FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

Evaluating Moisture Control of Variable Capacity Heat Pumps in Mechanically-Ventilated, Energy-Efficient Homes.

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Building AMERICA®
U.S. Department of Energy

Bringing Housing Innovations to Market

Introduction

- Tighter construction = less natural ventilation.
  - Whole-house mech. vent. more important
- Better insulation and windows decreases cooling.
- Results in more difficulty managing moisture.
- Potential Issues- comfort, building damage, health

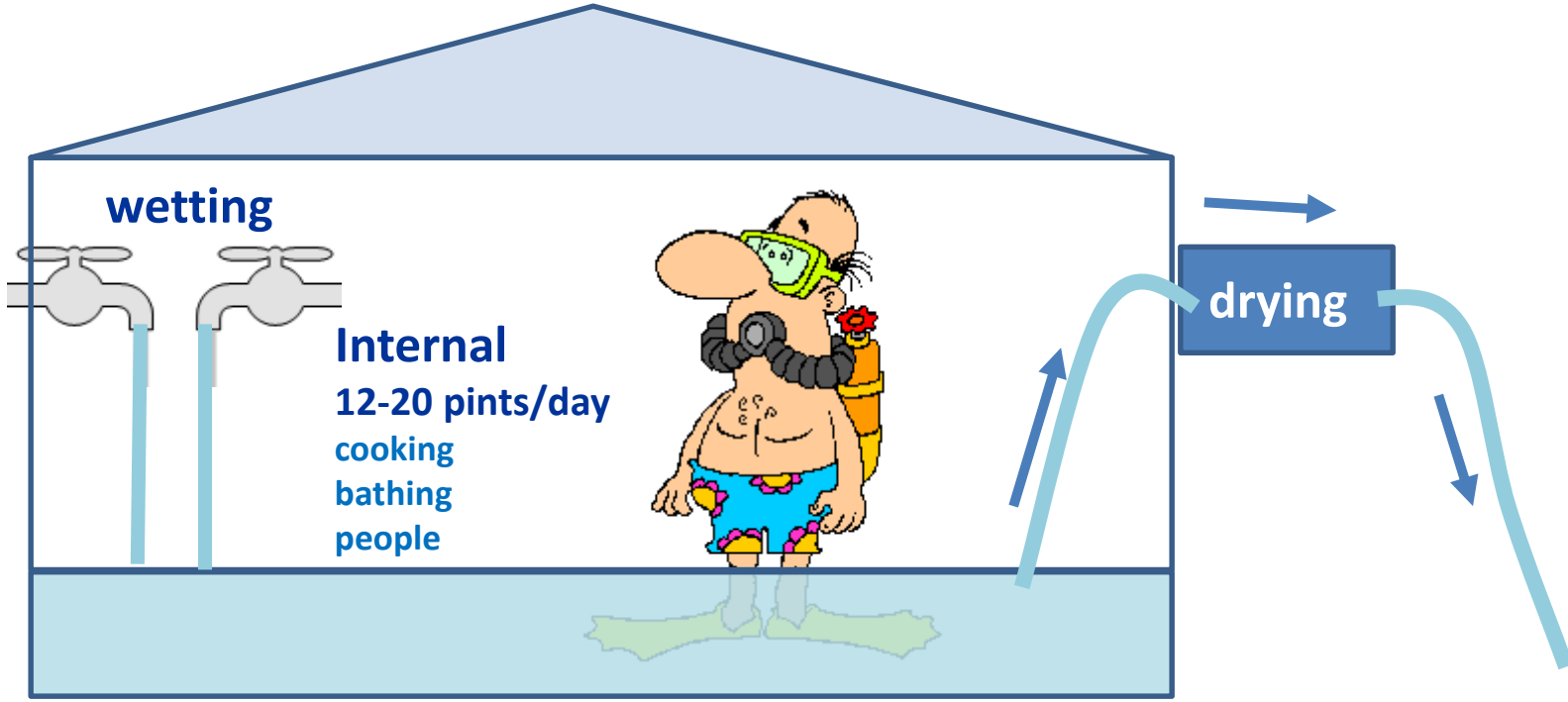
Introduction

- Variable Capacity (VC) heat pumps vary output of heat/cool.
  - Variable outdoor compressor speed and refrigerant
  - Variable indoor fan flow
  - Quiet
  - Long runtime
  - Energy efficient

