Commercial Absorption Heat Pump Water Heater

2016 Building Technologies Office Peer Review

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Project Summary

Timeline:
Start date: 10/1/13
Planned end date: 9/30/17

Key Milestones

1. Completed breadboard analysis; 9/4/2015
2. Completed alpha prototype; 11/18/15
3. Complete beta prototype fabrication and evaluation; 9/30/16

Budget:

Total Project $ to Date:

- DOE: $1,392K
- Cost Share: *

Total Project $:

- DOE: $2,200K
- Cost Share: *

Key Partners:

A.O. Smith
Stone Mountain Technologies, Inc.

Project Outcome:

An 140,000 BTU/hr GAHP achieving a cycle COP of 1.63 at the rated condition of 47 ^{o}F ambient.

The target market is the hospital, hotel and full service restaurant gas hot water heating market.

Field test unit will be ready in FY17.

* In-kind contribution from CRADA partner – exceeds DOE funding level; exact total is confidential information

Purpose and Objectives

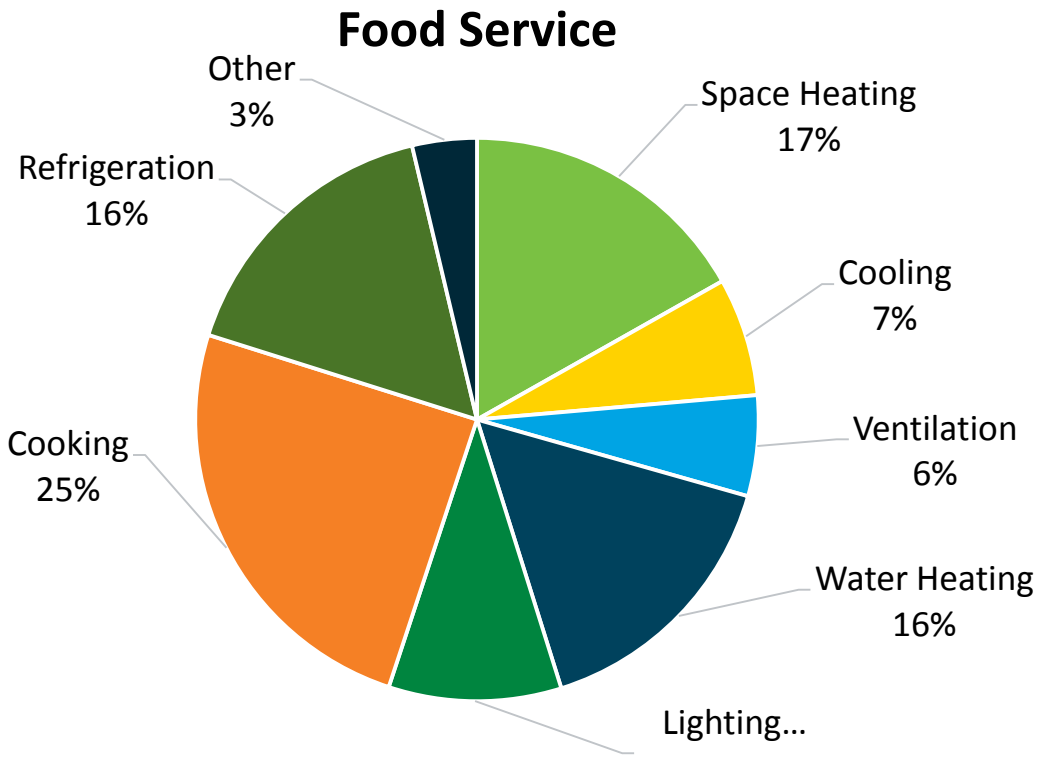
Problem Statement:

As stated in the BTO's MYPP

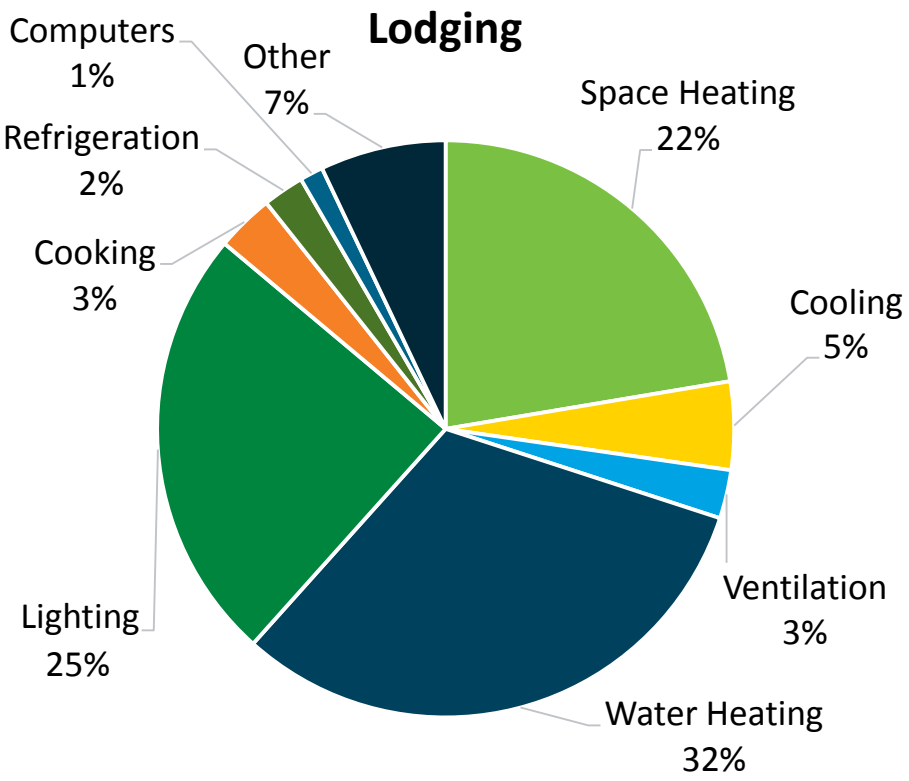
- **2020** Energy use intensity for WH **25%** lower than **2010** energy-efficient baseline – part of 1.8 quads energy savings
- In **2014**, natural gas provided **3** quads of the estimated **18** quads of commercial buildings energy use
- AHPWH achieving **45%** energy savings compared to ENERGY STAR-certified gas storage water heater
- **2020** Target Primary Energy Factor 1.2
- **2020** Target Installed Cost $7.14 ($/First Hour Rating)

