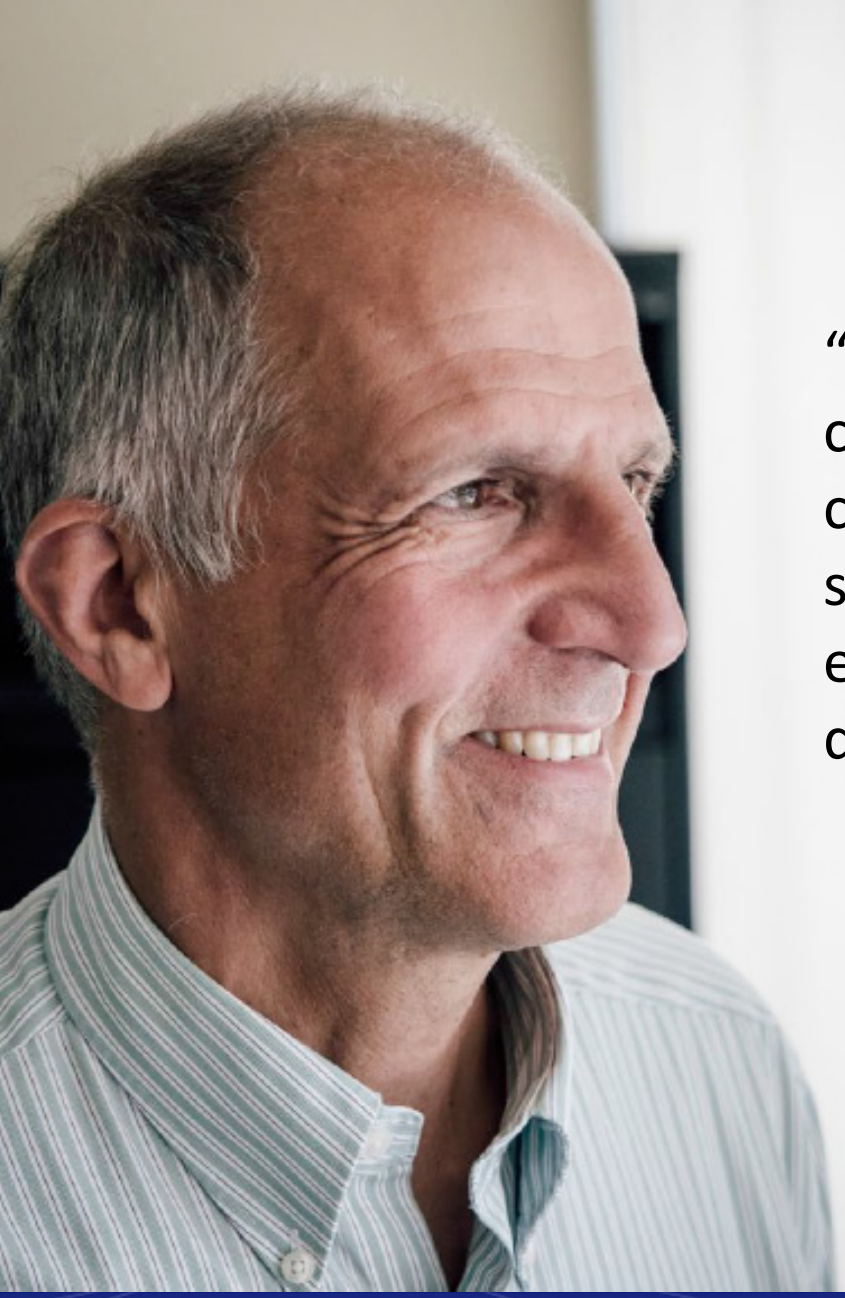
Western Cooling Challenge & Emerging Low Energy Air Conditioning Strategies

Jonathan Woolley
Western Cooling Efficiency Center
University of California, Davis

BEST Center Annual Institute: High Performance Building Technician Education
January 7, 2016







Mission

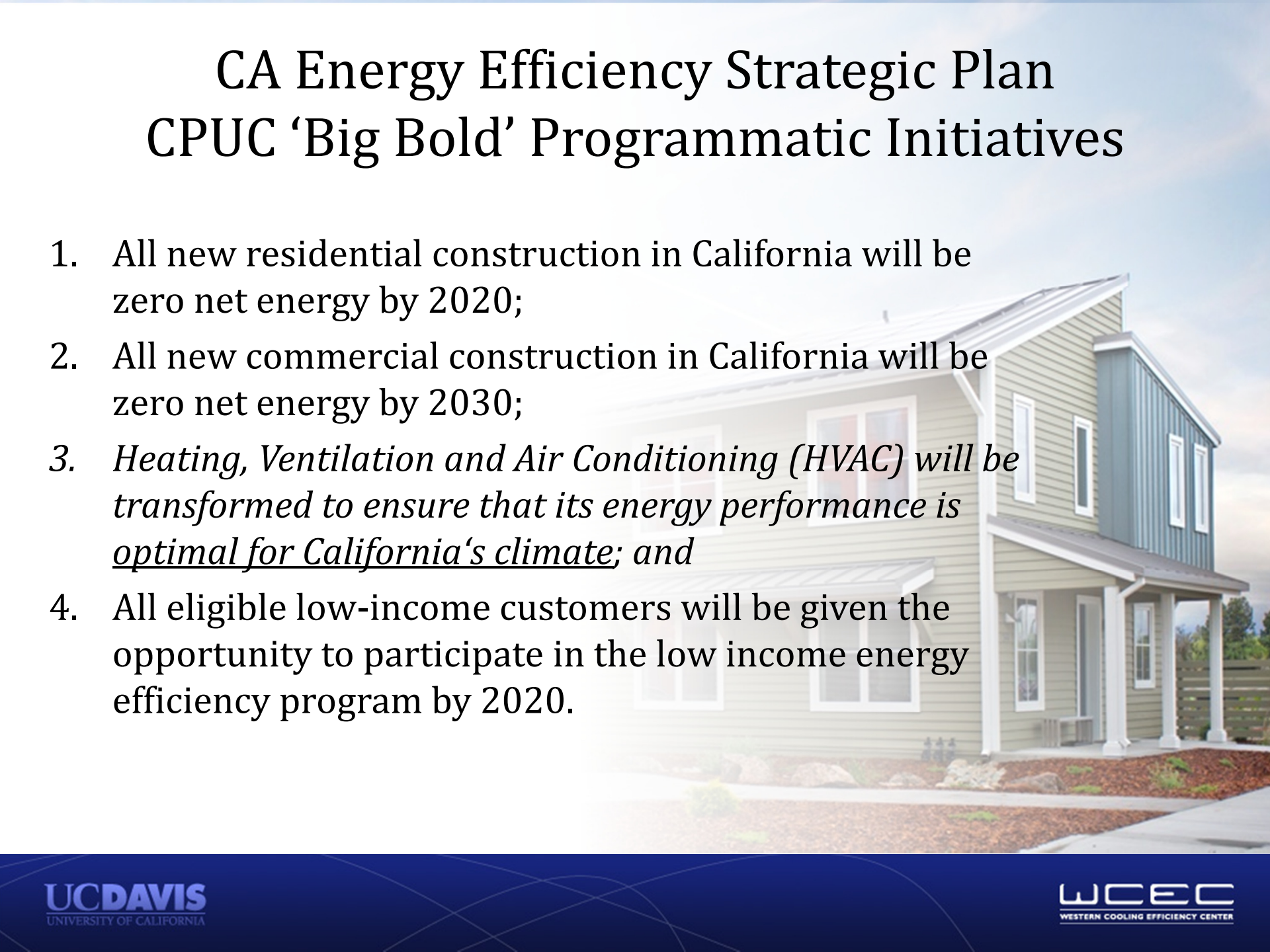
"To accelerate the development and commercialization of efficient heating, cooling, and energy distribution solutions through stakeholder engagement, innovation, research, development, education, and outreach."

CA AB 32 – Global Warming Solutions Act

- Firm limit on total GHG emissions
  - *1990 levels by 2020*
  - *80% below 1990 levels by 2050*
- Carbon Emissions Trading
- Inventories and regulates emissions from 800 largest industrial emissions sources
- Renewable Portfolio Standard
  - *33% renewable energy by 2020*
- GHG Emissions Standards for Vehicles
  - ~18% reduction in 2020
  - ~27% reduction in 2030
- Energy Efficiency Strategic Plan
- Codes and Standards for Buildings

CA Energy Efficiency Strategic Plan
CPUC 'Big Bold' Programmatic Initiatives

1. All new residential construction in California will be zero net energy by 2020;
2. All new commercial construction in California will be zero net energy by 2030;
3. *Heating, Ventilation and Air Conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California's climate; and*
4. All eligible low-income customers will be given the opportunity to participate in the low income energy efficiency program by 2020.



