# Stone Mountain Technologies, Inc.

## Compressors for Thermally-Driven Heat Pumps (TDHPs)

## Breaking 100% Efficiency Barrier for Heating


**SNEEC: NORA Technical Workshop**

**19September2017**

***Michael Garrabrant, President & CEO***

***Johnson City, Tennessee, USA***
***www.StoneMountainTechnologies.com***

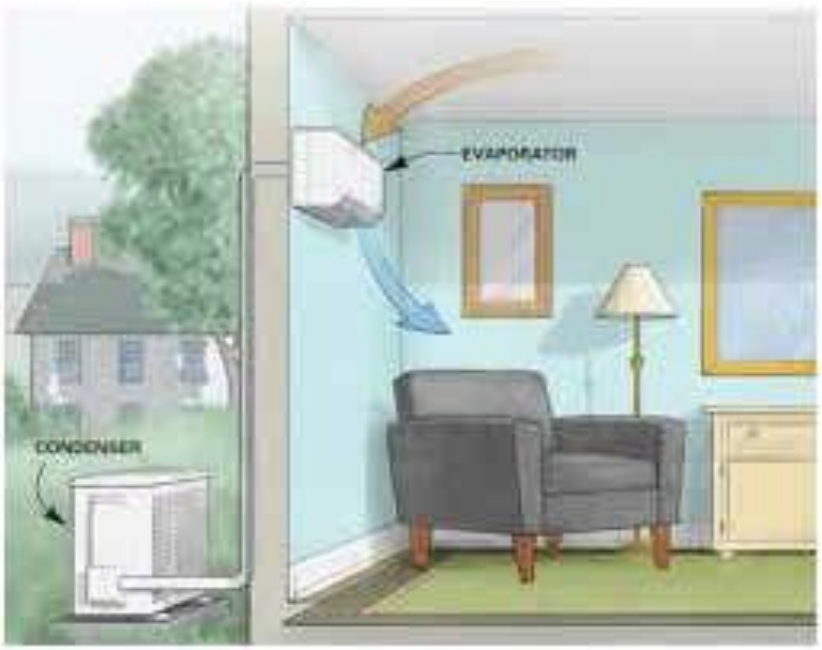
# Trend: Transition to Heat Pumps

**Global Heat Pump Shipments**

**+8.5% CAGR**

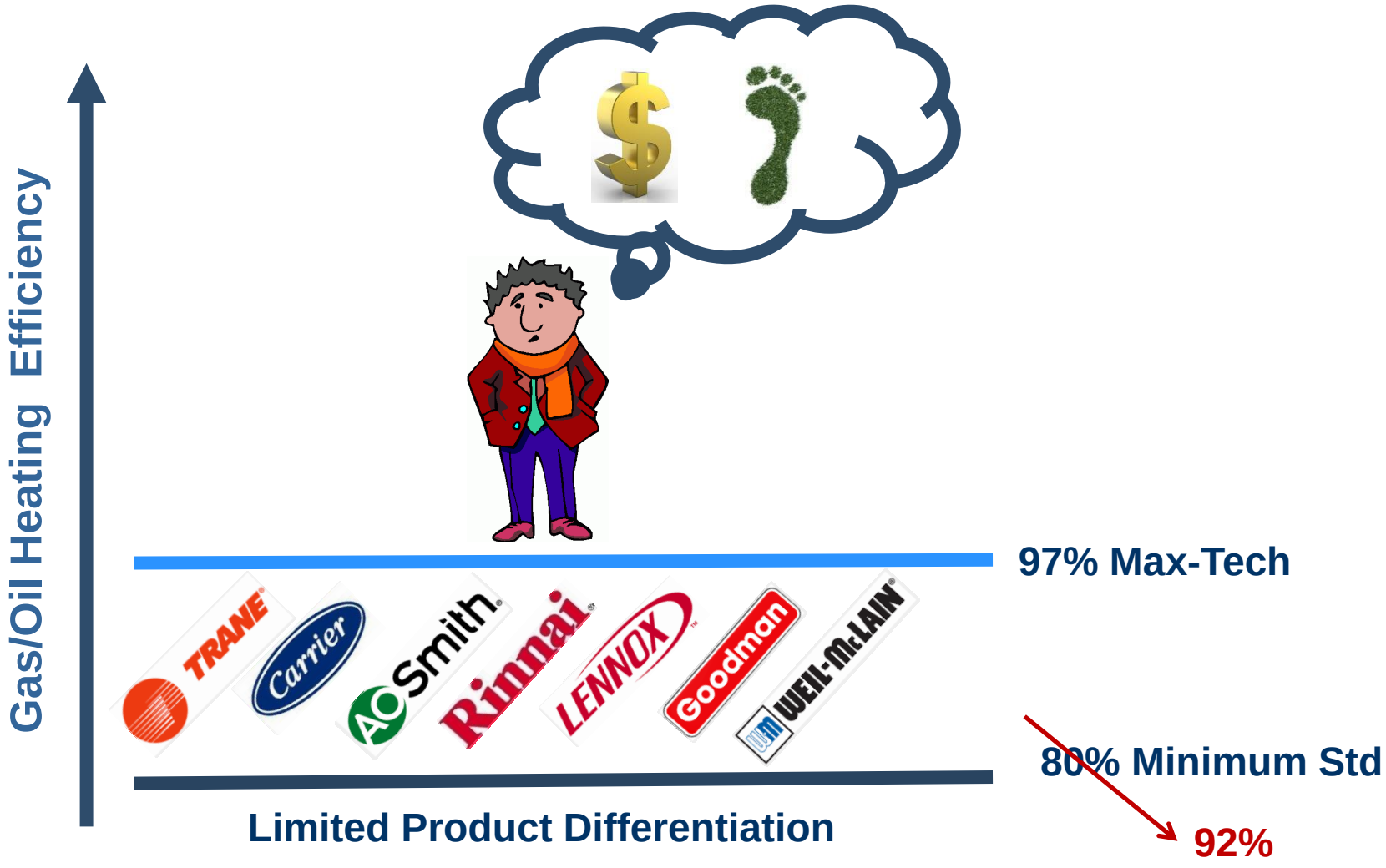
**Predicted to Accelerate**

# But 99.9% Are Electric …..

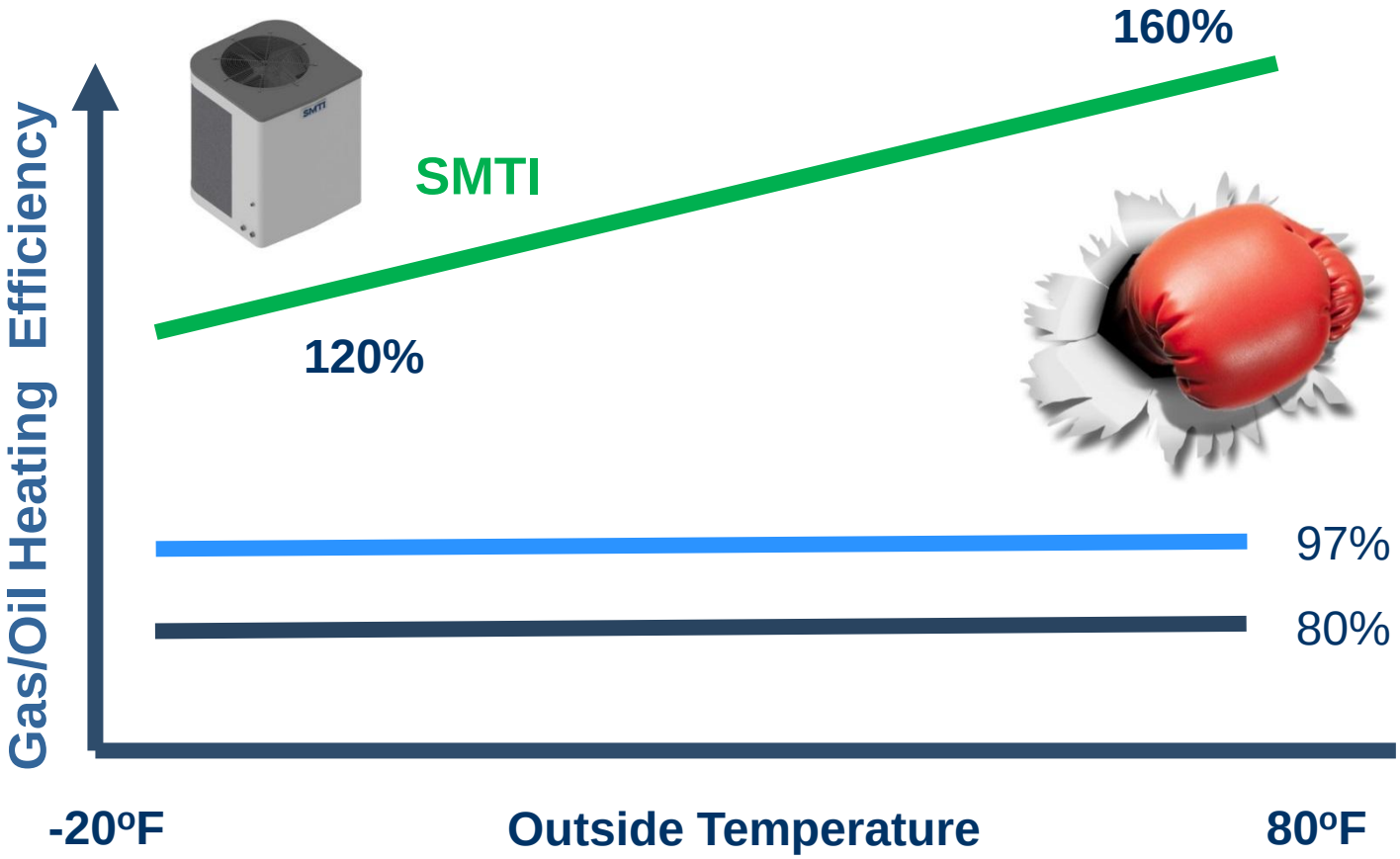



- **Low Heating Capacities**
- **Poor Cold Weather Performance**
- **Majority of Global Heating Is Gas or Fuel Oil……**

