Bourns College of Engineering
Center for Environmental Research and Technology

30 YEARS

OF INNOVATION

CE-CERT | 2021 ANNUAL REPORT

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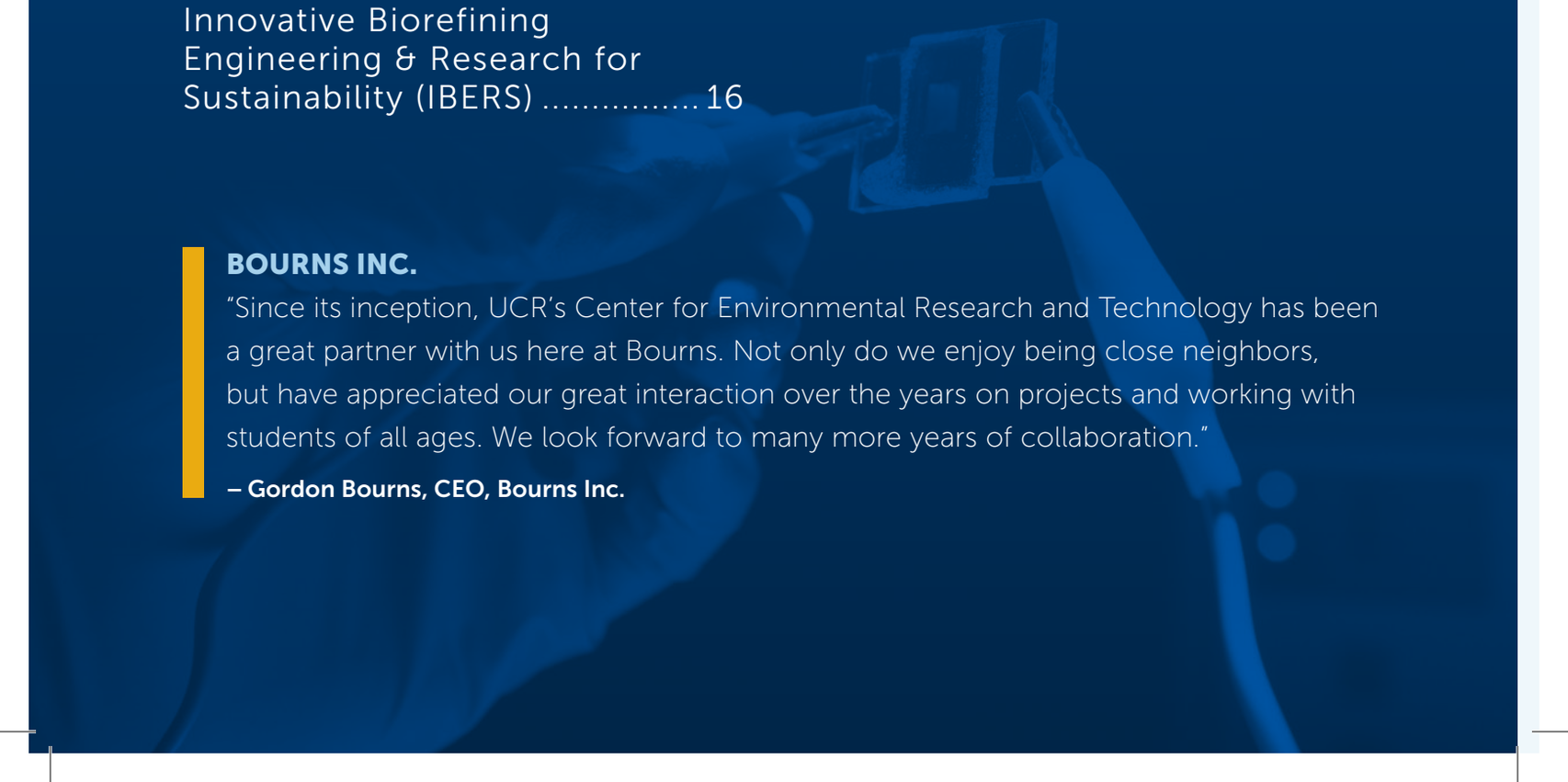


BOURNS INC.

"Since its inception, UCR's Center for Environmental Research and Technology has been a great partner with us here at Bourns. Not only do we enjoy being close neighbors, but have appreciated our great interaction over the years on projects and working with students of all ages. We look forward to many more years of collaboration."

– Gordon Bourns, CEO, Bourns Inc.

Message from the Director

As we slowly emerge out of the COVID-19 pandemic, CE-CERT faculty, staff, and students continue to conduct world-class research and have wrapped up another impressive year. In total, CE-CERT had 24 undergraduate and 56 graduate students participate in research projects in 2021. A total of 98 peer reviewed articles were published by different research groups and had approximately $27 million in active research projects. We conducted several important interdisciplinary research projects, tech transfer programs including the CalTestBed Initiative, as well as education and outreach activities including the STEP conference.

Another highlight of last year is that UCR joined the City of Riverside and numerous other stakeholders in welcoming the California Air Resources Board (CARB) to their new Southern California headquarters adjacent to our campus. This state of the art, unique, facility is quite spectacular. With this relocation, CE-CERT will enter into a new era of enhanced engagement and collaboration on research and training with CARB.

The year 2022 will also bring us to an impressive milestone: CE-CERT's 30th anniversary! This is a fun milestone to celebrate, but what makes it truly remarkable is how the breadth and depth of CE-CERT's research and educational activities have expanded over these three decades. This continuing success is testament to CE-CERT's fulfillment of its mission to be a world leader in air quality, energy, and transportation research and an honest broker that provides unbiased, science-based solutions to the most pressing challenges. The anniversary will be celebrated on April 15th, 2022 at CE-CERT. More details are available at **www.cert.ucr.edu/ce-cert-30th-anniversary**.

I would like to take this opportunity to acknowledge all of the key partners and benefactors who have collaborated with and supported CE-CERT over the years. However, the driving force behind this success story is the dedication of our faculty, staff, and students. I am proud to have been a part of this history and have had the pleasure of working with many of these devoted people over the years.

Looking forward, CE-CERT is poised for great growth in the future and to be a trusted leader in science and education. We have many major on-going initiatives, collaborations, and we are expanding our facilities.

This annual report provides some of the highlights over the last 30 years and acknowledges our many partners, supporters, and personnel. It is organized by research area, and touches on 2021 accomplishments while also providing a historical perspective. I hope you can join us on April 15th to celebrate this achievement.
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!

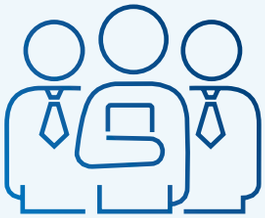
Sincerely,
Dr. Matthew Barth

CE-CERT had **24 undergraduate** and **56 graduate students** participate in research projects in 2021. A total of **98 peer reviewed articles** were published by different research groups and had approximately **$27 million in active research projects**.

98 PUBLICATIONS

$27m TOTAL ACTIVE PROJECTS

122 TOTAL ACTIVE PROJECTS



CE-CERT STUDENTS

24 UNDERGRAD

55 FACULTY & STAFF

56 GRADUATE

TOP
20

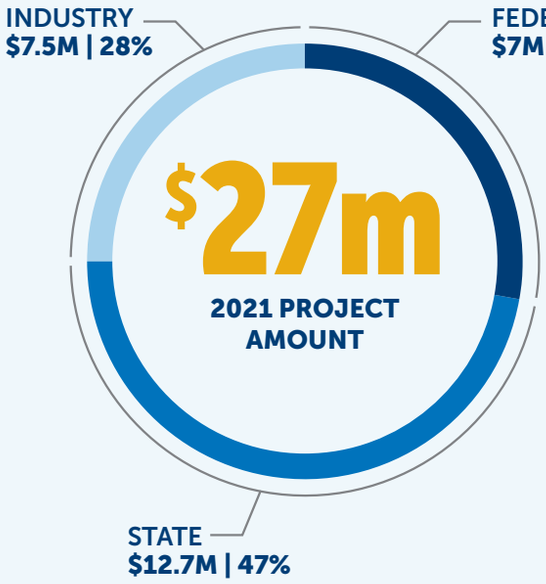
BEST PUBLIC GLOBAL UNIVERSITIES FOR ENGINEERING; US NEWS, BEST GLOBAL UNIVERSITIES

TOP
30

BEST SCHOOLS FOR ENGINEERING MAJORS FOR SALARY POTENTIAL, PAYSCALE

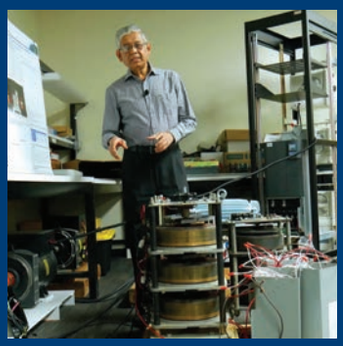
NUMBER
#1

UNIVERSITY IN THE U.S. FOR SOCIAL MOBILITY; TWO YEARS IN A ROW; US NEWS, BEST COLLEGES



NEW FACILITIES

CE-CERT's unique facilities continue to evolve and expand. We now have over 30 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 dynamometers, fuel storage space, chemistry laboratories, and student workshop space (among many other cool labs!). In 2021, we established three new laboratories:

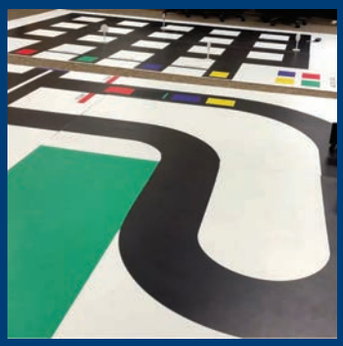


ELECTRICAL MOTOR SYSTEMS TESTING LABORATORY

This testing facility, developed by Dr. Sadrul Ula with California Energy Commission (CEC) funding, is capable of efficiency and load testing of electrical motors and Adjustable Speed Drive (ASD) up to 100 horsepower. The facility can also measure electric system harmonics. This is the first independent electric testing lab of its kind in the state of California capable of providing unbiased evaluation of motor efficiency under various operating conditions. This facility is also available for use by the industry professionals, academics, and other stakeholders as part of the CalTestBed program.

HYDROGEN LABORATORY

The Hydrogen Laboratory, part of the Sustainable Fuels Initiative, conducts research on sustainable hydrogen production, transport, and use. The team is currently investigating the effects of adding hydrogen to natural gas in the existing natural gas transmission and distribution system. This Hydrogen Blending Impacts Study (HBIS) is evaluating the effect of hydrogen blends and other key parameters on pipeline infrastructure materials and components including embrittlement, degradation, and leakage behavior. Lab capabilities include hydrogen blending, gaseous hydrogen exposure, electrochemical hydrogen charging, leak testing, gas composition analysis, elemental analysis, and Charpy impact testing. Other research projects include green hydrogen production, hydrogen fuel cell vehicle infrastructure planning, and policy analysis.

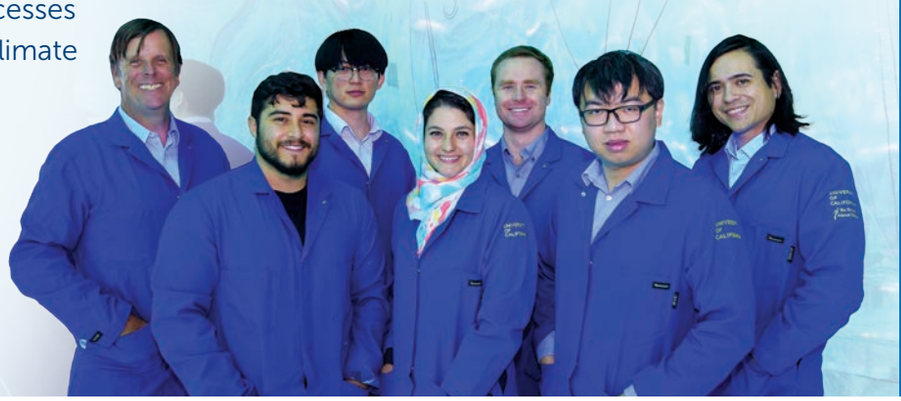


SMART CITY LABORATORY

CE-CERT has recently established a Smart City Laboratory to explore different emerging transportation solutions using connected and automated vehicles (CAVs), with the goal of improving transportation network efficacy. This laboratory got off to a quick start in in 2021, where it was set up to support our student team that competed in the International Autotrac Competition. This new laboratory supports two typical scenarios representing both highway driving with a parking facility and urban driving in a grid network. In this lab, a fleet of self-built small-scale CAVs can collaborate with each other to traverse these networks in an efficient manner. This lab is considered a stepping stone to enable more cost-effective and higher fidelity modeling and evaluation of cooperative automated driving and smart city technologies. Taking the "everything-in-the-loop" (XiL) simulation approach, the research team will extend the capability of this lab by further integrating the hardware with traffic and driving simulators. This will provide a solid foundation to support other CE-CERT transportation-related research and future smart city projects.

OVERVIEW

The mission of the Atmospheric Processes Laboratory (APL) Research Group is to further the understanding and model representation of the sources and impacts of air pollutants, including air toxics, ozone, particulate matter, and greenhouse gases. The APL Group approaches this mission by developing and applying advanced air quality measurement techniques, models, and data fusion approaches. These approaches are applied in both laboratory and field studies to characterize emissions from diverse sources such as vehicles, wildfires, agricultural operations, and consumer products; and to gain a process-level understanding of pollutant formation from these sources. The discoveries of the APL Group are used to answer questions on the relative importance of various sources and atmospheric processes on exposure, air quality, and climate at local to global scales.



