Today's Program

8:30-9:00am:	Breakfast
9:00-10:00am:	Welcome Introduction and WCEC Year in Review Mark Modera, WCEC Director
10:00-11:00am:	Recent Developments on California Energy Policy Nancy Skinner, State Assembly
11:00-1:00pm:	Flexible Lunch: WCEC Poster Session and Laboratory Tour
1:00-2:30pm:	Affiliate Highlight Session Jim McClendon - Walmart Amit Gupta - Aeroseal Matt Scully - Seeley
2:30-3:00pm:	BREAK
3:00-3:30pm:	Market Barriers to HVAC Retrofit Technologies Sarah Outcault, Behavioral Scientist, WCEC
3:30-4:00pm:	WCEC Future Research: Vinod Narayanan, Associate Director & Theresa Pistochini, Eng Manager
4:00pm:	Adjourn
5:00pm:	Complimentary Dinner - Seasons Restaurant, Davis, CA

WCEC AFFILIATES FORUM 2016

WCEC YEAR IN REVIEW

Mark Modera

WCEC MISSION

"Accelerate the development and commercialization of efficient heating, cooling, and energy distribution solutions through stakeholder engagement, innovation, R&D, education, and outreach."

WCEC Team

Departures

- None

Arrivals

- **Maru Fernandez (Financial Analyst)**
- Currently recruiting additional engineering staff
- Currently recruiting new Director for Energy Efficiency Center
- **Recently hired new Affiliate Relations Manager shared with EEC (Mark de Groh)**

Established April 2007
Part of the Energy Efficiency Center at UC Davis

Mark Modera	Director
Vinod Narayanan	Associate Director
Theresa Pistochini	Engineering Manager

6 Full-time Engineers
1 Behavioral Scientist
1 Post-Doc
7 Graduate Students
10 Undergrad Students
2 Support Staff

WCEC EXPERTISE

Unique Leadership in

- Climate-appropriate cooling technologies
- Evaporative cooling research
- Aerosol application of sealants
- Laboratory testing simulating hot/dry climates

Significant Expertise in

- 3rd party technology evaluation
- Modeling of buildings/systems/components
- Field monitoring of HVAC technologies
- Distribution systems for ventilation and thermal energy
- Test standards development
- Human behavior with respect to HVAC technologies
- Internet control of HVAC systems

WCEC Project Highlights

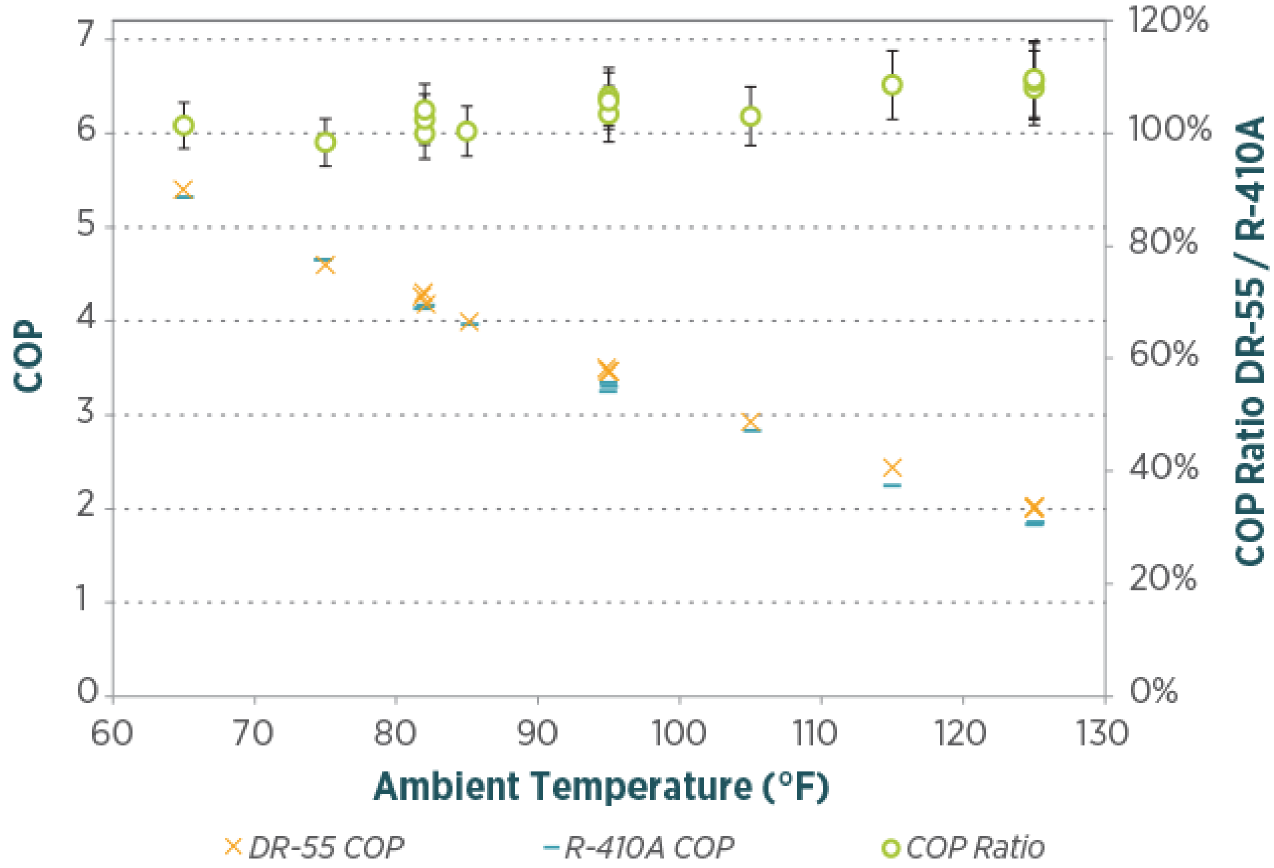
- Low Global Warming Potential Refrigerants
- Next Generation Residential HVAC
- Evaporative Cooling Technologies
- 2016 HVAC Codes and Standards Training




