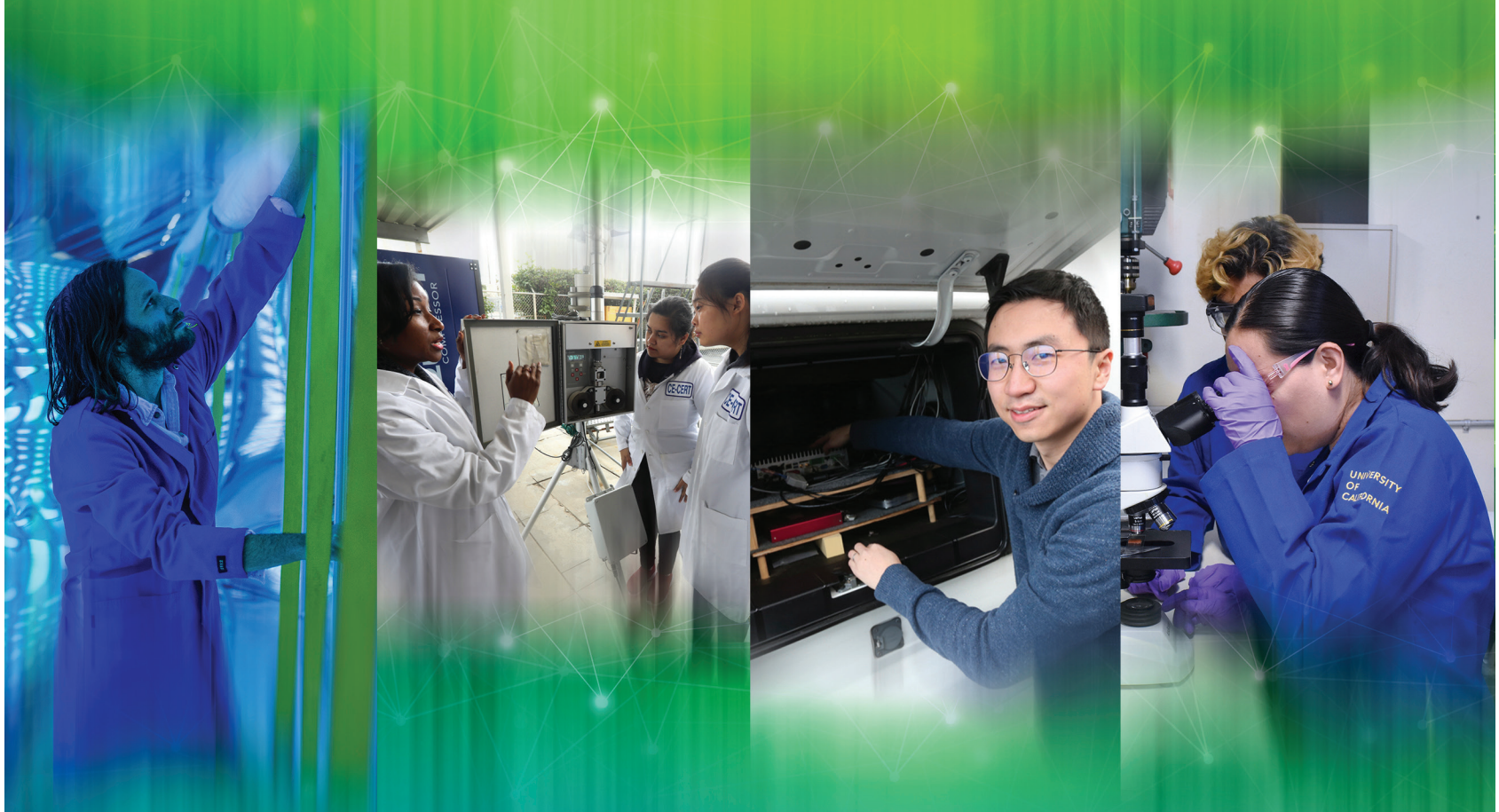


UNIVERSITY OF CALIFORNIA
UCRIVERSIDE | **CE-CERT**
BOURNS COLLEGE OF ENGINEERING
CENTER FOR ENVIRONMENTAL RESEARCH AND TECHNOLOGY



2018

ANNUAL REPORT

PUBLISHED MAY 2019

WELCOME TO THE CENTER FOR ENVIRONMENTAL RESEARCH AND TECHNOLOGY

The Bourns College of Engineering Center for Environmental Research and Technology brings together faculty, staff and students from a variety of backgrounds and disciplines in pursuit of the knowledge needed to move us toward our goal of environmental sustainability. From understanding how emissions impact air quality to developing the technologies needed to improve solar and other renewable energy sources, our research teams are continuing this tradition of innovation through research and development in support of the five focus areas shown below:

01 **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.

03 **Transportation Systems: Vehicle and Infrastructure Interaction:**

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

05 **Exposure and Health Effects:**

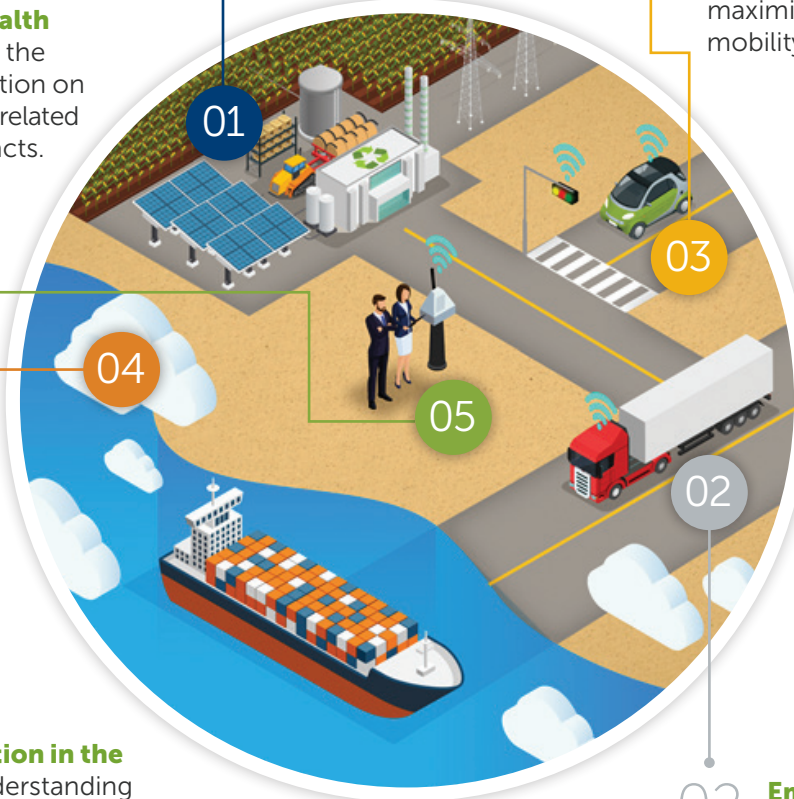
Exploring the effects of air pollution on human health and related quality of life impacts.

04 **Pollution Formation in the Atmosphere:**

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

02 **Emissions and Fuels:**

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



The distinctive mission of the University of California is to serve as a center of higher learning, providing long-term societal benefits through transmitting and discovering advanced knowledge and functioning as an active working repository of organized knowledge. CE-CERT addresses all three aspects of UC's overarching mission: research, education, and public service in the areas of air quality, transportation, and energy.

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"At the heart of our Center are the students—in 2018, we had nearly 50 undergraduates and 57 graduate students participating in our research."

It has been another exciting year here at UC Riverside's Bourns College of Engineering, Center for Environmental Research and Technology (CE-CERT), where we continue to expand our research program in a variety of directions. In 2018, CE-CERT grew its partnerships within US Department of Energy's Center for Bioenergy Innovation, the US Department of Transportation's National Center for Sustainable Transportation, and the Center for Transportation Emissions, Energy, and Health. We carried out a number of new research projects in renewable natural gas, air quality impacts of wildfires, and community air quality monitoring, to name a few. We also welcomed several new faculty and staff, including Professor Cesunica Ivey who is doing some excellent work in regional air quality modeling.

We also had a great year in terms of engagement, with many events and initiatives that brought together a number of stakeholders from industry, government, and academia. Most notably, we hosted the California Air Resources Board's 50th Anniversary Symposium and Technical Showcase, where we had over 300 participants, honoring CARB's 50-year history. In

addition, we carried out our first year of our emissions instrumentation certificate program as part of our Air Quality and Climate Research Training Program, sponsored by the South Coast Air Quality Management District.

At the heart of our Center are the students—in 2018, we had nearly 50 undergraduates and 57 graduate students participating in our research. Several of these students have won a variety of prestigious awards. I am hopeful that their time here is providing them with key real-world experience that you would not normally get from the classroom.

CE-CERT's unique resources, including our very capable faculty, staff, and students have attracted a variety and growing number of sponsors requesting our expertise in solving real-world challenges. This annual report highlights these research efforts and many of the people involved. To explore a bit deeper, you can find more detailed information on our website, www.cert.ucr.edu, where we describe all of the latest activities here at our Center.