DR. COCKER AND APL STUDENT RESEARCH GROUP IN ATMOSPHERIC PROCESSES CHAMBER. ▷

ORIGIN STORY

The Atmospheric Processes Laboratory was founded in 1992 when both Bill Carter and Dennis Fitz joined CE-CERT from UCR's Statewide Air Pollution Research Center (SAPRC). The main focus of research was the study of Volatile Organic Compound (VOC) ozone reactivity, which at the time was being considered for alternative fuel regulations for vehicles. One of the key research tools in this area were a variety of environmental chambers, where these reactions could be studied using a light source that simulated sunlight. In 1999, funding was acquired to build a unique new state-of-the-art environmental chamber that not only could be used to study ozone formation, but also the formation of particles in the atmosphere. Under the leadership of David Cocker (Chemical and Environmental Engineering faculty), this environmental chamber has a dedicated building that housed critical instruments to make these measurements. This chamber activity lead to the expansion of research in emissions from vehicles, wildfires, agricultural operations, and consumer products.

▽ DENNIS FITZ AND BILL CARTER COLLABORATING TOGETHER IN THE LABORATORY.

▽ IRINA MALKINA PULLING AIR SAMPLE FROM THE ENVIRONMENTAL CHAMBER.

2021 HIGHLIGHTS

- **Secondary Organic Aerosol Formation from Camphene Oxidation:** A collaboration between the Barsanti and Cocker groups, led by three graduate students: Qi Li, Jia Jiang, and Isaac Afreh, combined environmental chamber measurements, SAPRC chemical modeling, and GECKO simulations to improve our understanding of ozone and particle formation from camphene oxidation. The combined measurement-model approach yielded unique insights on specific reaction pathways that were previously unreported for this system.

- **Anthropause Ambient Air Study:** During the shelter-in-place restrictions, the Barsanti group worked with collaborators at Caltech and UC Irvine to collect ambient air samples during the unprecedented reduction in human activity, sometimes referred to as the "anthropause". The researchers worked together to ensure the safety of the students collecting the samples, while creating a data set that uniquely supports testing current understanding and hypotheses regarding urban ozone production under current and future conditions (as represented by negligible passenger vehicle emissions), as well as to answer some outstanding questions on the relative importance of emerging anthropogenic sources for pollutant formation.

SELECTED PUBLICATIONS

Peng, W., Le, C., Porter, W., Cocker, D., 2021, "Variability in aromatic aerosol yields under very low NOx conditions at different HOx regimes", *Environmental Science and Technology*.

Van Rooy, P., Purvis-Roberts, K., Silva, P., Nee, M., Cocker D., 2021, "Characterization of secondary products formed through oxidation of reduced sulfur compounds", *Atmospheric Environment*.

Sirmollo, C. L., Collins, D. R., McCormick, J. M., Milan, C. F., Erickson, M. H., Flynn, J. H., Sheesley, R. J., Usenko, S., Wallace, H. W., Bui, A. T., Griffin, R. J., Tezak, M., Kinahan, S. M., and Santarpia, J. L., 2021. "Captive Aerosol Growth and Evolution (CAGE) chamber system to investigate particle growth due to secondary aerosol formation," *Atmospheric Measurement Techniques, 14, pp 3351–3370*.

Van Rooy, P., Tasnia, A., Barlettea, B., Buenconsejo, R., Crounse, J. D., Kenseth, C. M., Meinardi, S., Murphy, S., Parker, H., Schulze, B., Seinfeld, J. H., Wennberg, P. O., Blake, D. R., Barsanti, K.C. 2021. "Observations of volatile organic compounds in the Los Angeles Basin during COVID-19", *ACS Earth & Space Chemistry*.

Li, Q., Jiang, J., Afreh, I., Barsanti, K.C., Cocker III, D. R. 2021. "Secondary organic aerosol formation from camphene oxidation: Measurements and modeling", *Atmospheric Chemistry and Physics Discussions*.

HISTORICAL MILESTONES

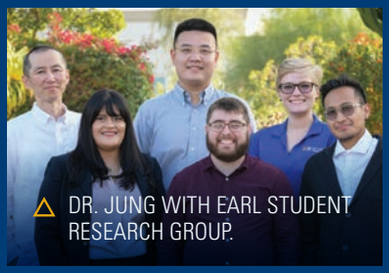
- In 1996, a Keck Foundation Grant supported the thorough **redesign of the APL large environmental chamber**. This redesign included vast improvements to chamber lifetime (up to 3 days) and particle lifetime (order of magnitude longer). The large environmental chamber now consists of one 120 m^3 FEP Teflon chamber and two small reactors for chemical reactivity assessment, making it one of the best chamber facilities in the world.

- In 2020, **CE-CERT received U.S. EPA STAR Award** to advance research related to air quality. The EPA STAR 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. The research enables representation of a broader range of pollutant sources to predict the air quality impacts of these sources across a wide range of environmental conditions and spatiotemporal scales.

△ DR. KELLEY BARSANTI

△ APL GRADUATE STUDENTS WORKING IN ENVIRONMENTAL CHAMBER.

OVERVIEW



△ DR. JUNG WITH EARL STUDENT RESEARCH GROUP.

The Emissions and Fuels Research (EFR) Group applies advanced technologies and methods to measure emissions and activity from numerous sources, such as passenger vehicles, heavy-duty vehicles, construction equipment, lawnmowers and other small engines, and the large engines that power locomotives and marine vessels. Emission measurements are critical information for those studying the impacts of these sources on human health and the environment. The EFR group's unique facilities support traditional laboratory testing, and more importantly, real-world emission measurements using the latest portable emissions/activity monitoring systems (PEMS/PAMS) and On-board Sensing and Reporting (OSAR) tools. The Environmental Aerosol Research Laboratory (EARL), headed by Professor Heejung Jung focuses on non-tailpipe emissions and vehicle cabin air quality research. EARL conducts field and dynamometer testing to quantify exposure to non-tailpipe emissions and brake activities. They also lead standardization of vehicle cabin air quality testing method and developing a new cabin air system to reduce infection of COVID-19 aerosol in a bus.

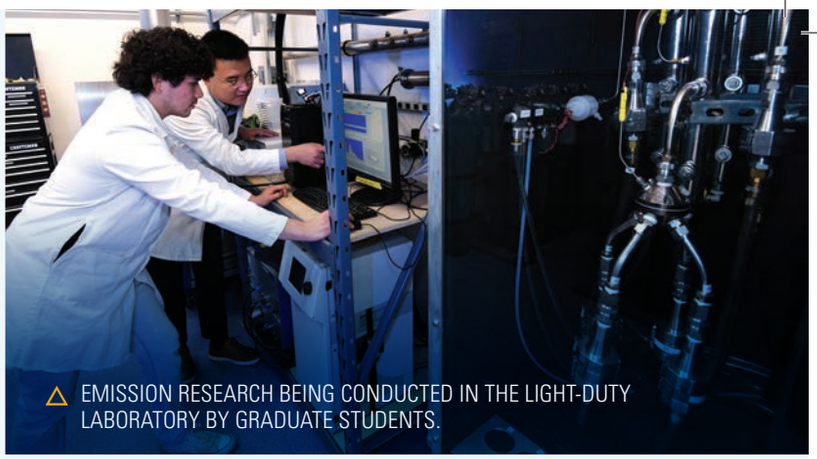
DR. KARAVALAKIS AND EFR STUDENT RESEARCH GROUP IN THE LIGHT DUTY LABORATORY ▽

ORIGIN STORY

The Emissions and Fuels research group was founded as one of the initial groups at CE-CERT by Joseph Norbeck. Both industry and regulators recognized there was a strong need for an "honest broker" to provide truly independent testing and analysis of vehicle emissions control technology and CE-CERT accepted that role. Initially, CE-CERT funding for this research area came from state agencies, such as the California Energy Commission (CEC), South Coast Air Quality Management District (SCAQMD), and the California Air Resources Board (CARB). This vehicle emissions research laboratory and program has greatly expanded over the years, focusing not only on light- and medium-duty vehicles, but also heavy-duty vehicles, engines, off-road equipment, and many other emission sources. The EFR laboratories are now probably the best university-based vehicle emissions laboratories.

△ EMISSIONS RESEARCH BEING CONDUCTED CE-CERT LIGHT-DUTY LABORATORY.

△ EMISSION RESEARCH BEING CONDUCTED IN THE LIGHT-DUTY LABORATORY BY GRADUATE STUDENTS.



△ EMISSION RESEARCH BEING CONDUCTED IN THE LIGHT-DUTY LABORATORY BY GRADUATE STUDENTS.

HISTORICAL MILESTONES

- The EFR group began operations of its **Vehicle Emissions Research Laboratory** (VERL, a light-duty chassis dynamometer laboratory) in 1996, when conducting its inaugural studies of "smoking" vehicles and developing emissions profiles for a variety of alternative fuel vehicles. VERL has continued to be a key resource in studies of various generations of automotive technologies, and different fuels technologies, including mixed alcohols and biodiesel. The laboratory was updated in 2018 with state-of-art equipment from a major gift from the company AVL. The technology change was revolutionary and provides simulation capabilities beyond what was possible in the previous lab.
- CE-CERT designed and developed the world's first **Mobile Emissions Laboratory** (MEL) in the early 2000s, which served as the foundation of the U.S. Measurement Allowance Program for in-use regulatory portable testing. MEL, along with CE-CERT's heavy-duty engine dynamometer, have also played a key role in developing biofuel regulations for diesel fuels in California. CE-CERT installed a state-of-the-art heavy-duty chassis dynamometer in 2010, which has played a key role in characterizing the emissions of heavy-duty vehicles and performance testing of heavy-duty electric vehicles. Research at all of these EFR group facilities has provided important findings that were included in technical support documents for a number of federal and state regulations.
- CE-CERT's EFR Group helped pioneer portable emissions measurement systems in 2011, focusing on real-world emission measurements rather than relying solely on laboratory measurements. The EFR group developed, operated, and tested a new portfolio of portable tools, serving as the "honest broker" in evaluating the efficacy of these tools, and applying them to emissions measurements from light-duty vehicles, heavy-duty vehicles, and marine vessels. As part of this effort, the EFR group established the international Portable Emissions Measurement System (PEMS) workshop in 2011, where industry, regulators, and practitioners meet annually. These portable tools now include the investigation of new small, portable emission monitors with reporting capabilities, called Onboard Sensing and Reporting (OSAR) devices, and established a consortium in that area in 2019.

2021 HIGHLIGHTS

- **CE-CERT completes its monumental 200-Vehicle Study:** In 2021, many EFR group research projects came to a culmination, including the completion of the **"200-Vehicle Study"** of heavy-duty trucks, and major studies of E15 and renewable diesel fuels.
- **Transition to Electric-Drive Vehicle Testing:** With the transition to carbon-neutral vehicles, CE-CERT has upgraded it vehicle testing facilities to carry out performance testing of electric-drive vehicles (i.e., battery electric, fuel cell). With these upgrades, CE-CERT is now testing a variety of electric-drive and other vehicles powered by traditional and alternative fuels.

SELECTED PUBLICATIONS

C. McCaffery, H. Zhu, T. Tang, C. Li, G. Karavalakis, S. Cao, A. Oshinuga, A. Burnette, K.C. Johnson, T. D. Durbin, 2021, "Real-world NOx emissions from heavy-duty diesel, natural gas, and diesel hybrid electric vehicles of different vocations on California roadways", *Science of the Total Environment*.

Yang J., Tang T., Jiang Y., Karavalakis G., Durbin T.D., Miller J.W., Cocker III D.R., Johnson K.C. Controlling emissions from an ocean-going vessel with a wet scrubber system. Fuel 2021, 304, 121323.

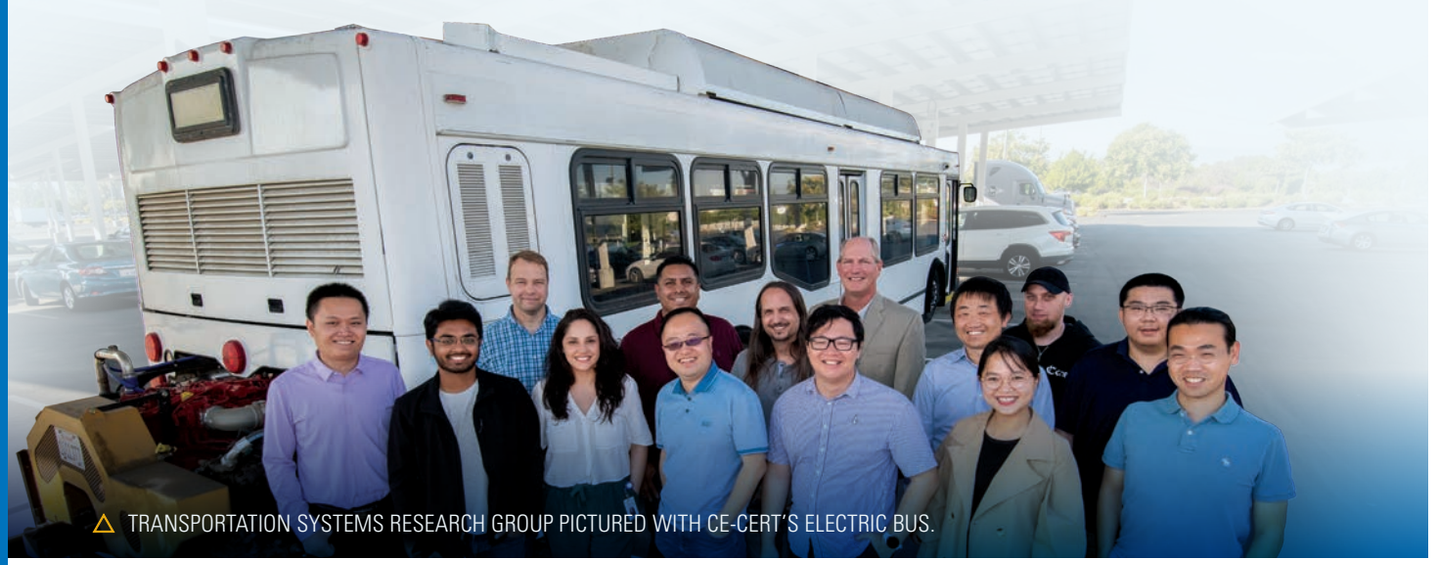
Kuittinen N., McCaffery C., Peng W., Zimmerman S., Roth P., Simonen P., Karjalainen P., Keskinen J., Cocker D.R., Durbin T., Rönkkö T., Bahreini R., Karavalakis G. Effects of driving conditions on secondary aerosol formation from a GDI vehicle using an oxidation flow reactor. Environmental Pollution 2021, 282, 117069.