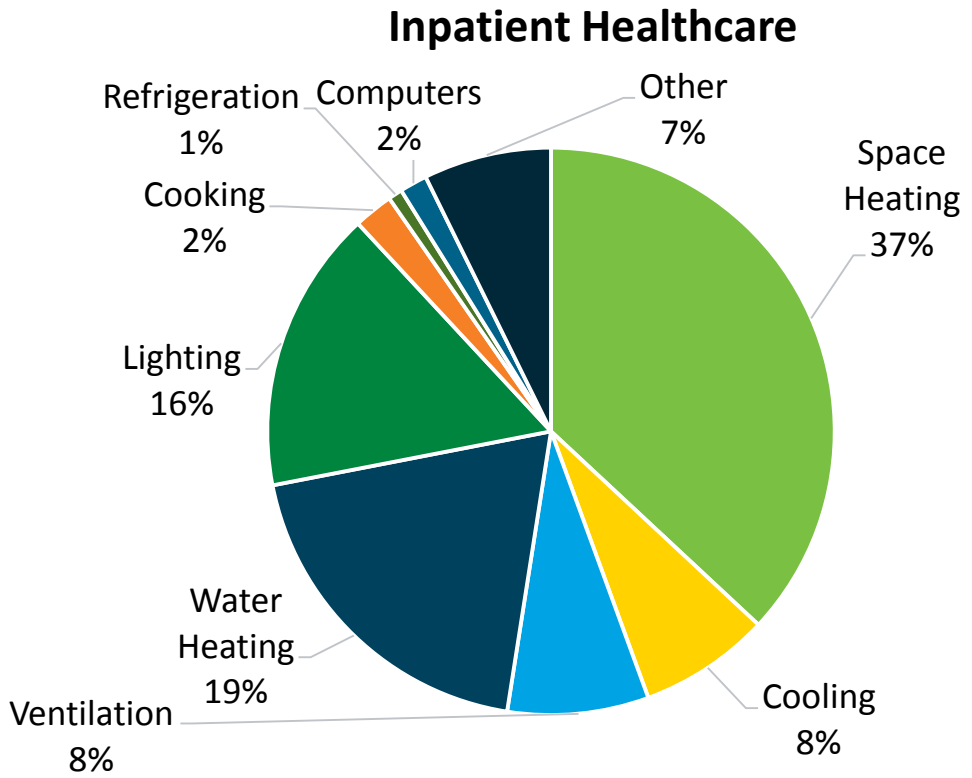
Purpose and Objectives

Target Market and Audience:
The natural gas commercial water heating market.
A special emphasis on retrofits with minimal total installed cost



Purpose and Objectives

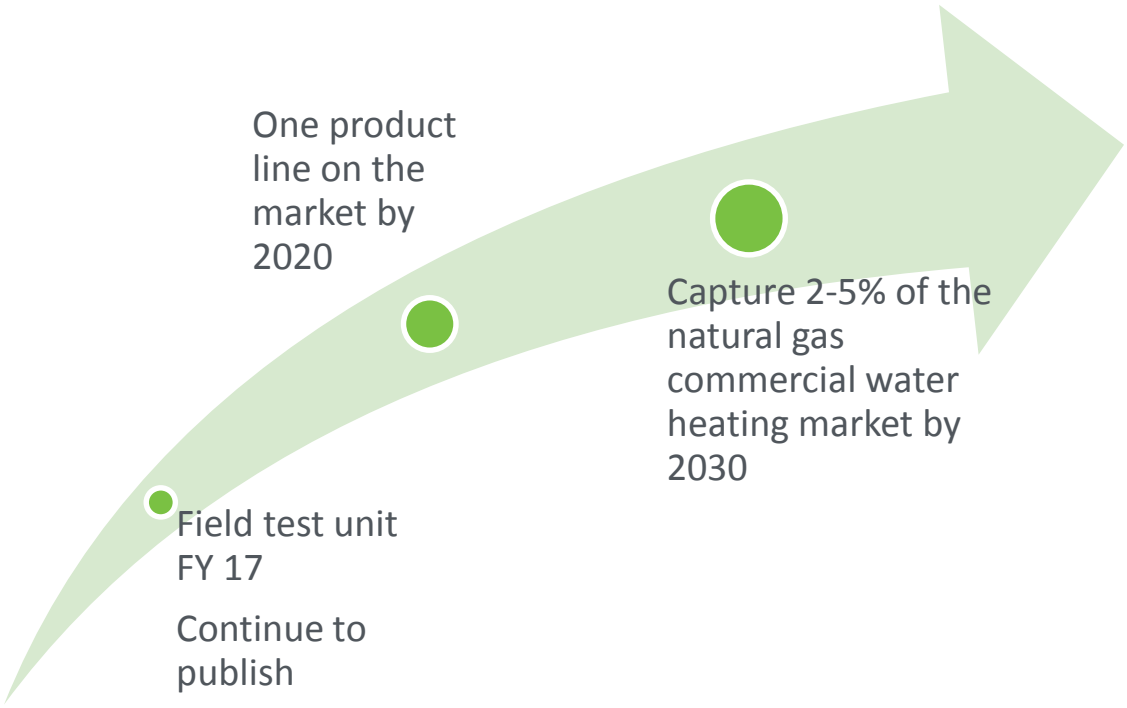




Purpose and Objectives

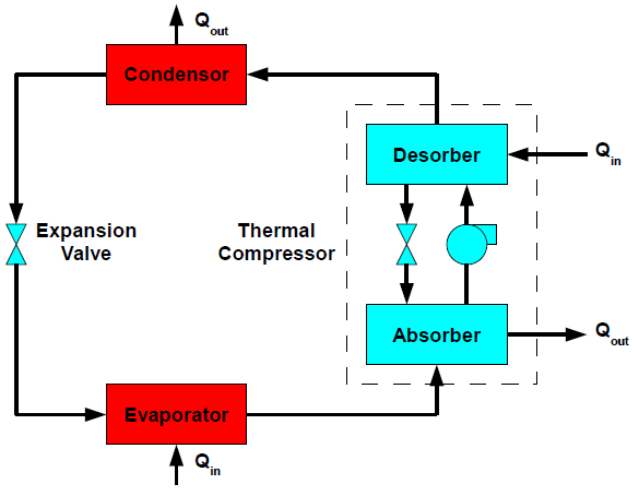
Impact of Project:

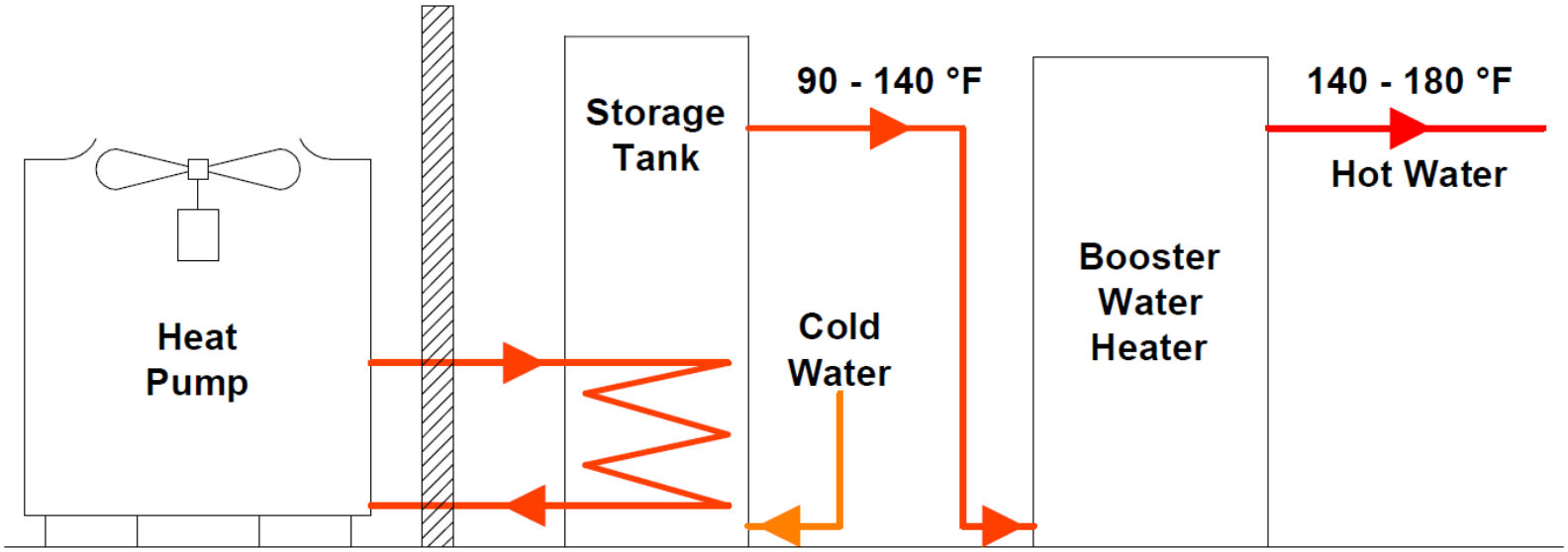
An 140,000 BTU/h HPWH unit achieving a cycle COP of 1.63 at 47 ^{o}F rated ambient conditions



Introduction

- Mechanical compressor replaced by Thermal Compressor
- Ammonia-water absorption system
- Heat Pump Unit sits outside building





Approach

Approach:

- Thorough single-effect cycle modeling to predict target performance
- System and Component analysis of the prototypes to identify areas of improvement
- Dedicated fabrication team at SMTI

Key Issues: High pressure drop on hydronic side and underperforming rectifier component

Distinctive Characteristics: Strong and dynamic relationship between partners and subcontractor

