



Bourns College of Engineering  
Center for Environmental Research and Technology

# CE-CERT

2023 ANNUAL REPORT



# CONTENTS

DIRECTOR'S MESSAGE	03	B <sup>3</sup> : BIOENERGY, BIOREFINING, AND BIOMATERIALS TEAM	16
2023 CE-CERT MAJOR HIGHLIGHTS	04	SOUTHERN CALIFORNIA RESEARCH INITIATIVE FOR SOLAR ENERGY (SC-RISE)	18
ATMOSPHERIC PROCESSES LABORATORY (APL)	06	GREENHOUSE GAS EMISSIONS LAB	20
EMISSIONS AND FUELS RESEARCH (EFR)	08	FACILITIES	22
TRANSPORTATION SYSTEMS RESEARCH (TSR)	10	ENGAGEMENTS & PARTNERSHIPS	24
SUSTAINABLE INTEGRATED GRID INITIATIVE (SIGI)	12	STUDENTS & SCHOLARSHIPS	26
SUSTAINABLE FUELS INITIATIVE (SFI)	14	ACTIVE PROJECTS LIST	28

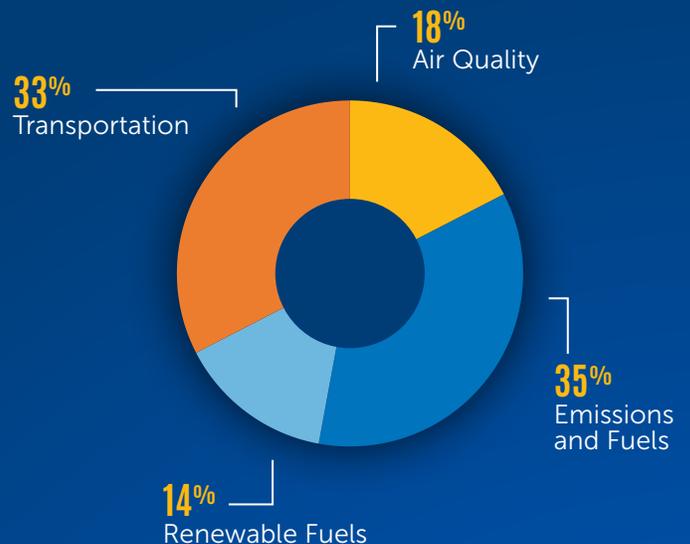
## OVERVIEW

Total Active Project Amount	<b>\$34,279,485</b> in active research funding
Total Active Projects	<b>85</b> Active research projects
CE-CERT Students	<b>94</b> Students supported <b>25</b> Undergraduate <b>69</b> Graduate
Faculty & Staff	<b>52</b>



Additional details on CE-CERT structure, personnel, funding, and publications are available at:  
<https://www.cert.ucr.edu/annualreport2023>

### ACTIVE AWARDS BY RESEARCH GROUP



# DIRECTOR'S MESSAGE



CE-CERT has completed another successful year filled with several important accomplishments. CE-CERT added four new faculty members to our roster and kicked off a number of research projects and programs. Dr. Markus Petters (Professor, Chemical and Environmental Engineering), Dr. Hang Qiu

(Assistant Professor, Electrical and Computer Engineering), Dr. Sarah Petters (Assistant Research faculty, CE-CERT), and Dr. Zisimos Toumasatos (Assistant Research faculty, CE-CERT) joined UCR and CE-CERT in 2023. Additionally, Dr. Georgios Karavalakis, long time CE-CERT researcher, was appointed as a Professor in UCR's Chemical and Environmental Engineering department. As detailed in the report, CE-CERT also expanded our research facilities, including the development of laboratory space for the new faculty.

We ended 2023 with over \$34M in active research projects! That research funding supports the 52 research staff members and more than 65 graduate students and 25 undergraduate researchers here. We are grateful for the many industry, and state, local, and federal government partners that have supported our research and challenged us to find solutions to the most pressing

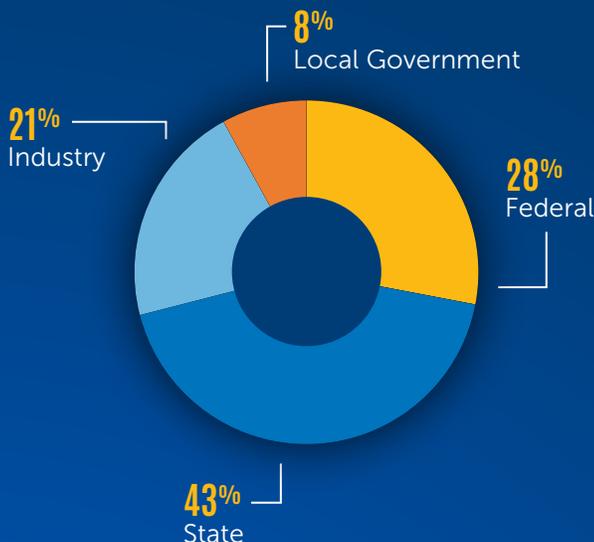
environmental problems. As evidence of our commitment to outreach and engagement, CE-CERT also hosted over 30 tours, engaging with a diverse spectrum of visitors from high school students to retirees and community members to academic, government, non-profit, and industry stakeholders.

An exciting ongoing development is the design and upcoming construction of a new facility under UCR's Opportunities to Advance Sustainability, Innovation, and Social Inclusion (OASIS) initiative. This new facility, to be located between UCR's main campus and the California Air Resources Board's Southern California Headquarters, will house three new state-of-the-art laboratories led by CE-CERT faculty. These laboratories, focusing on atmospheric chemistry and climate change, sustainable mobility, and sustainable energy systems, will have unique world-class capabilities that will accelerate research in these fields, encourage regional and national collaboration, and highlight UCR as a pioneering research institution. UCR is currently engaged in the construction contracting process and is fundraising for equipment that will be part of the facilities.

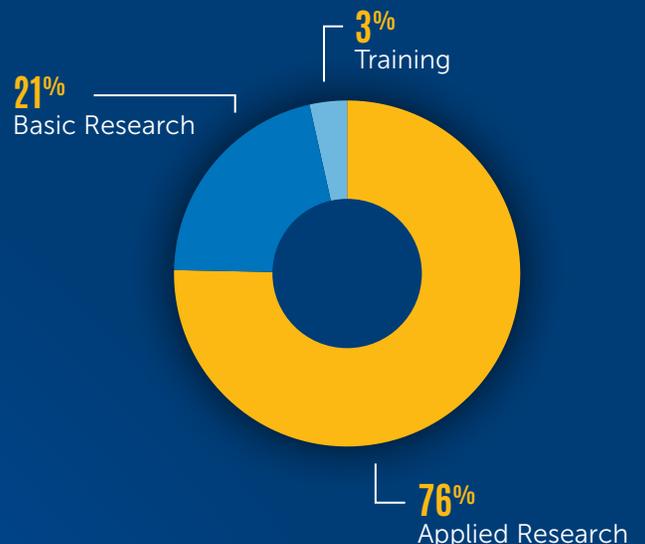
This annual report highlights the work of CE-CERT over the last year and acknowledges our many partners, supporters, and personnel. As always, you can find more detailed information on our website, [cert.ucr.edu](http://cert.ucr.edu). Feel free to reach out and let us know how we are doing!

Sincerely,  
**Dr. Don Collins**

## ACTIVE AWARDS BY SPONSOR TYPE



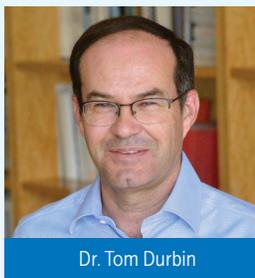
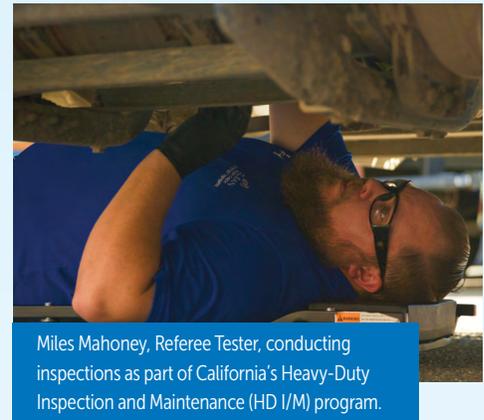
## ACTIVE AWARDS BY RESEARCH TYPE



# 2023 CE-CERT MAJOR HIGHLIGHTS

## CE-CERT LEADS THE STATE REFEREE PROGRAM TO IMPROVE CALIFORNIA'S AIR QUALITY

In a significant stride towards cleaner air and environmental responsibility, CE-CERT is proudly leading the State's Heavy Duty Inspection and Maintenance (HD I/M) program, also referred to as the Clean Truck Check Program. Enacted through Senate Bill 210 (Leyva; Chapter 298, Statutes of 2019), the HD I/M Program, approved by the California Air Resources Board, is a comprehensive heavy-duty vehicle inspection and maintenance regulation effort. Under the leadership of Dr. Tom Durbin, the program integrates periodic vehicle testing, advanced emissions monitoring, and robust enforcement strategies. CE-CERT's engagement in the state referee program ensures the identification and timely rectification of emissions-related issues, playing a crucial role in achieving substantial reductions in smog-forming and carcinogenic pollutants.

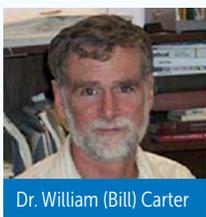


## DR. TOM DURBIN NAMED FELLOW OF THE SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

In recognition of his remarkable contributions to the world of mobility, Dr. Tom Durbin, a seasoned researcher at CE-CERT, has been named a Fellow of the Society of Automotive Engineers (SAE). With nearly three decades of experience under his belt, this achievement stands as a testament to Dr. Durbin's remarkable dedication, innovative contributions, and unwavering commitment to transportation research.

## UCR'S ECOCAR EXCELS IN YEAR 2, SECURES DUAL AWARDS IN ECOCAR EV CHALLENGE

UCR's EcoCAR team is revving up after a successful first year, securing two prestigious awards. The EcoCAR EV Challenge, spanning four years, witnessed the gathering of teams at the culmination of Year 1 to showcase accomplishments in Engineering, Project Management, Communications, and Diversity, Equity, and Inclusion. Standing out among fifteen North American universities, UCR's EcoCAR Team won both the Spirit of the Challenge and the Spirit of Communications awards. Now armed with the team vehicle, the Cadillac LYRIQ, and over 50 students on the team, the students are embarking on an ambitious Year 2 journey.



## THREE CE-CERT AFFILIATED FACULTY MEMBERS NAMED IN THE WORLD'S TOP 2% SCIENTISTS LIST FOR 2023

For the second year in a row, three distinguished members of CE-CERT affiliated faculty, Dr. Matthew Barth, Dr. William (Bill) Carter, and Dr. Georgios Karavalakis, have achieved recognition as top scientists in the world. This acknowledgment comes from Stanford University's database of highly cited scientists, which evaluates experts based on standardized metrics such as citations, h-index, co-authorship adjusted hm-index, citations to papers in different authorship positions, and a composite indicator (c-score). With scientists classified into 22 scientific fields and 176 sub-fields, this recognition is based on being among the top 100,000 scientists with or without self-citations or having a percentile rank of 2% or above in their respective sub-field.



## SCIENTISTS INVESTIGATE POLLUTION-CLOUD INTERACTION IN THE SOUTHERN CALIFORNIA INTERACTIONS OF LOW CLOUD AND LAND AEROSOL (SCILLA) EXPERIMENT OFF SOUTHERN CALIFORNIA COAST

In a groundbreaking research project based out of San Diego, CE-CERT researchers investigated the interaction between low-level clouds and a unique blend of clean ocean air and highly polluted air originating from the emissions-rich Los Angeles/Long Beach region. The research team, which includes Dr. Don Collins and Ph.D. student Minghao Han, conducted near-daily flights over the northeastern Pacific Ocean in June, focusing on San Clemente Island and the L.A. coast. The SCILLA experiment findings promise significant strides in understanding pollution dynamics, cloud formation, and environmental interactions off the Southern California coast.



Ph.D. Student Minghao Han stands in front of the aircraft used for the SCILLA project.