Refrigerant Testing (R-452B)

- First use of WCEC lab for industry- funded testing (Trane)
- "Drop In" R-410A Replacement
- Global Warming Potential (GWP) approximately 32% of R-410A
- Retrofit Process
  - Evacuate R-410A
  - Replace standard TXV with adjustable TXV
  - Charge R-452b by weight
  - Adjust TXV to superheat target
  - Adjust charge to sub-cooling target

Performance (DR-55 vs. R-410A)



- 5% Higher Efficiency at AHRI Condition (95°F)
- Similar Capacity (Less Power)
- Performance improves at high ambient temperatures

Next Generation Heat Pump Testing

Sponsored by California Energy Commission

Overall Project Objectives

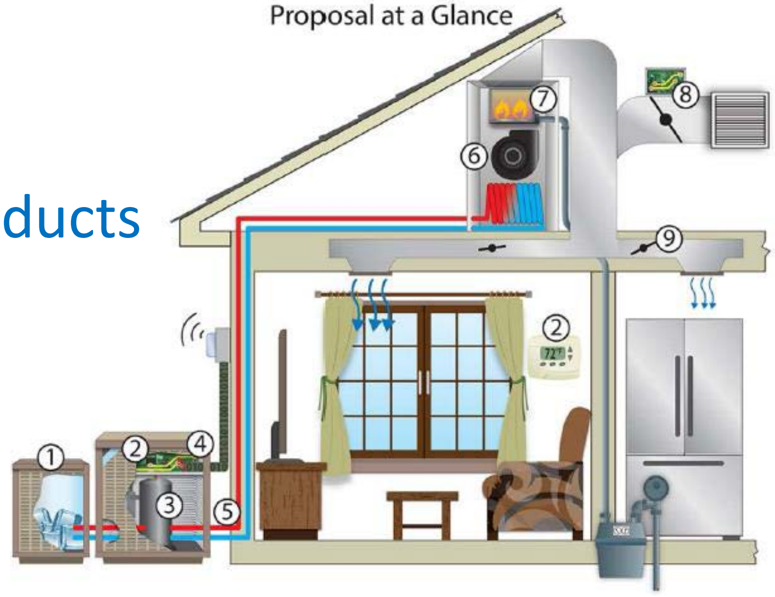
- Develop/Demonstrate residential next-gen space conditioner with variable capacity: Energy & Demand savings in California

WCEC Objectives

- Lab Testing of variable capacity equipment
  - Impact of duct system in attic
  - Impact of zoning controls
  - Impact of alternative refrigerant
- Develop/test model of equipment and ducts

Partners

- Electric Power Research Institute
- Daikin
- PG&E



Next Generation Heat Pump Testing

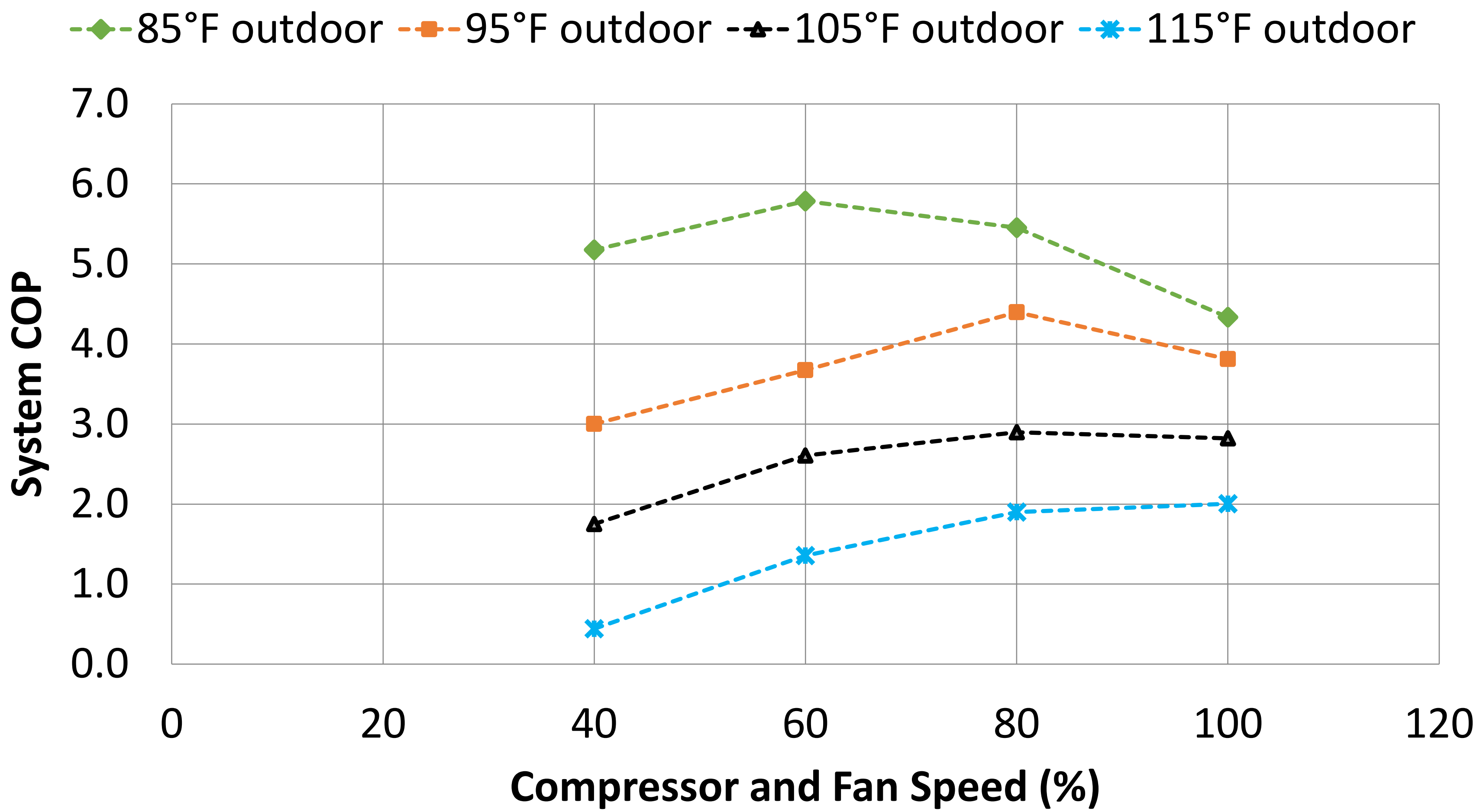
Entire duct system for actual home installed in hot chamber
(thanks to Villara for design and specs)