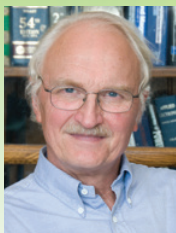
Sincerely,
Dr. Matthew Barth



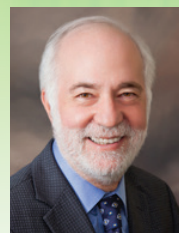
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ALAN LLOYD
Sr. Research Fellow, Energy Institute
University of Texas at Austin

ANNE MAYER
Executive Director,
Riverside County Transportation Commission

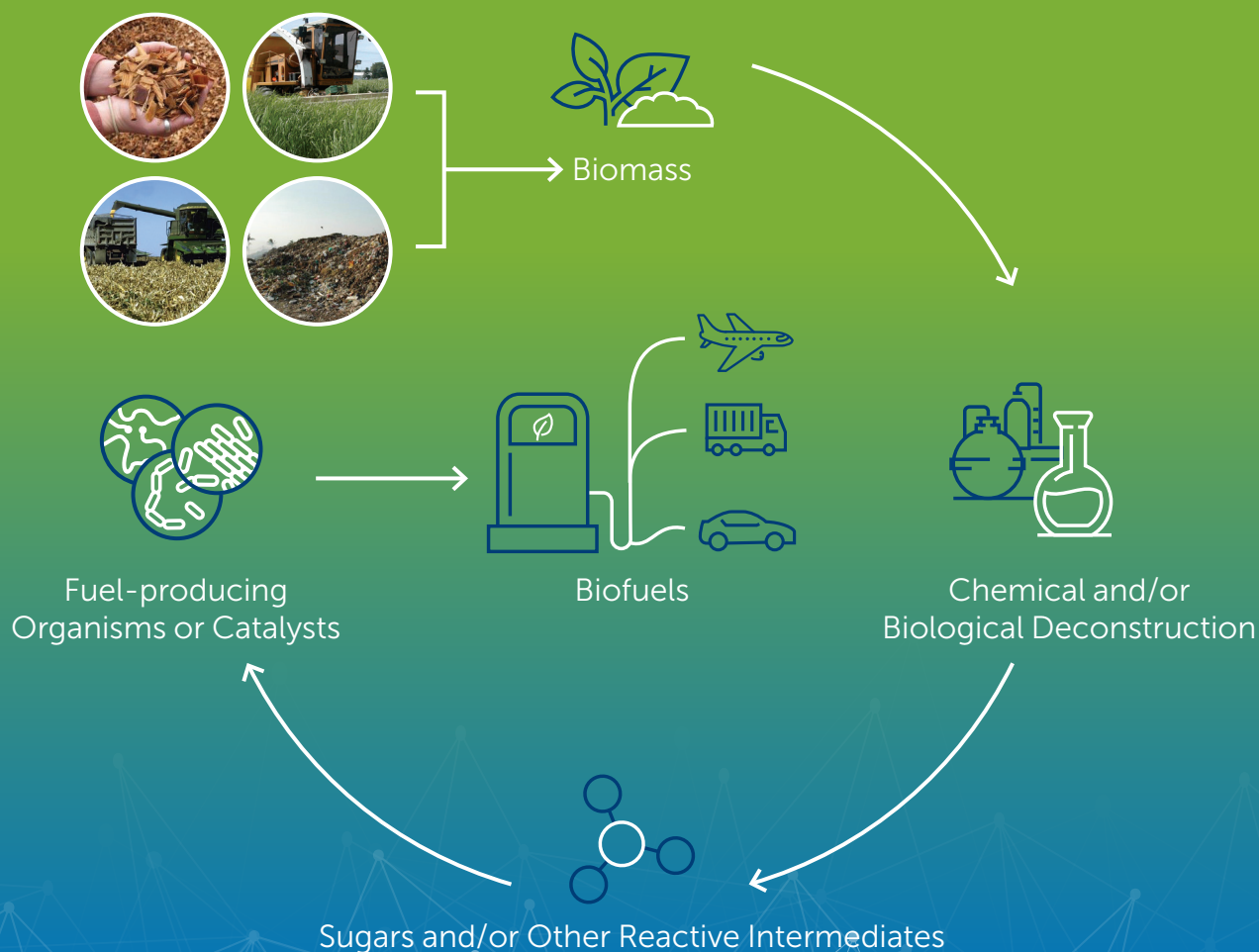
RENEWABLE ENERGY PRODUCTION & INTEGRATION

There is broad scientific consensus that global surface temperature warming trends will continue if a significant reduction in greenhouse gas (GHG) emissions isn't achieved in the near future. CE-CERT is addressing this issue by accelerating the transition to renewable energy through technologies that create energy from waste, capitalize on the sustainable energy sources that exist in nature, and explore methods to store, allocate, and integrate renewable energy with existing infrastructure.

AQUEOUS BIOMASS PROCESSING: CREATING BIOFUELS FROM PLANTS

What do corn stover, switchgrass, and woody crops have in common? These materials, along with other inedible crops and municipal wastes that are collectively called lignocellulosic biomass, can be converted into biofuels. Lignocellulosic biomass materials such as these are abundant, renewable, and not competitive with food products, but very expensive to process in terms of both money and energy. CE-CERT's research focuses on increasing the efficiency of this process while reducing its cost.

BIOFUELS LIFE-CYCLE



2018 RESEARCH HIGHLIGHTS

CE-CERT RESEARCHERS JOIN THE CENTER FOR BIOENERGY INNOVATION

In 2018, the Aqueous Biomass Processing research group celebrated its first year as a partner in the Center for Bioenergy Innovation (CBI). As one of four Biological and Environmental Research Centers funded by the U.S. Department of Energy Office of Science, the CBI's mission is to overcome critical cost barriers associated with the production of biofuels and other bio-derived products.

As a key part of the CBI team, the Aqueous Biomass Processing research group is focused on improving the deconstruction of biomass through the use of microorganisms by a process called consolidated bioprocessing (CBP). The group is currently working to understand how integrating pretreatment with CBP can improve overall performance, and is also identifying and documenting potentially influential factors such as the type of feedstock used. These data will be used by the team in comparative studies to determine which CBP strategies are the most promising for producing both biofuels and other related products.



Graduate student Priya Sengupta works on chemical separation.



Consolidated Bioprocessing (CBP): Employing a single microorganism or group of microorganisms to breakdown biomass by producing the needed enzymes without separate, expensive, enzyme production.

Graduate student Priyanka Singh examines a culture for bacterial growth.

2018 Renewable Fuels Group Faculty and Staff

Charles Cai, Associate Research Faculty
Rajeev Kumar, Associate Research Faculty
Alfredo Martinez-Morales, Managing Director, SC-RISE
Hamed Mohsenian-Rad, Associate Professor, Electrical & Computer Engineering
Chan Seung Park, Associate Research Faculty
Miroslav Penchev, Research Staff
Arun Raju, Assistant Research Faculty; Director, Center for Renewable Natural Gas
Mike Todd, Research Staff
Sadrul Ula, Research Faculty; Interim Energy Manager, UCR
Barry Wallerstein, Research Faculty; Senior Fellow, School of Public Policy
Charles Wyman, Professor, Chemical & Environmental Engineering
Nanpeng Yu, Assistant Professor, Electrical & Computer Engineering

Selected Publications

N. Kothari, S. Bhagia, M. Zaher, Y. Pu, A. Mittal, C.G. Yoo, M.E. Himmel, A.J. Ragauskas, R. Kumar and C.E. Wyman, "Cellulose Hydrolysis by *Clostridium Thermocellum* is Agnostic to Substrate Structural Properties in Contrast to Fungal Cellulases," *Green Chemistry*, vol. 21, pp. 2810 – 2822, 2018.

B. Seemala, X. Meng, A. Parikh, N. Nagane, R. Kumar, C. E. Wyman, A. Ragauskas, P. Christopher, and C. M. Cai, "Hybrid Catalytic Biorefining of Hardwood Biomass to Methylated Furans and Depolymerized Technical Lignin," *ACS Sustainable Chemistry & Engineering*, vol. 6, no. 8, pp. 10587–10594, 2018.

G. Svenningsen, R. Kumar, C.E. Wyman, and P. Christopher, "Identifying the Mechanism of Fructose Dehydration to 5-Hydroxymethylfurfural in Aqueous Dipolar Aprotic Solutions by Homogeneous Acids," *ACS Catalysis*, 8(6):5591-5600, 2018.

Key Sponsors and Partners

- Center for Bioenergy Innovation (CBI)
- DOE BioEnergy Technology Office (BETO) Incubator Program
- Ford Motor Company Chair in Environmental Engineering
- National Center for Sustainable Transportation (NCST)
- National Science Foundation
- USDA Biomass Research and Development Initiative Competitive Grants Program (BRDI)
- USDA National Institute for Food and Agriculture
- U.S. Department of Energy

CENTER FOR RENEWABLE NATURAL GAS: DEVELOPING ALTERNATIVES TO FOSSIL FUELS

Renewable Natural Gas (RNG) is an important alternative fuel that can help the State of California meet several greenhouse gas (GHG) and renewable energy targets. As a transportation fuel, RNG can result in an approximately 90% reduction in GHG emissions. Despite considerable potential, current RNG contribution on national and state levels is very small. CE-CERT's Center for Renewable Natural Gas (CRNG) is addressing this challenge by developing and validating technologies that will enable RNG production and use in substantial quantities in California and elsewhere.

RNG can be produced from a variety of local, renewable resources including municipal waste, green waste, biosolids, and dairy manure, and can be stored and delivered using existing infrastructure.

CRNG FOCUS AREAS

HIGH YIELD THERMOCHEMICAL RNG PRODUCTION

Developing cost-effective technologies to commercially produce fuel-grade RNG from carbonaceous waste (e.g. forest biomass, agricultural residue); addressing wide-scale adoption barriers such as feedstock logistics/pre-treatment challenges, tar formation, gas cleanup, and high capital costs.

POWER-TO-GAS PRODUCTION

Developing cost-effective systems to convert excess renewable electricity into hydrogen or methane as a means to increase the renewable energy content of the pipeline infrastructure while addressing grid capacity and storage issues.

METHANATION PATHWAYS

Optimizing hydrogen conversion to methane, especially in the power-to-gas context where direct hydrogen injection into pipeline or long term hydrogen storage is not viable.

LIFE CYCLE AND TECHNO-ECONOMIC ANALYSIS

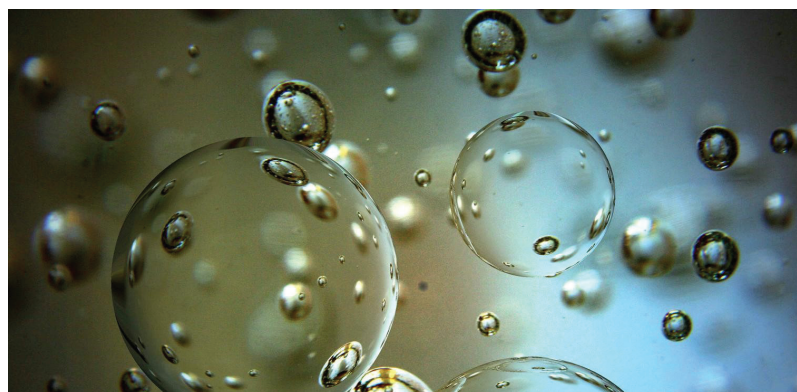
Conducting systems-level analyses of RNG production pathways to evaluate greenhouse gas and criteria pollutant emissions, material and energy balances (efficiencies) and commercial viability (economics).

ANAEROBIC DIGESTION

Optimizing digestion pathways and technology options and addressing logistic and cost issues associated with feedstock collection and conversion.

