4A: Development and Assessment of Commercial Gas Absorption Heat Pump Water Heaters

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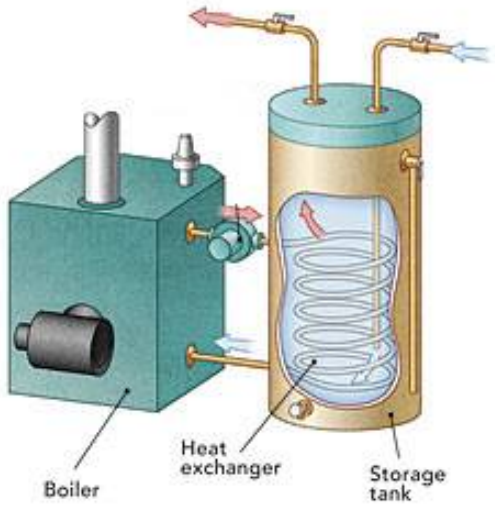
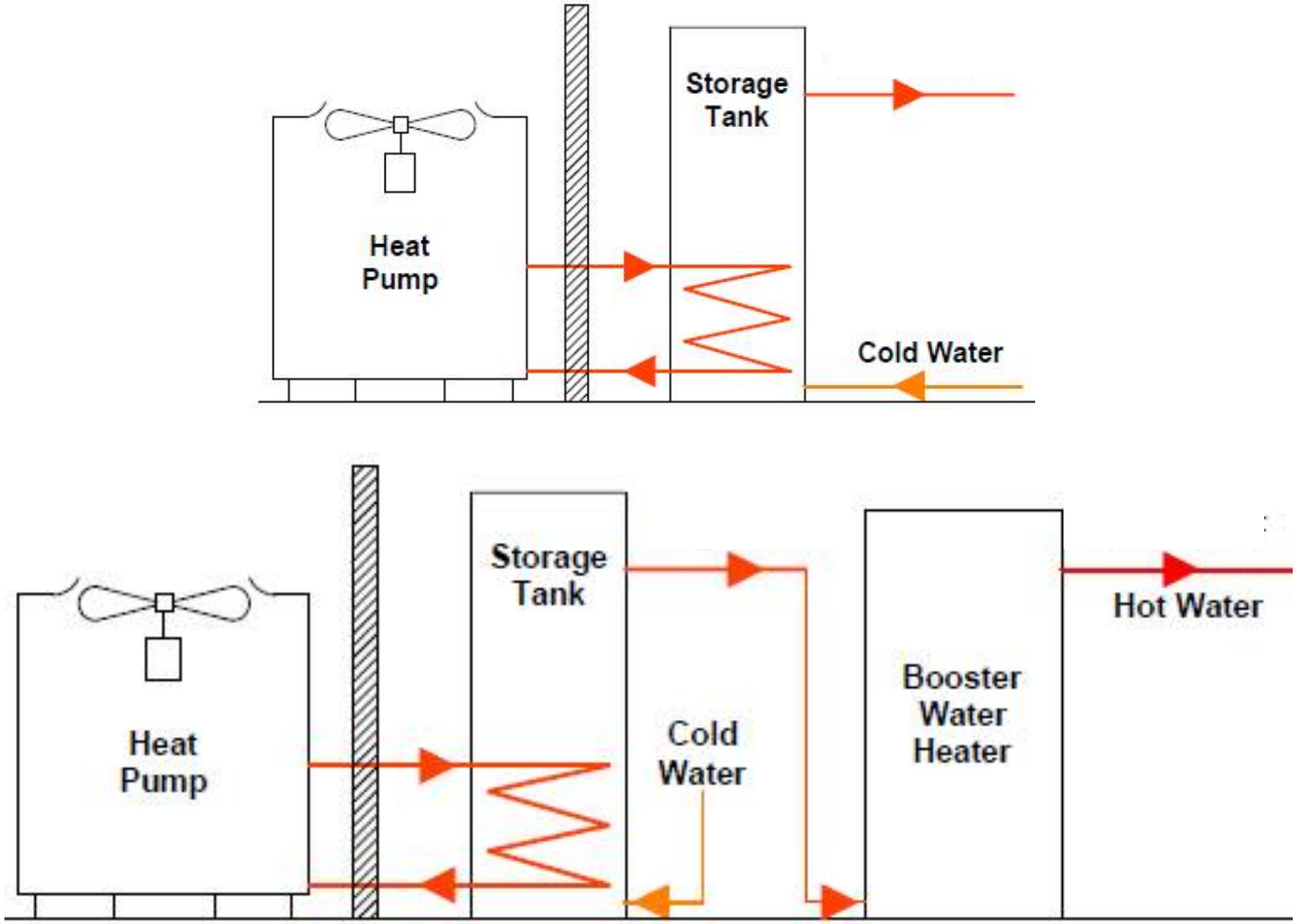
Commercial Water Heating Technologies

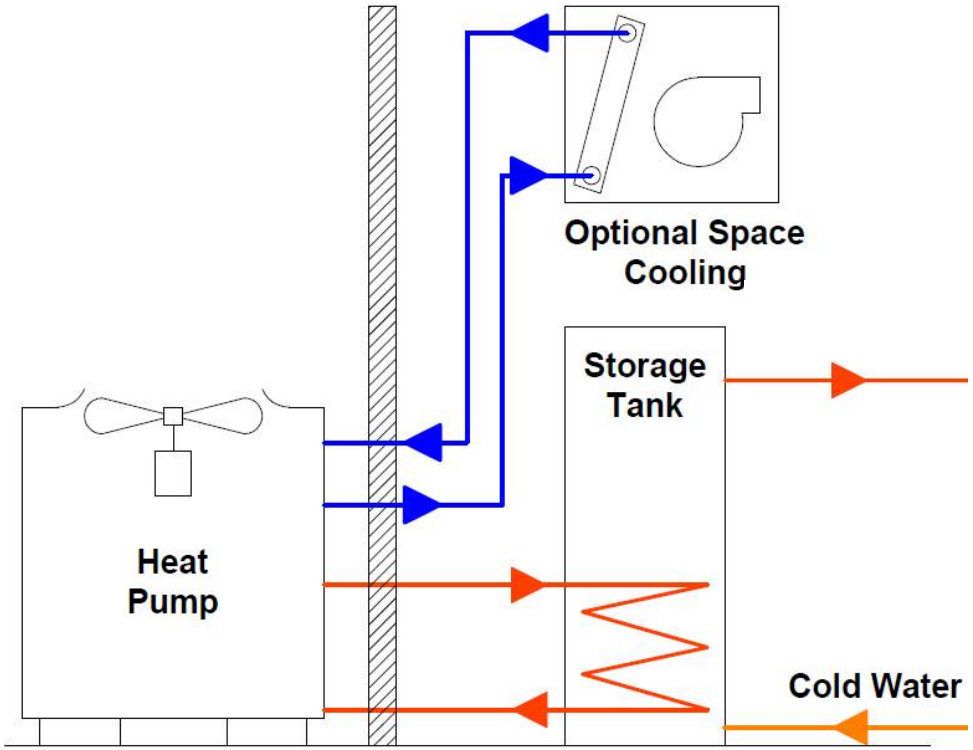


Commercial Water Heating Technologies

GAHP Commercial Water Heating



GAHP Commercial Water Heating



Gas-Fired Absorption Heat Pump

From Ambient Air

0.5

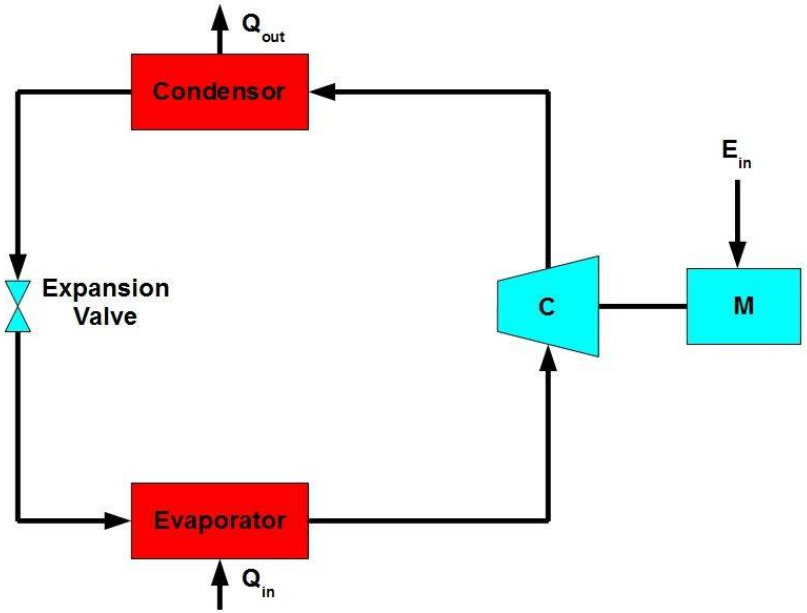
1.0

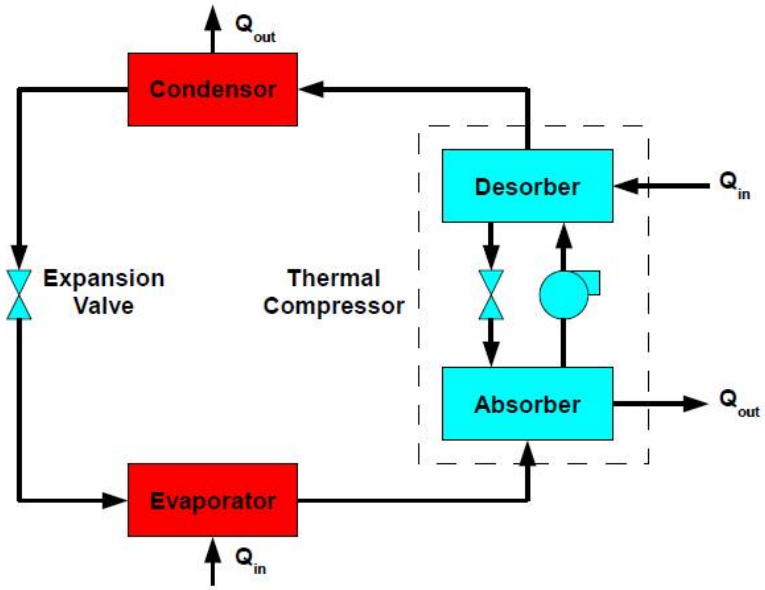
1.5

Fuel Source **

***** Natural Gas, Propane, Fuel Oil, BioDiesel, Renewable Gas, etc.***

How Does It Work?





$COP_h = Qcond/E_{in} = 3.0\text{-}4.0$

Qheat = ~1.1 x Qcooling

$COP_h = (Qcond + Qabs)/Q_{in} = 1.4\text{-}2.0$

Qheat = (Qcond + Qabs) ~ 2.5 times Qevap

Capacity & COP Remain High at Low Ambient Temperatures

SMTI Gas Absorption Heat Pumps

COP_{HHV} = 1.45 at 47/120°F

- Gas-Fired, Air to Water Heat Pump
- Condensing
- 4:1 Modulation

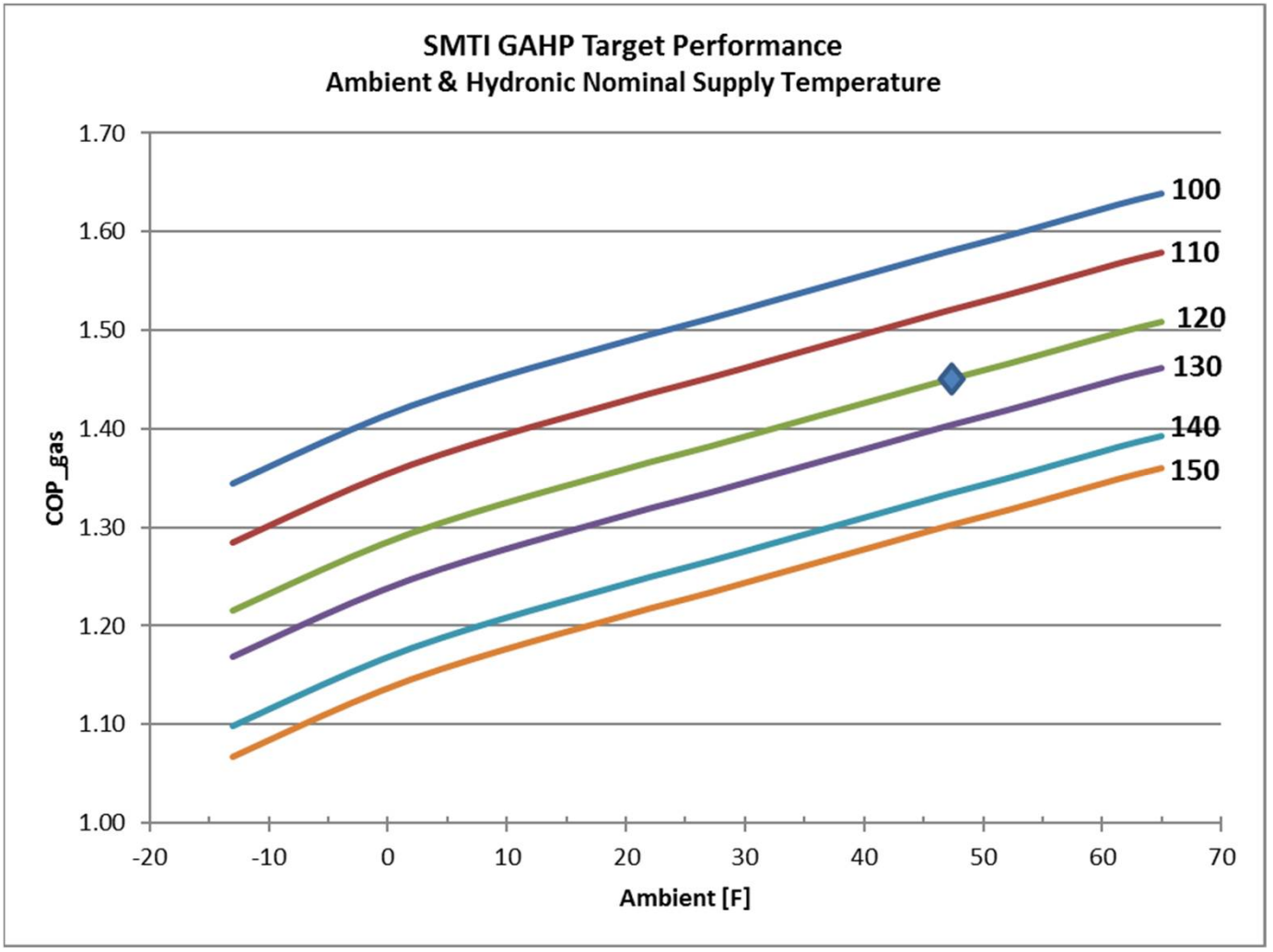
- 10,000 to 140,000 Bth Heating Output Models
- 20° F Hydronic Differential
- 160°F Maximum Hydronic Supply
- < -25°F Ambient