McCaffery C., Zhu H., Karavalakis G., Durbin T.D., Miller J.W., Johnson K.C. Sources of air pollutants from a Tier 2 ocean-going container vessel: Main engine, auxiliary engine, and auxiliary boiler. Atmospheric Environment 2021, 245, 118023.

Li C., Dixit P., Miller J.W., Bill Welch B., Nigam A., Soriano B., Lee J., Russell R.L., Jiang Y., Zhu H., Karavalakis G., Johnson K.C., Cocker D., Durbin T. Yard tractors: Their path to zero emissions. Transportation Research Part D: Transport and Environment 2021, 98, 102972.

OVERVIEW

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 computing, control, communication, and sensing technologies to transform today's vehicles and associated roadway infrastructure into sustainable transportation system solutions that take into consideration safety, the environment, health, mobility, and economics.

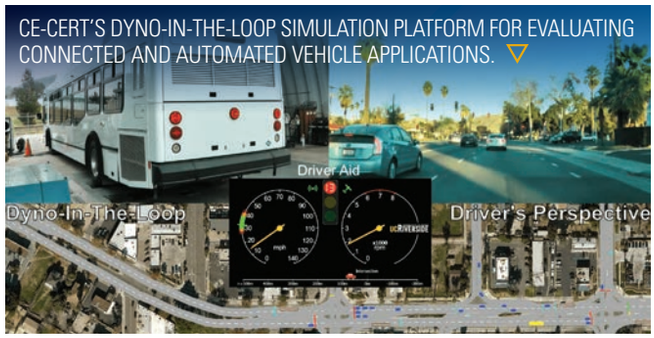


△ TRANSPORTATION SYSTEMS RESEARCH GROUP PICTURED WITH CE-CERT'S ELECTRIC BUS.

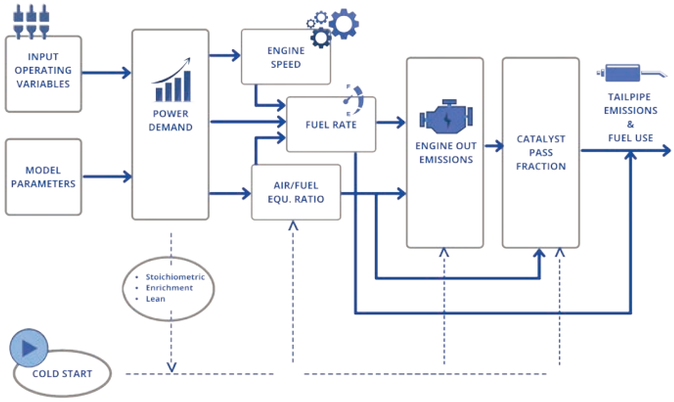
ORIGIN STORY

The Transportation Systems Research group was established in 1992 with an initial grant from the South Coast Air Quality Management District to develop better transportation modeling tools. Matt Barth (Electrical and Computer Engineering faculty) and Joe Norbeck hired several undergraduate students from the new Environmental Engineering program. Several of them (including Michael Todd and George Scora) graduated and subsequently joined the research group permanently, and continued as critical members of the TSR group. Over the years, the group expanded with additional undergraduate and graduate students, postdocs, and eventually research faculty, making it one of the largest active research groups at CE-CERT focusing on shared mobility, connected and automated vehicles, and vehicle electrification.

THE UCR INTELLISHARE CARSHARING SYSTEM WAS LAUNCHED IN THE LATE 1990S AS ONE OF THE FIRST MULTI-STATION, ONE-WAY TRIP CARSHARING SYSTEMS IN THE WORLD. ▷



CE-CERT'S DYNO-IN-THE-LOOP SIMULATION PLATFORM FOR EVALUATING CONNECTED AND AUTOMATED VEHICLE APPLICATIONS. ▽



△ COMPREHENSIVE MODAL EMISSIONS MODEL ARCHITECTURE DIAGRAM.

HISTORICAL MILESTONES

- In order to fulfill the need for microscopic emissions modeling, TSR designed and developed **Comprehensive Modal Emissions Model** (CMEM), one of the first modal emissions models that is still in use by researchers and government agencies. This type of model is necessary for evaluating emissions benefits of project-level or corridor-specific transportation control measures (e.g., HOV lanes), intelligent transportation systems (ITS) implementations (e.g., electronic toll collection), and traffic flow improvements (e.g., traffic signal coordination). This model was supported by the US DOT and US EPA.

- With the goal of making transportation more efficient, intelligent, and better for the environment, CE-CERT developed and operated one of the first electric vehicle carsharing systems called "**UCR IntelliShare**" in the late 1990's. This unique carsharing system operated on the UCR campus for nearly 11 years, resulting in 7 research papers and several patents that led to the development of various automated shared-use vehicle systems using environmentally friendly vehicles. This project won a Clean Air Award in 2010.

- The TSR group has excelled at the intersection of shared mobility, vehicle electrification, vehicle connectivity, and vehicle automation, conducting research on the environmentally-focused benefits of these intelligent transportation system technologies. The group has won several awards for pioneering this Eco-ITS Research Program.

2021 HIGHLIGHTS

- Collaborating with Toyota North American R&D, InfoTech (Mobility) Labs, researchers at **CE-CERT deployed a prototype Cyber Mobility Mirror (CMM) system at a real-world intersection** of University Ave. and Iowa Ave. in Riverside, California. This prototype leverages roadside LiDAR-based real-time traffic surveillance capability, advanced artificial intelligence technique (e.g., deep neural networks), and vehicle-to-everything (V2X) communications to support cooperative connected and/or automated driving applications in a mixed traffic environment. The research team conducted a first-of-its-kind field operational test to demonstrate and validate the performance of the prototype CMM system.

- **CE-CERT Student Team won 2nd Place in Autonomous Vehicle Traffic Challenge Competition:** Students Zhouqiao Zhao, Zhensong Wei, Yu Jiang (graduated), Xuanpeng Zhao, Shangrui Liu, and Pingbo Ruan, and faculty advisors Dr. Guoyuan Wu and Dr. Kanok Boriboonsomsin took 2nd place in this year's internationally recognized competition, AUTOnomous vehicle TRAffic Challenge (called AUTOTRAC), held on June 17, 2021. Funded by the European Commission under the Joint Research Centre's (JRC) Exploratory Research Program, this competition aims to raise awareness about the potential impact of automated vehicles' cooperation in future transport networks. The group built a scaled smart city platform with the goal to leverage cooperative automated driving to improve the transportation network efficiency. Building up the scaled smart city platform is a key step to enable more cost-effective and higher fidelity modeling and evaluation of Connected Automated Vehicles technologies via everything in the loop simulation (XiL). This platform will be an excellent resource to support other CE-CERT transportation-related research and future projects.

SELECTED PUBLICATIONS

Wang, Z., Wu, G., Boriboonsomsin, K., Barth, M. et al., "Cooperative Ramp Merging System: Agent-Based Modeling and Simulation Using Game Engine," SAE Intl. J CAV 2(2):115-128, 2019, https://doi.org/10.4271/12-02-02-0008; 2019 Vincent Bendix Automotive Electronics Engineering Award.

N. Williams, G. Wu and M. Barth, "Position Uncertainty-Tolerant Cooperative Merging Application for Mixed Multilane Traffic," in IEEE Transactions on Intelligent Vehicles, doi: 10.1109/TIV.2021.3120751.

Wu, G., Hao, P. Wang, Z., Jiang, Y., Boriboonsomsin, K., Barth, M., et al. (2021). "Eco-approach and departure along signalized corridors considering powertrain characteristics." SAE International Journal of Sustainable Transportation, Energy, Environment, & Policy, 2(1), 25-40, https://doi.org/10.4271/13-02-01-0002., 2021 Arch T. Colwell Merit Award.

OVERVIEW

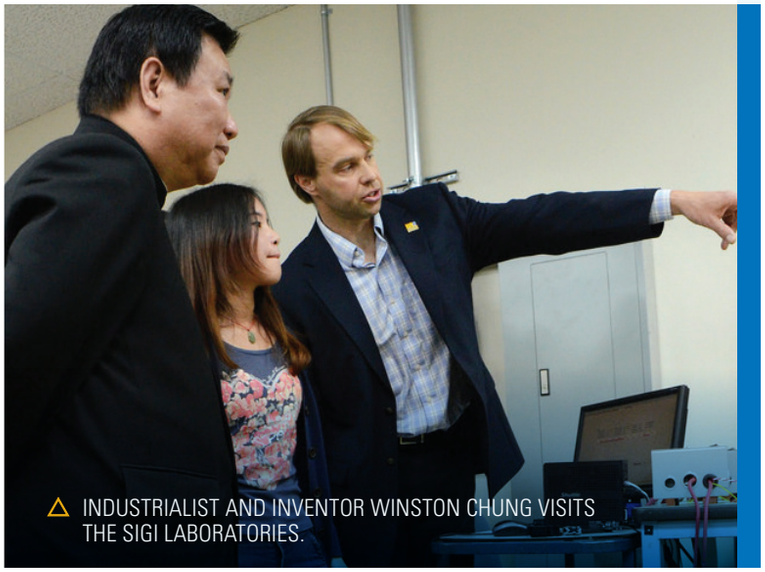
The Sustainable Integrated Grid Initiative was developed specifically to research and implement systems that demonstrate the successful integration of intermittent renewable energy, energy storage, and all types of electric and hybrid electric vehicles including mobile renewable backup generator (MORBUG) systems. Now in its ninth 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. Grid resiliency studies include Vehicle to Grid (V2G), Vehicle to Building (V2B), and islanding operations.

SUSTAINABLE INTEGRATED GRID INITIATIVE RESEARCH GROUP AT CE-CERT SOLAR CHARGING STATIONS. ▷

ORIGIN STORY

In 2013, CE-CERT's Sustainable Integrated Grid Initiative (SIGI) was established in response to the University of California President's Initiative to be the first research university to achieve carbon neutrality. The first two years of operation were supported by a multi million-dollar grant from the South Coast Air Quality Management District. As part of its initial mission, SIGI demonstrated that electric vehicles can be seamlessly introduced into the existing grid system through "smart integration" of renewable energy, storage, and advanced dispatch controls. Since then, SIGI's work has come to include solar electricity generation, smart distribution, commercial-scale energy storage, and electric transportation. Sadrul Ula joined CE-CERT in 2012 to help lead this critical research area.

△ SADRUL ULA TRAINS AN UNDERGRADUATE STUDENT IN MOTOR TESTING.



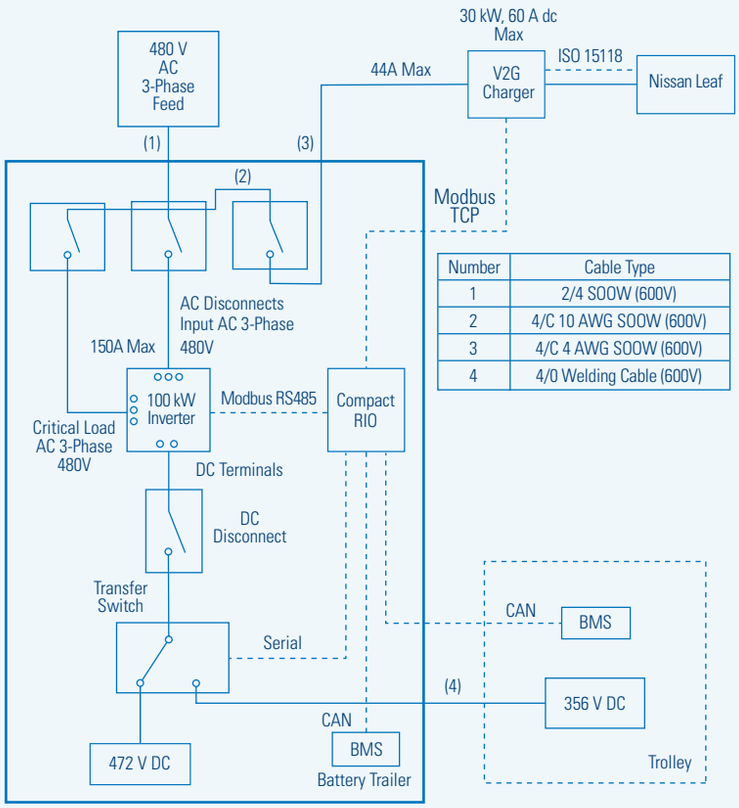
△ INDUSTRIALIST AND INVENTOR WINSTON CHUNG VISITS THE SIGI LABORATORIES.