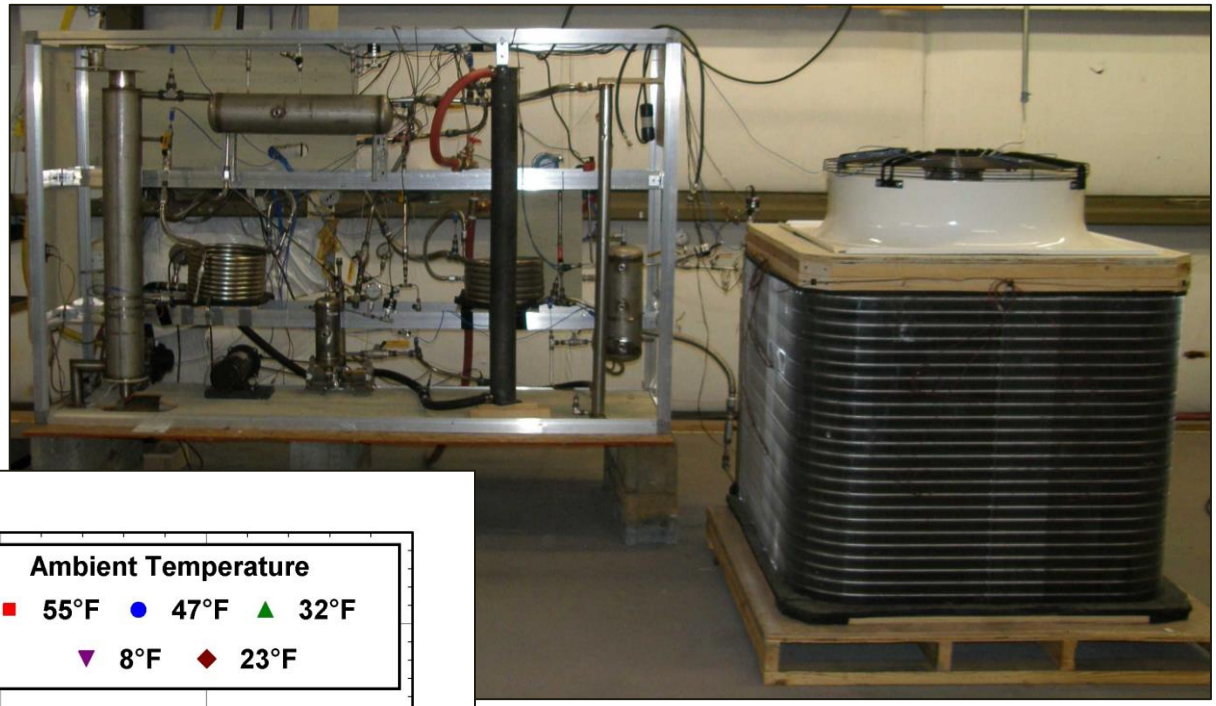
Progress and Accomplishments

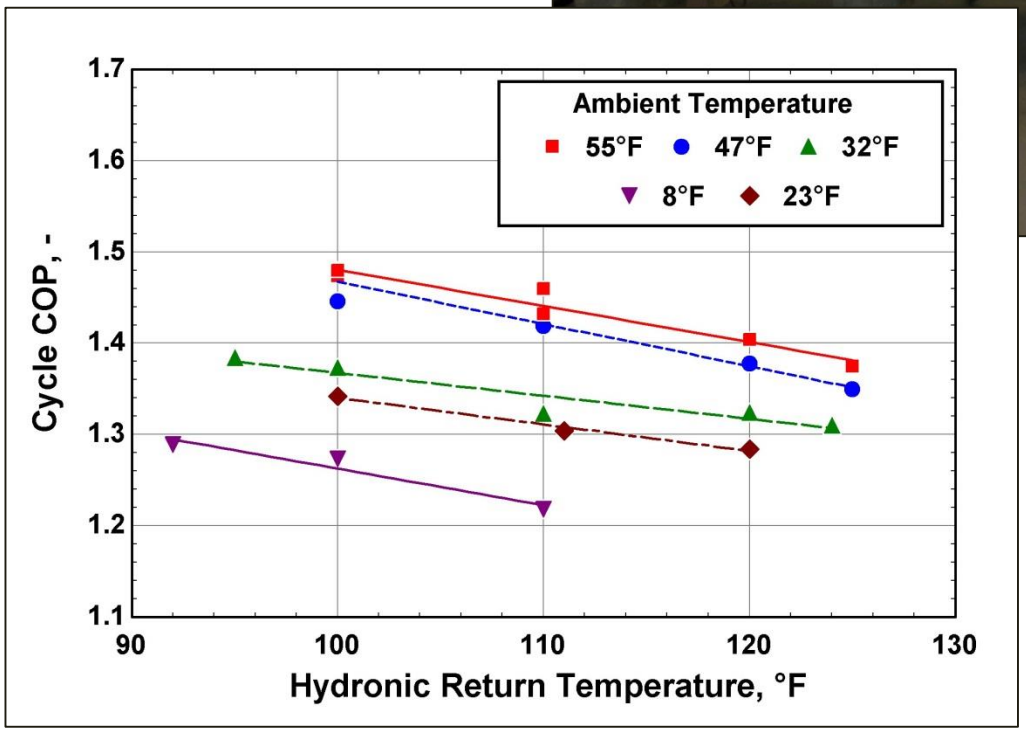
Accomplishments:

- ✓ Optimized single-effect cycle model to predict target performance
- ✓ Breadboard testing complete
  - ✓ 87% of performance target at design condition
  - ✓ 3:1 modulation achieved
- ✓ Alpha packaged prototype fabricated and tested
  - ✓ 92% of performance target at design condition
  - ✓ 3:1 modulation achieved

Progress and Accomplishments

- Cycle COP of 1.45 at design ambient/ return of 47/100°F





- Operation over significant ambient (0 to 55°F) and hydronic return (90 to 125°F) temperature ranges

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Progress and Accomplishments

Alpha Prototype

Nominal Output : 140,000 btu/hr (41.0 kW)

Gas Input: 97,000 btu/hr (28.4 kW)

Max Supply: 160°F (71°C)

Size: 49” × 66” × 65” (1.24 m × 1.68 m × 1.65 m)

Weight: ~1000 pounds

As of now:

Ambient: 0 to 78°F (-17.8 to 25.6°C)

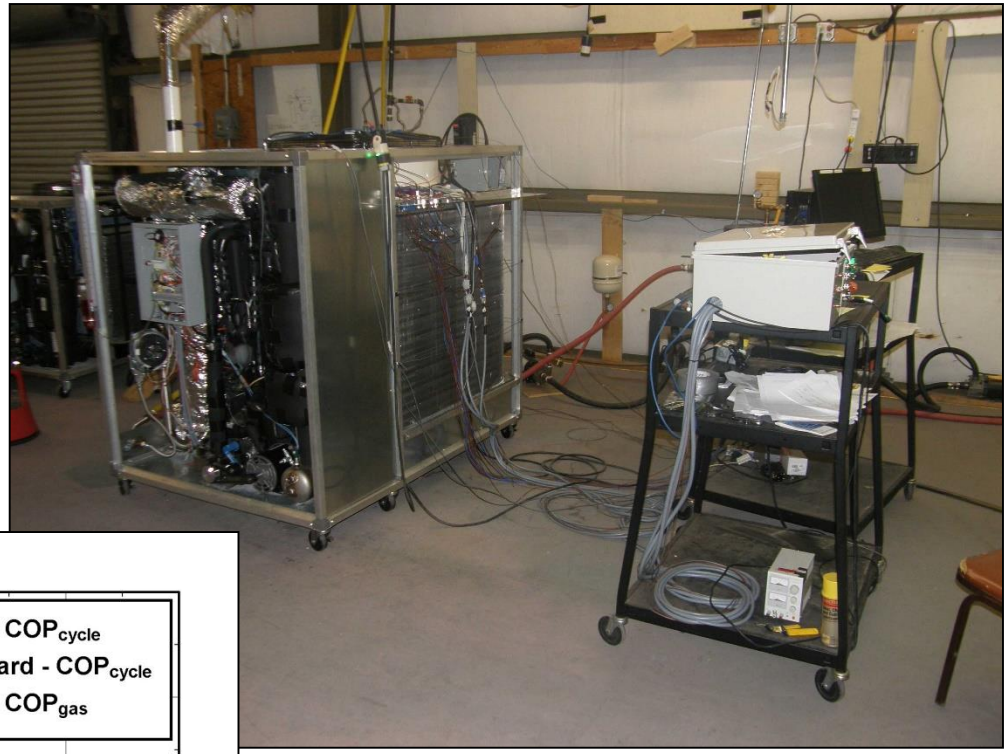
Hydronic Return: 80 to 125°F (26.7 to 51.7°C)

