



Celebrating Twenty Years of Success

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CE-CERT's original logo, left, emphasized the triangular relationship between government agencies, industry and academia with CE-CERT serving as an "honest broker" in scientific research. The current logo highlights the center's atmospheric chamber, its transportation focus and its location. Beginning on the next page, we follow the 20-year timeline of CE-CERT's history.



It is hard to believe that twenty years ago, CE-CERT had its humble beginnings as a brand new research “center” within the Bourns College of Engineering, initially addressing local air quality problems. CE-CERT started to expand quickly and two decades later, CE-CERT has “grown up” to be a premier research institute at the University of California, Riverside. As part of our mission, we continue to contribute towards improved environmental quality and energy efficiency by conducting a broad program of interdisciplinary basic and applied research and by providing educational opportunities for the next generation of engineers, scientists and policy-makers.

It has truly been my pleasure to see the progress we have made. When making plans for our 20th Anniversary, we sat down to reflect on our biggest successes—many that are highlighted in this annual report. These span our key research areas: emissions from advanced technologies and fuels, transportation systems research, atmospheric processes, sustainable energy fuels, and solar energy. We are now doing \$12 million annually in sponsored research, up from less than \$4 million in 2008. We are seeing our work used by regulators and industry to improve products and protect the environment. Our graduate students are receiving doctorates and masters’ degrees each year, and finding jobs in academia, industry and with regulatory agencies. Our undergraduates are being introduced to the practicalities of engineering, and enjoying their ability to translate their dreams for the environment into things that work.

The diversity of our research is one of the keys to our success. Spanning the disciplines of Chemical, Environmental, Mechanical, Electrical, Computer Science, and Material Engineering, we do the science for vehicle manufacturers and vehicle regulators; we work with industry interested in new fuels and new engine technologies; we work with the potential of solar power and its ties with smartgrids and energy distribution systems; we work with emerging technologies that guide drivers through traffic; we hold conferences to educate users about technologies such as portable testing systems.

And we think there’s more to come. We have excellent infrastructure. Our dynamometers can handle a variety of vehicles and engines. And our on-board equipment and expertise allows for testing under real-world conditions. Our atmospheric chamber allows us to delve into the chemistry of pollution formation to a degree impossible elsewhere and to collaborate on studies of the health effects. Our experience with vehicle control systems is unmatched and our laboratories allow groundbreaking work on new fuels.

For 2013, our major goal is to take the successes of the last two decades and envision a future for CE-CERT that brings all of our expertise, experience and equipment together on a wider range of research projects.

Matt Barth
Yeager Families Chair
CE-CERT Director



CE-CERT: A 20-Year Historical Perspective

92 Case Statement for CE-CERT published
CE-CERT ESTABLISHES OFFICES ON UCR'S CAMPUS



93 1st Grant Won: AQMD "Integrated Transportation/Emissions Modeling (ITEM) Framework"

93



CE-CERT Moves and Establishes Laboratories at Bourns Inc.

1ST WORLD CAR CONFERENCE HELD

It was a very successful year for the Transportation Systems Research group at CE-CERT, continuing to conduct leading-edge research in environmental-Intelligent Transportation System applications, advanced vehicle positioning and mapping, vehicle activity data collection and analysis, and integrated transportation-emissions modeling. It was unusual in that it was a standout year for the group for technology demonstrations.

Eco-friendly Intelligent Transportation Systems

As part of our Eco-friendly Intelligent Transportation Systems (ECO-ITS) research, we demonstrated with BMW and UC Berkeley how infrastructure-to-vehicle wireless communications can save fuel at roadway intersections. Using a sophisticated BMW-instrumented vehicle, we were able to do some initial experiments at Berkeley’s Richmond Field Station in Northern California early in the year. This was part of a larger Exploratory Advanced Research project with the Federal Highway Administration (FHWA) on Advanced Signalization. It provided the groundwork for some follow-on ECO-Signal research as part of the U.S. Department of Transportation’s AERIS research program (Applications for the Environment: Real-Time Information Synthesis). One of the highlights for the TSR group was instrumenting our own test vehicle later in the summer and demonstrating advanced eco-signal strategies both in Riverside and at the Turner Fairbanks Highway Research Center (TFHRC) in McLean Virginia. Using algorithms that were developed initially in simulations, we had the chance to test our technology under real-world driving conditions to directly measure both energy and emissions savings under different intersection scenarios. Overall we were able to prove that it is possible to reduce fuel consumption by as much as 20% by simply adjusting the speed of the vehicle as it approaches, drives through, and departs from a traffic light. We will be back in Northern California in the summer of 2013 conducting additional eco-signal experiments along a traffic corridor under different traffic conditions. We are now in the heart of the AERIS research program where, in addition to the eco-signal research, we are investigating other advanced ECO-ITS concepts such as dynamic eco-lanes, eco-transit signal priority, eco-cooperative adaptive cruise control, and connected eco-driving.

Vehicle Positioning and Mapping

Working with Electrical Engineering Professor Jay Farrell



The combination of instruments mounted on the vehicle and the pole-mounted equipment made up the test bed for vehicle positioning research for the Federal Highway Administration.

as part of a different Exploratory Advanced Research project with FHWA, we have successfully demonstrated a next generation vehicle positioning and mapping system.

Building on our initial vehicle positioning research, we developed a prototype positioning and mapping system that integrates on-board sensors with measurements from cooperative infrastructure signals. These sensors include computer vision, RADAR, and LIDAR, (Light Detection And Ranging), integrated together with an inertial measurement and GPS unit. By placing this sensor platform on a test vehicle, we could detect lane-level roadway features at centimeter-level accuracies. This allowed creation of a very accurate lane-level map that could be used for precise vehicle positioning applications. This was also successfully demonstrated at TFHRC and has led to a numerous other presentations at conferences and workshops. We expect that this research will continue to grow, enabling numerous lane-level ITS applications well into the future.

Eco-Driving

Closely associated with our ECO-ITS research, we continue to expand our eco-driving research. We are now in the second year of our U.S. Department of Energy eco-driving project that combines different systems that provide feedback to drivers to improve their fuel economy. In addition to incorporating trip planning and scheduling software, real-time eco-driving speed advice, and a follow-up trip reporting

94		<p>SOLAR HYDROGEN GENERATING STATION ESTABLISHED</p>		95	<p>CE-CERT Students Participate In Solar Thermal Challenge</p>	<p>1st Caltrans Project Awarded: Goods Movement Study for Los Angeles</p>
<p>Ford Becomes Founding Benefactor with \$10 million Challenge Grant</p>		<p>CE-CERT Builds H₂-Powered ICE Truck</p>		<p>Gasoline Particle Research Begins</p>		

Transportation Systems Research

system, we have expanded on our eco-routing algorithms in this project. First developed in 2008, our eco-routing algorithms have now been expanded to better handle arterial roadways, incorporating not only link travel times, but also intersection delay data. The eco-routing algorithms have also been adapted for heavy-duty trucks, as part of a University of California Transportation Center research project. For heavy duty trucks and their heavy loads, road grade and heavy congestion play a major role in route selection. In addition to trucks, we are now also applying the algorithms to electric-drive vehicles to maximize their range, a project that is funded by the California Energy Commission.

The group is now actively involved in CE-CERT's New Grid testbed project, where we are integrating solar energy generation, energy storage systems, and smartgrid systems to support electric-drive transportation (see more details on the New Grid project on page 8). This group is handling the electric vehicle side of the research, examining the vehicle-to-infrastructure communications and developing new charging strategies based on feedback from the state of the power grid. By the end of 2013, we should have a variety of electric vehicles associated with the New Grid system, allowing for a variety of research experiments.

