

Air-Source Integrated Heat Pump: Lab and Field Test Results

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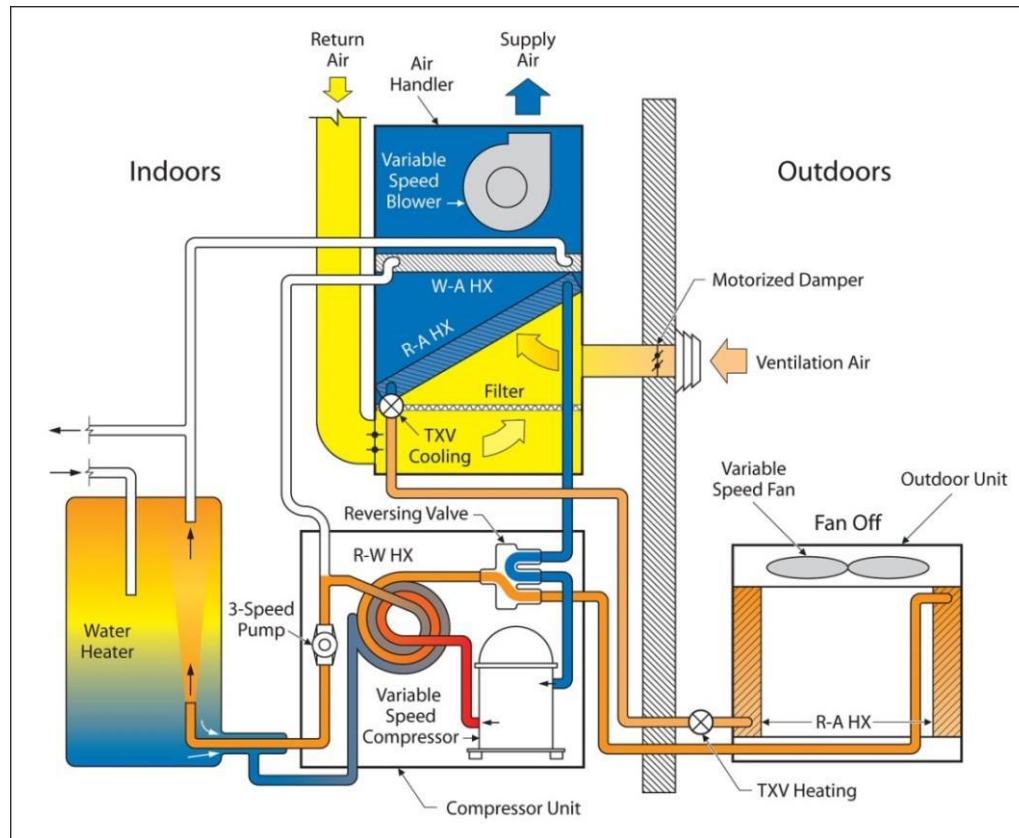


Outline

- Introduction
- Laboratory Tests
- Field Test
- Conclusions

Introduction

- General concept of “integrated heat pump” developed in FY05-07 (Murphy et al, 2007)



Introduction

- Simulations indicated that the concept could result in significant energy savings over the current minimum efficiency equipment in well insulated 1800 ft² homes.

Location	Heat Pump Cooling Capacity (tons)	Site Energy Use (kWh)	% energy savings vs. Baseline HVAC/WH	% energy savings for WH
Atlanta	1.25	3349	53.7	72.8
Houston	1.25	3418	53.7	80.2
Phoenix	1.50	3361	48.4	71.9
San Francisco	1.00	1629	67.2	74.6
Chicago	1.25	5865	45.6	61.6

Introduction

- Cooperative Research And Development Agreement (CRADA) was established with an industry partner
- Modes of Operation

Mode	ID HX	OD HX	DHW HX
Space Cooling (SC)	Blue	Red	Grey
Space Heating (SH)	Red	Blue	Grey
Dedicated Water Heating (DWH)	Grey	Blue	Red
Space Cooling + Desuperheating (SC+DS)	Blue	Red	Red
Space Heating + Desuperheating (SH+DS)	Red	Blue	Red
Space Cooling + Full Condensing Water Heating (SC+WH)	Blue	Grey	Red

Introduction

- 1st prototype was assembled and tested at the manufacturer's laboratory and at ORNL
- 2nd prototype shipped to ORNL for testing



Laboratory Tests

- 2nd prototype
 - Variable-speed compressor, indoor blower, outdoor fan, pump
 - Microchannel indoor and outdoor air-to-refrigerant HXs
 - Brazed-plate water-to-refrigerant HX
- Steady-state tests to map performance



Laboratory Tests

- Model calibrated to laboratory test data, and simulations re-run in larger, 2600 ft², homes.

Location	Site Energy Use (kWh)	% energy savings vs. Baseline HVAC/WH	% energy savings for WH
Atlanta	3440	53.3	70.0
Houston	2931	54.7	75.7
Phoenix	3572	46.7	72.2
San Francisco	2030	60.9	69.4
Chicago	6048	46.0	62.4

Field Test

- 2400 ft² home located in Knoxville, TN
- Original Home Energy Rating Score (HERS) of 92
- Internal loads delivered by space heaters and humidifiers based on Building America Benchmark