1. HONDA SMART HOME

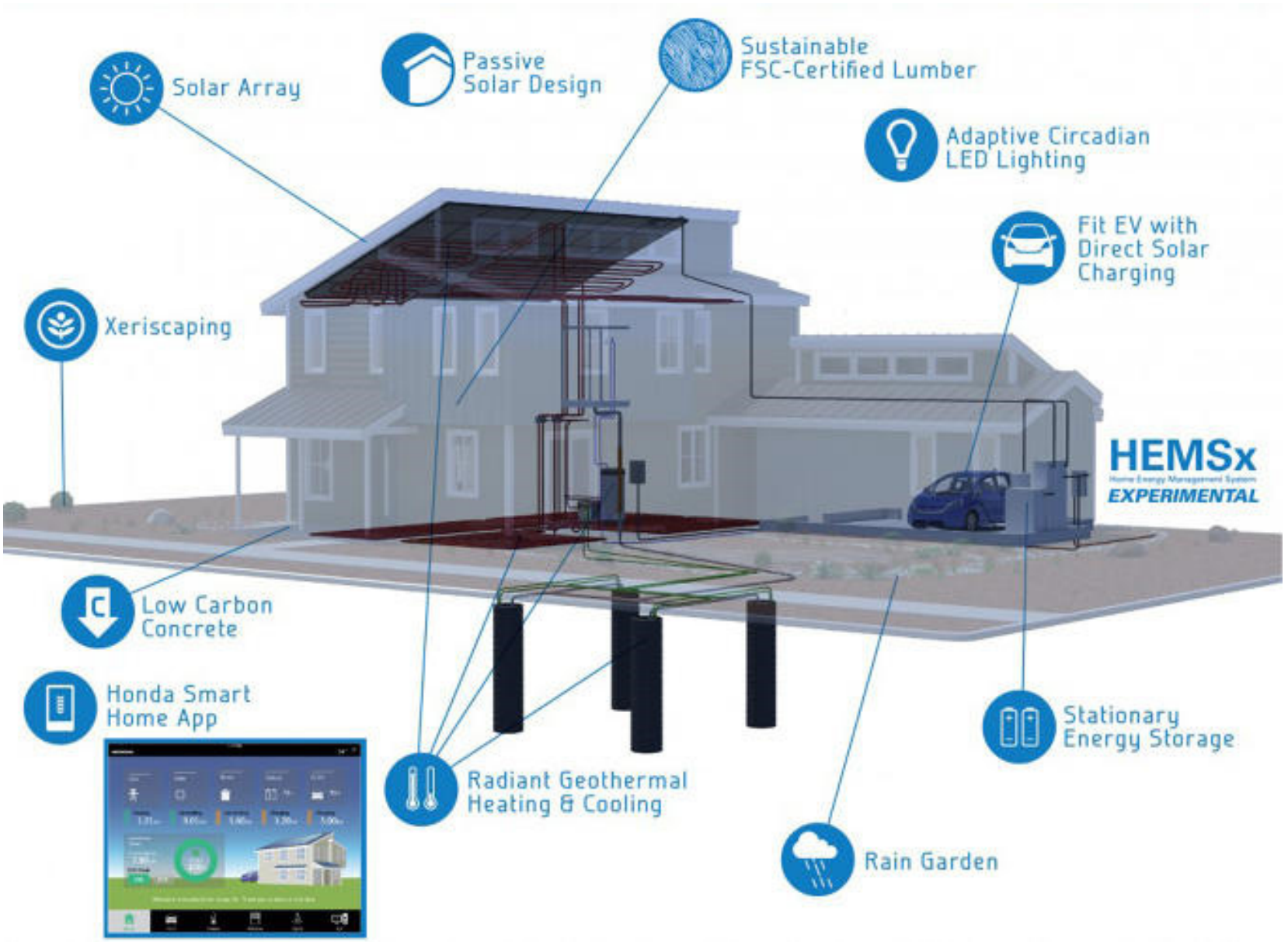
Honda Smart Home

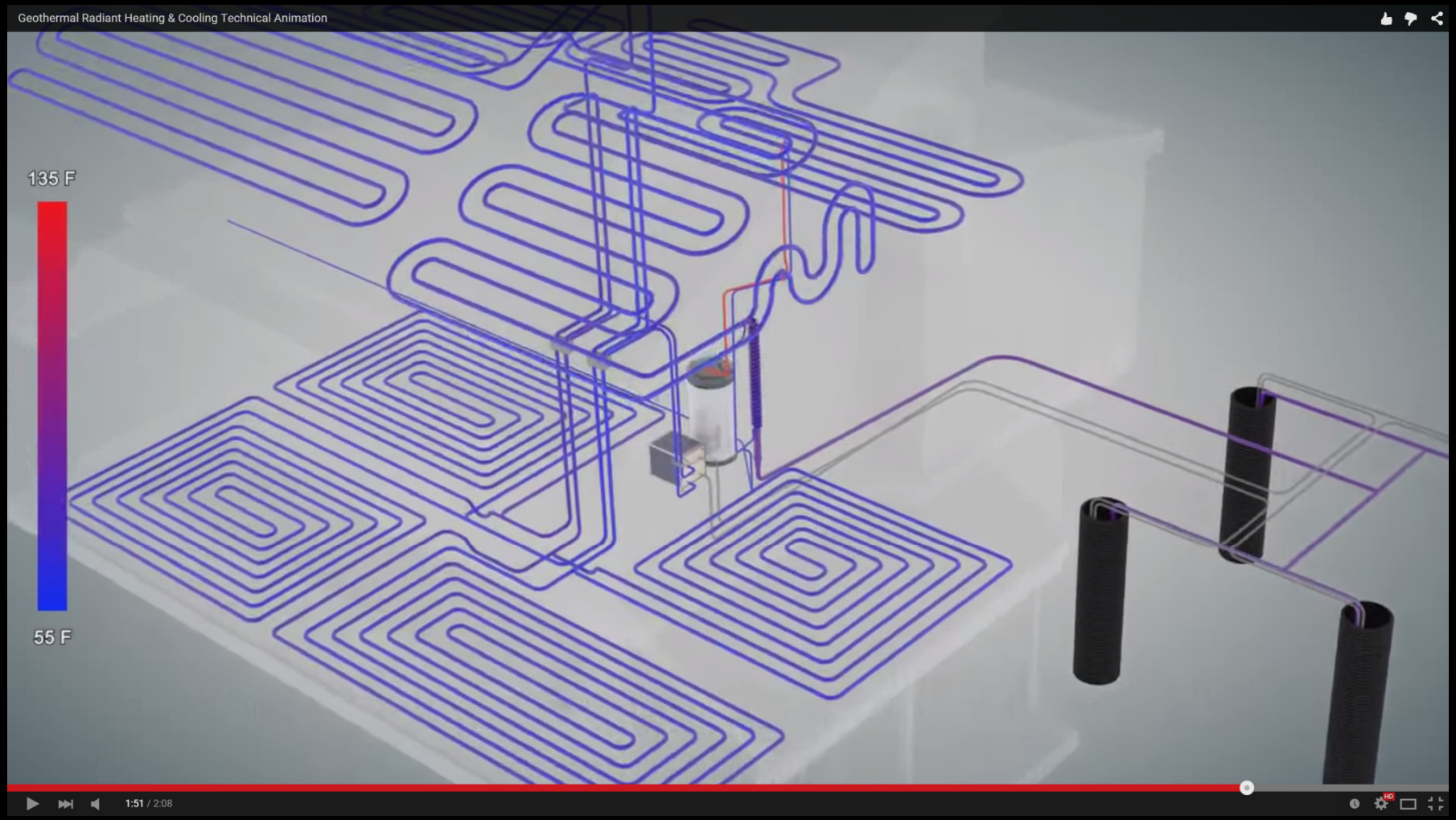
1. All electric home, no on-site combustion
2. Zero-net energy annually, include drive cycle for electric sedan
3. Demonstrate accessible design and construction practices
4. Actively manage loads, provide positive generation at peak

+

HONDA

The Power of Dreams

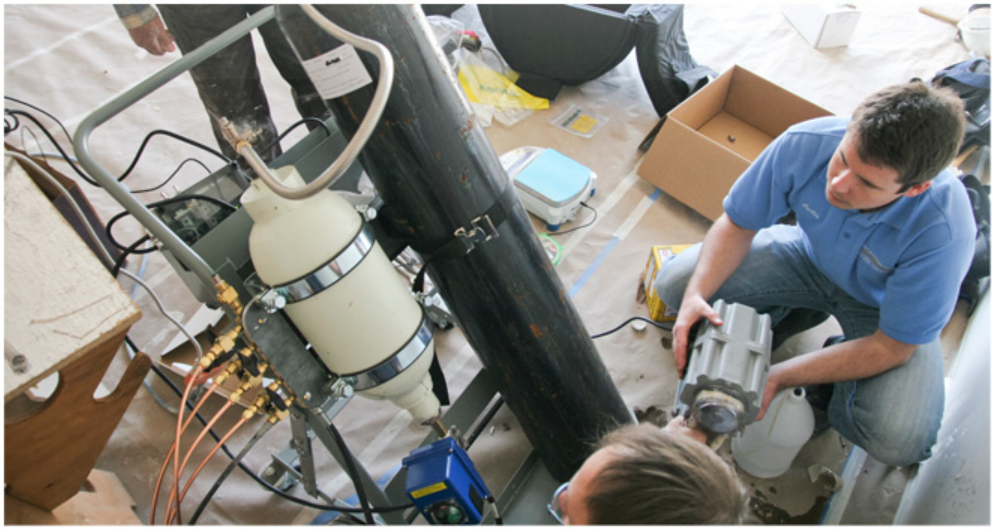

Solar Array
Passive Solar Design
Sustainable FSC-Certified Lumber
Adaptive Circadian LED Lighting
Fit EV with Direct Solar Charging
Xeriscaping
HEMSx
Home Energy Management System
EXPERIMENTAL
Low Carbon Concrete
Honda Smart Home App
Radiant Geothermal Heating & Cooling
Stationary Energy Storage
Rain Garden

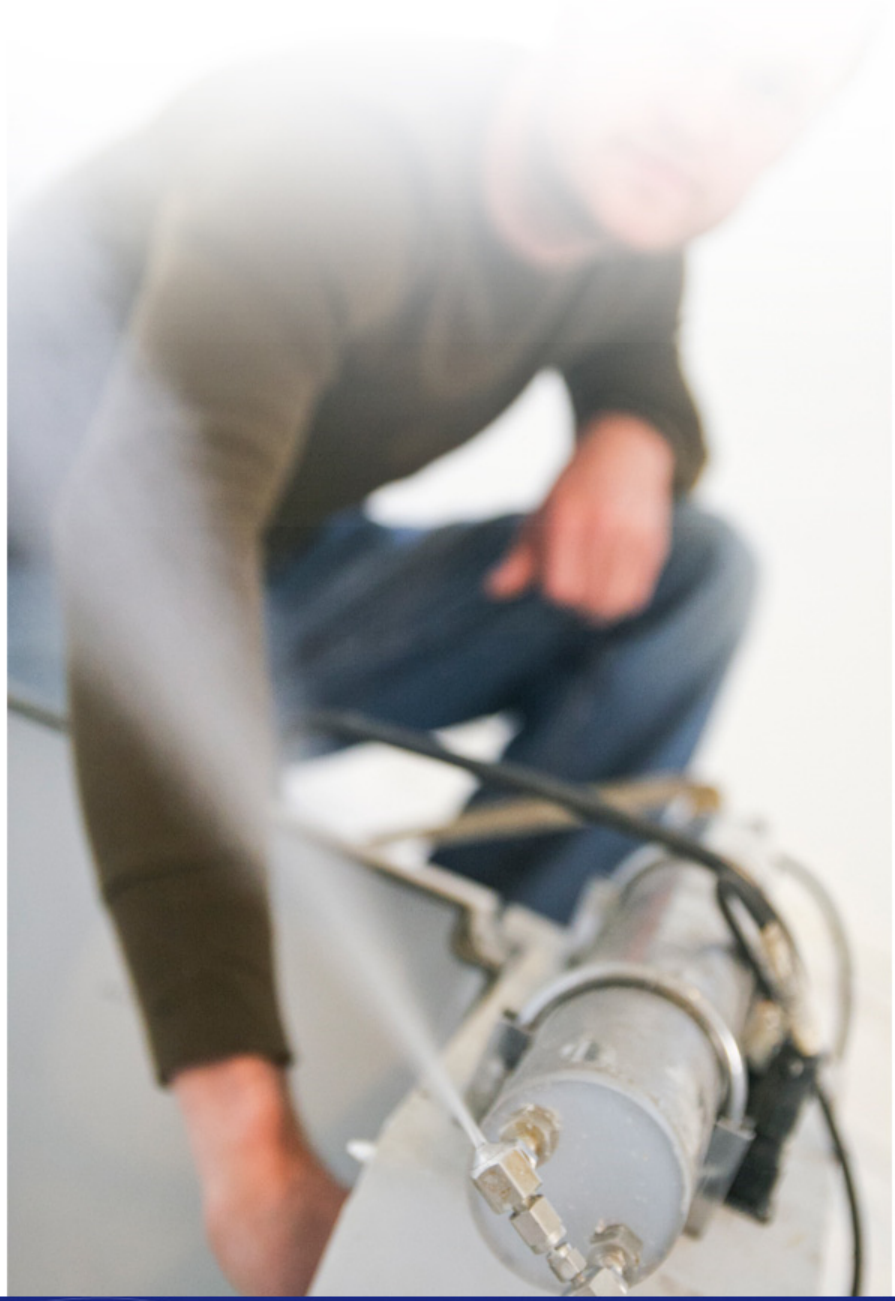

Geothermal Radiant Heating & Cooling Technical Animation
135 F
55 F
1:51 / 2:08

2. AEROSOL ENVELOPE SEALING

Aerosol Envelope Sealing

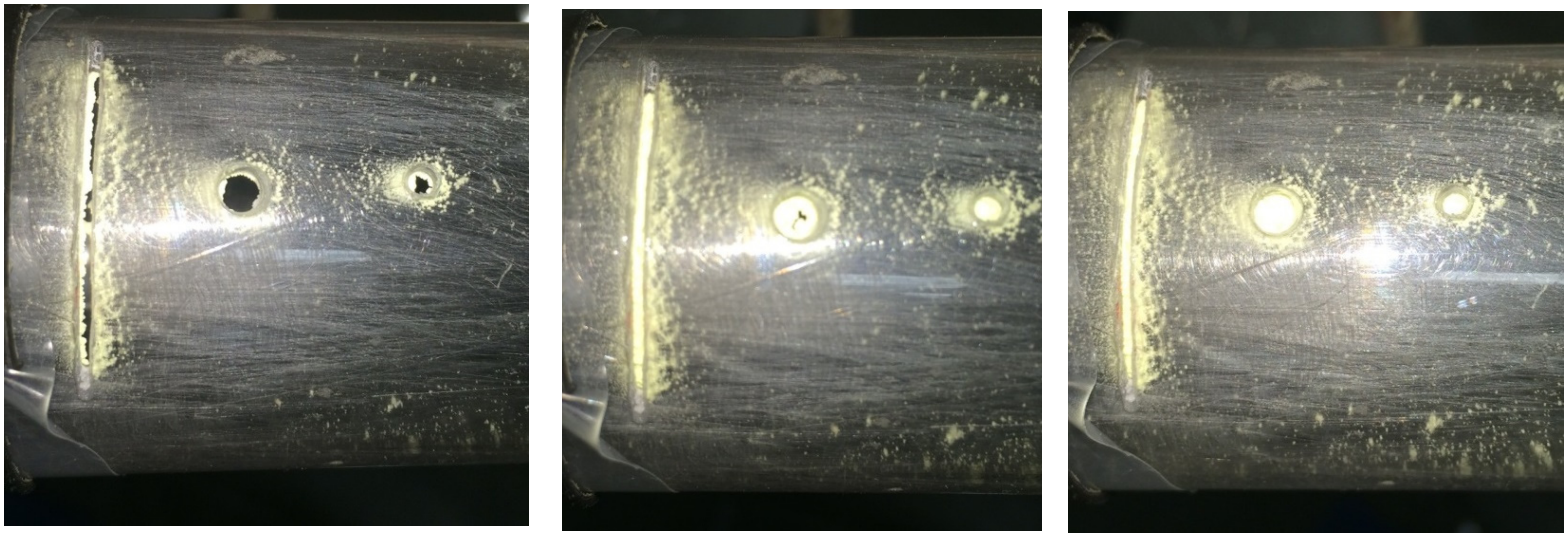
1. Automated method for sealing air leaks in building envelope
2. Reduces manual labor for locating and sealing leaks
3. Achieves unprecedented air tightness



