April 24th, 2017

BOARD OF ADVISORS MEETING

UC DAVIS
ENERGY EFFICIENCY CENTER

THANK YOU TO OUR SPONSORS

These sponsors have made significant financial contributions to support the Energy Efficiency Center's mission to accelerate the development and commercialization of energy efficiency technologies and to train future leaders in energy efficiency.

Front Cover: Rendering of the 2017 UC Davis Solar Decathlon house—OUR H_2Ouse—an original design that addresses the severe drought in California.

WELCOME

Welcome Members of the Board of Advisors and Special Guests,

Thank you for participating in our Spring 2017 Board of Advisors meeting. This is an exciting and important time to come together. We have experienced some great success this past year, including:

- Launching the Energy Graduate Group and recruiting our first class of students. (The first cohort arrives this Fall.)
- Advancing **strategic U.S. and global partnerships**, including deeper collaborations with the Office of Naval Research and Mexico, launching an India Initiative, and participating in the Mandela Washington Fellowship program's first energy-themed institute.
- Supporting critical **project-based learning opportunities**, including a UC Davis team to compete in the U.S. Department of Energy's Solar Decathlon.
- Partnering to develop key **energy data analytics software platforms.**
- Advancing one of 13 **UC Davis Big Ideas**—"Leading the Way to Climate Neutrality."
- Hiring **staff to fill essential needs**, including a Director of Development and Strategic Partnerships, a Senior Director of Development, a Senior Writer, and a Senior Development Engineer.

Looking ahead, we have important work to accomplish this year, including:

- **Recruiting a Faculty Director**—In 2015, we launched an international search for a faculty director. While this initial search did not result in a successful hire, we now have a new Chancellor identified who will start this summer and are well-positioned to relaunch this search to ultimately find a candidate that is the right fit.
- **Transitioning from a Center to an Institute**—Last year, the Energy Efficiency Center began the process of transitioning from a Center to an Institute. This year we are developing a strategic plan and brand/identity for the new Institute that builds upon the existing strengths of the EEC and UC Davis energy-related efforts.

Included in this information packet are biographies for all the participants and background information on the most recent and important initiatives we have underway. Although we will not have time in the day's meeting to go into all the work that is covered in this packet, we encourage you to follow-up with us on anything that might be of special interest to you and your team and respective network.

Thank you again for your support.

With much appreciation,

Benjamin M. Finkelor
Executive Director

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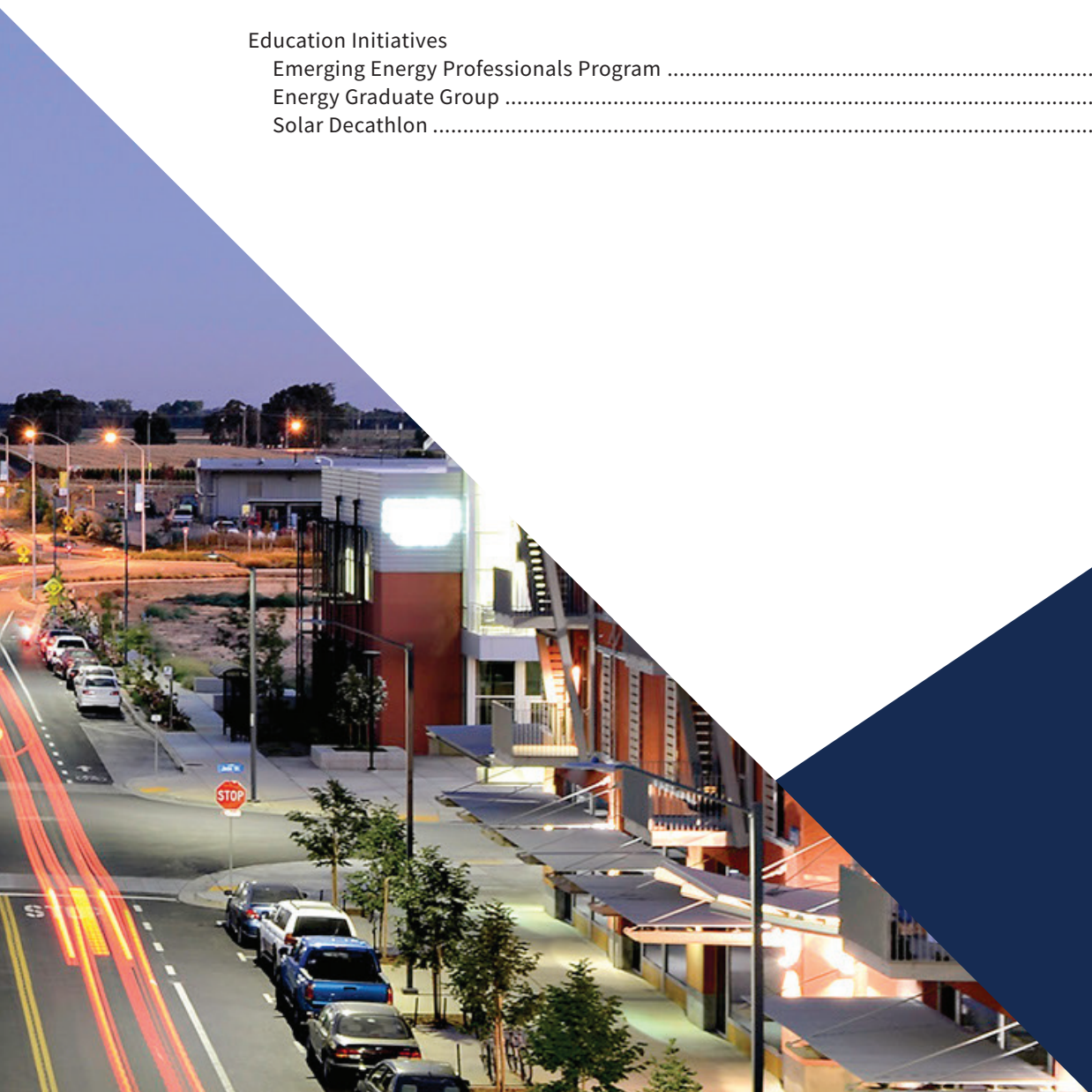

AGENDA

Board of Advisors Meeting
UC Davis Energy Efficiency Center

8:30 am **Arrival and Light Refreshments**

9:15am **Welcome & Introductions**
Ralph Cavanagh, Chair

New Board Members:
Laurie Giammona, PG&E
Nicole Howard, SMUD
Marc Ulrich, SCE
Patricia Wagner, SoCalGas

Special Guests:
Rob Bernard, Microsoft
Gordon Feller, Meeting of the Minds
Pat Remick, NRDC
Ian Rogoff, CalCEF
Marc van den Berg, DBL Partners

Board Members:
Robert Bienenfeld, Honda
David Jacot, LADWP
Michael Peevey
Mark Vanderhelm, Walmart
Caroline Winn, SDG&E

9:30am **Celebrating Art Rosenfeld**
Alan Meier, Adjunct Professor, Environmental Science & Policy; Senior Scientist, Lawrence Berkeley National Laboratory

[UC Davis plans to become a home for the study of Energy Productivity, building on the legacy of the Rosenfeld curve.]

9:40 am **Strategic Plan for the Institute**
Benjamin Finkelor, Executive Director, Energy Efficiency Center (EEC)

[Issues to consider throughout the day will be the Institute's Mission, Guiding Principles, and Goals.]

10:00 am **Research Highlights**

Siva Gunda, Director of Research and India Initiatives, EEC

10:10 am

Mark Modera, Director, Western Cooling Efficiency Center; Sempra Chair in Energy Efficiency; Professor, Civil & Environmental Engineering; Professor, Mechanical & Aerospace Engineering
Early results from projects involving Grid-Responsiveness, Integrative Solutions, and Disadvantaged Communities

10:30 am **Break**

10:45 am **Research Highlights Continued**
Frank Loge, Director, Center for Water-Energy Efficiency Center; Krone Endowed Professorship in Environmental Engineering; Professor, Civil and Environmental Engineering
Water, Energy, and Food Systems

11:05 am **Nicole Graeber,** Senior Development Engineer, California Lighting Technology Center
Alan Meier
Developments from the Edge of Lighting Research

11:25 am **Jae Wan Park,** Director, Green Transportation Laboratory; Associate Professor, Mechanical and Aerospace Engineering
Piloting Low-Cost Smart Grid using 2nd- Life Batteries

11:50 am **Aaron Smith**, Davis Energy Economics Program (DEEP); Professor, Agricultural & Resource Economics
Using Data to Conduct Policy and Program Evaluation

12:10 pm **Board Photo & Lunch**

12:50 pm **Making the Best of the Upcoming Four Years of Uncertainty**
The Collective Impact Initiative proposed by **Mark de Groh**, Director of Development and External Relations

4/24

1:00 pm **Discussion**

Who is going to be responsible for Energy Efficiency in the near- future? Given the recent change in federal leadership, how can UC Davis and its network of partners continue to advance solutions? What are the defining strategic initiatives the Institute should be working on to ensure we realize a resilient energy future?

To jumpstart this discussion, we are inviting the following Board members to make brief comments:
Caroline Winn - An IOU perspective
Nicole Howard - A municipal utility perspective
Patricia Wagner - A natural gas perspective
Mark Vanderhelm - A customer perspective

2:20 pm **Break**

2:35 pm **Investing in Human Capital**

Alissa Kendall, Chair, Energy Graduate Group; Professor, Civil & Environmental Engineering
Rao Unnava, Dean, Graduate School of Management

Exemplary Students:
Armando Casillas
Claire Halbrook
Nicholas Pappas

3:00 pm **Discussion**

What is needed in our new Energy workforce?

To jumpstart this discussion, we are inviting the following Board members to make brief comments:
Laurie Giammona - An IOU perspective
David Jacot - A municipal utility perspective
Rob Bernard - The importance of data science

3:30 pm **Wrap-up & Final Thoughts**

4:15 pm **Adjourn**

4:20 pm **Tours [Optional]**

Honda Smart Home Tour – a Glimpse into CA's Zero Net Energy Future
Ben Finkelor

Latest Laboratory Test at the Western Cooling Efficiency Center
Mark Modera

5:00 pm **Reception**

Our House, 808 2nd St, Davis, CA 95616

5:30 - 7:30pm

Dinner

Guest Speaker: **Nancy Skinner**, State Senator; Former Senior Policy Fellow

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BIOGRAPHIES: BOARD OF ADVISORS

Ralph Cavanagh

Ralph Cavanagh is the Co-Director of the Energy Program at the Natural Resources Defense Council. He has been a Visiting Professor of law at Stanford and UC Berkeley, a lecturer on law at the Harvard Law School, and a faculty member for the University of Idaho's Public Utility Executives Course. From 1993 to 2003, Cavanagh served on the U.S. Secretary of Energy's Advisory Board. His current board memberships include the Bipartisan Policy Center, the Bonneville Environmental Foundation, the California Clean Energy Fund, the Center for Energy Efficiency and Renewable Technologies, and the Renewable Northwest Project. He is a member of the National Commission on Energy Policy, established by the William & Flora Hewlett Foundation in 2002. He received the Heinz Award for Public Policy, the National Association of Regulatory Utility Commissioners' Mary Kilmarx Award, Yale Law School's Preiskel-Silverman Fellowship, and the Lifetime Achievement in Energy Efficiency Award from California's Flex Your Power Campaign. Cavanagh is a graduate of Yale College and Yale Law School.

Robert Bienenfeld

Robert Bienenfeld is Assistant Vice President, Environment and Energy Strategy for American Honda's Product Regulatory Office. Bienenfeld is responsible for policy (legislative proposals and regulatory rule making) as it relates to the automobile and its impact on the environment. In addition, he is responsible for recommending long-term strategies to address greenhouse gas, energy security, and air quality issues. Bienenfeld was responsible for Honda's discussions with the White House that led to the historic 2012–2016 and 2017–2025 Greenhouse Gas and Fuel Economy Regulations. Bienenfeld is a 30+ year Honda veteran. Key accomplishments include: the initial proposal for Honda's "Safety for Everyone" strategy, Honda's introduction of telematics, Honda's investments in car sharing, and vehicle refueling technologies. Bienenfeld led the launch of Honda's first battery electric car, the 1997-9 EV PLUS, Honda's first generation Civic natural-gas vehicle (1998), and the original Honda Insight (1999). Bienenfeld graduated from St. John's College.

Laurie Giammona

Laurie Giammona is Senior Vice President and Chief Customer Officer for Pacific Gas and Electric Company (PG&E). Giammona leads all aspects of PG&E's Customer Care and Corporate Real Estate Strategy and Services organization. She oversees service to 16 million people throughout Northern and Central California and manages seven million square feet of facilities supporting more than 20,000 employees. Giammona oversees billing, metering, revenue, call centers, local offices, account services, low income offerings and customer programs including energy efficiency, solar, electric vehicle and demand response portfolios. Giammona joined PG&E in 2012 as Vice President of Customer Service. Previously, she held senior level positions at Comcast, including Regional Vice President of Customer Care, and United Airlines. She currently is on the boards of the California Chamber of Commerce and the Wine Institute and serves on the executive board for the Make-A-Wish Foundation, Greater Bay Area.

Kathleen Hogan

Kathleen Hogan is Deputy Assistant Secretary for Energy Efficiency in the Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy. She oversees energy efficiency policy, program, and research portfolios including industrial, building, and vehicle technologies, along with federal energy management. Hogan served for more than 10 years as a division director at U.S. EPA and was responsible for the development and operation of EPA's clean energy programs, focused on removing market barriers for energy efficiency and renewable energy. These programs included the ENERGY STAR® program; programs for combined heat, power and renewable energy; corporate leadership programs; and efforts focused on state clean energy policies. She has been recognized for her work with a Presidential Rank Award, induction into the Energy Efficiency Hall of Fame of the U.S. Energy Association, and as a contributor to the Nobel Peace Prize awarded to the Intergovernmental Panel on Climate Change. Hogan holds a Ph.D. from Johns Hopkins University and a bachelor's degree from Bucknell University.

Nicole Howard

Nicole Howard is Chief Customer Officer at Sacrament Municipal Utility District (SMUD). Howard leads SMUD's $1.5 billion retail electric business, overseeing customer care and strategy, metering and billing and SMUD's programs and services, including energy efficiency, low-income assistance, electric vehicles, solar and advanced energy solutions. She also oversees corporate brand, marketing, communications and economic and community development. Since joining SMUD in 2002, Howard has held a variety of leadership roles in customer care, customer operations, procurement and distribution services. Howard holds a bachelor's degree in legal studies from UC Berkeley and a master's degree in public administration from CSU, Dominguez Hills. She sits on the Executive Committee of the Sacramento Metro Chamber Board, the Board of the Sacramento Black Chamber and the Western Energy Institute Customer Service Executive Council.

David Jacot

David Jacot, P.E., is the Director of Efficiency Solutions for the Los Angeles Department of Water & Power (LADWP). In this role, Jacot oversees all aspects of LADWP's offerings and strategies designed to overcome market barriers to the comprehensive adoption of energy efficiency by LADWP's customers. He has a Bachelor's degree in Mechanical Engineering from the University of Oklahoma, and a Master's degree in Urban and Regional Planning from California State Polytechnic University – Pomona, as well as 15 years of experience designing high performance building systems, modeling building energy usage, and managing cost-effective and investment-grade energy efficiency programs.

BIOGRAPHIES: BOARD OF ADVISORS

Dan'l Lewin

Dan'l Lewin is a Corporate Vice President at Microsoft, leading the company's work in civic technology, including campaign technologies, environmental sustainability, policy-oriented academic outreach, and university relations. Previously, he led the company's global engagement with startups and venture capitalists, and business relationships with strategic industry partners. Lewin reports to Microsoft President Brad Smith and also has executive and site responsibility for the company's operations in Silicon Valley. Lewin has spent more than 30 years as a Silicon Valley-based executive, leading sales and marketing divisions for companies including Apple Computer Inc., NEXT Inc., and GO Corp. Before joining Microsoft in 2001, he was CEO of Aurigin Systems Inc. Lewin serves on the boards of the Silicon Valley Community Foundation, World Business Chicago, and UI LABS. He is also on the Advisory Council for the Department of Politics at Princeton University. Lewin holds an AB in politics from Princeton University.

Wesley Lohec

Wesley E. (Wes) Lohec is vice president, Health, Environment, and Safety for Chevron Corporation, a position he has held since 2011. He is responsible for leading health, environment, and safety strategic planning and issues management; compliance assurance; and emergency response. He is also responsible for Chevron's Environmental Management Company, which manages environmental remediation and abandonment liabilities. Previously, Lohec served as managing director of the Latin America strategic business unit, from 2008 to 2011, for Chevron Africa and Latin America Exploration and Production Company in Caracas, Venezuela. He joined Chevron in 1981 as a drilling engineer and has held a number of positions with increasing responsibility in drilling, production engineering, operations, human resources, asset management, and business planning. Lohec is a member of the Society of Petroleum Engineers and is a registered professional engineer in the state of Texas. He earned a bachelor's degree in petroleum engineering from Texas A&M University.

Amory B. Lovins

Amory B. Lovins is a consultant, experimental physicist, author, and visionary in the fields of energy and resource efficiency, environmental policy, and security policy. He co-founded and currently serves as Chairman and Chief Scientist at Rocky Mountain Institute, a non-profit, independent, think-and-do tank that creates abundance by design. He is a member of the Advisory Board to the Chief of Naval Operations and of the National Petroleum Council. In 2009, *Time* named him one of the world's 100 most influential people, and *Foreign Policy*, one of the 100 top global thinkers. He has authored or co-authored 29 books and hundreds of papers, including "Natural Capitalism" and "Winning the Oil Endgame." His work has been recognized by a MacArthur Fellowship, a Time Hero for the Planet Award, and the Blue Planet and Volvo Environment prizes.

Barry Neal

Barry Neal is the Executive Vice President leading Wells Fargo's Environmental Finance activities, and managing a group whose primary focus is originating lending and investment opportunities in the renewable energy sector. His scope of activities is borne out of Wells Fargo's Environmental Commitments, first announced in 2005 and then expanded in 2012. These commitments include a focus on providing capital to environmentally-beneficial businesses and projects in several industry sectors including renewable energy, cleantech, energy efficiency, and real estate. Neal joined Wells Fargo in 2006, after spending more than 20 years in the energy and environmental sectors. Prior to joining Wells Fargo, he provided management consulting services to financial institutions and renewable energy development companies. Neal earned a M.S. in Energy Management & Policy from the University of Pennsylvania and a B.S. in Business Administration from the University of California at Berkeley.

Michael R. Peevey

Michael R. Peevey retired from the California Public Utilities Commission, where he served as President, at the end of his term in December, 2014. He is spending more time with his family while he writes a book on California energy-environmental policies over the past 40 years. Peevey was appointed President of the Commission by Gov. Gray Davis in 2002. From 1995 until 2000, he served as President of NewEnergy, Inc. Earlier, Peevey was President of Edison International and Southern California Edison. He has served on many boards and has received numerous awards recognizing his leadership in developing energy policy and promoting recognition of California's diverse population. He has received leadership recognition from the American Council for Energy Efficiency (2005), the Utility Minority Access Program (2006) and the California Solar Energy Industries Association (2006). He holds bachelor's and master's degrees in economics from the University of California, Berkeley.

Nancy Pfund

Nancy E. Pfund is Founder and Managing Partner of DBL Partners, a venture capital firm whose goal is to combine top-tier financial returns with meaningful social, economic and environmental returns in the regions and sectors in which it invests. As a leading player in impact investing, DBL has helped to reveal the power of venture capital to promote social change and environmental improvement. Pfund writes and speaks frequently on the field of impact investing. Pfund currently sponsors or sits on the board of directors of several companies including; Farmers Business Network, The Muse, Advanced Microgrid Solutions, Off-Grid Electric, Primus Power, and, prior to their public offerings, Tesla Motors and Pandora Media. She also served on the board of SolarCity until its acquisition by Tesla in December 2016. Prior to founding DBL, Pfund was a Managing Director in Venture Capital at JPMorgan, having started her investment career at Hambrecht & Quist in 1984.

BIOGRAPHIES: BOARD OF ADVISORS

Marc L. Ulrich

Marc Ulrich is vice president, Customer Programs & Services for Southern California Edison (SCE), one of the nation's largest utilities. He is responsible for SCE's energy efficiency, demand response and clean self-generation program portfolios and customer strategy, marketing, e-commerce and strategic alliance functions. Previously, Ulrich held several leadership positions at SCE, including vice president, Energy Contracts and Trading & Energy Operations; vice president, Renewable & Alternative Power; and director of Energy Planning. Prior to joining SCE in 2002, he worked for various companies, including Econ One Consulting, Enron, Georgia Power, and Southern Company. Ulrich holds bachelor's and master's degrees in economics from San Jose State University and a doctorate in economics from Auburn University.

Mark Vanderhelm

Joining Walmart in 2015, as Vice President for Energy, Mark Vanderhelm leads the team supporting Walmart U.S., including Retail Energy, Energy Regulation and Management, Energy Services, and Energy Development. He oversees the company's global commitment to energy efficiency, sustainability, and renewable energy. Vanderhelm joined the company from Exelon Generation, LLC in Pennsylvania, where he managed Generation and Renewables Development. In this role, he led the team responsible for developing new generation projects (gas, solar, biomass, storage, and hydro) and investing in new electricity-based technologies throughout the U.S. and Canada. Vanderhelm holds a bachelor's degree in Mechanical Engineering from University of Texas and a master's degree and doctorate in Nuclear Engineering from MIT, where he co-directed the Institute of Nuclear Power Operations' Reactor Technology Course for Utility Executives.

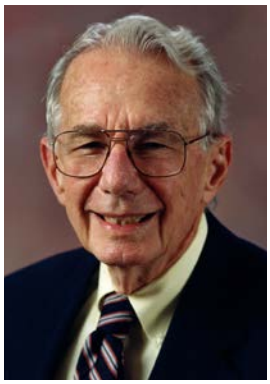
Patricia Wagner

Patricia Wagner is chief executive officer (CEO) of Southern California Gas Company (SoCalGas), a Sempra Energy regulated California utility. Wagner joined Sempra Energy in 1995 and has since held several leadership positions, including president and CEO of Sempra U.S. Gas & Power, where she was responsible for the company's U.S. renewable energy business and non-California natural gas assets. She has also served in key management roles at SoCalGas and San Diego Gas & Electric (SDG&E) in gas distribution operations and customer services. Previously, she held management positions at Fluor Daniel and worked for McGaw Laboratories and Allergan Pharmaceuticals. Wagner serves on the board of directors of Apogee Enterprises, Inc. She holds a master's degree in business administration from Pepperdine University and a bachelor's degree in chemical engineering from California State Polytechnic University, Pomona.

Caroline Winn

Caroline Winn is Chief Operating Officer for San Diego Gas & Electric (SDG&E), one of Sempra Energy's regulated California utilities. Winn became chief operating officer in January 2017. Previously, she served as chief energy delivery officer, overseeing all energy delivery activities, including electric distribution operations and gas services, customer services, and external and state legislative affairs. Since joining the company, Winn has held a number of leadership positions with SDG&E and Southern California Gas Company, including vice president of customer services and chief customer privacy officer. She has a bachelor's degree in electrical engineering from California State University, Sacramento and is a registered professional engineer in the state of California.

In memory and recognition



Arthur H. Rosenfeld

Arthur H. Rosenfeld received his Ph.D. in physics at the University of Chicago under Nobel Laureate Enrico Fermi, and then joined the Department of Physics at UC Berkeley. He later led the Nobel Prize-winning particle physics group of Luis Alvarez at Lawrence Berkeley National Laboratory. At that time, he changed his research focus to the efficient use of energy, and formed and led the Center for Building Science at LBNL. He was appointed to the California Energy Commission by two governors. Rosenfeld was responsible for the Public Interest Energy Research program, with an annual budget of $82 million; for energy efficiency, including the California energy efficiency standards for buildings and appliances; for collaborating with the Public Utilities Commission Proceeding on demand response, critical peak pricing, and advanced metering; and the Proceeding on Energy Efficiency Programs, with an annual budget of $600 million. He authored or co-authored nearly 400 refereed publications, received the Szilard Award for Physics in the Public Interest, the Carnot Award for Energy Efficiency from the U.S. Department of Energy, and the Berkeley Citation. He also received the Enrico Fermi Award, the oldest and one of the most prestigious science and technology awards given by the U.S. government. Rosenfeld passed away on January 27, 2017.