Ductless Mini-split Heat Pump Shown with a Dehumidifer

Effective Moisture Control Requires a Balance Between Wetting and Drying Processes

About 9.6 – 10.6 gallons (36.3-40.1 liters) of water needs to be removed from air each summer day.

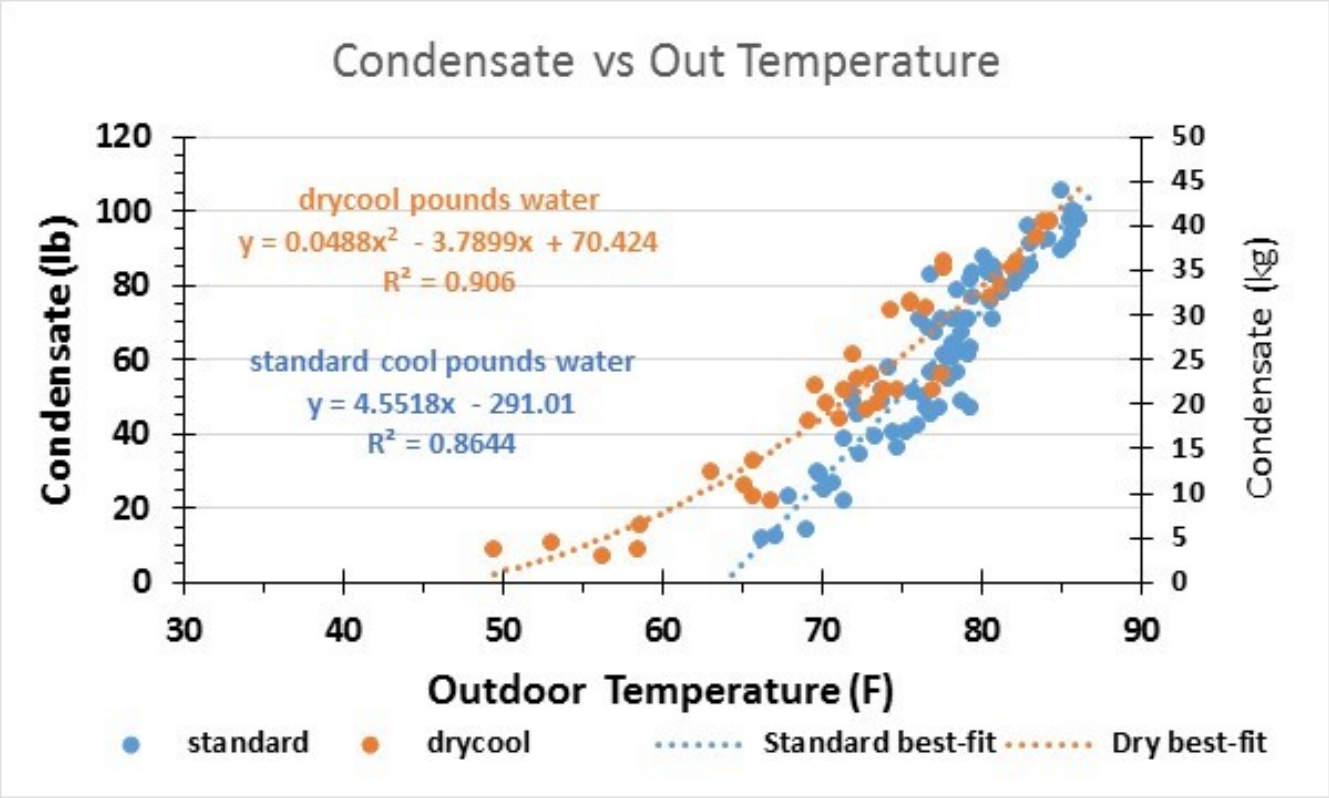


External
(Summer)
Mech. Vent. (48 pints)
Infiltration (17 pints)

