



April 24th, 2018

Board of Advisors Meeting

Thank you to our Sponsors



WELCOME



Welcome Members of the Board of Advisors and Special Guests,

Thank you for participating in our Spring 2018 Board of Advisors meeting. I am excited and honored to join the Energy Efficiency Institute as its interim faculty director. This is an exciting and important time to come together. We have experienced some great successes this past year, including:

Becoming an Institute. After a little over 10 years of accelerating the development and commercialization of energy efficiency solutions, and training future leaders in energy efficiency, the UC Davis Energy and Efficiency Center has become an institute. The institute, now named the Energy and Efficiency Institute (EEI), has two significant additions: 1) a broader mandate to accelerate sustainable energy systems and 2) the new UC Davis Energy Graduate Group.

Drafting a Strategic Plan. As a new institute, we have reassessed the organization and charted a vision for the next five years that: a) builds upon existing strengths, b) raises the profile of our research and development, c) increases the relevancy of our impact to policymakers and industry, and d) attracts additional funding. We look forward to discussing this plan with you and receiving your feedback.

Advancing Strategic U.S. and global partnerships. We developed deeper collaborations with the Office of Naval Research and Mexico, and are continuing to explore ways to broaden our reach to (as well as learn from) organizations outside of California.

Launching the Energy Graduate Group. We helped recruit the inaugural class of students and hosted a highly-successful orientation program and seminar series for them.

Hosting an Affiliates Forum. In collaboration with our affiliated research centers in lighting, HVAC, and water, we hosted the first ever Affiliates Forum. Attendees included current and potential affiliates and collaborators. The theme of our 2018 forum was Integrated Energy Solutions.

Reorganizing Administratively. To streamline both the internal administrative functions and strengthen energy research efforts by building upon campus strengths, the EEI and Western Cooling Efficiency Center reorganized administratively.

Looking ahead, we have important work to accomplish this year, including **recruiting a permanent faculty director**.

Included in this packet are biographies of the participants and background information on the most recent and important initiatives we have underway. Although we will not have time during the meeting to cover all the work in this packet, we encourage you to follow up with us on anything that might be of interest to you and your team.

Thank you again for all your support.

With much appreciation,

A handwritten signature in blue ink that reads "Mark Modera". The signature is fluid and cursive.

Mark Modera
Interim Faculty Director
Energy and Efficiency Institute

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Wifi Instructions

1. Choose ucd-guest
2. Click Connect to open Guest Registration Page
3. Create a ucd-guest account or use previous account
4. Enter information and click Register
5. Receive confirmation email and/or text message
5. Login

Agenda

10:30am

Arrival and Refreshments

11:00am – 11:20am

Welcome and Introductions

Ralph Cavanagh, Chair

New Board Members:

Jill Anderson, SCE

Paul Lau, SMUD

Special Guests

Commissioner Andrew McAllister, California Energy Commission

Professor Ashutosh Bhagwat, CalSO Board of Governors

George Minter, SoCalGas

11:20am – 12:20pm

Update on the Energy and Efficiency Institute

Ben Finkelor

Mark Modera

Michael Siminovitch

Frank Loge

12:20pm – 12:40pm

Update on the Energy Graduate Group

Alissa Kendall

12:40pm – 1:00pm

CEC Integrated Energy Policy Report

Siva Gunda, California Energy Commission

1:00pm – 1:45pm

Lunch with Energy Graduate Group Student Introductions

Exemplary Students:

Madison Hoffaker

Kabian Ritter

Alex Sloan

1:45pm – 3:15pm

Discussion: Current and Future Energy Trends – Where are we now and where are we going

To jumpstart the discussion, the following board members will make brief comments:

Ralph Cavanagh (Moderator)

Jill Anderson

George Minter

3:15pm – 3:45pm

Break

3:45pm – 5:15pm

Discussion: UC Davis Projects Addressing Current and Future Energy Trends

- California Energy Product Evaluation Hub
- UC Davis – Mexico Collaboration
- Concept Initiatives: Energy Solutions for Disadvantaged Communities, Efficiency in Healthcare, and Indoor Growing

5:15pm – 5:45pm

Wrap-up and Final Thoughts

6:30pm – 8:00pm

Dinner Discussion: Three Revolutions in Transportation

Professor Dan Sperling, Director of the Institute of Transportation Studies at UC Davis

Meeting Location: 1605 Tilia St, Davis
Conference Room 1103

Dinner Location: Seasons Restaurant
102 F St, Davis

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.



Jill Anderson

Jill Anderson is vice president of Customer Service Operations at Southern California Edison (SCE), one of the nation's largest electric utilities. She is responsible for leading SCE's energy efficiency, demand response and clean self-generation program portfolios and customer strategy, marketing, e-commerce and strategic alliance functions. Previously, Anderson was executive vice president and chief commercial officer at the New York Power Authority (NYPA), the country's largest state power organization. She was responsible for sales, marketing, new products and technology, and energy efficiency programs. In this role, Anderson also oversaw the marketing of NYPA's generation assets, trading, fuel operations, hedging, business development for new transmission and generation activities. Prior to this position at NYPA, she led energy policy, sustainability, corporate communications, regulatory affairs and government relations departments. Anderson received a Master of Business Administration degree from New York University and a Bachelor of Science in Mechanical Engineering degree from Boston University.



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.



