# Gas Emerging Technologies (GET) Program

# Gas Absorption Heat Pump (GAHP) #2 Performance Mapping

2026


SoCalGas

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# Agenda

**Project Leads**


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Public Dissemination – ET24SWG0003

- GAHPs in California
- Lab Study Objectives
- Test Plan
- Steady State Performance Experimental Data
- Load-Based (Transient) Performance Experimental Data
- EnergyPlus Modeling
- Recommendations

# Project Collaborators

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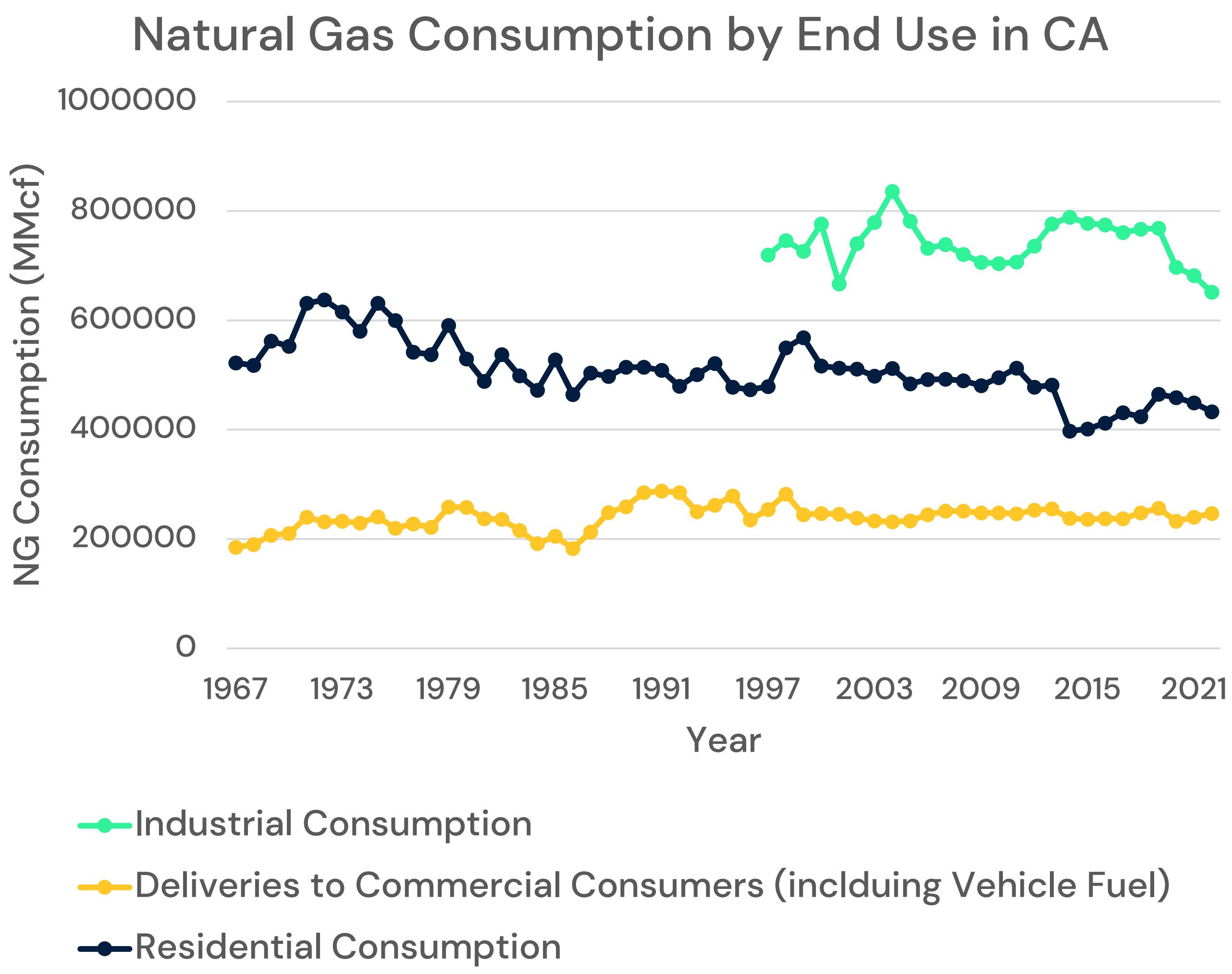
# Gas Absorption Heat Pumps

Background/application of Gas Absorption Heat Pump (GAHP) utilization and California legislation.

# California on Emissions Control

- Water heating is the largest nonindustrial 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)

# 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
  - Equipment commissioning
  - Steady state evaluation
  - Part Load (Transient) evaluation
- Develop performance mapping curves
- Contribute to EnergyPlus modeling data
- Compare the ANESI GAHP 80k to the Robur GAHP-A lab test (ET23SWG0015)

# Equipment Commissioning & Test Plan

# Equipment Installation and Commissioning

- ANESI GAHP 80K 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% |

# Target Conditions – Steady State

- ANESI GAHP 80K system


| Variable | Testing Range | Number of Points within Testing Range |
|---|---|---|
| Firing Rate [kBtu/h] | 14 kBtu/h (25% = Min), 28 kBtu/h (50%), 55 kBtu/h (94% = Max) | 3 |
| Outside Air Temperature (OAT) [°F] | 0°F-110°F | 9 |
| Return Temperature (RT) [°F] | 95°F-140°F | 5 |
| Propylene Glycol [vol%] | 35 vol% | 1 |

# Target Conditions – Part Load (Transient) – Standby Losses

- ANESI GAHP 80K system


| Variable | Testing Range | Number of Points within Testing Range |
|---|---|---|
| Outside Air Temperature (OAT) [°F] | 17°F-90°F | 3 |
| Tank Setpoint [°F] | 120°F & 140°F | 2 |
| Propylene Glycol [vol%] | 35 vol% | 1 |

Standby Losses:

- Measures tank losses under a no-draw condition.

# