

**Commercial Water Heating  
Residential Combo Systems  
*with*  
Gas Absorption Heat Pumps**

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**ACEEE Hot Water Forum**

**Nashville, TN**

**February, 2015**

# Topics of Discussion

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- ❖ **Technology Background and Status**
- ❖ **Commercial Water Heating Application**
- ❖ **Residential Combo System Application**

# GHP vs. GAHP

❖ **Gas Heat Pump (GHP) = Gas Engine Driven Vapor Compression Cycle**



✓ **Gas Absorption Heat Pump (GAHP) = Gas Absorption Heat Pump**



***Stone Mountain Technologies, Inc.***  
***Thermal Compressors for Sorption Heat Pumps***



- ❖ **Space Heating**
- ❖ **Water Heating**
- ❖ **Combo Systems**
- ❖ **Pool Heating**
- ❖ **Residential**
- ❖ **Commercial**

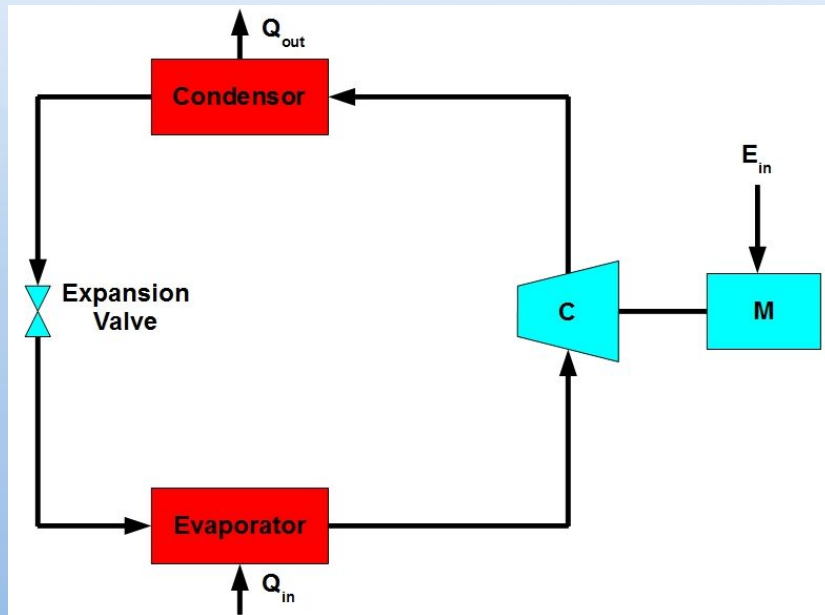


# Development Status

- ❖ **Residential Water Heater – 6 Field Test Units Installed**
- ❖ **80,000 Btu/hr GAHP – Alpha Prototype Under Test**
- ❖ **140,000 Btu/hr GAHP – Lab Testing**

