

Gas Emerging Technologies (GET) Program

Adsorption Gas Heat Pump Lab Tests

2026



Project Collaborators

ICF



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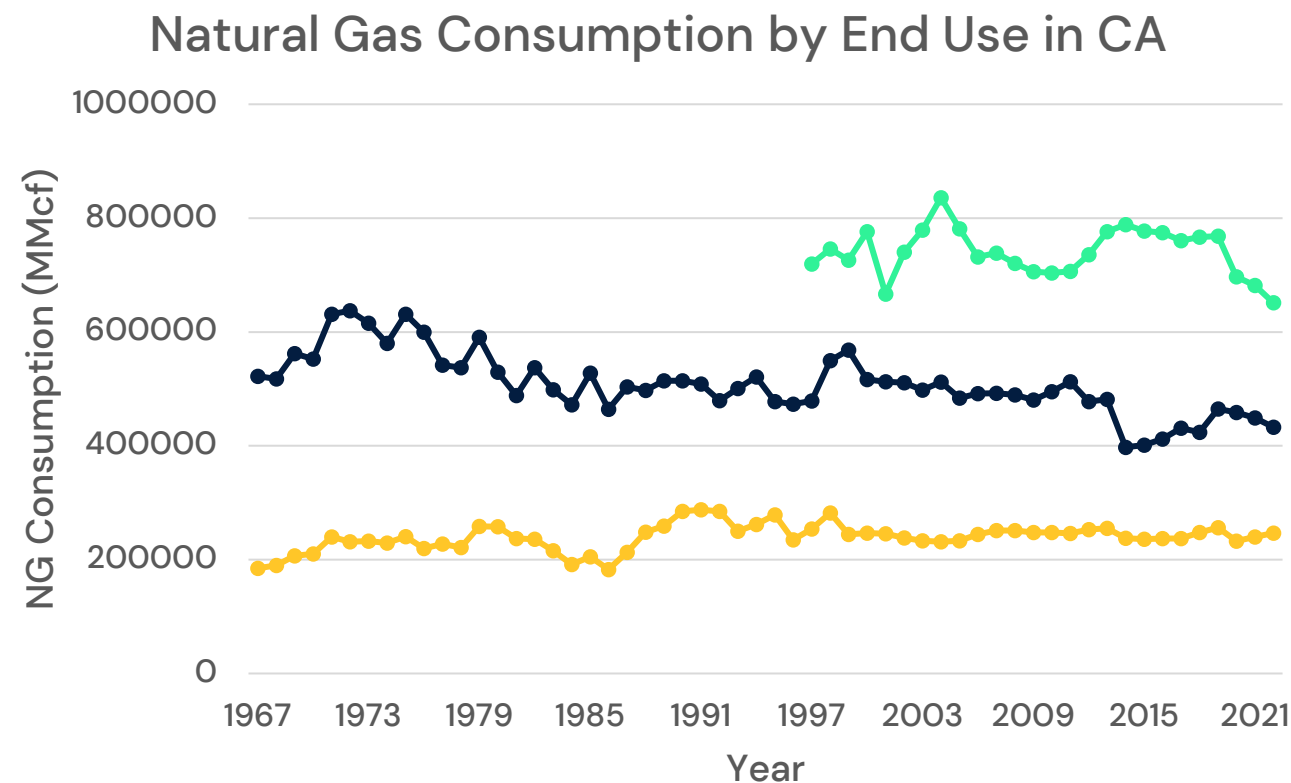


Agenda

- Water Heating in California
- Objectives
- Test Plan
- Unit Validation
- Laboratory Testing
- Technoeconomic Analysis
- Recommendations

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



— Industrial Consumption

— Deliveries to Commercial Consumers (including Vehicle Fuel)

— Residential Consumption

California Legislation

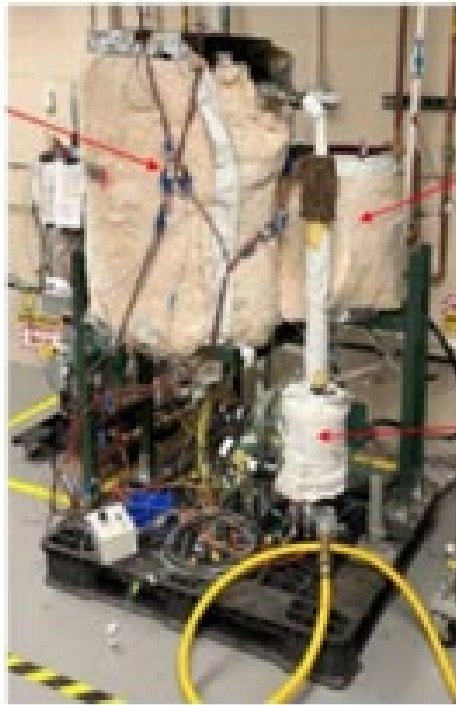
Title 24 Building Energy Efficiency Standards – requires the use of high-performance appliances in both new construction and retrofitted homes

TECH Clean CA – provides incentives and rebates that promote the adoption of high-efficiency water heating technologies

- Focus sector: Residential

Gas-Fired Adsorption Gas Heat Pump (AHPWH)

- Focus shifting to development of highly efficient Thermal Heat Pumps (THPs) for residential water heating
 - Manufacturer A: Gas-fired Adsorption Gas Heat Pump (AHPWH)
 - First, Second, Third Alpha and First Beta prototypes



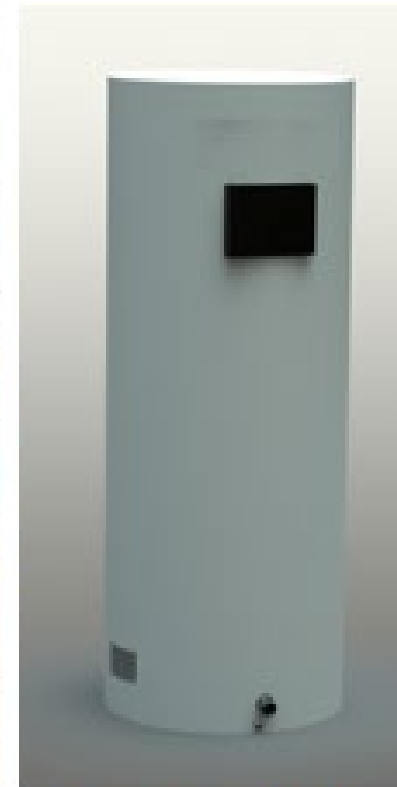
First Alpha



Second Alpha



First Beta

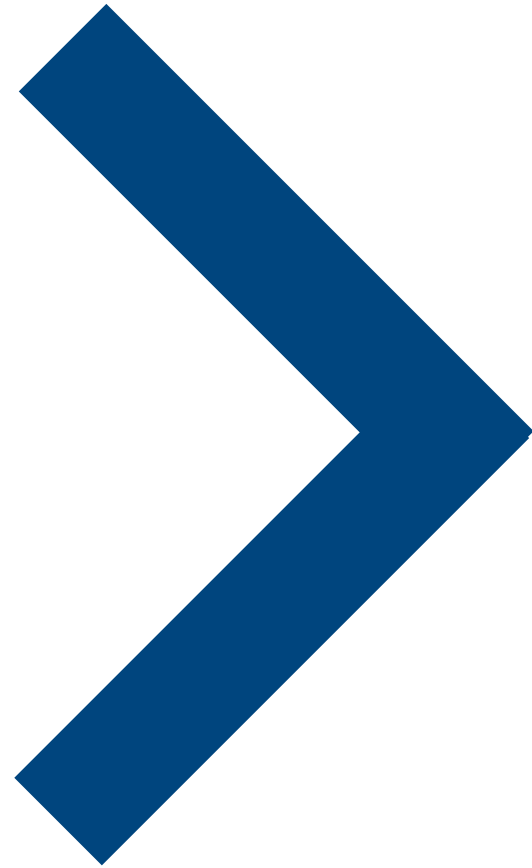


Expected final
product

Objectives

- Improve low uptake at the **sector** level
 - Primarily as it relates to the **residential** sector
- Continue technology development toward TRL 9
- Technology **performance** and **validation** in a controlled environment
- **Technoeconomic** analysis as it relates to the CA market
- Recommendations for prototype **improvement**





