UC DAVIS

CONVERGENCE

WCEC YEAR-IN-REVIEW 2015-2016

Combining research, demonstrations, policy and deployment to advance energy efficient thermal systems.

Welcome

WCEC'S MISSION IS TO ACCELERATE DEVELOPMENT AND COMMERCIALIZATION OF EFFICIENT HEATING, COOLING, AND ENERGY DISTRIBUTION SOLUTIONS THROUGH STAKEHOLDER ENGAGEMENT, INNOVATION, R&D, EDUCATION AND OUTREACH.

Welcome to the Western Cooling Efficiency Center's Year-In-Review for the 2015-2016 year. We are excited to share with you some notable developments from this past year, including new technologies developed in-house that are moving to the market. This Year-In-Review also displays the diversity and uniqueness of not only our latest research and findings; but also an increased range of new partnerships that greatly expand our impact in California and beyond.

This year, WCEC partnered with over 20 groups from both private industry and the public sector; including government organizations such as the Department of Energy, Department of Defense, Lawrence Berkeley National Laboratory, and the Electric Power Research Institute. We've also taken greater steps to partner with other prominent research divisions right here at UC Davis, including the Energy Efficiency Center, the Department of Public Health Sciences and the Department of Animal Science.

Testing technologies and writing research reports is an important step to move the energy efficiency needle forward. WCEC goes one step further by searching for new, sometimes unconventional perspectives to our energy issues, challenging long standing precedents, and engaging policymakers and standards organizations. This year, WCEC made progress on creating a new standard to test evaporative pre-coolers through ASHRAE Standard 212, and we are creating training videos on 2016 Title 24 Building Energy Efficiency Standards for residential HVAC systems to help unravel some of the complexities in building standards. These efforts have the potential to increase adoption rates of both new technologies and existing best practices for buildings.

LOOKING TOWARD OUR ENERGY FUTURE

Our research successes and innovations are owed largely to the cooperative interests and combined efforts of our valued network of industry partners, collaborators, and research sponsors. In light of the growing energy and environmental challenges we face, we know these upcoming years are important. WCEC is proud to be a part of this movement to advance a more sustainable energy efficient future.

WCEC's New Affiliates

TRANE — Over 120 years building HVAC solutions for both residential and commercial applications.

Air2O — Commercial HVAC solutions utilizing both direct, and indirect evaporative cooling technologies.

AEROSEAL — Effective, patented duct sealing solution for both residential and commercial applications.

SMC SOFTWARE MOTOR CORPORATION — Creators of software controlled electric motors that are efficient, connected and scalable for a range of applications.

New Intellectual Property Patents

Tracer Gas System

New system that allows for accurate airflow measurement over a wide range of operating conditions.

Clothes Dryers

High accuracy automatic shut-off sensors for clothes dryers.

Envelope & Pipeline Sealing

Automatically seal building envelope and low-flow gas pipeline leaks with instant verification of results.

Core Proficiencies

- Leaders in climate-appropriate cooling technologies
- In-house laboratory with environmental chamber capable of re-creating 95% of California's hot/dry climates
- Leaders in automatic aerosol sealing technology for buildings

Extensive Knowledge In:

- Building energy modeling
- Technology evaluation
- Cooling Hot/Dry climates
- Codes & Standards
- Human behavior in HVAC
- Thermal energy distribution
- HVAC system control

What is WCEC?

The Western Cooling Efficiency Center is an authoritative and objective research center at UC Davis that accelerates the development and commercialization of efficient heating, cooling, and energy distribution solutions.

Our work is increasingly important as energy policies in the US and California recognize the far-reaching implications of greenhouse gas emissions on our environment and changing climate.

HOW WE WORK

APPLIED RESEARCH

Working closely with manufacturers, policymakers and utilities, WCEC tests new and existing HVAC technologies in our laboratory. We also deploy real world demonstrations that provide objective technology evaluations of field performance. Our engineers recommend and implement performance improvements for the technologies tested.

HUMAN FACTORS & POLICY RESEARCH

We understand that even game changing technologies face considerable barriers to adoption that include policy, market and human interaction. WCEC works with policymakers, supporting codes and standards that will save energy and promote new, efficient technologies. We also work closely with our Utility partners, to evaluate technologies for market incentives, and in parallel, address human behavioral factors.

