2024 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BUILDING TECHNOLOGIES OFFICE

BTO Peer Review:
Highly Efficient gas Absorption Technology for Energy Reductions (HEATER)

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Highly Efficient gas Absorption Technology for Energy Reductions (HEATER)

Stone Mountain Technologies, Inc.

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Project Summary

OBJECTIVE, OUTCOME, & IMPACT

The HEATER project seeks to demonstrate and validate energy savings of production-ready Gas-fired Absorption Heat Pump (GAHP) technology. SMTI has developed GAHP prime for market acceleration following a robust, data-driven demonstration to validate cost and energy savings in a commercial-scale application.

Maclellan Hall, King University

TEAM & PARTNERS

- TDEC (Prime)
- SMTI (Technology Lead)
- NASEO (Education, Outreach, Dissemination)
- GTI Energy (M&V Plan Development)
- King University (Demonstration Site Host)

STATS

Performance Period: 6/1/2021 – 2/28/2025 (mod to extend to 10/31/2025)

DOE Budget: $504,600, Cost Share: $216,383

Milestone 1: Signed IPMP

Milestone 2: Selected demonstration site

Milestone 3: M&V plan development

Milestone 4: GAHP performance at or above COP of 1.4

Problem

- Technical / Market Problem: Reduction of gas use and corresponding decarbonization vs. traditional commercial water heating solutions.
- Problem Scale: From a broad perspective, the problem is global, but SMTI's focus is on residential space and water heating, and commercial water heating, for North American markets.
- Market Input: SMTI leadership has decades of combined experience in GAHP technology development combined with experience in renewables and water heating technology. This experience, in concert with understanding of the market size/opportunity (specifically commercial water heating) and the knowledge/patents to cost effectively develop and manufacture the solution being tested, have brought SMTI to market to address the need.
- Problem Size: US commercial water heater market is $639.5M, growing 9.2% from 2024 to 2032. Most of these water heaters operate in the efficiency range of 80% to 95%, while GAHP water heating targets 125% up to 140%. If we can conservatively reduce gas use 30%, we automatically reduce the pollution and greenhouse gas emissions the same amount.
- Impacted Sectors: All residential gas heating (furnaces, boilers) and water heaters, as well as offering an option vs. residential electric heat pumps, and commercial water heaters.

Problem

- Gas furnaces and boilers are fundamentally limited to coefficients of performance (COP) of <1.0; SMTI offers a gas absorption heat pump capable of achieving 1.4 CoP, a 40%+ improvement over current gas water heating technology
- Though GAHP technology offers high heating COPs, it has not achieved substantial market penetration primarily due to up-front cost and long economic payback
  - Efforts to manufacture at scale and reduce costs have been largely unsuccessful; SMTI has approached this challenge through a combination of intellectual property/patents to optimize efficiency, and standardization and manufacturing efficiency to reduce both cost of product acquisition as well as operating costs, to introduce an affordable solution to the market which can compete with well established legacy low efficiency water heating solutions.
  - Many versions of this technology require high pressures / temperatures to achieve efficiency; SMTI's application of gas absorption heat pump technology operates in the same pressure and temperature ranges as traditional gas water heating technology, while employing an environmentally friendly refrigerant which has zero global warming and ozone depletion potential (unlike electric heat pump technology).
- Cold-climate performance limitations similar to electric heat pumps; SMTI has designed a GAHP capable of collecting ambient heat down to much lower temperatures. It is designed to operate down to -40F/C and still offer performance equivalent to legacy gas heating equipment.
- High costs and performance have impeded residential applications; SMTI has designed a solution which offers from 3- to 5-year payback in residential applications. Gas utility incentives improve the payback even more while reducing up front entry costs. SMTI has commissioned market research through Decision Analyst, to survey homeowners and contractors on their willingness to accept and pay for GAHP technology vs. legacy gas and electric options – very positive results.

Alignment and Impact

- Successful demonstration of this technology will:
  - Contribute to the overall evaluation of the market readiness of SMTI's GAHP
  - Result in demonstrating proven technology which can reduce gas use with commensurate decarbonization, for commercial water heating applications
- The demonstration will help to highlight the technology's overall energy, operating cost and emissions savings potential in public sector and similar commercial applications
  - Increase Building Energy Efficiency: COP of 1.4, anticipated 30-50% annual gas savings
  - Prioritizing Affordability: 3-5 year projected payback period, 10-year net savings of $11,303
  - Minimize Emissions: along with gas savings and carbon reduction, tech uses refrigerants with zero Ozone Depletion Potential and Global Warming Potential
- Project's dissemination of information will inform the market of this technology as the next high efficiency gas heating appliance
- Reporting and information dissemination will inform policymakers and potential users of the savings potential & increase confidence in viability