Residential Efficiency Definitions

Compressor-Only COP	Ratio of cooling provided by the unit to the power input to condenser (cooling provided does not include blower fan heat impact): $$COP_{comp} = \frac{(h_{RP} - h_{SP}) * \dot{m} + P_{blower}}{P_{cond}}$$
Equipment COP	Ratio of cooling provided by the unit to the total power input to equipment (cooling provided includes blower fan heat impact): $$COP_{equip} = \frac{(h_{RP} - h_{SP}) * \dot{m}}{P_{cond} + P_{blower}}$$
Duct Efficiency	Ratio of delivered sensible cooling to the sensible capacity of the unit: $$Efficiency_{duct} = \frac{T_{Room} - T_{Grille}}{T_{RP} - T_{SP}}$$
System COP	Ratio of delivered cooling to the total power input to equipment: $COP_{sys} \frac{(h_{Room} - h_{Grille})}{P_{cond} + P_{blower}}$ $COP_{sys} \sim COP_{equip} \text{ x } Efficiency_{duct}$

Next Generation Heat Pump Testing

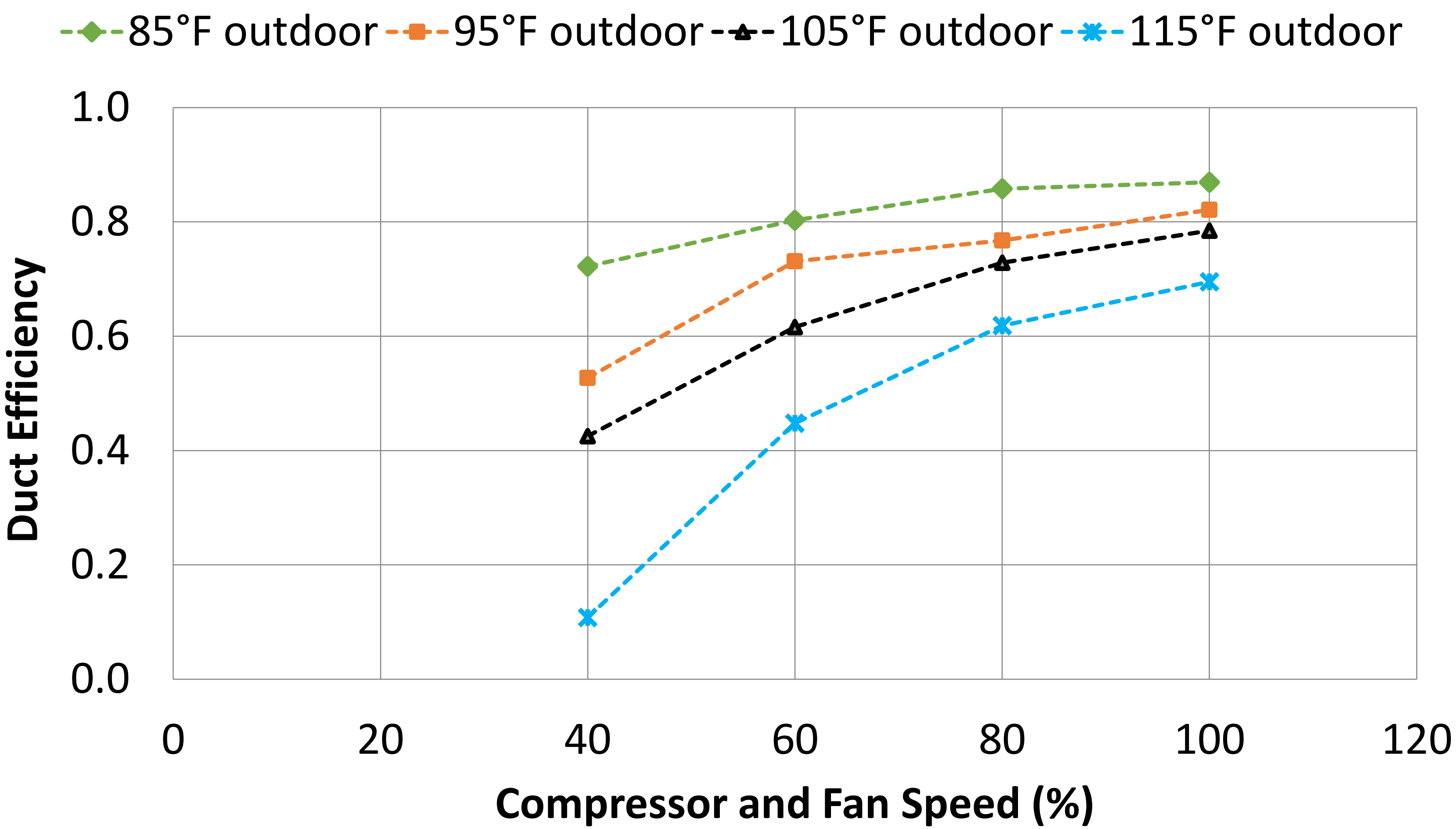
System COP vs Compressor Speed/Fan Speed (Synced)
Indoor conditions: 75°F DB /62.5°F WB