Learn more » wcec.ucdavis.edu

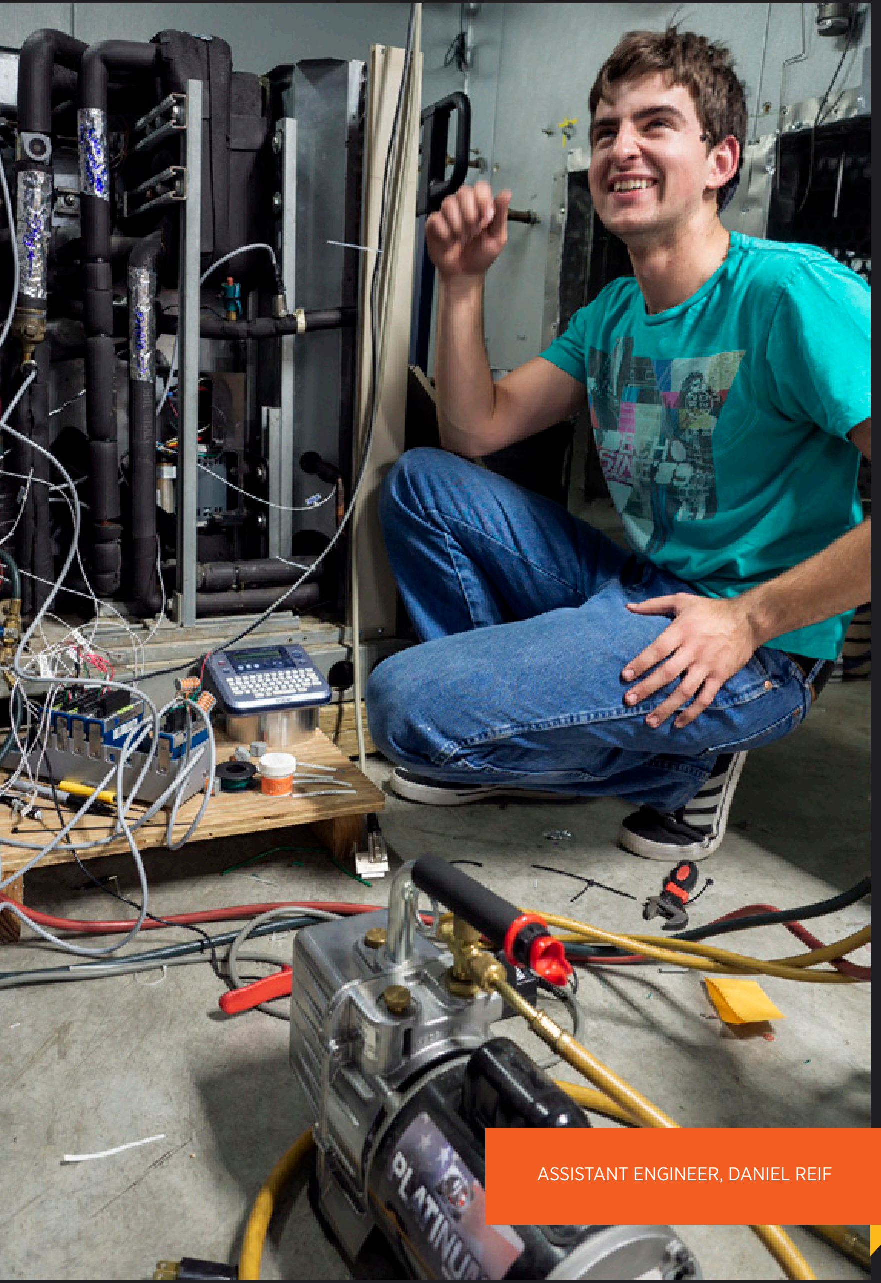
WCEC's NEW EMPLOYEES *for* 2015-2016

DERRICK ROSS
ASSISTANT ENGINEER

MARIA FERNANDEZ
FINANCIAL ANALYST

MATT STEVENS
ASSISTANT ENGINEER

RACHAEL LARSON
ASSOCIATE ENGINEER



ASSISTANT ENGINEER, DANIEL REIF

Performance Testing of a New Refrigerant

The modernization and economic growth in countries like China and India have led to an even larger marketplace for vapor compression cooling—and a larger overall carbon footprint and global warming potential (GWP). Because of the inevitable increase in vapor compression cooling throughout the world, solutions to reduce the global warming potential of each of these units can have a significant impact on our environment.

One part of that solution is to reduce the global warming potential of the refrigerants used in these systems. To that end, WCEC laboratory tested a new refrigerant, R-452B under a variety of conditions and compared the results to the standard refrigerant, R-410A. This refrigerant is claimed to have a 70% smaller GWP than R-410A. R-452B is also a drop-in replacement for 410-A, requiring no more than a possible TXV replacement to account for the change in operating pressures and refrigerant mass flow rate.

RESULTS

The results show that the equipment operating with R-452B refrigerant achieved similar capacity to the equipment operating with R-410A but used less total power in each test performed. The combination of providing comparable cooling capacity using less power is what results in the better efficiency observed for the unit operating with R-452B. R-452B showed a 5% improvement in the equipment coefficient of performance at the AHRI rated condition (95°F) and 4% improvement in coefficient of performance on average across all tested conditions.

PUBLICATIONS

Download WCEC's laboratory performance test case study for R-452B:

bit.ly/RefrigerantCS

EFFICIENCY SAVINGS

5% greater efficiency at AHRI conditions than R-410A

DISCHARGE PRESSURE PERFORMANCE

7% lower discharge pressure than R-410A

REFRIGERANT CHARGE PERFORMANCE

9% less refrigerant charge than R-410A

AEROSOL ENVELOPE SEALING OF A HOME IN CLOVIS, CA

Aerosolized Sealant for Building Envelopes

Building envelope leaks are a significant factor in energy consumption, accounting for over 30% of the total energy used for HVAC. Sealing buildings by means of aerosolized sealant particles is a promising technology, providing a comprehensive solution that can dramatically reduce the total leakage in buildings. Sealing building envelopes saves energy by eliminating infiltration of unwanted, unconditioned air, reduces the loss of conditioned air and reduces the demand for cooling and heating. Existing envelope sealing practices require many contractor hours, manually sealing leaks with no guarantee that the majority of leaks have been found or sealed. Sealing building envelopes with aerosol particles eliminates the guess-work—sealing leaks a person is unlikely to notice—all while providing instantaneous feedback and verified results.

NON-RESIDENTIAL DEMONSTRATIONS

Completed first year of Department of Defense demonstrations, to demonstrate this technology in non-residential applications including existing classrooms and office buildings.

Up to 65% Available leaks sealed in large, commercial buildings.

MULTIFAMILY SEALING DEMONSTRATIONS

Finished testing aerosol technology in 18 new construction apartments and 9 existing apartments.

Up to 90% Available leaks sealed in multifamily buildings.

DEPARTMENT OF ENERGY PROJECT

Single family home-based project focused on working closely with developers to determine several optimal options for application of aerosol sealing. Direct collaboration with Minnesota Center for Energy and Environment.

LICENSED TECHNOLOGY TO AEROSEAL FOR COMMERCIALIZATION

Aeroseal rolled out first prototypes of sealing equipment and software and are currently performing their first commercial applications, including 100 apartments in New York.

Advanced Heat Exchangers

WCEC has three projects underway related to advanced heat exchangers for power cycles. Specifically, the power cycle under consideration is a supercritical carbon dioxide (sCO_2) cycle. The sCO_2 cycle is being considered by DOE for power generation from fossil, solar, nuclear and high temperature waste heat sources. A key aspect of this cycle is the high efficiencies (on the order of 50%) obtained at moderate temperatures at the turbine inlet (on the order of 550°C) and compact turbomachinery. The efficiency of these cycles is heavily dependent on effective heat exchangers. To further this effort, WCEC is focusing on developing compact, high efficiency heat exchangers for these cycles. Unique test facilities are being developed to permit characterization of these heat exchangers at cycle operating pressures and temperatures.

