



# WCEC Activities Sampler

Mark Modera

Affiliates Forum

May 7, 2013

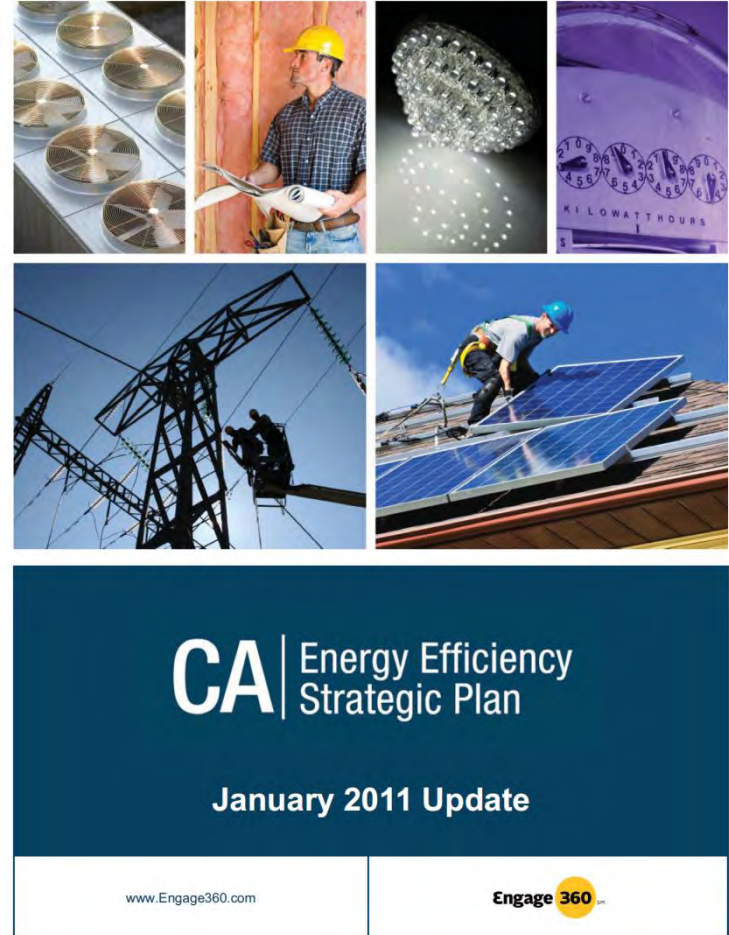


# WCEC MISSION SUMMARY

“Partner with stakeholders to identify technologies, conduct research and demonstrations, disseminate information, and implement programs that reduce cooling-system electrical demand and energy consumption in the Western United States.”

# CA Energy Efficiency Strategic Plan

- Accelerate market penetration of climate appropriate HVAC
  - 15% penetration by 2015
  - 70% of systems installed in 2020 to be optimized for California's climate



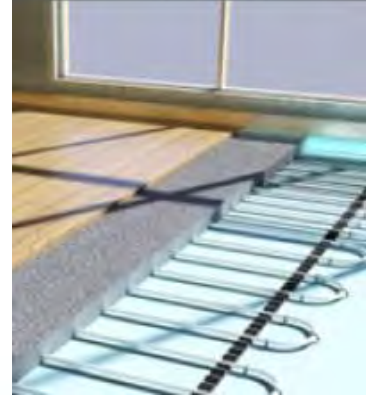


# WCEC TEAM



# WCEC RESEARCH PROGRAM

- Residential
  - Swimming Pools as Heat Sinks – Water Source Heat Pumps
  - **Residential Radiant Cooling**
  - Human Interface with In Home Energy Displays
  - **Ground Source Heat Pumps**
  - **Honda Smart Home (PNE)**
- Light Commercial and Retail
  - **Western Cooling Challenge – High-Efficiency Packaged A/C**
  - **RTU Retrofit Initiative**
  - Multi-Tenant Light Commercial Retrofit
  - Energy Plus Model of Hybrid Evaporative Cooling



# WCEC RESEARCH PROGRAM

- Multi-Family Residential, Hotels, Dorms
  - Hotel Control Study
  - Ventilation Diagnosis, Modeling and Improvement
  - **Phase-Change Hydronic Distribution**
- Institutional Sector
  - **PIER HVAC Technology Demonstrations**
- Codes and Standards
  - T-24 Code Change Proposals
  - CASE Demonstration Project
- Cross-Cutting
  - **Evaporative-Equipment Water Management**
  - Hybrid Evaporative Vapor-Compression Equipment
  - HVAC Performance Alliance
  - **Aerosol-Based Sealing of Enclosures**
  - HVAC Technician Instrument Lab
  - Automated Fault Detection and Diagnostics
  - **Maintenance Behavior**



# WESTERN COOLING CHALLENGE: Roof-Top Units for Western Climates

# UC DAVIS

## WESTERN COOLING CHALLENGE

# C E R T I F I E D

- Ongoing multiple winner competition
- Encourages commercialization of climate-appropriate technologies for Western United States
- Minimum 40% efficiency improvement over federal standards at hot-dry operating conditions



# Western Cooling Challenge Lab Testing

- **Coolerado H80** – NREL tested 2010 – **CERTIFIED**
  - Coolerado currently focuses on indirect only, cost challenges for H80
- **Speakman HCRS** – NREL tested 2011
  - Hybrid showed promise but needs revisions. AirMax focus on IDEC.
- **Trane Voyager DC** – Intertek tested 2012 – **CERTIFIED**
- **Munters EPX 5000 (DOAS)** – PG&E ATS tested 2013
  - Estimated 20% savings at peak for whole building HVAC
  - Laboratory test complete, analysis and reporting in progress
- **Seeley Climate Wizard**
  - Suite of RTU retrofits includes evap. condenser pre-cooling
  - Preparing for testing with PG&E ATS San Ramon, in summer 2013
- **AirMax IDEC**
  - “On Deck” for testing with PG&E ATS San Ramon, in fall 2013



