UCDAVIS
ENERGY EFFICIENCY CENTER


# Board of Advisors Meeting

December 2, 2014

# 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.

CalCEF

Pacific Gas and Electric Company

Southern California Edison
An Edison International Company

SMUD

Los Angeles Department of Water & Power

SDGE connected
A Sempra Energy utility

Southern California Gas Company
A Sempra Energy utility

Chevron

HONDA
The Power of Dreams

Walmart
Save money. Live better.

Microsoft

WELLS FARGO

Front Cover Photographs

**Top:** *The Honda Smart Home US celebrated its Grand Opening in March 2014, and the first occupants moved in this October.*

**Center:** *Nicole Biggart at the podium in her role as Director of the Energy Efficiency Center.*

**Bottom:** *California Conservation Corps during Energy Corps training at UC Davis West Village.*

## Welcome Special Guests and Members of the Board of Advisors,

Thank you for participating in our 2014 Board of Advisors meeting. As always, your engagement is critical to the on-going success of our programs and our ability to deliver on our mission. Among us, we have a unique collection of investors, advocates, experts, and friends of energy efficiency and when we gather in a room together, we are guaranteed to have interesting and productive conversations.

It's been a great pleasure to serve as the Chevron Chair and Director of the Energy Efficiency Center these past four and a half years. Although I will be stepping down in my role as Director and will be retiring from the Graduate School of Management this spring, I plan to stay involved with the center and continue my research in energy efficiency with my colleagues in the Social Sciences. The Center has come a long way as since I joined the group and I'm proud of our many achievements. Three particular investments I've made have positioned the center well for future success:

- New faculty positions dedicated to Energy Efficiency in Food Science, Water-Energy and HVAC;
- Co-location of our researchers here in West Village, the first ZNE community scale development in the country; and,
- Establishment of a Water-Energy center to complement our existing centers in lighting and HVAC.

In the following pages, you'll find our agenda for the day, bios for all of us, and background material highlighting our recent successes and active initiatives. We won't have time to fully brief you on everything that is covered in this packet; we encourage you instead to follow-up with us on anything that might be of special interest to you or your team/network.

Thank you again for all your support during my time as Director. I know my successor will be in good hands with all of you as well.

In appreciation,

Nicole Woolsey Biggart
Director, Energy Efficiency Center
Chevron Chair in Energy Efficiency
Professor, Graduate School of Management

# CONTENTS

# NOTES

# Board of Advisors Meeting
# Agenda

UC Davis West Village
1605 Tilia Street
Davis, California
Tuesday, December 2, 2014

## Tuesday, December 2, 2014

**10:30 a.m. Arrival and Light Refreshments**

**11:00 a.m. Welcome & Introductions**

**Michael Peevey**, *Chairman of the Board*

**New Board members:**

**Volker Heimeshoff**, *Walmart*
**Jeffrey Jacobs**, *Chevron*
**Bret Lane**, *SoCalGas*
**Frankie McDermott**, *SMUD*
**Barry Neal**, *Wells Fargo*
**Caroline Winn**, *SDG&E*

**Special Guests:**

**David Hochschild**, *California Energy Commission*
**Michael Li**, *US Department of Energy*
**Nancy Skinner**, *California State Assembly*
**David Muraki**, *California Conservation Corps*

**11:20 a.m. Director's Update**

**Nicole Woolsey Biggart**, *Director, Energy Efficiency Center (EEC); Chevron Chair in Energy Efficiency; Professor, Graduate School of Management*
**Ben Finkelor**, *Executive Director, EEC*
**Sumiko Hong**, *Director, Development and External Relations, EEC*

**Key Topics**

- **Branding, Fundraising, Faculty Updates**

**WI-FI INSTRUCTIONS**
Network: moobilenet
User name: itsdavis@gmail.com
Password: sustain

**11:35 a.m. Center Updates**

**Michael Siminovitch**, *Associate Director, EEC; Director, California Lighting Technology Center; Arthur H. Rosenfeld Chair in Energy Efficiency; Professor of Design*
**Mark Modera**, *Associate Director, EEC; Director, Western Cooling Efficiency Center; Sempra Chair in Energy Efficiency; Professor, Civil and Environmental Engineering; Professor, Mechanical and Aerospace Engineering*

**Key Topics**

- **Success Stories and Initiatives in Lighting and HVAC**

**12:35 p.m. Lunch**

**1:10 p.m. Honda Smart Home Tour and Board Photo**

**Akimasa Yasuoka**, *American Honda Motor Company, Inc.*

**1:45 p.m. cEnergi**

**Thomas Turrentine**, *Director, Plug-in Hybrid & Electric Vehicle Research Center*
**Justin Woodjack**, *Doctoral Student*

**2:00 p.m. Student Presentations**

**Kelsey Meagher**, *Doctoral Student, Low-income Energy Users*
**Taimour Khalid**, *Undergraduate, Energy Corps Initiative*

**2:10 p.m. Break**

**2:20 p.m. Integrating Big Data to Increase Resiliency & EE Market Penetration**

- Using Residential Smartmeter Data to Improve EM&V and Pricing Design
- Advancing Water-Energy Analytics
- Automating Data Analytics of Building Audits

to Transform and Standardize Performance-based EE retrofits for Small Commercial Buildings

**Aaron Smith**, *Professor, Agricultural & Resource Economics*
**Kevin Novan**, *Assistant Professor, Agricultural & Resource Economics*
**Frank Loge**, *Associate Director, EEC; Director Center for Water-Energy Efficiency Center (CWEE); Krone Endowed Professorship in Environmental Engineering; Professor, Civil and Environmental Engineering*
**David Muraki**
**Bill McNamara**, *Director - Energy Programs, California Conservation Corps*
**Ben Finkelor**
**Siva Gunda**, *Program Manager, EEC*

**Board Discussion Topics**

- Balancing Privacy & Security Concerns with Needs to Use Data for Research and Implementation of Programs;
- Maximizing Benefits of Smartmeters to Utilities, Customers, and Regulators, Identifying Priority Research Questions to Answer

**4:20 p.m. Solar Decathlon Briefing**
**Ben White**, *Doctoral Student*

**4:30 p.m. Wrap-up Discussion**

**5:00 p.m. Adjourn**

**5:30 p.m. Joint Board Reception and Dinner**
**ITS and EEC Board of Advisors and Invited Guests**
UC Davis Activities and Recreation Center

# BIOGRAPHIES: BOARD OF ADVISORS

## MICHAEL R. PEEVEY

Michael R. Peevey was appointed President of the California Public Utilities 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 many awards recognizing his leadership in developing energy policy and promoting recognition of California's diverse population, including a "Distinguished Citizen Award" from the Commonwealth Club of California for achievements in green and sustainable energy (2007), the Pat Brown Legacy Award (2003), named "Man of the Year" by The Power Association of Northern California, and recognized with the Climate Action Champion Award by the California Climate Action Registry (2004). 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.

## ELISABETH BRINTON

Elisabeth S. Brinton is Vice President, Corporate Strategy for Pacific Gas and Electric Company. Brinton joined PG&E in the fall of 2014 and is responsible for corporate strategy and corporate development. Most recently, she was Executive Vice President of Operations for C3 Energy. Prior to that, Brinton was Chief Customer Officer for SMUD, where she ran the vertically integrated utility's $2 billion retail business. Earlier Brinton was a senior executive in three successful startups, and was also founder and CEO of her own company in Silicon Valley, BPR, which she grew and successfully sold. Out of college, she worked on Capitol Hill for a member of Congress and for the House Judiciary Committee, staffing both environmental and energy policy issues. Brinton holds three bachelor's degrees from Principia College, is a Harry S. Truman Scholar, and a graduate of Singularity University's Global Executive Program. Brinton now serves as the co-chair for Singularity University's Energy and Climate Program.

## 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, which the William & Flora Hewlett Foundation established 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.

# BIOGRAPHIES: BOARD OF ADVISORS

## VOLKER HEIMESHOFF

Volker Heimeshoff is the vice president of Prototype and New Format Development for Walmart's Real Estate Division. Heimeshoff is focused on finding ways to take an efficient and cost effective approach while obtaining new locations and remodeling stores. Prior to joining the Real Estate Division, he led the Non-Store Operations Division in Health & Wellness, responsible for the manufacturing and distribution of all eyewear sold in Walmart Vision Centers. Heimeshoff also spent 8 years in retail operations for Walmart Germany as district manager and operations coordinator. He holds a Cand.Rer Oec (BA degree equivalent) from Ruhr-University Bochum, Germany, and a Diplom-Kaufmann (MBA equivalent) from Saarland University in Germany.

## 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 the division director at U.S. EPA 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.

## JEFFREY JACOBS

Jeffrey M. Jacobs is vice president of Chevron Technology Ventures. In this capacity he identifies, sponsors and demonstrates emerging technology and champions its integration into Chevron. In this role Jacobs leads strategic collaborations for acquiring primary carbon credits; and in developing advanced biofuels. Jacobs is Chairman of the U.S. Department of Energy's National Renewable Energy Laboratory's Biofuels Technical Review Panel. He is also a member of the Executive Steering Group for the Department of Energy's U.S. Drive Initiative. In addition, Jacobs is the current Chairman of the board of Catchlight Energy, the joint venture launched by Weyerhaeuser and Chevron in 2008 to develop advanced biofuels from forest-based biomass. Jacobs holds a Bachelor of Arts degree in biology/geology from Amherst College, a master of science in marine studies/geology from the University of Delaware, and an MBA in finance and economics from the Katz Graduate School of Business at the University of Pittsburgh.

# BIOGRAPHIES: BOARD OF ADVISORS

## DAVID JACOT

David Jacot, P.E., is the Director of Energy Efficiency 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.

## BRET LANE

Bret Lane is the Chief Operating Officer for Southern California Gas Company (SoCalGas), a Sempra Energy California regulated utility, and the largest natural gas utility in the US. Lane Oversees all activities related to the delivery of natural gas services to the 20 million consumers served by SoCalGas. Prior to becoming COO, Lane served as senior vice president of gas operations and system integrity for SoCalGas, responsible for all aspects of gas delivery services, including region operations, engineering, transmission, storage, and pipeline safety. He has held several other senior level positions with SoCalGas, including vice president of gas transmission and distribution, vice president of field services, vice president of environmental, safety and facilities, vice president of labor relations, and was Chief Environmental Officer. Lane holds a bachelor's of science degree in petroleum engineering from Oklahoma State University.

## DAN'L LEWIN

Dan'l Lewin is a Corporate Vice President at Microsoft, leading the company's work in civic technology, campaign technologies, and academic outreach; which promotes the work of scholars leading the dialogue on technology policy issues. Previously, he led Microsoft's global engagement with startups and venture capitalists, and business relationships with strategic industry partners. Lewin has executive and site responsibility for the company's operations in Silicon Valley, which currently employ more than 2,000 people. Lewin serves on the boards of the Churchill Club, Silicon Valley Community Foundation, the Stanford Institute for Economic Policy Research, World Business Chicago, and the Tech Museum of Innovation, where he served as past chairman of the Tech Museum Awards program. In addition, Lewin is on the Corporate Advisory Board of the National Venture Capital Association. He holds an AB in politics from Princeton University.

# BIOGRAPHIES: BOARD OF ADVISORS

## 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.

## FRANKIE MCDERMOTT

Frankie McDermott is the Chief Customer Officer at the Sacramento Municipal Utility District (SMUD) where he heads SMUD's Customer and Community Services department. McDermott runs SMUD's $1.4 billion retail electric business, including customer operations, services, and programs such as energy efficiency, renewables and advanced energy solutions. In addition, his role includes corporate strategy, brand, marketing, communications, and economic and community development, advancing SMUD's reputation and partnerships. McDermott has been SMUD's Customer Services Director since 2010, and in that role he was responsible for SMUD's overall retail strategy. He has been responsible for managing the changing relationships with customers as SMUD moves forward with its smart grid projects. McDermott joined SMUD in 2003. He previously held management roles in the semiconductor industry at NEC Electronics in Roseville, California and in Ireland. After engineering school in Ireland, he earned an MBA from Golden Gate University and completed the Berkeley Advanced Management Program at the Haas School of Business at UC Berkeley.

## 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. Earlier in his career, he was with Barakat & Chamberlin, an energy and environmental consulting firm, and Reading Energy Company, an independent power company, where he was one of the original founders. 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.

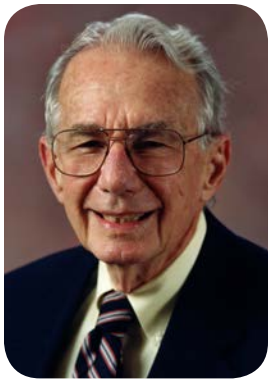
# BIOGRAPHIES: BOARD OF ADVISORS

## KEVIN PAYNE

Kevin M. Payne is senior vice president of Customer Service for Southern California Edison (SCE). He is responsible for SCE's demand-side management programs, customer products and services, customer engagement and call center operations, field services, account management and advanced metering. Prior to his current role, Payne was vice president of Engineering & Technical Services for SCE, overseeing the planning, engineering and designing of SCE's transmission and distribution systems. Payne has held various leadership positions within SCE. He began his career with SCE in 1986 in the Engineering and Construction department managing power plant retrofit and other engineering projects. Payne has a degree in mechanical engineering from the University of California, Berkeley and is a registered professional engineer.

## NANCY PFUND

Nancy Pfund is Managing Partner of DBL Investors, an investment firm focused on delivering strong financial returns together with positive social, environmental and economic impact. DBL Investors drives sustainability through a combination of investing in cleantech companies, investing in companies from more diversified sectors, and then helping these companies realize the economic benefits of environmental stewardship and branding. DBL Investor's first fund, the Bay Area Equity Fund, implements this strategy through a portfolio of investments in emerging growth companies located in lower income neighborhoods of the San Francisco Bay Area. Pfund sponsors or serves on the board of Elephant Pharmacy, Tesla Motors, Pandora Corporation, Brightsource Energy and Solar City. Previously, Pfund was a securities analyst, principal and managing director at JPMorgan (then Hambrecht & Quist). Pfund holds bachelor's and master's degrees from Stanford University and a master's degree from the Yale School of Management.



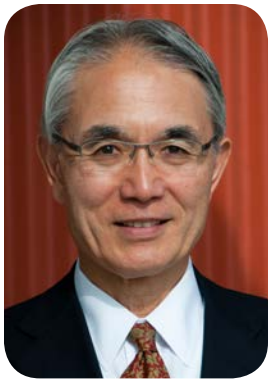
## ARTHUR H. ROSENFELD

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. He 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. Rosenfeld is author or co-author of 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. This award recognizes scientists of international stature for their lifetimes of exceptional achievement in the development, use, control or production of energy. This award is particularly meaningful as he was one of Enrico Fermi's last graduate students.

## CAROLINE WINN

Caroline Winn is vice president of customer services and chief customer privacy officer for San Diego Gas & Electric (SDG&E), one of Sempra Energy's regulated California utilities. Winn oversees all customer-related activities for SDG&E, including call centers, smart pricing program, energy efficiency, demand response and customer assistance programs, customer privacy, revenue cycle activities, electric rates and analysis, field services, corporate brand, marketing, and customer communications. Since joining the company in 1986 as an associate engineer, she has held a number of leadership positions with SDG&E and Southern California Gas Company (SoCalGas), including various positions within the electric transmission and distribution engineering and operations areas. Prior to her current position, Winn was director of supply chain management for both SDG&E and SoCalGas. Winn has a bachelor's degree in electrical engineering from California State University, Sacramento and is a registered professional engineer in the state of California.

# BIOGRAPHIES: BOARD OF ADVISORS



## AKIMASA YASUOKA

Akimasa Yasuoka is Senior Advisor to the Environmental Business Development Office of American Honda Motor Co., Inc. He created this office in 2011. The new organization is working on environmentally preferable projects such as the Green Dealer Initiative and the Smart Home, as well as researching future energy businesses. Prior to taking his current role, he was a senior vice president of product regulatory, safety and environmental policies and regulations. Through this role he has developed a long relationship with ITS-Davis, especially via the Car Link car-sharing research program, and the Sustainable Transportation Energy Pathways (STEPS) program. He worked for 24 years at Honda's R&D facilities in Japan, Germany and the United States, and also as the head of the Formula-1 race team in the 1990s. In part due to his engine-development experience, he is now interested in future energy management for alternative fuel vehicles.

# BIOGRAPHIES: SPECIAL GUESTS

## DAVID HOCHSCHILD

David Hochschild was appointed to the California Energy Commission by Governor Jerry Brown in February 2013. Commissioner Hochschild's career has spanned public service, environmental advocacy and the private sector. He first got involved in the solar energy field in 2001 in San Francisco as a Special Assistant to Mayor Willie Brown where he launched a citywide $100 million initiative to put solar panels on public buildings. He went on to co-found the Vote Solar Initiative, a 60,000-member advocacy organization promoting solar policies at the local, state and federal level. He served as executive director of a national consortium of leading solar manufacturers and worked for five years at Solaria, a solar company in Silicon Valley. In 2007-2008, he served as a commissioner at the San Francisco Public Utilities Commission. Commissioner Hochschild holds a B.A. degree from Swarthmore College and a Masters of Public Policy degree from Harvard's Kennedy School of Government and was a Coro Fellow in Public Affairs.