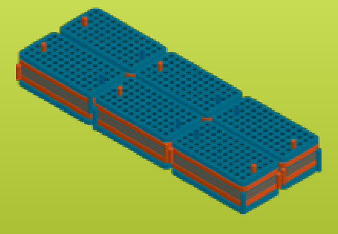
PROJECT 1: MICROCHANNEL SOLAR THERMAL RECEIVER DEVELOPMENT

In this project, the team is developing the next generation of solar thermal receivers that are capable of absorbing up to 1000 suns of thermal flux at exit sCO_2 fluid temperatures of 720°C. This new solar thermal receiver, combined with smaller turbines designed to use sCO_2, take up much less space and generate more overall electricity than traditional receivers—absorbing and transporting 100W per cm^2. Traditional receivers can only absorb up to 60W per cm^2, and the turbines used in combination with traditional receivers are larger and have larger energy losses.

At UC Davis, thermal characterization of flow through such microscale passages of the receiver was performed in Phase I of the project. In Phase II, UC Davis will be characterizing the performance of a 20 kW microchannel receiver on the newly commissioned 7-meter parabolic solar dish.

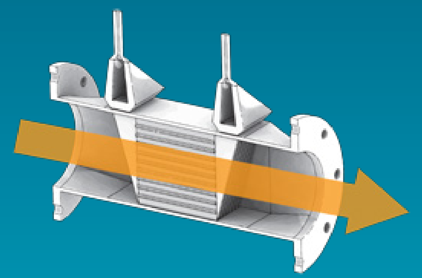
VINOD NARAYANAN, PROJECT LEAD, IN FRONT OF THE NEWLY COMMISSIONED 7-METER SOLAR DISH AT UC DAVIS.

SOLAR THERMAL RECEIVER TEAM: (LEFT TO RIGHT) CATON MANDE, VINOD NARAYANAN, ERFAN RASOULI



PROJECT 2: RECOUPERATOR FOR INDUSTRIAL PROCESSES

Solid model of a typical microchannel heat recuperator. The blue areas indicate colder sCO_2 fluid paths while the red areas indicate hot sCO_2 fluid pathways. The holes correspond to location of microscale pin fins in the heat exchanger structure.



PROJECT 3: RECOUPERATOR FOR GAS TURBINES

Cut away solid model of the 3D printed plastic heat exchanger for pressure drop testing.

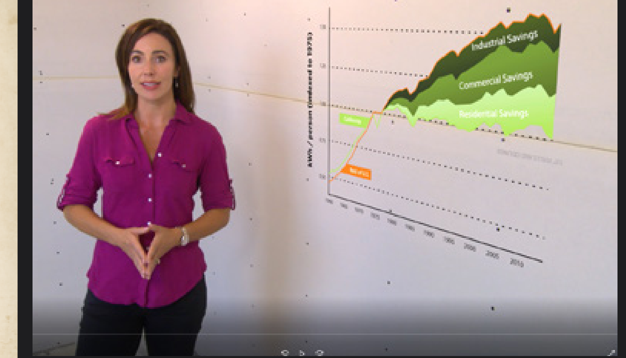
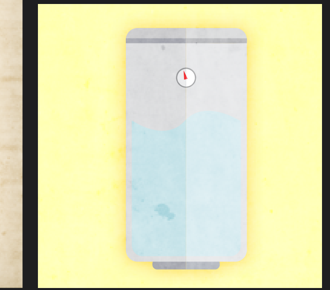
PROJECT 2: MICROCHANNEL RECUPERATOR FOR INDUSTRIAL PROCESSES

In this project, a high temperature recuperator that exchanges heat between two high pressure sCO_2 streams is being developed. A 1-2 kW recuperator will be characterized in WCEC's test facility in the coming year.

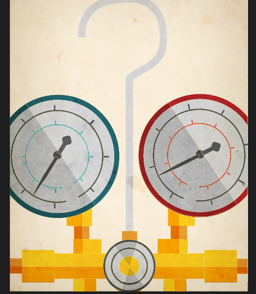
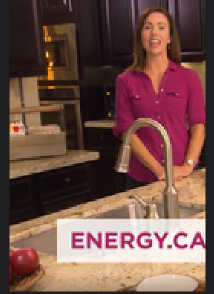
PROJECT 3: MICROCHANNEL RECUPERATOR FOR GAS TURBINES

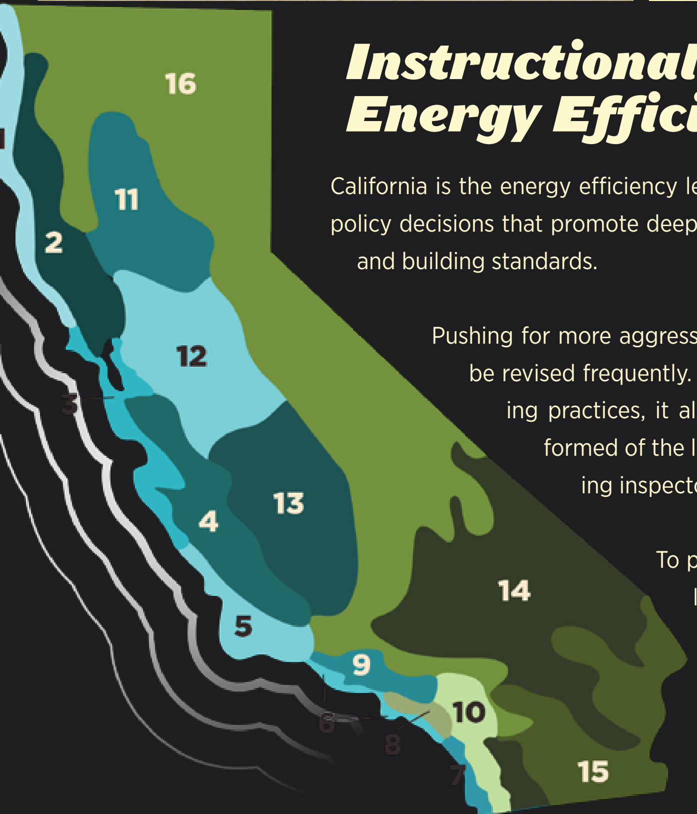
In this project, we propose that the waste heat from the exhaust of a gas turbine ship be recovered and used to generate power using a sCO_2 cycle. The emphasis of this project is on design and characterization of a heat exchanger that can be placed within the exhaust stream of the turbine to recuperate heat into the sCO_2 stream.

