ET Summit 2024

Presented by

Heat Pump Performance in California:

Fuel-Fired Water Heating Applications with Hydrogen Blends

Madeline Talebi
Energy Engineer
ICF

GTI ENERGY
solutions that transform

Project Collaborators

ICF

Steven Long, P.E.
Director of Engineering (West)

Alfredo Gutierrez, P.E.
Engineering Manager

Madeline Talebi
Energy Engineer

GTI Energy

Jason LaFleur
Senior Manager

Alejandro Baez Guada
Principal Engineer

Lee Van Dixhorn
Senior Engineer

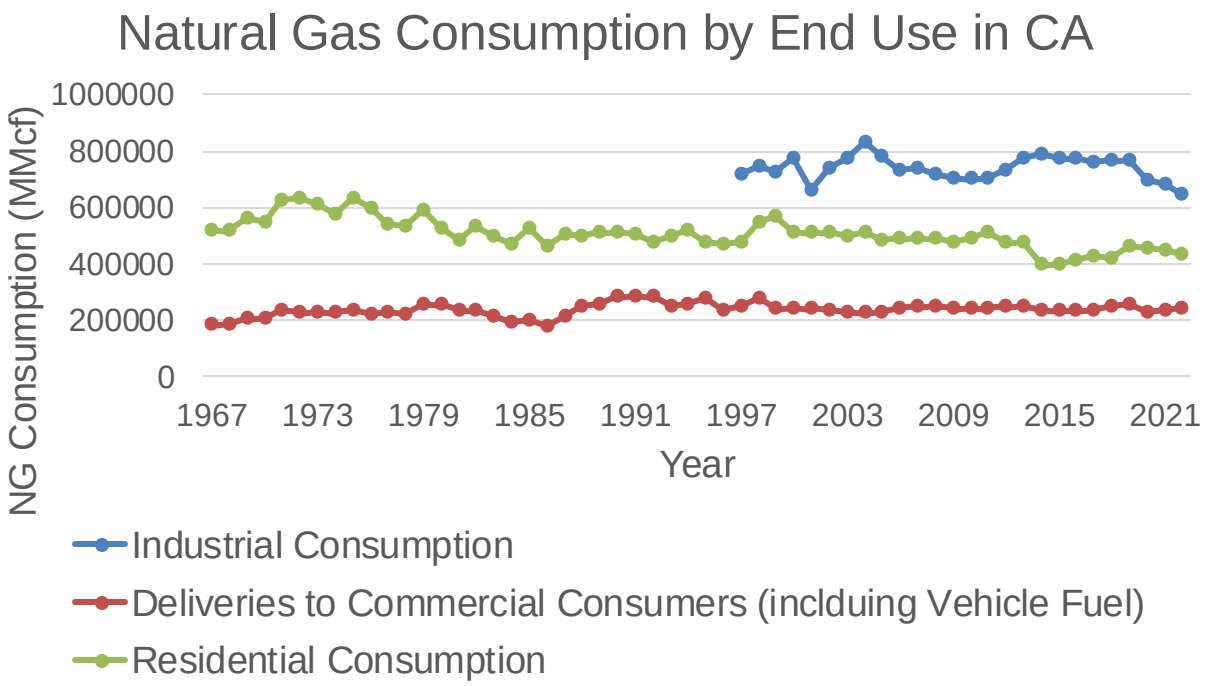
Ari Katz
Senior Engineer

Agenda

- Gas Absorption Heat Pumps (GAHP) in California
  - Hydrogen fuel blending
- Objectives
- Test Plan
- Hydrogen-Blend Test Set-Up
- Next Steps
- Key Takeaways and Future Studies

California on Emissions Control

- Water heating is the largest end-use of natural gas in California
- Natural Gas Consumption by End Use in the Industrial, Commercial, and Residential sector



California Bills & Legislation
SB 1477 (Building Decarbonization/Space Heating/Water Heating)
California Long Term EE Strategic Plan (CLTEESP)
AB 758 (Comprehensive EE in Existing Buildings Law)

- Focus sector: Multifamily (commercial) low-rise (5 stories or less)

US Energy Information Administration. "Natural Gas Consumption by End Use." https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm

Hydrogen Infrastructure

- Hydrogen blends of up to 5% (95% natural gas + 5% hydrogen) - generally safe
  - Blends between 5%-20% - increased likelihood of permeation
- Infrastructure is currently not sufficient for >5% hydrogen blend
  - At technology level, limited data available on GAHP hydrogen blend behavior

Country	Max Hydrogen Blend
USA (excluding Hawaii)	5%
USA (Hawaii only)	15%
Canada	5%
Europe	20%
Australia	5%

CPUC (2022). "CPUC Issues Independent Study on Injecting Hydrogen Into Natural Gas Systems." CPUC Issues Independent Study on Injecting Hydrogen Into Natural Gas Systems (ca.gov) & SoCal Gas (2024). "H2 Blending." H2 Blending | SoCalGas

Hydrogen Blending Projects in CA

- SoCal Gas led effort include the following demonstration projects:
  - University of California, Irvine: safely integrate blends into the campus infrastructure
  - Orange Cove: safely blend in the City of Orange, in Fresno County
- Hydrogen blending – key component to work towards achieving net-zero emissions by 2045

SoCal Gas (2024). "H2 Blending." H2 Blending | SoCalGas

Objectives

- Improve low uptake at the sector level
  - Primarily as it relates to the commercial sector
- Improve low uptake at the technology level
- Technology performance in a controlled environment
  - Steady state evaluation
  - Part Load (Transient) evaluation
- Emissions evaluation with hydrogen fuel blends
- Develop performance mapping curves
- Contribute to EnergyPlus modeling data

Equipment Installation and Commissioning

- Robur GAHP-A system

Variable	Tolerance
Flow Rate [GPM]	±2.0%
Outside Air Temperature (OAT) [°F]	±1.0°F
Return Temperature (RT) [°F]	±1.0°F
Supply Temperature [°F]	±1.0°F
Firing Rate (Energy Input) [kBtu/h]	±2.0%
Heating Output [kBtu/h]	±2.0%

Robur. "Installation, use and maintenance manual" (2020).

