CE-CERT

BOURNS COLLEGE OF ENGINEERING – CENTER FOR ENVIRONMENTAL RESEARCH AND TECHNOLOGY

2014 Annual Report

UC RIVERSIDE
UNIVERSITY OF CALIFORNIA

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Reflecting on 2014...

CE-CERT has made large strides this last year to increase its marketing and outreach to the general community. As such, we are often approached with a number of questions on a daily basis. For example:

"What will be the fuels of the future? Will they be safe? Affordable? Sustainable?"
"What's needed to ramp up America's Alternative Energy Revolution?"
"What role to clouds play in global warming?"
"Will automated vehicles be environmentally beneficial?"

These are some of the research questions we delve into every day. Often these questions provoke relevant, timely, and exciting research that will improve the quality of life for all. This year, we learned that we are closer than ever to finding an affordable path using non-food crops such as switchgrass to produce liquid fuels through a novel pretreatment process prior to fermentation. We are perfecting technology to help our cars drive intelligently (and automatically) to improve fuel economy and emissions. We have developed smarter routing technologies to guide traffic and pedestrians to take healthier air quality pathways. We have created new laboratories to help us better understand how toxic air pollution is formed after it comes out of a vehicle's tailpipe. We are also helping determine if there are new technologies that can reduce emissions from commercial cooking technologies.

Some of our research is now playing a key role in the University of California's lofty goal of reaching carbon neutrality by the year 2025. Our Sustainable Integrated Grid Initiative (SIGI) has spawned a number of research projects that focus on connecting electric-drive transportation with energy storage and renewable energy sources. We are evaluating a number of carbon-neutral fuels and energy systems. We are also investigating different deep energy efficiency concepts. Our students, who are the lifeblood of CE-CERT, are now earning new sustainability fellowships and are excelling in their research.

As you flip through this annual report, you will see each of our group's latest research that we publish, present, and teach. You will also see select highlights of the accomplishments of 2014, new graduates and faculty, and answers to the questions above, demonstrating how CE-CERT is playing a role in providing real-world solutions to today's challenges.

As always, I would like to thank our university and college leadership, our sponsors, and our faculty, staff and students who provide inspiration and dedication every day. Together, we are moving towards our goal of a sustainable, bright future!

Matt Barth
Yeager Families Chair
CE-CERT Director

Atmospheric Processes Laboratory (APL)

It has been another exciting year in the Atmospheric Processes Laboratory.

Environmental chamber research led by David Cocker continues to advance our understanding of the chemical pathways leading to secondary organic aerosol formation. Research continues on aromatic precursors connecting gas-phase and radical chemistry to aerosol formation potentials. Two APL chamber students, Derek Price and Chia-Li Chen are nearing completion of their Ph.D. programs on atmospherically relevant amines and aerosol formation from PAH precursors, respectively. Research continues on predicting changes in SOA formation and gas-particle equilibrium as a function of temperature; improving prediction of SOA formation from complex mixtures; and SOA formation from semi-volatile precursors. A major program on the atmospheric impacts of low vapor pressure volatile organic compounds (LVP-VOCs) from consumer products continues.

William Carter continues his periodic updates of the SAPRC gas-phase chemical mechanism and coordinates with the group on predicting secondary aerosol from aromatic species. Wendy Goliff has branched out on her research to include 3-D chemical transport modeling.

Gookyoung Heo was unfortunately lured away by the National Institute of Environmental Research (South Korea), although he still continues to interface with William Carter on multiple projects.

In climate and cloud related research led by Akua Asa-Awuku, cloud condensation nuclei (CCN) activation studies are being coupled with atmospheric chamber studies as well as flow tube studies to better understand how particles activate to form CCN. This data leads to important insight on the formation of clouds in the atmosphere and the subsequent effects on climate and health.

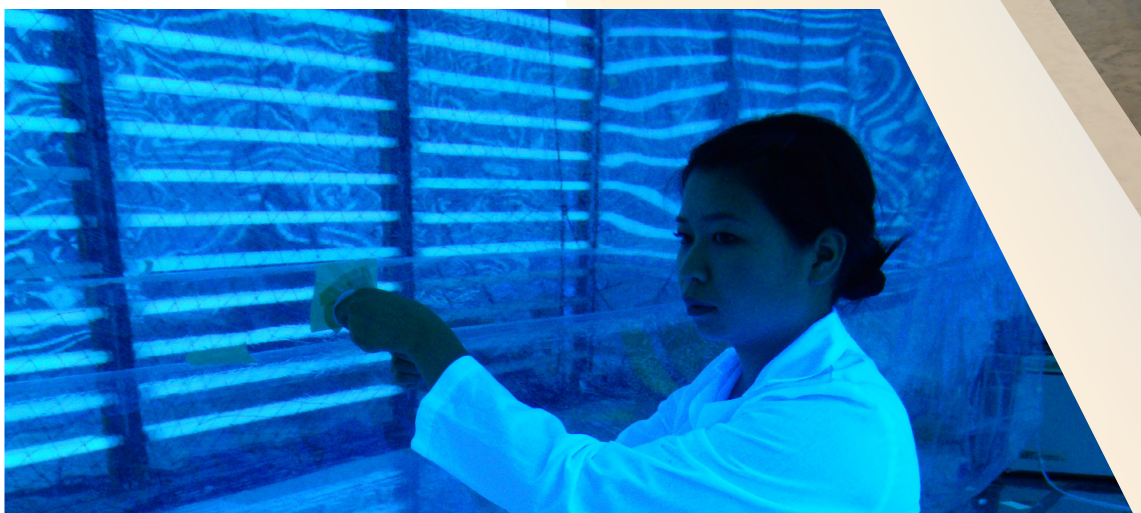
The EPA funded Black Carbon Organic Mixing State study is coming to a close, however, new work continues with the development of the UCR Portable Atmospheric Chamber. The first studies are slated for this summer and will continue over an 18 month period. Additional work continues on predicting CCN activity of both biogenic and anthropogenic precursors and the relationship of aerosol physical properties and composition to CCN activation properties from unique and varied sources. For example, the latest work explores both gas and particle phase emissions from waste water treatment systems. Akua Asa-Awuku was recently promoted to the rank of Associate Professor with tenure for her leading research on CCN and atmospheric aerosol.

APL researchers have also been working closely and submitted several proposals the with School of Medicine (SOM) faculty and the Center for Conservation Biology (CCB) to develop a new program at UC Riverside to study the direct impacts of air quality and allergens on human health. UC Riverside seed funding from the office of Research and Economic Development (RED) will be provided shortly to build an aerosol delivery interface system for the study of cardiovascular, neurogenerative, and neurodegeneratve health effects from exposure to well defined aerosol sources.

Finally, the undergraduate and graduate students continue to generate excitement and creativity in their research.