Paul Lau

Paul Lau is Chief Grid Strategy & Operations Officer at Sacramento Municipal Utility District (SMUD). He is responsible for the operations of SMUD's power markets, transmission and distribution grids, including the Balancing Authority of Northern California (BANC), the development of a holistic smart grid strategy and SMUD's research & development programs. Lau directs a number of departments and is the executive sponsor of SMUD's deployment of advanced metering infrastructure and smart grid initiatives. Prior to this appointment, he was the Assistant General Manager of Power Supply & Grid Operations. Lau is active in international energy issues and serves as a delegate with the United States Energy Association. He is a registered professional electrical engineer in the state of California and has more than 30 years of utility experience. Lau received his bachelor's degree in electrical power engineering from California State University, Sacramento. He also is a Senior Fellow of the American Leadership Forum.

Board of Advisors



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.



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.



Barry Neal

Barry Neal is the Executive Vice President leading Wells Fargo's Renewable Energy and Environmental Finance activities, 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 and 2018. 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.



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.

Board of Advisors



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. Under Winn's leadership, SDG&E is responsible for the safe and reliable delivery of clean natural gas and electricity to 3.6 million consumers in San Diego and southern Orange County. In her prior role as Chief Energy Delivery Officer, she oversaw SDG&E's electric and gas distribution operations, customer services, and external and state legislative affairs. Winn has three decades of experience in the energy industry and has been committed to creating a better customer experience; she led the creation of one of the first energy marketplace online platforms to offer customers energy-saving household products and services with instant rebates. Winn serves a number of boards and dedicates substantial time to motivating and mentoring women. Winn has a bachelor's degree in electrical engineering and is a registered professional engineer in the state of California.

Special Guests



Ashutosh Bhagwat

Ash Bhagwat is a Martin Luther King, Jr. Professor of Law at the University of California, Davis School of Law, where he teaches Administrative Law, Constitutional Law, and Economic Regulation. Prior to joining the Davis faculty in 2011, Professor Bhagwat was a member of the faculty at the UC Hastings College of the Law for seventeen years. He clerked for Judge Richard Posner of the Seventh Circuit, and Justice Anthony Kennedy of the United States Supreme Court. Professor Bhagwat is the author of *The Myth of Rights*, published by the Oxford University Press as well as numerous articles on a wide variety of legal subjects, with a particular focus on the First Amendment. Professor Bhagwat is a member of the American Law Institute. In May of 2011, Governor Jerry Brown appointed Professor Bhagwat to serve as a member of the Board of Governors of the California Independent System Operator.



Andrew McAllister

Andrew McAllister was appointed to the California Energy Commission by Gov. Edmund G. Brown in May 2012, and reappointed in January 2017. Commissioner McAllister has been working on clean energy deployment and policy for his entire 25-year career: beginning in the early 1990s in project engineering and development, evolving into program design and implementation, then moving into the policy arena. He has worked across the world to develop renewable energy generation, energy efficiency investments, and energy management systems. He administered two of California's signature renewable energy programs (California Solar Initiative, Self-Generation Incentive Program), developed and operated energy efficiency programs for utilities, and performed a broad range of policy-related research for California and the U.S. Federal government. Commissioner holds M.S. and PhD degrees from the Energy & Resources Group at UC Berkeley. He is a Returned Peace Corps Volunteer.



George Minter

George Minter is regional vice president of external affairs and environmental strategy for SoCalGas. He is responsible for the company's public affairs, community relations, public policy and energy and environmental affairs functions. Minter is a long-time policy professional specializing in energy and environmental matters, strategic planning, program development, communications and political advocacy. Before re-joining SoCalGas as senior director of policy and environment, Minter was managing principal for L.A.-based public affairs firms Greer/Dailey/Minter and GM Public Affairs. There he managed public policy initiatives and communications programs to approve large energy and land use projects. Prior to his career at SoCalGas, Minter was a political consultant handling local, state and national political campaigns, responsible for strategy development, campaign management, direct mail and television and radio production. Minter is a Phi Beta Kappa and honors graduate of the University of California at Berkeley.

Featured Students



Madison Hoffacker

Madison graduated with a B.S. in Environmental Science and Policy from Chapman University in 2013. Upon graduating, she worked for the Department of Global Ecology at the Carnegie Institution for Science (Stanford, California) as a GIS researcher. Madison became a Sustainable Energy Research Specialist jointly with the Energy and Resources Group at UC Berkeley and the Center for Conservation Biology at UC Riverside. Her work explored the geography of solar energy systems to understand the impact as well as the potential for large-scale solar energy systems within environmentally compatible locations. Madison's recent research interest is understanding the interaction and role of renewable energy at the nexus of land, food, energy, and water. Apart from research, she enjoys backpacking and discovering alternative backcountry roads when traveling.



Kabian Ritter

Kabian is originally from Orangeburg, SC and received his B.S. in Chemistry from Howard University in 2017. He is currently pursuing his PhD in Energy Systems under Dr. Jesus Velazquez focusing on material science chemistry and its applications to battery power as well as water remediation techniques. Kabian enjoys traveling, being outdoors, reading, gaming, and music production. One of his life goals is to explore Machu Picchu.



Alex Sloan

Alex has worked in energy efficiency since 2010, with a primary emphasis on residential home performance program implementation for California utilities and local governments. In addition to program management, he has provided training and resources on “house-as-a-system” and ENERGY STAR® appliances to hundreds of residential contractors, customers and retail sales associates. Alex is interested in investigating barriers and opportunities for bringing clean energy technologies to market. His inspiration for pursuing a sustainability-related career developed while he was studying abroad with UC Davis's Sustainable Cities of Northern Europe (SCONES) program in 2010. Alex holds a BS in Psychology from UC Davis and is a Building Performance Institute (BPI) Building Analyst and Proctor.

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.

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.