2018 RESEARCH HIGHLIGHTS

ENHANCING RENEWABLE FUEL PRODUCTION WITH CO₂ MICROBUBBLES



Carbon dioxide (CO₂) is a colorless, odor-free gas that serves a diverse variety of purposes in our world. From fire extinguishers to carbonated beverages, CO₂ makes many of our industrial technologies possible. As most people know, CO₂ is critical to our environment as plants use it for photosynthesis. CO₂ is also classified as a greenhouse gas (GHG) due to its heat trapping properties, and the rising level of this gas in our atmosphere is a significant contributor to climate change.

Dr. Arun Raju and his research team have partnered with SoCalGas and Perlemax to use CO₂ to increase the production rates of a fuel source that provides a significant reduction in criteria and GHG emissions: renewable methane.

The patented process improves the efficiency of anaerobic digestion through the introduction of CO₂ microbubbles into the digester, doubling production rates at new and existing facilities, and increasing the profitability of producing a renewable, environmentally sound fuel source.

"We believe this technology will play an important role in helping reduce greenhouse gas emissions while increasing renewable fuel production in California and elsewhere."

-Dr. Arun Raju, Director, Center for Renewable Natural Gas

STUDY IDENTIFIES RENEWABLE NATURAL GAS (RNG) AS A COST-EFFECTIVE ADDITION TO CALIFORNIA'S ENERGY PORTFOLIO

A recent study by the Center for Renewable Natural Gas (CRNG) evaluated the possible role of renewable natural gas in reducing greenhouse gas emissions across the transportation, building, and commercial and industrial sectors. Renewable natural gas can be produced by anaerobic digestion from sources such as landfill gas, animal manure, biosolids from wastewater treatment plants, and food and green waste, instead of being harvested from fossil fuels. As a non-fossil fuel, RNG contributes significantly less GHG emissions than standard natural gas.

ANAEROBIC DIGESTION: A PROCESS IN WHICH BACTERIA DECOMPOSE ORGANIC WASTE MATERIALS IN AN OXYGEN-FREE ENVIRONMENT, PRODUCING METHANE GAS AS A WASTE PRODUCT. THIS GAS CAN THEN BE HARVESTED AND CONVERTED TO A COMMERCIALLY USABLE FORM.

Another important benefit of RNG technology is its readiness for deployment due to a mature and extensive storage and distribution infrastructure, commercially proven production techniques, and the availability of natural gas vehicle technologies. Additionally, large scale renewable gas production could address emissions from certain sources that are unlikely to be mitigated in the near term, such as landfill gas.

In order to accelerate the production and use of RNG, one of the study's primary recommendations is that California adopt a natural gas standard. This standard would require the injection of increasing percentages of renewable gas into the natural gas pipeline infrastructure to meet specific renewable percentage targets, and developing an enhanced policy framework that supports a gradual increase of these percentages. Second, stable financing for RNG must be assured by addressing key production and use barriers.

When employed as part a comprehensive strategy, RNG could potentially replace as much as 5% or more of the state's total natural gas consumption at a cost comparable to other regulatory approaches.

55-99B
CUBIC FEET

**IN-STATE ANNUAL RNG
PRODUCTION POTENTIAL**

\$93-\$434
\$/TONNE

**COST OF
AVOIDED CO₂**

11.4M
METRIC TONNES

**TOTAL GHG EMISSION
REDUCTION POTENTIAL
FROM IN-STATE RNG**

Estimated CO₂ Avoidance
(Cost Range from CARB 2017
Scoping Plan Measures)

= -\$300 TO \$200 PER METRIC TONNE *

https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf

Selected Publications

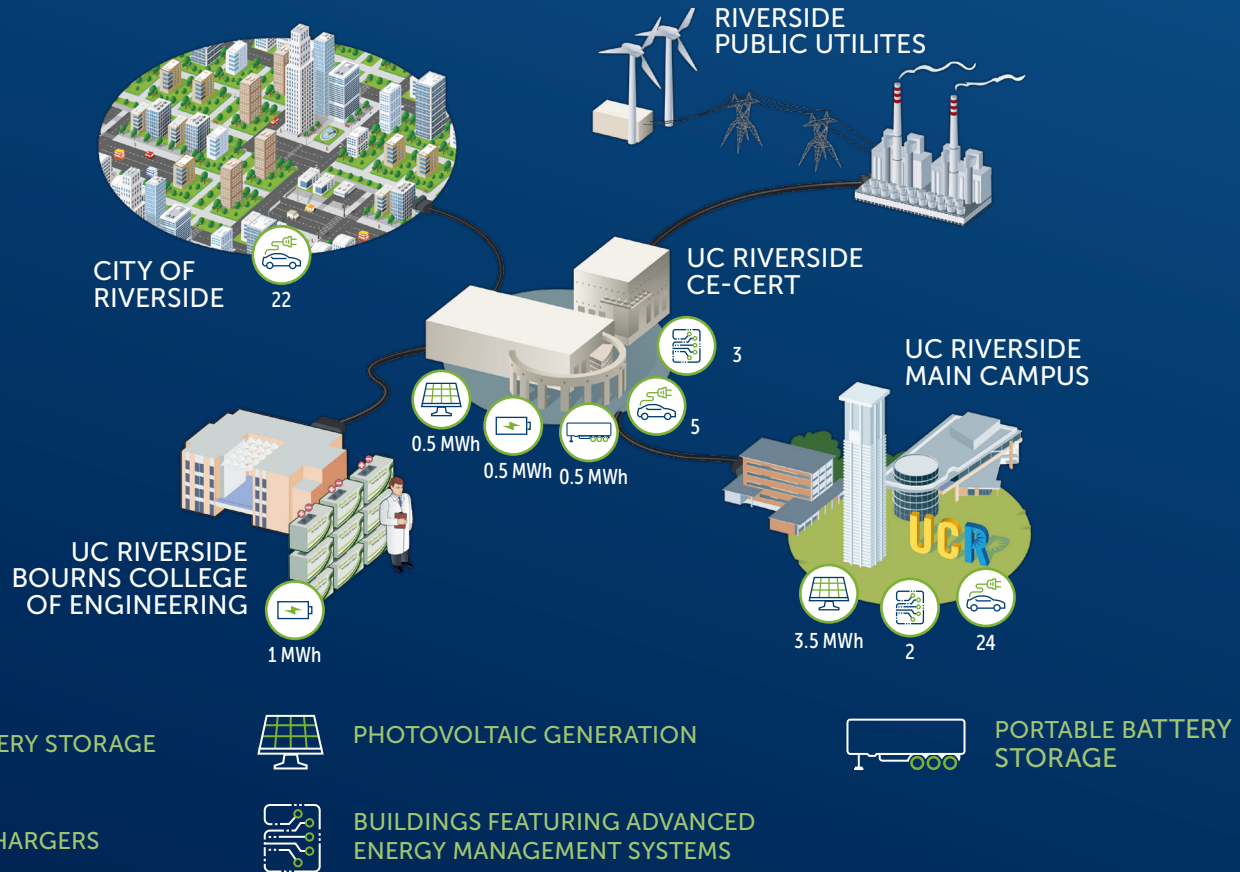
P. S. Roy, J. Song, K. Kim, C. S. Park, and A. S. Raju, "CO₂ Conversion to Syngas Through the Steam-Biogas Reforming Process," *Journal of CO₂ Utilization*, vol. 25, pp. 275-282, 2018.

Key Sponsors and Partners

- National Center for Sustainable Transportation
- South Coast Air Quality Management District
- Southern California Gas Company

MICROGRIDS AND ADVANCED ENERGY MANAGEMENT: INTEGRATING FUTURE RENEWABLES WITH TODAY'S TECHNOLOGY

Our Sustainable Integrated Grid Initiative (SIGI) testbed continues to provide a flexible, scalable platform for researchers to analyze the operations of microgrids under different conditions utilizing a variety of technologies. The testbed has key components located at CE-CERT and throughout Riverside (see below), and serves as a conceptual model for other microgrid installations in California.



2018 RESEARCH HIGHLIGHTS

SIGI TESTBED UTILIZED FOR VEHICLE-TO-GRID (V2G) INTEGRATION

While the idea of an electric vehicle using electricity from the grid to charge is familiar, it is less well known that EVs can provide energy to the grid as well. This concept of bi-directional energy flow is known as Vehicle-to-Grid (V2G), and is an important part of the SIGI testbed strategic plan. In 2018, the SIGI research team completed the planning and design phase required to begin integrating V2G strategies into the testbed. In order to create the complex algorithms needed to precisely manage grid resources, researchers developed charging profiles for all of the EVs that access the microgrid. These profiles provide a picture of how each vehicle behaves when connected, tracking the duration and frequency of the vehicle's charge, the state of its battery, and its overall energy impact. Hardware and software were also installed in CE-CERT's EV fleet, battery trailer, and electric trolley to enable the necessary energy monitoring and communication with the grid. The V2G data gathered from the testbed will provide valuable insight regarding its feasibility as a component of the future grid.



CHEMEHUEVI MICROGRID SYSTEM PROVIDES COMMUNITY WITH INCREASED POWER STABILITY AT A REDUCED COST



Array includes 232 solar panels that can generate up to 91.2 kW

The Chemehuevi Indian Reservation is a remote community located on the California side of Lake Havasu in San Bernardino county. In 2017, CE-CERT collaborated with industry and government partners to implement a microgrid system to address Chemehuevi's vulnerability to the power outages and maintenance downtime typical of a remote community with a single transmission line connection to the grid.

Since coming online, this microgrid has employed energy management strategies such as peak reduction, load shifting, demand response, and load control to significantly reduce the overall energy bill for the Chemehuevi Community Center, a vital part of the community that acts as the emergency response center for the tribe. The system can optimize solar energy to minimize energy use during on-peak periods and can serve as an energy backup, which is important for a customer that, according to Southern California Edison, experiences a significantly higher rate of power interruptions for longer durations than the average San Bernardino District 1 customer.

CUSTOMIZED ENERGY MANAGEMENT SYSTEM INCREASES ENERGY EFFICIENCY IN CALIFORNIA'S WATER SECTOR



Lloyd W. Michael Water Treatment Plant

Located in the city of Rancho Cucamonga, the Cucamonga Valley Water District (CVWD) serves a population of 190,000 with a per day average demand of 50 million gallons. To assist the site with optimizing its energy usage, CE-CERT researchers have implemented an energy management system that enables the integration and transmission of data from energy meters into existing on-site Supervisory Control and Data Acquisition (SCADA) systems.