# Current technology maxed at <100%



# Absorption Heat Pumps Break 100% Barrier




**…and work well at low outside temperatures!**

# Renewable Energy Content: 35%

***Solar Energy***
***(via the atmosphere)***

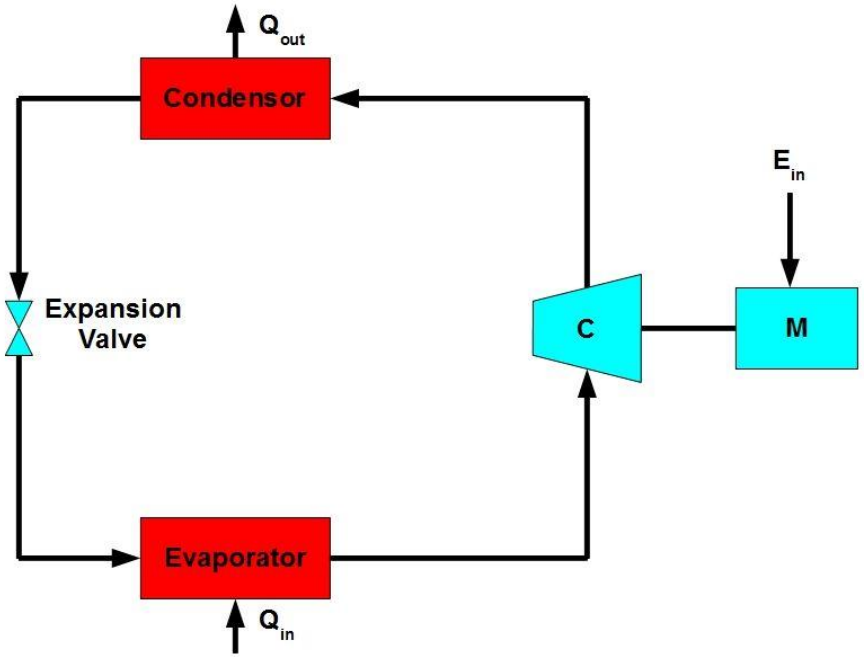
0.5


1.0

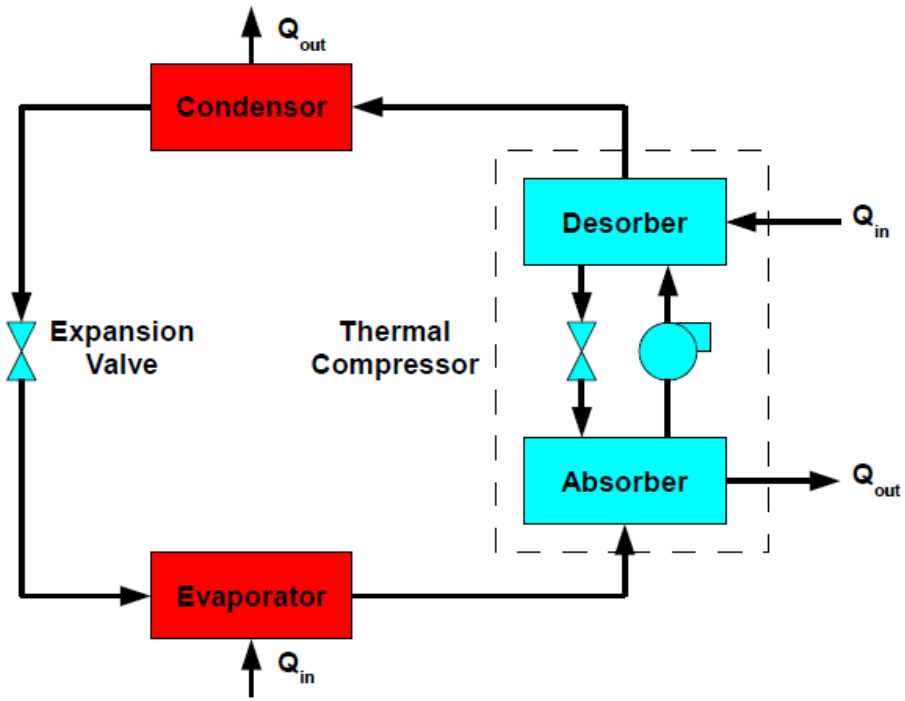

1.5

***Fuel Source***

# How Does Thermal Absorption Work?




Vapor Compression

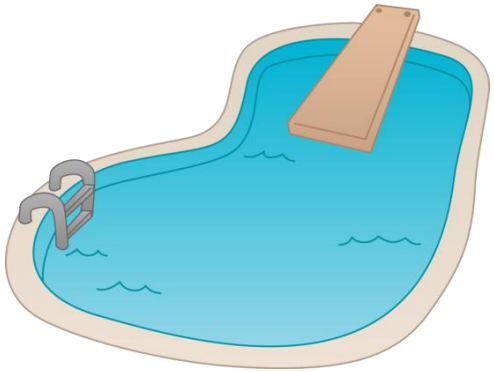



Thermal Compression

# Many Ways to Use Absorption Heating

buildings

water



pools

## Residential & Commercial

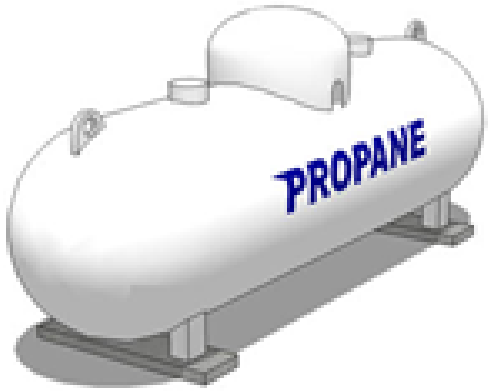
**10,000 – 140,000 btu/hr**

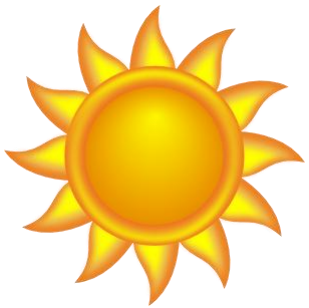
***(manifold multiple units up to ~ 700 kbtu/hr)***

# Fuel Agnostic



GAS NATURAL



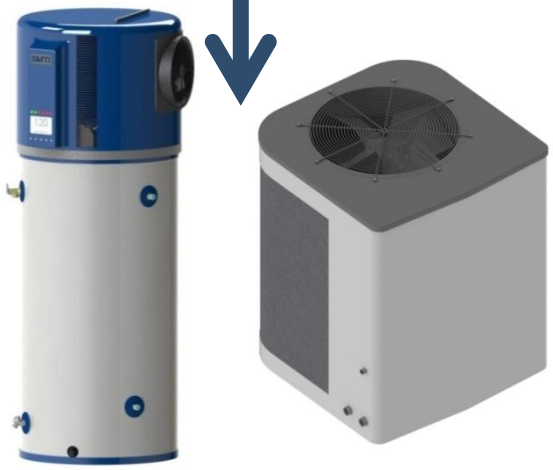



# B2B Business Model

**Thermal Compressor**

SMTI

**OEMS…**



**End Use Products**

- ✓ Cost-effective and rapid pathway to market
- ✓ OEM retains brand identity and customers
- ✓ Consolidate Volume Across Multiple Markets/OEMs
- ✓ End-product cost half of existing options