## MICHAEL LI

Michael Li is a senior policy advisor in the Office of Energy Efficiency and Renewable Energy at the US Department of Energy. He works on a variety of energy efficiency issues – primarily focusing on evaluation, measurements and verification, data access and privacy, state policy, and behavior based efficiency. He has also worked in the Office of Electricity and the Office of the Secretary while at the Department of Energy. Prior to joining the Department, Li was a senior policy advisor on climate change at the British Embassy in Washington and served as the chief of staff at the Maryland Energy Administration. He was a key author of many of Maryland's landmark energy policies, including Maryland's renewable portfolio standard and its statewide energy efficiency goals.

## DAVID MURAKI

David Muraki is the first Director of the California Conservation Corps to have "risen from the ranks." David initially joined the CCC in January 1978 as the Corps was gearing up following its creation by Governor Jerry Brown a little more than a year prior. Muraki served on staff of the CCC until 1996 in numerous capacities including administrator of the Del Norte Center, director of development, and manager of the planning and quality assurance division. In 1979, he started the CCC's iconic Backcountry Trails Project that has gone on to field 176 crews, build and maintain 10,840 miles of trails in national and state parks, forests, and wilderness areas throughout the state. From 1996 until his return to the CCC in 2007, Muraki served as deputy director for California Volunteers where he led public policy efforts and supported AmeriCorps national service and disaster volunteer programs. Since 2007 Muraki has served as the Director of the California Conservation Corps.

# BIOGRAPHIES: SPECIAL GUESTS

## NANCY SKINNER

Assemblymember Nancy Skinner represented the East Bay cities that stretch along the I-80 corridor from Hercules to Oakland from December 2008 through December 2014. Skinner served as Chair of the Assembly Budget Committee and previously served as Chair of the Assembly Rules Committee. A graduate of UC Berkeley, Skinner was active in Cal's student government, served on the Berkeley City Council and the East Bay Regional Park District Board, is a former small business owner and the founder of an international association of cities, Local Governments for Sustainability. She has an extensive background in climate change including director of the Cities for Climate Protection Campaign and coordinator of the 2005 Climate Action Summit between CEOs, Governor Schwarzenegger, and UK Prime Minister Blair. Assemblymember Skinner's successful legislation includes: the bills that required Amazon and other internet retailers to collect sales tax, made food stamps more available to hungry families, and protected renters and homeowners from foreclosure.

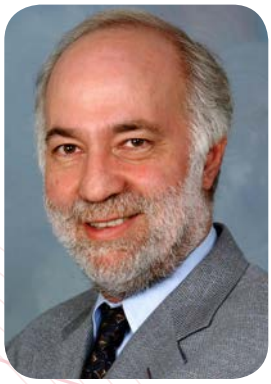
# BIOGRAPHIES: FACULTY LEADERSHIP

## NICOLE WOOLSEY BIGGART

Nicole Woolsey Biggart is Director of the UC Davis Energy Efficiency Center, and the Chevron Chair in Energy Efficiency. She joined the UC Davis Graduate School of Management in 1981 as one of the school's first faculty members and was its dean for six years. She was the Jerome J. and Elsie Suran Chair in Technology Management for eight years. Biggart is an expert in organizational theory and management of innovation. Her research interests include economic and organizational sociology, firm networks, industrial change and social bases of technology adoption. She has taught and written about adoption of sustainable technologies by industry and received the Aspen Institutes Faculty Pioneer Award in 2008. She was elected a Fellow of the American Association for the Advancement of Science in 2012.

## ANDREW HARGADON

Andrew Hargadon is the Charles J. Soderquist Chair in Entrepreneurship and Professor of Technology Management at the Graduate School of Management at University of California, Davis. He is the author of How Breakthroughs Happen: The Surprising Truth About How Companies Innovate (Harvard Business School Press 2003). His research focuses on the effective management of innovation and entrepreneurship, particularly in the development and commercialization of sustainable technologies. He has published numerous articles and chapters in leading scholarly and applied publications. His research has been used to develop or guide new innovation programs in a wide range of large organizations as well as multiple start-ups.



## DAN SPERLING

Daniel Sperling is Professor of Civil Engineering and Environmental Science and Policy, founding Director of the Institute of Transportation Studies at the University of California, Davis (ITS-Davis) and interim Director of the UC Davis Energy Institute. He is recognized as a leading international expert on transportation technology assessment, energy and environmental aspects of transportation, and transportation policy. He is Executive Director of the US Department of Transportation's (USDOT) $11.2 million National Center for Sustainable Transportation. He is winner of the 2013 Blue Planet Prize from the Asahi Glass Foundation of Tokyo, which has been described as the Nobel Prize for the environmental sciences. He is currently Vice Chair of the Executive Committee of the National Research Council's (NRC) Transportation Research Board (TRB), chaired the USDOT's National Spotlight Conference on Sustainable Energy and Transportation in 2012, is the 2013 chairman of the California Fuel Cell Partnership, was founding chair of the Alternative Fuels and Sustainability committees at TRB, is a board member of the California Air Resources Board, has served on 13 NRC committees on transportation and environmental topics, chaired the first transportation committee of the Davos World Economic Forum (2010), testified to Congress numerous times, and has authored 12 books and over 200 technical papers and reports.

# BIOGRAPHIES: FACULTY LEADERSHIP

## ANTHONY EGGERT

Anthony Eggert is the Executive Director of the Policy Institute for Energy, Environment and the Economy at UC Davis, which is dedicated to informing better policy through research. From 2007 through 2012, Eggert served as an appointee of Gov. Schwarzenegger and Gov. Brown in several senior positions including science and technology policy advisor to the chair of the Air Resources Board, commissioner for the California Energy Commission, and deputy secretary for energy policy of the California Environmental Protection Agency, overseeing clean energy and environmental policy development for California. Prior positions include advising the University of California on federal energy and climate policy, directing research on low-carbon fuels and vehicles at UC Davis' Institute of Transportation Studies, and as an engineer and then manager for Ford Motor Company. Eggert holds a bachelor's degree in mechanical engineering from University of Wisconsin, Madison and a master's degree in transportation technology and policy from the University of California, Davis.

## KURT KORNBLUTH

Dr. Kurt Kornbluth is the founder and director of the UC Davis Program for International Energy Technology and the UC Davis D-Lab. He is an adjunct professor in the Department of Engineering and Biological Sciences. His current research areas include hybrid fossil fuel/renewable electrical grids, and sustainable, low-carbon energy technologies for the developed and developing world. Kurt 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. He worked with Amy Smith at the MIT D-Lab during its inception and in 2008 created the D-Lab at UC Davis. He holds a PhD 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.

## FRANK J. LOGE

Frank Loge is Director of the UC Davis Center for Water-Energy Efficiency (CWEE) and Professor and Vice Chair of Graduate Studies, Department of Civil and Environmental Engineering and holds the Krone endowed professorship in Civil and Environmental Engineering. He is working to bridge the chasm between civil engineering and information technology to build a modern information architecture that enables intelligent water production, treatment, delivery, consumption, and post-treatment. Loge also serves on the City of Davis Water Advisory Committee and co-authored Davis's novel consumption-based fixed-rate water rate structure, which sends consumers a strong, fair conservation signal with revenue stability for water utilities. Loge holds a Ph.D. in civil and environmental engineering from the University of California, Davis.

## ALAN MEIER

Alan Meier is a Senior Scientist at Lawrence Berkeley National Laboratory and teaches core energy efficiency courses and supervises graduate student activities at the UC Davis EEC. His research has focused on understanding how people (and machines) use energy and the opportunities that exist for them (and technologies) to conserve. His 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 has now been endorsed by the G8 countries. He is editor of the journal Energy and Buildings, and the magazine Home Energy. He is the author of many articles and two books, "Supplying Energy through Greater Efficiency" and "Saving Electricity in a Hurry." He spent one year at Waseda University in Japan and three years at the International Energy Agency. Meier holds a Ph.D. in energy and resources from University of California, Berkeley.

## MARK MODERA

Mark Modera is the UC Davis Sempra Energy Chair in Energy Efficiency, Director of the Western Cooling Efficiency Center (WCEC), Professor in Civil and Environmental Engineering, and Professor in Mechanical and Aerospace Engineering. He was president of Aeroseal, Inc., a business he founded to commercialize a technology he developed at Lawrence Berkeley National Laboratory (LBNL). When Aeroseal was purchased by Carrier Corporation, Modera served as general manager and later vice president of strategic operations. He spent 25 years as a staff scientist at LBNL. His research interests include energy efficiency, ventilation and indoor air quality. Modera holds a master's degree from the University of California, Berkeley and a Ph.D. from Royal Institute of Technology in Stockholm, in mechanical engineering.

## KOSTANTINOS PAPAMICHAEL

Konstantinos Papamichael is Co-Director of the UC Davis California Lighting Technology Center and Professor in the Department of Design. During the last 25 years, he has been working on the development of energy efficiency strategies and technologies for buildings, focusing on fenestration systems and daylighting, as well as the integration of electric lighting and fenestration controls. He participates in a wide range of academic and professional activities related to computer-aided design, daylighting, electric lighting, energy and environmental impact and is author or co-author of over 80 publications related to research and development in these areas. Papamichael holds an architectural engineering degree from the Aristotelian University of Thessaloniki, Greece; a master's degree in architecture from Iowa State University; and a Ph.D. in architecture from the University of California, Berkeley.

# BIOGRAPHIES: FACULTY LEADERSHIP

## MICHAEL SIMINOVITCH

Michael Siminovitch is Director of the UC Davis California Lighting Technology Center (CLTC), Professor of Design, and the Rosenfeld Chair in Energy Efficiency. His work entails research and development in new residential and commercial lighting technologies. Siminovitch was part of the development team for California's Strategic Lighting Plan and helped lead efforts to update the state's latest Title 24 and Title 20 regulations for exterior lighting. He also helped establish UC Davis's Smart Lighting Initiative, one of the largest lighting retrofit projects in California, as a model strategy for the UC system and other institutions. Siminovitch has developed many successful lighting products, such as the Berkeley Lamp, which uses one-quarter the wattage of traditional lamps. He has also developed an innovative fluorescent down-lighting system for commercial and residential spaces, high performance torchiere, high efficiency sulfur lamp, and fiber optic illuminators. He holds a Ph.D. in architecture and human factors engineering from the University of Michigan.

## TOM TURRENTINE

Tom Turrentine is Director of the California Energy Commission's Plug-in Hybrid Electric & Vehicle Research Center at the UC Davis Institute of Transportation Studies (ITS-Davis). For the past 20 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, his center 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.

# BIOGRAPHIES: ASSOCIATED FACULTY & RESEARCHERS

## THOMAS BEAMISH

Thomas Beamish is Associate Director of the UC Davis Energy Efficiency Center and Associate Professor of Sociology at UC Davis. He has studied innovation processes in the commercial construction/real estate industry; social and organizational response to environmental change and disaster; and how and why community movements mobilize and respond as they do to "risky" developments. What ties these diverse projects together is his theoretical fascination with the intersection of institutions, social organization, and interpretive work. His focus in each of these projects has been the collective bases for "local rationalities" -- how sensemaking emerges from the places people live, the formal and informal social relations they are embedded within, and the collective memories and cognitive models they share as a result that help to explain their actions and inactions. Beamish holds a Ph.D. from the University of California, Santa Barbara.

## GIOVANNI CIRCELLA

Giovanni Circella is a post-doctoral researcher at the Urban Land Use and Transportation Center (ULTRANS) and the Institute of Transportation Studies (ITS) at the University of California, Davis. He also shares his time as a research engineer at the School of Civil and Environmental Engineering of the Georgia Institute of Technology (Georgia Tech) where he focuses on travel demand modeling, land use and transportation modeling, travel behavior research, discrete choice modeling, the impact of information communication technology on travel behavior, and the analysis of policies for sustainable transportation and the analysis of energy consumption. Circella has been principal investigator for three research projects at UC Davis, and has authored many scientific papers, project reports and contributions to scientific conferences. He is a licensed Professional Engineer (P.E.) in Italy. He received his Ph.D. in Transportation Planning from the Politecnico di Bari (Technical University of Bari), Italy in 2008 and an M.S. in Agricultural and Resource Economics from the University of California, Davis in 2009.

## AMY JAFFE

Amy Myers Jaffe is UC Davis Executive Director of Energy and Sustainability. She is a leading expert on global energy policy, geopolitical risk, strategic energy policy, corporate investment strategies in the energy sector, and energy economics. She has a joint appointment to the Graduate School of Management and the Institute of Transportation Studies (ITS-Davis). At ITS-Davis, Jaffe heads the fossil fuel component of the Sustainable Transportation Energy Pathways (NextSTEPS) program. Prior to joining UC Davis, Jaffe served as director of the Energy Forum and Wallace S. Wilson Fellow in Energy Studies at Rice University's James A. Baker III Institute for Public Policy. Jaffe is widely published, including as co-author of "Oil, Dollars, Debt and Crises: The Global Curse of Black Gold" (Cambridge University Press, 2010, with Mahmoud El-Gamal). She is a member of the Council on Foreign Relations. She holds a bachelor's degree in Near Eastern Studies and Arabic from Princeton University.

# BIOGRAPHIES: ASSOCIATED FACULTY AND RESEARCHERS

## KATRINA JESSOE

Katrina is an Assistant Professor of Agricultural and Resource Economics where she specializes in environmental and energy economics. Much of her recent research focuses on consumer and firm behavior in the energy and water sectors. Some ongoing and recent research projects include the analysis of time-variant pricing programs for residential and commercial electricity consumers and the interaction between energy and water conservation programs. These projects often involve collaborations with water and electric utilities, and state agencies. She received a BA from Princeton University in 2002 and a PhD in Environmental and Resource Economics from Yale University in 2009.

## VINOD NARAYANAN

Vinod Narayanan will be joining the Department of Mechanical and Aerospace Engineering at UC Davis as a Professor in March 2015. He is currently a Professor and the Welty Faculty Fellow in the School of Mechanical Industrial and Manufacturing engineering at Oregon State University (OSU). His areas of interest include microscale flow and heat transfer, solar thermal energy utilization, passive means to enhance thermal energy efficiency, infrared thermography methods, and thermal management. Sponsors of his group's current and past research include the National Science Foundation (NSF), National Aeronautical and Space Administration (NASA), Department of Energy, Office of Naval Research, Australian Research Council, Oregon Nanoscience and Microtechnologies Institute, Oregon Built Environment and Sustainable Technologies Center, and the American Society for Engineering Education. He earned his PhD from Texas A&M University in 2001.

## KEVIN NOVAN

Kevin Novan is an assistant professor in the Department of Agricultural and Resource Economics at UC Davis. Novan's research focuses on energy and environmental economics. Previous related projects include work estimating the pollution savings achieved by investments in renewable electricity; an analysis of the environmental impacts of bulk electricity storage; evaluation of the energy savings achieved by residential weatherization and informational programs. He received his PhD from UC San Diego in 2012.

# BIOGRAPHIES: ASSOCIATED FACULTY AND RESEARCHERS

## DAVID RAPSON

David Rapson joined the Economics Department at UC Davis in 2008. He specializes in the fields of industrial organization, energy and the environment, with a focus on how to achieve efficiency in energy markets. His research includes several collaborative studies with regulated utilities. These include the evaluation of dynamic pricing regimes, carbon offset programs, and the design and analysis of a large-scale randomized field experiment to test the effectiveness of Home Area Network technology (the customer-facing side of the "smart grid"). He holds a bachelor's degree from Dartmouth College, a master's degree in economics from Queen's University, and a Ph.D. in economics from Boston University.

## CHRISTOPHER SIMMONS

Christopher Simmons, an assistant professor in the Department of Food Science and Technology, specializes in energy and water efficiency in food processing. Simmons worked two years as a postdoctoral scholar at UC Davis and the Department of Energy's Joint BioEnergy Institute, resßearching biofuels and sustainable agriculture. Simmons' research focuses on improving energy and water-use efficiency in food processing. He is interested in improving strategies to convert leftover food residue from food processing into biofuels that can offset energy used during processing. He additionally investigates methods to use food processing wastewater for agricultural irrigation. Simmons holds a Ph.D. in biological systems engineering from UC Davis.

## AARON SMITH

Aaron Smith is a Professor of Agricultural and Resource Economics at the University of California, Davis, where he has been since 2001. Originally from New Zealand, he earned his PhD in Economics from the University of California, San Diego where he specialized in econometrics. His research focuses on quantitative analysis of policy and prices in energy, agriculture, and the environment. Recent project topics include identifying informed traders in commodity futures markets, estimating the effects of ethanol production on agricultural and energy markets, and modeling the efficiency of the California electricity reserves market.

# BIOGRAPHIES: ASSOCIATED FACULTY AND RESEARCHERS

## EDWARD SPANG

Ned is Associate Director for CWEE. His doctoral research focused on the link between water and energy at the global level, including the critical importance of improving efficiency in both sectors. Previous research included analyzing regional case studies related to improved water resource management in Central and South America. Parallel to his research on water, Ned developed expertise on energy systems as a coordinator of the MIT-Portugal Green Islands Project, where he worked closely with multiple universities, government agencies, NGOs, local communities and corporate partners to design an integrated, clean energy future for the Azores archipelago. Ned holds a Ph.D. from the Fletcher School of Law and Diplomacy, Tufts University.