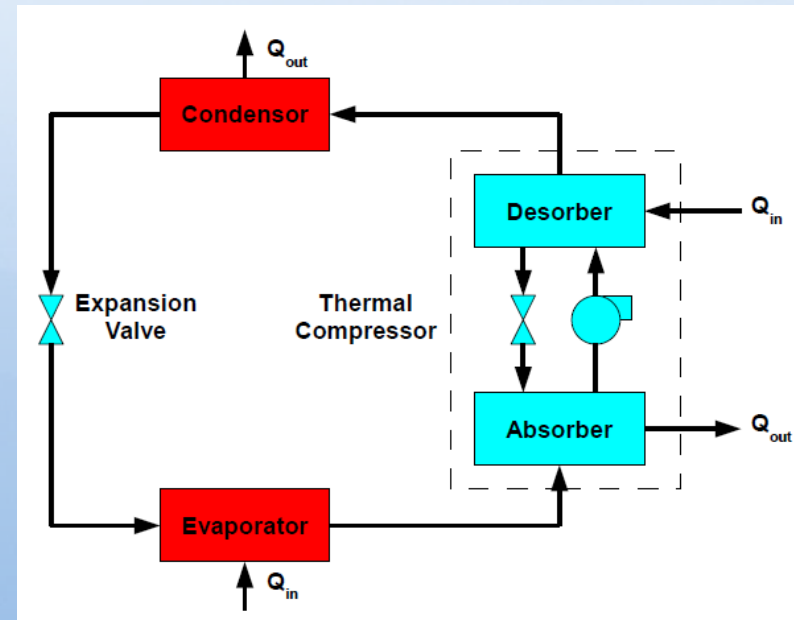


# How Does It Work?



$$COP_h = Q_{cond}/E_{in} = 3.0-4.0$$

$$Q_{heating} = 1.0-1.3 \times Q_{evap}$$

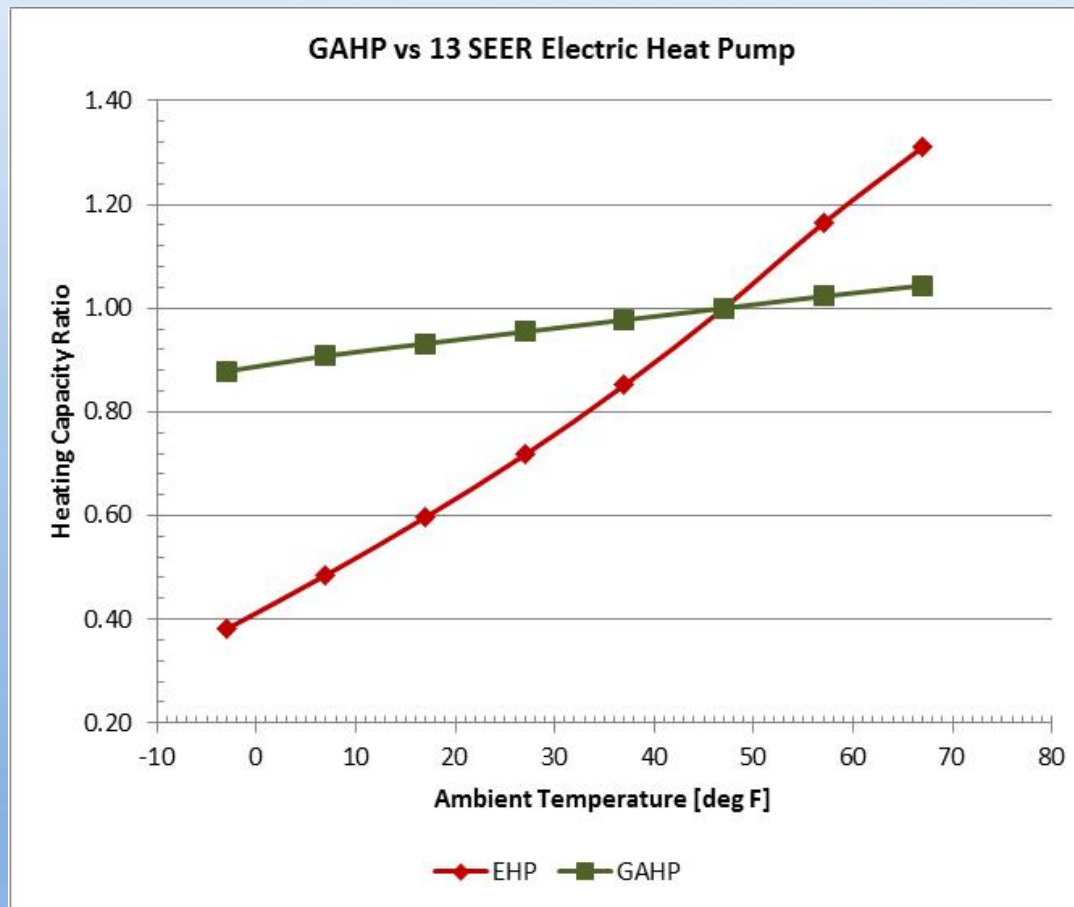


$$COP_h = (Q_{cond} + Q_{abs})/Q_{in} = 1.5-2.0$$

$$Q_{heating} = (Q_{cond} + Q_{abs}) \sim 2.5 \text{ times } Q_{evap}$$



# GAHP vs EHP Performance



*From A Marketing Perspective....*

## **Gas Absorption Heat Pumps:**

**Are NOT “Heat Pumps”**

**Are Very High Efficiency Furnaces or Boilers**



# SMTI Gas Absorption Heat Pump

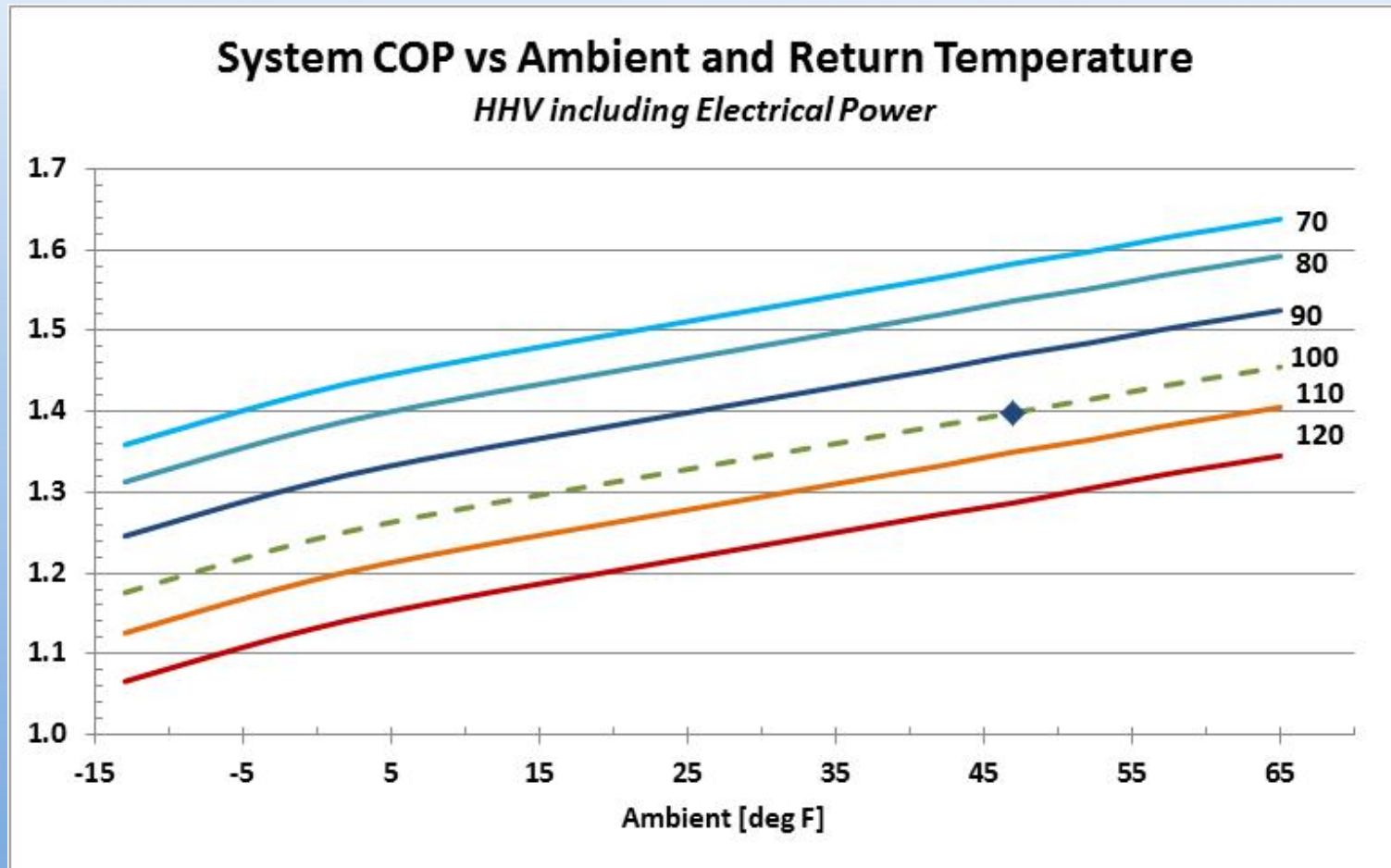
$$\text{COP}_{\text{HHV}} = 1.4 \text{ at } 47/100^{\circ}\text{F} \text{ (including parasitics)}$$

- ❖ Gas-Fired, Air to Water Heat Pump
- ❖ Condensing
- ❖ 3:1 Modulation
- ❖ 80,000 / 140,000 Bth Heating Output
- ❖ 47 F Ambient
- ❖ 100 F Return
- ❖ 20 F Delta
- ❖ Outdoor Installation