# Scalable and Flexible Design

**3 kW**


**6 kW**

**23 kW**


**40 kW**


**Anything In-Between**

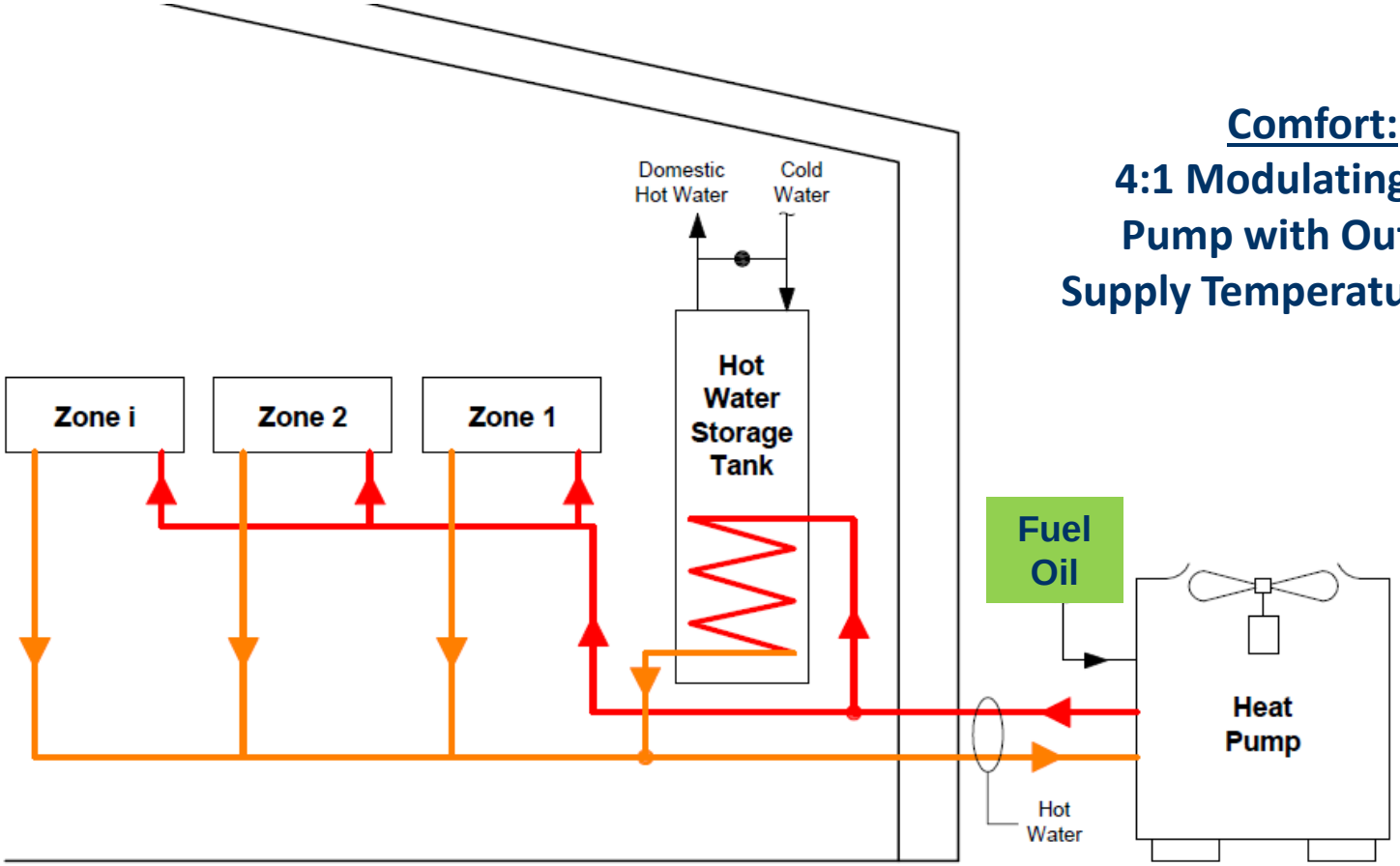
# SMTI Absorption Heat Pumps

## COP = 1.45 at 47/120°F

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

- 10,000 to 140,000 Bth Heating Output Models
- 20° F Hydronic Differential
- Outdoor Installation (no venting)

# Hydronic Space & Water Heating




**Comfort:**
**4:1 Modulating Heat Pump with Outdoor Supply Temperature Reset**

**Safety:**
**All Combustion Outside**

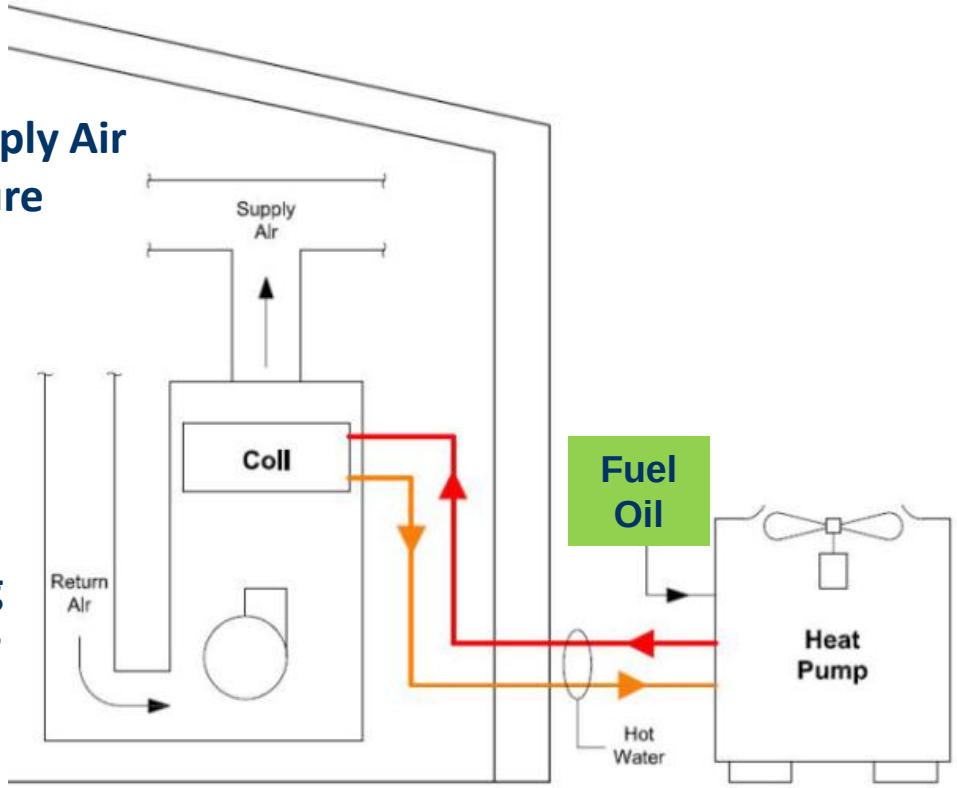
***Hybrid Model for All-Season Climate Control (patent pending) - 2 or 4 pipe installation***

# Forced-Air Space Heating

*Heating Dominated Climate Zones: 4000+ HDD*

**Controlled Supply Air Temperature**

**Fully Modulating Air-handler**



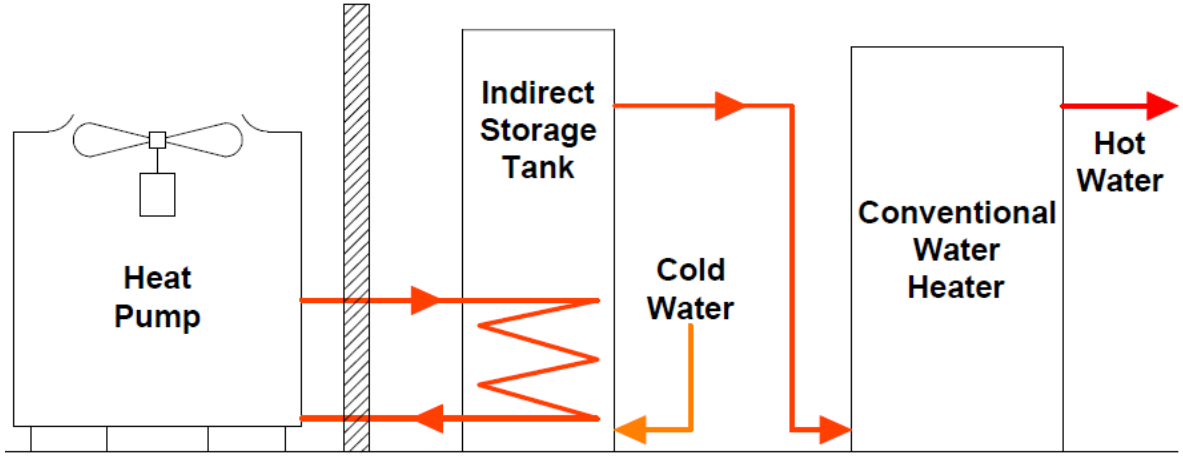

**4:1 Modulating Heat Pump with Ambient Reset**

**Outdoor Location for Safety**

***Hybrid Model for All-Season Climate Control (patent pending)***

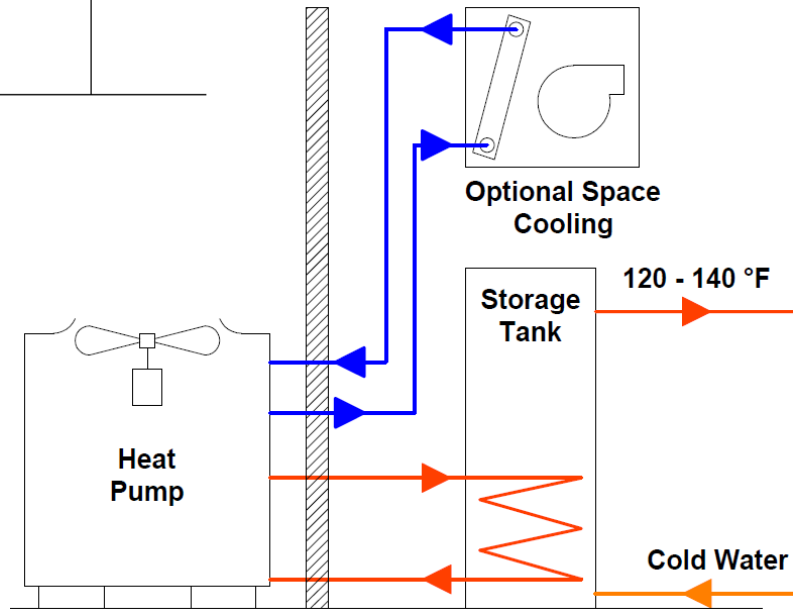
# Commercial Water Heating

*Size for 25-80% design load*




- **Food Service**
- **Education/Dormitory**
- **Hospitality**
- **Laundry**
- **Prisons**
- **Medical**

- **All Climate Zones**



# NORA Research Contract

## Develop and Test an 80,000 btu/hr Liquid Fuel-Fired Absorption Heat Pump with 4:1 Modulation

# Major Project Tasks

- **Residential Energy Modeling**
  - 7 Northeast Cities
  - Heating Only, Reversible, Hybrid
  - With and w/o Indirect Water Heating
  - Annual Cost Savings/Simple Payback