- Outdoor Installation (no venting)
- SCAQMD NOx Compliant
- GWP = 0

Patents Pending

SMTI GAHP Target Performance

Nominal 20F Rise



Family of GAHP Models

10 kBth **20 kBth** **80 kBth** **140 kBth**

Anything In-Between

gti

UTD Utilization Technology Development

U.S. DEPARTMENT OF ENERGY

neea

ENGIE

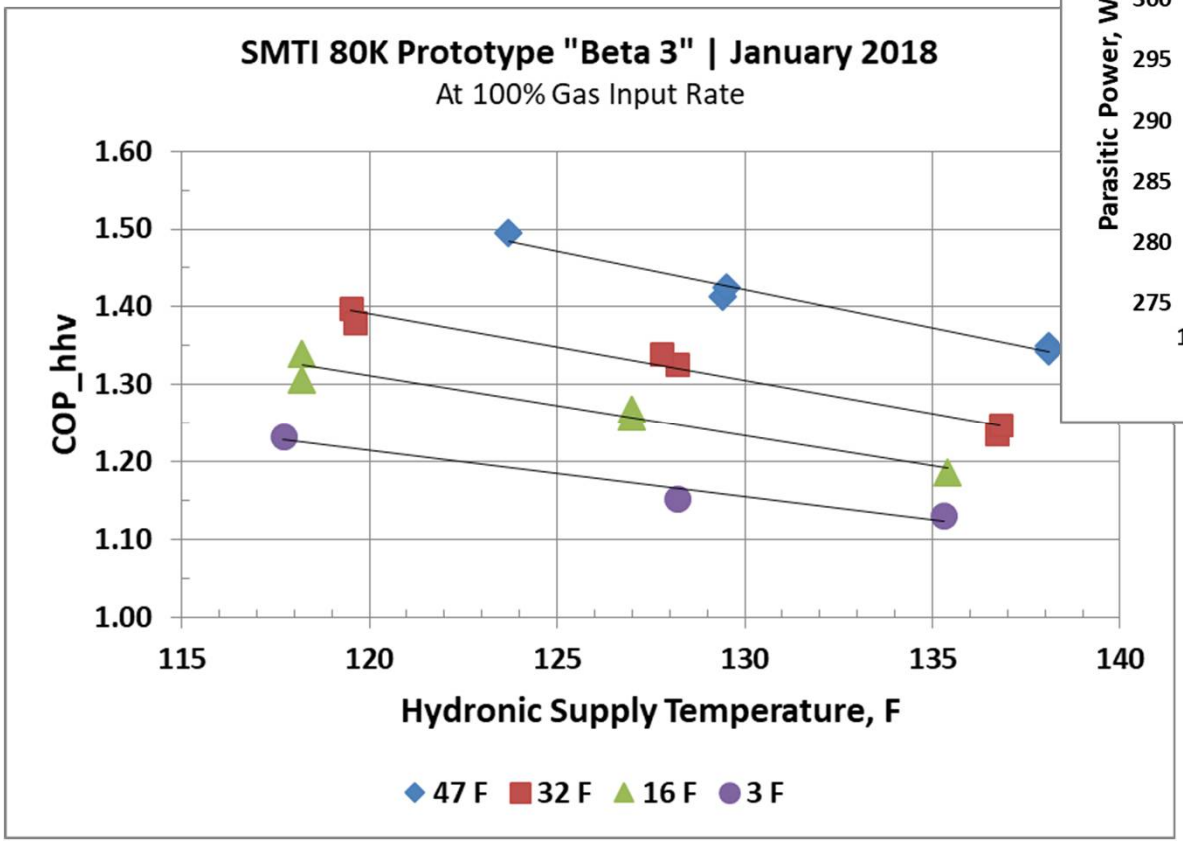
ornl OAK RIDGE NATIONAL LABORATORY

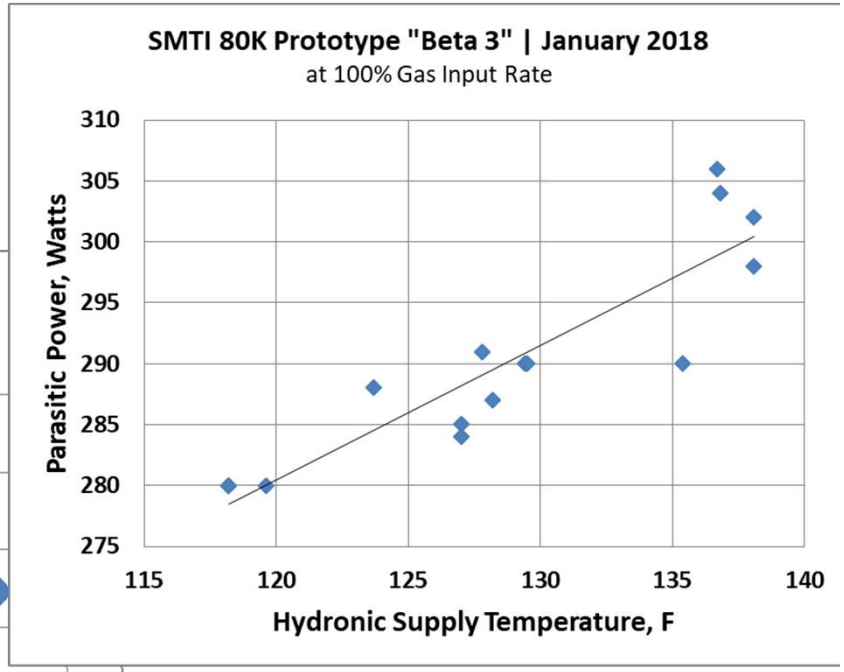
Most Recent GAHP Prototypes

80,000 Btu/hr “Beta 3”

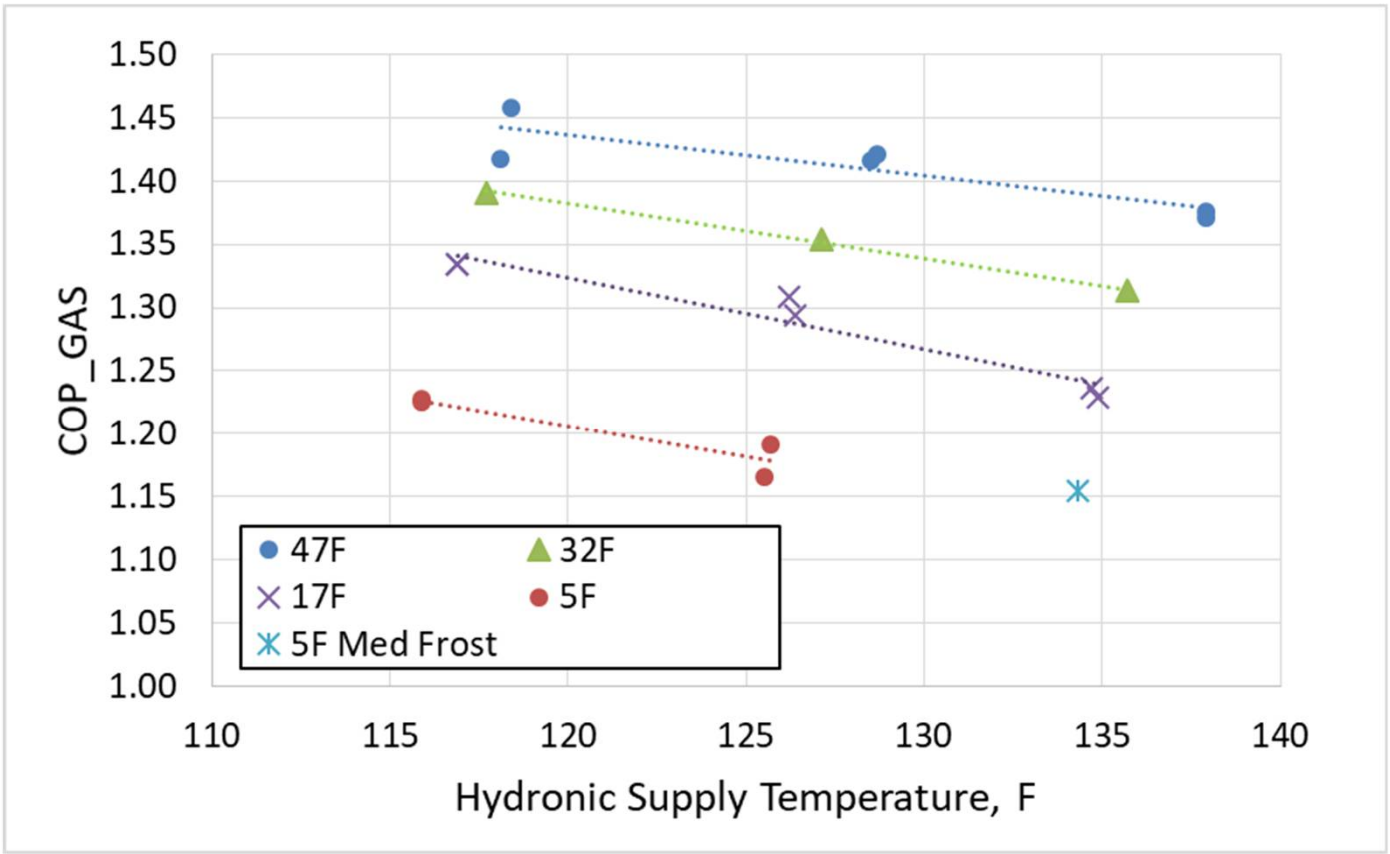
140,000 Btu/hr “Beta 2”

80K GAHP Beta 3





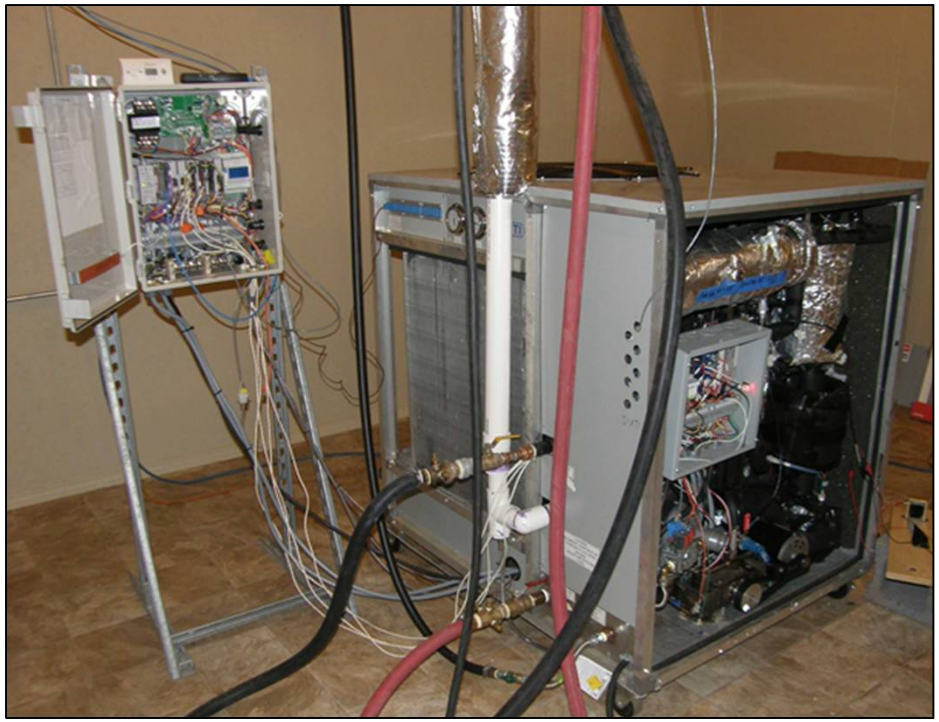
140K GAHP Beta 2



GAHP Reliability Testing

- Beta 1 runtime as of 2/16/18: 2002 hours
- Beta 2 runtime as of 2/9/18: 4400 hours

