2020 Annual Report

BOURNS COLLEGE OF ENGINEERING
CENTER FOR ENVIRONMENTAL
RESEARCH & TECHNOLOGY



UCR
College of Engineering –
Center for Environmental
Research and Technology

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Bourns College of Engineering
Center for Environmental Research & Technology

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Message From the Director

"DURING THESE UNCERTAIN TIMES, CE-CERT HAS BEEN ABLE TO CONTINUE PUSHING FORWARD ITS RESEARCH AGENDA, FOCUSED ON IMPROVING SOLUTIONS FOR AIR QUALITY, TRANSPORTATION, AND ENERGY."



The year 2020 will go in the record books as a year unlike any we've experienced before: a worldwide pandemic, civil unrest, and a major economic downturn. We also suffered from an uptick in air pollution here in Southern California, and climate disruptions continue to occur on an increasing basis. During these uncertain times, CE-CERT nevertheless has been able to continue pushing forward its research agenda, focused on improved solutions for air quality, transportation, and energy.

Over the last two years, we set out to expand our facilities, with a major redesign and buildout of our Atmospheric Process Lab, and the installation of our state-of-the-art Light-Duty Vehicle Laboratory where we can develop and evaluate future vehicle technology. These facility projects started in 2019 and took a bit more time than anticipated, but we managed to complete these in 2020; in turn allowing for a number of new research programs to move forward. Our research groups continue to expand their research with a variety of interesting projects, highlighted in this annual report. In addition, we were able to carry out a number of new integrated research projects, crossing the boundaries between our research groups.

Similar to many other organizations, the majority of our engagement activities in 2020 switched to become "virtual". We took advantage of on-line learning tools in our regular STEP (Science, Technology, and Engineering Program) conference, engaging over 500 high school students in actual do at-home projects. Several of our conferences and workshops also switched to be online, allowing us to continue our research interaction with academia, industry, and government agencies.

Students continue to be the life blood at CE-CERT, where in 2020 we had nearly 48 undergraduates and 56 graduate students participating in our research. Several of our students have won a variety of prestigious awards, and many have gone off to a variety of outstanding employment opportunities.

CE-CERT's faculty, staff, and students and unique resources continue to attract a growing number of sponsors requesting our expertise in solving real-world challenges. We are particularly proud to be part of the CalTestBed Initiative, where companies can come to CE-CERT and evaluate their technology using our facilities as cutting-edge testbeds.

This annual report highlights a variety of research efforts and many of the people here at CE-CERT, covering both 2019 and 2020. As always, you can find more detailed information on our website, www.cert.ucr.edu. Feel free to reach out and let us know how we are doing!

Sincerely,

DR. MATTHEW BARTH

Highlights

Demonstrating Zero Emission Freight through Volvo LIGHTS

CE-CERT is one of 15 major partners involved in The Volvo Low Impact Green Heavy Transport Solutions (LIGHTS) project. Volvo LIGHTS is a three-year $90 million project that began in February 2020. The main purpose of the project is to demonstrate that we can reliably move electric trucks between Los Angeles' two major ports and distribution points while producing less noise and zero emissions. The overall approach of Volvo LIGHTS is to begin commercial introduction of heavy-duty zero emission vehicles (ZEV) trucks while developing and demonstrating multiple configurations of zero-emission Class-8 electric trucks utilizing a common modular battery-based platform. The project will deploy the electric trucks in a variety of customer fleets that operate medium and heavy-duty freight trips in the greater South Coast Air Basin.

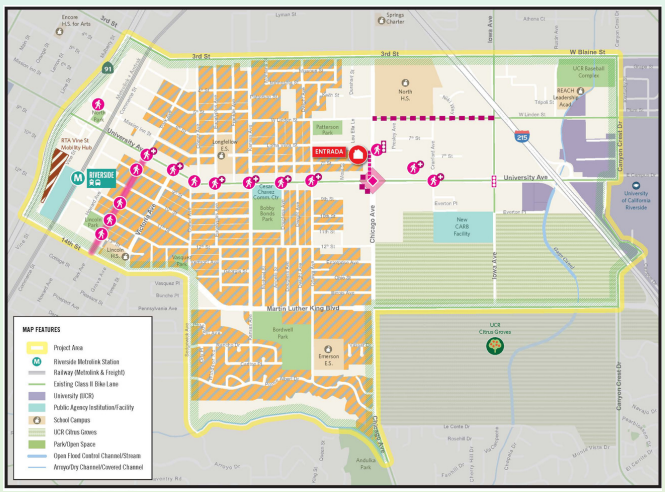
UCR CE-CERT's effort in this project is focused on vehicle performance evaluation and optimization, both in the laboratory and on the road. The evaluation will also include a deeper dive into vehicle lifecycle emissions. In addition, CE-CERT will develop novel algorithms for fleet management including dispatching in a constrained charging environment. CE-CERT is excited to be part of this large program that will show electric vehicle technology will make a difference in Southern California.



Volvo LIGHTS team at the March 2019 kick-off event

Building Riverside's Resiliency to Climate Change

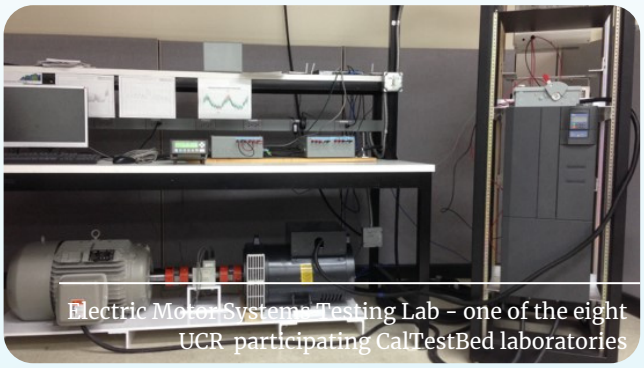
CE-CERT received $1.1 million to help revitalize the Eastside neighborhood, one of Riverside's oldest and largest residential neighborhoods. The funding is part of a $31.2 million Transformative Climate Communities and Affordable Housing and Sustainable Communities grant package to the City of Riverside by the State of California's Strategic Growth Council. The grants are the result of a broad community-based effort to empower the Eastside area, create new economic opportunities, and improve the health and well-being of the residents. The grants will fund high-qualiy multimodal transportation, affordable housing, urban greening, solar energy, and workforce development training.



CE-CERT will serve as the data partner to the City, and lead the effort to measure, track, model, and assess the progress in greenhouse gas reductions and other indicators on the diverse project elements. CE-CERT will work closely with the city, project leaders, and community stakeholders to assess public health, economic development, greenhouse gas reductions, and other outcomes.

Highlights

Commercializing New Technology through CalTestBed



Electric Motor Systems Testing Lab - one of the eight UCR participating CalTestBed laboratories

The CalTestBed Initiative is a California Energy Commission-funded effort to speed the commercialization of clean energy technologies. The program is led by New Energy Nexus in partnership with the University of California Office of the President and the Lawrence Berkeley National Laboratory. More than $6 million in testing vouchers have been awarded to 26 clean energy entrepreneurs in hopes to achieve 100 percent clean energy by 2045.

UCR received $1.1 million in vouchers to work with seven of the 26 clean energy entrepreneur groups: Stasis Group, Umida AG, GreenTech Motors, KIGT, ReJoule, Alpine Hydromet, and Future Motors. Research testing will commence in 2021.

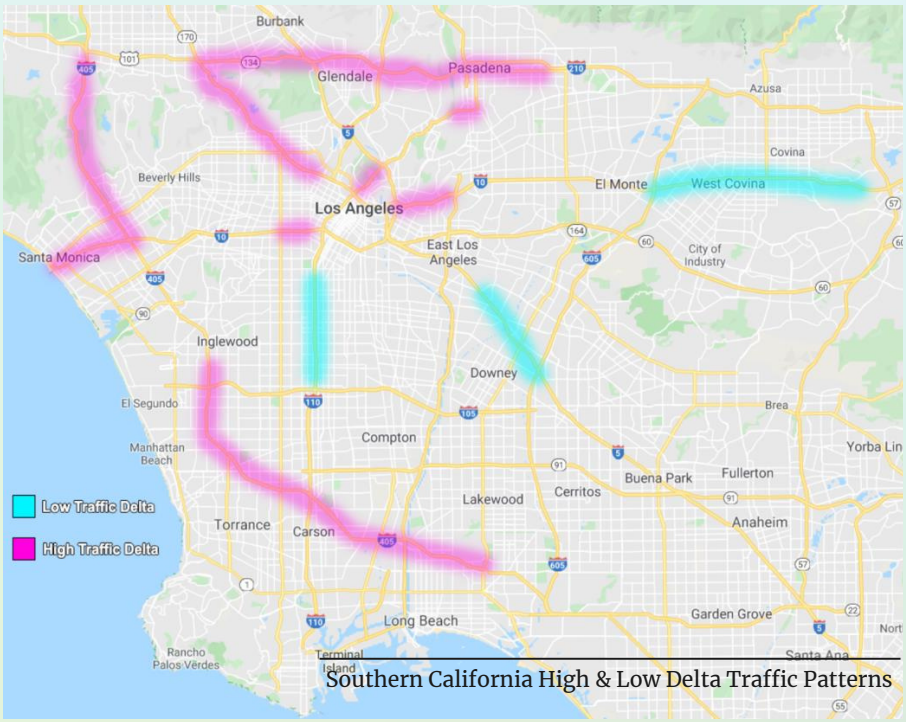
COVID-19 Research

With the pandemic hitting us in 2020, CE-CERT was able to initiate several COVID-19 related projects in recent months:

Integrated Framework to Determine Changes in Traffic Due to COVID-19 Mitigation Measures

CE-CERT has developed an integrated analysis framework to understand the effect of different restrictive and recovery activities on traffic across the timeline of the COVID-19 pandemic. Outputs include impacts on mobility, localized pollutant exposure and corresponding environmental equity for local and regional traffic scenarios.

Understanding such relationships will be important in creating and evaluating existing and potential new policies in response to any future such communicable disease outbreak. This research, led by Shams Tanvir, Sunni Ivey, and Matt Barth will provide valuable information to improve land use and air quality plans, providing public health, mobility, economic, equity, climate, and sustainability benefits.



Southern California High & Low Delta Traffic Patterns

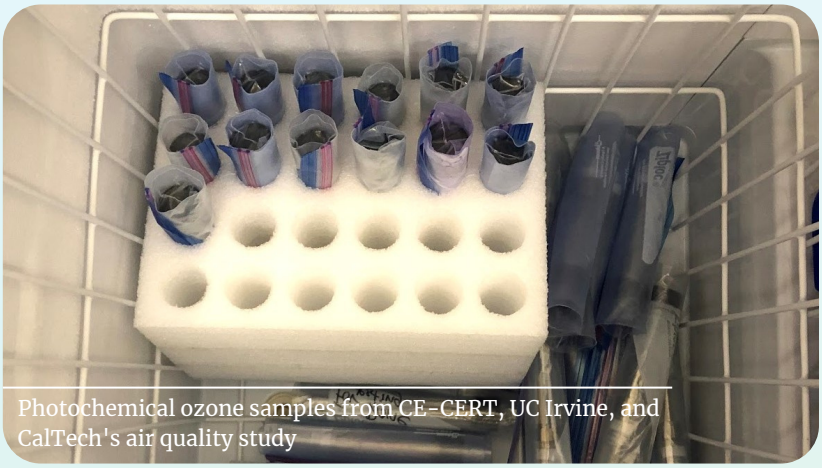
Highlights

Collaborative Air Quality Research in Response to Stay-at-home-orders

The shelter-in-place order across the state of California offers an unprecedented opportunity to test current understanding and hypotheses regarding photochemical ozone (O3) production under current and future conditions in Southern California, as well as to answer some outstanding questions on the relative importance of emerging anthropogenic sources for secondary pollutant formation. Funded by the National Science Foundation, CE-CERT's Dr. Kelley Barsanti is partnering with UC Irvine and Caltech to quantify ambient gas-phase organic compounds and particle-phase compositions during and after the shelter-in-place orders. Then the photochemical O3 production potential in the context of current and future emissions scenarios is estimated. This research warrants much urgency as this is a unique opportunity to study human activity and associated changes in emissions that have a limited window of time.



Air Quality Sampling Set Up



Photochemical ozone samples from CE-CERT, UC Irvine, and CalTech's air quality study

Land Use Predicts Pandemic Disparities



Dr. Sunni Ivey

A layered examination, led by Dr. Ivey, of COVID-19 morbidity was conducted in 2020 to understand the relative importance of various social, economic, and environmental determinates. Factors examined included, but was not limited to, residential location, median household income, and air pollution exposure. One determinant proved to be a more important predictor of COVID-19 disparities: land use. Decisions on land-use classification and the upzoning of parcels can lead to hazardous facilities being cited adjacent to minority and other vulnerable residential communities. Disproportionate environmental and health impacts on historically susceptible communities will continue to persist unless land-use equity is made a priority at all levels of governance. CE-CERT will continue to partner with experts to expand our land use impacts research.

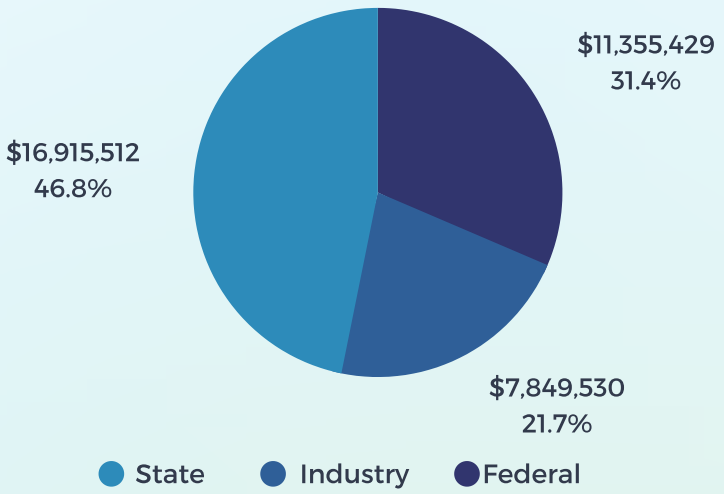
CE-CERT's Active Projects

Overview

110
2020 Active Projects

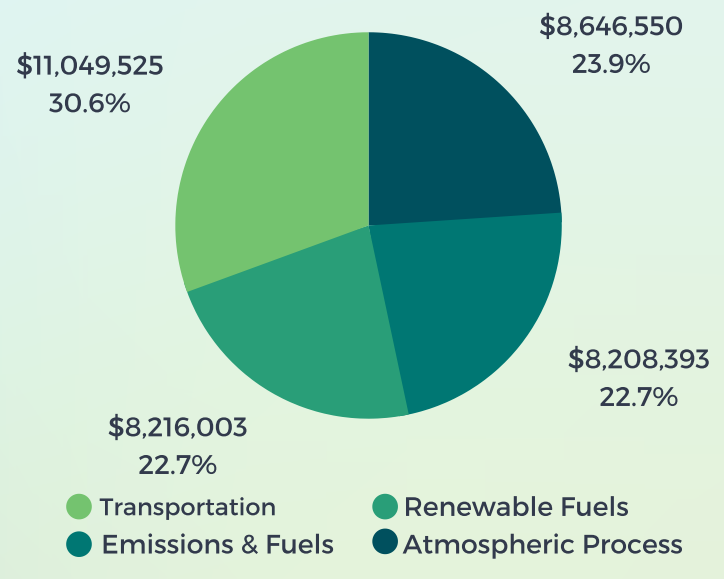
Totaling
$36,120,471

2020 Active Awards by Sponsor Catagory



CE-CERT continues to increase our active research portfolio, relying on a variety of research thrust areas with a wide variety of sponsorship. As of December, 2020, CE-CERT's active research portfolio totals over $36 million, up several million from prior years. To view the full active project list, visit pages 34-36.

2020 Active Awards by Research Group



Active Awards by Calendar Year (In Millions)



Research Areas

CE-CERT continues to organize itself around different groups that focus on specific research areas, while also carrying out integrated research across multiple areas. These research groups and some samples of their research are described below:



RENEWABLE ENERGY PRODUCTION & INTEGRATION

Creating renewable fuels from natural waste products, exploring pathways to market for existing alternative fuels, and designing and deploying commercial microgrids that use renewable energy sources and advanced energy management.

TRANSPORTATION SYSTEMS

Using intelligent vehicle and infrastructure to maximize safety, health benefits, mobility, and efficiency.

EMISSIONS & FUELS

Understanding vehicle operations, and how to modify them to maximize efficiency and minimize pollution.

POLLUTION FORMATION IN THE ATMOSTPHERE

Understanding how emission sources react in the atmosphere to form toxics, ozone, and particulates that impact human health.

Renewable Fuels Research:
Renewable Energy Production & Integration

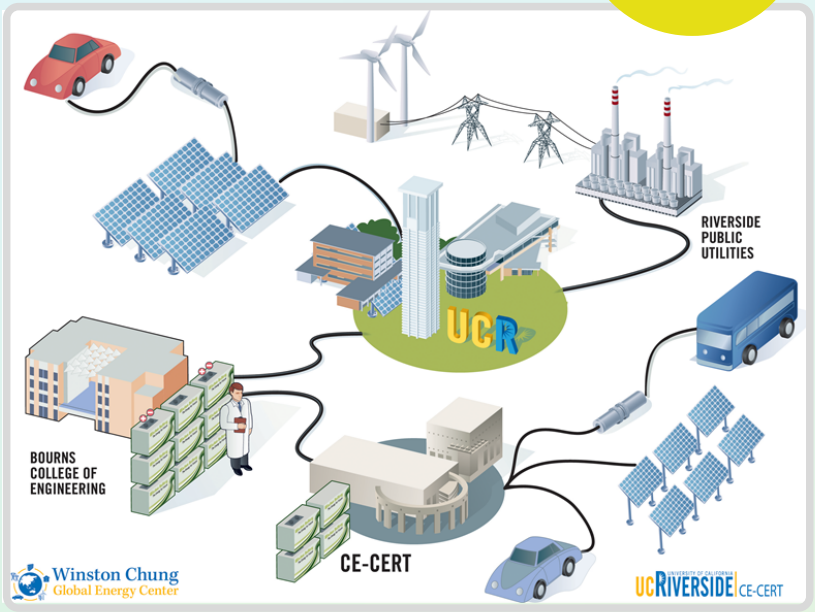
SUSTAINABLE INTEGRATED GRID INITIATIVE (SIGI) & THE SOLAR VALLEY CONSORTIUM

MISSION

The Sustainable Integrated Grid Initiative was developed specifically to research and implement systems that demonstrate the successful integration of intermittent renewable energy, energy storage, and all types of electric and hybrid electric vehicles and motors. Now in its sixth year of operation, the research testbed continues to assist researchers in analyzing the operations of microgrid systems under different conditions and for different installation types using a highly reconfigurable system consisting of interchangeable technology prototypes and an open source energy management platform.



Vehicle to Grid Battery Trailer



FOCUS AREAS

- Effectively and efficiently integrating utility scale renewable energy and transportation electrification with unique microgrid solutions;
- Characterizing and quantifying solar photovoltaic power production, and matching with energy storage and peak load reduction strategies including behind the meter building management.
- Demonstrating and validating pre-commercial technologies in microgrid technology and energy management algorithms.
- Training and educating at all levels in deploying and using renewable systems.
- The design, development, and evaluation of unique energy storage solutions, including power-to-gas, hydrogen production, and thermal energy storage, and second life batteries.
- Evaluating electric motor efficiency and designing associated control systems;
- Understanding the energy water agricultural nexus.
- Study of soiling, light induced degradation, and potential induced degradation on solar modules.

Critical Resilience for Fire and Emergency Facilities with the Soboba Band of Luiseno Indians


Invinity Energy System VRB *Photo Credit: Solar Power World*

The Soboba Band of Luiseño Indians is highly impacted by planned and unplanned public safety power shut offs and grid outages. During an outage, the tribe's fire station and emergency response facility is left without power, greatly limiting the ability to provide critical resources and life-saving responses to emergencies. GRID Alternatives and UC Riverside have installed a long-duration energy storage and renewable off-grid generation system with over 10-hours of continuous backup capability and a solar PV array to recharge the batteries with batteries with renewable energy during a prolonged outage. The system is demonstrated that this microgrid is improving the quality of life of the residences and providing energy cost savings to the community.

Solar Valley Conference


2019 Solar Conference

One of the highlights in 2020 was the formation of the Solar Valley Consortium, whose mission is to boost the deployment of solar power throughout Inland Southern California, and to build a clean green economy based on sustainable local resources. One of the major achievements has been the Solar Valley Conference & Webinar, where we examined the current public policy conditions under which solar operates, with an emphasis on creating pathways for increased deployment throughout Riverside and San Bernardino Counties. The conference focused on what decision-makers are thinking and planning, and how we can coordinate as an industry to get more done. Senior officials from the state, the counties, and cities discussed their initiatives and stakeholders worked together on a coordinated push to transition from fossil fuels to renewable energy.

KEY SPONSORS & PARTNERSHIPS

California Energy Commission
Los Angeles Department of Water and Power
UC Mexus
Air Quality Management District
Southern California Edison
Solar Max
Riverside Public Utilities
Inland Economic Growth & Opportunity
Fred Schwartz, Renewables Inc.



4-Quadrant Plug and Play Cooperative Units for Providing Model-Free Grid Services and Demand Side Management

This project is focused on developing and implementing a site level testing and demonstration to optimally coordinate a network of autonomous, plug and play, behind-the-meter solar-battery units. Energy storage in daily cycling scenarios and grid harmonization will then be evaluated in low-income, disadvantaged, and Native America tribal communities in High Fire Zones. The system will perform demand side management and participate in new developed grid services and innovative tariff options. It uses a disruptive technology for cooperative operation of a network of PQ-CUs to regulate the distribution grid voltage in real time through a novel model-free voltage management approach.


2019 Chenehuevi Ribbon Cutting Ceremony

Islanding Buildings using Electric Vehicles with Vehicle to Grid (V2G) Technology


Dr. Sadrul Ula

CE-CERT successfully implemented an islanded microgrid for an office building with an electric vehicle (EV) as the power source, demonstrating both charging and discharging of EV energy into the islanded microgrid. This system can be used along with other complementing renewable generation sources to help sustain and modulate a microgrid. Results of this demonstration showed that one EV with enough storage capacity and a properly sized inverter can sustain a residential microgrid by itself, while multiple EV's will support a commercial building sized microgrid. Future development work is needed to involve distributed energy integrators for combining capacities of various V2G microgrids for benefiting from grid ancillary services.