△ GRADUATE STUDENTS PERFORMING RESEARCH IN V2G MOBILE BATTERY TRAILER.

HISTORICAL MILESTONES

- Plug-in Electric Vehicles (PEVs) and optimized design and implementation of the PEV charging infrastructure will be critical aspects of our sustainable transportation future. Uncoordinated PEV charging can lead to avoidable energy costs and unwanted peaks on the electric grid. To address this, the SIGI group designed and developed a **real-world Vehicle to Grid (V2G)-integrated commercial building system**, integrating facility energy usage and travel data to optimize energy usage considering PEV stochasticity. This effort has also demonstrated microgrid resiliency in conjunction with V2G operations. Our recent V2G experiments have proven the validity of several V2G operational strategies, supporting both a microgrid and the traditional utility grid.

- In 2020, the SIGI group established its **unique motor evaluation laboratory** as part of UCR's CalTestBed partnership. The motor testing lab is utilized for testing innovative products from various electric motor entrepreneurs, using strict protocols and data analytics to determine motor efficiency. The lab is fully equipped with an AC and DC power supply capable of accurate measurement, a torque transducer, and various load banks that allow for testing different motor sizes.



Number	Cable Type
1	2/4 SOOW (600V)
2	4/C 10 AWG SOOW (600V)
3	4/C 4 AWG SOOW (600V)
4	4/0 Welding Cable (600V)

△ TRAILER LAYOUT WITH V2G CHARGING AND TROLLEY ISLANDED OPERATION.

2021 HIGHLIGHTS

- The SIGI Group evaluated natural gas and/or electrical energy savings potential at Western Municipal Water District (WMWD) and Glendale Water and Power (GWP) in 2021 under various load conditions. In addition, the SIGI group evaluated site configurations and recommended electrical and/or natural gas energy efficiency improvement strategies to help towards sustainable and resilient energy use.

SELECTED PUBLICATIONS

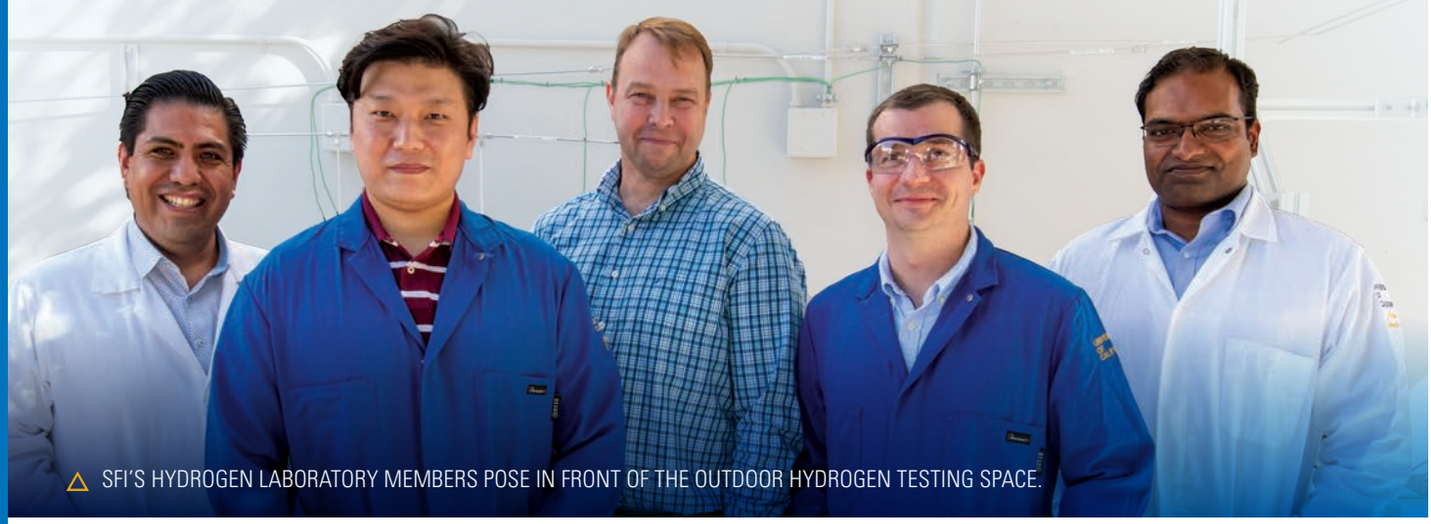
ASMJ Hasan, J. Yusuf, L. Enriquez-Contreras, S. Ula, "Bad Cell Identification of Utility-Scale Battery Energy Storage System through Statistical Analysis of Electrical and Thermal Properties", 2021 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe).

J. Garrido, M.J. Barth, L. Enriquez-Contreras, ASMJ Hasan, M. Todd, S. Ula, J. Yusuf, "Dynamic Data-Driven Carbon-Based Electric Vehicle Charging Pricing Strategy Using Machine Learning", 2021, 24th IEEE International Conference on Intelligent Transportation, Indianapolis, IN.

ASMJ Hasan, L. Enriquez-Contreras, J. Yusuf, M.J. Barth, S. Ula, "Demonstration of Microgrid Resiliency with V2G Operation" in IEEE Transportation Electrification Conference and Expo, Chicago, IL.

OVERVIEW

The Sustainable Fuels Initiative (SFI)'s mission is to advance and demonstrate sustainable energy solutions, including advanced technologies for the production and use of sustainable fuels such as green hydrogen and renewable natural gas. Focus areas include energy systems analysis, waste/biomass to energy, transportation electrification, high renewables grid management, techno-economic and life cycle assessment.



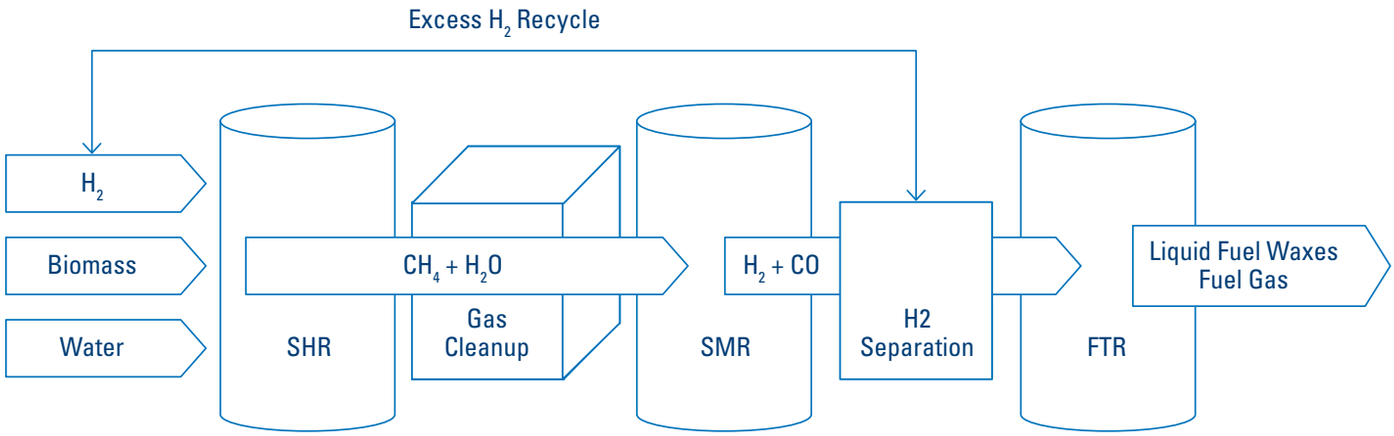
△ SFI'S HYDROGEN LABORATORY MEMBERS POSE IN FRONT OF THE OUTDOOR HYDROGEN TESTING SPACE.

ORIGIN STORY

Research on renewable fuels production using thermochemical conversion technologies began at CE-CERT in the late 1990s, led by Joe Norbeck with Colin Hackett and Chan Park as key team members. Arun Raju, current Director of Sustainable Fuels Initiative joined the research group in 2011. Their research led to several patents on thermochemical biomass and waste conversion to syngas followed by fuels and power. The research later expanded into multiple feedstocks and pathways and led to the establishment of the Center for Renewable Natural Gas (CRNG) in 2017. In 2020, the CRNG was integrated into the newly created Sustainable Fuels Initiative (SFI).

▽ ELECTROCHEMICAL HYDROGEN CHARGING OF METAL SAMPLES.

▽ PILOT SCALE GASIFIER AT CE-CERT.



△ SCHEMATIC DIAGRAM OF THE COUPLED STEAM HYDROGASIFICATION AND REFORMING PROCESS.

HISTORICAL MILESTONES

- The first patent for the CE-CERT-developed, novel Steam Hydrogasification process was granted in 2008. This technology converts carbonaceous feedstocks including high moisture materials such as biomass, biosolids, and waste into a high methane content synthesis gas. Several additional patents followed, including on biomass feedstock pretreatment, reforming, and fuel production.

- The SFI group unveiled a new energy-production pathway that converts biomass and waste into energy through steam hydrogasification while producing negligible emissions. The steam hydrogasification pathway was demonstrated at 0.1 ton per day of feedstock throughput and successfully converts a biomass and biosolids comingled feedstock into synthesis gas.

△ SFI SCIENTIST MIROSLAV PENCHEV USES AN ELEMENTAL ANALYZER TO CHARACTERIZE METAL SAMPLES EXPOSED TO HYDROGEN.

2021 HIGHLIGHTS

- Spring 2021 – SFI kicks off the Eastside Climate Collaborative with the City of Riverside and other partners. The Eastside project is a $31 million investment in the city by the state's Strategic Growth Council through the Transformative Climate Communities and Affordable Housing and Sustainable Communities Programs.

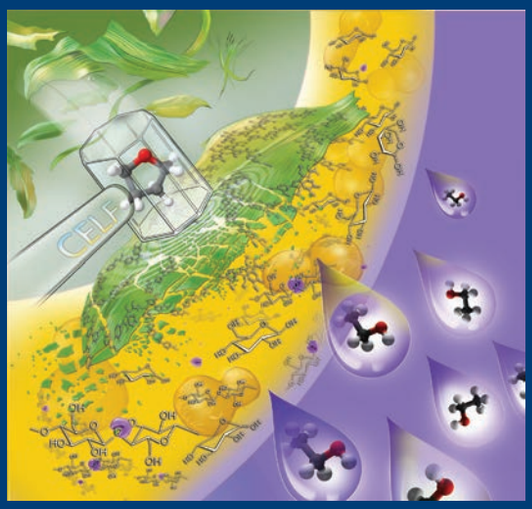
- Fall 2021 – SFI kicks off the Medium and Heavy-Duty Zero Emission Vehicle Infrastructure Blueprint Development project funded by the California Energy Commission. This project will develop a blueprint for charging and fueling stations and maintenance facilities for Medium and Heavy-Duty Battery Electric and Fuel Cell Electric Vehicles in the Inland Empire region.

SELECTED PUBLICATIONS

A.S.K. Raju, B.R. Wallerstein, K.C. Johnson, "Achieving NOx and Greenhouse gas emissions goals in California's Heavy-Duty transportation sector", Transportation Research Part D: Transport and Environment, 97, 2021

M.Fogel, H. Ajami, E. Aronson, R. Bahreini, W. Elders,D.Jenerette, D. Lo, T. Lyons, M. McKibben, W. Porter,A.Raju, K. Schwabe, C. Hung, and J. Nye, "Crisis at theSalton Sea: The Vital Role of Science", 2021, **https://doi.org/10.5281/zenodo.5149222**

OVERVIEW



The CE-CERT Innovative Biorefining Engineering and Research for Sustainability (IBERS) team focuses on conversion of cellulosic biomass to transportation fuels and chemicals through key fractionation, pretreatment, fermentation, and catalytic operations. The IBERS group's mission is to improve the understanding of these biomass conversion pathways to realize low-cost and sustainable production of renewable fuels, green chemicals, and bio-based materials for an advanced bioeconomy. The team also applies the valuable insights gained through fundamental research in chemistry, biology, and computational science to further advance technologies to dramatically reduce the cost of producing bioproducts.