Vehicle Activity Research

Our vehicle activity research continues to flourish with a number of different projects aimed at collecting data on how vehicles operate in the real world. For example, we now have over 100 vehicles instrumented in the Caltrans alternative-fuel-vehicle fleet, with their data pouring into our system server. These data allow us to analyze the effectiveness of the alternative fuel vehicle fleet operating across the state. Further, we are continuing with several research projects that estimate vehicle energy and emissions from sensors placed in the roadway infrastructure. In addition to analyzing link travel-time data and re-constructing vehicle trajectories, we are now able to perform vehicle classification to improve the overall energy/emissions estimate. As these energy and emission estimates improve, they can be effectively used in a variety of traffic management techniques.



Jeep Grand Cherokee (inset), with instrument package mounted on the roof, at the Federal Highway Administration's Turner Fairbanks Highway Research Center in McLean, VA.

Personnel

The success of our research program is due to the excellent research faculty, staff, and students—a few of whom are highlighted here: Dr. Guoyuan Wu has moved from his postdoc position to become a key research faculty member. Dr. George Scora has expanded his role as a project scientist. One of our recent graduates, Dr. Anh Vu, has been helping with many research projects, but is leaving for the automated vehicle group at Volkswagen. Finally, we had a very successful year-long visit in 2012 by Dr. Tetsu Ishizaka from Nihon University in Japan; we continue to collaborate on several research topics.

	<p>NCHRP Emissions Testing and Modeling Project Begins</p>	<p>Commercial Cooking Emissions Research Initiated</p>	<p>CE-CERT Participates in California Regional PM10 Air Quality Study</p>	<p>CRC E-24 PM TESTING BEGINS</p>	<p>Environmental Policy Study Group Formed</p>	
<p>96</p>	<p>VEHICLE EMISSIONS RESEARCH LABORATORY OPENS</p>	<p>SMOKING VEHICLE RESEARCH PROGRAM BEGINS</p>	<p>97</p>	<p>DIESEL TOXICITY RESEARCH PROGRAM INITIATED</p>	<p>SAPRC 97 CHEMICAL MECHANISM RELEASED</p>	<p>Car Sharing Simulation Research Begins</p>

Dr. Chan Seung Park gives a tour of the Steam Hydrogasification laboratory where the Thermochemical Conversion Processes team is working on efficiently converting biomass to natural gas variants. Below is the 19-foot process demonstration unit for bench scale testing of a new water-gas-shift process for producing synthetic natural gas.



The Sustainable Fuels **Thermochemical Conversion Processes (TCP) Team** had a productive year, including securing four new projects funded by both private industry and regulators. One of the largest is a \$1.4 million California Energy Commission award to further study UCR's patented Steam Hydrogasification Reaction (SHR), which uses biomass to produce alternative fuels or electricity. Conventional processes for Substituted Natural Gas (SNG) production require additional steps such as methanation of synthesis gas, which reduce process efficiency. TCP has been developing a novel process by combining the water-gas-shift process into SHR.

Recent demonstrations of the process with a bench scale reactor have shown very promising results. The research team also found SHR was enhanced by the addition of dolime, which has been dubbed Sorption Enhanced Steam Hydrogasification Reaction (SE-SHR). With the successful completion of the project, it is expected that SNG can be produced from local waste resources in a cost-effective, environmentally friendly manner and can be used for applications such as clean burning transportation fuel or fuel cells.

Additional research is underway in creating Renewable Natural Gas (RNG) from CO₂ byproducts emissions. RNG has been identified by the California Energy Commission as an important alternative fuel for replacing traditional sources and reducing emissions. The major challenges facing the large-scale use of RNG include lack of economic viability and lack of technology options required by most vehicle manufacturers. Most sources of RNG such as landfill gas, digester gas, and syngas from gasification or pyrolysis processes contain several contaminants along with significant quantities of moisture and CO₂. The CO₂ must be removed from the gas stream in order to increase the energy density so RNG can be used as a transportation fuel. But this process is inefficient and costly. The proposed project aims to develop a cost effective technology for CO₂ conversion into a commercially valuable co-product such as methanol or dimethyl ether, and a combined CO₂ separation and conversion process that converts the CO₂ into a commercially viable co-product such as potassium carbonate.

The Sustainable Fuels **Aqueous Biomass Processing** team (ABP) was supported by over \$3 million in extramural funding in 2012. The team made numerous oral and poster presen-

<p>CMAQ ATMOSPHERIC MODEL RELEASED BY EPA 98 CE-CERT Participates In Southern California Ozone Study</p>	<p>Advanced Vehicle Engineering Lab Established at Palm Desert Campus El Sobrante Agreement Established to Support Waste-to-Energy Research</p>	<p>Students Win 1st Place, Cold Start in NREL Ethanol Vehicle Challenge 99 HYNOL TRANSPORTATION FUEL RESEARCH PROGRAM BEGINS</p>	<p>UCR IntelliShare Shared-Use Vehicle Program Launched Study of Extremely Low Emission Vehicles Begins (SELEV)</p>
<p>RESEARCH PROGRAM AT CALIFORNIA SPEEDWAY BEGINS</p>			

Sustainable Fuels

tations and published 12 peer-reviewed technical papers in high impact journals. Four graduate students (three Ph.D.s and one M.S.) successfully defended their dissertations or theses and were recruited to excellent jobs. Three new graduate students joined the group.

In September, the first five years of a project in support of the BioEnergy Science Center (BESC) funded by the DOE Office of Science was completed. CE-CERT led the pretreatment research for this collaborative project among national leaders in the biomass field. The ABP team successfully extended their novel high throughput pretreatment and enzymatic hydrolysis (HTPH) system to dilute acid and dilute alkali pretreatments that achieved results comparable to more time-consuming and labor-intensive methods.

A collaboration with the National Renewable Energy Laboratory, Oak Ridge National Laboratory, the University of Georgia, and Georgia Tech showed that agave - a plant suitable for semi-arid land with no fertilizer - has promising, unique attributes for biofuels and chemicals production. The DOE Office of Science committed to fund BESC for another five years, with UCR playing a pivotal role in identifying genetically engineered plants with significantly reduced recalcitrance to sugar release and advancing pretreatments to reduce biomass deconstruction costs.

During 2012, the South Coast Air Quality Management District (SCAQMD) chose to fund the team to apply HTPH to identify cellulosic feedstocks with favorable characteristics for conversion to biofuels in California. This research includes validating conditions that maximize product yields by conventional pretreatment and hydrolysis systems. The team designed a new steam chamber for higher pressure and temperature HTPH that allow rapid screening of biomass materials to furfural and levulinic acid for catalytic conversion to hydrocarbon “drop-in” fuels.

NREL supported ABP to efficiently convert xylooligomers (XOs) from hydrothermal pretreatment of corn stover to sugars. UCR applied HTPH to define mild conditions for dilute acid hydrolysis of XOs into monomeric xylose at virtually theoretical yields.

In a project funded by the Sun Grant Initiative from U.S. Department of Transportation funds, ABP devised a novel single-phase solvent system that significantly enhanced furfural yields and solubilized a major fraction of lignin that otherwise interferes with downstream catalytic processing to “drop-in” fuels. Kinetic models are being applied to the experimental data to better understand reaction mechanisms for product formation and degradation to guide the design of better reactors. For USDA, a Ph.D. student advanced continuous fermentation of pretreated biomass to ethanol. A three-stage train of stirred fermenters is being employed to develop first-of-a-kind data on how these systems of commercial significance perform. In addition, kinetic models are being calibrated and used to help optimize performance.



Dr. Charles Wyman shows students progress in the development of efficient processes to convert biomass into energy.

