Laboratory Testing of Two Split-Unit Water Heaters: CO_2 and R-410a

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Session 7A

New Concepts for Heat Pump Water Heaters: Split Units and Alternative Refrigerants

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Ben Larson

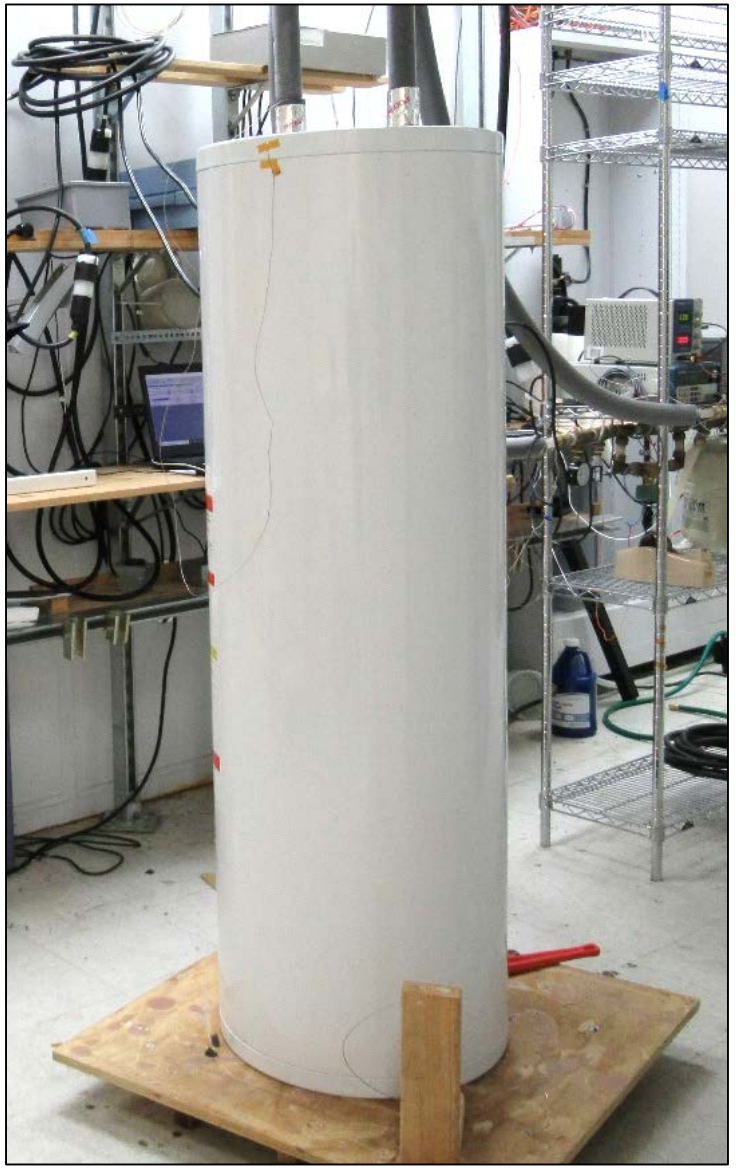
ben@ecotope.com

ECOTOPE

CONSULTING
RESEARCH
DESIGN

Methods, Testing Results, and Implications

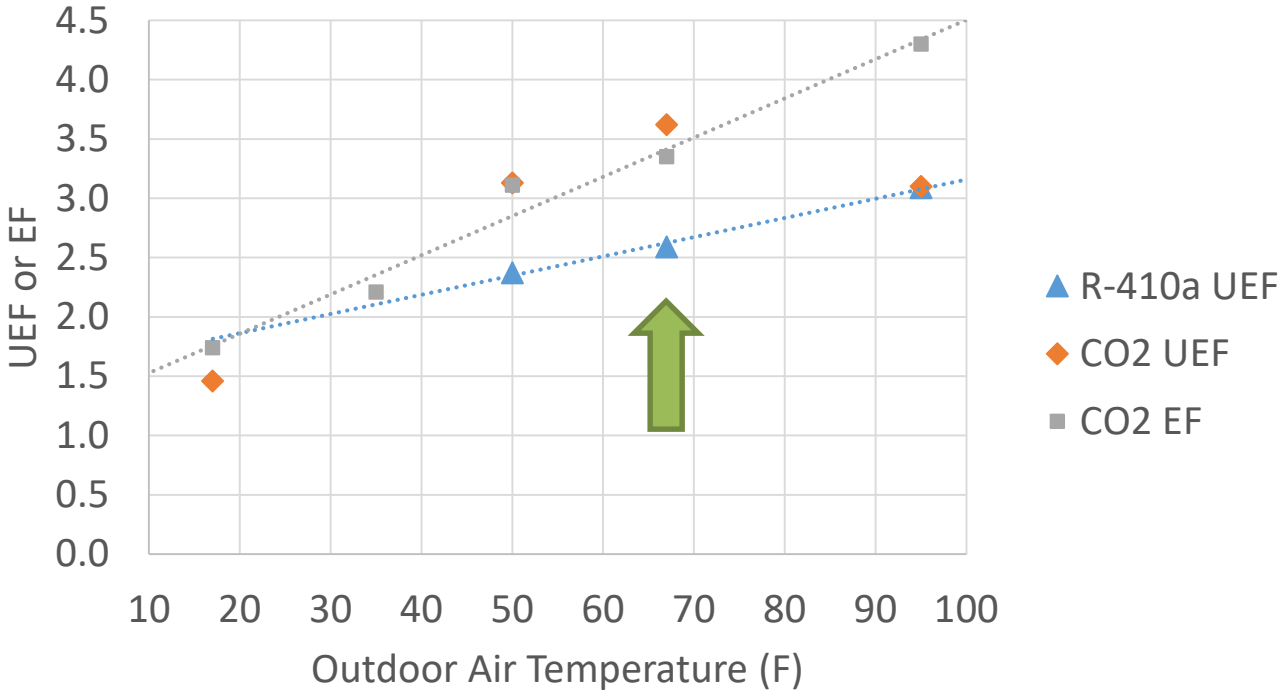
Product or refrigerant comparisons neither important nor focus of presentation



Equipment Specifications

	CO2 Unit	R-410a Unit
Refrigerant	CO_2	R-410a
Tank Size (gallons)	83	50
First Hour Rating (gallons)	109	39
Nominal Output Capacity	1 1/4 ton	1 1/4 ton
Compressor Type	Variable Speed	Variable Speed
Defrost	Active	Active
Low End Operating Range	< -20 F	-13 F
Heat Exchange	At outdoor unit	Condenser submersed in tank
Resistance Heat	None	3kW - mid-tank

SUT@ Varied Temperatures



- SUT is Simulated Use Test – 24 hour draw pattern
- Conditions: 95F Air, 70F Water; 50F-35F-17F, 50F Water
- Not all tests conducted across all units
- CO2 Unit had different control regimes between EF and UEF test

Shorter Test then 24-hour?