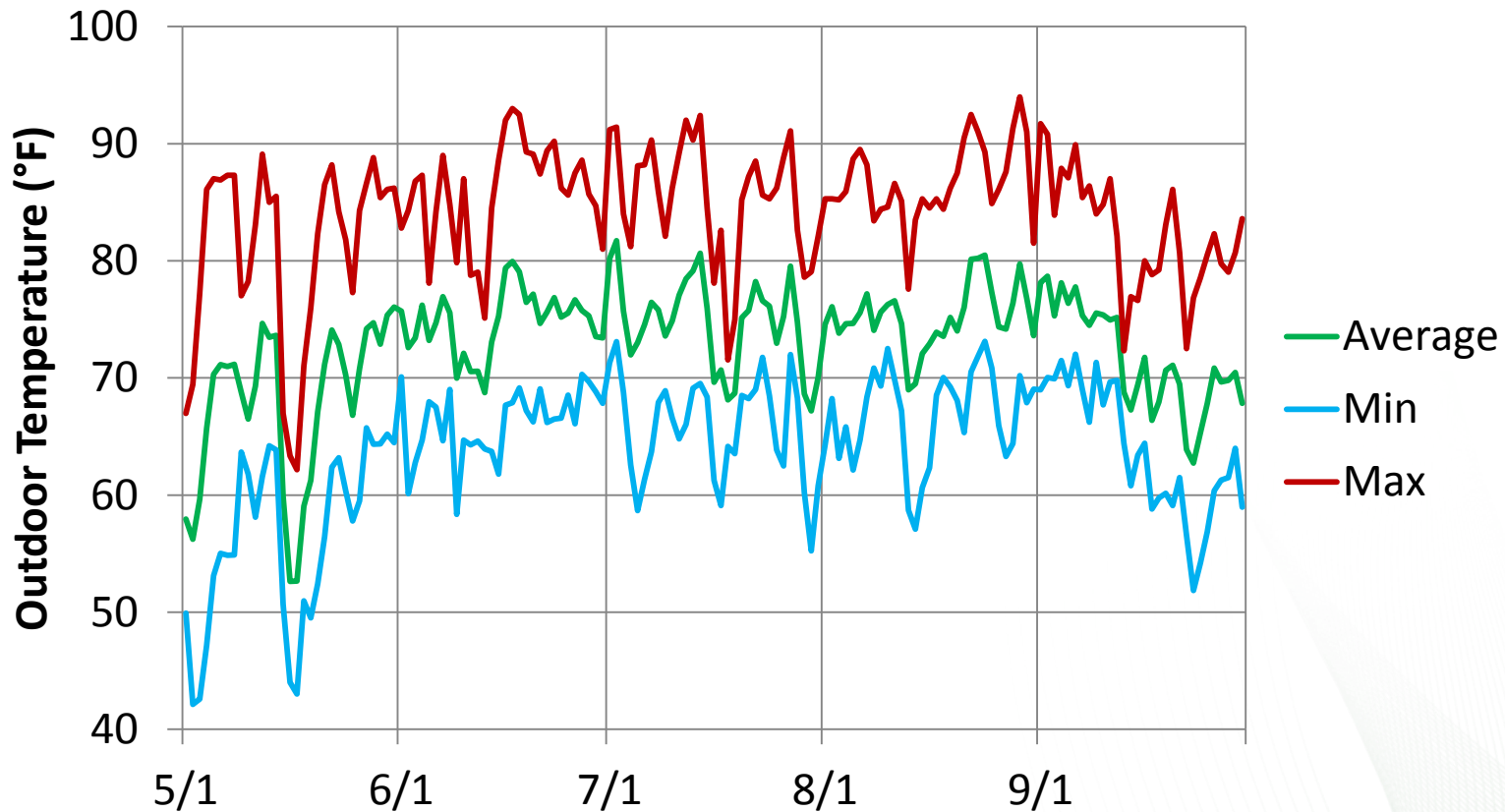
Field Test

- Water draws from Building America Domestic Hot Water Event Generator
- Average 58.1 gallons/day hot water use @ 120°F
- Equipment installed in garage
- Zoning used to split house into 2 zones (upstairs and downstairs)