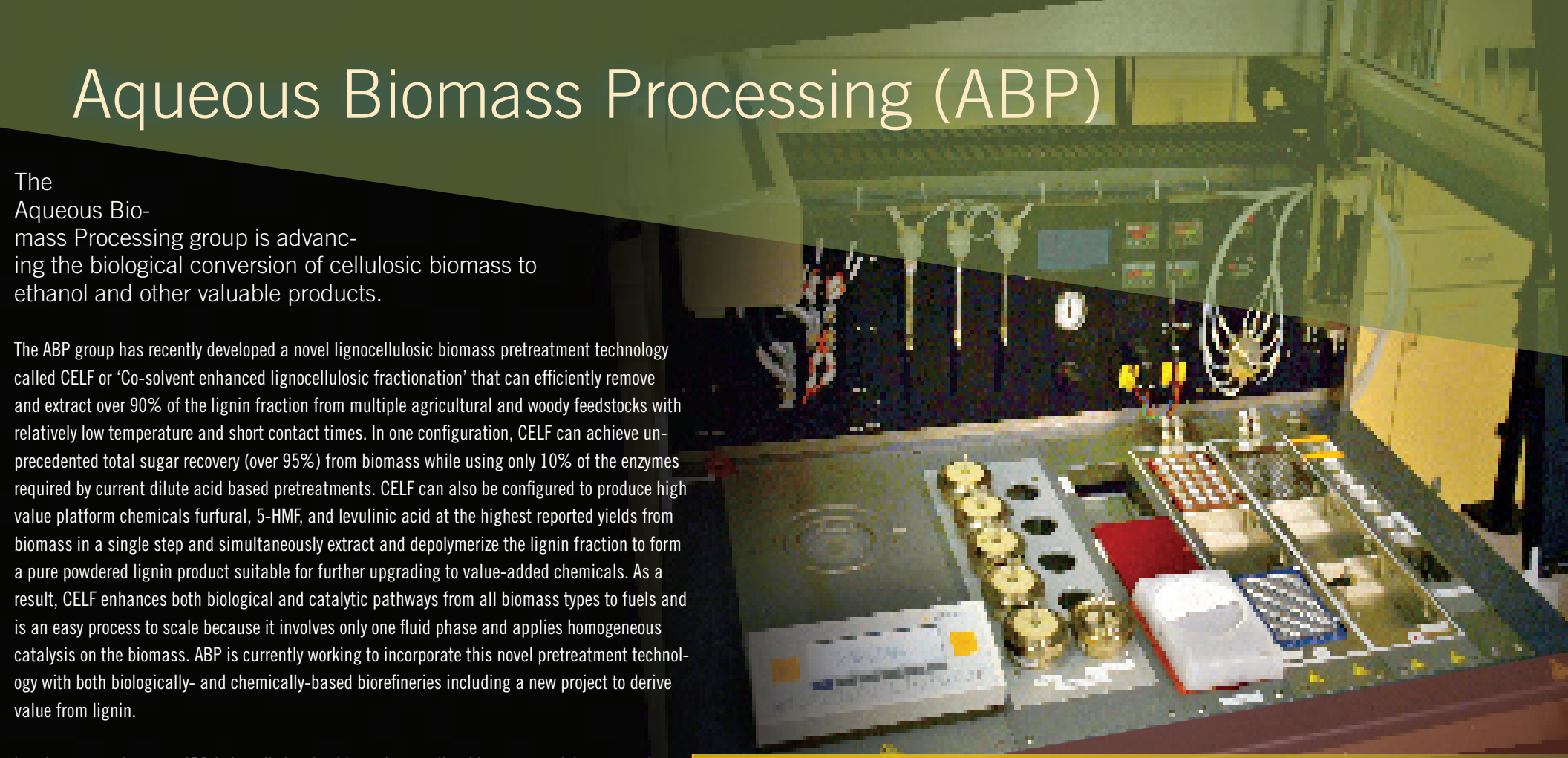
Many graduate students presented work at the American Association for Aerosol Research (AAAR) and American Geophysical Union (AGU) conferences this year, with Derek Price (pictured above) winning an AAAR award for best poster presentation. Undergraduate design teams worked along APL students researching NOx emission controls from lawn mowers and PM emission controls from residential barbeques. The two teams will demonstrate their devices at the annual P3 EPA competition in Washington DC.

Lastly, Kelley Barsanti, a new tenure-track faculty has been added to the APL research team. She brings many outstanding research skill sets and will immediately strengthen our capacity for predicting and modeling atmospheric organic aerosol formation. She will join the APL research team Summer of 2015.



The new PORTABLE environmental chamber -one of the largest- is made of 24m^3 collapsible Teflon film reactor suspended on a metal frame. The goal of the environmental chamber is to interface the progressive emissions research group with the capabilities in APL.

Aqueous Biomass Processing (ABP)



The Aqueous Biomass Processing group is advancing the biological conversion of cellulosic biomass to ethanol and other valuable products.

The ABP group has recently developed a novel lignocellulosic biomass pretreatment technology called CELF or 'Co-solvent enhanced lignocellulosic fractionation' that can efficiently remove and extract over 90% of the lignin fraction from multiple agricultural and woody feedstocks with relatively low temperature and short contact times. In one configuration, CELF can achieve unprecedented total sugar recovery (over 95%) from biomass while using only 10% of the enzymes required by current dilute acid based pretreatments. CELF can also be configured to produce high value platform chemicals furfural, 5-HMF, and levulinic acid at the highest reported yields from biomass in a single step and simultaneously extract and depolymerize the lignin fraction to form a pure powdered lignin product suitable for further upgrading to value-added chemicals. As a result, CELF enhances both biological and catalytic pathways from all biomass types to fuels and is an easy process to scale because it involves only one fluid phase and applies homogeneous catalysis on the biomass. ABP is currently working to incorporate this novel pretreatment technology with both biologically- and chemically-based biorefineries including a new project to derive value from lignin.

In other research areas, ABP is heavily involved in understanding biomass recalcitrance and characterizing its chemical, biological, and physical properties and its breakdown to sugars. The ABP have also investigated enzyme-substrate interactions to improve enzyme performance on pretreated biomass. In addition, the ABP team is investigating enzyme-free whole biomass digestion by thermophilic bacteria and simultaneous fermentation and enzyme saccharification to produce ethanol. Many of the team members belong to the BioEnergy Science Center (BESC) collaborative working to advance the understanding of plant recalcitrance and novel pretreatments of hybrid poplar and switchgrass energy crops. Others on are supported by USDA and UCTC, while the Ford Chair in Environmental Engineering enhances the ability to advance the production of biofuels.

RESEARCHER HIGHLIGHT

Improving Commercial Viability of Biofuels

Charles E. Wyman (pictured), Professor in Chemical and Environmental Engineering and Leader of the ABP group, is one of 16 authors of the paper, "Lignin Valorization: Improving Lignin Processing in the Biorefinery," which was published in the May 16 issue of Science. The paper outlines ways companies can commercialize and profit from what was thought to a waste product created when producing biofuels.

Advanced Thermochemical Research (ATR)

The Sustainable Fuels group's Advanced Thermochemical Research (ATR) Team is focused on developing new renewable energy production pathways and related research areas.

In 2014, the team finished the Process Demonstration Unit (PDU) development (shown on the right) which demonstrated that this process is viable at scale. Now proven, discussions on building a full size pilot plant of the Steam Hydrogasification process are underway with several potential commercial partners. The proposed project will convert biosolids and biomass into Renewable Natural Gas (RNG) at the City of Riverside Water Quality Control Plant. RNG is identified by the California Energy Commission as an important renewable fuel that can replace fossil fuels in an environmentally beneficial way.

The ATR team has also been developing a process for converting CO_2 into commercially valuable fuels and chemicals while reducing greenhouse gas emissions. The team is currently investigating the conversion of CO_2 into methanol, dimethyl ether, and carbonates. New pathways for CO_2 conversion are under development as part of these projects. CO_2 conversion to hydrogen is also being studied, focusing particularly on fuel cell applications using proprietary Heat Exchanger Platform (HEP) reactor.

Other projects in 2014 include the development of a fuel sensor that is a key enabling technology for Variable Natural Gas Vehicles (VNGVs). The ruggedized, cost-effective sensor measures the Wobbe number (a measure of energy flow) in real time and allows VNGVs to accept a broader range of Renewable Natural Gas (RNG) fuel properties compared to conventional RNG vehicles. The prototype of the sensor was successfully developed and evaluated with different RNG compositions.