# SMTI GAHP Target Performance

Nominal 20F Rise



# Commercial Water Heating

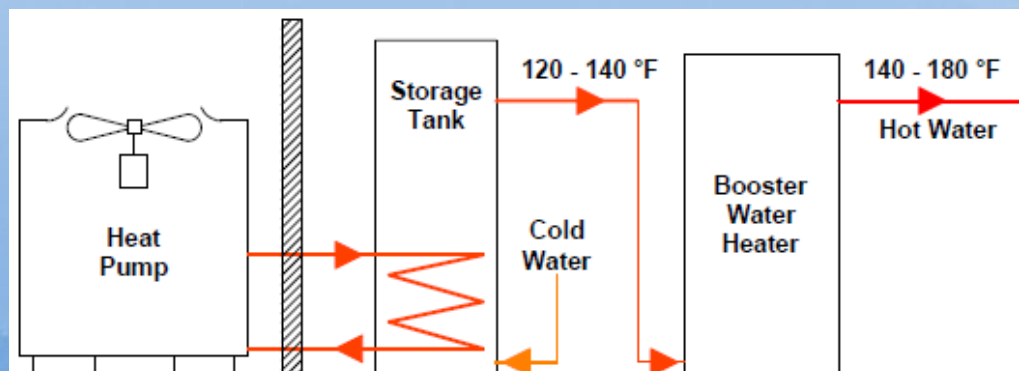
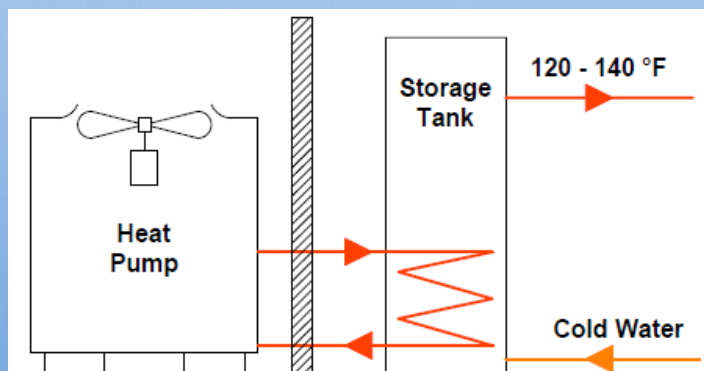
*“Planting Seeds from 5000 ft”*

## ❖ System Configuration

- ❖ Stand-Alone, Pre-Heat, Parallel
- ❖ Impact of Return Water Temperature: Heat Pump & Conventional
- ❖ Paired with Non-Condensing or Condensing

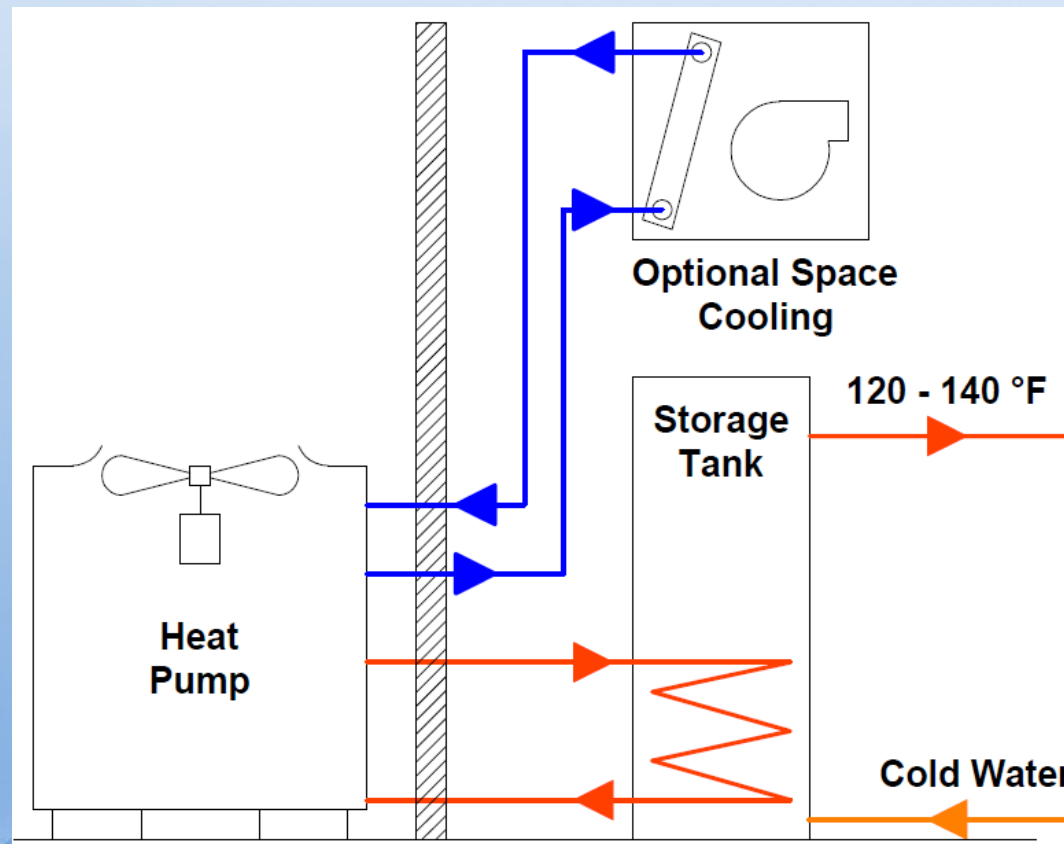
## ❖ Utility Cost Savings Estimate

## ❖ Simple Payback Analysis



# Commercial Water Heating

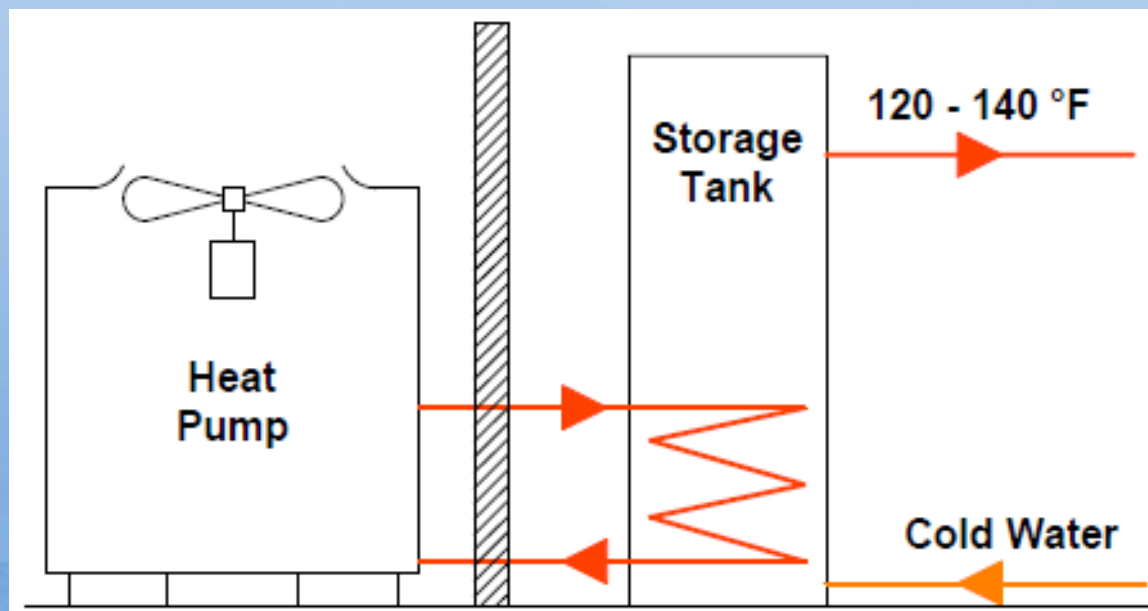
## Optional Simultaneous Space Cooling



# Commercial Water Heating

## *Stand-Alone Installation*

- ❖ Existing Installation 140,000 Bth or Less Input
- ❖ 140°F or Less Water Temperature Requirement
- ❖ 210 gph or Less @ 80°F Rise