System Description

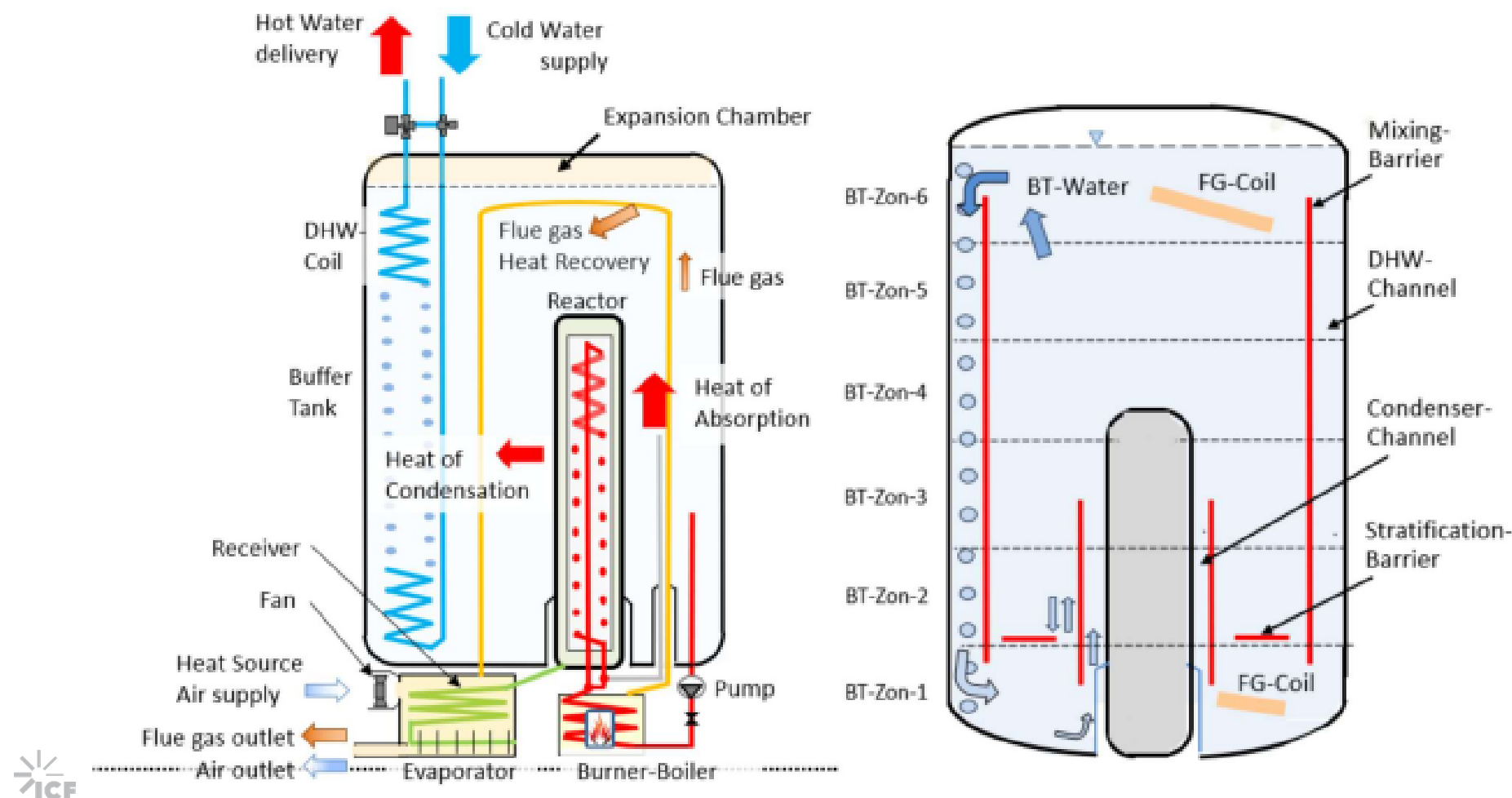
Schematic and Design Parameters

Main Processes/Mechaism

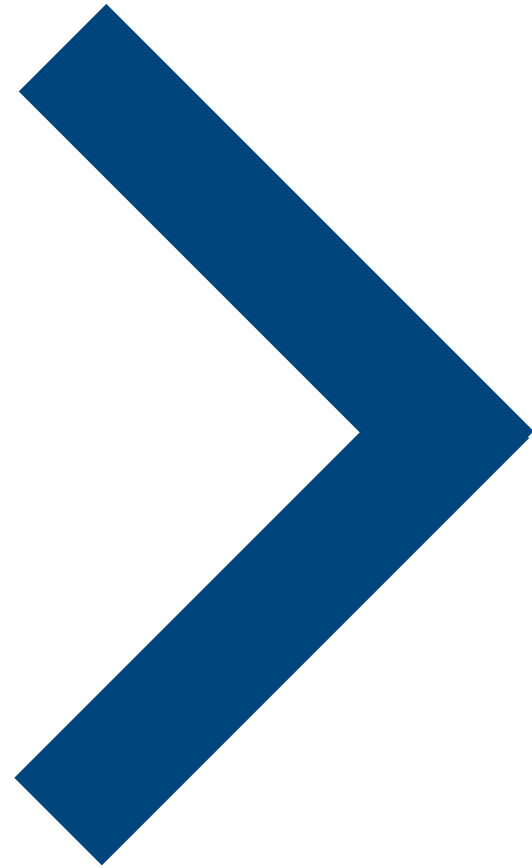
Reactor Heating – Desorption Phase

Pump Loop – Reactor Cooling

Heat Lift – Adsorption Phase



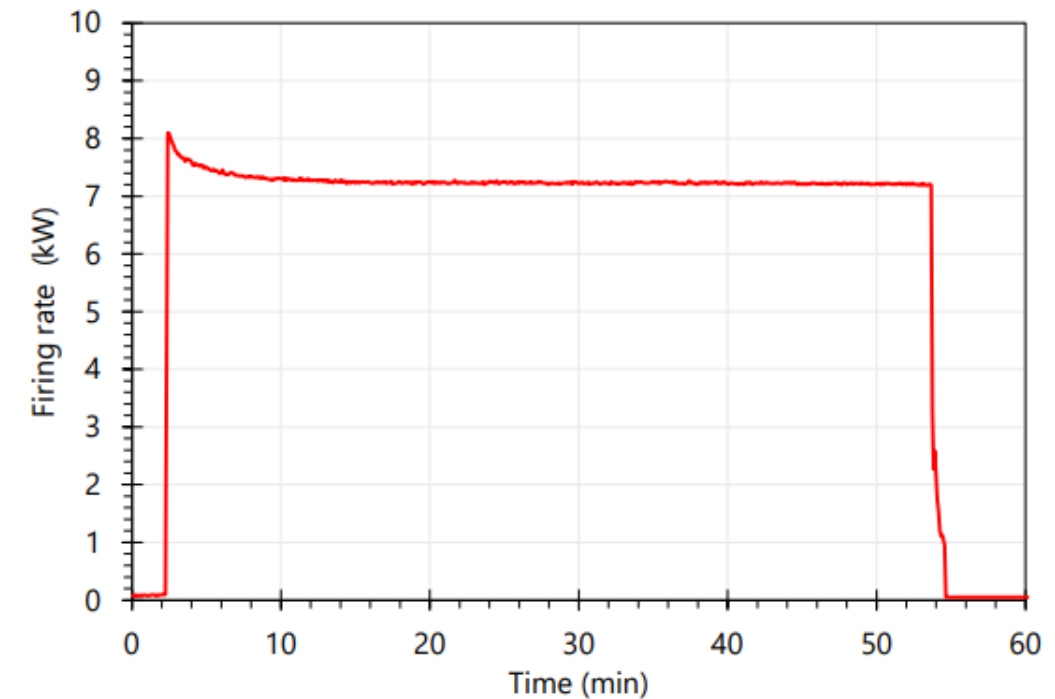
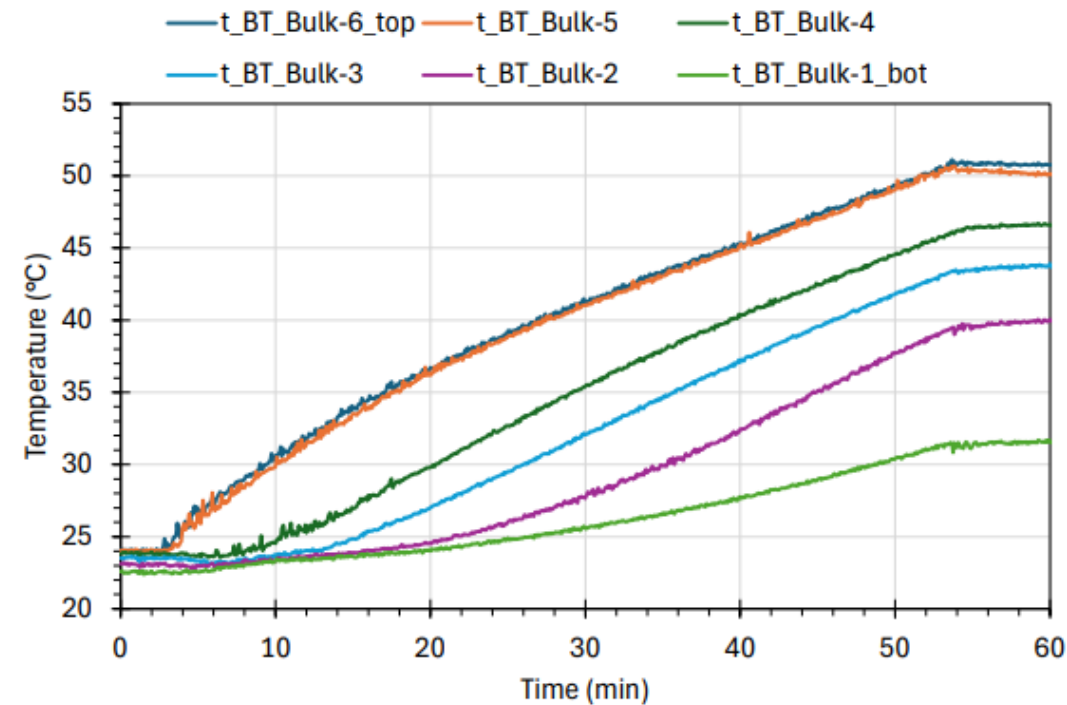
Parameter	Value