# WCC Pilot Field Evaluations

## Currently Installed and monitoring

- 4x DualCool retrofits – Target Palmdale
- 5x Trane Voyager DC – Ontario Mills, Marie Callenders & Solano Mall
- 2x Coolerado H80 – UC Davis & NAWS China Lake
- 1x Daikin McQuay Rebel – Harley Davidson Sacramento
- 1x Seeley Climate Wizard – Venita Rhea's Restaurant, Rocklin
- 1x Munters Oasis EPX – Temecula Civic Center
- 3x Climate Wizard & 3x Coolerado – WalMart Bakersfield

## Planned for installation in 2013

- 2x Trane Voyager DC & 2x Climate Wizard – InMotion Fitness, Chico
- 2x Munters EPX 5000 (DOAS) – Safeway & Whole Foods
- 1x Coolerado & 1x Climate Wizard – Verizon Wireless Cell Sites
- 1x AirMax, 1x Cooleardo, 1x Climate Wizard – Simi Valley

# RTU RETROFIT INITIATIVE



# RTU RETROFIT INITIATIVE

## Impetus

- RTUs are replaced every **15-20 years**
- Significant savings (**20-50%**) can be achieved more quickly by RTU retrofits

## Challenges

- Retrofits are discretionary purchases
  - Higher sales, transaction and implementation costs
- Lack of standards for performance





# RTU Retrofit Opportunities

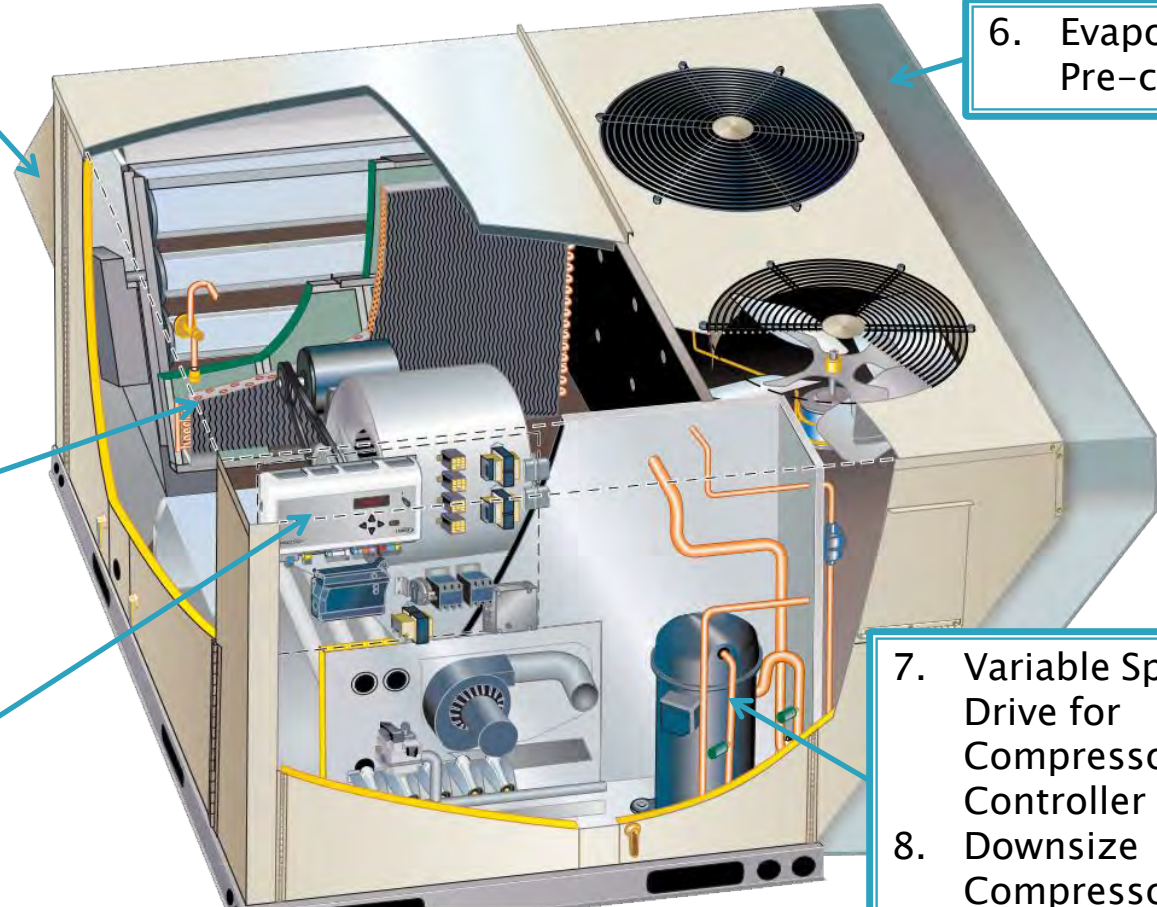
1. Advanced Economizer Controls
2. Demand Control Ventilation

3. Efficient Fan Motors
4. Variable Speed Drive for Fan and Controller

5. Fault detection and diagnostics

6. Evaporative Pre-coolers

7. Variable Speed Drive for Compressor and Controller
8. Downsize Compressor



# Evaporative Condenser–Air Pre–Cooler Test Protocol

ASHRAE TC 5.7 proposed new Test Standard  
for Evaporative Pre–Coolers

- Mark Modera is committee chair
- Second committee meeting in June 2013
- WCEC funded for protocol testing and development
  - Three residential pre–cooler products tested at interim facility in summer 2012
  - Results submitted to *Journal of Thermal Science and Engineering Applications*