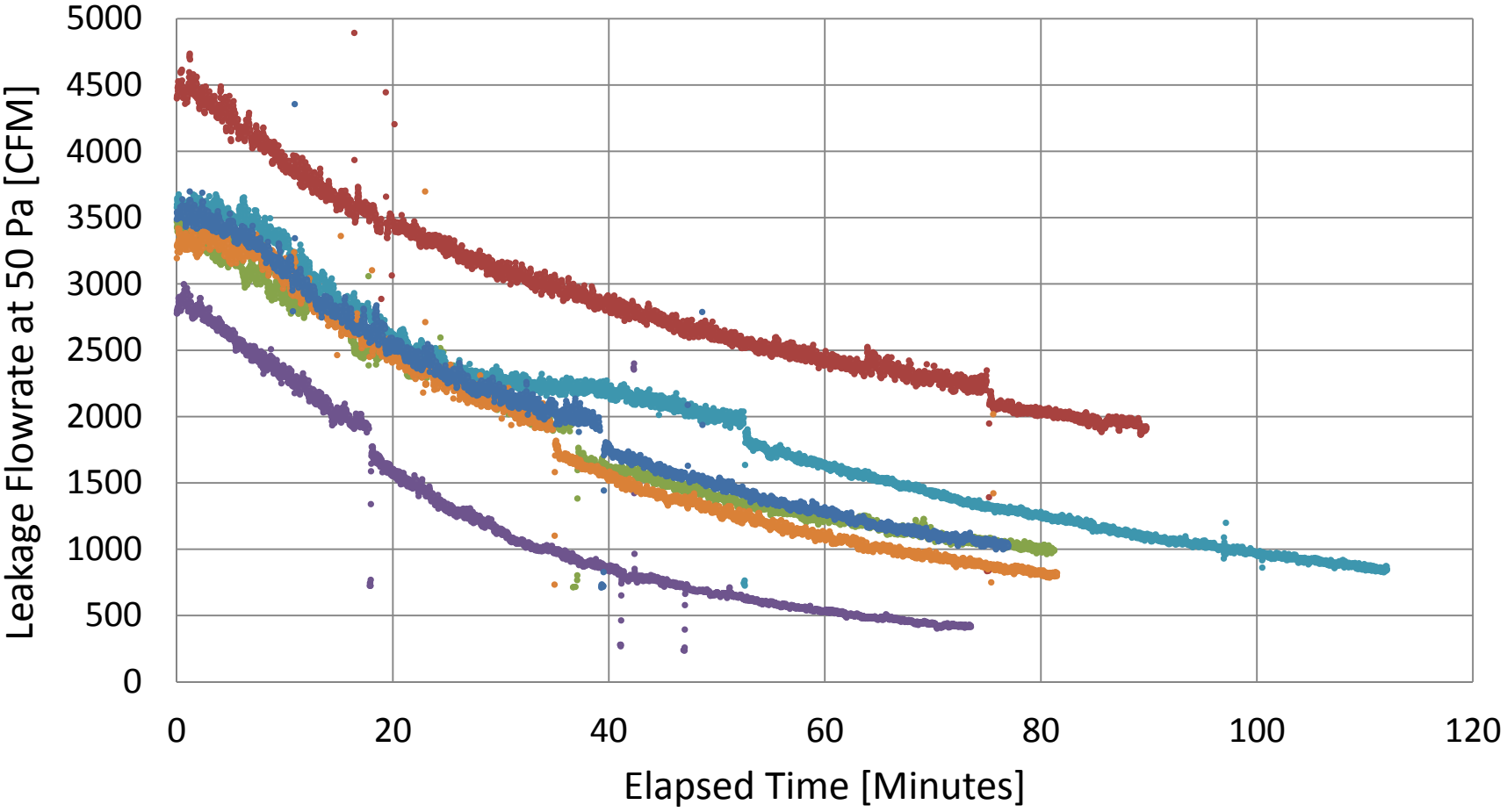


Automated sealing process is quick and precise

10 minutes → 30 minutes → 50 minutes



Aerosol Envelope-Sealing Real Time Performance



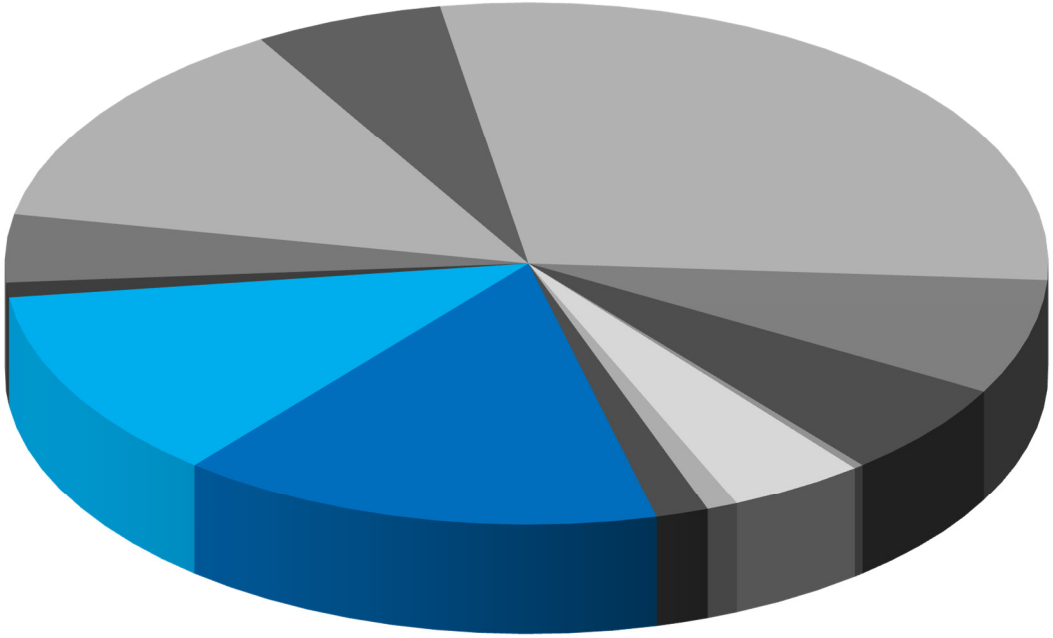
Next Directions for Aerosol Envelope Sealing

- Envelope Sealing for Existing Buildings
- Envelope Sealing Large Buildings
  - Sealing existing commercial buildings with Dept. of Defense
  - Lab testing of seal strength and durability
  - Modeling energy savings due to large-building sealing

3. WESTERN COOLING CHALLENGE

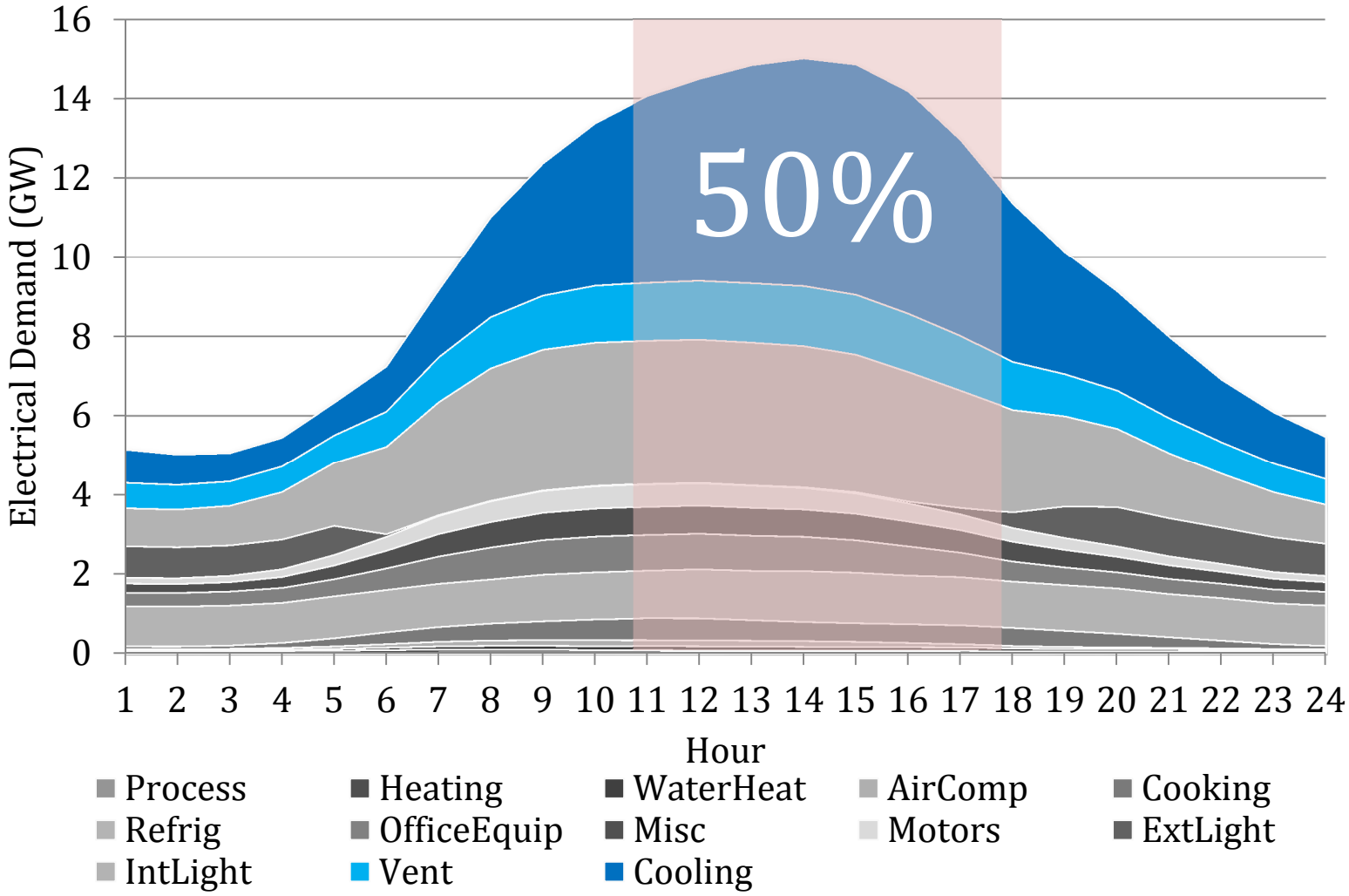
Cooling Contribution to Energy Use

CA Commercial Buildings



Heating
Cooling
Ventilation
Water Heating
Cooking
Refrigeration
Exterior Lighting
Interior Lighting
Office Equipment
Miscellaneous
Process
Motors
Air Compressors

Cooling is Responsible >50% of Peak Commercial Building Electric Demand



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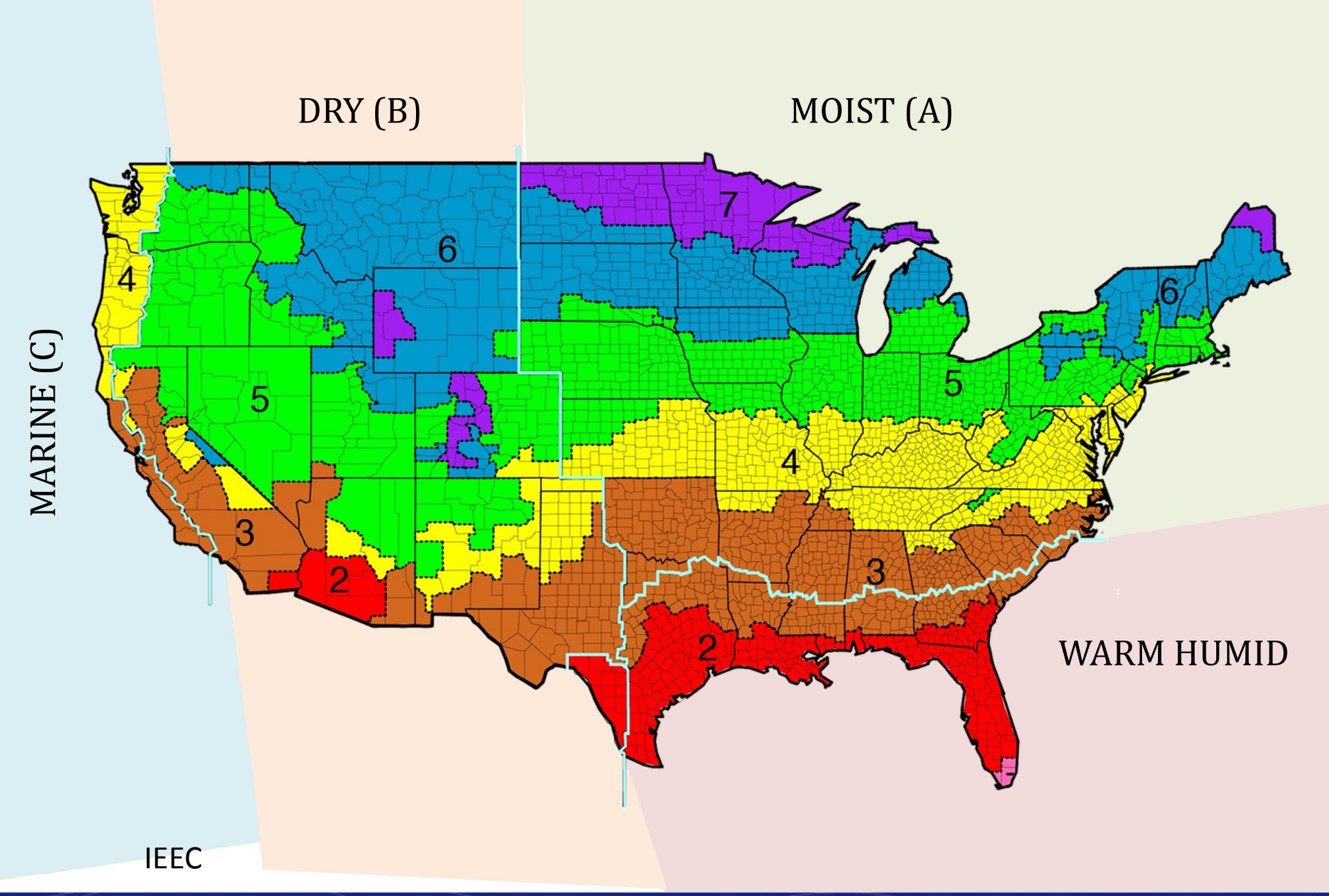
UNIVERSITY OF CALIFORNIA