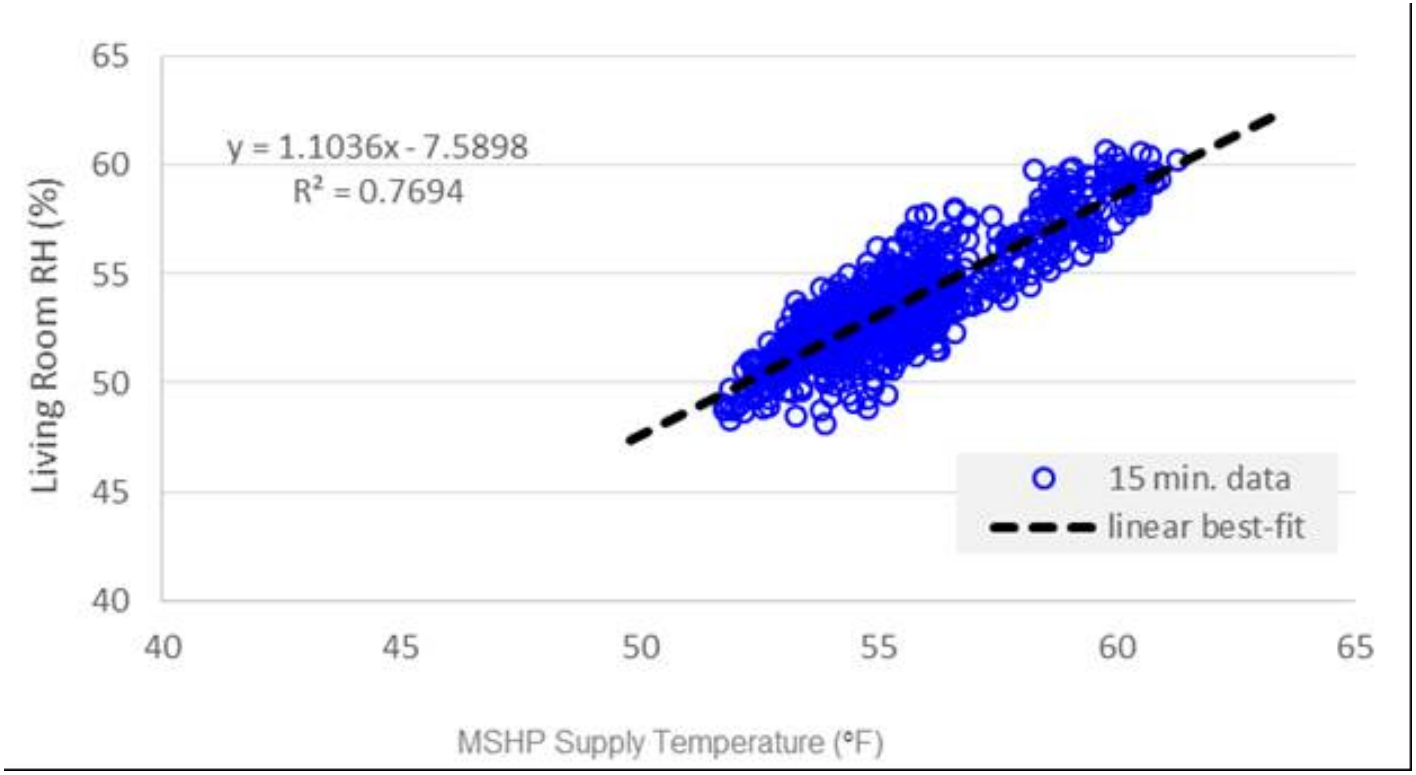
Internal
12-20 pints/day
cooking
bathing
people

