Fostering the Development and Commercialization of Climate Appropriate Cooling Technologies

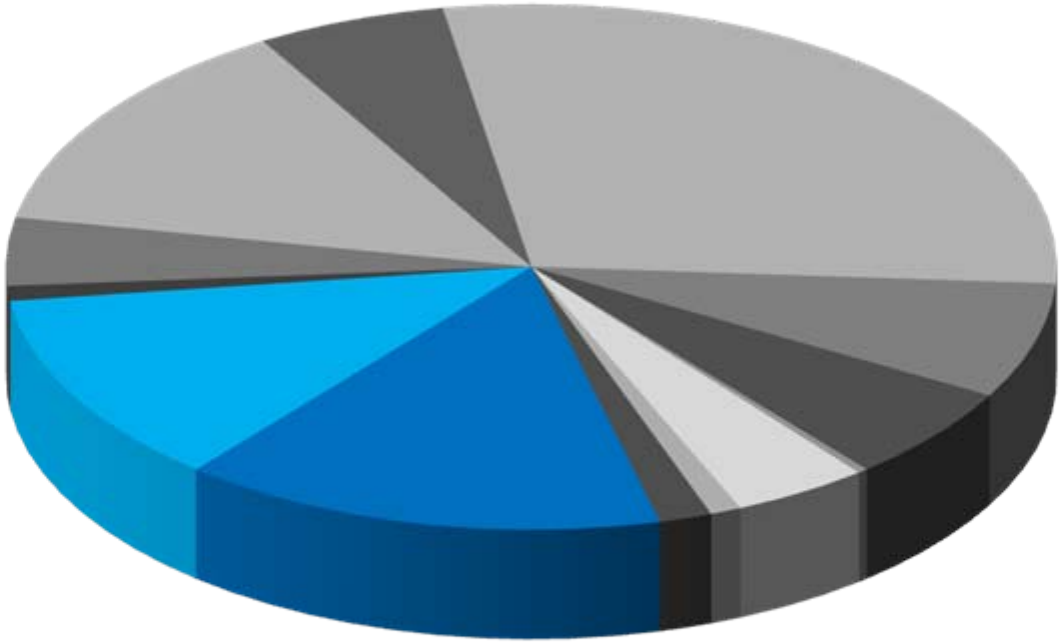
Jonathan Woolley

Western Cooling Efficiency Center, UC Davis

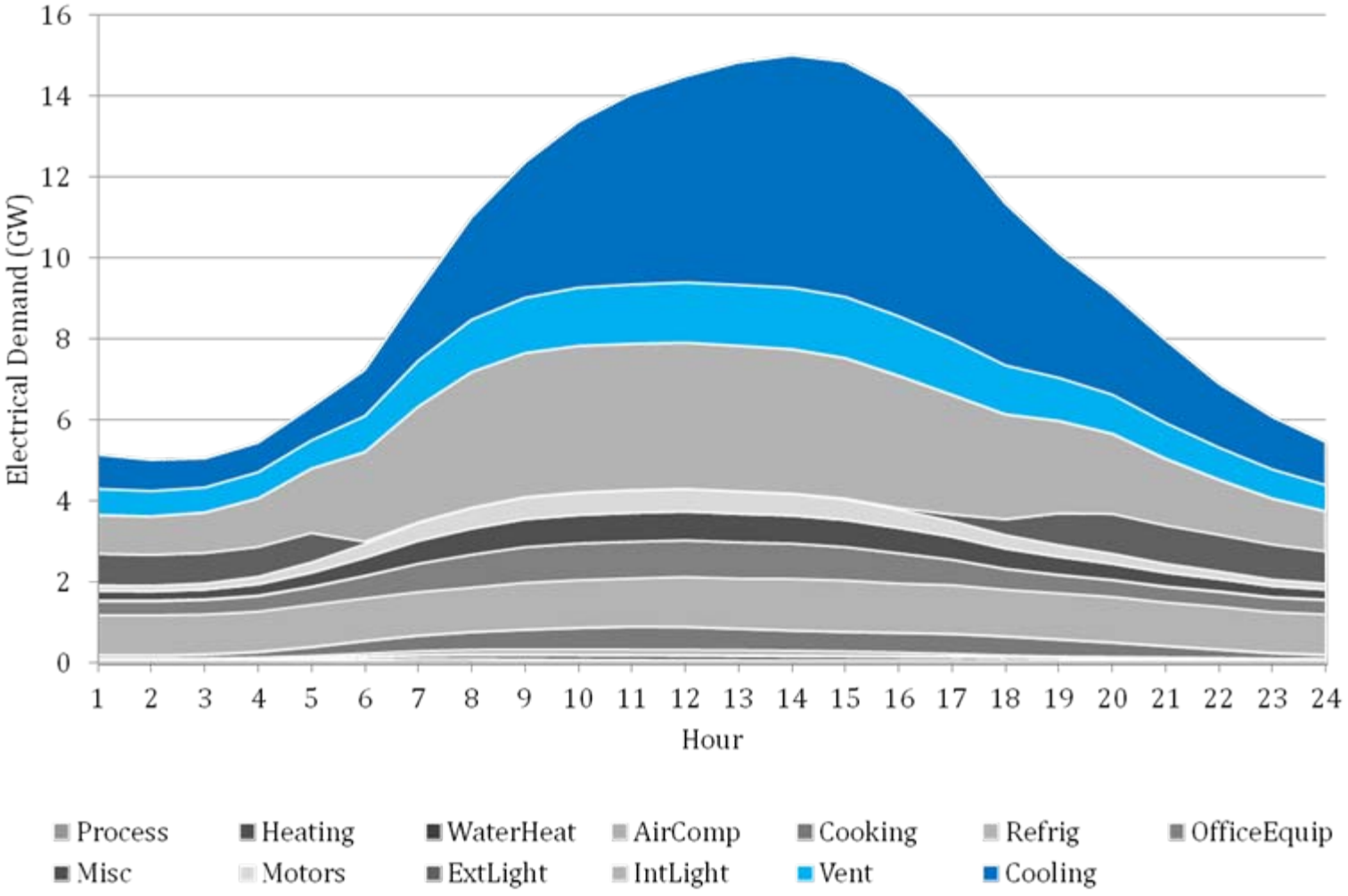
ACEEE National Conference on Energy Efficiency as a Resource