New 5–ton facility under construction at WCEC

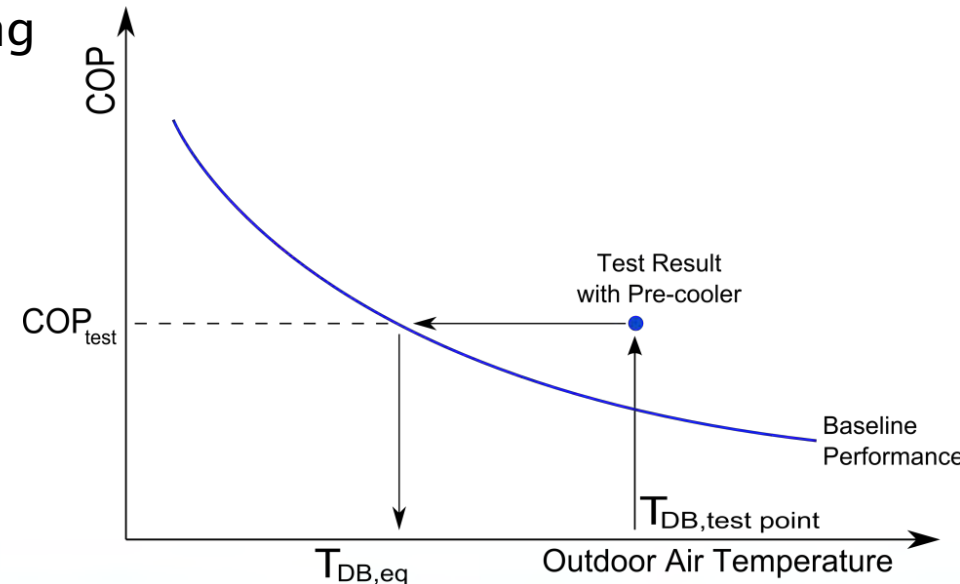
# Evaporative Pre-Cooler Lab Testing

## Three residential pre-coolers tested

- Tests conducted on Residential Split 3-ton condensing unit
- Evaporative load provided by refrigerant to water heat exchanger

## Major findings:

- Average evaporative effectiveness (EE) 8–25%
- Average water use effectiveness 20–50%
- New method of calculating EE using equivalent performance defined:
  - Accounts for pressure losses due to media
  - Not subject to errors in exit air humidity measurement
  - Accounts for water evaporation on coil

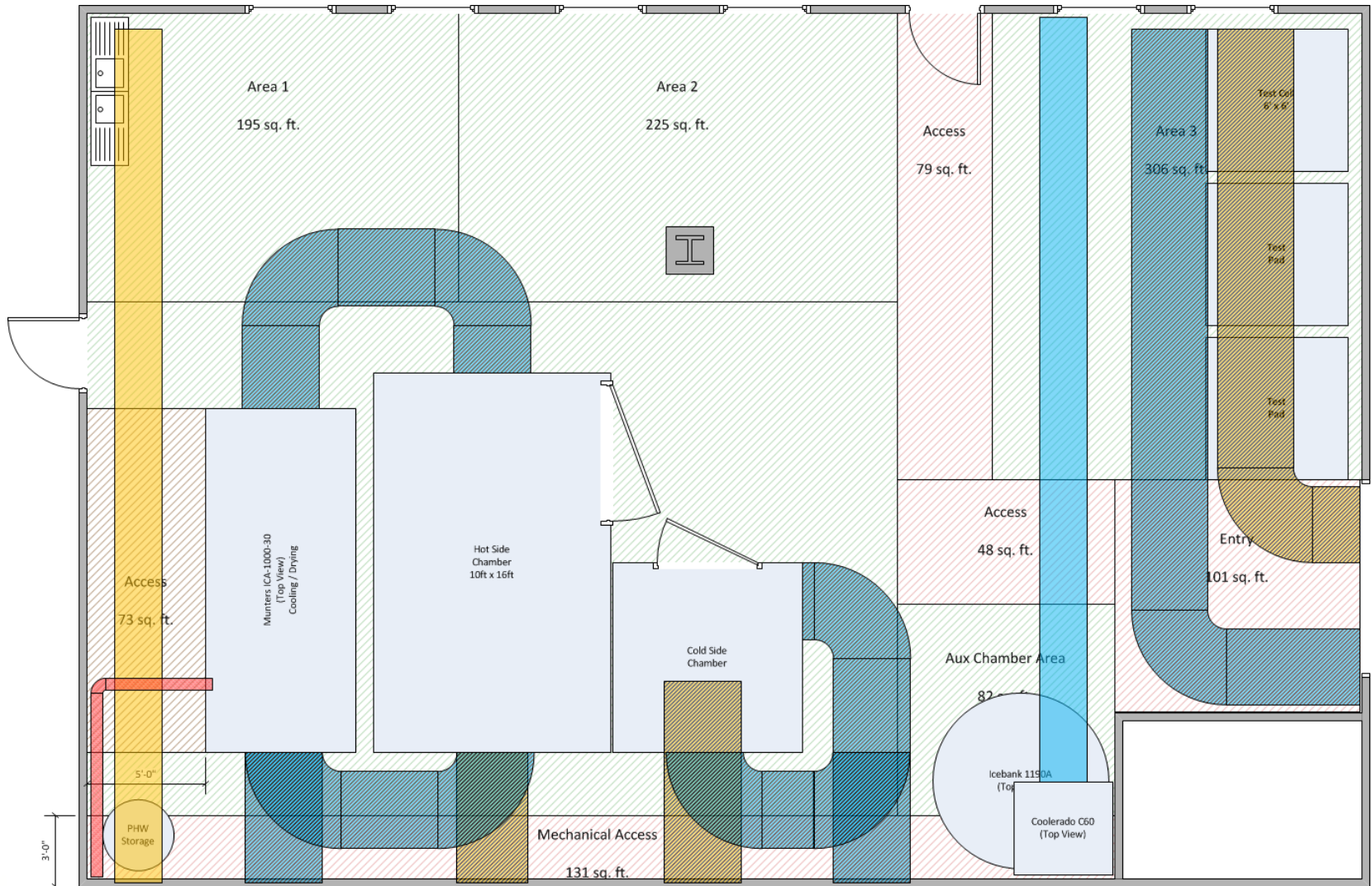




# WEST VILLAGE WCEC LAB

- Expected to be operational by June 2013
  - Up to 5-ton testing capabilities
    - Produce 2400–5000cfm of air at any condition between 60–110°F and 0.005 to 0.013 g/g of absolute humidity.
    - Up to 8000 cfm for wind tests (less conditioning capabilities)
    - Operable in 92% of Sacramento weather conditions according to NREL TMY3 data
  - Capable of AHRI standard test rating conditions
    - Can condition 100% exhaust air, 100% outdoor air, or a mixture of the two for decreased energy consumption
    - Large desiccant dryer allow for very hot and dry test conditions
  - Modular design for ease of upgrading and alterations

# WEST VILLAGE: WCEC LAB



# RTU RETROFIT INITIATIVE

## Other RTU retrofits

- Investigating Side-by-side testing of indirect- evaporative outdoor air retrofits
- Field testing of advanced controls and thermostats
- Multi-Tenant Light Commercial integrated retrofit development and demonstration
  - Compressor downsizing retrofit?

