WCEC
WESTERN COOLING EFFICIENCY CENTER


DRY (B)
MOIST (A)
MARINE (C)
WARM HUMID
IEEC
7
6
4
5
3
2
6
5
4
3
2

UCDAVIS

WESTERN COOLING CHALLENGE

CERTIFIED

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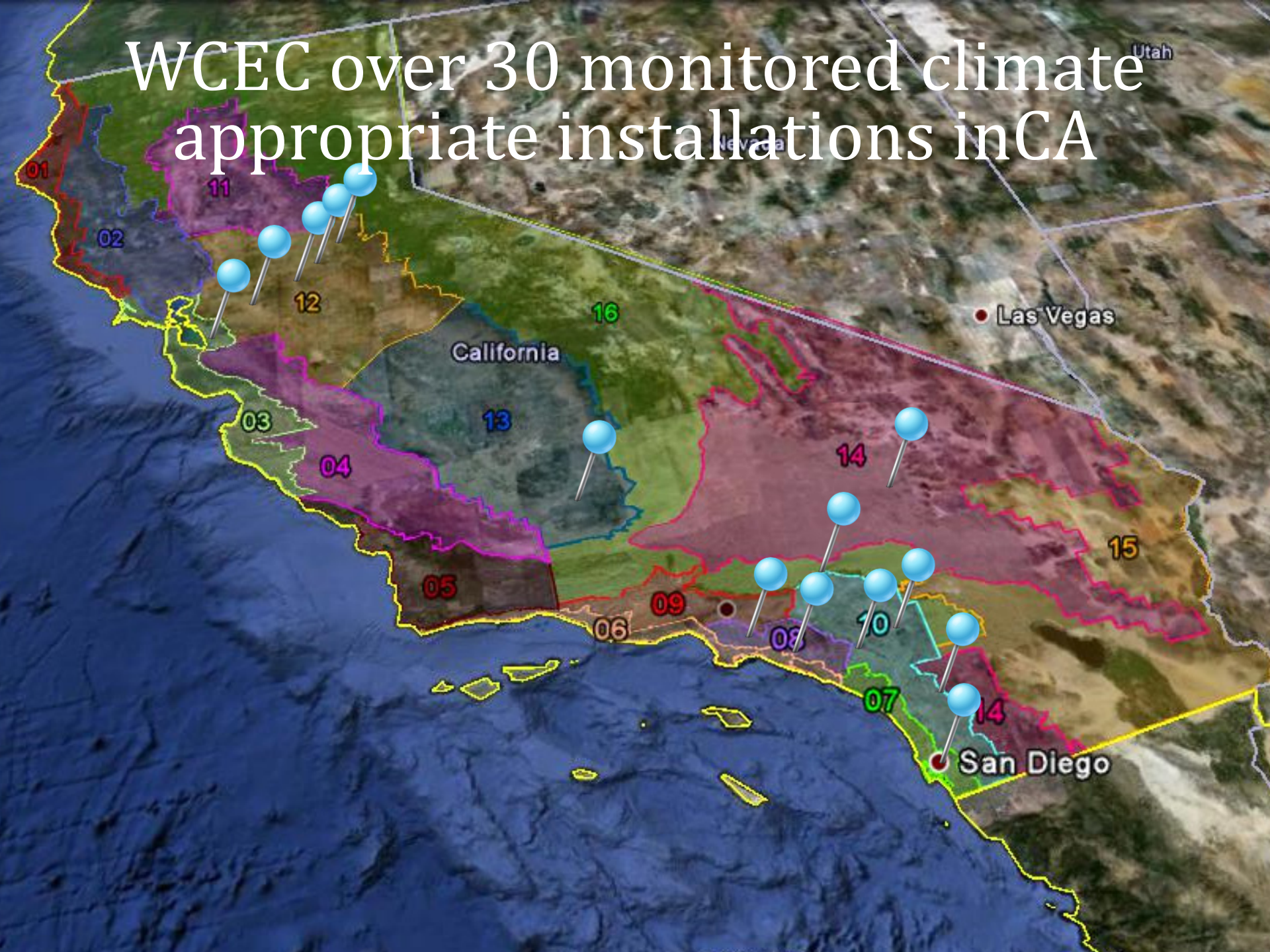
WCEC over 30 monitored climate appropriate installations inCA
Utah
Las Vegas
California
San Diego
01
02
03
04
05
06
07
08
09
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14
15
16

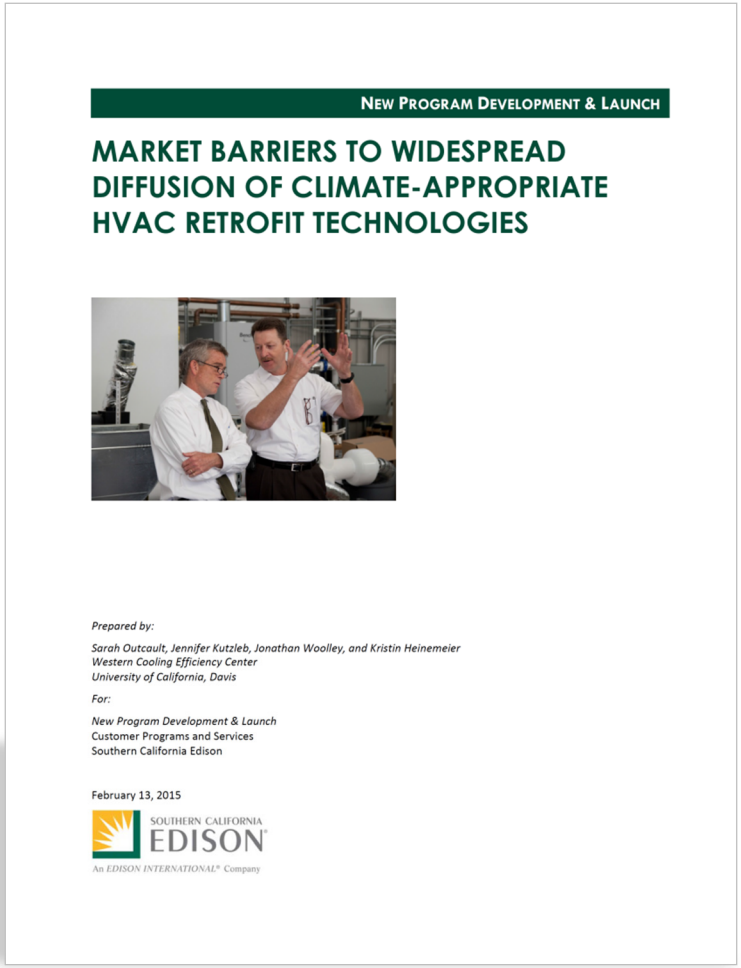
Climate Appropriate HVAC delivers major energy savings

- Laboratory test for Munters EPX 5000 DOAS indicates 20% savings for whole building HVAC peak demand. Field evaluation confirms major savings.
- Side-by-Side field evaluation of Climate Wizard & Coolerado achieves COP=15+ at peak, COP=25+ at part load
- Field evaluations for DualCool as new installation and retrofit show 40% energy savings at peak, consistent with laboratory testing.
- Indirect evaporative cooling for small data centers measures 40-70% daily kWh savings
- Laboratory test of Climate Wizard + RTU shows 65% savings for annual cooling energy consumption 85% savings at part load
- Condenser pre-cooling can reduce peak demand by as much as 27%, and deployed in conjunction with variable speed fan and compressor operation promises 38% savings.

In all cases realized performance depends on application and the quality of design, installation, and maintenance

New Report on Market Barriers for Climate Appropriate HVAC Technologies

- Explores the motivations, needs, and constraints of a range of market actors
- Identifies market barriers and other factors impeding adoption and promotion of downstream climate-appropriate HVAC retrofit technologies
- Identifies opportunities to address, reduce, eliminate or circumvent market barriers in order to increase adoption.



NEW PROGRAM DEVELOPMENT & LAUNCH

MARKET BARRIERS TO WIDESPREAD DIFFUSION OF CLIMATE-APPROPRIATE HVAC RETROFIT TECHNOLOGIES

Prepared by:

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University of California, Davis

For:

New Program Development & Launch
Customer Programs and Services
Southern California Edison