House Lab and Residential Field Study

Warmer Weather Results in More Moisture Removed From Indoors



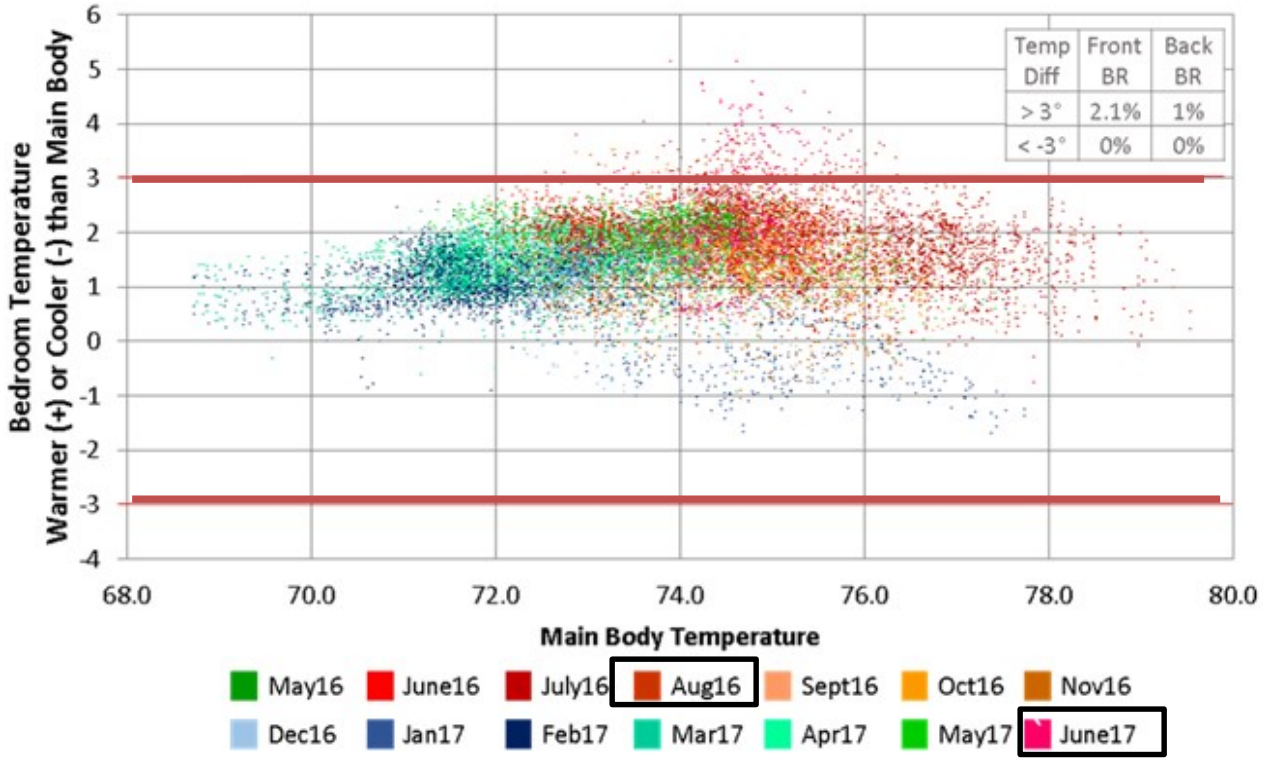
Colder Supply Temperature Results in Lower Indoor RH