<p>ANNUAL RESEARCH AWARDS EXCEED \$4 MILLION</p> <p>00</p> <p>Awarded 2nd Place Overall in 2000 NREL Ethanol Challenge</p>	<p>Comprehensive Modal Emissions Model (CMEM v.1) Released</p> <p>CARB Unregistered Vehicle Survey Begins</p>	<p>State-of-the-Art Atmospheric Chamber Opens</p> <p>New CE-CERT Administration Building Opens</p> <p>01</p> <p>Surveys of Nitrogen Compounds in South Coast Air Basin</p>	<p>DEVELOPMENT OF MOBILE EMISSIONS LABORATORY (MEL) BEGINS</p> <p>CRC EG1 Testing Begins with Differential Optical Absorption Spectroscopy</p>	<p>H₂-Powered Vehicle Clocked Fastest at 2001 World Finals</p>
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Grad student Mary Kacarab gives Riverside-area high school students a tour to stimulate interest in math and science.

It has been an exciting year in the Atmospheric Processes Laboratory (APL) with the successful completion of two Ph.D.'s, multiple peer-reviewed journal publications, and the addition of Dr. Gookyoung Heo to the CE-CERT research faculty. Dr. Heo is an expert computer modeler with significant experience in gas-phase kinetics and chemical transport modeling and provides the laboratory with key expertise in predictive ozone and secondary organic aerosol modeling. One of Dr. Heo's current projects funded by the California Air Resources Board (CARB) is focused on **gas-phase chemistry** to update and document atmospheric mechanisms for aromatic compounds and the Statewide Air Pollution Research Center (SAPRC) base mechanism. Reactions for individual volatile organic compounds are planned with upcoming funding from CARB. Additionally, a research project has been funded by the Texas Commission on Environmental Quality to research highly reactive alkenes and conduct 3-dimensional air quality modeling.

The atmospheric chemistry leading to **secondary organic aerosol formation from aromatic hydrocarbons** has remained a focal point of chamber research this past year. An updated predictive model, PM-SAPRC-2012 was delivered to CARB. This model provided secondary organic aerosol (SOA) formation predictions using the Carter-SAPRC gas-phase mechanism as an operating platform. A robust experimental database on over 17 aromatic hydrocarbons and their 1st generation oxidation products has now been generated. The database provides significant advances in our understanding of the roles of chemical structure on secondary organic aerosol formation and their chemical and physical properties. Further, the roles of the light dicarbonyl species formed from these reactions on further particle formation were examined in additional experimentation. These findings were presented at the American Association for Aerosol Research and several manuscripts on this subject are in preparation.

<p>Validation/Certification of MEL Laboratory</p> <p>02 Steam Hydrogasification Research Begins: Micro Batch Reactor</p>	<p>Emission Inventories Developed for Regional Haze Modeling</p> <p>CE-CERT Hybrid Electric Vehicle Races in Costa Rica</p>	<p>CRC E-60 Ammonia Tunable Diode Laser Spectroscopy Testing Begins</p> <p>CRC E-67 ETHANOL TESTING BEGINS</p> <p>03 Secondary Dilution System Developed to Measure PM, Semi-Volatile Organics, EC-OC Ratio and Toxics</p>	<p>Mini Batch Reactor Developed for Steam Hydrogasification Reaction</p> <p>SAPRC '03 Chemical Mechanism Released</p>
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Atmospheric Processes Laboratory

This year a multi-collaborator study on atmospheric impacts from **agricultural precursors to secondary organic aerosol** funded by the National Science Foundation was completed. For the first time, detailed chemical mechanisms were developed for primary, secondary, and tertiary amines, which verify field observations of enhanced aerosol formation near agricultural fields by amine based precursors. Additional secondary organic aerosol work on aging of complex mixtures including meat smoke, wood smoke, and vehicle exhaust allowed for detailed chemical and physical characterization of these sources as their atmospheric oxidation processes occurred. Active collaborations with the Claremont Colleges, Utah State, and U.S. Department of Agriculture personnel continued.

In climate and cloud related research, the first of its kind large scale laboratory studies of the **hygroscopic properties of sesquiterpene secondary aerosol** was published in Atmospheric Chemistry and Physics, and the hygroscopic properties of health related aerosol generated from cigarettes were also published in Aerosol Science and Technology.

Research also began in the area of **water nucleating properties of Black Carbon (BC)** containing aerosol from two distinct sources: biomass burning and vehicular emissions. The research team found that the contribution of black carbon to the total biomass burning aerosol mass decreases during aging and photochemistry in the chamber facility – which can affect cloud nucleation predictions and promote cloud nucleation activity in biomass burning systems. The APL group continues to develop a viable on-line technique to understand the nucleating properties of BC-aerosol compositions. The technique has been applied to vehicular studies that investigate the emission from alcohol-gasoline fuel blends. In these early stages, computation fluid dynamics has been used to simulate flows and control behavior in an apparatus built to control and modify BC/OC mixing states. Efforts have also begun to look at secondary particle formation and water-uptake of vehicular exhaust aged in the environmental reactor chamber.

Finally, the **undergraduate and graduate students**



Shunsuke Nakao works through the painstaking process of ensuring the bag is sealed tight before an experiment.

continue to play a vital role in supporting chamber research and in learning about our new chamber instrumentation - such as the PILS-ToF used to observe time dependent aerosol chemical composition changes from the oligomerization processes. Dr. Shunsuke Nakao and Dr. Christopher Clark defended their Ph.D. dissertations on such topics, while Ms. Lijie (Sara) Li and Ms. Chia-Li (Candice) Chen) advanced to candidacy. Two other students, Ms. Ping (Annie) Tang and Ms. Xiaochen (Esther) Tang, prepare to defend their Ph.D. dissertations in the coming months. Additionally, Diep Vu received an EPA STAR award, Ashley Vizenor received an USDA WRI Graduate Student Fellowship and Michael Giordano received an NSF Graduate Student Honorable Mention.

<p>Joe Norbeck Moves to Campus to Lead ERI/ Matt Barth Named Interim Director</p> <p>04</p> <p>LOCOMOTIVE, PORT, & HARBORCRAFT EMISSION RESEARCH BEGINS</p>	<p>PEMS Back-Up Generator Testing</p> <p>1st CE-CERT Shanghai Jiaotong University Research Exchange</p>	<p>Next-Generation Navigation Research Begins</p> <p>05</p> <p>Heavy Duty Engine Dynamometer Opens</p> <p>Construction of 11lb/hr Continuous Steam Hydrogasification Reactor</p>	<p>Cellulosic Ethanol Pretreatment Lab Opens</p> <p>EPA Funds PEMS Verification Testing Program</p> <p>CE-CERT Collaborates in WGA Air Quality and Regional Haze Modeling</p>
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The Winston Chung Global Energy Center (WCGEC) and the Southern California Research Initiative for Solar Energy (SC-RISE) enjoyed a year marked by growing collaboration, both with each other and outside groups.

An innovative project, called “The New Grid: Integrating Photovoltaics, Energy Storage, and a Local Utility for Electric Transportation” (see diagram below) is being funded primarily by the South Coast Air Quality Management District. WCGEC, SC-RISE and CE-CERT are teaming up for the research, supported by the City of Riverside and its Public Utilities agency, UCR’s Physical Plant, Transportation and Parking Services, and Capital and Physical Planning departments, along with Bourns, Inc., SolarMax, and the Riverside Transit Agency.