February 13, 2015

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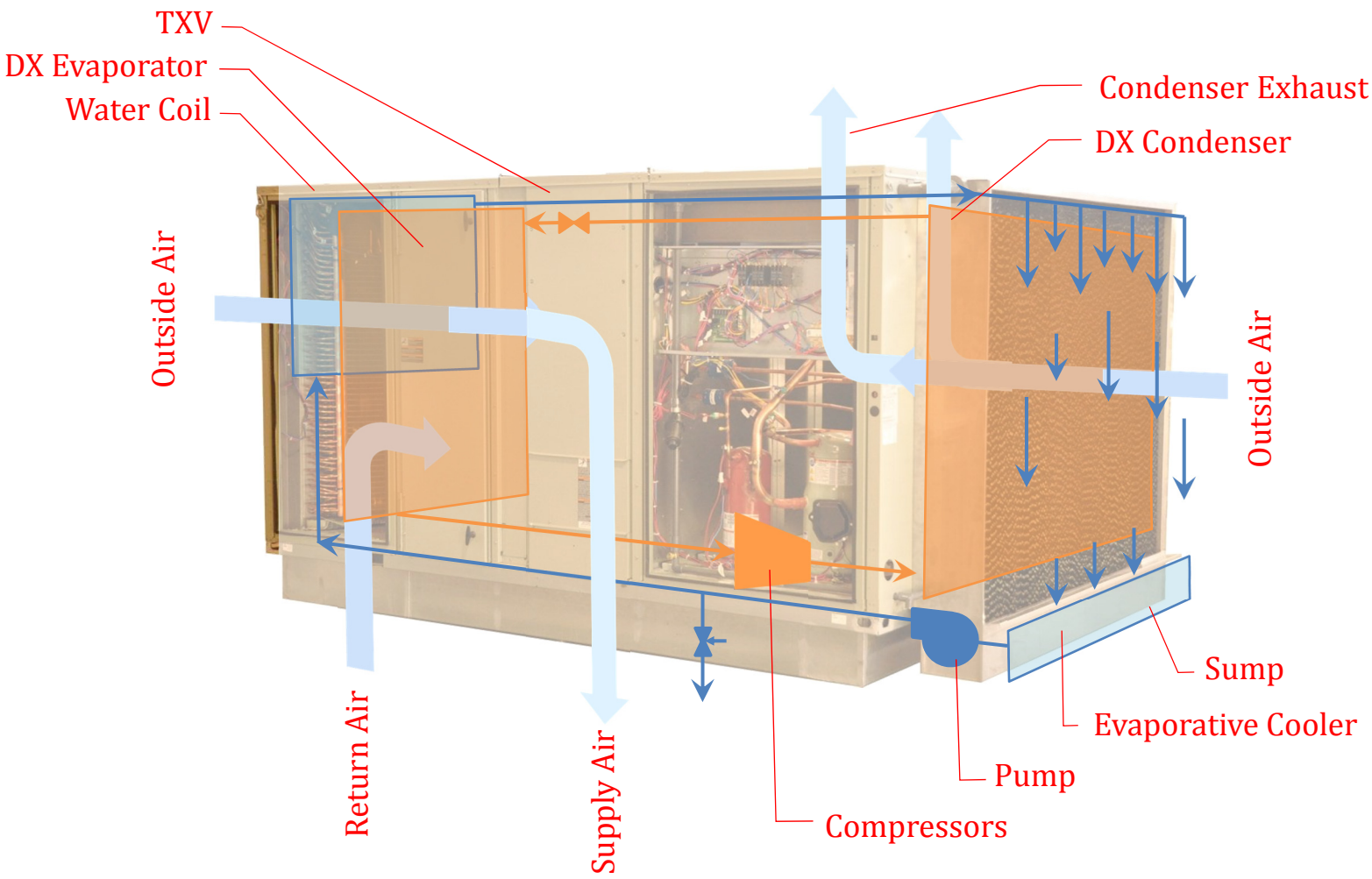
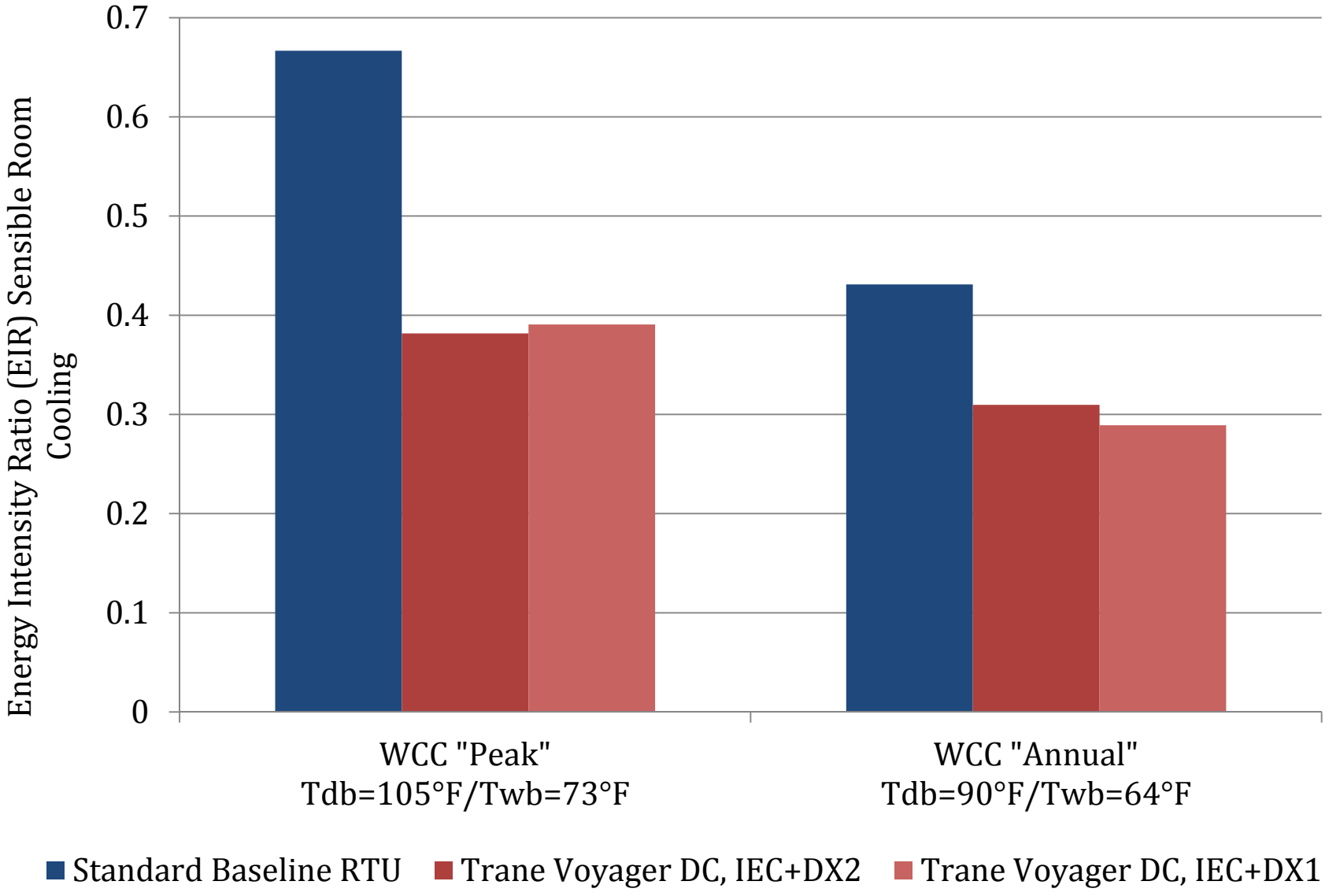
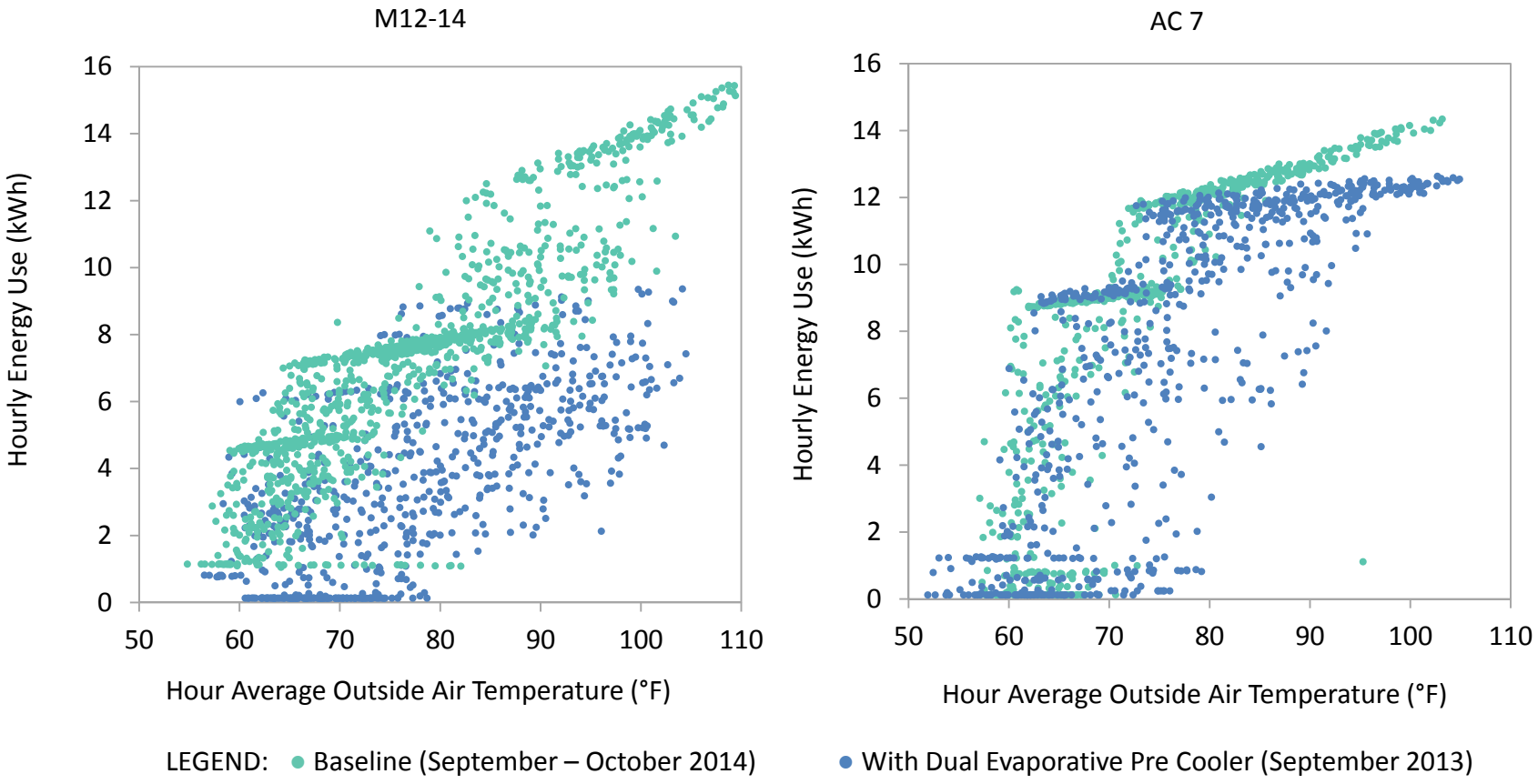
INTEGRATED COMFORT INC.


TXV
DX Evaporator
Water Coil
Outside Air
Condenser Exhaust
DX Condenser
Outside Air
Return Air
Supply Air
Compressors
Pump
Sump
Evaporative Cooler

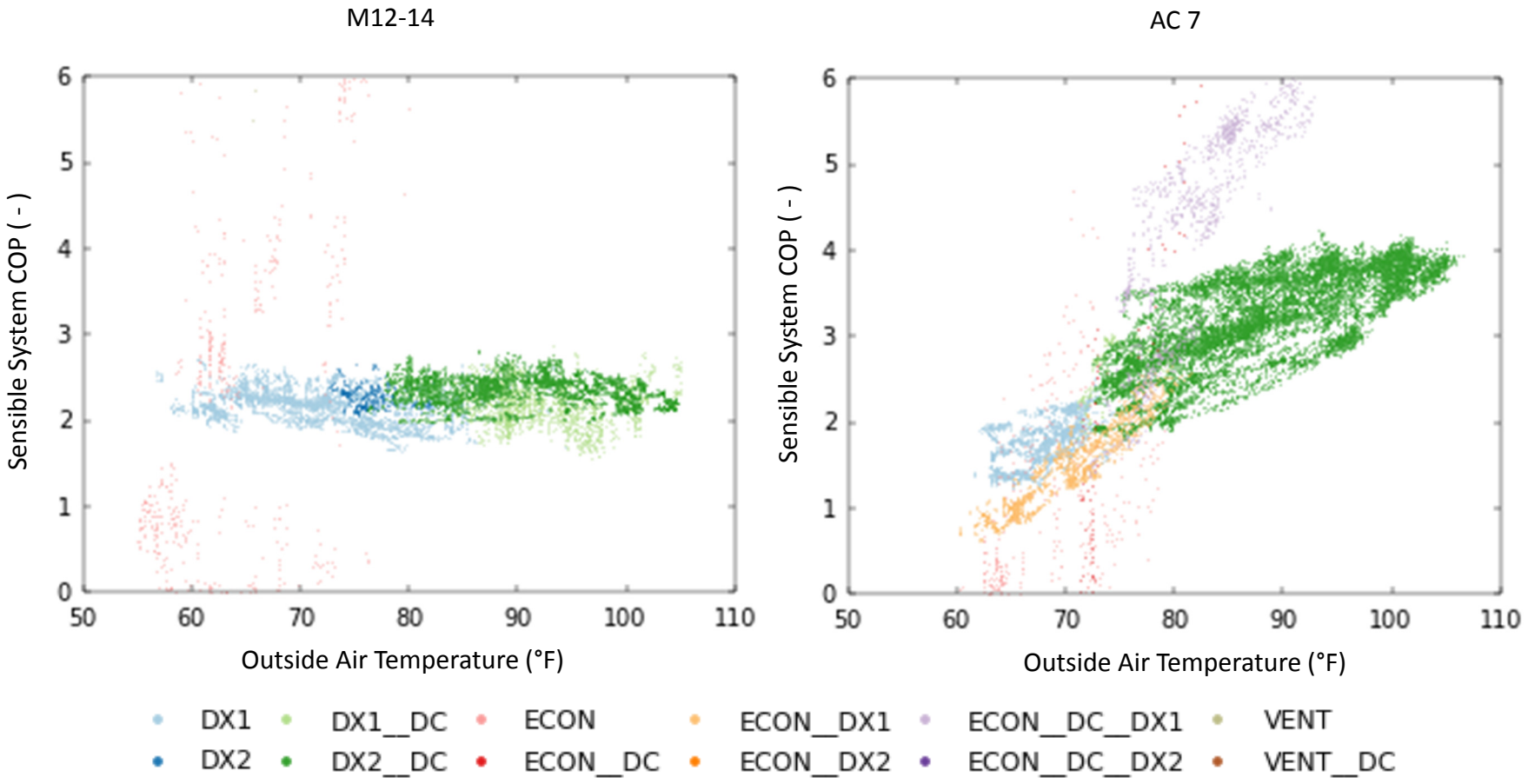

PVC DWV NSF


Energy Intensity Ratio (EIR) Sensible Room Cooling
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
WCC "Peak"
Tdb=105°F/Twb=73°F
WCC "Annual"
Tdb=90°F/Twb=64°F
Standard Baseline RTU
Trane Voyager DC, IEC+DX2
Trane Voyager DC, IEC+DX1