## FELIX WU

Felix Wu, a UC Davis professor of Computer Science, has been building prototype systems and doing "experimental" system research since 1995 to validate novel architectural concepts. He has worked in the areas of fault tolerant network, IPSec/VPN security policy, attack source tracing, wireless network security, intrusion detection and response, visual information analytics, and, more recently, future Internet design. Wu strongly believes that considering the factor of human relationships is necessary for any IT innovation. Therefore, his primary research objective is to help and contribute to the information technology advancement that would truly help human society. Wu recently released the SINCERE (Social Interactive Networking and Conversation Entropy Ranking Engine) search engine, which helps our Internet society to discover "interesting/unusual" discussions. Wu received his BS from Tunghai University, Taiwan, in 1985, both MS and PhD from Columbia University in 1989 and 1995, all in Computer Science.

# 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). He is secretary to the board of the Renewable Energy Institute International. He 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.

## SIVA GUNDA

Siva Gunda is an Energy Efficiency Center Program Manager. He oversees all the student projects at the center and runs the Market Assessment Assistance Program (MAAP). Prior to joining the EEC, he worked at General Electric, California Fuel Cell Partnership and the California Air Resources Board. He has been an Edison International Energy Efficiency Fellow and a UC Davis Center for Entrepreneurship Business Development Fellow. He was a winner in the 2007/08 Little Bang business plan competition. He is a University of California, Davis PhD candidate in Mechanical and Aeronautical Engineering with a focus on alternate energy systems. His research focus is on enhancing the performance of PEM fuel cells.

## SUMIKO HONG

Sumiko Hong is the Energy Efficiency Center's Director of Development and External Relations and is responsible for building strategic relationships with individuals, foundations and corporate entities to increase visibility, awareness of and financial support for the Energy Efficiency Center.  She holds bachelor's degree from UC Davis in International Relations.

# BIOGRAPHIES: STAFF

## JOE KROVOZA

Joe Krovoza is Senior Director for Development and External Relations for the EEC and Institute of Transportation Studies (ITS-Davis). In this capacity he oversees both institutes' public affairs, and works with companies and government agencies that support the EEC and ITS-Davis through partnerships, including contributions in support of faculty research and multi-party Institute research consortia. These programs include major energy and environmental transportation research initiatives such as the ITS-Davis Plug-in Hybrid & Electric Vehicle (PHEV) Research Center, Sustainable Transportation Energy Pathways (STEPS) program, and China Center for Energy and Transportation (C-CET). Krovoza holds a juris doctor degree from the UC Davis School of Law and a bachelor's degree from Occidental College in diplomacy and world affairs and economics.

## KATHERINE O. BANNOR

Katherine Bannor is the Executive Analyst for the Energy Efficiency Center. Her responsibilities include: developing agendas for visiting executives, scholars, and students; processing donor gifts; reconciling department expenses; drafting a wide range of correspondences; and assisting with grants management and coordination. Prior to her work with the EEC she worked for the National Endowment for Democracy in Washington, DC assisting their Government Relations and Public Affairs office. She holds a Bachelor's degree in Political Science and French from Beloit College and is currently completing a Master's degree from Rutgers University in Geography.

## JEREMY SMITH

Jeremy Smith is an Associate Development Engineer with 6 years experience in the fields of mechanical, industrial, and energy engineering. He received his MS in Renewable and Clean Energy from the University of Dayton where his research focused on energy informatics, industrial sector benchmarking, and grid parity. While at the University of Dayton, he spent 2 years as the Lead Engineer of the Industrial Assessment Center where he completed 25 energy assessments for industrial manufacturers, identifying savings over $3 million annually. He also holds a BS in Mechanical Engineering from the University of Cincinnati. Prior to joining EEC, Jeremy spent 2 years as a web and applications developer creating energy auditing software. His current focus at the EEC is energy modeling and simulation for California Prop 39.

### RYAN WOOD

Ryan Wood currently coordinates ongoing market research projects at the Energy Efficiency Center and assists in coordinating the Proposition 39 project. Ryan began working at the EEC as a student intern in early 2014 focusing on the development of the Prop 39 project, until he graduated in the summer and took a full time staff position. He holds a B.S. in biological sciences with an emphasis in marine biology from UC Davis.

### ENRIQUE YRABBA

Enrique Ybarra is the Assistant Project Manager for the Energy Efficiency Center's Proposition 39 work. He joined the EEC in February of 2014 as a student intern, and joined as full-time staff upon his graduation in June. He holds Bachelors' degrees in both Economics and History from UC Davis.

# UPDATE: CALIFORNIA LIGHTING TECHNOLOGY CENTER

The California Lighting Technology Center (CLTC) continues its commitment to stimulate, facilitate, and accelerate the development and commercialization of energy-efficient lighting and daylighting technologies. Some notable accomplishments in 2014 are highlighted below.

## LEADERSHIP ROLE IN INCORPORATING ADAPTIVE LIGHTING CONTROLS INTO TITLE 24 STANDARDS

CLTC played a leadership role in incorporating adaptive lighting controls into the 2013 Title 24 Building Energy Efficiency Standards. The new standards, which took effect July 1, introduced additional requirements for occupancy sensors, photosensors and multi-level lighting controls in more indoor and outdoor applications. By using sensors to reduce lighting power when spaces are unoccupied, adaptive lighting is one of the largest opportunities for energy savings. The standards will help California meet its ambitious energy and climate change goals.

The lighting portion of Title 24 incorporates many technologies developed through CLTC's work with the California Energy Commission's Public Interest Energy Research (PIER) program. Demonstrations of these technologies were conducted through the State Partnership for Energy Efficiency Demonstrations (SPEED) program and other PIER projects. The demonstrations provided data about the effectiveness, feasibility and affordability of adaptive lighting technologies that were included in the standards.

**"Strategies and technologies developed and demonstrated by projects through an Interagency Agreement funded by the California Energy Commission helped CLTC play a leading role in incorporating adaptive lighting controls in the latest Title 24 standards."**
**- Dr. Siminovitch**

CLTC played a leading role in incorporating adaptive lighting controls in the latest Title 24 standards.
Photo: Kathreen Fontecha

CLTC implemented a third-party LED Lamp Performance Testing Program in collaboration with energy stakeholders. Photo: Kathreen Fontecha

## REALIZING ENERGY EFFICIENT LIGHTING IN CALIFORNIA

CLTC is wrapping up a portfolio of projects designed to result in the development, demonstration, and support for the market adoption of new lighting strategies and technologies. The Energy Commission provided PIER funds for the work through an Interagency Agreement, which help California meet state energy efficiency goals. Work on the projects started in 2009 and ends in early 2015.

Over the past five years, CLTC developed new energy-efficient lighting strategies and technologies and brought them to market in partnership with industry, utilities and large end users. The research, development, outreach and technology transfer activities were done in collaboration with the Energy Commission, utilities, industry, and other academic and professional institutions. Some projects include dual-loop photosensor control system for daylight harvesting, adaptive networked interior and exterior lighting systems, and ongoing support for the development of next-generation codes and standards.

The strategies and technologies developed through the projects helped CLTC play a leading role in incorporating adaptive lighting controls in the latest Title 24 standards.

## ESTABLISHED LED PERFORMANCE DATABASE

CLTC collaborated with energy stakeholders to implement a third-party LED Lamp Performance Testing Program and a public database to house test results. The LED Performance Database will help utilities and others understand how the LED lamp market is changing and identify which lamps meet performance thresholds, such as the ones specified in the Voluntary California Quality LED Lamp Specification. The database is at: http://ledperformancedatabase.org/

The Energy Commission developed the California Quality specification collaboration with the California Public Utilities Commission (CPUC) to accelerate consumer adoption of LED lamps. California's investor-owned utilities are expected to begin utilizing the specification to decide which lamps to include in rebate and incentive programs supporting residential customers.

These programs are vital in establishing the California Quality specification. It will help fulfill the potential of LED replacement lamps in meeting statewide lighting efficiency goals.

## SERVED AS LEADING RESOURCE FOR TRAINING IN STATE

CLTC is a leading resource for training in California for the lighting portion of the Title 24 standards. For the latest iteration of Title 24, CLTC developed compliance training materials to help builders, contractors and lighting industry professionals learn about the updated standards, best practices and possible lighting strategies.

In partnership with the investor-owned utilities' statewide codes and standards team, the center offers classes and presentations on residential, retail, office, and outdoor lighting. CLTC is creating 2013 Title 24, Part 6 Lighting Design guides for four space types: residential, retail, office, and outdoor. The guides supplement CLTC's educational courses as well as the Energy Commission's compliance manuals.

## BUILT UNIQUE DAYLIGHTING CONTROLS TEST FACILITY

CLTC built a unique full-scale facility for daylighting controls that will be used for research, development, testing, and education efforts. Plans call for the test facility to be used for projects with manufacturers to evaluate and test emerging technologies and products. The Energy Commission provided funds for the facility, which was a project completed as part of the Interagency Agreement. The facility was developed in collaboration with lighting controls industry partners. The facility will support Title 24 standards requiring aggressive use of lighting controls to achieve deep energy savings.

**"We are building effective partnerships with several universities in Singapore, Thailand, and Hong Kong that are producing results including partnering on joint research projects, establishing lighting centers and hosting visiting scholars." - Dr. Siminovitch**

Kelly Cunninghman, CLTC Outreach Director, leading a demonstration.
Photo: Kathreen Fontecha

Honda Smart Home, where CLTC designed lighting system. Photo: Kathreen Fontecha

## AUTHORED ACCEPTANCE TEST TECHNICIANS PROGRAM FOR TITLE 24 WITH CALIFORNIA ADVANCED LIGHTING TECHNOLOGY CONTROLS PROGRAM (CALCTP)

CLTC authored the Certified Lighting Controls Acceptance Test Technician (CLCATT) program for the Title 24 standards with CALCTP. The center helped lead the effort to incorporate the CLCATT program into state code by building partnerships with industry, utilities and the Energy Commission. The program requires certified lighting controls acceptance technicians review and test installations to ensure controls operate as required by the standards. The requirement will maximize energy and cost savings from lighting controls. The Energy Commission approved the CALCTP's training and certification program.

## PROVIDED KEY LEADERSHIP IN DEVELOPING 2016 TITLE 24 STANDARDS

CLTC provides key leadership in developing the next generation of Title 24 standards. CLTC is leading and coordinating efforts on the draft 2016 residential standards. The draft lighting proposal will increase the adoption of high efficacy and high quality solid-state lighting products in new homes being built.

Support activities were conducted to help create forward-thinking standards and negotiate agreement among stakeholders. The activities included hosting meetings with industry and utility representatives, making key presentations to the Energy Commission and industry, providing input to Energy Commissioners and managers, and working with the Energy Commission to establish partnerships with top-level industry executives.

# UPDATE: WESTERN COOLING EFFICIENCY CENTER

This year, the Western Cooling Efficiency Center's (WCEC) continued commitment to advancing HVAC efficiency spanned a variety of disciplines and countries to deliver relevant analysis and research that further supported and fostered energy efficiency measures and technologies. In close partnership with industry stakeholders and valued affiliates, the Center met many new milestones this year through applied research, behavioral studies and even policy making.

WCEC worked on over 30 different research projects this past year, though this update will highlight just a few of these projects.

First, the rooftop packaged units (RTU) retrofits project successfully tested 4 different pre-coolers in WCEC's completed environment chamber. These efficient add-ons ranged between 20-80% for evaporative effectiveness. The high degree of variance in each of the pre-cooler designs resulted in a wide variety of performance across the 4 units tested, further justifying the need for a standardized testing platform.

Second, the Center completed research and code policy change recommendations for the multi-family ventilation project. The culmination of two years of modeled and real-world analysis will help increase indoor air quality, reduce energy use, and increase the consistency of ventilation within multi-family structures. In partnership with Benningfield, these new recommendations for multi-family structures will permeate into new codes and standards for future buildings.

WCEC was contracted by the Tokyo Gas Company of Japan to conduct research on the behavioral drivers of energy use and conservation. Trends in culture and demographics, geographic limitations, and response to recent natural disasters have created unique challenges and opportunities in Japan. WCEC designed and implemented an international comparative study of two zero net energy communities in Tokyo and Davis; and the Center's social science and engineering experts designed customized interventions to encourage energy conservation through use of passive cooling techniques and reduced AC usage in summer.

WCEC Student researchers, Cyrus Ghandi and Kaitlyn Thatcher finish instrumenting a rooftop unit for testing in WCEC's environment chamber. Photo: Paul Fortunato

## NEW ASSOCIATE DIRECTOR

The WCEC would like to welcome Dr. Vinod Narayanan to the Center as the new Associate Director working alongside Dr. Mark Modera. Dr. Narayanan earned his PhD in Mechanical Engineering from Texas A&M University. His most recent position was as the Associate Professor of Engineering at Oregon State University with a specialty in microscale flow and heat transfer for energy efficiency applications including solar thermal, solar fuels, thermal management, and phase-change heat transfer. Dr. Narayanan brings a strong background in heat and mass transfer research that the WCEC will apply in new ways to conduct HVAC research, as well as experience in addressing cooling challenges in large-scale applications such as in power plants. His background will expand the range of research the WCEC will be able to perform for its sponsors, allowing the Center to address HVAC inefficiencies in new and novel ways. Dr. Narayanan will start with the WCEC in March 2015, but is already writing research proposals for the center.

## IMPORTANT ADDITIONS TO OUR STAFF

WCEC recently recruited UC Davis mechanical and aeronautical engineering professor Ralph Aldredge to head the Phase-Change Materials research project. Dr. Aldredge is a strong asset to WCEC's staff with expertise in computational models and algorithms for simulation of reactive-flow dynamics. Dr. Aldredge is currently working with WCEC's newest Graduate Student Researcher, Kris Karas, on the Phase Change Materials research for hydronic systems.

WCEC would also like to welcome Sarah Outcault to its team. Dr. Outcault is a Behavioral Scientist conducting research and implementing studies that explore the drivers of technology adoption, use and maintenance, as well as discovering opportunities for market intervention. Before her time at WCEC, Dr. Outcault worked as an Assistant Policy Analyst at the RAND Corporation and studied Economic History at the London School of Economics.

To further support UC Davis' educational mission, and the WCEC's commitment to exposing students to pertinent applied science, WCEC hired 18 new student researchers to support the professional staff of engineers. These students will help build experiments, do modelling research and turn wrenches out in the field.

## CENTER REACHES OUT TO A WIDE AUDIENCE

WCEC participated in many prominent conferences and fostered new local and international partnerships. Notably, Mark Modera, Theresa Pistochini, and Kristin Heinemeier attended both ASHRAE conferences to further refine the testing protocols for RTU retrofits and chaired a standard project committee on the standards development for fault detection on RTUs. Kristin Heinemeier and Sarah Outcault also presented their work at the ACEEE conference on economizer controls and the behavioral factors of contractors that service them.

WCEC met directly with a number of diverse companies this year, with 3 of these becoming new affiliates: Belimo,

WCEC Affiliate Forum member Nick DeChamps from Munters
Photo: Paul Fortunato

Tokyo Gas, and Carel. The success of these meetings are being realized today with current behavioral research involving Tokyo Gas, a combined proposal utilizing new economizer controls from Belimo, and laboratory testing of Carel's media-less evaporative pre-cooler technology.

WCEC's annual Affiliate's Forum this year fostered a lively discussion on a variety of HVAC related topics including the implementation of evaporative technologies into the marketplace; a discussion about the strategies needed to increase the quality and consistency of contractor commissioning and maintenance; and a brief look at the new energy efficiency funding from the California Energy Commission.

WCEC engineers utilizing a testing apparatus to measure the flow rates through the exhaust shaft of a multi-family building.

## PROJECT UPDATES

### MULTI-FAMILY VENTILATION

The multifamily ventilation project funded by the California Energy Commission (CEC) was completed this year. The ultimate goal of this project was to propose changes to current California ventilation codes to address issues with ventilation in multifamily buildings. The project used a characterization effort followed by modeling and a field demonstration to determine the most appropriate methods that can be codified to improve ventilation in multifamily buildings. The following is a description of the suggested changes to Title 24 proposed by the WCEC.