Henry Gomez presenting to the SIGI research group

FACULTY & STAFF

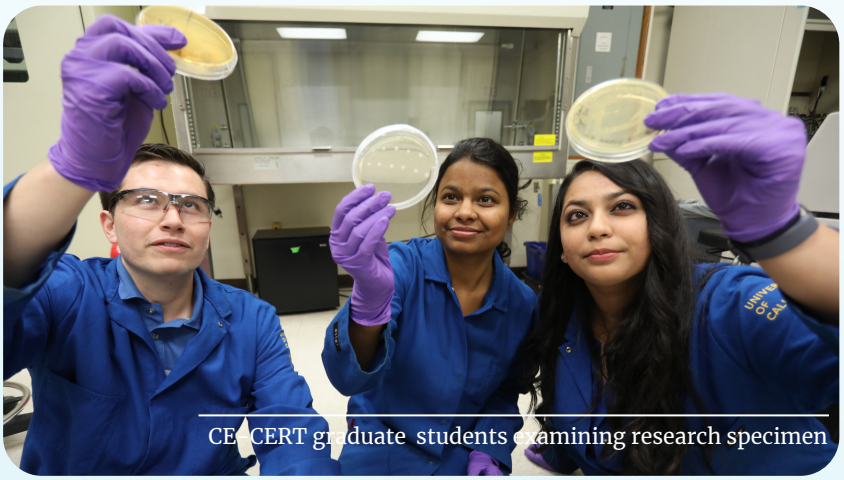
Alfredo Martinez-Morales, Project Scientist
Sadrul Ula, Research Faculty
Henry Gomez, Research and Development Engineer
Mike Todd, Principal Development Engineer
Matthew Barth, Professor & Director
Miro Penchev, Project Scientist
Taehoon Lim, Postdoc
David Willmon, Co-Chair SVC
Hamed Mohsenian-Rad, Professor, Affiliated Faculty
Ron Loveridge, Co-Chair SVC, Affiliated Faculty

Renewable Fuels Research:
Renewable Energy Production & Integration

SUSTAINABLE FUELS RESEARCH

MISSION

The mission of the Sustainable Fuels Research (SFR) group is to advance and demonstrate sustainable energy solutions, in particular low carbon footprint renewable liquid and gaseous fuels. Focus areas include advancing biological, catalytic, and thermochemical conversion of sustainable resources into renewable liquid and gaseous fuels to benefit California, the country, and the world. Projects range from developing new processes and materials to bench and pilot scale demonstrations and testing.



CE-CERT graduate students examining research specimen





Graduate student, Priyanka Singh prepares sample

FOCUS AREAS

- Developing innovative techniques for lignocellulosic biomass pretreatment and deconstruction for sustainable production of renewable fuels, renewable chemicals, bio-plastics, and bio-composites.
- Advancing biological and thermochemical and catalytic conversion of sustainable non-food biomass feedstocks into renewable liquid fuels, chemicals, and their precursors.
- Advancing hydrogen and renewable methane production technologies through water electrolysis using renewable electricity.
- Advancing portable hydrogen production for "hydrogen-on-demand" applications for transportation and industry.
- Exploring innovative pathways to convert CO_2 streams into liquid fuels and chemicals with reduced carbon intensity.
- Improving the understanding of sustainable fuels technologies and apply fundamental insights gained to advance their economic and environmental attributes.

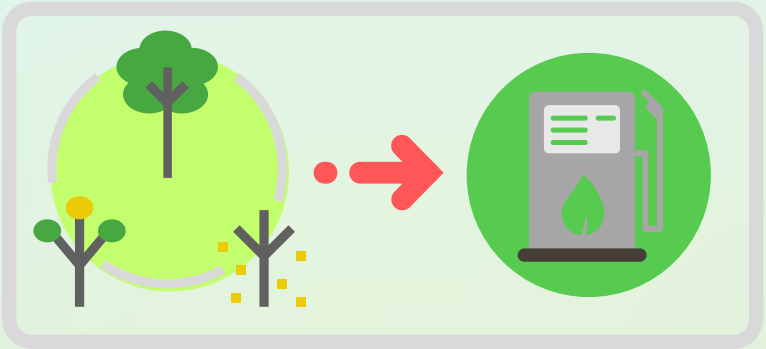
CE-CERT Kicks Off Project on Hydrogen Injection into Natural Gas Infrastructure


Dr. Arun Raju

Senate Bill 1369 requires the California Public Utilities Commission (CPUC) to undertake specified actions to advance the state's clean energy and pollution reduction objectives. One such action is production of renewable or "green" electrolytic hydrogen. Dr. Arun Raju and his team is conducting a Hydrogen Blending Impacts Study for the CPUC that assesses safety concerns associated with injecting hydrogen into the existing natural gas pipeline system at various percentages in compliance with Senate Bill 1369. The study includes experimental and modeling analysis assessing degradation and durability of the natural gas pipeline system, natural gas pipeline leakage rates, and embrittlement of select valves, fittings, and materials.

Community Scale Bio-Power Generation

The vast majority (90%) of our natural gas is from non-renewable sources imported via pipeline from out-of-state. However, a large portion of readily available forest-biomass could be converted into ultra-clean pipeline-quality renewable gas via thermo-chemical gasification. Taylor Energy is developing waste gasification technology intended for community-scale fuels production and bio-power generation at their pilot scale Biomass Gasification Test-Facility located at the CE-CERT. This test facility has been used to develop the biomass-to-syngas process that will enable production of pipeline-quality renewable gas.





KEY SPONSORS & PARTNERSHIPS

California Public Utilities Commission
Department of Energy
Environmental Protection Agency
Oak Ridge National Laboratory
Southern California Gas Company
Taylor Energy
University of Tennessee
Vertimass, LLC
Volvo Truck Corporation
Worcester Polytechnical Institute

Creating Renewable Materials from Hemp



2020 VentureWell Grant Recipients for their work in hemp processing

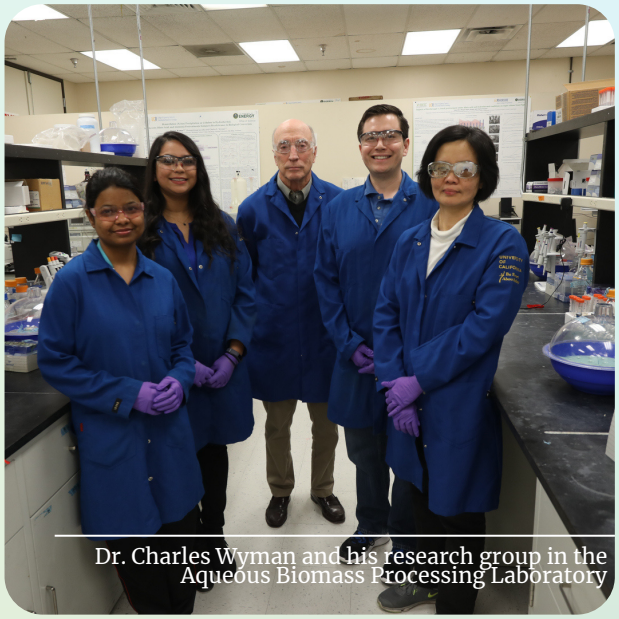
Dr. Charles Cai has developed and patented an improved pulping method that uses a naturally derived solvent, creates no toxic waste, emits no carbon dioxide, and converts nearly 100% of the hemp plant into useable components, such as cellulose fiber for use in textiles and construction, resinous lignin for use in bioplastics, sugars for use as sweeteners, and extractives for use in wellness products.

Dr. Cai is now working with a team of undergraduate students to commercialize the hemp-processing technology through funding from the EPA's People, Prosperity and the Planet Program, or EPA P3. Last year, the team demonstrated proof of concept for using the Co solvent Enhanced Lignocellulosic Fractionation (CELF) pulping method to make an improved type of hempcrete, a concrete-like, carbon sequestering building material made from hemp fibers. Now, during Phase 2, the team is building a custom CELF reactor able to handle larger quantities of hemp and optimize the reaction to tune the properties of the resulting fiber and lignin products. In an effort to identify new products and market opportunities, the research team has joined forces with startup InnovaCan, as well as companies Hempire USA, a member of the US Hemp Building Association, Match Patch Pro, and The Hurd Co.


Traditional hempcrete made with untreated hemp hurds (left); experimental hempcrete made CELF-treated hemp fibers (center); and agitated CELF-treate fibers (right)

FACULTY & STAFF

Charles Wyman, Distinguished Professor
Charles Cai, Research Faculty
Arun Raju, Research Faculty
Bhogeswararao Seemala, Project Scientist
Kourosh Vafi, Project Scientist
Brent Scheidemantle, Project Specialist
Barry Wallerstein, Research Faculty


Dr. Charles Wyman and his research group in the Aqueous Biomass Processing Laboratory

Emissions and Fuels Research

MISSION

The Emissions and Fuels Research (EFR) Group applies advanced technologies and methods to the measurement of emissions and activity from all sources to increase understanding of their impacts to human health and the environment. The wide array of studied sources includes cars and light-duty trucks, heavy-duty freight trucks and construction equipment, lawnmowers and other small engines, and the large engines that power marine vessels. EFR's facilities support not only laboratory testing of these sources, but field testing through the use of PEMS (Portable Emissions Measurement Systems) and PAMS (Portable Activity Measurement Systems) devices.

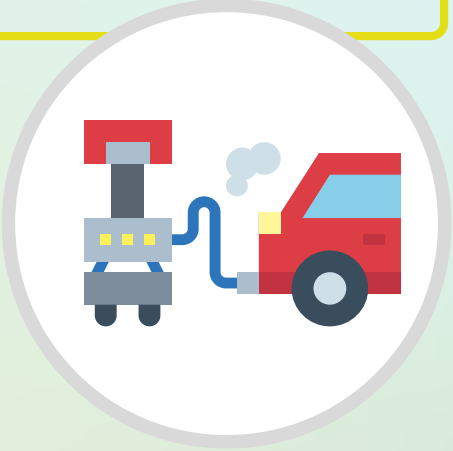


Dr. Thomas Durbin and Graduate Students performing tests in the Heavy-Duty Dynamometer Laboratory

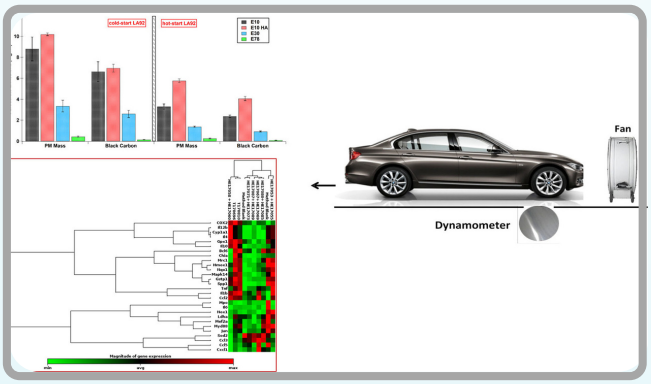
FOCUS AREAS

- Advance the efficiency, performance and emissions from future sustainable transportation options, especially in the goods movement area, advanced electric drive vehicles and vessels, and emerging fueled vehicles such as biofuel and hydrogen.
- Conduct experimental studies to measure and understand contributors to secondary aerosols, toxics and non-exhaust PM sources that impact human health.
- Improve measurement techniques and sensor-based monitors for estimating emissions and performance under laboratory and in-use conditions.
- Continue to measure the criteria, toxic and GHG emissions from stationary in-use operations, including distributed power generation, cooking and building applications.


CE-CERT's state-of-the-art Heavy Duty Chassis Dynamometer



Leading California Efforts for More Renewable Fuels: New Study Examines Impact of Increased Ethanol Percentage on Gasoline Vehicle Primary Emissions and Secondary Aerosols



Dr. Georgios Karavalakis leads this project with a team of CE-CERT researchers, Dr. Akua Asa-Awuku from the University of Maryland, and Dr. Martin Shafer, Dr. Jocelyn Hemming, and Dr. Dagmara Antkiewicz from the University of Wisconsin - Madison. The study concludes that increasing the percentage of ethanol in gasoline to between 30% and78% ethanol (as compared to baseline fuel with 10% ethanol) in a flex fuel gasoline direct injection passenger vehicle reduced tailpipe emissions of particulate matter, total hydrocarbon, non-methane hydrocarbon, carbon monoxide, and BTEX toxics (benzene, toluene, ethylbenzene, xylenes, and 1, 3-butadiene). However, emissions of formaldehyde and acetaldehyde substantially increased with the higher ethanol blends. Commissioned by the Urban Air Initiative, the study is published in the journal Science of the Total Environment, and is featured on the Governor's Biofuels Coalition website. This study will lead to more in-depth research funded by CARB, the ethanol industry, and USCAR in 2021.

EPA Emissions Modeling


Ryan Drover

CE-CERT is working closely with the U.S. EPA in developing a stand-alone state-of-the-science emission modeling system for marine emissions, which includes ocean-going vessels. During 2020, CE-CERT's Ryan Drover developed a database of criteria, greenhouse and air toxic emissions from both harbor craft and ocean-going vessels to use in the initial trials for developing this new model. The field work, curtailed during 2020 due to COVID-19, will resume in 2021.