# Commercial Water Heating

## *Stand-Alone Installation vs. Non-Condensing Storage*

<b>gpd</b>	<b>500</b>	<b>1000</b>	<b>1500</b>	<b>500</b>	<b>1000</b>	<b>1500</b>	<b>500</b>	<b>1000</b>	<b>1500</b>
gph, avg	31	63	94	31	63	94	31	63	94
<b>Baseline</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>
Baseline COP	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
<b>Climate</b>	<b>Warm</b>	<b>Warm</b>	<b>Warm</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Cool</b>	<b>Cool</b>	<b>Cool</b>
Avg Ambient [F]	60	60	60	50	50	50	40	40	40
Baseline Input [Bth]	75,000	100,000	199,000	75,000	100,000	199,000	75,000	100,000	199,000
GAHP Capacity [Bth]	80,000	80,000	140,000	80,000	80,000	140,000	80,000	80,000	140,000
Water Temp Rise [F]	80	80	80	80	80	80	80	80	80
Avg HP COP <sub>g</sub>	1.55	1.55	1.55	1.47	1.47	1.47	1.4	1.4	1.4
<b>Therms Saved/Yr</b>	<b>726</b>	<b>1451</b>	<b>2177</b>	<b>683</b>	<b>1367</b>	<b>2050</b>	<b>643</b>	<b>1285</b>	<b>1928</b>
Baseline Utility, \$/yr	\$1,799	\$3,599	\$5,398	\$1,799	\$3,599	\$5,398	\$1,799	\$3,599	\$5,398
GAHP Utility, \$/yr	\$1,037	\$2,073	\$3,094	\$1,087	\$2,174	\$3,246	\$1,136	\$2,272	\$3,393
Utility Savings \$/yr	\$763	\$1,525	\$2,303	\$712	\$1,424	\$2,152	\$663	\$1,326	\$2,005
<b>3-Yr Savings</b>	<b>\$2,288</b>	<b>\$4,576</b>	<b>\$6,910</b>	<b>\$2,136</b>	<b>\$4,273</b>	<b>\$6,455</b>	<b>\$1,989</b>	<b>\$3,979</b>	<b>\$6,015</b>