The following code change proposals are a result of research conducted for the Unique Multifamily Code Relevant Measures (UMCRM) PIER project. The ventilation component of this research evaluated:

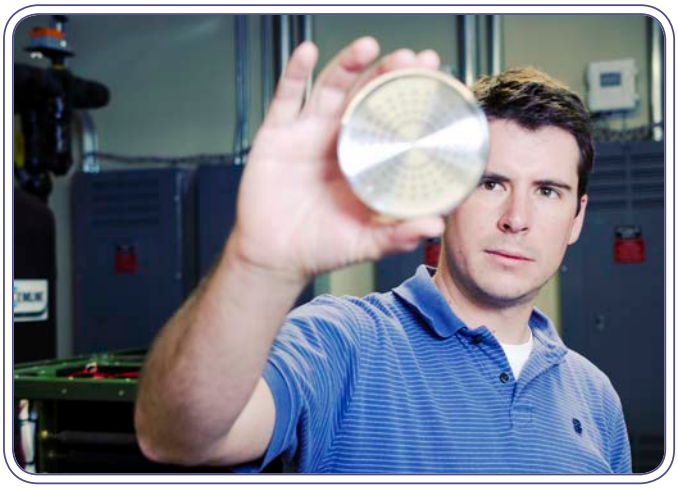
- Current California code requirements for indoor air quality ventilation of multifamily buildings;
- Existing California multifamily building stock, construction practices, and ventilation systems;
- Modeled energy use and airflow of individual unit versus central shaft exhaust systems; and
- Measured energy use and ventilation airflow from field retrofits of one high-rise multifamily building with central shaft exhaust ventilation systems.

This final report proposes changes to the 2016 California Title 24 Building Energy Efficiency Standards regarding indoor air quality ventilation of multifamily buildings. In summary, WCEC recommends 1) unifying all multifamily residential ventilation requirements by extending current requirements for new low-rise multifamily buildings to new high-rise multifamily buildings, and 2) for high-rise multifamily buildings that use central shaft ventilation systems, two new requirements that are necessary to ensure that these systems perform as energy efficiently as possible and do not under- or over-ventilate homes.

**The culmination of two years of modeled and real-world analysis will help increase indoor air quality, reduce energy use and increase the consistency of ventilation within multi-family structures.**

### AUTOMATED SEALING OF BUILDING ENVELOPES USING AEROSOLS

Building envelope leaks contribute significantly to HVAC energy usage- accounting for roughly 30% of the energy used by HVAC systems. Sealing those leaks manually is expensive and time consuming, and in many cases cannot



WCEC engineer, Curtis Harrington, examines a plate from a cascade impactor, used to test overall particle size distribution from different aerosol nozzles. Photo: Paul Fortunato

be conducted cost-effectively. However, pressurizing a facility while simultaneously producing aerosolized particles to seal those leaks is a promising technology that can provide a comprehensive, economical solution with immediately verifiable results. Sealing building envelopes saves energy by reducing infiltration of unwanted outside air, reducing the loss of conditioned air, and lowering the demand for cooling and heating—enabling both electric and gas savings.

**Latest Aerosol technology can now seal over 80% of available leaks in a home in under 2 hours.**

Through further laboratory testing and refinement, WCEC has re-worked the aerosol injection technology to seal spaces more thoroughly and quickly, all while using less sealant. The first demonstration of this revised design was in 4 different apartments, approximately 800 square feet each, in New York City. In each of these apartments, WCEC managed to seal over 80% of the available leaks in under two hours, a significant increase in demonstrated sealing rates in such a short time. Previous WCEC sealing demonstration results using older systems could seal up to 60% of available leaks in a longer timeframe.

The latest demonstration of WCEC's current aerosol technology proves that this technology can also perform well in larger homes. WCEC sealed 3 large- 2,500-3,000 square foot homes - in Clovis, California at a sealing rate of 80% of available leaks, in approximately 2 hours.

In order to further this promising technology's move to the market, WCEC will begin training other researchers in Minnesota on how to use the system. This training will be a valuable process for understanding the learning curve of this technology in the hands of those that have never used it before.

## MOVING FORWARD

WCEC will participate in a variety of diverse projects ranging from improving codes and standards, increasing gas efficiency and even collaborating on establishing new energy efficiency modeling and controls programming technologies. One project, in partnership with the California Public Utilities Commission, is to conduct measurement and verification on investor owned utilities' energy efficiency programs. WCEC will conduct interviews and surveys of customers, contractors, and HERS Raters (code compliance verification providers) to identify what some of the most important barriers are to taking out permits and complying with the energy code, and what some of the "tricks of the trade" are from successful contractors.

As it moves forward, WCEC is expanding its defined role in energy efficiency to also include gas-use efficiency. The Center is looking into ways to decrease gas and electrical energy use in clothing dryers by refining the sensors in a dryer that determine if the clothing is actually dry. In addition, WCEC will be laboratory and field-testing a gas-fired heat pump; and will continue moving forward on adapting aerosol-sealing technology to seal low-flow gas pipelines.

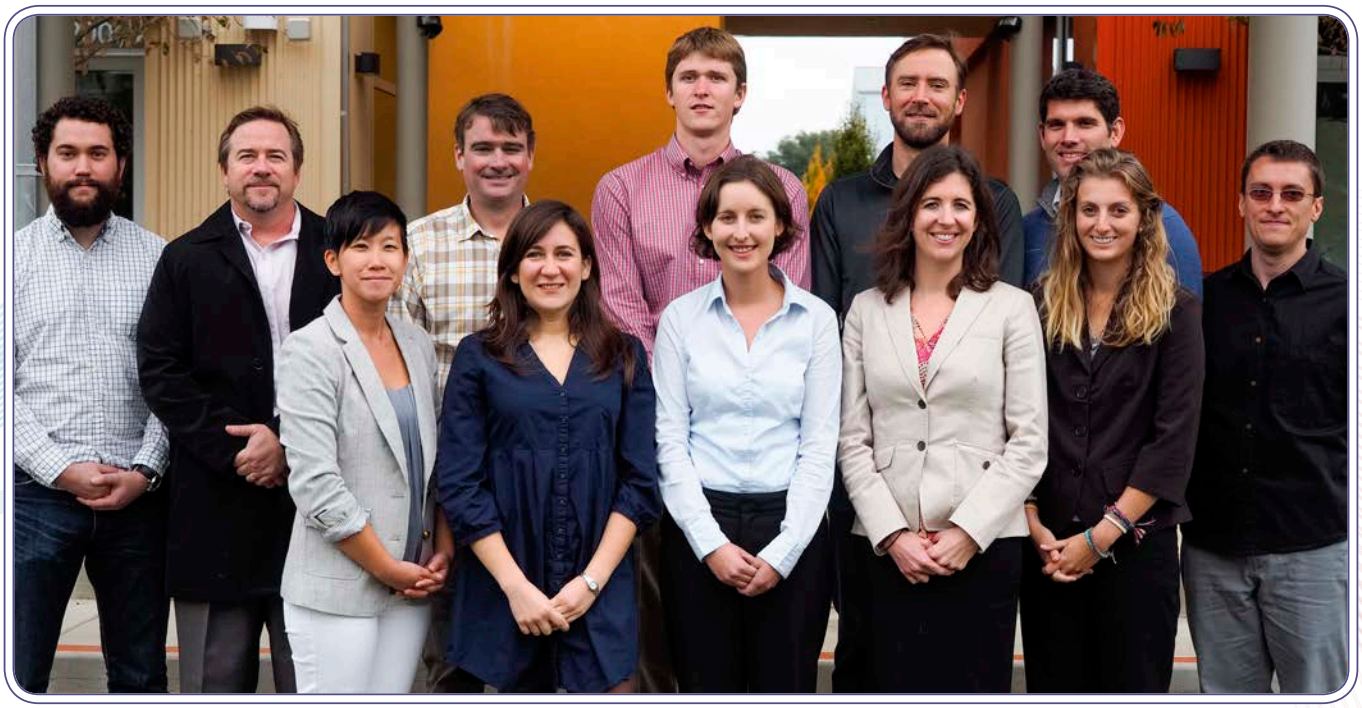
# UPDATE: CENTER FOR WATER-ENERGY EFFICIENCY

This year has been a year of significant growth and development for the Center for Water–Energy Efficiency (CWEE) as it has grown from just a few people to a thriving team of twelve. Building on the work performed the previous year, CWEE has focused on a methodology for utility data management and security, streamlined its method of water-energy analytics, advanced its ability to measure water–energy intensity through innovative software and programing development, and moved forward with exploring behavior-based water conservation. Its internal efforts and projects with private partners hold a similar goal of advancing the public's and utilities' understanding of the water–energy nexus. CWEE's work in this area provides an important contribution to the California Public Utility Commission's policy mandating water and energy utility partnerships to pursue joint water and energy resource savings.

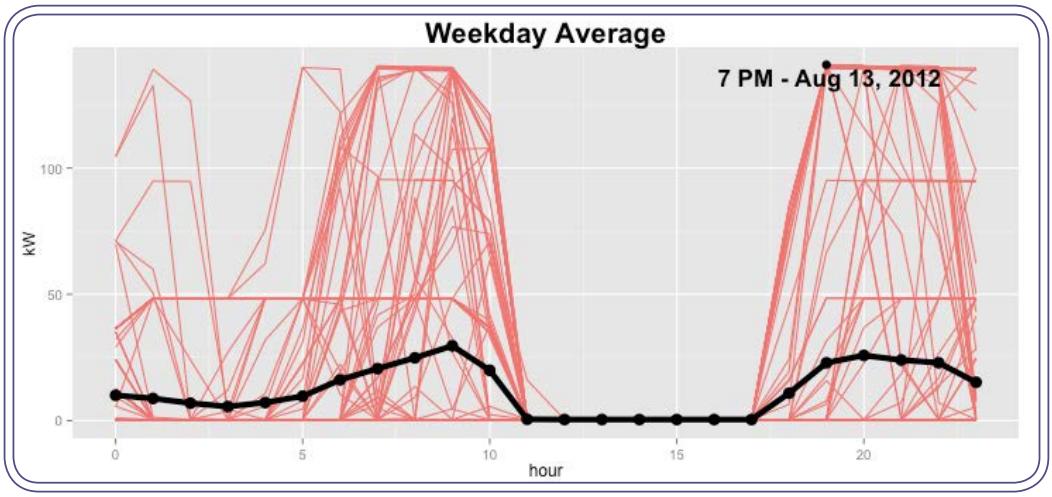
**"Our advanced analytics are providing a greater visibility of the energy dynamics within the water sector. This is the essential first step in designing effective programs to jointly optimize water-energy resources and for enabling partnerships between water and energy utilities." - Dr. Spang**

## ADVANCING ENERGY INTENSITY ANALYTICS

Over the last year CWEE has further developed a systematic approach to assess the energy intensity of delivered water. Through evaluating the energy intensity of a water system throughout space and time, utility agencies receive insight into how to direct water system management improvements. Furthermore, it opens a path to intersecting energy and water data streams for system-wide optimization of water and energy resources. For example, linking leak loss data to water–energy intensity data enables a water utility to calculate the amount of water lost as well as the amount of energy embedded in those water losses. CWEE's



CWEE staff. (Back row L-R): Andrew Holguin, Don Thompson, Frank Loge, Reed Thayer, Benjamin White, Edward Spang, and Florin Negrea. (Front row L-R): Halona Leung, Soraya Manzor, Sara Miller, Kendra Olmos, and Juliana Walton. Photo: Paul Fortunato




Visualization of all weekday electricity load curves for a large water pumping facility with the calculated average load curve (black line) and the identified hour of largest load draw by the facility.

developments over the past year will enable a streamlined process (including the collection, processing, and analysis of utility data) for generating energy intensity values across a water agency.

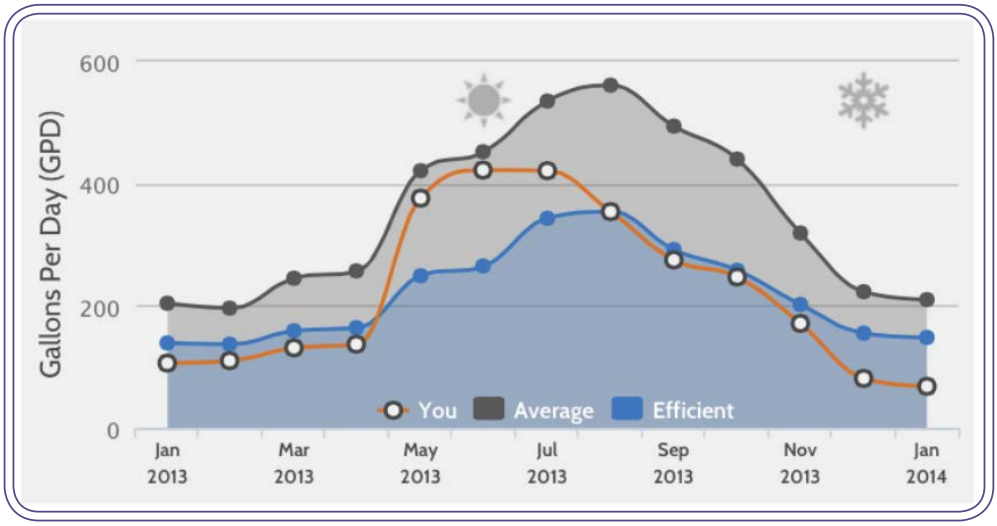
The value of water–energy intensity information is twofold. First, water utilities can use it to enhance their efficiency directly by targeting conservation efforts and infrastructure upgrades informed by the energy outcomes of their actions. Second, as water–energy efficiencies become more sophisticated, the possibility emerges of carbon-equivalency trading measured in the amount of water volume saved. A water utility that conserves enough water could monetize the savings, offsetting some lost sales revenues by selling the carbon offset equivalent on the California–Québec international carbon market. Making water–energy efficiencies a tangible and exchangeable asset is now a question of policy, not of underlying science.

## OTAY CASE STUDY

Building off the study of energy intensity in the East Bay Municipal Utility District (EBMUD) system, CWEE partnered with San Diego Gas & Electric (SDG&E) to evaluate the energy intensity of the regional water system in San Diego County. CWEE collaborated with the San Diego County Water Authority, the regional water wholesaler, and the Otay Water District. Given high-resolution data available for the water system pumps, reservoirs, and treatment plants, CWEE performed water-energy analytics to aggregate, analyze, and visualize the data and model the flow of energy through the system. This work will allow the water district to optimize the operation of their pumps to benefit from time-of-use energy charges, identify inefficient equipment, and perform deterministic analytics over varying timescales.

## ADVANCING THE SMART WATER GRID

Furthering its data-driven approach to energy analytics in the water sector, CWEE is developing a "smart water grid" approach of integrating and interpreting broader data streams to provide a full system view of utility infrastructure. CWEE is currently collaborating with information technology and utility partners to integrate real-time water use and energy intensity data, including big data sourced from Geographic Information Systems, supervisory control and data acquisition, and advanced metering infrastructure systems. The result will be a streamlined view of the water-energy interconnection for utilities which will allow the agency to: 1) deploy maintenance and infrastructure improvements that are prioritized in terms of water, energy, and cost savings; 2) determine the associated costs and benefits of maintenance or capital efficiency investments to the water utility and the local energy provider (in terms of reduced energy demand); and 3) allow for strategic targeting and investment in water conservation and energy efficiency improvements across the water network (source treatment, distribution, end use, and wastewater treatment and collection). With this development CWEE aims to help bridge the gap between energy and water utilities and enhance resource efficiency for both utility sectors.




Behavior-based water conservation messaging based on seasonal and normative residential water consumption data. Photo courtesy of WaterSmart Software Inc.

As data gathering and interpretation become more advanced, CWEE foresees water infrastructure that is constantly recording and reporting operational data to cloud services, and advanced software in the cloud designed to enable rapid, profound interpretation of multiple dimensions of water delivery and treatment data.

## WATER RATE STRUCTURE UPDATES

In the past year, CWEE has continued its research and development of Consumption-Based Fixed Rates (CBFR), a water rate structure that enables water conservation without threatening the income stability of water utilities. CWEE's work on developing the CBFR method and the related implementation challenges will be published in the Journal of American Water Works Association in February 2015. The papers discuss the innovative design of the rate structure, the adoption challenges of implementing CBFR in the City of Davis, and the equity implications of CBFR in relation to more conventional water rate structures.

The rate equity study has the potential to be particularly influential on future rate design and adoption. A utility's water rate structure includes an inherent amount of water that must be used before the fixed part of the rate is effectively paid for and each additional unit of water used only costs the variable rate. This "consumption to fairness" value varies based on the rate structures' proportion of fixed and variable components, and this indicator can be related to household income to estimate the equitability of a range of rate structures. Using the City of Davis as a case example, CWEE shows a negative correlation between household income and the number of people paying unfair rates (i.e. using less water than the "consumption to fairness") under conventional water rate structures. Importantly, this effect can be diminished for rate structures with large volumetrically-based proportions, such as CBFR. CWEE believes that this approach will evolve into an important tool for utilities to ensure rate equity when considering the implementation of new water rates in their territory.

## BEHAVIOR-BASED CONSERVATION

Through research and pilot projects, CWEE is assessing the potential for behavior-based water interventions to reduce residential water usage, energy usage, and increase investment in energy- and water-efficient technologies. This approach leverages behavior-based water conservation as a tool to achieve water and energy savings and encourage water and energy utility partnerships.