ORIGIN STORY

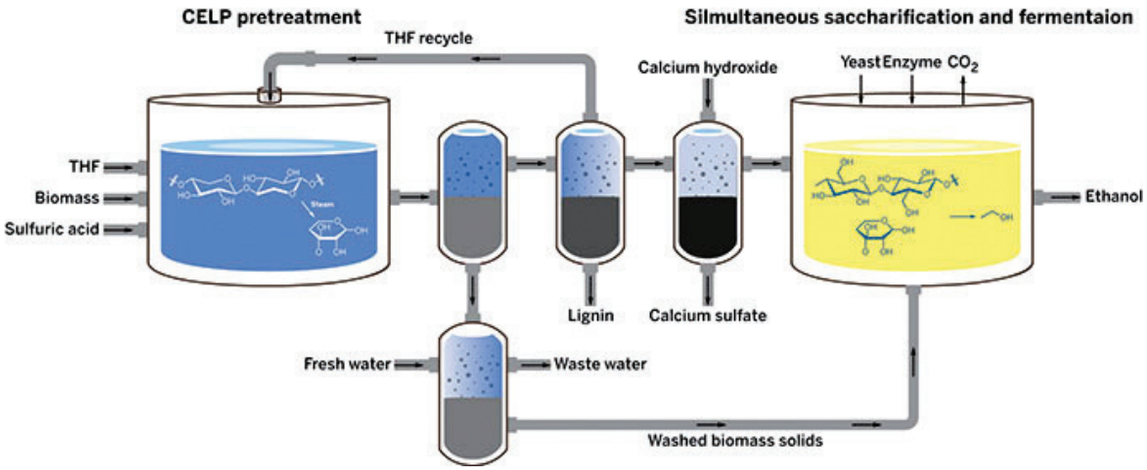
In 2005, Professor Charles Wyman joined UCR, where he began his research into the conversion of low-cost, nonedible cellulosic biomass to fuels and chemicals. The Innovative Biorefining Engineering and Research for Sustainability (IBERS) research group focused on leading the advancement of technologies for cellulosic biomass conversion to fuels, chemicals, and materials as well as biomass conversion to ethanol and other products. Charles Cai joined the group in 2010, bringing expertise in yeast fermentation and chemical process engineering as an Associate Scientist from Amyris. This research has led to the invention of Dr. Cai's Co-solvent Enhanced Lignocellulosic Fractionation (CELF) process, which is IBERS' internationally recognized advanced pretreatment and fractionation technology.

▷ IBERS STUDENT RESEARCHERS CONDUCT CONTINUOUS ETHANOL FERMENTATION STUDIES USING CORN STOVER ON BIOREACTORS.

HISTORICAL MILESTONES

- The IBERS team invented a novel biomass pretreatment technology known as Cosolvent Enhanced Lignocellulosic Fractionation (CELF) that employs a combination of tetrahydrofuran (THF) and various dilute acids to target fractionation of the three major components from cellulosic biomass: cellulose, hemicellulose, and lignin. In addition to achieving high yields of these components, the team demonstrated that CELF cellulose can be almost completely deconstructed into fermentable glucose sugars at economically viable enzyme loadings that other pretreatments cannot match. In addition, IBERS also demonstrated that CELF makes possible fermentation of 20% of the lignin carbon in switchgrass to organic acid products for funneling to fuel precursors.
- Scale-up of CELF from a stirred 1-L autoclave reactor to a steam-heated unstirred 1-gal reactor demonstrated scalability of the CELF reaction from bench to pilot scale. The IBERS pilot regularly processes various biomass at 10 wt.% solids achieving a heat-up time of less than 5 minutes. A high-pressure steam-heated clover reactor was modified to expedite operation with a wide range of catalytic reactions.
- The IBERS group currently maintains academic records for: 1) highest ethanol titers from high solids simultaneous saccharification and fermentations operation (SSF) of both forestry and agricultural biomass (87g/L), 2) highest total carbon yield of fungible fuel products from biomass using a single integrated process (60%), and 3) highest single-step biomass liquefaction yield (99%).

▽ CELF PRETREATMENT FIGURE COSOLVENT-ENHANCED LIGNOCELLULOSIC FRACTIONATION (CELF) PROVIDES HIGH SUGAR AND ETHANOL YIELDS WITH LOW ENZYME INPUT.



2021 HIGHLIGHTS

- IBERS research includes modifying ZSM-5 catalysts for ethanol conversion into gasoline, jet, and diesel fuels and hydrocarbon chemical building blocks. During 2021, the focus was on modifying the catalyst to increase the carbon number distribution range to better match that needed for blending with jet fuel. The IBERS team showed that treating ZSM-5 with NaOH increased catalyst pore volumes and thereby enhanced liquid hydrocarbon yields and selectivity to higher carbon number hydrocarbons from ethanol. Project funded by Department of Energy.
- Professor Charles Wyman elected to the National Academy of Engineering for advances in transforming lignocellulosic feedstocks into low-carbon-footprint fuels and chemicals.

SELECTED PUBLICATIONS

Patri AS, Mohan R, Pu Y, Yoo CG, Ragauskas AJ, Kumar R, Kisailus D, Cai CM, Wyman CE. 2021. "THF Co-Solvent Pretreatment Prevents Lignin Redeposition from Interfering with Enzymes Yielding Prolonged Cellulase Activity," *Biotechnology for Biofuels* 14(1): 1-13.

Lu ML, Wyman CE. 2021. "Elucidation of Native California Agave americana and Agave Deserti Biofuel Potential: Compositional Analysis," *PLOS One* 16(5): e0252201.

Wang YY, Scheidemantle B, Wyman CE, Cai CM, Ragauskas AJ. 2021. "Polyurethanes Based on Unmodified and Refined Technical Lignins: Correlation between Molecular Structure and Material Properties," *Biomacromolecules* 22(5): 2129-2136.

OVERVIEW

The Southern California Research Initiative for Solar Energy Group focuses on multiple aspects of research, demonstration, and engagement related to Solar Energy. The Advanced Materials and Energy Devices Laboratory (AMEDL) focuses on fundamental research and technology development, while the Solar Valley Consortium works with key stakeholders in public policy matters of high importance for transforming the counties of Riverside and San Bernardino into the Solar Valley of California.

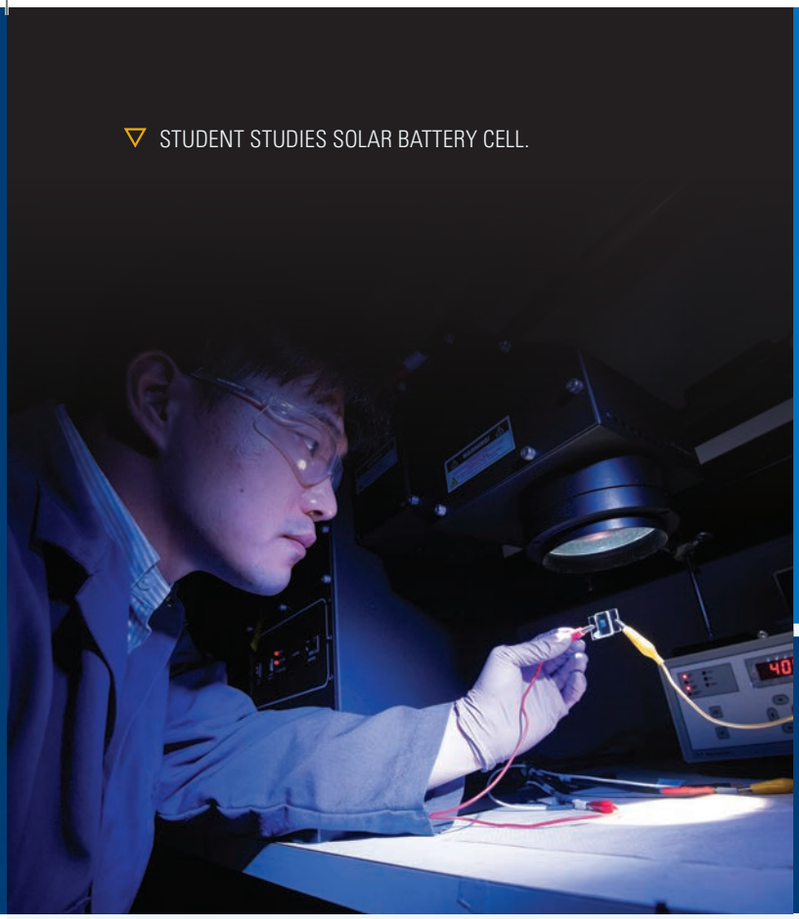
▽ DR. MARTINEZ WITH ADVANCED MATERIALS & ENERGY DEVICES RESEARCH GROUP.

ORIGIN STORY

The Southern California Initiative for Solar Energy (SC-RISE) was established as a result of a four-party agreement signed in 2007 by Reza Abbaschian, former dean of UCR's Bourns College of Engineering, Ron Loveridge, former mayor of Riverside, and representatives from the city of Sendai, Japan and Sendai's Tohoku University. Alfredo Martinez-Morales joined as the Managing Director of SC-RISE in 2010. This initiative was inspired by the need to adopt solar power in South California through research, technology, and education – with a strong emphasis on acting as an honest broker in promoting science to improve environmental policy.

▽ SC-RISE RIBBON CUTTING CEREMONY.

▽ SENIOR DESIGN PROJECT ON WATER DESALINATION INCORPORATING SOLAR THERMAL CONCENTRATORS.



▽ STUDENT STUDIES SOLAR BATTERY CELL.

2021 HIGHLIGHTS

- UC Riverside Office of Technology Partnerships selected CE-CERT's "Solar Battery" technology as a grant recipient for a Proof of Concept Award (POC). The Solar Battery is a unique technology that combines power collection and power storage in a single solar panel. The technology invented at AMEDL eliminates the need for battery backup for solar systems and reduces the overall installed cost for solar.
- The SC-RISE group was recognized with the Sunshine Award for Collaboration by GRID Alternatives Inland Empire during GRID's 10 Year-Anniversary Virtual Celebration. The award honors organizations who create partnerships and work together for the greater good of Inland communities.

SELECTED PUBLICATIONS

Lim, T., Mirabedini, P. S., Jung, K., Greaney, P. A., & Martinez-Morales, A. A. (2021). High-index crystal plane of ZnO nanopyramidal structures: Stabilization, growth, and improved photocatalytic performance. Applied Surface Science, 536, 147326.

HISTORICAL MILESTONES

- The Chemehuevi Indian Tribe Microgrid Project, initiated in 2018, was completed in 2021. This project engineered, deployed and demonstrated a solar-plus-energy storage microgrid to demonstrate peak reduction, load shifting, demand response, and load control at the Chemehuevi Indian Tribe Community Center.

This project featured a design and the development of custom energy management system by the SC-RISE team with the main objectives of reducing overall electricity costs, utilizing renewable solar energy efficiently, and providing additional resiliency to the Chemehuevi Community Center building.

△ CHEMEHUEVI INDIAN TRIBE MICROGRID:

- **A** AC-DC INVERTER;
- **B** DC-DC CONVERTER;
- **C** FLOW BATTERY;
- **D** GRID ISOLATION DISCONNECT;
- **E** SOLAR CARPORT;
- **F** SOLAR INVERTER;
- **G** BATTERY INVERTER AND CONTROLLER;
- **H** LI-ION BATTERY SYSTEM.

CE-CERT 2021-22 SCHOLARSHIP RECIPIENTS

In 2021, thirteen students were awarded a total of $44,500. We would like to congratulate them on their hard work and thank our generous donors who made these awards possible.

ESTHER F. HAYS GRADUATE FELLOWSHIP
- Zihan Zhu, Chemical and Environmental Engineering
- Jubair Yusuf, Electrical Engineering
- Xishun (Heeson) Liao, Electrical and Computer Engineering
- Zhouqiao Zhao, Electrical Engineering

COLIN E. HACKETT GRADUATE AWARD
- Ningjin Xu, Chemical and Environmental Engineering

SALIM KHAN GRADUATE AWARD
- Tianbo Tang, Chemical and Environmental Engineering

WILLIAM R. PIERSON / FORD GRADUATE AWARD
- Hanwei Zhu, Chemical and Environmental Engineering

MILLER DURBIN RESEARCH AWARD
- Chas Frederickson, Mechanical Engineering

FORD MOTOR COMPANY UNDERGRADUATE AWARD
- Grace Johnson, Mechanical Engineering

JIM GUTHRIE RESEARCH AWARD
- Alexander Nguyen, Biochemical Engineering
- Yi Ji, Environmental Engineering
- Dwaraknath Ravichandran, Electrical Engineering
- Kevin Urrutia Avila, Electrical Engineering

THIRTEEN STUDENTS WERE AWARDED SCHOLARSHIPS TOTALING

$44.5K

CE-CERT 2021-22 NATIONAL CENTER FOR SUSTAINABLE TRANSPORTATION AWARD RECIPIENTS

Five graduate students were awaraded total of $100,000, to support their education and research in sustainable transportation. 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 FELLOWSHIP AWARD
- Ryan Drover, Chemical and Environmental Engineering
- Luis Fernando Enriquez-Contreras, Electrical and Computer Engineering
- Chas Fredrickson, Mechanical Engineering
- Jacqueline Garrido, Electrical and Computer Engineering

NCST DISSERTATION AWARD
- Jubair Yusuf, Electrical and Computer Engineering

STUDENT HIGHLIGHTS

CHAS FREDERICKSON, MECHANICAL ENGINEERING
Miller Durbin Research Award

Chas's graduate research is focused on understanding the activity patterns and, when available, the emissions of off-road equipment, including construction equipment, agriculture tractors, and port equipment. In addition to off-road equipment, Chas studies harbor craft vessels and their operational patterns within their resident harbor. He hopes to expand his research to incorporate ocean going vessels.

ZHOUQIAO ZHAO, ELECTRICAL ENGINEERING
Esther F. Hays Graduate Fellowship

Zhouqiao's research focus is on intelligent transportation system (ITS), especially connected and automation enabled cooperative management framework for mixed traffic. Introducing cooperation to the road users, could result in major improvements in safety, mobility, and environmental sustainability. After graduating, he aims to bridge the gap between research and industry by designing the blueprint of the future transportation system to optimize safety, mobility, and energy efficiency. Zhouqiao pursued this major because he believes that the automation and robotization will be (and has already been) the revolution that could deeply change the relations of production and also improve the efficiency and sustainability of operating. He hopes to be one of the people contributing to this revolution.