September 27, 2011

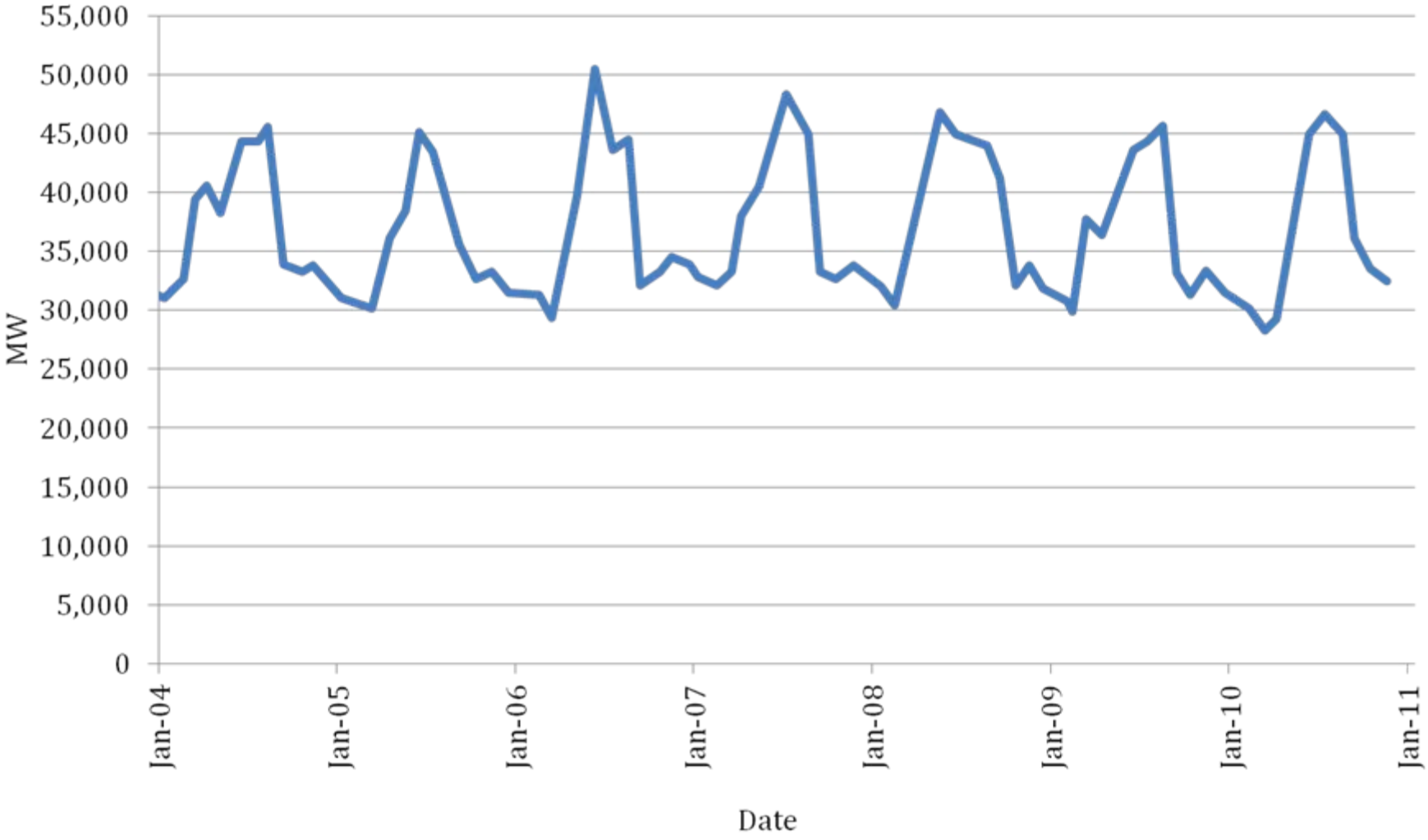
Cooling Contribution to Energy Use

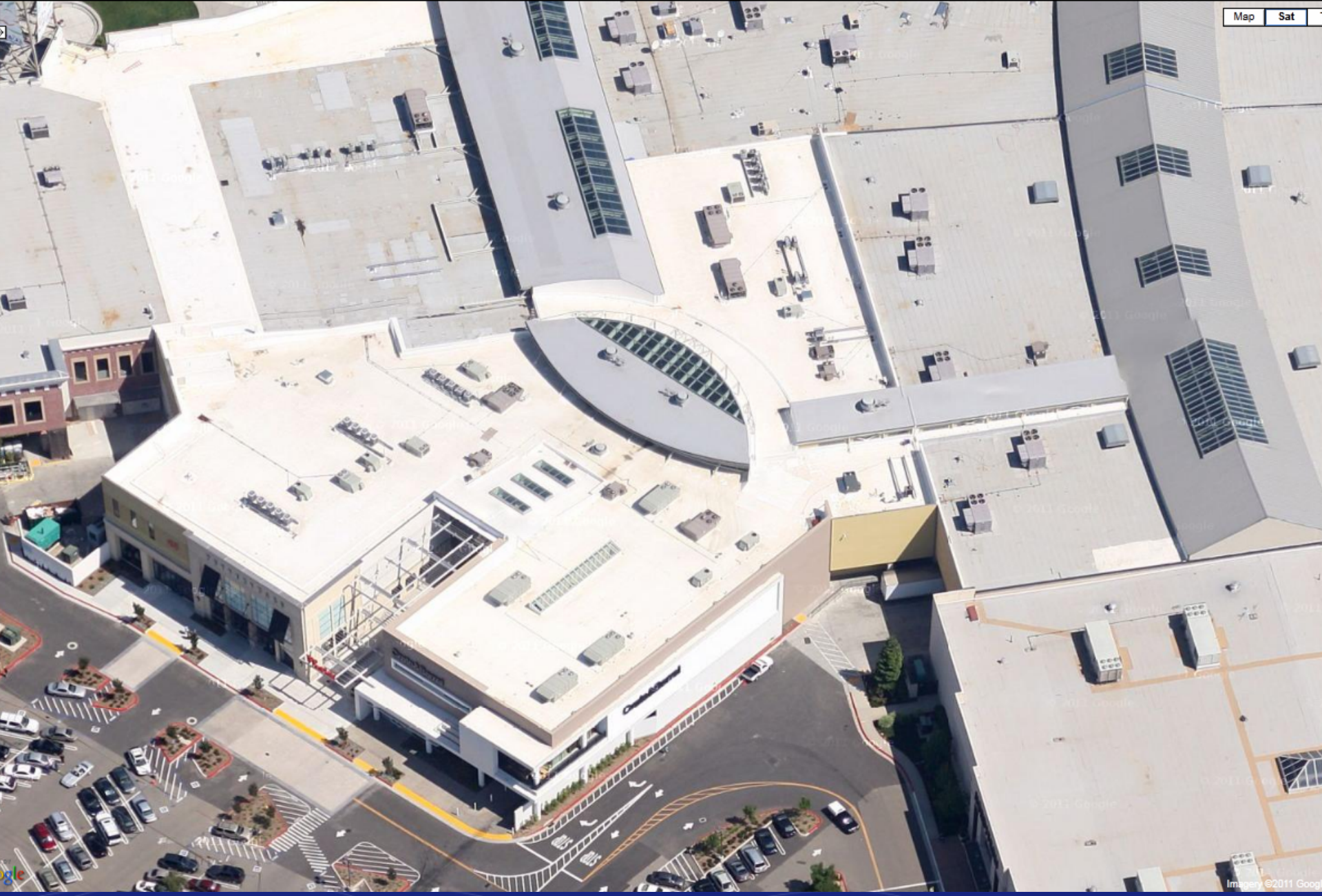


Cooling Contribution to Peak



The Peak Demand Problem




Map
Sat
Imagery ©2011 Google

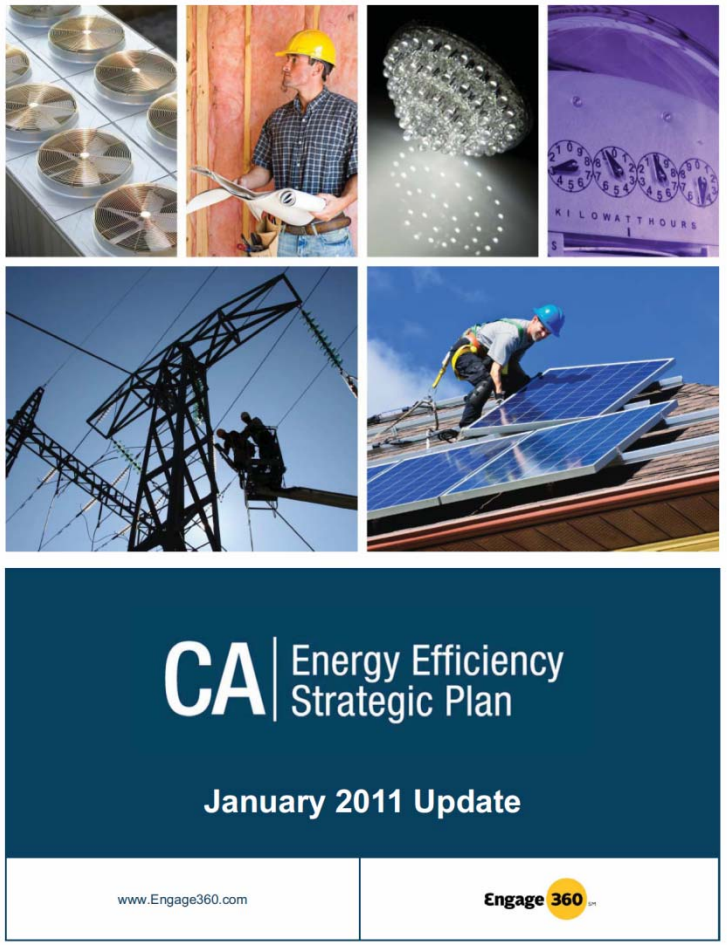
So Many Efficiency Improvements for Conventional Rooftop Units

- VFD fan conversion, part-capacity operation
- Multi-stage, part-load compressor operation
- Demand controlled ventilation
- Advanced economizer controls
- Extended fan run time
- High sensible heat ratios
- Fan motor efficiency
- Electronically controlled expansion valves
- Evaporative condenser pre-coolers
- Indirect evaporative cooling addition
- Maintenance!
- Fault Detection


National Renewable Energy Laboratory Visitors Center

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
- Western HVAC Performance Alliance crafting HVAC action plan

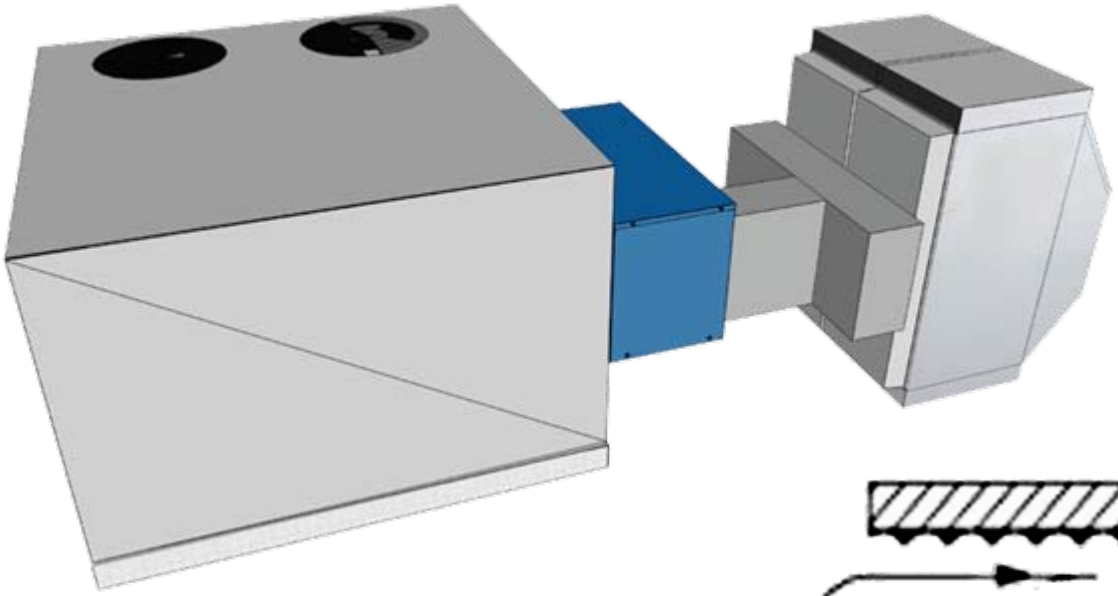


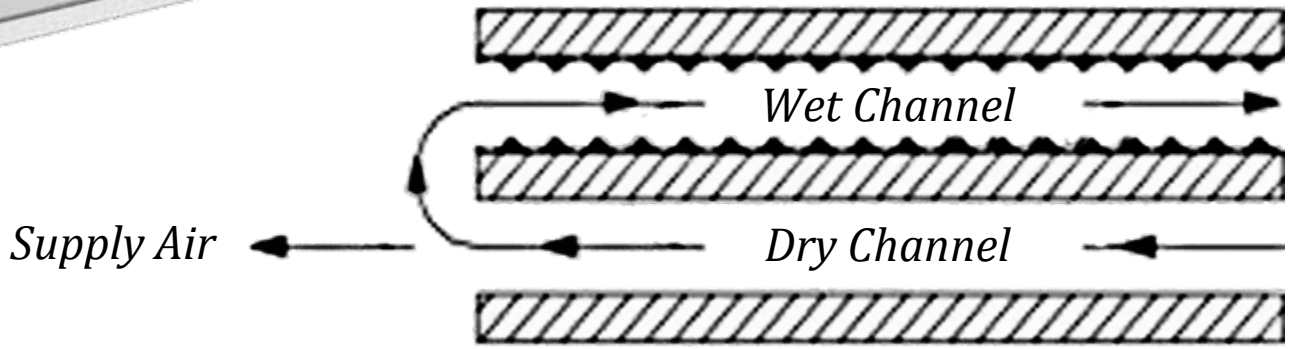
What is '*Climate Appropriate*'?