CWEE's current pilot study involves assessing behavior-based water conservation through technology deployment and data analysis. It has partnered with WaterSmart Software, a software conservation tool that communicates customer water consumption and compares it to that of their neighbors. Customized water reduction strategies are shared and the customer can track their water savings. This new tool is proving successful in achieving water reductions based on behavioral modifications of the consumer. CWEE's goals in this study are to determine 1) how much of the total water use reduction observed from the technology deployment is attributable to behavior change; 2) the

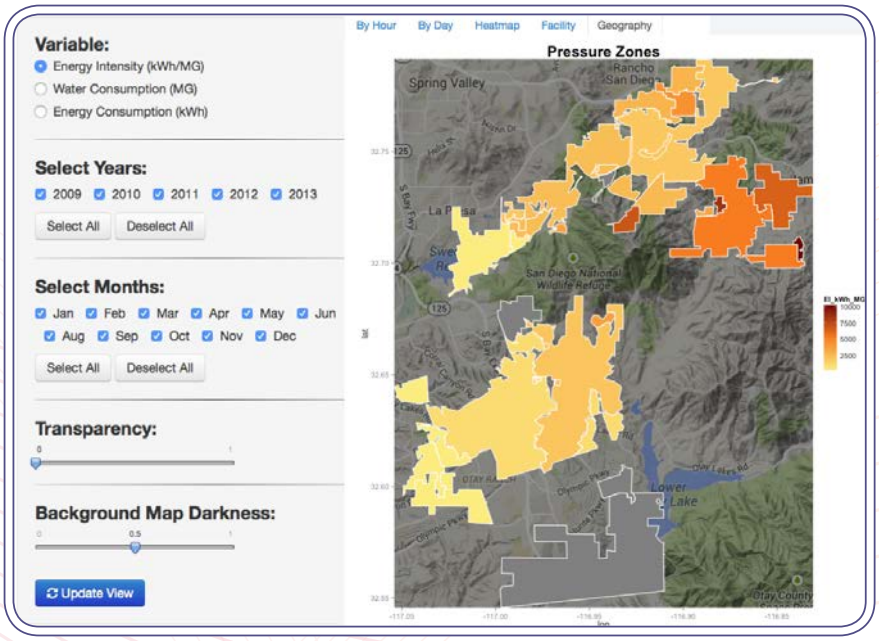
proportion of hot water savings relative to the total water use reduction; and 3) the energy and greenhouse gas (GHG) savings associated with the hot water use reduction.

While the pilot study is just beginning, CWEE spent the last year building a strategic partnership between CWEE, WaterSmart Software, the city of Burbank, Southern California Gas Company (SoCalGas), and the Metropolitan Water District (MWD). With funding support from SoCalGas and MWD, WaterSmart's software will be deployed to educate the residential consumers in Burbank on the water-energy connection and opportunities to conserve hot water. A key characteristic of the project is that Burbank represents a city that has high-resolution, interval data for all household utilities, including water, gas, and electricity. Leveraging this "big data" on the residential side will allow CWEE to measure and verify the water, hot water, and resultant energy savings from the WaterSmart intervention. By running this full-scale experiment, CWEE will determine the effectiveness of this approach, which has the potential to generate significant water–energy savings with very little capital investment.

## ADDITIONAL ACHIEVEMENTS

This year CWEE attracted attention outside of California from the Mitchell Foundation in Austin, Texas. This is the beginning of a possible long-term partnership with the Foundation and Austin Water to provide organization and structure to their existing data platform, perform energy intensity analytics on the Austin water system, and utilize the findings to develop additional analytics (e.g. power analysis to evaluate and reduce peak power load consumption). This initiative also provides an important opportunity for collaboration on water management issues with additional partners in Texas (such as the University of Texas, Pecan Street Project, and the Natural Resources Defense Council) working to address similar water scarcity issues as those faced in California.

In addition to finding opportunities outside California, CWEE's new partnership with Los Angeles Department of Water and Power (LADWP) exemplifies strong growth over the last year as it is the largest water and energy utility in the country. CWEE will perform a large-scale energy intensity study on the entire LADWP water infrastructure by utilizing the methodologies fine-tuned with data management and energy analytics. This work will be the foundation for bringing together LADWP data and analyzing where improvements to the water network would be best performed (e.g. reducing peak power, identifying pumps for replacement, determining areas for energy or water savings, etc.) CWEE is eager to participate in this first step in creating a water and energy efficient LADWP water system.




CWEE developed analytical platform for energy intensity analysis.

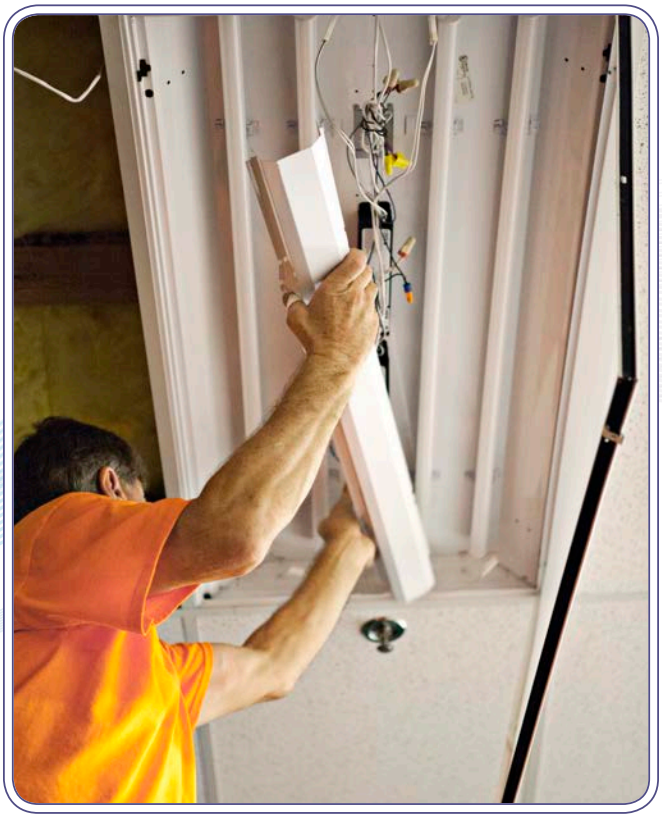
# UPDATE: EDUCATION

## ESTABLISHED LIGHT-RITE CALIFORNIA

CLTC created the Lighting Retrofit Information, Training and Education consortium (Light-RITE California), which is a statewide educational program to ensure best practices for lighting retrofits are implemented in public buildings.

The program is expected to deploy in 2015. It will focus on the top lighting retrofit strategies proven to capture significant savings. CLTC developed the support structure for the draft program proposal and built partnerships and agreements for the program among stakeholders including CPUC, industry and utilities.

The program ensures that senior managers involved in public building retrofit projects are trained and certified to complete a variety of tasks including conducting a building audit and measuring and verifying project results. The curriculum will be available to California Community Colleges and utility training centers around the state, supplemented by an online education component.



CLTC Light-RIght installation at Watermelon Music in Davis, CA. Photo: Kathreen Fontecha

## EFFICIENCY EDUCATION

### COURSES

The EEC offers the most extensive set of courses in energy efficiency anywhere. UC Davis does not (yet) offer a degree in energy efficiency - instead, the EEC offers courses to complement traditional degrees. However, students can still get a solid foundation in the theory and practice of energy efficiency by taking a "core" set of courses consisting of:

Fundamentals of energy efficiency;
Economics of energy efficiency; and
Zero Net Energy Paths.

Graduate students from a wide range of fields (from Engineering to Textile Science to Business) typically enroll in these courses because they are popular electives. By the end of the year, students have a good understanding of the basic concepts of energy demand and efficiency, economics, and policies. Parts of the lecture notes have been adopted by efficiency courses in many other universities - including MIT, Berkeley, York University, Boise State, and Carnegie-Mellon.

Students learn by measuring energy use, beginning with appliances in their homes and extending to cars and whole buildings. They investigate how the energy is transformed into useful services and how to squeeze more services from less energy and they learn to evaluate costs and benefits of these actions. Students come from every continent, so case studies may use real problems in Davis, Dubai, Shanghai, or Chicago.

These courses prepare students for career in energy efficiency. Many "graduates" have entered the workforce in utilities, consulting firms, and government agencies.

### DEGREES

We are working with the several parts of the university to form a new Energy Graduate Group that will permit students to earn Masters and Doctoral degrees in energy-related fields.

### CURRICULUM DEVELOPMENT WORKSHOP (JUNE 2014)

York University (Ontario), in cooperation with the EEC, hosted the second workshop for faculty teaching energy efficiency. (The first was at UC Davis.) Participants discussed developing curricula, textbooks, and other resources to facilitate education. The long-term goal is to establish a consensus on how to introduce this new, cross-disciplinary, topic into graduate programs.

## PIET ZERO NET ENERGY INITIATIVE

Supported by the UC Davis Energy Conservation office, the Zero Net Energy Initiative is designed to provide outreach and education as well as save energy on the UC Davis campus and its neighboring communities. During 2014, interdisciplinary student teams worked on a variety of projects including building simulations to estimate energy and cost savings of proposed retrofits at Sproul Hall. For 2015, projects include behavioral strategies for energy efficiency at student dormitories through the implementation of a Campus Energy Feedback System (CEFS).

Students learn the basic concepts of energy demand and efficiency, economics, and policies through many of the EEC's popular elective courses.

### NOVEL GROUND-SOURCE HEAT PUMP TECHNOLOGY AT UC DAVIS DOMES

Funded by Pacific Gas and Electric (PG&E) and with support from the National Science Foundation (NSF), this project seeks to demonstrate the viability of low-cost cost ground source heat pumps to reduce space conditioning energy use. In 2014 PIET completed the 2-year $250,000 project at the UC Davis Domes and is now in the monitoring and documentation phase. Upcoming publications document how, in many climates zones, the combination of novel drilling technology and low cost packaged heat pump systems can save California consumers money on heating and cooling. As a follow-on to this project, PIET has submitted a $2 million proposal to the California Energy Commission to expand this study to other residences on campus.

### D-LAB ONE HEALTH

Working with the UC Davis Engineering, Veterinary, and Medical schools, PIET has launched a new graduate seminar, D-lab One Health, to expose students to community issues around energy, agriculture, and health. The class, offered fall 2014, has attracted 30 veterinary, medical, engineering, and social-science students and will be a feeder into the current D-Lab hands-on courses.

**The UC Davis Path to Zero-Net Energy course gives studies hands-on experience with real clients and real projects.**

# UPDATE: MULTI-TENANT LIGHT COMMERCIAL PROJECT

Funded by the California Energy Commission's (CEC) Public Interest in Energy Research (PIER) Program and with support from the three California investor owned utilities (IOUs) - SCE, Sempra and PG&E - along with the Sacramento Municipal Utility District (SMUD) and the Los Angeles Department of Water and Power (LADWP), UC Davis has been involved in a multi-year study aimed at developing integrated strategies to enable deep energy savings in existing light commercial buildings that house multiple small and medium business tenants – those commonly referred to as strip malls. It has historically been very difficult to achieve extensive retrofits that reduce energy usage due to a combination of technical and institutional barriers inherent to multi-tenant light commercial (MTLC) buildings.

Owing to the split incentives that exist between the tenants and the building owners in this market sector, coupled with limited availability of capital to invest on the part of both parties, building efficiency improvements in this space are largely achieved by the 3rd party direct install (DI) programs deployed by Utilities. However, implementing deep energy saving retrofits (which necessitate incorporating HVAC measures) is too costly for utilities to foot the bill for every project. Therefore most current DI programs make only small upgrades to spaces leased by individual tenants. This means measures implemented through these programs are often limited to deploying highly cost-effective lighting measures.

There is a unique opportunity to transform energy usage in existing MTLC properties in California through strategies that overcome market and institutional barriers and that deploy deep energy saving retrofit solutions. A major strategic approach is to deploy integrated retrofit packages at a whole-building level rather than limiting the focus to tenant-level development - the hypothesis being that by deploying measures at a building level, the required cost effectiveness is met for HVAC measures by taking advantage of economies of scale.


The research teams at UC Davis have worked to achieve two major goals - first, to use market research to characterize the MTLC market and devise methods of overcoming financial and institutional barriers to retrofitting them; and second, to develop, test, and demonstrate whole-facility retrofit solutions in order to facilitate the transformation of energy usage patterns in the MTLC market. Together with the California Lighting Technology Center (CLTC) and the Western Cooling Efficiency Center (WCEC), the Energy Efficiency Center has set forth four key objectives:

- Gather relevant market and technology data to characterize and segment the MTLC market;
- Test and evaluate retrofit technology options to investigate whole-building and tenant-specific solutions;
- Create cost-effective scalable

integrated solutions considering multiple criteria: energy, comfort and economic performance and constraints; financial mechanisms to support implementation; delivery strategies for wide market penetration; and

- Demonstrate performance and viability of integrated solutions.

As part of gathering relevant market data to characterize and segment the MTLC market, UC Davis researchers aggregated a large dataset combing primary and secondary research. A market intelligence database was developed that aggregated MTLC building attributes, in-person technical audits of buildings, interviews with industry stakeholders, and questionnaires targeted at tenants, building owners, and property managers. The market intelligence database is comprised of 1,000 randomly selected MTLC buildings, meant to be a representative sample of MTLC buildings in California. Using Google Maps aerial and street views, researchers gathered building attributes such as square footage, roof color, orientation of the building front, number of tenants, tenant types, and other features that may impact retrofit needs and opportunities. The aerial survey data was augmented with on-site audit data of a subsample in collaboration with the California Conservation Corps (CCC). UC Davis provided audit skills training to a select crew of corpsmembers, who then performed basic energy audits on a set of buildings from the market intelligence database.

With additional support from SDG&E, specific market research is currently being conducted to further understand the restaurant tenants in MTLC buildings. Since restaurants represent the most energy intensive and complex of the tenant end-uses seen in MTLC buildings, more focus is necessary to better understand them and their impact on the larger MTLC market.

Other primary data include ongoing interviews with representatives from utilities, financial institutions, 3rd party implementers, and other relevant industry leaders. Data from these interviews is analyzed to better understand what market and institutional barriers exist on both the demand and supply sides of retrofits for the MTLC market. Building owners and tenants were also interviewed to gather their perspectives and decision making process.

**There is a unique opportunity to transform energy usage in existing MTLC properties in California by developing strategies to overcome market barriers to retrofitting and to pursue impactful whole-building retrofit solutions.**

In order to develop the integrated packages and investigate the interactive effects between various lighting, HVAC, and envelope measures that were identified as suitable for the MTLC sector, five different building archetypes were created based on the market characterization. Parametric building simulations are currently being conducted to quantify saving from different measure packages. These whole-building solutions will be semi-customizable, offering the customer different technology packages based on a range of cost options. To test the effectiveness of these simulation, demonstrations of integrated solutions are currently underway at 3 sites; one supported by SCE in Upland; one in Sacramento being funded by SMUD, and one in Davis.

### COST ELASTICITY OF SCALING HVAC RETROFITS

One of the fundamental assumptions of the project is that by targeting deployment of energy efficiency at a building level rather tenant level will reduce the cost of HVAC measures due to economies of scale. A research study is currently underway to test this assumption. Approximately 2000 contractors are being contacted and asked for a simulated bid on a hypothetical building. The results from this study will be used to establish the cost elasticity.

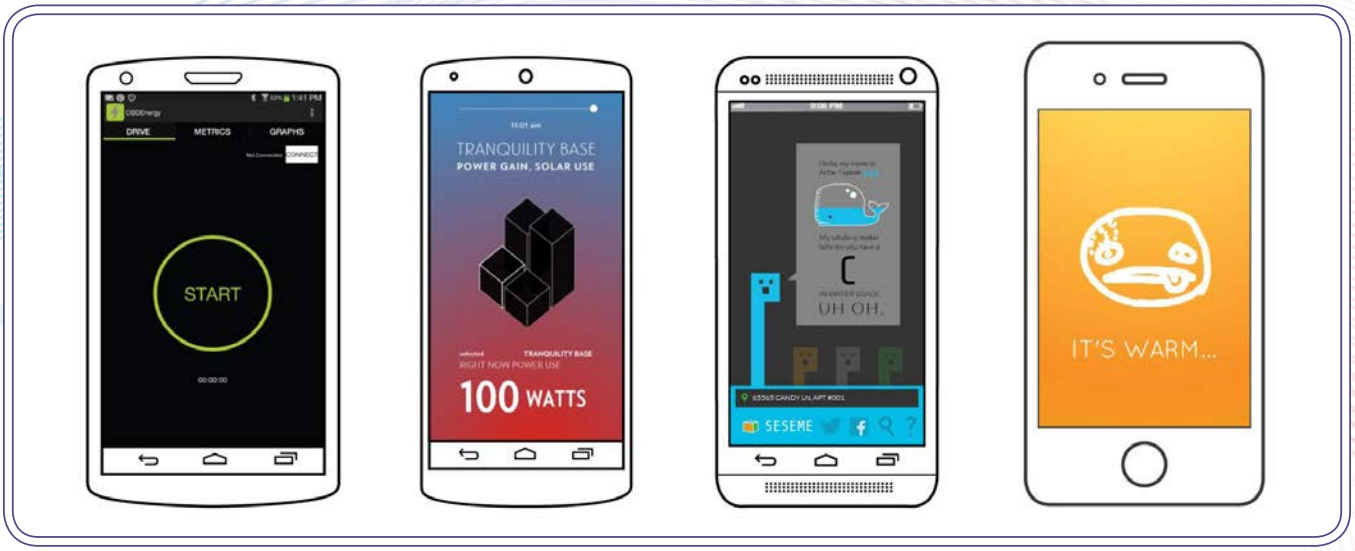
# UPDATE: cENERGI

Now in its second year of operation, the Consumer Energy Interfaces (cEnergi) research group, made up of electrical and mechanical engineers, computer programmers, behavioral scientists, and designers is looking to further develop its diverse portfolio of multidisciplinary projects. This portfolio includes smartphone applications that relay carbon emission information from engines to drivers, experimental virtual reality environments on the Oculus Rift platform, and a physical sculpture-like kinetic data visualization "monument." Refinements undertaken in the second year have turned mock-up apps into fully-fledged Android applications, and cardboard statues have given way to welded steel geometry.