## CE-CERT LEADS CARB-FUNDED RESEARCH ON NON-EXHAUST VEHICLE EMISSIONS

CARB has awarded a major research grant to a team of experts including CE-CERT, Eastern Research Group (ERG), Ricardo, and LINK Engineering. The project, led by Dr. Georgios Karavalakis, focuses on measuring non-exhaust emissions from both light-duty and heavy-duty vehicles, with an emphasis on brake and tire wear particulate matter. The goal is to develop specialized sampling systems and measurement protocols. Co-principal investigators Dr. Kent Johnson, Dr. Heejung Jung, and Dr. Zisimos Toumasatos are leading the comprehensive analysis of brake and tire PM samples, including assessing their chemical composition and toxicological properties. The program will enhance the understanding of non-exhaust emissions and contribute to effective strategies for managing air quality and protecting public health.



Dr. Markus Petters



Dr. Sarah Petters



Dr. Hang Qiu



Dr. Zisimos Toumasatos

## CE-CERT WELCOMES FOUR NEW FACULTY MEMBERS: DR. MARKUS PETERS, DR. SARAH PETERS, DR. HANG QIU, AND DR. ZISIMOS TOUMASATOS; DR. GEORGIOS KARAVALAKIS BECOMES A FACULTY MEMBER

CE-CERT proudly announces the addition of four faculty members to our team: Dr. Markus Petters, Dr. Sarah Petters, Dr. Hang Qiu, and Dr. Zisimos Toumasatos. Dr. Markus Petters joins UCR's Chemical and Environmental Engineering (CEE) department as a Professor while Dr. Qiu is appointed Professor at the department of Electrical and Computer Engineering (ECE). Dr. Petters and Dr. Toumasatos will be CE-CERT research faculty members. Additionally, Dr. Georgios Karavalakis, long time CE-CERT researcher, has been appointed as a Professor with UCR's CEE department. The CE-CERT team is excited to work with these faculty to expand and add depth to the Center's research programs.

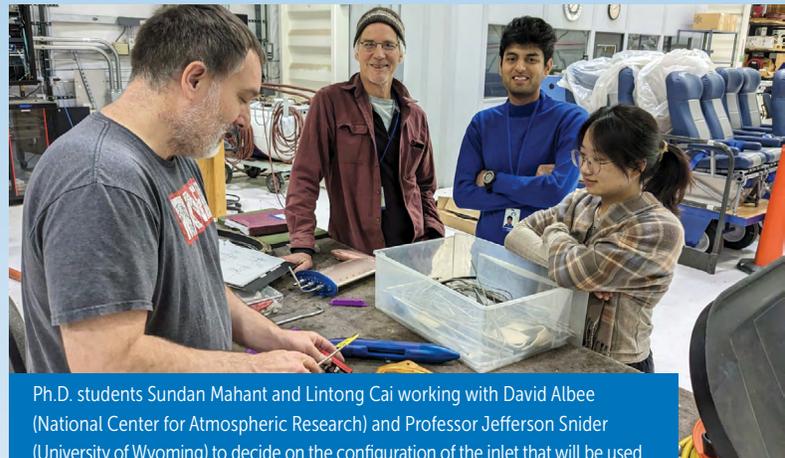
# ATMOSPHERIC PROCESSES LABORATORY (APL)

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

## 2023 HIGHLIGHTS

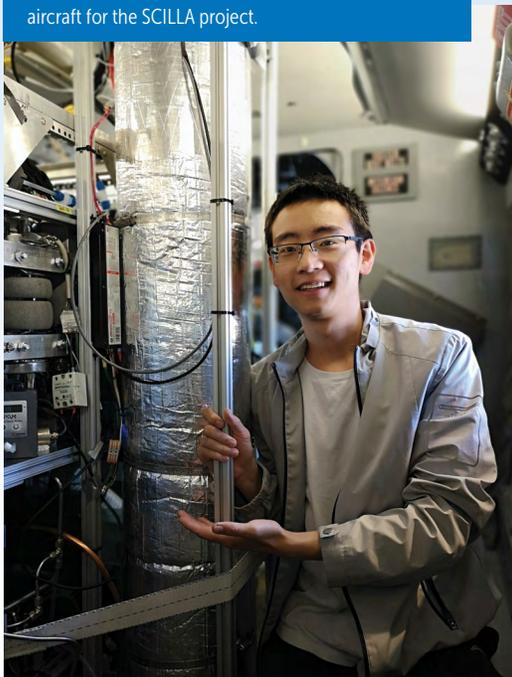
01

**Department of Energy Southern California Interactions of Low cloud and Land Aerosol (SCILLA) project:** In June 2023, APL researchers Dr. Don Collins and Dr. Roya Bahreini and Ph.D. students Minghao Han and Brad Ries operated several instruments on board a research aircraft that conducted 21 flights off the coast of San Diego and into the Los Angeles Basin. Among the objectives of the DOE-sponsored study was to provide a comprehensive description of the sources, processing, chemistry, climate-altering properties, and spatial distribution of the particulate matter impacting population centers and the offshore environment of Southern California.



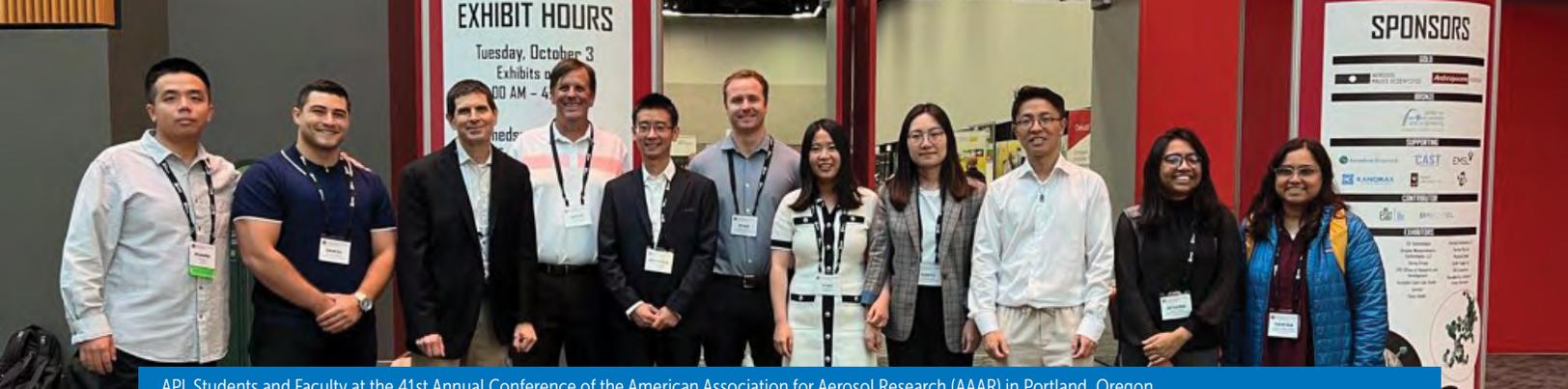
Ph.D. students Sundan Mahant and Lintong Cai working with David Albee (National Center for Atmospheric Research) and Professor Jefferson Snider (University of Wyoming) to decide on the configuration of the inlet that will be used to bring sample air into the aircraft to be used during the CAESAR project.

Minghao Han, Ph.D. student, on board the research aircraft for the SCILLA project.



02

**National Science Foundation CAESAR Project:** APL researchers are gearing up for the upcoming NSF-funded Cold-Air Outbreak Experiment in the Sub-Arctic Region (CAESAR) campaign. The project will take the NSF Lockheed C-130 Hercules aircraft to profile the atmosphere to better understand the clouds that form when Arctic cold air leaves the polar ice cap and travels southward over the warmer water. The project will involve several approximately 10-hour-long research flights departing from Kiruna (Sweden), flying to the ice edge and back again sampling aerosol and cloud properties along the way. Ph.D. students Lintong Cai and Sunandan Mahant worked with faculty member Markus Petters to set up and install instrumentation on the aircraft to measure aerosol properties, including cloud condensation nuclei, refractory black carbon, and the aerosol size distribution. *Campaign blog:* [caesar2024.github.io/](https://caesar2024.github.io/)



APL Students and Faculty at the 41st Annual Conference of the American Association for Aerosol Research (AAAR) in Portland, Oregon.

**03** APL researchers continued their collaboration with EFR on several key initiatives, including evaluation of secondary organic aerosol from heavy-duty diesel emissions and measurement of in-use ship emissions.

**04** Researcher Chen Le achieved a major milestone by thoroughly improving the chamber data analysis system. This enhancement integrates particle dynamics into both the existing and newly introduced UCR-chambers, representing a significant step forward in our research capabilities.

## AWARDS AND HONORS



- Dr. Sarah Petters - Juan Fernandez de la Mora High-Resolution Half-Mini DMA Prize Competition
- Graduate Student Ryan Drover Selected as Science Policy Scholar-in-Residence with the National Science Policy Network
- Graduate Students Xuanlin Du and Daniel Gonzalez Selected for UCR Science to Policy Certificate Course

## KEY PUBLICATIONS



- Quevedo, D., Gao, Z., Do, K., Bahreini, R., Collins, D., & Ivey, C. (2023). Multidecadal Analysis of Meteorological and Emissions Regimes for PM<sub>2.5</sub> Across California. *Environmental Science and Technology Air*, doi: 10.1021/acsestair.3c00019.
- Mahant, S., Yadav, S., Gilbert, C., Kjærgaard, E. R., Jensen, M. M., Kessler, T., Bilde, M., & Petters, M. D. (2023). An open-hardware community ice nucleation cold stage for research and teaching. *HardwareX*, doi: 10.1016/j.ohx.2023.e00491.
- Petters, M. D., Pujiastuti, T., Rasheeda Satheesh, A., Kasparoglu, S., Sutherland, B., & Meskhidze, N. (in press). Wind-Driven Emissions of Coarse Mode Particles in an Urban Environment. *Atmospheric Chemistry and Physics*. <https://doi.org/10.5194/egusphere-2023-951>.
- Petters, S. S., Kjærgaard, E. R., Hasager, F., Massling, A., Glasius, M., & Bilde, M. (2023). Morphology and hygroscopicity of nanoplastics in sea spray. *Physical Chemistry Chemical Physics*, doi: 10.1039/D3CP03793B.
- Le, C., Xu, N., Li, Q., Collins, D., & Cocker, D. (In Press). Experimental Characterization of Particle Wall-Loss Behaviours in UCR Dual 90m<sup>3</sup> Chamber. *Aerosol Science and Technology*. doi: 10.1080/02786826.2023.2294056.

- Ghadimi, S., Zhu, H., Durbin, T. D., Cocker III, D. R., & Karavalakis, G. (2023). Exceedances of Secondary Aerosol Formation from In-Use Natural Gas Heavy-Duty Vehicles Compared to Diesel Heavy-Duty Vehicles. *Environmental Science & Technology*, 57(48), 19979-19989. doi: 10.1021/acs.est.3c04880.

## PROFESSIONAL ACTIVITY

- American Association for Aerosol Research

## FACULTY LIST

- David Cocker, Professor of Chemical & Environmental Engineering
- Don Collins, Professor of Chemical & Environmental Engineering and CE-CERT Director
- Markus Petters, Professor of Chemical & Environmental Engineering
- Sarah Petters, Assistant Research Engineer
- Roya Bahreini, Professor of Environmental Sciences and CE-CERT affiliate faculty
- Will Porter, Assistant Professor of Environmental Sciences CE-CERT affiliate faculty

## KEY SPONSORS AND PARTNERS

- California Air Resources Board
- Coordinating Research Council
- Department of Energy Atmospheric System Research Program
- Environmental Protection Agency
- National Science Foundation Atmospheric Chemistry Program
- National Science Foundation Community Instruments and Facilities (CIF) Program
- National Science Foundation Physical and Dynamical Meteorology Program



# EMISSIONS AND FUELS RESEARCH (EFR)

**MISSION:** The Emissions and Fuels Research (EFR) group applies advanced technologies and methods to measure emissions and activity from various sources, such as passenger vehicles, heavy-duty vehicles, off-road equipment, and large engines that power marine vessels and locomotives. This information is critical to understanding the impacts of mobile sources on emission inventories, human health, and the environment. In recent years, the EFR group has considerably expanded its research activities beyond traditional laboratory measurements to focus more on measurements under in-use conditions using methods such as the latest Portable Emissions/Activity Monitoring Systems (PEMS/PAMS) and On-board Sensing and Reporting (OSAR) tools. EFR has also expanded its research in characterizing the performance of next-generation battery electric and hydrogen-powered vehicles with on-site high-power recharging and hydrogen refueling, and studying blends of hydrogen with natural gas.