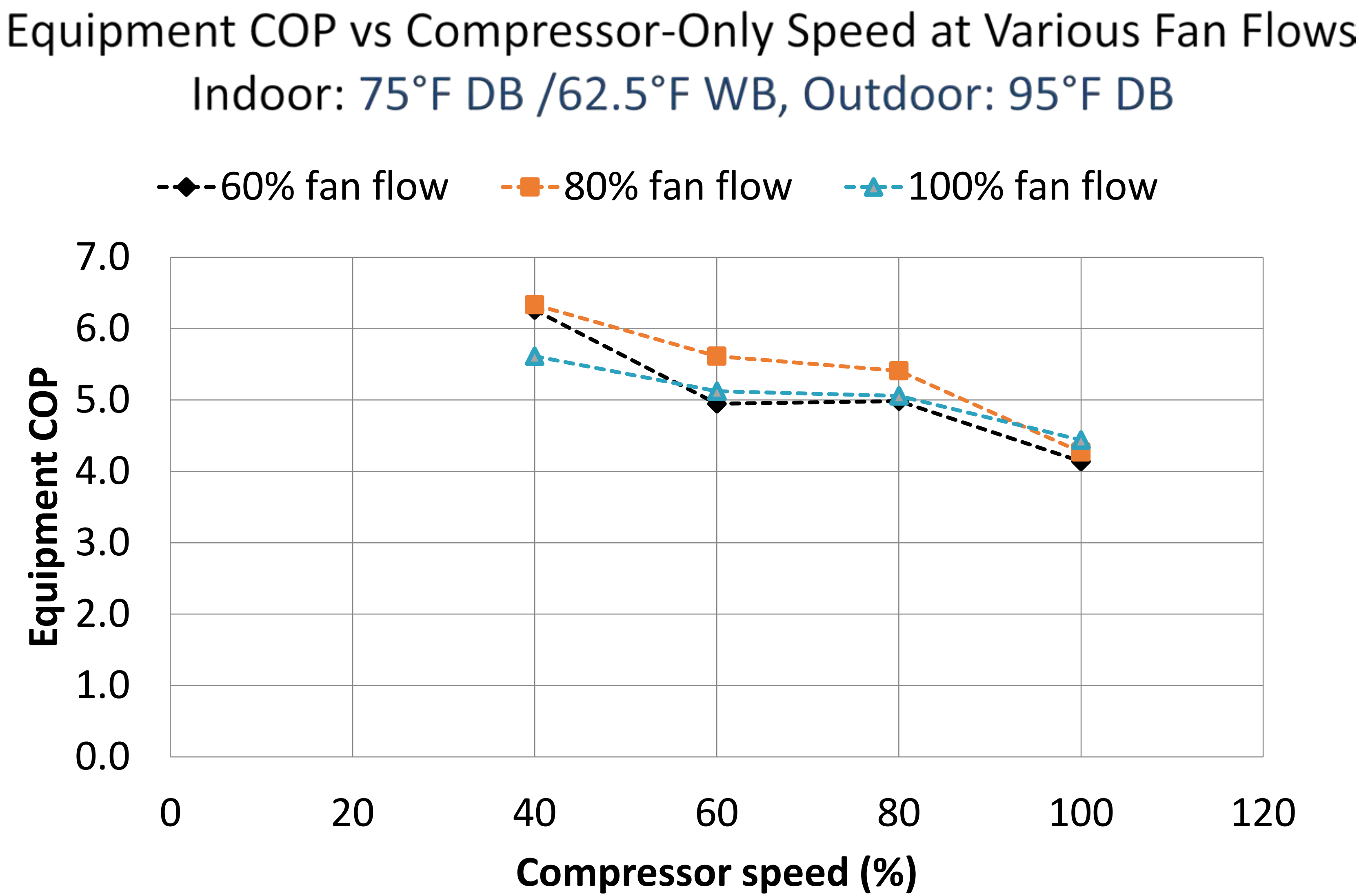
Next Generation Heat Pump Testing

Duct Efficiency vs Compressor Speed/Fan Speed (Synced)