Thermal Control

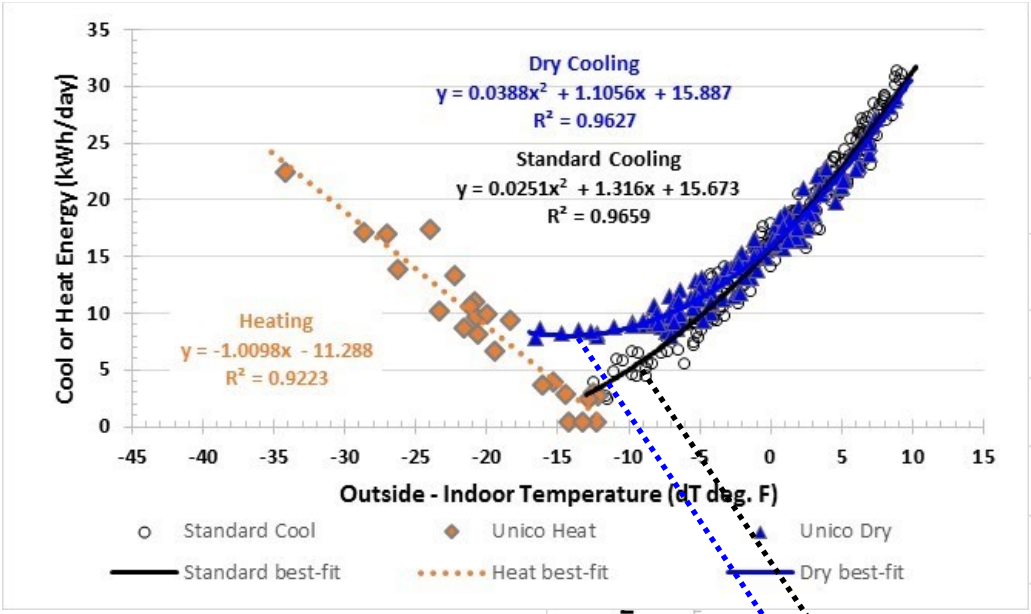
Thermal distribution was acceptable from all tested VC systems.

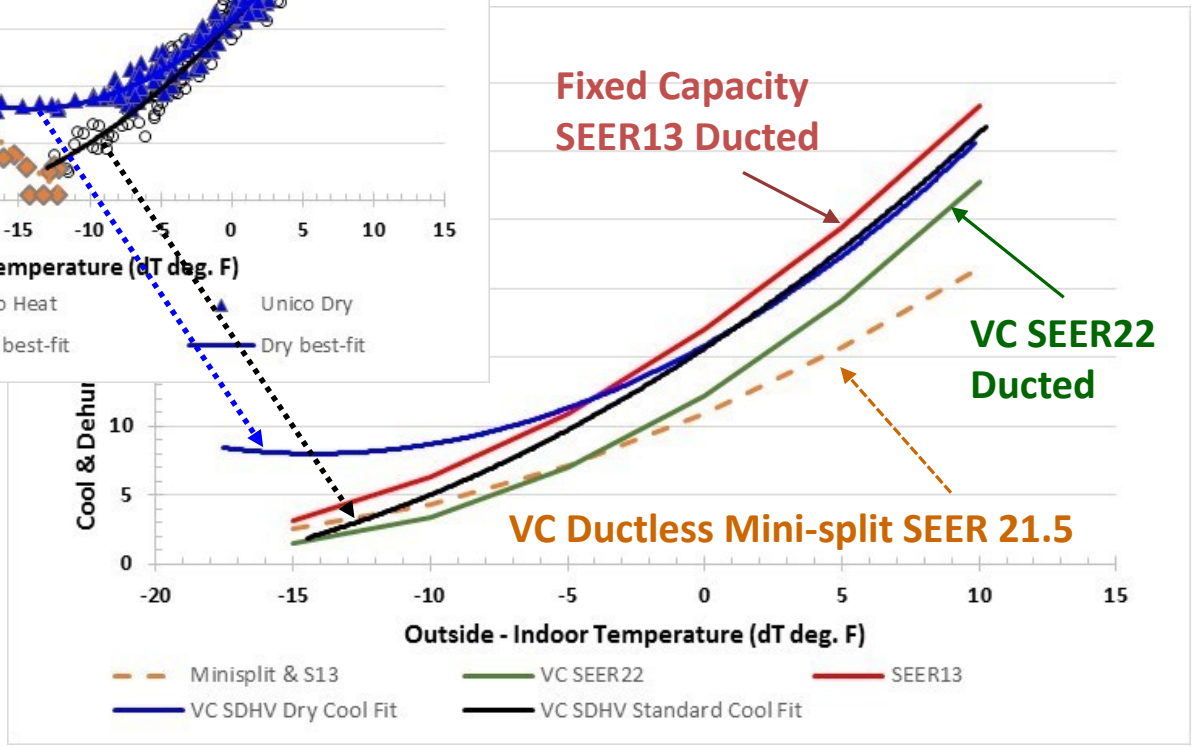
dT>3F Only 1.4% of time for 11 bedrooms in 4 homes (prefer indoor about 76F).