Tank Size	~ 40 gallon water (150 liter)
Footprint	28x28 in
Height	59 in
Burner Output Range	5 – 34 kBtu/hr (1.5 – 10 kw)
Ammonia Charge	1.5 kg



Installation & Commissioning

Direct Firing Test

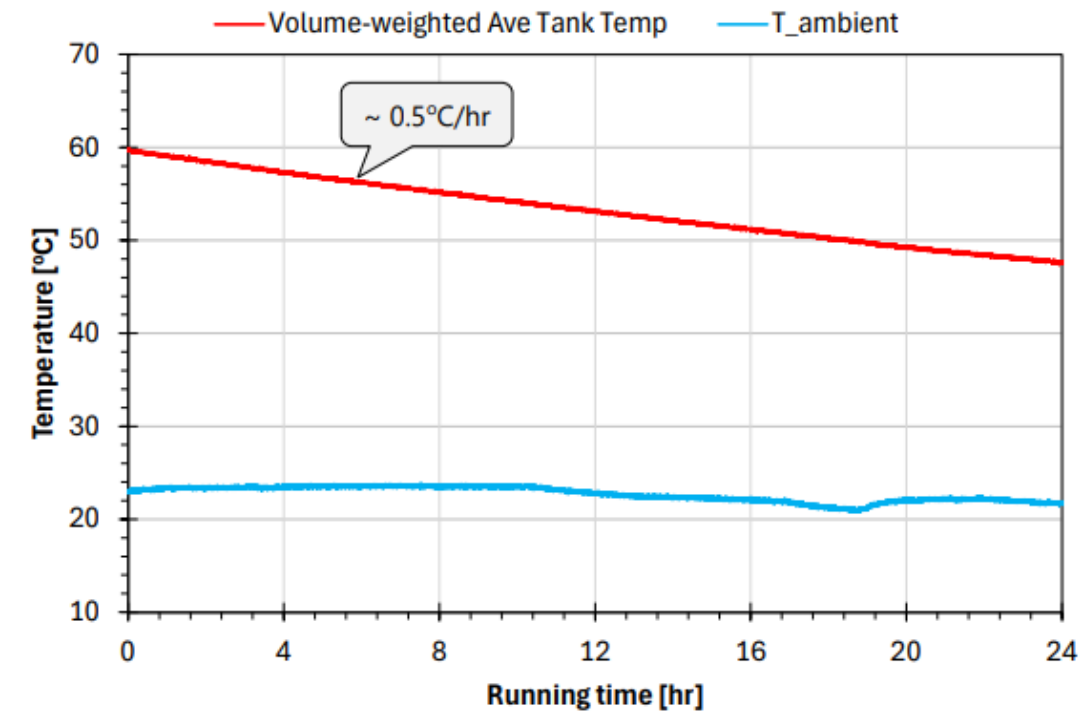
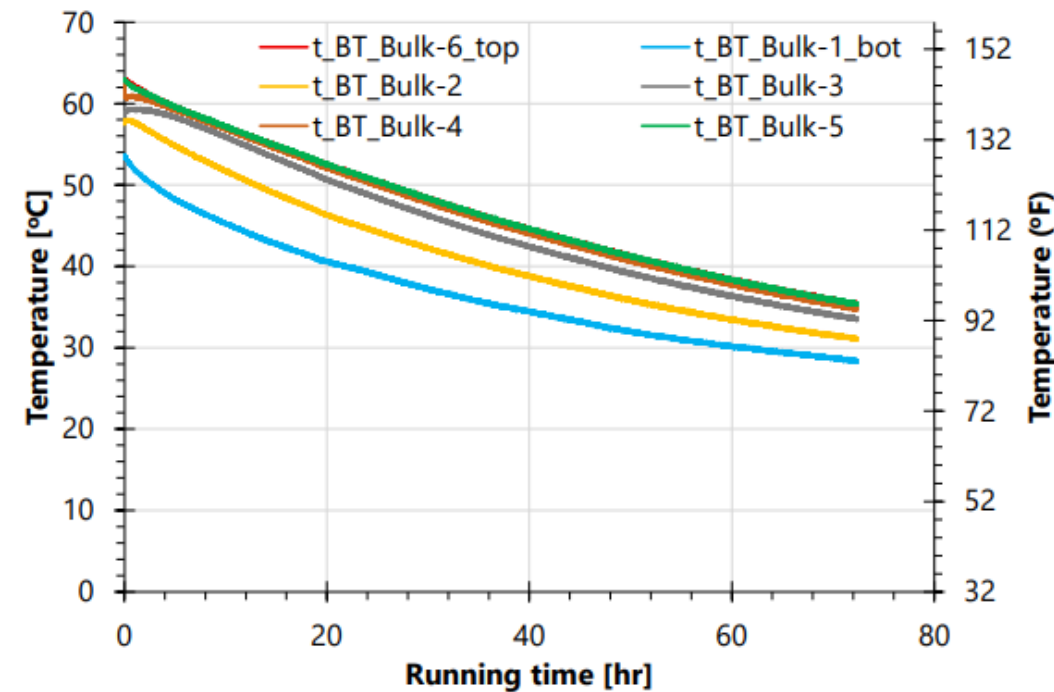
- Unit equipped with sensors and instrumentation to measure energy efficiency and emissions