## 2023 HIGHLIGHTS

**01 OSAR Advancements:** The EFR Group continued to excel in its On-board Sensing and Reporting (OSAR) research area, achieving a significant milestone with the development of a new sensor-based micro portable emissions measurement system named OSAR. Successfully deployed on over 200 heavy-duty vehicles and equipment, this system monitors in-use emissions, contributing to advancements in real-time data collection.

**02 Pioneering Marine Vessel Emissions Research:** The EFR Group expanded its research by conducting extensive studies to characterize emissions from marine vessels. This included rigorous testing of commercial harbor craft and ocean-going vessels, employing the latest emission control technology across standard and real-sailing operating modes.

Dr. Tom Eckel, along with graduate students Ryan Drover and Kyah Gracia, geared up in fire suits during a field expedition.



**03 Referee Program in Heavy-Duty Inspection and Maintenance:** The EFR group launched California's Heavy-Duty Inspection and Maintenance (HD I/M). The HD I/M team conducted referee inspections of heavy-duty vehicles, addressing additional inspection needs beyond typical testing requirements. Inspection sites are located at CE-CERT, California State University at Fresno, and collaborations with over 10 California Community Colleges are underway, aiming for additional site implementation by the spring of 2024.

**04 Ongoing Studies in Advanced Vehicle Technologies:** The EFR Group continues to lead several ongoing studies to characterize the performance of zero and near-zero-emission heavy-duty vehicles. This includes research on battery electric and hydrogen-powered fuel cell electric trucks with several commercial manufacturers, and an ultra-low NOx heavy-duty natural gas engine operated on blends of natural gas with hydrogen.



Miles Mahoney, Referee Tester, conducting inspections as part of California's Heavy-Duty Inspection and Maintenance (HD I/M) program.

## AWARDS AND HONORS



- Dr. Tom Durbin was named a Fellow of the Society of Automotive Engineers.
- Dr. Georgios Karavalakis achieved recognition on Stanford's list of the top 2% of scientists worldwide.
- Dr. Georgios Karavalakis joins UCR as a full-time faculty member.
- Spectrum News 1 with Tom Durbin: Multimedia journalist Parker Collins came to CE-CERT in May to cover UCR serving as referees for CARB's truck emissions regulation.

## KEY PUBLICATIONS



- Zhu, H., Ma, T., Toumasatos, Z., Cao, S., Karavalakis, G., Johnson, K. C., & Durbin, T. (2024). On-road NOx and NH3 emissions measurements from in-use heavy-duty diesel and natural gas trucks in the South Coast air Basin of California. *Atmospheric Environment*, 316, 120179.
- Ma, T., Li, C., Luo, J., Frederickson, C., Tang, T., Durbin, T. D., Johnson, K. C., & Karavalakis, G. (2024). In-use NOx and black carbon emissions from heavy-duty freight diesel vehicles and near-zero emissions natural gas vehicles in California's San Joaquin Air Basin. *Science of the Total Environment*, 907, 168188.
- Tang, T., McCaffery, C., Ma, T., Hao, P., Durbin, T. D., Johnson, K. C., & Karavalakis, G. (2023). Expanding the ethanol blend wall in California: Emissions comparison between E10 and E15. *Fuel*, 350, 128836. <https://doi.org/10.1016/j.fuel.2023.128836>.

## FACULTY LIST

- Kent Johnson, Research Faculty
- Tom Durbin, Research Faculty
- Wayne Miller, Research Faculty
- Georgios Karavalakis, Professor of Chemical and Environmental Engineering
- Heejung Jung, Professor of Mechanical Engineering
- David Cocker, Professor of Chemical and Environmental Engineering
- Zisimos Toumasatos, Assistant Research Engineer
- Thomas Eckel, Project Scientist

## KEY SPONSORS & PARTNERS

- |  |   |   |
|--|---|---|
| <ul style="list-style-type: none"> <li>• 3DATX</li> <li>• AKKA</li> <li>• AVL</li> <li>• California Air Resources Board</li> <li>• California Energy Commission</li> <li>• CALSTART</li> <li>• Caltrans</li> <li>• Cummins, Inc.</li> <li>• U.S. Department of Defense</li> <li>• U.S. Department of Energy</li> </ul> | <ul style="list-style-type: none"> <li>• U.S. Department of Transportation Maritime Administration</li> <li>• Eastern Research Group, Inc.</li> <li>• HEAT</li> <li>• HEM Data</li> <li>• Horiba</li> <li>• National Center for Sustainable Transportation</li> <li>• NGK Sparkplugs</li> <li>• RA Automotive</li> <li>• Sensors, Inc.</li> </ul> | <ul style="list-style-type: none"> <li>• Southern California Gas Company</li> <li>• Tetra Tech, Inc.</li> <li>• The Texas A&amp;M University System</li> <li>• TSI Incorporated</li> <li>• U.S. Environmental Protection Agency</li> <li>• Volvo Truck Corporation</li> </ul> |
|--|---|---|

# TRANSPORTATION SYSTEMS RESEARCH (TSR)

**MISSION:** The Transportation Systems Research (TSR) Group stands at the forefront of cutting-edge advancements in shared, electric, connected, and automated vehicles, dedicated to addressing the environmental and energy challenges associated with transportation. Leveraging expertise in advanced computing, control, communication, and sensing technologies, the TSR Group strives to transform vehicles and roadway infrastructure into sustainable transportation solutions, prioritizing safety, environmental impact, health, mobility, and economics. In 2023, the TSR Group continued to achieve significant milestones in advancing the development of their real-world smart intersection, while concurrently prioritizing education and actively engaging in initiatives to nurture the next generation of environmental stewards.

## 2023 HIGHLIGHTS

- 01 EcoCAR EV Challenge:** The UCR team is currently in the second year of the four-year US Department of Energy EcoCAR EV Challenge. During the previous year, the team engaged in design of a new propulsion system architecture and the associated control system. Additionally, they developed an advanced perception system, selecting various sensors and devices for integration into the vehicle, and the software architecture for connectivity and automation. The team was honored with the EcoCAR Spirit of the Challenge Award and the Spirit of Communications Award. The team recently received a new Cadillac LYRIQ, subjecting it to rigorous tests to establish a performance baseline.
- 02 Record-breaking Year for TSR Ph.D. Graduates:** In 2023, the TSR Group achieved a significant milestone as they proudly witnessed the graduation of six Ph.D. students. The newly conferred Ph.D.s include Abdullah Fuad Un-noor, David Oswald, Jacqueline Garrido Escobar, Xishun Liao, Zhensong Wei, and Zhouqiao Zhao. This remarkable accomplishment highlights the research group's caliber and underscores their commitment to cultivating and producing outstanding scholars in the field of sustainable transportation.
- 03 US DOT University Transportation Center Competition:** The TSR Group played a pivotal role in several extensive proposals aiming to establish USDOT-sponsored transportation centers nationwide. The group secured success with three major centers: The National Center for Sustainable Transportation (NCST), as a top National Center, achieved a successful renewal grant. The center is headquartered at UC Davis with partners at USC, Georgia Tech, University of Vermont, Texas Southern University, and Cal State Long Beach. The TSR Group also contributed to the successful renewal proposal for the Tier-1 center, CARTEEH (Center for Advancing Research in Transportation Emissions, Energy, and Health), in partnership with Texas A&M, Johns Hopkins, Georgia Tech, Morehouse College, and North Dakota State University. Lastly, they participated in a successful proposal for a new center, CARNATIONS (Center for Assured & Resilient Navigation in Advanced Transportation Systems), with collaborators from Stanford, Virginia Tech, Illinois Institute of Technology, and Chicago State University. Focused on navigation-related transportation resiliency topics, this center presents exciting research opportunities for the TSR Group in the coming years.
- 04 Sustainable Transportation Summer Course:** Through a James Irvine Foundation grant, the TSR Group successfully developed and launched a transformative Sustainable Transportation Summer Course in August 2023. The three week course integrates theoretical concepts with practical applications, diving into topics such as Eco-Friendly Intelligent Transportation Systems, Zero Emission Vehicles, Transportation Engineering, and Transportation Policy.

EcoCAR Team gathers together in front of the new team vehicle, the 2023 Cadillac LYRIQ.



## AWARDS AND HONORS



- US Department of Energy's EcoCAR EV Challenge: the 2023 Spirit of the Challenge Award
- US Department of Energy's EcoCAR EV Challenge: the 2023 Spirit of Communications Award
- Ziran Wang, Yougang Bian, Steven E Shladover, Guoyuan Wu, Shengbo Eben Li, Matthew J Barth recognized for the 2017-2020 IEEE Intelligent Transportation Systems Magazine Outstanding Survey Paper Award
- Jay Farrell and Matthew Barth achieved recognition on Stanford's list of the top 2% of scientists worldwide.

## KEY PUBLICATIONS



- Yusuf, J., Hasan, A. S. M. J., Garrido, J., Ula, S., & Barth, M. J. (2023). A Comparative Techno-economic Assessment of Bidirectional Heavy Duty and Light Duty Plug-in Electric Vehicles Operation: A Case Study. *Sustainable Cities and Society*, 95, 104582.
- Bai, Z., Nayak, S. P., Zhao, X., Wu, G., Barth, M. J., Qi, X., Liu, Y., Sisbot, E. A., & Oguchi, K. (2023). Cyber Mobility Mirror: A Deep Learning-Based Real-World Object Perception Platform Using Roadside LiDAR. *IEEE Transactions on Intelligent Transportation Systems*, 24(9), 9476-9489. doi: 10.1109/TITS.2023.3268281.
- Liu, H., Liao, Y., Hao, P., Boriboonsomsin, K., & Barth, M. (2023). Evaluating the Order Dispatching Strategies for a Dynamic On-Demand Meal Delivery System—A Case Study in the City of Riverside. In *International Conference on Transportation and Development*, pp. 490 - 502.
- Boriboonsomsin, K., Tanvir, S., & Barth, M. (2023). Modeling the Impacts of Low Emission Zone on Route Diversion and Emissions of Heavy-Duty Trucks: A Southern California Case Study. *Transportation Research Record*. <https://doi.org/03611981231172747>.