BIOGRAPHIES: SPECIAL GUESTS

Robert Bernard

Robert Bernard is Chief Environmental and Cities Strategist for Microsoft. A 17 year Microsoft veteran, he is responsible for defining and implementing the global strategy for the company's environmental and cities efforts. Under his leadership, Microsoft has established a carbon neutral goal and the first-of-its-kind internal carbon fee. Bernard and his team are also responsible for Microsoft CityNext to help cities around the world better leverage technology to realize safer, healthier, better educated, more modern and sustainable places for people to live and work. Prior to this role, Bernard was the GM for the global ISV program where he managed teams supporting partnerships with over 50,000 software partners. He received his bachelor's from Columbia University and his Master or Business Administration from The Wharton School at the University of Pennsylvania.

Gordon Feller

Gordon Feller is the Co-Founder of Meeting of the Minds, a global thought leadership network and knowledge-sharing platform focused on the future of sustainable cities, innovation and technology. He serves as a consultant to Cisco focused on Internet of Things and Talent. Gordon has worked in the area of emerging technology for three decades, most recently consulting on projects which harness the power of data (whether in the cloud, pulled via mobile networks from IoT-enabled end-points, or other advanced technologies) for solving complex problems. From 2010-2016, Feller was the Director of Urban Innovation at Cisco Systems headquarters in Silicon Valley where he served in an executive capacity within the company's programs focused on cities. Prior to joining Cisco, Feller was the CEO of Urban Age Institute, an international non-profit research and training organization, which began inside the World Bank and spun off in 2001. He received bachelor's and master's (cum laude) degrees from Columbia University.

Pat Remick

Pat Remick is Senior Energy Communications Strategist for the Natural Resources Defense Council. Based in Washington, D.C., she works closely with NRDC's worldwide Energy & Transportation Program and focuses primarily on energy efficiency issues. Remick joined NRDC in January 2013 after a decade of state-level advocacy work and a lengthy career as a full-time and freelance journalist. She has worked for such media outlets as CNN, United Press International, AARP Bulletin, a variety of newsletters and websites, and newspapers in Texas and New Hampshire. Remick also co-authored two professional development books and is an award-winning mystery short story writer. She earned a bachelor's in communications with a minor in journalism from the University of New Hampshire.

Ian Rogoff

Ian Rogoff is Executive Chairman of HelioPower, an integrated energy solutions company and its affiliated companies, Helio Energy Solutions and Helio Micro Utility. He is an active investor in software and renewable energy fields, serving as Co-Founder and General Partner at Sierra Nevada Partners, an investment management company established to buy and grow sustainable businesses located in the Western U.S. Rogoff serves as Chairman of the Nevada Institute for Renewable Energy Commercialization, a non-profit public-private partnership that integrates researchers, experienced entrepreneurs, business executives and venture capital to identify and fund viable renewable energy solutions. He has diverse industry experience including software, discrete manufacturing, aerospace and energy. Rogoff holds a B.S. in electrical engineering from the University of Miami, a M.S. in Industrial Engineering from The Georgia Institute of Technology, a M.A. from Stanford University, and has completed an executive management program at Dartmouth College.

Rao Unnava

Rao Unnava is Dean of the UC Davis Graduate School of Management. He joined the Graduate School of Management in June 2016 following 32 years at The Ohio State University's Fisher College of Business, where he earned his Ph.D. and most recently served as the W. Arthur Cullman professor of marketing. At the Fisher College of Business, Unnava also served as the associate dean of undergraduate programs, associate dean of executive education, and director of doctoral programs in business. Unnava is also one of the founders of Angie's List. He is on the board of directors of the American Marketing Association, and serves on the board of the Bay Area Council, the largest business-centric public policy organization in the San Francisco region. Unnava earned his Ph.D. in business administration from The Ohio State University's Fisher College of Business, his Post Graduate Diploma in management from the Indian Institute of Management Calcutta, and his B.Tech. in electronics engineering from Jawaharlal Nehru Technological University.

Marc van den Berg

Marc van den Berg is a Partner at DBL Partners. He is a member of the firm's investment committee and an active investor and director. Prior to DBL Partners, van den Berg was a General Partner at Technology Partners and a Managing Director at VantagePoint Capital. During his 10 years in venture investing van den Berg has backed numerous successful companies in the material science and energy efficiency landscape such as Bridgelux, Amprius, iWatt, Kinetic, Liquid Robotics and Kaiam Inc. Prior to his venture capital career, van den Berg spent 25 years in both venture backed startups and multi-national public companies in Silicon Valley and abroad. He has held numerous director positions at semiconductor and clean energy and clean water companies and enjoys assisting entrepreneurs in their quests to grow exciting new ventures. van den Berg is a graduate of Santa Clara University with a degree in Electrical Engineering.

BIOGRAPHIES: FEATURED STUDENTS

Armando Casillas

Armando Casillias is an incoming Energy Graduate student from Bakersfield, California. While attending UC Merced in pursuit of a B.S. in Mechanical Engineering, Armando worked for Facilities Management as an energy analyst where he developed a passion and appreciation for sustainability and building energy efficiency. Armando's research interests include HVAC systems, building automation and energy management. He plans on working with the Energy Conservation Office this summer as a Graduate Student Researcher and is interested in working with Dr. Mark Modera as part of the Western Cooling Efficiency Center (WCEC) this coming year.

Claire Halbrook

Claire Halbrook is currently a first-year MBA student at the UC Davis Graduate School of Management interested in how companies create a business case for sustainability. She began her career in environmental policy at the California Environmental Protection Agency (CalEPA) as part of the Capital Fellowship Program. Claire later transitioned to Pacific Gas and Electric Company (PG&E) where she spent four and a half years in PG&E's Regulatory Affairs and Energy Procurement organizations. She worked on a number of energy and environmental policies including implementation of the California Cap-and-Trade Program, the Low Carbon Fuel Standard, the CPUC's new Integrated Resource Plan, and the Clean Power Plan. Claire currently works part-time on building electrification efforts at the Sacramento Municipal Utility District (SMUD) and serves as a carbon market research assistant for Professor Jim Bushnell. She will intern this summer with Johnson and Johnson's sustainability team.

Nick Pappas

Nick Pappas is a first-year MS student in the Transportation Technology and Policy Graduate Group, intending to transfer to the Energy Graduate Group in Fall 2017. His academic focus is the electrification of transportation and industrial energy systems in the context of California's transforming energy landscape. Nick's recent projects include a cost-optimization analysis of the operations of the UC Davis central cooling system, a grid dispatch-based study of electric vehicle integration in a high-renewables environment, and an analysis of electrification opportunities for California bus fleets (on-going). Prior to his graduate program, Nick worked on energy and climate policy at Southern California Edison and in the California State Legislature, focusing on policies related to customer rates, renewable procurement, generator emissions, demand-side management, and customer choice (DA, CCA, and self-generation). He graduated from UC Davis with a BA in Economics in 2010 and completed the Jesse M. Unruh Assembly Fellowship in 2011.

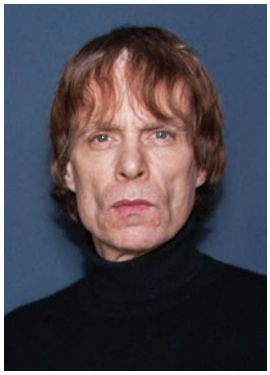
BIOGRAPHIES: FACULTY LEADERSHIP

Frank Loge

Frank Loge is Director of the Center for Water-Energy Efficiency, a professor in the Department of Civil and Environmental Engineering, and the current holder of the Ray B. Krone Endowed Professorship in Environmental Engineering at the University of California, Davis. He began his career studying water and wastewater treatment and has developed a strong interest in the relationship between energy, water, and health. He advocates performing fundamental research to advance knowledge and developing and deploying technologies and policies that improve environmental quality and the efficiency of resource consumption. His research efforts focus on the energy and health implications of engineered and natural systems, designing sustainable systems and technologies, and entrepreneurship and finance. Dr. Loge holds a Ph.D. in Civil and Environmental Engineering from the UC Davis and is a licensed Professional Engineer in the state of California.

Mark Modera

Mark Modera is Director of the UC Davis Western Cooling Efficiency Center (WCEC), Professor in the Departments of Civil and Environmental Engineering and in Mechanical and Aerospace Engineering, and is the Sempra Energy Chair in Energy Efficiency. Prior to joining WCEC, he worked at Carrier Corp., where he was Vice-President, and at Lawrence Berkeley National Laboratory (LBNL). While at LBNL, Modera developed an aerosol-based duct sealing process, and subsequently established Aeroseal, Inc. to commercialize the technology. He has a diverse set of research interests, including energy efficiency, ventilation, and indoor air quality. Modera received a master's degree in mechanical engineering from the University of California, Berkeley and a Ph.D. in mechanical engineering from the Royal Institute of Technology in Stockholm.



Michael Siminovitch

Michael Siminovitch is Director of the California Lighting Technology Center (CLTC), Professor in the Department of Design, and the Arthur H. Rosenfeld Chair in energy efficiency. Siminovitch participated on the leadership team for California's Strategic Lighting Plan and helped lead efforts to improve the 2013 Title 24, Part 6 standards for exterior lighting. He co-authored the original California Advanced Lighting Controls Training Program (CALCTP) and now serves on its board of directors. He also established the UC Davis Smart Lighting Initiative, one of the largest lighting retrofit projects in California, to reduce lighting energy use 60% below 2007 levels. In 2014, Siminovitch was selected by UC President Janet Napolitano as an inaugural member of the UC Global Climate Leadership Council. He received master's degrees in Industrial Design and Architecture from the University of Illinois and a doctoral degree in Architecture and Human Factors Engineering from the University of Michigan.

BIOGRAPHIES: FACULTY LEADERSHIP

Andrew Hargadon

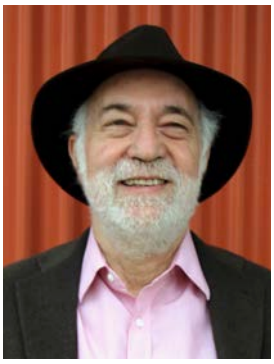
Andrew Hargadon is the Charles J. Soderquist Chair in Entrepreneurship and Professor of Technology Management at the UC Davis Graduate School of Management. His research focuses on the effective management of innovation and entrepreneurship, particularly in the development and commercialization of sustainable technologies. Hargadon is the founding director of two key centers at UC Davis—the Mike and Renee Child Institute for Innovation and Entrepreneurship and the Energy Efficiency Center. He has published numerous articles and chapters in leading scholarly and applied publications, and is the author of Sustainable Innovation: Build Your Company's Capacity to Change the World (Stanford University Press, 2015) and How Breakthroughs Happen: The Surprising Truth About How Companies Innovate (Harvard Business School Press 2003). Prior to his UC Davis appointment, Hargadon worked at Apple Computer and Stanford University. He received his master's in mechanical engineering and his Ph.D in organizational behavior from Stanford University.

Kurt Kornbluth

Kurt Kornbluth is founding Director of the UC Davis Program for International Energy Technology and the UC Davis D-Lab, Adjunct Assistant Professor in the Department of Biological and Agricultural Engineering, and Associate Director for the UC Davis Blum Center for Developing Economies. Kornbluth's research areas include hybrid fossil fuel/renewable electrical grids, and sustainable, low-carbon energy technologies for the developed and developing world. He has worked in the field of international development, renewable energy, and energy efficiency since 1993 and has a diverse background including implementing appropriate technology projects in Africa and Central America. In 2015, the University of California named him a Climate Action Champion for UC Davis as part of the UC Carbon Neutrality Initiative. Kornbluth holds a Ph.D. in mechanical and aeronautical engineering from UC Davis and is a UC Davis Graduate School of Management Business Development Fellow as well as an NSF IGERT fellow.

Alan Meier

Alan Meier is a senior scientist at Lawrence Berkeley National Laboratory, Adjunct Professor at UC Davis in the Department of Environmental Science and Policy, and a faculty researcher and Associate Director of Curriculum at the UC Davis Energy Efficiency Center. His research focuses on understanding how people and equipment use energy and opportunities to reduce consumption. Meier's research on "standby power use" in appliances—equal to 1% of global CO2 emissions— led him to propose an international plan to reduce standby power loss in all devices to less than 1 watt, which was endorsed by the G8 countries. He is Executive Editor (and founder) of the journal Home Energy and is the author of many articles and two books, Supplying Energy through Greater Efficiency and Saving Electricity in a Hurry. Meier holds a Ph.D. in energy and resources from University of California, Berkeley.



Dan Sperling

Daniel Sperling is Professor of Civil Engineering and Environmental Science and Policy, and founding Director of the UC Davis Institute of Transportation Studies. He is recognized as a leading international expert on transportation technology assessment, energy and environmental aspects of transportation, and transportation policy. He holds leadership positions on key boards and committees and in 2007 was appointed to serve as a member of the California Air Resources Board. Sperling was the 2013 Chair of the California Fuel Partnership and the 2015 Chair of the National Academies' Transportation Research Board. In recognition of his work, Sperling received the 2013 Blue Planet Prize and the 2010 Heinz award. He has authored or edited over 200 technical articles and 12 Books, including Two Billion Cars (Oxford University Press, 2009) and has testified 10 times to the U.S. Congress and state legislatures. Sperling received his Ph.D. in transportation engineering from the University of California, Berkeley.

Tom Turrentine

Tom Turrentine is Director of the UC Davis Plug-in Hybrid Electric & Vehicle Research Center. For the past 25 years, he has studied consumer response to alternative fuels, vehicle technologies, road systems, and policies with environmental benefits. His most recent work includes "Taking Charge," California's plan for electrification of transport, and multi-year projects to study consumer use of the BMW Mini-E, Prius PHEV conversions, the Nissan Leaf, and specially designed energy feedback displays in vehicles. In the coming years, Turrentine will be working with car companies and power utilities on purchase and use patterns of new electric and plug-in hybrids, developing tools to advise deployment of infrastructure, integration of plug in vehicles to California's grid, and ways to restructure the cost of lithium batteries. He holds a Ph.D. in anthropology from UC Davis.

ASSOCIATED FACULTY AND RESEARCHERS

Name	Title	Department	Research
Nina Amenta	Professor, Computer Science Chair, Computer Science	Computer Science	• Visualization • User interfaces • Smart grid
Gwen Arnold	Assistant Professor, Environmental Science and Policy --- Co-Director, Center for Environmental Behavior	Environmental Science and Policy	• Hydraulic fracturing • Regulation and policymaking
Shota Atsumi	Associate Professor, Chemistry	Chemistry	• Biofuels
Thomas Beamish	Professor, Sociology	Sociology	• Environment, Hazards, Risks • Social and Community Movements • Organizations, Institutions and Economy • Science, Technology and Innovation Studies
Louise Berben	Associate Professor, Chemistry	Chemistry	• Solar fuels • CO2 conversion • Hydrogen production
Catherine Brinkley	Assistant Professor	Human Ecology	• City and regional planning • Place-based policies and interventions • Food-energy-water nexus • Integrating agricultural ecosystems with urban areas • District heating
David Bunch	Professor, Graduate School of Management	Graduate School of Management	• Consumer choice behavior and modeling • Decision and management sciences
James Bushnell	Professor, Economics	Economics	• Energy markets • Utility regulation • Climate change • Environmental regulation

Name	Title	Department	Research
Colin Carter	Distinguished Professor, Agricultural and Resource Economics --- Director, Giannini Foundation of Agricultural Economics	Agricultural and Resource Economics	• Commodity markets • International trade • China's rural economy
Giovanni Circella	Researcher, Institute of Transportation Studies --- Research Engineer, Georgia Tech	Institute of Transportation Studies	• Travel behavior analysis, survey methods, demand modeling • Transportation planning and sustainability • Land use planning and modeling
Case van Dam	Chair, Mechanical and Aerospace Engineering	Mechanical and Aerospace Engineering	• Wind energy
J.P. Delplanque	Professor, Mechanical and Aerospace Engineering --- Director, California Small Hydro Collaborative --- Energy Graduate Group Graduate Advisor	Mechanical and Aerospace Engineering	• Combustion • Hydropower • Modeling and simulation
Georgia Drakakaki	Assistant Professor, Plant Sciences	Plant Sciences	• Biofuels • Cell wall • Algae • Biomass
Zhiliang (Julia) Fan	Associate Professor, Department of Biological and Agricultural Engineering --- Energy Graduate Group Graduate Advisor, Recruitment and Admissions	Biological and Agricultural Engineering	• Biofuels • Metabolic engineering • Fermentation • Process modeling
Annaliese Franz	Associate Professor, Chemistry	Chemistry	• Biofuels • Catalysis • Chemical transformations to produce biofuels

ASSOCIATED FACULTY AND RESEARCHERS

Name	Title	Department	Research
Rebecca R. Hernandez	Assistant Professor, Land, Air, Water Resources --- Assistant Earth System Scientist, Agricultural Experiment Station	Land, Air, Water Resources	• Water-limited environments • Geography of energy • Land-energy-ecology nexus
Amy Jaffe	Executive Director, Energy & Sustainability	Graduate School of Management	• Sustainability practices in the energy industry • Fuels markets and fueling infrastructure • Global oil and gas markets and geopolitics • Alternative energy business models • U.S. energy policy
Tina Jeoh	Assistant Professor, Biological and Agricultural Engineering	Biological and Agricultural Engineering	• Cellulosic biofuels • Bioconversion
Katrina Jessoe	Associate Professor, Agricultural and Resource Economics	Agricultural and Resource Economics	• Environmental and energy economics • Consumer and firm behavior
Alissa Kendall	Associate Professor, Civil and Environmental Engineering Chair, Energy Graduate Group	Civil and Environmental Engineering	• Life cycle assessment • Renewable energy • Transportation energy
Sangtae Kim	Professor, Materials Science of Engineering	Materials Science of Engineering	• Nanomaterials • Energy storage • Fuel cells
Kirill Kovnir	Assistant Professor, Chemistry	Chemistry	• Materials for energy • Thermoelectrics • Superconductors • Battery materials
John Labavitch	Professor Emeritus, Plant Sciences	Plant Sciences	• Plant cell wall metabolism
Cynthia Lin Lawell	Associate Professor, Agricultural and Resource Economics --- Associate Professor, Environmental Science and Policy	Agricultural and Resource Economics Environmental Science and Policy	• Environmental and natural resource economics • Energy economics

Name	Title	Department	Research
Heiner Lieth	Professor Extension Specialist	Plant Sciences	• Greenhouse and nursery production • Soilless culture • Photovoltaic energy production in agriculture
Bryan Jenkins	Professor, Biological and Agricultural Engineering --- Chair / Director, California Renewable Energy Center Biological and Agricultural Engineering	Economics	• Energy systems • Optimization • Thermochemical conversion
Mark Mascal	Professor, Chemistry	Chemistry	• Integrated biorefinery • Renewable fuels and materials • Biomass valorization • Biomass-derived platform chemical
Sabbie Miller	Assistant Professor, Civil and Environmental Engineering	Civil and Environmental Engineering	• Life cycle assessment • Alternative materials development • Sustainability and structural design
Frances Moore	Assistant Professor, Environmental Science and Policy	Environmental Science and Policy	• Economic and social impacts of climate change • Energy-water-food nexus
Adam Moule	Assistant Professor, Chemical Engineering and Material Sciences	Chemical Engineering and Material Sciences	• Solar materials
Erich Muehlegger	Associate Professor, Economics --- Research Associate	Economics & National Bureau of Economic Research	• Regulation and taxation of energy markets • Industrial organization • Public finance • Environmental policy
Vinod Narayanan	Professor, Mechanical and Aerospace Engineering --- Associate Director, Western Cooling Efficiency Center	Mechanical and Aerospace Engineering & Western Cooling Efficiency Center	• Energy efficiency • Heat and mass transfer enhancement • Phase change heat transfer • Microtechnology

ASSOCIATED FACULTY AND RESEARCHERS

Name	Title	Department	Research
Kevin Novan	Assistant Professor, Agricultural and Resource Economics	Agricultural and Resource Economics	• Environmental economics • Applied econometrics
Joan Ogden	Professor, Environmental Science and Policy	Environmental Science and Policy	• Alternative fuels • Energy transitions • Hydrogen and fuel cells • Energy infrastructure
Frank Osterloh	Professor, Chemistry	Chemistry	• Solar energy • Photovoltaics • Photocatalytic water splitting • Hydrogen • Nanomaterials
Jae Wan Park	Associate Professor, Mechanical and Aerospace Engineering	Mechanical and Aerospace Engineering	• Efficiency energy systems • Fuel cells • Batteries • Electric grid
David Rapson	Assistant Professor, Economics	Economics	• Energy economics • Energy markets • Energy policy
Pamela Ronald	Professor, Plant Pathology --- Professor, Genome Center --- Director, Grass Genetics, The Joint Bioenergy Institute --- Faculty Director, Institute for Food and Agricultural Literacy	Plant Pathology	• Biofuels • Grass genetics • Cell wall biosynthesis
Chris Simmons	Assistant Professor, Food Science and Technology	Food Science and Technology	• Biofuels • Waste-to-energy • Water/Energy nexus
Aaron Smith	Professor, Agricultural and Resource Economics	Agricultural and Resource Economics	• Biofuels • Residential energy efficiency • Energy price dynamics

Name	Title	Department	Research
Edward (Ned) Spang	Assistant Professor, Food Science and Technology --- Associate Director, Center for Water-Energy Efficiency	Food Science and Technology	• Water, energy, and food resource systems
Gil Tal	Professional Researcher, The Plug-in Hybrid & Electric Vehicle (PH&EV) Research Center --- Transportation Research Director, China Center for Energy and Transportation		• Alternative fuel vehicles • Travel behavior • Travel demand modeling • Transportation planning
Jean VanderGheynst	Professor, Biological and Agricultural Engineering	Biological and Agricultural Engineering	• Biofuels • Algae • Bioconversion
Jesus M. Velazquez	Assistant Professor, Chemistry	Chemistry	• Rational design of well-defined dimensionally reduced materials • Nanoelectronics, energy conversion devices, and environmental remediation
Stephen M. Wheeler	Professor, Human Ecology	Human Ecology	• Urban and regional planning • Sustainability • Climate action planning
Felix Wu	Professor, Computer Science --- Associate Dean, Academic Personnel and Research, College of Engineering	Computer Science	• Social computing • Information search and analytics • Cyber security • Internet architecture and protocols
Dong Yu	Associate Professor, Physics Physics	Physics	• Solar energy • Nanostructure solar cells
Ruihong Zhang	Professor, Biological and Agricultural Engineering	Biological and Agricultural Engineering	• Bioenergy • Biofuels • Waste-to-energy conversion

BIOGRAPHIES: STAFF

Benjamin Finkelor

Benjamin Finkelor is Executive Director of the UC Davis Energy Efficiency Center. Prior to joining the EEC, he served in a variety of roles within the clean technology sector, including director of business development for a local clean-energy start-up company, interim executive director for CleanStart (a Sacramento-based business incubator supporting local clean energy technology ventures and entrepreneurs), and as a clean-tech analyst for the private equity arm of the California Public Employees' Retirement System (CalPERS). Finkelor holds a master's degree in business administration from the University of California, Davis Graduate School of Management. He also earned an emphasis in corporate environmental management through the Bren School at University of California, Santa Barbara. His undergraduate degree is from University of California, San Diego.

Katherine Bannor

Katherine Bannor is Program Manager for the Energy Efficiency Center where she manages the core research programs and projects of the Center. She is responsible for facilitating research, development, demonstration, and deployment activities; the strategic growth of key research areas; and stakeholder outreach and engagement. Bannor previously served as the Center's Project Manager where she was responsible for overseeing contracts from utilities, government agencies, and others to ensure quality and timely completion of research objectives. Before joining the EEC, she worked in Washington, DC for the National Endowment for Democracy in their Office of Government Relations and Public Affairs. Bannor holds a Bachelor's Degree in Political Science (and French) from Beloit College in Wisconsin, and a Master's Degree in Geography from New Jersey's Rutgers University.

Karen M. Block

Karen M. Block is Senior Director of Development for UC Davis Energy. She is responsible for increasing individual contributions to energy programs at UC Davis and assisting with foundation proposals. Prior to this role, she was director of development for the Division of Social Sciences in the UC Davis College of Letters and Science. Block also worked for UC Berkeley where she held positions in corporate and foundation relations, annual giving, and reunion fundraising. She has a background in arts and education. Block received a master's in education from San Francisco State University and a bachelor's in performing arts from Emerson College.