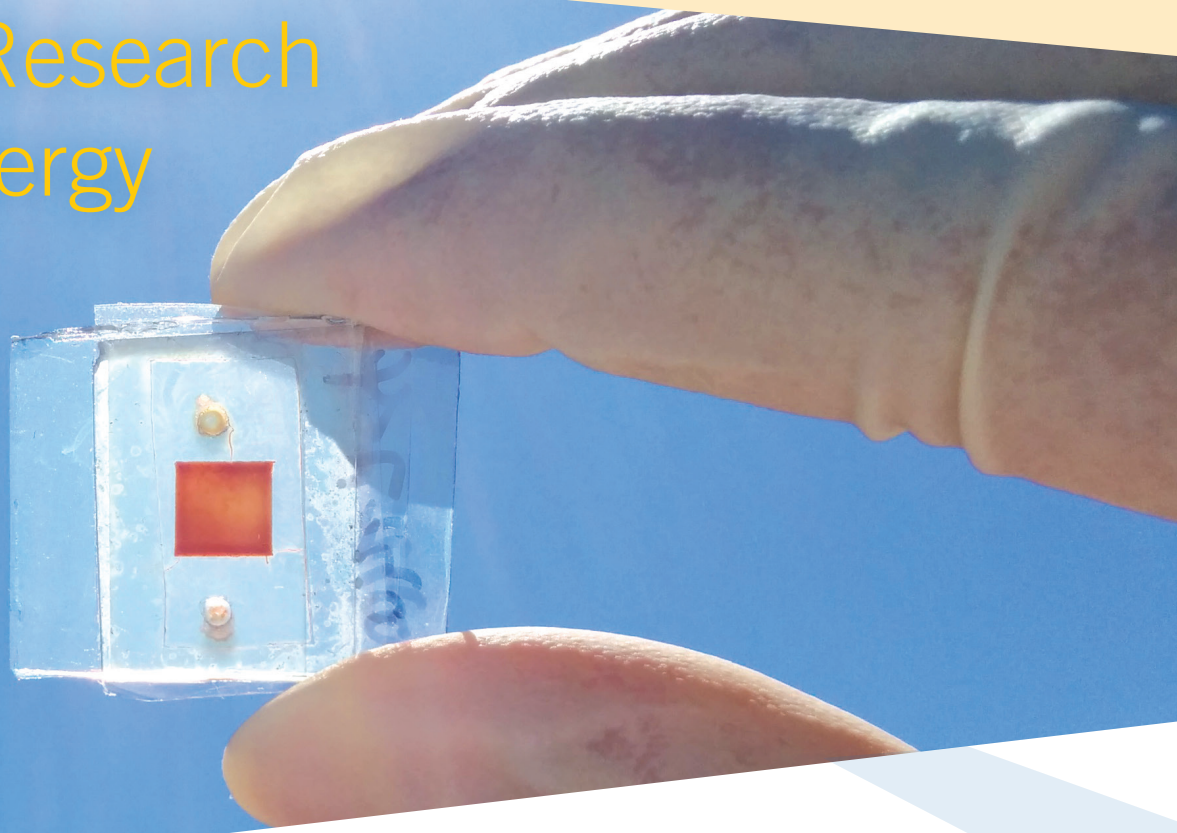
Analyses of various pathways to make hydrogen from biomass is underway with the support from the California Air Resources Board. The team is conducting comparative process analysis with several computational tools for the technoeconomic process analysis.

RESEARCHER HIGHLIGHT

Turning Harmful Gas into Valuable Fuels, Chemicals

A University of California, Riverside researcher, Arun Raju (pictured), is leading a team that won a $500,000 grant to study a process that transforms harmful greenhouse gas emissions into valuable fuels and chemicals by using a unique catalyst. The novelty of the process is an innovative catalyst for the bi-reforming reaction, referred to as pyrochlores. Temperatures around 900 degrees Celsius are typically required to produce syngas. Few materials can withstand these temperatures when coupled with the presence of steam. A preliminary analysis found that the proposed technology, if implemented at commercial scales, has the potential to reduce greenhouse gas emissions by one million tons per year or more.

Southern California Research Initiative for Solar Energy (SC-RISE)



2014 was another exciting year for SC-RISE, continuing to advance research by further diversifying research agendas, developing strategic partnerships with industries and other UC campuses, and expanding roles in the area of solar energy, battery and electric grid indergation. Specific activities are provided below.

Advanced Solar Technologies Institute (UC Solar)
Building upon an existing collaborative relationship with UC Merced and other UC Campuses, SC-RISE participated in the renewal of the UC Solar Institute in 2014. The Institute was renewed by the UC Office of the President (UCOP) through the Multi-campus Research Program Initiative (MRPI) for four additional years. As part of UC Solar, SC-RISE will continue to provide expertise in the development of photovoltaic materials, innovative solar cell architectures, and the design, integration, and demonstration of grid integrated technologies and advanced energy storage systems.

ZnO-TiO2 nanowire-nanoparticle (NW-NP) hybrid material system – In the area of energy generation, the focus continued on developing a ZnO-TiO_2 hybrid material system, as a photoelectrode for dye sensitized solar cells (DSSCs). Experimentally, SC-RISE has studied the effect of the partial pressure of Zinc vapor during material synthesis. This is critical importance because by understanding and controlling the synthesis conditions for this hybrid system, this will enable researchers to nano-engineer the optoelectrical, photocatalytic, chemical and mechanical properties of our ZnO-TiO_2 material. In 2015, we will explore expanding the applications of our material system into areas that include water purification, hydrogen generation, decomposition of Volatile Organic Compounds (VOC), self-cleaning surfaces, and additional photovoltaic applications beyond DSSCs.

Concentrated Photovoltaic (CPV) Receiver

This project is supported by the California Energy Commission (CEC) and in collaboration with Clean Energy Research Associates (CERA). In 2014, SC-RISE evaluated and demonstrated the potential for the proposed CPV receiver to be used as a replacement technology to the central receiver of existing Concentrated Solar Power (CSP) systems. SC-RISE results are encouraging and provided a pathway toward improving the engineering design and performance of the system. In 2015, SC-RISE will continue the work and are pursuing funding from the Department of Energy through the Sun Shot Initiative.

2014 Inaugural UC Riverside Solar Conference – In partnership with CE-CERT and the Center for Sustainable Suburban Development (CSSD), SC-RISE organized a Solar Conference at UCR on February 6. The conference attendees included city leaders, city planners, council members, industries, utility companies, and the general public. A variety of panel discussions covered advances in technology, public policy, economics, and the associated environmental and sustainability issues.

Ionothermal Synthesis of LiFePO4 NPs – In an effort to optimize the performance of Li-ion batteries, SC-RISE have developed an ionothermal synthesis method for the production of stoichiometric and crystalline LiFePO4 (LFP) nanoparticles. Through this approach, SC-RISE has demonstrated that high quality LFP material can be produced using a fraction of the energy typically needed in other synthesis routes. Cycling testing of batteries made with this material has demonstrated good performance with implications for increasing energy capacity and cycle life of Li-ion batteries. Additionally, this process has high potential for large-scale implementation due to its lower cost of production, lower temperature requirement, and environmental benignity.

Transportation Systems Research (TSR)

The TSR group continues to conduct leading-edge research in environmentally-oriented Intelligent Transportation System (ITS) applications, advanced vehicle positioning and mapping, vehicle activity data collection and analysis, and integrating electric-drive transportation with smartgrid technology. In 2014, TSR completed its major US-Department of Energy research project on eco-driving and started a number of new projects with the California Department of Transportation, the California Air Resources Board, Nissan, and the Federal Highway Research Administration. TSR made a number of presentations at a variety of conferences worldwide and have had a number of student accomplishments and awards. A few highlights are provide below.