## PROFESSIONAL ACTIVITY

- Matthew Barth, IEEE Intelligent Transportation Systems Society, Vice-President of Education
- Matthew Barth, U.S. EPA Mobile Sources Technical Review Subcommittee: Member; Chair: EPA Modeling Workgroup
- Matthew Barth, Senior Editor, IEEE Transactions on Intelligent Transportation Systems
- Kanok Boriboonsomsin, Vice Chair, Environmental Justice and Goods Movement Subcommittee, Air Quality and Greenhouse Gas Mitigation Committee, Transportation Research Board
- Kanok Boriboonsomsin, Member, Executive Committee, Center for Advancing Research in Transportation Emissions, Energy and Health
- Kanok Boriboonsomsin, Associate Editor, IEEE Intelligent Transportation System Magazine
- Guoyuan Wu, Associate Editor, IEEE Transactions of Intelligent Transportation Systems

- Guoyuan Wu, Associate Editor, IEEE Open Journal of Intelligent Transportation Systems
- Guoyuan Wu, Associate Editor, SAE International Journal of Connected and Automated Vehicles
- Guoyuan Wu, Member, Standing Committee of Research Innovation, Implementation and Management Committee, Transportation Research Board
- Guoyuan Wu, Member, Standing Committee, Vehicle-Highway Automation Committee, Transportation Research Board
- Guoyuan Wu, Member, Governing Board of Virtual Open Innovation Collaborative Environment for Safety (VOICES), U.S. Department of Transportation

## FACULTY LIST

- Matthew Barth, Professor of Electrical & Computer Engineering, and BCOE Associate Dean for Research and Graduate Education
- Kanok Boriboonsomsin, CE-CERT Associate Director of Finance & Administration, Research Faculty
- Guoyuan Wu, Research Faculty and Adjunct Professor of Electrical & Computer Engineering
- Peng Hao, Research Faculty
- George Scora, Research Faculty
- Konstantinos Karydis, Associate Professor of Electrical & Computer Engineering
- Jay Farrell, Professor of Electrical & Computer Engineering
- Hang Qiu, Assistant Professor of Electrical & Computer Engineering

## KEY SPONSORS AND PARTNERS

- Caltrans
- California Air Resources Board
- California Attorney General's office
- City of Riverside
- Honda
- James Irvine Foundation
- Leidos
- National Science Foundation
- Riverside County Transportation Commission
- Southern California Association of Governments
- South Coast Air Quality Management District
- Sumitomo Electric
- Toyota InfoTech
- U.S. Department of Energy
- USDOT: Center for Advancing Research in Transportation Emissions, Energy, and Health
- USDOT: Center for Assured & Resilient Navigation in Advanced Transportation Systems
- USDOT: National Center for Sustainable Transportation
- Volvo Trucks
- Western Riverside Council of Governments

# SUSTAINABLE INTEGRATED GRID INITIATIVE (SIGI)

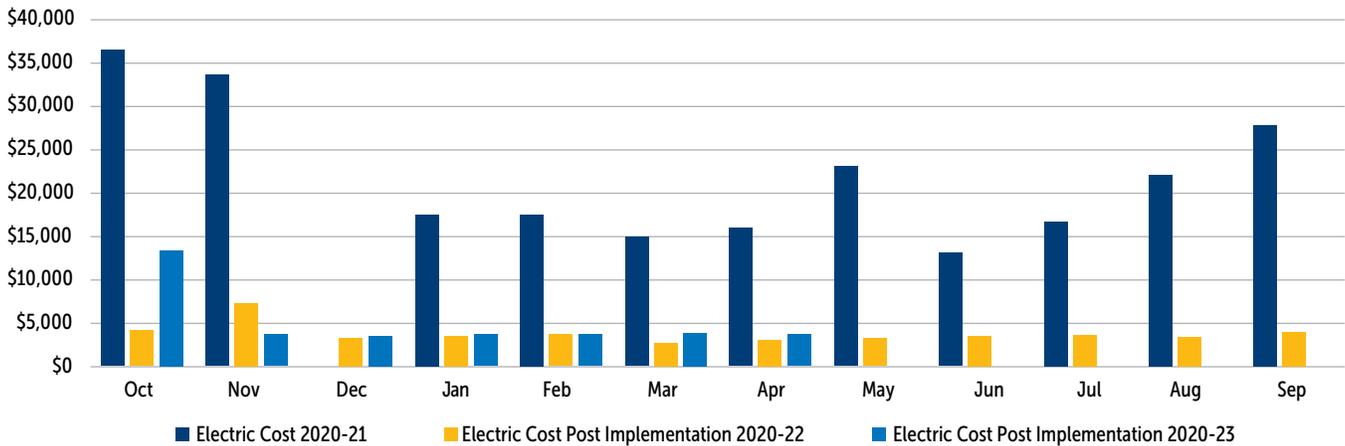
**MISSION:** The Sustainable Integrated Grid Initiative (SIGI) targets research and implementation of systems that demonstrate the successful integration of intermittent renewable energy, energy storage, and all types of battery electric vehicles, hybrid electric vehicles, and motors. Recent research and demonstrations focus on bidirectional EV charging, microgrid energy operations, and water-energy nexus management strategies.

## 2023 HIGHLIGHTS

**Water-Energy Nexus:** Water pumping consumes 20% of all electricity in California. UCR developed operational strategies for reducing peak demand and energy cost. Annual energy bill was \$382,320 in 2021-22 which dropped to \$204,030 after energy saving implementation – a saving of \$177,989 in a single pumping station.



## ELECTRIC COST COMPARISON PRE/POST-IMPLEMENTATION



**01 Water-Energy Nexus:** Application of energy management strategies for water pumping applications in the Southern California and Riverside region. Demonstration of operational energy profiles to reduce peak energy loads in regional water delivery systems. Development of water-energy nexus strategies to reduce California’s peak energy loads.

**02 Bidirectional EV Charging Optimization:** Cost optimization and load management strategies are evaluated utilizing data from CE-CERT’s bidirectional EV charging infrastructure and microgrid operations. Cost functions and deep learning-based models are developed to optimize energy use and microgrid functionality.

**03 Analysis of Microgrid Islanding Operations:** CE-CERT’s research explores a real-world microgrid operations at CE-CERT’s laboratory facilities. Islanding operations demonstrate the feasibility of demand response, load management, and islanding in a real microgrid. Energy management algorithms and strategies are developed, demonstrated, and optimized.

**04 CalTestBed:** The SIGI testing facility, developed with California Energy Commission (CEC) and CalTestBed, has completed projects with several companies such as Sylvatex, Alpine Hydromet, and Dakota Energy.

## KEY PUBLICATIONS



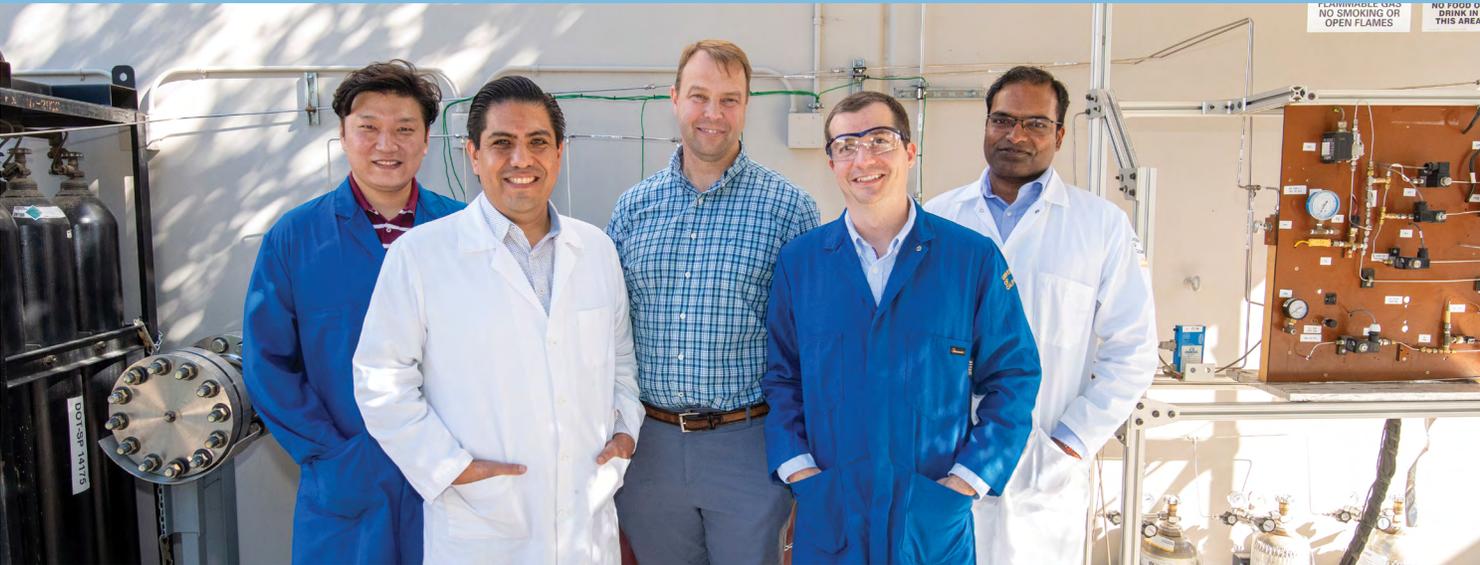
- Yusuf, J., Hasan, A. S. M. J., Enriquez-Contreras, L. F., & Ula, S. (2022). A Centralized Optimization Approach for Bidirectional PEV Strategy Selection in a Commercial Building-Integrated Microgrid. Available at SSRN: <https://ssrn.com/abstract=4203561> or <http://dx.doi.org/10.2139/ssrn.4203561>.
- Enriquez-Contreras, L. F., Hasan, A. S. M. J., Yusuf, J., Garrido, J., & Ula, S. (2022). Microgrid Demand Response: A Comparison of Simulated and Real Results. 2022 North American Power Symposium (NAPS), Salt Lake City, UT, USA, pp. 1-6. doi: 10.1109/NAPS56150.2022.10012248.
- Yusuf, J., Hasan, A. S. M. J., & Ula, S. (2022). EV Penetration Impact Analysis on Transmission System using Co-Simulation. 2022 IEEE Transportation Electrification Conference & Expo (ITEC), Anaheim, CA, USA, pp. 1154-1158. doi: 10.1109/ITEC53557.2022.9814058.

## FACULTY LIST

- Sadrul Ula, Research Faculty
- Matthew Barth, Professor of Electrical & Computer Engineering, and BCOE Associate Dean for Research and Graduate Education
- Mike Todd, Research Faculty

## KEY SPONSORS & PARTNERSHIPS

- Caltestbed – Sylvatex, Dakota Energy, Alpine Hydromet
- Kern County Community College District
- RHETTA – CALSTART, EPRI
- Southern California Edison
- Western Municipal Water District

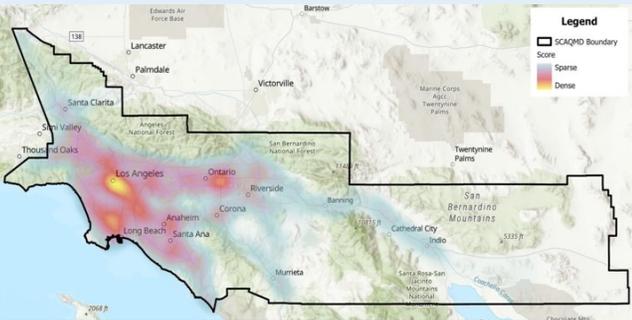


# SUSTAINABLE FUELS INITIATIVE (SFI)

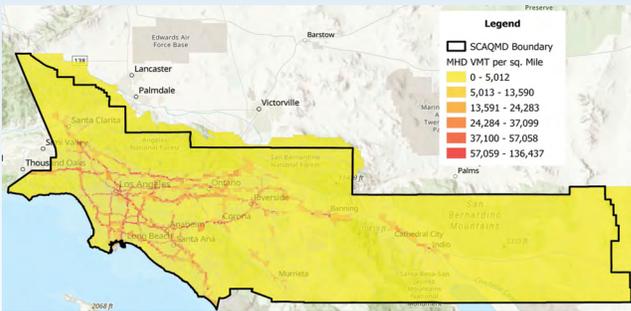
**MISSION:** The Sustainable Fuels Initiative (SFI)'s mission is to advance and demonstrate sustainable energy solutions, including advanced technologies for the production and use of sustainable fuels such as green hydrogen and renewable natural gas. Focus areas include energy systems analysis, transportation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

## 2023 HIGHLIGHTS

**01** SFI kicked off a new project to evaluate the planning for Zero Emissions Vehicle Infrastructure Analysis for Medium-Heavy Duty Vehicles in the California – Mexico border region. This project, sponsored by UC Alianza MX, will develop a roadmap for charging and refueling infrastructure for Medium and Heavy Duty (MHD) battery electric vehicles (BEV) and fuel cell electric vehicles (FCEV).