Average hourly temperature difference between SEV1 bedrooms and the main body

House Lab Space Conditioning Energy





Potential Daily Cooling Energy Savings from Fixed Capacity to Variable Capacity

(Central Ducted Systems)

Lab Test Configuration	SEER 13 FC kWh/day	SEER 14 VC kWh/day (%)	SEER 22 VC kWh/day (%)
OA Near Central Return; Dehumidifier Enabled @ 60% RH	24.4	22.4	19.2
Savings Relative to SEER 13	---	2.0 **(8.2%)**	5.2 **(21.3%)**
Savings Relative to SEER 14	---	---	3.2 **(14.3%)**

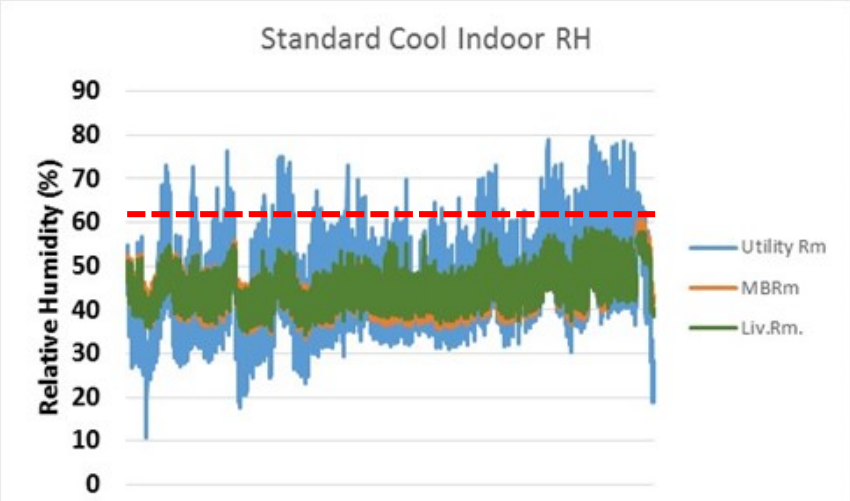
Daily Space Conditioning Energy for a Typical Summer Day with dT = 5°F

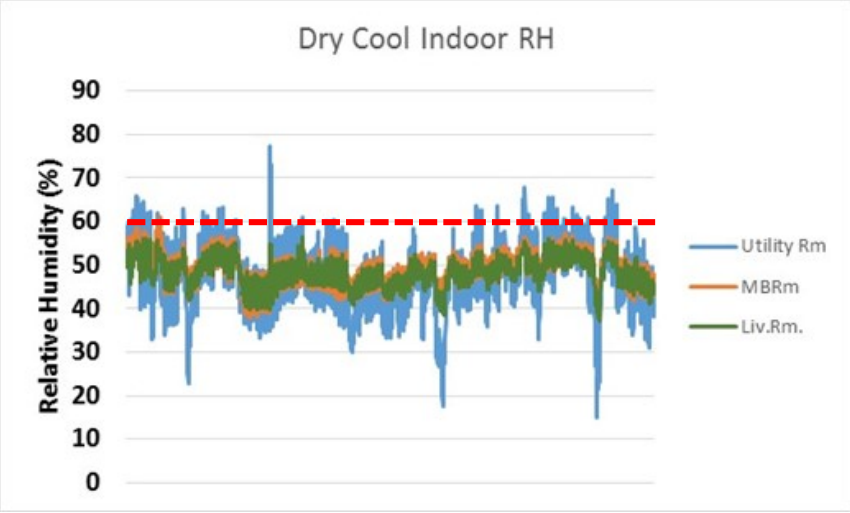
Predicted Annual Cooling Energy, Peak Cooling Power, Use and Savings

