thousands of households in participating cities by providing a community-based competition framework for achieving measurable voluntary reductions of energy use and vehicle travel. Analysis of the competition data provided insights into the demographic and socioeconomic characteristics, attitudes, and motivations of households that participated in the pilot project. Participation in the Challenge was most intense as program deadlines approached, and results reveal that households which tracked electricity saved an average of 14% relative to a control population. Together, these results suggest that inter-city competitions can be a promising strategy to reduce community-wide greenhouse gas emissions. Due to the project's success in encouraging collaboration and participation through social marketing strategies, and demonstrating measurable GHG reductions, additional rounds of the competition are underway and can be used to engage households in energy efficiency and sustainability. *ARB Contract 10-325*

The next round of the CoolCalifornia Challenge, in partnership with Energy Upgrade California, will wrap up in April 2016. Learn more about the Challenge by visiting *cachallenge.org*.

Evaluating the Benefits of Light Rail Transit

This research project implemented the first before-and-after evaluation of the impact of a light rail transit investment in California on travel behavior and the active transportation co-benefits for nearby residents. The study found that long-term households living within walking distance (about 1/2 mile) of a new Expo Line light rail station in south Los Angeles had lower personal vehicle miles, on average 11 miles less each day, compared to control households. While travel behavior changed, living near the light rail station was not associated with a change in walking or bicycling travel. New residents that moved in after the light rail station opened were younger, had higher rental rate and income, and had different travel behavior, including double the light rail ridership rates than the longer-term residents. These findings provide insight into the potential of transit investments to reduce vehicle miles traveled.
ARB Contract 12-313

Quantifying the Comprehensive Greenhouse Gas Co-benefits of Green Buildings

Green buildings offer a comprehensive approach to reduce greenhouse gas (GHG) emissions by minimizing the energy, water, waste, and transportation impacts from buildings. Green buildings also offer improved indoor air quality to protect occupant health, assure comfort, and maximize productivity. Previous research has focused on the operational energy performance of green buildings and its GHG consequences, but little has been done to quantify the GHG consequences of other building operations and management strategies rewarded by green building certification systems like the Leadership in Energy and Environmental Design (LEED) green building rating system. This research project is the first known effort to quantify the real-world performance of almost 200 commercial buildings throughout California that obtained green building certification under the LEED for Existing Building Operations and Maintenance (LEED-EBOM) rating system. On average, the certified green commercial buildings cut GHG emissions from both water consumption and solid waste by 50% and lowered transportation-related GHG

emissions by 5%, when compared to traditional California office buildings. Transportation is over 100 times more GHG-intense per square foot of office building than either water or waste, and is also more than twice as GHG-intense per square foot as operational energy. The results suggest that building-level transportation strategies have the potential to substantially reduce building-associated GHGs. This information can support incorporation of GHG reduction strategies in the state's mandatory Green Building Standards Code and local government building codes. *ARB Contract 11-323*

Mobile Sources and Fuels

Technical Analysis of Vehicle Load-Reduction Potential for Advanced Clean Cars

Passenger car and light truck manufacturers are implementing strategies such as aerodynamic drag improvements, reduced tire rolling resistance, and mass optimization to reduce greenhouse gas emissions and improve fuel economy. Model year 2014 vehicles were studied to determine the extent to which vehicle load reduction technolgies have already been applied. The potential reduction in CO_2 emissions from the application of best-in-class load reduction technologies is up to 10.4%, which is nearly one third of the 34% needed to meet the requirements of *California's Advanced Clean Cars Program*. This analysis provides valuable input for the Mid-Term Review of the Advanced Clean Cars regulations, and will help ARB shape light-duty vehicle policy going forward. Automobile manufacturers, as well as tire manufacturers, continue to look for designs and materials that improve aerodynamics and provide lower rolling resistance while still satisfying handling and durability criteria. *ARB Contract 13-313*

Assessment of the Emissions and Energy Impacts of Biomass and Biogas Use in California

In recent years, biomass has provided about 2% of California's electrical power mix, but could provide 8% by 2020. Most of this biomass has come from woody material, but energy is increasingly being derived from other sources, including municipal solid waste, food processing waste, animal manure, and wastewater treatment. This study assessed the air quality impacts of existing and projected bioenergy capacity in California, focusing on biomass feedstocks and advanced technologies. Emission factors were combined with facility locations and entered into an air quality model to predict impacts from possible bioenergy scenarios. With current technology, the maximization of bioenergy production could increase NO_X emissions by 10% in 2020, which would cause increases in ozone and PM2.5 concentrations. However, the use of technological upgrades and emission controls would minimize these air quality impacts. The results should assist in the development of strategies to meet the state's *Renewable Electricity Standard* and *Low Carbon Fuel Standard*. *ARB Contract 11-307*

About the Air Resources Board's Research Program

California's progress on addressing environmental problems is guided by a strong scientific knowledge base. The Air Resources Board sponsors a comprehensive program of research into the causes, effects, and solutions to the air pollution problem, supporting its regulations on cars, trucks, fuels, power plants, and other sources. The research is done under the guidance of ARB's Research Screening Committee and in partnership with the University of California system and other research institutions.

Learn more about these projects including their final reports, public seminars, articles in scientific journals, and other products by visiting *www.arb.ca.gov/research*.