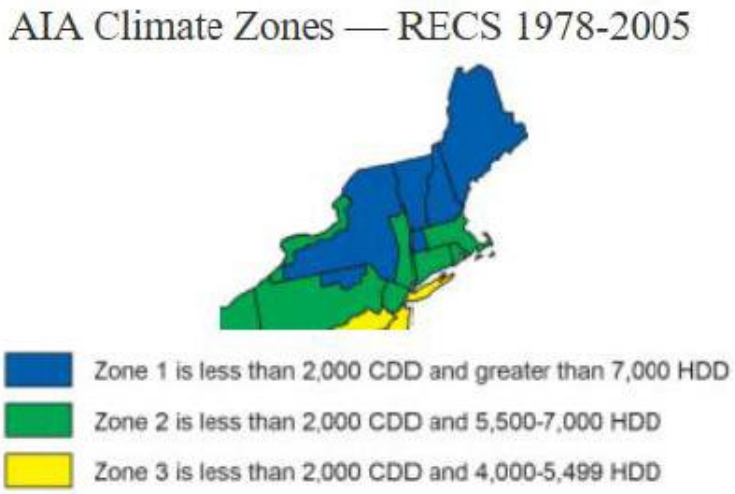
- **Dealer/Contractor Interviews**

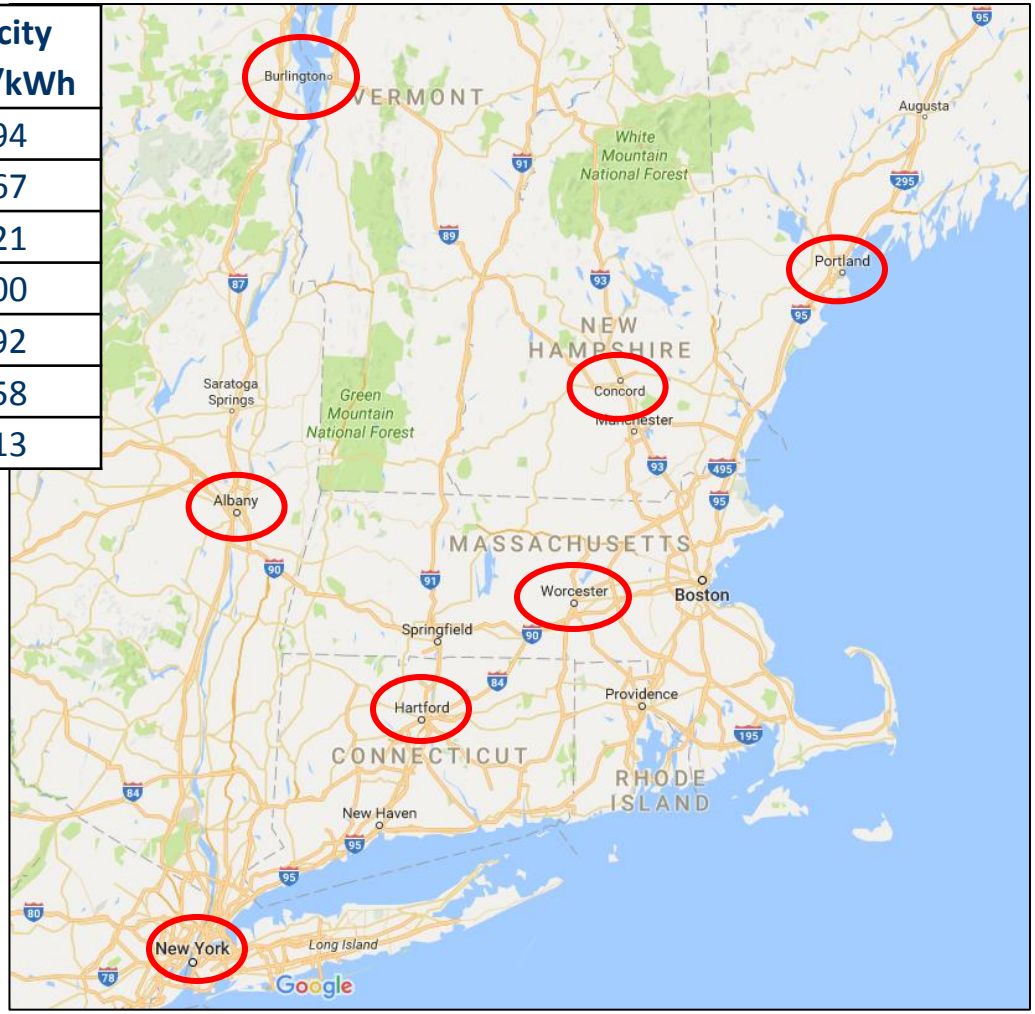
- **Burner-Desorber-CHX Bench Testing**
  - Prove 4:1 Modulation w/Babington Burner

- **LFAHP Prototype Testing**
  - SMTI
  - Brookhaven National Lab

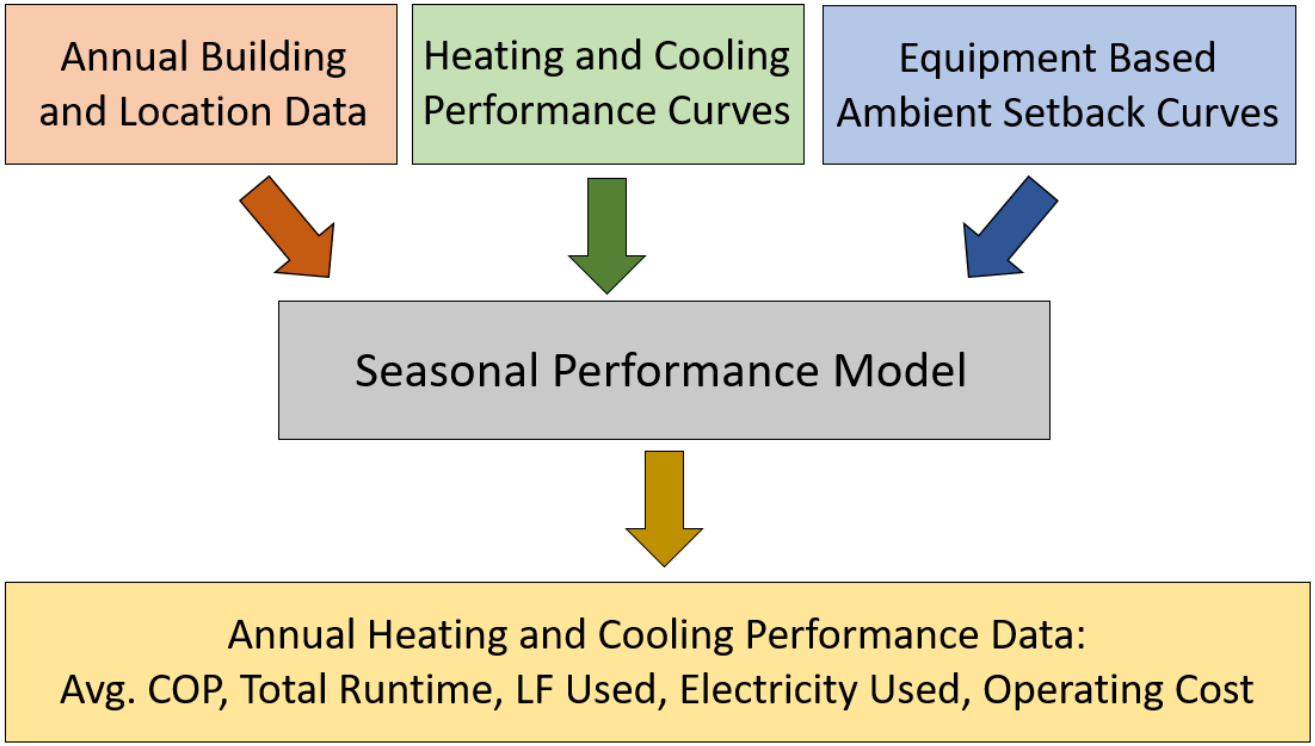
# Locations Investigated - Overview

| Location | Heating Oil Price, $/Gal | Electricity price, $/kWh |
|---|---|---|
| Portland, Maine | 2.049 | 0.0694 |
| Hartford, Connecticut | 2.482 | 0.1267 |
| New York City, New York | 2.753 | 0.2321 |
| Albany, New York | 2.462 | 0.1100 |
| Concord, New Hampshire | 2.231 | 0.1392 |
| Burlington, Vermont | 2.309 | 0.1558 |
| Worcester, Massachusetts | 2.390 | 0.1313 |