KEY SPONSORS & PARTNERS

Air Resources Board
Air Quality Management District
AVL
Department of Defense
Department of Transportation Maritime Administration
Eastern Research Group, Inc.
HEM Data
Horiba
Ingevity Corporation
MBTech North America LLC
National Center for Sustainable Transportation
NGK Sparkplugs
RA Automotive
Sensors Inc.
Southern California Gas Company
Tetra Tech, Inc.
The Texas A&M University System
TSI Incorporated
UC Davis
Volvo Truck Corporation

Brake and Tire Wear Particles Emerging Source of Air Pollution

Professor Heejung Jung and his team have recently conducted a field test in Anaheim and Long Beach, CA near Interstates 5 and 710 respectively to study brake and tire wear particulate matter (PM) in a project funded by California Air Resources Board (CARB).

Brake and tire wear PM presents a large fraction among non-exhaust particle emissions from vehicles. CARB's legislative effort has resulted in much lower tailpipe (or exhaust) PM emissions over the years but has not affected non-exhaust PM emissions. Thus, non-exhaust sources, including brake and tire wear PM, have become larger contributors to traffic-related emissions as well as to ambient PM2.5 (particles less than 2.5 um) concentrations.



The upwind sampling site next to Interstate 5 in Anaheim, California

The measurement included online and offline sampling of air pollutants using multiple instruments and sampling methods: some conventional and others recent state-of-art instruments and methods. The main goal of the project is to understand chemical and physical nature of non-exhaust PM specifically brake and tire wear PM in the real-world measurement in comparison to well-controlled laboratory characterization. The team also aims to understand relationship between brake and tire PM emissions and traffic data.



EFR members, Kent Johnson, Mark Villela, and lead GSR Chas Frederickson conducting research on a marine vessel



Testing in the Light Duty Laboratory

FACULTY & STAFF

Kent Johnson, Research Faculty
Mark (Tom) Durbin, Research Faculty
Wayne Miller, Research Faculty
Georgios Karavalakis, Research Faculty
Heejung Jung, Professor
Robert Russell, Research Faculty
David Cocker, Professor
Chengguo Li, Project Specialist
Mark Villela, Research & Development Engineer
Daniel Gomez, Research & Development Engineer
Dan Hartnett, Development Technician
Andrew (Chance) McCaffery, Jr. Specialist
Victor Olivares Moran, Jr. Specialist
Tianyi (Jerry) Ma, Volunteer Assistant Specialist

Transportation Systems Research:
Vehicle & Infrastructure Interaction

MISSION

The CE-CERT Transportation Systems Research group applies the latest advances in the field of Intelligent Transportation Systems (ITS) to mitigate the environmental and energy issues associated with moving goods and people. The group focuses on developing and implementing advanced vehicle computing, control, communication, and sensing technologies to transform today's vehicles and transportation systems to a truly sustainable solution that considers the environment, safety, economics, health and mobility.

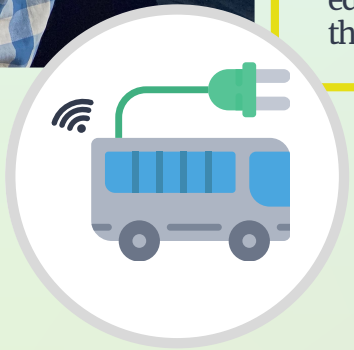


Testing of the connected ECO-Bus


TSR Graduate students conducting study for NextCar project

FOCUS AREAS

- The design, development, and evaluation of intelligent transportation system strategies to reduce energy consumption and emissions; in addition, examine and promote co-benefits for mobility, safety, economics, and health.
- The design, development, and evaluation of new innovative navigation systems, including mapping and positioning systems, for improving safety and mobility;
- Developing and refining new integrated transportation and emissions modeling methods;
- The design, development, and evaluation of new systems and strategies for electric-drive transportation and their interface to the electric grid;
- Investigating shared mobility solutions to improve mobility with minimal environmental impact;
- Developing and organizing an integrated campus-wide transportation center with educational courses and common research themes.



Eco-Driving Technology

CE-CERT TAKES ECO-DRIVING SIMULATOR TO CONSUMER ELECTRONICS SHOW



TSR members at the 2020 Consumer Electronic Show

The UC Riverside research team attended the convention at the invitation of the U.S. Department of Transportation, which partly funded the research through the National Center for Sustainable Transportation.

For many drivers, merging onto a freeway is a frustrating and inefficient task. Smooth merges often require a view of the cars already on the freeway — the mainline cars — and excellent timing with the gas pedal. Rarely does everything line up perfectly, and both mainline and merging drivers end up braking and accelerating, wasting gas and increasing vehicle emissions, not to mention risking occupant safety. Peng Hao and Guoyuan Wu, research faculty members at CE-CERT, solved this problem with technology that allows cars to communicate with each other and subsequently recommend speeds that create a gap between mainline vehicles so the merging vehicle can slide in. When done right, drivers can improve fuel consumption by approximately 10%-40% and reduce emissions dramatically.

To test this technology, designed to be incorporated into the software of internet-connected "smart" cars, doctoral students Ziran Wang and Xishun Liao built a sophisticated driving simulator using the latest gaming software and equipment. Users sat in a bucket seat and guided a simulated car through several possible scenarios using a steering wheel and brake and accelerator pedals. They followed onscreen speed cues to merge smoothly onto a busy freeway or open a gap for a merging car. At completion, users saw the percent difference between their expected and actual fuel consumption and vehicle emissions.

SUCCESSFUL DEMONSTRATION OF ECO-DRIVING TECHNOLOGY



Field implementation of a heavy-duty truck in Carson, California

In 2016, the State of California funded two technology projects to reduce emissions and petroleum use, and improve the health and quality of life of communities disproportionately burdened by environmental pollution. On March, 2019, CE-CERT joined partners Volvo, the California Air Resources Board, and the California Energy Commission for a demonstration of a technology that will be key to achieving this goal.

Pioneered by CE-CERT, this "Eco-Drive" technology was demonstrated using two heavy-duty trucks and a small passenger bus, along ten signalized intersections in the City of Carson, directly adjacent to the Wilmington community of Los Angeles. Real-time traffic signal phase/timing data was obtained wirelessly, on route, to then provide audio/visual feedback (via tablet) to truck drivers to modulate their speeds. Benefits of this technology include reducing truck travel times, intersection delays, emissions, and operating costs.


Student using interactive driving simulator

Mobile Robotic Lab for In-Situ Sampling Measurements



Base Robot for the plant-moisture-measuring system

Global food resources are increasing in scarcity due to increasing populations, and decreasing arable land and climate change. Accurate assessments of multiple spatiotemporal conditions, such as evapotranspiration, can help alleviate barriers to food production by providing information to precisely monitor water requirements in farming. However, the most precise water use measurement used today requires the use of a pressurized chamber, an instrument that is labor intensive and cumbersome to operate, resulting in sparse sample sets that are unable to provide precise adjustment of agricultural inputs. For the first time, Dr. Konstantinos Karydis is developing a mobile robotic lab that is capable of autonomously selecting regions to sample, physically collect leaves, and immediately perform on-board analysis to measure leaf water potential, improving the accuracy, precision and efficiency used in present-day pressure chamber technology. The mobile lab system features both aerial vehicles as well as ground robots, and during the project we will design a novel robotized pressure chamber enabling the measurement of leaf water potential at scale. The system will be tested and validated in the field in four different agronomic testbeds in California on four different perennial crops in collaboration with commercial partners.

Driving Simulator at 2020 Consumer Electronic Show



KEY SPONSORS & PARTNERS

California Air Resources Board
California Department of Transportation
ERG
Honda R&D Co., LTD.
National Science Foundation
National Center for Sustainable Transportation
Office of Environmental Health
Hazard Assessment
Productivity APEX, Inc.
South Coast Air Quality Management District
Texas Transportation Institute
Toyota Infotechnology Center
Toyota Motor North America, Inc.
U.S. Department of Energy, ARPA-E Program
U.S. Department of Transportation
UC Davis
UC – Institute of Transportation Studies
University of Southern California
Volvo Truck Corporation

CE-CERT Receives Prestigious IEEE ITS Society Institutional Lead Award



Eco Approach & Departure - GLIDE located in the Innovation Corridor

This year CE-CERT was awarded the prestigious IEEE Intelligent Transportation System Society Institutional Lead Award for the Center's contribution to environmental technologies to improve transportation, air quality, and energy efficiency.

This award is given annually for ITS researchers, practitioners, and research and development teams who have made significant contributions to research in ITS related fields, developed and deploy successful ITS system implementations, or demonstrated leadership in promoting ITS technologies. These awards are established to recognize, promote, and publicize major research contributions, applications innovations with real-world impacts, and ITS institutional leadership.



FACULTY & STAFF

Matthew Barth, Professor and Director
Kanok Boriboonsomsin, Research Faculty
Guoyuan Wu, Research Faculty
Peng Hao, Research Faculty
Barry Wallerstein, Research Faculty
George Scora, Project Scientist
Jill Luo, Project Specialist
Nigel Williams, Project Specialist
Mike Todd, Principal Development Engineer
Alex Vu, Development Engineer
Dylan Brown, Project Specialist
Henry Gomez, Project Specialist
Konstantinos Karydis, Professor
Karthick Ramakrishnan, Professor, Affiliated Faculty



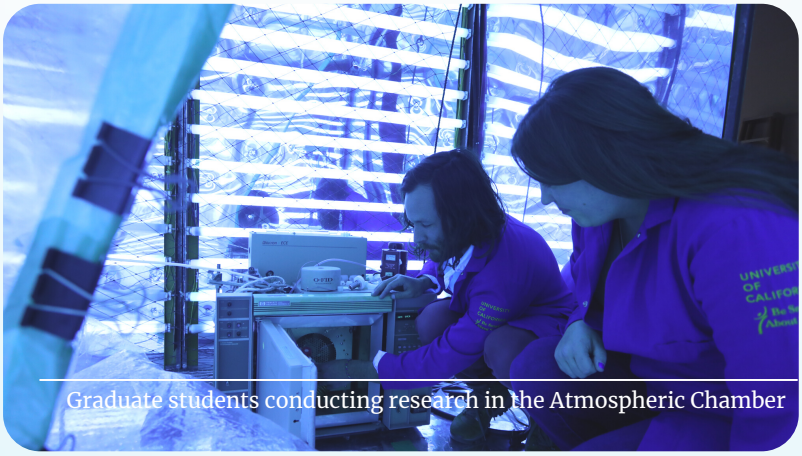
Emissions & Fuels Research Group

Atmospheric Process Laboratory

Pollution Formation in the Atmosphere

MISSION

The Atmospheric Processes Laboratory (APL) Research Group's mission is to gain an improved understanding of the sources and impacts of particles, air toxics, ozone, and greenhouse gases and apply advanced air quality measurement, modeling, and data fusion approaches to characterize air pollution throughout the United States. These advanced approaches are used to understand secondary organic aerosol formation in the atmosphere and answer questions related to exposure and source characterization. Researchers use our many various chambers to recreate atmospheric conditions to study the impacts of emissions from diverse sources such as vehicles, wildfires, agricultural operations, and consumer products.



Graduate students conducting research in the Atmospheric Chamber

FOCUS AREAS

- Operate a suite of atmospheric simulators including the world's largest indoor environmental chamber to gather data to improve models and source characterization.
- Advance the technology and approaches for atmospheric simulator design and operation.
- Provide data integration for high resolution air pollution mapping.
- Improve near source and regional air quality models for predicting ozone, particulate matter, and GHG pollution and field testing/truthing of modeling results.
- Assist in improving the community's knowledge and interpretation of low-cost air quality monitoring and environmental justice issues by providing advice, designs, deployment, and interpretation of scientific studies.