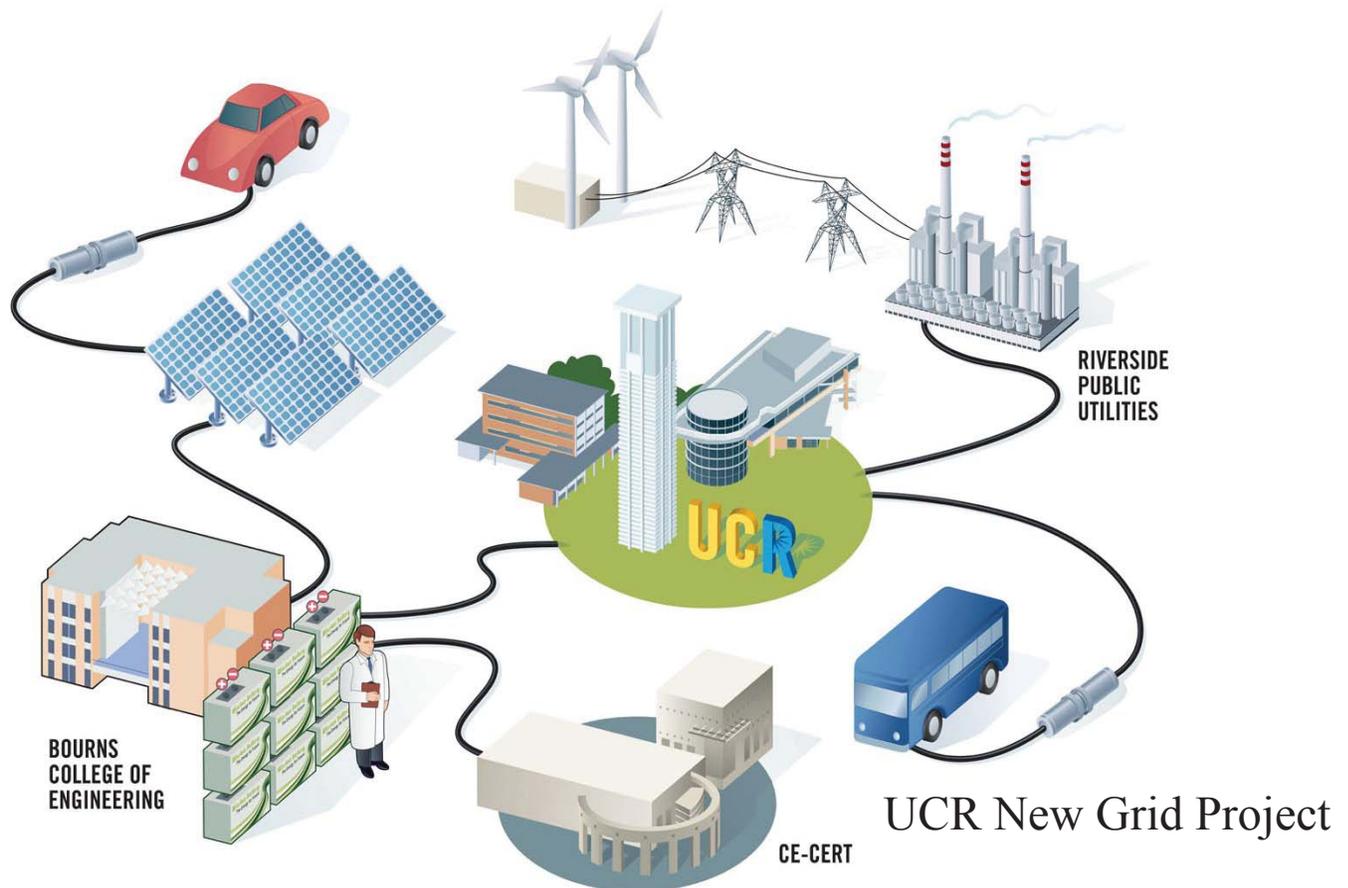
The key participants are helping to integrate four primary project components:

- 1) Up to two megawatts of integrated solar photovoltaics capacity on campus and at CE-CERT.
- 2) 2.2 megawatt-hours of battery-energy capacity;
- 3) Several Level II electric vehicle charging stations and

- one Level III fast charging station and,
- 4) An electric trolley route servicing the general UCR region.

This integrated renewable energy system will create a unique utility-connected smartgrid research testbed which couples energy generation, storage, and electric transportation. The successful deployment of this integrated renewable energy generation and energy storage project for electric transportation will place Riverside at the leading edge of advanced distributed energy management. In addition, the testbed system will allow for training and research in a variety of smartgrid technologies for UCR students and the City.

In other activities, Dr. Sadrul Ula, Managing Director of Winston Chung Center, and Dr. Alfredo Martinez-Morales, Managing Director of SC-RISE, conducted a 10-week training course through UCR Extension for 20 executives from the Energy Market Regulating Agency of Turkey. As part of this program the group visited various federal, state and local government and regulatory agencies in California,



<p>06</p> <p>WM Keck Foundation Instrumentation Gift to APL</p> <p>MEL Gaseous Emissions Successfully Correlates with Southwest Research Institute</p>	<p>CE-CERT Becomes Founding Member of the BioEnergy Science Center</p> <p>Gaseous PEMS On-Road Measurement Allowance Testing Program Begins</p>	<p>07</p> <p>Matt Barth Named CE-CERT Director</p> <p>MOU Signed with Tsinghua University (China)</p>	<p>SAPRC '07 Chemical Mechanism Released</p> <p>Steam Hydrogasification Technology Commercialized</p> <p>On-Road PM PEMS Testing Begins</p> <p>CE-CERT Surpasses \$8 million in Annual Research Awards</p>
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Southern California Research Initiative for Solar Energy and The Winston Chung Global Energy Center

Nevada, Texas and Washington, DC. Site visits were made at various solar, wind, hydroelectric, natural gas, coal and nuclear power plants.

In yet another WCGEC-SCRISE collaboration, a feasibility study, supported by the U.S. Department of Commerce, through the state's Economic Development Administration, will determine the best way to design a resource center to support the development of sustainability enterprises and industry in the Inland Empire region. SC-RISE and WCGEC will inventory existing resources, establish a consultative board, and perform technology assessment and mentoring with companies to obtain first-hand information on what the real needs are and how effectively such a center would be able to support entrepreneurship in renewable energy and other sustainability technologies.

At SC-RISE, Dr. Martinez-Morales, in collaboration with Dr. Liliana Hechavarría of the Universidad del Istmo (UNITSMO), Tehuantepec, Mexico, were funded by the UC MEXUS program to investigate and develop a novel quasi-state dye-sensitized solar cell (DSSC). Both are active researchers in the area of DSSC and solvent free electrolytes, respectively. The proposed joint research effort will leverage their complementary expertise and create synergies for a long-term collaborative program between the SC-RISE and El Instituto de Estudios de la Energía at UNITSMO.

At the Winston Chung Center, the California Energy Commission funded Dr. Ula's continuing research in improving the energy efficiency of buildings. Field data are being collected on electricity use by large heating, ventilating and air conditioning motors. Data analysis will help develop protocols which will allow the selection of properly sized and energy efficient motors – the largest energy users as a group in any building.

The WCGEC is also funding materials research in energy storage. The goal of this project is to explore and



Kimberly Huynh and Luis Duarte work on a student project designing a mobile solar-power system. For more information, see page 14.

demonstrate how electrochemically grown lithium-iron phosphate (LiFePO_4) nanowires could be an effective cathode electrode material for improving the battery energy and power density for lithium-ion rechargeable energy storage systems. One-dimensional structures such as nanowires offer advantages for enhancing battery performance including large surface to volume ratio, efficient electron-conducting pathways for ions through the electrodes, and, a 1-dimensional geometry that can promote facile strain relaxation during battery operation. These nanowires are being studied to demonstrate a charge storage capacity greater than existing bulk and thin-film LiFePO_4 cathodes.