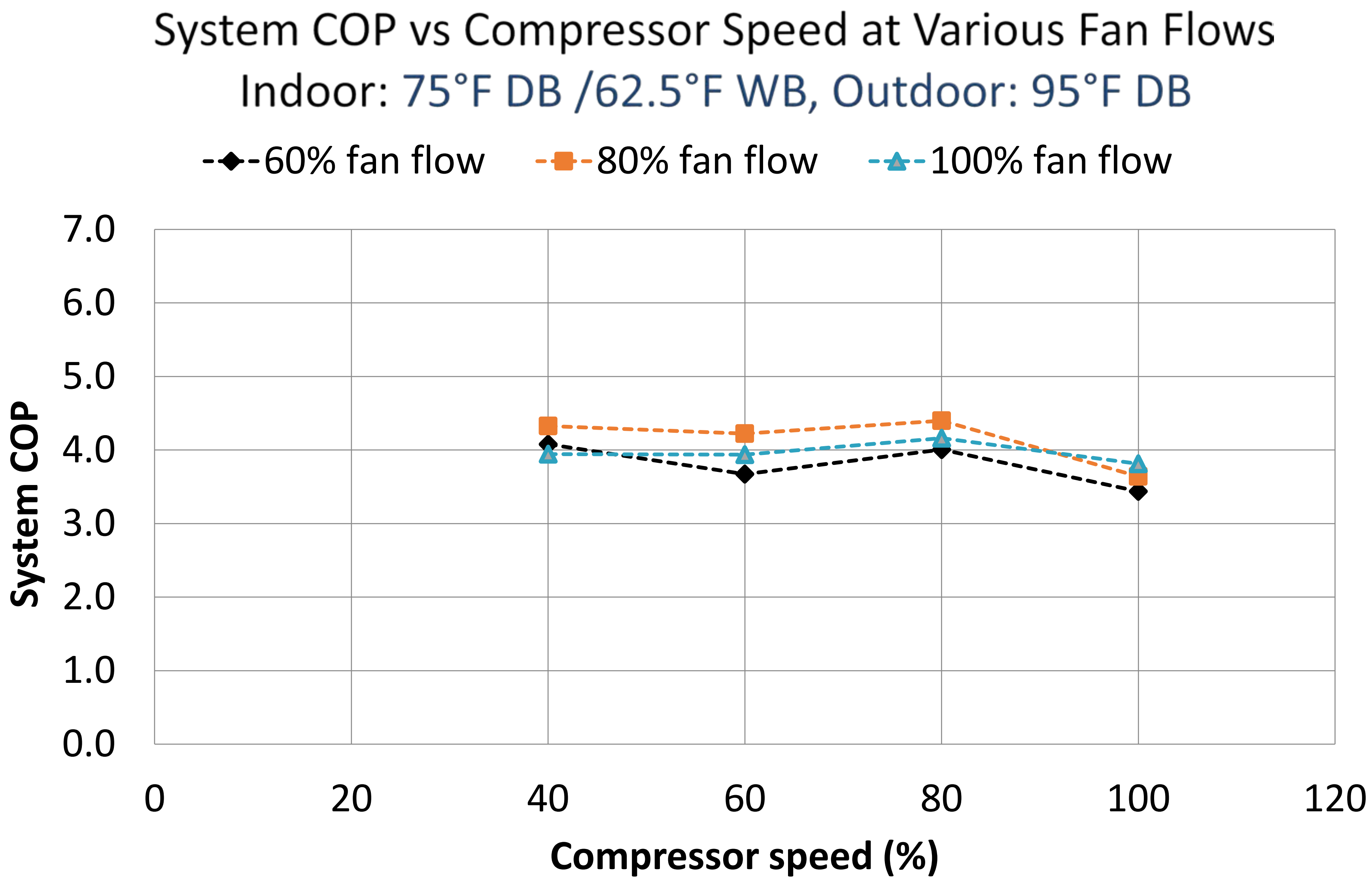
Indoor conditions: 75°F DB /62.5°F WB



Next Generation Heat Pump Testing



Next Generation Heat Pump Testing



Does evaporative cooling make sense in CA?

- No humidity added to space
  - Indirect evaporative
  - Condenser air pre-cooling
- Energy savings is coincident with peak demand
- **HOWEVER:** Water consumption a concern during a drought

Does evaporative cooling make sense in CA?

Generation Water Savings Partially Offsets On-Site Consumption

- Recent evaluations of evaporative cooling technology show water use of **2-10 gal/kWh** savings
- California average water use for electricity generation is **~1.4 gal/kWh**
    - Thermal generation estimated at **<1 gal/kWh**
    - Hydro electric generation estimated at **>10 gal/kWh**
    - Water-use intensity for generation varies by region

Water Costs Amount to Roughly **10% of the value** of Energy Savings (not counting demand charges)

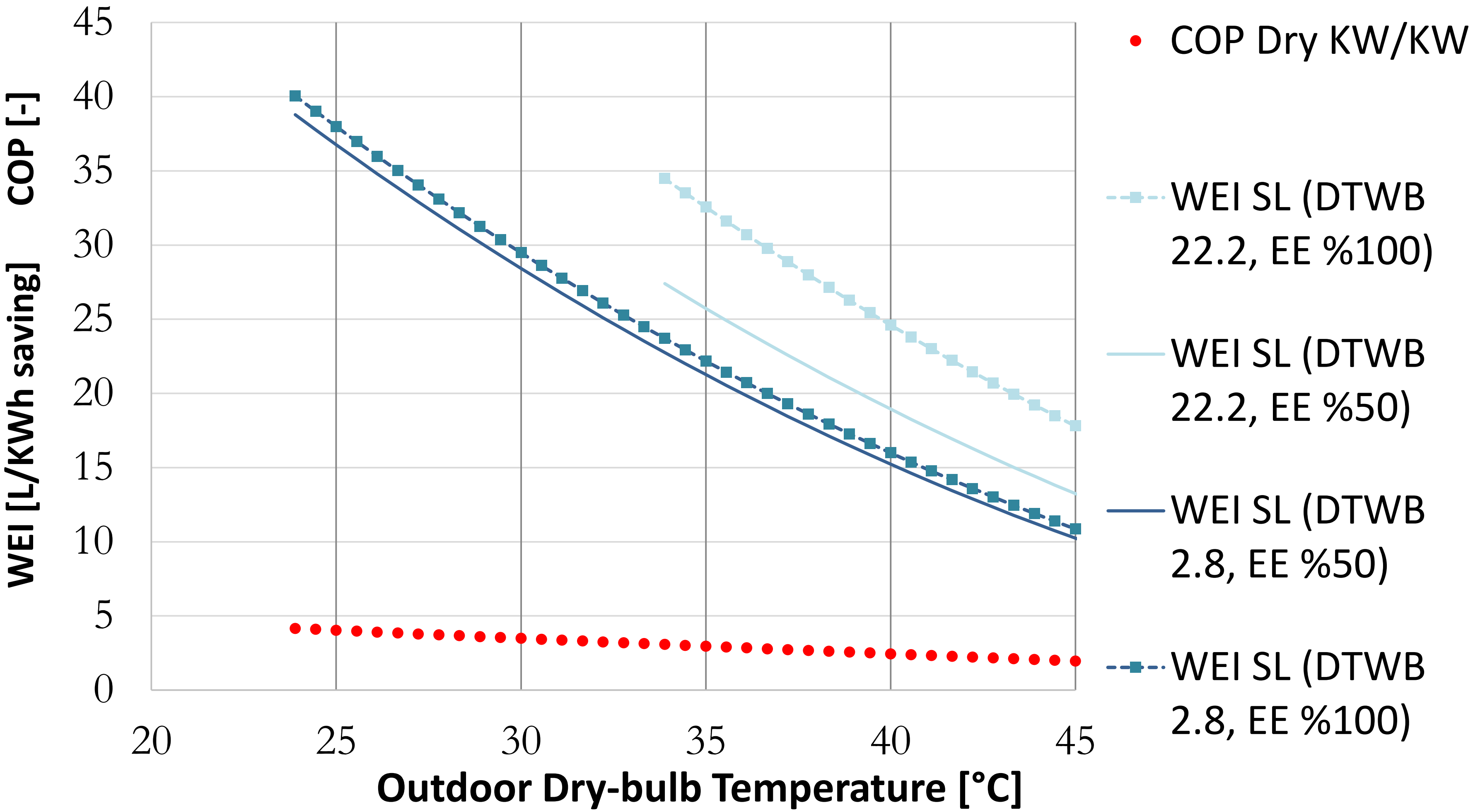
Does evaporative cooling make sense in CA?