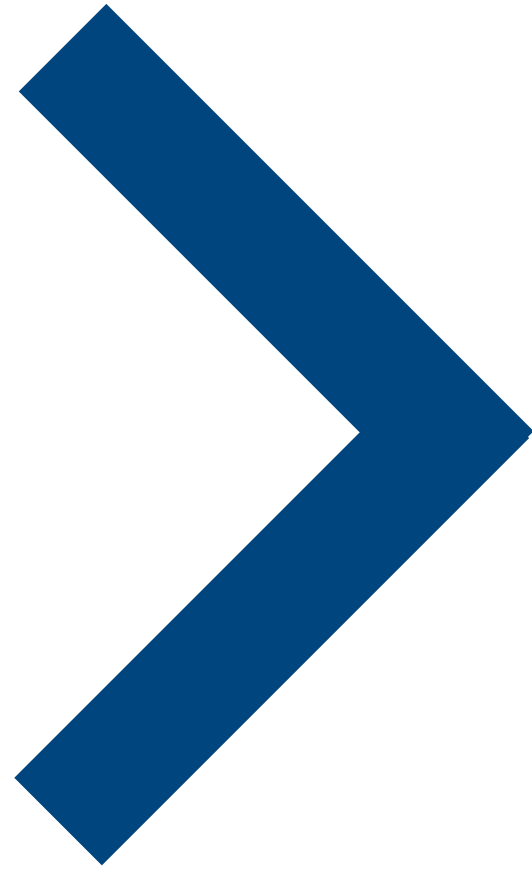
- [Left] Figure: tank temperature stratification successfully established
- [Right] Figure: firing rate of ~25 kBtu/hr (7.3 kW)

Buffer Tank Standby Test

- Unit equipped with sensors and instrumentation to measure energy efficiency and emissions



- [Left] Figure: burner deactivation → water temperature decrease of 21.6°F (12°C) over 24-hrs
- [Right] Figure: cooling rate + energy = heat transfer coefficient of 5.79 Btu/hr·°F (11 kJ/hr·°C)