Target Conditions – Steady State

- Robur GAHP-A system

Variable	Testing Range	Number of Points within Testing Range
Flow Rate [GPM]	13.6 GPM	1
Outside Air Temperature (OAT) [°F]	17°F-90°F	5
Return Temperature (RT) [°F]	110°F	1
Propylene Glycol [vol%]	35 vol%	1
Hydrogen Blend [%]	0-30%	4

Robur. "Installation, use and maintenance manual" (2020).

Target Conditions – Part Load

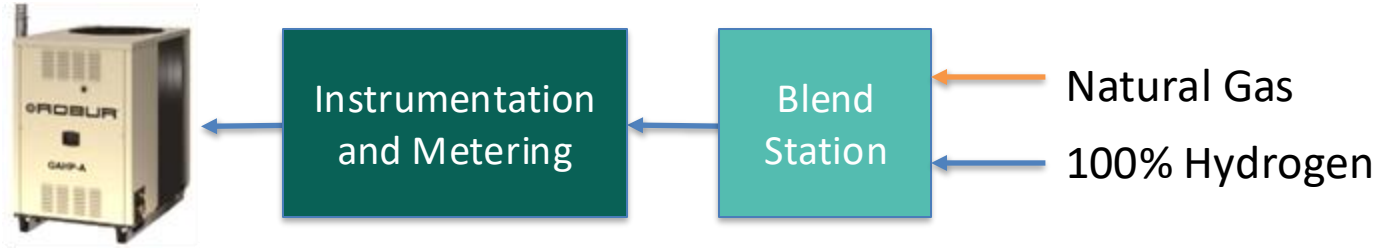
- Robur GAHP-A system

Variable	Testing Range	Number of Points within Testing Range
Flow Rate [GPM]	13.6 GPM	1
Outside Air Temperature (OAT) [°F]	47°F	1
Return Temperature (RT) [°F]	110°F	1
Propylene Glycol [vol%]	35 vol%	1
Hydrogen Blend [%]	10-30%	3
ON Runtime [hr.]	**0.1-0.7 hr.**	**5**
OFF Time [hr.]	**0.5 hr.**	**1**

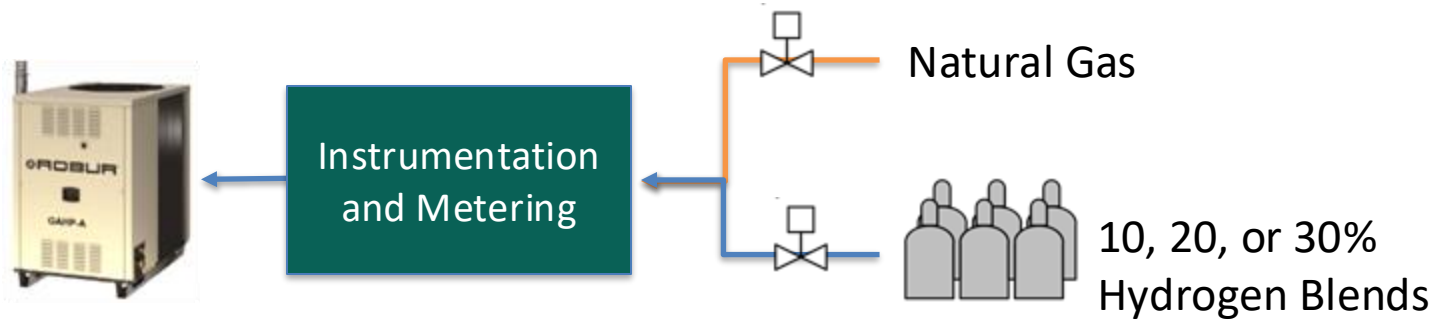
Robur. "Installation, use and maintenance manual" (2020).

Hydrogen-Blend Test Set Up

- Original Plan: Utilize blend station using 100% Hydrogen to the needed blends.



- *Revised plan: Utilize cylinders with 10%, 20%, and 30% Hydrogen blends.
  - *This addresses regulations and safety concerns of potential 100% hydrogen in an enclosed test chamber.



- Steady state testing at ambient temperatures of 17-90°F
- Part-load testing for ON times of 0.1 to 0.7 hours with 0.5 hours Off.
- Emissions comparison test points of O_2, CO_2, CO, and NOx

EnergyPlus Modeling Integration

- Objective: forecast…

(1) Energy Consumption

(2) Utility Bills

(3) Greenhouse Gas Emissions

- Targeted audience:

(1) California Policymakers

(2) Program Designers

(3) Software Developers

(4) Manufacturers

Recommendations

Key Takeaways

- Further assessment of hydrogen readiness at a technology level
- Blended hydrogen tanks (10, 20, 30%) used instead of blending natural gas and 100% hydrogen on site for safety considerations

Future Studies

- Steady state and load-based testing
- Emissions comparison at various hydrogen blends
- EnergyPlus performance mapping development
- Additional "market-ready" GAHP experimental testing for EnergyPlus modeling integration

This project was conducted through the ICF implemented, SoCalGas administered California Statewide Gas Emerging Technologies Program.

The project report can be found on cagastech.com

For more information, contact get@caenergyprograms.com

Madeline Talebi
Energy Engineer
ICF
madeline.talebi@icf.com
LinkedIn

ICF

GTI ENERGY
solutions that transform

SoCalGas