Desalination is Worst-Case Water-Use Scenario

- Desalination produces **70-100 gallons per kWh** consumed
  - Evaporative cooling consumes **2-10 gallons/ kWh** saved
    - ⇨ **7x to 50x** electricity multiplier
    - Equivalent to getting back **7-50 kWh** for investing **1 kWh**
    - Desalinization can operate at night and evaporative cooling reduces peak demand during the day

- Increases water cost approximately **3x** ⇨ still cost effective

Does evaporative cooling make sense in CA?



⇨ Normalized water use lower at higher outdoor temperatures

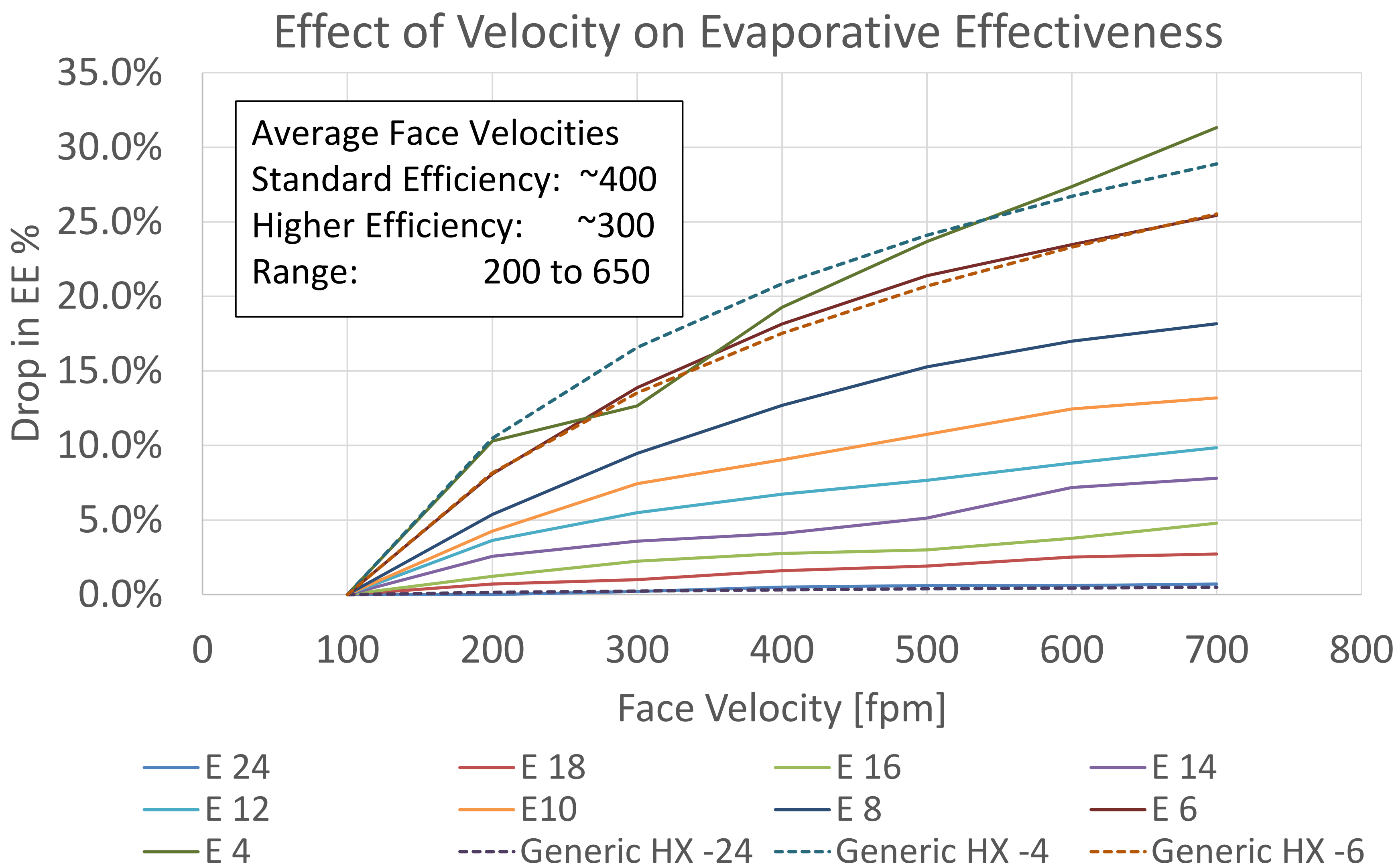
ASHRAE Standard for Evaporative Pre-Coolers

ASHRAE Standard 212P

Method of Test for Determining Energy Performance and Water-Use Efficiency of Add-On Evaporative Pre-Coolers for Unitary Air Conditioning Equipment

