Commercial Absorption Heat Pump Water Heater

2017 Building Technologies Office Peer Review

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Project Summary

Timeline:
Start date: 10/1/13
Planned end date: 6/30/18

Key Milestones
1. Field site selection: 3/31/17
2. Report evaluation of field study to date: 9/30/17

Budget:
Total Project $ to Date:
• DOE: $1792.9K
• Cost Share: *

Total Project $:
• DOE: $1,920K
• 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°F ambient.
The target market is the hospital, hotel and full service restaurant gas hot water heating market.
Field test unit 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
Purpose and Objectives

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

Purpose and Objectives

Lodging:
- Space Heating: 32%
- Lighting: 25%
- Cooking: 3%
- Refrigeration: 2%
- Computers: 1%
- Other: 7%

Inpatient Healthcare:
- Space Heating: 37%
- Lighting: 16%
- Cooking: 2%
- Refrigeration: 1%
- Computers: 2%
- Other: 7%
- Ventilation: 8%
- Cooling: 8%

Buildings Energy Data Book: 3.1 Commercial Sector Energy Consumption,
http://buildingsdatabook.eren.doe.gov
Purpose and Objectives

Impact of Project:
An 140,000 BTU/h HPWH unit achieving a cycle COP of 1.63 at 47°F rated ambient conditions

- Field test unit FY 17
- Continue to publish, seek additional funding
- One product line on the market by 2020
- Capture 2-5% of the natural gas commercial water heating market by 2030
Introduction - Layout

• Mechanical compressor replaced by Thermal Compressor
• Ammonia-water absorption system
• Heat Pump Unit sits outside building
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: Field site location

Distinctive Characteristics: Harnessing energy from the outside ambient to push well beyond COP values of 1
Progress and 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

• Beta packaged prototype fabricated and tested
  – 97% of performance target at design condition
  – 3:1 modulation achieved
Progress and Accomplishments

![Graph and equipment images]
Progress and Accomplishments

Beta 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:
56.25” × 40.75” × 61.25” (1.43 m × 1.04 m × 1.56 m)

Weight:
~850 pounds

Modulation:
3:1

30% reduction in size from Alpha to Beta Prototype
Progress and Accomplishments

Beta unit testing at ORNL:
• Testing performed at full and reduced firing rates
• COP of 1.31 at 47/100°F design ambient/return (90% of 1.45 target)
• Performance limited by underperforming Rectifier
Progress and Accomplishments

Beta unit testing at SMTI:

- Alternative Rectifier design investigated and installed in unit
- Performance improved to highest level to date
- COP of 1.41 at 47/100°F design ambient/return (97% of 1.45 target)
Progress and Accomplishments

On average, the GAHP configuration offered an annual gas savings of 35%.

Progress and Accomplishments

- Payback analysis for 7 cities studied by Geoghegan et al. (2016)
- Capital cost of conventional high efficiency system assumed to be $11,500
- Capital cost of GAHP system assumed to be $18,800
- At national average of $1.20/therm, payback is 3.7 years
Next Steps and Future Plans

- Ongoing reliability testing with Beta 1 at SMTI
- Flyer distributed to identify potential field sites
- Fabrication & Testing of Beta 2 prototype at SMTI (June 2017)
  - Target incremental performance improvements
  - Controls optimization
  - Test under commercial water heating conditions
- Beta 2 Field Test (July 2017)
  - Installed in commercial application in Northeast Tennessee
- Pursue Commercial Buildings Integration funding

Johnson City, TN
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:

- In constant communication with ORNL via conference calls, emails, and task reports

Communications:

ACEEE Hot Water Forum, Portland OR, 2016 and 2017
ASHRAE, St. Louis, 2016
Purdue Conference, 2016
IEA Heat Pump Conference, 2017
REFERENCE SLIDES
**Project Budget**

**Project Budget:** DOE Total $1920k  
**Cost to Date:** $1792.9k  
**Additional Funding:** None expected

### Budget History

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<th>FY 2017 – 9/30/17 (planned)</th>
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## Project Plan and Schedule

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## Current/Future Work

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<td>Q4 Milestone: Report Field Study evaluation to date</td>
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