In order to improve reliability of the heat exchangers during multiple thermal operating cycles, a monolithic recuperator using additive manufacturing is proposed. In Year 1 of the project, WCEC completed the design of a heat recuperator. A key constraint on the design is the available pressure drop on the turbine exhaust side. In order to validate the design for this constraint, a plastic 3-D printed recuperator was tested and the pressure drop results compared against the model predictions. In Year 2, performance of an additively manufactured recuperator will be characterized with sCO_2 fluid through microscale passages within the plates of the recuperator structure.





Instructional Videos for California's 2016 Building Energy Efficiency Standards

California is the energy efficiency leader in the US, and much of that success is due to policy decisions that promote deep energy savings through efficient building practices and building standards.

Pushing for more aggressive energy savings requires that building standards be revised frequently. While this can promote new, energy efficient building practices, it also leads to confusion for those who must stay informed of the latest requirements including plans examiners, building inspectors, contractors and builders.

To provide another avenue to obtain information on the latest standards, the California Energy Commission (CEC) funded WCEC to create video-based courses that cover the 2016 Building Energy Efficiency Standards for residential HVAC systems.

WCEC has completed the creation of this training module, which includes 9 video courses:

- *Introduction: Mandatory, Prescriptive and Performance Requirements: Understanding the Differences*
- *What's New in 2016*
- *Mandatory Measures for Heating and Cooling Systems*
- *Automatic Setback Thermostats*
- *Mandatory Measures for Air Distribution Systems*
- *Indoor Air Quality and Mechanical Ventilation*
- *Prescriptive Method of Compliance*
- *Performance Method of Compliance*
- *HVAC Alterations and Changeouts*

PATH FORWARD

WCEC is working with the CEC to continue this effort and create video courses for the Commercial HVAC Systems sections of the 2016 Building Energy Efficiency Standards.

Market Barriers to Energy Efficient Technology Adoption

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

Data was collected from scores of individuals, primarily through in-depth interviews. The principles of behavioral economics were used to identify stakeholders' behavioral drivers according to their motivations, abilities, and triggers.

Analysis of the data identified numerous factors that impede market adoption, including:

- *Concerns about sustained technical performance for a given application*
- *Uncertainty in upfront and ongoing costs, and energy savings*
- *Complications and lack of clarity in stakeholder roles*
- *Lack of information from credible sources received by relevant stakeholders*
- *Greater efforts required to buy, sell, install and maintain emerging technologies, relative to the conventional choices*
- *Preference for and inertia supporting the status quo*
- *Weak triggers to spur adoption when the motivation and ability exists.*

DISSEMINATION

The final report on the study can be found here:
bit.ly/WCECMarketBarriers

The research was also presented at the 2015 Behavior, Energy and Climate Change Conference in Sacramento, CA, and at the 2016 WCEC Affiliates Forum, which can be viewed here:
bit.ly/MarketBarriersPresentation

A publication for the academic press is in progress.

PATH FORWARD

Follow-up work to address some of these market barriers is underway with the support of Southern California Edison. WCEC is developing outreach videos to address the critical elements identified in the study, and will test them as a proof of concept with various stakeholders to determine whether this method of market intervention holds promise.

SARAH OUTCAULT, BEHAVIORAL SCIENTIST AND PROJECT LEAD

Next-Generation Residential Space-Conditioning System

The focus of this project, funded by the California Energy Commission and led by the Electric Power Research Institute (EPRI), is to integrate several advanced technologies available world-wide or in the RD&D phase into a single space-conditioning system for residential buildings that is cost-effectively optimized for California's climatic conditions.

The full project team will evaluate several technologies including automated demand response, alternative refrigerants, and heat recovery ventilators. The WCEC is under subcontract to EPRI to specifically test the performance of a variable speed heat pump system connected to typical ductwork that is located outside of the conditioned space. The lab testing for this project is measuring the performance of the duct system and determining appropriate strategies for controlling variable speed equipment based upon the overall system performance.

TWO-PHASE LABORATORY TESTING

In Phase I the WCEC looked at system performance for a standard single-zone duct system, and Phase II will implement zoning controls on the same duct system to reduce thermal losses in the ducts. In both cases, the air-tight ductwork experiences the same conditions as the outdoor condensing unit. These duct-zone temperatures roughly represent an average of the conditions seen by ductwork in an attic (hotter than outdoors) and in a crawlspace (cooler than outdoors). The Phase I testing for this project has shown an improved COP for the equipment when running at low speeds; however, during hot outdoor conditions the duct losses increase at lower fan speeds. In some cases the thermal losses through the duct system can negate the improvement in efficiency of the equipment when running at lower speeds.

PH.D CANDIDATE, SREENIDHI KRISHNAMOORTHY, BUILDING THE TEST APPARATUS FOR NEXT-GENERATION RESIDENTIAL SPACE CONDITIONING SYSTEMS.