<p>08 CARB Biodiesel Engine Study Begins</p> <p>Emissions Measurement and Modeling Research from Heavy Duty Construction Vehicles Begins</p>	<p>ECO-Intelligent Transportation System Research Begins</p> <p>Development of Synthetic Population Data Model for Riverside County</p>	<p>09 Research in Black Carbon, Cloud Nucleation, Climate Change Begins</p> <p>PM PEMS On-Road Measurement Allowance Testing Begins</p>	<p>SC-RISE Solar Initiative Formed</p> <p>Next-Generation Vehicle Positioning Research Begins</p> <p>Alt-Fuel Vehicle Telematics Research Program Begins</p>
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The Emissions and Fuels Research (EFR) group continues to play an important role in studying not only how to help achieve federal air quality standards, but in determining impacts on climate change and energy use as well. The recently released National Research Council report, *Transitions to Alternative Vehicles and Fuels*, provides a glimpse of the year 2050 when greenhouse gases for transport will be reduced by 80% and vehicles will reach the equivalent efficiency of 180 miles per gallon. CE-CERT is at the cutting edge of this research to understand the impact of the wide range of different goods movement vehicles and the potential of new fuels and technologies to help make this vision a reality.

In 2012 the EFR group authored a globally published research paper showing that emissions of criteria pollutants and greenhouse gases from existing ocean-going vessels can be reduced up to 60% by slow steaming. The group also measured the benefits of converting existing harbor tugs to the newest hybrid configuration. Both were first-time measurements of such benefits on operating ships. In a different report, the group documented the benefits of cleaner fuels and engines for the people living in port communities.

As with ocean-going vessels, little research has been focused on off-road equipment until recently, despite its significant air quality impacts and energy footprint. During 2012, the EFR group made the first measurements of in-use emissions from newly introduced commercial hybrid off-road construction equipment using a CE-CERT-designed test unit meeting all the latest federal standards. The simultaneous measurement of the activity of multiple power supplies and the gaseous and particu-

late emissions are making this research complicated. In other mobility research, the EFR group is studying battery-driven cargo handlers for use within the terminals and large electric trucks for local delivery outside the terminals. On the lighter-duty side, CE-CERT was awarded the Coordinating Research Council (CRC) auto-oil project to investigate the physical and chemical nature of emissions from modern vehicles at levels that are almost too low to measure.

The characterization of the specific emissions impacts of alternative and renewable fuels is another key research area for the EFR group. With the California Air Resources Board (CARB), CE-CERT is studying the certification of B5 biodiesel blends and B20 biodiesel blends with additives. In a CRC grant, the EFR group is exploring tailpipe emissions from modern light duty diesel vehicles using California and Federal diesel fuels blended with 20% biodiesel. Low fuel prices and greenhouse gas emissions have spurred interest in heavy-duty vehicle applications. CE-CERT is evaluating natural gas blends with funding from the California Energy Commission (CEC), CARB, and the South Coast Air Quality Management District (SCAQMD). EFR is carrying out research on the emissions from modern conventional gasoline and gasoline direct injection vehicles with gasoline blends containing various levels of ethanol and butanol. CE-CERT also is evaluating the PM composition and health effects of the measured emissions.

Another area of study for the group is the evaluation of emissions control technologies for cooking over grills fired from below and their impact on health effects. Our findings on the im-



This past year, research by the Emissions and Fuels Research group shows that emissions can be reduced by 60% by cutting the

portance of the particulate mass emission when cooking burgers with under-fired char broilers made manifest. This research is pointing towards new regulations. The EFR

<p>Heavy-Duty Chassis Dynamometer Opens</p> <p>10</p> <p>CARB PMP#2 On-Road Testing</p>	<p>Jacques & Eugene Yeager Conference Room Dedication</p> <p>Alt-Fuels Research Center of Excellence Formed</p>	<p>PM Added to SAPRC Chemical Mechanism</p> <p>11</p> <p>1st PEMS Conference and Workshop</p>	<p>CRC E-83 Olefin Study Begins</p> <p>Winston Chung Global Energy Center Formed</p> <p>Spectroscopic Laboratory Established</p>
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Emissions and Fuels Research



*...s and Fuels Group established that the emissions of criteria pollutants and greenhouse gases from ocean-going ves-
...e ship's speed, as with this container ship approaching the Golden Gate Bridge, San Francisco, CA.*

en cooking ham-
ational news and
FR group is also

extensively involved at the frontier in the development
of Portable Emissions Measurement Systems (PEMS)
for evaluating in-use emissions and and advanced spec-

troscopic techniques for measuring species such
as ammonia and hydrochloric acid from power
plants.

2012

Advanced Mapping &
Positioning Research
Begins

New Grid Energy
Research Project Begins

CE-CERT
CELEBRATES
20 YEARS OF
ACHIEVEMENT



CE-CERT Celebrates

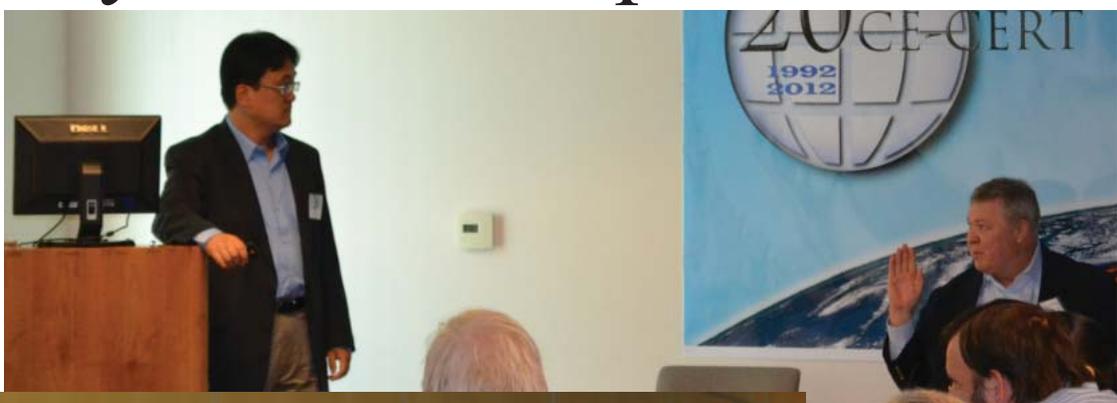


David Cocker, above, and Charles Wyman, right, give the kind of research presentations that have board member Timothy Johnson of Corning, Inc., below, leaning forward with questions.



With a day of research presentations

Center founder Joseph Norbeck discusses a point after a presentation by Tao Huai, Manager of the regulation development section of the California Air Resources Board.



Board members Timothy Johnson of Corning, Rashid Shaikh of the Health Effects Institute, Jeff Jetter of Honda and Gordon Bourns of Bourns, Inc. go over the day's research in the lobby after the presentations.

a 20th Anniversary



Staff members Kurt Bumiller, Valerie Thomas, Junior Castillo, Berenice Murillo-Quintana, and Angelique Jones-Butler enjoy dinner.



Tao Huai of the Air Resources Board and students Zhongqing Zheng and Michael Grady at the table.



Mrs. and Mr. Joe Norbeck hit the floor.

and an evening of food and fun



CE-CERT Director Matt Barth, Reza Abbaschian, Dean of the Bourns School of Engineering, and Joe Norbeck, founding director of CE-CERT, welcome guests to the dinner.



Lindsay Yee and Wayne Miller reconnect.



Daniel Sandez and Kathy Vang at the bar.



Matthew Barth, CE-CERT Director, at left, Ronald Loveridge, former Riverside Mayor, David Libatique, Director of Governmental Affairs, Port of Los Angeles, and Tim DeMoss, the port's Clean Truck Program Manager, in front of an electric truck on the CE-CERT dynamometer.

Can heavy-duty trucks run by electricity handle the load in the real-world?