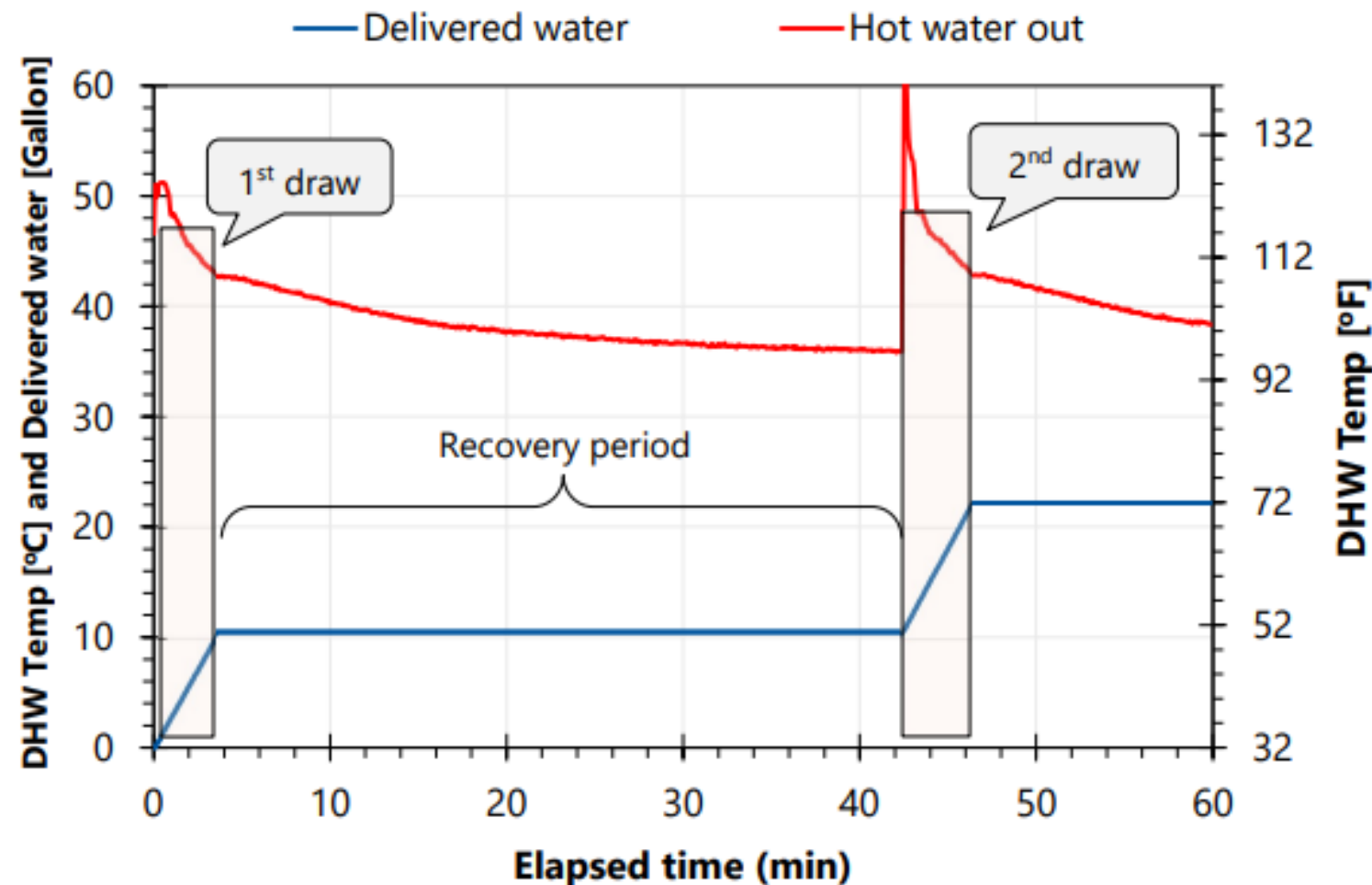


Equipment Evaluation

First Hour Rating (FHR) Testing

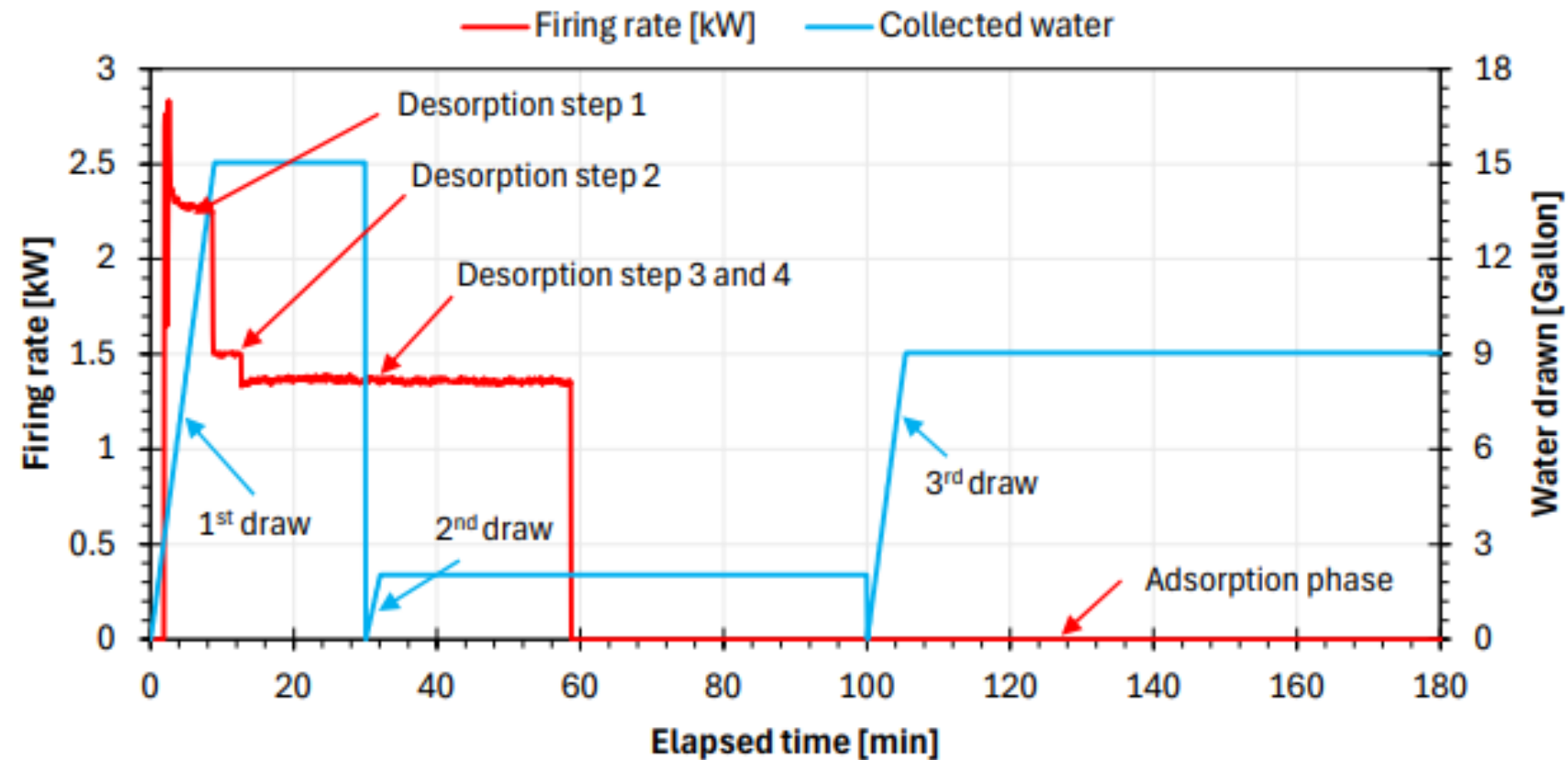
- Test used to determine draw pattern (i.e., small, medium, or large)

Draw	Total Volume	Firing Rate	Draw Pattern
Experimental Draw (1 st + 2 nd)	22.2 gal (84 L)	9.5 kBtu/hr (2.8 kW)	Small
Manufacturer Draw	51 gal (193 L)	25 kBtu/hr (7.3 kW)	Medium



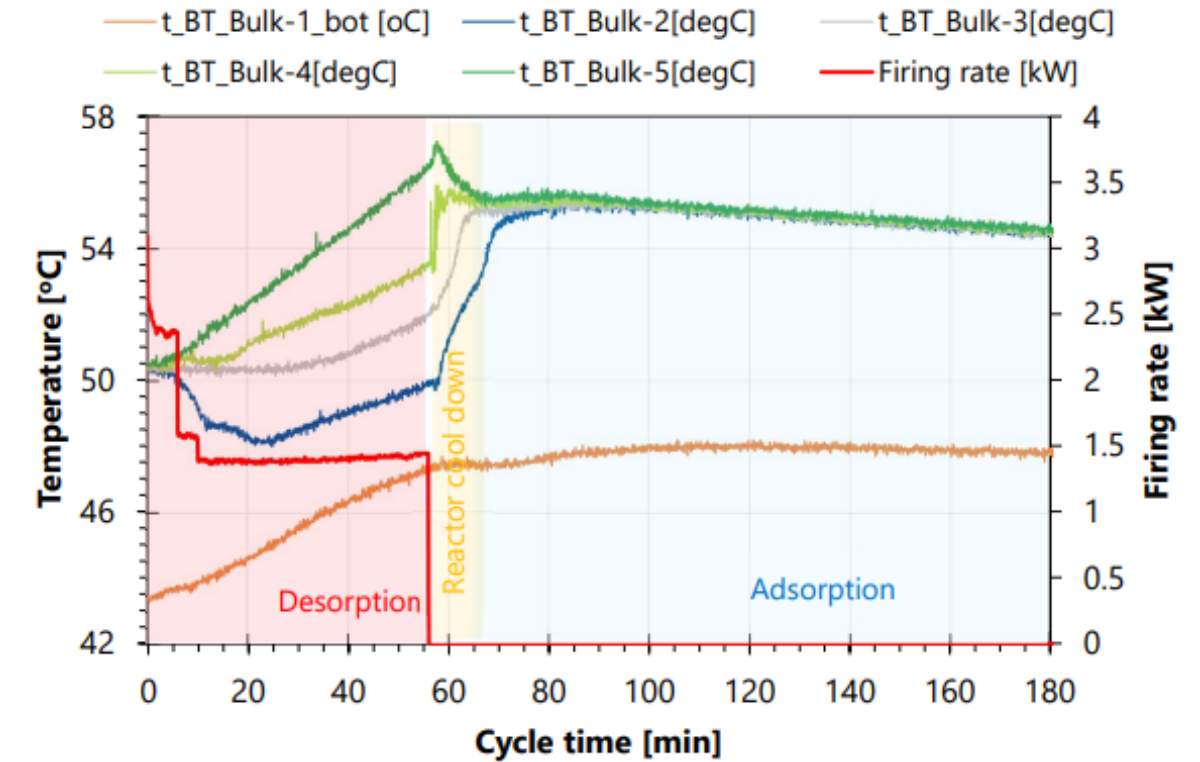
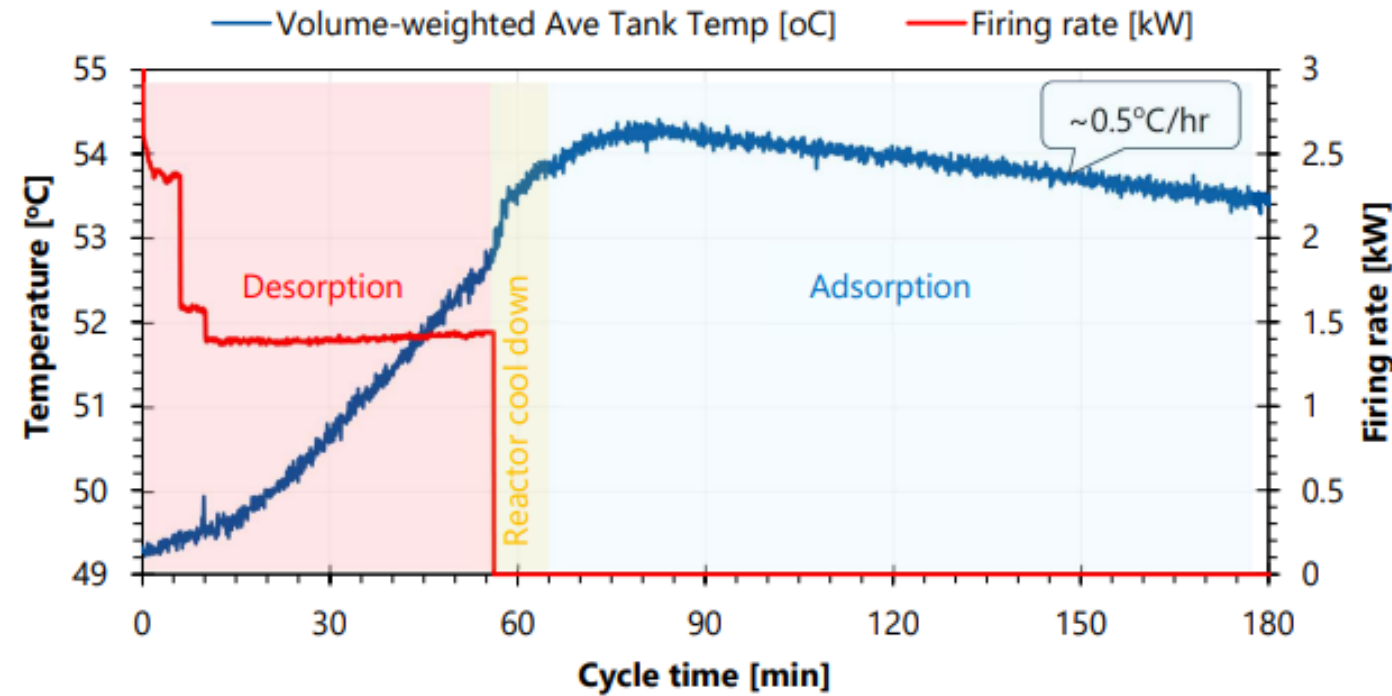
- ← Experimental Draw (1st + 2nd)
- FHR test conducted under direct firing mode to inform optimization strategies
 - UEF testing is conducted in heat pump mode