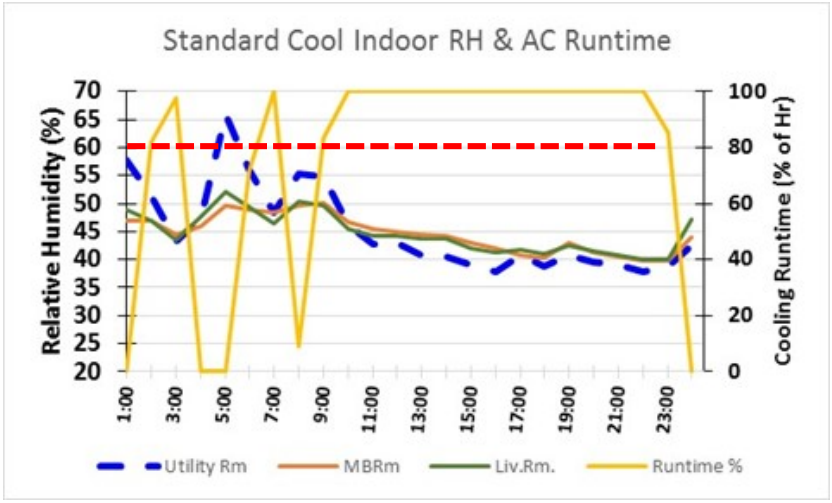
(Savings Relative to Ducted FC SEER 13)

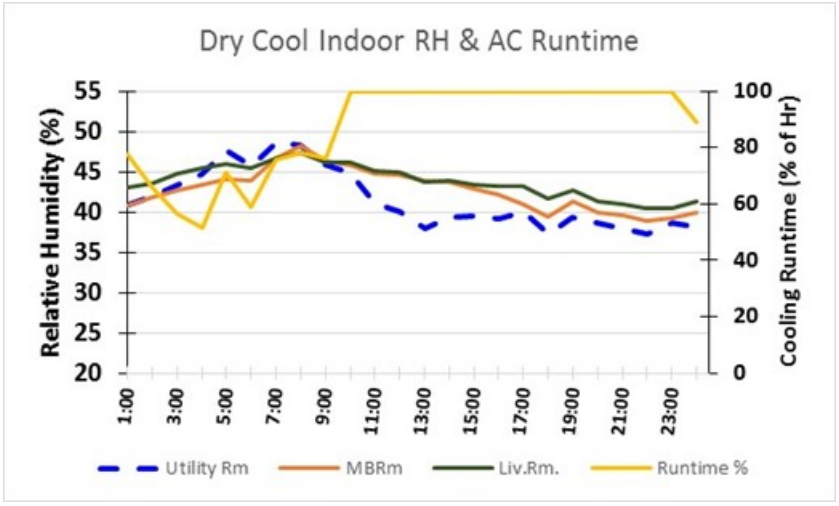
Test Case	Annual kWh (Mbtu)	Annual Savings kWh/yr (Mbtu), %	Peak kW (kBtu/h)	Peak Reduction kW (kBtu/h), %
1 Ducted Fixed Cap. SEER 13; DH	4820 (16.45)	---	2.04 (6.97)	---
2 Ducted Variable Cap. SEER 22; DH	3743 (12.77)	1078 (3.68) **22.4%**	1.56 (5.33)	**0.48** (1.64) **23.5%**
3 Ductless MSHP SEER 21.5; no DH	3224 (1.10)	1596 (5.45) **33.1%**	1.49 (5.09)	**0.55** (1.88) **27.0%**