Dr. Sunni Ivey and her research group examine an air quality monitor

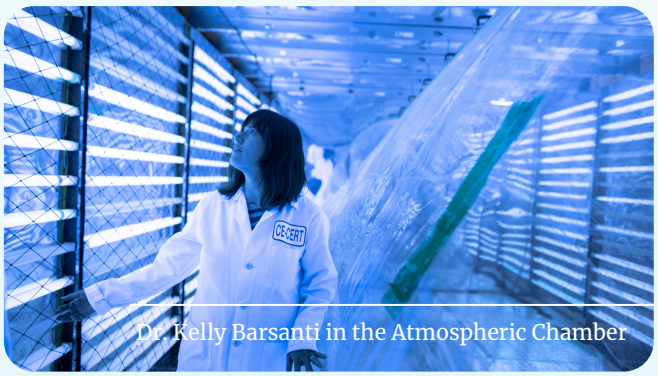


Dr. Don Collins studies Oxidation Flow Reactor with his research group

U.S. EPA Awards over $780,000 to Advance Research Related to Air Quality

The U.S. Environmental Protection Agency has awarded a Science to Achieve Results (STAR) grant to Dr. Kelley Barsanti to advance research in understanding sources of air pollution from less understood volatile chemical sources such as wildland fires and improve the air quality modeling of such sources.

"This award represents an exciting opportunity to build on the UCR & CE-CERT legacy of developing chemical mechanisms to represent the behavior of pollutants in the atmosphere, while addressing the current needs of our communities to represent a broader range of pollutant sources and to predict the air quality impacts of these sources across a wide range of environmental conditions and spatiotemporal scales," - Associate Professor Kelley Barsanti of UC Riverside's Marlan and Rosemary Bourns College of Engineering.



Dr. Kelly Barsanti in the Atmospheric Chamber



Dr. David Cocker with Atmospheric Process Research Group

KEY SPONSORS & PARTNERSHIPS

Air Resources Board
Baylor University
California Department of Transportation
Coordinating Research Council
Cummins Westport
Department of Energy
Department of Transportation Maritime Administration
Droplet Measurement Technologies
Eastern Research Group, Inc.
Environmental Protection Agency
Gas Technology Institute
Gladstein, Neandross & AssociatesNational Oceanic and Atmospheric Administration
National Science Foundation
Portland State University
South Coast Air Quality Management District
Tetra Tech, Inc.
The Texas A&M University System
UC Berkeley
UC Davis
UC Irvine
Volkswagen Group of America, Inc.

Poorest Inland Empire Communities Have Highest Fine Particulate Matter Exposure

Residents of lower-income parts of Inland Southern California experience higher exposure to lung-damaging particulate matter inside their own homes than do people who live in wealthier areas, concludes a pilot study by environmental engineers at UC Riverside. The project, led by Dr. Cesunica Ivey, used portable particulate matter sensors to measure individual exposure to fine inhalable particles, with diameters 2.5 micrometers and smaller (PM2.5) to understand which microenvironments posed the greatest exposure risk in the region. PM2.5 lodges in respiratory tract tissues and can cause diseases such as asthma.

The work is part of a larger effort to develop a streamlined, robust, and accessible PM2.5 exposure assessment approach to support environmental justice analyses as required by Assembly Bill 617. The researchers recruited 18 adults from five cities in Riverside and San Bernardino counties: Moreno Valley, Riverside, San Bernardino, Redlands, and Yucaipa. Participants wore small sensors everywhere they went for seven days and left them in the bedroom when they slept. The sensors automatically uploaded data at regular intervals.

Though the small sample size and preliminary nature of the study precludes definitive answers, the large amount of data collected show that the method works to identify exposure disparities. Participants from San Bernardino, which has the highest poverty rate, experienced higher home exposures compared with participants from other cities. Participants from Redlands/Riverside, which have the second and third lowest poverty rates, respectively, had lower home personal exposures and higher personal exposures outside of the home. Since all participants spent the most time at home, participants from the poorest community experienced overall higher personal exposures, despite high participant mobility and low variability in ambient PM2.5 during the study.



Aerial view of Riverside, California

FACULTY & STAFF

David Cocker, Professor
Don Collins, Professor
Kelley Barsanti, Professor
Cesunica Ivey, Professor
Bill Carter, Emeritus Research Chemist
Paul Van Rooy, Postdoc
Ivan Acquaah, Project Specialist
Francesca Hopkins, Professor, Affiliated Faculty
Akula Venkatram, Professor, Affiliated Faculty

Engagement & Partnerships

The power of connection!

Even through this uniquely challenging year, CE-CERT continues to engage with colleagues and the public through webinars and virtual conferences, competitions and celebrations. We take great pride in our established partnerships with industry, government and other academic institutions as this is key to our success. Below are a few highlights of recent activities.

NCST & SCE Co-Sponsor STEPCon Conference & Learning Modules

The Science and Technology Education Partnership (STEP) was established to bridge the skills gap between our K-12 students and high-technology industry needs. This year the STEPCon conference significantly exceeded their expected registrants and digitally welcomed 22,054 students and 483 teachers. UCR Professors and Graduate Students taught a two-week interactive seminar targeted to high school participants. Over 700 high school students chose programs in either sustainable transportation solutions, microgrids, or artificial intelligence –machine learning.



GEMS at STEPCON 2019

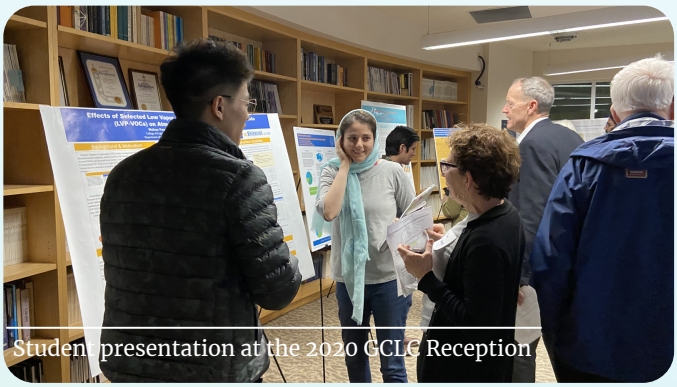
Clean Air Day



CE-CERT and Coalition for Clean Air hosted a successful webinar that informed the community on the impacts of transportation in Southern California and how we plan to improve air quality using emerging technologies.

Global Climate Leadership Council Meeting

CE-CERT proudly hosted the Spring 2020 GCLC open house where members continued to work towards the UC goal of achieving carbon neutrality by 2025. UCR showcased our progress in transitioning to renewable energy so far and over 50 students presented their sustainability research to the UC participants.



Student presentation at the 2020 GCLC Reception

CARTEEH Symposium

CE-CERT and Texas A&M hosted the 2019 Center for Advancing Research in Transportation Emissions, Energy, and Health Symposium (CARTEEH) where experts from the medical profession, engineering, and public policy advocated for advancing research on transportation emissions to minimize health impacts. Discussion revolved around observed health impacts and brainstorming on ways to reduce health related air pollution impacts including premature mortality, asthma, lung cancer, stroke, autism, dementia, diabetes and obesity.

CE-CERT Students

CE-CERT's interdisciplinary approach connects students from various backgrounds to work cooperatively on hands-on research. We employ over 40 undergraduate students at any given time - majoring in engineering, science, business, and policy. We also support the research and thesis efforts of over 50 engineering graduate students.

2019-2020 UNDERGRADUATE STUDENTS

Ivan Acquaah
Yahya Alshanti
Kevin Busch
Guadalupe Castro
Mario Cazares
Kyle Davis
Cindy Duong
Danial Esaid
Jonah Fernando
Joseph Gozum
Laura Grigoryan
Fei Gu
Adriana Gueta
Samantha Hanson
Zoey Hou
Diana Ibarra-Gomez
Alexis Illich
Franklin Ippolito
Yi Ji
Grace Johnson
Mai Le
Brenda Lopez
Zachary Lyons
Matthew Marquis
Jack Maynard
Laura McAlister
David Mendez-Jimenez
Joshua Milne
Alondra Moreno
Matthew Ngo
Crystal Pargas
Jonathan Parker
Kharla Pimentel
Leo Ruan
Shaan Saiyb
Juana Sanchez
Matthew Scudder
Zicheng Shan
Brett Trenier
Jasmin Velasquez
Christian Walker
Runze Wang
Reid Watanabe
Nathan Wilde
Timothy Woodard
Jim Xu
Ruoming Xu
Wendell Zhang

2019-2020 GRADUATE STUDENTS

Issac Afreh
Luis Contreras-Enriquez
Khanh Do
Ryan Drover
Thomas Eckel
Rumana Faruque
Brandon Feenstra
Chas Frederickson
Jacqueline Garrido Escobar
Sahar Ghadimi
Fei Gu
ASM Jahid Hasan
Yu Jiang
Jia Jiang
Kichang Jung
Alija Kabir
Arash Kahsfi Yeganeh
Jiyong Kim
Chen Le
Seungjin Lee
Qi Li
Xishun Liao
Yejia Liao
Taehoon Lim
Shangrui Liu
Jack Maynard
Cavan McCaffery
Ayla Moretti
Saswat Nayak
Roland David Oswald
Weihan Peng
Xinze Peng
Minerva Robles
Pingbo Ruan
Matthew Scudder
Priya Sengupta
Shiva Sharma
Priyanka Singh
Candice Sirmollo
Christos Stamatis
Tianbo Tang
Abdullah Un-Noor
Minerva Uribe-Robles
Paul Van Rooy
Chao Wang
Zhensong Wei
Nigel Williams
Hao Xin
Ningjin Xu
Yun Xue
Fei Ye
Jubair Yusuf
Zhouqiao Zhao
Xuanpeng Zhao
Zihan Zhu
Hanwei Zhu

Student Awards & Highlights

A Lasting Legacy: CE-CERT Establishes New Energy Innovation Scholarship

Life-long energy innovation leader Neal Richter's legacy will live on through the G. Neal Richter Energy Innovation Scholarship. Dr. Richter initiated an endowed scholarship to support students studying energy innovation. The fund reflects his values and was established to further advance the academic quality, excellence and benefits of energy research. The scholarship established at the CE-CERT will provide financial assistance to undergraduate or graduate students studying alternative energies at CE-CERT.

"It was an honor to work with Neal Richter during his time at UCR," said CE-CERT Director Matt Barth. "He brought intangible knowledge to our program and I'm thrilled his legacy will continue through this scholarship."



Dean Reza Abbaschian and Matthew Barth presenting Neal Richter with Distinguished Service Award

CE-CERT SCHOLARSHIP RECIPIENTS

ESTHER F. HAYS GRADUATE AWARD

2019-2020
Isaac Afreh, Chemical & Environmental Engineering
Chen Le, Chemical & Environmental Engineering
Seungjin Lee, Chemical & Environmental Engineering
Ayla Moretti, Chemical & Environmental Engineering

2020-2021
Khanh Do, Chemical Engineering
Jia Jiang, Chemical & Environmental Engineering
Candice Sirmollo, Chemical & Environmental Engineering

J. WAYNE MILLER & THOMAS DURBIN GRADUATE AWARD

2019-2020
Cavan McCaffery, Mechanical Engineering

2020-2021
Hanwei Zhu, Chemical & Environmental Engineering

JIM GUTHRIE UNDERGRADUATE AWARD

2019-2020
Danial Esaid, Computer Engineering

2020-2021
Brenda Lopez Reyna, Mechanical Engineering

SALIM KHAN GRADUATE AWARD

2019-2020
Khanh Do, Chemical Engineering

2020-2021
Ningjin Xu, Chemical & Environmental Engineering

COLIN E. HACKETT GRADUATE AWARD

2019-2020
Priyanka Singh, Chemical & Environmental Engineering

2020-2021
Sahar Ghadimi, Chemical & Environmental Engineering

WILLIAM R. PEIRSON & FORD GRADUATE AWARD

2019-2020
Weihan Peng, Chemical & Environmental Engineering

2020-2021
Zhensong Wei, Electrical Engineering

FORD MOTOR COMPANY UNDERGRADUATE AWARD

2019-2020
Michelle Le, Mechanical Engineering

2020-2021
Golden Se, Chemical Engineering

Student Awards & Highlights

NATIONAL CENTER FOR SUSTAINABLE TRANSPORTATION DISSERTATION & FELLOWSHIP RECIPIENTS

NCST provides national leadership in advancing environmentally sustainable transportation through cutting-edge research, direct policy engagement, and education of our future leaders. NCST is one of seven national centers funded by the U.S. Department of Transportation's University Transportation Centers (UTC) Program, and the only national center focused on the Fixing America's Surface Transportation (FAST) Act research priority area of Preserving the Environment.