24-Hour Simulated UEF Testing



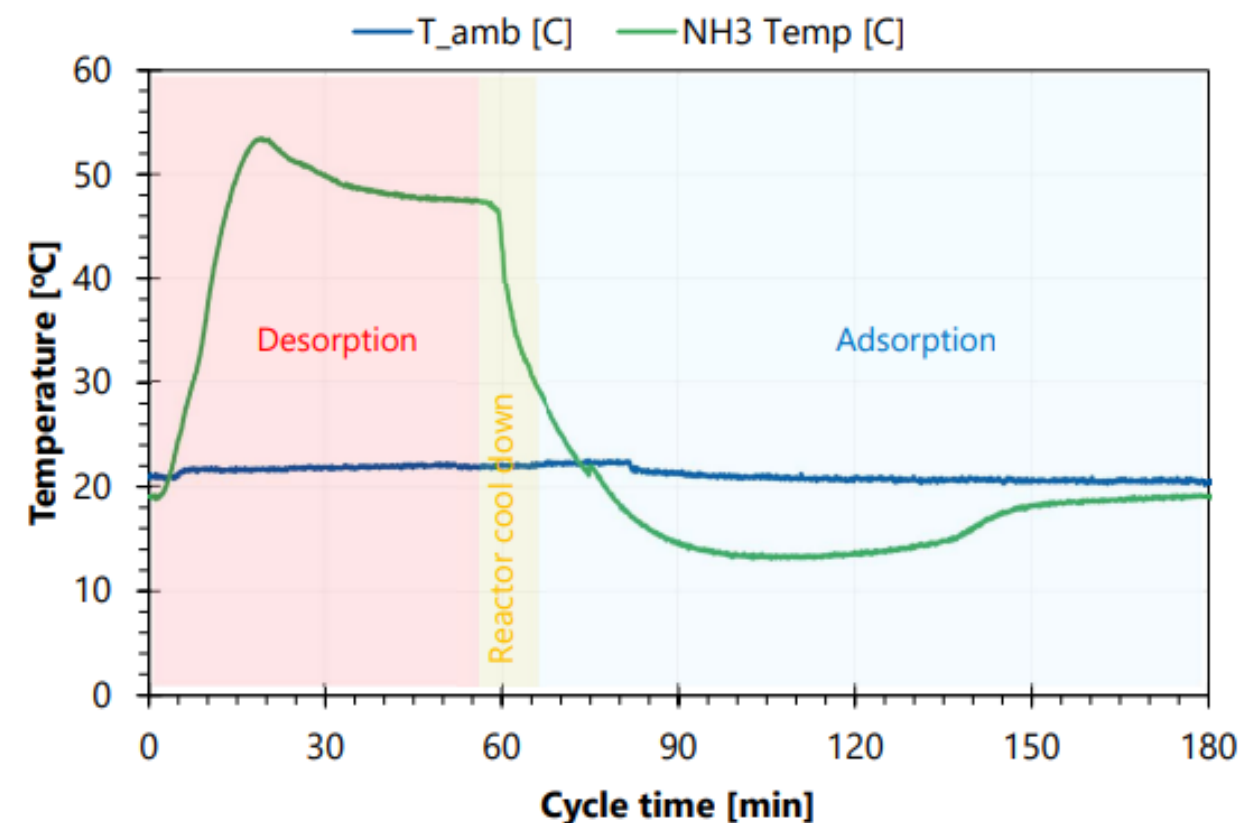
- Zone 4 thermocouple reduces to 140°F (60°C) → heat pump cycle begins
- First 3 hours of the UEF test (3 hot water draws)
 - Desorption phase (56 min) → reactor cool down (10 min) → adsorption phase (1 hr 54 min)

24-Hour Simulated UEF Testing



- [Left] figure – reactor cooling and adsorption begin at approximately same time
 - Once peak temperature reached, temperature steadily decreases at $\sim 0.5^{\circ}\text{C/hr}$
- [Right] figure – low temperature lift across 6 thermocouples
 - Low water temperature at bottom zone (t_BT_Bulk-1_bot[degC]) facilitates the adsorption process