EV Explorer, a tool that lets consumers learn about the viability and cost of electric vehicles for their personal routines, has been released to acclaim from Google Earth, the Global Fuel Economy Initiative, and the Institute of Electrical and Electronics Engineers. The cEnergi team pursues these projects and more in its new space adjacent to the Plug-In Hybrid and Electric Vehicle Research Center, using students' personal funds to procure equipment and fabricate workspace furniture. The result is an increasingly unique and unconventional collaborative environment that represents an alternative approach to innovation and energy research at UC Davis.

## PROJECT PREVIEWS

- SESEME - Social Energy Sensing Monument expresses building energy data through motion and light, accompanied by an informational mobile application. This innovative structure will be installed at the Student Community Center in Winter Quarter 2015.
- EV Explorer - Web application that allows users to input their commutes and calculates energy costs, comparing any number of electric vehicles against any gasoline car.
- OBDEnergy - App integrating Android mobile OS with vehicle on-board diagnostics to provide immediate eco-driving feedback. Uses OBD-II Bluetooth plug-in transmitter to retrieve real-time fuel data from engine and displays fuel use and carbon footprint to driver.
- Trip Log - Web and mobile application that incentivizes users to choose transportation modes using demographic-targeted comparisons - i.e., fuel use displayed in terms of consumed pizza.
- Carbon Trips - Android app that displays carbon costs of different flight routes between user-input sources and destinations, organized by environmental efficiency.
- Thermal Comfort Cues for HVAC Control - Proposal for a machine-based procedure to identify gestures related to thermal comfort through the use of a Microsoft Kinect camera, possibly leading to regulation of heating and cooling of a building.




cEnergi's portfolio of smartphone applications on iOS and Android

- Interactive Design Student Proposals - Glenda Drew's Interactive Design course (DES 157) students proposed interface designs focusing on ease of navigation and encouragement of environmentally-friendly behaviors in laundry machines, thermostats, and more.
- TEMPR - Visual iOS app proposal that enables campus community members to give feedback on air conditioning and learn more about campus energy use, while competing amongst one another to be more eco-friendly.
- Research and Future Publications
- Feedback Message Framing Effects
- Behaviorally-Relevant Eco-Driving Typology
- Impacts of Earth Hour
- Resident Energy Engagement in Efficient Communities


cEnergi student tests out a virtual reality environment on the Oculus Rift.

cEnergi students welding a kinetic data visualization monument

# UPDATE: INTERNATIONAL ACTIVITIES

Founded in 2009, the UC Davis Program for International Energy Technologies (PIET) seeks to accelerate the development and commercialization of low-cost, clean and efficient energy technologies worldwide. In keeping with its international focus, the UC Davis Program for International Energy Technologies (PIET) and D-Lab are engaging more students than ever on real-world, innovative, and hands-on energy projects on campus and abroad. With a focus on market-based energy solutions in both developed and developing countries, multidisciplinary faculty and student teams work with clients to understand their specific technical, social, environmental, and economic issues.

## INTERNATIONAL DEVELOPMENT AND INNOVATION NETWORK

As a member of the USAID-funded International Development Innovation Network, D-Lab works with a consortium of universities to develop energy technology targeted at poverty alleviation. In 2014 PIET graduate students coordinated with partners in Tanzania to organize a five-week design summit with 80 designers, practitioners, and educators from all over the world. A team led by PIET graduate student Carl Jensen went on to win $10,000 in the Big Bang business contest with its grain storage idea - now a start-up company in Zambia. In 2015 the PIET student team will help organize a Colombian design summit as well as developing an innovation center in Sao Paulo, Brazil.


## US/DENMARK RENEWABLE ENERGY SUMMER COURSE

The US/Denmark Summer Renewable Energy Course, supported by an NSF PIRE grant, brings US and Danish students and faculty together to study renewable energy issues in California and Denmark. This course is organized in collaboration with UC Santa Cruz, Aalborg University, and Danish Technical University. Highlights for the 2014 edition, hosted by UC Santa Cruz and UC Davis, included a visit to the California Independent System Operator to learn about grid integration of renewables in the state and a tour to Makani Power, a Google X green startup developing airborne wind power extraction systems.

## TOKYO GAS COMPANY PARTNERSHIP

Over the last year, researchers at the Western Cooling Efficiency Center have embarked on a noteworthy partnership with Affiliate Member Tokyo Gas Company. Dr. Alan Meier of the EEC has had a long standing interest in Japan, and has collaborated with Tokyo Gas Company in the past. This new partnership takes that collaboration to the next level.

Under the leadership of Dr. Kristin Heinemeier, the HVAC Behavioral Research Initiative (HBRI) grew in scope this year to look at the differences in behavior among households in the US and in Japan, whose energy intensities vary significantly.

The HBRI team has long been interested in shedding light on the well-documented phenomenon that even in identical homes or apartments in the same location, energy consumption can vary by a factor of three or more. UC Davis' West Village Net Zero Community is a prime example of this. Meanwhile, Tokyo Gas was wrestling with this same question with their new very-low energy

apartment building in Yokohama, "E-Sogo."

Careful design and passive cooling techniques resulted in savings on the order of 30% over standard construction, but researchers at Tokyo Gas felt that they could get even more savings by investigating the human factors that went into choices that affect energy use. In one early study, they achieved about 10% energy savings due to feedback on time of use of energy. They were interested in continuing in this vein by developing and testing another program of education, feedback, rewards, and other motivators to encourage occupants to engage in more efficient behaviors.

Dr. Sarah Outcault led a research project at both West Village and at E-Sogo to combine well established behavioral factors such as education, reminders, consumption feedback, positive reinforcement, commitment, targets, and norms in an intervention designed to significantly reduce air conditioning energy use.

It soon became evident, however, that the behaviors that the research was trying to encourage would be very different for the two properties, since in the US most air conditioning is done with central systems, and in Japan most air conditioning is done with more targeted room units (mini-splits). Also, the very dry climate in Davis and reliable delta breezes at night provided opportunities for cooling that are not present in Yokohama.

At E-Sogo, the desired behaviors were:

- Use of timer;
- Increase temperature setting;
- Remember to turn down after an initial "blast" of cooling;
- Put AC in "Cool" mode, not "Dry" mode;
- Attempt alternatives before turning on the AC:
  - Attitude ("coping strategies")
  - Floor, ceiling or table fan (with timer)
  - Ice pillow, neck towel, etc.
  - Other (drink, adjust clothing, take shower, reduce activity, go somewhere else).

At West Village, the desired behaviors were:

- Increase temperature setting;
- Open windows at night to precool the apartment;
- Use ceiling fans as an alternative before turning on the AC.

Researchers also conducted supplementary interviews with the lowest AC users at E-Sogo, since there was no need to encourage them to further reduce their AC consumption but they could still provide valuable information.

While it was expected that some of the low consumption at E-Sogo would be due to frequent unoccupied periods, that was not the case. Most of the interviewees simply had a frugal lifestyle: they were attuned to avoiding "waste" and referred to this as a "personality trait." Mostly, they did not intend to use AC, and if they did use the AC, it was just for a short time, and they always turned it off when they left the room.

Researchers found that by redefining the problem as one of "avoiding waste" rather than "reducing consumption," residents are able to find ways to avoid wasting energy (for example, by making sure that consumption patterns match occupancy patterns closely) and to consider alternatives before resorting to the use of AC. In fact, the responses to

Several researchers spent time in Japan working on this study, including Dr. Heinemeier's three-week visit in July to interview low consumption E-Sogo occupants.

the following question by the E-Sogo and West Village residents highlights a fundamental difference in strategy and attitude.

Perhaps by relaxing the American definition of "unacceptable" the West can explore new and previously unthinkable ways to provide adequate conditions while reducing energy use. The Japanese have proven that it can be done: there is not an inherent physiological constraint on temperatures, but a matter of attitude and culture.

## CLTC PARTNERSHIP WITH ASIA-PACIFIC ECONOMIC COOPERATION (APEC)

CLTC strengthened its partnership with King Mongkut's University of Technology Thonburi (KMUTT) as part of efforts to advance lighting efficiency at the international level.

This summer, CLTC director Michael Siminovitch led a graduate-level seminar on LED luminaire design at KMUTT in Bangkok, Thailand. In the fall, CLTC and UC Davis welcomed KMUTT leaders to campus. During the visit, the universities signed a memo of understanding supporting collaboration between their lighting research centers. Last year, UC Davis and KMUTT worked with APEC to host a symposium for universities and institutions across Asia. The Department of Design at UC Davis is collaborating with KMUTT and Tongji University in Shanghai, China on a proposal to APEC to support a second round of workshops focused on sustainable building design.

Such exchanges help strengthen the relationship between UC Davis, United States-based energy-efficiency research organizations and Asian communities involved in the energy-efficiency projects supported through APEC. It will help to establish centers of expertise that can share best practices.

**One other interesting finding was that while most of these low-consumers "coping" without air conditioning reported being uncomfortable, they also reported that this was very acceptable. This is a startling finding, because in the US and many other western cultures, "uncomfortable" and "unacceptable" are considered to be synonymous.**

UC Davis and KMUTT leaders sign a memo of understanding supporting collaboration between the campuses' lighting centers. Photo: Kathreen Fontecha

# NOTES

# SOLAR DECATHLON

For the first time, UC Davis has been selected to participate in the US Department of Energy's (DOE) Solar Decathlon, an intense 2-year design competition. Students are tasked with designing and building solar-powered, energy-efficient, cost-effective, and market-appealing houses as part of a rigorous competition with 20 participating universities. The winner is the team that creates the best balance of energy production and efficiency, affordability, market appeal, and aesthetic design. The Solar Decathlon is widely recognized as showcasing innovation in energy efficiency, renewable energy, and sustainable design.

The 2015 Solar Decathlon competition is set for October at the Orange County Great Park in Irvine, California. The competition involves university teams developing the full architectural and engineering design of a house and constructing the structure on their respective campuses. The structures are then disassembled and transported to the competition site. The in-person competition will take place over four weeks – one week to construct the houses on the competition site, two weeks of competing, and another week to decommission the houses. The 2-weeks of rigorous competition will include judging 10 different areas including architecture, market appeal, engineering, communications, comfort, affordability, appliances, home life (demonstrating the functional ability of the house), commuting (incorporating generating energy for and using an electric vehicle), and energy balance (where the house must achieve zero-net energy use). The houses will be on display to the public during the competition to provide education and insight on methods of renewable energy generation and energy efficiency.

The DOE developed the Solar Decathlon to achieve three primary objectives -1) providing the public with tools and ideas for reducing residential energy use by showcasing renewable energy and innovative design strategies, 2) showing through example that energy efficiency and renewable energy systems can provide equal comfort and style to a typical modern home and at a reasonable price, and 3) fostering capable design and engineering students to lead the nation in clean-energy solutions.

## MEET THE UC DAVIS TEAM - AGGIE SOL

The Center for Water-Energy Efficiency is leading the UC Davis student team "Aggie Sol" and managing the design, construction, and fundraising for the competition. Aggie Sol is working to create a marketable, sustainable, zero-net energy (ZNE) home at a cost far below market value for ZNE homes. The team's long-term goal is to drive innovation in the residential housing market to make ZNE housing affordable to those with incomes less than the median value in the United States. Their short-term goal is to use the 2015 Solar Decathlon as an opportunity to design and build a residential housing model for American farmworkers – Aggie Sol's target market. To be successful, their design will address the numerous health, living, and cost concerns associated with the majority of current farmworker housing conditions.

Aggie Sol Team.


Rendering of Aggie Sol's design.

Aggie Sol students working up Zero Net Energy housing designs.

**"We're trying to drive down the price point of zero-net-energy housing to help the housing market understand that you can have affordable, nice homes that are zero net energy."**
**- Dr. Frank Loge**

To meet their goals, team Aggie Sol is researching and incorporating low-cost efficiency technologies and materials, focusing on passive solar design, and learning how to balance quality and attractiveness with affordability. The house will demonstrate cutting-edge energy efficiency research from the Energy Efficiency Center focusing on "smart home" innovations that will manage energy inputs and losses. High-efficiency lighting, heating, cooling, ventilation, hot water, and other appropriate technologies, will be driven by grid-tied photovoltaic panels. Since much of California's agricultural land is arid, the design will also include water efficiency and conservation technologies.

The team believes that creating attractive, affordable, dignified worker housing will serve the interests of local governments as well as those of farm laborers by making areas with enhanced housing stock more attractive to workers. This is especially important at a time when farmers are reporting increasing difficulty finding sufficient labor to harvest their crops. Against this backdrop, the availability of decent housing will provide value, as it will enable growers in farm regions to compete for workers based not only on money, but also on quality of living conditions.

UC Davis students and staff from the Colleges of Agriculture & Environmental Sciences, Letters & Sciences, Engineering, and the Energy Efficiency Center as well as private local firms are contributing to the Aggie Sol team's research and design efforts. Students have explored the issues related to farm worker housing to customize the design to their target market. The design and engineering teams are working on demonstrating a cutting-edge sustainable dwelling that offers ZNE accommodations and will serve workers at a price point local, county, state, and private housing providers can afford. Meanwhile, the fundraising and communications teams are working diligently for donations to fund the project and marketing their efforts through social media and website development.

As of November 2014, Aggie Sol has submitted 80% design development construction drawings to the DOE and is awaiting their comments. The team just finished a design critique and charrette with UC Davis staff and local industry mentors to refine and further develop their design. Final construction drawings are due in February and construction on the UC Davis campus will begin shortly after.

# UPDATE: CHILD CENTER FOR INNOVATION AND ENTREPRENEURSHIP

In 2013-14, the Child Family Institute for Innovation and Entrepreneurship continued to move forward with its Sustainable AgTech Innovation Center (SATIC), funded by a $1 million grant from the US Department of Commerce's Economic Development Administration's 2012 i6 Challenge: Sacramento Region Clean AgTech Innovation Center Development Project.

SATIC supports 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. The key programs in 2013-14 included the Innovation Seed Fund and the Agricultural Innovation Entrepreneurship Academies.

The Ag Innovation Entrepreneurship Academy took place in October 2013 and June 2014 at UC Davis. The 2013 and 2014 academies were designed for researchers and early-stage start-ups working in agriculture and food to support commercialization of agriculture and food systems technologies. The academy combines focused lectures, practical exercises, networking sessions and hands-on experiences in an innovative format to help participants explore how their research can make a broader impact in industry, the marketplace, and the world. Participants learned to identify market needs and opportunities, develop a network of experts to support their venture, and create agriculture 'food chain' clusters of innovation. The academies featured 60 guest speakers and mentors from the agriculture and business communities, including Roll Global, BioConsortia, Aracadia Biotech and Bayer CropScience. 68 researchers attended the academies, including 45 from UC Davis. Approximately 15 early-stage ventures are under development from academy alumni.