NCST DISSERTATION AWARD

2019-2020
Priya Sengupta, Chemical & Environmental Engineering
Chao Wang, Electrical Engineering

2020-2021
Ayla Moretti, Chemical & Environmental Engineering
Yun Xue, Electrical & Computer Engineering

NCST FELLOWSHIP AWARD

2019-2020
Roland David Oswald, Electrical Engineering

2020-2021
Priyanka Singh, Chemical & Environmental Engineering
Sahar Ghadimi, Chemical & Environmental Engineering



Chao Wang, Electrical Engineering

Chao previously worked with the CE-CERT Transportation Systems Research Group on a US DOE funded project that will estimate the impacts of Connected and Automated Vehicles (CAVs) and shared mobility on California's traffic in terms of mobility and energy use. A California-based simulation environment has been created using BEAM (the Modeling Framework for Behavior, Energy, Autonomy, and Mobility), and simulations are being implemented to test the impacts of different CAV and shared mobility applications such as Eco-Approach and Departure (EAD) and ride sharing.
Being enthusiastic about computers and the autonomous vehicles industry, Chao now works at Google on research and development in the areas of vehicle perception and urban big data mining, where he is combining his interests in physics, mathematics, and electrical engineering.



Priyanka Singh, Chemical & Environmental Engineering

Priyanka's research involves the use of Co-solvent Enhanced Lignocellulosic Fractionation (CELF) pretreatment of cellulosic biomass which produces a stream that is rich in hemicellulose sugars and lignin, an aromatic polymer, and leaves solids containing mostly broken-down cellulose or glucan that can then be fermented down streams. Lignocellulosic biomass is a renewable resource with the potential to significantly reduce dependence on petroleum for production of fuels and chemicals which is a major push for sustainable transportation. She is developing processes to maximize total sugar release from hemicellulose and cellulose and CELF lignin by identifying process conditions (time, temperature, loadings) from switchgrass and poplar wood for biological conversion into biofuels and bioproducts.

Student Highlights



Yun Xue, Electrical Engineering

The main objectives of Yun's research work in sustainable transportation utilizes real-world data from solar PV, buildings and electrical vehicles charging profiles, to develop intelligent, yet practical control algorithms for different types of microgrids and/or microgrid clusters that directly support the integration of electric vehicles. Her goals are to develop smart charging strategies for campus wide electric vehicles aggregation; coordinate Level 3 charging with real-time battery control among individual microgrid; and propose a microgrid cluster approach by connecting neighboring microgrids through an advanced bi-level autonomous and coordinated energy management system. Post-graduation Yun hopes to work with renewable energy organizations to promote education and research.



Priya Sengupta, Chemical & Environmental Engineering

Priya worked with the CE-CERT Aqueous Biomass Processing Research Group on cellulosic ethanol production from hardwood poplar, which involves chemically breaking down the biomass by a recently developed technology called Co-Solvent Enhanced Lignocellulosic Fractionation (CELF). One of her research goals was to recover most of the pure wood lignin from the liquid stream produced from wood fractionation and further incorporate it in making high-value products such as plastics. Priya sees herself in academia inspiring future STEM students to continue the work on sustainable energy. She also has a strong desire to make a significant contribution to the field of sustainable aviation fuels from lignocellulosic biomass, as well as creating high quality bioplastics by incorporating the lignin recovered from bio-refineries.



Isaac Afreh, Chemical & Environmental Engineering

"I have always been in interested in chemistry as a subject, so I chose this major because it offers the opportunity to apply chemistry to real life challenges."

Isaac's research uses GECKO-A to probe secondary organic aerosol (SOA) formation from camphene, which has been identified as a dominant monoterpene in biomass burning emissions from different fuel types during laboratory and field studies. His goal is to improve the representation of monoterpenes in gas-phase chemical mechanisms used in large-scale air quality models for predicting secondary organic aerosol (SOA) from biomass burning. After graduation, Isaac plans to join an air quality agency where he can apply his knowledge and skills in chemical mechanism development and air quality modeling to benefit society.

Student Highlights



Ayla Moretti, Chemical & Environmental Engineering

"In five years, I want to be researching emissions in order help determine causes of air pollution and identify areas that need better emission regulations."

Ayla is currently measuring organic aerosol (OA) formation from gasoline vehicle emissions with a temperature-controlled dilution sampler to account for additional OA formation during the dilution and cooling process, on the timescale of near-roadway emissions. One of her research goals is to aid regulators in better understand and predicting the particulate matter emitted from vehicle emissions, on the timescale of near-roadway, in order to improve the understanding of how they affect human health, air quality, and the environment.



Khanh Do, Chemical Engineering

" I want to be a developer for the Community Multiscale Air Quality Model and improve its representation of atmospheric processes. I will integrate machine learning into atmospheric modeling software to reduce simulation time and increase the accuracy."

Khanh is currently working on a project to investigate why the ozone concentrations of the South Coast Air Basin (SoCAB) have slightly increased despite the efforts of SCAQMD to reduce the anthropogenic emissions over the past 30 years. His ultimate research goal is to utilize large air quality and climate datasets, and turn the data into digital recognized patterns. This deep learning trick reduces an enormous amount of computing power, energy costs, and run time, accelerating research.



Ji Jiang, Chemical & Environmental Engineering

“Before I started my PhD career, I was a weather forecaster in China. One of my daily tasks was to provide the air quality index to the public. I wanted to contribute to China’s air quality problem and improve this situation. This inspired me to quit my job and apply for a PhD program in air quality.”

Jia has developed a semi-explicit gas-phase chemical mechanism for furans. This mechanism is compatible with current and prior versions of the wildly used SAPRC gas-phase mechanism. The new mechanism was developed to facilitate a broad application of the mechanism for atmospheric and air quality modeling. Following her PhD, her goal is to obtain a research position in an air quality agency – using her knowledge to improve air quality and public health.

Student Highlights



Candice Sirmollo, Chemical & Environmental Engineering

“Being a first-generation college graduate has resulted in challenges during my education but has also helped me to grow in perseverance and has provided me with a very supportive community of mentors, family, and friends that encourage me to stay motivated with my studies and research.”

Candice’s current research focuses on the growth and atmospheric processing of small particles in the atmosphere, under ambient conditions. Some of these particles will grow to large enough sizes to serve as secondary sources of cloud condensation nuclei (CCN), which have an indirect effect on climate. Her goal is to go on a field campaign at a rural site in Oklahoma, using the newly designed dual chamber system to investigate the growth and processing of small particles in the atmosphere.



Weihan Peng, Checmical & Environmental Engineering

"I chose this major because I want to use my knowledge to make contribution to reduce global warming and air pollution. I see myself working in industry and developing new technology to reduce emissions from vehicle and vessel engines, or working in an environmental consulting company."

Weihan’s research focuses on studying the formation of atmospheric pollution using innovated methodologies. His projects include the study of primary emissions from marine vessels with different fuels and technologies and the study of secondary pollutant formation from vehicle exhaust. His research goal is to better understand the chemistry of secondary organic aerosol formation in atmosphere and improve accuracy of the air quality models to help the regulators better limit the pollutants concentrations in atmosphere.



Sahar Ghadimi, Chemical & Environmental Engineering

“I really love the environment and would like to save it for future generations, including my children. I believe air pollution control research is one of the most important areas that affects global warming and public health.”

Sahar’s research focuses on the investigation of SOA formation from heavy duty vehicles (with engines that are equipped with different after-treatments) using a batch reactor (smog chamber). The physicochemical properties and the composition of the secondary aerosols from the exhaust emissions of each vehicle/fuel combination are collected and examined in the Mobile Atmospheric Chamber. She really enjoys teaching and hopes to stay in academia as a faculty in one of the top universities. This fellowship will provide opportunities to attend teaching workshops.

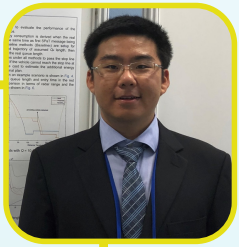
Student Highlights



Brenda Lopez Reyna, Mechanical Engineering

"I would like to be remembered for being tenacious. When I set my mind on something, I always find a way to achieve it. This trait has led me to become a strategic thinker finding unique ways to solve problems that are not apparent."

Brenda's current research project focuses on studying non-tailpipe emissions from light and heavy-duty vehicles. Particularly, brake and tire wear emissions from the California 5 freeway in Anaheim and the 710 highway in Long Beach. She eventually plans to get her PhD at the University of California, Riverside and engage in environmental policy making and advocate for STEM research funding.



Zhensong Wei, Electrical Engineering

"I chose this major because I wanted to develop real-world applications that can contribute to improving air quality and reducing greenhouse gas emissions."

Zhensong's current research focuses on deep learning-based vehicle control and traffic management systems to help vehicles improve safety and reduce energy consumption in different driving scenarios. His future research goals are to develop vehicle automation applications associated with driving safety and energy management, which can be applied to fully autonomous vehicles. Post-graduation Zhensong hopes to continue his work in the industry to reduce vehicle emissions and energy consumption.



Cavan McCaffery, Mechanical Engineering

"I pursued mechanical engineering because I wanted to lower the environmental impacts of mechanical devices from a design standpoint."

Cavan's research focuses on generating data on how different renewable fuel sources and after treatment systems affect the overall emissions provided by different mobile sources in real world situations. His future research goals are to provide an impact on mobile source emissions and to provide valuable data that can be used by regulatory industries.

CE-CERT Alumni Establish Scholarship Award to Honor Emissions and Fuels Research Advisors

The 2019-2020 academic year introduced the J. Wayne Miller and Thomas Durbin Graduate Research Award, a $1,000 scholarship made possible by donors Dr. Jiacheng Yang and Dr. Sam Tanfeng Cao, both CE-CERT alumni. Cavan McCaffery was the first recipient of the J. Wayne Miller and Thomas Durbin Graduate Research Award.

Looking Forward:
Stategic Goals

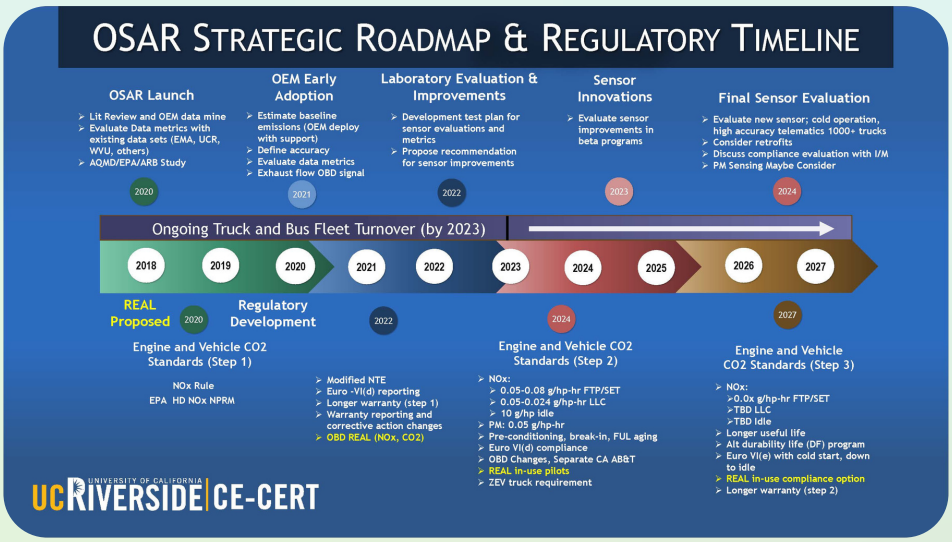
CE-CERT plans to continue to enhance our partnerships and expand our research program over the next several years in terms of breadth and depth by supporting an effort called OASIS and kickstarting new consortia. Additional efforts to support our research enterprise will include updating laboratory and research space, restructuring our Board of Advisors, and creating training and educational courses

Increasing our Impact through OASIS

OASIS (Opportunities to Advance Sustainability, Innovation and Social Inclusion) is joint effort by UCR, the City and County of Riverside, Cal State San Bernardino and Riverside Community College District to create an innovation hub around green tech. OASIS will serve as an eco-system for industry, government and academia to collaborate on sustainability solutions here in the Inland Empire. OASIS will create living laboratories featuring cutting edge sustainability solutions. These laboratories will serve as a platform for tech transfer, job skills training, and research.