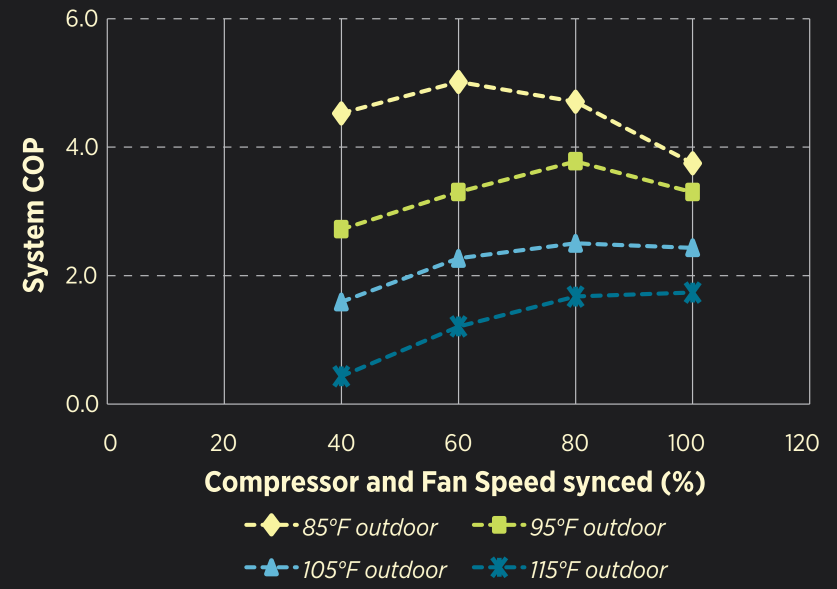


Figure 1: Coefficient of Performance for variable speed, unconditioned ducted systems at different compressor and fan speeds and outside air temperatures

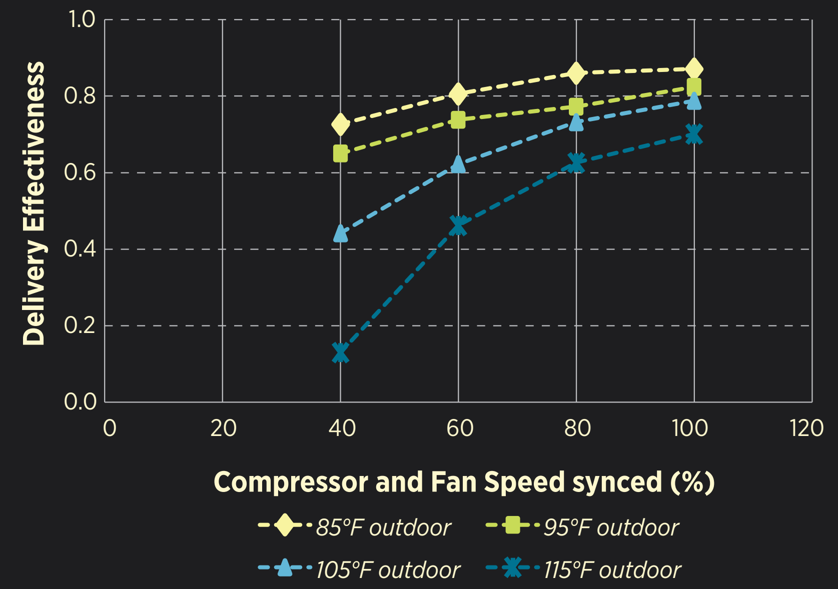


Figure 2: Effective delivery of conditioned air for variable speed, unconditioned ducted systems at different compressor and fan speeds and outside air temperatures

Figure 1 and 2 present some of the results of Phase I testing. Figure 1 shows that at lower outdoor (i.e. duct-zone) air temperatures the optimal system COP occurs at lower system speeds, and as temperatures get warmer around the ductwork the optimal speed increases all the way to 100% for the hottest temperatures. Figure 2 shows the delivery effectiveness of the duct system, which is the fraction of cooling supplied by the unit that makes it to the grilles in the conditioned space. Clearly the efficiency of the duct system is strongly dependent on the speed of the system and the temperature of the space in which the ducts are located. Increasing the amount of duct insulation or locating the ducts in conditioned space would significantly improve the delivery effectiveness of this duct system.

Phase II of this project is scheduled to begin in early 2017 and will look at control strategies for improving delivery effectiveness and overall system performance, particularly at low-speed operation. The results from Phase II will also develop recommendations for appropriate automated demand response control actions. We expect that the use of zoning will be able to counteract the duct efficiency penalties associated with reduced compressor and fan speeds.

Does Evaporative Cooling Make Sense in Arid Climates?

Conventional wisdom on evaporative cooling says this technology only makes sense in hot and dry climates. And in those climates, water is scarce, particularly during periods of drought, which raises the question of whether it is worth using evaporative cooling in the first place. This conventional wisdom does not take into account new evaporative products and cooling accessories that broaden the climatic reach of this technology. Likewise, new research shows that evaporative cooling is viable, even when taking water-use in drought-prone regions into account.

To fully answer this question about evaporative cooling in arid climates, There are three phases of research this project delves into:

1. A performance metric that reflects water and energy interdependencies,
2. The water/energy performance of evaporative pre-coolers and evaporative condensing units
3. The energy and economic cost for three different water resources (tap water, rainwater, and water produced through a desalination process).

1. PERFORMANCE METRIC (WATER ENERGY INDEX—WEI)

WCEC collected evaporative cooling data from a retrofitted 4-ton York roof top unit at a variety of outdoor dry-bulb temperatures. The metric includes both the volume of water for evaporation and an additional 15% water for maintenance.

2. WATER/ENERGY PERFORMANCE OF EVAPORATIVE PRE-COOLERS AND EVAPORATIVE CONDENSING UNITS

Using the water use intensity (WEI) from a variety of laboratory experiments shows that evaporative cooling consumes 9-40 liters of water per kWh saved.

3. ENERGY AND ECONOMIC COST FOR THE MOST ENERGY/COST INTENSIVE WATER GENERATION: DESALINATION

To get the clearest picture regarding the overall cost in both dollars and water, WCEC mapped the water-use of evaporative technologies onto the most expensive form of water generation: Desalination. **Desalination produces 80-280 liters of potable water for every 1 kWh used. For every 1 kWh used to make water with Desalination, that same water used in evaporative cooling can save 2-30 kWh.**

In terms of cost, water produced from desalination costs $1.65 per 1,000 liters produced, while electricity costs $0.08 - $0.37 for every 1 kWh. **Therefore, every $1 invested in desalination water yields $1.2 - $25 in electricity cost savings, depending on the technology employed and the local cost of electricity.**

DEMAND RESPONSE WITH EVAPORATIVE PRE-COOLERS

Evaporative pre-coolers provide the largest energy savings impact during peak electricity demand times, and water-use efficiency is highest during those hours of the day. A holistic solution could be to run evaporative pre-coolers as part of a demand response program during the day that would provide utility-dispatchable demand reduction. Likewise, desalination can operate at night when electricity demand is low. WCEC is currently working on a project to test evaporative pre-coolers as a utility-dispatchable demand reduction technique.