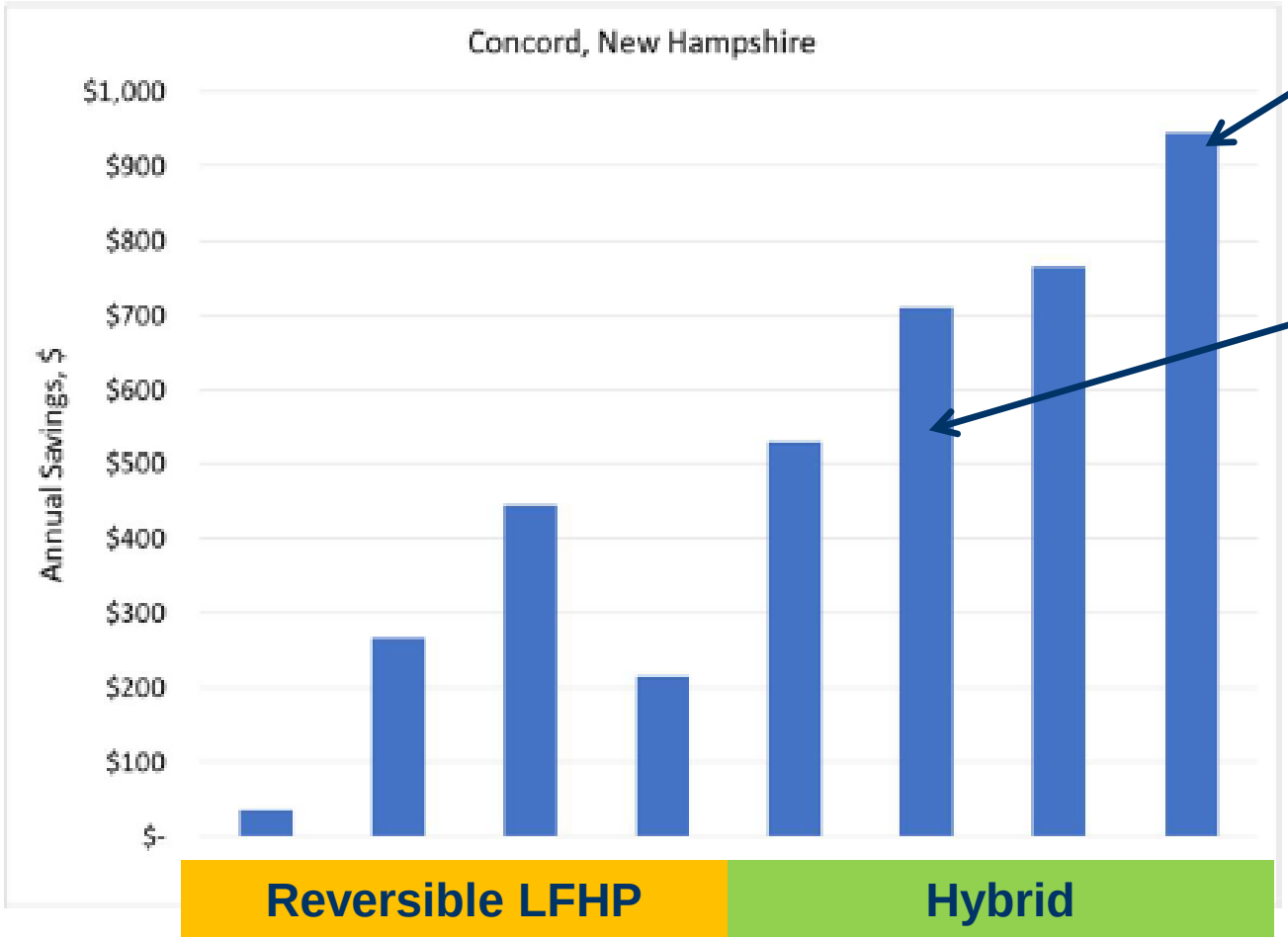



# Modeling Performed




**2500 sqft ranch house, 60 kbth design heating load at 0°F**

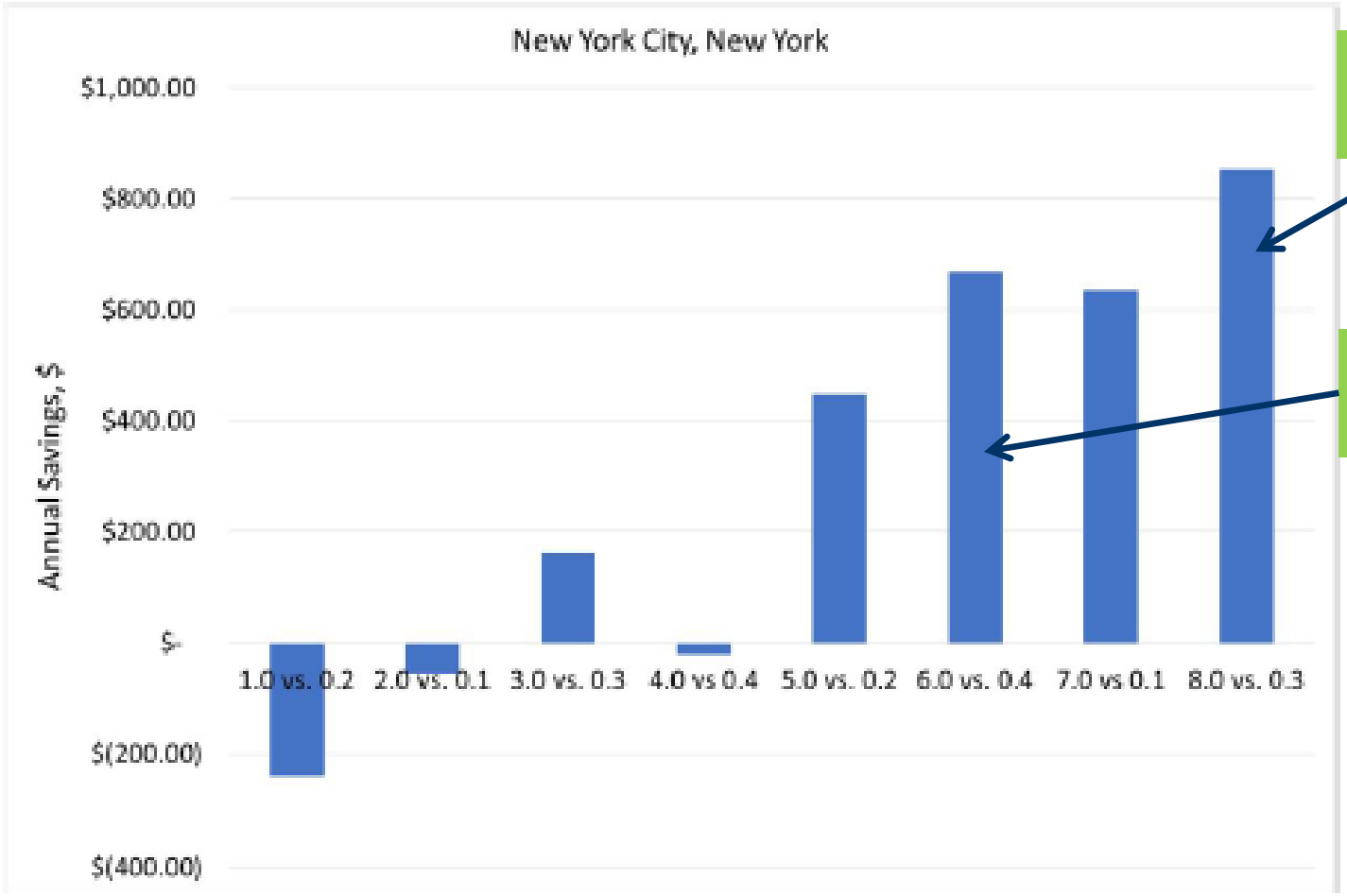
# Concord, NH (zone 1): Annual Cost Savings