24-Hour Simulated UEF Testing



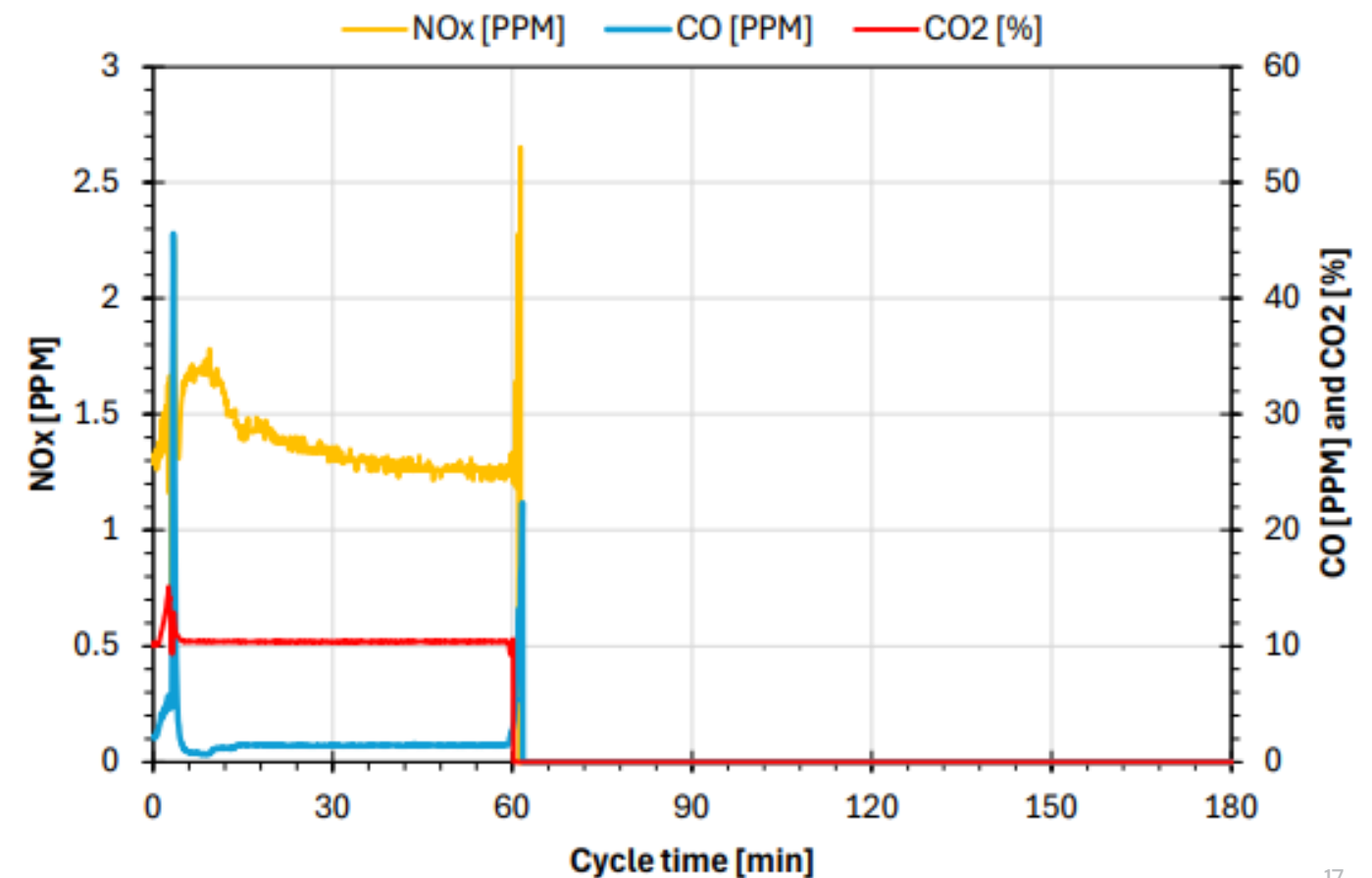
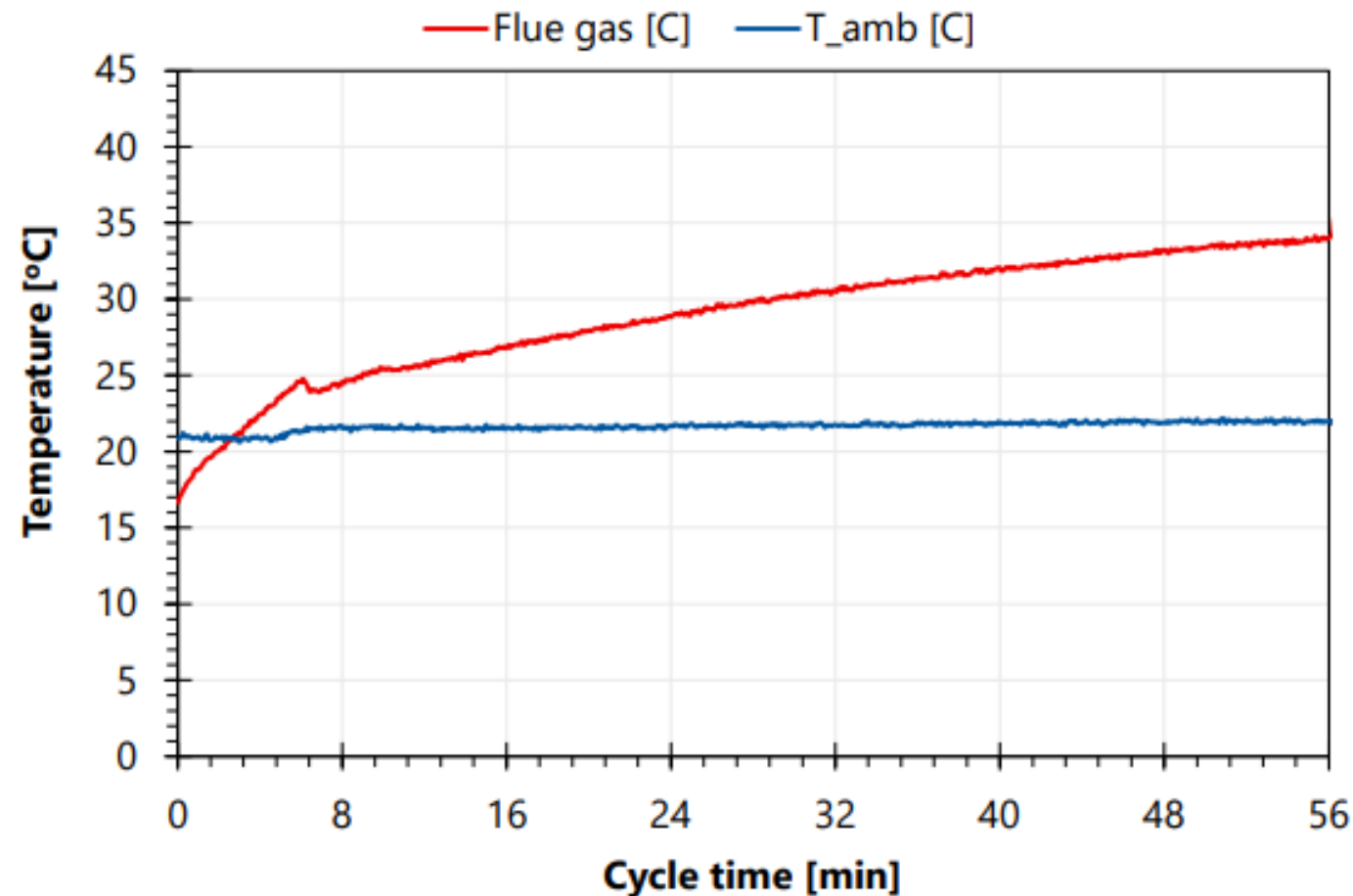
Parameter	Value
Initial Average Tank Temperature	136.8°F (58.2°C)
Final Average Tank Temperature	127.4°F (53.0°C)
Average Ambient Temperature	70.1°F (21.2°C)
Average Discharge Water Temperature	121.3°F (49.6°C)
Average Inlet Temperature	59°F (15°C)