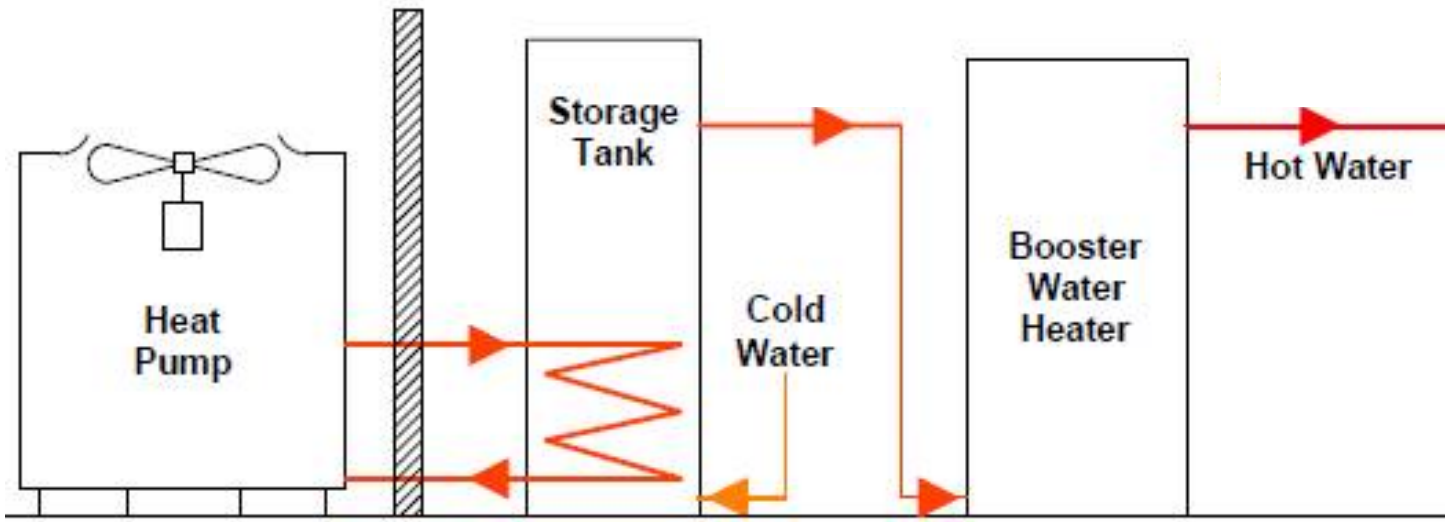
Beta 1 GAHP installed at home in Northeast TN



Beta 2 GAHP hydronically coupled to heat rejection facility with variable speed fan

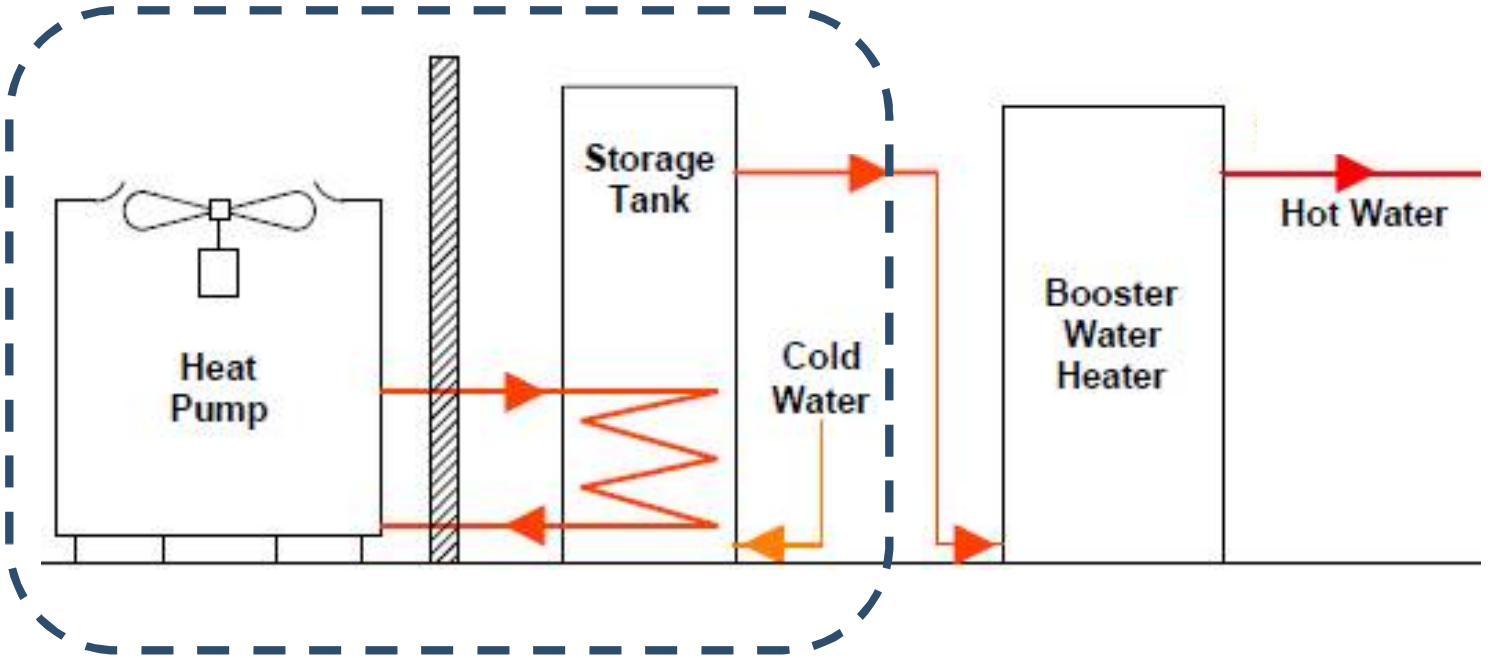
Full-Service Restaurant Simulated Use Testing