As a result, the CVWD has realized a 41% average monthly electricity demand reduction due to improved pump and system management by operators, who can now use a combination of historical and real-time data to make critical operational decisions. It is projected that statewide deployment of this technology could result in an estimated peak demand reduction of 1,200 MW, equaling savings of up to \$379 million annually for water facility operators as well as an annual GHG emissions reduction equivalent to 30,304 metric tons of CO₂e. Ratepayers will also realize benefits from this system, such as a more stable grid and higher electricity availability during peak usage times.

Selected Publications

T. Lim, G. Ico, K. Jung, K. N. Bozhilov, J. Nam, and A. Martinez-Morales, "Crystal Growth and Piezoelectric Characterization of Mechanically Stable ZnO Nanostructure Arrays." *CrystEngComm*, vol. 20, no. 38, pp. 5688-5694, 2018.

P. S. Roy, J. Song, K. Kim, J.-M. Kim, C. S. Park, and A. S. Raju, "Effects of CeZrO₂-Al₂O₃ Support Composition of Metal-Foam-Coated Pd-Rh Catalysts for the Steam-Biogas Reforming Reaction," *Journal of Industrial and Engineering Chemistry*, vol. 62, pp. 120-129, 2018.

Key Sponsors and Partners

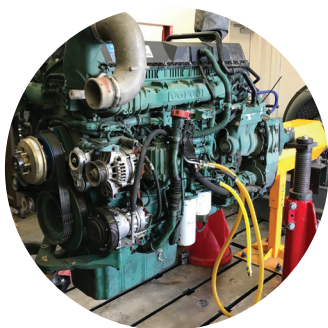
- | | |
|-----------------------------------|------------------------------|
| • California Energy Commission | • OSIsoft |
| • Chemehuevi Indian Tribe | • Pacific Energy |
| • Cucamonga Valley Water District | • Primus Power |
| • EnSync | • Southern California Edison |
| • GRID Alternatives | • Sunpower |

02

EMISSIONS AND FUELS

The Emissions and Fuels research team at CE-CERT is applying advanced technologies and methods to measure emissions from all types of sources, including cars and light-duty trucks, medium and heavy-duty vehicles and construction equipment, and the large engines that power ocean going vessels.

THREE TESTING APPROACHES CAN BE EMPLOYED INDEPENDENTLY OR TOGETHER TO ASSESS ENGINE AND VEHICLE PERFORMANCE



ENGINE DYNAMOMETER TESTING



CHASSIS DYNAMOMETER TESTING



PORTABLE EMISSIONS MEASUREMENT SYSTEM (PEMS)

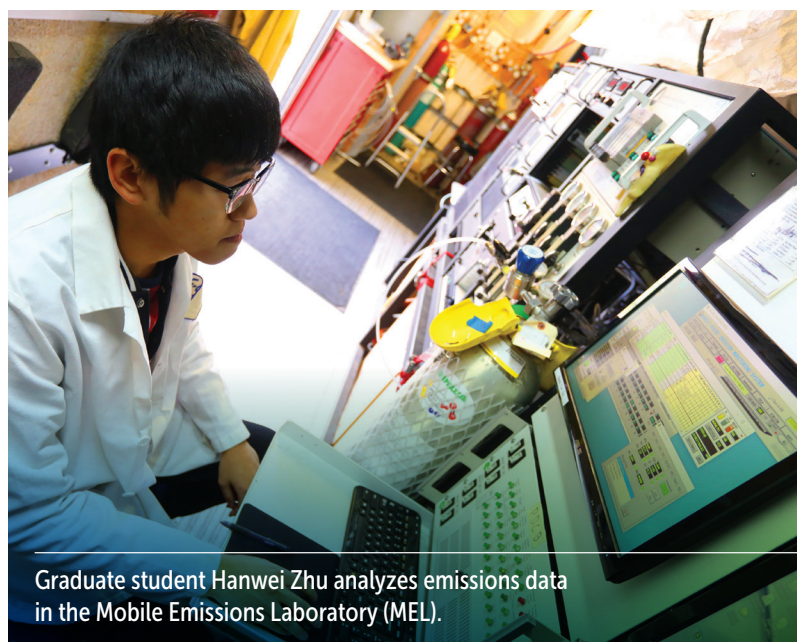
"Large scale and accelerated deployment of near zero-emissions engine technology is vital for achieving the necessary emission reductions to achieve federal air quality standards in 2023 and 2031. To meet our air quality goals, we must continue to see improvements in the transportation sector, which contributes the most air pollution in our region."

- **Wayne Nastri, Executive Officer of the South Coast Air Quality Management District** -

2018 RESEARCH HIGHLIGHTS

RESEARCHERS EXPLORE THE BENEFITS OF SWITCHING MARINE VESSELS FROM DIESEL TO LNG

CE-CERT researchers collaborated with the National Research Council Canada, Wärtsilä, the Mechanical Engineering Department and the Environmental Engineering Department at the University of British Columbia to measure the benefits of switching a modern large marine ferry from diesel to liquefied natural gas (LNG). The ferry was tested under real world operating conditions for criteria pollutants, air toxics, greenhouse gases, and black carbon using multiple methods. Results showed that PM mass and NO_x emissions were reduced by 93% and 92%, respectively. The project was funded by Transport Canada, the Maritime Administration (MARAD) and the California Air Resources Board.



Graduate student Hanwei Zhu analyzes emissions data in the Mobile Emissions Laboratory (MEL).

STUDY FINDS THAT NATURAL GAS ENGINE ACHIEVES CALIFORNIA'S LOWEST SMOG-FORMING NO_x EMISSIONS STANDARD

Heavy-duty diesel vehicles represent one of the largest sources of NO_x emissions and fuel consumption in North America. Used for drayage and goods movement, approximately 70% of the heavy-duty trucks on the road fall into this classification.

Researchers evaluated a Cummins Westport 11.9 liter Near-Zero Ultra Low NO_x Natural Gas (NG) engine for regulated and non-regulated emissions, ultrafine particles, global warming potential, and fuel economy during in-use testing. Results showed that the natural gas engine produced much lower NO_x levels (on average between 0.0012

and 0.02 g/bhp-hr) than those of a comparable diesel truck operating in and around the ports, and maintained those emissions during all types of driving conditions.

However, some pollutants such as ammonia, methane and particle numbers were higher in the NG engine than in its diesel-fueled counterpart, an emissions trade-off that must be carefully evaluated when determining the best fuel choice for health and environmental impacts. Still, NG vehicles could play a significant role in achieving the NO_x inventory goals given the near zero emission factors demonstrated.

NO_x (oxides of nitrogen): A mixture of gases composed of nitrogen and oxygen that can irritate the respiratory system. NO_x enters the atmosphere primarily through vehicle and power plant emissions and reacts with other chemicals to form ozone and particulate matter, both of which are also detrimental to human health.



2018 Emissions and Fuels Group Faculty and Staff

Tom Durbin, Research Faculty
Kent Johnson, Associate Research Faculty
Heejung Jung, Associate Professor, Mechanical Engineering
Georgios Karavalakis, Associate Research Faculty
Wayne Miller, Research Faculty
Robert Russell, Assistant Research Faculty
Daniel Sandez, Research Staff
George Scora, Assistant Project Scientist
Mark Villela, Research Staff

Selected Publications

L. Pham, J. Yang, K. Johnson, T. Durbin, G. Karavalakis, W. Miller, D. Kittelson, and H. S. Jung, "Evaluation of Partial Flow Dilution Systems for Very Low PM Mass Measurements," *Emission Control Science and Technology*, vol. 4, no. 4, pp. 247–259, 2018.

K. Boriboonsomsin, T. Durbin, G. Scora, K. Johnson, D. Sandez, A. Vu, Y. Jiang, A. Burnette, S. Yoon, J. Collins, Z. Dai, C. Fulper, S. Kishan, M. Sabisch, and D. Jackson, "Real-World Exhaust Temperature Profiles of On-Road Heavy-Duty Diesel Vehicles Equipped with Selective Catalytic Reduction," *Science of The Total Environment*, vol. 634, pp. 909–921, 2018.

Y. Jiang, J. Yang, S. Gagné, T. W. Chan, K. Thomson, E. Fofie, R. A. Cary, D. Rutherford, B. Comer, J. Swanson, Y. Lin, P. V. Rooy, A. Asa-Awuku, H. Jung, K. Barsanti, G. Karavalakis, D. Cocker, T. D. Durbin, J. W. Miller, and K. C. Johnson, "Sources of Variance in BC Mass Measurements from a Small Marine Engine: Influence of the Instruments, Fuels And Loads," *Atmospheric Environment*, vol. 182, pp. 128–137, 2018.

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J. Yang, P. Roth, T. D. Durbin, K. C. Johnson, D. R. Cocker, A. Asa-Awuku, R. Brezny, M. Geller, and G. Karavalakis, "Gasoline Particulate Filters as an Effective Tool to Reduce Particulate and Polycyclic Aromatic Hydrocarbon Emissions from Gasoline Direct Injection (GDI) Vehicles: A Case Study with Two GDI Vehicles," *Environmental Science & Technology*, vol. 52, no. 5, pp. 3275–3284, 2018.

Key Sponsors and Partners

- California Air Resources Board
- Growth Energy
- ICM, Inc.
- Manufacturers of Emission Controls Association
- Maritime Administration of the US Department of Transportation
- South Coast Air Quality Management District
- Volvo Trucks

TRANSPORTATION SYSTEMS: VEHICLE & INFRASTRUCTURE INTERACTION

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 the movement of goods and people. The group focuses on the development and implementation of the advanced vehicle computing, control, communication, and sensing technologies that will transform today's vehicles and transportation systems to improve their safety, efficiency, and economics while reducing their environmental impact.