# Packaged HVAC Advanced Controls Retrofits

Category	Product	Description
Advanced Thermostat	<p>ecobee Smart Thermostat</p>  	<ul style="list-style-type: none"> <li>• Wirelessly communicating thermostat</li> <li>• Remote monitoring</li> <li>• Simple replacement of existing thermostat</li> <li>• Independent control of set points and schedules for temperature and fan</li> <li>• Demand response enabled</li> </ul>
Economizer Controller	<p>Honeywell JADE™ W7220 Economizer Controller</p>  	<ul style="list-style-type: none"> <li>• Economizer controls</li> <li>• LCD display for simple diagnostics</li> <li>• Demand controlled ventilation capable               <ul style="list-style-type: none"> <li>• Typically based on CO<sub>2</sub> or occupancy</li> </ul> </li> </ul>
Retrofit Kit	<p>EnerFit</p>  	<ul style="list-style-type: none"> <li>• Optimizes the operation of a packaged unit based on thermal load, internal temperature set point, occupancy, humidity and CO<sub>2</sub>.</li> <li>• Provides economizer controls and demand controlled ventilation</li> </ul>

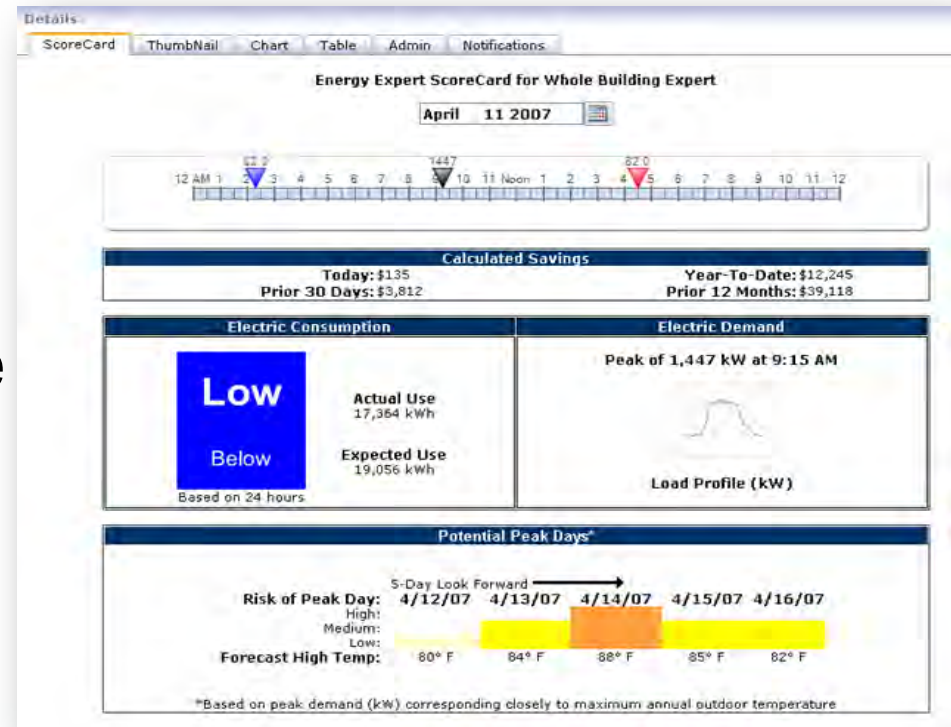


# Packaged HVAC Advanced Controls Retrofits

Product	Description of Experimental Design	Quantity
<p>ecobee Smart Thermostat</p>  	<p>Technical:</p> <ul style="list-style-type: none"> <li>• Utility bill comparison               <ul style="list-style-type: none"> <li>• Degree day normalization</li> <li>• Temperature vs. kWh</li> </ul> </li> </ul> <p>Behavioral:</p> <ul style="list-style-type: none"> <li>• Surveys pre/post</li> <li>• Evaluating success of completing assignments (change the schedule etc.)</li> </ul>	<p>~40</p>
<p>Honeywell JADE™ W7220 Economizer Controller</p>  	<ul style="list-style-type: none"> <li>• Extensive monitoring of RTU</li> <li>• Week on / Week off comparison               <ul style="list-style-type: none"> <li>• Degree day normalization</li> <li>• Temperature vs. kWh</li> <li>• Run-time</li> </ul> </li> </ul>	<p>~4</p>
<p>EnerFit</p>  	<ul style="list-style-type: none"> <li>• Extensive monitoring of RTU</li> <li>• Week on / Week off comparison               <ul style="list-style-type: none"> <li>• Degree day normalization</li> <li>• Temperature vs. kWh</li> <li>• Run-time (&amp; run-time vs. kWh)</li> <li>• Temperature vs. COP</li> </ul> </li> </ul>	<p>~4</p>

# FAULT DETECTION AND DIAGNOSTICS

- Technology that uses hardware, sensors, and software to detect and diagnose problems with Rooftop Units
- WCEC is advancing technology through standards development and code change proposals