Heat map of preferred locations for future medium/heavy duty zero emission vehicles EV charging and hydrogen fueling stations



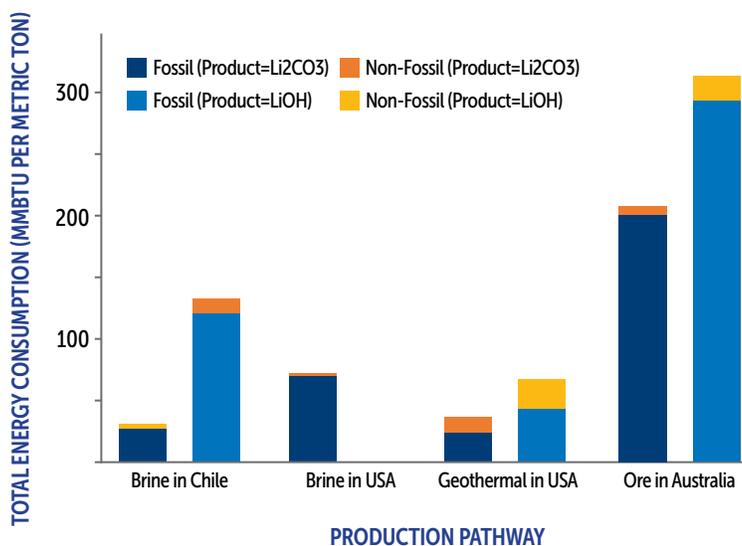
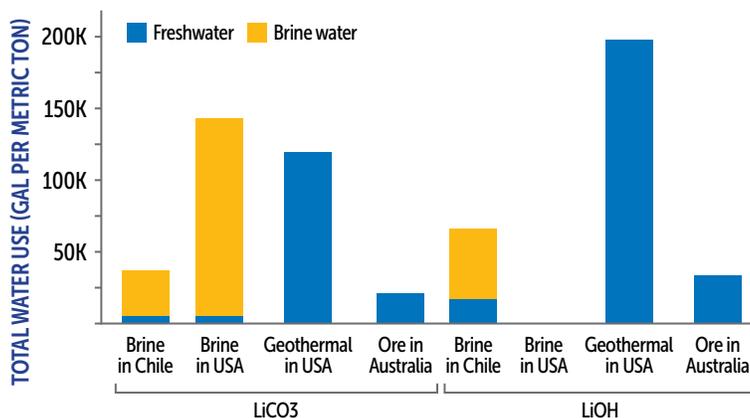
Daily medium/heavy duty vehicle miles traveled per transportation analysis zone (normalized by the surface area)

**02** SFI releases report on developing an eco-manufacturing hub around lithium resources in the Salton Sea geothermal field. The project, funded by a grant through UCR's OASIS initiative, included community engagement, a workforce development analysis, and environmental impact analysis of proposed lithium recovery from the Salton Sea geothermal field.

**03** Dr. Miroslav Penchev participated in a panel discussion on the Environmental Impacts of Hydrogen as part of the HyBlend Phase II Kick-Off Meeting. The HyBlend project is a collaborative research and development effort aimed at addressing the technical barriers to blending hydrogen in the natural gas infrastructure.

**04** Dr. Arun Raju participated in a panel discussion on 'The transition to ZEV at the US-Mexico border' at the 2nd Annual Mexico - United States Binational Forum on The Transition To Zero-Emission Vehicles held in Guadalajara, Mexico in November 2023.

GREET life cycle assessment of resource use by different lithium production pathways



## KEY PUBLICATIONS



- Taylor, D., Taylor, D., & Raju, A. (2023). Renewable Syngas Methanation. California Energy Commission Project Final Report. Publication Number: PIR-18-004.
- Penchev, M., Adler, P., & Raju, A. (2023). Developing an Eco-Manufacturing Hub around Lithium Resources in the Salton Sea Geothermal Field. UCR OASIS Project Final Report.

## FACULTY AND STAFF LIST

- Arun S.K. Raju, CE-CERT Associate Director of Operations, Research Faculty and Adjunct Professor of Chemical & Environmental Engineering
- Miroslav Penchev, Assistant Project Scientist
- Alfredo A. Martinez-Morales, Research Faculty
- Michael Todd, Principal Development Engineer

## KEY SPONSORS AND PARTNERS

- California Energy Commission
- City of Riverside
- Pacific Gas & Electric
- Southern California Gas Company
- Strategic Growth Council
- Taylor Energy
- UC Alianza MX

# B<sup>3</sup>: BIOENERGY, BIOREFINING, AND BIOMATERIALS TEAM



Congressman Mark Takano visits CE-CERT to congratulate Prof. Cai and his team on winning a US DOE grant to develop new low-carbon pulping technologies. (From left: Charles Cai, Mark Takano, Brent Scheidemantle, and Chad Larson)

**MISSION:** The B<sup>3</sup> research team's goal is to transform earth-abundant agricultural and forestry plant waste and plant residues, otherwise known as lignocellulosic biomass, into renewable liquid fuels and bioproducts. Uniquely, the team has specialized in developing low-cost technologies to allow more efficient breakdown of biomass to recover valuable biomass intermediates such as sugars and lignin, that may serve as building blocks for the development of alternative fuels, plastics, and composites. The team is well-known for the invention of Co-solvent Enhanced Lignocellulosic Fractionation (also known as CELF): a next-gen biomass pretreatment technology that promises to reduce the cost of biomass deconstruction and fractionation while improving the performance of biomass-based products.

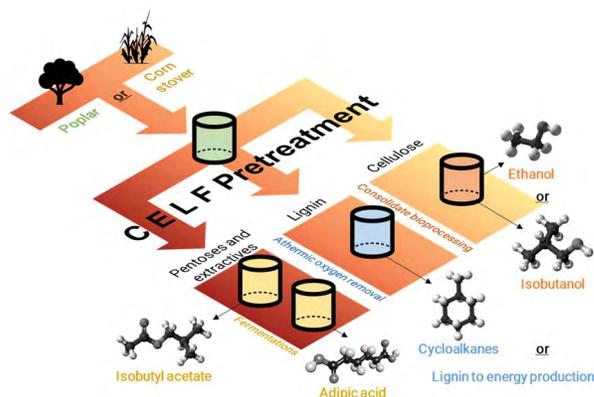
## 2023 HIGHLIGHTS

**01** Through project funding from the US Environmental Protection Agency, the team has developed techniques for transforming newly legalized industrial hemp into a high-performance "hempcrete 2.0". With their team of graduate and undergraduate students, they developed a stronger and more insulating hempcrete that can be mass-produced at lower cost than previous traditional hempcrete products. The team applies CELF (co-solvent enhanced lignocellulosic fractionation) pulping of raw hemp sticks (no decortication) directly to achieve the material properties they desire before incorporation into hempcrete. Furthermore, they have found that this technique is also fully compatible with other hardy biomass feedstocks such as almond tree waste and elephant grass.



Hempcrete made from raw decorticated hemp hurd (left) and CELF pulped hemp stalk (right). Our team recently demonstrated a stronger and more insulating Hempcrete 2.0 than traditional hempcrete. The samples pictured were produced using identical 1.1:3 (biomass:binder:water) ratios in formulation. Funding from US EPA.

**02** Through project funding from the US Department of Energy, the team has partnered with researchers at Oak Ridge National Laboratories (ORNL), National Renewable Energy Laboratories (NREL), and University of Tennessee Knoxville (UTK) to develop a high-fidelity computer model. This model calculates the economics and environmental impacts of a full-scale biomass biorefinery utilizing CELF technology that transforms poplar wood and corn stover into sustainable aviation fuels (SAFs), green chemicals, and fuel alcohols. The analysis demonstrated the possibility of supplying alcohol-derived SAF to the market at competitive prices – as low as \$3.15/GGE (gallon of gasoline equivalent) – as well as carboxylic acids and esters. This manuscript detailing their findings was recently accepted into the prestigious journal of *Energy & Environmental Science*.



Simplified diagram for a CELF-based biorefinery outlining the potential suite of renewable liquid fuels and bioproducts that could be economically obtained from a hypothetical full-scale plant. CELF: Co-solvent Enhanced Lignocellulosic Fractionation. Funding from US DOE.

**03** Through project funding from the Advanced Research Projects Agency-Energy (ARPA-e), the team is currently investigating the manufacture of lignin-based polyurethanes (LPU). Specifically, this ambitious project seeks to develop lignin-polyurethane insulating foams for home and commercial installation while achieving greater sustainability and the elimination of toxic ingredients in traditional polyurethane manufacturing. In 2023, the team not only achieved all the performance metrics (strength and insulation) for their LPU products but also developed an LPU process that completely eliminates the use of toxic isocyanates in a new formulation called non-isocyanate polyurethane (NIPU).



Lignin-based non-isocyanate polyurethane (lignin-NIPU) insulating foams were successfully synthesized in a room temperature solvent-free system from pine wood and poplar (POP) wood lignin, incorporating 30-70% CELF lignin. These foams seek to replace conventional polyurethane insulation in homes and commercial buildings. Funding from US ARPA-e.

## KEY PUBLICATIONS



- Klein, B. C., Scheidemantle, B., Hanes, R. J., Bartling, A. W., Grundl, N. J., Clark, R. J., Biddy, M. J., Tao, L., Trinh, C. T., Guss, A. M., Wyman, C. E., Ragauskas, A. J., Webb, E. G., Davison, B. H., & Cai, C. M. (2023). Economics and global warming potential of a commercial-scale delignifying biorefinery based on Co-solvent Enhanced Lignocellulosic Fractionation. *Energy & Environmental Science*. <https://doi.org/10.1039/D3EE02532B>.
- Seo, H., Singh, P., Wyman, C. E., Cai, C. M., & Trinh, C. T. (2023). Rewiring metabolism of *Clostridium thermocellum* for consolidated bioprocessing of lignocellulosic biomass poplar to produce short-chain esters. *Bioresource Technology*. <https://doi.org/10.1016/j.biortech.2023.129263>.
- Ekwe, N. B., Tyufekchiev, M. V., Salifu, A. A., Schmidt-Rohr, K., Zheng, Z., Maag, A. R., Tompsett, G. A., Cai, C. M., Onche, E. O., Ates, A., et al. (2023). Bamboo as a Cost-Effective Source of Renewable Carbon for Sustainable Economic Development in Low- and Middle-Income Economies. *Energies*. <https://doi.org/10.3390/en16010331>.
- Cai, C., (2023). Polyurethanes and methods to prepare polyurethanes. *US Patent US20230365740*.

## PROFESSIONAL ACTIVITY

- Charles M. Cai, American Institute of Chemical Engineers
- Charles M. Cai, American Chemical Society
- Charles M. Cai, Materials Research Society
- Charles M. Cai, Technical Association of the Pulp and Paper Industry

## FACULTY LIST

- Charles M. Cai, Associate Research Professor and Associate Adjunct Professor of Chemical & Environmental Engineering

## KEY SPONSORS AND PARTNERS

- US Advanced Research Projects Agency-Energy
- US Department of Energy
- US Environmental Protection Agency

# SOUTHERN CALIFORNIA RESEARCH INITIATIVE FOR SOLAR ENERGY (SC-RISE)



**MISSION:** 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 basic research and technology development, while the Distributed Energy Resources Laboratory (DERL) works on applied research related to the design, integration, deployment, demonstration, and validation of renewable energy, green infrastructure, and new clean technologies. The Solar Valley Consortium (SVC) 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.

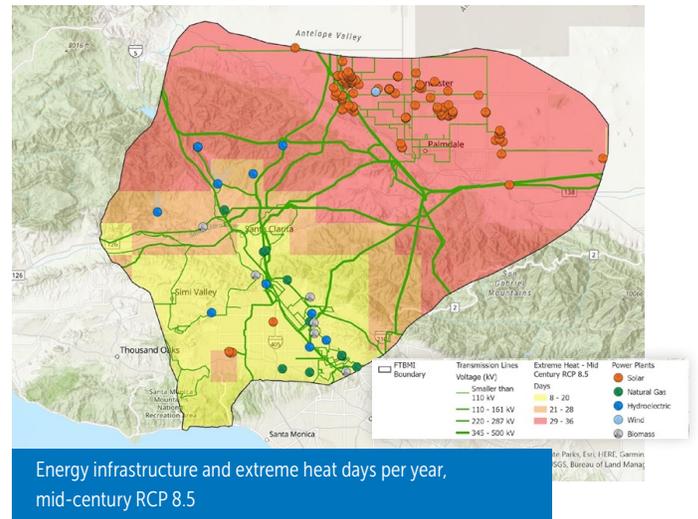
## 2023 HIGHLIGHTS

**01** The Solar Valley Consortium convened its eighth annual conference on September 14, 2023, with a central focus on the ambitious goal of deploying 20,000 acres of solar and storage annually over the next 25 years, in alignment with California’s clean energy objectives. Centered on crucial themes such as land and transmission availability, permitting processes, and policy frameworks, the conference assembled leading experts from various sectors of renewable energy. These discussions yielded essential insights and strategies pivotal for advancing California’s renewable energy agenda. View the conference recording at [cert.ucr.edu/svc-webinar-91423-virtual-conference](https://cert.ucr.edu/svc-webinar-91423-virtual-conference).