Every $1 invested in creating water through desalination can yield $1.20 - $25 in electricity cost savings using evaporative technologies.

Sub Wet-Bulb Evaporative Chillers (SWEC) for Building Cooling Systems

The SWEC technology uses an evaporative cooling process to chill water for use in building cooling systems. The SWEC designs tested utilized multi-stage indirect evaporative cooling designs to chill water below the wet-bulb temperature of the outdoor air. The theoretical limit for the supply water temperature is the dew-point of the outdoor air.

The performance of the tested SWEC chillers illustrates a large energy savings potential in hot dry climates. The results also reveal that, under a wide range of weather conditions, the SWEC technology can produce chilled water at temperatures between 60 to 66°F, which is desirable for serving a radiant cooling system with efficiencies much higher than vapor compressor air conditioning systems.

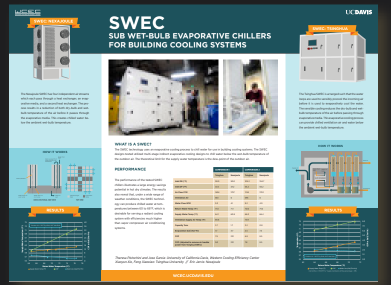
PROJECT REPORTS

Download the full laboratory performance report for the Nexajoule SWEC unit.

bit.ly/SWECnexajoule

Download the full laboratory performance report for the Tsinghua SWEC unit.

bit.ly/SWECtsinghua



PROJECT POSTER

Download the SWEC comparison poster displayed at ACEEE.

bit.ly/ACEEEswec

NEXAJOULE: 1.5-TONS

The Nexajoule SWEC has four independent air streams which each pass through a heat exchanger, an evaporative media, and a second heat exchanger. The process results in a reduction of both dry-bulb and wet-bulb temperature of the air before it passes through the evaporative media. This creates chilled water below the ambient wet-bulb temperature.

TSINGHUA: 3.5-TONS

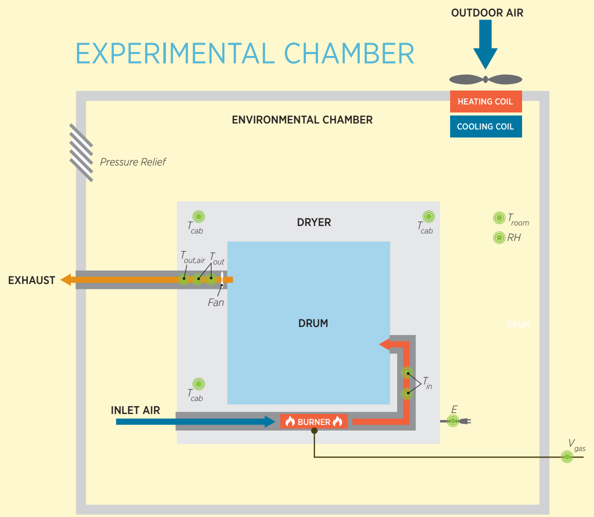
The Tsinghua SWEC is arranged such that the water loops are used to sensibly pre-cool the incoming air before it is used to evaporatively cool the water. The sensible cooling reduces the dry-bulb and wet-bulb temperature of the air before passing through evaporative media. This evaporative cooling process can provide chilled ventilation air and water below the ambient wet-bulb temperature.

Energy-Efficient Clothes Dryers: Automatic Cycle Termination Controller

In the interests of promoting energy efficiency and satisfying consumers, there has been a move toward automatic termination controllers in residential dryers, which use some method of sensing to determine when the load is dry. However, available test data shows that these control systems do not fare well when their energy efficiency performance is measured.

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

EXPERIMENTAL CHAMBER



CATON MANDE, DEVELOPMENT ENGINEER EXAMINING DRYER IN WCEC'S TEST CHAMBER

PERFORMANCE RESULTS

In a standard DOE test conducted three times, the controller shut-off the dryer when 2% remaining content was predicted and measured results showed a remaining moisture content of 1.62%, 1.89%, and 1.93% for the three tests. **For drying the DOE standard test load, the controller used between 5-15% less total energy in comparison to three similar gas dryers tested by DOE. The research team calculated that the controller shut-off the dryer within seven seconds of when the dryer reached the desired 2% remaining moisture target.**

The research team ran 16 additional tests evaluating the controller over a variety of conditions in which room temperature conditions were varied and load type and size were varied. One test was excluded because a large amount of lint was collected in the drying process which affected the ability to accurately weigh the load at the end of the test. For these 15 tests, the results varied between 1.3 - 6.7% remaining moisture content. All but one test had a remaining moisture content between 1.31 - 5%, where 5% is higher than the DOE test standard of 2%, however, would still be considered "dry" by consumers. The energy consumed for the drying cycles varied between 1.40-4.13 kWh, where the energy consumption was a function of the size and composition of the load. More details are available in the case study, "Energy Efficient Clothes Dryers: Automatic Cycle Termination Controller" available here:

bit.ly/dryercasestudy

PATH FORWARD

WCEC seeks a commercial partner to license the technology and implement it in commercial dryers. WCEC has received additional funding from Sacramento Municipal Utility District to test the controller in electric dryers to supplement the testing completed with a gas dryer. The research team also plans to develop the real-time energy efficiency reporting metrics and fault detection capabilities of the technology.