TIANBO TANG, CHEMICAL AND ENVIRONMENTAL ENGINEERING
Salim Khan Award

Tianbo's research focus is on emissions and fuels, and is working on CE-CERT's new ethanol project involving the comparison of exhaust emissions between E10 CaRFG and splash blended E15. The purpose of this project is to investigate the emissions impact of increasing the ethanol content of California gasoline from 10% to 15% on a total of 20 light-duty vehicles from various technology groups (i.e. engine displacements, year, make and model). This project will facilitate the California Air Resources Board's adoption of the E15 specifications requested by the ethanol industry. He recently participated in the new light-duty lab (in partnership with the automotive consulting firm AVL) to build up, place, and perform practice tests on the necessary instruments to check and verify the new systems.

XISHUN (HEESON) LIAO, ELECTRICAL AND COMPUTER ENGINEERING
Esther F. Hays Graduate Fellowship

Heeson's current research focus is on implementing the "Digital Twin" concept in the Transportation Systems Research area, allowing physical entities (e.g., road users and infrastructure) to be well modeled and represented by their respective digital replica for building an intelligent transportation system (ITS) in the cyber world. One of his research goals is to understand human driver's behavior to improve road safety, traffic efficiency, and the environment. Heeson chose this major because he wanted to develop real-world applications that can contribute to improving road safety, traffic efficiency and reducing greenhouse gas emissions.

NINGJIN XU, CHEMICAL AND ENVIRONMENTAL ENGINEERING
Colin E. Hackett Graduate Award

Ningjin's current research focus on the design, construction, and characterization of two flow tube reactors, which are Accelerated Production and Processing of Aerosols (APPA) reactor and Bio-OFR. She is working on laboratory studies of the APPA reactor, which can be a useful tool to study aqueous aerosol formation. The APL research group previously designed a Particle Formation Accelerator (PFA) OFR for studying gas-SOA. Several characterization experiments were deployed in the APPA reactor as they did in the PFA OFR, including particle collection efficiencies, intensity level and distribution, the residence time distribution of gases and particles, and droplet formation and size.

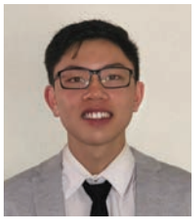
CALIFORNIA AIR RESOURCES BOARD

"CARB has collaborated with UCR scientists and researchers from our earliest efforts to address air pollution. The cutting-edge research performed at CE-CERT has validated and helped accelerate CARB's groundbreaking actions, and expanded our ability to address the full complexity of California's air quality issues. CE-CERT is a valuable contributor to this work, and we look forward to continuing this partnership as we work to address the difficult challenges of climate change and ensuring clean air for all of California's communities."

– Annette Hebert, Deputy Executive Officer, California Air Resources Board

ZIHAN ZHU, CHEMICAL AND ENVIRONMENTAL ENGINEERING
Esther F. Hays Graduate Fellowship

Zihan's research consists of two parts: drone-based multi-gas measurements and the Captive Aerosol Growth and Evolution (CAGE) chambers study. During her drone measurement research, she completed a four-month continuous daily ozone and particulate matter measurements throughout the pandemic. Currently, she working on analyzing the data and developing new approaches to include NOx measurement in this year's ozone season. For the CAGE study, two CAGE chambers are developed in a parallel mode with gas-phase and seed aerosol perturbation experiments planned to be performed.



ALEXANDER NGUYEN, BIOCHEMICAL ENGINEERING
Jim Guthrie Research Award

Alexander has assisted in the research on the Innovation Corridor, which is a stretch of road through Downtown Riverside that has been zoned as a testbed for the development of technological solutions to reducing the number of atmospheric pollutants generated from urban environments. His role on the project is to provide data analysis and modelling to allow principal investigators to focus on the main objectives of the project. Alexander hopes that his future research will attribute to the solution in creating a sustainable future for Earth and aspire to one day help solve the global atmospheric crisis humans have generated.

DWARAKNATH RAVICHANDRAN, ELECTRICAL ENGINEERING
Jim Guthrie Research Award

Dwaraknath is working to observe the effects of COVID-19 induced lockdowns traffic activity and the air quality levels in the Southern California region. He is also assisting in developing research on possible correlations with socio-economic factors of the observed areas, to see if disadvantaged communities have been more affected by the decrease in traffic activity caused by the pandemic. Post-graduation, Dwaraknath sees himself working at a company that has a mission that he can be proud of. He hopes to be able to work in a career that gives him flexibility, as well as the opportunity to work on a diverse set of projects that would help continue further his knowledge within STEM.

KEVIN URRUTIA AVILA, ELECTRICAL ENGINEERING
Jim Guthrie Research Award

Kevin's research involves improving the field of precision agriculture through the use of autonomous ground drones and soil sensors. The drone moves through the field passing multiple soil sensors and collection data on the conditions of the soil through Bluetooth. In turn, the drone allows for the farm management to get an accurate representation about the conditions of the land in a form of a gridded GPS map. Allowing the farm management to adjust their agriculture techniques based on these maps and for a more sustainable form of managing the land.

LUIS FERNANDO ENRIQUEZ-CONTRERAS, ELECTRICAL AND COMPUTER ENGINEERING
NCST Fellowship Award

Luis is developing an integrated platform for electric vehicle chargers in a microgrid using a universal software and interface. As part of this research, he is focused on developing a free and open-source Python library for integrating various microgrid components and electric vehicle charging infrastructure. This library is meant to facilitate and optimize the data acquisition and control of the various components of a microgrid and EV chargers. The major advantage of this library is that it will be component agnostic, which allows the users to configure all the components in one library and easily add and swap components regardless of manufacturer.

JACQUELINE GARRIDO, ELECTRICAL AND COMPUTER ENGINEERING
NCST Fellowship Award

Jacqueline's current research focuses on studying EV charging behaviors to minimize carbon emissions. Her project aims to develop new EV charging strategies that are focused on minimizing carbon emissions, while addressing other performance metrics. As a critical component, this project will consist of an extensive study to understand and model activity and charging patterns of light-duty (LD), medium-duty (MD), and heavy-duty (HD) electric vehicles. With the current target of 100% zero emission vehicles by 2035 in California, this project will address smart and innovative solutions not only to charge these vehicles, but to also optimize vehicle schedules and routes, with the goal of minimizing CO_2 emissions.

CE-CERT STUDENTS

CE-CERT's interdisciplinary approach connects students from various backgrounds to work cooperatively on hands-on research. We employ over 25 undergraduate students at any given time - majoring in engineering, science, business, and policy. We also support the research and thesis efforts of nearly 60 engineering graduate students.

2021 GRADUATE STUDENT LIST

- Ivan Aquaah
- Issac Afreh
- Zhengwei Bai
- Jiahe Cao
- Luis Contreras-Enriquez
- Khanh Do
- Ryan Drover
- Xuanlin Du
- Thomas Eckel
- Jacqueline Garrido Escobar
- Chas Frederickson
- Abdullah Un-Noor Fuad
- Sahar Ghadimi
- Daniel Gonzalez
- ASM Jahid Hasan
- Diana Ibarra-Gomez
- Yu Jiang
- Jia Jiang
- Alija Kabir
- Jiyong Kim
- Guadalupe Lara
- Chen Le
- Seungjin Lee
- Qi Li
- Heeson Liao
- Yejia Liao
- Shangrui Liu
- Brenda Lopez
- Tianyi (Jerry) Ma
- Ayla Moretti
- Saswat Nayak
- Roland David Oswald
- Minerva Robles
- Pingbo Ruan
- Samiha Shahid
- Shiva Sharma
- Lu Shi
- Priyanka Singh
- Christos Stamatis
- Tianbo Tang
- Afsara Tasnia
- Zhensong Wei
- Hao Xin
- Ningjin Xu
- Yun Xue
- Arash Kahsfi Yeganeh
- Jubair Yusuf
- Zhouqiao Zhao
- Xuanpeng Zhao
- Hanwei Zhu
- Zihan Zhu

2021 UNDERGRADUATE STUDENT LIST

- Haneen Abbas
- Yahya Alshanti
- Trang Bui
- Laura Grigoryan
- Fei Gu
- Franklin Ippolito
- Yi Ji
- Grace Johnson
- Mia Klijako
- Kevin Liu
- Kora Luu
- David Mendez-Jimenez
- Joshua Milne
- Jonathan Parker
- David Phung
- Kharla Pimentel
- Dwaraknath Ravichandran
- Shaan Saiyb
- Candice Sirmollo
- Ashley Siu
- Brett Trenier
- Jasmin Velasquez
- Hao Xin
- Ruoming Xu

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

"The development of green technology is key to cleaner air in California and beyond. For 30 years, South Coast Air Quality Management District has partnered with CE-CERT on innovative research projects as well as the education and training of a green workforce—with a few graduates coming to work at South Coast AQMD. We look forward to future collaboration with UCR as they continue their important work."

– Wayne Nastri, Executive Officer, South Coast Air Quality Management District

CE-CERT continues to increase our active research portfolio, relying on a variety of research thrust areas with a wide variety of sponsorship. In 2021, CE-CERT's active research portfolio of 122 projects with a total budget over $27 million.

122

PROJECTS TOTALING OVER $27 MILLION

ATMOSPHERIC PROCESSES

Community Air Grant Proposal for J.W. North High School in Riverside, California
California Air Resources Board | Nicole Cleary

Environmental Chamber Experiments to Improve Secondary Organic Aerosol Model Prediction
California Air Resources Board | David Cocker

Application of Aerial Platform Technologies to CARB landfill inspection and analytical procedures
California Air Resources Board | Francesca Hopkins

Mapping Aerosol Processes across Houston during convective cell events
Department of Energy Office of Science | Don Collins

Assessment of greenhouse gas and air quality benefits of dairy digester installation in California
California Energy Commission | Francesca Hopkins

National Environmental Justice Collaboration
Environmental Protection Agency | Cesunica Ivey

The Influence of NOx on SOA and Ozone
Coordinating Research Council | David Cocker

Development and Evaluation of Databases and Estimation Methods for Predicting Air Quality Impacts of Emitted Organic Compounds
Coordinating Research Council | William Carter

Direct measurement of small particle growth and aging at SGP | Department of Energy Office of Science/Office of Basic Energy | Don Collins

Catalytic NO and CO Emission Control Unit for SmallOff-road Engines
Environmental Protection Agency | David Cocker

Scalable Chemical Mechanisms of Emerging Sources for Community Air Quality Predictions
Environmental Protection Agency | Kelley Barsanti

Investigating the Nighttime Chemistry of Biomass Burning Emissions | National Oceanic and Atmospheric Administration | Kelley Barsanti

Building and testing the framework to integrate detailed chemical measurements and predictive biomass burning models | National Oceanic and Atmospheric Administration | Kelley Barsanti

Using Observations of Gaseous Compounds in the LA Basin during COVID-19 to Elucidate Sources and Atmospheric Processes Affecting Urban Air Quality | National Oceanic and Atmospheric Administration | Kelley Barsanti

Index of Chamber Atmospheric Research in the United States | National Science Foundation | David Cocker

Collaborative Research: Urban Air Quality During the COVID-19 Shelter-In-Place Orders
National Science Foundation | Kelley Barsanti

Biogenic Emissions and Aerosol Response on the North Slope | National Science Foundation | Kelley Barsanti

Harnessing Graphical Processing Units (GPUs) to Accelerate the Computational Efficiency of Air Quality Modeling Systems for Four-Dimensional Ai
National Science Foundation | Cesunica Ivey

Toxicant Production and Mitigation in the Electronic-Cigarette | National Institute of Environmental Health Sciences | Kelley Barsanti

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 | Cesunica Ivey

Understanding and Mitigating Wildfire Risk in California
California Air Resources Board | Kelley Barsanti

Ultrafine aerosol particle formation and impacts in Houston during TRACER
Department of Energy Office of Science | Don Collins

EMISSIONS & FUELS

Activity Data of Off-Road Engines in Construction
California Air Resources Board | Tom Durbin

Low Emission Diesel (LED) Study
California Air Resources Board | Tom Durbin

Real-world tire and brake wear emissions
California Air Resources Board | Heejung Jung

Confirmatory and Efficacy Testing of Additive-Based Alternative Diesel Fuel Formulations | California Air Resources Board | Tom Durbin

Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15 | California Air Resources Board | Georgios Karavalakis

Collection and Analysis of Agricultural Equipment
California Air Resources Board | Tom Durbin

CARB Emissions Compliance Testing
California Air Resources Board | Tom Durbin

Emission Testing and Test Method Development for Commercial Harbor Craft and Ocean-Going Vessels
California Air Resources Board | Kent Johnson

Renewable Diesel Agricultural Engine Testing
California Air Resources Board | Tom Durbin

Smog Check Performance Report
California Department of Consumer Affairs | Tom Durbin

Medium and Heavy-Duty EV Deployment - Data Collection
Department of Energy, Office of Energy Efficiency & Renewable Energy | Kent Johnson

Vessel and Port Emissions Testing | Department of Transportation Maritime Administration | J. Wayne Miller

Measurement of Criteria Emissions from the MARAD RRF Vessel Cape Henry | Department of Transportation Maritime Administration | Kent Johnson