2018 RESEARCH HIGHLIGHTS

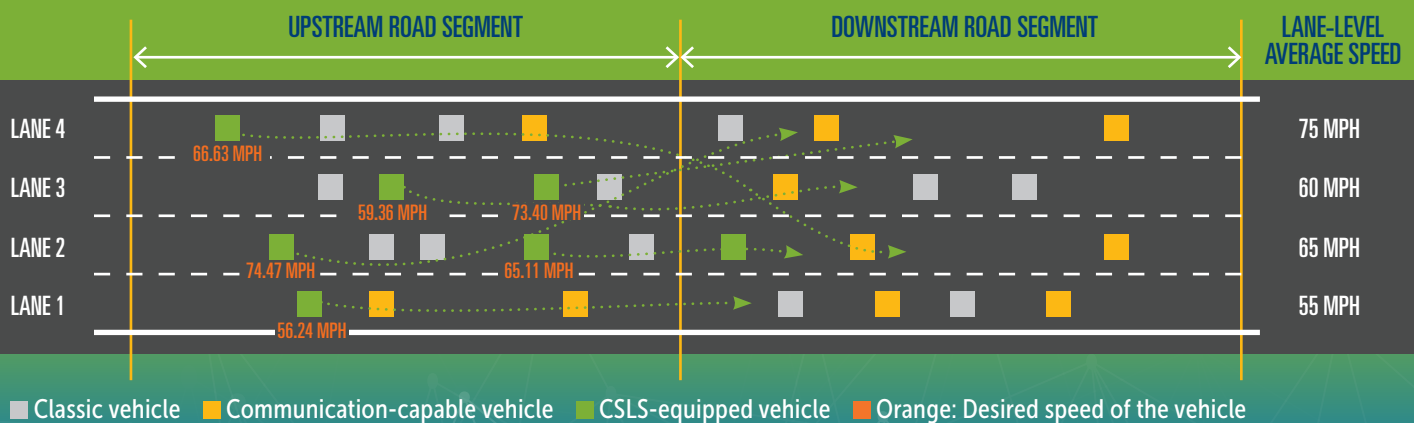
CE-CERT AND HONDA DEVELOP TRANSPORTATION SAFETY APPLICATIONS

2018 was a productive year for CE-CERT's collaboration with Honda R&D Americas, Inc. in the development and evaluation of a variety of innovative Connected Vehicle applications. Three new applications were developed that utilize connected vehicle data to increase transportation safety:

- **Cooperative Smart Lane Selection (CSLS)** allows connected vehicles to develop a cooperative protocol for lateral maneuvers such as lane changes (see below).
- **Automatic/Anticipatory Lane Change** prevents unsafe lane changes by predicting the motions of other connected vehicles. This is an improvement over existing systems as it incorporates real-time data from the other vehicles in addition to vehicle sensors.
- **Lane Hazard Prediction and Traffic Jam Prevention** allow connected vehicles to determine which lane a hazard is located in or to detect an upcoming bottleneck in time for the driver to adjust accordingly.

These applications are currently being evaluated in a traffic simulation environment to develop a more in-depth understanding of their performance when integrated with each other and under different scenarios that address congestion levels, penetration rates, and communication protocols.

ILLUSTRATION OF THE COOPERATIVE SMART LANE SELECTION (CSLS) APPLICATION



DYNO-IN-THE-LOOP TESTING TECHNOLOGY APPLIED TO HYBRID ELECTRIC BUS



Hybrid electric bus undergoing DiL testing

CE-CERT is applying its Dynamometer-in-the-Loop (DiL) testing technology to the development of an innovative vehicle-powertrain eco-operation system for natural-gas-fueled plug-in hybrid electric buses, as part of its ARPA-E project. In this testing protocol, data are fed into the system from a high-fidelity traffic simulator, which then sends the desired control signals to the bus as it “drives” on the dynamometer. The DiL protocol eliminates the need for on-road testing and provides more accurate operational scenarios than the typical use of driving cycles.

The system currently being tested incorporates in-traffic vehicle dynamics into the bus powertrain controls to manage combustion engine output, electric motor output and battery state of charge. Preliminary test results from the ARPA-E research have demonstrated up to 25% energy improvements for a specific target corridor.

CONNECTED VEHICLE TESTING ON RIVERSIDE INNOVATION CORRIDOR

The Riverside Innovation Corridor, a six-mile section of University Avenue between UC Riverside and downtown Riverside, is now being used by CE-CERT’s test vehicles to advance several research projects. The Innovation Corridor is equipped with roadside communications equipment at several key traffic signals, along with other state-of-the-art technologies to help improve safety, mobility and environmental sustainability. The Innovation Corridor is quickly becoming one of the key testbeds in southern California for Connected and Automated Vehicle applications.

CE-CERT’s research team is conducting experiments that utilize the signal phase and timing (SPaT) data from the intersections. These SPaT data are directly transmitted to the test vehicles. The SPaT data (along with GPS location data) are used to recommend driver actions that will result in an eco-friendly approach to a signalized intersection. For example, this particular application may direct the driver to reduce his or her speed in order to coast down earlier to a red light, or modestly increase speed to make it safely through the intersection on a green light.

Research data shows that an energy savings of 10% - 20% can be realized through the use of these applications.

Future plans for the corridor include the addition of vehicle-to-grid communications and new generation air quality sensors.

2018 Transportation Systems Group Faculty and Staff

Richard Arnott, Distinguished Professor, Economics
Matthew Barth, Professor, Electrical & Computer Engineering
Kanok Boriboonsomsin, Associate Research Faculty
Jay Farrell, Professor, Electrical & Computer Engineering
Peng Hao, Assistant Research Faculty
Kent Johnson, Associate Research Faculty
Konstantinos Karydis, Assistant Professor,
Chemical & Environmental Engineering
Zak Kassas, Assistant Professor, Electrical & Computer Engineering
Jill Luo, Assistant Research Faculty
Daniel Sandez, Research Staff
George Scora, Assistant Project Scientist
Mike Todd, Research Staff
Guoyuan Wu, Assistant Research Faculty
Qi Zhu, Assistant Professor, Electrical & Computer Engineering

Selected Publications

D. Tian, G. Wu, P. Hao, K. Boriboonsomsin, and M. J. Barth, “Connected Vehicle-Based Lane Selection Assistance Application,” *IEEE Transactions on Intelligent Transportation Systems*, pp. 1–14, 2018.

J. Luo, K. Boriboonsomsin, and M. Barth, “Reducing Pedestrians Inhalation of Traffic-Related Air Pollution Through Route Choices: Case Study in California Suburb,” *Journal of Transport & Health*, vol. 10, pp. 111–123, 2018.

X. Shan, P. Hao, K. Boriboonsomsin, G. Wu, M. Barth, and X. Chen, “Partially Limited Access Control Design for Special-Use Freeway Lanes,” *Transportation Research Part A: Policy and Practice*, vol. 118, pp. 25–37, 2018.

Key Sponsors and Partners:

- Honda R&D Americas, Inc.
- Oak Ridge National Laboratory
- National Renewable Energy Laboratory (NREL)
- Riverside Transit Agency
- Toyota
- U.S. Department of Energy
Advanced Research Projects Agency – Energy (ARPA-E)
- US Hybrid
- Volvo

POLLUTION FORMATION IN THE ATMOSPHERE

CE-CERT's Atmospheric Processes Laboratory is the largest and most technologically advanced facility in the world for the study of chemical processes in the atmosphere. The laboratory consists of two 90 cubic meter atmospheric chambers, which are used to characterize how secondary air pollutants form from such diverse sources as transportation, wildfires, and agriculture. The chamber precisely controls variables such as temperature, pressure, humidity, and light to model a wide range of real world conditions. The laboratory also features a smaller mobile chamber that can be moved to various locations to conduct research on-site.

2018 RESEARCH HIGHLIGHTS

A COLLABORATIVE RESEARCH EFFORT PROVIDES INSIGHT INTO THE EFFECT OF AGRICULTURAL OPERATIONS ON AIR QUALITY

Large-scale agricultural operations are major sources of gas phase amines and reduced sulfur compounds, both of which are of suspected importance in secondary aerosol formation. However, the effects of environmental conditions on their interaction is not well known. CE-CERT researchers are collaborating with the United States Department of Agriculture, Western Kentucky University, and the Claremont Colleges to develop this understanding.

The indoor chamber was used to measure the concentration, density, and volatility of the secondary aerosol formed by these compounds during oxidation. Results suggest that these interactions are important to regional air quality, which may influence future models and agricultural operations policy development.



Dr. David Cocker (5th from left) and the Atmospheric Processes Research Group

RESEARCHERS STUDY AIR QUALITY IMPACTS OF WILDFIRES



The increase in catastrophic wildfires in the Western U.S. provides opportunity and motivation to study how burning materials impact the quality of our air. Dr. Barsanti and her research group use advanced analytical techniques to identify and interpret patterns among thousands of compounds resulting from combustion of

wildland fuels. In 2019, the group will travel to Idaho to participate in a large-scale smoke measurement field campaign (FIREX-AQ), where they will use airborne and mobile instrumentation to collect data that will be used to predict the air quality impacts of wildfire emissions.



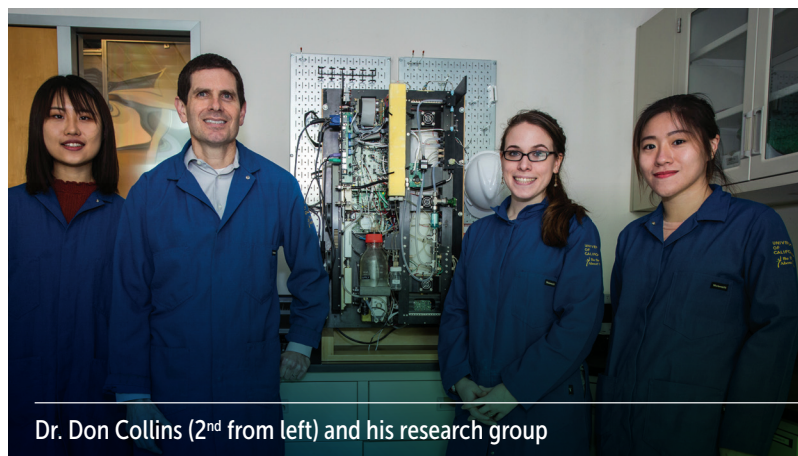
Dr. Kelley Barsanti (far left photo), Dr. Lindsay Hatch and the Analytical Research Group (above)

THE ATMOSPHERIC PROCESSES RESEARCH GROUP WELCOMES TWO NEW FACULTY MEMBERS

The Atmospheric Processes research group is pleased to welcome two new Chemical and Environmental Engineering faculty in 2018.

Dr. Don Collins previously served as the Director of the Center for Atmospheric Chemistry and the Environment at Texas A&M University. His research focuses on the production, properties, and effects of atmospheric aerosols.

"Our research group studies the properties, effects, and atmospheric processing of aerosol particles. Our research efforts are largely motivated by the need to better constrain i) the controls and impacts of aerosol-phase water, ii) the growth and transformation of aerosol particles in various environments, and iii) the impact of aerosols on clouds and of clouds on aerosols."



Dr. Don Collins (2nd from left) and his research group



Dr. Cesunica Ivey is a former postdoctoral researcher in the Department of Physics at the University of Nevada Reno, and also served as a visiting scientist at NOAA's Geophysical Fluid Dynamics Laboratory. Her research interests include source apportionment of fine particulate matter, regional air quality modeling for health applications, global atmospheric modeling, and environmental justice.