Alissa Kendall

Alissa Kendall is a Professor of Civil & Environmental Engineering and Chair of the Energy Graduate Group at UC Davis. Her research applies principles of industrial ecology and environmental engineering by developing and implementing life cycle assessment (LCA) methods for vehicles and fuels, civil infrastructure, and food and bioenergy production systems with the ultimate goal of mitigating climate change and other environmental and resource challenges. Kendall’s teaching interests mirror this interdisciplinary, problem-oriented research program. She teaches Life Cycle Assessment for Sustainable Engineering, a core class in the Energy curriculum, and an undergraduate class in Urban Systems and Sustainability. She has received a number of honors and awards related to research and teaching. Kendall holds a B.S. in Environmental Engineering from Duke University and an M.S. and Ph.D. from the University of Michigan, Ann Arbor.



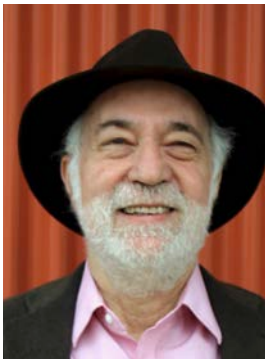
Kurt Kornbluth

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 & Researchers

Name	Title	Department	Research
Nina Amenta	Professor ----- Department Chair	Computer Science	<ul style="list-style-type: none">• Visualization• User interfaces• Smart grid
Gwen Arnold	Assistant Professor ----- Co-Director, Center for Environmental Behavior	Environmental Science and Policy	<ul style="list-style-type: none">• Hydraulic fracturing• Regulation and policymaking
Shota Atsumi	Associate Professor,	Chemistry	<ul style="list-style-type: none">• Biofuels
Louise Berben	Associate Professor	Chemistry	<ul style="list-style-type: none">• Solar fuels• CO2 conversion• Hydrogen production
Catherine Brinkley	Assistant Professor	Human Ecology	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• Consumer choice behavior and modeling• Decision and management sciences
James Bushnell	Professor	Economics	<ul style="list-style-type: none">• Energy markets• Utility regulation• Climate change• Environmental regulation

Name	Title	Department	Research
Colin Carter	Distinguished Professor ----- Director, Giannini Foundation of Agricultural Economics	Agricultural and Resource Economics	<ul style="list-style-type: none"> • Commodity markets • International trade • China's rural economy
J.P. Delplanque	Professor ----- Director, California Small Hydro Collaborative	Mechanical and Aerospace Engineering	<ul style="list-style-type: none"> • Combustion • Hydropower • Modeling and simulation
Georgia Drakakaki	Assistant Professor	Plant Sciences	<ul style="list-style-type: none"> • Biofuels • Cell wall • Algae • Biomass
Zhiliang (Julia) Fan	Associate Professor ----- Energy Graduate Group Graduate Advisor	Biological and Agricultural Engineering	<ul style="list-style-type: none"> • Biofuels • Metabolic engineering • Fermentation • Process modeling
Annaliese Franz	Associate Professor	Chemistry	<ul style="list-style-type: none"> • Biofuels • Catalysis • Chemical transformations to produce biofuels
Andrew Hargadon	Professor of Technology Management ----- Charles J. Soderquist Chair in Entrepreneurship	Graduate School of Management	<ul style="list-style-type: none"> • Energy efficiency design and management

Associated Faculty & Researchers

Name	Title	Department	Research
Rebecca R. Hernandez	Assistant Professor ----- Assistant Earth System Scientist, Agricultural Experiment Station	Land, Air, Water Resources	<ul style="list-style-type: none"> • Energy geography & energy knowledge systems • Environmental impacts, trade-offs & synergies of energy development • Land-use, land sparing & energy infrastructure planning • Food-energy-water nexus • Sustainable solar energy development & wildlife interactions
Bryan Jenkins	Professor ----- Chair/Director, California Renewable Energy Center	Biological and Agricultural Engineering	<ul style="list-style-type: none"> • Energy systems • Optimization • Thermochemical conversion
Tina Jeoh	Assistant Professor	Biological and Agricultural Engineering	<ul style="list-style-type: none"> • Cellulosic biofuels • Bioconversion
Katrina Jessoe	Associate Professor ----- Energy Graduate Group Advisor	Agricultural and Resource Economics	<ul style="list-style-type: none"> • Environmental and energy economics • Consumer and firm behavior
Alissa Kendall	Professor ----- Chair, Energy Graduate Group	Civil and Environmental Engineering	<ul style="list-style-type: none"> • Life cycle assessment • Renewable energy • Transportation energy
Sangtae Kim	Professor	Materials Science of Engineering	<ul style="list-style-type: none"> • Nanomaterials • Energy storage • Fuel cells

Name	Title	Department	Research
Kurt Kornbluth	Assistant Adjunct Professor ----- Director, Program for International Energy Technologies & D-Lab ----- Associate Director, UC Davis Blum Center for Developing Economies	Biological and Agricultural Engineering	<ul style="list-style-type: none"> • Climate neutrality • Energy efficiency • Consumer behavior • Renewable energy technologies
Heiner Lieth	Professor ----- Extension Specialist	Plant Sciences	<ul style="list-style-type: none"> • Greenhouse and nursery production • Soilless culture • Photovoltaic energy production in agriculture
Frank Loge	Professor ----- Director, Center for Water-Energy Efficiency ----- Krone Endowed Professor in Environmental Engineering	Civil and Environmental Engineering	<ul style="list-style-type: none"> • Information technology • Water/Energy nexus • Water/Health • Conservation • Sustainable systems & technologies
Mark Mascal	Professor	Chemistry	<ul style="list-style-type: none"> • Integrated biorefinery • Renewable fuels and materials • Biomass valorization • Biomass-derived platform chemicals
Alan Meier	Adjunct Professor ----- Faculty Researcher, Energy and Efficiency Institute ----- Senior Scientist, Lawrence Berkeley National Laboratory	Environmental Science and Policy	<ul style="list-style-type: none"> • Energy efficiency • Energy demand • Economics • Behavior and energy use

Associated Faculty & Researchers

Name	Title	Department	Research
Sabbie Miller	Assistant Professor	Civil and Environmental Engineering	<ul style="list-style-type: none"> Life cycle assessment Alternative materials development Sustainability and structural design
Mark Modera	Professor ----- Interim Faculty Director, Energy and Efficiency Institute ----- Director, Western Cooling Efficiency Center ----- Sempra Chair in Energy Efficiency	Civil and Environmental Engineering ----- Mechanical and Aerospace Engineering	<ul style="list-style-type: none"> End-use energy efficiency Energy distribution systems Building energy management Ventilation and indoor air quality
Frances Moore	Assistant Professor	Environmental Science and Policy	<ul style="list-style-type: none"> Economic and social impacts of climate change Energy-water-food nexus
Adam Moule	Assistant Professor ----- Energy Graduate Group Advisor	Chemical Engineering and Material Sciences	<ul style="list-style-type: none"> Solar materials
Erich Muehlegger	Associate Professor	Economics	<ul style="list-style-type: none"> Regulation and taxation of energy markets Industrial organization Public finance Environmental policy
Vinod Narayanan	Professor ----- Associate Director, Western Cooling Efficiency Center	Mechanical and Aerospace Engineering	<ul style="list-style-type: none"> Energy efficiency Heat and mass transfer enhancement Phase change heat transfer Microtechnology

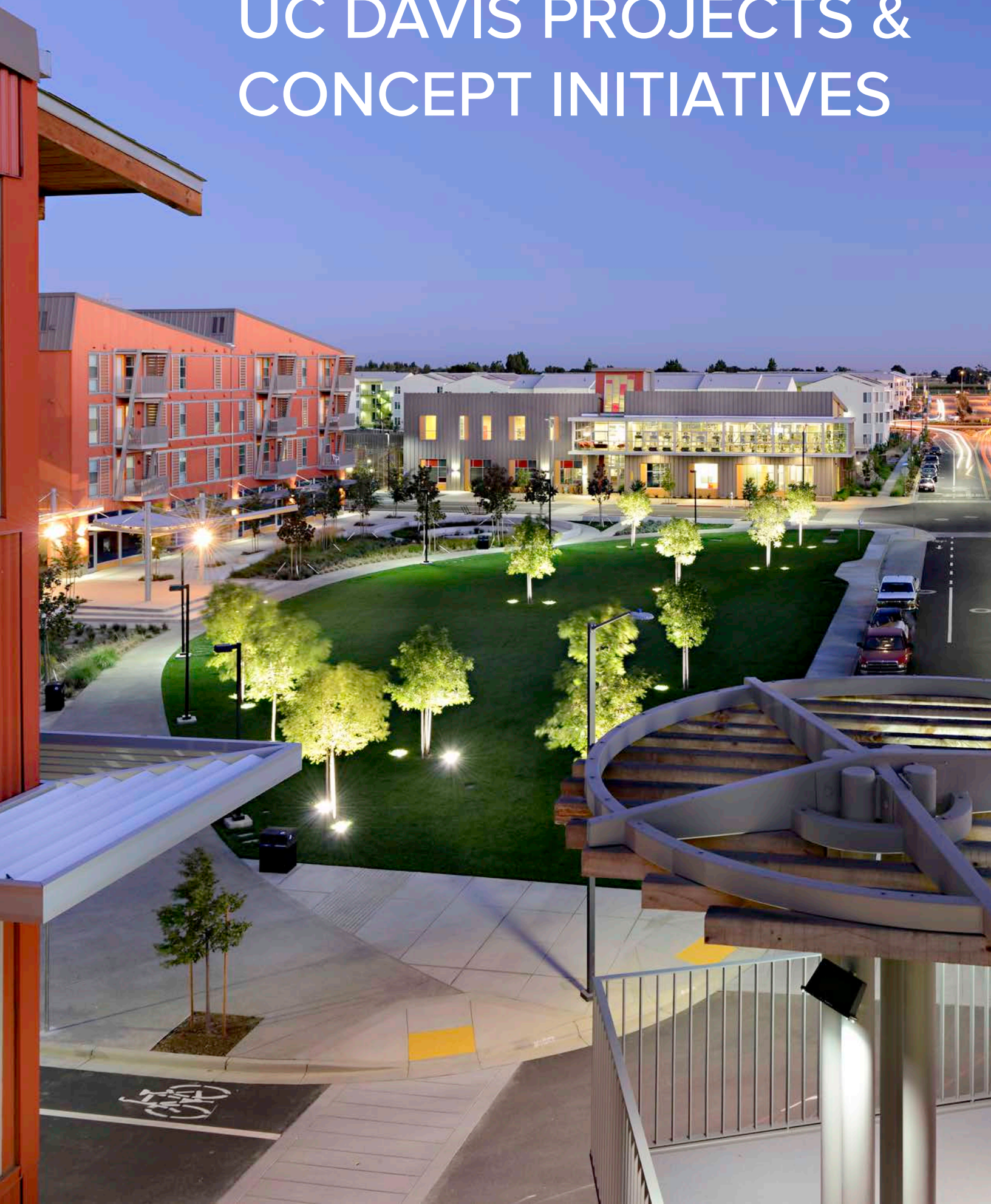
Name	Title	Department	Research
Kevin Novan	Assistant Professor	Agricultural and Resource Economics	<ul style="list-style-type: none"> • Environmental economics • Applied econometrics
Joan Ogden	Professor	Environmental Science and Policy	<ul style="list-style-type: none"> • Alternative fuels • Energy transitions • Hydrogen and fuel cells • Energy infrastructure
Frank Osterloh	Professor	Chemistry	<ul style="list-style-type: none"> • Solar energy • Photovoltaics • Photocatalytic water splitting • Hydrogen • Nanomaterials
Jae Wan Park	Associate Professor	Mechanical and Aerospace Engineering	<ul style="list-style-type: none"> • Efficiency energy systems • Fuel cells • Batteries • Electric grid
David Rapson	Assistant Professor	Economics	<ul style="list-style-type: none"> • Energy economics • Energy markets • Energy policy
Pamela Ronald	Professor ----- Professor, Genome Center ----- Director, Grass Genetics, The Joint Bioenergy Institute ----- Faculty Director, Institute for Food and Agricultural Literacy	Plant Pathology	<ul style="list-style-type: none"> • Biofuels • Grass genetics • Cell wall biosynthesis
Chris Simmons	Assistant Professor	Food Science and Technology	<ul style="list-style-type: none"> • Biofuels • Waste-to-energy • Water/Energy nexus

Associated Faculty & Researchers

Name	Title	Department	Research
Aaron Smith	Professor	Agricultural and Resource Economics	<ul style="list-style-type: none"> • Biofuels • Residential energy efficiency • Energy price dynamics
Edward (Ned) Spang	Assistant Professor ----- Associate Director, Center for Water-Energy Efficiency	Food Science and Technology	<ul style="list-style-type: none"> • Water, energy, and food resource systems
Daniel Sperling	Professor ----- Founding Director, Institute of Transportation Studies ----- Founding Chair, Policy Institute for Energy, Economics and the Economy	Civil and Environmental Engineering & Environmental Science and Policy	<ul style="list-style-type: none"> • Transportation and energy systems • Transportation and energy policy
Gil Tal	Research Director, The Plug-in Hybrid & Electric Vehicle (PH&EV) Research Center ----- Transportation Research Director, The China Center for Energy and Transportation ----- Admission Graduate Advisor, Graduate Groups in Transportation Technology, and Policy (TTP)		<ul style="list-style-type: none"> • Alternative fuel vehicles • Travel behavior • Travel demand modeling • Transportation planning
Case van Dam	Professor ----- Department Chair Professor	Mechanical and Aerospace Engineering	<ul style="list-style-type: none"> • Wind energy

Name	Title	Department	Research
Jean VanderGheynst	Professor	Biological and Agricultural Engineering	<ul style="list-style-type: none"> • Biofuels • Algae • Bioconversion
Jesús M. Velázquez	Assistant Professor	Chemistry	<ul style="list-style-type: none"> • Rational design of well-defined dimensionally reduced materials • Nanoelectronics, energy conversion devices, and environmental remediation
Stephen M. Wheeler	Professor	Human Ecology	<ul style="list-style-type: none"> • Urban and regional planning • Sustainability • Climate action planning
Dong Yu	Associate Professor	Physics	<ul style="list-style-type: none"> • Solar energy • Nanostructure solar cells
Ruihong Zhang	Professor	Biological and Agricultural Engineering	<ul style="list-style-type: none"> • Bioenergy • Biofuels • Waste-to-energy conversion

UC DAVIS PROJECTS & CONCEPT INITIATIVES



Launching the California Energy Product Evaluation Hub

With few rigorous product evaluations to inform purchasing decisions, large commercial and institutional customers face enormous uncertainty and high costs associated with purchasing advanced energy efficiency, renewable distributed energy generation and energy storage products—collectively defined as distributed energy resource (DER) products. Existing third-party resources do not typically provide information on specific products, nor do they allow for side-by-side comparisons of similar products or provide all of the information consumers need to make informed buying decisions. Relying on manufacturers' studies is also problematic given the potential biases in such studies. There is little incentive for market actors to fill this gap, which hinders the diffusion of promising DER products on a large scale.

With \$11 million from the California Energy Commission, the Energy and Efficiency Institute will develop the California Energy Product Evaluation (Cal-EPE) Hub to:

- 1) evaluate selected DER products in a rigorous and transparent manner, and
- 2) disseminate widely evaluation results to large commercial and institutional customers that use a formal procurement process.



The evaluations will allow ‘apples-to-apples’ comparisons of similar products, as well as comparisons to existing government and industry standards. Testing will be completed at respected and experienced institutions with comprehensive test facilities including UC Davis, UC Berkeley, and Lawrence Berkeley National Laboratory (LBNL). The evaluations, and the supporting data, will be made available through a public web platform.

Providing detailed, comprehensive, and generalizable information in a format that facilitates comparisons, will provide buyers with far more valuable information on which to base their procurement decisions. By providing large customers with the tools they need to make informed purchasing decisions, the Hub will stimulate more widespread adoption of proven DER products, reducing California’s overall energy use and greenhouse gas emissions.

Partnerships with Mexican Institutions

In 2018, UC Davis received three awards from Mexico's Ministry of Energy (SENER) and its National Council for Science Technology (CONACYT) to work in partnership with Mexican research institutions on energy efficiency research, development, and demonstration. The three projects are investments in capacity building which will help Mexico meet its ambitious clean energy goals.