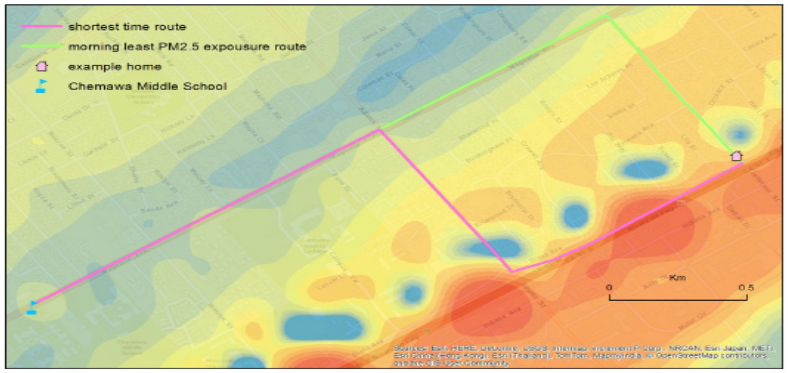
President Barack Obama views a video featuring UC Riverside research while touring the Turner-Fairbank Highway Research Center.
Photo credit: Chip Somodevilla/Getty Images

Eco-friendly Intelligent Transportation Systems

In addition to making great strides in eco-friendly ITS applications as part of the U.S. Department of Transportation's AERIS research program (Applications for the Environment: Real-Time Information Synthesis), the TSR group is now involved in exciting research on connected automated vehicles referred to as the GlidePath project. Sponsored by the Federal Highway Administration, the TSR group is working with other researchers at Turner Fairbanks Highway Research Center in McLean, Virginia in automating vehicle longitudinal control as the vehicle travels through signalized intersections. CE-CERT's previously developed "eco-approach and departure" algorithm is the basis of the field experimentation where it is expected that a vehicle can save up to 18% fuel by having the vehicle automatically speed up or slow down as it travels down a signalized corridor. A major demonstration is anticipated in the Spring of 2015. We continue to publish quite a number of papers on this topic and other ECO-ITS research projects.

Completed Projects for the California Department of Transportation (Caltrans)

TSR completed the alternative fueled vehicle monitoring project for Caltrans where the travel and fueling patterns of over 100 Caltrans' E-85 flex fuel vehicles was traveled to determine how effective the vehicles are at reducing greenhouse gas emissions. TSR also completed two interrelated projects for Caltrans to improve emission factors for "managed lanes" and high-speed driving (over 65 mph). For the managed lanes project, we collected vehicle



activity data in both regular lanes as well as on various types of managed lanes (e.g., HOV, HOT) on California freeways. Then, we developed specific energy and emission factors for vehicles traveling in these managed lanes, which differ by as much as 20% compared to the regular lanes. For the high-speed driving project, emissions were measured from 12 light-duty vehicles on chassis dynamometer and another 3 on road (with portable emissions measurement systems). Using the measurement data, emission factor vs. speed curves were developed and compared to standard models. It was found that there are notable energy and emission differences at high speeds beyond 65 mph (e.g., the regulatory models slightly overestimates CO_2, slightly underestimates THC, NOx, $PM_{2.5}$, and PM_{10}, and significantly underestimates CO).

New Research Direction

There has been interest in increasing public health consideration in transportation. As an extension of the eco-routing research, the TSR group has developed new "Pedestrian Routing" algorithms. In this research, a novel pedestrian navigation tool was developed that finds the "least exposure" routes (pictured left) for pedestrians when they want to avoid $PM_{2.5}$. This tool was evaluated on over 3,500 simulated trips in Riverside, CA, showing that it can reduce exposure to $PM_{2.5}$ by 25% on average with only 1% increase in walking distance.

Left - Real Time Lidar Imaging device
Right - Nissan Altima with the lidar imaging device

Personnel

The TSR group continues to do well due to the excellent research faculty, staff, and students. In 2014, the TSR group graduated three Ph.D. students: Dr. Haitao Xia concluded his connected vehicle research, Dr. Scott Boskovich finished his multi-agent systems work, and Dr. Haiyu Zhang completed his advanced vehicle position research. All of these students have gone on to great jobs and TSR wishes them well. In addition, TSR welcomes a new postdoctoral research scholar, Dr. Peng Hao who has great experience in advanced traffic engineering. Graduate students David Kari was the recipient of a GAANN fellowship, Jill Luo was awarded the prestigious Helene Overly Memorial Scholarship (Women in Transportation), and Qiu "Apple" Jin was awarded the Esther Hays Fellowship at CE-CERT. Congratulations to all!

Level 3 DC charging large vehicles with big batteries such as buses; and commercial or service fleets with very little recharging downtime.

RESEARCHER HIGHLIGHT

Cutting Electric Vehicle Energy Use 51 Percent

Guoyuan Wu (pictured) in collaboration with fellow researchers Matthew Barth and Kanok Boriboonsomsin, created a vehicle navigation tool that can cut electric vehicle energy use up to 51 percent, outlined in their report to the California Energy Commission.

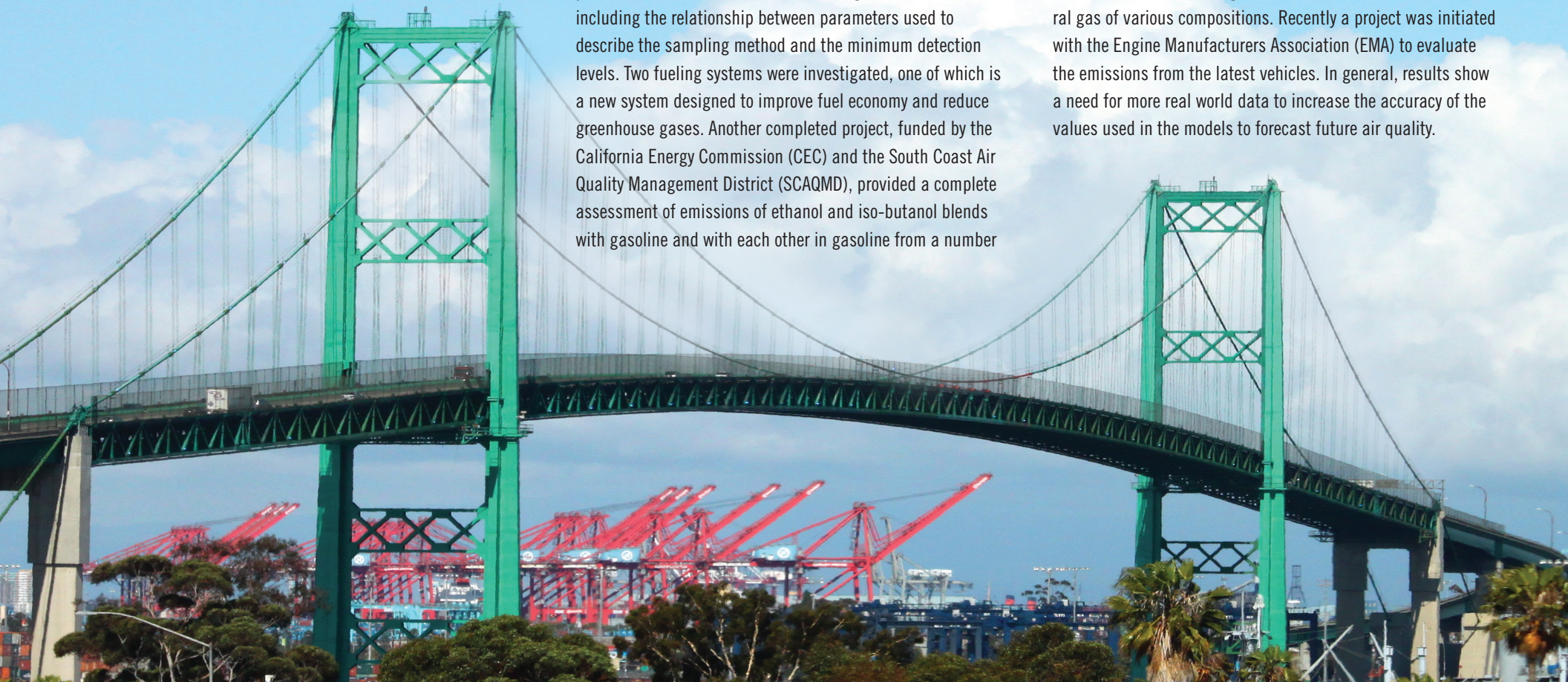
Emissions and Fuels Research (EFR)

The impact of emissions on human health and the environment remains a global concern and an active research area, especially as the emissions of concern has expanded from solely criteria pollutants to toxic air contaminants and now greenhouse gases.