Approach

- Current Solutions:
  - Other GAHP models developed with low economic viability
  - Primarily commercial water-heating applications
  - Success in residential sector has overall been low
- Much of the commercial water heating market isn't aware of, or interested in evaluating high efficiency solutions due to cost, complexity, and unwillingness to change their legacy solution, particularly when hot water may be mission critical
- Sectors:
  - Residential (both SFH and MFH)
  - Commercial (small- and large-scale)
  - Public sector
  - Other applications include snow/ice melt, pool heating, agriculture and livestock process &/or cleaning (eggs, tomato, floral, etc.)

Approach

- Novel Technology
  - Low-cost, 4:1 modulating, gas-fired absorption air-source heat pump
  - Capable of providing both space and water heating
  - Heating capacity of 80 kBTU/hr (23 kW)
  - COP: 1.45 at 47°F ambient, 1.20 at 0°F ambient
  - 30-50% improvement in heating efficiency compared to direct-fired furnaces, boilers and water heaters
  - Primary energy savings potential for 2030 and applicable gas heating applications is 1,080 Tbtu (59 MM CO2), based on BTO Market Calculator

GAHP comparison with 95% Condensing Water Heater

Simple Payback: 80 kBtu/hr GAHP vs 95% Condensing Water heater		
Installed Cost, GAHP	$11,000	
Installed Cost, 95% CWH	$7,000	
Incremental Initial Cost Premium	$4,000	
Building Heating Load (yr) - 3000 gallons/day	400	MMBTU
Natural Gas Used, GAHP (1.45 COP_gas)	276	MMBTU
Natural Gas Used, 95% CWH	421	MMBTU
Electric Used, GAHP	2000	kWh
Electric Used, 95% CWH	300	kWh
Cost of Natural Gas, GAHP ($12.02/MMBtu)	$3,316	$/yr
Cost of Natural Gas, 95% CWH ($12.02/MMBtu)	$5,061	$/yr
Cost of Electricity, GAHP ($0.1264/kWh)	$253	$/yr
Cost of Electricity, 95% CWH ($0.1264/kWh)	$38	$/yr
Total Operating Cost, GAHP ($/yr)	$3,569	$/yr
Total Operating Cost, 95% CWH ($/yr)	$5,099	$/yr
Annual Operating Cost Savings ($/yr)	$1,530	$/yr
Simple Payback	**2.6**	yr
10-year Net Savings	$11,303	

Approach

- Demonstration Period
  - Identification of potential site hosts across Tennessee that meet the following criteria:
    - Adequate/substantial base load of hot water usage daily
    - Existing natural gas line hookup
    - Sufficient space for installation
    - Little to no site alterations or disruptions required
    - Willing, enthusiastic site host employees
  - Prior field demonstration work
  - 10-12 month field validation
    - Covers all seasons and site use patterns throughout the year

Approach

- Selected Site: King University (Bristol, TN)
- Specific building is **Maclellan Hall**, which is a 2-story brick combination administrative building with a full service cafeteria that also provides catering and meals year-round and on weekends (open to the general public certain times, most times serves only students and staff). Building hot water is served by a central plant located across the street providing 170-180F water to a 257 gallon Lochinvar storage tank connected to a plate heat exchanger.

Approach

Barriers:

- Product operation: project team has proactively swapped a pre-production unit for a production unit having several design changes
- Support network: SMTI has a customer service manager and several technicians on staff ready to support remotely and in person
- Concern over the technology and/or refrigerant: SMTI has developed marketing collateral to address this
- Market adoption: SMTI is a member of several large North American organizations promoting the technology and is working with sales channel partners and contractors at many regional and North American trade shows like AHR, AEE, CMPX, etc.

Commercialization Strategy:

- SMTI has began commercializing the product having launched in early 2024 in US and Canadian markets
- Using manufacturer representatives and several hundred contractors already trained, it is working at local levels on organic sales opportunities, as well as with many gas utilities on developing incentives to overcome current cost difference vs. legacy appliances.

Benefit Validation:

- Measurement & verification data comparing baseline energy use with legacy central plant and Lochinvar tank, vs. the SMTI GAHP solution; GTI Energy will collect and analyze all data.