- Project 1: UC Davis will work with the Universidad Autonoma de Guadalajara (UAG) to establish a “sister” lighting application research center for the development of demonstration projects of new lighting systems to improve energy efficiency.
- Project 2: UC Davis will work with Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM or Tec de Monterrey) to develop a consortium for energy efficiency in non-residential buildings.
- Project 3: UC Davis will work with the Center for Research and Teaching of Economics (CIDE) on the analysis of improvements in energy efficiency and energy conservation in the non-residential electrical sector.

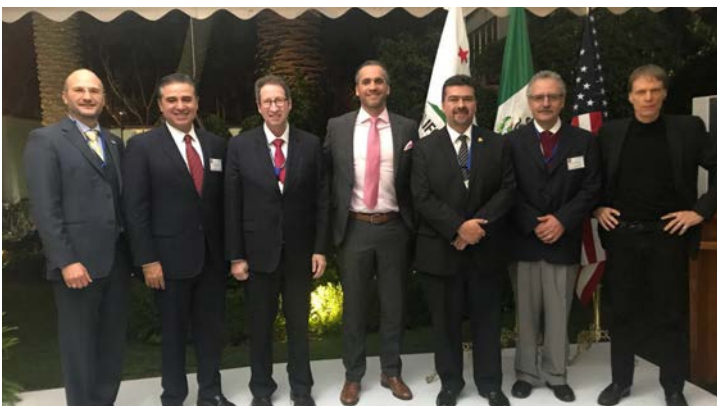
Joint research projects will increase collaboration on energy efficiency, renewable energy, and economic development and will help reinforce the strong partnerships the UC System has developed with Mexico's Ministry of Energy and Mexican academic institutions in the areas of clean energy and energy efficiency.

Background

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 innovative 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.

“I am glad to see that with the participation of the best talent from the University of California system and our academic and research institutions, along with the private sector and the governmental sector, we are addressing the challenges and laying the conditions to make sure that Mexico can transition to a low carbon economy.”

– Leonardo Beltran Rodriguez, Deputy Secretary for Planning and Energy Transition



On November 16, 2017, there was a ceremony at Casa de la Universidad de California announcing the funding awards. The award ceremony was attended by UC Vice Chancellors for Research from the UC campuses, Mexican colleagues from leading academic institutions, government officials, and lead researchers that collaborated on the awarded proposals.

Veterans to Energy Initiative

The goal of the Veterans to Energy Initiative is to foster a partnership among three critical sectors—the military, higher education institutions, and the energy industry in California—to facilitate the transition of service members into rewarding energy careers. This initiative involves education, outreach, and awareness components.

Education

The education component includes: 1) a 2-day Fast Track to Energy Careers training program to expose student veterans to the energy field, 2) a pilot program at UC Davis for veteran students transferring from community colleges, and 3) an energy Skills Bridge training course being developed as a part of service members' transition program.

Outreach

The outreach component involves expanding relationships with military installations, veterans' centers, and personnel in California to broaden the reach of our education programs and insure that all interested veterans are able to take advantage of these offerings.

Awareness

The awareness component focuses on ensuring that utility companies, and specifically hiring managers, understand the ways in which an individual's military experience and training translate to the energy industry.

Key Accomplishments

- Established a Working Group for Advancing Veterans in the Energy Industry in California—The Energy and Efficiency Institute (EEI) worked closely with the Office of Naval Research and PG&E to initiate an “Energy Partnership” comprised of military installations and organizations, higher education institutions, and California's utility industry.
- Developed a New Partnership Between UC Davis and CSU San Marcos—UC Davis faculty and researchers will be connected with CSUSM student veterans who are interested in pursuing graduate degrees in energy-related fields.
- Developed a New Course at UC Davis for Student Veterans—The Coordinator of the University's Veterans' Success Center, taught a course entitled “Strategies for Academic Success for Student Veterans” in order to help Student Veterans transition to the university culture.

Upcoming Projects

Host the Fasttrack to Energy Careers for Veterans Bootcamp— On September 24-25, the EEI, in conjunction with PG&E, will host a 2-day Training Course for student veterans interested in pursuing careers in the energy field.

Advanced the Skills Bridge Training Program—The partnership is working to finalize the curriculum, secure significant grant funding, and to obtain Camp Pendleton base agreements.

“ The Energy and Efficiency Institute 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. ”



Concept Initiative: Developing Capacity to Address Energy Solutions for Disadvantaged Communities

California policymakers are committed to ensuring that investments made by State agencies (CPUC, CARB, CEC, CalISO, and the Strategic Growth Council) address energy, climate, and environmental challenges in a manner that will yield direct and indirect benefits to disadvantaged communities. Utilities are similarly increasing their focus on meeting the needs of its disadvantaged customers. The EEI is investing the time and effort of two of our lead researchers, Sarah Outcault, Market Transformation Research Director, and Theresa Pistoichini, Director of Engineering, to spearhead an effort to further develop the Institute's capacity and strategic partnerships to address energy solutions for disadvantaged communities.

Over the last few years, the EEI has worked on a number of projects to address the complex needs of various buildings and residents in this underserved sector. Using multidisciplinary teams of researchers with expertise on energy in buildings, indoor air quality, and the social sciences, we have advanced projects to improve comfort, energy efficiency, and environmental conditions in schools and housing among disadvantaged communities (e.g., low-income, farm workers, senior citizens) across California. In each case, we have drawn on the expertise of our community partners to build our understanding of the unique challenges we must tackle to meet the primary project objectives related to energy and efficiency.