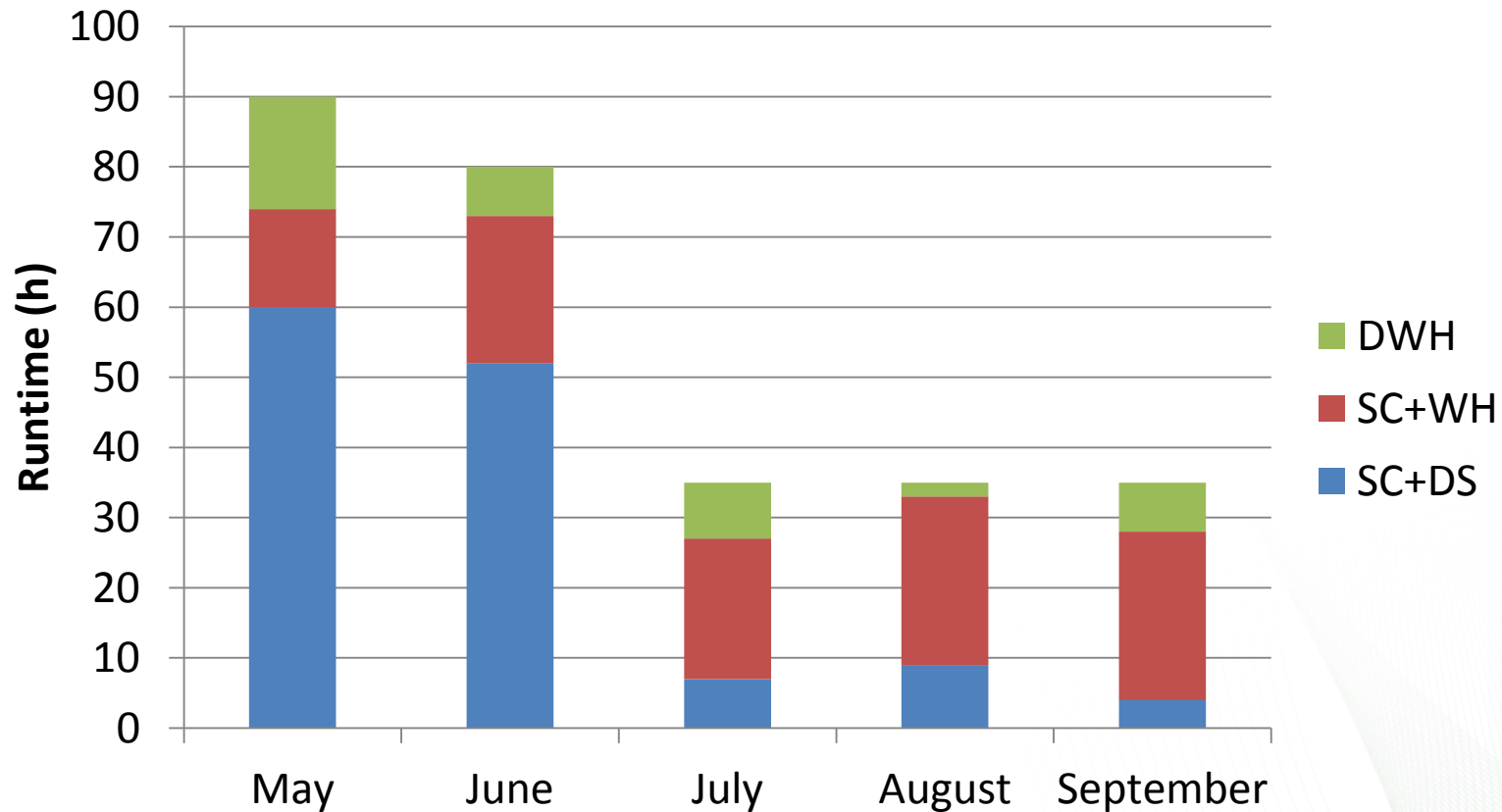
Field Test

- Summer Daily Outdoor Temperatures (Hourly Data)