Mark de Groh

Mark de Groh is Director of Development and Strategic Partnerships for the UC Davis Energy Efficiency Center, where he leads strategic initiatives, collaborations, and fundraising. He is a nationally recognized leader in the sustainability and smart cities sectors, bringing nearly two decades of experience with organizational design and deployment to UC Davis. Prior to joining the EEC, de Groh led philanthropic fundraising for the U.S. Green Building Council and was the chief innovation officer at the American Architectural Foundation. He is a longtime advisor of Meeting of the Minds, an appointed member of the World Smart City Forum, and a past scholar for the Aspen Ideas Festival. He holds advanced degrees in history from both The Ohio State University and Princeton University with a focus on place-based identities and urban systems.

Christie Farrell

Christie Farrell is Analyst for the UC Davis Energy Efficiency Center. Her responsibilities include: developing agendas for visiting executives, scholars, and students; drafting a wide range of correspondences; and assisting with various graphic design projects. Prior to her current position, Farrell was involved in the EEC Intern Development Program. She holds a bachelor's degree in design from the University of California, Davis.

Siva Gunda

Siva Gunda is Director of Research and the India Initiative at the UC Davis Energy Efficiency Center. He supports the oversight of the day-to-day operations of the Center as well as the development of its research agenda. Gunda is also currently leading two of the Center's strategic initiatives: one focused on development of a data platform and the other on development of research collaborations in India. Prior to joining the EEC, he worked at General Electric, California Fuel Cell Partnership, PG&E and the California Air Resources Board. Gunda has been an Edison International Energy Efficiency Fellow, UC Irvine International Sustainability Fellow and a UC Davis Center for Entrepreneurship Business Development Fellow. He is a UC Davis PhD candidate in Mechanical and Aeronautical Engineering with a focus on alternate energy systems.

BIOGRAPHIES: STAFF

Kristin Heinemeier

Kristin Heinemeier is Principal Engineer for the UC Davis Energy Efficiency Center. For over thirty years, her work has sought to encourage a substantial transformation of the technologies, programs, codes and standards, and industry best practices that lead to HVAC performance. Specifically, she has focused on the role of contractors and technicians, and the factors that encourage or discourage them from delivering quality systems. Heinemeier was one of the founders of the Western HVAC Performance Alliance and was awarded the ASHRAE Fellow award in recognition of her many years of leadership and service. She has worked for UC Davis for ten years (including eight with the Western Cooling Efficiency Center). Previously, Heinemeier worked for LBNL, Honeywell International, Texas A&M, and PECI. She received her Ph.D. in Building Science from the University of California, Berkeley, and is a licensed mechanical engineer.

Taimour Khalid

Taimour Khalid is Project Assistant at the UC Davis Energy Efficiency Center. He is responsible for assisting with the implementation and fiscal management of EEC projects, such as the Multi-Tenant Light Commercial Project, K-12 Energy Education Program, Berkeley Aerial Data Collection Project, and Proposition-39 Project. Khalid previously worked at Morgan Stanley in Sacramento as a Financial Trainee. Before coming to the United States, he worked as a sales intern at Pak Elektron Limited, an appliances manufacturing company. Khalid holds a bachelor's degree in economics and statistics from the University of California, Davis.

Alicia Loge

Alicia (Ali) Loge is Senior Writer for the UC Davis Energy Efficiency Center. She is responsible for planning, writing, editing, and producing print and online materials for audiences in academia, government, industry, and the general public. Prior to joining the EEC, Loge was a research and communications consultant for the Children and Nature Network, a researcher at Yale University, and a communications program manager for the National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center. Loge holds a master's degree in environmental health and sustainability from the Yale School of Forestry and Environmental Studies and a bachelor's degree in biology from Smith College.

David Vernon

David Vernon is Senior Development Engineer for the UC Davis Energy Efficiency Center, focusing on Zero Net Energy commercial buildings, energy efficiency and air quality in schools, tools supporting market transformation in building energy efficiency, and exergy analysis of energy systems. Past work includes research, development, and commercialization of fuel cells and hydrogen production technologies, waste heat recovery, and waste resources utilization through work as a professor in the Environmental Resources Engineering Department at Humboldt State University, the Schatz Energy Research Center, UC Davis Hydrogen Production and Utilization Laboratory, the National Renewable Energy Laboratory, Polyfuel spinoff from SRI, Los Alamos National Laboratory, and W.L. Gore and Associates. He received an M.S. and Ph.D. in Mechanical and Aerospace Engineering from UC Davis and a B.S. in Materials Science and Engineering from the University of Wisconsin-Madison.

RESEARCH CENTER UPDATES

UPDATE: CALIFORNIA LIGHTING TECHNOLOGY CENTER

The California Lighting Technology Center (CLTC) accelerates the development and commercialization of energy-efficient lighting and daylighting technologies. The Center produces new technologies, inventions, patents, and license agreements, as well as engineering specifications, market research, resources, lighting guides, and working and white papers. The CLTC works in partnership with designers, manufacturers, end users, utilities, government agencies, and others. Center faculty and staff also provide curriculum and instruction for education and training courses, and conduct workshops, seminars, and outreach activities.

Key Accomplishments 2016

Incorporating the "California Quality" Specification into the 2019 Title 20

CLTC is leading a new era of lighting that merges color quality with energy efficiency. The Center conceived of a new lighting quality standard—the Voluntary California Quality LED Lamp Specification—that was adopted by the California Energy Commission (CEC). It is intended to support energy policy makers and the lighting industry in moving consumers away from inefficient incandescent lighting toward more efficient light-emitting diode (LED) lighting technology by ensuring that consumers' expectations for lighting quality and performance are met. The California Specification represents the CEC's minimum requirements for an LED light to be considered "California Quality." LED lamps that meet the standard are now available in the marketplace and are eligible for rebates, and effective this past January, new homes built in California must have lighting that meets the California Quality standard. Importantly, the Center successfully worked with the CEC to incorporate the standard into the forthcoming lamp performance requirements contained in the 2019 Appliance Efficiency Standards, which will go into effect on January 1, 2020.

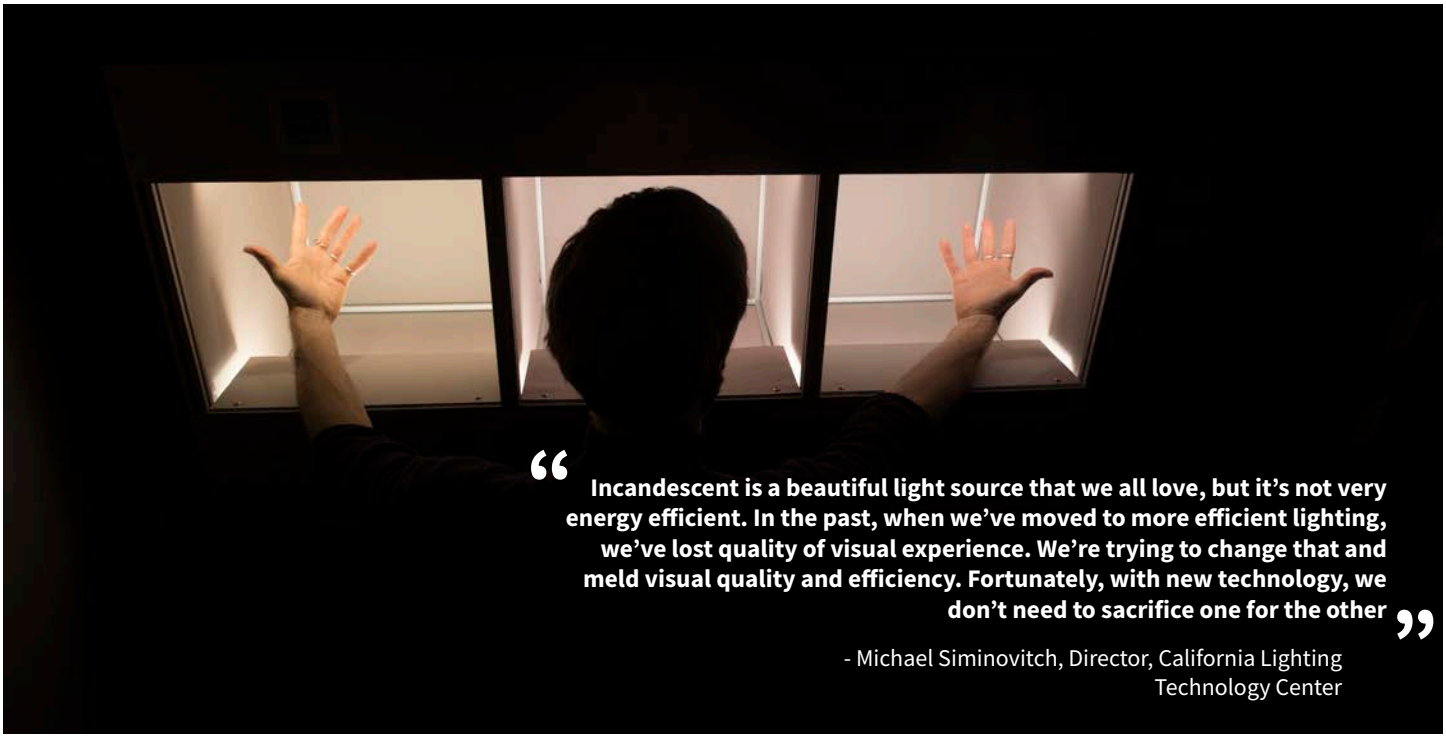
Connected the Million Lamp Challenge as a University of California Statewide Activity

The University of California (UC) purchases large quantities of directional and ominidirectional lamps (A lamps), including incandescent and CFL technologies. These lamps represent an enormous opportunity for energy savings, waste stream mitigation and maintenance cost benefits by replacing them with high-performance, high-quality LEDs. The CLTC proposed the Million Lamp Challenge—a high visibility, statewide lamp conversion program to promulgate the use of high efficiency, high quality LED replacement lamps across the University of California network—and successfully worked with key partners across the UC system to ensure that the Challenge is developed and implemented statewide.

The Center is working to develop a new generation of LED lighting solutions.

Co-led the APEC Best Practices Conference in Asia

With funding from the Asia-Pacific Economic Cooperation (APEC), the CLTC continued to lead an initiative focused on developing lighting strategies designed for use in sustainable building projects. This initiative supports workshops intended to build a collaborative of researchers at universities including King Mongkut's University of Technology Thonburi in Thailand (KMUTT), Tongji University in Shanghai, China and the University of Singapore. In 2016, CLTC co-led an APEC best practices conference in Asia to share lighting best practices that will achieve deep energy savings through retrofitting existing buildings.



CLTC Director Michael Siminovitch uses his hands to compare the color quality of a lamp meeting the California Quality Specification (right) and one that does not. Photo: Karin Higgins

Advanced Corridor, Stairwell and Restroom Control Technologies for CASE to support the 2019 California Building Energy Efficiency Standards

The California Energy Commission’s (CEC) energy efficiency standards have saved Californians millions in reduced electricity bills since 1977. The California Building Energy Efficiency Standards contain energy and water efficiency requirements (and indoor air quality requirements) for newly constructed buildings, additions to existing buildings, and alterations to existing buildings. The CEC updates the standards on an approximately three-year cycle. The CLTC worked with the CEC to advance corridor and restroom lighting requirements for the 2019 California Building Energy Efficiency Standards. These new lighting requirements will result in huge energy savings. The CLTC also created a number of guides and fact sheets to increase knowledge and implementation of code-compliant lighting for California’s residential and non-residential buildings. These guides and fact sheets can be found on CLTC’s website: http://cltc.ucdavis.edu.

Improved and Advanced Energy Efficiency Workforce Development

A majority of incumbent workers are not trained on energy efficiency, and even those that have training are faced with frequent changes in technology, codes, and standards. The CLTC continued collaborations with the California Community Colleges (CCC)—the largest system of higher education in the nation, with 2.1 million students attending 113 colleges—on a shared initiative to improve and advance energy efficiency workforce development to meet industry standards and employer needs in the clean energy economy. This collaboration is identifying opportunities for improving CCC curriculum and instructor knowledge with respect to lighting and energy efficiency. In support of these efforts, the CLTC created and developed lighting program kits that advance lighting curriculum and training materials.

CLTC Director Michael Siminovitch hosted representatives from the California Community Colleges to discuss advanced lighting curriculum and training materials for contractors and building professionals of the future.

Key Projects 2017:

Launch and Implement the Million Lamp Challenge with Industry and State Partners

CLTC will work with industry and state partners to launch and implement the Million Lamp Challenge. As part of the Challenge, the UC will develop a specification and solicitation in line with the current California Quality LED Lamp Specification, which will be disseminated to industry for a large competitive purchase by the UC. The UC will then align or partner with multiple campuses across the state to initiate a unified multi-year lamp purchase, deployment, and supporting educational program.

> **"There is an enormous opportunity to achieve rapid energy savings at scale across California university campuses by deploying a novel lamp swap out program."**

Solidify the 2019 Codes and Standards Proposals for the California Energy Commission

The CLTC is working with the California Energy Commission on the 2019 Building Energy Efficiency Standards. The Center is focused on updating codes and standards for stairwell and bathroom lighting controls. The 2019 Standards will go into effect on January 1, 2020.

Finalize Circadian Lighting Protocol for Hospital and Healthcare Applications

There is growing evidence that the intensity and spectrum of light sources found in homes, workplaces, and hospitals can have a significant impact on people's health and wellbeing. Circadian-friendly lighting design creates environments that resemble the intensity and spectral variations of light over the course of a day, gently adjusting throughout the day from the blue to the red spectrum. CLTC has been introducing this amber-toned lighting into hospital rooms and corridors, and to the Honda Smart Home in UC Davis' West Village. In 2017, the Center will finalize its circadian lighting protocol for hospital and healthcare applications.

Define Consumer Studies on Color Quality

The CLTC will continue its work on restoring high color quality to energy-efficient lighting. In 2017, the Center will define a series of consumer studies on color quality to advance understanding of consumer preferences.

Broader Context: Key Challenges

- **Understanding the human factors equation in energy efficiency—** how human factors reinforce and drive energy efficiency.
- **Addressing the large training disconnect—** there are a lot of new energy efficient technologies, but there is not a lot of effort placed on training the workforce on these technologies.

The Center is finalizing a circadian lighting protocol for hospital and healthcare applications.

UPDATE: CENTER FOR WATER-ENERGY EFFICIENCY

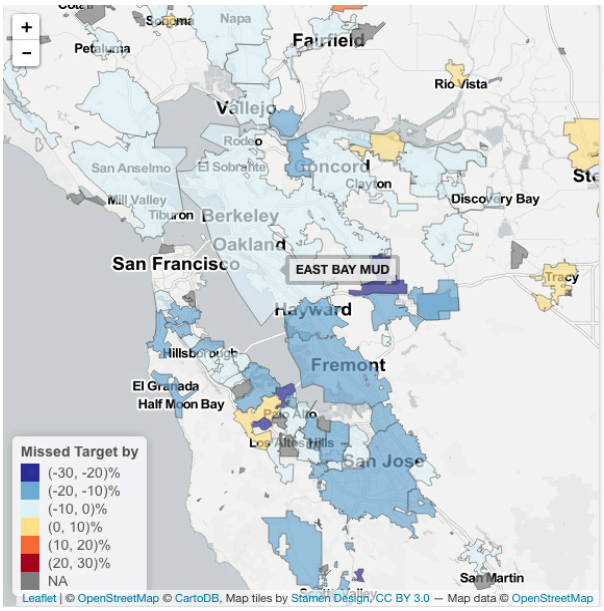
The Center for Water-Energy Efficiency (CWEE) continues its commitment to identifying, developing, and testing innovative technologies and practices for aggressive improvements in water-energy efficiency; designing policies and outreach activities that facilitate market access and penetration of innovative water-energy conservation strategies and technologies; and serving as a collaborative hub for universities, industrial partners, and government agencies to advance water-energy research, education, technology development, and policy assessment. As the Center embarks on its seventh year, there are notable accomplishments to share.

Key Accomplishments 2016

Awarded Runner-up in Green Gov Data Challenge

The State Water Board hosted a data challenge in the Spring of 2016 with a focus on creating apps, visualizations, and other tools that demonstrate the use of publicly available data beyond its current utilizations. The CWEE team, led by Data Scientist Andrew Holguin, received runner-up in the California Green Gov Challenge for their application CA H2Open.

The CA H2Open application creates a visualization of how the 400+ California water utilities responded to the Governor's mandate of a 25% reduction of statewide water use in urban water suppliers relative to 2013 levels. In addition to displaying a summary of water use relative to the conservation target for each district, the application also calculates the electricity savings associated with the reduced demand on water infrastructure services. One of the significant findings is that the embedded electricity savings associated with the observed achievements in water conservation is roughly equivalent to the total first-year electricity savings estimated for all of the investor owned utility energy efficiency programs implemented from July through September 2015 (the period where data was available for both initiatives). This application can be found at: https://cwee.shinyapps.io/greengov/.



This application creates a visualization of how the 400+ California water utilities responded to the Governor's mandate of 25% statewide water conservation in urban water suppliers relative to 2013 levels.

> **"I think one of the biggest lessons for me and others in the state as we begin to think about the path forward is the real potential to invest energy efficiency money into water conservation."**
>
> **- Frank Loge, Director, Center for Water-Energy Efficiency**

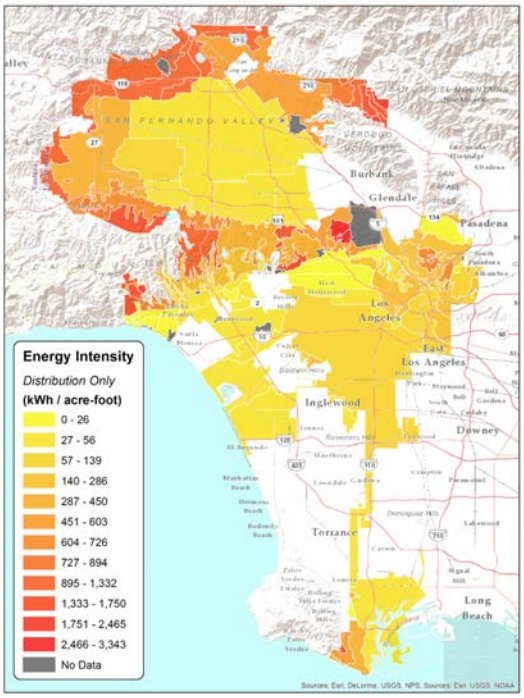
Hosted Water and Energy Data Security and Privacy Workshop

After performing a handful of energy intensity studies for California utilities, the Center found that policies and procedures were needed to streamline data sharing contract negotiations and customer data aggregation. Currently, each entity has its own procedures and policies on how it acquires, aggregates, and shares customer data to outside entities and undergoing individual negotiations across 400+ water utilities is not feasible. With the support of the S. D. Bechtel Jr. Foundation, the Center put together a two-day workshop to hear from water and energy industry leaders in the state, federal, and private sectors on streamlined solutions to share data more widely, while retaining necessary privacy and security standards.

Workshop participants agreed that streamlining water and energy use data and contracts between agencies would be an important step toward resource use efficiency and ensuring drought resilience in California. Participants also acknowledged that maintaining customer privacy within trusted parameters was essential. As a next step, the Center will bring together a consortium of stakeholders to pilot the trusted data platform CWEE has been developing.

Completed Los Angeles Department of Water and Power and Los Angeles Sanitation Bureau Energy Intensity Analysis

The water sector is an emerging target for energy efficient efforts in the State of California as it is estimated that 20% of the state's electricity and 30% of non-powerplant natural gas is used to move, treat, and heat water. CWEE developed a methodology for managing big utility data and analyzing the high resolution energy intensity (EI) of water systems across multiple spatial and temporal scales in order to provide customized recommendations for water utilities. In 2016, the Center completed an energy intensity analysis on the nation's largest municipal water and energy utility and wastewater system. The Los Angeles Department of Water and Power and the Los Angeles Sanitation Bureau each cover 473-515 square miles and approximately 4 million customers with some overlap in territory. With the EI assessment, both agencies have visualizations on high EI pressure zones in order to roll out customer energy efficiency programs, target high EI zones for infrastructure upgrades, and apply decision making to offset pumping during peak energy demand.



Average energy intensity (distribution only) by pressure zone for the LADWP system (2008-2013).

> **"The water sector is an emerging target for energy efficient efforts in the State of California as it is estimated that 20% of the state's electricity and 30% of non-powerplant natural gas is used to move, treat, and heat water."**

Key Projects 2017

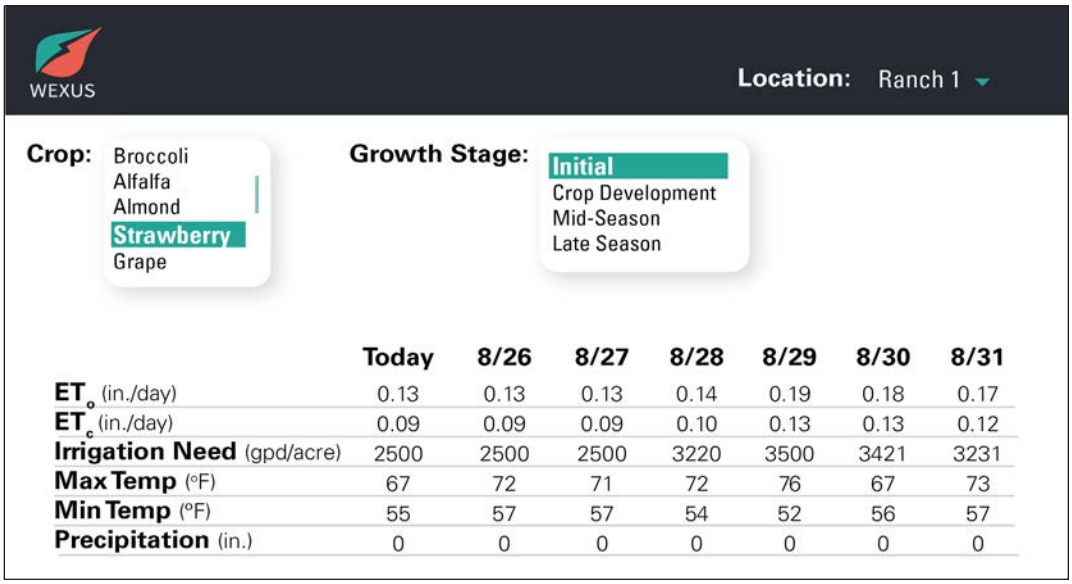
Develop a Secure Data Platform

In partnership with Microsoft Corporation Inc., and in consultation with the UC Davis Office of the Chief Information Officer and the College of Engineering IT Department, CWEE is in the process of creating a cloud-based data privacy and security platform that meets the strict requirements of the National Institute of Standards and Technology (NIST). The platform will enable CWEE to obtain private data, such as customer level electricity data, for research. This is the first step in developing a trusted data platform for sharing utility data.

CWEE and IT staff discussing secure data platform.

Complete Project on Agricultural Water-Energy Optimization for California's Farms

The Center will be wrapping up a California Energy Commission (CEC) and Wexus Technologies project this year. The goal of the project is to tailor water-energy optimization to specific California farms by: 1) creating a network map of the agricultural irrigation distribution system for each grower that would generate a GIS map of energy intensity (EI) for specific farm zones; 2) inform growers of optimum crop irrigation by integrating a common methodology into the existing Wexus app that factors in evapotranspiration, rainfall, crop type, and growth stage; and 3) design data visualizations and a benchmarking tool to communicate to growers their efficiency compared to other similar farms.



	Today	8/26	8/27	8/28	8/29	8/30	8/31
ET_o (in./day)	0.13	0.13	0.13	0.14	0.19	0.18	0.17
ET_c (in./day)	0.09	0.09	0.09	0.10	0.13	0.13	0.12
Irrigation Need (gpd/acre)	2500	2500	2500	3220	3500	3421	3231
Max Temp (°F)	67	72	71	72	76	67	73
Min Temp (°F)	55	57	57	54	52	56	57
Precipitation (in.)	0	0	0	0	0	0	0

Prototype integration of predictive irrigation estimates based on evaportranspiration, rainfall, crop type, and growth stage into the Wexus Technologies app as an interactive portal for farmers.