Communities are expected to meet federal standards for criteria pollutants, have lower greenhouse gas emissions and be working towards a sustainable transportation system. The EFR group continues to act as an independent research team that works with creators of new technology to evaluate emissions from proposed and newly introduced fuel and engine technologies that are offered as solutions for communities to conform with multiple air quality goals.

A number of projects related to mobile sources were carried out in 2014. Technology used in light-duty vehicles (LDVs) continues to advance at a rapid pace given the new Tier 3 Vehicle Emission and Fuel Standards and the Renewable Fuels standard. One completed project, CRC E-99, funded by the automotive and fuel manufacturers in collaboration with the California Air Resources Board (CARB), investigated particulate matter (PM) emissions from gasoline vehicles, including the relationship between parameters used to describe the sampling method and the minimum detection levels. Two fueling systems were investigated, one of which is a new system designed to improve fuel economy and reduce greenhouse gases. Another completed project, funded by the California Energy Commission (CEC) and the South Coast Air Quality Management District (SCAQMD), provided a complete assessment of emissions of ethanol and iso-butanol blends with gasoline and with each other in gasoline from a number of vehicles, including some with the latest fueling technology. A third completed project, the Coordinating Research Council's AVFL-17b, evaluated biodiesel and renewable diesel blends in a number of modern technology LDVs.

NOx emissions from heavy-duty, diesel trucks (HDDTs) are a key reactant in ozone formation. The EFR group carried out a deeper analysis of the real world emissions data generated earlier in the project funded by the SCAQMD and the Ports in the Los Angeles area. Results indicated NOx emissions exceeded the certification standard in "real world" stop-and-go driving but not when tested according to the NTE rules. A completed study for CARB and CEC investigated emissions from HDVs with natural gas of various compositions. Recently a project was initiated with the Engine Manufacturers Association (EMA) to evaluate the emissions from the latest vehicles. In general, results show a need for more real world data to increase the accuracy of the values used in the models to forecast future air quality.



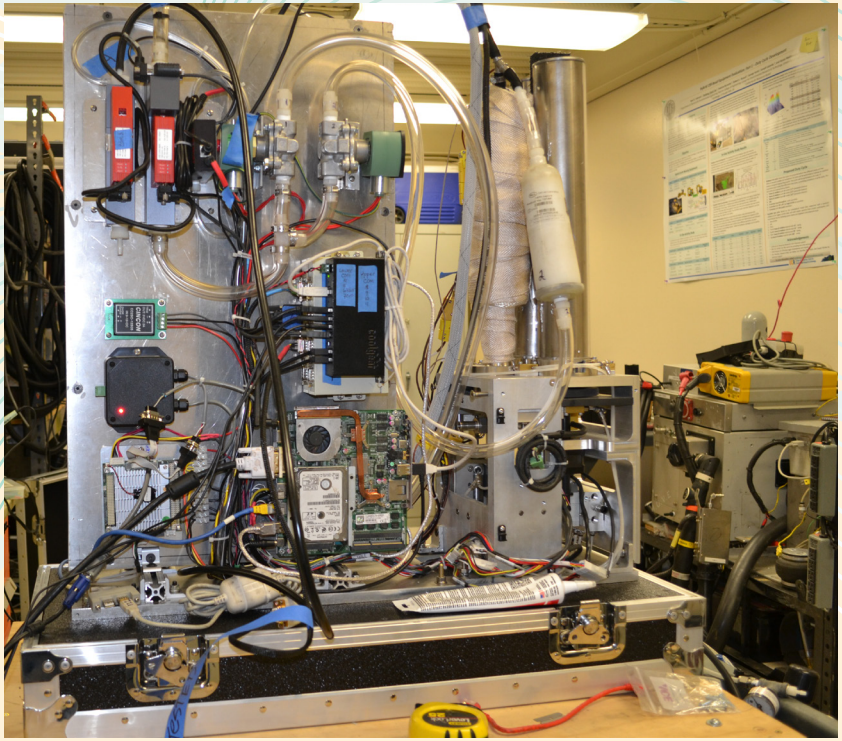
Sam Cao, a UC Riverside graduate student, tested cars in conjunction with Motor Trend. Photo Credit: UCR Today

For some communities, like Los Angeles, the current and projected NOx inventory far exceeds the carrying capacity of the basin, even in 2023 with all new regulatory controls are in place, so revolutionary technology changes will be needed. Questions are being asked: "Can HDDTs be replaced by vehicles with zero or near-zero emissions?". The EFR group works with a number of companies that are leading the way to transporting goods from the port with zero/near-zero emissions. Another question: "How do we develop a sustainable freight strategy?" Toward that end, UCR evaluated on their chassis dynamometer two all-electric cargo handling equipment units with the latest generation. Results showed significant improvements both in vehicle performance and energy utilization over earlier prototypes. Although zero/near-zero emissions are the design specifications, it is important to check the energy efficiency of power supplied by the batteries. EFR is working with the ports, SCAQMD and CARB to create a specific "goods movement" driving cycles to uniformly test zero/near-zero vehicles as many new ideas and products are built. All agree there should be a standard evaluation method.

Working with California and international partners, the key project on ships was the measurement of control efficiency for scrubbing exhaust gases from auxiliary engines on a ship as international and federal rules allow the use of higher sulfur fuels with a scrubber. Additionally new heavy fuel oils are being manufactured at refineries that meet the sulfur standard. So the question in both cases is: "Do NOx and PM levels degrade?" The EFR group met with the providers of scrubber technology and the new heavy fuel oils and is testing these technologies when vessals are at sea. More work is planned given the paucity of data on this topics.

The EFR group started a new project with CARB to investigate current technology for the small (<37kW) diesel engines used in off-road applications. The technology evaluation for the Tier 4f rule was completed about 10 years ago, allowing for greater experience with NOx and PM controls.

The EFR group is also extensively involved at the frontier in the development of Portable Emissions Measurement Systems (PEMS) for evaluating in-use emissions. As part of PEMS research, the EFR group hosted a fourth annual Portable Emissions Measurement Workshop on April 3 and 4. The 150 attendees included over 30 different companies, agencies and industries. The conference is a prominent venue for advancing new concepts and expanding the use and relevance of PEMS.



Winston Chung Global Energy Center (WCGEC)

Winston Chung Global Energy Center moved into a new leased 2,500 square feet facility and continued to expand research activities in large battery storage and grid integrated technologies. As part of these efforts the following key activities were performed.

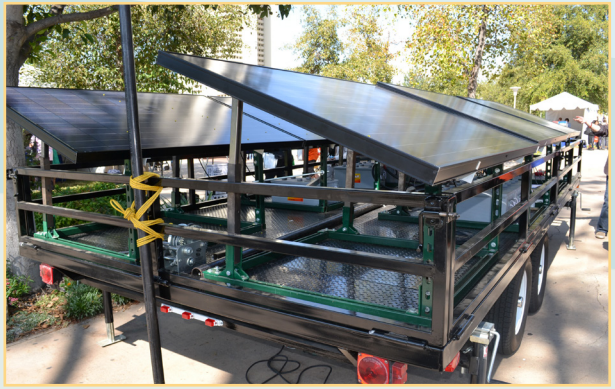
Smart Grid Testbed - WCGEC, SC-RISE and CE-CERT have teamed up in an interdisciplinary project called "The New Grid: Integrating Photovoltaics, Energy Storage, and a Local Utility for Electric Transportation" as part of the Sustainable Integrated Grid Initiative (SIGI). SIGI is one of the largest renewable energy project of its kind in the state, placing UC Riverside at the leading edge of renewable distributed energy management. SIGI was developed specifically to research the integration of intermittent renewable energy, energy storage, and all types of electric and hybrid electric vehicles. A very well attended dedication ceremony for SIGI took place on May 21, 2014, and now solar PV is delivering up to 4 MW power to UCR buildings. The SIGI infrastructure was funded in part by the South Coast Air Quality Management District's New Grid project, with significant in kind contributions from Winston Battery, SolarMax Technologies, and Bourns, Inc. The New Grid project will demonstrate using renewable generation for electric transportation and allow for training and research in a variety of smartgrid technologies for UCR students and Riverside Public Utility (RPU) personnel.