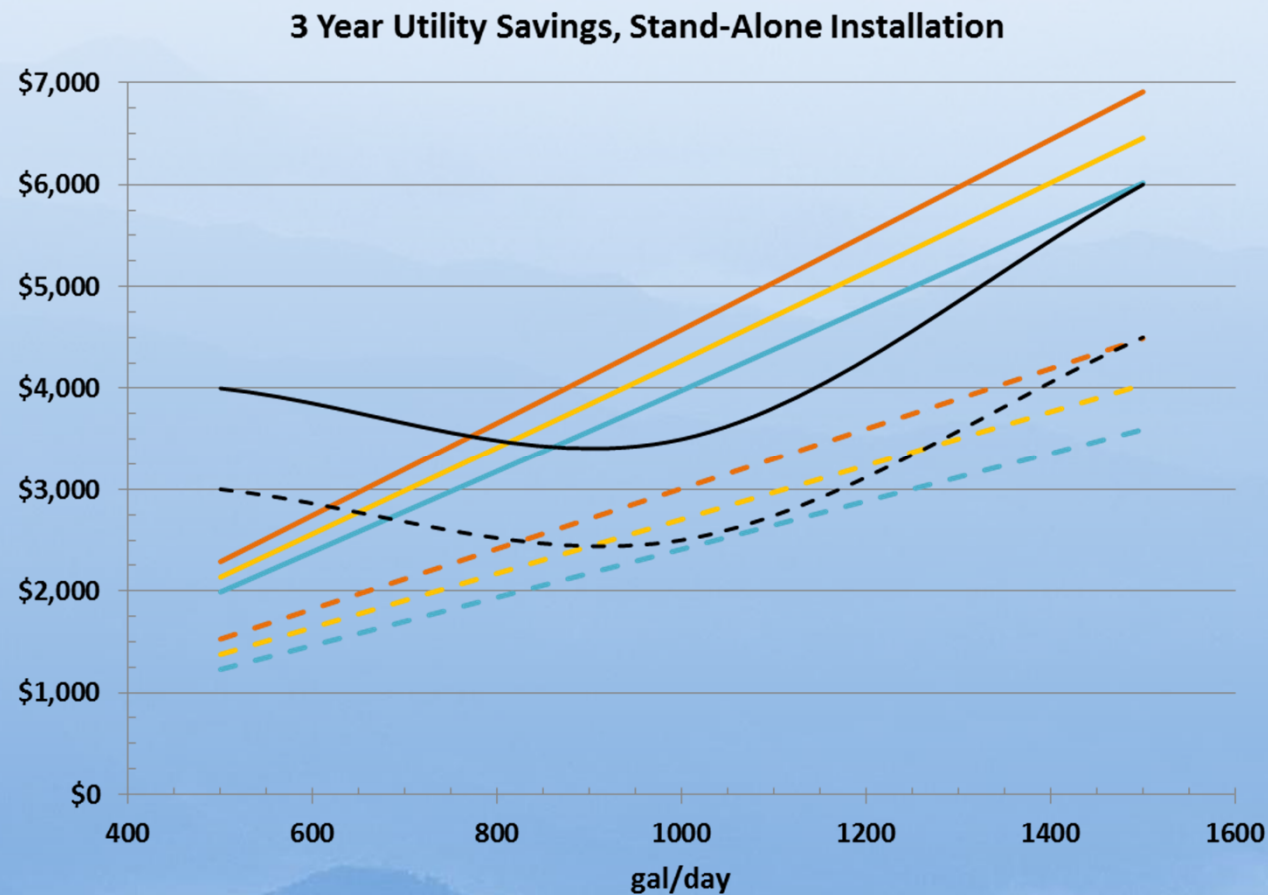
# Commercial Water Heating

## *Stand-Alone Installation vs. Condensing Storage*

<b>gpd</b>	<b>500</b>	<b>1000</b>	<b>1500</b>	<b>500</b>	<b>1000</b>	<b>1500</b>	<b>500</b>	<b>1000</b>	<b>1500</b>
gph, avg	31	63	94	31	63	94	31	63	94
<b>Baseline</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>
Baseline COP	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
<b>Climate</b>	<b>Warm</b>	<b>Warm</b>	<b>Warm</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Cool</b>	<b>Cool</b>	<b>Cool</b>
Avg Ambient [F]	60	60	60	50	50	50	40	40	40
Baseline Input [Bth]	75,000	100,000	199,000	75,000	100,000	199,000	75,000	100,000	199,000
GAHP Capacity [Bth]	80,000	80,000	140,000	80,000	80,000	140,000	80,000	80,000	140,000
Water Temp Rise [F]	80	80	80	80	80	80	80	80	80
Avg HP COP_g	1.55	1.55	1.55	1.47	1.47	1.47	1.4	1.4	1.4
<b>Therms Saved/Yr</b>	<b>489</b>	<b>978</b>	<b>1466</b>	<b>447</b>	<b>893</b>	<b>1340</b>	<b>406</b>	<b>812</b>	<b>1218</b>
Baseline Utility, \$/yr	\$1,545	\$3,076	\$4,591	\$1,546	\$3,076	\$4,591	\$1,546	\$3,076	\$4,591
GAHP Utility, \$/yr	\$1,037	\$2,073	\$3,094	\$1,087	\$2,174	\$3,246	\$1,136	\$2,272	\$3,393
Utility Savings \$/yr	\$509	\$1,003	\$1,497	\$459	\$902	\$1,345	\$410	\$804	\$1,198
<b>3-Yr Savings</b>	<b>\$1,527</b>	<b>\$3,008</b>	<b>\$4,490</b>	<b>\$1,376</b>	<b>\$2,705</b>	<b>\$4,036</b>	<b>\$1,229</b>	<b>\$2,411</b>	<b>\$3,595</b>

# Commercial Water Heating

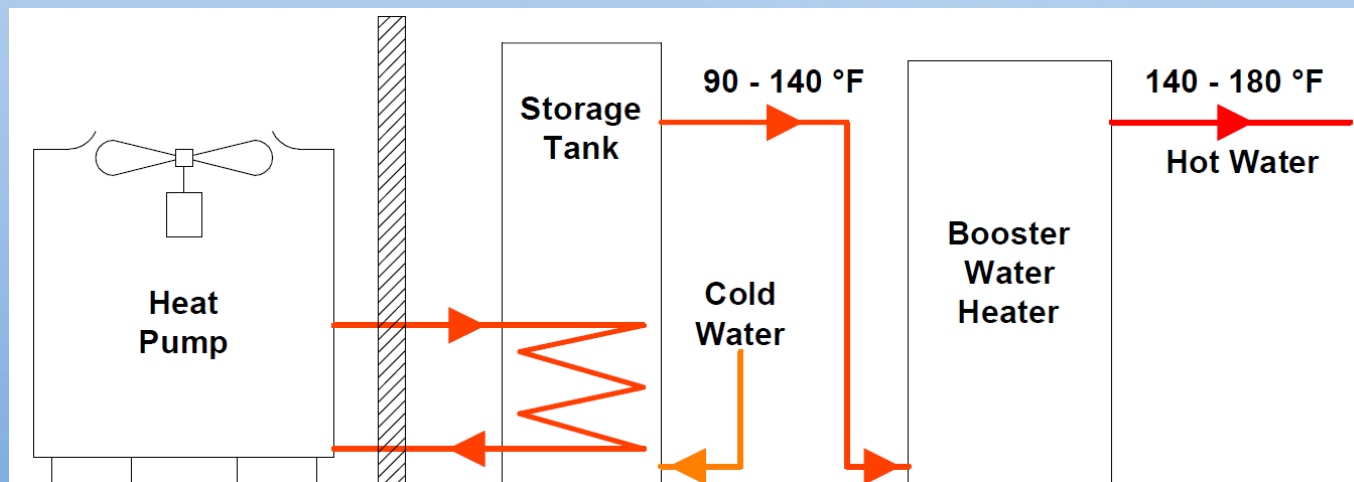
## *Stand-Alone Installation Simple 3yr Payback Level*



# Commercial Water Heating

## *Pre-Heater Installation*

- ❖ Full Service Restaurant: 2000 – 3000 gpd
- ❖ Heat Pump Used As Pre-Heater (140,000 Btu/hr)
- ❖ Condensing or Non-Condensing Booster