Increase Winery Water-Energy Savings

The California Energy Commission (CEC) is sponsoring a project at the Center to test the water-energy efficiency of two technologies on-site at Jackson Family Wines in Sonoma County. The proposed technology demonstration and deployment project will integrate two efficient technologies: (1) reverse osmosis water treatment to treat wine barrel wash water to potable standards; and (2) wine-to-wine heat exchangers to both heat and cool the wine as needed to stabilize and prevent crystallization of white wine. Widespread adoption of indoor water reuse in the commercial and industrial sector has proved challenging largely due to the permit requirements in California. This project aims to increase widespread acceptance of indoor water reuse in the food and beverage industry by highlighting technology benefits and publicizing effective strategies for designing and navigating the challenging permitting process.

> **"The Center aims to increase widespread acceptance of indoor water reuse in the food and beverage industry by highlighting technology benefits and publicizing effective strategies for designing and navigating the challenging permitting process."**

Broader Context: Key Challenges

- **Water and Energy data security** to ensure compliance withstate and federal regulations on customer data while also allowing researchers and utilities to share data to conduct research and inform sustainable water policy.
- **Groundwater extraction estimates using energy data** in order to sustain California's agriculture, economy, drought resilience, and infrastructure (e.g. curtailing subsistence).
- **Solutions for water utilities to participate and manage energy resources** based on demand response events and to optimize resource distribution in order to reduce greenhouse gas emissions.

Total Annual Savings	
Fresh Water	> 1.4 MG fresh water
Electricity	~ 246,000 kWh
Natural Gas	~ 28,000 therms
GHG Emission	~ 504,000 lbs CO_2e
Cost*	$ 54,418

*Energy utility cost savings

Projected annual savings at wine making facility with the implementation of indoor water reuse technologies.

UPDATE: PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER

The Plug-in Hybrid & Electric Vehicle (PH&EV) Research Center collaborates closely with California utilities, the Electric Power Research Institute, automakers, and other research institutions on research aimed at developing a sustainable market for plug-in vehicles. In 2016, the PH&EV Research Center continued its multi-year longitudinal research program called "Rollout and Ramp-up" which is designed to advise plug-in electric vehicle (PEV) market stakeholders. This program has major funding from the California Energy Commission, U.S. DOE, California Air Resources Board and added support from PG&E, SMUD, SDG&E, BMW, Subaru, Audi, Toyota, Alliance of Automobile Manufacturers, ChargePoint and EV Go. The primary research emphases continue to be consumer awareness and behavior, and market development and understanding.

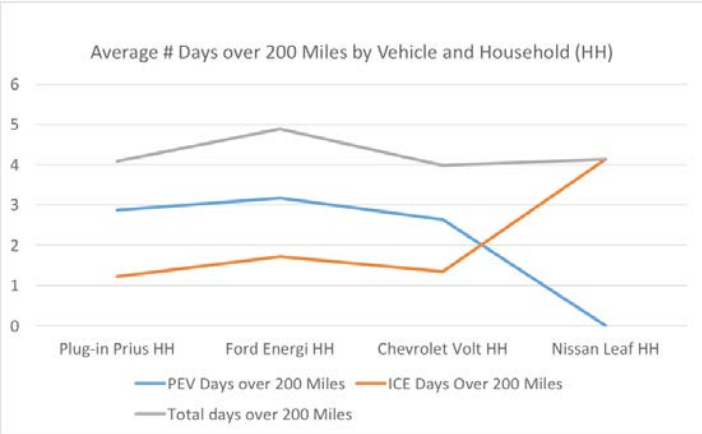
Key Accomplishments 2016

Conducted Research to Investigate Whether Commuters can Combat the Duck Curve with Plug-in Electric Vehicles

PH&EV Center researchers built a rule-based model and conducted scenario analysis to evaluate the potential benefits of workplace charging for vehicle-grid integration (VGI) in a solar-heavy generation future. The scenario analysis simulates temporal distribution of charging demand under different workplace charging strategies for plug-in electric vehicles (PEVs). Researchers found that if all commuters in California drove a plug-in hybrid vehicle with 40 miles all electric range, 85% of projected additional energy produced by solar generation could be used to cleanly power travel. Similarly, if all commuters drove a battery electric vehicle (BEV) with 100 miles range, 96% of the additional energy could be used. Results were published by the 2016 Transportation Research Board.

Advanced Plug-in Electric Vehicle Travel and Charging Behavior Research

Researchers continued work on this on-going project to study real-world PEV use in the context of total household travel behavior through the use of surveys, data loggers, and interviews. There are currently 6 models being monitored, the Plug-in Prius, Ford C-max Energi and Fusion Energi, Chevrolet Volt, Nissan Leaf, BMW i3 REx, and Tesla Model S. Monitors are placed in participants' Plug-in vehicles for a year, along with their gasoline vehicles. This enables comparisons within the household and across models. A unique feature of this research is the ability to gather infrequent long distance trips which have a bearing on purchase behavior and infrastructure need. In examining the data, researchers found that on average households are similar in their long-distance travel, but all travel is shifted to the gasoline vehicles in Leaf households. The Leaf is a battery only vehicle, whereas the others are PHEVs with a backup engine.



This figure shows the average number of days households traveled over 200 miles in a day and which vehicle was chosen.

> **"A unique feature of the Center's research is the ability to gather infrequent long distance trips which have a bearing on purchase behavior and infrastructure need."**

Developed an EV Infrastructure Toolbox

Researchers developed a Geographical Information Systems (GIS) based toolbox that uses PEV market and use data to estimate public charging infrastructure needs under a variety of circumstances. Importantly, the toolbox allows users to personalize the assumptions and analysis for their region. The tool was developed with funding from the California Energy Commission, aimed at Municipal Planning Organizations and others as the users, and has continued to undergo continued updates.

Kicked Off a Project to Understand PEV Markets around the World

The PH&EV Research Center kicked off a project, funded by ClimateWorks, to work collaboratively with international researchers to understand PEV markets around the world. In 2016, the Center held three workshops with our collaborators to focus on understanding the impacts of policy and regulations, financial and non-financial incentives, electricity and infrastructure, and consumer awareness on the market growth. Collaborators are all researchers with insightful data sets interested in working together to create policy briefs on each of these topics. The final briefs and an in-depth research report will be completed in 2017.

Tom Turrentine, Director of the PH&EV Research Center, at the initial international workshop in Gothenberg, Sweden to understand PEV markets around the world.

Conducted Projects to Create Community and Promote Green Behavior in West Village and UC Davis

Housed at the PH&EV Center, the Consumer Energy Interfaces Lab (cEnergi) is wrapping up projects that are geared toward creating community and promoting green behavior in West Village and UC Davis. Specifically, the team is finishing an energy dashboard for West Village research centers; a hardware/software system, the likes of which would cost tens of thousands of dollars if purchased from a commercial vendor. cEnergi is also completing a new online flight search tool that highlights carbon emissions information, nudging air travelers toward greener flights. The team plans to pitch this tool to various departments on campus to help raise awareness of travel behavior in the context of campus carbon neutrality goals.

“cEnergi is wrapping up an energy dashboard for West Village research centers; a hardware/software system, the likes of which would cost tens of thousands of dollars if purchased from a commercial vendor.”

UC Davis West Village.

Homeowner charging plug-in electric vehicle.

Key Projects 2017

Advance Plug-In Electric Vehicle Travel and Charging Behavior

The Center is studying real-world travel and charging behavior through on-board vehicle data collection of PEV owning households throughout California. Data collection for this project started in 2015 and will continue through 2018, with an expanding number of PEV vehicle types and households in the project. The result will be a better understanding of the role plug-in vehicles play in the context of a complete household, including the time and location of fuel and electricity use, on-road efficiency, and travel trends.

Bring a Behavioral Perspective to Key Energy and Water Research Projects

cEnergi postdoc, Angela Sanguinetti, is collaborating with the Western Cooling Efficiency Center (WCEC) and the Center for Water-Energy Efficiency (CWEE), bringing a behavioral perspective to projects involving consumer feedback on energy and water consumption. For example, with CWEE and WaterSmart, in a project funded by Department of Water Resources, Sanguinetti is investigating the impact of home water reports on not only water efficiency, but also the potential for behavioral spillover into energy efficiency. Sanguinetti is also assisting with behavioral research aspects of four WCEC projects, including consumer adoption and user research for new cattle cooling technologies; survey research to inform battery storage system design for The Sustainable City in Dubai; impact assessment for integrated demand side management retrofits in low income multifamily housing, and survey research to determine teachers' experiences and needs in terms of HVAC retrofits in K-12 schools.

Continue PEV Market Analyses

The PH&EV Center works with a broad array of collaborators to conduct ongoing analysis of the growth of the PEV Market in the U.S. and internationally. Researchers use consumer surveys and sales data to conduct analyses. Partners for 2017 include BMW, Audi, Subaru, CEC, CARB, and ClimateWorks. This broad area of research includes international collaborations and policy briefs which will be released in 2017.

Broader Context: Key Challenges

- **Continuing growth of the PEV Market in a rapidly changing environment**. The past six years have brought many changes to the plug-in vehicles market. The challenge will be to continue to measure and understand the new generation of PEV buyers, changing policies and vehicle offerings – particularly the impact of long-range battery electric vehicles.
- **Integration of Electric Vehicle technologies with shared and autonomous technologies**. Research is critical to understand how these technologies and use-cases can work together to allow consumers to achieve clean, affordable, and reliable transportation needs.
- **Understanding the impact of electricity pricing of purchase and use through smart charging.** Utility rates are not competitive with gasoline in many cases. Lower utility rates are possible with smart charging with a promise of expanding the market.
- **The business model for charging infrastructure remains challenging**. Infrastructure is fairly expensive with little chance of return on investment in many cases for a site host.
- **Consumer education on plug-in vehicles remains a challenge.** Many consumers do not consider a plug-in vehicle simply because they do not know about them.

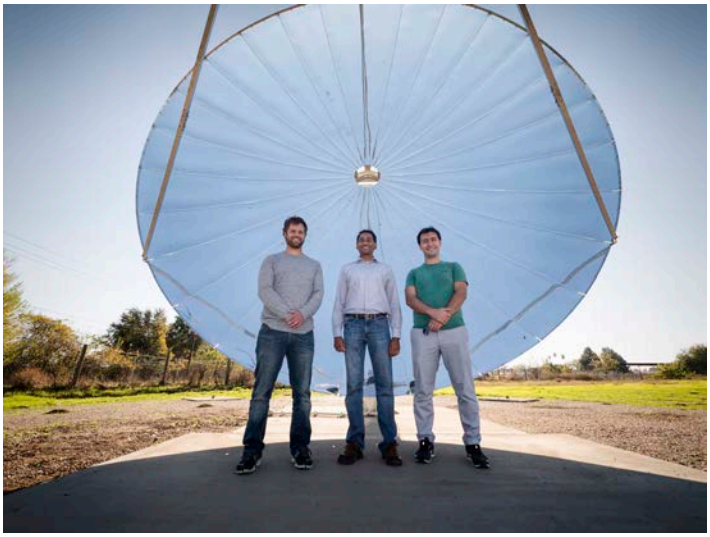
UPDATE: WESTERN COOLING EFFICIENCY CENTER

The Western Cooling Efficiency Center (WCEC) accelerates development and commercialization of efficient heating, cooling, and energy distribution solutions through stakeholder engagement, innovation, R&D, education and outreach. WCEC is comprised of 13 full-time professional engineers, a behavioral scientist, and support staff working on 15 different projects for a variety of stakeholders, including the Department of Defense, the California Energy Commission, and the major utilities. Our research successes and innovations are owed largely to the cooperative interests and combined efforts of our valued network of industry partners, collaborators, and research sponsors. WCEC is proud to be a part of this movement to advance a more sustainable energy efficient future.

Key Accomplishments 2016

Advanced Heat Exchangers

WCEC is developing the next generation of solar thermal receivers. These new solar thermal receivers, combined with smaller turbines designed to use sCO_2, take up much less space and generate more overall electricity than traditional receivers—absorbing and transporting 100W per cm^2. Traditional receivers can only absorb up to 60W per cm^2, and the turbines used in combination with traditional receivers are larger and have larger energy losses. These new microscale thermal receivers/heat exchangers are created using a 3-D printed additive production process, and the Center is researching a variety of applications for this new technology including: exhaust heat energy recovery in large industrial processes and gas turbine applications such as large naval ships. In Phase I of the project, researchers examined thermal characterization of flow through the microscale passages of the receiver. In Phase II, UC Davis will characterize the performance of a 20 kW microchannel receiver on the newly commissioned 7-meter parabolic solar dish.



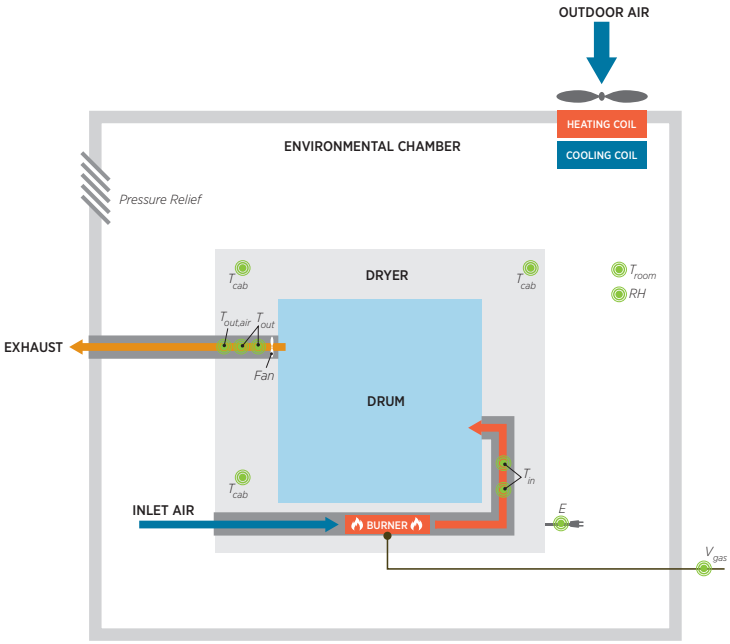
WCEC's Solar Thermal Receiver Team in front of the newly commissioned 7-meter solar dish at UC Davis.

Created CEC Training Videos

California is the energy efficiency leader in the U.S., and much of that success is due to policy decisions that promote deep energy savings through efficient building practices and building standards. Pushing for more aggressive energy savings requires that building standards be revised frequently. While this can promote new, energy efficient building practices, it also leads to confusion for those who must stay informed of the latest requirements including plans examiners, building inspectors, contractors, and builders. To provide another avenue to obtain information on the latest standards, the California Energy Commission (CEC) funded WCEC to create video-based courses that cover the 2016 Building Energy Efficiency Standards for residential HVAC systems. WCEC has completed a 9-course training module for residential HVAC standards, and has been re-contracted by the CEC to create more courses for commercial HVAC standards.

Developed Technology for Energy Efficient Clothes Dryers

WCEC, funded by the California Energy Commission's Energy Innovation Small Grant Program, developed an automatic dryer cycle termination controller that utilized the relationship between dryer drum inlet temperatures and outlet temperatures to accurately predict the end of the drying cycle. The technology promises to be more accurate and robust in performance under different load and environmental conditions in comparison to existing technology. The low-cost automatic controller was demonstrated in the laboratory to reduce energy use in gas clothes dryers by accurately terminating the drying cycle. In addition, researchers found that information obtained in the drying cycle can be used to predict real-time energy efficiency metrics to track dryer performance over time as a means for fault detection and to provide information to the consumer. Download WCEC's Case Study on this technology: bit.ly/dryercasestudy.



Experimental environment chamber design for the clothes dryer project.

> **We want to start creating best practices for this industry [indoor cannabis farms] as it develops… It's hard to retrofit after the fact. It's better to build it right the first time. There are solutions out there if one goes looking.**
>
> **–Theresa Pistochini, Engineering Manager WCEC**

Conducted Laboratory Testing of an Energy Efficient Dehumidifier for Indoor Farms

Indoor farming operations do not require the typical ratio of sensible cooling (which maintains air temperature) and latent cooling (which maintains humidity levels) required for residential or commercial buildings. In order to meet these specialized requirements, dehumidification systems are often necessary. Traditional dehumidification systems provide dehumidification and increase the air temperature, as opposed to the desired dehumidification and reduction of air temperature. An alternative is MSP Technology's dehumidification system that uses a plate air-to-air heat exchanger and a cooling coil that is part of a split compressor-based refrigeration system. This process results in a ratio of sensible to latent cooling that is well suited for indoor farming applications. Through a project funded by Xcel Energy, WCEC conducted experimental laboratory testing and numerical modeling to estimate the annual energy savings produced by using MSP Technology's dehumidification system over a traditional dehumidification system. Researchers found that implementation of MSP Technology's system has the potential to save 30% or more of the energy used for dehumidification and cooling in indoor farming applications. Download the Case Study: http://bit.ly/mspcasestudy.

Advanced Development of Next-Generation Residential Space-Conditioning Systems

WCEC is working on a project, funded by the California Energy Commission and led by the Electric Power Research Institute (EPRI), to integrate several advanced technologies available world-wide or in the RD&D phase into a single space-conditioning system for residential buildings that is cost-effectively optimized for California's climatic conditions. The full project team will evaluate several technologies, including automated demand response, alternative refrigerants, and heat recovery ventilators. The WCEC is under subcontract to EPRI to specifically test the performance of a variable speed heat pump system connected to typical ductwork that is located outside of the conditioned space. Through lab testing, researchers are measuring the performance of the duct system and determining appropriate strategies for controlling variable speed equipment based upon the overall system performance.

Building the test apparatus for next-generation residential space conditioning systems.

Key Projects 2017

Improve Water & Energy Efficiency in California's Dairy Industry

Heat stress remains a major cause of diminished milk production and increased disease among lactating dairy cows, with annual losses directly related to heat stress exceeding $800 million. Current methods to reduce thermal stress on cows require significant amounts of energy and water and the resulting hot, moist environment promotes bacterial growth, posing a hazard to the health of the livestock. More importantly, the current approaches consume significant amounts of water since the application of water is imprecise and wets the general area. WCEC will demonstrate two novel approaches, relative to the current practice, of cooling livestock. In the first approach, conduction cooling (CC), researchers will cool the bedding area beneath the cow using heat exchange mats embedded in the soil. To reduce energy consumption, water flowing through the heat exchange mats will be chilled using a novel Sub-Wet Bulb Evaporative Chiller. In the second approach, targeted convection cooling, researchers will use fabric ducting to direct cool air on the cows. The air will be cooled using a high-efficiency direct evaporative cooler. Both of these approaches promise significant water and energy savings compared to standard practices (28-38% reduced energy and 73-86% reduced water consumption).

Develop Energy Efficient HVAC Packages for Existing Residential Buildings

New standards, building practices, and advanced technologies have significantly improved the energy efficiency and safety of homes in California. Existing homes, however, which make up the majority of the residential building stock, are left behind with underperforming equipment. One major shortcoming of older homes is the reliance on leaks in the building shell to provide ventilation for the occupants. Not controlling the source and amount of ventilation air in a home has been demonstrated to not only promote unhealthy conditions for the occupants, but also introduces additional conditioning loads that the heating and cooling equipment must remove. Sealing the leaks in the building shell and implementing smarter ventilation strategies improves conditions for the occupants and reduces cooling energy use and peak demand which allows for downsized air conditioning equipment for the home. In 2017, the WCEC will begin to address these challenges by developing energy efficient HVAC packages for existing residential buildings.

Conduct Project on Market Facilitation of Energy Efficient HVAC Technologies

Much of the behavioral work on HVAC technology adoption focuses on customers, to the exclusion of other critical stakeholders. However, if the middlemen - e.g., distributors, contractors – do not adopt efficient technologies, the question of customer adoption is moot. This study, funded by Southern California Edison, aims to fill that gap – and look beyond the issue of high costs - by targeting

WCEC will demonstrate two novel approaches to cooling livestock.

the myriad barriers to adoption faced by a range of stakeholders. Previous research conducted by WCEC identified key behavioral barriers to the adoption of energy efficient technologies for distributors/contractors, and those findings are the basis for this new project. This project looks to alleviate some of these barriers by creating informational videos on new technologies using interviews and information from building owners, designers and planners that already use these new technologies.

Identify Ventilation Solutions for Energy Efficient California Schools

In 2013, the implementation the California Clean Energy Jobs Act (Proposition 39) allocated approximately $550 million annually to improve energy efficiency and expand clean energy generation in schools. There is anecdotal evidence that the HVAC retrofits being done through this program are not utilizing advanced HVAC technologies that have the potential to increase energy efficiency and indoor environmental quality over minimally code-compliant systems. WCEC's proposed research will demonstrate the technical performance and marketability of selected advanced HVAC technologies to facilitate increased adoption in California schools. This project will survey the energy efficiency and ventilation characteristics of recent HVAC retrofits in schools, field test the technical performance of advanced HVAC systems designed to deliver improved ventilation and energy efficiency, estimate the potential environmental and health impacts of technology diffusion, and identify ways to address market barriers that currently impede broader market adoption.

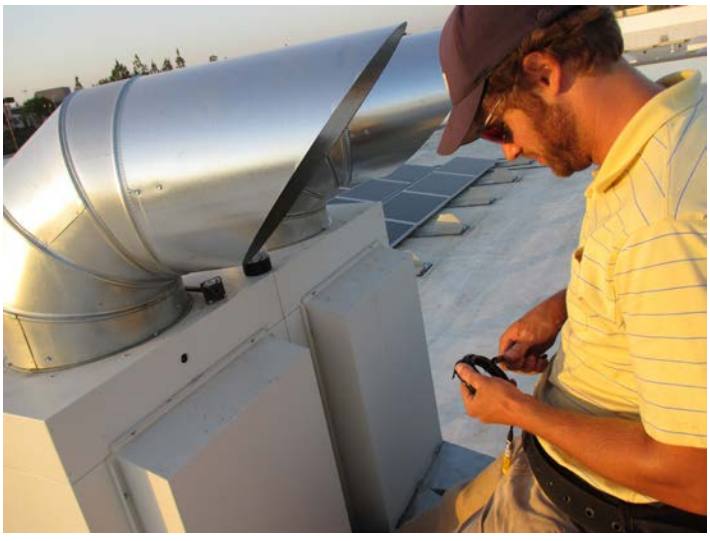
Develop Cost-Constrained Optimization of Energy Efficiency for Multifamily and Commercial Buildings

Although the technical feasibility of achieving zero net energy (ZNE) in many building types in California has been well documented, the optimal strategy for achieving the highest percentage of ZNE that is cost-effective remains unclear. The number of building types and technologies are too numerous to answer these questions through field studies. Instead, WCEC will use whole building simulations to determine the best path to achieving California's ZNE goals, which could then, in principle, be validated through field studies. With the assistance of EPRI and BIRAEnergy, the WCEC will use EnergyPlus to model technologies for reducing net electricity consumption and demand in multi-family residential and commercial buildings. Researchers will conduct simulations in each of California's 16 climate zones. They will then use simulation results in a cost-benefit analysis to determine the maximum percent of ZNE that can be cost effectively achieved in each building type and climate zone.

Broader Context: Key Challenges

- **Barriers to market adoption of energy efficient technologies:** The HVAC industry is a slow moving, risk-adverse industry: All along the entire supply chain—from distributor, retailer, contractor to customer—there are long held behavioral biases based on specific motivations of each stakeholder that must be resolved so energy efficient technologies can gain more traction in the marketplace. http://www.etcc-ca.com/sites/default/files/reports/et14sce7060_market_barriers_to_hvac_retrofit_technologies_final.pdf
- **Concern regarding water consumption of evaporative cooling technologies:** In order to fully quantify the energy and water use impacts of cooling equipment, it is important to quantify the relationship between water and energy. A WCEC analysis shows that evaporative technologies still "make sense" in California even when an energy intensive desalination process is used to generate water. See our webinar: http://wcec.ucdavis.edu/resources/webinars/
- **Complexity of forecasting and verifying energy efficiency savings:** Energy savings from HVAC technologies are affected by many variables including indoor building loads and ventilation rates, outdoor weather, building construction, and control strategies for the HVAC equipment. Therefore, testing and modeling of HVAC technologies is a complex process that involves laboratory testing, field testing, and building energy modeling. This challenge increases the time and resources required to move a technology from concept to widespread deployment.

> **"Every $1 invested in creating water through desalination can yield $1.20-$25 in electricity cost savings using evaporative technologies."**
>
> **–Mark Modera, Director, Western Cooling Efficiency Center**



WCEC will identify ventilation solutions for California schools.