The Port of Los Angeles is looking toward a new generation of electric trucks in an effort to reduce their emissions profile. Together with manufacturer Balqon Corp., the Port contracted with CE-CERT to test the performance of the truck's batteries and their ability to handle the unique cargo-

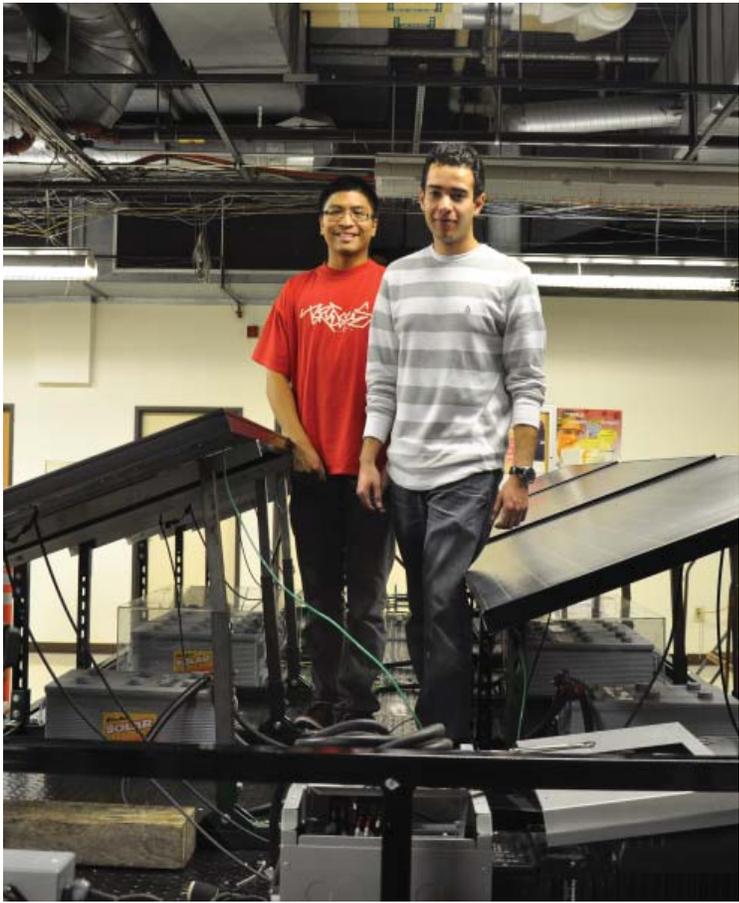
handling demands of port operations.

Dr. Kent Johnson and his Emissions and Fuels Group team tested the trucks over eight different driving schedules for several hours. Among the tests was one which simulated taking a full load up a hill. The team used CE-CERT's heavy-duty chassis dynamometer and other equipment to mimic real-world driving conditions.

Dr. Sadrul Ula, Managing Director of the Winston Chung Global Energy Center, guided a group of engineering students who designed a mobile solar-power system for campus. The project was the work of two generations of students. It was started in the 2011-2012 academic year as the senior design project of four seniors – Abel Garcia, Joseph Vicario, Meir Shachar and Ryan Sixt. After the first group graduated, another group brought the system to fruition. Those students were: J.P. Rebong (left), Luis Duarte (right), Jonathan Wong and Kimberly Huynh (not pictured).

The mobile solar power system, a sustainable alternative to a diesel- or gasoline-powered generator, is an 18-foot trailer with six solar panels, a wind turbine and eight rechargeable batteries, each of which is several times larger than a car battery. The batteries store the energy for later use.

The system's first test was to help design a solar system to pump water in UCR's Community Garden. In addition, it is designed to go everywhere from on-campus concerts to forest areas where researchers are doing field work.



Highlights of 2012



Heather McKenzie, who earned her Ph.D. in Chemical and Environmental Engineering under Dr. Charles Wyman of the Sustainable Energy Systems Group, in the spring, joined the faculty of the University of British Columbia in the fall.

CE-CERT engages in dozens of outreach activities every year. One highlight from 2012 was four Riverside Unified School District high school students participating in research programs in the Atmospheric Processes Laboratory. Students investigated “The Use of Chemical Compounds to Sustain Safer Indoor Ozone Concentrations,” “Black Carbon Emissions from Camp Fires,” and “Sustainable Methods for Particulate Removal in the Martian Atmosphere.”

CE-CERT also stepped up to help host the Science and Technology Education Partnership for the first time. The conference brought together 240 high school students for in-depth laboratory tours. CE-CERT graduate students interacted and taught the students about different careers in math and science.



Dr. Heejung Jung won the Ralph R. Teetor Education Award from the Society of Automotive Engineers. The award recognizes young professors who successfully prepare students for the challenges faced by society. Dr. Jung’s research focuses on diesel PM emissions.



Visitors to the annual Portable Emissions Measurement Systems (PEMS) Conference study an exhibit. The conference, attended by 175 people in 2012, presents updates on the technology, its uses and its potential results for regulators, industry and researchers.

To you, it may just look like lunch, but to the South Coast Air Quality Management District, emissions from char-broiling hamburger patties are a significant contributor to particulate pollution in Southern California. Those emissions can also contribute to cancer.

The district turned to CE-CERT to get solid data which it could use to develop effective regulations for the char-broilers that cook the burgers with burners underneath the meat.

Bill Welch, the CE-CERT engineer who led the study, and his team cooked hundreds of burger patties on grills from five manufacturers and measured the particulate emissions going up the vents.



CE-CERT helped the South Coast Air Quality Management District host a Lawnmower Exchange, where hundreds of older, more polluting models were taken off the lawns of Southern California and replaced by electric models.



2012 Publications

Journal Articles:

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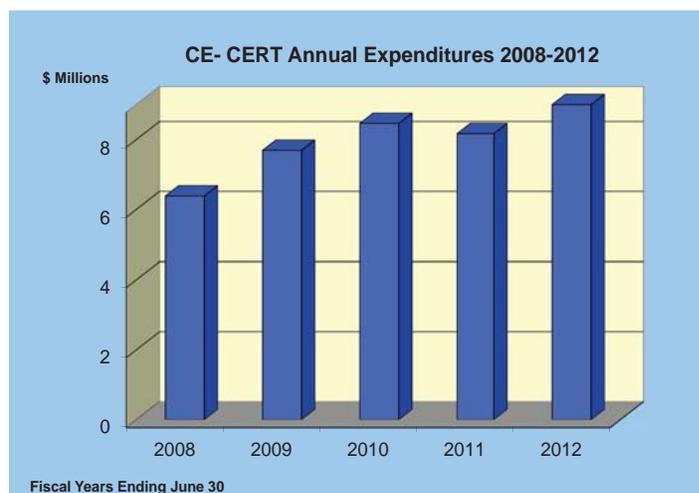
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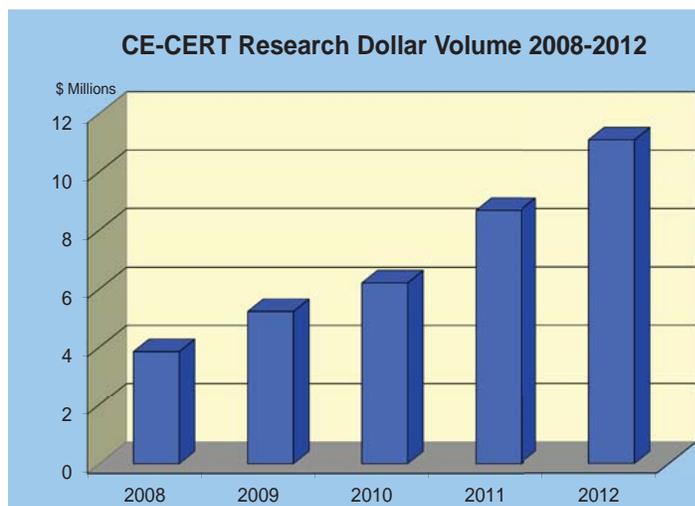
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Patents:

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Contracts and Grants Awarded in 2012 -- (A total of 47):

Asa-Awuku, Akua. U.S. Environmental Protection Agency. "Climate Impact of Advanced Diesel Emissions Control Technologies."