Establishing New Constortia

The EFR group launched the OSAR consortium successfully in 2020. OSAR joins experts from industry, academia, and government agencies to collaborate on developing the next generation of on-board sensors, analysis, and reporting systems for assessing the real-world impact of mobile source emissions, and on developing the best mechanisms for real-time emissions reporting that properly accounts for concerns regarding proprietary information, privacy, data uncertainty, and economic considerations. In 2021, we will be evaluating the possibility of turning our DYMMS research into a consortia and kickstarting the Solar Valley consortia.



Facilities

The CE-CERT campus has expanded in recent years to accommodate more than 25 laboratories, three outside company-tenants, four separate buildings, and a quarter of an acre of outdoor laboratory space. Our laboratories are supported by full time facilities and safety personnel, and our personnel and students have access to a machine shop, cold storage, in house gas and liquid nitrogen supplies, vehicle lifts, fuel storage space, and student workshop space. A complete description of the laboratories and the services they provide can be found on our website: www.cert.ucr.edu/laboratoryservices. Recent additions are highlighted below.

Aerosol Research Laboratory

Dr. Don Collins' research group has built an outdoor portable environmental chamber to study the formation and reactions of aerosol particles. The outdoor chambers are connected to the instrumentation in the Atmospheric Process Laboratory through a port created in the exterior wall, enabling suite of instrumentation to be used for the characterization process during field projects. This research is providing new information on the controls and impacts of aerosol-phase water, the growth and transformation of aerosol particles in various environments, and the impact of aerosols on clouds and of clouds on aerosols.



Construction of the Portable Environmental Chamber

Light Duty Laboratory



Light Duty Laboratory

In partnership with AVL Test Systems, Inc., CE-CERT launched its state-of-the-art Light Duty vehicle Laboratory (LDL) to better support State, National, and International emissions and greenhouse gas reduction goals. The new LDL facility will become the cornerstone of CE-CERT's research for light-duty vehicles, as well as providing services for industrial customers. The LDL facility meets all CFR 1065/1066 requirements and is equipped with the same equipment, designs, software, configurations as will be used in new Southern California headquarters facility that will be located in Riverside.

Vehicle-to-Grid Capabilities added to CE-CERT's Microgrid

With funding from Southern California Edison, in 2020 CE-CERT added hardware and software capability to allow vehicles to become fully integrated in to CE-CERT's microgrid. It is now possible to "island" CE-CERT's administration building (take it off the electric grid) and power the building from the energy stored in our electric vehicles.



Mike Todd giving a Vehicle to Grid (V2G) demonstration

Selected Publications

CE-CERT Researchers and Graduate Students continue to work towards environmental solutions through their extensive research. In 2019 CE-CERT issued 75 publications and papers and in 2020 issued 76. Below are our selected publications. To view the extended 2019-2020 list visit: www.cert.ucr.edu/research/publications.

K Do, H Yu, J Velasquez, M Grell-Brisk, H Smith, CE Ivey, "A data-driven approach for characterizing community scale air pollution exposure disparities in inland Southern California", Journal of Aerosol Science, Vol.152, 2020.

JC Corbin, W Peng, J Yang, DE Sommer, U Trivanovic, P Kirchen, J Wayne Miller, S Rogak, DR Cocker, G Smallwood, P Lobo, Stephanie Gagne, "Characterization of particulate matter emitted by a marine engine operated with liquefied natural gas and diesel fuels", Atmospheric Environment, Vol. 220, January 2020.

J Luo, K Boriboonsomsin, M Barth, "Consideration of exposure to traffic-related air pollution in bicycle route planning", Journal of Transport & Health, vol. 16, 2020.

K Jung, T Lim, A Martinez-Morales, "CuO shell as a protective layer to improve the stability of ZnO nanorods-based photoelectrode in DSSCs", Applied Surface Science, Vol. 507, 2020.

SV Pingali, MD Smith, SH Liu, TB Rawal, Y Pu, R Shah, BR Evans, V Urban, B Davison, C Cai, A Ragauskas, H O'Neill, J Smith L Petridis, "Deconstruction of biomass enabled by local demixing of cosolvents at cellulose and lignin surfaces", Proceedings of the National Academy of Sciences, Vol. 117, 2020.

J Jiang, WPL Carter, DR Cocker III, KC Barsanti, "Development and Evaluation of a Detailed Mechanism for Gas-Phase Atmospheric Reactions of Furans", ACS Earth and Space Chemistry, Vol. 4, Issue 8, 2020.

Z Wang, X Liao, C Wang, D Oswald, G Wu, K Boriboonsomsin, M Barth, K Han, B Kim, P Tiwari, "Driver Behavior Modeling using Game Engine and Real Vehicle: A Learning-Based Approach", *IEEE Transactions on Intelligent Vehicles*, Vol. 5, Issue: 4, pp. 738-749, 2020.

P Roth, J Yang, W Peng, DR Cocker III, TD Durbin, A Asa-Awuku, G Karavalakis, "Intermediate and high ethanol blends reduce secondary organic aerosol formation from gasoline direct injection vehicles", *Atmospheric Environment*, Vol. 220, 2020.

C McCaffery, H Zhu, C Li, TD Durbin, KC Johnson, H Jung, R Brezny, M Geller, G Karavalakis,
"On-road gaseous and particulate emissions from GDI vehicles with and without gasoline particulate filters (GPFs) using portable emissions measurement systems (PEMS)"
Science of the Total Environment, Vol. 710, 2020.

X Meng, B Scheidemantle, M Li, Y Wang, X Zhao, M Toro-González, P Singh, Y Pu, C Wyman, S Ozcan, C Cai, A Ragauskas, "Synthesis, Characterization, and Utilization of a Lignin-Based Adsorbent for Effective Removal of Azo Dye from Aqueous Solution", ACS Omega, Vol. 5, 2020.

Z Liu, B Mayer, K Venkiteshwaran, S Seyedi, A Raju, D Zitomer, P McNamara, "The state of technologies and research for energy recovery from municipal wastewater sludge and biosolids"
Current Opinion in Environmental Science & Health, Vol. 14, pp. 31-36, 2020.

Z Wang, Y Bian, S Shladover, G Wu, S Li, M Barth, "A Survey on Cooperative Longitudinal Motion Control of Multiple Connect and Automated Vehicles", IEEE Intelligent Transportation, Vol. 12, Issue 1, pp 4-24, 2019.

X Qi, Y Luo, G Wu, K Boriboonsomsin, M Barth, "Deep Reinforcement Learning Enabled Self-learning Control for Energy Efficient Driving", Transportation Research Part C: Emerging Technologies, Vol. 9, pp. 67-81, 2019.

J Yang, P Roth, T Durbin, M Shafer, J Hemming, D Antkiewicz, A Asa-Awuku, G Karavalakis, "Emissions from a flex fuel GDI vehicle operating on ethanol fuels show marked contrasts in chemical, physical and toxicological characteristics as a function of ethanol content", Science of The Total Environment, Vol. 683, pp. 44-54, 2019.

J Yang, P Roth, H Zhu, T Durbin, G Karavalakis, "Impacts of gasoline aromatic and ethanol levels on the emissions from GDI vehicles: Part 2. Influence on particulate matter, black carbon, and nanoparticle emissions", Fuel, Vol. 252, pp. 812-820, 2019.

Y, C Wyman, C Cai, A Ragauskas
"Lignin-Based Polyurethanes from Unmodified Kraft Lignin Fractionated by Sequential Precipitation", ACS: Applied Polymer Materials, Vol. 1, 2019.

B Feenstra, V Papapostolou, S Hasheminassab, H Zhang, B Der Boghossian, D Cocker, A Polidori, "Performance evaluation of twelve low-cost PM2.5 sensors at an ambient air monitoring site", Atmospheric Environment, Vol. 216, 2019.

Y Tan, P Henderick, S Yoon, J Herner, T Montes, K Boriboonsomsin, K Johnson, G Scora, D Sandez, T Durbin, "On-Board Sensor-Based NO x Emissions from Heavy-Duty Diesel Vehicles", Environmental Science & Technology, Vol. 53, pp. 5504-5511, 2019.

X Hu, T Liu, X Qi, M Barth, "Reinforcement Learning for Hybrid and Plug-In Hybrid Electric Vehicle Energy Management: Recent Advances and Prospects", IEEE Industrial Electronics Magazine, Vol. 13, Issue 3, pp. 16-25, 2019.

Active Projects List

FEDERAL ACTIVE PROJECTS: 37 Active Federal Projects Totaling $11,355,429

- **Building and Testing the Framework to Integrate Detailed Chemical Measurements and Predictive Biomass Burning Models** | National Oceanic and Atmospheric Administration | Barsanti, APL
- **Center for Advancing Research in Transportation Emissions, Energy and Health** | The Texas A&M University System | Ivey, APL
- **Collaborative Research: ICARUS - Index of Chamber Atmospheric Research in the United States** | National Science Foundation | Cocker, APL
- **Direct measurement of small particle growth and aging at SGP** | Department of Energy Office of Science/Off of Basic Energy |Collins, APL
- **Investigating the Nighttime Chemistry of Biomass Burning Emissions** | National Oceanic and Atmospheric Administration (NOAA) |Barsanti, APL
- **Measurement of Criteria Emissions from the MARAD RRF Vessel Cape Henry** | Department of Transportation Maritime Administration | Ivey, APL
- **Hyperlocal Monitoring of Traffic-Related Air Pollution to Assess Near-Term Impacts of Sustainable Transportation Interventions** | U.S. Department of Transportation via UC Davis | Ivey, APL
- **RAPID: Collaborative Research: Urban Air Quality During the COVID-19 Shelter-In-Place Orders | National Science Foundation** | Barsanti, APL
- **Scalable Chemical Mechanisms of Emerging Sources for Community Air Quality Prediction** | Environmental Protection Agency | Barsanti, APL
- **Strategies: Riverside Air Monitoring Project (RAMP)** | Itest | Barsanti, APL
- **Toxicant Production and Mitigation in the Electronic-Cigarette** | Portland State University | Barsanti, APL
- **Mapping Aerosol Processes across Houston during convective cell event** | Baylor University | Collins, APL
- **Ultrafine aerosol particle formation and impacts in Houston during TRACER** | UC Irvine | Collins, APL

- **U.S. Army Research Lab: A Large Outdoor Motion-tracking Arena for Research on Heterogeneous Autonomous Multi-robot Systems** | Department of Defense | Karavalakis, EFR
- **Vessel and Port Emissions Testing** | Department of Transportation Maritime Administration | Miller, EFR
- **Real-World brake activity of heavy-duty vehicles** | UC Davis | Jung, EFR
- **Center for Advancing Research in Transportation Emissions, Energy and Health** | The Texas A&M University System | Karavalakis, EFR
- **Developing New and Improving Existing Mobile Source Emission Inventories** | Easter Research Group, Inc. | Durbin, EFR
- **Developing a Database for Marine Emissions** | Eastern Research Group, Inc | Durbin, EFR
- **Heavy-Duty Vehicle Testing and Data Analysis** | Eastern Research Group, Inc | Durbin, EFR
- **Developing a Database for Marine Emissions** | Eastern Research Group, Inc | Miller, EFR