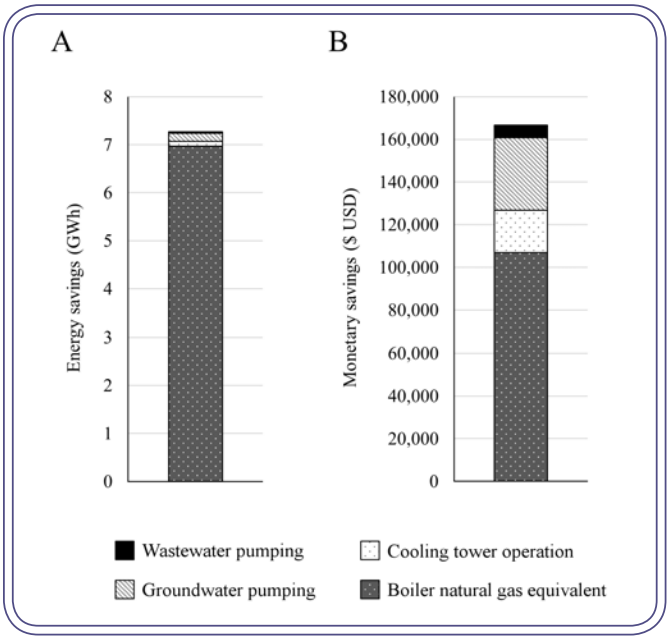
The second request for proposals for the Innovation Seed Fund was held in February 2014. The seed fund provides funding from $5,000-$25,000 for researchers to prototype potential agriculture and agriculture-related innovations and research. Applicants must be UC Davis researchers, faculty, undergraduates, postdocs or graduate students. As of September 2014, 22 projects have been funded to support early-stage prototyping in support of the commercialization of clean and sustainable agriculture and food systems innovations and technologies. The seed fund provides a critical funding resource to move innovations to the next stage of commercialization.


| Second Round: Spring 2014 | | |
|---|---|---|
| Project Name | Project Lead | Summary |
| Seedling tracer technology for agricultural robotic vision systems | Kent Bradford | Seed coatings with systemic fluorescent dyes to improve the efficiency and accuracy of vision-based robotic systems for crop thinning, weed control, and plant population management. |
| Desiccant drying technology for high-value seeds | Kent Bradford | A highly efficient system for seed drying utilizing a desiccant to provide continuous dry air that can replace heated air drying while providing benefits for seed quality, reduced energy, and labor costs. |
| Sustainable Stevia Production and Processing in California's Central Valley | Michael Campbell | Establish an economically profitable and environmentally sensitive method to grow and process Stevia so that it will become a commercial crop in California's Central Valley. |
| Cultivation of a California malting industry | Joshua Hegarty | An initiative to reignite the cultivation of a California based barley malting industry to supply the California craft brewing industry with malt grown and processed within the state. |
| Rapid detection and prediction of failure in cheese production. | Sudheendra Lakshmana | Rapid screening of raw materials such as milk, fermentation broth and other starter materials for bacteriophages (phages) so as to pro-actively reduce production costs associated with dead vats or fermentation failure. |
| Bio char pelletization for safe and site specific soil remediation | Adina Boyce | Bio char pelletization for safe and site specific use is intended develop bio char for application with growers, coupled with further information to assist growers in proper usage. |
| Bioprocessing method to recover value from dairy waste streams. | Dave Dallas | Development of a commercially feasible reactor prototype to capture bioactive endogenous milk peptides (EMP) currently wasted in dairy processing streams. |
| Novel value-added products from agricultural by-products | You-Lo Hsieh | Converting under-utilized agricultural and food processing by-products (rice straw, almond shells, olive stones, tomato and grape pomace) in California into high performance materials for commercially viable value-added functional products. |
| Foodful.ly web and mobile application to reduce food waste | Brianna McGuire | A web service and mobile application that offers unprecedented food management features to both grocery shoppers and grocery providers everywhere with the goal of reducing food waste. |
| Refining dairy whey streams into high value added biofuel co-products. | Juliana Nobrega | Refining dairy whey streams to into high value added biofuel co-products. |
| Sustainable approach to delivering nutrients and bioactives in processed foods | Stephen Young | Promoting stability of nutrients and bioactives in processed foods without synthetic chemicals by utilizing spent yeast from brewing and wine production facilities as a vehicle for encapsulation of said compounds, which will provide a sustainable, value-added product for use in food and nutraceutical industries. |

The above projects were funded in the second round

# WATER-ENERGY EFFICIENCY IN FOOD PROCESSING

As the nation's largest food processing state, California contains many opportunities for recovering both waste heat and water in food processing facilities. To understand where recovery efforts can have the greatest benefit to resource efficiency, current water and energy use in food processing must be understood and quantified. To this end, the Simmons lab conducts water-energy nexus (WEN) analyses of food processing facilities. The WEN analysis is a systematic methodology, based on Department of Energy assessment guidelines and tools that quantifies water and energy usage associated with individual unit operations in food processing facilities.




The lab's first target is the California tomato processing industry, for which a WEN analysis was conducted at a tomato paste processing facility by UC Davis researchers in 2012. Based the WEN analysis, hot condensed water removed from tomato juice via evaporators was identified as an abundant source of relatively clean water and low-grade waste heat that is largely unutilized under current practices. Heat transfer modeling indicated that recovering this water and waste heat would be both possible and economically desirable, with potential annuals savings of over $200,000 per facility via reduced use of purchased natural gas and electricity during processing. Moreover, the research highlighted a need to invent new processing methods that can best utilize recovered low-grade waste heat in order to maximize value to the processor. Developing and validating these new processing techniques has become an active area of research for the laboratory. Moving forward, the lab will use the momentum of the WEN work in the tomato processing industry to promote WEN analysis in a broader range of food processing facilities.

# NOTES

# POLICY INSTITUTE FOR ENERGY, ENVIRONMENT AND THE ECONOMY

Created in 2012, the UC Davis Policy Institute for Energy, Environment and the Economy leverages university expertise and engages directly with decision-makers to deliver credible, relevant, and timely information and analysis to inform better energy and environmental policy.

The Policy Institute responds to the challenge faced by governments at every level to promote a healthy, growing economy while simultaneously improving environmental quality, increasing efficiency, diversifying the energy supply, creating greater resiliency to energy disruptions, and responding to climate change. The Institute accomplishes its mission through various activities and initiatives, examples of which are provided below.

## ZERO EMISSION VEHICLES

Zero emission vehicles (ZEVs), which include plug-in electric and hydrogen fuel cell vehicles, offer the potential to reduce urban smog, achieve deep reductions in greenhouse gas emissions, reduce petroleum demand, and diversify the transportation energy supply. The Policy Institute, in partnership with the Institute of Transportation Studies and the PH&EV Research Center, initiated the Zero Emissions Market Acceleration Program (MAP) to help cities and states meet their sustainable transportation goals. The initiative currently includes ten states, nine cities, and two counties. Agencies, non-governmental organizations, automakers, and partner institutions collaborate to:

- Provide accessible analytical resources to help create and implement market development strategies;
- Assist stakeholders in developing credible ZEV education and outreach strategies; and
- Deliver science-based information about the technological and societal value of ZEVs.

By bringing together regional research and non-governmental institutions, the Zero Emission MAP initiative enables decision makers to implement efficient strategies to sustain and accelerate the growth of zero emission vehicle markets.

The Policy Institute's activities on ZEV's also extend beyond the US. In a landmark international collaboration on clean vehicle adoption, the University of California, Davis, and the China Automotive Technology and Research Center established a Memorandum of Understanding (MOU) to work together on plug-in and fuel cell electric cars in China and the U.S. The five-year MOU establishes the China–U.S. ZEV Policy Lab, a partnership between UC Davis, the world's leading university on sustainable transportation, and CATARC, the administrative body that oversees and regulates many activities of the auto industry in China, the world's largest new-car market.

## CLIMATE ADAPTATION POLICY

As a consequence of climate change, we are already experiencing increases in record heat, storms, drought, and wildfires. Climate change is a global challenge, but the strategies to adapt to its effects are typically implemented locally. Therefore, local governments are at the frontline for planning and response and play a critical role in protecting communities from existing and growing hazards. Local and state decision-makers have a strong need for the latest research on climate impacts at a relevant scale. The Policy Institute is addressing this need in the following ways:

- Serve as a founding member and Vice Chair of the Capital Region Climate Readiness Collaborative (Climate Readiness Collaborative), which promotes greater coordination and cooperation at the local and regional level to adapt to current and future impacts of climate change. The Policy Institute serves as the liaison between the extensive team of experts at UC Davis and the stakeholders in the Sacramento region who are advancing community and ecosystem resilience;
- Partner, through the Climate Readiness Collaborative, with other collaborative efforts from San Diego, Los Angeles and the Bay Area, and the Governor's Office of Planning and Research, to form the Alliance of Regional Collaboratives for Climate Adaptation;
- Work with local government partners and university experts to develop an assessment of the highest priority needs to inform adaptation planning in the Sacramento region;
- Coordinate input and participation of UC Davis,

Sacramento State University, and other regional academic adaptation experts in relevant meetings, planning processes, document review, hearings, and priorities development;
- Develop and participate in the National Building Climate Solutions conference resulting in a toolkit for developing regional adaptation collaboratives; and
- Serve as a UC Davis representative to support the development of UC Berkeley's Climate Readiness Institute.

The Policy Institute is also leading a US EPA project on "Integrating Information from Climate Scientists and Resource Managers: Informing Preparedness and Adaptation to Extreme Event Impacts on Air and Water Quality in California". This project will develop and test a set of indicators of extreme events in order to provide more relevant and accessible climate change information and improve management of climate risks to the air and water quality sectors in California. The project will integrate inputs from resource managers and climate scientists to develop a policy-relevant, interpretable and accessible set of indicators. Development of these indicators will serve as an educational exercise for both resource managers and climate scientists. Resource managers will learn about the potential for current climate science to address their information needs and where uncertainties and limitations remain, and the climate science community will learn about impact-relevant findings which further analysis efforts may be directed in the future.

## CLIMATE CHANGE MITIGATION POLICY

Climate change mitigation refers to the strategies and policies that are being pursued to reduce emissions of greenhouse gases. This has been a major focus for the Policy Institute, as policy leaders and practitioners have asked for direct engagement to inform the policy process with objective research and analysis and expert review. Some of the Institute's major activities and initiatives in climate policy are detailed below.

### CARBON MARKETS

The Policy Institute, along with the International Emissions Trading Association and Resources for the Future, hosted a half-day symposium, California Linking through 2020: The Golden State's Role in the Development of Carbon Markets, exploring various considerations of linking climate policies and markets from different jurisdictions.

### STATE CLIMATE POLICY

The Policy Institute is providing analytical and technical assistance to California, Washington, Oregon, and British Columbia on low-carbon fuel strategies and policies relevant to the Pacific Coast Action Plan on Climate and Energy. The Institute also provides research and insights to the Transportation and Climate Initiative (TCI) of northeastern states.

### CLIMATE POLICY MODELING

The Policy Institute, in partnership with ITS and NextSTEPS, established the California Climate Policy Modeling Forum which brings together senior policymakers, modeling groups and key stakeholders to improve the state of knowledge about modeling and scenarios for future technology adoption, energy use, air quality and greenhouse gas (GHG) emissions, and to identify plausible mid-point goals and targets for GHG emissions between 2020 and 2050.

# THE ENERGY LIBERTY INITIATIVE

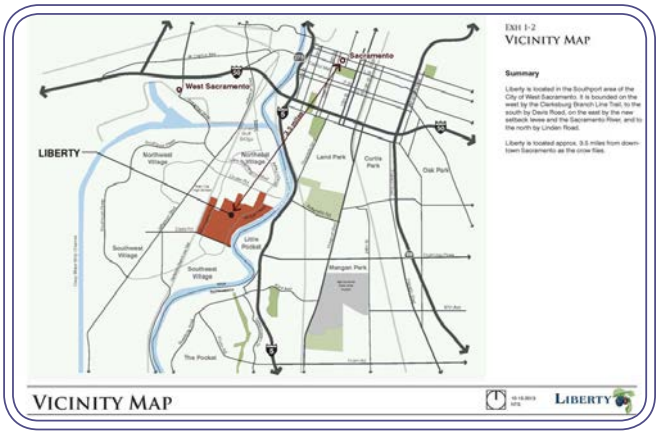
The Energy Liberty Initiative (ELI) is a collaborative effort between the developers of the Liberty Community, their various subcontractors and industry partners, PG&E, UC Davis, and other thought leaders that are advancing the goal of Zero Net Energy (ZNE) construction at the community-scale. At the heart of the ELI is a unique community project development currently in the design phase in West Sacramento, California. The project represents a unique opportunity to develop and demonstrate advanced energy solutions that deliver economic and environmental benefit to the community's future residents and to the broader electricity grid. The effort will draw upon the lessons learned and best practices derived at West Village, the nation's first planned ZNE community, and will ultimately be the first wholly private large-scale development designed and deployed for ZNE.

## THE ELI BUILDS ON THE FOUNDATION OF THE UC DAVIS WEST VILLAGE ENERGY INITIATIVE

In his remarks at the UC Davis West Village ribbon cutting ceremony in October 2011, UC Davis Graduate School of Management Professor and founding director of the Energy Efficiency Center, Andrew Hargadon, likened the West Village Energy Initiative to the invention process of Thomas Edison. For example, before Edison broke ground on the first central power plant ever built in the US, he had produced 14 patents involving electric light. Once he began construction, he produced 368 more.

The UC Davis West Village Energy Initiative followed on Edison's tradition. From its inception as an "environmentally responsible campus housing project" to its current status as the nation's largest planned ZNE community and home to the University's Energy and Transportation research programs, UC Davis West Village has steadily contributed to the practical knowledge of how to plan, construct, operate and improve upon a large-scale, sustainable, mixed-use neighborhood.

The Liberty Community and the ELI represents a unique opportunity to innovate further, taking the lessons learned and best practices put to work in West Village and advancing them in the field with a developer interested in making community-scale ZNE homes a reality in the private sector.




## PG&E SUPPORTED THE LIBERTY PROJECT TO PURSUE ZNE

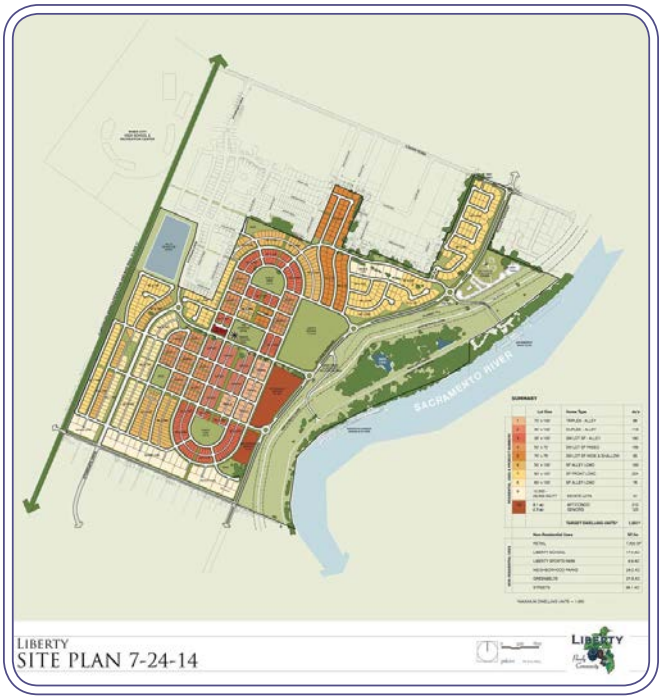
The Liberty Project was submitted and accepted as the only community-scale project to participate in the PG&E Zero Net Energy Pilot Program. As part of the PG&E Zero Net Energy Pilot Program, consultants conducted a Community-Scale Zero Net Energy Case Study in December 2012. This study informed the developer and its consultant team to reorient the streets in order to better optimize the site for solar access and Delta Breezes. PG&E then retained the services of Davis Energy Group and BIRA to conduct an energy model for one home plan. Through their builder network, the Liberty Project team gathered actual cost data based on this one model and began pursuing a cost-effective ZNE strategies and goals for the development. PG&E also helped make the introduction to the UC Davis California Lighting Technology Center and Michael Siminovitch. Dr. Siminovitch worked collaboratively with the Liberty team, led by Judi Schweitzer of Schweitzer & Associates, Inc. (S+A). The CLTC created a high-level (Draft) Community-wide Liberty LED Lighting Initiative Guidebook for Liberty to use in all land uses, including way finding, place making for its horizontal infrastructure and vertical buildings.

**"The most important advances in new technologies come through the process of building, debugging, and continually learning and improving technologies in use."**
**- Andrew Hargadon**

## SUCCESSFUL INITIATIVE WOULD LEAD TO FIRST ADOPTION OF ZNE FOR THE PRIVATE SECTOR

The ELI represents a consortium of stakeholders including PG&E, the UC Davis Energy Efficiency Center, the UC Davis Western Cooling Center, the UC Davis California Lighting Technology Center, the Davis Energy Group, and S+A that are striving to realize the potential for ZNE at the community-scale in Liberty. Efforts by the consortium will focus on closing the "knowledge gaps" in addressing the various land uses (including a diversity of residential single- and multi-family housing types, retail, sports park, K-8 school, community recreational clubhouse and pools, etc.). Significant knowledge gaps remain including but not limited to understanding the energy balance for Liberty, understanding HVAC strategies ideal for Liberty, and understanding an optimal cost-effectiveness strategy and business models for achieving ZNE and potentially distributed storage at the community-scale and for each of the various land uses.

The Liberty Project could be one of the next community-scale ZNE projects in the country, only this time as an entirely private sector development.



# TRANSFORMING THE MARKET FOR BUILDING AUDITS

Achieving broad-scale adoption of comprehensive energy efficiency retrofits in our State's building stock requires a market transformation of the existing service model. UC Davis is developing a consortium of private and public sector stakeholders seeking to transform the market for building retrofits of K-12 schools and small commercial buildings. This unique collaboration between relevant California public agencies, municipal and investor owned utilities, and non-profit and private sector firms will create a model end-to-end platform that California K-12 schools can use to gain access to:

- standardized high quality audits and recommendations on energy conservation measures to deploy;
- bids from contractors that seek to do the work to install selected measures;
- opportunities for financing, incentives, and rebates that will provide necessary funding for all aspects of the retrofit; and,
- a secure centralized database that will track and analyze the savings generated by the retrofit project.

When refined, this same platform can be deployed in other geographies (to schools outside of California) and in other markets (to properties such as offices, hotels, and other building types). The more end-users and building owners that utilize the platform, the more the platform will continually be improved in terms of the recommendations and the accuracy of the predicted savings. Additionally, this platform will be a source of unprecedented amounts of data, with which stakeholders (including researchers and policymakers) can make informed decisions.