Assumed Installation Configuration



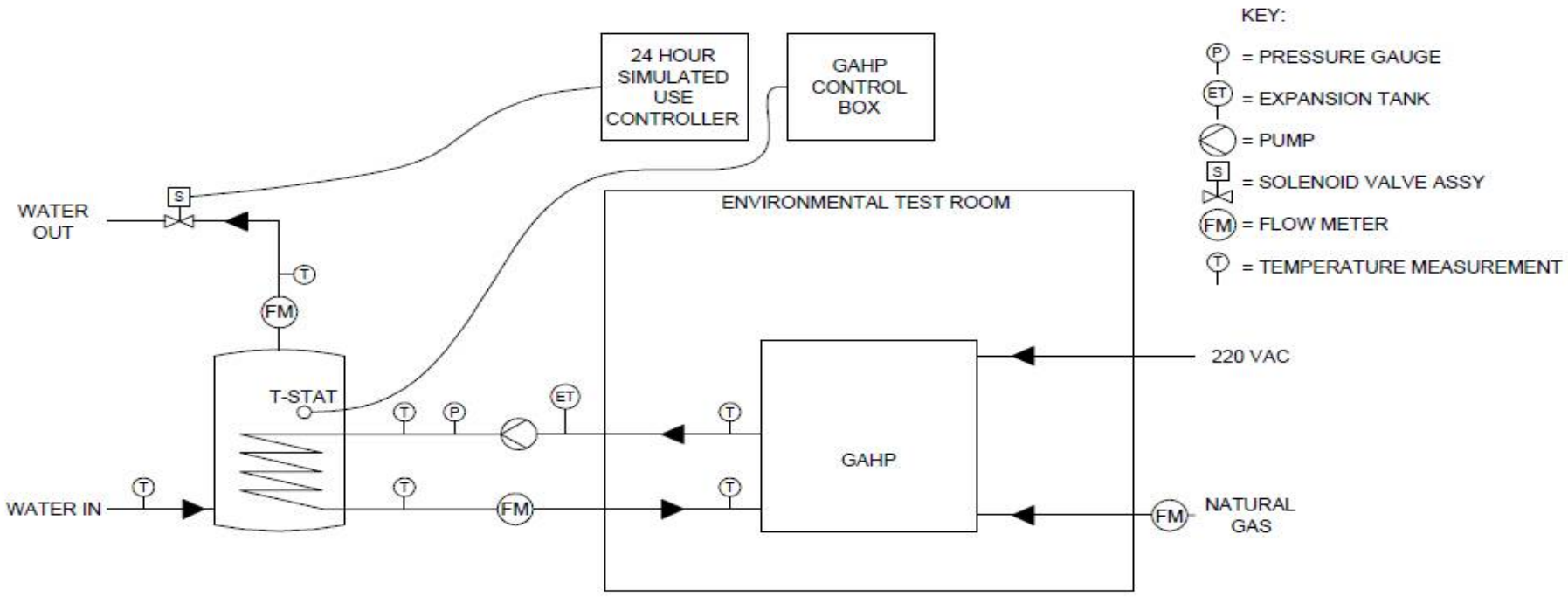
Assumed Installation Configuration

Test Control Volume



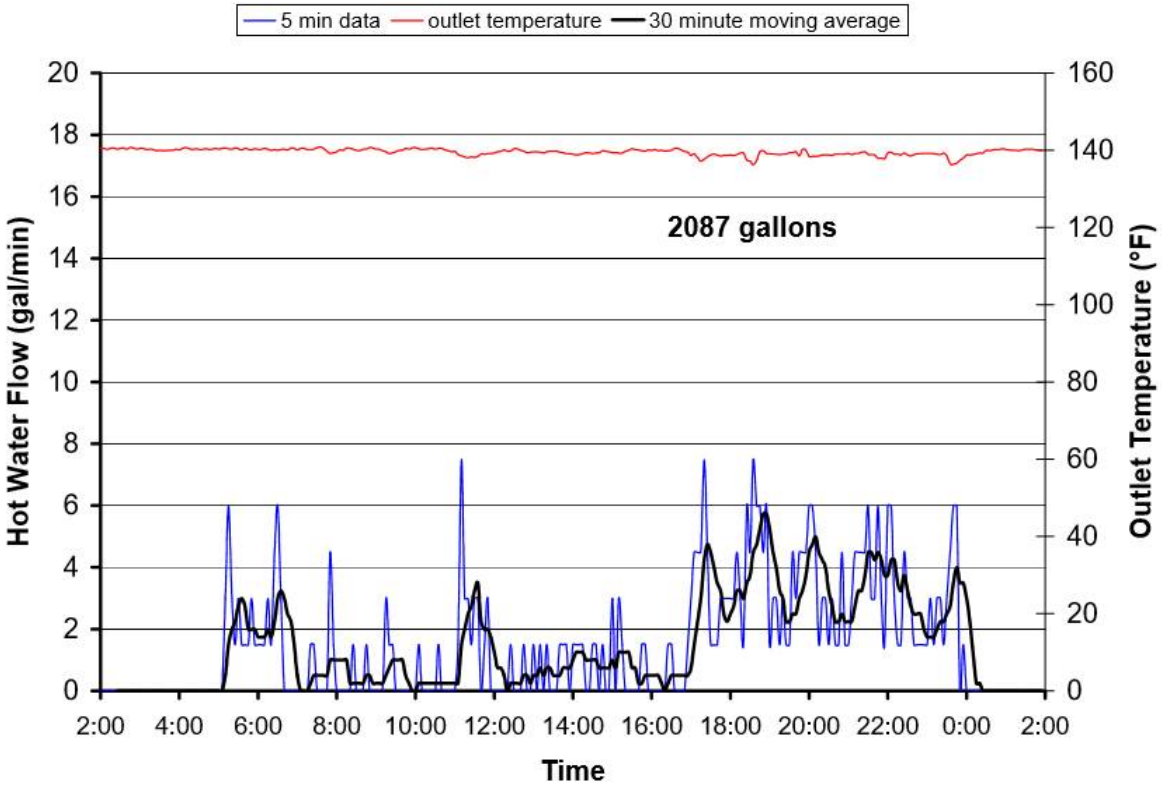
Test Set-up

- 80 kBth GAHP “Alpha 3” Prototype
  - COP 5-10% lower than more recent “Beta” Prototypes
- Hydronically Coupled to 113 Gallon Indirect Storage tank
- Chamber Ambient: 50ºF **



**** Average ambient contiguous U.S (2015): 54.4ºF***

Full Service Restaurant Draw Pattern



Wallace and Fisher, 'Energy Efficiency Potential of Gas Fired Commercial Hot Water Heating Systems in Restaurants,' (2007)

Tests Performed At:

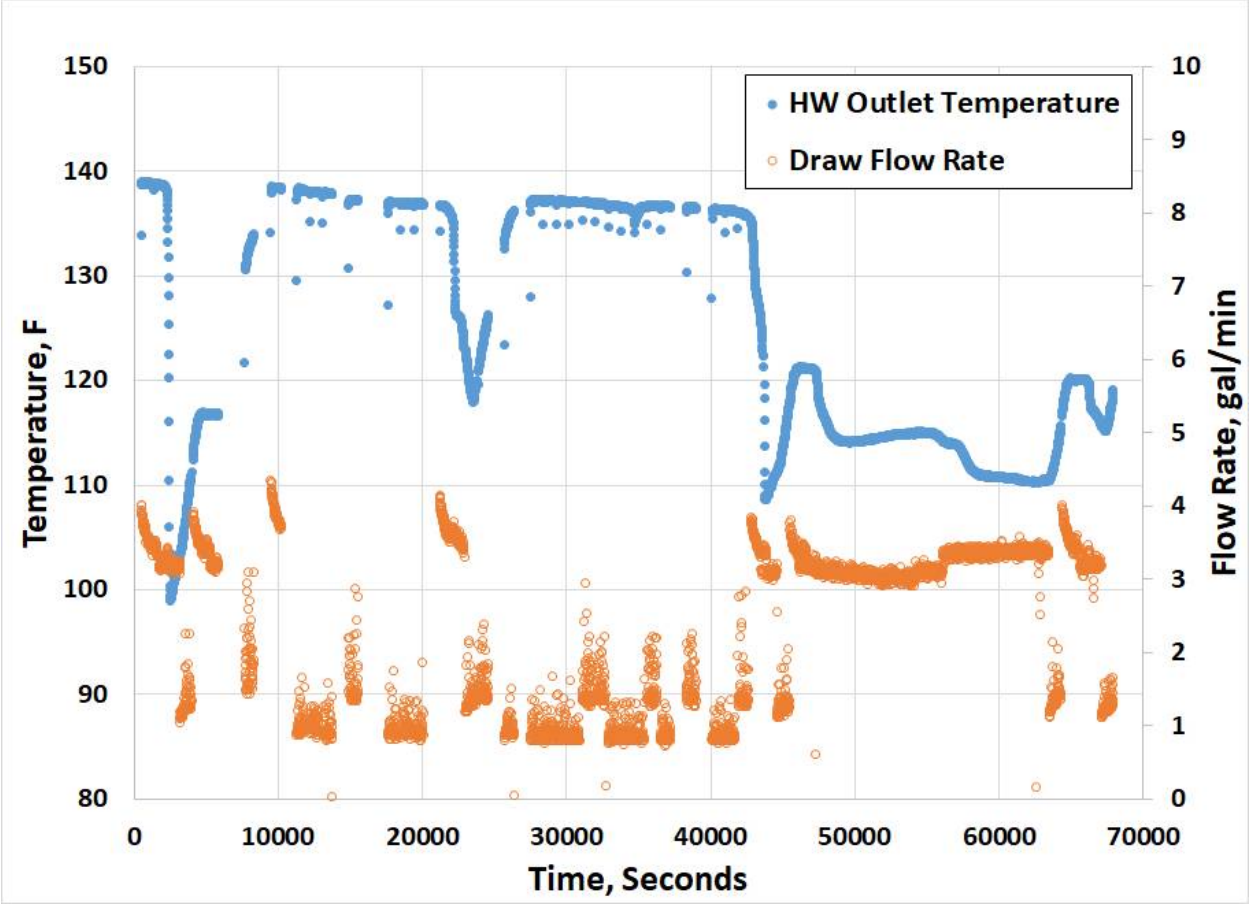
100% (~2000 gpd)

125% (~2500 gpd)

75% (~1500 gpd)