GLOBAL IMPACT EFFORTS

UPDATE: CHINA CENTER FOR ENERGY AND TRANSPORTATION

The China Center for Energy and Transportation (C-CET) is the leading international center for the study of transportation energy activities in China, and the only center of its kind in North America. Established by the UC Davis Institute of Transportation Studies (ITS-Davis) in partnership with leading Chinese universities, C-CET leverages the breadth of knowledge across institutions to create a unique hub focused on China's rapidly evolving transportation energy sector. C-CET brings together ITS-Davis' network of leading international analysts and scholars and China's leading scholars to provide fundamental understandings through original, independent analysis and joint U.S.-China research.

Key Accomplishments 2016

Advanced Collaborations as part of the China-U.S. ZEV Policy Lab

Established through a five-year Memorandum of Understanding (MOU) signed in China in September 2014, the China-U.S. ZEV Policy Lab represents a global milestone in international collaboration on clean vehicles development. The MOU focuses on joint research and cooperation between UC Davis and the China Automotive Technology and Research Center (CATARC), the administrative body that oversees and regulates many activities of the auto industry in China. The collaboration will help expand the global market for zero emission vehicles (ZEVs) by providing intellectual support for design of ZEV policies and analysis of consumer markets, including demand for charging stations, different types of ZEV technologies, and effectiveness of incentives. This past year researchers:

- Held a roundtable discussion with key representatives from UC Davis, the California Air Resources Board, EV100, and the Ministry of Industry and Information Technology.
- Hosted officials from China's R& D program on ZEVs, the China-U.S. Clean Vehicle Center, and EV100.
- Held workshops in the U.S. and China to share best practices and further collaborative research and policy practices.
- Published papers in Chinese & English on the Chinese PEV market.

> **"The United States and China are the world's largest automobile markets and oil consumers, both importing more than half the oil they consume. Over the long-term, much of the energy-consuming infrastructure of the 21st century, including future vehicle fleets, has yet to be built and therefore will benefit from accelerated development of clean vehicle technologies."**

Officials from China's R& D program on ZEVs, the China-U.S. Clean Vehicle Center, and EV100 visited UC Davis in August 2016.

> **"It's a great honor for us to be invited to partner with the CERC-Clean Vehicles Consortium. It reinforces the value of our UC Davis research, in particular, and of California's policy practices, in general."**
>
> **–Dan Sperling, Founding Director, Institute of Transportation Studies**

Invited to Join the U.S.-China Clean Energy Research Center Clean Vehicles Consortium

C-CET was invited to join the U.S.-China Clean Energy Research Center (CERC) Clean Vehicles Consortium, a research program sponsored by the Ministry of Science and Technology of China and the U.S. Department of Energy. The CERC-Clean Vehicles Consortium seeks to contribute to dramatic improvements in technologies with the potential to reduce the dependence of vehicles on oil and reduce emissions of greenhouse gases. It aims to build a foundation of knowledge, technologies, human capabilities, and relationships in mutually beneficial areas that will position the United States and China for a future with highly efficient clean vehicles that have very low environmental impacts. C-CET is conducting research focused on consumer behavior and efficient vehicle marketability.

C-CET will continue its research on PEV consumer behavior.

Key Projects 2017

Advance Research focused on Consumer Behavior and Efficient Vehicle Marketability

As part of its work on the CERC-Clean Vehicles Consortium, C-CET will continue its research on PEV consumer behavior by conducting large-scale surveys, focus groups, and interviews.

Continue to Facilitate Discussions and Provide Technical Support through the China-U.S. ZEV Policy Lab

C-CET will host a meeting with key stakeholders of the China-U.S. ZEV Policy Lab in Pacific Grove, California, in conjunction with the UC Davis Institute of Transportation Studies (ITS-Davis) Biennial Asilomar Conference. In addition, C-CET will provide training for Chinese officials and OEM executives.

Partner with Energy Foundation China

C-CET is exploring opportunities to work with Energy Foundation China, a grant-making charity organization dedicated to China's sustainable energy development, on its Sustainable Cities Program and Green Freight Initiative.

UPDATE: INDIA INITIATIVE

The India Initiative is an early stage initiative to develop an engagement platform that enhances UC Davis' collaboration with energy related activities in India. India will be a key player in shaping the world energy agenda due to its rapid economic development, urbanization, and increased access to services, in combination with its sheer size, opportunity, and human capital. While a number of small research collaborations are currently in place with entities in India, UC Davis, through the India Initiative, now has an opportunity to develop a focused and impact-driven engagement with India to advance solutions to global energy challenges.

Key Accomplishments 2016

Established a Strong Foundation

In 2016, EEC helped begin the process of launching a non-profit in India (referred hereafter as the "sister" center) to serve as a gateway platform for engagement in India. The EEC, along with the board of the sister center, are currently working with the Government of Andhra Pradesh, a south Indian State, to receive land allocation and funding to establish the sister center. To date, the sister center has been formally registered and is currently working on establishing a brick and mortar (physical) presence. The EEC is actively working to establish a governing and organizational structure for the sister center to best engage with a diversity of partners in the U.S. and globally. The sister center is in the process of establishing MOUs with a number of local colleges, universities, think tanks, and industry partners.

Key Projects 2017

Host a 2017 Summer Energy Academy

The sister center in collaboration with the Leadership Foundation, a local non-profit focused on developing future leaders in India, and institutional support from the EEC will host a summer academy for underprivileged local college students that lack the opportunity for experiential, real-world training in the field of sustainability. The two-week program will feature lectures from local educators and industry professionals, as well as students and staff from UC Davis and UC Irvine. The students attending the summer academy will receive in class training and be given an opportunity to apply their skills to specific issues in the local community.

Host a Sustainability Strategy Workshop

The sister center will host a three-day workshop in the city of Visakhapatnam (Vizag), a rapidly developing and upcoming local economy in India. The workshop will be facilitated by Dr. Mojahan Sami of UC Irvine and is expected to be attended by 25-30 Indian non-profits, representing a diversity of geographic locations and focal areas. These non-profits are developing and implementing solutions to address sustainability and challenges related to the food-water-energy nexus in India. The goal of this event is to develop a needs and opportunities assessment for India Initiatives to better strategize future efforts of the EEC.

> **"Just three countries—India, China, and Nigeria—are expected to account for 37% of the wold's urban population growth between 2014 and 2050, with India projected to add the most urban dwellers. Rapid population growth and urbanization will have a dramatic effect on the increased demand for jobs, housing, energy, clean water, food, transportation infrastructure, and social services. It will also be a significant factor in addressing climate change."**
>
> **–United Nations World Urbanization Prospects**

Organize a California State Leadership Visit

The EEC is currently working with the California Energy Commission to organize a visit with California State leadership, which could include Governor Brown, commissioners of the California Energy Commission, etc., to further the Subnational Global Climate Leadership Memorandum of Understanding (Under2MOU). The EEC, with support from the sister center and the Government of Andra Pradesh in South India, hopes to advance subnational leadership in India related to the Under2MOU.

> **The India Initiative is an early stage initiative to develop an engagement platform that enhances UC Davis' collaboration with energy related activities in India.**

Siva Gunda, Director of Research and the India Initiative for the EEC, delivering a guest lecture in India.

UPDATE: MANDELA WASHINGTON FELLOWSHIP

The Mandela Washington Fellowship for Young African Leaders is a U.S. State Department initiative that brings approximately 1,000 young professionals from sub-Saharan Africa to colleges and universities across the U.S. for six weeks to hone their skills and participate in various professional development opportunities. In 2016 the State Department chose UC Davis to host the first cohort of Fellows with a specific emphasis on energy professionals. Given the success of this energy pilot program, and the enthusiasm the Fellows showed for their time here, the State Department has chosen UC Davis to host a new group of energy-focused Fellows in 2017.

> **"The Energy Efficiency Center aims to provide training and professional development opportunities for Mandela Washington Fellows working in the energy field so that they can expand energy services and reliability to reach the 70% of Africans who live without electricity."**

Key Accomplishments 2016

Attended Energy-Focused Academic Sessions at UC Davis

From mid-June through late July 2016, faculty, researchers, staff, and students across UC Davis worked with 25 Fellows, who hailed from 20 countries across sub-Saharan Africa. Fellows attended academic sessions led by professors in Biological and Agricultural Engineering; the Graduate School of Management; the Department of Land, Air, and Water Resources; and the Department of Environmental Science and Policy, among others. Researchers and staff from the Energy Efficiency Center, Western Cooling Efficiency Center, Center for Water-Energy Efficiency, Plug-in Hybrid & Electric Vehicle Research Center, and the Program for International Energy Technologies met with the Fellows to discuss their work.

Fellows learning about the Honda Smart Home with project manager Michael Koenig.

Fellows touring the California Independent Systems Operator facility.

Participated in Unique Regional Energy Opportunities

In addition to gaining knowledge from, and interacting with, UC Davis experts, the Fellows also had the opportunity to meet others in the region working in the energy field. The group traveled to the California Independent Systems Operator in Folsom to see firsthand how the state manages the flow of electricity and how it forecasts supply and demand. The group also traveled to Berkeley to visit Lawrence Berkeley National Lab and a few Bay Area-based energy start up companies. The Fellows also spent a day in Sacramento to meet with state energy policymakers at the California Energy Commission and the Governor's Office, and had the opportunity to be introduced on the floor of the State Assembly. On campus, the Fellows toured the university's bio-digester, its 16.3 megawatt solar power plant, Russell Ranch, and West Village.

Created Talks to Highlight their Accomplishments

Throughout the first half of their time at UC Davis, the Fellows worked on individual 'Ignite Talks' – five minute TED-style talks that highlighted their accomplishments and hopes for improving energy access and efficiency in their home countries. They received feedback on their presentations from each other and fellowship staff. Fellows presented their ideas to one another and the public and one presentation was chosen to represent the UC Davis cohort at the Presidential Summit, which brought together all 1,000 Fellows, in Washington, DC. Adele Yayra Boadzo of South Africa represented UC Davis and spoke of her clean energy activism and solar entrepreneurship as the founder of Hope Rises Solar, an organization that trains women in solar technologies to electrify their communities.

Fellows meeting with staff from the California Energy Commission, California Public Utilties Commission, and Water Forum to learn about the various ways the state is dealing with the drought and to brainstorm methods that may be appropriate in their home countries.

Key Projects 2017

Hosting a 2017 Cohort of Mandela Washington Fellows

From mid-June through the end of July 2017, UC Davis will host the new cohort of Mandela Washington Fellows, again with a focus on young professionals working in the field of energy in the public sector. Fellows will have the opportunity to meet with many of the same individuals as th 2016 group, with a particular emphasis on those working on policy issues either from the academic, public, or private arena. In addition, the UC Davis team will work with the city of Davis to allow Fellows the opportunity to see first-hand how a municipal government makes decisions related to the city's energy infrastructure and efficiency.

The curriculum for the 2017 Mandela Washington Fellowship in Sustainably Extending Energy Services will include coverage of the following substantive areas:

- History and background of energy issues in the U.S., Africa, and beyond;
- Overview of global electricity supply, demand, distribution, and regulation;
- Challenges and opportunities in both traditional and renewable models;
- Energy efficiency, demand reduction, and storage;
- Rural electrification, distributed, and off-grid solutions;
- Decarbonization of the energy supply;
- The water-energy nexus;
- The policy and economics of energy; and
- The future beyond the grid.

> **"Fellows will leave the program with increased capabilities to affect real change in their home institutions, companies, and governments. They will gain skills around the design, evaluation, and viability of clean energy projects; approaches to challenges around the integration of renewable energy and energy efficiency strategies; and an increased understanding of innovative policy, regulatory, and entrepreneurial approaches to energy projection and distribution."**

UPDATE: UC DAVIS-MEXICO COLLABORATION

In 2014, inspired by Governor Brown's commitment to a stronger California-Mexico partnership, President Napolitano launched the UC-Mexico Initiative to bring together scholars and leaders from the University of California with those from distinguished sister institutions in Mexico to consider innovate ways to broaden and deepen connections for the benefit of all. Energy was one of the five key topics identified by the Initiative, and an Energy Working Group, led by Lawrence Berkeley National Laboratory, was established in 2015. UC Davis was tasked with leading the working group in Energy Efficiency.

> **"The purpose of the UC-Mexico Initiative is to think broadly and boldly about the complex issues that affect lives on both sides of the border, and to engage more strategically in educational and research collaborations that involve not only academia, but foundations, corporations, and governments in both the U.S. and Mexico."**

Key Accomplishments 2016

In 2015, UC Davis began focusing on opportunities to generate sustainable energy solutions in Mexico. In 2016, we explored collaborations by hosting and participating in events in Davis, San Francisco, Guadalajara, Monterrey, and Mexico City.

March 31-April 1, 2016: Convened a Mexico-California Energy Efficiency Workshop, which included 5 different University of California campuses and labs and 12 different Mexican agencies and universities.

May 4, 2016: Hosted visit with Deputy Secretary of Energy Leonardo Beltrán.

June 1, 2016: Participated in the Subnational Clean Energy Ministerial event in San Francisco. We met with the Secretary of Energy Pedro Joaquin Coldwell and also connected with Sergio Medina Gonazález, now appointed as head of Jalisco's newly formed Energy Commission.

Week of July 11, 2016: A UC Davis delegation visited regulatory agencies, laboratories, and universities working on sustainable energy in Guadalajara and Mexico City. The main focus of these visits was to explore the potential of establishing a sister lighting technology center.

August 9, 2016: Hosted dinner for Mexico's energy regulatory commission (CRE) delegation from Mexico.

Week of August 22, 2016: Visited universities in Guadalajara and Monterrey to explore partnerships, especially those regarding the establishment of a sister lighting technology center.

November 29-December 1, 2016: UC Davis participated in a collaborative workshop at Casa de la Universidad de California in Mexico City to help accelerate the transition to energy efficient buildings and cities in Mexico. The UC Davis Delegation had six participants representing efficiency opportunities in lighting, HVAC systems, water-energy efficiency, whole building energy audits and retrofits, workforce development, and plug-load efficiency.

Members of the UC Davis Delegation (Michael Siminovitch and Paul Dodd) in Mexico.

Key Projects 2017

- Launch a sister lighting technology center at a Mexican university.
- Conduct research and implement demonstrations on climate specific, cost-effective, energy efficient HVAC systems for Mexico, as well as efficient plug-load solutions.
- Leverage some of the success we have had through Prop 39 in California to help Mexico deploy energy efficiency audits and retrofits of public buildings in Mexican state and city facilities.
- Conduct a pilot research project on how to use California best practices to support municipal water utilities in Mexico to save both energy and water.
- Design and conduct train-the-trainer programs on energy efficiency technologies through a partnership with Instituto of Tecnologico de la Construccion in Mexico City. The first training session is scheduled for April 2017.
- Continue partnering with Tec de Monterrey to research ways to harmonize the energy markets between California and Mexico.
- Explore additional partnerships in other energy and energy efficiency areas related to Agriculture and Food Processing.
- Use the UC Davis Energy Graduate Group that is launching in fall 2017 to host students, post-docs, and faculty from Mexico.
- Continue to host additional delegations and events.

> **"UC Davis is the Disneyland of energy efficiency for researchers from around the world."**
>
> **- Odon de Buen, Director General, Comisión Nacional para el Uso Eficiente de la Energía, México**

Participants at the collaborative workshop at Casa de la Universidad de California in Mexico City.

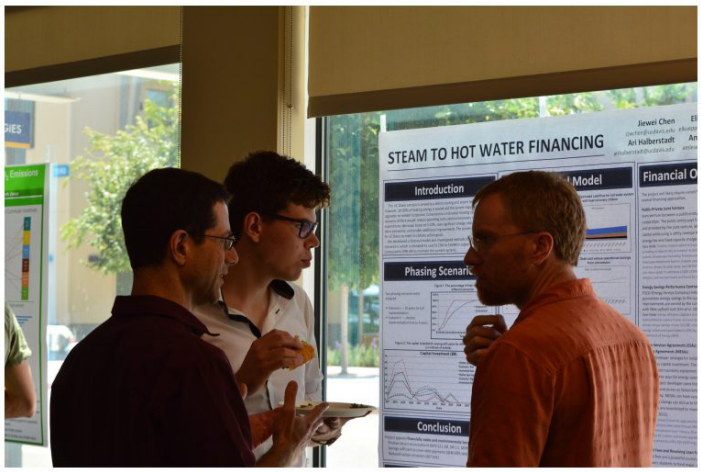
UPDATE: PROGRAM FOR INTERNATIONAL ENERGY TECHNOLOGIES AND D-LAB

The Program for International Energy Technologies (PIET) accelerates the development and commercialization of low-cost, clean, and efficient energy technologies worldwide. PIET has developed D-Lab and the Path to Zero Net Energy (PZNE) Initiative to engage students in finding solutions to energy issues in both developed and developing countries. D-Lab focuses on innovative technologies and business models that allow people at the "bottom of the pyramid" to save or earn more money. The PZNE Initiative, in partnership with the Facilities Management Energy Conservation Office, focuses on applied energy efficiency and renewable energy projects in the building and transportation sectors at UC Davis. With a focus on market-based energy solutions, multidisciplinary faculty and student teams work with clients to understand specific technical, social, environmental, and economic issues.

Key Accomplishments 2016

Completed Key Projects for Zero Net Energy Initiative

The PIET, in collaboration with the UC Davis Energy Conservation Office, developed a multidisciplinary course—A Path to Zero Net Energy: A Hands-on Approach—to educate and engage students on issues of energy use, demand, energy efficiency, renewable energy, and climate neutrality, as well as their associated technical, economic, social, and political challenges. Through lectures, field-trips, and hands-on projects, students understand the concepts behind zero net energy buildings and communities, and the associated climate and economic issues. In 2016, student teams worked on a variety of projects, including investigating financing and the potential energy savings if UC Davis switched to a hot water heating system, and evaluating the effectiveness of the Green Commuting Program at the UC Davis Sacramento Medical Center on commuting emissions reductions.



Students from the Path to Zero Net Energy class presenting their work on steam to hot water financing.

Received a Seed Grant to establish a D-Lab Satellite in Georgia

D-Lab, in collaboration with international partners, shares and disseminates curriculum and successful practices for project development with a focus on energy, climate, agriculture, and education. Through exploratory visits and short-term courses, D-Lab Satellites transfer capacity and promote project sustainability. In 2016, PIET received funding from the UC Davis College of Engineering, Global Affairs, College of Agricultural and Environmental Sciences, and Biological and Agricultural Engineering to work with the Georgian Institute for Public Affairs and the Bediani Regional Educational Center to establish a D-Lab Satellite project in Georgia. In the first phase of this project, the UC Davis D-Lab team delivered a 2-week training for rural farmers in Bediani, Georgia to build capacities around local governance and environmental protection. In the second phase of this project, team members held exploratory meetings with local stakeholders to understand local needs and identify future cooperative activities and short- and long-term collaboration mechanisms.

> **"The involvement of the UC Davis D-Lab in evaluating developed courses as a short term contribution was crucial. After the exploratory visit, we are starting to develop long-term cooperations between the two Universities. It will also introduce relevant educational, thematic curriculas essential for GIPA to modify and extend knowledge in the fields of Environmental Protection, Natural Resources Management, Rural and Agriculture Development."**
>
> **- Kakhaber Bakhtadze, Program Director, Georgia Institute of Public Affairs (GIPA)**

Kurt Kornbluth and the UC Davis D-Lab team delivering training for rural farmers in Bediani, Georgia to build capacities around local governance and environmental protection.

Established a "Dry Chain" Working Group

In 2015, UC Davis and Mars, Incorporated launched the UC Davis Innovation Institute for Food and Health to seek solutions to global issues in food, agriculture, and health. In 2016, PIET, in partnership with Colorado State University, received Institute funding to develop a "dry chain" working group. This group is investigating strategies for low energy food drying and preservation with the goal of enhancing food security and energy savings.

Key Projects 2017

Continue Core Class *A Path to Climate Neutrality: A Hands-on Approach*

PIET, in collaboration with the UC Davis Energy Conservation Office, will continue to offer the class *A Path to Climate Neutrality: A Hands-on Approach*. Instructors provide a brief overview of energy use in the U.S. and the world, as well as current trends and innovations for Zero Net Energy in the commercial, residential, and transportation sectors. Students will engage in weekly participatory labs and lectures, listen to guest speakers, and make field trips, all designed to promote a further depth of understanding with regards to specific energy issues. Multidisciplinary student focus group teams will be formed, working for an actual client and projects that will inform on-going efforts on energy and climate issues. Teams will present their findings and recommendations to a review panel for feedback.

> **"PIET, in collaboration with the UC Davis Energy Conservation Office, offers a unique multi-disciplinary course to educate and engage students in issues of energy use, demand, energy efficiency, renewable energy and climate neutrality, as well as their associated technical, economic, social, and political challenges."**

Investigate Strategies for Food Drying and Preservation

In 2017, PIET will continue its partnership with Colorado State University to investigate strategies for food drying and preservation with the goal of enhancing food security and energy savings. The working group will officially be launched in May when the UC Davis Innovation Institute for Food and Health holds its first conference focusing on high efficiency food processing.

Advance Collaboration with D-Lab Satellite in Georgia

PIET will continue its work with Georgia to identify and implement key activities that build capacities around local governance and environmental protection. PIET received a seed grant from Global Affairs, the College of Agricultural and Environmental Sciences, and the College of Engineering to conduct a follow-up training with Tbilisi State University.

Students working on multidisciplinary teams to address critical energy and climate issues.

COLLABORATORS

UC DAVIS MIKE AND RENEE CHILD INSTITUTE FOR INNOVATION AND ENTREPRENEURSHIP

The UC Davis Mike and Renee Child Institute for Innovation and Entrepreneurship serves as the nexus for entrepreneurship education and research—and as a springboard for entrepreneurial initiatives on the UC Davis campus. To accomplish this, the Institute brings science, engineering and business students and faculty together with experienced entrepreneurs, investors and corporate leaders in a highly collaborative environment that blends effective theory with hands-on participation and solution-driven innovation. The Institute provides researchers, MBA students and others with the necessary skills, resources and network support to turn their ideas into action. Whether for profit or for social benefit—or both—the Institute's programs enable students to envision a better world and make it a reality.

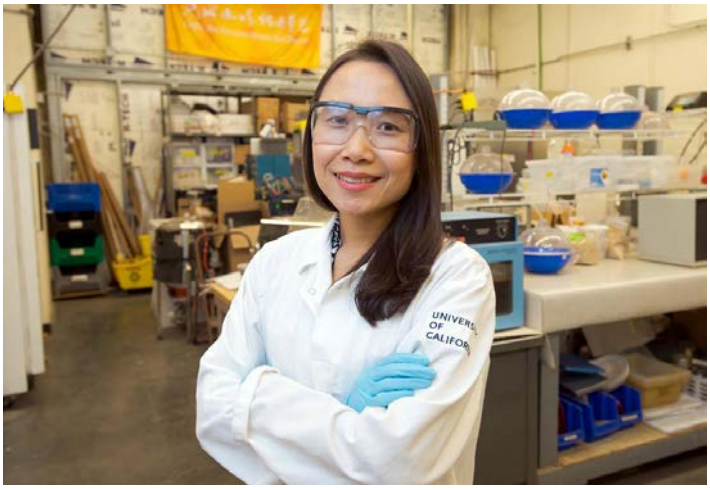
Key Accomplishments 2016

Received $400,000 Grant to Expand the Big Bang! Business Competition

The Institute received a $100,000 per year for four years grant in collaboration with California State University, Fresno, to expand the Big Bang! Business Competition down the Central Valley with a renewed focus on energy efficiency, and to make Big Bang! workshops remotely accessible as webinars. The $400,000 in funding is part of a $5 million grant the California Energy Commission awarded to the BlueTechValley Innovation Cluster, based at Fresno State. The goal: to cultivate a regional innovation cluster that incubates and supports services that dramatically accelerate the commercialization of water, energy and ag technology. This project will help connect emerging technologies to region-specific needs and opportunities in 39 counties from central to northern California.

Received $800,000 from AB 2664

In January 2017, UC Davis received $2.2 million in funding from Assembly Bill 2664, the Innovation and Entrepreneurship Expansion bill. The Institute will receive $800,000 of this funding intended to propel new innovation and entrepreneurship efforts across the University of California system. On campus, program implementation is being managed by the Office of Research and is driven by the strong collaborative relationship between Venture Catalyst and the Institute. The funds will support new and expand existing activities and programs that benefit campus innovators and entrepreneurs across disciplines, schools and colleges—with an emphasis on human health, agriculture, animal health and engineering. Beneficiaries include postdoctoral trainees, graduate students and the undergraduate community, as well as local entrepreneurs. Within this framework, the Institute will lead a novel partnership with UC Merced to create and implement a Central Valley Entrepreneurship Academy.