Top Left: *SIGI's fully operational UCR Trolley that is a fully electric vehicle*
Top Right: *Michael Pazzani, UCR'S Vice Chancellor of Research and Economic Development speaking during the May 21 Ribbon Cutting Ceremony.*
Bottom-Left to Right: *Ben Benoit, Council Member; Reza Abbbascian, BCOE Dean; Matthew Barth, CE-CERT Director; Gordon Bourns, Bourns Inc CEO; Ching Liu, Executive Vice President of SolarMax Technology; Winston Chung, Founder of Winston Global Energy, Michael Pazzani, Vice Chanellor of RED; and Rusty Bailey, Riverside Mayor*

Mobile Battery System – A 500 kWh battery system was installed on a mobile trailer along with its own 100 kW inverter charger. This trailer is designed with the flexibility of being able to be connected to any of the three major buildings of CE-CERT and help shift energy between on-peak and off-peak periods. It can also be deployed at any utility or industry location for on-site R&D projects.

When the mobile and stationary battery systems are integrated with the 500 kW solar PV and building systems, we will be able to demonstrate and test a number of different energy management strategies. An example strategy would be to demonstrate a Net Zero Energy (NZE) building system, where electrical energy produced and consumed on site are balanced on a yearly basis. California is requiring that by 2020 all new residential buildings and by 2030 all new commercial buildings to be NZE. With the SIGI testbed and associated infrastructure, we are uniquely positioned to develop the best energy management systems that allow for the design of efficient NZE buildings.

Research Highlights– WCGEC's recent successes in securing funding include a $3 million CEC EPIC funded project on electrical efficiency improvements of the water systems of California. WCGEC is also part of a SC-RISE lead $2.6 million project funded by another CEC EPIC program on clean energy solutions that support California's industries, the environment, and the electrical grid. WCGEC also have two other interesting projects on V2G and distribution grid control funded by SCAQMD and RPU, respectively. WCGEC just completed a CEC funded project focusing on research in improving the energy efficiency of buildings.



Professor Akua Asa-Awuku, Chemical and Environmental Engineering

What Role do Clouds Play in Climate Warming?

CHALLENGE: What role do clouds play in climate warming? Each year, industrialized countries around the world pump billions of tons of carbon particles into the atmosphere, contributing to rising incidents of cancer, heart-related illness and infectious disease. Serving as seeds for formation, such particles reflect light and heat in different ways, contributing to global warming and the resulting cycles of severe floods or drought. In order to develop cleaner technologies and stronger environmental policies, scientists require a much deeper understanding of how carbon particles interact to form rain, how they affect temperature, and how they influence weather systems.

SOLUTION: Akua Asa-Awuku employs CE-CERT's world's largest indoor atmospheric research chamber to better understand the chemical interactions that create and mitigate air pollution. Her work focuses on the role of short-lived black carbon particles in cloud formation, as well as on the interaction of clouds and aerosol. To study the tiny particles, Asa-Awuku makes optical measurements based on the color of the particles. Like the difference between wearing a white or dark shirt on a sunny day, the particles can have a cooling or warming effect in the atmosphere.

What's Needed to Ramp Up America's Alternative Energy Revolution?

CHALLENGE: While Americans largely agree that the biofuels industry benefits our environment, economy and energy independence, public support for alternative fuels waxes and wanes with the volatility of oil and the price at the pump. This, combined with other factors, results in a very unstable environment in which to build a renewable energy business. In addition, the type of woods used as biomass to produce fuel contain a large percentage of lignin—a substance that gives plants their rigidity—which is extremely difficult to process and break down. How can we help industry leaders reduce costs by making their products in a less expensive way?

SOLUTION: Biomass sources such as poplar wood and switchgrass are abundant and renewable because they come from non-food sources. With funding from the U.S. Department of Energy, Charles Wyman is pioneering new approaches involving the pretreatment of biomass which softens the plant material so the sugars can be more quickly extracted and converted to energy. His research may soon enable companies to commercialize and profit from bioenergy crops with new products, such as engineered plastics, as well as with fuels produced at much lower cost.

Professor Charles Wyman, Chemical and Environmental Engineering

Kanok Boriboonsomsin and Matt Barth
Researchers, Electrical and Computer Engineering

Will Automated Vehicles be Environmentally Beneficial?

CHALLENGE: Today's society is marching forward in developing and deploying automated vehicles. These automated vehicles will certainly be more convenient, potentially safer, and should improve mobility. However, it is unclear whether they will reduce greenhouse and pollutant emissions.

SOLUTION: Using the latest simulation modeling tools, a new research program in understanding the implications of automated vehicles on the environment was developed. The initial research has shown that if automated vehicles are autonomous (i.e., that they rely solely on on-board sensors), then there will not be much improvement in either mobility or the environment. However, if the automated vehicles are also connected (i.e., that they also are able to communicate with other vehicles and the infrastructure), then they have the potential to solve congestion problems and cut back significantly on emissions. Some of the latest research appears in a book chapter in the recent book Road Vehicle Automation, titled "Vehicle Automation and Its Potential Impacts on Energy and Emissions". Currently conducting field research experimentation as part of the Federal Highway Administration's GlidePath research program. In this project, a partially automated vehicle is able to speed up or slow down on its own in order to minimize energy and emissions as it drives through traffic intersections.

Are all Biofuels Good for the Environment?

CHALLENGE: As our nation delves into energy independence and production of renewable energy, biofuels are replacing some of our conventional gasoline and diesel fuels. Biofuels can be made in many ways, from corn to biodiesel to soy based ethanol mixed with gasoline. Each combination of biofuels create different emissions when burned in a vehicle, and some of these can create toxic pollutants that impact human health and the environment.

SOLUTION: UCR researchers are working with fuel companies, automobile manufacturers, and regulatory agencies to better understand these impacts and to ensure that our future fuels will be safe to use. This project can specify which levels of biodiesel need additional control technologies to lower pollutants. In CE-CERT laboratories, certified by California as the State's alternative fueled certification testing center, experiments are conducted to measure the fuel impacts under controlled conditions allowing us to understand pollutants from lawnmowers to big rigs to carrier ships. Researchers can then see how the pollutants combine in the largest atmospheric chamber of its kind. Then, researchers are taking the results and working with UCLA and UCR's new School of Medicine to understand how these toxic particles enter into the respiratory and pulmonary system and create diseases.

Georgios Karavalakis
Researcher, Chemical and Environmental Engineering

CE-CERT Expands Its Community Engagement Efforts

CE-CERT co-hosted alongside Charge Ahead California, an Electrical Vehicle Day this past November 16th, to provide the public the opportunity to learn more about electric vehicles and provide information on rebates offered for solar panel use and electrical vehicles.

Local leaders, including Riverside City Council Member Mike Gardner (pictured above on a Segway) and a representative from Assembly member Jose Medina's office, presented talks about the importance of cleaning up the transportation sector. Lastly, participants were able to learn how electric vehicles can help reduce air pollution, improve health and save money.