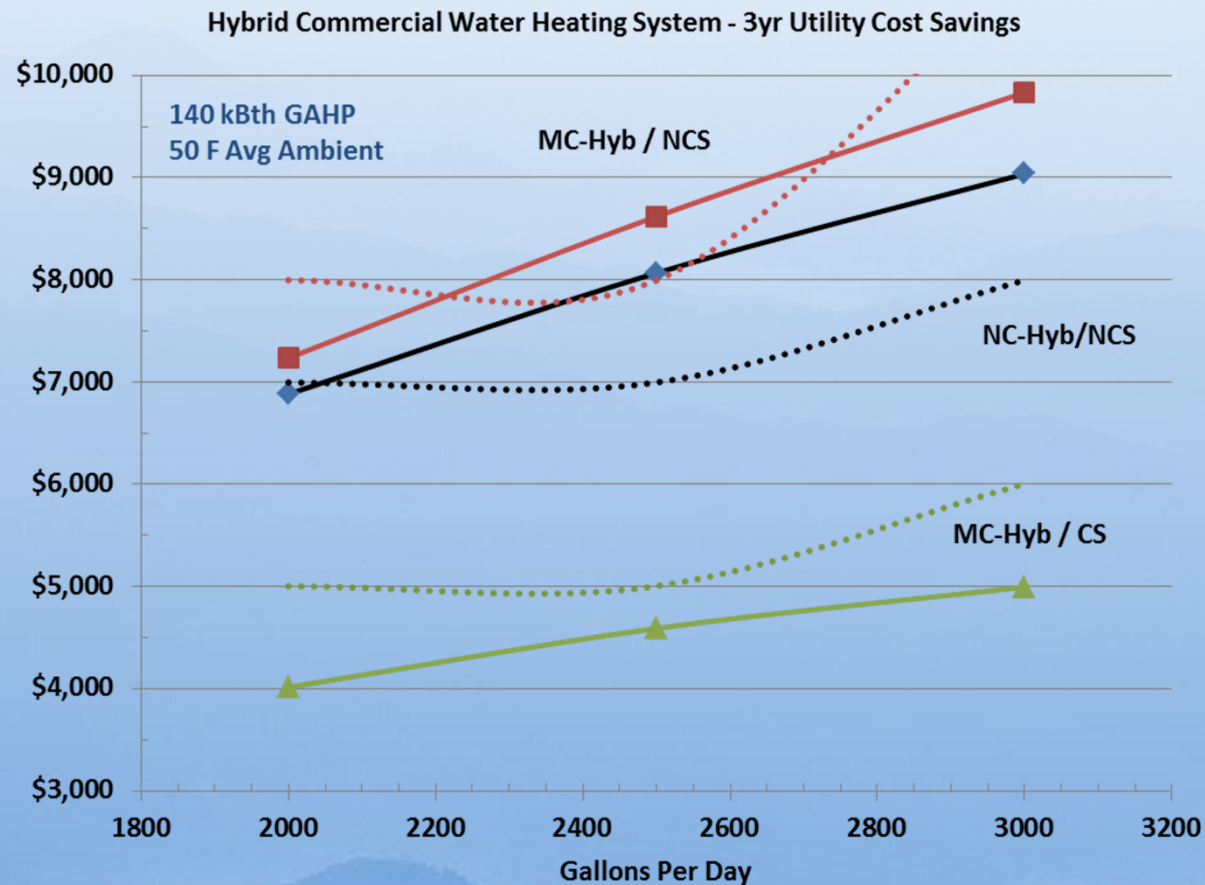
# Commercial Water Heating

## *Pre-Heater Installation*

<b>gpd</b>	<b>2000</b>	<b>2500</b>	<b>3000</b>	<b>2000</b>	<b>2500</b>	<b>3000</b>	<b>2000</b>	<b>2500</b>	<b>3000</b>
gph, avg	125	156	188	125	156	188	125	156	188
<b>Baseline</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>NCS</b>	<b>CS</b>	<b>CS</b>	<b>CS</b>
<b>Direct Fired COP</b>	<b>80%</b>	<b>80%</b>	<b>80%</b>	<b>88%</b>	<b>88%</b>	<b>88%</b>	<b>88%</b>	<b>88%</b>	<b>88%</b>
Climate	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>	<b>Mid</b>
Avg Ambient [F]	50	50	50	50	50	50	50	50	50
Direct Fired Input [Bth]	200,000	200,000	400,000	200,000	200,000	400,000	200,000	200,000	400,000
GAHP Capacity [Bth]	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000	140,000
Water Temp Rise [F]	80	80	80	80	80	80	80	80	80
Avg HP COP	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
<b>% GAHP</b>	<b>80%</b>	<b>75%</b>	<b>70%</b>	<b>80%</b>	<b>75%</b>	<b>70%</b>	<b>80%</b>	<b>75%</b>	<b>70%</b>
<b>Therms Saved/Yr</b>	<b>2187</b>	<b>2563</b>	<b>2870</b>	<b>2296</b>	<b>2733</b>	<b>3116</b>	<b>1349</b>	<b>1549</b>	<b>1695</b>
Hybrid System, \$/yr	\$4,902	\$6,307	\$7,783	\$4,784	\$6,123	\$7,518	\$4,784	\$6,123	\$7,518
Savings, \$/yr	\$2,295	\$2,690	\$3,013	\$2,413	\$2,874	\$3,277	\$1,337	\$1,529	\$1,664
<b>3-Yr Savings</b>	<b>\$6,886</b>	<b>\$8,069</b>	<b>\$9,038</b>	<b>\$7,239</b>	<b>\$8,621</b>	<b>\$9,832</b>	<b>\$4,012</b>	<b>\$4,587</b>	<b>\$4,991</b>