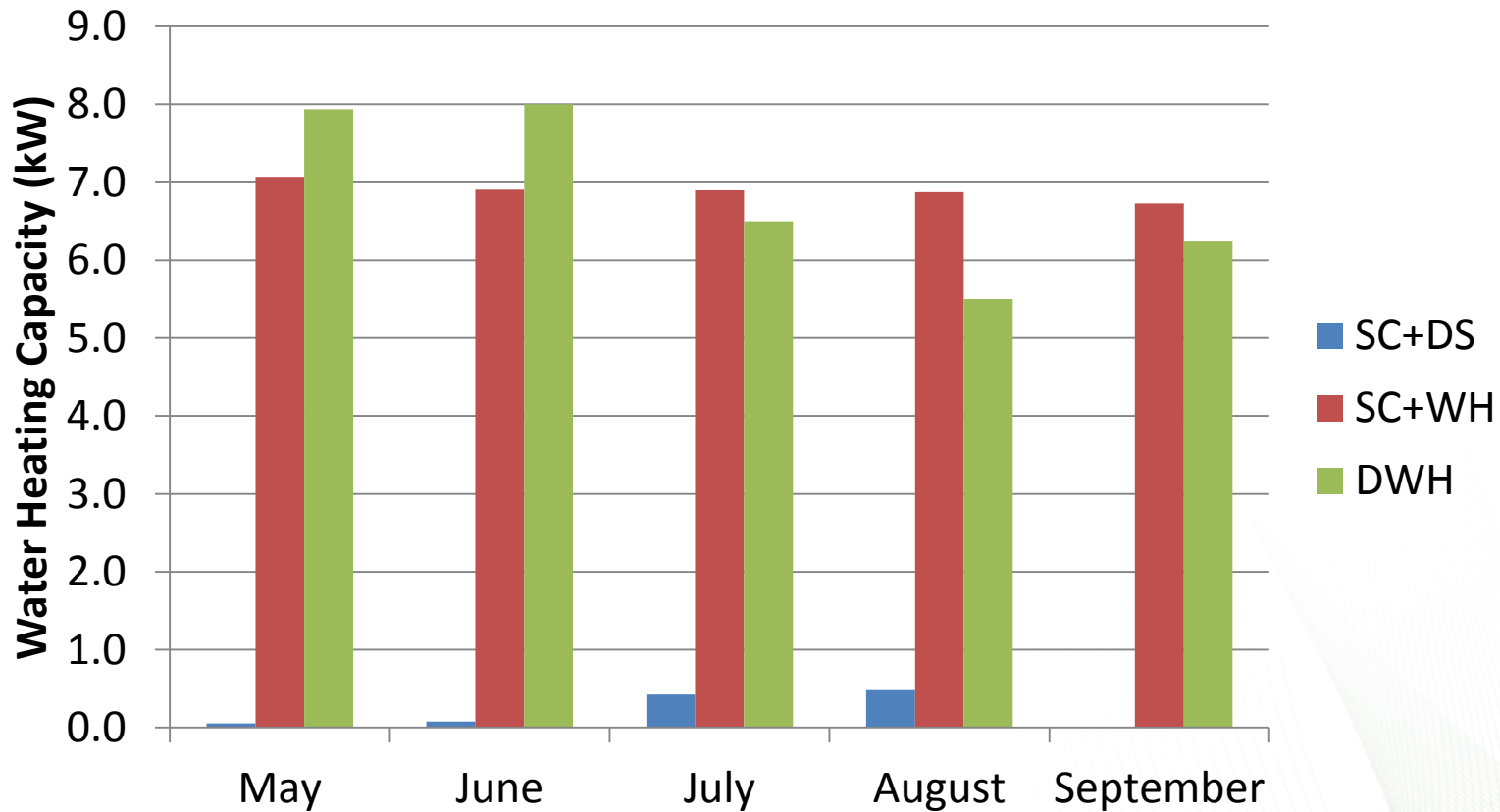
Field Test

- Summer Water Heating – Runtime by Mode



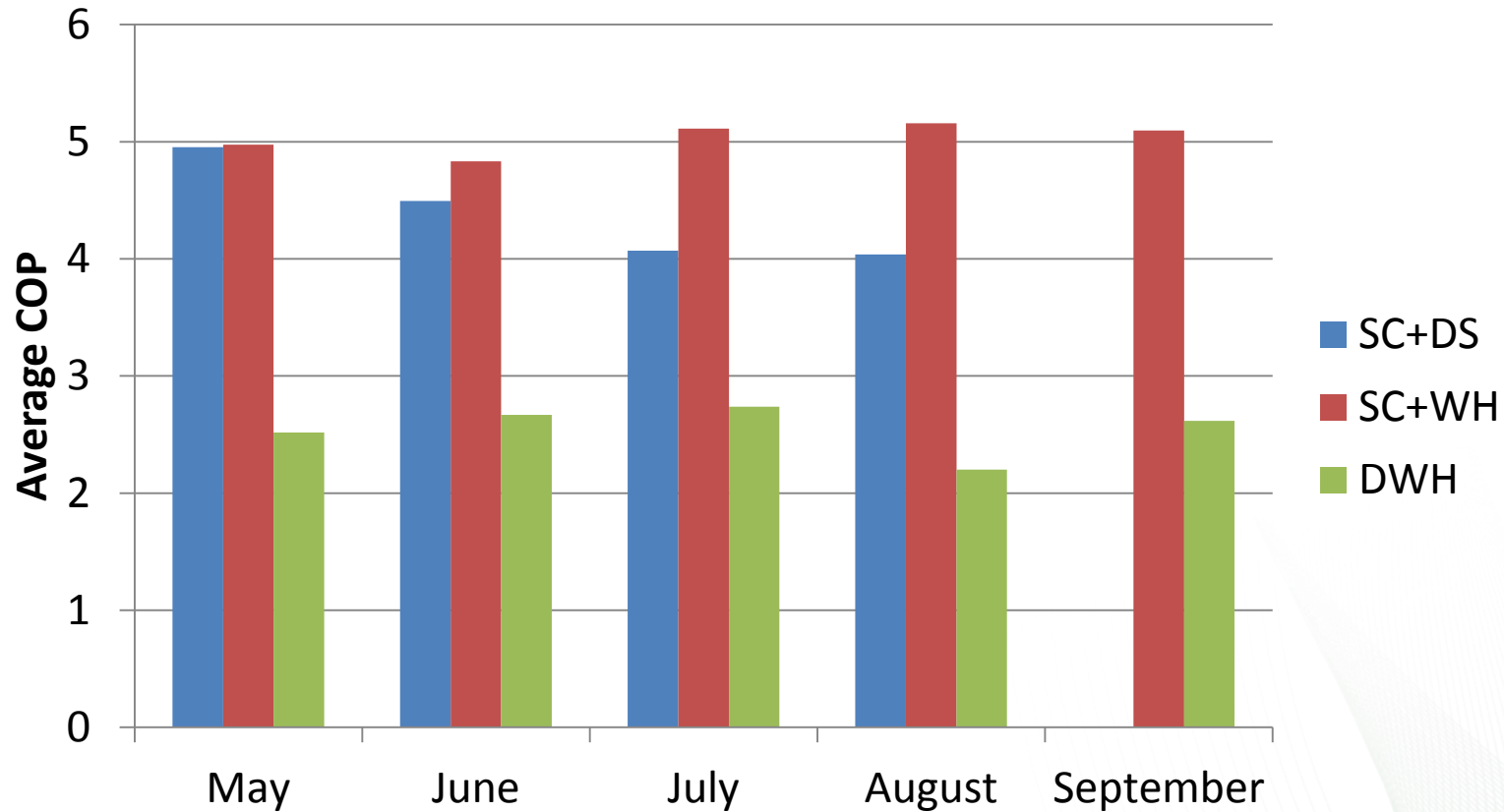
Field Test