**02** The SOLSTICE (Stakeholder Collaboration on Land and Transmission Availability for Solar and Storage in Inland California’s Energy Transition) Project, funded by the Opportunity to Advance Sustainability Innovation and Social Inclusion, is focused and actively engaged in Riverside and San Bernardino counties. Its primary focus is exploring land and transmission availability for solar and storage to support California’s clean energy and environmental justice goals. SOLSTICE addresses critical challenges including land-use policies, zoning, environmental constraints, and transmission capacity. Collaborating with state and federal agencies, utilities, and solar developers, the project is dedicated to developing actionable strategies for efficient land acquisition and transmission enhancement.

# 03

CE-CERT, in partnership with Climate Resolve and the Council for Watershed Health, developed the Fernandeano Tataviyam Band of Mission Indians' Tribal Climate Resiliency Plan. This plan, which integrates traditional ecological knowledge with contemporary scientific approaches, prioritizes community engagement. It strategically addresses the crucial transition from fossil fuels – the primary source of U.S. energy and greenhouse gases – to electricity increasingly sourced from renewable resources, such as solar energy. The plan aims to combat climate-related hazards, preserve cultural heritage, promote economic growth, and enhance environmental sustainability. Its strategies focus on ensuring clean water, maintaining healthy forests, revitalizing urban areas, and fostering comprehensive community involvement, all orchestrated through the Outreach Framework Plan.



## AWARDS AND HONORS



- Dr. Alfredo A. Martinez-Morales, Invited Speaker, World Solar Energy Forum
- Dr. Alfredo A. Martinez-Morales, Invited Moderator, 2023 California Land Recycling Conference: People, Partnerships, Progress
- Dr. Alfredo A. Martinez-Morales, Invited Panelist, California-Mexico 2030 Summit: Turning Climate Challenges Into Opportunities
- Dr. Musa Yilmaz, Scientific and Technological Research Council of Turkey (TUBITAK) Fellowship

## KEY PUBLICATIONS

- Micheli, L., Smestad, G.P., Khan, M.Z., Lange, K., Almughary, H.M.I., Abraim, M., Alamat, Y., Anderson, C.B., Bentouba, S., Figgis, B., Fuke, P., Hachicha, A.A., Karim, M., Kottantharayil, A., Martinez-Morales, A.A., Alami Merrouni, A., Olivares, D., Picotti, G., Rabanal-Arabach, J., Wiesinger, F. and Ilse, K. (2024). Soiling in Solar Energy Systems: The Role of the Thresholding Method in Image Analysis. *Solar RRL*, 8, 2300654. <https://doi.org/10.1002/solr.202300654>.
- Uribe-Robles, M., Ortiz-Islas, E., Rodriguez-Perez, E., Valverde, F. F., Lim, T., & Martinez-Morales, A. A. (2023). Targeted delivery of temozolomide by nanocarriers based on folic acid-hollow TiO<sub>2</sub>-nanospheres for the treatment of glioblastoma. *Biomaterials Advances*, 151, 213442. <https://doi.org/10.1016/j.bioadv.2023.213442>.
- Akinci, T. C., Akgun, O., Yilmaz, M., & Martinez-Morales, A. A. (2023). High order spectral analysis of ferroresonance phenomena in electric power systems. *IEEE Access*, 11, 61289-61297. <https://doi.org/10.1109/ACCESS.2023.3286817>.
- Alkhanafseh, Y., Akinci, T. C., Ayaz, E., & Martinez-Morales, A. A. (2023). Advanced Dual RNN Architecture for Electrical Motor Fault Classification. *IEEE Access*, 12, 2023. <https://doi.org/10.1109/ACCESS.2023.3344676>.

## PROFESSIONAL ACTIVITY

- Solar Valley Consortium, Co-chair, Dr. Alfredo A. Martinez-Morales
- International Journal of Smart Grid and Sustainable Energy Technologies, Editorial Board, Dr. Tahir Cetin Akinci
- Balkan Journal of Electrical and Computer Engineering, Editor in Chief, Dr. Musa Yilmaz

## FACULTY LIST

- Alfredo A. Martinez-Morales, Research Faculty
- Miroslav Penchev, Assistant Project Scientist
- Tahir Cetin Akinci, Visiting Scholar
- Musa Yilmaz, Visiting Scholar

## KEY SPONSORS AND PARTNERS

### Key sponsors:

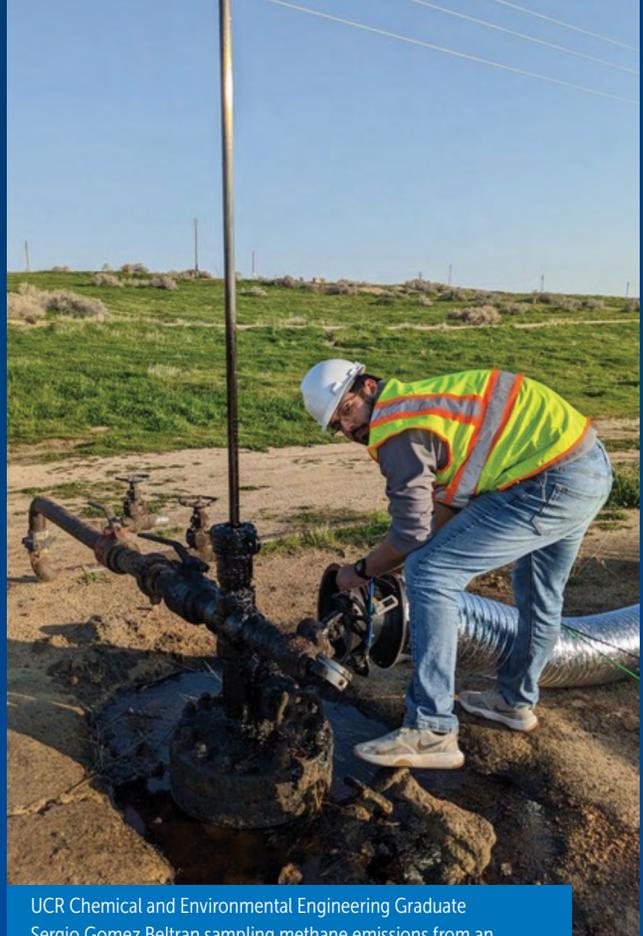
- California Clean Energy Fund
- California Department of Transportation
- California Energy Commission
- California Resiliency Challenge
- California Strategic Growth Council
- Eurosemillas Technology Acceleration Program
- Opportunity to Advance Sustainability Innovation and Social Inclusion

### Solar Valley Consortium Members:

- EDF Renewables
- GRID Alternatives
- Intersect Power
- Riverside County
- Riverside Public Utilities
- San Bernardino County
- Southern California Edison
- Sunrun
- Western Riverside Council of Governments

# GREENHOUSE GAS EMISSIONS LAB

**MISSION:** The Greenhouse Gas Emissions Lab studies emissions that affect the climate and air quality to develop the science of reducing these emissions. Their focus is primarily on emissions of methane from anthropogenic sources, but also emissions of carbon dioxide, nitrous oxide, carbon monoxide, and ammonia. They utilize diverse methodologies such as field studies with a mobile laboratory, isotope measurements in the environment, spatial mapping, and other atmospheric and soil science techniques to better understand emission sources.



UCR Chemical and Environmental Engineering Graduate Sergio Gomez Beltran sampling methane emissions from an oil well using a dynamic chamber set up.

## 2023 HIGHLIGHTS

**01** Dr. Francesca Hopkins and graduate student Alyssa Valdez attended a workshop, *The Coming Flood of Remote-Sensed Methane Data: Implications for Methane Control Policies*, at the UCLA School of Law Emmett Institute on Climate Change & the Environment in October. The meeting was attended by Argentine Senator Gladys Gonzalez and former Chair of the California Air Resources Board, Mary Nichols.

**02** The Greenhouse Gas Emissions Lab cooperated with NASA Jet Propulsion Lab's AVIRIS-3 airborne imaging spectrometer to carry out a controlled methane release experiment in November 2023.

**03** Dr. Javier Gonzalez-Rocha, a UCR Chancellor's Postdoctoral Fellow, was appointed Assistant Professor in the Department of Applied Mathematics, at the University of California, Santa Cruz.

**04** Michael Rodriguez defended his Ph.D. in December and will be moving on to a postdoc in January at UC Merced to continue work on the environmental impact of agricultural waste management.



Controlled methane release experiment held at UC Riverside's Agricultural Operations facility to test Dr. Akula Venkatram's dispersion model. UCR's Laboratory for Isotope Measurements in the Environment/Analysis Vehicle for On-road Capture of Atmospheric Data and Observations (LIME/AVOCADO) shown in the background (photo credit: Dr. Javier Gonzalez Rocha)

## AWARDS AND HONORS



- Graduate students Michael Rodriguez and Alyssa Valdez won the best presentation awards (oral and poster) at the first Latinx in the Environment UC-wide conference held in Riverside in October.
- Dr. Francesca Hopkins became a member of the CARB Research Screening Committee.
- The Greenhouse Gas Emissions Lab, along with Dr. Javier Gonzalez Rocha's Atmos Robotics Lab at UC Santa Cruz, was awarded seed funding to mentor community college students from the San Joaquin Valley, the Exchange and Support for California Academic Latinx in Experiential Research in the Atmospheric Sciences (ESCALERAS) program.

## KEY PUBLICATIONS



- Frausto-Vicencio, I., Heerah, S., Meyer, A. G., Parker, H. A., Dubey, M., Hopkins, F. M. (2023). Ground solar absorption observations of total column CO, CO<sub>2</sub>, CH<sub>4</sub>, and aerosol optical depth from California's Sequoia Lightning Complex Fire: Emission factors and modified combustion efficiency at large scales. *Atmospheric Chemistry and Physics*, 23(8), 4521–4543. <https://doi.org/10.5194/acp-23-4521-2023>.
- Zhu, Z.\*, González-Rocha, J., Ding, Y., Frausto-Vicencio, I., Heerah, S., Venkatram, A., Dubey, M., Collins, D. R., & Hopkins, F. M. (2023). Toward on-demand measurements of greenhouse gas emissions using an uncrewed aircraft AirCore system. *Atmospheric Measurement Techniques Discussions*. <https://doi.org/10.5194/egusphere-2023-1527>.

- Gebiola, M.t, Rodriguez, M. V.t, Garcia, A., Garnica, A., Tomberlin, J. K., Hopkins, F. M., & Mauck, K. E. (2023). Bokashi fermentation of brewery's spent grains positively affects larval performance of the black soldier fly *Hermetia illucens* while reducing gaseous nitrogen losses. *Waste Management*, 171, 411–420. <https://doi.org/10.1016/j.wasman.2023.09.033>.

## PROFESSIONAL ACTIVITY

- American Geophysical Union Fall Meeting

## FACULTY LIST

- Dr. Francesca Hopkins, Department of Environmental Sciences
- Dr. Akula Venkatram, Department of Mechanical Engineering

## KEY SPONSORS AND PARTNERS

- California Air Resources Board
- California Energy Commission

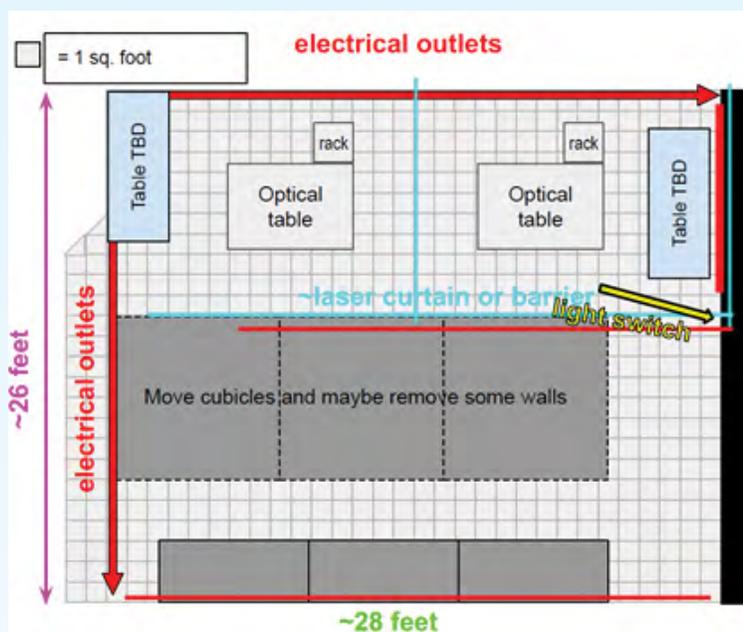
\*equal contribution of lead authors

# FACILITIES

Established in 1992, CE-CERT is the largest research center at UCR. CE-CERT facilities are fundamental to our teams' efforts to tackle society's most pressing environmental challenges in air quality, climate change, energy, and transportation. CE-CERT maintains a steadfast commitment to enhancing research capabilities and continuously expanding its laboratories to further contribute to the understanding and mitigation of environmental issues.