Progress and Future Work

Accomplishments to Date:

- Identified and Selected Site Host
  - King University has been a great partner and has taken on its role enthusiastically, providing reasonable access to facilities to project team and required information on request
- Completed M&V Plan
  - Leveraging the experience and expertise of GTI Energy, a robust measurement and verification plan was developed to inform the collection of data during the trial period
- Installation of M&V and GAHP Components
  - Installation of components took place throughout CY 2024 Q3 and concluded in September 2024
- Demonstration Kicked-Off
  - Trial period began at site in early October 2024

Progress and Future Work

Obstacles and Barriers:

- Difficulties encountered in site recruitment
  - Primary identified site host rescinded involvement several months after DOE award execution
  - Multiple other entities expressed interest only to drop out as well
  - TN State Building Commission approval process for capital projects proved to be major barrier to partnering with a State government facility
  - Public non-State entities that were engaged were apprehensive about participating, despite availability of federal funds to provide for site host personnel time/materials
  - Required characteristics of site (hot water usage, natural gas hookup, existing facilities) limited available options for demonstration
- Longer-than-expected timelines for:
  - Site evaluation and planning for install
  - Contractor training and coordination
  - Unforeseen delays: 1) engineering changes to the product design; 2) site-specific delays; for example, university experienced leak in the Lochinvar tank and needed a subsequent replacement

Progress and Future Work

Lessons Learned/Best Practices:

- Communication is key
  - Project team has maintained consistent, regular touchpoints and lines of communication
  - There is always something to discuss
  - Regular communications have included:
    - Weekly: TDEC internal
    - Weekly: TDEC and SMTI
    - Bi-weekly check-ins between DOE and TDEC (and SMTI on as-needed basis)
    - Weekly: SMTI, GTI, King University
    - NEW: Check-ins between TDEC, SMTI, and NASEO to begin with launch of demonstration

- Ensure availability of options early.
  - Design in some flexibility towards site selection at the start of the project.
  - Major project setbacks mainly due to site host decommitment

- Anticipate delays
  - Can happen for any number of reasons.

Progress and Future Work

Plans for the Remainer of Period of Performance:

- Demonstration
  - Operate GAHP technology at site for a period of 10-12 months with continuous data collection
  - Baseline, GAHP, summary analyses to be conducted
- Continued Identification of Channels and Audiences
  - Industry associations, conferences, newsletters, public sector organizations, etc.
- Information Dissemination
  - Development of reports including summary analyses, techno-economic analyses, and presentations to share through the identified channels

Deviations from Stated Project Plans:

- Simultaneous baseline and GAHP data collection

Progress and Future Work

Looking Ahead:

- Commercialization:
  - SMTI has already undertaken commercialization, but this specific project will be used in support of commercial water heating applications sales and support across North America.
- Future Plans:
  - SMTI is exploring options to continue to continue to work with King University and other demonstration sites for further field trial work. The site has been an active participant, and it is a great site to test product innovations and cost reductions in a safe “real world” environment.
- Needs:
  - The project must collect a comprehensive performance comparison to use in disseminated materials to validate the commercial water heating application.
  - Additional support could include testimonial from participants, site visits, use of application in collateral, etc.

Thank you

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Reference Slides

Project Execution

	FY2021				FY2022				FY2023				FY2024				FY2025				
Planned budget					$320,173.00				$202,180.00				$198,630.00								
Spent budget	$7,715.80				$35,702.52				$22,135.51				$90,425.07								
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Past Work																					
Q1 Milestone: IPMP																					
Q2 Milestone: Final Site Selection																					
Q3 Milestone: Develop GAHP M&V Plan																					
Q4 Milestone: Laboratory Testing																					
Current/Future Work																					
Q5 Milestone: Baseline Summary Data Analysis																					
Q6 Milestone: Continuous Data Analysis																					
Q7 Milestone: Continuous Data Analysis																					
Q7 Milestone: Identify Channels and Audiences																					
Q8 Milestone: Continuous Data Analysis																					
Q8 Milestone: Dissemination of Preliminary Findings																					

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- Explanation for delays/slips in schedule on next slide

Project Execution

Deviations from projected schedule

Delays in the project and deviations from the schedule and planned milestones as depicted in the previous slide are primarily due to:

- Difficulties encountered in site recruitment
  - Primary identified site host rescinded involvement several months after DOE award execution
  - TN State Building Commission approval process for capital projects proved to be major barrier to partnering with a State government facility
  - Public non-State entities that were engaged were apprehensive about participating, despite availability of federal funds to provide for site host personnel time/materials
  - Required characteristics of site (hot water usage, natural gas hookup, existing facilities) limited available options for demonstration
- Longer-than-expected timelines for:
  - Site evaluation and planning for install
  - Contractor training
  - Delays at site (water tank leak and replacement)

Team

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