Commercial Absorption Heat Pump Water Heater

2016 Building Technologies Office Peer Review

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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:**

<table>
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<th>A.O. Smith</th>
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<td>Stone Mountain Technologies, Inc.</td>
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**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 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

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

- One product line on the market by 2020
- Field test unit FY 17
- Capture 2-5% of the natural gas commercial water heating market by 2030
- Continue to publish
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
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 ft³ to 1104 ft³ 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:
ASHRAE 2016 in St. Louis and Purdue Conference 2016
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
**Project Budget**

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

### Budget History

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<thead>
<tr>
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<th>FY 2015 (past)</th>
<th>FY 2016 (current)</th>
<th>FY 2017 – 9/30/17 (planned)</th>
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<tr>
<td><strong>DOE</strong></td>
<td>$1260k</td>
<td>$540k</td>
<td>$400k</td>
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<tr>
<td><strong>Cost-share</strong></td>
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# Project Plan and Schedule

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<thead>
<tr>
<th>Task</th>
<th>Q1 (Oct-Dec)</th>
<th>Q2 (Jan-Mar)</th>
<th>Q3 (Apr-Jun)</th>
<th>Q4 (Jul-Sep)</th>
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<tr>
<td>Past Work</td>
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<td>Q4 Go/No-Go: Complete BB prototype design</td>
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<td>Q4 Milestone: Complete BB analysis</td>
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<td>Q4 Milestone: complete alpha</td>
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<td>Current/Future Work</td>
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<td>Q3 Milestone: submit alpha testing report</td>
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<tr>
<td>Q4 Milestone: submit beta performance report</td>
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**Project Schedule**

- **Project Start:** 10/1/13
- **Projected End:** 9/30/17

**Past Work**

- Q4 Milestone: Complete BB prototype design
- Q4 Milestone: Complete BB analysis
- Q4 Milestone: complete alpha

**Current/Future Work**

- Q3 Milestone: submit alpha testing report
- Q4 Milestone: submit beta performance report

**Legend:**
- ● Milestone/Deliverable (Originally Planned) use for missed
- ● Milestone/Deliverable (Actual) use when met on time