Going forward, we plan to launch an initiative to gather information on the complexities of addressing energy needs for disadvantaged communities, and to convene leaders working in this space (from internal partnerships at UC Davis with the Center for Regional Change and the Center for Poverty Research, to external partnerships with NGOs such as Global Green, the Greenlining Institute, and Energy Efficiency for All) to help us prioritize the many issues we might address. The information and strategic input we collect will put us in a better position to leverage research contracts and grant proposals to focus on disadvantaged communities. If successful, those projects would help to build yet another core competency within the EEI, one that is essential to achieving California's ambitious carbon reduction goals and ensuring more equal access to the benefits from technological progress.

This broader work will leverage three existing projects we already have underway, all of which are funded by the CA Energy Commission:

Demonstrating Affordable, Comfortable and Grid Integrated Zero Net Energy Communities

On this project, UC Davis is working under subcontract to EPRI with three community developers to design and build over a hundred affordable, comfortable, integrated Zero Net Energy (ZNE) apartments in two disadvantaged communities. This project aims to develop residential ZNE designs with minimal extra costs that conform to production builder practices, are comfortable and inviting for residents, and reduce both utility bills and required electrical grid infrastructure. UC Davis is contributing to design of space conditioning and management of indoor air quality, perception of ZNE and behavioral surveys, as well as data analysis to determine building performance.

Field Study to Assess Occupant Experience Related to Energy Efficient Upgrades in Low-Income, Multifamily Communities

On this project, UC Davis is working under subcontract to EPRI to conduct a field studies to deploy energy efficient retrofit packages for low-income, multi-family buildings in Southern and Central California. The research team is measuring energy savings, indoor air quality improvements, and benefits to owners and occupants. EEI is leading tasks to measure indoor air quality and characterize occupant behavior and satisfaction, including participant engagement, pre- and post- intervention survey design and implementation, and analysis. We are also advising on HVAC upgrades.

Field Study to Assess Occupant Experience of Energy Efficient Upgrades of Low-Income, Single-Family Residences

Field experiment to document the energy, indoor air quality and cost effectiveness of a pair of cutting-edge residential energy efficient upgrade packages. EEI researchers are measuring occupant behavior and satisfaction, pre- and post- upgrade through in-depth household interviews. The retrofit packages focus on an advanced compressor-less cooling technology combined with building envelope sealing and mechanical ventilation. These improvements are expected to reduce energy consumption and peak demand of the homes while also providing improved indoor air quality.

Potential Partners:

- Greenlining Institute
- Global Green
- Energy Efficiency for All
- UC Davis Center of Poverty Research
- UC Davis Center for Regional Change

Concept Initiative: Evaluating the Healthcare Service Impacts of Advanced Building Technology and Design Solutions

Our CA Lighting Technology Center (CLTC) and Western Cooling Efficiency Center (WCEC) have identified efficient ways to deliver lighting and HVAC solutions (respectively) that have the potential to improve patient comfort and outcomes and enhance clinical care in healthcare environments. Through partnerships with clinical researchers and healthcare facilities administrators, the UC Davis Energy and Efficiency Institute seeks to develop and conduct evidence-based assessments that will validate and quantify the impact to healthcare services and resource efficiency of technology and design improvements to the built environment. UC Davis will partner with the Center for Health Design and its Built Environment Network (BEN) to identify and select medical institutions that are willing to partner on performing this research. Hospitals that have expressed interest in such collaboration include, among others: the UC Davis Medical School, the UC Irvine Medical School, Kaiser Permanente, and the Boston Medical Center. Based upon obtaining funding from State and Federal agencies and associations, we will work to select and design advanced energy-efficient enhancements to healthcare facilities, while conducting rigorous analysis on the impacts relative to quality patient experiences and clinical care.

Background

Hospitals and the healthcare industry use sizeable amounts of energy and power. The UC Davis Energy and Efficiency Institute and its affiliated research centers are partnering with the Center for Health Design to identify advanced building technologies that can provide higher-quality environments for patients and clinicians that also use resources more efficiently. The effort will involve designing and conducting interdisciplinary pilots and demonstrations that assesses the potential of advanced novel concepts in human-centric design to promote healing and wellness within the patient health-care community. Integrated concepts that will be explored include:

- Circadian lighting for patient rooms and corridors
- Recovery enhancing lighting in patient rooms
- Improved color discernment lighting in exam rooms (dermatology and cardiology)
- Safety-enhancing pathway lighting
- Improved HVAC systems providing better air-quality and optimal levels of ventilation
- Cleaner and more efficient coils within current HVAC systems
- Improved water quality

UC Davis is uniquely capable of partnering on this effort, based upon our expertise and track record of successes translating our applied research into the commercialization of advanced lighting and HVAC systems in the broader built environment. We are already well positioned to apply our experience to the broader healthcare setting. Our Institute and centers are working with the UC Davis Medical School and programs at UC Irvine to test lighting technologies, including Circadian Corridor Lighting – a ceiling-integrated fixture providing both general ambient white LED lighting and nighttime ambient amber LED lighting, combined with lighting control systems incorporating appropriate dimming and switching. In addition, we have established two ongoing test sites for high-color quality lighting in examination rooms for dermatology.

UC Davis HVAC researchers have previously worked with hospitals to better manage air flow patterns (i.e. zone pressurization and depressurization) using lower air flows, and thereby less energy. One of the unique technologies utilized was a way to seal leaks hard-to-find, hard-to-reach leaks remotely with aerosolized sealants.