## MULTIMODAL OPTICS GROUP LAB

CE-CERT has new laboratory space developed for the Multimodal Optics Group headed by Dr. Luat Thanh Vuong, the newest CE-CERT affiliate faculty member. Luat's lab is dedicated to advancing the understanding of data through spectral methods and physics-informed approaches. The lab explores light propagation in dynamic environments and explores the impact of turbulence, aerosols, and gas constituents for spatiotemporal and spectroscopic detection as well as free-space optical sensing and communication.



## NEW LABORATORY SPACE FOR DR. KARAVALAKIS AND DR. PETERS

01

### Sustainable Mobility and Environment Laboratory - Dr. Georgios Karavalakis:

The first lab, now home to the Sustainable Mobility and Environment Laboratory led by Dr. George Karavalakis, focuses on advancing the understanding of emissions from mobile sources. Research within this lab is centered on the impacts of low-carbon and zero-carbon fuels, advanced aftertreatment controls, and engine technologies on tailpipe emissions and secondary aerosol formation. The team also conducts comprehensive studies on non-exhaust particulate and gaseous emissions, specifically from brakes and tires, utilizing a range of measurement techniques and sampling protocols.

02

### Atmospheric Nanophysical Chemistry Laboratory - Dr. Sarah Suda Petters:

The second lab welcomes faculty member, Dr. Sarah Petters, specializing in atmospheric nanophysical chemistry. The facility is equipped for aerosol physical chemistry studies, bench-top experiments examining multiphase aerosol reaction mechanisms, and collaborative research on urban air quality and microplastic aerosols.

## EFR'S ADVANCED SHED TESTING LABORATORY

The EFR group's advanced SHED Testing laboratory is a significant step in emissions research. Widely recognized in the automotive industry, SHED Testing simulates real-world scenarios to assess Volatile Organic Compound (VOC) emissions from material samples or entire vehicles. Key features include versatile testing capabilities, an innovative Webber EMI Movable Roof System ensuring absolute control over SHED volume, adaptability for various equipment beyond automotive applications, and a comprehensive 'turn-key' evaporative test system. This facility not only contributes to standardized testing but also positions EFR at the forefront of pioneering advancements in emissions control and mitigation.



## ECOCAR LABORATORY

The UCR EcoCAR has a newly constructed garage tailored for the comprehensive transformation of the team vehicle, the 2023 Cadillac LYRIQ. This garage serves as a dedicated workspace where the students will dismantle and rebuild the Cadillac LYRIQ EV as part of the EcoCAR EV Challenge. UCR's team, utilizing onboard sensors and V2X connectivity, will implement automated control features, refine powertrain systems, and optimize energy use from the grid. This hands-on experience not only shapes the future of transportation but also cultivates students as leaders in the automotive industry. Explore more about the EcoCAR program at [vtcseries.org/about-the-ecocar-ev-challenge](https://vtcseries.org/about-the-ecocar-ev-challenge).

## MOBILE RENEWABLE BACKUP GENERATION (MORBUG)

CE-CERT has developed a second fully equipped trailer for the Mobile Renewable Backup Generation (MORBUG) project. Custom-fabricated battery racks have been installed on the MORBUG trailer, with ongoing efforts to define modified or advanced deployment requirements. The team is also working on the system's communication, monitoring, control architecture, and component configuration. The innovative MORBUG project aims to provide power for critical loads, significantly reducing emissions associated with the decreased use of fossil fuels. By strategically charging MORBUG batteries during periods of available solar energy and delivering power when needed, the project enhances the value of intermittent renewable energy as dispatchable energy. UCR plans to deploy a completed MORBUG at the CE-CERT facility's parking lot, enabling integrated operation, evaluation, and supervised field implementation.



# ENGAGEMENT & PARTNERSHIPS

CE-CERT remains dedicated to fostering meaningful engagement and partnerships as integral components of its mission. Throughout the year, the center actively participated in conferences and forged unique collaborations that amplify the impact of its research initiatives. Emphasizing community outreach, CE-CERT's efforts have flourished with a specific focus on engagement with stakeholders. The center prioritized engagement with young students, imparting knowledge about CE-CERT's work, and encouraging their involvement in environmental problem-solving. The overarching goal is to inspire and empower the next generation, instilling a sense of responsibility and contribution toward building a sustainable future. These concerted efforts represent CE-CERT's dedication to forging lasting collaborations by connecting research, education, and community participation.

## FACILITY TOURS

CE-CERT proudly hosted over 30 facility tours throughout the year, welcoming a diverse audience, including city officials, community members, professors, industry representatives, and high school students. These tours not only offer an opportunity to explore the center's laboratories and research areas but also serve as platforms for engaging in meaningful dialogues and sharing insights. This collaborative approach is integral to fostering partnerships that are essential for advancing CE-CERT's mission. Through these concerted efforts, the center strives to make impactful advancements in its research while actively contributing to the collective knowledge in environmental science and technology.

Christy Jackiewicz and Nabih Haddad from the US Department of Energy (US DOE) visited CE-CERT to learn more about the center's internship programs and to see DOE-supported projects in action.



## SPEAKS NSF GRADUATE STUDENT RESEARCH TRAINEESHIP

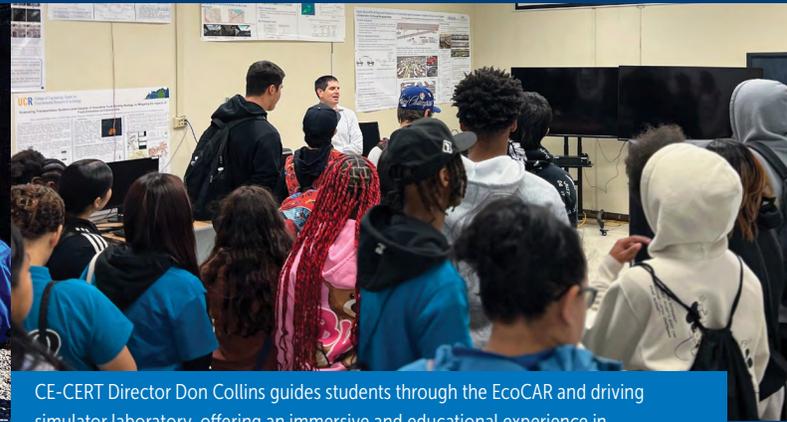


**The Science to Policy Education:** Activating Knowledge for Sustainable Transportation (SPEAKS) Program takes center stage in cultivating a new generation of researchers equipped with innovative solutions and the ability to engage with the public and policymakers for meaningful societal impact. Funded by a five-year grant from the National Science Foundation (*NSF Award 2152258*), this NSF Graduate Student Research Traineeship (NRT) integrates engineering, social science, environmental science, and public policy with a focus on developing diverse next-generation leaders and policy-makers in science, industry, and government.

SPEAKS goes beyond traditional academia by combining multi-disciplinary coursework, collaborative research, internships, mentorship, networking and professional development opportunities, and partnerships with the UCR Science-to-Policy program and the National Science Policy Network. Led by PI, Dr. Matt Barth, SPEAKS Faculty and External Advisory Board members welcomed the first cohort of doctoral students in Fall 2023. Through comprehensive training in user- and stakeholder-based research methods, SPEAKS students gain a broad skill set that will enable them to not only be well-versed in their disciplines but also well-prepared to enact change in the real world. To learn more about the SPEAKS program, visit [cert.ucr.edu/speaks](https://cert.ucr.edu/speaks).



Graduate students share insights on SIGI microgrids and sustainable energy solutions.



CE-CERT Director Don Collins guides students through the EcoCAR and driving simulator laboratory, offering an immersive and educational experience in sustainable transportation research.

## HIGH SCHOOL COLLABORATIONS

### CE-CERT and the Science and Technology Education Partnership (STEP)

**Partnership (STEP):** For nearly a decade, the Science and Technology Education Partnership (STEP) has stood as a cornerstone of CE-CERT's commitment to bridging the skills gap between K-12 students and the needs of high-tech industries. At the heart of this collaboration is STEPCon, an annual event where CE-CERT actively contributes to the success of the high school portion. Additionally, CE-CERT's involvement in STEP's Summer Learning Labs, part of the STEM Solutions program, is to provide high school students with hands-on STEM learning experiences at no cost. These commitments reflect CE-CERT's ongoing efforts to support education and skills development in the community.

- **STEM Solutions Summer Learning Labs: CE-CERT hosted the STEP Summer Learning Labs:** STEM Solutions, welcomed over 40 students to explore CE-CERT's various laboratories including the Sustainable Integrated Grid Initiative (SIGI), Autonomous Robots and Control Systems (ARCS) Laboratory, Drone Lab, Atmospheric Processes Lab (APL), and the Heavy-Duty Chassis Dynamometer (HDCD). The interactive sessions allowed students to experience first-hand the systems and simulations that CE-CERT students utilize for their research and learn more about the academic pathways the student researchers are taking.
- **CE-CERT's Collaboration with Annual STEPCon:** CE-CERT's ongoing collaboration with the annual Science and Technology Education Partnership (STEPCon) continues to advance STEM education in the Inland Empire. CE-CERT hosted 40 local high school students, providing them with an immersive experience in real-world environmental research by showcasing our work in sustainable transportation, microgrids, and atmospheric processes. The goal of these hands-on experiences is to inspire the next generation of scientists and engineers.

### CE-CERT hosts high school students from the Moreno Valley TRIO Programs

CE-CERT proudly partnered with the Federal TRIO Programs and Moreno Valley College to host 45 high school students. These initiatives, specifically designed to identify and support individuals from disadvantaged backgrounds, assist students in preparing for and successfully graduating from college. By hosting these tours, CE-CERT hopes to inspire and guide the next generation, providing them with insights into the world of environmental research and sustainable technologies.

## OUTREACH

**Sustainable Transportation Summer Course:** CE-CERT's Sustainable Transportation Summer Course was a highlight of 2023's international engagement. Bringing together students from the University of California, Riverside, and Universidad Autónoma de Querétaro in Mexico, the program facilitated a unique learning experience focused on zero-emission vehicles, transportation engineering, and policy.

**BCOE Launch Fest:** CE-CERT participated in the very first "Launch Fest", a welcome event hosted by Bourns College of Engineering (BCOE) for new students coming to UCR. This exciting event, held at the grassy knoll (A&I Bowl), provided a vibrant platform for attendees, including first-years, transfers, and graduate students, to explore a variety of activities. As part of the event, CE-CERT graduate students were present to share their enthusiasm for environmental research, introducing incoming engineering students to the impactful work and resources available at CE-CERT.

Students gather in front of the stone art piece entitled "Petrified Petrol Station" in the courtyard of the California Air Resources Board's Southern California headquarters in Riverside, CA.



# STUDENTS & SCHOLARSHIPS

**CE-CERT** fosters collaboration and innovation among students, supports the research and thesis efforts of engineering graduate students, and provides them with access to cutting-edge technology and expert guidance. In 2023, we had 69 graduate and 25 undergraduate students from diverse academic and cultural backgrounds. By bringing together students from different disciplines, CE-CERT encourages cross-pollination of ideas and approaches, resulting in unique and effective solutions to complex environmental challenges.