'*Climate Appropriate*' Improvements Evaporative Condenser Air Coolers

- Reduces refrigerant condenser temperature
- Lowers head pressure
- Reduces compressor power

'*Climate Appropriate*' Improvements
Indirect Evaporative Cooling






UCDAVIS
WESTERN COOLING CHALLENGE
CERTIFIED

UCDAVIS
UNIVERSITY OF CALIFORNIA

WCEC
WESTERN COOLING EFFICIENCY CENTER

Minimum Performance Criteria

	Western Cooling Challenge Peak	Western Cooling Challenge Annual
Outside Air Condition *Tdb°F/Twb°F* (°C)	105/73 (40.6/22.8)	90/64 (32.2/17.8)
Return Air Condition *Tdb°F/Twb°F* (°C)	78/64 (25.6/17.8)	78/64 (25.6/17.8)
Outdoor Ventilation *cfm/nominal-ton* (*L/s-kW*)	120 (16.1)	120 (16.1)
External Static In WC (*Pa*)	.7 (174)	.7 (174)
Minimum Sensible Credited Capacity *% of nominal*	NA	80%
Minimum Sensible Credited EER *kbtu/kWh (COP)*	**14 (4.1)**	**17 (5.0)**
Maximum Water Use *gal/nominal-ton-hr* (*L/kJ*)	NA	4 (.24)
Maximum Supply Air Humidity *lb/lb* or *g/g*	.0092	.0092

Western Cooling Challenge Advances *Hybrid* Rooftop Packaged Units

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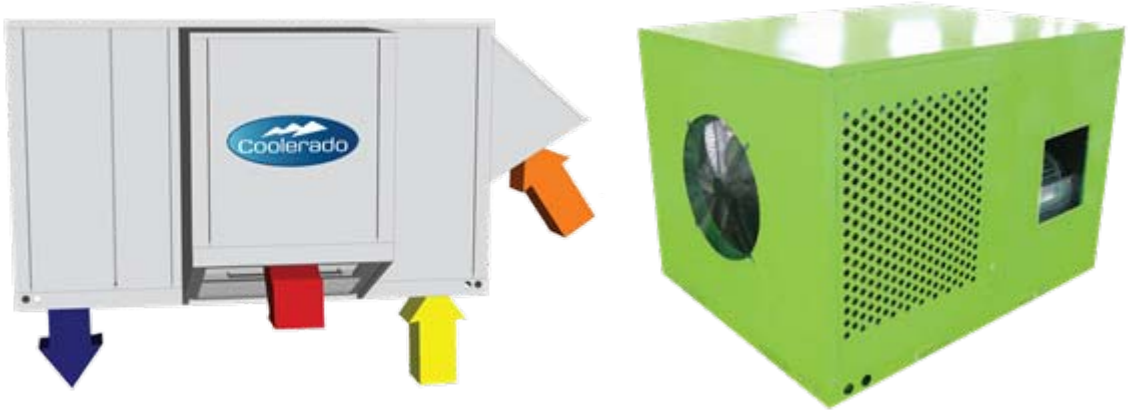
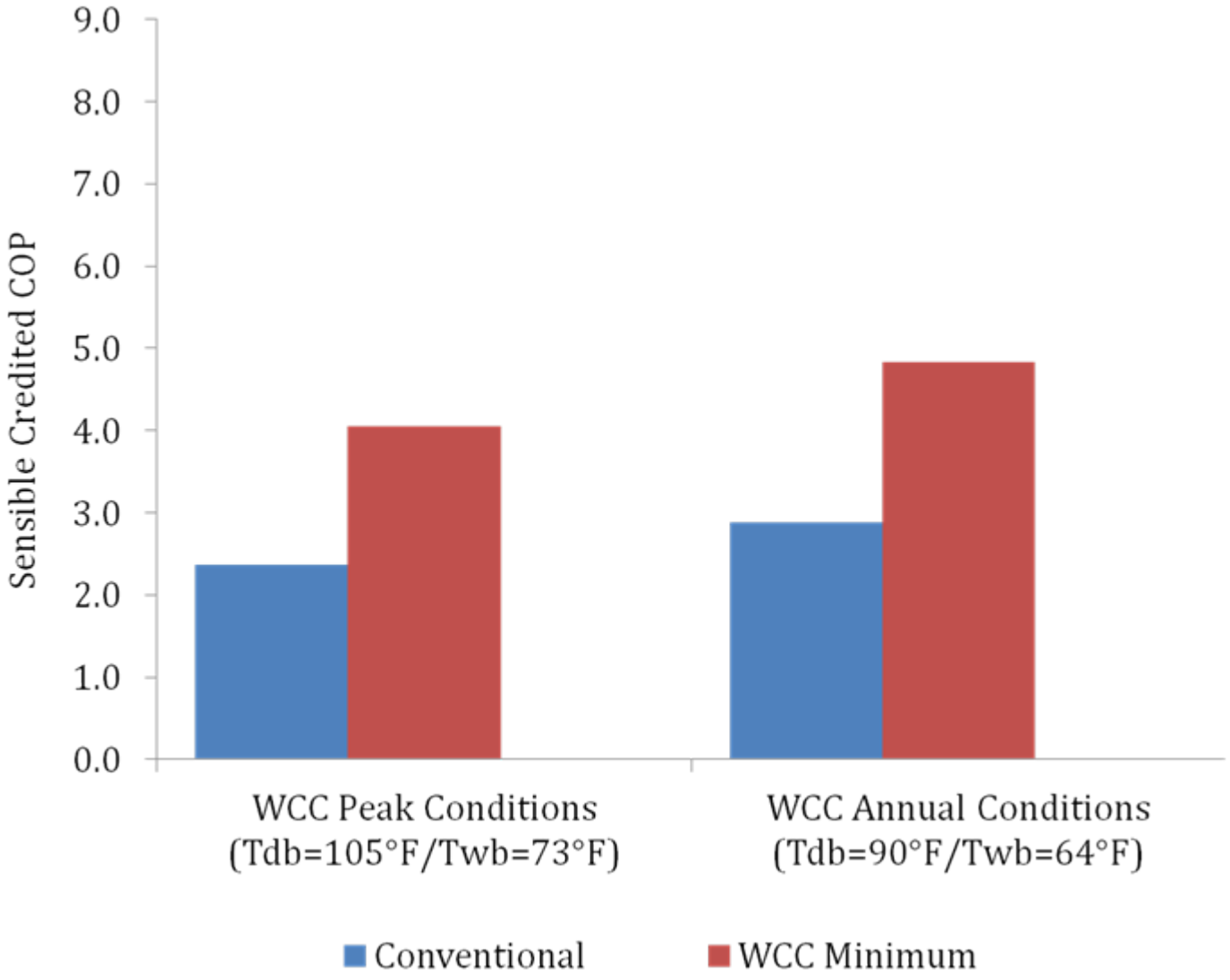


- Ongoing multiple winner competition
- Minimum 40% improvement over federal standards
- Encourages commercialization of climate appropriate technologies optimized for Western United States
- Various system architectures - indirect evaporative plus high efficiency vapor compression