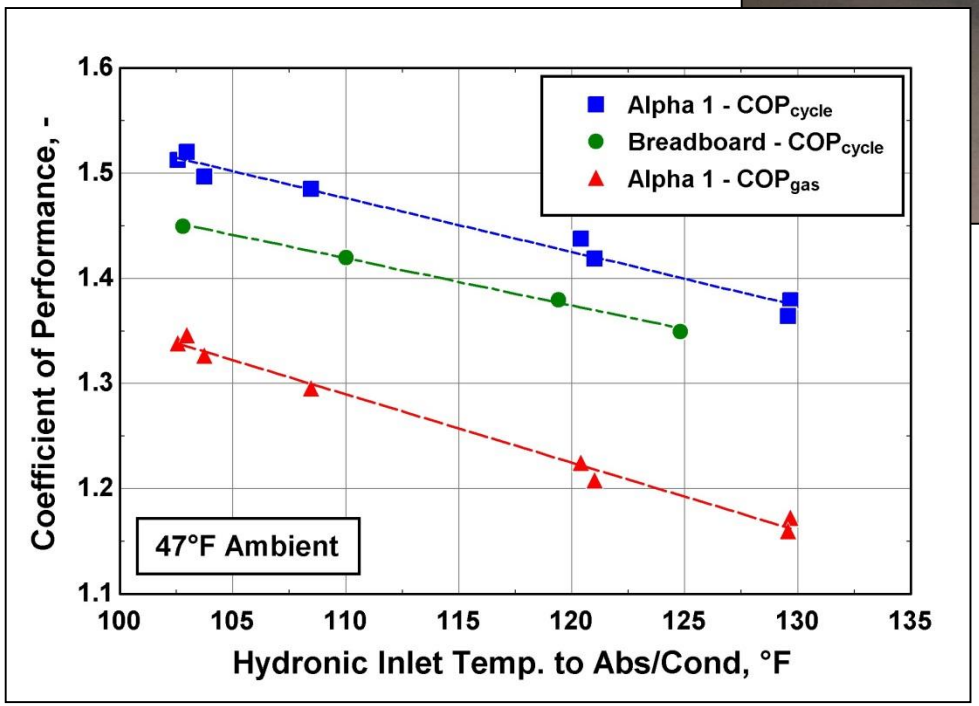
Hydronic Supply: 92 to 142°F (33.3 to 61.1°C)

Modulation: 3:1

Progress and Accomplishments

- Cycle COP of 1.51 at design ambient/return of 47/100°F
- Alpha Unit COP improvement of 0.06 compared to breadboard System