**vs 80% boiler w/water heating**

**vs 95% furnace w/water heating**

# New York City (zone 3): Annual Cost Savings




**vs 80% boiler w/water heating**

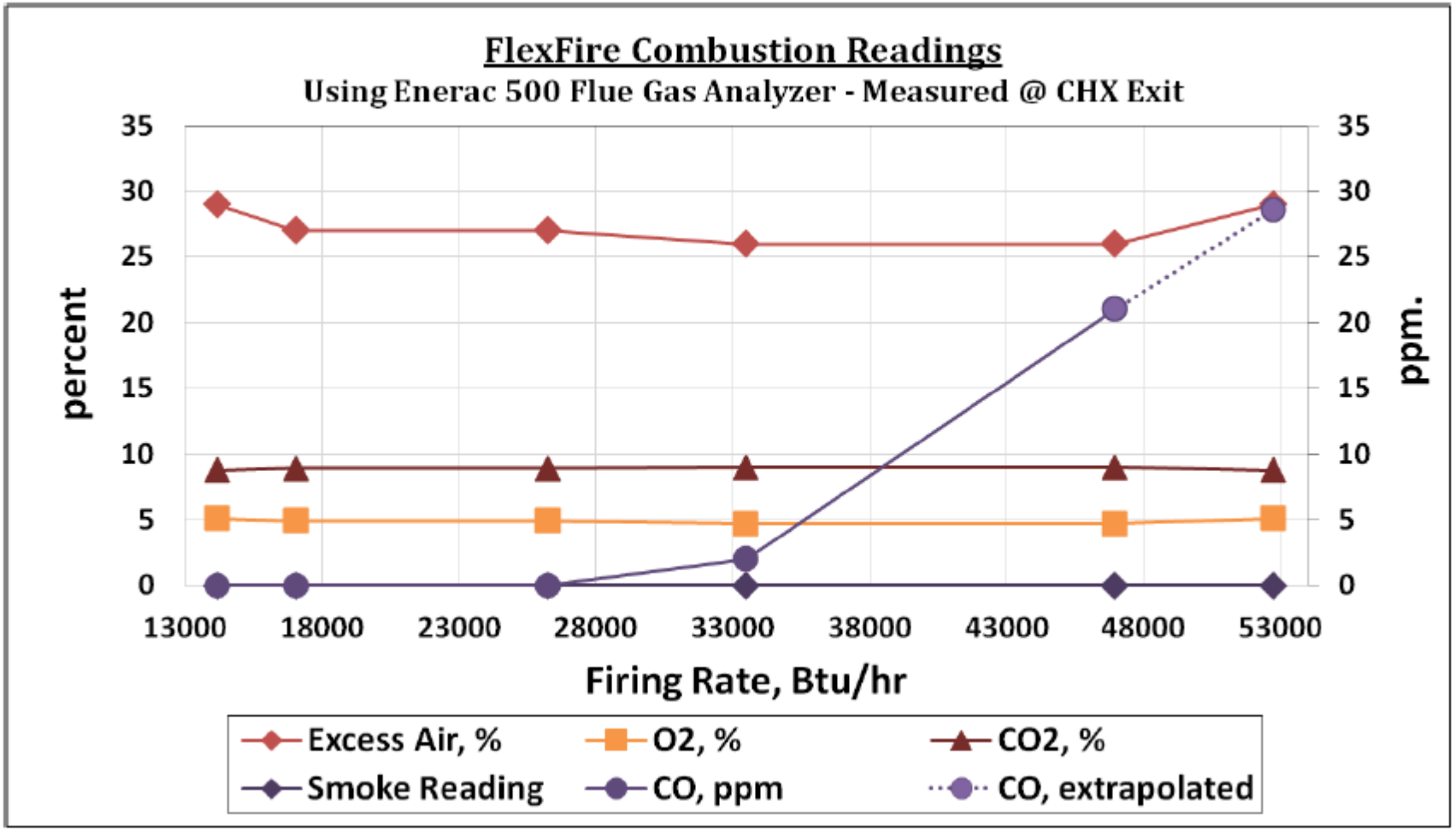
**vs 95% furnace w/water heating**

**Reversible LFHP** | **Hybrid**

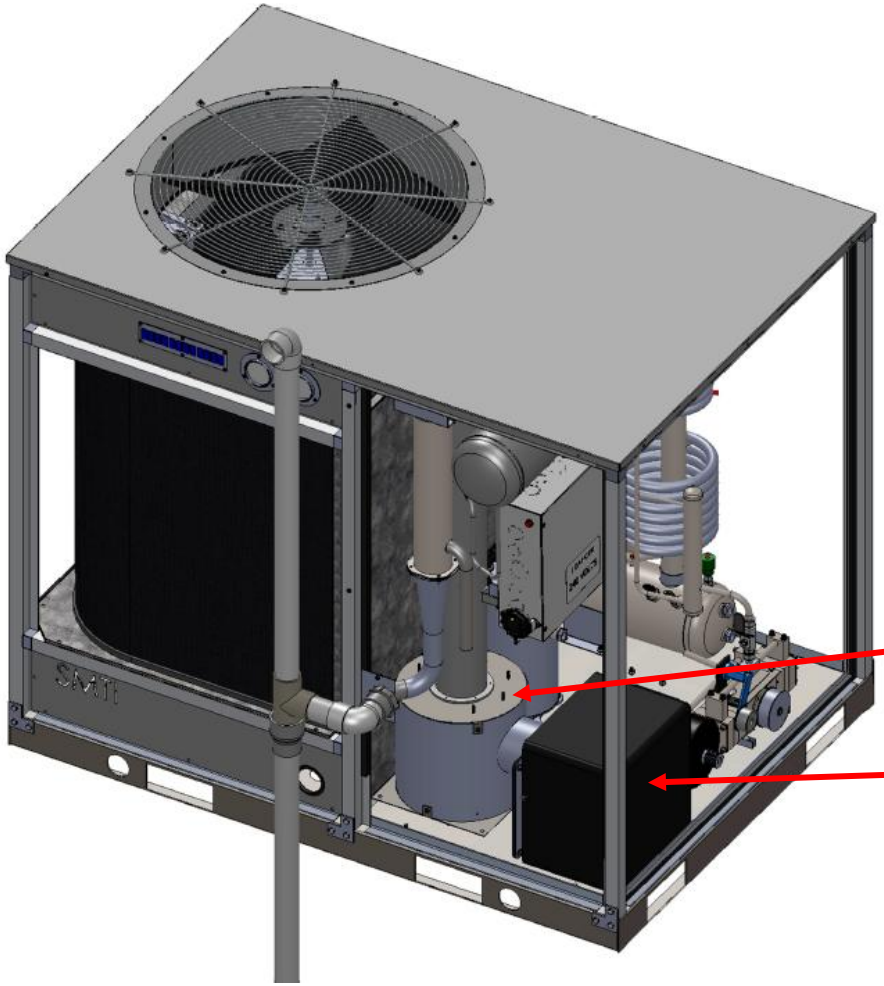
# Simple Economic Payback

| | |
|---|---|
| **Reversible LFAHP:** | **1 year to never** |
| **Hybrid LFAHP/EAC:** | **0.5 to 5 years** |
| **Separate LFAHP/EAC:** | **2.4 to 5.1 years** |

# Bench Testing



# 80 kbth Prototype



**Overall Package Dimensions:**
**38 x 54 x 46” (W x L x H)**

Firebox allowing for horizontal fire

Babington FlexFire Burner Assembly

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# Thank You !


**Michael Garrabrant, President & CEO**
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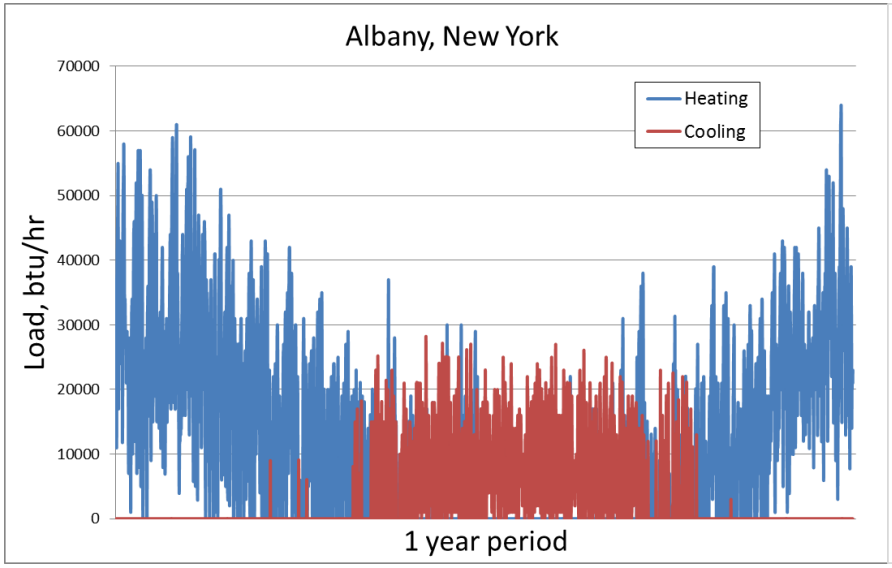
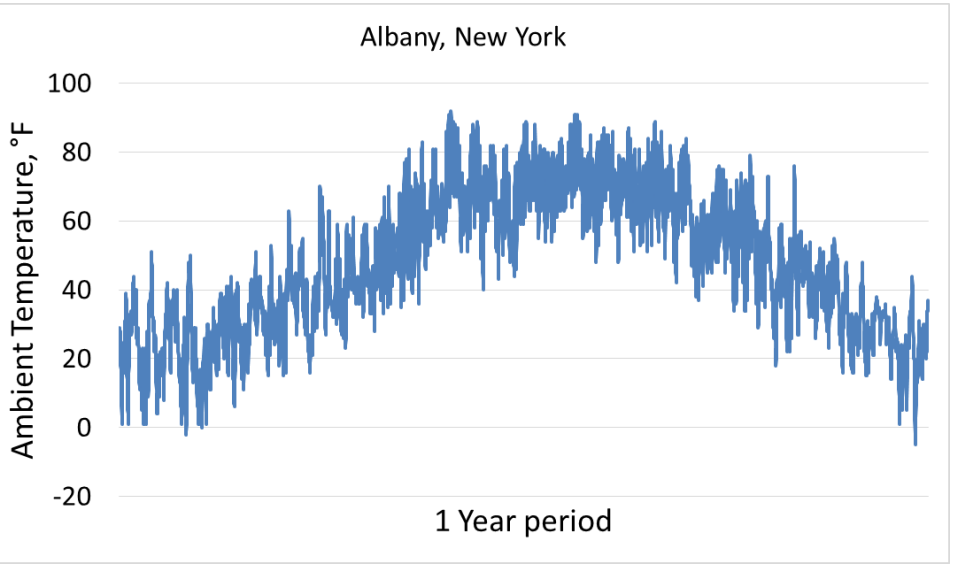
www.stonemountaintechnologies.com
**(423) 735-7400**

# Building Investigated

- Standard code construction home modeled
  - Ranch style home
  - 2500 sqft
  - R30 Attic
  - 2 x 4 wall basement
  - Sized to have a 60 kbtu/hr heating load at 0°F

- Load and ambient data for Albany, NY
  - Yearly space heating load of 104.0 Mbtu in Albany, NY, 68.5 Mbtus in NYC, NY and 120.9 Mbtus in Burlington, VT



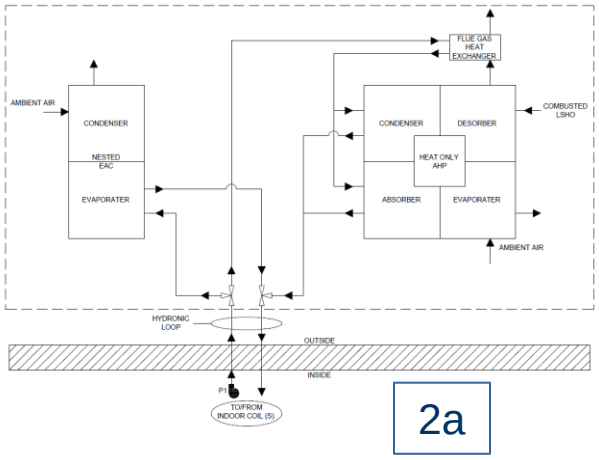
# Detailed Configurations Investigated

| Case (Configuration) | Heating/cooling systems | Indoor heating/cooling equipment | DHW |
|---|---|---|---|
| 0.1 | Standard Boiler, 14 SEER AC | Radiator Coupled, mini-split | No |
| 0.2 | Condensing furnace, 14 SEER AC | Air Handler Coupled | No |
| 0.3 | Standard Boiler, 14 SEER AC | Radiator Coupled, mini-split | Yes |
| 0.4 | Condensing furnace, 14 SEER AC | Air Handler Coupled | Yes |
| 1 (1a) | Reversible LF-AHP | Air Handler Coupled | No |
| 2 (1b) | Reversible LF-AHP | Radiator coupled, zoned coils | No |
| 3 (1b) | Reversible LF-AHP | Radiator coupled, zoned coils | Yes |
| 4 (1b) | Reversible LF-AHP | Air Handler Coupled | Yes |
| 5 (2a) | Heating Only LF-AHP, 14 SEER AC | Air Handler Coupled | No |
| 6 (2b, 2c, 3) | Heating Only LF-AHP, 14 SEER AC | Air Handler Coupled | Yes |
| 7 (2b, 2c, 3) | Heating Only LF-AHP, 14 SEER AC | Radiator coupled, mini-split or zoned coils | No |
| 8 (2b, 2c, 3) | Heating Only LF-AHP, 14 SEER AC | Radiator coupled, mini-split or zoned coils | Yes |