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Heavy-Duty Vehicle Testing and Data Analysis
Environmental Protection Agency | Tom Durbin

NOx Sensor Evaluation and Support: Sensor Performance and Aging Behavior in Real World
Environmental Protection Agency | Kent Johnson

Developing a Database for Marine Emissions
Eastern Research Group, Inc. | J. Wayne Miller

Characterizing Emissions and Activity from Nonroad and Heavy-Duty Vehicles
Environmental Protection Agency | Kent Johnson

Equipment Loan for the testing of heavy-duty vehicles to gather activity and emission data under CRADA 818-A-19
Environmental Protection Agency | Kent Johnson

Optimized Hybrid Ultra-Low NOx Class 8 Heavy Duty Natural Gas Truck | Gas Technology Inst. | Kent Johnson

Advanced Off-Road NG Vehicle Demonstration and Evaluation
Gladstein, Neandross & Associates | Kent Johnson

Plasma-Enhanced Electrostatic Precipitation of Diesel Particulates using High Voltage Nanosecond Pulses
National Science Foundation | Heejung Jung

Evaluation of Hydrogen-Natural Gas on Engine Performance and Durability | Pacific Gas and Electric Company | Georgios Karavalakis

In-Use Emissions Testing and Fuel Usage Profile of On-Road Heavy-Duty Vehicles
South Coast Air Quality Management District | Tom Durbin

Secondary Organic Aerosol (SOA) Forming Potential from Heavy-Duty Diesel Vehicles and Heavy-Duty Natural Gas Vehicles
South Coast Air Quality Management District | Georgios Karavalakis

Hexavalent Chromium Emissions from Industrial Heat Treating Furnaces
South Coast Air Quality Management District | Georgios Karavalakis

Renewable Diesel for Off-Road Diesel Engines
South Coast Air Quality Management District | Georgios Karavalakis

Onboard Sensing, Analysis, and Reporting (OSAR): Phase 1 Sensor Evaluation on Heavy Duty Trucks
South Coast Air Quality Management District | Kent Johnson

Investigate Effects of Ethanol-Gasoline Fuel Blend on Criteria Emissions and Secondary Organic Aerosol (SOA) Formation from Light-Duty Vehicles
South Coast Air Quality Management District | Georgios Johnson

POLB LCTF + AQIP Off-road Equipment data monitoring
Port of Long Beach | Kent Johnson

Data Collection and Analysis under the California Air Resources Board (CARB) Zero-and-Near-Zero Emissions Freight Facility Grant
California Air Resources Board | Tom Durbin

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Los Angeles County Department of Public Works | Tom Durbin

Pasha Green Omni Terminal Project performance Testing
Port of Los Angeles | Tom Durbin

Real-World brake activity of heavy-duty vehicles
California Department of Transportation | Heejung Jung

TRANSPORTATION SYSTEMS

Hybridization and full electrification potential in off-road applications | California Air Resources Board | Kanok Boriboonsomsin

Durability and Performance of Zero-Emission and Near-Zero-Emission Off-Road Equipment
California Air Resources Board | Kanok Boriboonsomsin

Analysis of vehicle emissions control technologies
American Honda Motor Co., Inc. | Matthew Barth

Partnership for laboratory testing, research, publications, education, and/or operations
AVL Test Systems, Inc. | Matthew Barth

Alternative HOV Lane Operational Strategies for Congestion Mitigation in California
California Department of Transportation | Kanok Boriboonsomsin

Evaluation of Hybrid Electric Street Sweepers
California Department of Transportation | George Scora

Data Collection and Analysis in Riverside Clean Car Share
California Air Resources Board | Peng Hao

Collaboration Agreement
Gladstein, Neandross & Associates | Matthew Barth

Research for the effect on the fuel efficiency by Reactive Force Pedal | Honda Motor Co., ltd. | Matthew Barth

Phase 2 Development and Evaluation of Reactive Force Pedal Technology | Honda Motor Co., ltd. | Matthew Barth

Connected Vehicle-based Advanced Detection of Slow-Down Events on Freeways | Honda Motor Co., ltd. | Guoyuan Wu

Development of Connected and Automated Vehicle Algorithms and Support at the FHWA's TFHRC
Federal Highway Administration | Guoyuan Wu

Mobile Robotic Lab for In-Situ Sampling and Measurement
National Institute for Food and Agriculture | Konstantinos Karydis

Extracting Dynamics from Limited Data for Modeling and Control of Unmanned Autonomous Systems
National Science Foundation | Konstantinos Karydis

Morphological Computation for Resilient Dynamic Locomotion of Compliant Legged Robots
National Science Foundation | Konstantinos Karydis

Port of Los Angeles Freight Transportation Project
California Energy Commission | Kanok Boriboonsomsin

Technical Assistance for Advanced, Low- and Zero-Emissions Mobile and Stationary Source Tech
South Coast Air Quality Management District | Matthew Barth

Air Quality & Climate Research Training Program
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Development and Application of Environmentally-Friendly Intelligent Transportation System (ECO-ITS) Freight Strategies
South Coast Air Quality Management District | Kanok Boriboonsomsin

Monitoring, Modeling, and Mitigating Emissions and Air Quality Impacts of Goods Movement in Inland Southern California Environmental Justice Community
State of California Department of Justice | Matthew Barth

Stratosfuel Hydrogen Station | Matthew Barth

Center for Advancing Research in Transportation Emissions, Energy and Health
Department of Transportation, Research and Innovative Technology Administration | Kanok Boriboonsomsin

Developing Situation Awareness Capability within the Digital Twin Framework Activating/Deactivating Connected Vehicle (CV) Applications in Mixed Traffic
Toyota Motor North America, Inc. | Guoyuan Wu

UCR Innovation Corridor Smart Sensing
Toyota Motor North America, Inc. | Matthew Barth

Climate Change Research for the California Strategic Growth Council | California Governors Office of Planning and Research | Matthew Barth

Integrating Zero Emission Vehicles into the Caltrans Fleet
California Department of Transportation | Michael Todd

National Center for Sustainable Transportation
Department of Transportation, Research and Innovative Technology Administration | Matthew Barth

Evaluating the Effectiveness of 'SmartPedal' Systems for Vehicle Fleets
California Department of Transportation | George Scora

Low-Carbon Transportation Incentive Strategies Using Performance Evaluation Tools for Heavy-Duty Trucks and Off-Road Equipment | California Air Resources Board | Kanok Boriboonsomsin

Estimating the Impacts of Automatic Emergency Braking (AEB) Technology on Traffic Energy and Emissions
Department of Transportation, Research and Innovative Technology Administration | Guoyuan Wu

Evaluating System-Level Impacts of Innovative Truck Routing Strategies
University Transportation Centers | Kanok Boriboonsomsin

Connectivity-Based Cooperative Ramp Merging in Multimodal and Mixed Traffic Environment
University Transportation Centers | Guoyuan Wu

Volvo Low Impact Green Heavy Transport Solutions (LIGHTS)
Volvo Truck Corporation | Kanok Boriboonsomsin

Exploring the environmental impacts of Intelligent Transportation Solutions | Waycare Technologies ltd. | Matthew Barth

RENEWABLE ENERGY PRODUCTION & INTEGRATION

Access to UCR site to collaborator for installation of soiling station
Alliance for Sustainable Energy, LLC. | Martinez-Morales, Alfredo

Salton Sea Geothermal Lithium Recovery Demonstration Project
California Energy Commission | Arun Raju

Chemehuevi Indian Tribe Microgrid
California Energy Commission | Alfredo Martinez-Morales

Developing a MHD ZEV Infrastructure Blueprint for the South Coast
California Energy Commission | Arun Raju

Hydrogen Blending Impacts Study
California Public Utilities Commission | Arun Raju

Digester performance data to evaluate the effectiveness of a CO_2 microbubble system in increasing methane production rate from the digester | City of Riverside | Arun Raju

Eastside Climate Collaborative Transformative Climate Communities Initiative | Strategic Growth Council | Arun Raju

Southern California Energy Innovation Network (SCEIN) 2.0
California Energy Commission | Arun Raju

Senior Experience for real-world problem solving situations | CSU San Marcos, University Auxiliary & Research Services Corp | Alfredo Martinez-Morales

A Green Approach to Pulping Hemp for Construction
Environmental Protection Agency | Charles Cai

Critical Resilience for Fire and Emergency Facilities with the Soboba Band of Luiseno Indians
California Energy Commission | Alfredo Martinez-Morales

Enabling California's Resilient Tribal Communities with Mobile Renewable Power
California Energy Commission | Alfredo Martinez-Morales

Battery energy storage system
Growing Energy Labs, Inc. | Alfredo Martinez-Morales

Yeast strains | Mascoma Corporation | Charles Wyman

Advanced Technologies for Biomass Deconstruction and Lignin Valorization | Oak Ridge National Laboratory | Charles Wyman

Speeding Anaerobic Digestion with CO_2 Microbubbles
Southern California Gas Company | Arun Raju

Renewable Syngas Methanation
California Energy Commission | Arun Raju

Hollow Titanium Dioxide Nanospheres as a Delivery System of Chemoattractant Factors for Human Dopaminergic Axons
UC Mexus | Alfredo Martinez-Morales

Next Generation of Ligno-Polyurethanes
University of Tennessee | Charles Cai

Advancing the National Bioeconomy through Regional Sun Grant Centers | National Institute for Food and Agriculture | Charles Cai

Modification of Zeolite Catalyst to Increase Carbon Number and Reduce Aromatics for Conversion of Ethanol to Jet Fuel
Department of Energy, Office of Energy Efficiency and Renewable Energy | Bhogeswararao Seemala

Initial Parametric Scoping Study for Methanol Conversion to Hydrocarbons by Vertimass Catalyst Formulation
Vertimass, LLC | Charles Wyman

A Catalytic Process to Convert Municipal Solid Waste Components to Energy | Department of Energy, Office of Energy Efficiency and Renewable Energy | Charles Cai

NATIONAL CENTER FOR SUSTAINABLE TRANSPORTATION

"CE-CERT has been an integral partner of our National Center for Sustainable Transportation, a prominent university transportation center sponsored by the US Department of Transportation. Not only are researchers from CE-CERT producing key research results towards various transportation solutions, they regularly collaborate in other NCST activities including informing our policy makers, training at various levels, and conducting a number of community outreach events."

– Susan Handy, Director, National Center for Sustainable Transportation, University of California, Davis

HISTORICAL MILESTONES

1992

Dr. Joseph Norbeck hired as CE-CERT Founding Director, coming from the Chemistry Department at Ford Motor Company. CE-CERT is established and begins research projects in emissions testing and hydrogen fuel.

1993

CE-CERT moves from UCR campus to the Bourns Technology Park to expand its facilities. Subsequently, CE-CERT receives several grants from the California Energy Commission and the South Coast Air Quality Management District to establish its vehicle testing laboratory.

1996

CE-CERT awarded a large research grant from the National Cooperative Highway Research Program to develop better emissions models that are used in transportation forecasts.

2012

Southern California Research Initiative in Solar Energy (SC-RISE) is established, focused on renewable electricity. This expands further to the Sustainable Integrated Grid Initiative (SIGI), launched in 2014.

2010

CE-CERT holds its 1st Annual Portable Emissions Measurement Systems (PEMS) Conference, still going strong today!

2007

CE-CERT's Steam Hydrogasification Reaction Technology commercialized.

2014

CE-CERT expands its research interest into **Health Effects**, later joining with the UCR School of Medicine in the BREATHE (Bridging Regional Ecology, Aerosolized Toxins, & Health Effects) Center.

2015

CE-CERT researchers develop a new CELF (co-solvent enhanced lignocellulosic fractionation) process for biofuels production.

2017

CE-CERT initiates a large in-use emissions testing and verification program in the wake of Volkswagen dieselgate; the same year, CE-CERT established a new Center for Renewable Natural Gas.

1997

CE-CERT students get organized and enter five years of student competitions sponsored by the Society of Automotive Engineers (SAE); this included the Propane Vehicle Challenge and the Ethanol Vehicle Challenge.

1999

CE-CERT greatly expands its energy research program, with the construction of its energy conversion facility (Hynol, waste-to-energy) sponsored by EPA and industry partners.

2000

CE-CERT breaks ground on two new buildings, the CE-CERT Administration Building and the Atmospheric Processes Laboratory Building on 5 acres of property adjacent to the Bourns facility.

2005

Facilities continue to expand: a major Keck Foundation grant provided key instrumentation to the Atmospheric Processes Chamber Facility; next, CE-CERT's Heavy-Duty Chassis Dynamometer facility established with support from CARB and other industry partners.

2004

Professor Matt Barth named (Interim) Director of CE-CERT, then confirmed in 2007. Professor Joe Norbeck continues his sustainable fuels research at CE-CERT.

2002

Design, development, and construction of CE-CERT's "Mobile Emissions Laboratory" (MEL), a one-of-a-kind laboratory on wheels that is still producing impactful results today.

2018

Working closely with the City of Riverside, CE-CERT established the Riverside "Innovation Corridor" testbed which is used for Connected and Automated Vehicle research.

2020

CE-CERT joins the UC-wide 2019 CalTestBed program, providing unique testing facilities that demonstrate a variety of new energy innovations in California. The same year, the On-Board Sensing Analysis and Reporting (OSAR) Consortium is established, developing next generation emissions monitoring systems.

2021

CE-CERT TURNS 30 YEARS OLD!