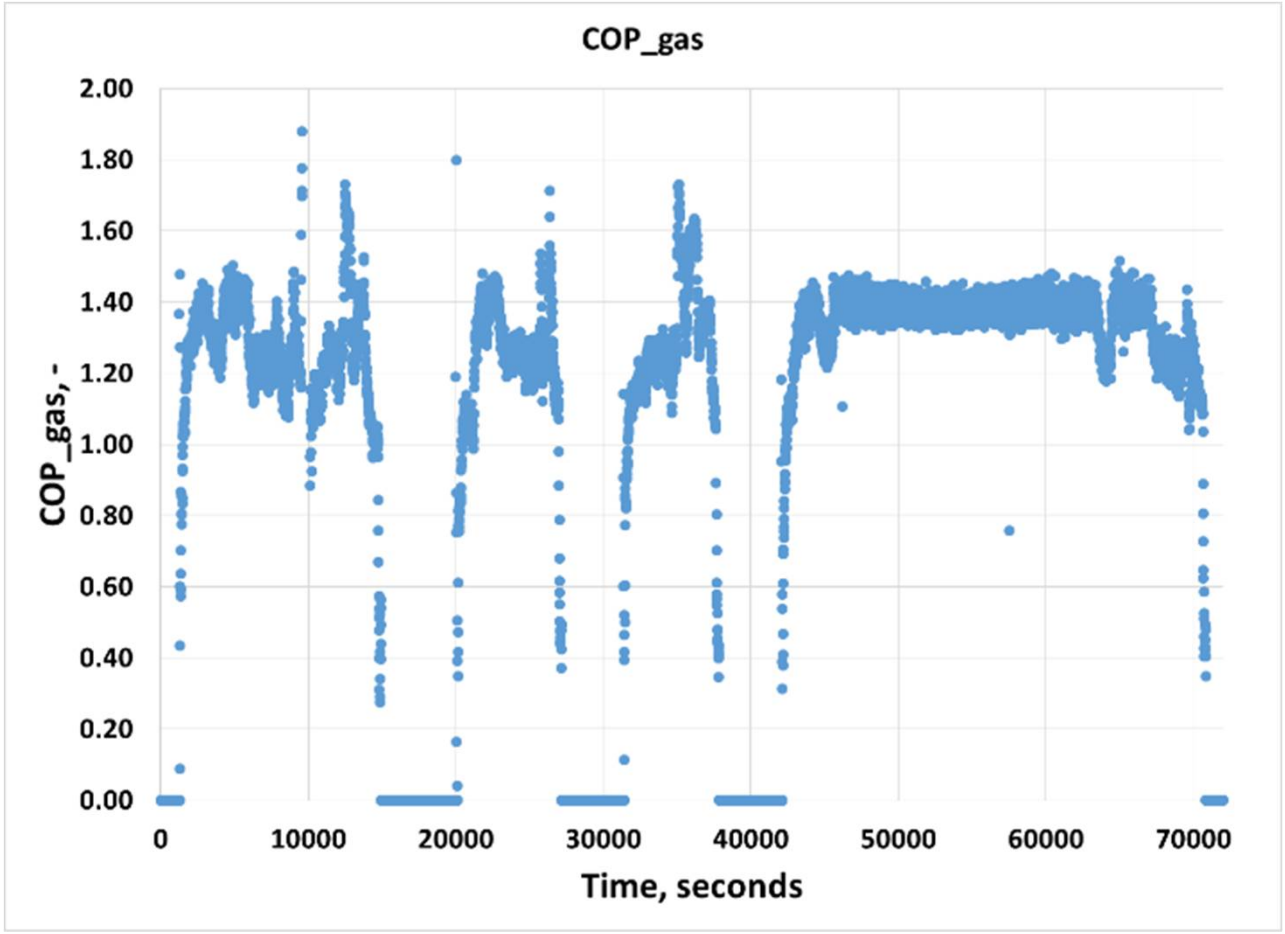
100% (~2,000 gallons) at 50°F Ambient

- Avg Tank inlet & outlet water temps: 69.3°F & 124°F
- 99.5% above 100°F
- 69% above 120°F
- GAHP provided 72% of delivered energy (140°F supply)
- Average GAHP COP: 1.32



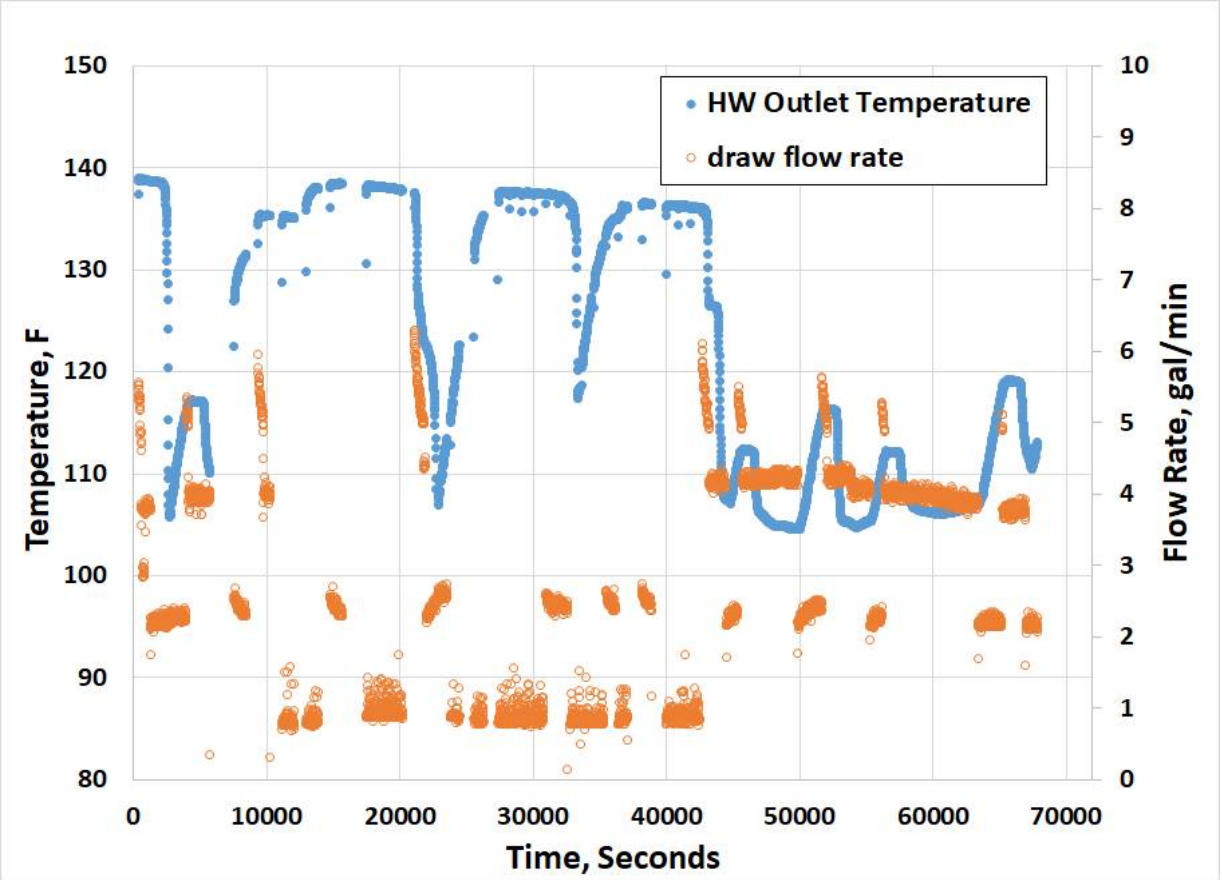
**** Two tests completed (Test 1,2) with virtually identical results***