## CE-CERT 2023-2024 SCHOLARSHIP RECIPIENTS

CE-CERT has a robust Scholarship program and is proud of the recipients of the **2023-2024 Scholarship Awards, totaling \$40,500.**

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

Ryan Drover  
Afsara Tasnia  
Xuanpeng Zhao  
Minghao Han  
Haishan Liu

### COLIN E. HACKETT GRADUATE AWARD

Brenda Lopez Reyna

### WILLIAM R. PIERSON/ FORD GRADUATE AWARD

Abdullah Fuad Un-Noor

### MILLER DURBIN RESEARCH AWARD

Tianyi Ma

### ATMOSPHERIC PROCESSES LABORATORY (APL) AWARD

Thomas Eckel

### TRANSPORTATION SYSTEMS RESEARCH (TSR) AWARD

Zhengwei Bai

### SALIM KHAN AWARD

Alyssa Valdez

### FORD MOTOR COMPANY UNDERGRADUATE AWARD

Madeleine Haddad

### JIM GUTHRIE RESEARCH AWARD

Brandon Kim  
Bryan Chen

## STUDENT AWARD HIGHLIGHTS



### ESTHER F. HAYS GRADUATE FELLOWSHIP

**Ryan Drover**  
Chemical and Environmental Engineering



### MILLER DURBIN RESEARCH AWARD

**Tianyi Ma**  
Mechanical Engineering



### ESTHER F. HAYS GRADUATE FELLOWSHIP

**Afsara Tasnia**  
Chemical and Environmental Engineering



### ATMOSPHERIC PROCESSES LABORATORY (APL) AWARD

**Thomas Eckel**  
Chemical and Environmental Engineering



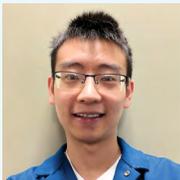
### ESTHER F. HAYS GRADUATE FELLOWSHIP

**Xuanpeng Zhao**  
Electrical and Computer Engineering



### TRANSPORTATION SYSTEMS RESEARCH (TSR) AWARD

**Zhengwei Bai**  
Electrical and Computer Engineering



### ESTHER F. HAYS GRADUATE FELLOWSHIP

**Minghao Han**  
Chemical and Environmental Engineering



### SALIM KHAN AWARD

**Alyssa Valdez**  
Environmental Science



### ESTHER F. HAYS GRADUATE FELLOWSHIP

**Haishan Liu**  
Electrical and Computer Engineering



### FORD MOTOR COMPANY UNDERGRADUATE AWARD

**Madeleine Haddad**  
Mathematics



### COLIN E. HACKETT GRADUATE AWARD

**Brenda Lopez Reyna**  
Mechanical Engineering



### JIM GUTHRIE RESEARCH AWARD

**Brandon Kim**  
Chemical and Environmental Engineering



### WILLIAM R. PIERSON / FORD GRADUATE AWARD

**Abdullah Fuad Un-Noor**  
Electrical and Computer Engineering



### JIM GUTHRIE RESEARCH AWARD

**Bryan Chen**  
Mechanical Engineering

# 2023 ACTIVE PROJECT LIST

CE-CERT continues to increase our active research portfolio, relying on a variety of research thrust areas with a wide variety of sponsorship. In 2023, **CE-CERT's active research portfolio consists of over 87 active projects totaling over \$34 million.**

## AIR QUALITY

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

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 | Barsanti, Kelley

Collaborative Research: BEAR-oNS: Biogenic Emissions and Aerosol Response on the North Slope | National Science Foundation | Barsanti, Kelley

Understanding and Mitigating Wildfire Risk in California UC Berkeley | Barsanti, Kelley

Updates to and Condensation of State-wide Air Pollution Reach Center (SAPRC) atmospheric chemical mechanism Air Resources Board | Carter, William

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

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

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

PanCeria: Catalytic NO and CO Emission Control Unit for Small Off-road Engines | Environmental Protection Agency Cocker, David

Understanding the Sources and Formation Regimes of Present-day PM<sub>2.5</sub> to Mitigate Particulate Pollution in California Air Resources Board | Collins, Don

TRACER-MAP: Mapping Aerosol Processes across Houston during convective cell events | Baylor University | Collins, Don

Understanding the impact of pollution aerosol from Los Angeles/ Long Beach on clouds and radiation in and upwind of the EPCAPE study domain | Department of Energy | Collins, Don

Ultrafine aerosol particle formation and impacts in Houston during TRACER | UC Irvine | Collins, Don

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

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

Toward Air Quality and Climate Resilience in West San Bernardino | Center for Community Action and Environmental Justice | Ivey, Cesunica

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

## EMISSIONS & FUELS

CARB Emissions Compliance Testing | Air Resources Board Durbin, Mark

Collection and Analysis of Agricultural Equipment Activity Data Air Resources Board | Durbin, Mark

Heavy-Duty Inspection and Maintenance Referee Program Air Resources Board | Durbin, Mark

Heavy-Duty Optional Low NO<sub>x</sub> Vehicle Testing | Air Resources Board | Durbin, Mark

Renewable Diesel Agricultural Engine Testing | Air Resources Board | Durbin, Mark

Smog Check Performance Report | California Department of Consumer Affairs | Durbin, Mark

**Emissions Testing on Caltrans F59PHI Locomotives**  
Capital Corridor Joint Powers Authority | Durbin, Mark

**Heavy-Duty Vehicle Testing and Data Analysis** | Eastern Research Group, Inc. | Durbin, Mark

**CEC Data Collection and Analysis – AID**

Grant Project | Tetra Tech, Inc. | Durbin, Mark

**Data Collection and Analysis under the California Air Resources Board (CARB) Zero-and-Near-Zero Emissions Freight Facility Grant** | Tetra Tech, Inc. | Durbin, Mark

**CDA: vehicle technologies and products** | Tetra Tech, Inc. Durbin, Mark

**Demonstration of Sensor Technologies for On-Road and Off-Road Heavy-Duty Diesel Vehicles** | Air Resources Board Johnson, Kent

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

**Medium and Heavy-Duty EV Deployment - Data Collection**  
Calstart | Johnson, Kent

**Fuel Cell Truck Evaluation** | Cummins | Johnson, Kent

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

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

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

**In-Use Gas Can Testing** | Air Resources Board Karavalakis, Georgios

**In-Use Off-Road Engine 'Real' Data Analysis** | Air Resources Board | Karavalakis, Georgios

**Electric Truck Research and Utilization Center (eTRUC) | Electric Power Research Institute** | Karavalakis, Georgios

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

**Evaluation of Hydrogen-Natural Gas on Engine Performance and Durability** | Southern California Gas Company Karavalakis, Georgios

**Evaluation of Hydrogen-Natural Gas on Engine Performance and Durability** | South Coast Air Quality Management District Karavalakis, Georgios

**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 | Karavalakis, Georgios

**Emissions and efficiency measurements of a capture and control system for container vessels** | STAX Engineering | Karavalakis, Georgios

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

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## TRANSPORTATION

**NCA: Collaboration Agreement** | Gladstein, Neandross & Associates, LLC | Barth, Matthew J

**NRT-FW-HTF: Science to Policy Education: Activating Knowledge for Sustainable Transportation (SPEAKS)**  
National Science Foundation | Barth, Matthew J

**Evaluation of Potential Higher Emissions Events for Heavy-duty CNG Vehicles** | South Coast Air Quality Management District Barth, Matthew J

**OMEGA: Objective Measurement/Monitoring/Mitigation of Emissions from Goods Movement and Impacts on Air Quality**  
South Coast Air Quality Management District | Barth, Matthew J

**Technical assistance with alternative fuels, biofuels, emissions testing and zero-emission transportation technology**  
South Coast Air Quality Management District | Barth, Matthew J

**Air Quality & Climate Research Training Program**  
South Coast Air Quality Management District | Barth, Matthew J

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

**National Center for Sustainable Transportation** | UC Davis Barth, Matthew J

**UCR EcoCAR EV Challenge Team** | UChicago Argonne, LLC Barth, Matthew J

**UCR EcoCAR EV Challenge MSI support** | UChicago Argonne, LLC Barth, Matthew J

**Exploring the environmental impacts of Waycare's Intelligent Transportation Solutions** | Waycare Technologies, LTD. Barth, Matthew J

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

**City of Rialto: Smart Cities Plan to Mitigate Impacts of Warehousing and Logistics** | Southern California Association of Governments | Boriboonsomsin, Kanok

**Center for Advancing Research in Transportation Emissions, Energy and Health** | The Texas A&M University System  
Boriboonsomsin, Kanok

**Mobility Services** | Uber Technologies, Inc. | Boriboonsomsin, Kanok

**Decentralized and Cooperative Traffic Signal Network for Freight Energy Efficiency, Safety, Sustainability, and Public Health** | Xtelligent, Inc | Boriboonsomsin, Kanok

**Development of J2945/A Compliant MAP creation tool**  
Leidos, Inc. | Farrell, Jay

**Vehicle Miles Traveled and Emissions Impacts of On-Demand Delivery Services** | California Polytechnic State University, San Luis Obispo | Hao, Peng

**Health-Based Truck Route Assessment for the Cities of Riverside/Moreno Valley** | Riverside County Transportation Commission | Hao, Peng

**Data Collection and Analysis in Riverside Clean Car Share**  
City of Riverside | Hao, Peng

**Evaluating the Impacts of Clean Miles Standard on Transportation System** | University of Southern California | Hao, Peng

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

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

**RI: Small: Collaborative Research: Extracting Dynamics from Limited Data for Modeling and Control of Unmanned Autonomous Systems** | National Science Foundation | Karydis, Konstantinos

**Field Study of Battery-Electric Sweepers** | Caltrans California Department of Transportation | Scora, George

**Analysis, Modeling and Simulation (AMS) Framework for Automated Trucks** | Leidos, Inc. | Wu, Guoyuan

**Enhanced Personalized Advanced Driving Assistance System using the Digital Twin Approach** | Toyota Motor North America, Inc. Wu, Guoyuan

**Enhancing Personalized Adaptive Cruise Control by Leveraging Driver Digital Twin** | Toyota Motor North America, Inc. Wu, Guoyuan

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## RENEWABLE ENERGY

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

**Advancing the National Bioeconomy through Regional Sun Grant Centers** | University of Tennessee | Cai, Charles

**Lignin-derived Carbon Storing Foams for High Performance Insulation** | Advanced Research Projects Agency - Energy  
Cai, Charles

**Advanced Technologies for Biomass Deconstruction and Lignin Valorization** | Department of Energy - Bioenergy Technologies Office  
Cai, Charles

**A Catalytic Process to Convert Municipal Solid Waste Components to Energy** | Worcester Polytechnic Institute  
Cai, Charles

**Critical Resilience for Fire and Emergency Facilities with the Soboba Band of Luiseno Indians** | Grid Alternatives  
Martinez-Morales, Alfredo A.

**Enabling California's Resilient Tribal Communities with Mobile Renewable Power** | Grid Alternatives | Martinez-Morales, Alfredo A.

**Tribal Resilience Plan Development - Fernand o Tataviam Band of Mission Indians** | Fernand o Tataviam Band of Mission Indians | Martinez-Morales, Alfredo A.

**Salton Sea Geothermal Lithium Recovery Demonstration Project** | Berkshire Hathaway Inc. | Raju, Arun

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

**Southern California Energy Innovation Network (SCEIN) 2.0**  
Cleantech San Diego Association | Raju, Arun

**Digester performance data to evaluate the effectiveness of a CO2 microbubble system in increasing methane production rate from the digester** | City of Riverside | Raju, Arun

**Eastside Climate Collaborative Transformative Climate Communities Initiative** | City of Riverside | Raju, Arun

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

**Renewable Syngas Methanation** | Taylor Energy | Raju, Arun

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## CALTESTBED PARTNERS

**Future Motors** | Ula, Sadrul

**Umida AG** | Ula, Sadrul

**KIGT** | Todd, Michael

**Stasis Group, Inc** | Todd, Michael

**Alpine Hydromat** | Todd, Michael

**Rejoule** | Todd, Michael

**Enzync** | Martinez-Morales, Alfredo A.

**ONYX Power** | Martinez-Morales, Alfredo A.

**Sylvatex** | Todd, Michael

**Cyclonatix** | Ula, Sadrul

**GreenTech Motors** | Ula, Sadrul

**Dakota Energy Systems** | Ula, Sadrul

**Xponent Power, Inc.** | Todd, Michael





**Bourns College of Engineering**  
**Center for Environmental Research and Technology**

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