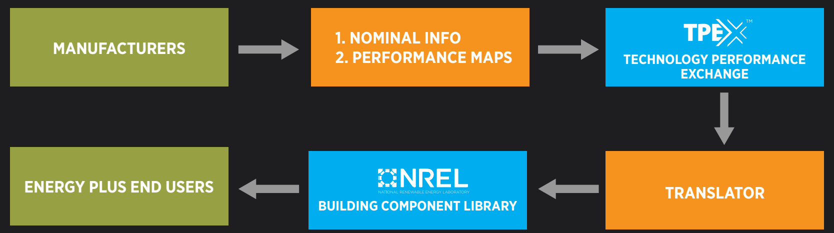
THE HYBRID AIR CONDITIONER MODELING TEAM: (LEFT TO RIGHT) YUANXIAN CHEN, YITIAN LIANG, NICHOLAS CABREN, JONATHAN WOOLLEY, & KYLE CHEUNG

Modeling Hybrid Air Conditioners

Hybrid air conditioners incorporate the advantages of various cooling components in variable speed, multi-mode, machines. These systems are climate appropriate energy measures that recognize how cooling needs and efficiency opportunities are different in each region. With funding from the Department of Energy and Southern California Edison, and in collaboration with several industry partners, UC Davis students are developing modeling tools to support broader application of climate appropriate hybrid air conditioners.

DATA AND INFORMATION FLOW

Manufacturers input performance data into the Technology Performance Exchange including: nominal info and performance maps for each mode. Then the data is compiled, and translated into a format for use in EnergyPlus. The data's performance curves will be transferable to modeling users on the Building Component Library.



- » Developed a standard format for representation of performance data for unitary hybrid air conditioning equipment.
- » In collaboration with industry partners, we developed custom models for three hybrid air conditioning systems (Seeley ClimateWizard, Munters EPX5000, Trane Voyager DC).
- » Developed an EnergyPlus module for "Unitary Hybrid Air Conditioners". Currently we have a development branch of EnergyPlus with a functional prototype for the model.
- » Facilitated a three day project workshop at NREL in September:
  - Undergraduate research fellows presented about custom models they developed for indirect evaporative and hybrid air conditioning equipment
  - Introduced students and manufacturer collaborators to low energy building design concepts
- » Sponsored a capstone mechanical engineering design project which developed an EnergyPlus model of Zero Net Energy office building and explored the optimization of design parameters.
- » Facilitated a graduate-level journal review seminar on building energy efficiency research and technology.

Field Performance Test of Indirect Evaporative Coolers on Cellular Sites

Through funding from Souther California Edison, WCEC installed two different Indirect Evaporative Coolers (IECs) at two different cellular sites in Placentia and Cudahy, California and monitored these installations over a 9-month period. Indirect evaporative cooling is an efficient method of cooling in California's hot and dry climates. It is different from a direct evaporative cooler in three significant ways, including:

- It does not add moisture to the conditioned space;
- It can cool to a lower temperature; and
- It exhausts a portion of the air moved.

RESULTS

Results from this field test compare the conventional air conditioners installed on these buildings to the indirect evaporative coolers. **The indirect evaporative coolers showed a coefficient of performance increase of 2x - 10x the efficiency of the traditional, installed DX systems.**

RECOMMENDATIONS

The research team recommends IECs as an impactful measure to reduce energy consumption and peak demand for cooling in commercial buildings. However, the team also recommends that utility efficiency programs, and other efforts to advance the technology, should remain cognizant of some of the challenges that can hinder performance and limit the persistence of savings. It is especially important that any installation of this measure be paired with a quality service agreement. For this specific field test, the cellular telephone company had a standing service contract.

Read the full report:
bit.ly/IDECcellular

PLACENTIA, CA RESULTS

COEFFICIENT OF PERFORMANCE COMPARISON

TRADITIONAL DX	IDEC
2-3 At air temperatures from 80-110°F	**7-12** At air temperatures from 80-110°F

CUDAHY, CA RESULTS

COEFFICIENT OF PERFORMANCE COMPARISON

TRADITIONAL DX	IDEC
2-3 At air temperatures from 80-110°F	**10-18** At air temperatures from 80-110°F

Laboratory Testing of an Energy Efficient Dehumidifier for Indoor Farms

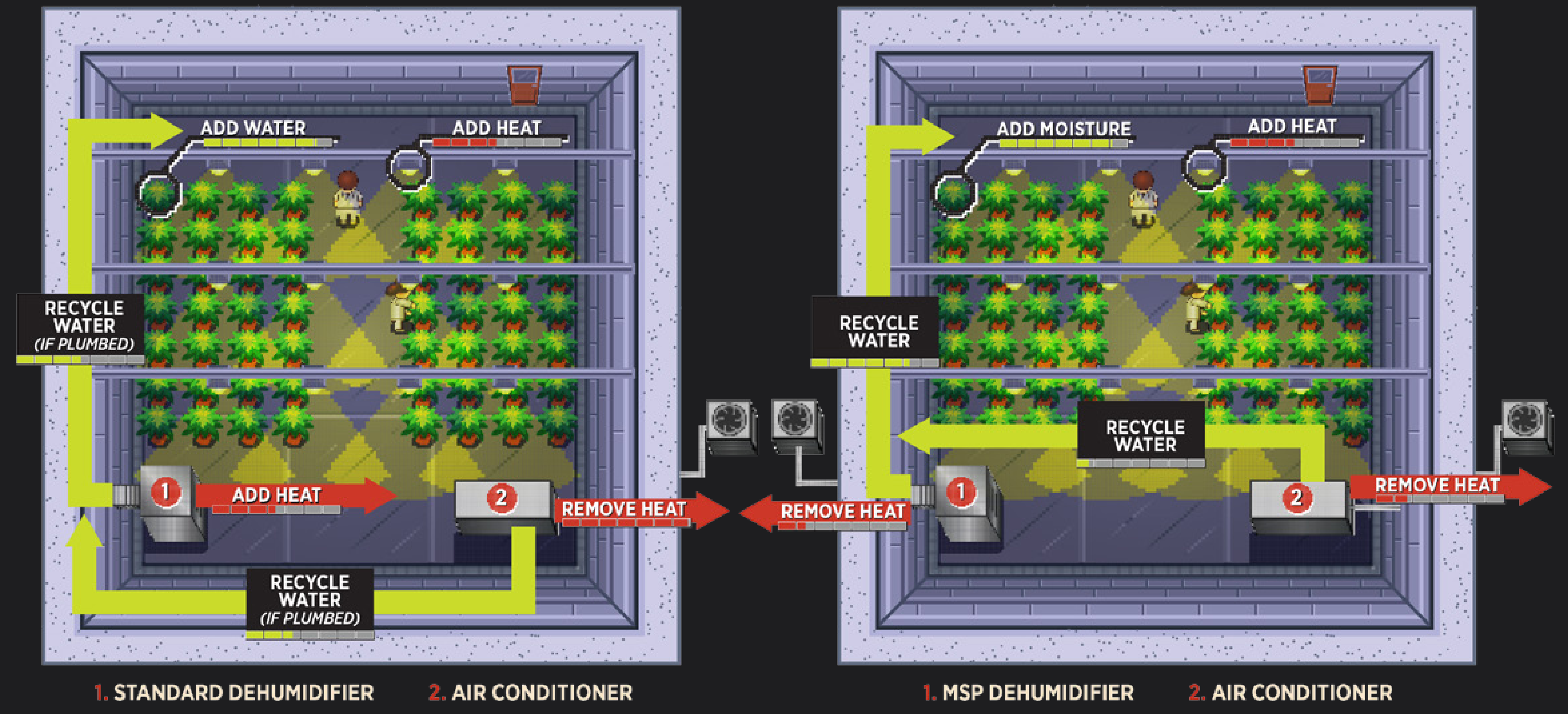
Indoor farming operations do not require the typical ratio of sensible cooling (which maintains air temperature) and latent cooling (which maintains humidity levels) required for residential or commercial buildings. In order to meet these specialized requirements, dehumidification systems are often necessary.