- Summer Water Heating – Average Capacity



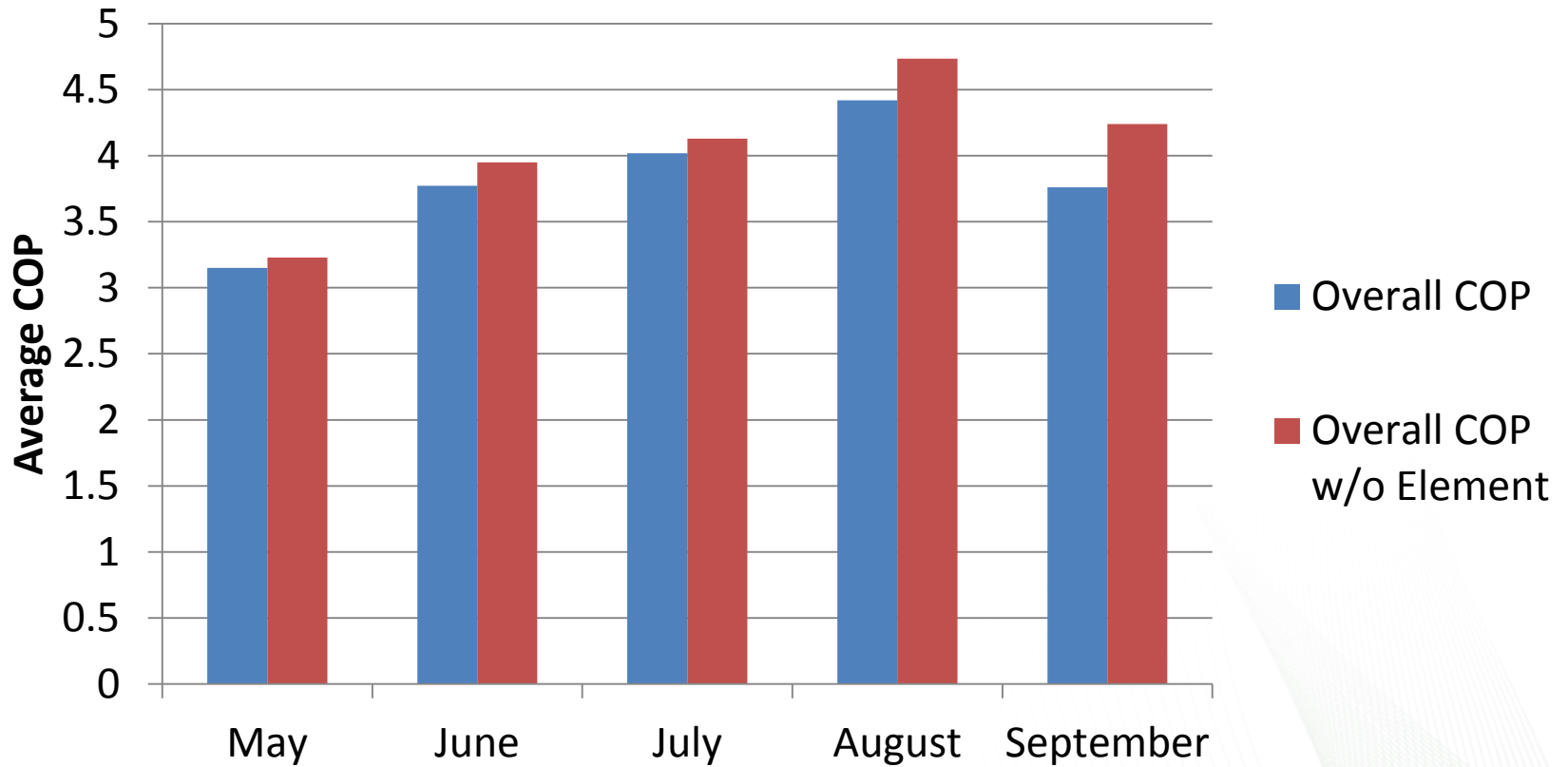
Field Test

- Summer Water Heating – COP by Mode



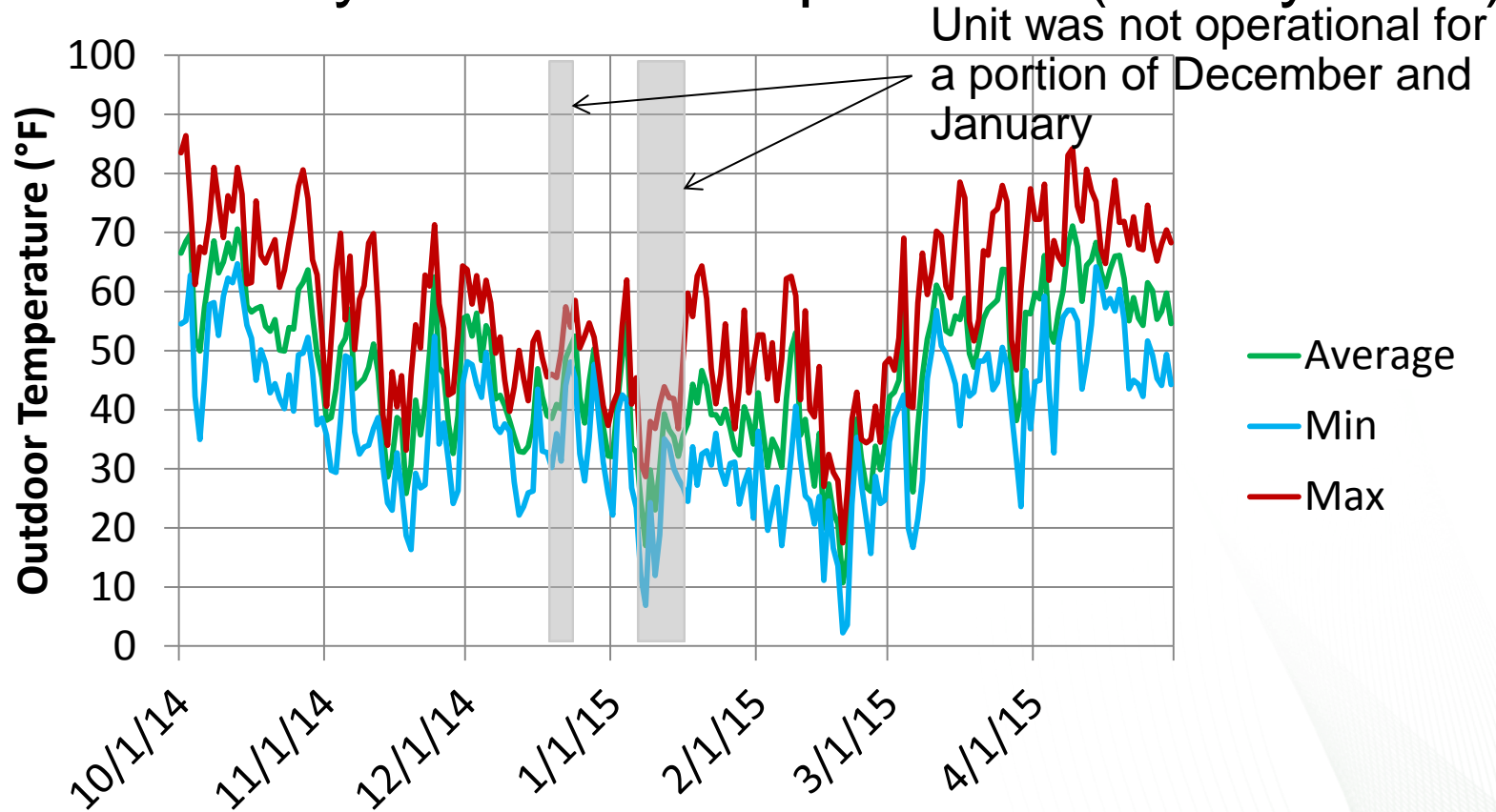