Energy Use Signature ~50% On-Peak Savings



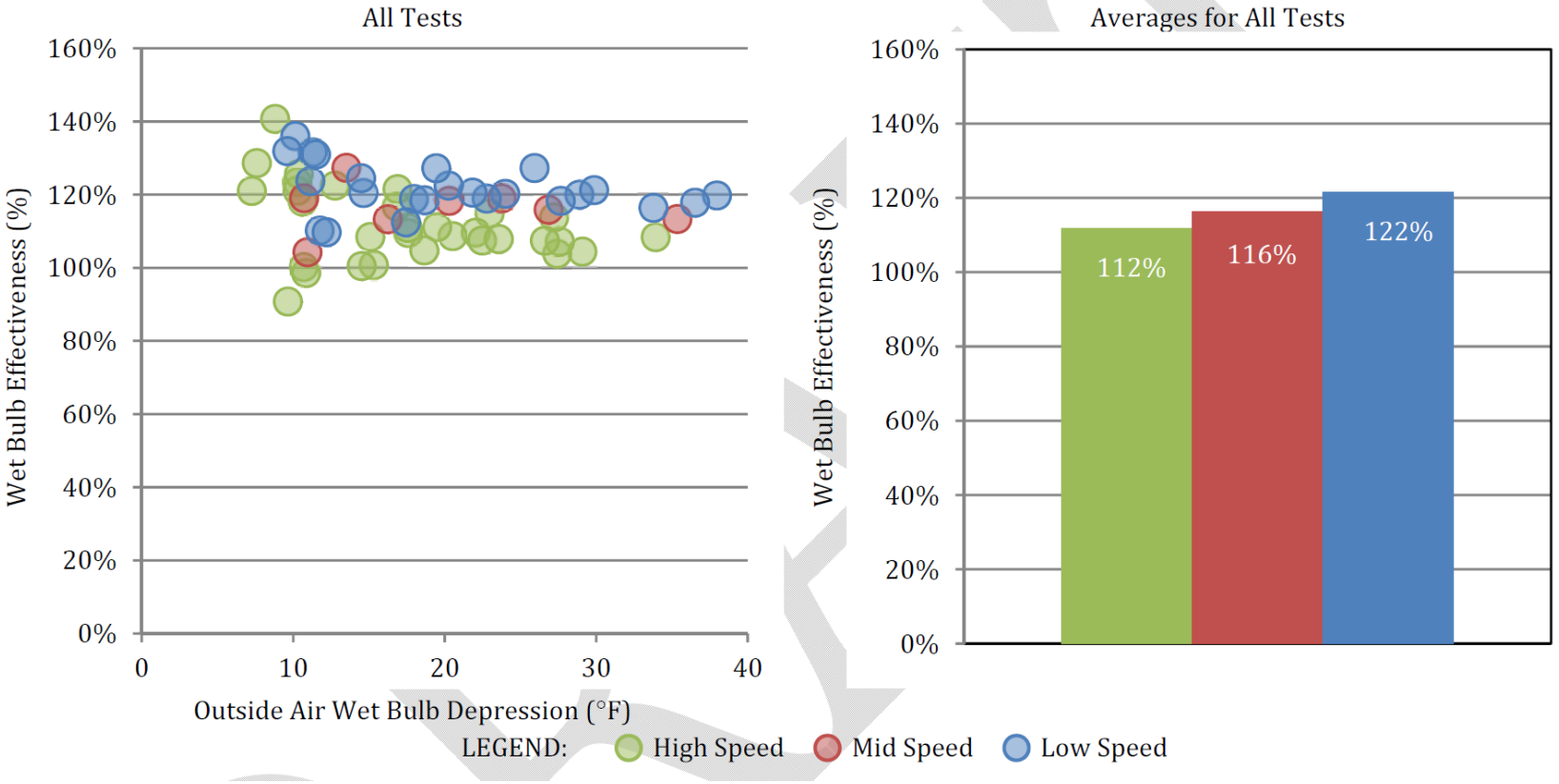
System Sensible Efficiency



Lab testing of Climate Wizard + Conden-So-Cool as RTU retrofit indicates **65% annual savings**

Indirect Evaporative Cooling
Separation of Mass Transfer & Heat Transfer

Lab testing of Climate Wizard + Conden-So-Cool as RTU retrofit indicates **65% annual savings**



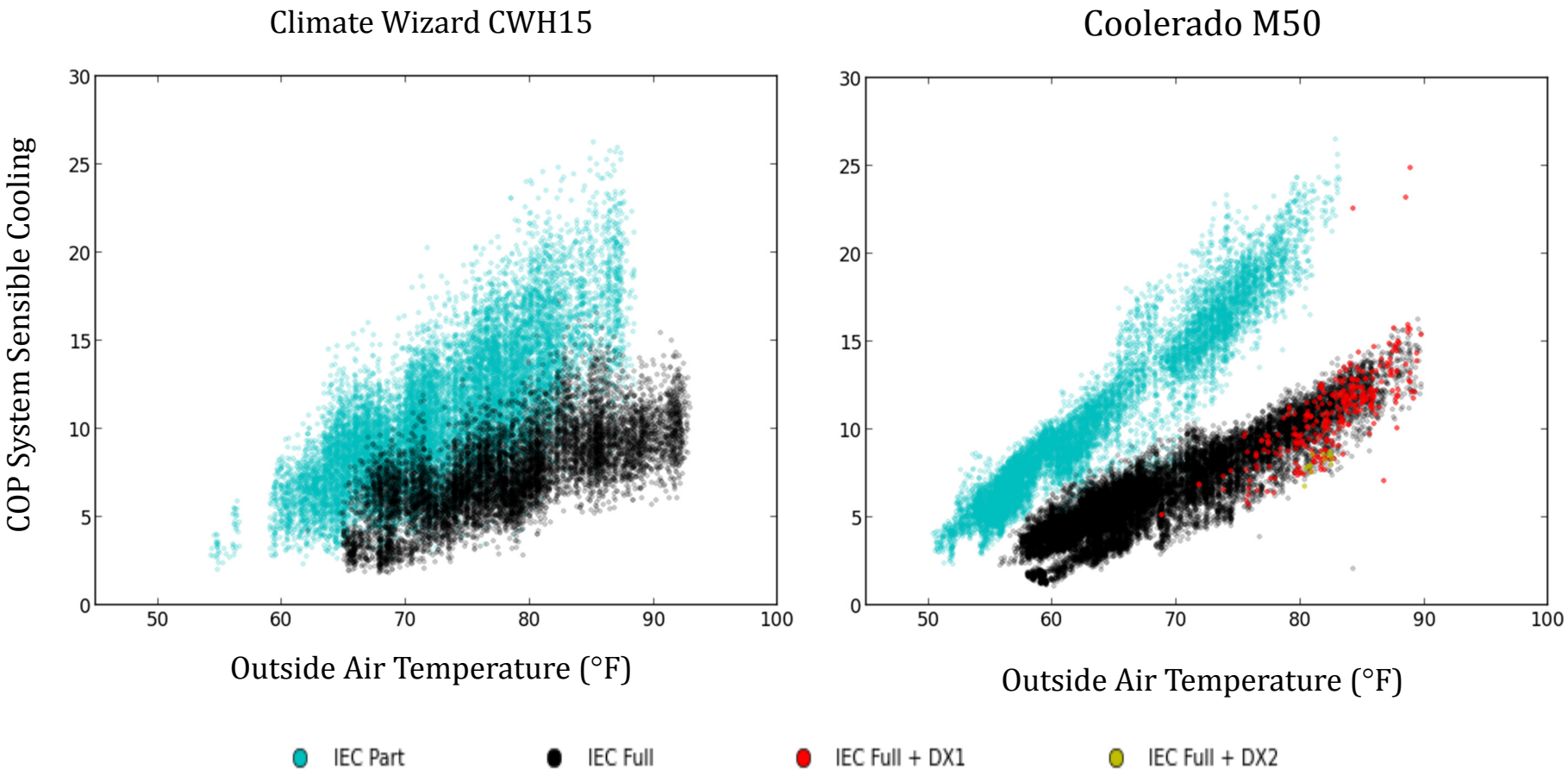
SIDE-BY-SIDE EVALUATION OF TWO **INDIRECT EVAPORATIVE AIR CONDITIONERS** ADDED TO EXISTING PACKAGED ROOFTOP UNITS

- Installed two manufacturers
- Indir. Evaporative
- Cools air without moisture add.
- Variable speed
- 100% outside air
- Integrated with existing RTU
- Controls development

Coolerado

SEELEY INTERNATIONAL

Sensible System Coefficient of Performance



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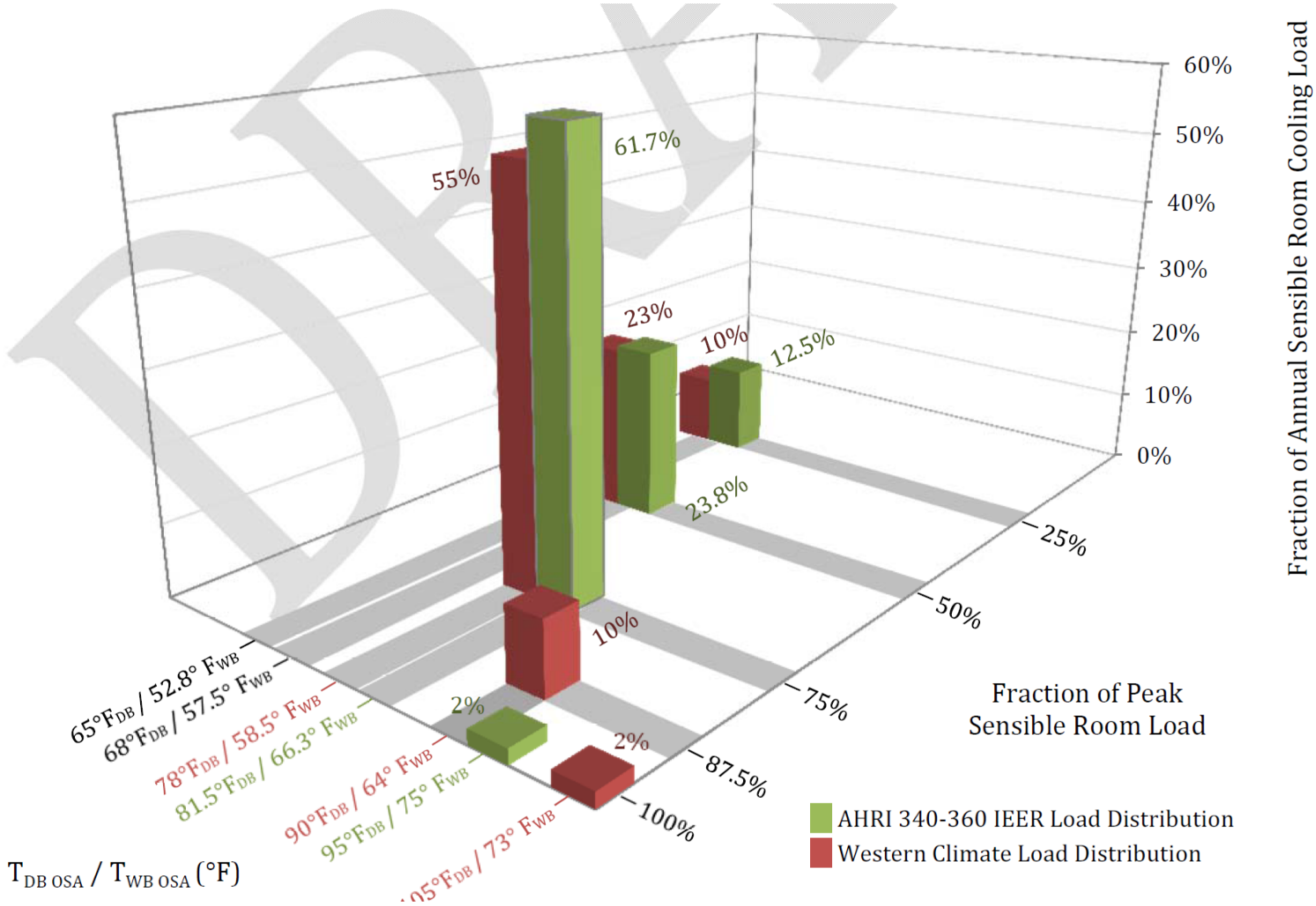

Indirect Evaporative Cooling for Small Data Centers (Cell Tower Sites)