- Designed to allow utility programs to understand performance of different evaporative pre-cooler products
- Measures Evaporative Effectiveness and applies to "generic" RTU
- **Recent development:** Measure Evap Effectiveness at multiple face velocities
- **Schedule:** Vote for *Public Review* this year

ASHRAE Standard for Evaporative Pre-Coolers



User-Oriented Modeling Tools for Climate-Appropriate Hybrid Rooftop Air Conditioners

THE PROBLEM

- Annual simulation of performance for climate appropriate air conditioners is currently difficult and therefore rarely conducted
- Tools for design engineers do not accommodate hybrid systems

THE PROJECT

- Funding from US DOE and SCE, partnership with NREL and LBNL to develop EnergyPlus model and surrounding resources

OBJECTIVES

- Develop a generalized model for hybrid unitary air conditioners that accommodates multiple system architectures, each with many modes of operation
- Develop a structure for standard representation of performance data

MANUFACTURERS

Facilitates communication of performance data from manufacturers to engineers

1. NOMINAL INFO
2. PERFORMANCE MAPS

Provides manufacturers a simple template spreadsheet to input performance data

TPEX™
TECHNOLOGY PERFORMANCE EXCHANGE

Manufacturers upload performance data to Technology Performance Exchange - a web based portal for sharing performance data

TRANSLATOR

Translator automatically changes table data to format required for EnergyPlus

NREL
NATIONAL RENEWABLE ENERGY LABORATORY
BUILDING COMPONENT LIBRARY

Data and lineage are available through NREL Building Component Library

ENERGY PLUS END USERS

EnergyPlus ‘hybrid air conditioner’ object is simple to use without expert knowledge

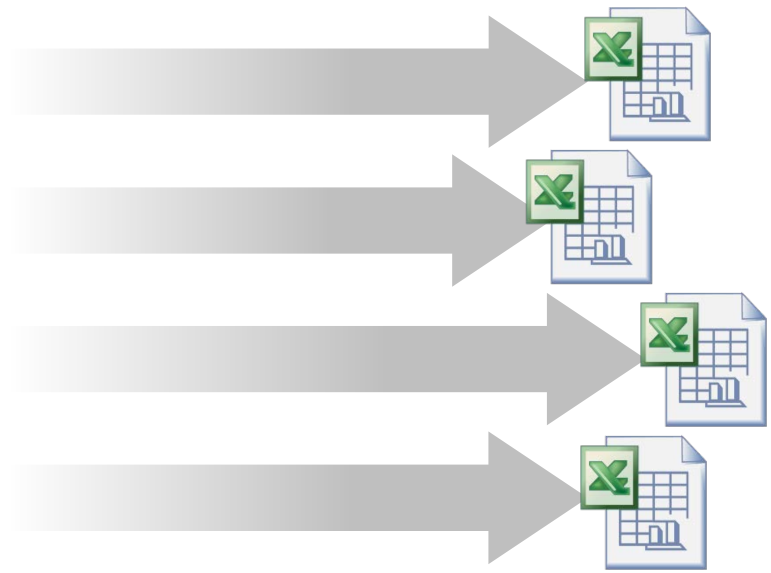
Technology Performance Exchange: Facilitates Clear Input of Performance Data

PRODUCT ENTRY FORM

- Identifying information
- Nominal performance metrics
- Number of operating modes
- For each mode
  - MIN-MAX T_{OSA}/RH_{OSA}/HR_{OSA}
  - MIN-MAX T_{RA}/RH_{RA}/HR_{RA}
  - MIN-MAX OSAF each mode
  - MIN-MAX supply airflow rate

Manufacturer inputs general information via web

PERFORMANCE MAP TEMPLATES



TPEX automatically generates templates for each performance map

Manufacturers Performance Data: Simple Spreadsheet Template

OPERATING CONDITIONS
Outside temperature
Outside humidity
Return air temperature
Return air humidity
Supply airflow rate
Outside air fraction

SYSTEM PERFORMANCE
Supply air temperature
Supply air humidity
Electricity use
Heating energy use
Water use

Template defines series of operating conditions

Manufacturer inputs system performance at each condition

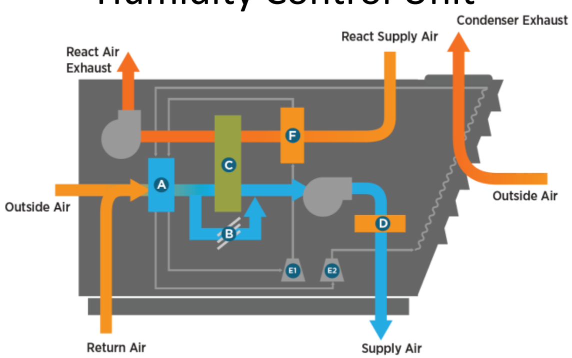
Partners: Three Manufacturers to Pilot Tool

- 2015-2016 focused on developing performance maps with manufacturers
- 2016-2017 will focus on testing and validating the simulation tool
- Welcome additional manufacturer participation for 2016-2017

- Working with NREL to expand TPEX
- Working with LBNL to integrate model into EnergyPlus model