UC Davis is currently working with the following organizations on this endeavor:

- California Conservation Corps (CCC) – collaborating on building survey methodology, workforce training and development, installation
- California Community Colleges – collaborating on workforce training
- California Clean Energy Fund (CalCEF) – collaborating on financing component

- UC Davis is developing partnerships with all California Utilities and select software providers to advance the effort.

The California Clean Energy Jobs Act (Proposition 39) represents a unique opportunity to pilot this model platform. K-12 Schools throughout California collectively have access to over $350M/year over the next 4 years through Proposition 39 funding that can be used to conduct energy efficiency retrofits and upgrades to their facilities. The reputation of energy efficiency as a resource is very dependent on a successful rollout of this investment by the State. It is critical that the resulting retrofits from this program generate long-term valuable returns on investment to stakeholders in the form of fiscal savings, energy savings and GHG mitigation, improved comfort and performance to students and teachers, and economic development throughout the State.

- UC Davis partnered with the California Conservation Corps (CCC) to train and empower CCC Corpsmembers to conduct low-cost comprehensive building surveys and energy analyses of K-12 schools, that will allow especially those smaller schools that do not have their own technical resources to make informed decisions.
- UC Davis and Sierra College co-developed a curriculum and trained more than 180 Corpsmembers on how to conduct building surveys. UC Davis will continue to work with the CCC and the California Community Colleges to scale this training program further.

- UC Davis has informally collaborated with the California Energy Commission to make sure the recommendations our reports provide K-12 schools are consistent with the Energy Commission guidelines under the California Clean Energy Jobs Act.
- The automated tools and methodology UC Davis is developing in concert with CCC is creating a model for a low-cost, comprehensive, educational building audit approach. Increasingly it will rely and be updated by the state of the art expertise available within the UC Davis CA Lighting Technology and Western Cooling Efficiency Centers.
- UC Davis will publish the building survey methodology and training curriculum it has co-developed, and will work to make the data analytics tool a publicly accessible resource, so that the commercial sector can begin to utilize the tools and the personnel (Corpsmembers) that have been produced to-date.
- These efforts are uniquely positioned to transform the way and scale at which California targets retrofitting small and medium size commercial buildings.
- As of December 2nd, UC Davis has generated more than 150 reports for schools across the State and has begun analysis on more than 300 additional schools. The CCC has conducted audits of over 900 total schools across the state and is actively transcribing the data to be sent to UC Davis in the coming months.
- Schools are using these reports to submit their expenditure plans for California Energy Commission approval of Prop 39 funds
- Calculations show an average annual savings potential of over 81,000 kWh and over $16,000, depending on size and vintage of the buildings, with an average savings of 20-40%.

UC Davis is seeking support from industry sponsors and grant making agencies to further refine its efforts.

- Migrating data collection to a Tablet-based approach will greatly increase timeliness and quality of the report generation process – reducing the possibility for transcription errors and eliminating the labor intensive demand of paper based processes.


- Incorporating Smartmeter data in the analysis and including rebate and incentive information available from local Utilities can streamline the process for K-12 schools requesting building surveys and improve the accuracy and cost-effectiveness of the energy conservation measures
- With additional resources, the audit approach can include analysis of opportunities for solar PV installations and water conservation measures, which are currently not included in the audit approach.
- Over time the centralized database will grow and allow for benchmarking of schools performance; such a database allows for analysis of the actual savings schools are capturing from energy measures
- We are currently applying for funding support under a DOE funding opportunity and we are also soliciting support from Foundations.

## ABOUT THE ENERGY CORPS PROGRAM

The CCC has been involved in energy conservation efforts, since its earliest days. In the summer of 2013 the EEC at UC Davis contracted CCC to conduct basic walk-in surveys of Multi-Tenant Light Commercial (MTLC) buildings to gather data required for market research of the MTLC segment. As a part of the contract, the EEC trained a team of corpsmembers to perform the necessary audits. The collaborative framework where the corpsmembers collected the field data and UC Davis conducted training and completed the analysis and reporting, proved to be a successful model. The success opened doors for an inter-agency initiative between UC Davis and CCC to further the

collaborative framework. Under the initiative, UC Davis and CCC would foreseeably partner around a variety of market research projects where CCC would collect the field data and UC Davis would train the CMs, perform analysis on the data collected and produce reports. Under the funding allocated to CCC via Proposition 39, CCC launched the Energy Corps program, its first major effort funded through the "Clean Energy Job Creation Fund." The funding provided enables the CCC to assist California schools with energy surveys, and potentially simple retrofit projects. These surveys are currently in progress, and many schools that have already been surveyed are awaiting energy assessment reports. In each school audit, the CCC develops a data set that the UC Davis team can utilize to produce the reports. During their site visit, the CCC crew collects an inventory of equipment and appliances that use electricity, natural gas, and other fuels. They also record each school's site layout and building characteristics, as well as obvious operations and maintenance (O&M) issues that they come across. This collected data is transcribed and sent to UC Davis for compilation and analysis.

UC Davis then determines appropriate energy conservation measures (ECMs), costs of the ECMs, and compiles an audit report to be sent to the school to which it pertains. Each report contains the school's energy consumption (electricity and natural gas), and their annual costs. These data are then inserted into a benchmarking calculator provided by the CA Energy Commission in order to determine their energy use intensity (EUI) and show comparisons of their energy habits with national averages.

All participating schools receive the following documents:

- An energy audit report compiled by the UC Davis Energy Efficiency Center
- A draft of the California Energy Commission's Energy Savings Calculator
- Spreadsheet inventories of the schools' appliances, lights, and HVAC systems
- Sketches from the field audit compiled in a (PDF) report by the California Conservation Corps

The ultimate goal of each report is to provide the school with their current energy performance, and a straightforward guideline for achieving deep energy efficiency retrofits on their campus.

## ABOUT PROPOSITION 39

The California Clean Energy Jobs Act was created with the approval of Proposition 39 in the November 6, 2012, statewide general election. Proposition 39 added Division 16.3 (commencing with Section 26200) to the Public Resources Code, added Sections 25136, 25136.1 and 25128.7 to the Revenue and Taxation Code, and amended Sections 23101, 25128, 25128.5 and 25136 of the Revenue and Taxation Code. The statute made changes to the corporate income tax code and allocates projected revenue to the General Fund and the Job Creation Fund for five fiscal years, beginning with fiscal year 2013-14. Under the initiative, approximately $550 million annually is available to be appropriated by the Legislature for eligible projects to improve energy efficiency and expand clean energy generation. For fiscal year 2013-14, California's Legislature, through Senate Bill (SB) 73 (Committee on Budget and Fiscal Review, Chapter 29, Statutes of 2013) appropriated Proposition 39 revenue as follows:

- $381 million in awards to local educational agencies (LEAs), which include: county offices of education, school districts, charter schools, and state special schools, for energy efficiency and clean energy projects.
- $47 million in awards to California community college districts (CCDs) for energy efficiency and clean energy projects.
- $28 million for low-interest and no-interest revolving loans and technical assistance to the California Energy Commission (Energy Commission).
- $3 million to the California Workforce Investment Board to develop and implement a competitive grant program for eligible workforce training organizations to prepare disadvantaged youth, veterans, and others for employment in clean energy fields.
- In addition to the above SB 73 appropriations, Governor Edmund G. Brown's 2013–14 Budget Act, appropriated Proposition 39 revenue as follows:
- $5 million to the California Conservation Corps

(CCC) to perform energy surveys and other energy conservation-related activities. In the subsequent four fiscal years, 2014-15 through 2017-18, LEAs and community college districts (CCD) will receive allocations from the Job Creation Fund, when funds are appropriated by the Legislature, for eligible energy efficiency and clean energy projects that create jobs in California.

## ABOUT THE CALIFORNIA CONSERVATION CORPS

The California Conservation Corps (CCC) is a state department of California that falls under the state cabinet-level California Resources Agency and was launched in 1976. The CCC is a work development program for men and women primarily between the ages of 18 to 25. Members of the CCC are referred to as "corpsmembers" (CMs). The CMs are trained and work in a variety of projects that include environmental conservation, fire protection, land maintenance, and emergency response to natural disasters.

# SMARTMETER DATA – PRICING AND EFFICIENCY IMPACTS

Researchers at the Energy Efficiency Center, Kevin Novan and Aaron Smith of the Agricultural and Resource Economics Department, are working on an exciting new project in conjunction with the Sacramento Municipal Utility District (SMUD) in which they will compile and analyze smart-meter data. They will then produce estimates of private savings from energy efficiency investments and report on how well alternative pricing strategies align the savings of consumers with reduced emissions and generation costs.

## PROJECT OVERVIEW

Expansions in smart metering technology have opened the door for widespread use of a range of dynamic electricity pricing options, which are now being actively considered by utilities and policymakers. The Sacramento Municipal Utility District (SMUD) conducted one such study, in which it evaluated time of use (TOU) and critical peak pricing (CPP) plans. SMUD plans to offer TOU pricing to a subset of their residential customers by 2017. In addition, the California Public Utilities Commission (CPUC) is currently evaluating proposals for residential rate changes under AB327, including TOU pricing.

Dynamic pricing strategies have the potential to dramatically alter the costs of providing electricity over several different time frames. Over the very short-run (second-to-second or minute-to-minute), dynamic price signals can be combined with smart, end-use appliances to balance real-time supply and demand and maintain grid stability. Over slightly longer time frames (hour-to-hour or day-to-day), dynamic price signals can flatten the daily load profile – providing savings in generation, transmission, and capacity costs. Many of these benefits stem from load shifting rather than reductions in total use. In contrast, very little attention has been directed towards the potential for alternative pricing policies to reduce load in the long-run by changing appliance and energy-efficiency investments.

Researchers will examine how a range of different pricing policies would alter the incentives consumers face when deciding whether to make long-lived investments in new appliances and energy efficiency upgrades to their homes.

For example, compared to tiered pricing regimes, would TOU pricing make an investment in an energy efficient air conditioner more attractive to a residential consumer? If so, how much additional cost savings would be achieved under TOU pricing? To understand the long-run impacts of dynamic pricing, and in particular, the total energy savings that could be achieved, it is vital to understand how dynamic pricing will impact investments in energy efficiency. Rather than using engineering estimates of the efficiency of appliances or energy efficiency upgrades, the Energy Efficiency Center researchers use data on actual energy use. Thus, estimates are based on how people use energy, and any rebound effects caused by consumers changing their energy use patterns after upgrading can thereby be incorporated.

## RESEARCH METHOD

To evaluate the alternative pricing policies, researchers will first compare energy use before and after a rebate was received for a new appliance or upgrade. Then the precise amount of energy saved during each hour of the day and across various temperature ranges will be calculated. To validate the estimates, researchers will construct a sample of households with similar characteristics and assign them a placebo rebate date. If the estimates are valid, then there should be no change in energy use in the placebo households.

Next, Smith and Novan will estimate the energy cost savings that the households created by investing in each of the individual appliances or upgrades to their homes. Using information on the current tiered rate structure, they can first produce estimates of the actual savings the consumers experienced on their bills. Because the data allows the measurement of savings by hour of the day and by temperature, researchers can also estimate how much consumers would have saved if they had been subject to an alternative pricing schedule such as flat rates, various fixed

charges, minimum bill requirements, TOU, CPP, or RTP. Comparing the consumer savings for different energy efficiency investments under different pricing policies will provide insights into how each pricing strategy impacts the incentives to invest in energy efficiency.

This study will use actual electricity use under a tiered pricing scheme to predict long-run savings under alternative pricing schemes. This exercise requires assumptions about the likely short-run (hour-to-hour) response of consumers to a different pricing scheme. Novan and Smith will assume that consumers react similarly to the observed responses in several recent studies (e.g., Jimenez et.al. (2014), Jessoe and Rapson (2014), Borenstein (2015)). They will also investigate how changes in the assumed short-run response affect our estimates of the long-run effects.

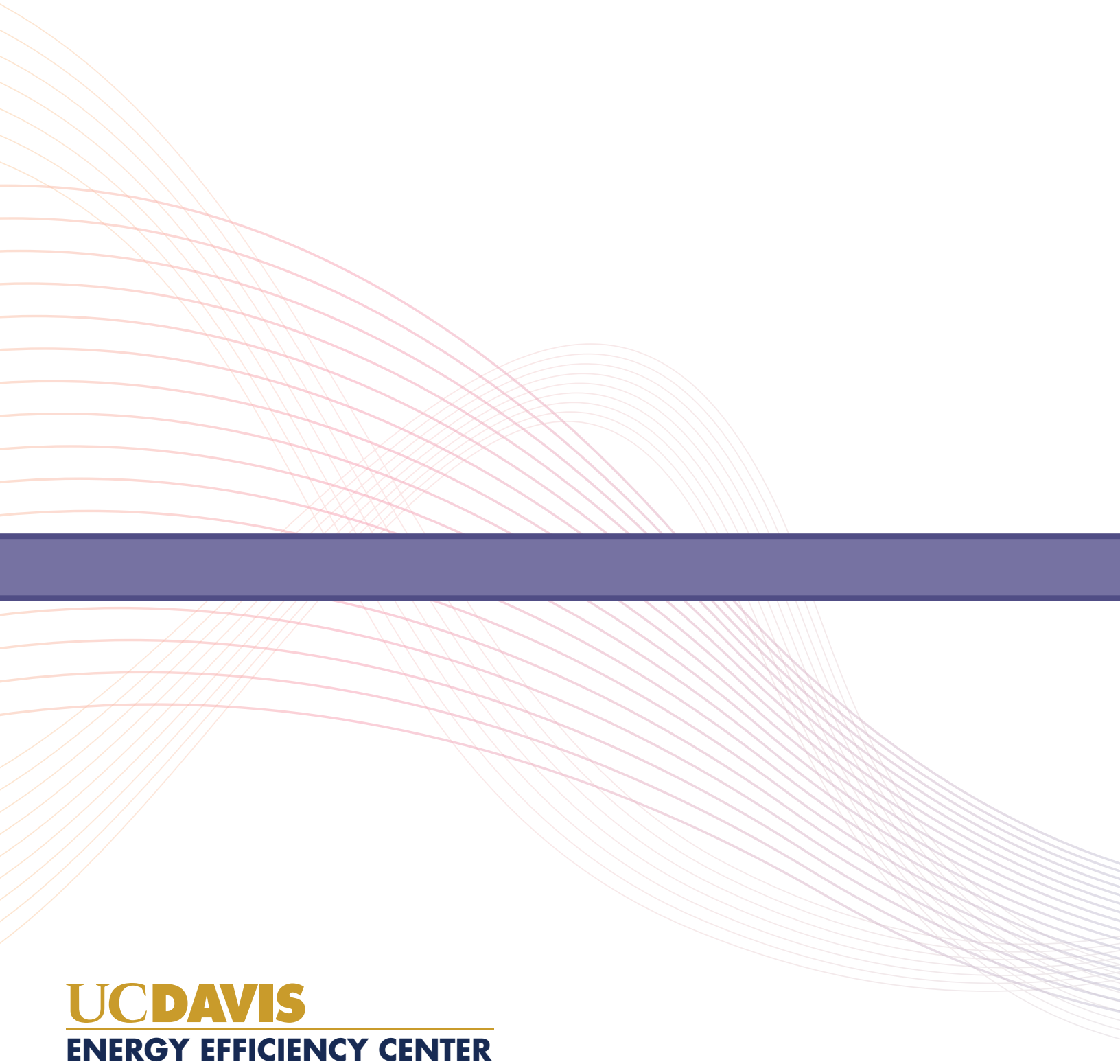
An ideal pricing policy would align the private cost savings to consumers and the social cost savings achieved by investing in energy efficiency. Social cost savings include avoided generation costs and the avoided pollution costs achieved by each energy efficiency upgrade. Such an ideal pricing policy would incentivize households to invest in the optimal level of energy efficiency as well as the optimal set of energy efficient technologies. Using the observed California investor wholesale electricity prices and the emissions factors associated with the marginal generator, researchers can estimate the avoided generation costs and the avoided pollution costs achieved by each energy efficiency upgrade. Therefore, to evaluate the efficacy of the various pricing policies, it is necessary to also compare the social cost savings and the private cost savings under each of the alternative pricing policies.

In addition to exploring how the various pricing options impact the incentives to invest in energy efficiency, this research will also provide guidance on how smart-meter data can be utilized to improve the design and targeting of energy efficiency subsidies. To do so, Novan and Smith will use the County Assessor and Census data to first identify factors that determine participation in rebate programs. For example, do movers frequently invest in energy efficiency upgrades? Is there a pattern in consumption prior to receiving a rebate? Next, they will identify factors that affect the magnitude of the energy savings achieved. For example, do upgrades save more energy in older homes? Combined, these results can highlight how availability and analysis of smart meter data can be used to more efficiently design/target energy efficiency rebates.

**These results can highlight how availability and analysis of smart meter data can be used to more efficiently design/target energy efficiency rebates.**

# NOTES

# NOTES



UCDAVIS

ENERGY EFFICIENCY CENTER

University of California, Davis
1605 Tilia St. • Suite 100
Davis, CA 95616