Business Development Fellow Natthiporn Aramrueang is a postdoctoral researcher in the Biological Systems Engineering Department at UC Davis. Her research interest is to discover and develop new methods and technology for production of renewable energy and value-added products, resource utilization and organic waste treatment.

Expanded Partnership with the National Labs

In early June 2015, nearly 50 researchers from Lawrence Livermore National Laboratory (LLNL) and Sandia National Labs (SNL) attended the first-ever National Labs Entrepreneurship Academy (NLEA) at the San Ramon campus of the UC Davis Graduate School of Management. LLNL's Industrial Partnerships Office organized the event in collaboration with Institute staff. Since then, we have conducted three additional Bay Area NLEA events serving LLNL and Sandia. The three-day academy is designed to help drive innovation at the labs by teaching lab scientists and engineers the entrepreneurial skills that will help them in the innovation process, whether they're working with industry or government sponsors, or, if they choose, becoming part of a startup based on Lab technology.

Scientists and engineers from Lawrence Livermore National Laboratory and Sandia National Labs participating in the Institute's 2016 National Labs Entrepreneurship Academy.

Kicked Off the 2016-2017 Big Bang! Business Competition

The Big Bang! is the largest annual business competition in the Sacramento region and provides a year-round forum for new and early-stage startups to collaborate, develop and test business ideas. The 2016-2017 Big Bang! kicked off in October 2016 with a record-setting turnout for the opening event featuring a fireside chat with Jason Washing, director of global partnerships at Google. Last year the competition awarded nearly $50,000 in prize money. This year's growing list of prizes emphasize innovations in clean energy, food and agriculture, and biomedical and technology.

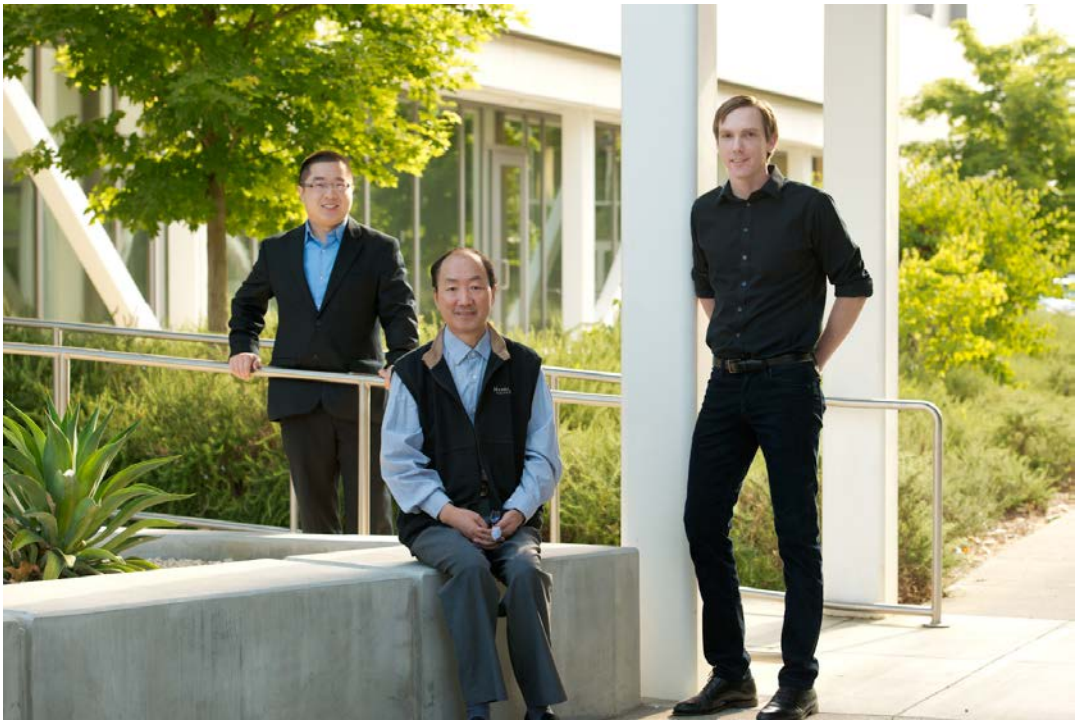
Big Bang! Competition kickoff.

"It's amazing to see how far our teams can go. In October, many of their ideas are just that: ideas. By May, with a ton of hard work, support and mentorship, many of these ideas are prime-time as companies, licensed technologies or nonprofits."

- Professor Andrew Hargadon, founder and faculty director of the Child Family Institute for Innovation and Entrepreneurship

Completed Economic Development Administration Grant

The Sustainable AgTech Innovation Center (SATIC) was funded by a $1 million grant from the U.S. Department of Commerce's Economic Development Administration's 2012 i6 Challenge: Sacramento Region Clean AgTech Innovation Center Development Project. From its launch in 2012, SATIC supported the commercialization of clean and sustainable agricultural technologies by focusing on identifying and accelerating new ventures promoting sustainability in the agricultural field — including new agricultural practices, water and energy efficiency in production and food processing, advances in nutrition, food quality and safety, and new food products. Funding provided by the EDA i6 grant provided seed funding for approximately 25 ag-related university startup ventures, enabled UC Davis and the surrounding region to host 4 ag innovation entrepreneurship academies and other special events, and fostered collaboration across the region. During the grant period, the renewed regional focus on ag innovation helped UC Davis launch both the World Food Center and the Innovation Institute for Food and Health. SATIC partnered with both entities to promote ag innovation throughout the grant period. While SATIC ceased operations with the conclusion of grant funding in December 2016, the Institute looks forward to continued collaboration with these two ag-focused UC Davis entities.



Big Bang! Business Competition finalist team Super Lithium Technology is developing a durable high-power battery for automobiles and stationary energy storage.

Key Projects 2017

Host Annual Ignite Conference

The annual Ignite conference provides MBA students and others with a chance to meet some of the most successful and up-and-coming entrepreneurs in the Bay Area. Students learn from their personal stories, successes, and failures. The intense immersion experience includes a full day of Bay Area field trips, followed by two days with thought-provoking speakers on campus. Field trip companies in 2017 include Tesla and Lyft, leaders in energy resources/transportation efficiency. Ignite is a collaboration between UC Davis Graduate School of Management and Rice University.

> **“Students learn from the personal stories of entrepreneurs working to build their companies and from the successes—and failures—of the best and brightest that the Bay Area has to offer.”**

Complete the 2016-2017 Big Bang! Business Competition

In May 2017, the top five Big Bang! finalists will give presentations at the final awards ceremony. The 1st and 2nd place winners will be announced. Audience members will vote for the People’s Choice Award winner. Besides the First, Second and People’s Choice prizes, the 2016-2017 competition will award prizes sponsored by Davis Roots, as well as a Syngas Challenge Award, a UC Davis Biomedical Innovation Award, the Gary Simon CleanTech Award and others.

Conduct a Fifth National Labs Entrepreneurship Academy

The Institute will conduct a fifth National Labs Entrepreneurship Academy, this time serving a blend of Sandia and Los Alamos National Labs employees in Santa Fe, N.M. Through the academies, the Institute brings together local and regional resources, mentors and speakers to actively cultivate the culture of innovation centered around national lab technology.

Continue Efforts to Expand the Big Bang! Business Competition and Develop a Central Valley Entrepreneurship Academy

In 2017, the Institute will advance efforts to expand the BigBang! Business Competition down the Central Valley and to make BigBang! Workshops remotely accessible as webinars. The Institute will also develop new, and expand existing, activities and programs that benefit campus innovators and entrepreneurs, including the creation and implementation of a Central Valley Entrepreneurship Academy.

UPDATE: INSTITUTE OF TRANSPORTATION STUDIES

The Institute of Transportation Studies at the University of California, Davis (ITS-Davis) is the leading university-based transportation program in the word. The Institute is renowned for its multidisciplinary approach to sustainable transportation research and education. ITS-Davis has more than 120 masters and doctoral graduate students working with 60+ faculty. Our innovative, objective research provides essential support for science-based policies and strategic business decisions. ITS-Davis teams have led critical research projects for 15+ state, national and international agencies and partnered with more than 60 companies and environmental non-profits on influential policy and industry planning initiatives.

Key Accomplishments 2016

Played a Leadership Role at the 95th Annual Transportation Research Board Meeting

In January, 30 ITS-Davis academic & research faculty and students were highly visible at the 95th annual Transportation Research Board (TRB) meeting in Washington, D.C., which attracted 12,000 transportation professionals from around the world. ITS-Davis representatives presented their research at conference sessions and workshops and presided over committee meetings. The ITS-Davis-led National Center for Sustainable Transportation hosted a Capitol Hill policy forum, Increasing the Efficiency and Economic Competitiveness of the Nation's Freight System. ITS-Davis Director Dan Sperling completed his chairmanship of TRB's Executive Committee, which oversees the board's programs and activities, engaging more than 7,000 engineers, scientists, and transportation researchers and practitioners from academia, private and public sectors, including state departments of transportation and the U.S. DOT. TRB is a major division of the National Research Council, the private, nonprofit institution that serves as the operating arm of the National Academy of Sciences and the National Academy of Engineering.

ITS-Director Dan Sperling speaking at the Transportation Research Board annual meeting in Washington, D.C.

Assisted in the Development of the California Sustainable Freight Action Plan

In May, the State of California released for review the California Sustainable Freight Action Plan (CSFAP), with ITS-Davis and National Center for Sustainable Transportation researchers contributing significantly: convening stakeholders and providing technical assistance in the development of the plan. The UC Davis team oversaw the development of two of the six white papers accompanying the CSFAP. The leaders of ITS-Davis' Sustainable Freight Initiative are Civil and Environmental Engineering Professor Miguel Jaller, a Transportation and Technology and Policy faculty member, and Sustainable Transportation Energy Pathways Co-Director Lew Fulton. Professor Jaller and researcher Fulton outlined the key points of the CSFAP, and ITS-Davis researchers' collaborations with state policymakers in producing it, in a GreenLight blog posted on the ITS-Davis website.

Commemorated our 25th Anniversary

In October, ITS-Davis hosted a two-day celebration commemorating our 25th anniversary. The premier event was a dinner gala, with more than 300 guests in attendance representing our many partners in sustainable transportation from over the years—sponsors and colleagues from industry, government, academia and non-profits. A quarter century of ITS-Davis memories and research and educational accomplishments were captured in a speech by Founding Director Dan Sperling. Professor Sperling recognized the contributions of many in the room and noted that the Institute is now "a proud, 25-year-old millennial… collaborative, connected and tech smart." The weekend events also served as a homecoming for many ITS-Davis alumni.

Several ITS-Davis graduates served on panels at the second-day symposium; the panels included graduates now prominent at Argonne National Laboratory, the International Council on Clean Transportation, the Metropolitan Transportation Commission, the California Air Resources Board, and the University of New Mexico and Portland State University.

Dinner guests toast the 25th anniversary of ITS-Davis at the October gala dinner.

Received $14 million Grant from the U.S. Department of Transportation

In December, the U.S. Department of Transportation announced its selection of the National Center for Sustainable Transportation (NCST), led by ITS-Davis, to receive a five-year grant totaling approximately $14 million ($2.8 million in the initial year) to advance a more sustainable transportation system. A six-university consortium, NCST is one of only five national transportation centers awarded under the University Transportation Centers program reauthorized by the federal Fixing America's Surface Transportation Act. It is the only national transportation center focused on environmental preservation and the only one in California. The award solidifies UC Davis' prominence as the nation's leading university on sustainable transportation.

> **"I applaud the U.S. Department of Transportation for its investment in reducing the effects of the transportation system on our natural resources, including energy, climate, air, water, and land."**
>
> **- Susan Handy, UC Davis Professor and NCST Director**

> **"Despite, or perhaps because of, the tectonic political shifts around the world, life in our corner is good. Our research on sustainable transportation is valued more than ever. It's exhilarating, demanding, challenging, and rewarding. We've come so far in the past 25 years, thanks to the many accomplishments and contributions of our faculty, researchers, students, and staff."**
>
> **- Professor Dan Sperling from his 2017 ITS-Davis Director's Letter**

Key Projects 2017

Advance the 3 Revolutions Policy Initiative

The ITS-Davis 3 Revolutions Policy Initiative had its origins last year when the Institute convened leading academic, government, private industry, and public interest stakeholders to explore solutions to steer the three transportation revolutions—shared mobility, electrification, and autonomous vehicles—toward the public interest. The 3 Revolutions Policy Initiative was launched in March 2017 with the unveiling of a website, the release of policy briefs guest-authored by leading transportation experts in six areas (climate, active travel, transit, equity, governance) and a release of a survey on the coming trends in new mobility. A priority ongoing project for the Institute, the ITS-Davis 3 Revolutions Policy Initiative will host additional events and publicize an ongoing series of policy briefs, followed by a book—with contributions from many of the 2016 conference participants. Sponsors include The 11th Hour Project of The Schmidt Family Foundation, ClimateWorks, The Pisces Foundation, and The Energy Foundation.

Host Asilomar Conference on Transportation and Energy

This August, ITS-Davis will against host the Asilomar Conference on Transportation and Energy. This is the 16th Biennial event of the leading international conference dedicated to transportation energy issues. Organized under the auspices of the Energy and Alternatives Fuels Committees of the U.S. Transportation Research Board, the 2017 conference, Transportation Innovation and Policy in a Fragmenting World, will respond to an acknowledgment highlighted at the Paris climate conference (COP21) in December 2015 that transportation, beyond vehicles and fuels, has not received enough attention. The conference will address emerging issues, including "global peak oil demand," vehicle electrification, sustainable freight, and the energy impact of shared mobility and

automated vehicles. It will also address the growing skepticism of globalization and shifting climate policies—the emerging trends, tensions and uncertainties. The conference will provide leaders and experts from industry, government, academia, and the environmental community the opportunity to explore energy and transportation strategies.

Advance the Work of Affiliated Programs/Centers

The Sustainable Transportation Energy Pathways (STEPS) program is now in its third, four-year cycle. With sponsorship from 28 major companies and government agencies, it conducts interdisciplinary research on the transition to a sustainable transportation energy future for California, the U.S. and the world. Coming this May is a major global transportation research report by STEPS Co-Director Lew Fulton, in conjunction with the Institute for Transportation and Development Policy—the third in a series of reports Fulton has done with ITDP. This research is supported by Climate Works Foundation, William and Flora Hewlett Foundation, and the Barr Foundation.

The China Center on Energy and Transportation (C-CET)—in partnership with the California Air Resources Board, and Chinese government ministries, regional governments, and major Chinese universities—facilitates information exchange and knowledge-sharing to help shape that country's rapidly evolving transportation energy sector. Researchers have played a central role in informing the design of zero emission vehicle policies in China, and we are expanding our role to other transportation challenges. C-CET is also conducting consumer behavior research under the U.S.-China Clean Vehicle Center, a major U.S. Department of Energy-funded program.

Broader Context: Key Challenges

- Understanding the opportunities, challenges and limitations in light of the **tectonic political shifts** on climate change, emissions and fuel standards, nationally and globally.
- How best to steer transportation innovations toward **equitable results** that are in the public interest.
- How best to continue to **encourage women and students of diverse backgrounds** to pursue transportation education and careers, bringing their unique insights and perspectives.

The China Center for Energy and Transportation continues to forge relationships with government and industry in China, following the signing of an MOU to establish the U.S.-China ZEV Policy Lab.

UPDATE: ENERGY & TRANSPORTATION SENIOR POLICY FELLOWSHIP PROGRAM

In 2015, the UC Davis Energy Efficiency Center, in collaboration with all of the Energy and Transportation research centers at UC Davis, launched the Senior Policy Fellowship program to increase and extend the impact of the ongoing research, education, and outreach of University faculty, staff, and students in the fields of sustainable energy, transportation, and energy efficiency. The Senior Policy Fellow, and supporting program, has provided a valuable resource for researchers working on technology development and policy analysis by advancing their efforts to inform and influence policymakers, at the local, state, and national level. The Senior Policy Fellow was supported by an informal Industry Advisory Council. The Council gave active parties in the private sector an opportunity to provide valuable feedback, and to help bring relevant research to the attention of the marketplace.

Nancy Skinner as Senior Policy Fellow

State Senator Nancy Skinner served as Senior Policy Fellow for the UC Davis energy and transportation programs from April 2015 to October 2016. Her expertise helped ensure that energy and transportation research informed and influenced policymakers at the local, state, and national level.

Key Accomplishments 2016

Participated in Leading Forums

- Skinner served on the Global Leadership Council (GCLC), the task force coordinating the University of California's systemwide Carbon Neutrality Initiative.
- Skinner secured speakers for, and served as facilitator for, the Government Leaders panel at the UC Systemwide Climate Summit held in October 2015 at UC San Diego. She also advised on content and author submissions for the University of California's Bending the Curve report.

Nancy Skinner and California State Senator Fran Pavley at the University of California's Climate Summit in October 2015.

Stakeholders and experts participating in the workshop "Using Data to Cut Building Energy & Increase Building Energy Efficiency."

Convened High-Level Workshops

- Skinner convened three workshops between April and August 2016 on key energy topics. A variety of stakeholders participated in these workshops, bringing valuable insights and stimulating energizing discussions. Summaries of these workshops are available on the EEC website: https://eec.ucdavis.edu/events/the-eec-releases-three-energy-workshop-summaries/.
- Skinner brought together energy industry leaders for a workshop on helping K-12 schools make the most of Prop 39 funding to ensure that more money goes back to classrooms rather than toward operational costs.

Facilitated Key Interactions

- Skinner facilitated key interactions between energy and transportation researchers and staff and policymakers, such as with commissioners at the California Energy Commission.
- Skinner coordinated review and comments on draft legislation, such as legislation aimed at increasing energy efficiency of commercial and residential buildings built prior to Title 24.

Spoke at Conferences and Seminars

- Skinner served as a guest instructor and advisor, and assisted with syllabus development, for a UC Davis graduate seminar Translating Research to Policy.
- Skinner spoke at a number of conferences and seminars, including the Alliance for Clean Technology Solutions, the United Nations Association Climate Symposium, and the California Association of Environmental Professionals.

About Nancy Skinner

Elected in November 2016, State Senator Skinner represents California's 9th District. A social justice advocate, energy and climate expert, and an accomplished legislator, Skinner completed three terms in the State Assembly. In the Assembly, she served as Chair of three committees: Budget, Rules, and Natural Resources. During her time in the Assembly, Skinner authored dozens of important new laws. She is a graduate of UC Berkeley with a B.S. and an M.A.

"I had a great year as Senior Policy Fellow with the Energy Efficiency Center. The Energy, Transportation, and Policy Institute research cluster at West Village is a vibrant community engaged in cutting edge and innovative research, with great potential for interfacing with and influencing the public and private sector."

- Nancy Skinner, former UC Davis Senior Policy Fellow on Energy and Transportation Policy

Nancy Skinner speaking at a conference on school energy use on April 30, 2015.

RESEARCH INITIATIVES

UPDATE: ALIGNING WORKFORCE DEVELOPMENT

Since 2014, the Energy Efficiency Center has partnered with the California Community Colleges Chancellor's Office (CCCCO) to ensure students going into the energy field are well trained, have a solid foundation in the principles and practices of efficiency, and have exposure to potential employers and career pathways. The initial project of this collaboration was a gap analysis, completed in 2015, with the assistance of the California Lighting Technology Center and the Western Cooling Efficiency Center in which researchers interviewed instructors and studied course offerings and syllabi to determine opportunities for improvement within the community college system.

> **"The California Community Colleges is the largest system of higher education in the nation, with 2.1 million students attending 113 colleges. These colleges provide students with the knowledge and background necessary to compete in today's economy."**

Key Accomplishments 2016

Hosted Community College Educators from Around the Country

In January 2016, UC Davis hosted approximately 60 community college educators from across the country attending the Building Efficiency for a Sustainable Tomorrow (BEST) Center's Annual Institute. This Institute focused on "High Performance Building Technician Education: Skills for Energy Management & Building Operations" and provided educators with the opportunity to hear about the research being done at the EEC and its affiliated Centers, with a focus on ways in which these developments will affect building operations in the coming years and decades. The group was also given the opportunity to tour the California Lighting Technology Center, Western Cooling Efficiency Center, and West Village.

Konstantinos Papamichael, Co-Director of the California Lighting Technology Center and a Professor in the Department of Design, providing a tour of their research facility.

Completed a Market Brief on the "Market Opportunities for Entry-Level Auditors"

At the end of the year, the EEC completed a Market Brief for the CCCCO on the "Market Opportunities for Entry-Level Energy Auditors." This work was inspired by the success of the California Conservation Corp's Energy Corps program through Proposition 39 and spurred by the idea that there may be an opportunity for the community colleges to train students to conduct basic building energy audits that would lead to reliable work as the state ramps up its efficiency efforts. Researchers found that it is difficult for employers to find capable energy auditors and that there is a lack of skilled auditing professionals currently in the marketplace. Those interviewed for the report generally agreed that the Community Colleges were probably best positioned to address this need. The EEC recommended a pilot training program that would infuse auditing curriculum into existing trade programs and create a new market-aligned Commercial Buildings Assessor Program.

> **"It is difficult for employers to find capable energy auditors and there is a lack of skilled auditing professionals currently in the marketplace. The Community Colleges are well-positioned to address this need."**

Stakeholders participating in the workshop "Ensuring High Performance Buildings through a Skilled Workforce."

Convened a Workshop "Ensuring High Performance Buildings through a Skilled Workforce"

In August 2016, the EEC convened a workshop entitled "Ensuring High Performance Buildings through a Skilled Workforce." This event brought together energy companies, government officials, NGOs, consulting firms, financial institutions, utility companies, and labor representatives to discuss the state's recent efficiency mandates for existing buildings and what these mandates mean for the energy workforce. The workshop tackled the questions: Do we have an appropriate number of trained personnel to meet the state's building energy goals? What are the occupational and skilled workforce needs, both for incumbents and new entrants, that have to be addressed? How do we ensure coordination among the entities that need to be involved to ensure the state's workforce challenge is addressed?

Key Projects 2017

The next phase of research aims to develop and execute a legislative and regulatory strategy that enables the Community College system to create a public-private partnership. This partnership will align the state's major education and training resources with California's Clean Energy and Pollution Reduction mandates. The outcomes of this project will be research that: enables data-driven decisions for investment in priority opportunities, eliminates major barriers and creates evidence-based models. In addition, education, training, and workforce development will be integrated across multiple state agencies, colleges, universities, apprenticeship programs, ratepayer-funded training, community-based organizations, and workforce development boards. Finally, the work will seek to integrate multiple funding streams to create optimum leverage among education, training, and workforce development programs.

Broader Context: Key Challenges

- The state of California has some of the most ambitious energy efficiency and energy reduction goals in the country, yet it is **unclear whether there is an adequate workforce capable of taking up this challenge.**
- In order for efficient technologies to meet their full potential, it is **imperative that they are commissioned and maintained by well-trained professionals** with an understanding of the principles of energy efficiency that allow them to maximize system efficiency.

UPDATE: COMPREHENSIVE BUILDING ASSESSMENTS

Over the last 5 years, the EEC and its many partners—three IOUs, SMUD, LADWP, UC Davis Facilities, the California Conservation Corps, the Office of Naval Research, and the California Community Colleges—have worked on developing solutions to transform the small and medium commercial building stock to achieve zero-net-readiness. Some of the key efforts to date include:

- Development of cost-effective, whole building, integrated, deep energy efficiency retrofit packages for Multi-Tenant Light Commercial Buildings.
- Assistance in community scale ZNE planning, including the UC Davis West Village development.
- Development of cost effective, scalable models for low-cost energy assessments through a combination of:
    - Development of a new entry-level workforce (including college and high school students) for cost-effective data collection by stratifying the data collection process.
    - Development of IT tools (such as tablet-based audit tools, automated assessment report generation, etc.) that enable an entry-level workforce to gather vital information with a relatively small amount of training.
- Development of tools for end-user feedback and control.

The EEC is working with key partners to transform small and medium commercial building stock to achieve zero-net-readiness.

Key Accomplishments 2016

Based on market research results, the needs of our key partners in these market transformation efforts, and policy goals adopted by the University of California, we identified a strong need for a "free," easy to use, energy and resource assessment and management software platform that serves the needs of decision makers as well as end users. In 2016, the EEC and the UC Davis Energy Conservation Office (ECO), with financial support from Office of Naval Research (ONR), kicked off a new initiative to develop a robust software platform to address the needs of the UC Davis campus. The platform architecture will serve as a backbone to facilitate all key elements of the decision-making process for users that manage the energy, and affiliated maintenance and operations of energy equipment and systems, of small and medium sized buildings by integrating existing tools and developing new capabilities. The cloud-based solution allows users to asses and manage energy efficiency retrofit projects, distributed generation assets, as well as demand response needs.