# MANAGING WATER ISSUES

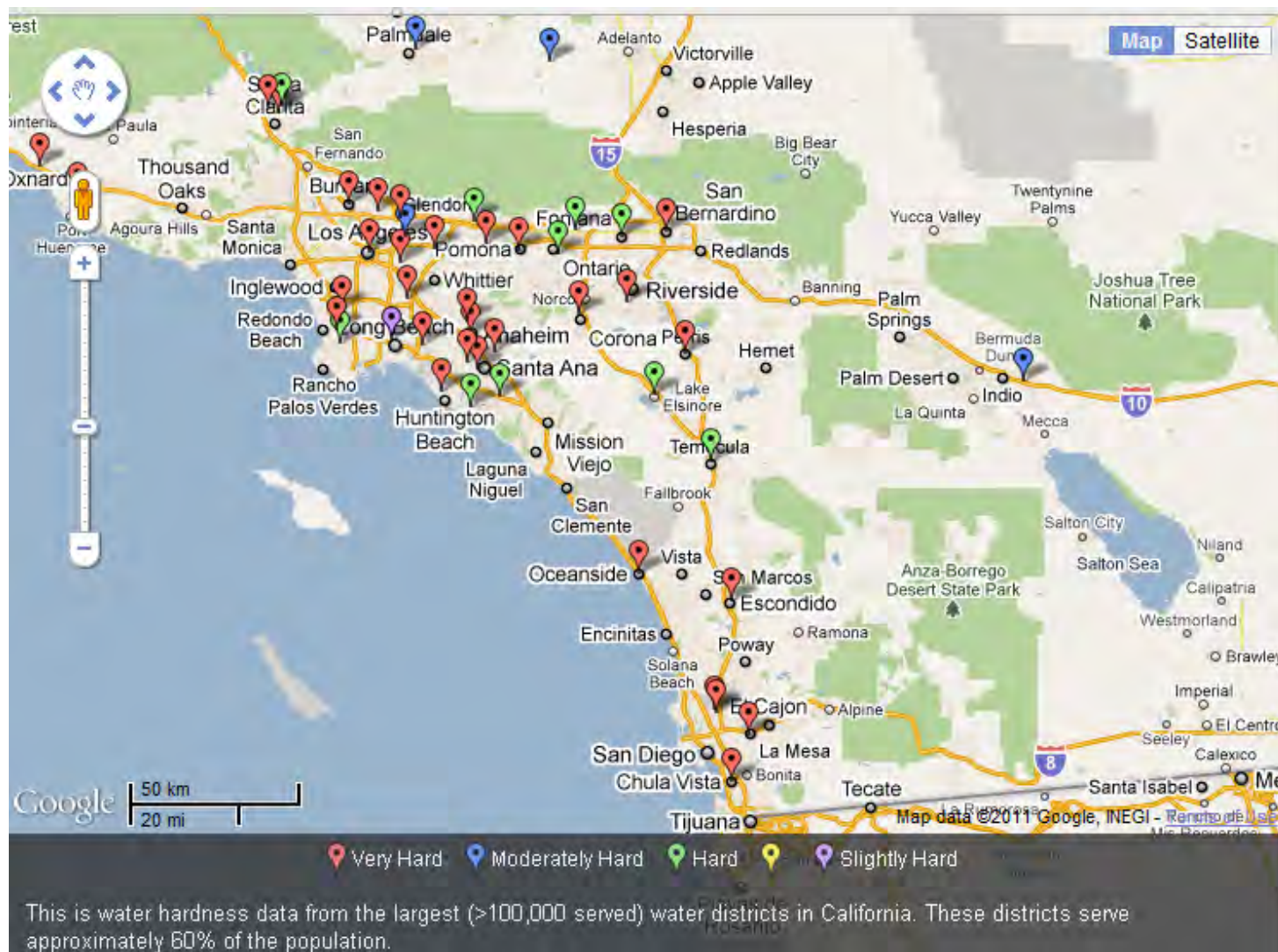
## Activities

- Testing to Failure
  - Indirect Evaporative Cooler
  - Evaporative Condenser
  - Miniature heat exchangers and coils
- Testing Water Management Strategies
  - Bleed Rates
  - Magnetic Treatment
  - Other Treatments
- Alternative Water
  - Grey water
  - Rain water