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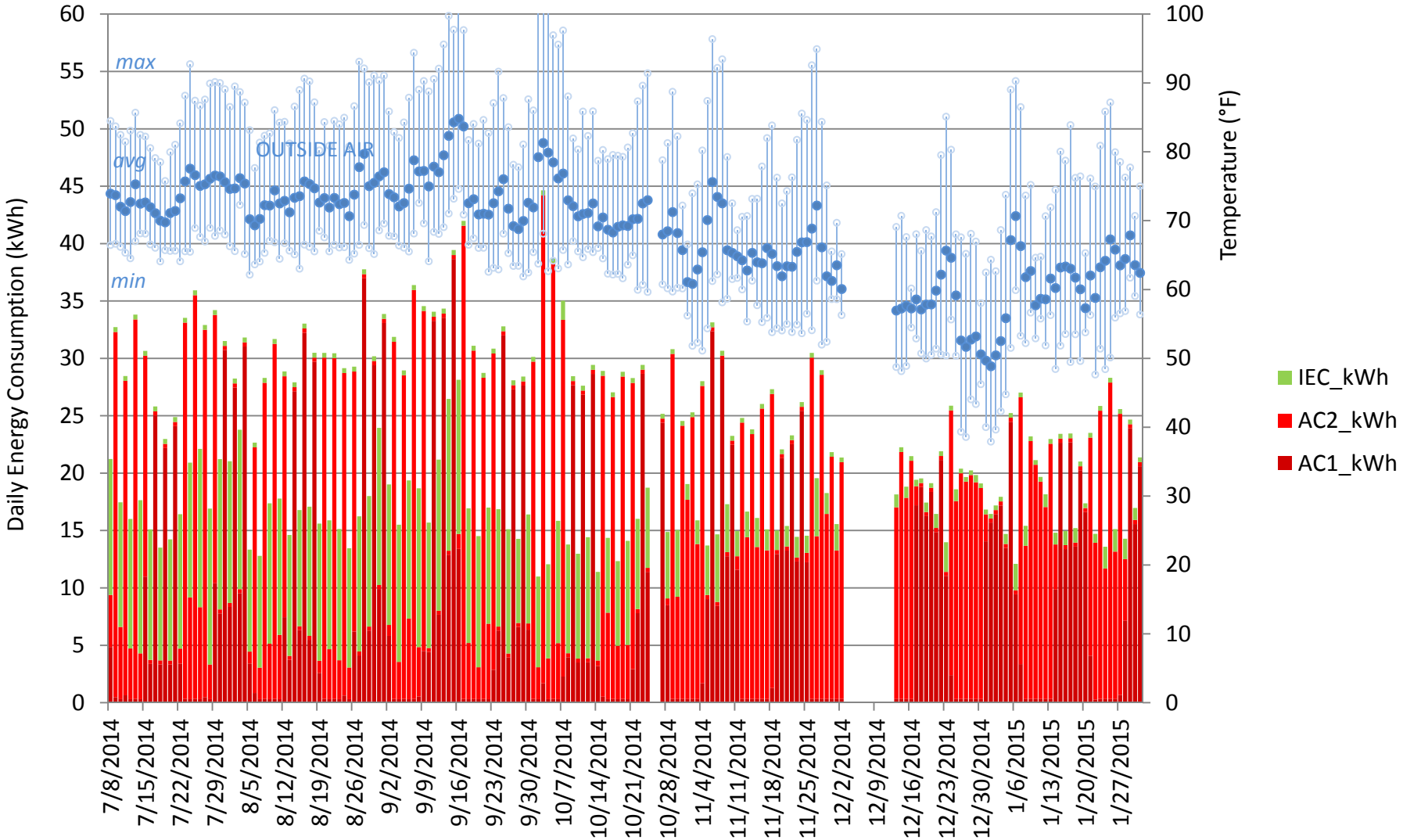
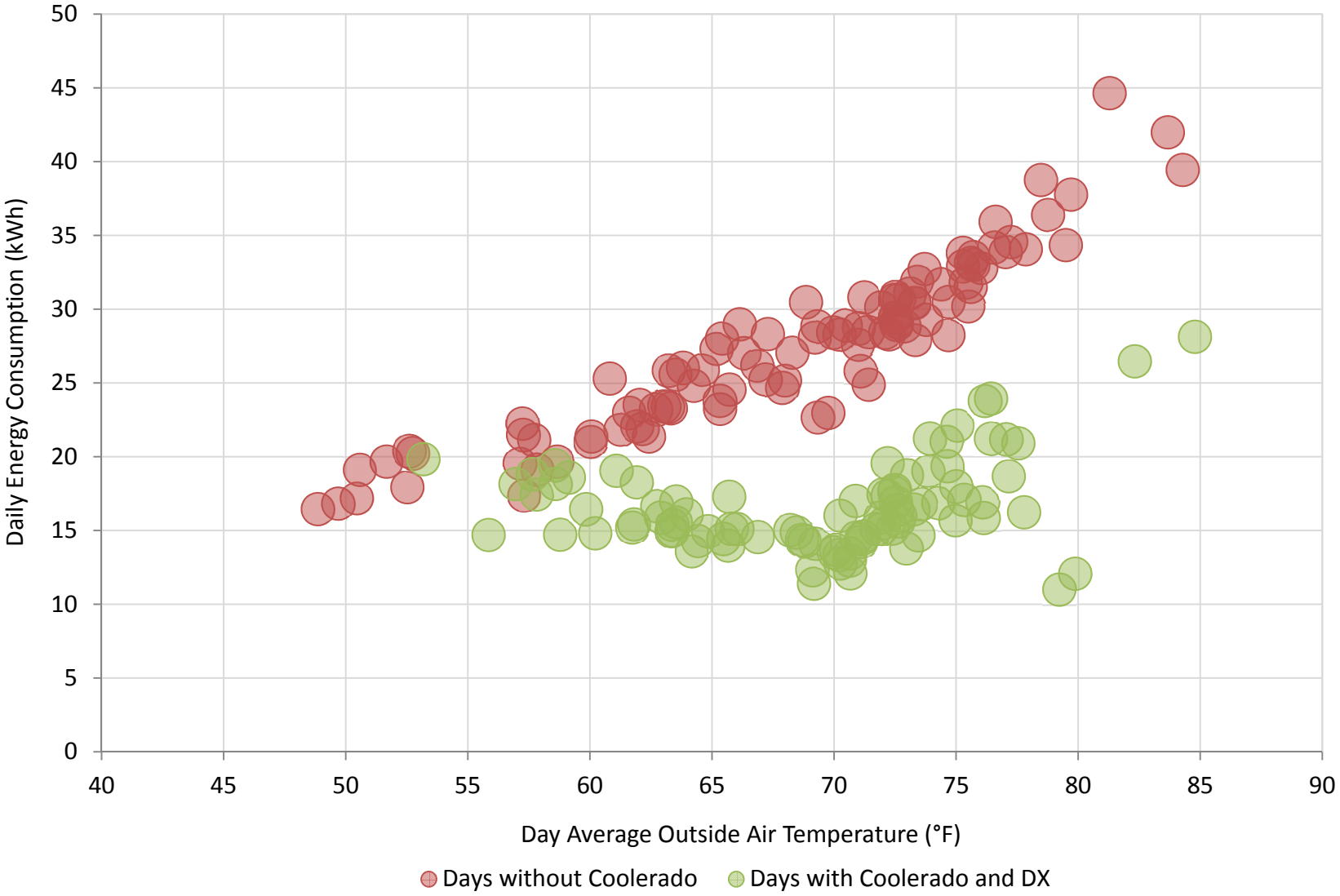
Daily Total HVAC Energy Consumption at Cudahy Cell Site

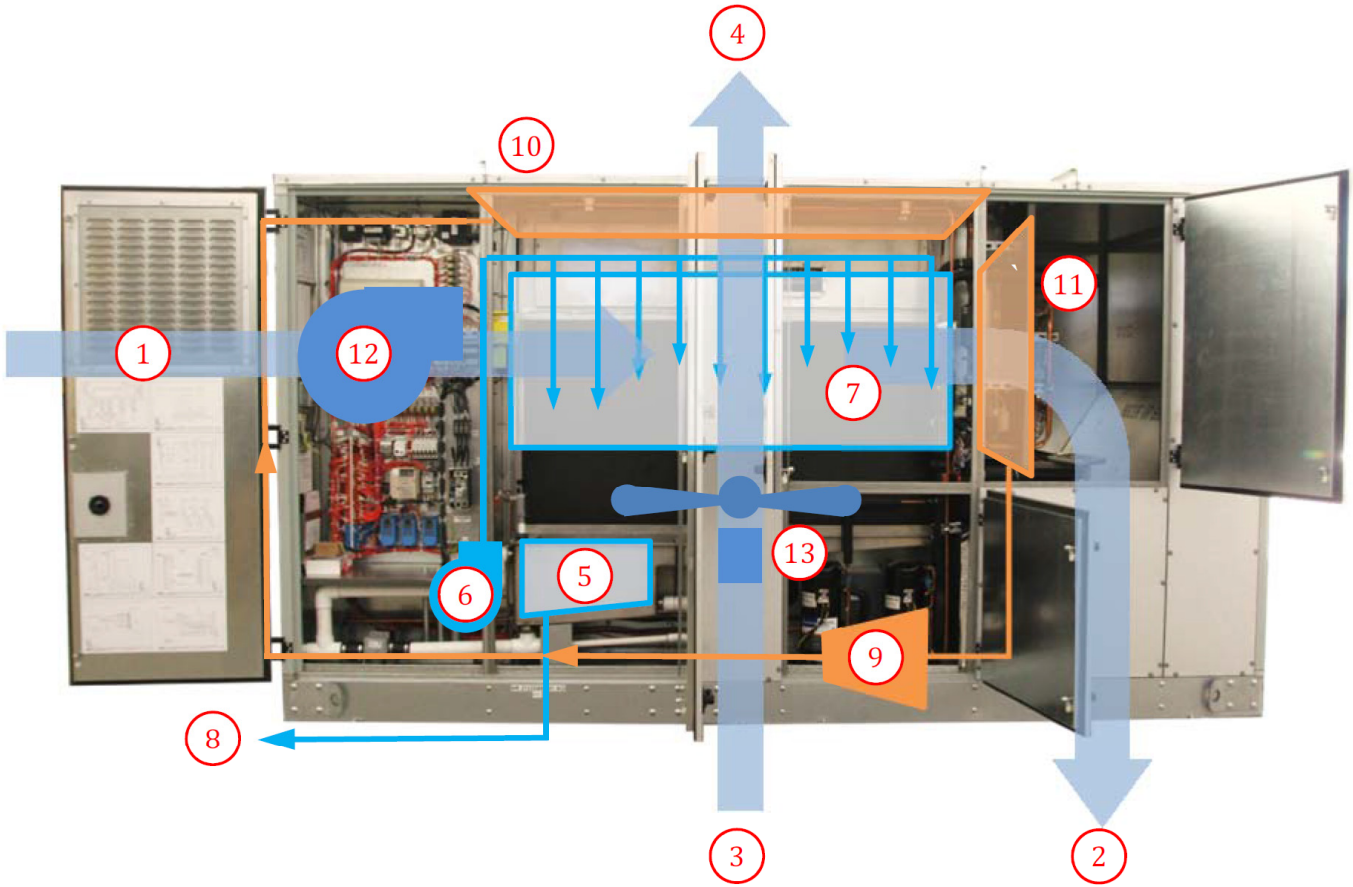


Daily Total HVAC Energy Consumption at Cudahy Cell Site



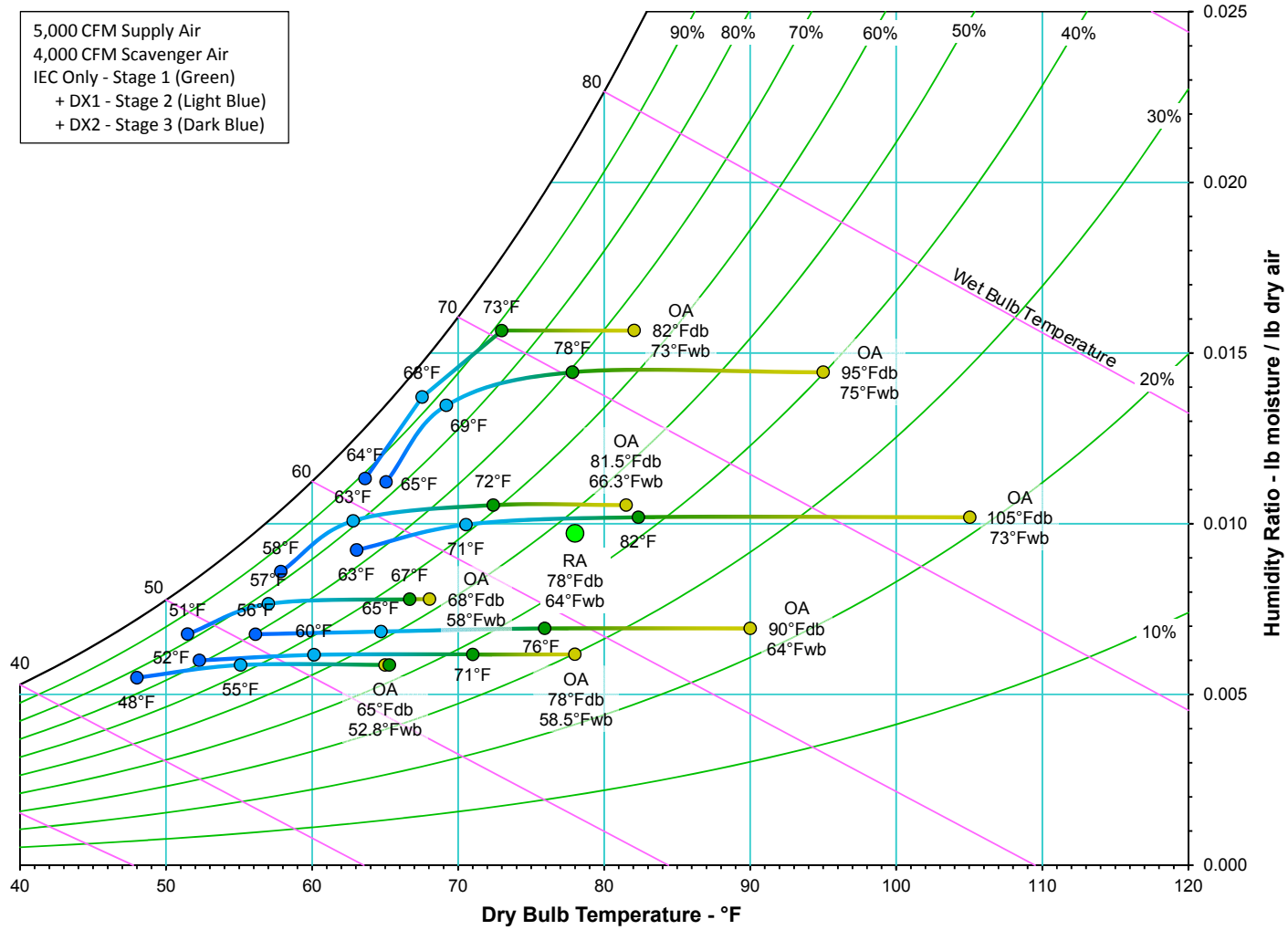
A Unitary Hybrid Air Conditioner

Unitary Hybrid DOAS



1	*Outside Air (Primary Inlet)*	5	*Sump*	10	*DX Condenser*
2	*Supply Air*	6	*Circulation Pump*	11	*DX Evaporator*
3	*Return Air (Secondary Inlet)*	7	*EPX (Indirect Evap. Heat Exch.)*	12	*Blower (Primary Air)*
4	*Exhaust Air*	8	*Drain*	13	*Fan (Secondary Air)*
		9	*Compressors*		