Minimum Performance Criteria



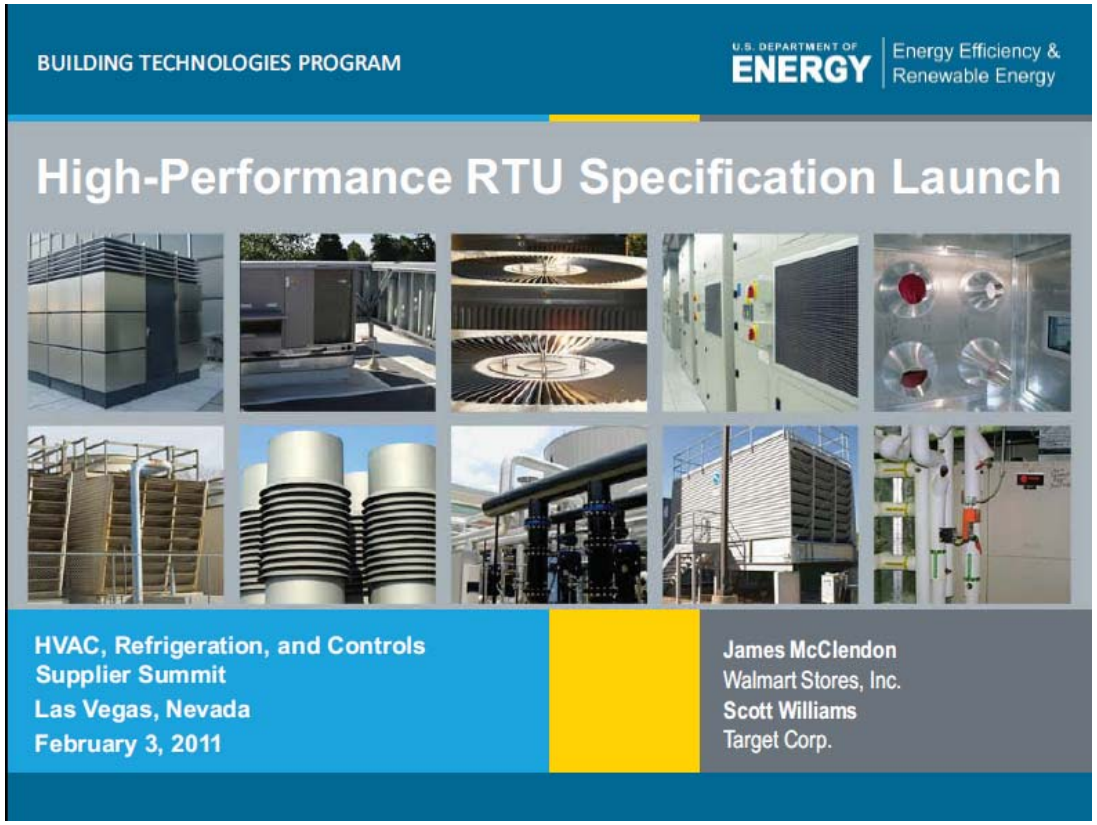
Advantages of Hybrid Cooling

- Various system architecture opportunities!
- Electricity demand, energy consumption and carbon footprint for space cooling cut by over 50%
- Capable of providing the comfort of standard AC system in any California Climate Zone
- Flexible – can be used in new systems and as a retrofit component
- Improved ventilation -100% fresh air operation in hot dry conditions at low cost
- Reduced water consumption relative to IDEC systems
- Water is a renewable cooling resource – on-site waste water could be used for evaporation

Western Cooling Challenge Advances Commercial Production

- Minimum production capacity
- Warranty equipment
- Provide laboratory testing
- Conduct field evaluations
- Support market introduction
- Advocate for application of certified technologies

DOE Advanced RTU Challenge



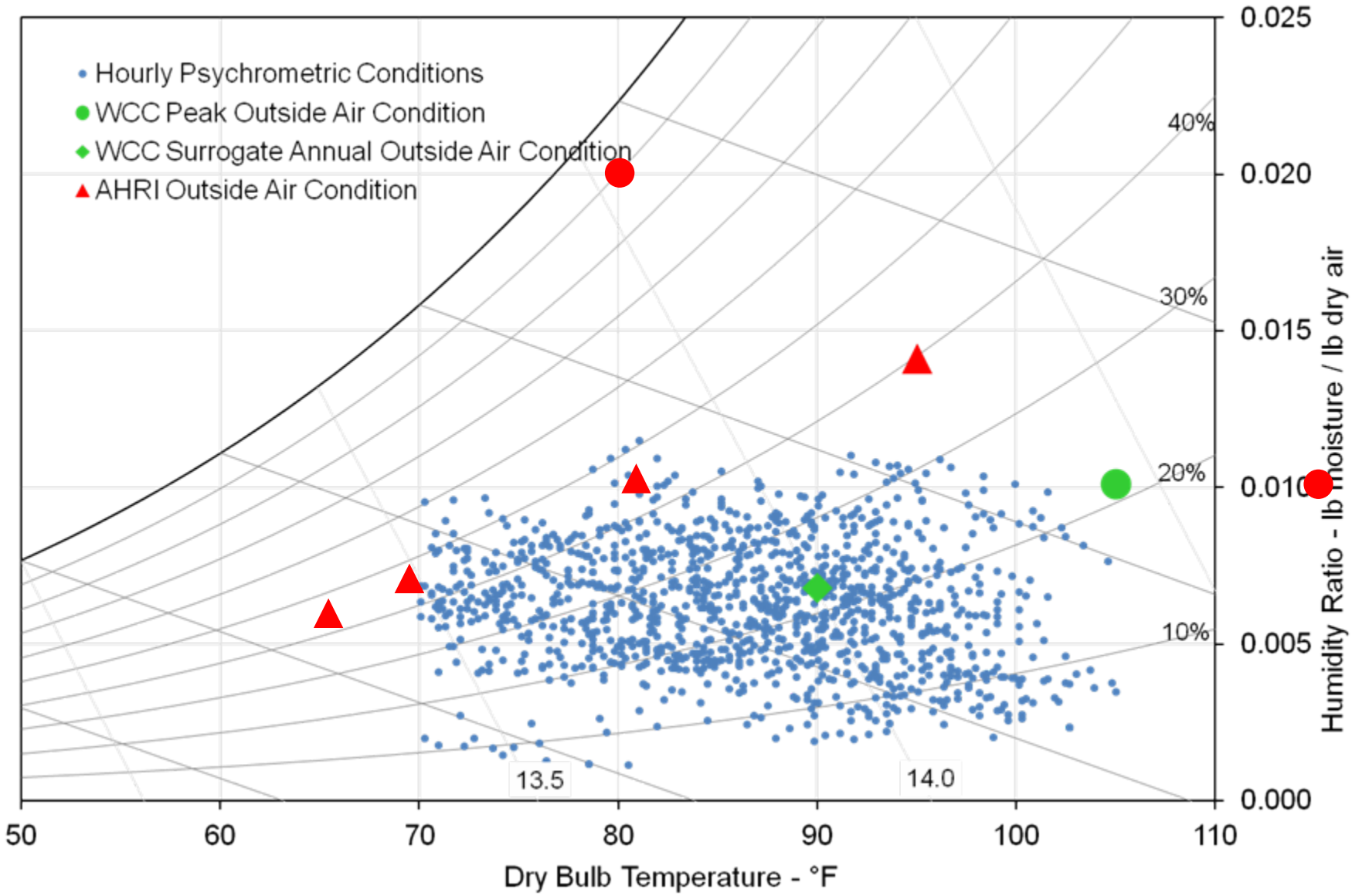
- Minimum IEER=18
- Explicit specifications

Energy Efficiency Ratio - EER

- Common metric, AHRI Standard 340/360
- 95°F db and 75°F wb outdoor air conditions
- 80°F db and 67°F wb return air conditions
- Representative of efficiency at peak
- Does not represent how equipment might save energy at part load
- Not a climate specific metric

Integrated Energy Efficiency Ratio - IEER

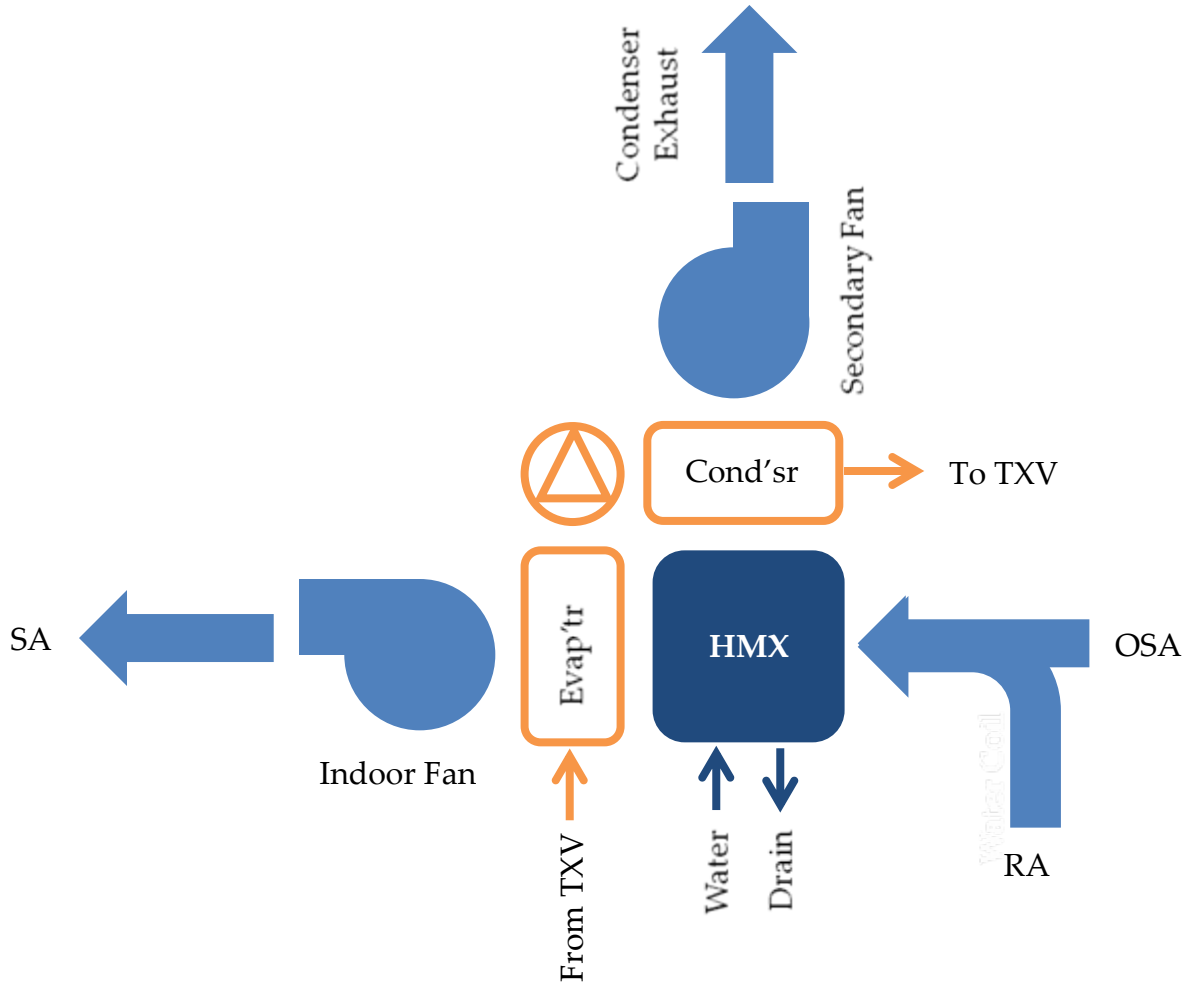
- Aggregate of performance measured at multiple meteorological conditions and part load operating modes
- Weighted for time operating in each scenario
- Not a climate specific metric