Asa-Awuku, Akua. National Science Foundation. "CAREER: Toward an understanding of secondary aerosol formation, particle ageing in droplets, and cloud processing."

Asa-Awuku, Akua. U.S. Environmental Protection Agency. "Understanding the Hygroscopic Properties of Black Carbon/Organic Carbon Mixing States: Connecting climate and health impacts of anthropogenic aerosol."

Barth, Matthew. UC Berkeley. "Near-Term Transportation Energy and Climate Change Strategies."

Barth, Matthew. U.S. Department of Energy/Miscellaneous Offices and Programs. "Next Generation Environmentally Friendly Driving Feedback Systems Research and Development."

Barth, Matthew. RITA (via Booz Allen Hamilton). "AERIS - Identification and Evaluation of Transformative Environmental Applications and Strategies."

Barth, Matthew. CalTrans. "Phase 3: Research and Development of an Alternative Fuel Fleet Monitoring System."

Barth, Matthew. Nissan Motor Co., Ltd. (Japan). "Phase 2 Research, Development, and Evaluation of ECO-ITS Technology to Support Off-Cycle CO₂ Reductions."

Barth, Matthew. UC Berkeley. "Region 9 University Transportation Center: University of California Transportation Center."

Barth, Matthew. South Coast Air Quality Management District. "The New Grid: Integrating Photovoltaics, Energy Storage, and a Local Utility for Electric Transportation."

Boriboonsomsin, Kanok. California Department of Transportation, Division of Research and Innovation. "High Occupancy Vehicle (HOV) System Analysis Tools District 8 HOV Facility Performance Analysis."

Boriboonsomsin, Kanok. California Transportation Commission. "Reducing Uncertainty in Modeling Vehicle Emissions at High Speed in California."

Boriboonsomsin, Kanok. California Transportation Commission. "Air Quality: The Effectiveness of Managed Lanes in California."

Carter, William. California Air Resources Board. "Update and Documentation of the SAPRC Mechanism and Associated Software and Data Files."

Durbin, Tom. Electric Power Research Institute. "UCR Laboratory TDL Test Cell Modifications for Investigation of Moisture Interference."

Durbin, Tom. Electric Power Research Institute. "Testing TDL Instrument for Measurement of HCl and HF."

Durbin, Tom. South Coast Air Quality Management District. "Determining the Physical and Chemical Composition and Associated Health Effects of Tailpipe PM Emissions."

Durbin, Tom. American Petroleum Institute. "Impacts of Aromatics in Late Model Vehicles."

Durbin, Tom. California Air Resources Board. "Evaluation of Fuel Additives as Certified Biodiesel B20 NOx Mitigation Strategies."

Goliff, Wendy. South Coast Air Quality Management District. "Development and Operation of a Test Facility for Determination of Emissions Control Efficiency for Commercial Cooking Operations."

Johnson, Kent. Emisense Technologies, LLC. "Analysis and Testing of the EmiSense Electronic PM Sensor on various Heavy Duty Diesel Vehicles."

Jung, Heejung. Coordinating Research Council. "Very Low PM Mass Measurement."

Jung, Heejung. National Science Foundation. "Fate and transformation of diesel emissions."

Karavalakis, George. Coordinating Research Council. "Biodiesel and Renewable Diesel Characterization and Testing in Modern LD Diesel Passenger Cars and Trucks."

Karavalakis, George. South Coast Air Quality Management District. "Characterization of the Physical, Chemical, and Biological Properties of PM Emissions, VOCs, and Carbonyl Groups from Under-fired Charbroilers."

Karavalakis, George. South Coast Air Quality Management District. "Health Effects of PM Particles Emitted from Heavy-Duty

Vehicles - A Comparison Between Different Biodiesel Fuels."

Karavalakis, George. California Air Resources Board. "Biodiesel Emissions Characterization Study of Engines Fueled with B5 Biodiesel Blends."

Martinez-Morales, Alfredo. UC MEXUS "Dye-Sensitized Solar Cells Based on a ZnO NW-TiO₂ NP Photo-Anode and a Solvent Free PEG-TiO₂ Composite."

Miller, Wayne. South Coast Air Quality Management District. "In-Use Emissions Testing and Demonstration of Retrofit Technology for Control of On-Road Heavy-Duty Engines."

Miller, Wayne. Bristol Harbor Group, Inc. "Measurement of Criteria Pollutant Emissions from Vessels Operated by the US Army Corps of Engineers and using Advanced Fuels."

Miller, Wayne. Southeast Missouri Regional Planning Commission. "Development of Emission Factors for Repowered Towboat for MARAD Project."

Norbeck, Joseph. California Energy Commission. "RNG and Fungible Fuels Infrastructure Compatibility Study."

Park, Chan. California State University, San Diego. "Investigation of a New Process for SNG Production using Steam Hydrogasification."

Park, Chan. California Energy Commission. "The Enhancement of SNG Production by Sorption-Enhanced Steam Hydrogasification Process with In Situ CO₂ Capture."

Russell, Robert. California Department of Transportation, Division of Planning. "Developing a Model to Quantify Emissions from Heavy-Duty Construction Equipment as Related to Job Site Activity Data."

Wu, Guoyuan. California State University, San Diego. "Eco- Routing Navigation System for Electric Vehicles."

Wyman, Charles. Alliance for Sustainable Energy, LLC. (National Renewable Energy Laboratory). "Characterization and Conversion of Xylooligomers Released During Hydrothermal (HT) and Low Severity Dilute Acid (LS-DA) Pretreatments."

Wyman, Charles. Oregon State University. "Enhanced Production of Reactive Intermediates from Cellulosic Biomass for Aqueous-Phase Catalytic Processing to Drop-In Fuels."

Wyman, Charles. Oak Ridge National Laboratory. "Identification of Optimal Pretreatment and Conversion Conditions (Activity leader: C. Wyman, UCR)."

Wyman, Charles. Oak Ridge National Laboratory. "Biomass Characterization Pretreatment Research."

Wyman, Charles. South Coast Air Quality Management District. "Identification of Biomass Feedstocks for Production of Reactive Intermediates for Conversion to Liquid Fuels in California."

Scholarship and Award Winners

Victor Aguilar, Ford Undergraduate Scholarship
Joseph Menke, Ford Undergraduate Scholarship
Amir Rusamzadeh, Jim Guthrie Scholarship
Maryam Hajbabaee, UCTC Dissertation Award
Xiaochen Tang, Esther Hayes Graduate Fellowship
Mohammad Khan, Ford Pierson Graduate Fellowship
Charles Cai, UCTC Graduate Fellowship
Denton DeLoss, UCTC Graduate Fellowship
Derek Price, UCTC Graduate Fellowship
Daniel Short, UCTC Graduate Fellowship
Hongjia Li, Martin Keller Award, best student poster presentation
in the characterization area at the Bioenergy Science Center
(BESC), Summer retreat, 2012
Johnny Wang, Research Advancement Program
Victor Aguilar, Research Advancement Program
Nigel Williams, Research Advancement Program

Ph.D.s granted

Xin Fan. “*Investigation of the Effect of In-Situ Catalyst on the Steam Hydrogasification of Biomass,*” Current Position: Faculty, Chemistry Dept., University of California, Riverside.

Seyedehsan Hosseini. “*Physical and Chemical Characterization of Particle and Gas Phase Emissions from Biomass Burning,*” Current Position: In the market.

Hongjia Li. “*Interactions of Lignin and Hemicellulose and Effects on Biomass Deconstruction,*” Current Position: Senior Engineer, DuPont Industrial Biosciences.