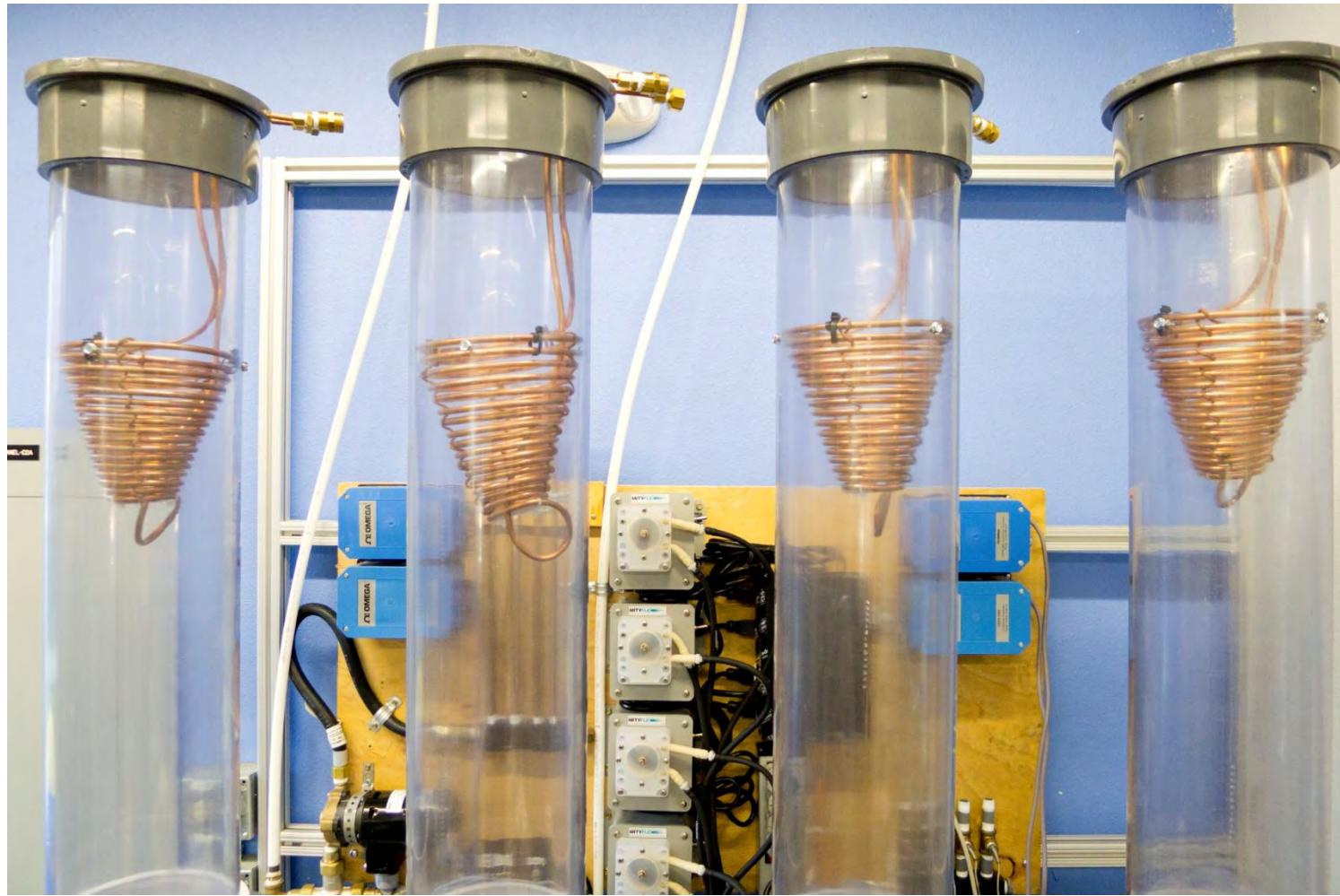


# WATER QUALITY VS. LOCATION





# WATER MANAGEMENT TESTING



# MANAGING WATER ISSUES

## Initial Findings

- Thermal performance reduction is modest, and take a long time to occur
- **Data suggests that lower bleed rates work better than higher bleed rates**
  - Ca and Mg behave differently
  - Recommended 15% bleed rates for Southern California
- Magnets seemed to have some effect
- Pumps seem to be the component most sensitive to water quality

# Residential Radiant Cooling with Peak Load Shifting

Primary aim to reduce peak load

Combine chilled water storage with low cost radiant panels

Project completed December 2012





# Residential Radiant Cooling with Peak Load Shifting

## Energy Savings

Peak power reduction	94%
Power savings	19%

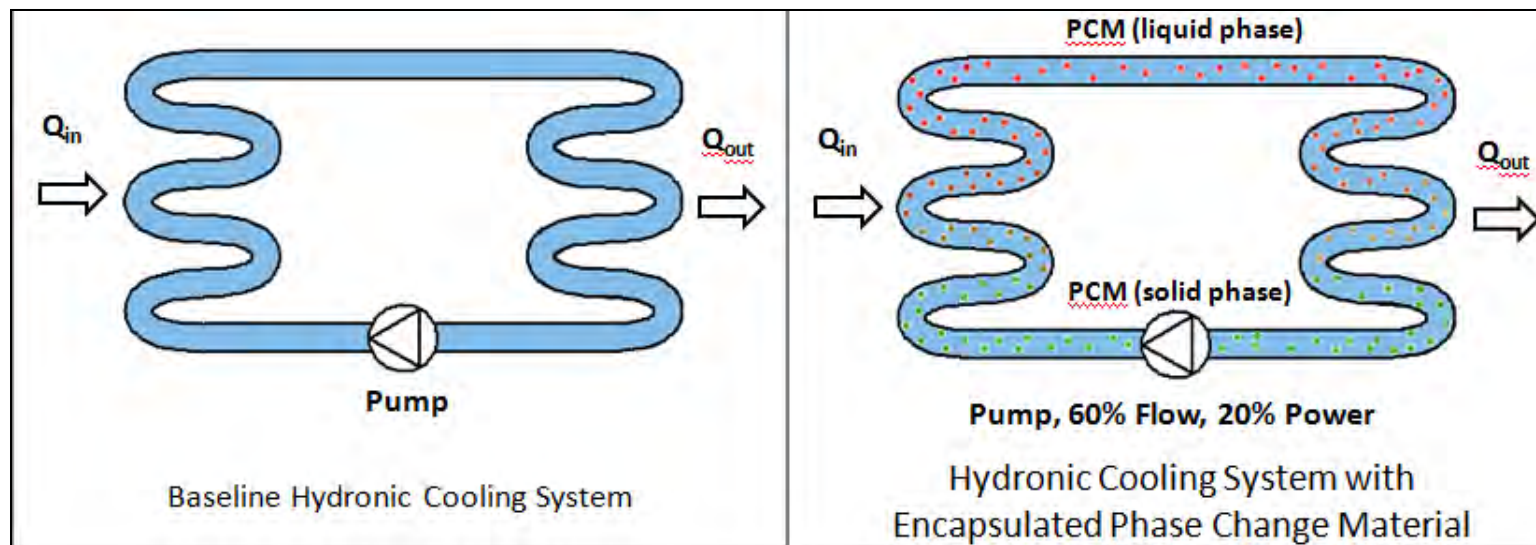
Anticipated payback 5–10 years w/o incentives <2 years with \$1200/kW





**NOT JUST COOLING!**

# Incorporating Phase Change Materials into Hydronic Systems



**CONCEPT:** Use encapsulated Phase Change Material to increase heat capacity

⇒ decrease pumping power by up to 60%

**EXAMPLE APPLICATION:** Fan coil systems in hotels

# Phase Change Materials for Hydronic Systems



## Initial results

- Thermally cycled PCMs show no sign of degradation
- Mechanically cycled PCMs show signs of clumping
  - currently studying reasons and impacts

# Building Shell Sealing with Aerosol Particles

## Basic Concept

- Seal New-Construction Building Shells at Rough-In
- Seal Existing Construction at time of occupancy change, or from attic and/or crawlspace
- Reduce cost, get better tightness and get automated certification





# Automated Sealing of Building Leaks



# AEROSOL ENVELOPE SEALING



*Aerosol sealed the leak between this can light and the wall*



*Aerosol sealed this leak between this electrical outlet and the wall*

## TAKEAWAYS

- Sealed 50% of all leaks
- Stopped pre-maturely
- No residual sealant build-up on floors, wiring or walls