Hourly Psychrometric Conditions
WCC Peak Outside Air Condition
WCC Surrogate Annual Outside Air Condition
AHRI Outside Air Condition
40%
30%
20%
10%
13.5
14.0
0.025
0.020
0.015
0.010
0.005
0.000
Humidity Ratio - lb moisture / lb dry air
50
60
70
80
90
100
110
Dry Bulb Temperature - °F

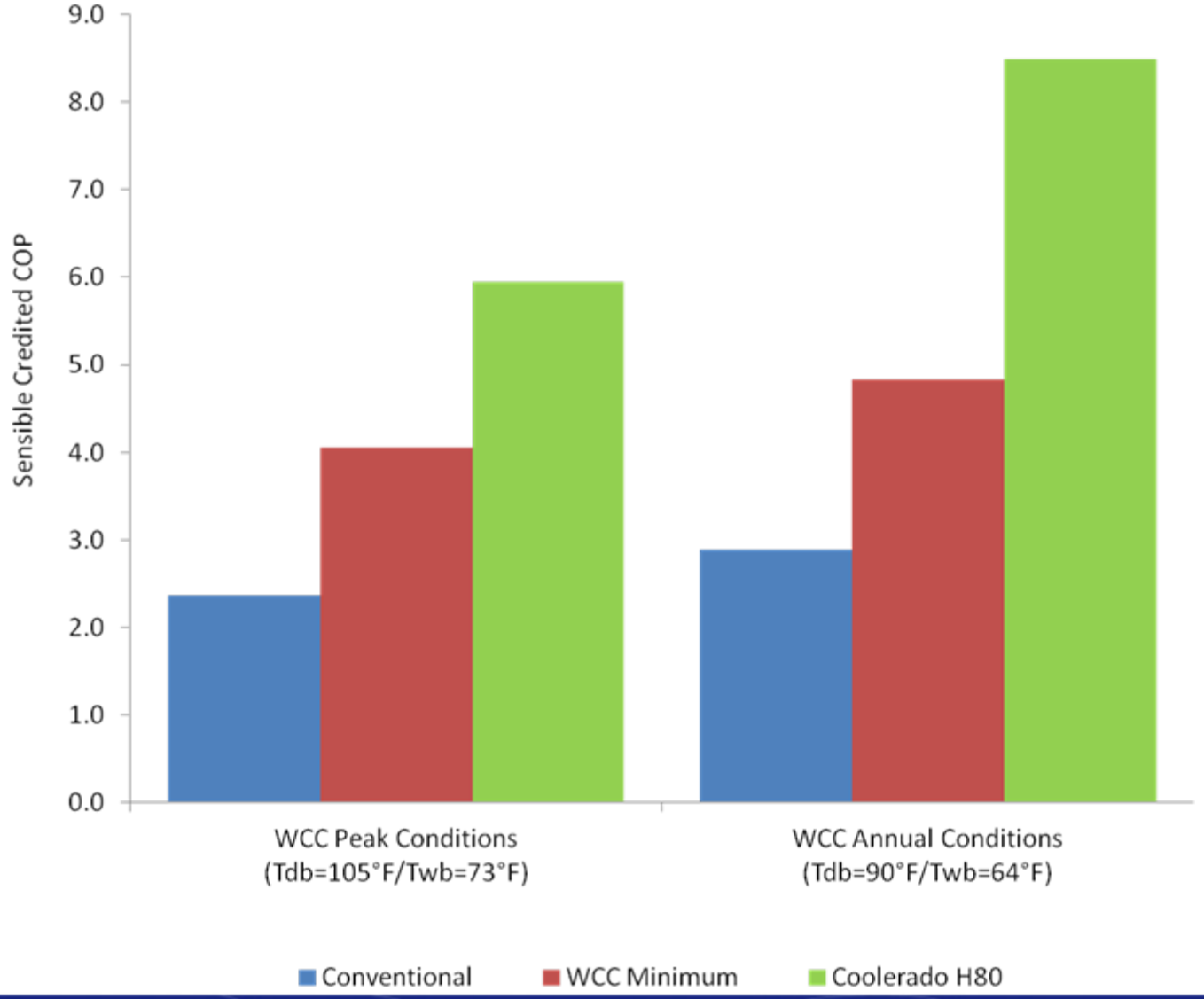
A success story

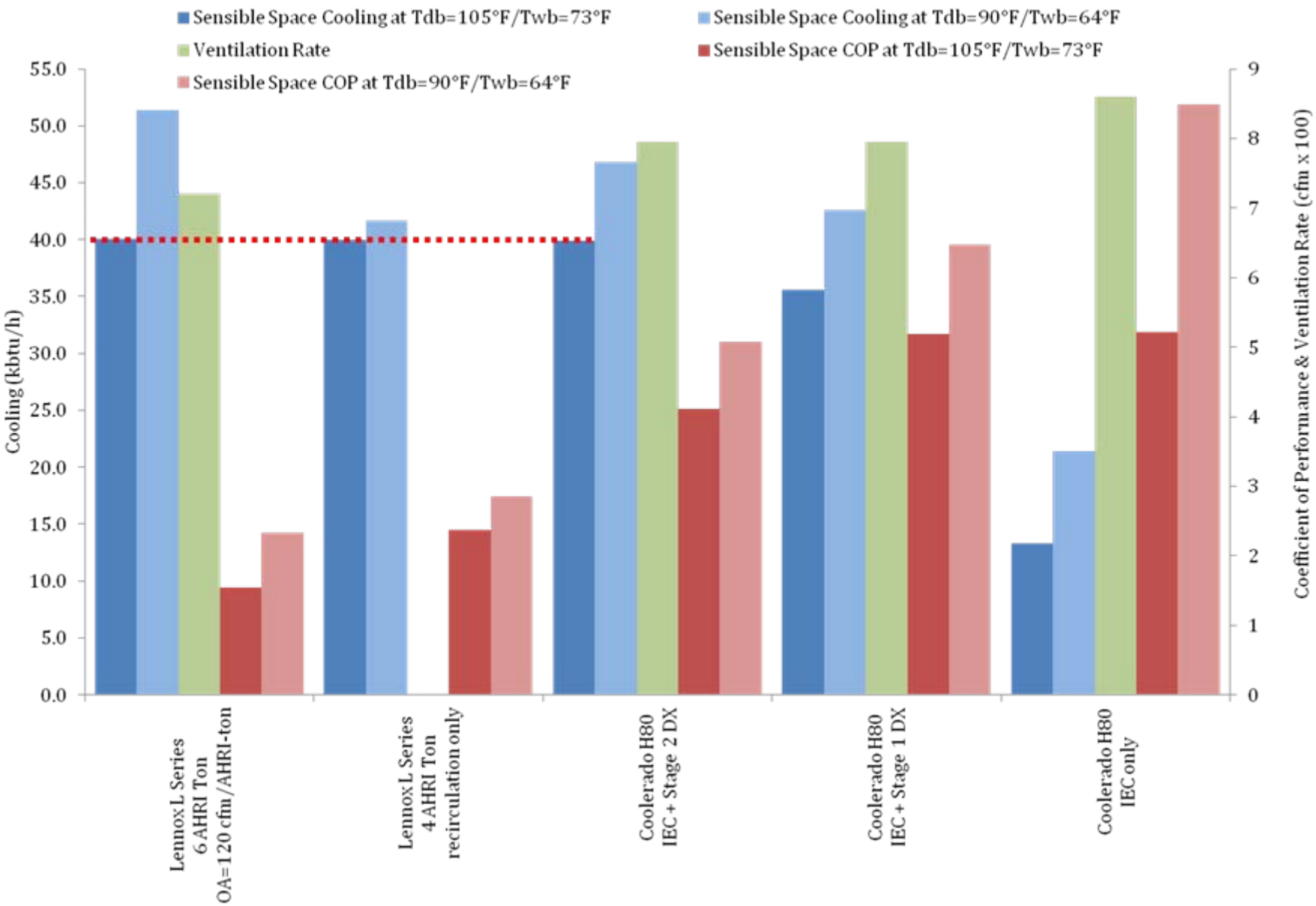

Coolerado®

Coolerado H80

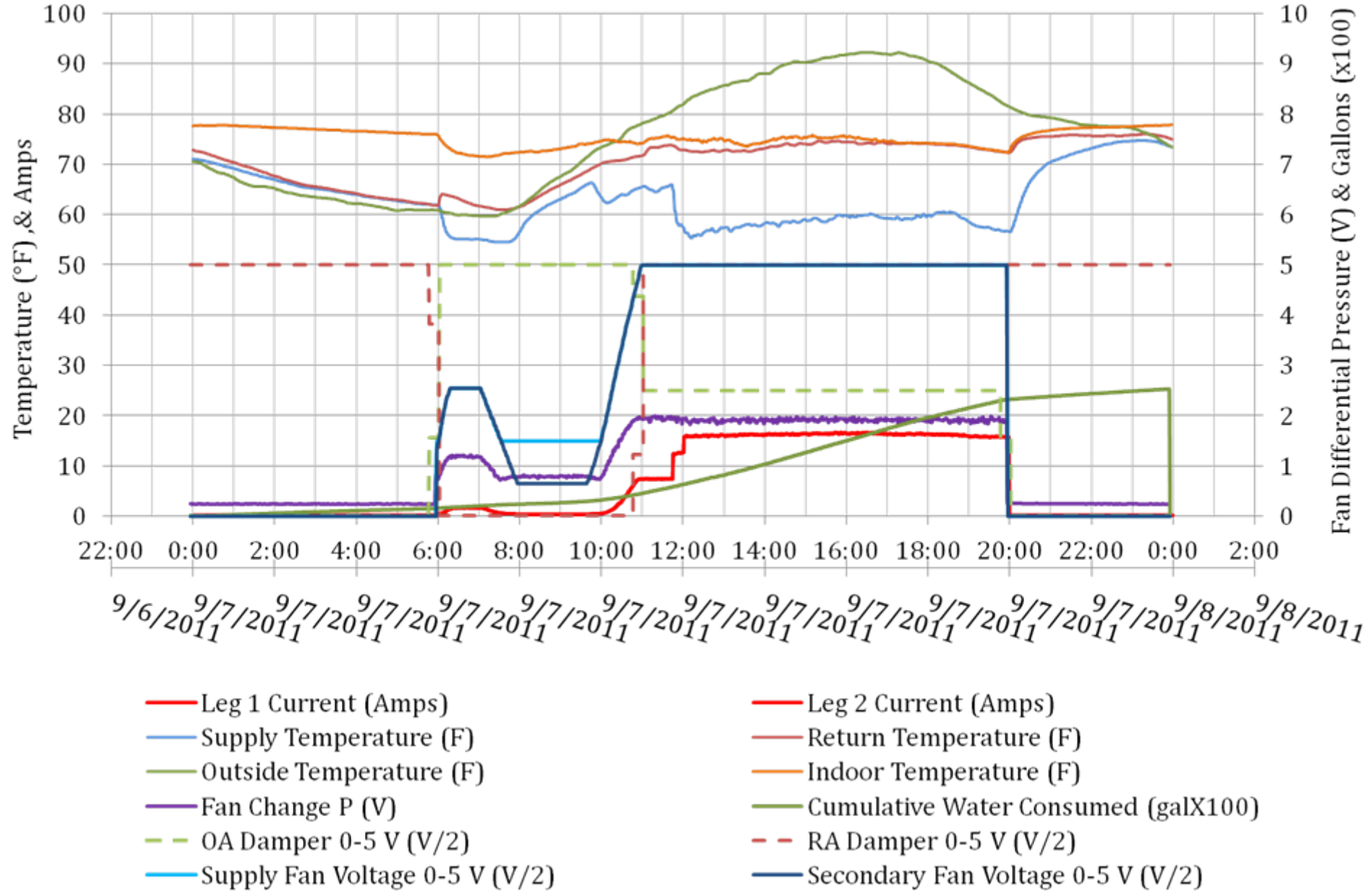


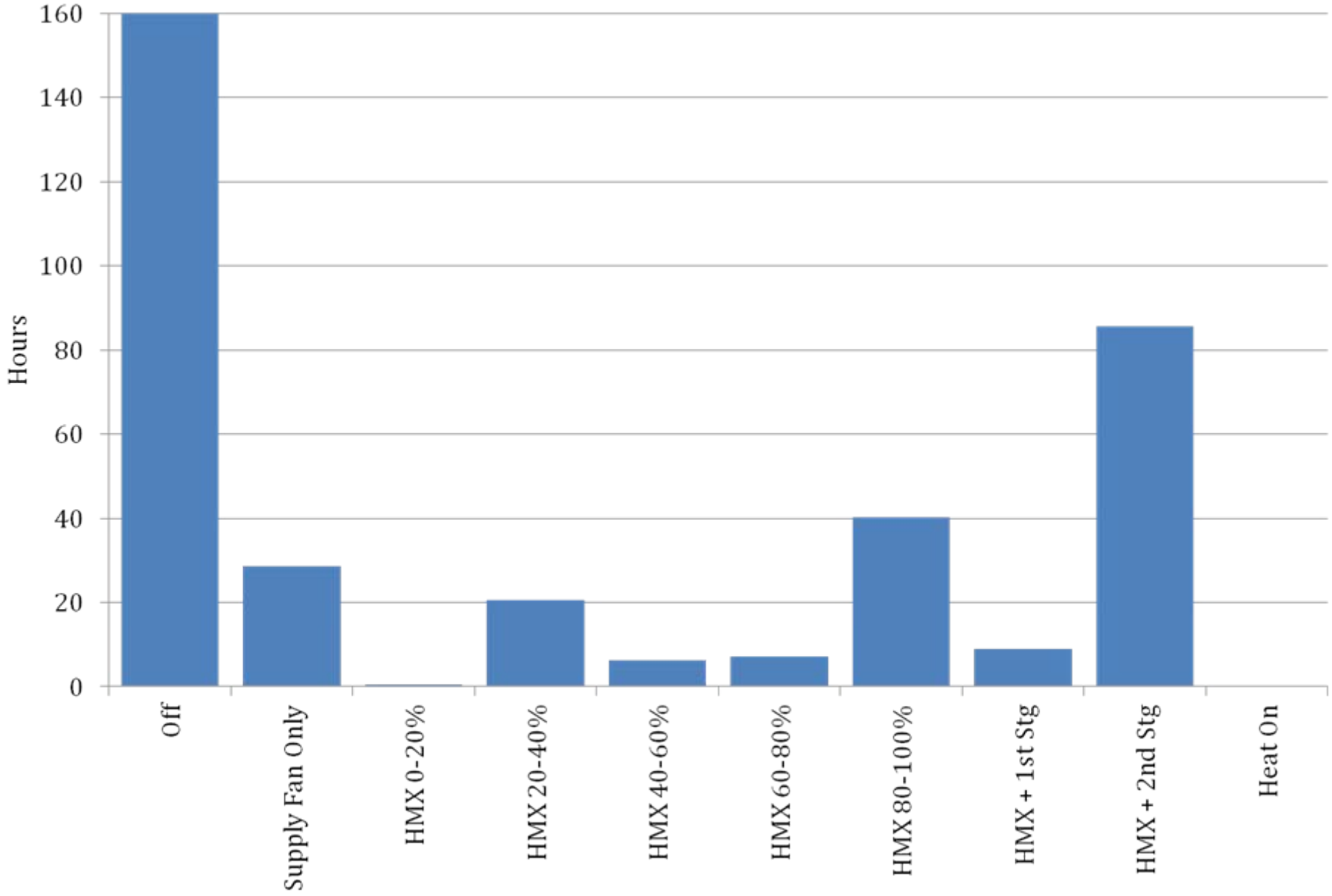
Minimum Criteria Exceeded

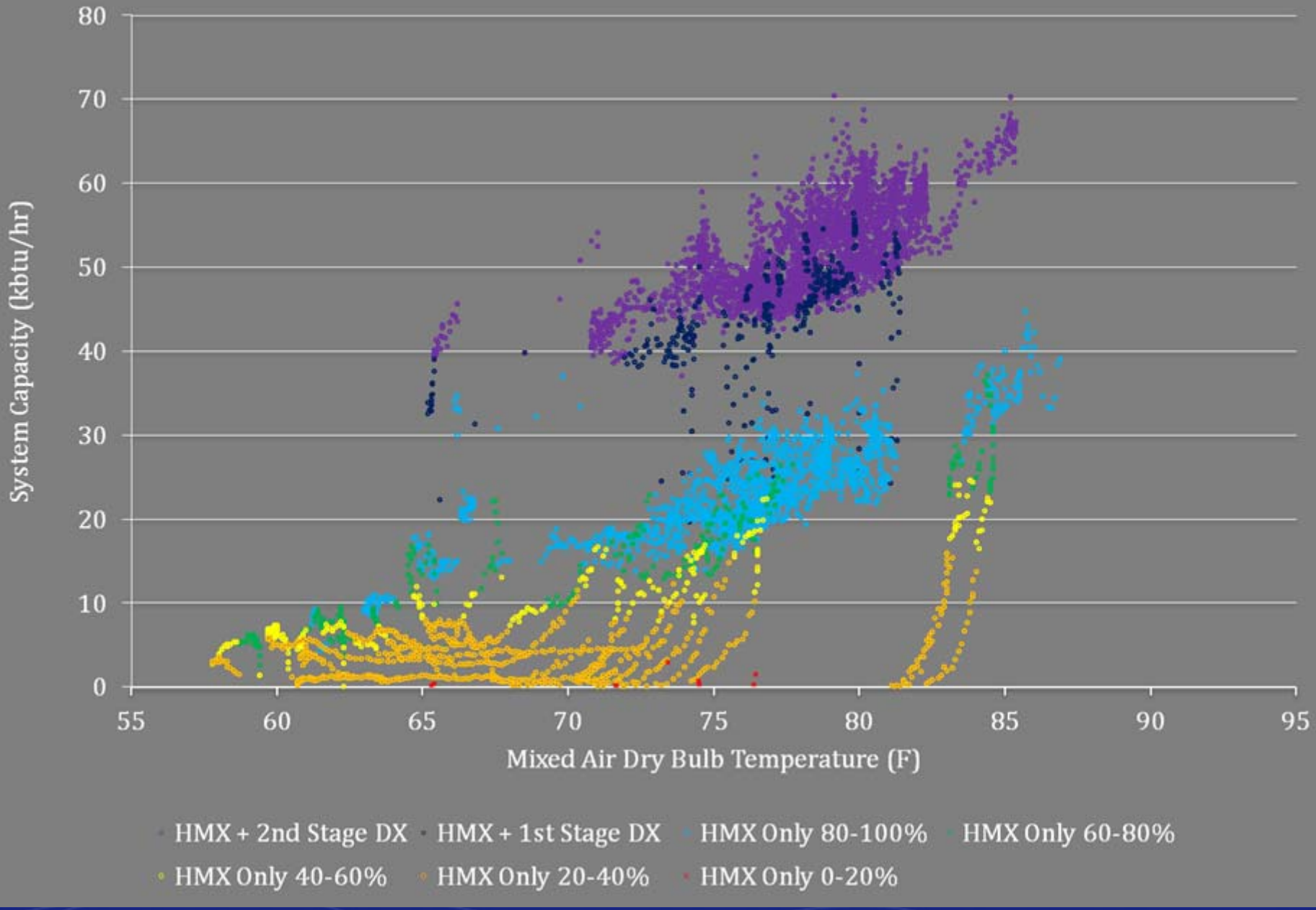


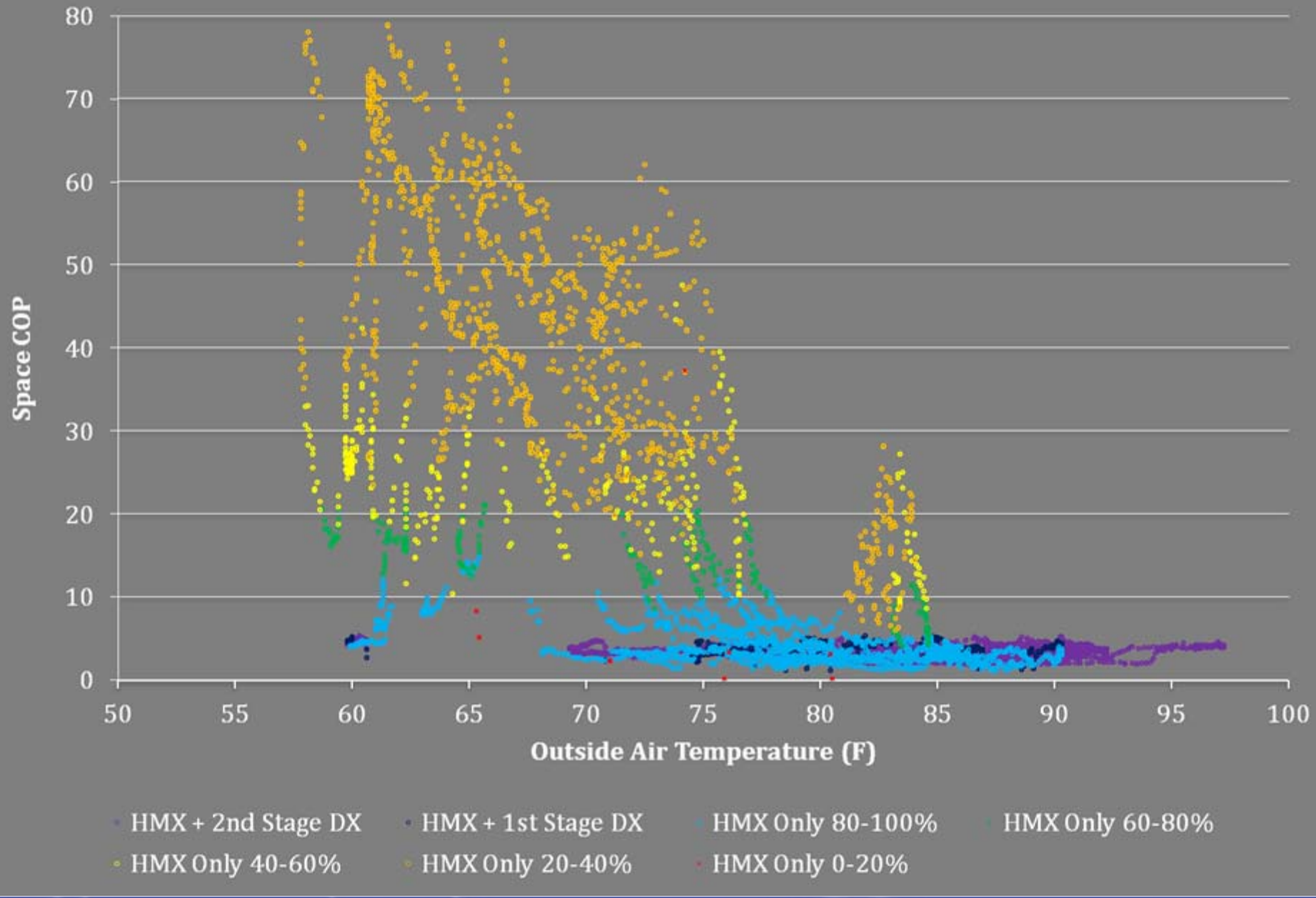