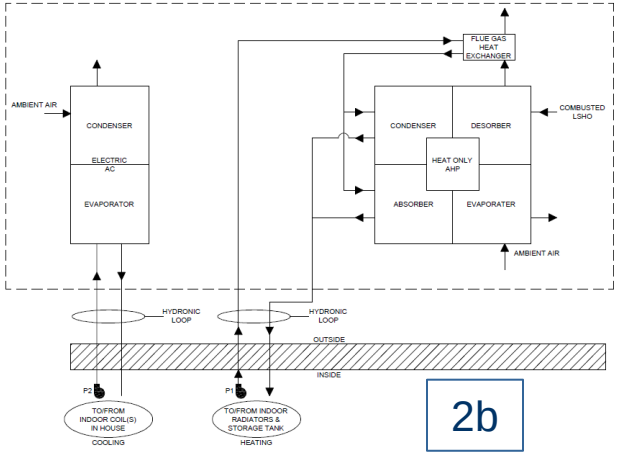
# Detailed Configurations Investigated

| Configuration | Heating/Cooling System | Number of pipes | Heating Plumbing | Cooling Plumbing |
|---|---|---|---|---|
| 1a | Reversible LF-AHP | 2 | Hydronic | Hydronic |
| 1b | Reversible LF-AHP | 4 | Hydronic | Hydronic |
| 2a | Hybrid LF-AHP-EAC | 2 | Hydronic | Hydronic |
| 2b | Hybrid LF-AHP-EAC | 4 | Hydronic | Hydronic |
| 2c | Hybrid LF-AHP | 4 | Hydronic | Refrigerant |
| 3 | Heating Only LF-AHP & EAC | 4 | Hydronic | Refrigerant |

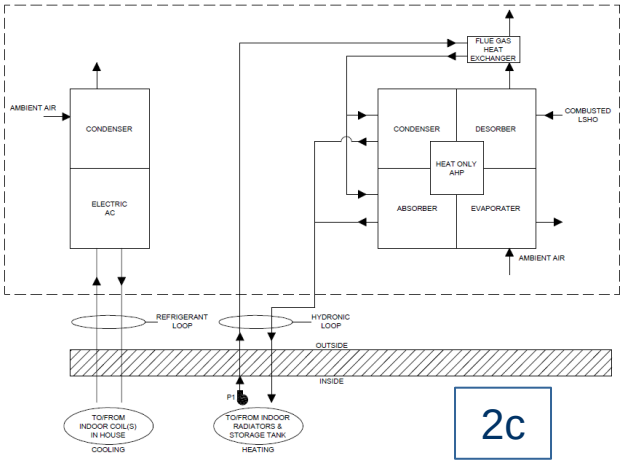
Configurations considered to the hybrid system (2):




2a



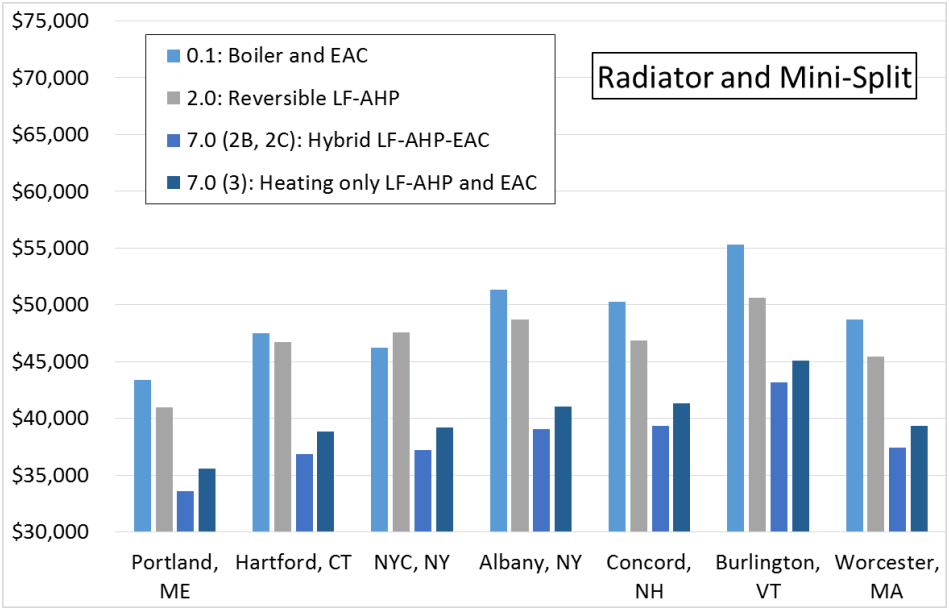

2b

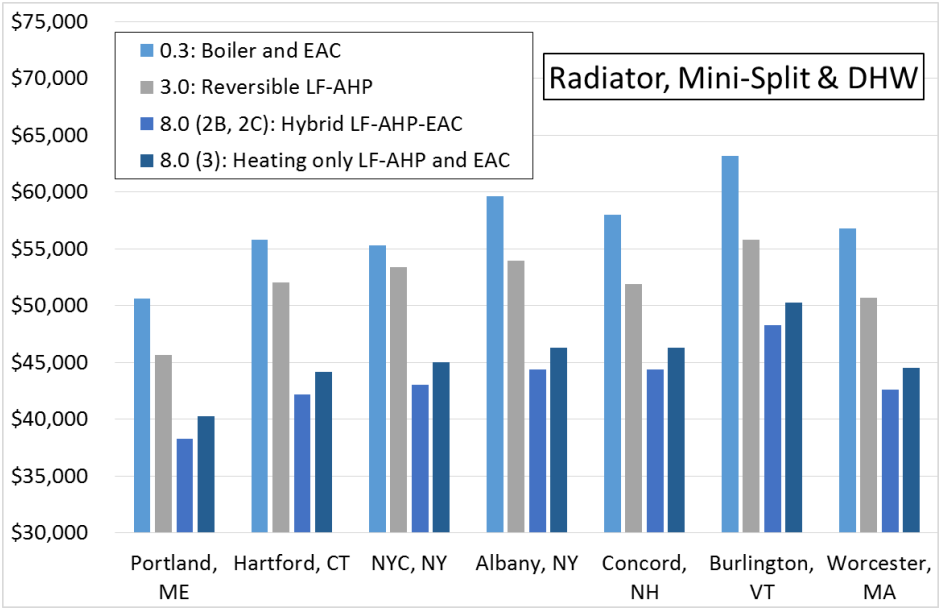



2c

# Results – 15 Year Total Cost - Boiler

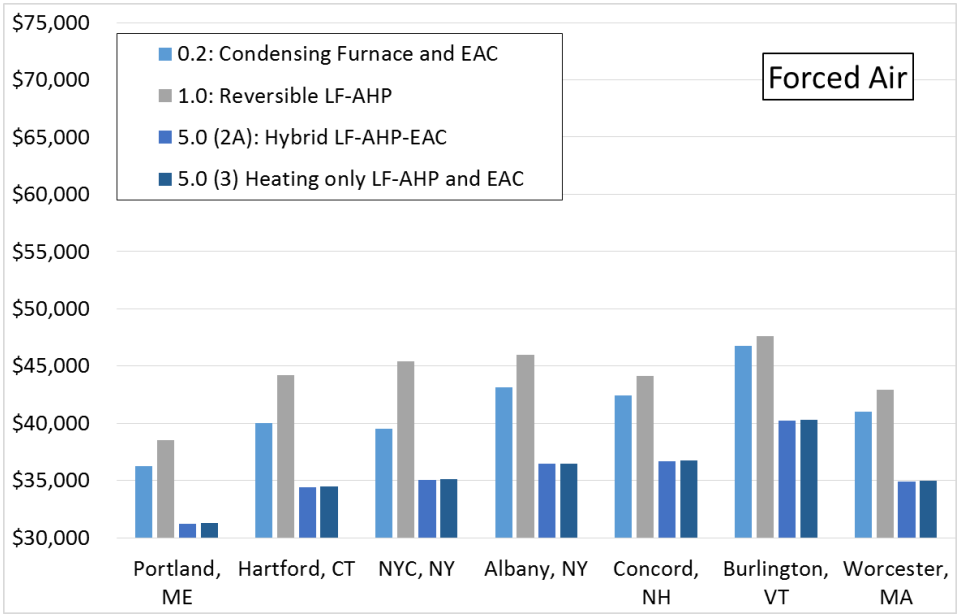
- Hybrid LF-AHP/EAC offers lowest total cost for all scenarios
- Heating only LF-AHP cost slightly higher than Hybrid system
- Reversible LF-AHP offers lowest savings of all LF-AHP configurations compared to standard boiler system

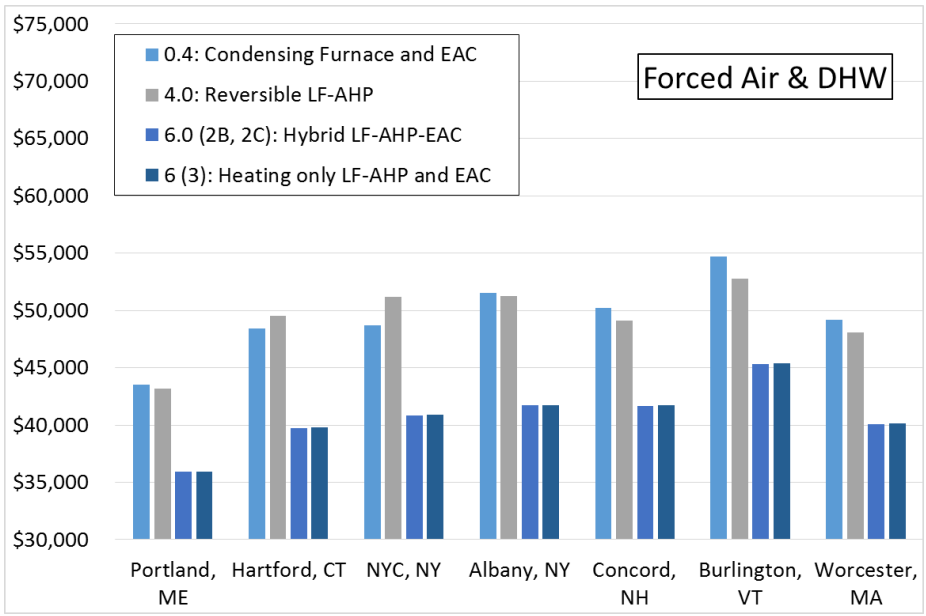


# Results – 15 Year Total Cost - Furnace

- Hybrid LF-AHP/EAC offers lowest total cost for all scenarios
- Heating only LF-AHP cost competitive with Hybrid system
- Reversible LF-AHP more expensive than condensing furnace in most cases