"Given that the transportation sector is the State's number one source of air pollution, we need to revolutionize the way we drive." said Michelle Kinman, from Environment California Research and Policy Center. Assemblymember Medina helped support the recently passed legislation to make electric vehicles more affordable and available.

Hands On Education for

Engineering will have a major impact on our society's ability to achieve sustainable lifestyles. Yet, most high school age kids don't have a good picture of what engineering is and how it can help solve our most pressing problems. With the support of organizations such as Edison, Bank of America, and others, CE-CERT has had an opportunity to expand its teaching influence to include a diverse group of high school students. "The students not only learn about science and technology but are inspired by the college students they meet. This collaboration has benefited the high schools, our university and our community, and has resulted in increasing awareness and interest in the sustainable environment.", said Director, Matt Barth.

CE-CERT has several ongoing programs designed to engage, excite and demonstrate the interdisciplinary nature of Science, Technology, Engineering and Mathematics (STEM) education for grades 9-12 as it applies to engineering. For example, the Solar Energy Alvord Solar Energy Education Program is an eight week course carrying out five units of credit towards graduation. The sessions are one hour, each week, with an emphasis on hands-on activities to introduce kids to what solar energy is all about and how to make solar panels.

Another activity is the Science Technology Education Partnership Conference. 340 high school students from five different high schools in California's Inland Empire region attend each year. The targeted students are strong in math and science core curriculums.

High School Students

Students experiencing CE-CERT's laboratories to learn how intelligent transportation technologies work, how to make solar panels, making alternative fuels from waste, and how air pollution is formed and how it affects climate change.

Academic Collaborations – Beyond UCR

Bringing together the brightest minds from different disciplines is essential in developing innovative solutions for many of our environmental challenges. Over the years CE-CERT has collaborated with over 40 academic institutions in developing sustainable solutions. Some recent notable partnerships include work with USC, UCLA, UC Merced, UC Davis, Georgia Tech, Vermont University, and University of Wisconsin-Madison.

Georgia Tech

UC DAVIS

UCLA

UNIVERSITY OF CALIFORNIA UC MERCED

USC

The UNIVERSITY of VERMONT

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

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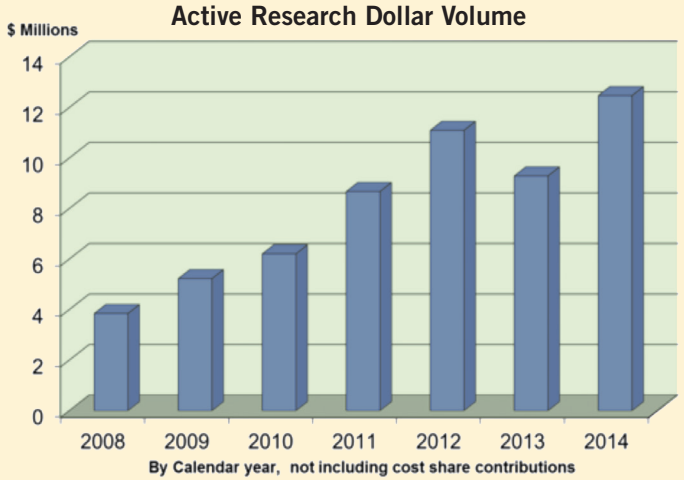
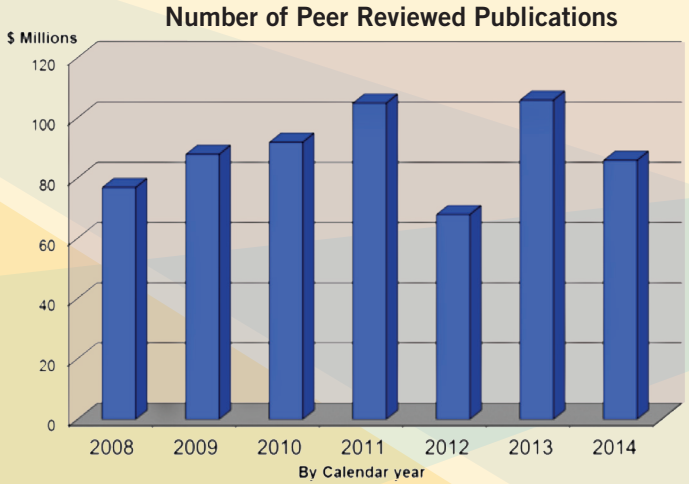
Finances and Funding

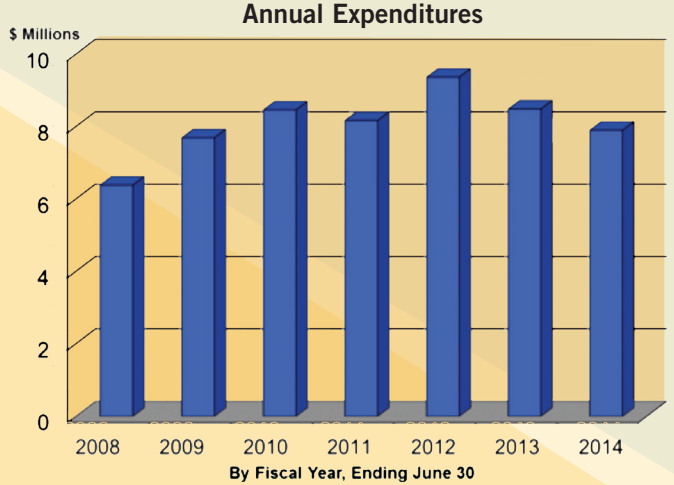
Overall, CE-CERT's active research award volume continued to grow through 2014. As of the end of 2014, we are engaged in projects with direct funding of over 12.7 million dollars.





CE-CERT continues to grow strategically, aligning our research both with the state's needs and UCR's vision of a premier research university. This means stabilizing some mature areas of research while rapidly expanding other areas, such as renewable energy development and sustainable transportation.

Our annual research expenditures and publications, which trail loosely behind awards, have remained relatively stable. Now that we are welcoming new faculty, researchers, and laboratories, increased research awards are expected in the next few years.



Contract and Grants

Asa-Awuku, Akua. Environmental Protection Agency. Understand the Hygroscopic Properties of Black Carbon/Organic Carbon Mixing States: Connecting Climate and Health Impacts of Anthropogenic Aerosol.

Asa-Awuku, Akua. Georgia Institute of Technology. Faces Career Invitation.

Asa-Awuku, Akua. National Science Foundation. Career: Toward an Understanding of Secondary Aerosol Formation, Particle Ageing in Droplets, and Cloud Processing.

Barth, Matthew. Booz Allen Hamilton INC. AERIS - Identification and Evaluation of Transformative Environmental Applications and Strategies.

Barth, Matthew. Booz Allen Hamilton INC. Technical Support for AERIS International Joint Research Activities.

Barth, Matthew. Booz Allen Hamilton INC. US/EU Connected Vehicle Sustainability Working Group Joint Research Whitepapers and Workshop.

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

Barth, Matthew. Leidos, INC. Fundamental Research in Freeway Lateral Maneuvers.

Barth, Matthew. Leidos, INC. GlidePath Algorithm, Documentation, Evaluation, and Integrity.

Barth, Matthew. Nissan Motor Co., LTD. Phase 2 Research, Development, and Evaluation of ECO-ITS Technology to Support off-Cycle CO2 Reduction.

Barth, Matthew. South Coast Air Quality Management District. South Coast Air Quality Management District RFP #P2012-01: Technical Assistance for Advanced, Low- and Zero- Emissions Mobile and Stationary Source Technology.

Barth, Matthew. UC Berkeley. ECO-Driving Technology and Behavior Research for Heavy-Duty Trucks.

Barth, Matthew. UC Berkeley. Extending Eco-Approach Research to Actuated Traffic Signals.

Barth, Matthew. UC Berkeley. University of California Center on Economic Competitiveness in Transportation: UCCONNECT.