Sensible Space Cooling at Tdb=105°F/Twb=73°F
Sensible Space Cooling at Tdb=90°F/Twb=64°F
Ventilation Rate
Sensible Space COP at Tdb=105°F/Twb=73°F
Sensible Space COP at Tdb=90°F/Twb=64°F
Cooling (kbtu/h)
Coefficient of Performance & Ventilation Rate (cfm x 100)
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
9
8
7
6
5
4
3
2
1
0
Lennox L Series 6 AHRI Ton OA=120 cfm/AHRI-ton
Lennox L Series 4 AHRI Ton recirculation only
Coolerado H80 IEC + Stage 2 DX
Coolerado H80 IEC + Stage 1 DX
Coolerado H80 IEC only


Coolerado
bryant


Temperature (°F) ,& Amps
Fan Differential Pressure (V) & Gallons (x100)
100
90
80
70
60
50
40
30
20
10
0
10
9
8
7
6
5
4
3
2
1
0
22:00
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
2:00
9/6/2011
9/7/2011
9/8/2011
Leg 1 Current (Amps)
Leg 2 Current (Amps)
Supply Temperature (F)
Return Temperature (F)
Outside Temperature (F)
Indoor Temperature (F)
Fan Change P (V)
Cumulative Water Consumed (galX100)
OA Damper 0-5 V (V/2)
RA Damper 0-5 V (V/2)
Supply Fan Voltage 0-5 V (V/2)
Secondary Fan Voltage 0-5 V (V/2)

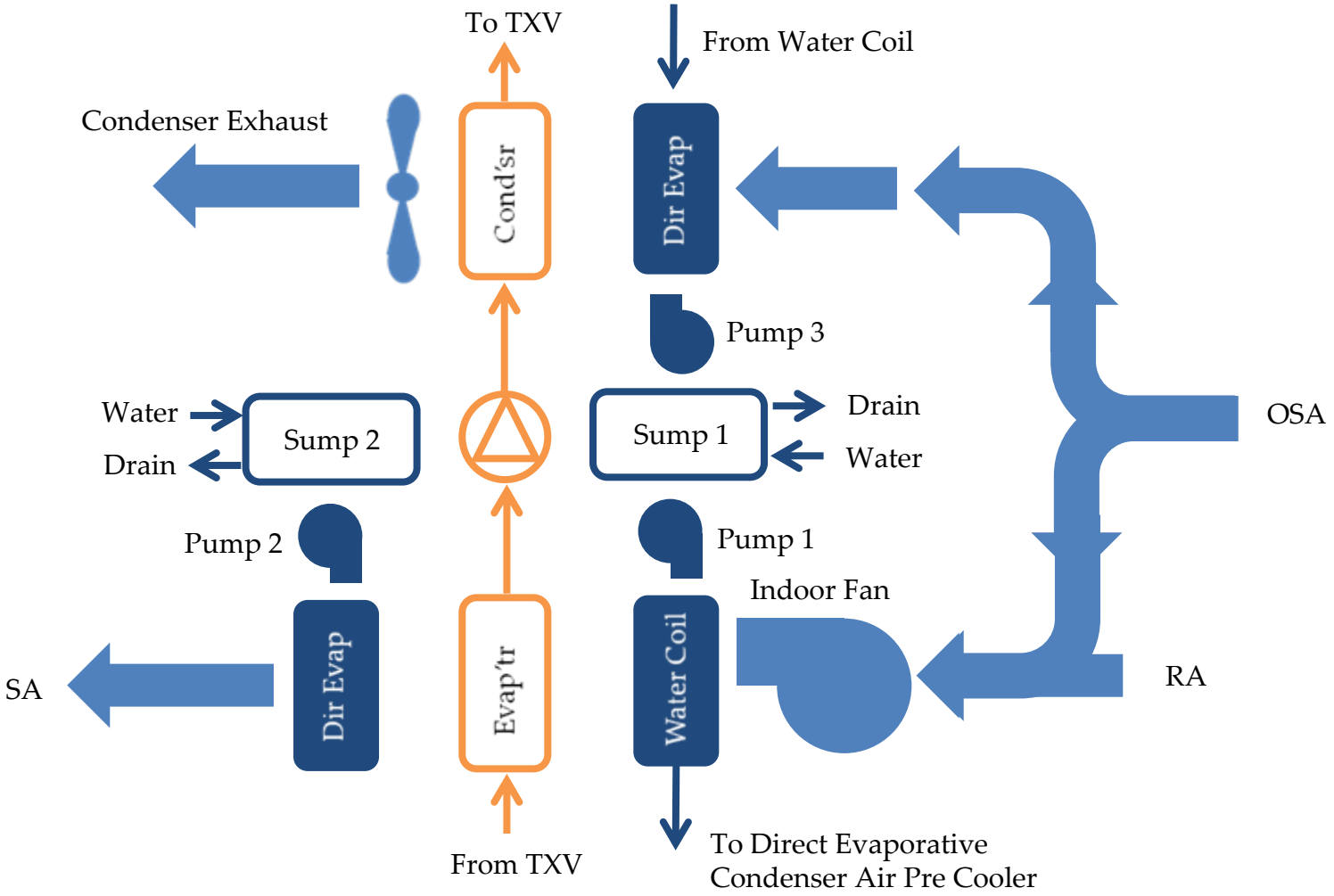

Hours
160
140
120
100
80
60
40
20
0
Off
Supply Fan Only
HMX 0-20%
HMX 20-40%
HMX 40-60%
HMX 60-80%
HMX 80-100%
HMX + 1st Stg
HMX + 2nd Stg
Heat On