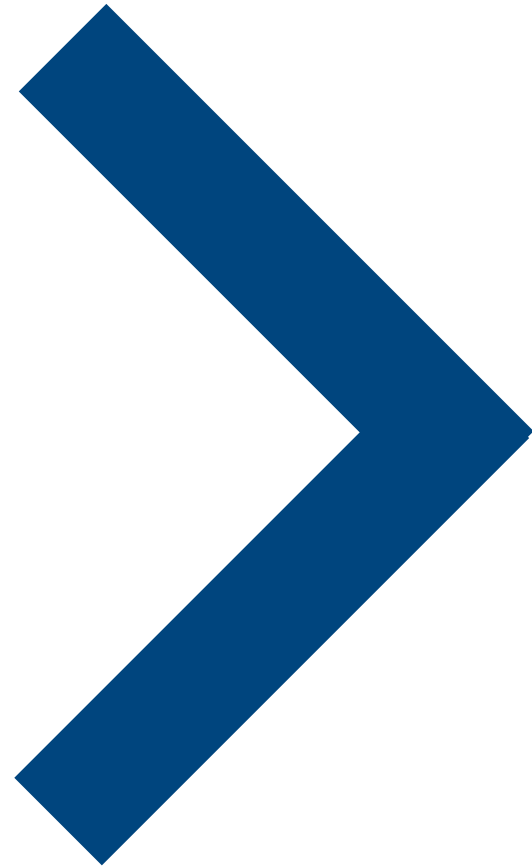
Parameter	Value
Total Gallon Delivered	55.36 gallons
UA	7.14 Btu/hr.-°F (13.5 kJ/hr.-°C)
Recovery Efficiency	68.9%
UEF	0.68

- Ammonia temperature decreased during the adsorption phase
 - Salt adsorbed ammonia vapor from the evaporator but slowed due to the high temperature at the bottom of the tank
 - High tank temperature ultimately inhibited ammonia from being adsorbed to the reactor

Emission Test

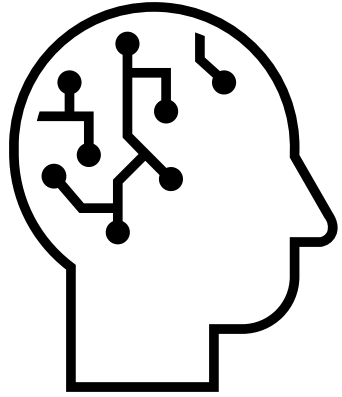
- Behavior during one heat pump cycle
- Flue gases @ 95°F (35°C)
 - Signifies flue gas condensation
 - Below the dew point (typically 130-135°F (54-57°C))
- Behavior during one heat pump cycle
- Emissions remain low
 - CO/NOx spikes: Burner ignition causes high temperatures
- Profile suggest high combustion [efficiency](#)





Technoeconomic Analysis

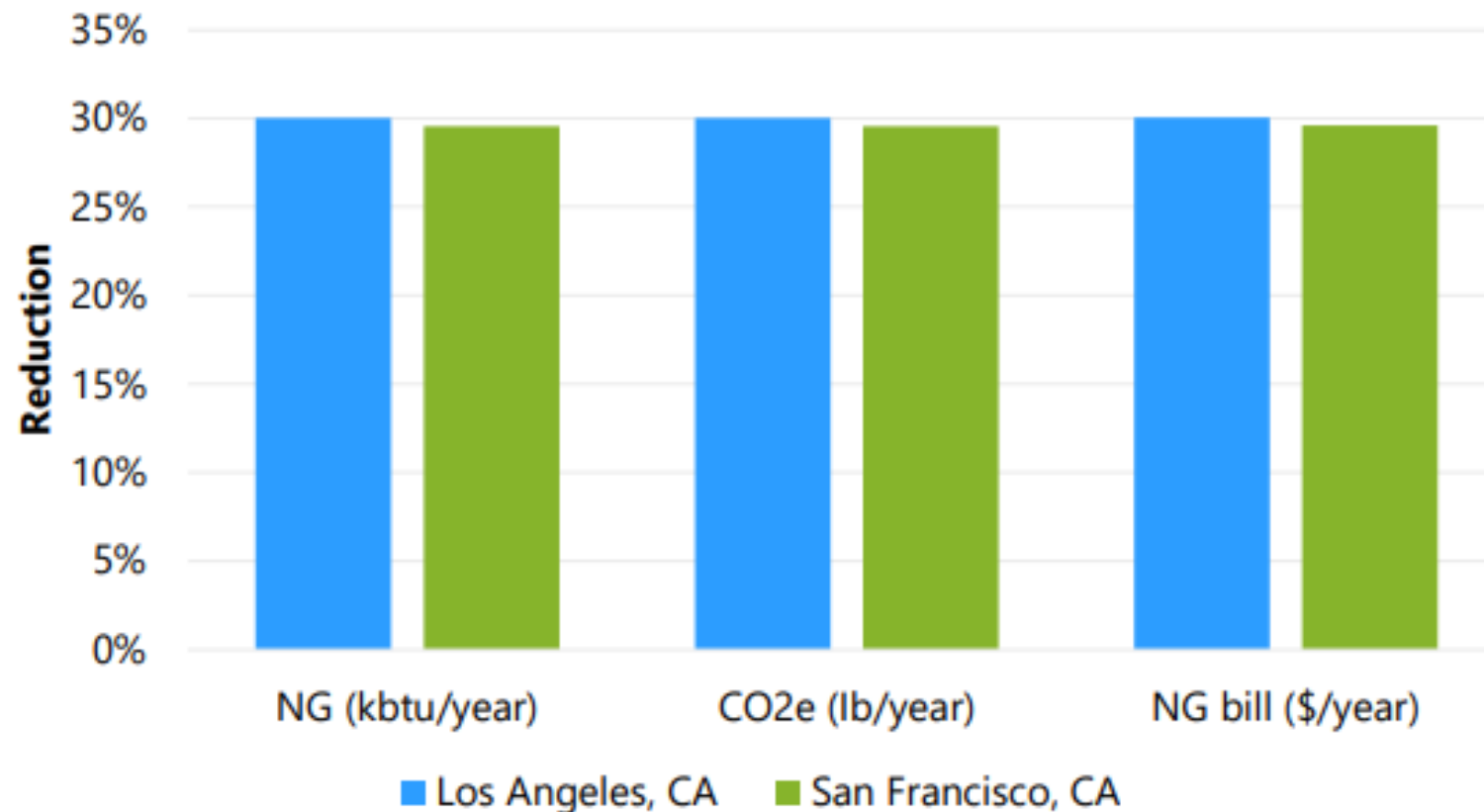
Technoeconomic Analysis



- **Objective:** forecast...
 1. Energy Consumption
 2. Utility Bills
 3. Greenhouse Gas Emissions
- Analysis utilized **BEopt** (Building Energy Optimization Tool) software, developed by the National Renewable Energy Laboratory (NREL)
 - Simulates residential building energy performance
 - Assumed → Single-family residential building w/ 4 occupants

Technoeconomic Analysis

- Reduction in energy, emissions, and utility bill
 - Experimental Emerging technology (2nd beta model) UEF = 0.68
 - Not ideal for analysis, therefore, Ideal UEF of 1.1 used in graph below
 - Incumbent technology UEF = 0.66 vs. Ideal Emerging technology (2nd beta model) UEF = 1.1



Key Takeaways & Recommendations for Future Studies

Key Takeaways

- 
1. Overall study aligns with federal initiatives and **California decarbonization** strategies.
 2. The **FHR test** (under direct fire) resulted in total draw of 22.2 gal (84 L) at 9.5 kBtu/hr (2.8 kW).
 3. The unit achieved a **UEF of 0.68** with a recovery efficiency of 69% showing promising results in the AHPWH technology space.

Future Studies

1. Improvements related to the burner **quality/material/insulation** and overall structural design.
2. Studies related to **temperature stratification** within the buffer tank to optimize adsorption processes and minimize energy losses.
3. **Technoeconomic** analysis to quantify savings where the AHPWH achieves a $UEF > 1.0$.

For More Information

Visit CAGasTech.com or contact the GET Program for support and questions.
E: GET@CAEnergyPrograms.com



ICF is a SoCalGas authorized contractor responsible for implementing this program through 12/31/2027.

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