Barth, Matthew. UC Davis. Eco-Friendly Intelligent Transportation System Technology for Freight Vehicles.

Barth, Matthew. UC Davis. National Center for Sustainable Transportation.

Boriboonsomsin, Kanok. Air Resources Board. Collection of Activity Data from On-Road Heavy-Duty Diesel Vehicles.

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

Boriboonsomsin, Kanok. UC Davis. Environmentally-Friendly Driving Feedback Systems Research and Development for Heavy-Duty Trucks.

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

Cocker, David. Environmental Protection Agency. NOx-Out: Selective Catalytic Reduction System.

Cocker, David. Environmental Protection Agency. Technology for the Reducing BBQ Particulate Matter.

Durbin, Tom. Air Resources Board. Evaluation of the Feasibility, Cost-effectiveness, and Necessity of Equipping small Off Road Diesel Engines with Advanced PM and/or NOx Aftertreatment.

Durbin, Tom. Air Resources Board. Evaluation of the Performance and Air Pollutant Emissions of Vehicle Operating on Various Natural Gas Blends- Phase 2.

Durbin, Tom. Eastern Research Group, INC. National Deployment of Portable Emissions and Activity Measurement Systems in Support of the Development and Improvement of Mobile Source Emission Factors.

Durbin, Tom. Electric Power Research Institute. Laboratory Evaluation of New Laser at 2.301µm TDL NH3 Analyzer.

Durbin, Tom. Engine Manufacturers Association. Heavy-Duty Chassis Dynamometer Testing.

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

Farrell, Jay. University of Virginia. Cooperative Transportation System Pooled Fund Study.

Goliff, Wendy. Bay Area Air Quality Management District. Development and Operation of a Lab for Determination of Cooking Emissions Control Efficiency.

Goliff, Wendy. Pacific Southwest Research Station. Secondary Pollutant Formation in the Lake Tahoe Basin.

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

Johnson, Kent. Air Resources Board. Development of a Portable In-Use Reference PM Measurement System.

Jung, Heejung. Air Resources Board. Very Low PM Mass Measurements for Light-Duty Vehicles.

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

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

Karavalakis, Georgios. 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, Georgios. University of California, Los Angeles. The Development of Quantitative Cellular Assays for Use in Understanding the Chemical Basis of Air Pollutant Toxicity.

Martinez-Morales, Alfredo. Winston Global Energy Limited. Battery and Energy Research.

Miller, Wayne. Army Engineer/ Humphrey's Engineer Center Support Activity. New Tools for Estimating and Managing Local/Regional Air Quality Impacts of Prescribed Burns.

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.

Park, Chan. California State University, San Diego State University. Development of a Fuel Sensing Technology for a Variable-blend Natural Gas Vehicle.

Park, Chan. South Coast Air Quality Management District. PDU Scale Demonstration Of Substituted Natural Gas Production from Wet Wastes Using Steam Hydrogasification Process.

Raju, Arun. California State University, San Diego State University. Methane Bi-Reforming in a Heat Exchanger Platform Reactor.

Raju, Arun. Climate Changes and Emissions Management Corporation. CO2 Conversion to Methanol through Bi-reforming.

Russell, Robert. Air Resources Board. Evaluation of the Impact of Emissions averaging and Flexibility Programs for all Tier 4 Final off-road diesel engines.

Russell, Robert. Hug Filtersystem. Emissions Verification Testing of Diesel Particulate Filter (DPF) Selective Catalytic Reduction (SCR) System with Teo Tugboats.

Wyman, Charles. National Institute for Food and Agriculture. Coupling Highly Efficient Bioprocessing with Catalytic Conversion for Conversion of Agricultural Wastes into Drop-in Fuel Additives.

Wyman, Charles. Oak Ridge National Laboratory. Identification of Optimal Pretreatment and Conversion Conditions.

Wyman, Charles. UC Davis. Co-Production of Gluconic Acid and Isobutanol from Cellulosic Biomass.

Who's who?

Scholarships/Fellowships/Student Awards:

Anna Almario,
Ford Undergraduate Scholarship,
June 2014

Nigel Williams,
Jim Guthrie Research Award,
June 2014

Chia-Li (Candice) Chen,
William R. Pierson Graduate Fellowship,
June 2014

Diep Vu,
Esther F. Hays Graduate Fellowship,
June 2014

Jill Luo,
Helene Overly Memoral Scholarship,
December 2014

Qiu (Apple) Jin,
Colin E. Hackett Graduate Award,
June 2014

May-Ling Lu,
University of California Center for Economic Competitiveness in Transportation Graduate Fellowship, June 2014

Liem Pham,
National Center for Sustainable Transportation Graduate Fellowship,
June 2014

Nicholas Gysel, National Center for Sustainable Transportation Graduate Fellowship, June 2014

Ashley Vinezor,
National Center for Sustainable Transportation Graduate Fellowship, June 2014

Undergraduate Students

Carola Acurio
Danh Alkurdi
Javier Beingolea
Tyler Berte
Celine Chau
Timothy Chow
Brian Cruz
Kyle Daly
Allen De Leon
Jackson Dulla
Alexandra Itkis
Ramon Jauregui
Jordan Jones
Matthew Lee
Su Anne Lee
Shannon Lopez
Jonathan Matson
Kelly McCoy
Jesse Mendoza
Wartini Ng
Carlton Nguyen
Dennis Nguyen
Weihan Peng
Luis Perez
Lydia Plett
Edwin Rodriguez
Margarita Rodriguez
Jeanette Sanchez
Kyle Schaefer
Bradley Schwandt
Grace Shin
Taylor Stenehjem
Joanna Vasquez
Alyssa Yan
Shiyun Yao
Tiffany Yeh
Melanie Zecca
Lauren Aycock
Eli Brewer
Michael Han
Rachael Hirst
Dustin Kwon
Rachael Lomax
Maria Sanchez-Reyes
Yun Tsai
Jinyu Xu
Alexander Abravanel
Alexander Jimenez
Jonathan Dayap
Yujie Cao
Alexander Chang
Brett Fontaine
Roberto Chavarria
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Tyler Corrales
Richard Dinh
Wyatt Duvall
Joseph Fan
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David Maier
Emil Navarez
Russell Perry
Luis Rios
Marco Rubio
Tiffany Yeh
Andrew Yu
Anna Almario
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Kyle Hunter
Daniel Lee
Timothy Legere
Yuanyuan Liu
Omar Osman
Brian Perdomo
Vincent Saint
Priyanka Singh
Kalyn Situ
Michael Tulisiak
Chantell Williams
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Emily Petrillo
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Chao Wang
Nigel Williams
Jesse Coronado
Ashley Lee
Evelyn Rocha
James Pletcher
Isreal Tamiru
Colin Eckerle
Nigel Williams
Ryo Huntamer
Marquel Lee
Osten Anderson
Phillip Mui
Chen-Kuan Tiow
Anh Thach
Luis Duarte
Michelle Ta
Claudia Lau
Bibiana Culau-Lopes
Kevin Castillo
Shrey Prajapati
Daniel Gomez
Carlos Espinoza
Nolan Fan
Junhyuk Kang
Joe Menke
Cuevas Eduardo
Henry Yang
Jonathan Wong
Daniel Situ
Chun Yu Liang
Daniel Quach
William LeFevre
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George Liv
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Kyle Russell
Rebecca Hom
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Derek Price
Ashley Erin Vizenor
Diep Vu
Nicholas Gysel
Yang Li
Yue Lin
Desiree Smith
Fei Gu
Ye "Daisy" Li
Taehoon Lim
Melina Roshandell
Yun Xue
Samarthya Bhagia
Rachna Dhir
Charles Cai
Ninad Kothari
Justin Kovanis
Mayling Lu
Vanessa Thomas
Nikhil Nagane
Thanh Yen Nguyen
Abhishek Patri
Partho Roy
Vincent Van
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