Xiaoming Lu. “*Development and Application of Advanced Models for Steam Hydrogasification: Process Design and Economic Evaluation,*” Current Position: Post-doctoral student at Harvard U.

Qian Luo. “*The Development of Warm Gas Cleanup Technologies for the Removal of Sulfur Containing Species from Steam Hydrogasification,*” Current Position: Engineering Laboratory, Riverside.

Heather McKenzie. “*Tracking Lignin and Hemicellulose Deconstruction During Hydrothermal Pretreatment of Biomass,*” Current Position: Ass’t Professor, U. of British Columbia.

Zhongqing Zheng. “*Investigation of Solid Particle Number Measurement of Engine Emissions,*” Current Position: Project Leader, AVL, Michigan.

Master’s degree granted

Yueh-Du Tsai. “*Dilute Acid Hydrolysis of Oligomers in Hydrothermal Pretreatment Hydrolyzate into Monomers with High Yields,*” Current Position: Engineering Company, Taiwan

Faculty

Richard Arnott, Professor of Economics
Akua Asa-Awuku, Ass’t Professor of Chemical and Environmental Engineering
Matthew Barth, CE-CERT Director and Professor of Electrical Engineering
Kanok Boriboonsomsin, Research Faculty, Intelligent Transportation Systems
William Carter, Research Faculty, Atmospheric Chamber
David Cocker, Professor of Chemical and Environmental Engineering

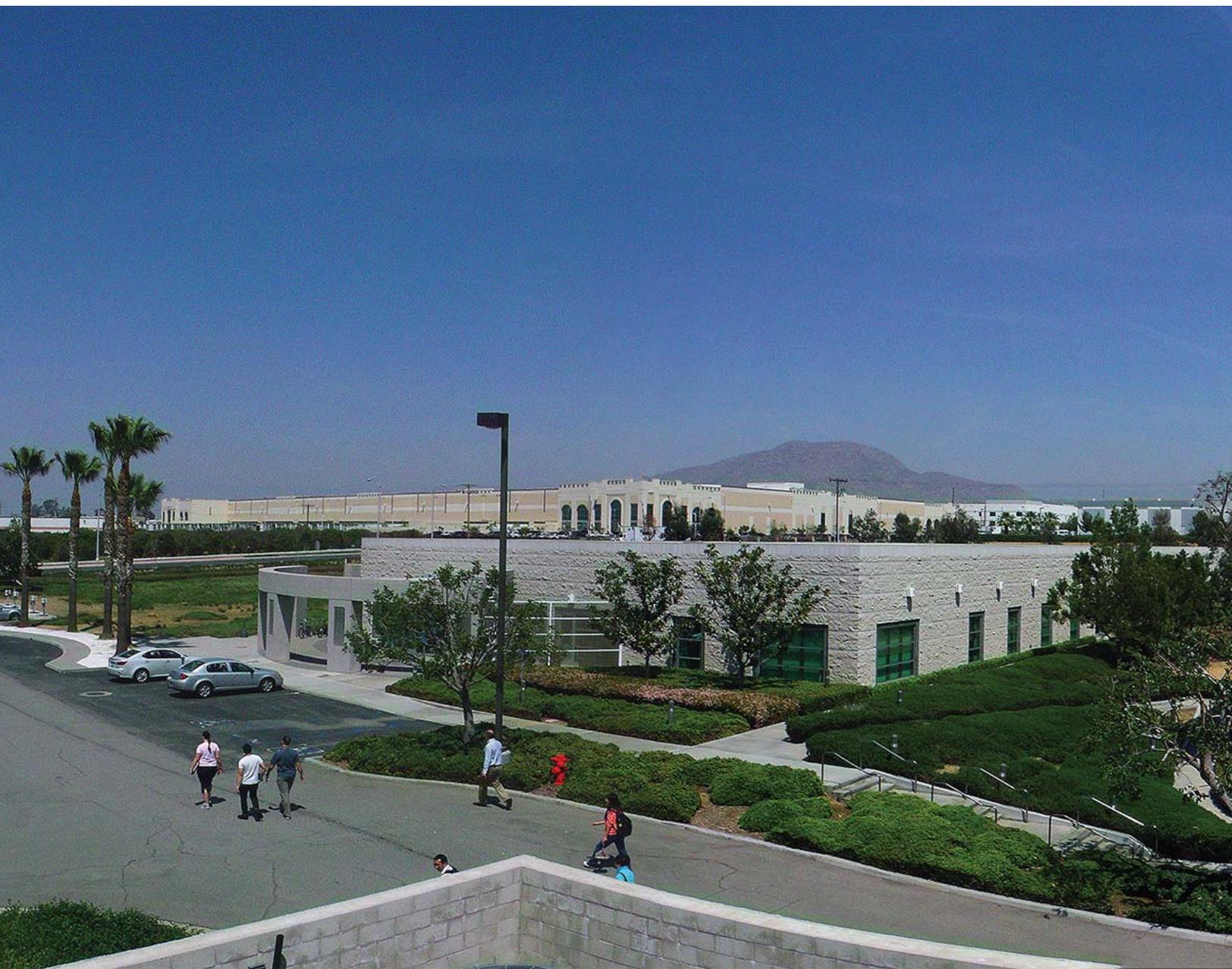
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Wendy Goliff, Research Faculty, Atmospheric Chamber
Kent Johnson, Research Faculty, Emissions Engines and Fuels
George Karavalakis, Research Faculty, Emissions Engines and Fuels
Rajeev Kumar, Research Faculty, Sustainable Fuels
Heejung Jung, Ass’t Professor of Mechanical Engineering
Alfredo Martinez-Morales, Research Faculty, Southern California Research Initiative for Solar Energy
J. Wayne Miller, Research Faculty, Emissions Engines and Fuels
Joe Norbeck, Professor Emeritus of Chemical and Environmental Engineering
Chan Seung Park, Research Faculty, Sustainable Fuels
Marko Princevac, Assoc. Professor of Mechanical Engineering
Robert Russell, Research Faculty, Emissions Engines and Fuels
Sadrul Ula, Research Faculty, Southern California Research Initiative for Solar Energy
Guoyuan Wu, Research Faculty, Intelligent Transportation Systems
Charles Wyman, Professor of Chemical and Environmental Engineering

Postdoctoral Scholars

Gookyoung Heo, Atmospheric Chamber
Shaokai Gao, Atmospheric Chamber
Taiying Zhang, Sustainable Fuels
Anh Vu, Intelligent Transportation Systems

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Undergraduate Students: Samir Benouar, Kevin Castillo, Tiffany Chea, William Chen, Eduardo Cuevas, Joseph Dean, Joshua Scott Dolson, Luis Duarte, Wyatt Duvall, Steven Em, Carlos Espinoza, Nolan Fan, Peter Seing Huang, Kimberley Huynh, Nicholas Jarak, Daisy Jimenez, Junhyuk Kang, Claudia Lau, Lani Lee, Eli Lichtenberg VI, Gary Liu, Joseph Menke, Shawn Miata, Faith Morel, Elaina Munro, Jeremy Nelson, Duc Minh Nguyen, Duyen Nguyen, Ray Nishii, Andrew Ong, Mayura Patankar, Robin Picchi, Joseph Pichette, Shrey Prajapati, Daniel Quach, Dingli Qin, Rajesh Reddy, Adam Rodriguez, Ali Roohani, Jesus Adrian Sahagun, Letia Solomon, Stephanie Stasiuk, Michelle Ta, Hasam Taghizadeh, Anh Thach, Yun Jui Tsai, Tiffany Viggiano, Johnny Wang, Charles Wardle, Nigel Williams, Jonathan Wong, Jinyu Xu, Henry Yang, Jing Yang



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