"The Air Quality Modeling and Exposure Laboratory seeks to understand fine-scale spatial and temporal variability in air pollutant exposure of residents of Inland Southern California. We utilize both field and modeling techniques to answer questions related to high-risk micro-environmental exposure and environmental injustices. We employ the latest atmospheric modeling and data analysis tools to best understand our unique, local air quality."



Dr. Cesunica Ivey (far right photo) and her research group examine an air quality monitor

2018 Atmospheric Processes Group Faculty and Staff

Kelley Barsanti, Assistant Professor, Chemical & Environmental Engineering
Bill Carter, Emeritus Research Chemist
David Cocker, Professor, Chemical & Environmental Engineering
Don Collins, Professor, Chemical & Environmental Engineering
Lindsay Hatch, Assistant Project Scientist
Cesunica Ivey, Assistant Professor, Chemical & Environmental Engineering
Georgios Karavalakis, Associate Research Faculty
Konstantinos Karydis, Assistant Professor, Electrical & Computer Engineering
Avi Lavi, Research Staff
Akula Venkatram, Professor, Mechanical Engineering

Selected Publications

C.-L. Chen, L. Li, P. Tang, and D. R. Cocker, "SOA Formation from Photooxidation of Naphthalene and Methylnaphthalenes with M-Xylene And Surrogate Mixtures," *Atmospheric Environment*, vol. 180, pp. 256–264, 2018.

N. Gysel, P. Dixit, D. A. Schmitz, G. Engling, A. K. Cho, D. R. Cocker, and G. Karavalakis, "Chemical Speciation, Including Polycyclic Aromatic Hydrocarbons (Pahs), and Toxicity of Particles Emitted from Meat Cooking Operations," *Science of The Total Environment*, vol. 633, pp. 1429–1436, 2018.

L. E. Hatch, A. Rivas-Ubach, C. N. Jen, M. Lipton, A. H. Goldstein, and K. C. Barsanti, "Measurements of I/SVOCs in Biomass-Burning Smoke Using Solid-Phase Extraction Disks and Two-Dimensional Gas Chromatography," *Atmospheric Chemistry and Physics*, vol. 18, no. 24, pp. 17801–17817, 2018.

Key Sponsors and Partners

- Bureau of Land Management Joint Fire Science Program
- California Air Resources Board
- National Oceanic and Atmospheric Association
- National Science Foundation
- Manufacturers of Emission Controls Association
- South Coast Air Quality Management District

EXPOSURE & HEALTH EFFECTS

CE-CERT research faculty continue to partner successfully with UCR's BREATHE (Bridging Regional Ecology, Aerosolized Toxins, and Health Effects) Center, an interdisciplinary collaborative of diverse UC Riverside faculty who work together to conduct research on regional climate modeling, the health impacts of aerosolized particles, and the social and policy issues surrounding air quality.

2018 RESEARCH HIGHLIGHTS

CE-CERT AND BREATHE PUBLISH FIRST COLLABORATIVE PAPER

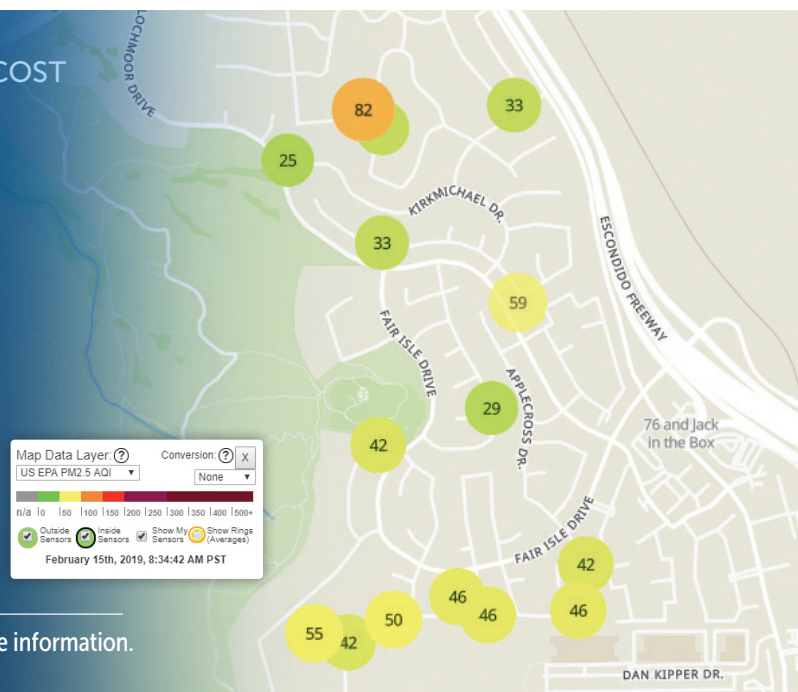
The CE-CERT and BREATHE research partnership produced its first collaborative publication for the journal *American Society for Neurochemistry* in 2018. The paper (listed below) presents the findings of a first of its kind whole-body exposure inhalation study of the effects of alternaria alternata particulates (a common fungal

allergen associated with asthma) on inflammation in the lungs and central nervous system. Strikingly, researchers saw a decrease in the expression of select innate immune molecules in the region of the brain regulating respiration, despite inducing overt lung inflammation

CE-CERT PARTNERS WITH SCAQMD TO MAKE LOW-COST COMMUNITY AIR QUALITY MONITORING A REALITY

As a result of the passage of California Assembly Bill 617, the state now requires a plan to monitor criteria air pollutants in local communities. Dr. David Cocker, Dr. Cesunica Ivey, and Dr. Kelley Barsanti along with graduate student Brandon Feenstra are working with the South Coast Air Quality Management District (SCAQMD) and other partners to make portable, low-cost air quality sensors a part of that plan. One initiative led by SCAQMD with funding of \$750,000 from the Environmental Protection Agency provides local communities with training and assistance to select, implement, and maintain these sensors, and to correctly interpret the resulting data. In collaboration with a local community organization, the Sycamore Highlands Community Action Group, Dr. Cocker's team deployed sensors in the Riverside community of Sycamore Highlands, which has been significantly impacted by goods transportation and the construction of large warehouses and distribution hubs.

Sycamore Highlands sensor deployment. See www.purpleair.com for more information.



2018 Exposure and Health Effects Faculty and Staff (CE-CERT)

Kelley Barsanti, Assistant Professor, Chemical & Environmental Engineering
 Kanok Boriboonsomsin, Associate Research Faculty
 David Cocker, Professor, Chemical & Environmental Engineering
 Don Collins, Professor, Chemical & Environmental Engineering
 Lindsay Hatch, Assistant Project Scientist
 Cesunica Ivey, Assistant Professor, Chemical & Environmental Engineering
 Heejung Jung, Associate Professor, Mechanical Engineering
 Georgios Karavalakis, Associate Research Faculty
 Jill Luo, Research Specialist
 Akula Venkatram, Professor, Mechanical Engineering

Selected Publications

X. Peng, A. M. Madany, J. C. Jang, J. M. Valdez, Z. Rivas, A. C. Burr, Y. Y. Grinberg, T. M. Nordgren, M. G. Nair, D. Cocker, M. J. Carson, and D. D. Lo, "Continuous Inhalation Exposure to Fungal Allergen Particulates Induces Lung Inflammation While Reducing Innate Immune Molecule Expression in the Brainstem," *ASN Neuro*, vol. 10, 2018.

Key Sponsors and Partners

- BREATHE Center at UC Riverside School of Medicine
- Riverside Unified School District
- South Coast Air Quality Management District

ENGAGEMENT AND PARTNERSHIPS

THE POWER OF CONNECTION

2018 was a year of collaboration for CE-CERT, with several events and initiatives designed to bring together diverse stakeholders for the common purpose of moving toward sustainability. In addition to continuing its tradition of STEM-focused community engagement and educational activities, CE-CERT is building the industry and government partnerships needed to develop the technology, policy, and workforce of the future.



HORIBA: CONCEPT CONFERENCE, JANUARY 30-31

100 emissions industry professionals hosted by HORIBA and CE-CERT.

AVL TEST SYSTEMS, INC.: AIR QUALITY AND CLIMATE RESEARCH TRAINING (ACT) PROGRAM PEMS COURSE, JULY 9-20

CE-CERT and AVL celebrated the successful launch of this joint certification emissions training course funded by South Coast Air Quality Management District.



UC RIVERSIDE OFFICE OF SUSTAINABILITY

CE-CERT was proud to support the relaunch of the UCR Office of Sustainability and its commitment to implementing policy to support initiatives such as green building design and operations, clean energy, and zero waste.



CALIFORNIA AIR RESOURCES BOARD: 50TH ANNIVERSARY SYMPOSIUM AND TECHNICAL SHOWCASE, MAY 17

300 participants from industry, government, academia, and the community honored CARB's 50 year history of innovative research at this CE-CERT hosted event.

AVL TEST SYSTEMS, INC.: RIBBON-CUTTING CEREMONY, MARCH 22

In-house partner AVL donated \$1 million worth of emissions testing instrumentation and software to modernize the CE-CERT light-duty testing facility.



BOURNS, INC.: 8TH ANNUAL SCIENCE AND TECHNOLOGY EDUCATION PARTNERSHIP (STEP) CONFERENCE, OCTOBER 3

CE-CERT and Bourns, Inc. hosted 271 high school students from the Riverside Unified School District for a day of hands-on research projects to inspire the future pursuit of STEM careers.

RIVERSIDE UNIFIED SCHOOL DISTRICT: INSPIRE HER MIND EVENT, NOVEMBER 15

100 female high school students toured the CE-CERT laboratories and discussed research with graduate students in an effort to spark and maintain interest in STEM careers.



2018 ALUMNI

HOW HAS YOUR EXPERIENCE AT CE-CERT PREPARED YOU FOR THE WORKFORCE?



Yu Jade Jiang, Ph.D.

Chemical and Environmental Engineering
Combustion and Emissions Systems Engineer at Cummins, Inc.

"The Emissions and Fuels research group provided not only my professional training, but also great opportunities to connect with the 'real emissions' world."



Ninad Kothari, Ph.D.

Chemical Engineering
Scientist, Fermentation Process Development at Amyris, Inc.

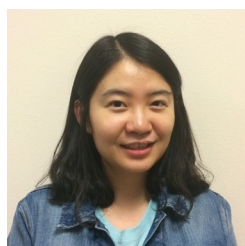
"The most influential experience I had at CE-CERT was the culture of teamwork and interdisciplinary collaboration that allowed for innovative research. It is very important to harness everyone's strengths and build a community at your workplace!"