UC Davis faculty and staff researchers will be needed for the initial design and ongoing research associated with these types of research projects. Our researchers will need to partner with commensurate researchers at CHD to design and conduct the analysis on the impacts to key performance indicators by the technology retrofits, in the form of patient outcomes (satisfaction scores, recovery rates, number of trips and falls, etc.) and worker productivity (absenteeism, turnover, etc.). Collaboration with healthcare facilities will also be critical, since they will dedicate the space and personnel to accommodate and implement the projects. We will work with them to quantify the energy and maintenance impacts of the upgrades. Additionally, we will also work with clinicians to better assess the potential enhancement of patient care associated with high-quality lighting (dermatology and cardiology).

Lastly, manufacturers and consulting firms will play an important role in supporting the appropriate selection, installation, and commissioning of the equipment. Additional effort by all parties will be required to coordinate the initial research as well as to recruit industry partners and identify and submit promising large proposals for research funding.

Potential Funding Agencies

- Agency for Healthcare Research and Quality (AHRQ)
- California Energy Commission

Potential Industry Partners

- Mazzeti + GBH
- Phillips
- Schneider Electric
- Vantage Controls
- Visa Lighting

Concept Initiative: Establish an Indoor Growing Facility

Establish an Indoor Growing Facility to Research and Demonstrate Best Practices for Improved Energy and Water Use Efficiency and Reduced Environmental Impacts

With funding initially from a consortium of California Utilities and augmented with potential follow-on funding from the California Energy Commission and other state and federal agencies, UC Davis is seeking to design, build, and operate an Indoor Growing Facility that will allow researchers to test energy and water efficiency, as well as the environmental impacts of operations. Initial Utilities that have expressed interest in establishing and funding this resource are SMUD and PG&E. Other Utilities likely to be interested are SCE, SDG&E, LADWP, and Xcel Energy.

Background

Utilities across the country are under significant pressure to provide electricity, water, and waste infrastructure for the rapidly expanding indoor cultivation market place. Recent research by our Western Cooling Efficiency Center (WCEC) and others suggests that improving energy efficiencies in lighting, HVAC design and efficiency, and building envelope could reduce energy consumption of indoor growing facilities by 50% or more. Additional savings in water consumption and best practices in waste management are also worthy of exploring. Policymakers, utility providers, and indoor growing companies will benefit from a research facility devoted to exploring ways to achieve such savings. The UC Davis Energy and Efficiency Institute and its affiliated research centers are partnering with the College of Agriculture and Environmental Science to establish this important research facility.

Proposed Research Facility

A state-of-the-art indoor growing facility is critical to understanding the environmental needs of plants being cultivated indoors. Such infrastructure would enable researchers to understand and identify best practices for plants in an indoor growing environment, including:

- Lighting levels (spectrum distribution, schedule, intensity, optics, etc.);
- Chamber conditions (Temperature, humidity);
- Air quality levels (CO2 levels);
- Planting arrangements (density, spacing, vertical arrangement)
- Pest management systems
- Nutrient and water delivery methods and rates;
- Crop modeling and tracking so as to optimize harvesting and management practices; and,
- Waste collection and disposal solutions.

Researchers will study the levels necessary for the optimal productivity of high value vegetables and herbs and will, in some cases, study plant proxies that approximate needs for other high value indoor grown commodities. Through this research, scientists will monitor the resulting energy consumption and performance of the systems, with five-minute time resolution that includes:

- Power consumption of lights
- Power consumption of cooling equipment
- Power consumption of dehumidification equipment
- For cooling and dehumidification equipment: Supply and return air temperature, humidity and air flow rate
- Electricity and/or gas consumption for heating
- Gas consumption for CO2 production
- Water consumption rates for plant watering
- Room air, temperature, humidity, and CO2 level
- Outdoor air conditions in relation to heating and cooling

Armed with these data, researchers can test and develop the more efficient equipment and approaches that can deliver target operating levels. Examples include:

- Advanced lighting systems that include spectral and temporal controls functions
- High efficiency air conditioning and dehumidification systems including:
- Variable refrigerant flow (VRF) systems
- MSP Technology's dehumidification system that utilizes plate air-to-air heat exchangers for sensible heat recovery
- Desert Aire's GrowAire System
- Aerosol building envelope sealing technology to reduce air infiltration and pests from the outdoors

Objective

The objective of this work will be to develop a centralized research facility for California that will develop best practices for indoor plant cultivation based on third-party objective research and testing. This will integrate lighting, air-conditioning, controls as well as water and soil management solutions. Information gathered on building loads and growing practices, combined with demonstration of energy-efficient building systems, would enable Utilities to create best-practice design guides and rebate programs for indoor growing to reduce the connected load and uncertainty in demand forecasting for new and existing facilities.

Facility Details

Facilities on the UC Davis campus would include:

- In-door production facility of adequate size and flexibility to accommodate multiple layered (vertical) growing systems using the most advanced indoor production technologies. This would be a clean-room facility with separate chambers to allow temperature and light optimization research. A simple deep-flow hydroponic system will be used as default system with more advanced systems provided by others for testing.
- Lab space for doing plant sciences lab work related to the research projects. This includes instrumentation to measure nutrients in irrigation solutions, photosynthetic performance of plants, stomatal performance of leaves, as well as biomass determinations (fresh and dry weight).
- Lab space for engineering work related to setting up and instrumenting any of the production systems. This includes data logging systems, hydroponics systems, etc.

Potential Manufacturing Partners

- Aessence (San Jose and Shanghai): leading innovative aeroponic systems for indoor production of food and medicinal crops
- General Hydroponics
- Osram Opto-electronics
- LEDvance Lighting
- Philips Horticulture (Signify)
- MSP Technology
- Desert Aire
- AeroSeal
- Various grower organizations





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