# Commercial Water Heating

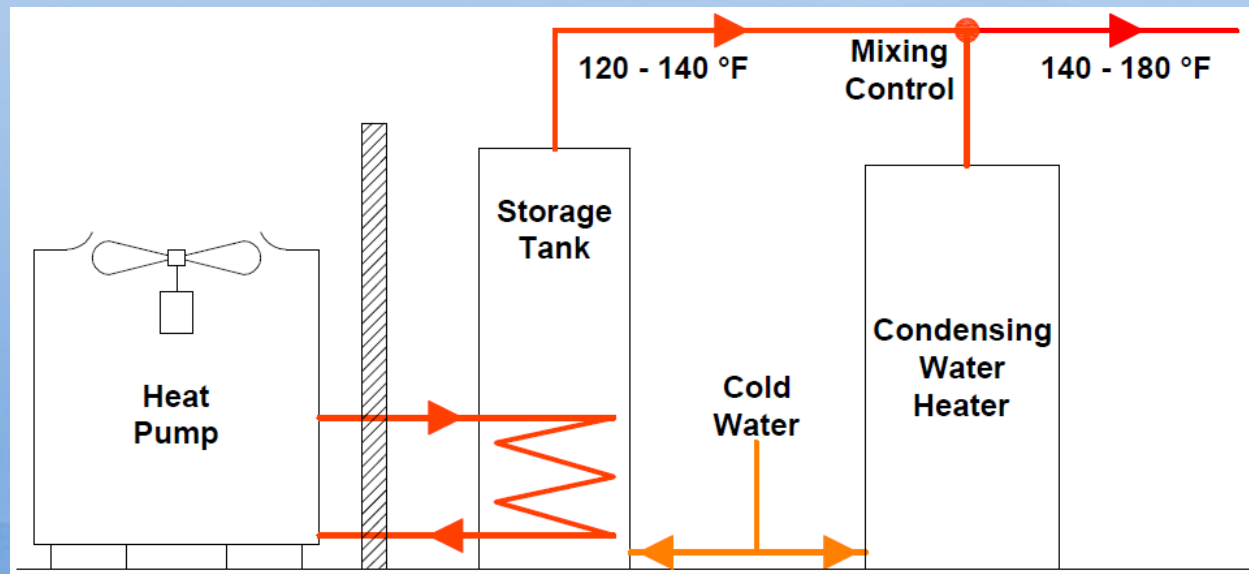
## *Pre-Heater Installation*



# Commercial Water Heating

## *Parallel Installation*

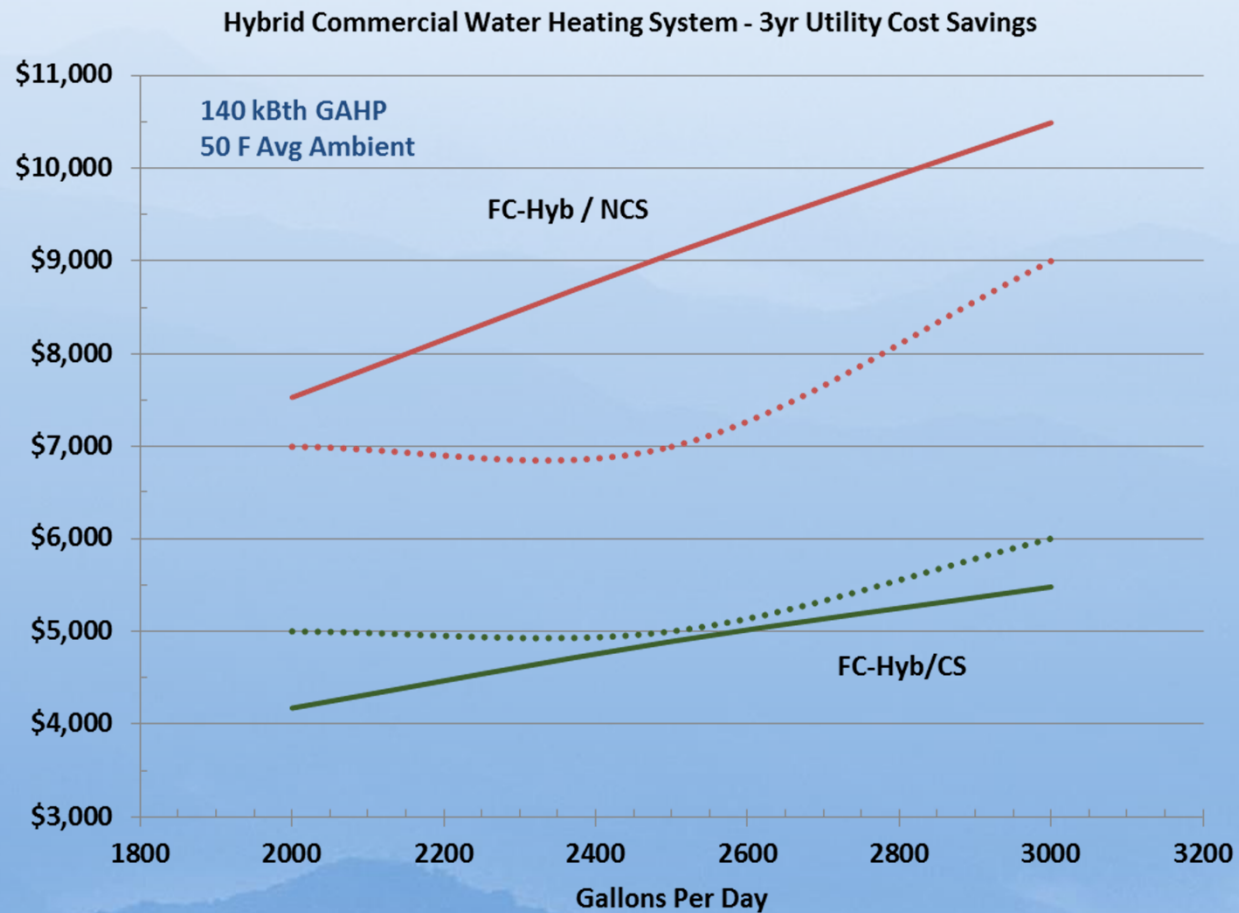
- ❖ Full Service Restaurant: 2000 – 3000 gpd
- ❖ 140,000 Btu/hr Heat Pump
- ❖ Condensing Peaking Water Heater





# Commercial Water Heating

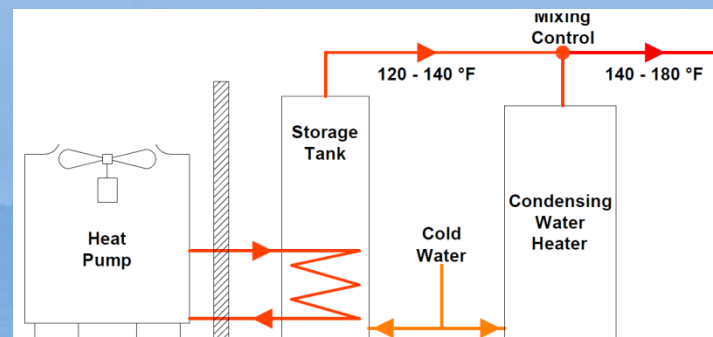
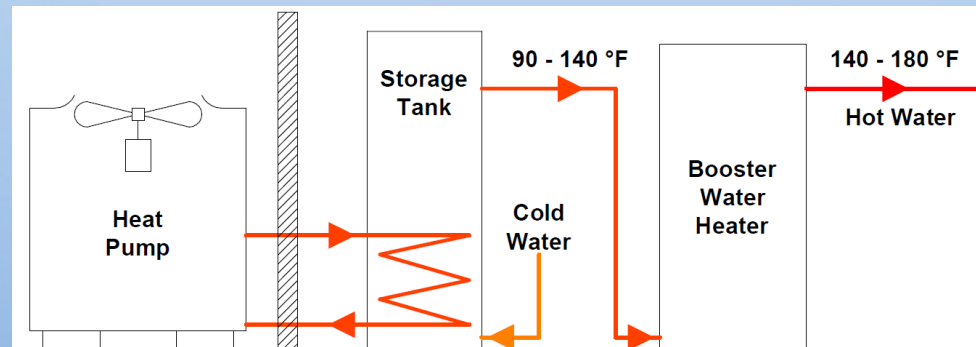
## *Parallel Installation*