Abhishek Patri, Ph.D.

Chemical and Environmental Engineering
Scientist, Fermentation at BioConsortia, Inc.

"Working at CE-CERT was crucial to my development as a professional scientist as it blends the experience of an academic researcher with an industrial setting. This really made my transition into the R&D industry very smooth and I am sure it has made me a better researcher and scientist."



Danyang Tian, Ph.D.

Electrical and Computer Engineering
Research Engineer at Honda R&D Americas, Inc.

"The effective guidance of my advisor and my participation in various exciting, real-world research projects have opened my mind to different possibilities, enhanced my research abilities, and helped me to better express myself scientifically."



Jiacheng Joey Yang, Ph.D.

Chemical and Environmental Engineering
Air Resources Engineer, In-Use Compliance Section at the California Air Resources Board

"CE-CERT provided real industry perspective and encouraged students to be enthusiastic about research, develop an understanding of the real world, and become more mature and thoughtful researchers."

2018 DISSERTATIONS AND DEGREES AWARDED

Yu Jiang, Ph.D.

Chemical and Environmental Engineering

"Emissions and Their Implications From Heavy-Duty Diesel Vehicles and Marine Engines."

Ninad Kothari, Ph.D.

Chemical Engineering

"Integration of Clostridium Thermocellum Consolidated Bioprocessing With Thermochemical Pretreatments for Fuel Ethanol Production From Switchgrass."

Weihua Li, Ph.D.

Chemical and Environmental Engineering

Abhishek Patri, Ph.D.

Chemical and Environmental Engineering

"Biological Conversion of Alamo Switchgrass Carbohydrates following Co-Solvent Pretreatment."

Patrick Roth, Ph.D.

Chemical and Environmental Engineering

"Secondary Organic Aerosol Formation from Gasoline Direct Injection Vehicles: The Impact of Exhaust After-Treatment and Fuel Composition."

Partho Roy, Ph.D.

Chemical and Environmental Engineering

"Development of Technologies for RNG Utilization."

Danyang Tian, Ph.D.

Electrical and Computer Engineering

"Connected Vehicles: An Integrated Analysis of Safety, Mobility and Environmental Sustainability."

Jiacheng Yang, Ph.D.

Chemical and Environmental Engineering

"Impact of Alternative Fuels and Emission Control Systems on Small Engines to Large Ocean Going Vessels."

Glen Svenningsen, Ph.D.

Chemical and Environmental Engineering

2018 THESES AND DEGREES AWARDED

Yuehua Gu, M.S.

Chemical and Environmental Engineering

William Lichtenberg, M.S.

Chemical and Environmental Engineering

Michele Simkins, M.S.

Chemical and Environmental Engineering

"Evaluating the Changing Mass Spectra Signature and Secondary Impact of Emissions Generated by Charbroiling Beef Hamburger Patties Using Data from Environmental Chamber and Oxidation Flow Reactor Experiments."

WHERE ARE THEY NOW?



Dr. Ashley Vizenor

Chemical and Environmental Engineering (2017)

Adjunct Professor of Chemistry, Fullerton College and CSU San Bernardino

"The most influential experience for me was the opportunity to network and collaborate with all of the different backgrounds and specialties at CE-CERT. I have been able to incorporate so many examples of chemistry and engineering into my lectures that my students are amazed at how much chemistry is around them."



Dr. Emmanuel Fofie

Chemical and Environmental Engineering (2017)

Air Resources Engineer, In-Use Compliance Section, California Air Resources Board



Dr. Xuewei Qi

Electrical and Computer Engineering (2017)

AI Scientist, Autonomous Vehicle Division, General Motors

SELECTED STUDENT HIGHLIGHTS: 2018



Isaac Afreh

Chemical and Environmental Engineering

Isaac presented at the Gordon Research Seminar and Conference in Les Diablerets, CH, Switzerland, an event designed to showcase cutting-edge research at the graduate level. His presentation title was "Development of Model Surrogates for Monoterpenes to Improve Predictions of Secondary Organic Aerosol." He was also awarded a \$500 travel grant to attend the 10th Annual International Aerosol Conference in St. Louis, MO.



Brandon Feenstra

Chemical and Environmental Engineering

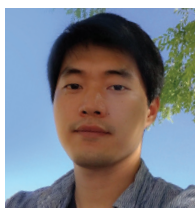
At the 10th International Aerosol Conference (IAC), Brandon co-facilitated a tutorial with SCAQMD on the use of low cost air quality sensors, presented 12 months of data from a network of 24 particulate sensors, and discussed techniques to manage data from a distributed network of air quality sensors using cloud-based tools. He also attended the 2018 Air Sensors International Conference (ASIC), where he presented on cloud-based data management techniques to ingest, stream, and perform analytics on data collected networks of air quality sensors.



Michelle Le

Mechanical Engineering

Michelle was awarded a \$5,000 Susan Van Note Memorial scholarship by the Women in Transportation organization for her work in emissions and fuels. She currently serves as a UC Riverside University Honors Outreach & Alumni Relations Ambassador.



Seungjin Lee

Chemical and Environmental Engineering

Seungjin was awarded 3rd place in the UCR Solar Energy Poster Competition in 2018 for his poster titled "A Proposed Design for a Quasi-Solid State Electrolyte using TiO₂ Hollow Spheres for Lithium-ion Batteries."



Ayla Moretti

Chemical and Environmental Engineering

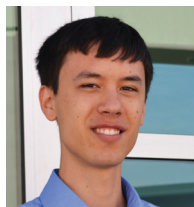
Ayla was recognized as the University Transportation Centers (UTC) Student of the Year, and attended the Council of University Transportation Centers (CUTC) award banquet in Washington DC.



Weihan Peng

Chemical and Environmental Engineering

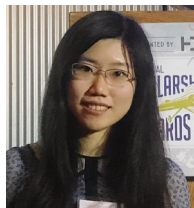
Weihan completed the liquefied natural gas marine vessel emission campaign with National Research Council in Canada and the University of British Columbia, which was the first comprehensive study comparing marine vessel emissions from LNG and traditional marine fuel. He was also invited to provide specialized training for delegations from the US and China as a part of the US-China Green Ports Initiatives Meeting.



Nigel Williams

Mechanical Engineering

Nigel was the recipient of a \$2,500 2018 ITS California Student Scholarship Award for his work in intelligent transportation systems.



Fei Ye

Electrical and Computer Engineering

Fei was awarded a \$5,000 Helene M. Overly Memorial scholarship by the Women in Transportation organization for her work in intelligent transportation systems.



Daniel Zaragoza

Environmental Engineering

Daniel served as the principal vehicle operator and PEMS installation technician for the 2018 Volkswagen compliance testing project, and participated in an SCAQMD-funded research project that conducted in-use PEMS testing of heavy duty diesel and natural gas vehicles. He also received the Krieger and Stewart Scholarship for academic achievement from the Bourns College of Engineering.

2018 GRADUATE STUDENTS

Isaac Afreh	Ryo Huntamer	Anuja Patil	Zhensong Wei
Christian Alcaraz	Jia Jang	Weiham Peng	Nigel Williams
Alejandra Ayala	Kichang Jung	Xinze Peng	Ningjin Xu
Francisco Caballero	Chen Le	Priya Sengupta	Fei Ye
Claudia Chaves-Villareal	Seungjin Lee	Priyanka Singh	Jubair Yusuf
Rumana Faruque	Qi Li	Candice Sirmollo	Zhouqiao Zhao
Brandon Feenstra	Yaqiong Li	Christos Stamatis	Hanwei Zhu
Sahar Gahadimi	Taehoon Lim	Abdullah Fuad Un-Noor	Zihan Zhu
Fei Gu	May Ling Lu	Minerva Uribe-Robles	Khanh Do
Asm Hasan	Cavan McCaffery	Paul Van Rooy	
Yuan-Pu Hsu	Ayla Moretti	Chao Wang	
I-Hsein Huang	Roland David Oswald	Ziran Wang	

2018 UNDERGRADUATE STUDENTS

Raffay Ahmed	Sebastian Gomez	Jack Maynard	Juana Sanchez
David Alaniz-Brainard	Joseph Gozum	Laura McAlister	Matthew Scudder
Hector Barajas	Samantha Hanson	Taymour Mohammed	Shrivatsav Shankar
Ion Basa	Alexis Illich	Hoda Mostafa	Albert Soriano
Cory Brown	Grace Johnson	Samantha Nelson	Rany Tith
Mario Cazares	Ho-Ren Kang	Amanda Nguyen	Alan Tran
Jackie Chan	Darren Kwee	Crystal Pargas	Christian Walker
Terry Chiang	Mai Le	Brian Perdomo	Reid Watanabe
Tyler Corrales	Michelle Le	Kharla Pimentel	Hao Xin
Tom Eckel	Shangrui Liu	Miguel Robledo	Yue You
Danial Esaid	Zachary Lyons	Pingbo Ruan	Alexander Yu
Daniel Frink	Sammy Macaluso	Marco Rubio	Daniel Zaragoza

CE-CERT UNDERGRADUATE PUBLICATION FEATURED IN INDUSTRY JOURNAL

Undergraduate Research Advancement Program (RAP) participants Rebecca Silva and Michael Han, in conjunction with Dr. Heejung Jung, authored the publication "Scaling Trends of Electric Vehicle Performance: Driving Range, Fuel Economy, Peak Power Output, and Temperature Effect," which was published in the World Electric Vehicle Journal in November 2018.

2018 SCHOLARSHIP AND FELLOWSHIP AWARDEES

ON SUSTAINABILITY: HOW WILL WE GET THERE?

GRADUATE AWARD WINNERS



**WILLIAM R. PIERSON/FORD
GRADUATE AWARD**

Priya Sengupta

Chemical and Environmental Engineering

"The evolution of sustainable, renewable, and clean aviation fuel from lignocellulosic biomass could significantly reduce greenhouse gas emissions and help prevent climate change."



**COLIN E. HACKETT ENDOWED
ENGINEERING RESEARCH AWARD**

Weihan Peng

Chemical and Environmental Engineering

"Through the use of different forms of renewable energy instead of leaning solely on fossil fuels."



**ESTHER F. HAYS GRADUATE
FELLOWSHIP AWARD**

Paul Van Rooy

Chemical and Environmental Engineering

"Through lifestyle changes, and a successful push to make science apolitical that will allow us to become more sustainable. Good public transit and long lasting storage for renewable energy are needed as well."