100% (~2,000 gallons) at 50°F Ambient



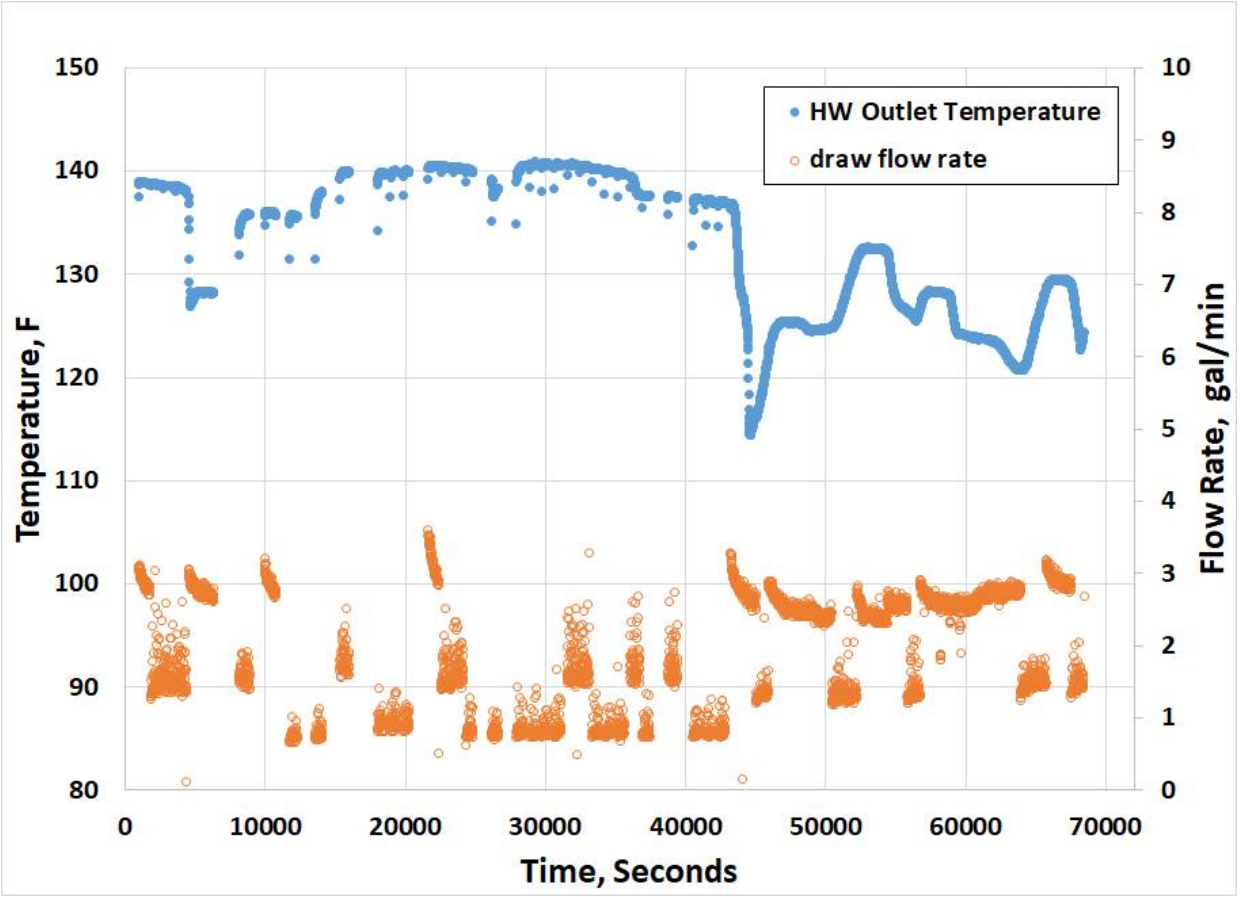
125% (~2,500 gallons) at 50°F Ambient

- Avg Tank inlet & outlet water temps: 70.8°F & 121°F
- 100% above 100°F
- 31% above 120°F
- GAHP provided 67% of delivered energy (140°F supply)
- Average GAHP COP: 1.35

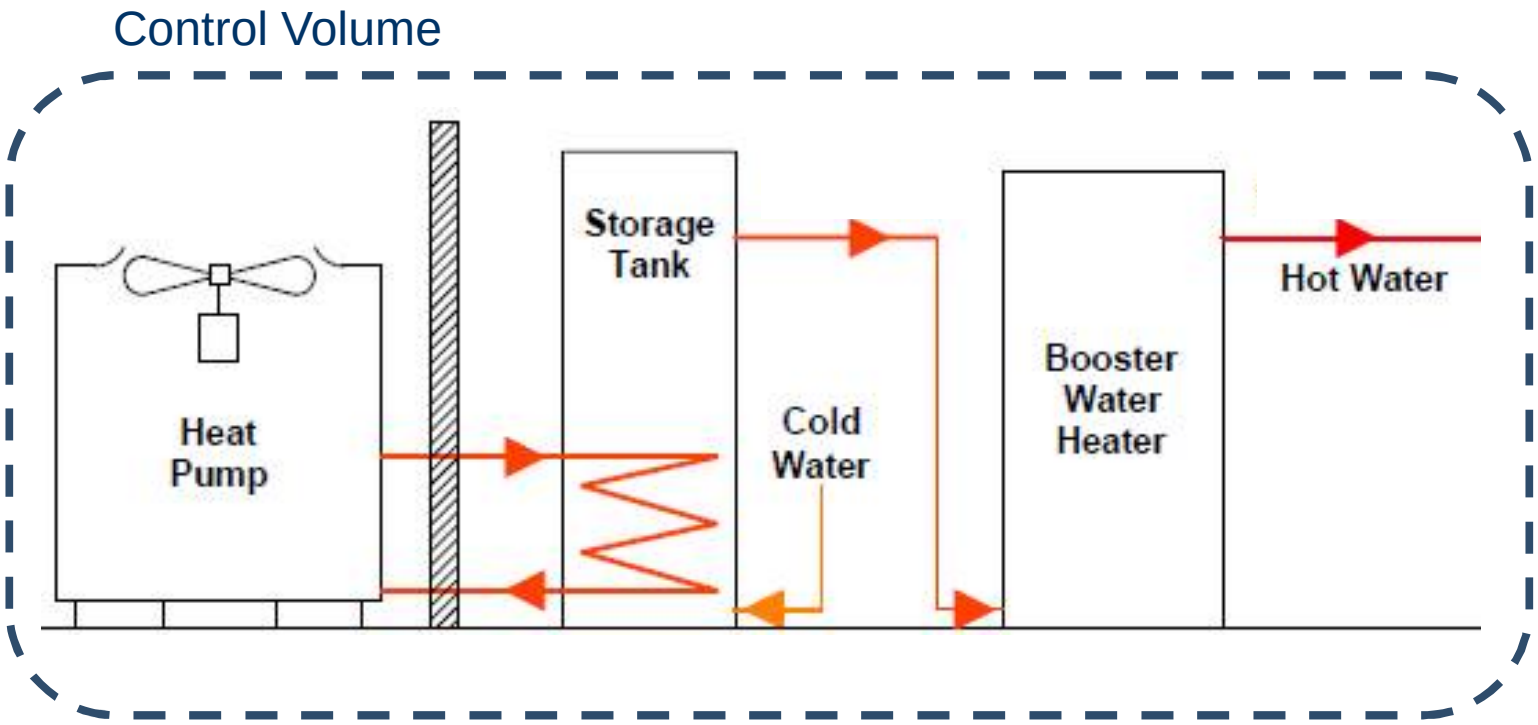


75% (~1,500 gallons) at 50°F Ambient

- Avg Tank inlet & outlet water temps: 72.2°F & 132°F
- 100% above 110°F
- 98% above 120°F
- GAHP provided 85% of delivered energy (140°F supply)
- Average GAHP COP: 1.25



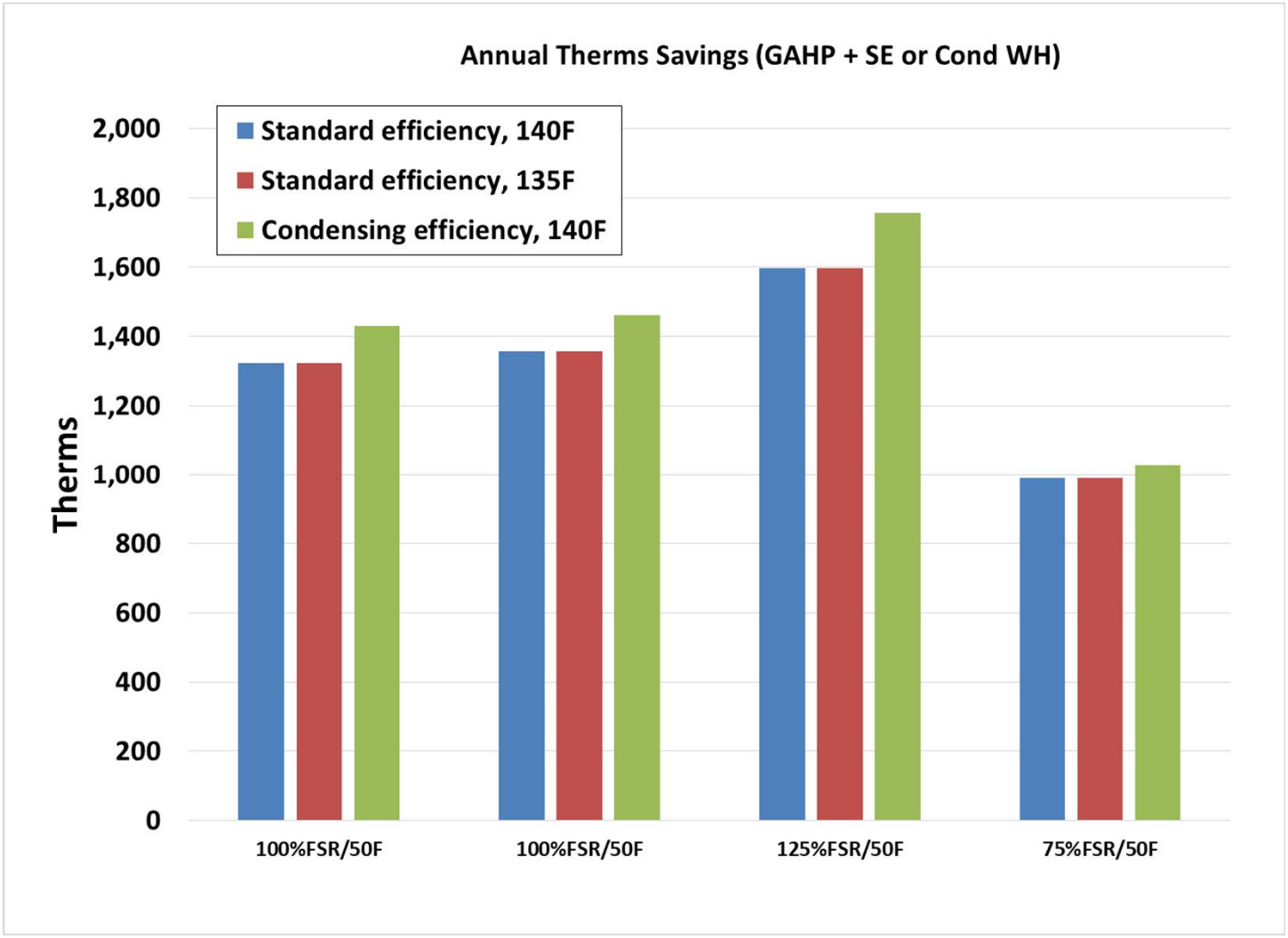
Extending Study with Modeling



- COP_gas of heat pump only
- COP_gas of system with GAHP and Standard WH targeting 140°F
- COP_gas of system with GAHP and Standard WH targeting 135°F
- COP_gas of system with GAHP and Condensing WH targeting 140°F