- **A Green Approach to Pulping Hemp for Construction** | Environmental Protection Agency | Cai, RFR
- **A Green Approach to Pulping Hemp for Construction** | Environmental Protection Agency | Cai, SFR
- **Advanced Technologies for Biomass Deconstruction and Lignin Valorization** | Oak Ridge National Laboratory | Wyman, RNR
- **Next Generation of Ligno-Polyurethanes** | University of Tennessee | Cai, RFR

- **An Innovative Vehicle-Powertrain Eco-Operation System for Efficient Plug-in Hybrid Electric Buses** | ARPA-E | Barth, TSR
- **Assessing Roadway Infrastructure for Future Connected & Automated Vehicle Deployment in CA** | ITS | Wu, TSR
- **Assessing Roadway Infrastructure for Future Connected & Automated Vehicle Deployment in CA** | ITS | Boriboonsomsin, TSR
- **Center for Advancing Research in Transportation Emissions, Energy and Health** | The Texas A&M University System | Boriboonsomsin, TSR
- **Center for Advancing Research in Transportation Emissions, Energy and Health** | The Texas A&M University System | Luo, TSR
- **Estimating the Impacts of Automatic Emergency Braking (AEB) Technology on Traffic Energy and Emissions** | University of Southern California | Wu, TSR
- **Evaluating System-Level Impacts of Innovative Truck Routing Strategies** | University of Southern California | Boriboonsomsin, TSR
- **Las Vegas License Plate Survey** | ERG | Boriboonsomsin, TSR
- **Development of an Innovation Corridor Testbed for Shared Electric Connected and Automated Transportation** | U.S. Department of Transportation via UC Davis | Barth, TSR
- **Eco-friendly Cooperative Traffic Optimization at Signalized Intersections** | U.S. Department of Transportation via UC Davis | Hao, TSR
- **Development of Eco-Friendly Ramp Control based on Connected and Automated Vehicle Technology | U.S. Department of Transportation via UC Davis | Wu, TSR**
- **Extracting Dynamics from Limited Data for Modeling and Control of Unmanned Autonomous Systems** | National Science Foundation | Konstantinos, TSR

Active Projects List

INDUSTRY ACTIVE PROJECTS: 32 Active Industry Projects Totaling $7,849,530

- **Characterization of aerosol size distributions in India during the CAIPEEX study** | Droplet Measurement Technologies | Collins, APL
- **Development and Evaluation of Databases and Estimation Methods for Predicting Air Quality Impacts of Emitted Organic Compounds** | Coordinating Research Council | Carter, APL
- **n/a** | Cummins Westport | Ivey, APL
- **NOx Sensor Evaluation and Support: Sensor Performance and Aging Behavior in Real World** | Eastern Research Group, Inc. | Ivey, APL
- **Catalytic NO and CO Emission Control Unit for Small Off-road Engines** | Environmental Protection Agency | Cocker, APL
- **POLB LCTF + AQIP Off-road Equipment data monitoring** | Tetra Tech, Inc. | Ivey, APL
- **The Influence of NOx on SOA and Ozone Formation** | Coordinating Research | Cocker, APL
- **Ultra-Low Nox NG HDT Evaluation** | Cummins Westport | Ivey, APL
- **Volkswagen Group In-Use Testing Services and Reporting** | Volkswagen Group of America, Inc. | Ivey, APL

- **Renewable Diesel for Off-Road Diesel Engines** | South Coast Air Quality Management District |Karavalakis, EFR
- **Data Collection and Analysis under the California Air Resources Board (CARB) Zero-and-Near-Zero Emissions Freight Facility Grant** | Tetra Tech, Inc. | Durbin, EFR
- **Devil's Gate Emissions Monitoring and Verification** | Tetra Tech, Inc. | Durbin, EFR
- **Evaluation of Hydrogen-Natural Gas on Engine Performance and Durability** | Southern California Gas Company | Karavalakis, EFR
- **Ingevity Adsorbed Natural Gas Vehicle In-Use Emissions Testing** | Ingevity Corporation | Karavalakis, EFR
- **PEMS Emissions Testing on 9 Light-Duty Vehicles** | MBtech North America LLC | Karavalakis, EFR

- **A Catalytic Process to Convert Municipal Solid Waste Components to Energy** | Worcester Polytechnic Institute |Cai, RFR
- **Evaluate RNG's Role in achieving a 100% RPS in California** | **Southern California Gas Company** | Raju, RFR
- **Hydrogen Blending Impacts Study** | California Public Utilities Commission | Raju, RFR
- **Modification of Zeolite Catalyst to Increase Carbon Number and Reduce Aromatics for Conversion of Ethanol to Jet Fuel** | Vertimass, LLC | Wyman, RFR

- **Speeding Anaerobic Digestion with CO2 Microbubbles** | Southern California Gas Company | Raju, RFR

- **Coordinated Operation of Shared Micro-Mobility for a Sustainable City Transportation System** | ITF | Tanvir, TSR
- **Changes to traffic patterns and localized air quality** | ITF | Tanvir, TSR
- **CAV Applications Effectiveness Analysis** | Honda | Wu, TSR
- **CAV Applications Effectiveness Analysis** | Honda | Wu, TSR
- **Connected Eco-Driving for Heavy-Duty Conventional and Plug-In Hybrid Electric Trucks** | Volvo Truck Corporation | Boriboonsomsin, TSR
- **Developing Situation Awareness Capability within the Digital Twin Framework Activating/Deactivating Connected Vehicle (CV) Applications in Mixed T** | Toyota Motor North America, Inc. | Wu, TSR
- **Development and Evaluation of Honda's Reactive Force Pedal Technology** | Honda R&D Co., Ltd. | Tanvir, TSR
- **Development and Evaluation of Honda's Reactive Force Pedal Technology** | Honda R&D Co., Ltd. | Tanvir, TSR
- **Eurosemillas Technology Acceleration Program** | Eurosemmillas | Boriboonsomsin, TSR
- **Evaluating Connected Vehicle Applications in a Mixed Traffic Environment using a Digital Twin Approach** | Toyota Infotechnology Center |Wu, TSR
- **Volvo Low Impact Green Heavy Transport Solutions (LIGHTS)** | Volvo Truck Corporation | Boriboonsomsin, TSR

STATE ACTIVE PROJECTS: 41 Active State Projects Totaling $16,915,512

- **A Catalytic Process to Convert Municipal Solid Waste Components to Energy** | Worcester Polytechnic Institute |Cai, RFR
- **Evaluate RNG's Role in achieving a 100% RPS in California** | **Southern California Gas Company** | Raju, RFR
- **Hydrogen Blending Impacts Study** | California Public Utilities Commission | Raju, RFR
- **Modification of Zeolite Catalyst to Increase Carbon Number and Reduce Aromatics for Conversion of Ethanol to Jet Fuel** | Vertimass, LLC | Wyman, RFR

- **Advanced Off-Road NG Vehicle Demonstration and Evaluation** | Gladstein, Neandross & Associates | Ivey, APL
- **Combined Empirical/Chemical Transport Air Quality Modeling and 'Big Data' Analysis of Meteorological and Emissions Impacts on Air Quality in the South** | South Coast Air Quality Management District | Ivey, APL

Active Projects List

INDUSTRY ACTIVE PROJECTS (CONT.)

- **Community Air Grant Proposal for J.W. North High School in Riverside, California** | Air Resources Board | Cleary, APL
- **Community Air Grant Proposal for J.W. North High School in Riverside, California** | Air Resources Board | Cleary, APL
- **Emission Testing and Test Method Development for Commercial Harbor Craft and Ocean-Going Vessels** | Air Resources Board | Ivey, APL
- **Environmental Chamber Experiments to Improve Secondary Organic Aerosol Model Prediction** | Air Resources Board | Cocker, APL
- **Onboard Sensing, Analysis, and Reporting (OSAR): Phase 1 Sensor Evaluation on Heavy Duty Trucks** | South Coast Air Quality Management District | Ivey, APL
- **Optimized Hybrid Ultra-Low NOx Class 8 Heavy Duty Natural Gas Truck** | Gas Technology Inst. | Ivey, APL
- **Quantify the Effect of Roadside Barrier on Near Road Air Pollutant Dispersion and Concentration** | CalTrans | Venky, APL
- **Understanding and Mitigating Wildfire Risk in California** | UC Berkeley | Barsanti, APL

- **Activity Data of Off-Road Engines in Construction** | Air Resources Board | Durbin, EFR
- **200 Vehicle Study (In-Use Emissions Testing and Fuel Usage Profile of On-Road Heavy-Duty Vehicles)** | Air Quality Management District | Durbin, EFR
- **CARB Emissions Compliance Testing** | Air Resources Board | Durbin, EFR
- **Collection and Analysis of Agricultural Equipment** | Air Resources Board |Durbin, EFR
- **Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15** | Air Resources Board | Karavalakis, EFR
- **Confirmatory and Efficacy Testing of Additive-Based Alternative Diesel Fuel Formulations** | Air Resources Board | Durbin, EFR
- **Hexavalent Chromium Emissions from Industrial Heat Treating Furnaces** | South Coast Air Quality Management District | Karavalakis, EFR
- **Literature review | Air Resources Board** | Karavalakis, EFR
- **Low Emission Diesel (LED) Study** | Air Resources Board | Durbin, EFR
- **Real-world tire and brake wear emissions** | Air Resources Board | Jung, EFR
- **Secondary Organic Aerosol Forming Potential from HD Diesel vehicles & HD Natural Gas Vehicle** | Air Quality Management District | Karavalakis, EFR
- **Updates to Heavy-Duty Emission Deterioration in EMFAC** | Eastern Research Group, Inc. | Durbin, EFR
- **Volvo Low Impact Green Heavy Transport Solutions (LIGHTS)** | Volvo Truck Corporation | Durbin, EFR

- **Campus Energy Fund** | University of California Riverside | Ula, RFR
- **CEC Indian Tribe-Chemehuevi Indian Tribe Microgrid | California Energy Commission** | Martinez-Morales, RFR
- **Development of a Photo-rechargeable Battery System** | Los Angeles Department of Water and Power | Martinez-Morales, RFR
- **Hollow Titanium Dioxide Nanospheres as a Delivery System of Chemoattractant Factors for Human Dopaminergic Axons** | UC Mexus | Martinez-Morales, RFR
- **Renewable Syngas Methanation** | Taylor Energy | Raju, SFR
- **Volvo Low Impact Green Heavy Transport Solutions (LIGHTS) | Volvo Truck Corporation** | Raju, SFR

- **Air Quality and Climate Training Program** | South Coast Air Quality Management District | Barth & Cleary
- **Alternative HOV Lane Operational Strategies for Congestion Mitigation in California** | California Department of Transportation | Boriboonsomsin, TSR
- **Climate Change Research for the California Strategic Growth Council** | UC Davis | Barth, TSR
- **Development and Application of Environmentally-Friendly Intelligent Transportation System (ECO-ITS) Freight Strategies** | South Coast Air Quality Management District | Boriboonsomsin, TSR
- **Evaluation of Hybrid Electric Street Sweepers** | California Department of Transportation | Scora, TSR
- **Geofencing as a strategy to lower emissions in disadvantaged communities** | Air Resources Board | Boriboonsomsin, TSR
- **Hybridization and full electrification potential in off-road applications** | Air Resources Board | Boriboonsomsin, TSR
- **Port of Los Angeles Freight Transportation Project** | Productivity Apex, Inc. | Boriboonsomsin, TSR
- **Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Tec** | South Coast Air Quality Management District | Barth, TSR
- **Integrating Zero Emission Vehicles into the Caltrans Fleet** | UC Davis | Todd, TSR
- **Update CalEnviroScreen's Traffic Density Indicator** | Office of Environmental Health Hazard Assessment | Hao, TSR

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Thank you!