Field Test

- Summer Water Heating – Overall COP



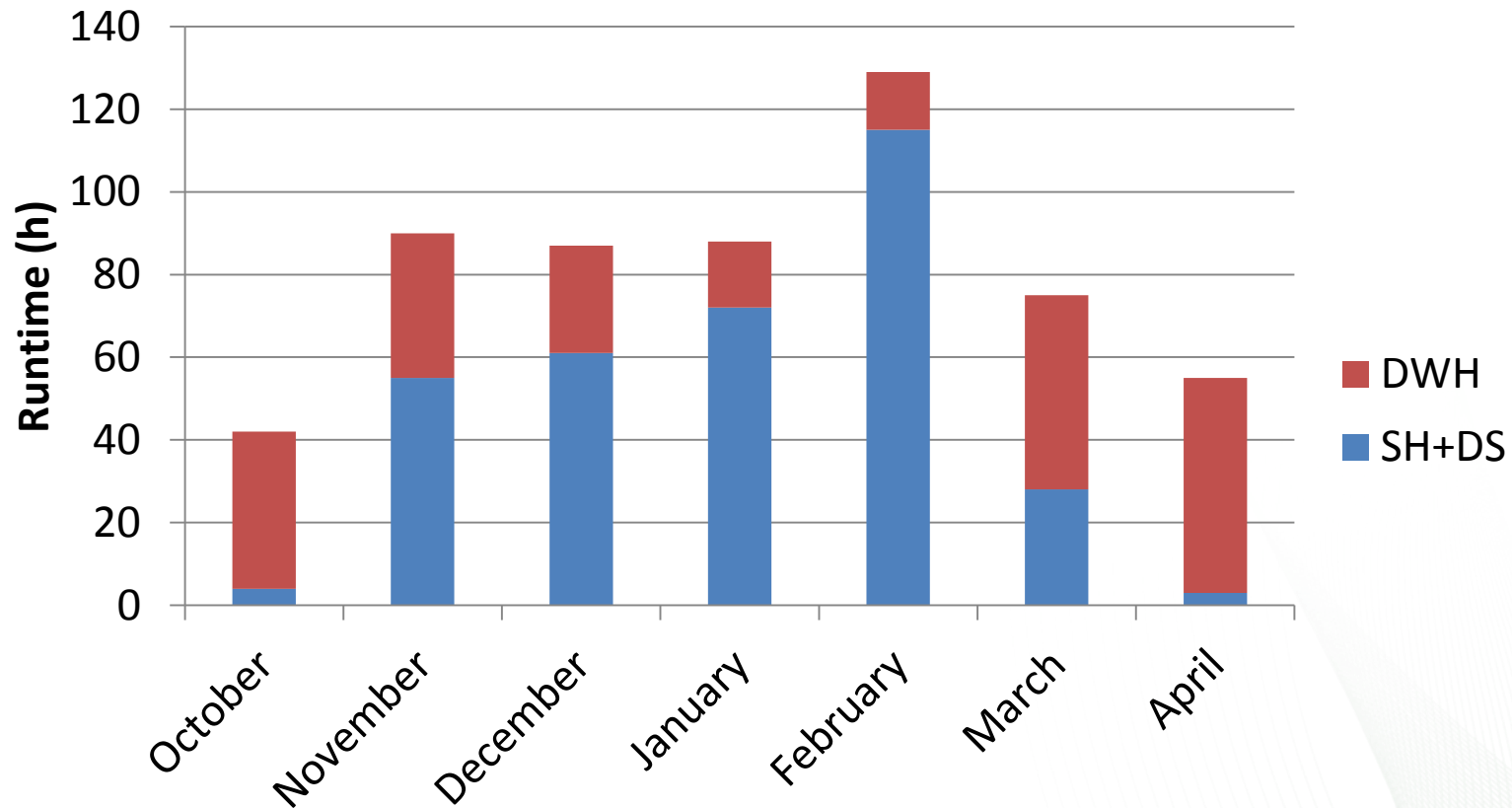
Field Test

- Winter Daily Outdoor Temperature (Hourly Data)