## GOALS FOR NEXT TEST

- Use new particle generator
- Shorten project time



# Test Sealing West Village Apartment

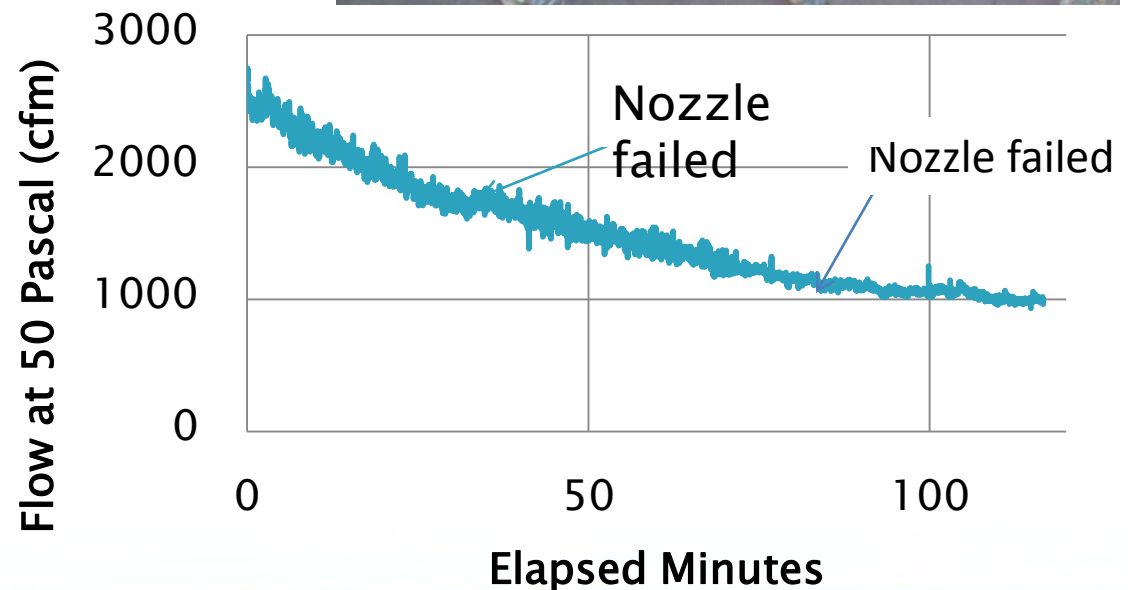
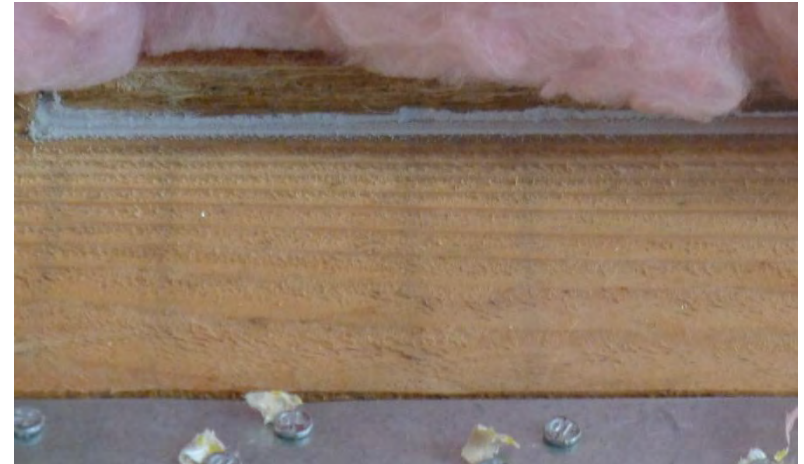
- Performed at pre-insulation phase of construction
- 4 injection points
- 100 Pascal building pressure
- 1,000 psi nozzle pressure
- Tremco sealant





# Test Sealing West Village Apartment

- Sealed 60% of leaks in less than 2 hours
- Two nozzles failed during test
- HERS leakage test results will be compared to aerosol sealing at drywall phase and standard sealing methods



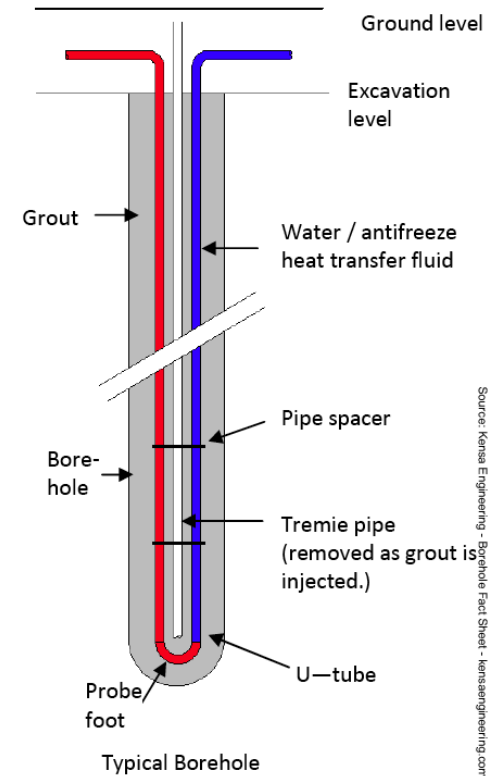
# AEROSOL ENVELOPE SEALING

## Current Status

- Obtained Proof of Concept in the Lab
  - Used 8' high box to mimic house
- Performed Sealing in FIVE Houses
  - Habitat for Humanity in Stockton
  - Apartment at West Village
  - Sealed existing home at occupancy change
- Have Partnership with Major Sealant Manufacturer
  - Using new sealant and injector

# Ground Source Heat Pump

- Conventional Earth HX
  - Requires deep bores of small diameter
  - Requires specialized and expensive equipment
  - Requires large amount of setup and labor to advance the drill head



Summary

Conventional U-Tube



# Directional Drilling (DD)



Directional Drilling

- Directional drilling
  - Less expensive equipment than conventional
  - Eliminates multiple setups
  - Can drill multiple bores from a single location
  - Can drill under structures
- Installation at residential house in Sacramento is underway

Status

# Large Diameter Earthbore (LDEB)



Earth Auger

- LDEB Technique
  - Less expensive equipment than conventional
  - Water filled pipe is used for thermal storage
  - Heat is exchanged with fluid in the pipe and the earth
- To be installed at Honda Smart Home in West Village