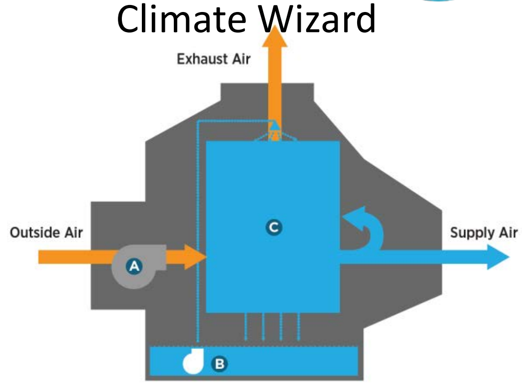
Munters

Humidity Control Unit



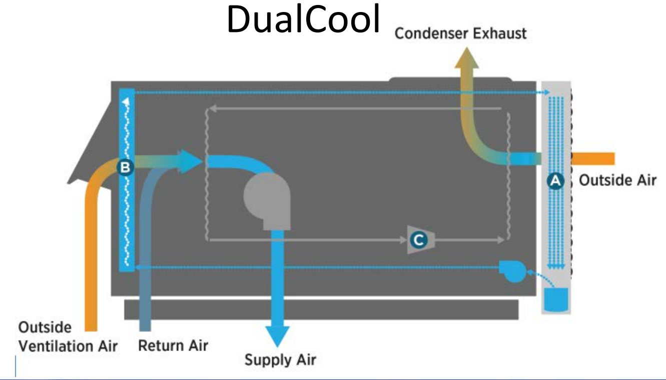
SEELEY INTERNATIONAL

Climate Wizard

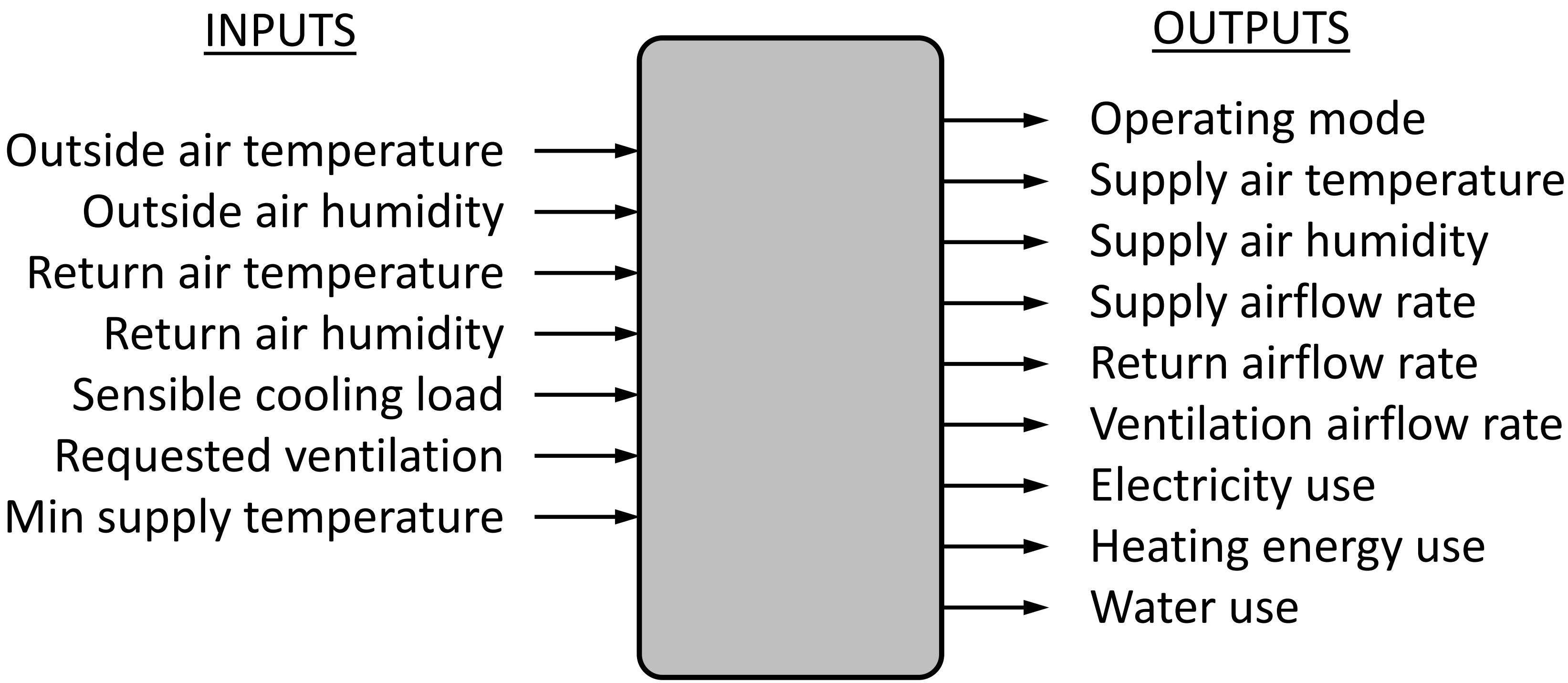


INTEGRATED COMFORT INC.

DualCool



Inputs and Outputs: Each Simulation Time Step within EnergyPlus



2016 Building Energy Efficiency Standards Residential HVAC Video Courses

- CEC Funded Project to Increase Code Compliance
- On-line Video Training Library Under Development
- Opportunity to Build on Engineering/Outreach Expertise

- Course 1: Mandatory, Prescriptive and Performance Requirements: Understanding the Differences
- Course 2: What's New in 2016
- Course 3: Mandatory Measures for Heating and Cooling Systems
- Course 4: Mandatory Measures for Thermostats
- Course 5: Mandatory Measures for Air Distribution Systems
- Course 6: Indoor Air Quality and Mechanical Ventilation
- Course 7: The Prescriptive Method
- Course 8: The Performance Method
- Course 9: HVAC Change-outs

CASE STUDIES | PRESS ARTICLES | NEWS | HVAC PRESENTATIONS | NEWSLETTER | REPORTS PUBLICATIONS | INTERVIEWS | RESEARCH EDUCATION | DEMONSTRATION BRIEFS | OVERVIEW | OUTREACH | MISSION | CONTACT | TECHNICAL SERVICE AGREMENTS |

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| TECHNOLOGY TOPICS | SECTOR RESEARCH | BEHAVIORAL RESEARCH | SYSTEMS INTEGRATION | CONTROLS | DEMAND SIDE MANAGEMENT | EVAPORATIVE TECHNOLOGIES | RADIANT COOLING | MULTI-TENNANT LIGHT COMMERCIAL |