Performance in each mode of operation



MUNTERS EPX 5000 DOAS

ONE MACHINE

20%

WHOLE-BUILDING
ON-PEAK HVAC

DEMAND SAVINGS

MUNTERS EPX 5000

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WESTERN COOLING EFFICIENCY CENTER

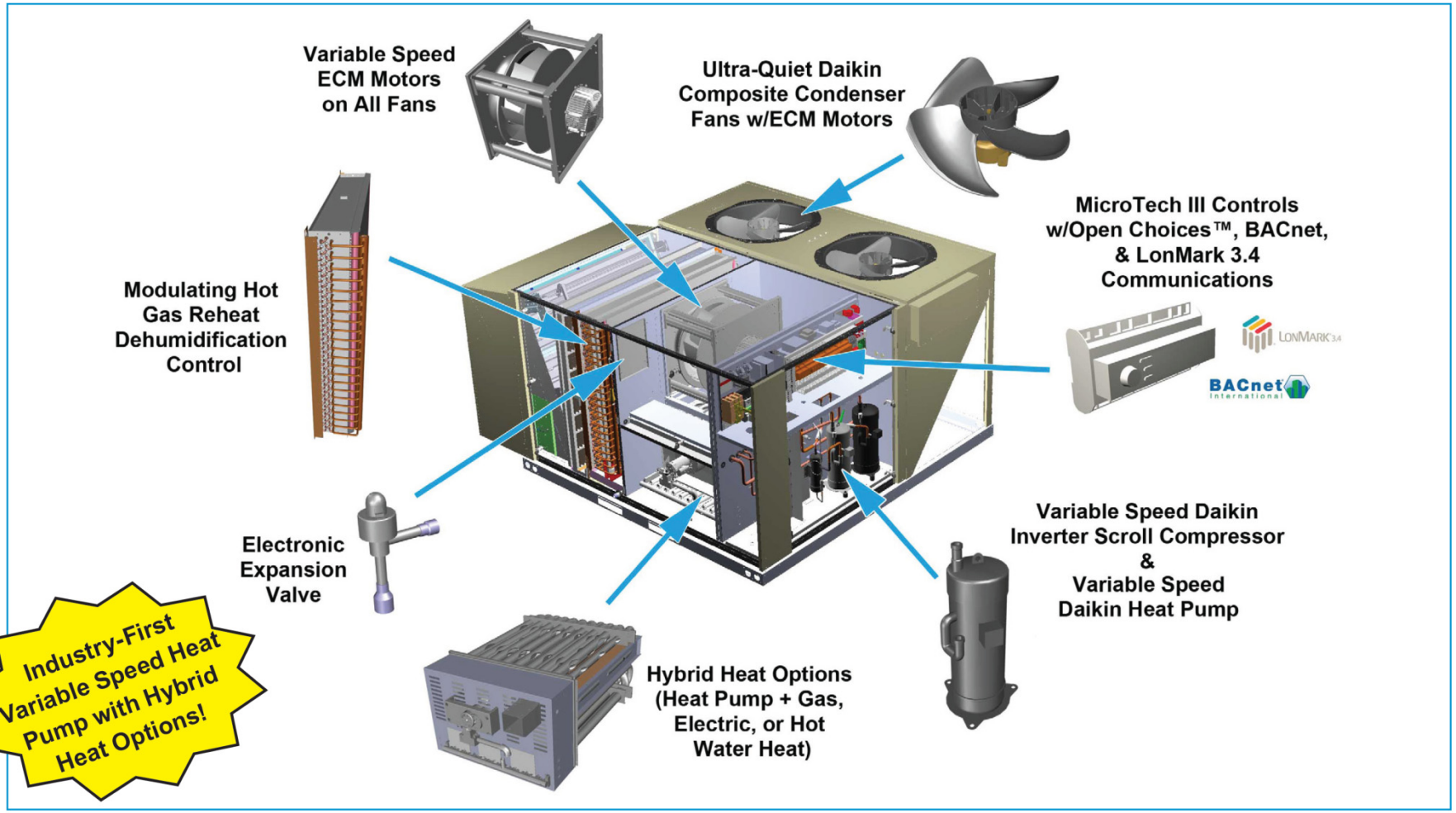
In all cases realized performance depends on application and the quality of design, installation, and maintenance

DOE's High Performance RTU Challenge pushes efficiency improvements

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Minimum IEER=18
- DDC capabilities
- Automated Monitoring
- AFDD
- Wireless Communication

Daikin McQuay Rebel

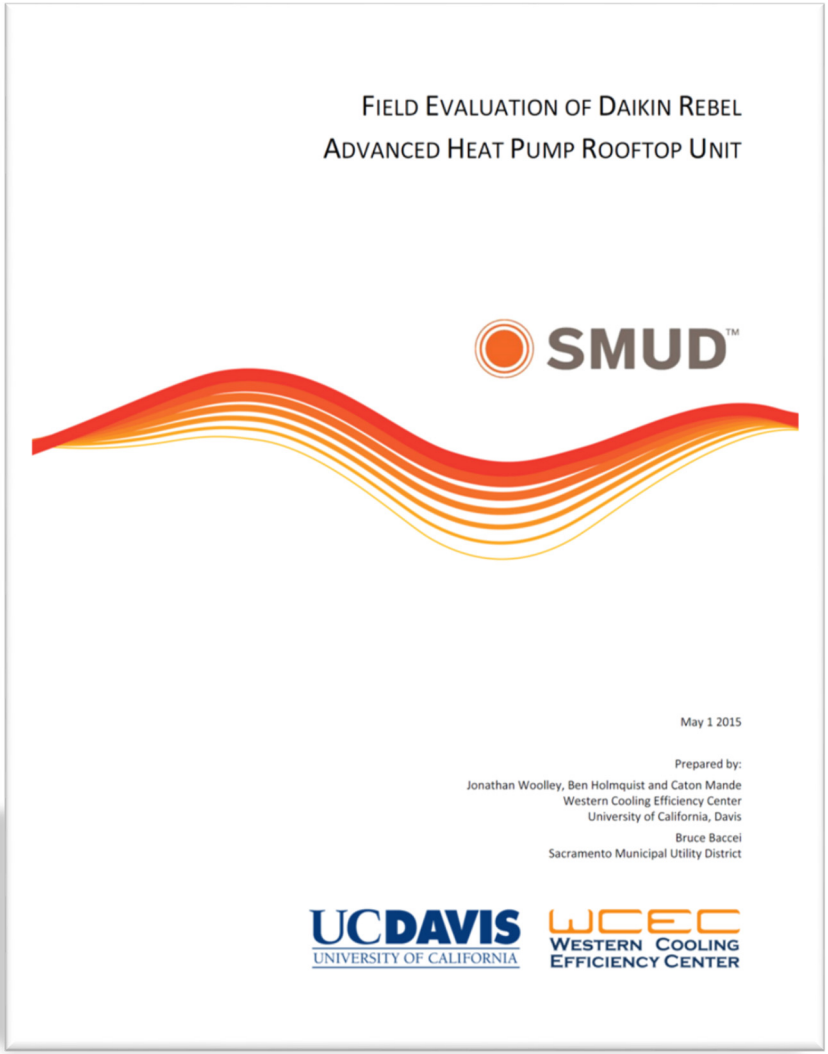


Demonstration at Harley Davidson

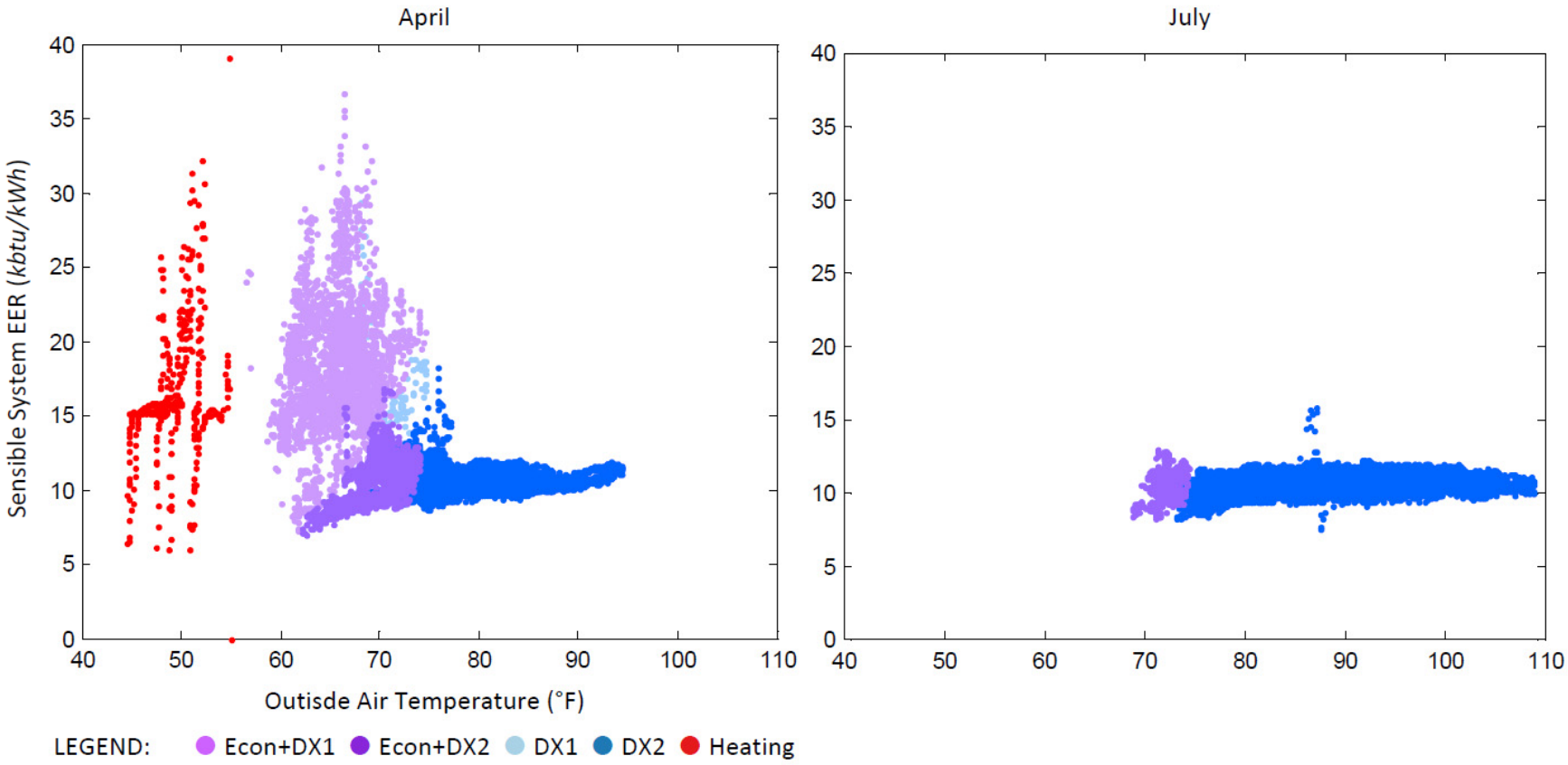
SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.℠

Field Test Report

- Load weighted EER=12 (claimed IEER = 20.6)
- Very little part capacity operation for this proejct
- Challenges with commissioning and controls
- Need for professional training for advanced rooftop units



Realized performance is highly dependent on application and technician know how



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