# Results – Simple Payback Period (yrs)

| Payback Periods | | | | |
|---|---|---|---|---|
| **Location** | 1.0 vs 0.2 | 2.0 vs. 0.1 | 3.0 vs. 0.3 | 4.0 vs. 0.4 |
| Portland, ME | Never | 2.8 | 1.5 | 13.1 |
| Hartford, CT | Never | 6.3 | 1.9 | Never |
| NYC, NY | Never | Never | 3.4 | Never |
| Albany, NY | Never | 2.6 | 1.3 | 13.1 |
| Concord, NH | Never | 2.1 | 1.2 | 10.0 |
| Burlington, VT | Never | 1.6 | 1.0 | 7.8 |
| Worcester, MA | Never | 2.2 | 1.2 | 10.0 |
| **Location** | 5.0 (2A) vs. 0.2 | 6.0 (2B, 2C) vs. 0.4 | 7.0 (2B, 2C) vs. 0.1 | 8.0 (2B, 2C) vs. 0.3 |
| Portland, ME | 4.7 | 3.3 | 0.8 | 0.6 |
| Hartford, CT | 4.3 | 3.0 | 0.7 | 0.6 |
| NYC, NY | 5.0 | 3.2 | 0.9 | 0.6 |
| Albany, NY | 3.8 | 2.7 | 0.6 | 0.5 |
| Concord, NH | 4.2 | 3.0 | 0.7 | 0.6 |
| Burlington, VT | 3.9 | 2.8 | 0.6 | 0.5 |
| Worcester, MA | 4.1 | 2.9 | 0.7 | 0.6 |
| **Location** | 5.0 (3) vs 0.2 | 6.0 (3) vs. 0.4 | 7.0 (3) vs. 0.1 | 8.0 (3) vs. 0.3 |
| Portland, ME | 4.8 | 3.4 | 3.6 | 2.9 |
| Hartford, CT | 4.4 | 3.0 | 3.4 | 2.6 |
| NYC, NY | 5.1 | 3.3 | 3.9 | 2.9 |
| Albany, NY | 3.8 | 2.7 | 2.9 | 2.4 |
| Concord, NH | 4.3 | 3.1 | 3.3 | 2.6 |
| Burlington, VT | 3.9 | 2.9 | 3.0 | 2.4 |
| Worcester, MA | 4.1 | 2.9 | 3.2 | 2.5 |

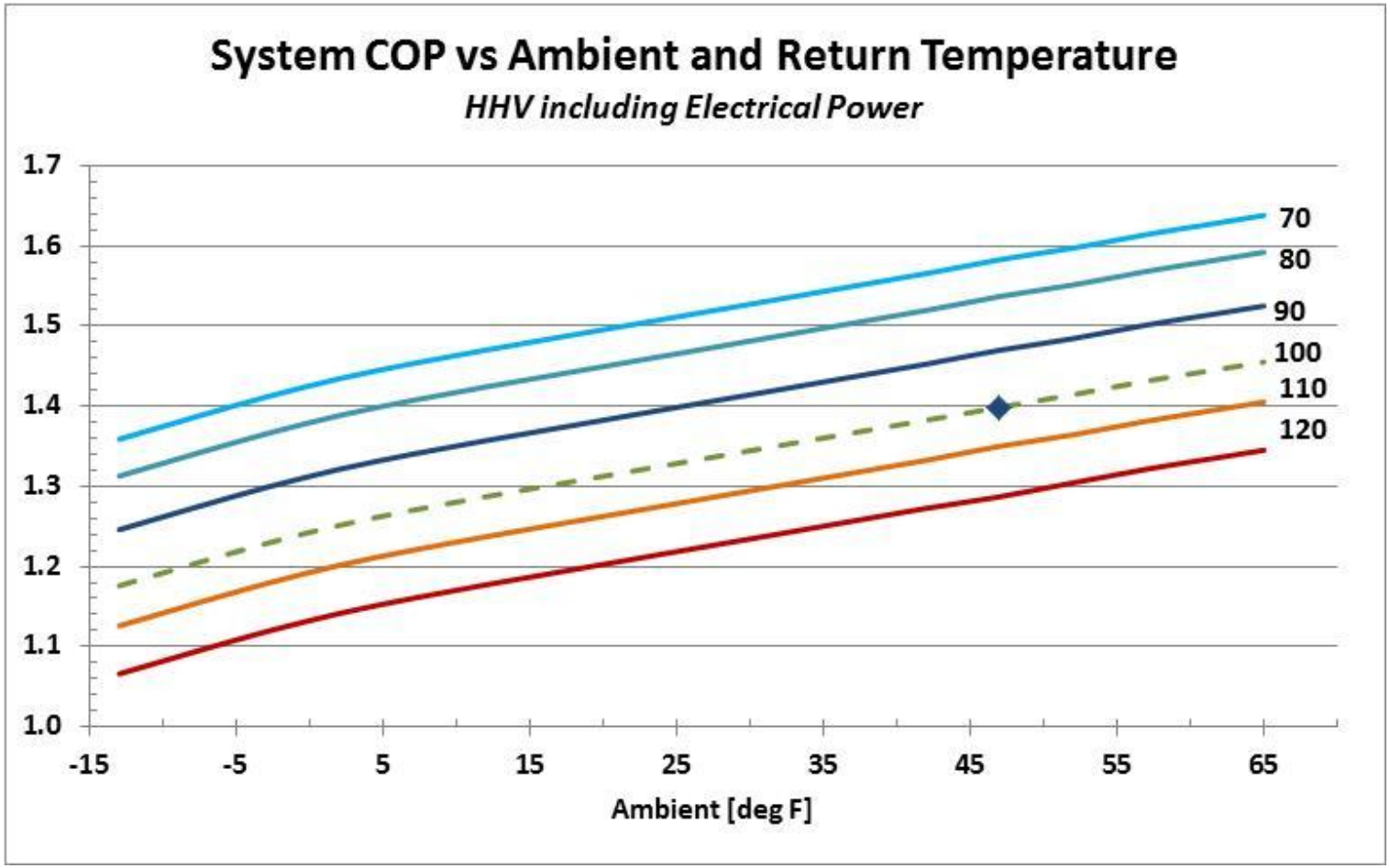
Reversible LF-AHP

Hybrid LF-AHP/EAC

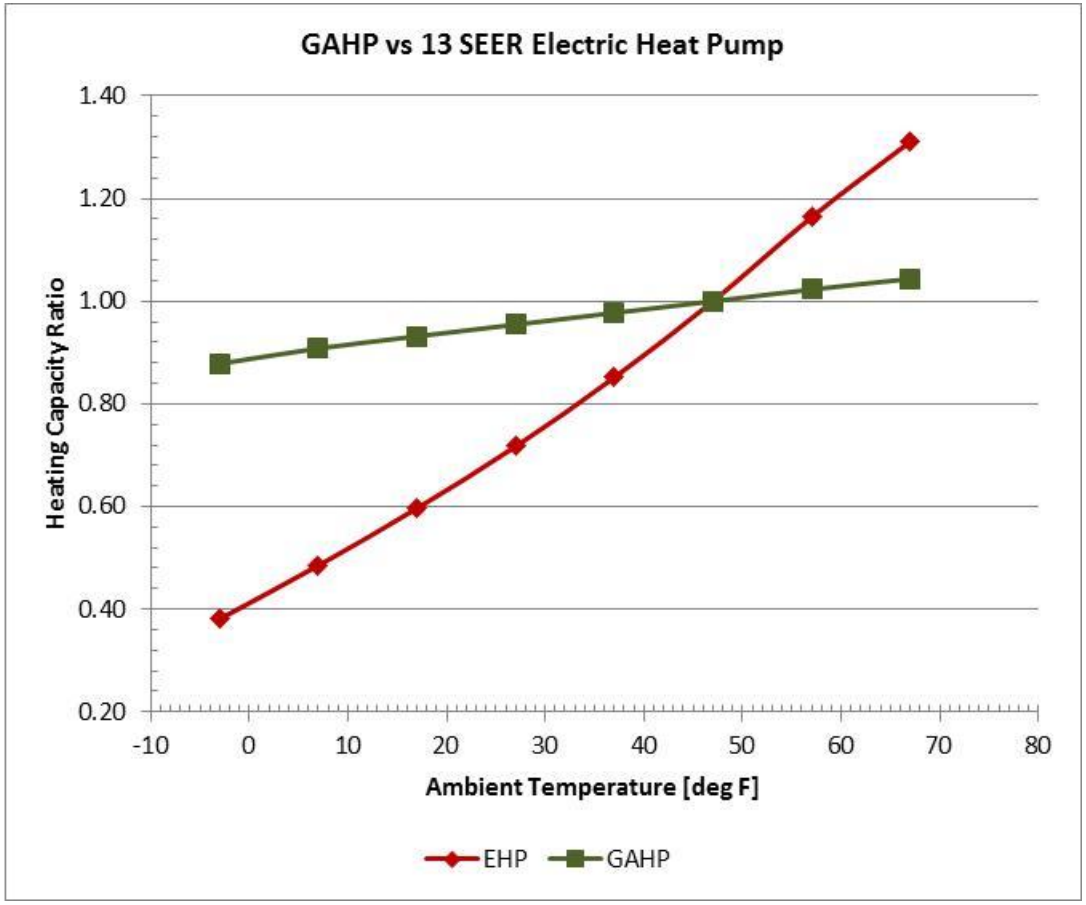
Separate LF-AHP & EAC

# SMTI AHP Target Performance

## Nominal 20F Rise



# 85% Rated Heating Capacity at 0º F




**Carrier 25HBB3C (13 SEER, 8 HSPF, nominal 3RT)**