Traditional dehumidification systems provide dehumidification and increase the air temperature, as opposed to the desired dehumidification and reduction of air temperature. An alternative is MSP Technology's dehumidification system that uses a plate air-to-air heat exchanger and a cooling coil that is part of a split compressor-based refrigeration system. This process results in a ratio of sensible to latent cooling that is well suited for indoor farming applications.

Through a project funded by Xcel Energy, experimental laboratory testing and numerical modeling were performed to estimate the annual energy savings produced by using MSP Technology's dehumidification system over a traditional dehumidification system. The results of this project forecast that implementation of MSP Technology's system has potential to save 30% or more of the energy used for dehumidification and cooling in indoor farming applications.

Download the Case Study:
http://bit.ly/mspcasestudy

DERRICK ROSS, ASSISTANT ENGINEER, INSTRUMENTING THE MSP DEHUMIDIFIER



WHAT'S NEXT

Field Testing – WCEC recommends conducting field testing of the technology to further assess and quantify the energy savings that can be achieved with the new MSP Technology's dehumidification system.

Indoor Agriculture Industry – Due to the recent legalization of recreational cannabis in California, there will be an increase in indoor cultivation of the crop. Therefore, this technology will become more important than ever to reduce the high energy consumption associated with indoor cannabis cultivation.

ENERGY SAVINGS

30-65%

Forecasted energy savings compared to traditional dehumidification systems.

WATER RE-USE

100%

Amount of water removed from the air that can be re-used to water plants.

Notable Outreach and Events Timeline 2016

Presentations

Meetings

Notable WCEC Tours

JAN

ASHRAE Conference, Orlando: Subcommittee Chair SPC212, SPC215, ASHRAE Standards Committee, Technical Committee 5.7

FEB

Forum on Dry Climate Home Performance: Design and Performance of the Honda Smart Home

DOE Building Technology Office Annual Peer Review: User Oriented Modeling Tools for Unitary Hybrid Air Conditioners

MAR

Pacific Rim Thermal Engineering Conference: Design of Compact Heat Exchangers for Supercritical Carbon Dioxide Cycles

Pacific Rim Thermal Engineering Conference: Dynamics of Heat Transfer During Bubble Ebullition from a Microheater

Pacific Rim Thermal Engineering Conference: Directional Condensate Motion of Highly Wetting Fluid on an Asymmetrically Structured Surface

Singapore Meeting: Aerosol Sealing of Ducts, Buildings and Other Enclosures

APR

MAY

JUN

Department of Defense Presentation: Automated Aerosol Sealing of Building Envelopes

ASHRAE Conference, St. Louis: Subcommittee Chair SPC212, SPC215, ASHRAE Standards Committee, Technical Committee 5.7

Mandela Washington Fellowship Tour

JUL

AUG

ACEEE Conference: Outside the Box - Climate Appropriate Hybrid Air Conditioning as a Paradigm Shift for Commercial Rooftop Packaged Units

ACEEE Conference: Cooling Strategies: Japan vs. the U.S.

ACEEE Conference: Aerosol Sealing

Delegation from Japan

Mayor of Chiayi City and Government officials from Taiwan

SEP

Delegation from Ukraine

OCT

Center for the Built Environment, UC Berkeley: Occupancy Sensing Learning Thermostats

BECC Conference: Cooling Strategies: Japan vs. the U.S.

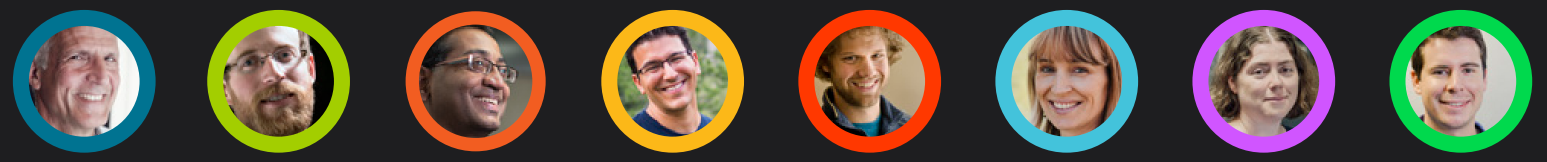
NOV

U.S. Navy: Design of Compact Heat Exchangers for Supercritical Carbon Dioxide Cycles / Dynamics of Heat Transfer During Bubble Ebullition from a Microheater / Directional Condensate Motion of Highly Wetting Fluid on an Asymmetrically Structured Surface

DEC

Presentation and WCEC Tour for California Assemblymember Bill Quirk

EPIC Symposium: Improving Water and Energy Efficiency in California's Dairy Industry



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