Once the platform is developed for UC Davis, it could be applied to other institutions. In 2016 the project team:

Developed Key Partnerships and Commitments

The project team developed key partnerships and commitments from a diverse set of advisors representing the building energy industry to support platform development.

Developed a Preliminary Scope

Based on needs and advice from industry partners, the project team developed a preliminary scope for the platform. The software platform will be comprised of five key modules; (1) portfolio analysis, (2) assessment and recommendations (3) project implementation support (4) evaluation, measurement and verification (EM&V), and (5) fault detection and diagnostics (FDD). The platform aims to develop an integrated end-to-end solution for energy asset assessment and management. To achieve that end, each of the five modules of the platform allow for participating partners and existing free products to interface the platform via Application Programming Interfaces.

Key Projects 2017

In 2017, the project team will:

- Define the overall platform requirements.
- Develop an architecture schema.
- Refine/complete and integrate the Portfolio Analysis and Site level assessment module into the platform.

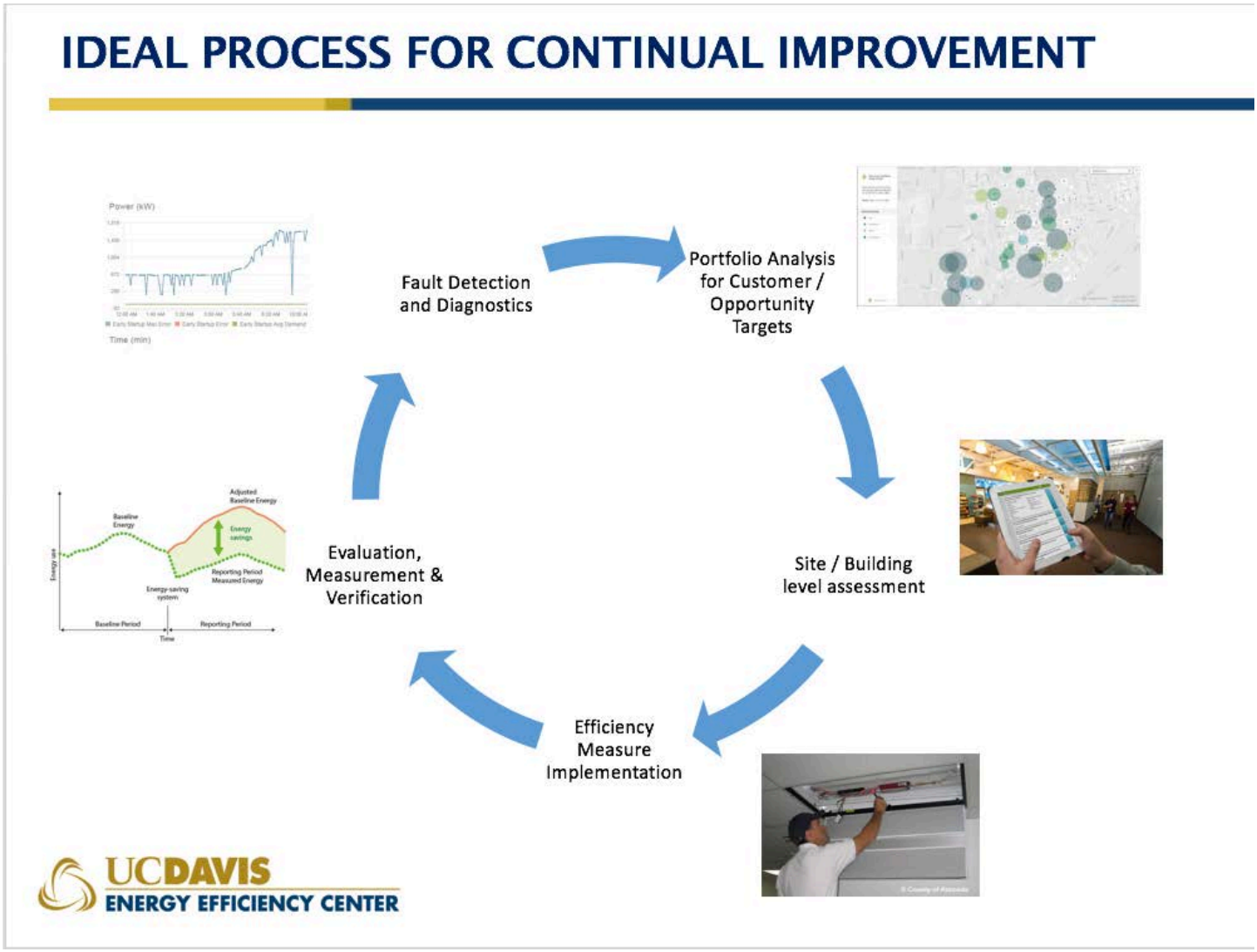


Diagram showing the five key modules of the software platform.

“There is a strong need for a “free,” easy to use, energy and resource assessment and management software platform that serves the needs of decision makers as well as end users.”

DAVIS ENERGY ECONOMICS PROGRAM

The Davis Energy Economics Program (DEEP) supports economic research on all aspects of the energy industries, spanning fuels markets, energy consumption, electricity regulation and deregulation, vehicle markets, and emissions trading. The Program is centered around a core group of six faculty and draws participants spanning several units across UC Davis, including Economics, Agricultural and Resource Economics, Environmental Sciences, and the Institute of Transportation Studies. DEEP provides an intellectual hub through which the Davis energy economics community, industry, and policymakers gather and exchange ideas, research, and information on the challenges and opportunities facing today's energy sector.

Key Accomplishments 2016

Hosted Weekly Meetings and Seminars with Invited Guests

DEEP hosted weekly lunchtime meetings with key guests from industry, government, academia, and the press. These lunches provide a forum for DEEP faculty to meet and discuss energy issues and research with UC Davis graduate students and stakeholders. DEEP also hosted an Energy and Environmental Economics seminar series during fall quarter. The weekly seminar series featured presentations from leading academics from around the world.

DEEP hosted a number of weekly meeting and seminars with invited guests.

Provided Short Courses to Key Stakeholders

DEEP provided one and two day courses on the economics of regulation, energy and the environment. Attendees included key state agency and legislative staff from California, Oregon and Washington, as well as many industry participants. A special two-day course held last December for California legislative staff on the economics of climate regulation had over 40 participants from key California Senate and Legislative offices and committees.

Provided Formal and Informal Policy Advice

DEEP faculty continued to be heavily involved in California energy and environmental policy. They frequently interacted with State and local agencies by providing testimony, participating in public advisory committees, and providing informal feedback on a variety of issues, including cap-and-trade market design, renewable electricity integration, distributed energy resource policy, energy efficiency evaluation and policy, electricity and water tariff design, clean fuel standard policy design, and vehicle incentives.

Participated in and Organized Research Workshops on the Electric Utility of the Future

DEEP, in conjunction with partners at the University of Chicago, and the National Bureau for Economic Research (NBER) organized a series of research and policy meetings on the topic of the electric utility of the future. These efforts have been supported by the Sloan Foundation. The first meeting was held at Berkeley in March 2016 and the second at the University of Chicago in October 2016. These meetings brought together academics, industry practitioners, regulators, and policy-makers in collaborative workshops. The workshops explored the technical and economic challenges for electricity distribution systems caused by increasing adoption of distributed energy resources, including solar PV, distributed storage, and electric vehicles. This initiative is also supporting a series of small research projects by faculty at UC Davis and elsewhere. Research results will be presented in workshops in 2017 and future years.

> **"DEEP supports economic research on all aspects of the energy industries, spanning fuels markets, energy consumption, electricity regulation and deregulation, vehicle markets, and emissions trading."**

Jim Bushnell of DEEP participating in a research workshop.

Published Research Results to Advance the Field

DEEP faculty published the results of their research on a number of topics this past year. A few of these research projects/papers are listed below.

- **Machine Learning from Schools about Energy Efficiency**—David Rapson and colleagues studied the impacts of energy efficiency investments at public K-12 schools in California. By developing a novel machine-learning approach they found that energy efficiency projects reduced electricity consumption between 2 to 5% on average, which can result in substantial savings to schools.
- **Residential Building Codes Do Save Energy**—Kevin Novan, Aaron Smith, and a doctoral student analyzed hourly smart-meter data and found that the average single-family house built just after 1978 uses 13% less energy for cooling than a similar house built just before 1978.
- **Generation Green: Renewable Electricity in the United States**—James Bushnell and Kevin Novan surveyed the recent history of renewable electricity and its impact on power markets and energy policy in the U.S.
- **Electricity Prices, Groundwater, and Agriculture: The Impacts of Electricity Subsidies in India**—Katrina Jessoe and a colleague from the World Bank found that electricity subsidies meaningfully increase groundwater extraction, impacting agricultural output and crop composition.
- **Policy Shocks and Market-Based Regulations: Evidence from the Renewable Fuel Standard**—Cynthia Lin, Aaron Smith, and a colleague from Iowa State University estimated the effect of three 'policy shocks' that reduced expected biofuel mandates in 2013.

Key Projects 2017

Continue to Develop Research Portfolio on Electric Vehicles

For the past several years, DEEP researchers have been working with UC Davis colleagues and the California Air Resources Board to better understand a variety of issues surrounding vehicle choice and usage, including plug-in electric vehicles in the secondary market and the impact of electric vehicle rebate programs. In 2017, as part of a UC Davis Caltrans research grant, David Rapson and Erich Muehlegger will use a rich dataset of electric vehicle purchases to examine the distribution of greenhouse gas abatement benefits and costs in California. In addition, David Rapson and Erich Muehlegger will be partnering with the Caltrans and the Air Resources Board to better understand environmental justice and barriers to low-income electric vehicle adoption.

Conduct Research on the Economic and Physical Challenges for Electricity Distribution Systems

DEEP is pursuing funding from the Sloan Foundation and other sources for a more extensive empirical research project that is attempting to measure and document the impacts of distributed energy resources on the distribution systems of California Utilities. A major component of this project will be to consolidate and combine a disparate set of datasets on distribution system configurations, investments, and performance with other datasets on the locations of electric vehicles and other distributed energy resources.


DEEP is working to improve understanding of the impacts of distributed energy resources on the distribution systems of California Utilities.

"DEEP provides an intellectual hub through which the Davis energy economics community, industry, and policymakers can gather and exchange ideas, research, and information on the challenges and opportunities facing today's energy sector."

DEEP researchers will be conducting a randomized controlled trial to evaluate an informational program that targets recent movers to better understand household decisions to participate in energy efficiency programs.

Conduct Research to Understand Household Participation in Energy Efficiency Programs

Despite the generous subsidies available to homeowners, participation in energy efficiency programs remains low. Partnering with Sacramento Municipal Utility District (SMUD), Kevin Novan and Aaron Smith will conduct a randomized controlled trial to evaluate an informational program that targets recent movers. This research will provide a nuanced understanding of how targeting information towards recent movers will affect households' decisions to participate in different energy efficiency programs. By doing so, we hope to provide guidance on how SMUD, and other utilities, can more effectively target their energy efficiency programs to encourage participation.

Broader Context: Key Challenges

- Working with policy makers to **implement their policies in ways that make them more amenable to ex-post evaluation**—empirical researchers need to be able to identify a comparison group that is either randomly assigned or that can provide a credible control group for evaluating a policy.
- When the conditions do exist for rigorous empirical work, **the availability of quality data is still an important challenge**. While valuable data are collected by regulatory agencies and other institutions, it is becoming increasingly difficult for researchers to gain access to these data due to restrictive guidelines and/or cost, among other factors.

UPDATE: EEC – MILITARY COLLABORATION

UC Davis was selected as one of six universities to receive multi-million dollar funding from the U.S. Office of Naval Research to conduct energy research and train military personnel as part of the Navy Enterprise Partnership Teaming with Universities for National Excellence (NEPTUNE) pilot program. NEPTUNE aims to help the Navy and Marine Corps discover ways to improve energy conservation, generate renewable energy, and implement energy-efficient technologies, while giving active duty military, military dependents, and veterans the chance to immerse themselves in university-level research. The Energy Efficiency Center and its affiliated research centers are conducting four research projects on energy efficiency. The EEC has also engaged in collaborations across campus to increase and improve services to veteran students and across the energy sector to ensure high-quality, rewarding professional opportunities for veterans through education, training, professional development, and networking.

Key Accomplishments 2016

Advanced Key Research Projects

As part of the NEPTUNE program, the EEC and its affiliated research centers are undertaking four research projects. Each project will help the Navy reach its energy goals and will employ and train undergraduate and graduate level students that are prospective, current, and former military personnel.

- **Plug-in Electric Vehicle Decision Making Data Based Tools:** Researchers are using and combining existing datasets to create and improve analysis tools for PEV use and electric vehicle infrastructure location and use.
- **Occupancy Sensing for Lighting Controls in Outdoor Applications:** Researchers are developing new, improved strategies and technologies for occupancy sensing in outdoor applications, which will address the shortcomings of existing solutions.
- **High Performance Recuperators for Waste Heat Recovery Cycles:** Researchers are developing an experimentally-validated design of a compact recuperator for sCO_2 power cycles. The principles used in the recuperator design could also be used in the design of low backpressure heat recovery units in absorption/adsorption cycles and other applications.
- **Portfolio-level Energy Auditing and Decision-making Methods & Tools:** Researchers are facilitating market transformation by standardizing and lowering the cost of the energy audit process, method, and analysis used by industry.

Approximately 50 faculty, researchers, and students from NEPTUNE-funded universities met at UC Davis in November 2016 to share progress on their projects.

Hosted NEPTUNE Program Review

In November 2016, the Energy Efficiency Center hosted faculty and students from the five other universities receiving NEPTUNE funding – Purdue University, Arizona State University, the Massachusetts Institute of Technology, the US Naval Academy, and the Naval Postgraduate School – along with representatives from the Office of Naval Research for a semi-annual Program Review. Researchers and students showcased the progress of their work, met potential collaborators from the other institutions, and discussed issues of concern regarding the transition from military personnel to student and potential career pathways moving forward. As a part of this Program Review, the EEC invited Mary King, VP of Human Resources for Pacific Gas & Electric, and an Army Veteran, to speak to the group and other guests on the opportunities for veterans in the utility sector and the energy field more broadly.

Advanced Energy Audit Tools

The EEC NEPTUNE project is focused on developing software tools to support low-cost building energy audits, automated data cleaning and analysis, and automated report generation to communicate the opportunities for energy and cost savings available in existing buildings. Researchers and students refined tablet-based forms with real time data validation that guide energy audits and enable lower skilled workers to perform fast and accurate audits supported with automatically tagged and sorted photos of equipment for data validation. The team also developed analysis logic to enable data collection and analysis at different levels of detail to match different types of savings opportunities from brief surveys to more in depth audits. They gathered cost and performance data for different types of equipment to support cost and savings estimates and collaborated with the UC Davis facilities Energy Conservation Office on data visualization and portfolio decision support.

As a part of its November Program Review, UC Davis hosted a poster session that allowed NEPTUNE students, and others at UC Davis working on related projects, to showcase their work to a larger audience.

Spoke at Key Energy Seminar

In an effort to increase opportunities for collaboration between NEPTUNE schools, the Naval Postgraduate School in Monterey invited researchers working on each of the above projects, in addition to EEC Executive Director Ben Finkelor, to speak to students enrolled in the school's Energy Seminar. The objective of the seminars is to introduce students to energy policy, conservation, and technology advances that impact the country's energy supply and demand. In addition to providing a platform for UC Davis faculty and researchers to present their work, these seminar engagements allowed presenters to meet with NPS students and faculty with similar research interests, facilitating student recruitment for UC Davis research projects and partnerships with faculty.

Worked to Strengthen Services to the Military Student Population

One of the primary goals of the NEPTUNE program is to increase educational opportunities for military students on campus. As it stands, UC Davis has a relatively small military student population and because of this, fairly limited resources for those students on campus. The EEC spearheaded an effort to increase collaboration and communication between the various offices and centers on campus who frequently serve military students in order to strengthen and expand these services wherever possible. As a part of this effort, the EEC has worked with Beth Broome, the Senior Advisor to the Provost on STEM Strategies and Earl Raehsler, Coordinator of the UC Davis Veteran Success Center, to find areas of overlap various campus initiatives and increasing the number of military students choosing to pursue degrees at UC Davis.

Key Projects 2017

Initiate a Working Group for Advancing Veterans in the Energy Industry in California

The EEC is working closely with the ONR and PG&E to initiate an "Energy Partnership" comprised of military installations and organizations, higher education institutions, and California's utility industry to:

- Train active-duty military service members through an on-base skills bridge program for both immediate in-demand utility industry careers and longer-term employment pathways requiring additional education, such as the Energy Graduate Program (or undergraduate-level programs focused on energy) at the University of California, Davis;
- Remove barriers and increase access within the University of California admissions, building a short- and long-term pipeline of military Veteran students; and
- Design a program certificate and launch a pilot program whereby the certificate is recognized to streamline Veteran applicants during the admissions process for universities and applications process for utilities.

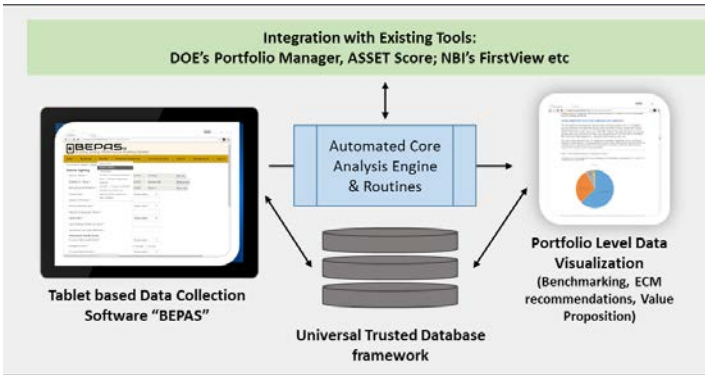
In May 2017, the Energy Efficiency Center will host an initial stakeholders Working Group to elicit additional input and ensure the needs of each group are being addressed. The remainder of the year will be focused on working with the group and others to develop curriculum, pathways, and other program elements such that the formal training program is ready to launch in 2018.

> **"The Energy Efficiency Center is working to build collaboration both internally and externally to strengthen education and career services for veterans and to promote careers in the energy field."**

UC Davis context. While this class will not be exclusively open to veteran students, the goal is to have at least 50% enrollment of veteran students; the EEC plans to meet this goal by working closely with veterans services on campus to encourage enrollment and ensure useful degree credit for participation.

Continue to Advance Key Research Projects

The EEC and its affiliated research centers will continue to advance research as part of its four NEPTUNE projects. These projects will help the Navy reach its energy goals and will employ and train undergraduate and graduate level students that are prospective, current, and former military personnel.



The EEC, in collaboration with the Center for Water-Energy Efficiency, are working to improve energy auditing and decision-making methods for small and medium sized buildings.

Broader Context: Key Challenges

- The Navy and the Marine Corps, in addition to the military more broadly, have committed to increasing operational efficiency, therefore **requiring a strong investment in energy reduction** where possible.
- There are approximately **2.5 million veterans** of the recent and ongoing conflicts in Iraq and Afghanistan. Many of these individuals use their GI Bill benefits to attend college or obtain advanced degrees.
- **Many fields within the energy sector are experiencing a 'graying' workforce**—a large number of skilled workers will be needed over the next 5 or so years.

> **"Through its NEPTUNE funding, the EEC, WCEC, CLTC, CWEE, and PH&EV Center are conducting research projects that can help the military achieve its goal of reduced energy use, and have hired a number of student veterans to assist in this work."**

Submit Proposal to the Office of Naval Research for Renewed Funding

The EEC received positive feedback from ONR at its November Program Review and in additional conversations with NEPTUNE program staff, ONR has encouraged the EEC to submit a proposal for renewed funding as soon as possible. New funding will cover work for a 3 year period and will allow for $1 million/year instead of the $750,000/year the university is currently receiving. This additional funding will allow for the continuation of the existing NEPTUNE funded projects at the EEC, WCEC, CLTC, CWEE, and PH&EV Center and will also be used to fund a few new projects—the Emerging Energy Professionals Program, campus services for veteran students, and a course aimed at focusing leadership skills, specifically among veteran students.

The new focusing leadership course, which will be aimed at incoming community college transfer students, and specifically veterans, will help students translate existing leadership skills into academic success through the use of organizational leadership and design thinking. This class will be project-based and capped at 10 students to ensure ample opportunity for participation and access to the professor. UC Davis is working with Jaqueline Hettel of Arizona State University, another NEPTUNE award recipient, to translate a course that she has had much success with to the

UPDATE: FOOD-WATER-ENERGY NEXUS

As the nation's largest food processing state, California has many opportunities for recovering both waste heat and water in food processing operations. Drs. Chris Simmons and Ned Spang, Assistant Professors in the Department of Food Science and Technology, are advancing the University's efforts to understand the interconnections between food-water-energy systems and identify opportunities to improve efficiency in the delivery and use of these critical resources. Current research efforts include estimating water and energy savings achieved by reducing food losses and waste, community-scale energy production from food waste, development of novel food waste management technologies, and assessment of technologies via technoeconomic and life cycle assessment approaches.

Key Accomplishments 2016

- **Completed a water energy nexus case study** of an industrial tomato processing facility in collaboration with Campbell Soup Company. This case study will be published in the Journal of Industrial Ecology.
- **Conducted the first life cycle assessment** using tomato processing residual biomass as soil amendments to disinfect soil in lieu of fumigation. Researchers found that the soil amendment approach reduced primary energy demand and global warming potential compared to fumigation. This study was published in the Journal of Cleaner Production.
- **Obtained $1.2 million** from the National Institute of Occupational Safety and Health to advance and characterize waste-derived soil amendment disinfestation approaches to displace fumigation.
- **Launched a new graduate elective course** on Sustainable Food Systems. This course introduces students to technologies and analytical approaches related to water and energy efficiency, waste management, and environmental impact at the farm, processing facility, industry, regional, and global levels.
- **Developed an undergraduate project** to repurpose food processing products (previously considered "waste") into novel, healthy, and affordable food products, and established a partnership with the health food and juicing company, Urban Remedy, to use the high-quality fruit and vegetable pulp leftover from their juicing operations.
- **Started a project to measure on-farm losses** of tomato, spinach, and peach crops, and to assess the life-cycle resource impacts of these crop losses in collaboration with the World Wildlife Fund and the Global Cold Chain Alliance.

> **"By finding several avenues to valorize food waste streams, we're trying to make the economic incentives match the sustainability incentives for waste management."**
>
> **–Chris Simmons, Assistant Professor in the Department of Food Science and Technology**

Assistant Professor Christopher Simmons (center) visits with Campbell Soup Co. executives at the Campbell's processing facility in Dixon, CA.

Key Projects 2017

- **Extend water energy nexus assessments** to the brewing and dairy industries.
- **Conduct technical studies and life cycle assessments** to compare soil disinfestation using waste-derived soil amendments against fumigation in field trails.
- **Determine the composition of microbial communities** capable of biomethane production under high solids conditions using next generation DNA sequencing.
- **Expand the scope of the Sustainable Food Systems graduate course** by including additional technologies and analytical techniques. In addition, students from other graduate groups, including Biological Systems Engineering and Geography, will be engaged to participate.
- **Map and assess the coverage and quality of food loss and waste data** in the existing literature.
- **Pursue research on the appropriate scale for anaerobic digestion systems to process food waste to energy,** such as large centralized facilities or small-scale, on-site facilities.

"End of Waste" Undergraduate Project Team at the food processing facility of our industrial partner, Urban Remedy.

The UC Davis and UC Cooperative Extension teams next to a freshly prepared plot for testing fumigation alternatives.

> **"Water energy nexus assessments reveal that for certain food processors, the key to energy efficiency may be water efficiency."**

> **"By reducing food losses and waste, we can recover the significant upstream energy and water use previously allocated to produce that food."**

Broader Context: Key Challenges

- Food/beverage processing industries **need water nexus data across many facilities** to permit benchmarking.
- **Microbial community structure, function, and dynamics must be better understood** in biofuel fermentation systems to improve yield and kinetics.
- **The performance of soil fumigation alternatives must be characterized to the same extent as conventional fumigation.** The energy and environmental benefits of such alternatives must be assessed at the life cycle level.
- Roughly **40% of food is currently lost or wasted,** nationally and globally, which represents a tremendous amount of wasted water, energy, and other resource inputs.
- Given the importance of reducing food waste, there is **insufficient data on the quantity and quality of waste** across the food supply chain and with the end consumer.