Status

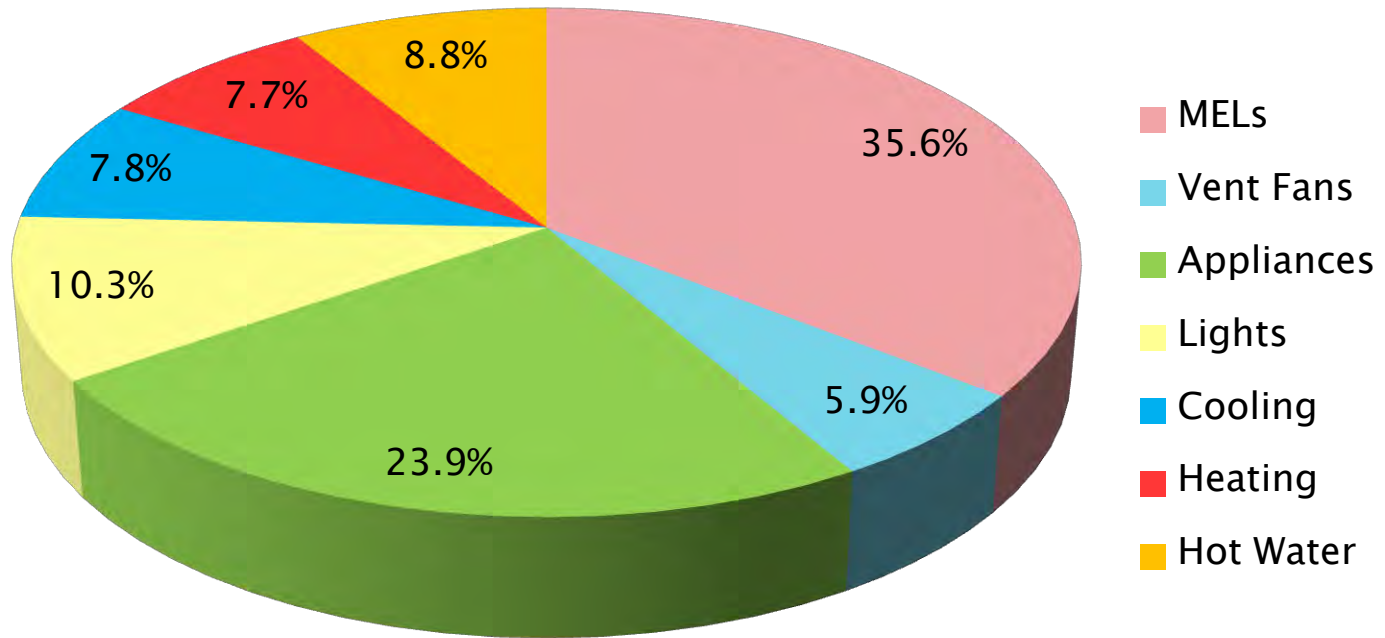
# Honda Smart Home

1. All electric home, no on-site combustion
2. Zero-net energy annually, include drive cycle for electric sedan
3. Demonstrate accessible design and construction practices
4. Actively manage loads, provide positive generation at peak





# HSH Estimated Annual Electric Uses



# HSH Mechanical Features

- Nighttime ventilation cooling & natural ventilation
- Multi-function reversible heat pumps
  - Heating, cooling, & DHW
- Radiant heating and cooling
- Aerosol sealant for building envelopes
- Drain water heat recovery
  - Greywater captured for irrigation
- Low cost geothermal systems
- Advanced ventilation controls for 62.2
- Passive solar design elements
- Very high R-value construction
- Centralized mechanical layout



# Advancing Zero Net Energy Initiatives

1. Forward CA ZNE 2020 goals
2. Integrated approach
3. Expand from Honda Smart Home
4. “*Energy Positive Homes*” Proposal
  - Habitat for Humanity, Honda, BIRA, ICI, SD&B, DEG, CLTC, WCEC
  - Focus on life cycle costs
  - Address many tech. challenges
  - Significant education components
  - Three ZNE demo homes
  - Address electric and gas
  - >\$3M committed partnership





# State Program for Energy Efficiency Demonstrations (SPEED)

- Field demonstration and monitoring of new energy efficiency technologies

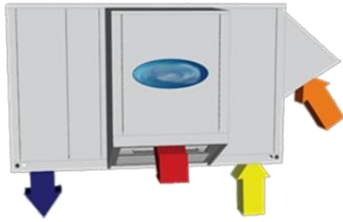


- Demonstration Studies
  - Facilitate installations of promising technologies in UC/CSU/CCC
  - Develop case studies detailing performance and economics
- Scaled Deployment Studies
  - Develop informational materials and business-case justification to support widespread adoption of energy savings technologies
  - Facilitate system-wide deployment of proven technologies and monitor performance
- Outreach
  - CHESC Conference and other California facilities focused conferences

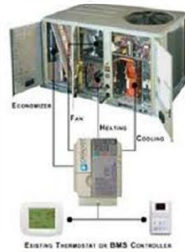
SPEED Program

Program Goals

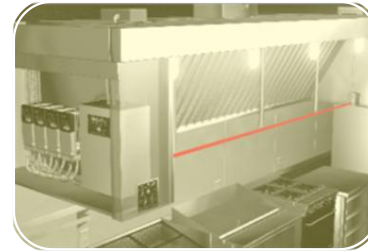
# Current SPEED Investigations



Climate Optimized  
RTU



RTU Retrofit  
Controller



Kitchen Hood  
DCV



Laboratory Fume  
Hood DCV



Evaporative Cooled  
Condenser



Laboratory ACH  
DCV



Shut-the-Sash  
Campaign

RTU Retrofit / Replacement

Kitchen / Laboratory  
Demand Control Ventilation

# Current SPEED Investigations



Advanced CV/VAV  
Controls



Occupancy Sensing  
Thermostats



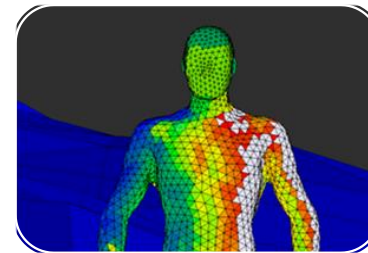
LEED Platinum  
UCD Gallagher Hall



NZE Project  
UCSB Rec Center



Duct Leakage  
Sealing



PEC Study  
UC Berkeley

Building System Retrofits

New Construction / Whole  
Building



# THANK YOU!

For more information, contact us at...

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