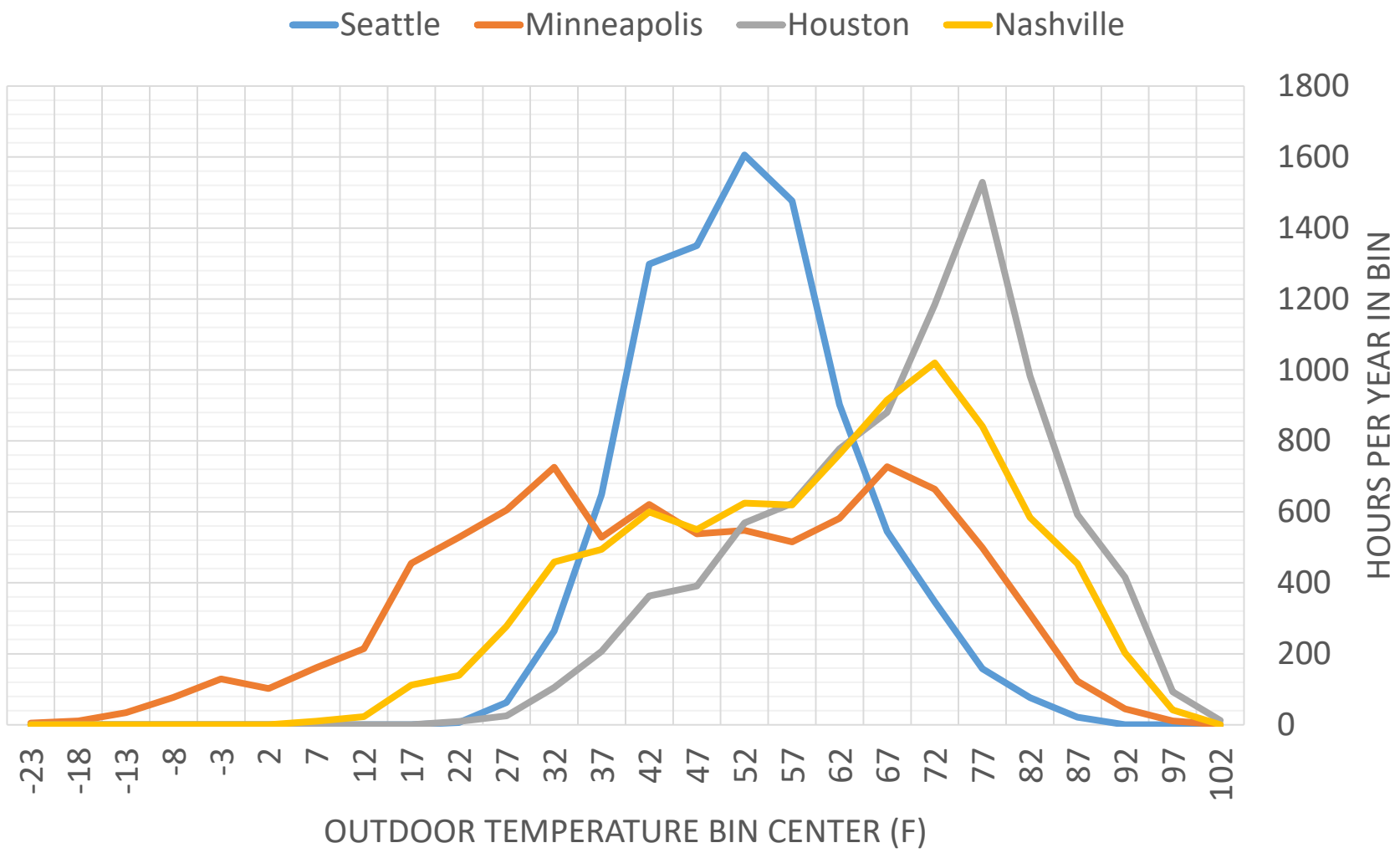
- COP-Style Measurement
- Test Procedure:
  - Fill tank with cold water and watch heat pump heat up tank
  - (No draws in this test)
- Calculate cumulate COP over the entire reheat cycle
  - Energy rise in tank / Energy input

UEF Compared to COP-Style Test

- Does it scale vs temperature in the same way?