UPDATE: FACULTY RESEARCH HIGHLIGHTS

We continue to reach out and expand our community of faculty and researchers engaged in energy research and teaching. A few star faculty we have recently brought into the fold and are highlighted below.

District heating is being broadly adopted in Europe.

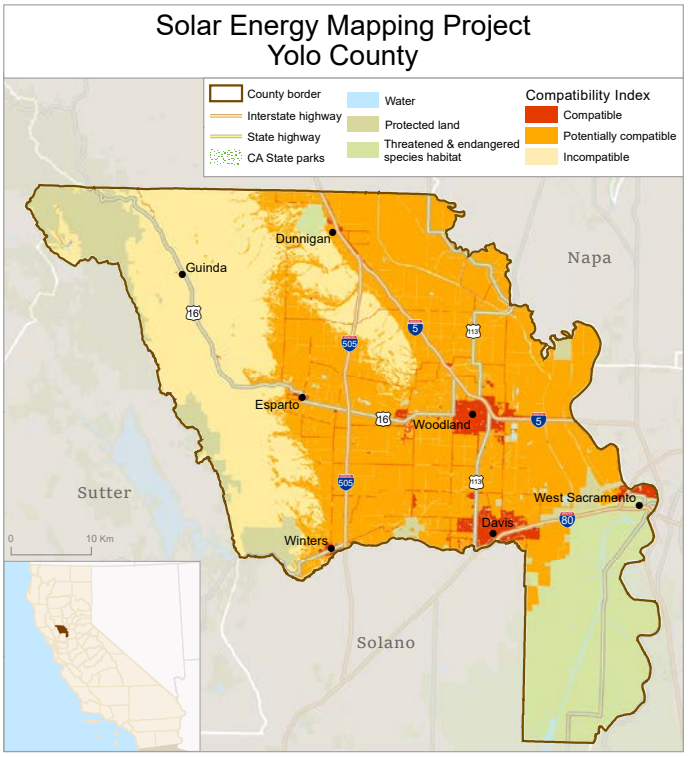
Catherine Brinkley: District Heating Facilities

Dr. Catherine Brinkley is an Assistant Professor in Community and Regional Development at UC Davis. Her research supports planning and siting for energy facilities. She is particularly interested in the place-based impacts of district heating facilities, which have been broadly adopted in Europe as a means of decreasing greenhouse gas (GHG) emissions while re-localizing energy sourcing. In district heating, instead of every building having its own boiler, heat is produced and then distributed through underground pipes to nearby buildings. Heat can be produced through biomass boilers, coupling to industrial waste heat, geothermal, or heat storage during peak production from renewables. In this way, district heating can be more efficient than traditional heating and electric systems. Dr. Brinkley is exploring the siting and expansion of existing US district heating systems and conversion to biomass fuels. While biomass incineration has been a chief means of localizing energy and reducing GHG emissions for many countries, there is often concern from nearby communities about the impact of smokestacks on air pollution, health, home prices, and resulting economic development. By examining the connections, she can inform policies that improve sustainable land-use and equitable access to health.

Rebecca Hernandez: Integrating Renewables into Ecosystems

Dr. Rebecca Hernandez is an Assistant Professor in the Department of Land, Air and Water Resources at UC Davis. She studies the intersection between energy development and the environment, and particularly how solar energy can be deployed to reduce greenhouse gas emissions, water scarcity, and land-cover change. While solar energy has one of the greatest climate change mitigation potentials, the diffuse nature of solar energy necessitates that large swaths of space or land be used to collect and concentrate solar energy into forms usable for human consumption, increasing concern over potential impacts on natural ecosystems, their services, and biodiversity therein. Some of her projects include:

- Optimizing solar facility configuration effects on habitat, managed plants, and essential species interactions. In 2016, she received a 3-year grant from the California Energy Commission to advance this research.
- Advancing techno-ecological synergies—mutually beneficial relationships between technological and ecological systems, such as using old landfill sites to generate solar power.
- Exploring the solar energy potential of the largest rooftops in the United States by completing solar energy technical potential and modeling analyses for 25 buildings,



Map for Yolo County showing suitability for solar energy development.

demonstrating how much energy can be produced and how much natural habitat can be saved by developing solar on rooftops instead of near national and state parks and open spaces.

- Mapping California's solar energy potential using the Carnegie Energy and Environmental Compatibility (CEEC) model. This adaptable multi-criteria decision support tool incorporates hydrologic, socioeconomic, topographic, energy infrastructure, and ecological resource opportunities and constraints to identify compatible, and incompatible locations, as well as theoretical and technical solar energy potential.

> **"You're using degraded land, you're producing renewable energy and you're bringing back some functioning to that parcel of land too. It's like a win-win-win scenario."**
>
> **- Rebecca Hernandez, Assistant Professor in the Department of Land, Air and Water Resources at UC Davis**

SunPower's solar research-and-development ranch south of Davis. Photo: Sue Cockrell

J. Heiner Lieth: Controlled Environment Agriculture

Dr. Heiner Lieth is Professor and Extension Specialist in the Department of Plant Sciences at UC Davis. His research focuses on greenhouse and nursery production, soilless culture, and applications of photovoltaic energy production in agriculture. Some of his projects include:

- Improving knowledge and technology for greenhouse and in-door production operations to reduce water and energy use and costs. He is currently investigating energy efficiency in grow houses.
- Dual use of sunlight for both plant production and electricity generation. He explores opportunities related to plant production in the shadow of solar photovoltaic panels in agriculture and horticulture.
- He is collaborating with SunPower at their new research center in Davis to further this research.

Jae Wan Park: Advancing Microgrid Systems

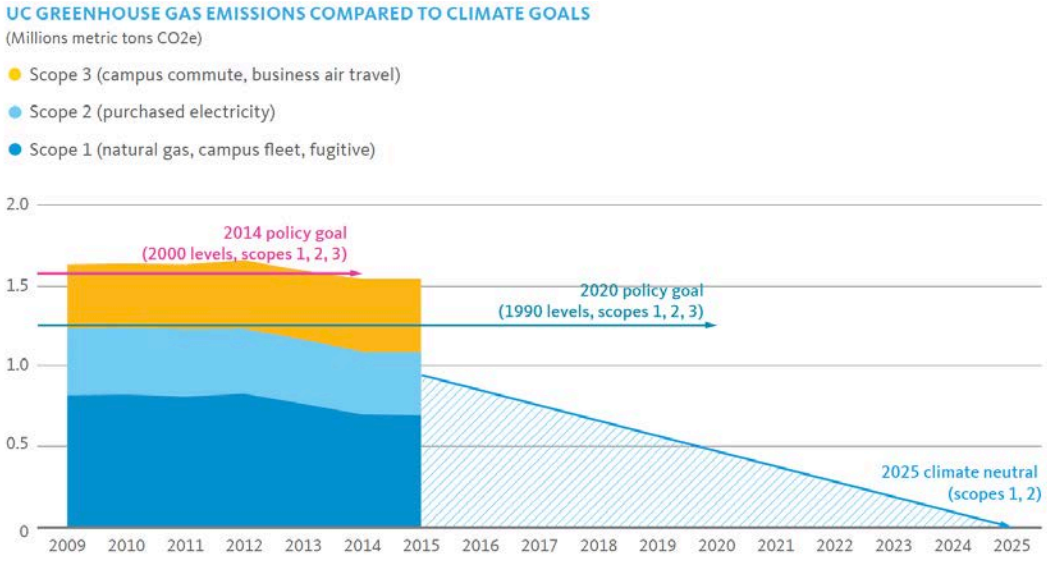
Dr. Jae Wan Park is an Associate Professor in the Department of Mechanical and Aerospace Engineering at UC Davis. His research focuses on green energy systems with batteries and proton exchange membrane fuel cells. He is director of the UC Davis Green Transportation Laboratory, Kor-US Transportation Study Program at the UC Davis Institute of Transportation Studies, and the UC Davis Formula Hybrid racing team. One of Dr. Park's current research projects, supported by a grant from the California Energy Commission, is to build a microgrid system at the Robert Mondavi Institute's (RMI) Brewery Winery and Food Science Building (BWF) in order to reduce the BWF's daily peak-time energy demand. Dr. Park and his research team are building a smart Electrical Energy Storage System using retired Electric Vehicle batteries. This system will provide a cost effective and efficient energy storage solution for the BWF and its multiple community-scale renewable generators (solar PV arrays) and will act as an important buffer—aligning maximum solar energy generation with RMI's peak grid energy demand.

Testing a second-life Electrical Energy Storage battery bank.

UPDATE: CLIMATE NEUTRALITY AND SUSTAINABILITY

University of California

In November 2013, President Napolitano announced the Carbon Neutrality Initiative, which commits UC to emitting net zero greenhouse gases from its buildings and vehicle fleet by 2025, something no other major university system has done. To achieve carbon neutrality by 2025, UC is taking bold steps to expand its energy efficiency efforts and dramatically increase its use of energy from renewable sources. In 2014, President Napolitano formed a Global Climate Leadership Council to advise UC on achieving carbon neutrality by 2025 and furthering the UC's other longstanding sustainability goals. The council is comprised of scientists, administrators, students and experts from inside and outside the UC. Michael Siminovitch, Director of the California Lighting Technology Center, is a council member.



UC greenhouse gas emissions compared to climate goals.

> **"UC has pledged to become carbon neutral by 2025, becoming the first major university to accomplish this achievement."**

UC Accomplishments

- **On-site solar photovoltaic systems** have been installed at 12 locations, with 36 MW of 100 percent carbon-free electricity in operation. Another 13 MW of on-site solar projects are in the planning and construction phases.
- UC secured two sources of **renewable biogas**, which together will offset approximately 10 percent of UC's current natural gas consumption.
- The first of two **large-scale solar photovoltaic projects** began generating electricity in Fresno County in the fall of 2016 for UC's Wholesale Power Program—the university provides electricity directly to all (or portions of) seven campuses and three medical centers that are eligible to procure electricity from entities other than investor-owned or publicly-owned utilities. The second system is expected to be online by the summer of 2017. Together they bring UC to a total of 80 MW of off-campus solar. Once up and running the projects will generate electricity in the amount roughly equal to 14 percent of UC's total electricity use.
- To date, 1,023 university projects have registered with the **Energy Efficiency Partnership program**, a unique program with the California State University system and the state's four investor-owned utilities to improve the energy performance of higher educational facilities, receiving $82 million in incentive payments and avoiding $28 million in annual energy costs, net of project debt service payments. In 2016 alone, 28 energy efficiency and 17 new construction projects participated in these programs, earning $4.4 million in incentives. These projects are projected to avoid over $550,000 annually in utility bill costs due to their energy efficient design strategies.
- In 2016, the UC Office of the President developed a **Strategic Planning Framework for Carbon Neutrality**. This framework outlines potential strategies and costs for reaching the 2025 goal and will be a living roadmap to help identify systemwide actions that can be taken to help UC reach its goal.
- In 2016, the University of California named **Faculty Climate Action** Champions at each campus to work with students on projects aimed at building community engagement and

awareness. Kurt Kornbluth, Director of the Program for International Energy Technologies and D-Lab, was named a Climate Action Champion for his work with UC Davis facilities management to identify on-campus opportunities for carbon reduction and his creation of a climate-focused, project-based curriculum through his collaborations with faculty from multiple disciplines.

Kurt Kornbluth, a Faculty Climate Action Champion, with students.

UC Davis

UC Davis is leading the way among the 10 campuses within University of California, proactively making efforts to reduce greenhouse gas emissions and achieve carbon neutrality. Eight years ago, UC Davis developed the 2009-2010 Climate Action Plan—a roadmap for the journey toward a more sustainable future—which is now helping to achieve the campus' part in the University of California's goals. The plan analyzes campus issues around greenhouse gas emissions reductions, energy use, and energy sourcing.

UC Davis Accomplishments

- In November 2015, UC Davis formally dedicated a **16.3 MW large solar power plant**, the largest known of any university campus, which yearly will generate approximately 33 million kilowatt-hours for the campus, and reduce greenhouse gas emissions by about 14,000 metric tons.
- In fall 2015, UC Davis participated in the **Cool Campus Challenge**—an online pledge campaign that engaged nearly 20,000 staff, students, and faculty in reducing UC's carbon footprint.
- The Program for International Energy Technologies and the UC Davis Energy Conservation Office worked together to provide students in **project-based learning classes** with real, campus-based climate neutrality and energy policy projects such as: building a financial analysis tool for conversion of campus district steam heating to hot water heating, analyzing energy storage options, analyzing potential for ocean wave-generated energy, and assembling and reviewing complex commuting data for the campus Medical Center.
- UC Davis moved up two spots to place **first in environmental sustainability** in the 2016 international GreenMetric Global Ranking, a survey of more than 500 colleges and universities conducted by the University of Indonesia. The campus also placed eighth in the Sierra Club's "Cool Schools" 2016 ranking.

UC Davis Solar Farm.

"UC Davis was named the most sustainable university in the world in the 2016 International GreenMetric Global Ranking, a survey of 516 colleges and universities from 74 countries conducted by the University of Indonesia."

UC Davis Big Idea: Leading the Way to Climate Neutrality

In 2015, UC Davis issued a call to faculty, staff, and students for "big ideas" to serve as the foundation for a second comprehensive fundraising campaign. Interest from across the university was unprecedented with nearly 200 ideas received. The campaign steering committee evaluated these ideas and selected 13 to move forward. Dr. Kurt Kornbluth of the Program for International Energy Technologies is the faculty champion for the Big Idea "Leading the Way to Climate Neutrality." In the coming months, these big ideas will undergo feasibility studies and will be marketed to targeted groups.

The Leading the Way to Climate Neutrality Initiative builds on the successful track record of partnership among faculty, students, staff and industry to make UC Davis a zero-carbon campus by 2025. This transdisciplinary, university-wide initiative will accelerate efforts to pilot, finance and implement carbon reduction projects, the savings from which will be reinvested. Through project-based learning opportunities, faculty, students and staff will collaboratively test and operationalize cutting-edge research and translate this work to the public. In the process, we will spearhead a feasible carbon neutrality model for large institutions worldwide and provide the next generation of energy leaders with the knowledge and hands-on skills to foster global resilience to climate change. For more information on this initiative, please visit: http://piet.ucdavis.edu/?page_id=482.

> **"These ideas have the potential to shape the future of UC Davis for generations to come and lead to discoveries that will solve both California and the world's most pressing problems."**
>
> **- Shaun Keister, Vice Chancellor, Development and Alumni Relations**

> **"We know that in order to end reliance on fossil fuels, we must simultaneously increase energy efficiency and the share of energy from renewable resources. The challenge is to do so in ways that are large scale, fiscally solvent, and engage stakeholders at all levels, most notably students, in a meaningful way."**
>
> **- Kurt Kornbluth, Director, Program for International Energy Technologies**

Students participating in the Path to Zero Net Energy course—a course that will be expanded under the Climate Neutrality Leadership Initiative.

UPDATE: WEST VILLAGE

UC Davis West Village (West Village) is a neighborhood on the UC Davis campus designed to be the home for approximately 3,000 students and 500 staff and faculty families. The overarching goals for the community are to:

- Create a great community and desirable place to live that will help UC Davis recruit the best and the brightest students, faculty, and staff.
- Enable faculty and staff to purchase new homes locally, at below market prices, and to expand the choices for students to live near campus.
- Develop the site and buildings according to sound environmental principles so as to reduce reliance on cars, limit energy consumption, enable renewable energy production, and contribute to a healthy environment.

First Phase of Development

The first phase of the West Village community was developed through a public-private partnership between UC Davis and West Village Partnership, LLC, a joint venture of Carmel Partners from San Francisco and Urban Villages from Denver. During this first phase, which consisted of rental apartments and mixed-use commercial/retail space, the West Village Energy Initiative (WVEI) was established to work towards the goal of achieving Zero Net Energy (ZNE) from the grid annually. While significant progress has been made toward this goal, achieving 100 percent ZNE for this phase of West Village is challenging now that occupancy in the units has increased with 600 additional residents authorized to live in the apartments.

> **“There is a great need for housing for our work force that is within walking or biking distance of campus. It’s an ongoing recruitment challenge, especially for junior faculty, that we can solve right here on our land.”**
>
> **- Ralph Hexter, Acting Chancellor for UC Davis**

Next Phases of Development

In Fall 2017, UC Davis will start building the next phases of West Village, which will include more student housing; rental staff and faculty townhomes; and for-sale, below-market, single family homes. Construction on the first units is planned to commence in December 2017. UC Davis will control this new phase of construction and the campus intends for these new facilities to carry forward the Zero Net Energy goal and incorporate a variety of sustainability-based goals, using proven, cost-effective technologies and best practices. One overarching new goal is carbon neutrality.

Research Row

As part of this new neighborhood rollout, UC Davis is creating “Research Row” by assigning three lots that will be controlled by the UC Davis research community for the purposes of studying sustainability technologies, solutions, and behaviors. These lots will be located near the Honda Smart Home (HSH) and will leverage West Village and the HSH as leading demonstrations of advanced sustainable development.

UC Davis West Village.

EDUCATION INITIATIVES

UPDATE: EMERGING ENERGY PROFESSIONALS PROGRAM

The Emerging Energy Professionals Program (EEPP) is a year-long program designed to train UC Davis undergraduate and graduate students in the skills and thinking essential to pursuing professional careers in energy. The EEPP aims to: provide students with a baseline, real-world understanding of energy technologies and solutions within the context of the energy services industry; advance their professional development and leadership abilities; and expose them to future career pathways and assist them in career planning and growth.

Key Accomplishments 2016

- **Held a professional panel on Trends in Electricity Generation** with partners from the Sacramento Municipal Utility District and the California Independent System Operator.
- **Received a tour of the UC Davis Solar Power plant** to improve knowledge and understanding of the facility and technologies used.
- **Engaged students in a discussion on renewable energy generation** to advance understanding of opportunities and challenges in this area and the importance of an interdisciplinary approach.

Students discussing key energy topics.

Students working together on an energy research project.

Key Projects 2017

- **Hold professional development workshops on resume writing and interviewing skills** to help students learn how to best emphasize their experiences in the energy field.
- **Work with the Lawrence Berkeley National Lab** on commercial energy optimization research, data models in energy application, and python coding.
- **Develop white papers,** covering topics from biofuels to battery optimization in residences, as a result of work with the Lawrence Berkeley National Lab.

> **“The EEPP employs a variety of learning opportunities, including guest speakers, student presentations, field trips, guided discussions, and applied trainings over the course of three quarters.”**

> **“Students involved in EEPP research policies and technologies in energy, become familiar with market and data analysis, learn about the energy market in California, and attend weekly meeting at UC Davis West Village.”**

UPDATE: UC DAVIS ENERGY GRADUATE GROUP

The UC Davis Energy Graduate Group (EGG) is a new graduate group on campus, welcoming its first class in fall 2017. UC Davis is a world leader in energy and our mission is to produce graduates who will be energy leaders and experts in government, the private sector, and academia. The EGG offers M.S. and Ph.D. degrees in Energy Systems in two tracks of study: 1) Energy Science & Technology, and 2) Energy Policy & Management. With over 50 affiliated faculty, EGG students take relevant coursework from across the UC Davis campus and undertake interdisciplinary research to address pressing environmental, economic, policy, and social challenges related to energy production and consumption facing California, the U.S., and the world.

EGG addresses energy systems broadly, with a focus on renewable energy, transportation fuels, and energy efficiency.

Key Accomplishments 2016

- Received approval for EGG by UC Davis and the UC Office of the President.
- Developed an EGG faculty group of more than 50 faculty, drawing from 16 different departments across campus.
- Appointed EGG standing committees and leadership.
- Conducted outreach via our website, videos, and career fairs to recruit EGG's first class of students.

> **"The energy industry in California, and around the nation, currently has an unmet demand for highly skilled employees with interdisciplinary graduate training in energy."**

> **"The Energy Graduate Group provides the interdisciplinary training required to tackle the energy challenges of the 21st century and beyond."**

Key Projects 2017

- Selecting and admitting EGG's first class of students.
- Finalizing EGG courses.
- Developing and hosting EGG's first Energy Seminar Series, in Fall 2017 and Winter 2018, where invited experts from academia, industry, and government will present on topics relevant to today's energy challenges.

Alissa Kendall, Chair of EGG, working with graduate students on a project.

Broader Context: Key Challenges

- **Building knowledge & awareness** of EGG among undergraduate students, feeder programs, and academic advisors.
- **The ability to successfully compete** for top graduate candidates among more established programs.

UPDATE: UC DAVIS SOLAR DECATHLON

UC Davis is proud to participate for a second time in the U.S. Department of Energy's Solar Decathlon. The Solar Decathlon, which is held every two years, challenges college teams to design, build and operate solar-powered homes that are cost-effective, energy-efficient, and attractive. The UC Davis team is building off of its success in the 2015 competition where they won first place for affordability and commuting for their zero net energy house designed for farmworkers. The 2017 competition takes place in October in Denver, CO. Preparing for the Solar Decathlon is a multidisciplinary effort involving undergraduate and graduate team members from many academic backgrounds. The team is assisted along the way by UC Davis faculty and staff. Engineering professor Frank Loge, director of the Center for Water-Energy Efficiency, is the faculty advisor, a role he held for the 2015 competition.

Key Accomplishments 2016

Established a Solid Design Theme

Establishing a theme is the first step to a great house design—it guides decisions for selecting materials and technological innovations while at the same time unifying them into a cohesive vision. Early on, the team decided to address an issue that touches every resident of California: the drought. The team's ultimate goal is to propose an affordable, energy-efficient solution to water waste at the residential level by focusing on innovative technologies and modifying user behavior.

Completed Construction & Planning Documents

The design of the house has progressed in 2016 from concept to a full set of construction documents that students have made themselves. These plans represent a fully functional house that meets all applicable building codes. In addition to these plans, students have developed a comprehensive cost estimate for the house and a complete communications strategy for educating the public about their efforts. The multi-disciplinary aspect of this capstone project makes such a coordinated effort possible with minimal faculty and staff assistance.

UC Davis Solar Decathlon Team.

The UC Davis Team (the Blue Mustangs) is building Our H_20use—an original design that addresses the severe drought in California by cutting the water use in a typical residence in half, while maintaining the same level of comfort at an affordable price point.

> **"Because of the recent drought, this year we're really striving to get as close to zero net water as possible. To do this, we're emphasizing the use of efficient appliances and fixtures along with educating users on how to change habits and conserve water. We're also reducing water usage by treating greywater and using it for outside irrigation purposes."**
>
> **- Kara Barcza, Blue Mustangs' Water Engineering Lead and a fourth-year Civil and Environmental Engineering student at UC Davis**

Received Critical Support from the University and Private Institutions

The team has been fortunate to gain significant support from the University and has continued to foster support from private institutions such as Heising-Simons Foundation, SunPower, PG&E, and many others. Without the monetary and material support of these sponsors, building a house and competing in a competition like the Solar Decathlon would not be possible.

Key Projects 2017

Build the House

Construction has begun on the house and its surrounding structures as part of a core class in the Civil and Environmental Engineering Department (ECI 128 – Green Construction). This effort will continue in the Spring Quarter in a similar fashion. While students learn about the theory of Green Construction in the classroom, significant lab time is spent in the field building the house—from foundation and framing to utilities and finish work. The process is facilitated by faculty, staff, and industry professionals who help train students to enter the engineering and design workforces with not only applied theory but invaluable practical experience.

Test the House Systems

Once the house is built, students will work to test the house systems and optimize them for use in the competition itself. This phase is imperative to the team's success at the Denver event in October. It is one thing to design a system on paper, and yet another to build it. This next step of ensuring both quality and workmanship will be the final step to establishing a successful submission into the competition.

Compete in the Solar Decathlon

In late September, the house will be disassembled and transported to Denver, CO for the Solar Decathlon competition. There, the team will reassemble the house and compete for 9 days in 10 different contests ranging from Engineering and Architecture to Home Life and Market Potential against 13 other universities from around the country. After the competition, the house will be packed up and brought back to UC Davis, where hopefully, it will be permanently set on campus and used as student housing, yielding valuable energy and water use data to University researchers and the next round of Solar Decathlon participants from UC Davis.

Team members use a circular saw as part of ECI 128 "Green Construction."