# Thermally-Driven Gas Heat Pump Combis

## OVERVIEW

- Extended operation of three early-generation GHPs in Wisconsin for the 2019-2020 heating season.
- Installed and monitored next-generation GHPs at three single family homes near Chicago, IL and one in Toronto, ON over 2019-20, with two sites continued over 2020-21.
- Evaluated strategies for improved reliability and enhancing delivered comfort via system controls.
- Characterized equipment costs, installation costs, and lessons learned for improving ease and lowering cost of installation.

## RESULTS

- **Energy Savings:** Significant therm savings, up to 33%-46% across demo efforts, as a combi with commensurate GHG reductions, over baseline furnace and water heaters.
- **Thermal Comfort:** Increased supply air temperatures at colder outside air conditions.
- **Costs:** Estimated to be ~25% higher than replacing both a furnace and water heater, but expected to reduce over time.
- **Emissions Impact:** CO2e emission savings ranged from 14% to 42% depending on location and baseline equipment

*A Thermally-driven Gas Heat Pump (GHP) is a fuel-fired air-source heat pump that provides space and water heating in a "combi" application.*

A team led by GTI and including Stone Mountain Technologies, Inc. (SMTI) developed a low-cost GHP proof-of-concept and evaluate it through laboratory and field testing. Initiated in 2019, this multi-phase project was funded by a utility collaborative with the goal of demonstrating a pre-production design of the GHP, custom air-handling unit (AHU), and other system components. This demonstration evaluated many aspects of this emerging technology, including GHP performance and reliability, efficacy of system controls, end user comfort, ease/complexity of installation, and servicing/maintenance.

The core of the GHP combi system is an 80 kBtu/h GHP, designed by SMTI with support from GTI and industry, and is based on the single-effect vapor absorption cycle using the $NH_3/H_2O$ working pair. Shown in prior demonstrations[2], these air-to-water GHPs have a 141% AFUE, 4:1 system modulation, ultra-low $NO_x$ emissions, defrost capability, and no supplemental heating. As a combined space/water heating system ("combi"), the GHP heats an indirect loop, which is coupled with an AHU, to provide forced-air heating, and an indirect water storage tanks to provide domestic hot water (DHW).

In addition to reduced energy input required to operate these units, the unit's outdoor location, smaller form factor, and associated lower emissions are better adapted to residential applications. This is a significant opportunity for residential and commercial retrofits, and potentially Zero Net Energy (ZNE) new home markets[3].

*Figure 2: Pilot installations of the Next Gen GHP*

## SUCCESS FACTORS

- **Product and Market Maturity:** Potential market entry in 2-3 years.
- **Program Readiness:** Pre-commercial pilots of GHP are complete/in progress in Ontario, Illinois, Wisconsin, California, and Tennessee, in residential, multifamily, and commercial sectors.

## REFERENCES


1) Garrabrant, M., and Keinath, C. (2020). *Pre-Commercial Scale-Up of a Gas-Fired Absorption Heat Pump*, Report DOE-SMTI-8219-1 prepared for DOE under contract DE- EE0008219.
2) Glanville, P, et al. (2019). *Demonstration and Simulation of Gas Heat Pump-Driven Residential Combination Space and Water Heating System Performance*, ASHRAE Transactions; Atlanta Vol. 125.
3) GTI (2019) *Gas Heat Pump Technology and Market Roadmap.*


## CONTACT


Jason LaFleur, Project Manager
jlafleur@gti.energy

Paul Glanville, Technical Lead
pglanville@gti.energy


## SPONSORS

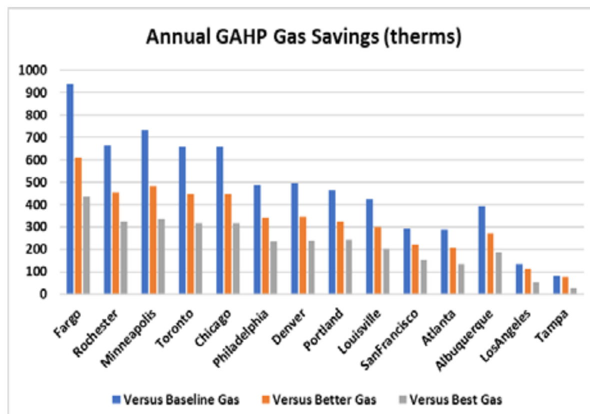

Intermountain Gas
Southern Companies
Southern California Gas
Enbridge Gas
Spire Energy
NEEA


# Results

At these seven residential demonstration sites, GHPs have shown a) high-efficiency operation in cold climates, b) delivered comfort for both space/water heating loads, c) reduction in complexity of installations, and d) improved reliability with >16,000 operating hours. In this recent phase, the Next- Gen units in Toronto and Chicago, IL ran for 8,000+ hours, generating nearly 60,000 gallons of hot water and 300+ MMBtus of space heating. Using billing data and a modeled baseline, these GHPs provided up to 33% therm savings as a combi system, where earlier generation GHPs in Wisconsin had greater savings up to 46%, due to greater runtime (colder winters, larger homes) and other factors. An area for improvement, GHPs consumed 300-1000 kWh/year on average, in addition to the incremental power for the AHU and circulation pumps.

GTI laboratory testing of the GHP to ANSI Z2.40.4 standard resulting in seasonal Annual Fuel Utilization Efficiency (AFUE) of 141% for Region IV (average US climate) and 138% for cold climates.

With a custom simulation of the GHP units and using datasets generated in these demos[1], GTI estimated the energy savings compared to gas-fired and electric alternatives. In all cases modeled, the GHPs provide the lowest operating costs and lowest GHG emissions.




# Challenges and Next Steps

Barriers to GHP adoption include lack of knowledge among contractors; simplifying equipment installation and proper training will be critical for technology implementation. Perceived historical complexity and high costs associated with absorption technology and natural refrigerants will need addressed. Challenges and further development needs include:

- Size and logistics of GHP system transport/installation
- Timing retrofits, replacing both space and water heat systems
- Sourcing specialized hydronic materials and ammonia supply chains
- Continued system and control enhancement for reliability and efficiency
- Simplified system components for quicker plug-n-play installations
- Technology development to integrate latent and sensible cooling

First costs may be reduced by increasing contractor training and experience with combi technology in general, and GHP technology in specific and increasing consumer awareness and demand.