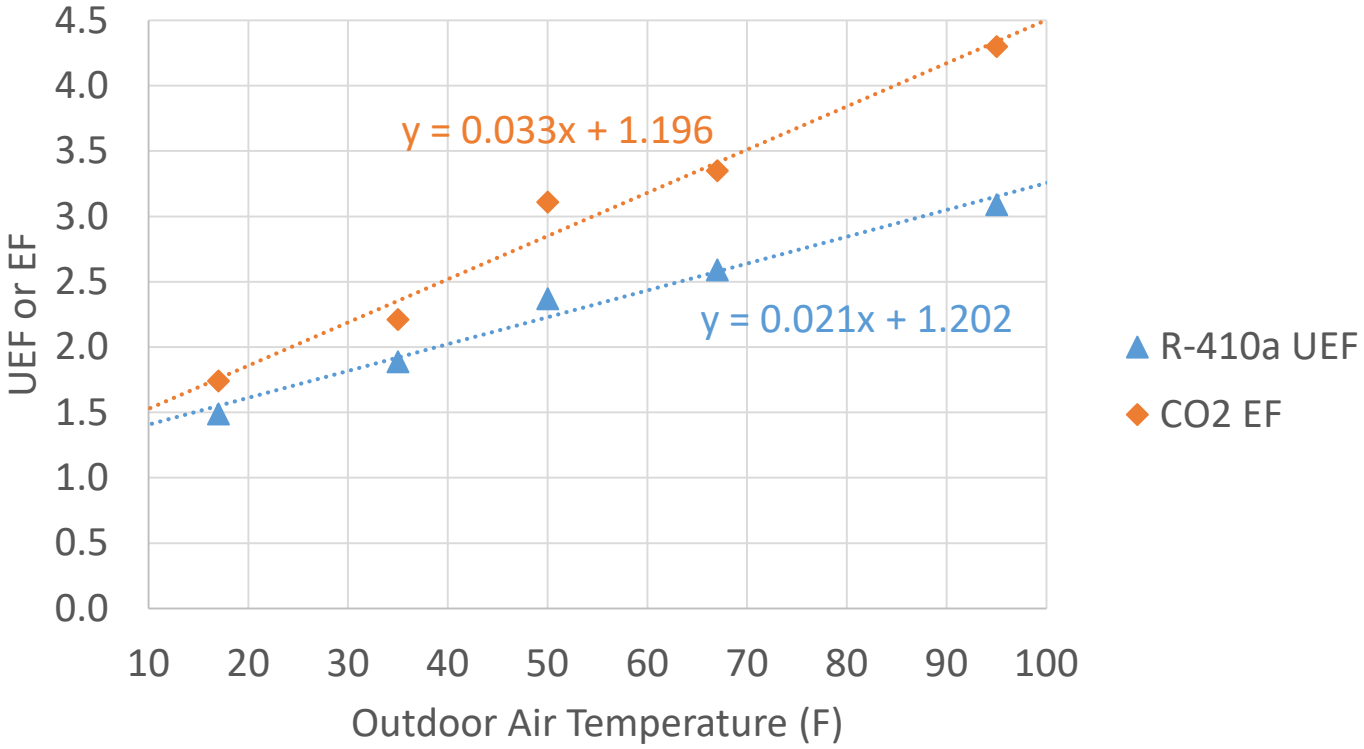
	CO2 Unit			R-410a		
Outside Air Temperature (F)	**Energy Factor (EF)**	**COP**	**COP/EF Ratio**	**Uniform Energy Factor (UEF)**	**COP**	**COP/UEF Ratio**
17	1.74	2.1	1.21		1.71	
35	2.21	2.75	1.24		2.17	
50	3.11	3.7	1.19	2.37	2.57	1.08
67	3.35	4.2	1.25	2.59	2.96	1.14
95	4.3	5	1.16	3.09	3.8	1.22
	Average Ratio:		1.21	Average Ratio:		1.15

Annual Temperature Profiles



Performance in Different Climates

- Calculate annual efficiency
  - Use linear fit of efficiency vs temperature to all measurement points
    - (could also use linear point to point estimates instead of full data)



Performance Estimates

- R-410a Unit showed little difference across climates
  - Similar to singular value of UEF from standard conditions test
- CO2 Unit showed more variation
  - Leads to dissimilarities from standard conditions test

	Annual Efficiency	
Climate	**CO2 Unit**	**R-410a Unit**
Minneapolis	2.7	2.2
Raleigh	3.2	2.5
Boston	2.9	2.3
Chicago	2.9	2.3
Houston	3.5	2.6
Seattle	2.9	2.2
Nashville	3.2	2.5

Implications

- Different equipment shows different performance variation with outdoor temperature
  - One temperature condition not enough to accurately differentiate between products
- Performance vs outdoor temperature appears reasonably linear (so far)
- 24-hour simulated use tests can be a burden to repeat at multiple conditions
  - Can we find a shorter test?
    - COP-style measurement too limited
    - Is a shorter draw pattern possible? 12 hours, 18 hours?

Recommendations

- Recommend four temperature test points
  - At, or near, these conditions:

Dry-Bulb Temperature, °F	Wet-Bulb Temperature, °F	RH (%)	Inlet Water Temperature, °F
5	2	30	42
34	31	72	47
68	57	50	58
95	69	25	67

  - Retain option for bonus lower temperature point or replacement of 5F point with higher temperature if equipment range limited
- Explore opportunities for shorter simulated use tests
- In lieu of shorter test, recommend using current UEF 24-hour patterns

Q & A

- Thanks!