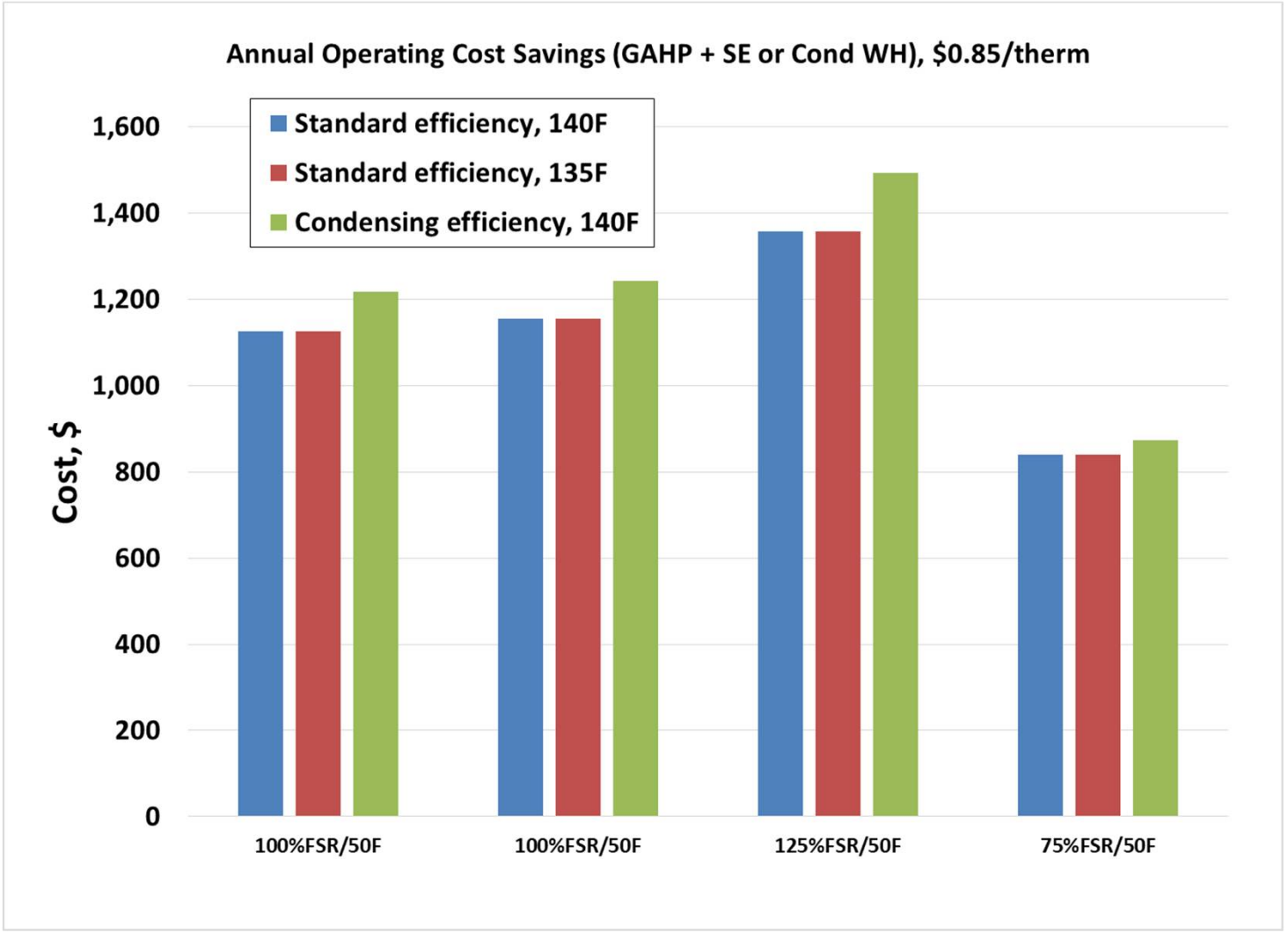
Annual Therms Saved

Compared to 80% Storage Tank Installation



Annual Savings at $0.85/therm

Compared to 80% Storage Tank Installation



Simple Payback: 2500 gpd

80 kbth GAHP + 100g IST + 199k/100g "Booster" Water Heater

vs

Two 199k/100g Non-Condensing Storage Water Heaters

Two 199k/100g Condensing Storage Water Heaters

	GAHP	NC	Cond
Installed Cost	$14,370	$10,130	$13,200
Therms Used/yr	4,863	6,651	5,912
kWhr/yr	1,317		266
Gas Cost/yr	$4,620	$6,318	$5,616
Electric Cost/yr	$132		$27
Therms Saved/yr (vs NC)	1,788		
Net Savings/yr (vs NC)	$1,567		
Simple Payback, yrs (vs NC)	**2.7**		
Therms Saved/yr (vs Cond)	1,049		
Net Savings/yr (vs Cond)	$891		
Simple Payback, yrs (vs Cond)	**1.3**		

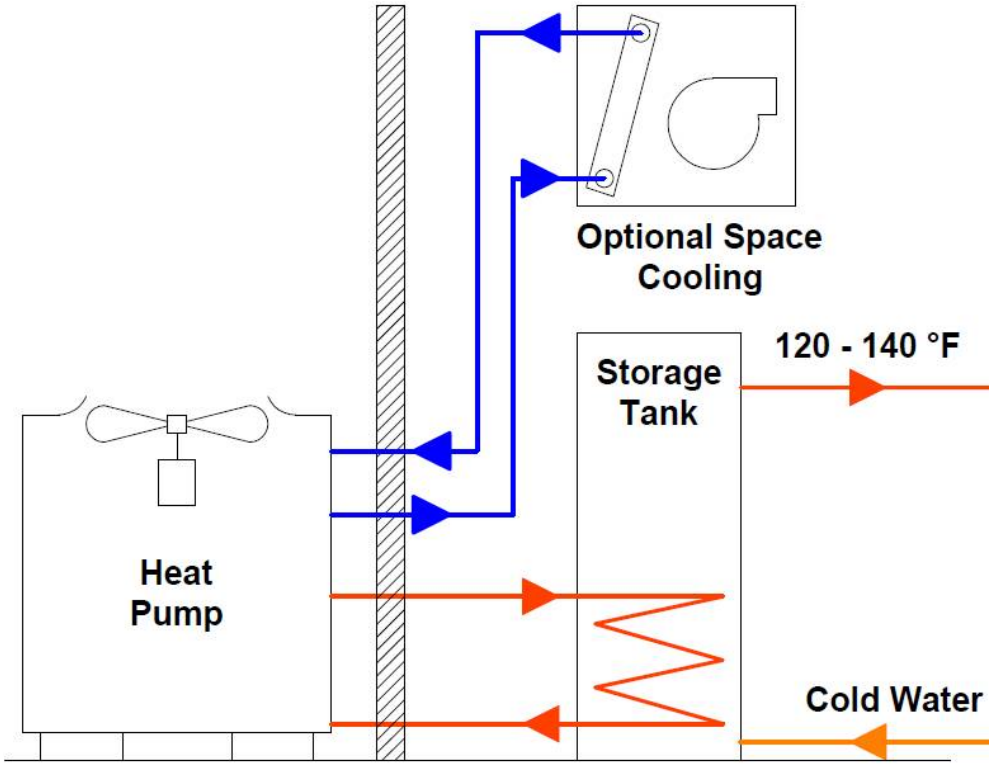
Natural Gas: $0.95 per therm ***Electricity: $0.10 per kWhr***

Summary

- An 80,000 btu/hr GAHP connected to 113 gallon tank can provide the majority of the water heating load required for typical Full Service Restaurants
- GAHP systems offer significant therm and dollar savings
- Total daily draw has a significant impact on savings
- Size of storage tank internal heat exchanger can have a large impact on average COP of GAHP
- Future testing with Beta GAHP prototypes should show higher energy and cost savings

Next Steps in 2018

- Two full service restaurant field tests in Los Angeles
- **Water heating and kitchen cooling**



Other GAHP Projects in 2018

- Commercial Laundry Field Test
  - (see my presentation from Session 3C)
- 3 residential combi field tests in cold climate regions
- Six residential water heater field tests in Los Angeles
- Multi-family combi field test in Chicago
- 20 kbtu/hr residential combi prototype (net zero energy)
- Fuel-oil / Bio-diesel residential combi prototype

Acknowledgments

Thank You!

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