System Capacity (kbtu/hr)
80
70
60
50
40
30
20
10
0
55
60
65
70
75
80
85
90
95
Mixed Air Dry Bulb Temperature (F)
HMX + 2nd Stage DX
HMX + 1st Stage DX
HMX Only 80-100%
HMX Only 60-80%
HMX Only 40-60%
HMX Only 20-40%
HMX Only 0-20%


Space COP
80
70
60
50
40
30
20
10
0
50
55
60
65
70
75
80
85
90
95
100
Outside Air Temperature (F)
HMX + 2nd Stage DX
HMX + 1st Stage DX
HMX Only 80-100%
HMX Only 60-80%
HMX Only 40-60%
HMX Only 20-40%
HMX Only 0-20%

A Failure

Speakman Air$_2$O Quattro



18V

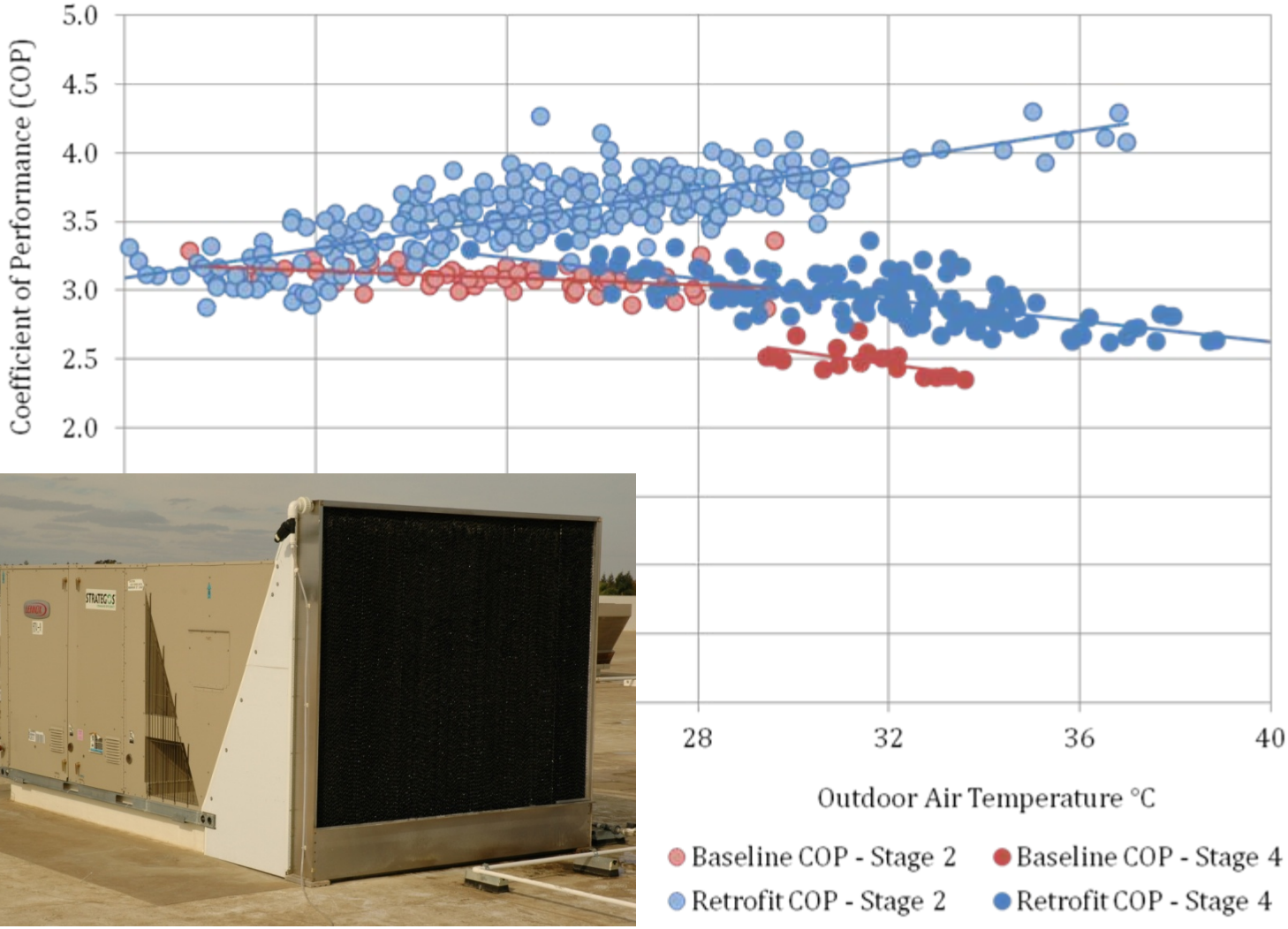
A Breakthrough

TRANE®

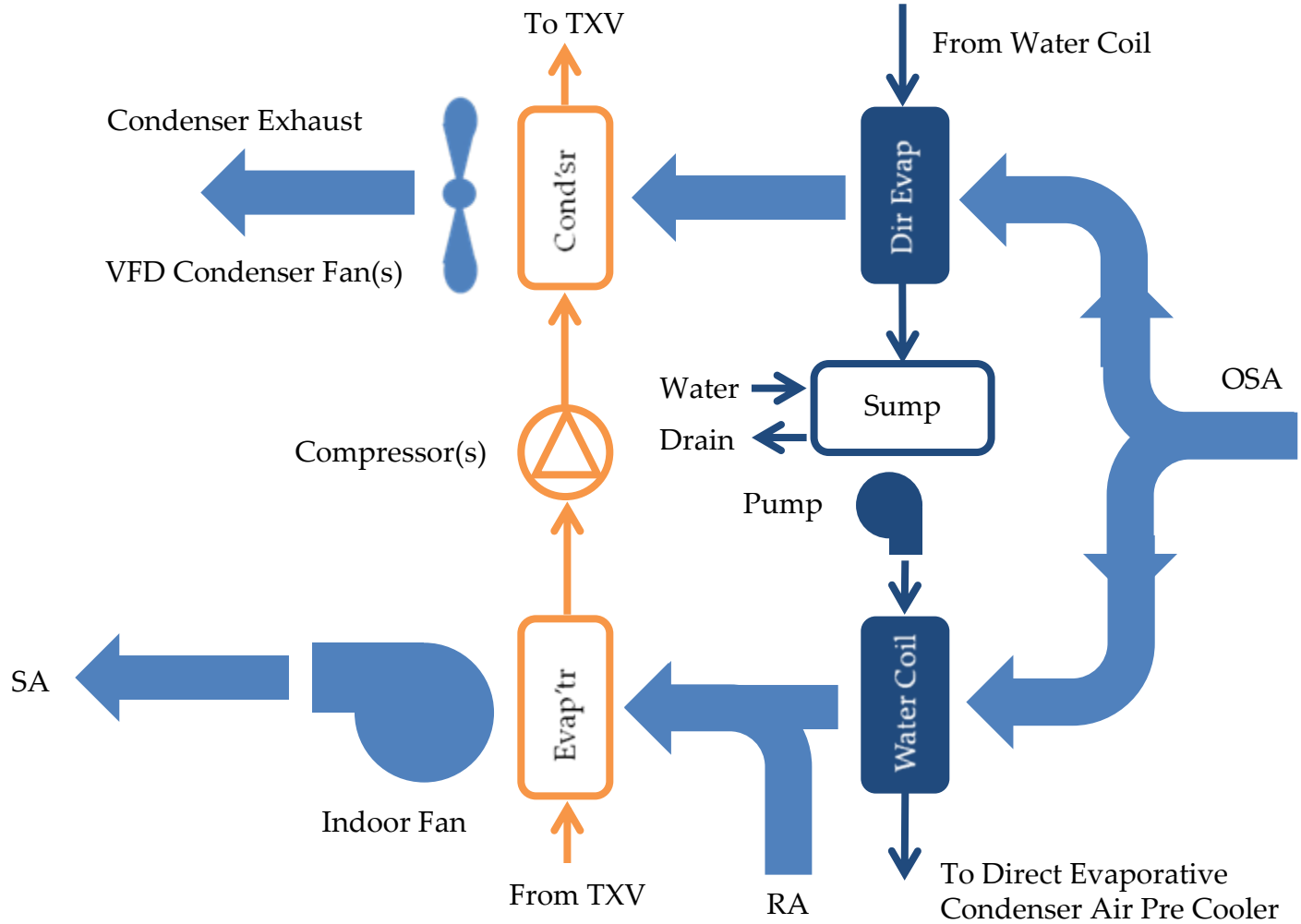
RTU Retrofits for Retail Buildings

- Condensate capture and recycling
- Evaporative cooling for refrigeration condenser
- Hybrid cooling retrofit for rooftop packaged units

Dual Cool Testing



Trane Voyager DC



Laboratory Testing

Western Cooling Challenge is Ongoing

- Laboratory and field testing
- Market introduction
- Incremental improvements to equipment
- Additional participants

Jonathan Woolley, jmwoolley@ucdavis.edu
Western Cooling Efficiency Center, wcec.ucdavis.edu