House Lab RH Control





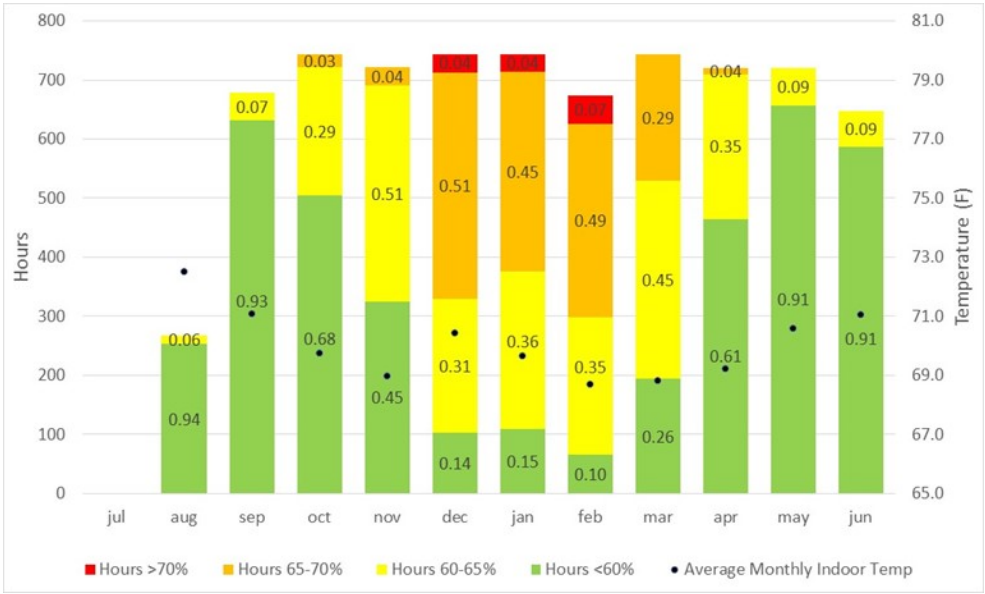




Field Study RH Control

- High frequency in hourly average RH >60%.
  - Assoc. with overnight and seasonal low-load periods
  - -with elevated supply air temp. (high SHR during low-load)

- RH maintained low enough to avoid high potential for health or durability issues.
- No reported comfort complaints from occupants.



Average hourly RH and monthly average temperature in SS2

Conclusion

- Field studies indicate VC not controlling RH <70% well-enough during low-load periods in mech. vent. homes. RH >70% control OK.
- Lab study of SDHV VC system shows VC can manage RH well and may be able to maintain all hours below 50% RH with improved DRY cool mode.
- VC provided good thermal distribution.
- VC cooling savings range from 8% to 33% compared to Fixed Cap (VC SEER 14 lowest and VC MSHP SEER 21.5 ductless highest).

Conclusion

Variability of indoor RH levels primarily from variability of:

- Mechanical Ventilation Rates
- Internal Moisture Generation
- Cooling SHR of Air Conditioning

Summary
VC Great Potential and Needs Improved

- Need improved algorithms & control architecture to improve Dry modes.
  - Need to maintain colder coil during low load and decrease SHR.
  - Need to utilize lowest capacity over longer periods during low load.

Summary

VC Great Potential and Needs Improved

- Cooling should prioritize efficiency over RH control in STANDARD mode.
- Prioritize RH control over efficiency in DRY mode.
- Use RH sensor to intelligently move back into high efficiency when RH low enough.

Thank You

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