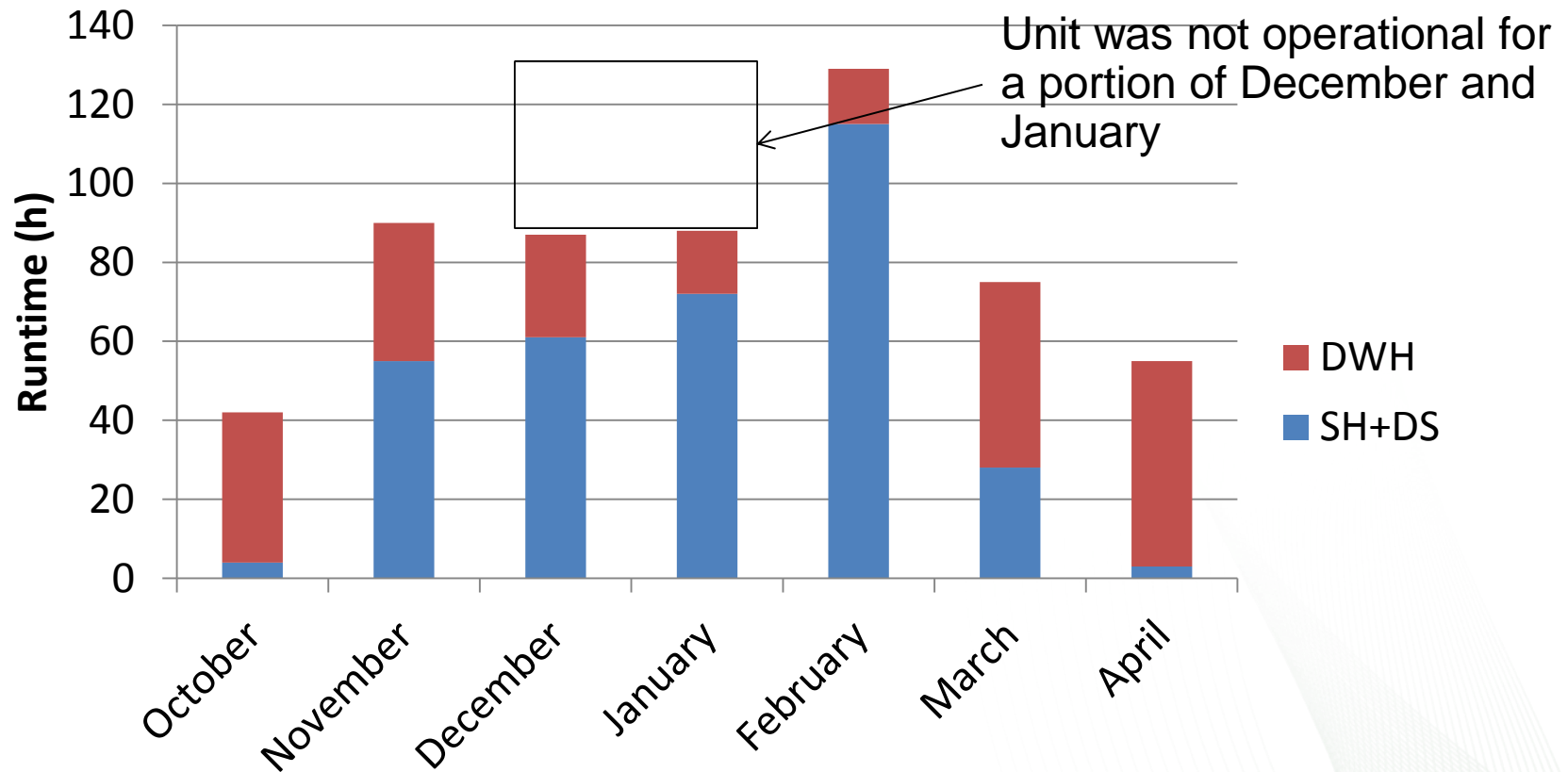
Field Test

- Winter Water Heating – Runtime by Mode



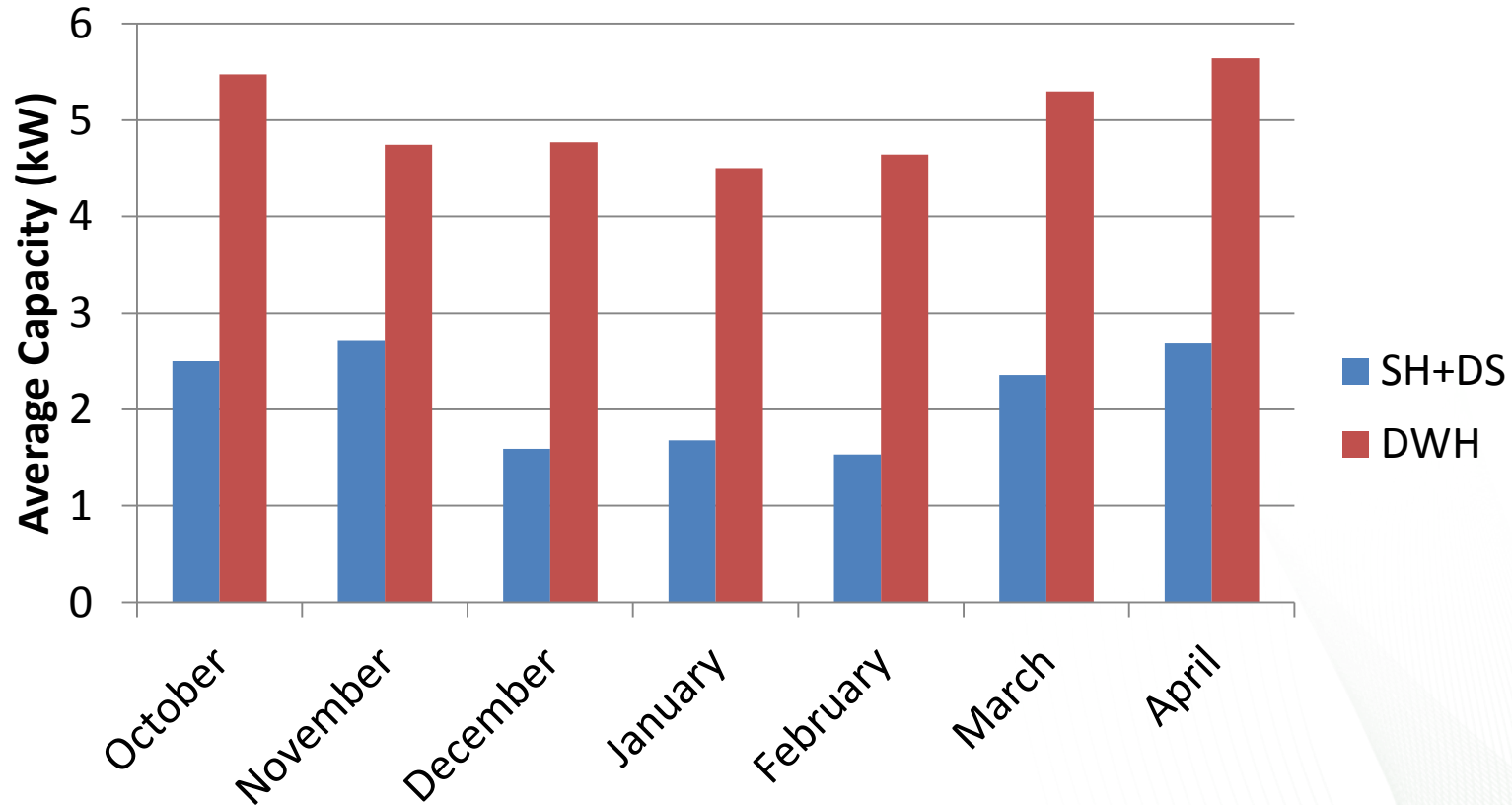
Field Test

- Winter Water Heating – Runtime by Mode



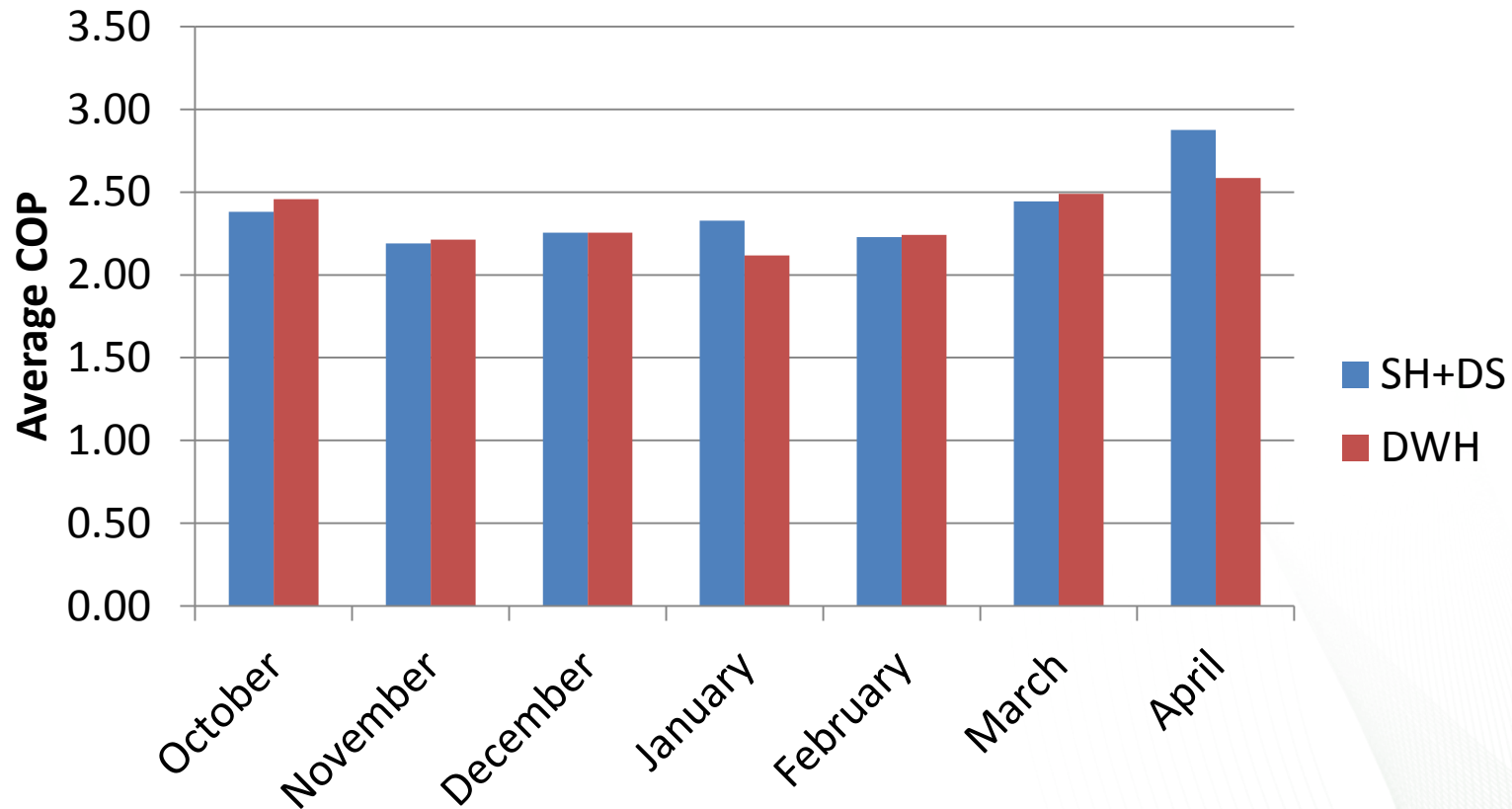
Field Test

- Winter Water Heating – Average Capacity



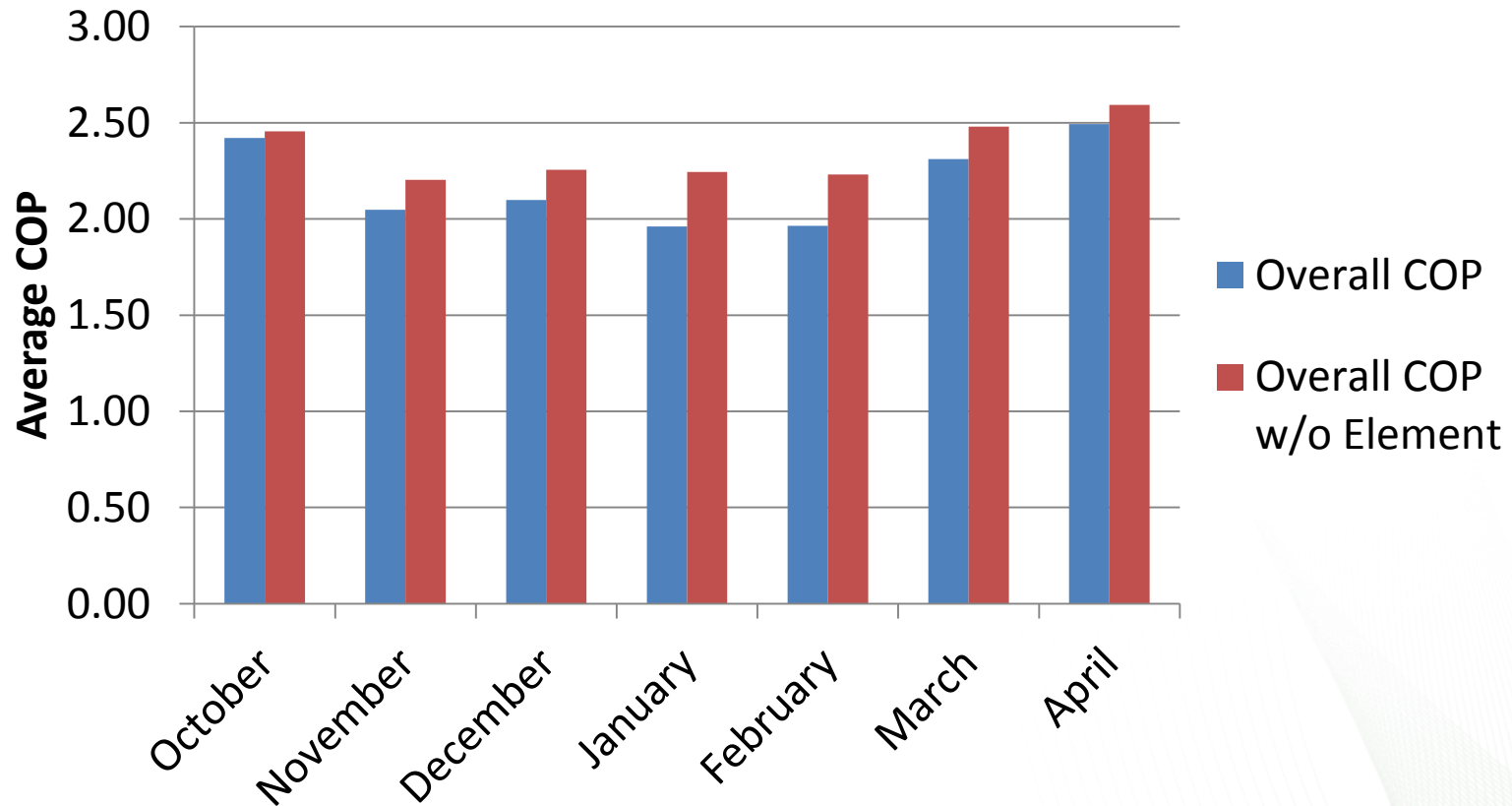
Field Test

- Winter Water Heating – Average COP



Field Test

- Winter Water Heating – Overall COP



Conclusions

- Annual Water Heating COP
 - 2.68 including WH element use
 - 2.89 not including WH element use
- Estimated 63% savings over standard electric storage water heater
- Based on test results, applications with thermal loads dominated by water heating and space cooling yield the best savings
 - Restaurants, commercial laundries, health/fitness centers, lodging facilities, etc.

Discussion

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