CE-CERT is honored to highlight the generous donors who have contributed to the success of nearly 160 students who have received scholarships and fellowships throughout the past 30 years. These awards have helped facilitate and enhance our student research and their pursuits of both undergraduate and graduate degrees.

160

STUDENTS RECEIVED SCHOLARSHIPS AND FELLOWSHIPS THE PAST 30 YEARS

FORD MOTOR COMPANY UNDERGRADUATE AWARD

The Ford Motor Company Undergraduate Scholarship was established in 1995, as part of a major gift to the Bourns College of Engineering from Ford Motor Company. The award is to encourage and aid undergraduate students in pursuit of careers in engineering.

WILLIAM R. PIERSON/FORD GRADUATE FELLOWSHIP

The William R. Pierson/Ford Graduate Fellowship was also established as part of the gift from Ford Motor Company to encourage and aid graduate students in pursuit of careers in engineering and doing research at CE-CERT.

JIM GUTHRIE RESEARCH AWARD

Established in 1995 by Jim and Debbi Guthrie, prominent business leaders in the Riverside community, to encourage academic excellence and critical thinking at the undergraduate level.

ESTHER F. HAYS GRADUATE FELLOWSHIP AWARD

The Esther F. Hays Graduate Fellowship was established in 1999 by Esther Hays, to encourage and aid graduate students in pursuit of careers in engineering and doing research at CE-CERT. Dr. Hays was an academic physician, community activist, and philanthropist who supported UC Riverside's programs in medicine, engineering, and music. In retirement, she served on the boards of the Riverside Philharmonic, The Press Enterprise newspaper, and the UCR Foundation. For 12 years she was an assistant to a board member for the South Coast Air Quality Management District. This CE-CERT fellowship is given annually to a full-time graduate student to offset University of California, Riverside, academic and/or research expenses.

SALIM KHAN GRADUATE AWARD

This award is dedicated to Salim Khan, the father of CE-CERT alumnus, Mohammad Yusuf Khan (Ph.D., June 2013), in honor of his commitment to the education of his children and to the service of his community. Mr. Khan was the embodiment of the values of perseverance and hard work, facing several health and financial challenges in his determination to help others.

COLIN E. HACKETT ENDOWED ENGINEERING RESEARCH GRADUATE AWARD

The Colin E. Hackett Endowed Engineering Research Award was established in 2005 by Nora Hackett and the Hackett Family in honor of the late Colin Hackett who served as a senior research faculty at CE-CERT following his retirement in 2000, after 27 years of service at Sandia National Labs in Livermore, CA.

G. NEAL RICHTER SCHOLARSHIP IN ENERGY INNOVATION

Dr. G. Neal Richter was a leader in energy innovation and expert in gasification for more than 50 years. As an undergraduate, he majored in chemical engineering at Yale, then received his Ph.D. in 1957 from the California Institute of Technology. As a retiree, he served as a Chevron Fellow Emeritus and volunteered at CE-CERT, working with various energy-related projects. To further advance the academic quality, excellence and benefits of energy research, Dr. Richter, his family and friends, established an endowed fund in 2015 in his honor to support undergraduate or graduate students studying alternative energies at CE-CERT.

FUTURE CHAMPIONS OF STUDENT SUCCESS

In 2022, CE-CERT will initiate three graduate scholarships to help grow support for research in three crucial areas of concentration: Atmospheric Processes, Emissions & Fuels, and Transportation Systems. Each endowed award will create annual resources, opportunities, and programs for graduate students to shine.

ATMOSPHERIC PROCESS GRADUATE AWARD

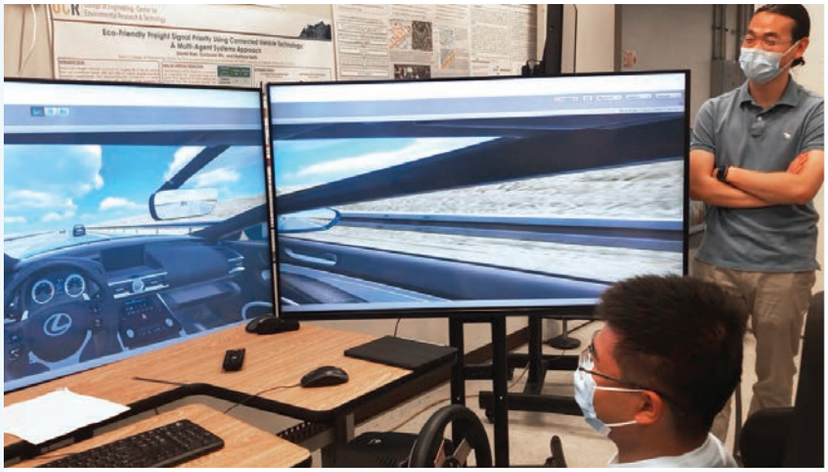
The CE-CERT Atmospheric Processes Research Group advances understanding of the chemical pathways leading to secondary organic aerosol formation in the atmosphere. Through this award the Atmospheric Processes Research Group's faculty and alumni recognize and celebrate the mentorship, dedication and hard work which helped to launch many successful careers for Bourns College of Engineering alumni in the engineering field.

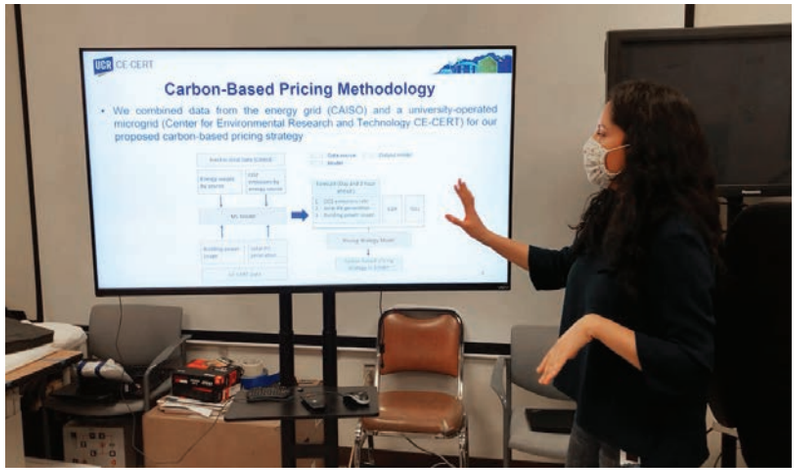
J. WAYNE MILLER AND THOMAS DURBIN GRADUATE RESEARCH AWARD

The J. Wayne Miller and Thomas D. Durbin Graduate Research Award is dedicated to the UCR CE-CERT Emissions and Fuels Research (EFR) team faculty advisors: J. Wayne Miller, Thomas D. Durbin, David R. Cocker, Kent C. Johnson, Heejung Jung, Georgios Karavalakis, and Joseph Norbeck who have each mentored many chemical and environmental engineers over the years.

TRANSPORTATION SYSTEMS & RESEARCH GRADUATE RESEARCH AWARD

The Transportation Systems Research Group applies the latest advances in the field of Intelligent Transportation Systems (ITS) to the mitigation of the environmental and energy issues associated with the movement of goods and people. Through this award the Transportations Systems Research Group's faculty and alumni recognize and celebrate the mentorship, dedication and hard work which helped to launch many successful careers for Bourns College of Engineering alumni in the engineering field.





- AdaptiveARC
- Advanced Engine Technologies, Inc.
- Advanced Research Projects Agency-Energy
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- Alliance of Automobile Manufacturers
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- Cleantech San Diego Association
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- Coachella Valley Association of Governments
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- Department of Energy National Energy Technology Laboratory
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- Department of Transportation Maritime Administration
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- Economic Development Administration
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- Engine Manufacturers Association
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- Environ Holding, Inc.
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- Federal Trade Commission
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- Gas Technology Institute
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- ICM, Inc.
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- International Sustainable Systems Research Center
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- Khan, Salim
- Manufactures of Emission Controls Association
- Maricopa Association of Governments
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- McCain Inc.
- MCNC
- Mendel Biotechnology, Inc.
- Menon & Associates, Inc.
- Milk Producers Council
- NASA Ames Research Center
- National Center for Sustainable Transportation
- National Cooperative Highway Research Program
- National Institute for Food & Agriculture
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- National Science Foundation
- Naval Facilities Engineering Command
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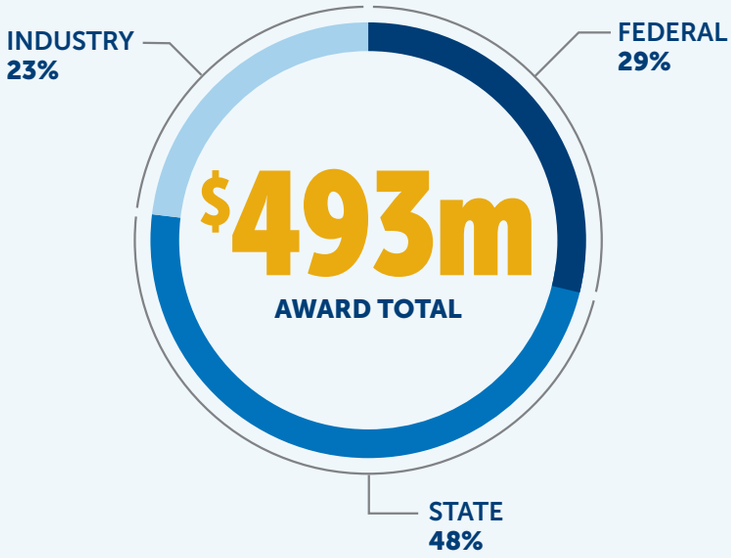
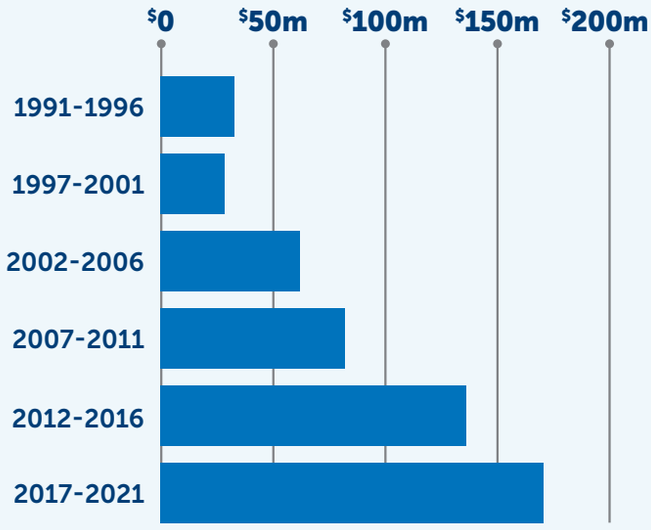


1991-2021 AWARD AMOUNT



- NGK Spark Plug Co. LTD. (Japan)
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- Oak Ridge National Laboratory
- Office of Environmental Health Hazard Assessment
- One Roof Energy
- OPONE ROOF ENERGY
- OPSIS AB
- Oregon State University
- Oryxe Energy International, Inc.
- Pacific Fuel Cell Corporation
- Pacific Gas & Electric Company
- Pacific Southwest Research Station
- Packard Foundation
- Partners for Advanced Transportation Technology
- Pierson, William
- Portland State University
- Power Waste Gasification, LLC
- Productivity APEX, Inc.
- Propane Education & Research Council
- Purac
- Ramboll Environ US Corporation
- Richter, Les
- Richter, Neal
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- Riverside County Transportation Commission
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- San Joaquin Valley Unified Air Pollution Control District
- Sandia National Laboratories
- Sensors, Inc.
- SK Energy, Co., LTD.
- SOCAL Ship Services
- Social Science Research Council
- South Coast Air Quality Management District
- Southern California Gas Company
- Southwest Research Institute
- Space & Naval Warfare Systems Command
- Spawars Center
- State of California Department of Justice
- State of Nevada
- Stratosfuel Hydrogen Station
- Taylor Energy
- Terraforce, Inc.
- Tetra Tech., Inc.
- The Consumer Specialty Products Association
- The Texas A&M University System
- Toyota Infotechnology Center
- Toyota Motor North America, Inc.
- Transpower
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- University of California Tranportation Center (Berkeley)
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- University of Massachusetts
- University of Southern California
- University of Tennessee
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TOYOTA

"During the past four years, Toyota InfoTech Labs in Silicon Valley has been collaborating with CE-CERT through multiple research projects about connected and automated vehicle technology. Besides more than 20 joint publications, Toyota has also been benefited from student interns who are CE-CERT graduate students, and full-time researchers who are CE-CERT alumni. We truly appreciate the contributions from CE-CERT to help us advance mobility technologies, and hope this partnership will continue for many more years."

– Ziran Wang, Principal Researcher, Toyota InfoTech Labs

CALIFORNIA ENERGY COMMISSION

"Congratulations to CE-CERT on its 30th anniversary! This is a remarkable achievement and an occasion to celebrate. The California Energy Commission is proud of its broad and meaningful collaboration with CE-CERT over the past three decades. This includes sponsoring competitive research and demonstration programs that have addressed critical issues related to sustainable transportation, advanced emissions measurement and control strategies, biomass and waste conversion to fuels, renewable energy deployment including microgrids in disadvantaged communities, and advanced energy efficiency strategies. Over this time, CE-CERT has distinguished itself as an unbiased organization that provides science based solutions to real world problems. I look forward to continuing our partnership."

– David Hochschild, Chair, California Energy Commission

Bourns College of Engineering
Center for Environmental Research and Technology

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