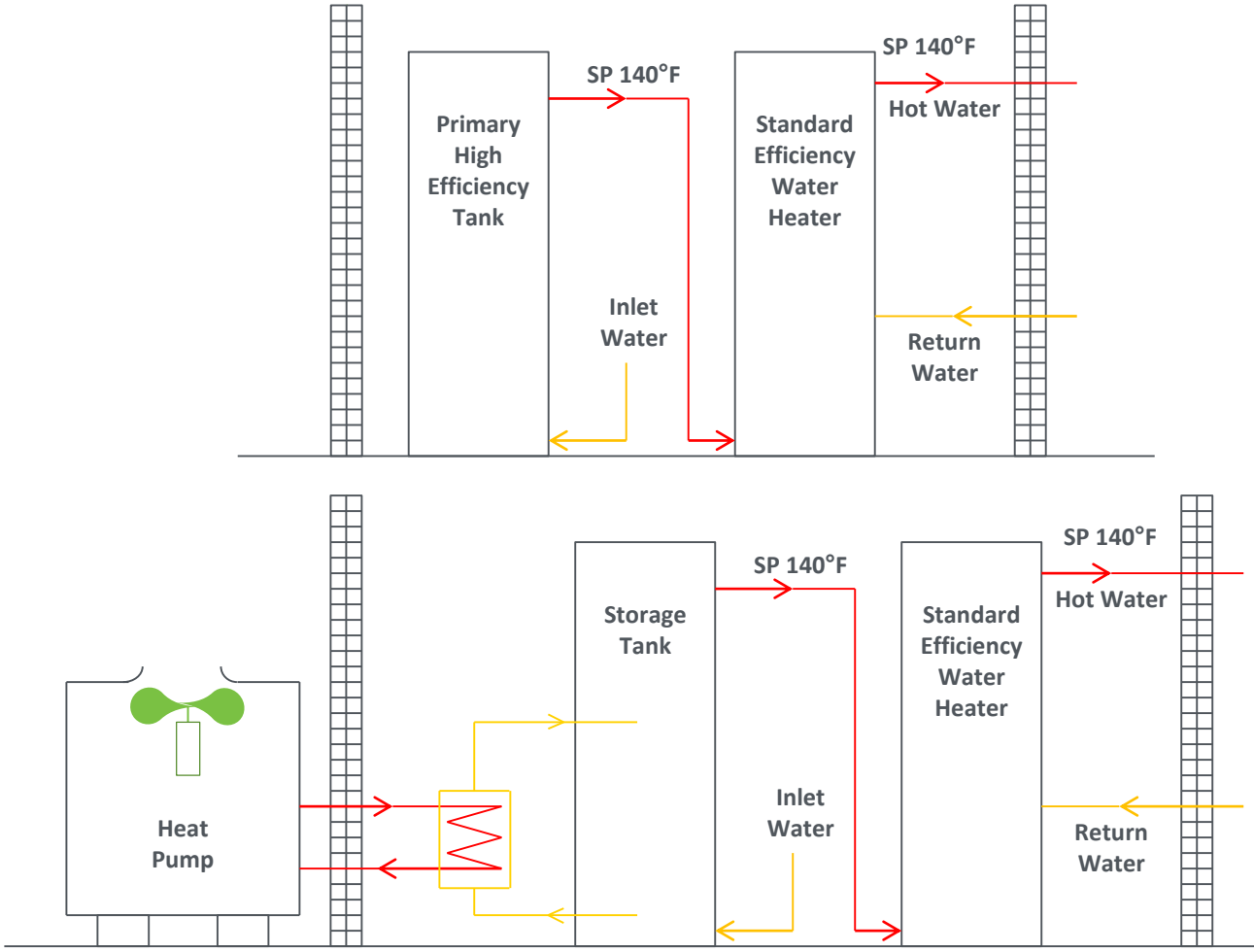




- 3:1 modulation achieved
- Environmental Chamber Characterization underway at ORNL

Progress and Accomplishments

Market Impact:



EnergyPlus simulations reveal average daily gas consumption drops from **1638** ft^3 to **1104** ft^3 based on real water draw data from a **full service restaurant** located in San Ramon, CA.

Progress and Accomplishments

Lessons, Issues & Opportunities:

- Rectifier performance below design for Breadboard and Alpha unit
  - Component design change to limit heat exchange with surroundings
- Pressure loss management across components with 14 gpm hydronic flow

Project Integration and Collaboration

Partners, Subcontractors, and Collaborators:

- **ORNL:** Expertise in building equipment performance evaluation and modeling

- **AO Smith (OEM):** Provides component design, fabrication, testing support, market research, and cost share to the project

- **SMTI:** Provides component and system design, fabrication, testing, testing support, and market research

Project Integration:

- Both are in constant communication with ORNL via conference calls, emails, and task reports

Communications:

Commercial Water Heating Using Gas Absorption Heat Pumps , ACEEE Hot Water Forum, Portland OR, February 2016
ASHRAE 2016 in St. Louis and Purdue Conference 2016

Next Steps and Future Plans

Next Steps and Future Plans:

- Continued Testing & Verification of Alpha unit by ORNL (March to April 2016)
  - Steady-state testing
- Fabrication & Testing of Beta prototype at SMTI (May 2016)
  - Target incremental performance improvements
  - Controls optimization
  - Test under commercial water heating conditions
- Testing of Beta unit by ORNL (June 2016)
  - Steady-state testing

REFERENCE SLIDES

Project Budget

Project Budget: DOE Total $2200k
Cost to Date: $1392k
Additional Funding: None expected

Budget History					
10/1/13 – FY 2015 (past)		FY 2016 (current)		FY 2017 – 9/30/17 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$1260k	*	$540k	*	$400k	*

* In-kind contribution from CRADA partner – exceeds DOE funding level; exact total is confidential information

Project Plan and Schedule