# Commercial Water Heating

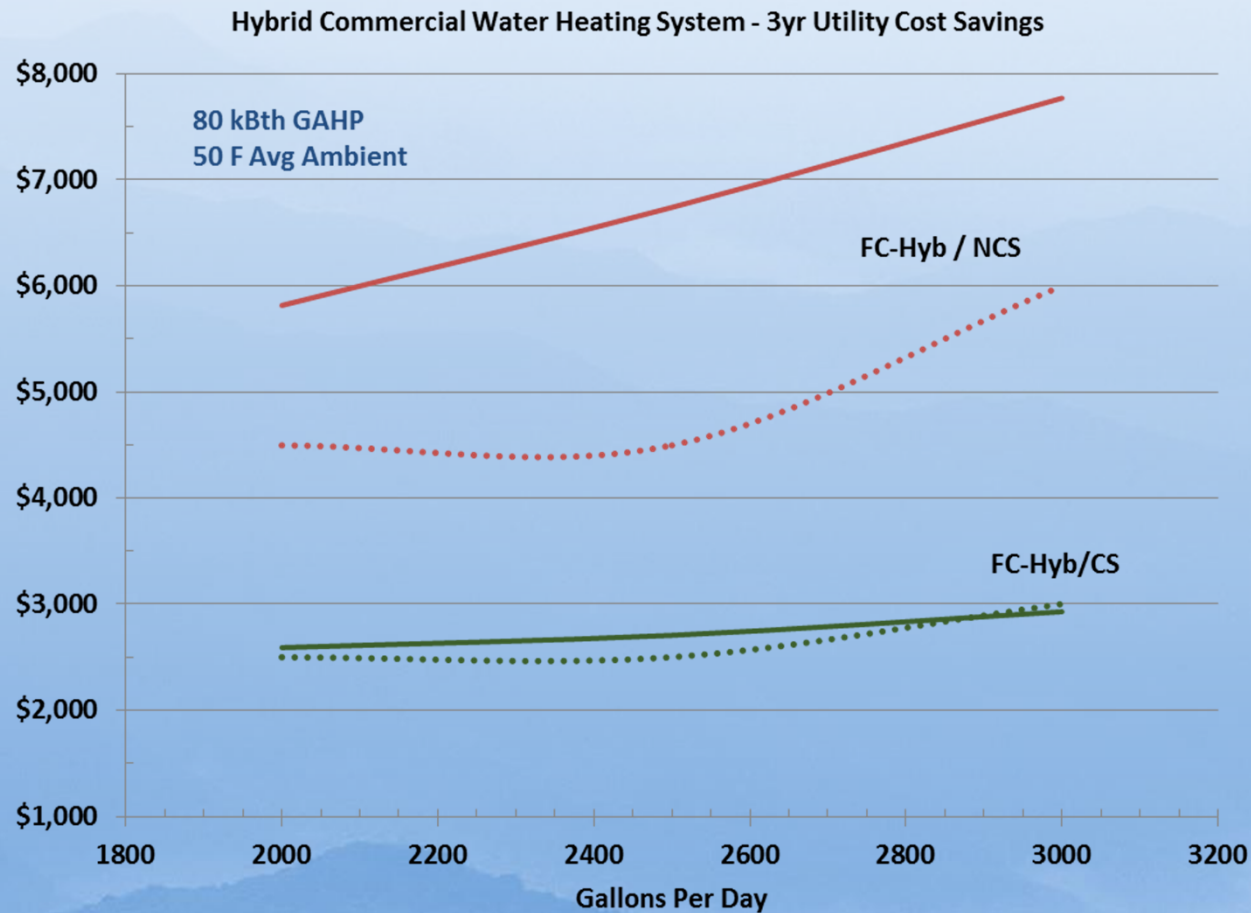
## *Pre-Heat / Parallel Installation*

- ❖ Full Service Restaurant: 2000 – 3000 gpd
- ❖ 80,000 Btu/hr Heat Pump
- ❖ Condensing Peaking/Booster Water Heater




# Commercial Water Heating

## *Pre-Heat / Parallel Installation, 80,000 Btu/hr GAHP*

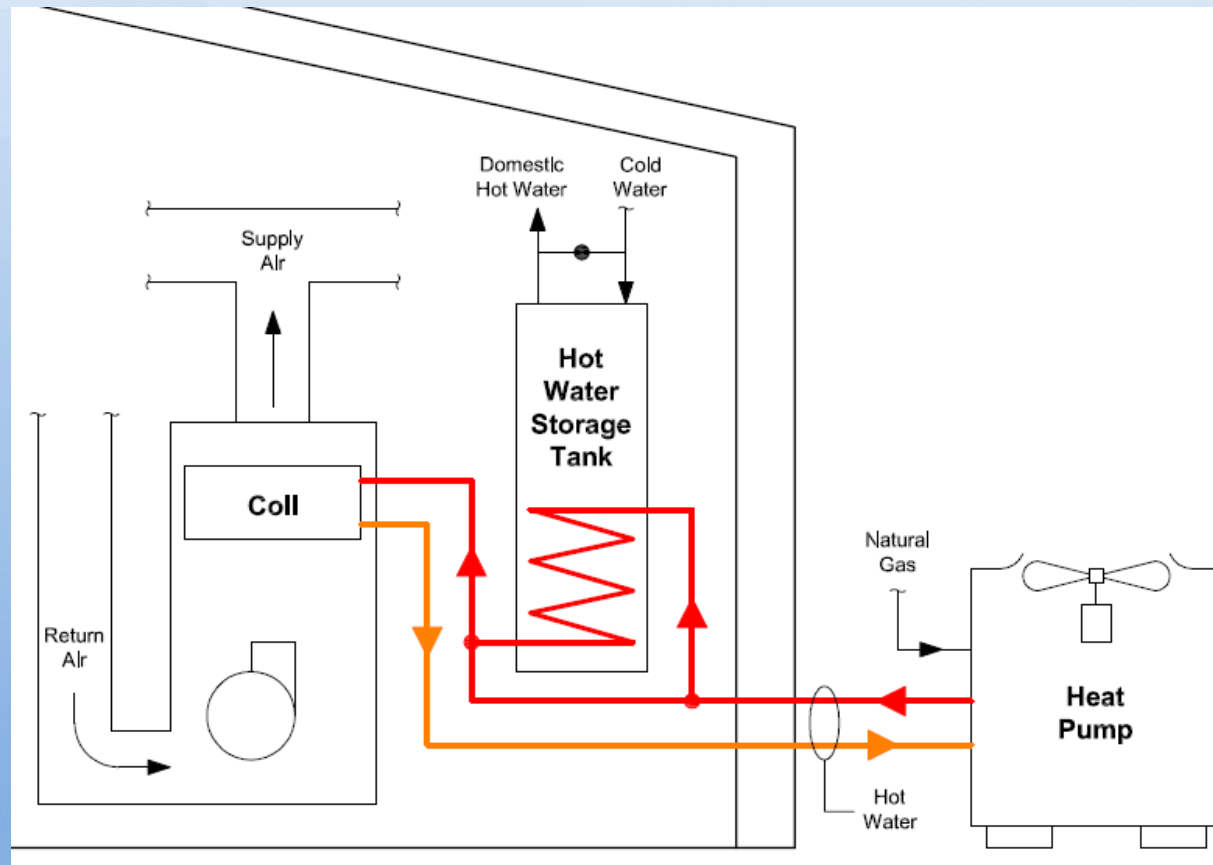


# GAHP Commercial Water Heating

## *Conclusions & Thoughts*

- ❖ Potential 2-3 yr Simple Payback for many applications
- ❖ 3-4 yr Simple Payback for most others
- ❖ GAHP / Storage Tank sizing important
- ❖ Method of Interface with Direct-Fired equipment critical
- ❖ Climate Zone Dependency Complex (ambient/water temperature)
- ❖ Application Modeling w/representative draw patterns to develop optimum system hardware by application.
- ❖ Capital Utilization  System Design

# Residential GAHP Combo Systems



# GAHP Residential Combo System Analysis

## *Assumptions*

- ❖ Region IV & V BIN: Heating Load/Ambient/GAHP COP
- ❖ 64 gpd, 55 / 50 F CWT (Region IV / V)
- ❖ Summer COP\_gas 1.6 / 1.5 for Region IV/V
  - ❖ 3,000 Btu per day standby loss
- ❖ Low & High Efficiency Baseline
  - ❖ 80% Gas Furnace / 0.60 EF Gas Storage Water Heater
  - ❖ 95% Gas Furnace / 0.63 EF Gas Storage Water Heater



# GAHP Residential Combo System Analysis

## *High Level Results*

	Region 4		Region 5	
<b>Space Heating</b>				
Baseline COP	0.8	0.95	0.8	0.95
Therms Saved/yr	743	469	829	547
Utility Savings, \$/yr	\$758	\$430	\$832	\$493
<b>Water Heating</b>				
Baseline EF	0.60	0.63	0.60	0.63
Therms Saved/yr	135	124	139	127
Utility Savings, \$/yr	\$149	\$136	\$152	\$138
<b>Total</b>				
Therms Saved/yr	<b>878</b>	<b>593</b>	<b>968</b>	<b>674</b>
Utility Savings, \$/yr	<b>\$907</b>	<b>\$566</b>	<b>\$984</b>	<b>\$631</b>
Installed Cost Premium	\$3,300	\$2,350	\$3,300	\$2,350
Simple Payback, Yrs	3.6	4.2	3.4	3.7

# Acknowledgements

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- ❖ **U.S. Department of Energy**
- ❖ **Gas Technology Institute**
- ❖ **Oak Ridge National Laboratory**



**Thank You !**

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