**ESTHER F. HAYS GRADUATE
FELLOWSHIP AWARD**

Brandon Feenstra

Chemical and Environmental Engineering

"Low-cost air quality sensors and cloud-based data platforms for the management of sensor data with the capability of adding additional data sources to provide insights for air quality models and forecasting."



**ESTHER F. HAYS GRADUATE
FELLOWSHIP AWARD**

Fei Gu

Materials Science and Engineering

"My personal contribution is to develop an approach to reducing the processing cost of the Lithium Iron Phosphate (LFP) synthesis used in the development of Li-ion battery, which will improve battery safety and performance."

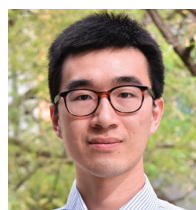


**ESTHER F. HAYS GRADUATE
FELLOWSHIP AWARD**

Danyang Tian

Electrical and Computer Engineering

"I plan to contribute through the study of Intelligent Transportation Systems (ITS), including advanced driver assistance systems applications that combine with advanced sensors and connectivity technologies to make vehicles safer and more energy efficient."



**SALIM KHAN
GRADUATE AWARD**

Wei Wang

Electrical and Computer Engineering

"Data mining techniques are an important advancement. The data-driven approach has become more popular as it frees us from complicated physical models and achieves even better performance in energy management, such as HVAC control in buildings."

The generous support of our donors provided **\$38,500** in 2018 toward the research and professional development opportunities that prepare our students to create a more sustainable future.

UNDERGRADUATE AWARD WINNERS



FORD UNDERGRADUATE AWARD

Danial Esaid

Computer Engineering

"The rapid growth of data science has and will continue to dramatically move us toward sustainability."

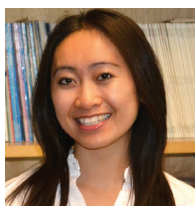


JIM GUTHRIE RESEARCH AWARD

Samantha Hanson

Environmental Engineering

"My goal is to experiment with both tri-methyl-amines and methane sulfonic acid in order to gather information on these concentrations that will contribute to the understanding of how agricultural emissions affect climate change, human health, and environmental health."



JIM GUTHRIE RESEARCH AWARD

Michelle Le

Mechanical Engineering

"I believe that the technological advancements that are most important for sustainability are water and air filtration systems since the most essential things for all of us are clean air and water."



JIM GUTHRIE RESEARCH AWARD

Alexander Yu

Mechanical Engineering

"We begin by reducing consumption while learning to still live full and enriching lives, and then continue to develop future technologies while adapting today's technology to be more efficient and sustainable."

OUR DONORS: INVESTING IN THE FUTURE

**ONE DONATION.
INFINITE POSSIBILITIES.**

- Advanced Engine Technology (AET) Endowment
- CE-CERT Regional Properties, Inc. Endowment
- Colin E. Hackett Endowed Engineering Research Award
- Esther F. Hays Graduate Fellowship Award
- G. Neal Richter Student Support Fund in Energy Innovation
- Jacques and Eugene Yeager Families Endowed Chair
- Jim Guthrie Research Award
- W. Ruel Johnson Endowed Chair
- Joseph Norbeck Memorial Fund for Student Success
- Packard Foundation Fellowship in Environmental Engineering
- Roberta Nichols Yakel Scholarship
- Salim Khan Graduate Award
- Tanfeng Cao Award
- USA Waste of California and the County of Riverside
- William Pierson & The Ford Foundation

LOOKING BACK ON 2018...



30
FULL TIME STAFF AND
RESEARCHERS



12
GRADUATE
DEGREES
AWARDED



\$29 MILLION
IN ACTIVE AWARD DOLLARS

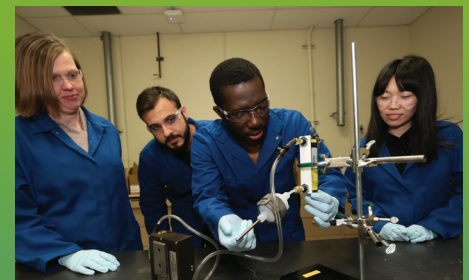
57
GRADUATE
STUDENTS



2,571
VISITORS HOSTED
AT OVER 30 EVENTS,
TOURS, AND
CONFERENCES

112
PUBLICATIONS*

30
INTERDISCIPLINARY
FACULTY



47
UNDERGRADUATE
STUDENTS



86 PARTNERSHIPS WITH
INDUSTRY AND ACADEMIA

*Visit <https://www.cert.ucr.edu/research/publications> for more information

COLLABORATIVE DISCIPLINES

BIOENGINEERING
BUSINESS
CHEMICAL AND ENVIRONMENTAL ENGINEERING
CHEMISTRY
COMPUTER ENGINEERING
COMPUTER SCIENCE AND ENGINEERING

ELECTRICAL AND COMPUTER ENGINEERING
ENVIRONMENTAL SCIENCE
MATERIALS SCIENCE AND ENGINEERING
MECHANICAL ENGINEERING
MEDICINE
PUBLIC POLICY

...AND LOOKING AHEAD TO 2019

CE-CERT plans to strengthen key stakeholder engagement in 2019 through the introduction of new consortia. These partnerships will link industry professionals, representatives from government and regulatory agencies, researchers, and educators with the resources needed to address pressing environmental challenges in air quality, mobility, and renewable energy. Member benefits include first access to technology and intellectual property, 1:1 collaborations with research faculty and students, recommendations to prioritize directed research projects, and inter-campus networking and branding opportunities.

The Dynamic Mobility Management System (DyMMS) and Onboard Sensing, Analysis, and Reporting (OSAR) consortia are currently open for membership. The Biofuels and Sustainable Integrated Grid Initiative (SIGI) consortia are in the development stages and are expected to begin issuing membership invitations in 2020.

CONSORTIA OBJECTIVES:

- 01 Generate cutting-edge research
- 02 Cultivate innovation with industry through exploration of key questions with the intention of creating technology
- 03 Develop a pipeline of Graduate Student Fellowships to create the talent needed to meet industry needs
- 04 Direct policy engagement and education of our future leaders
- 05 Fast-track individual research agreements
- 06 Host Visiting Industry Fellows (VIF)

DYNAMIC MOBILITY MANAGEMENT SYSTEMS (DYMMS)

- Prototype control system development
- Real-time vehicle operations optimization
- Continuous feedback management

ONBOARD SENSING, ANALYSIS, AND REPORTING (OSAR)

- Next-generation sensor development
- Data analysis and modeling
- Systems verification

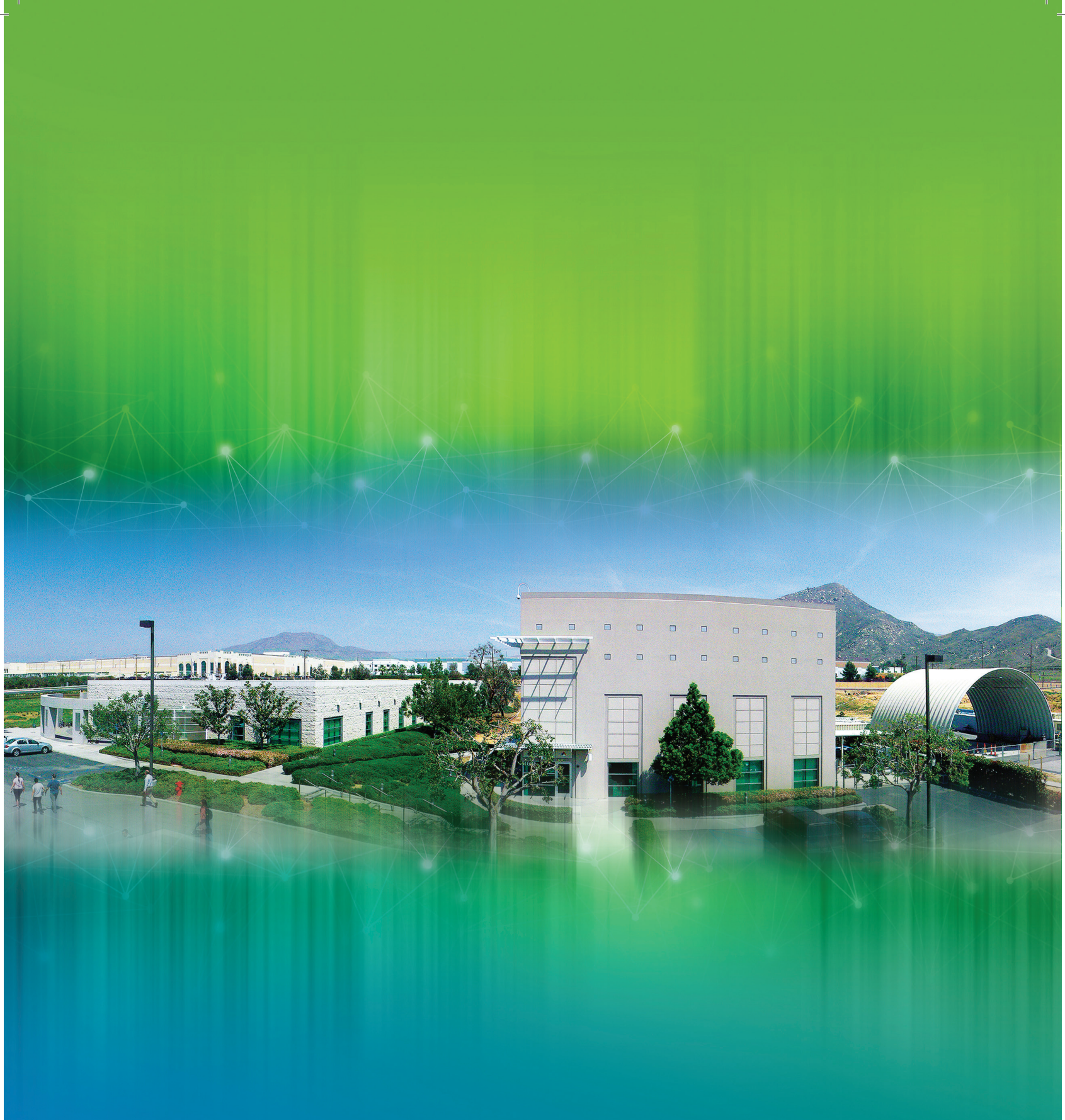
SUSTAINABLE INTEGRATED GRID INITIATIVE (SIGI)

- In development

BIOFUELS

- In development





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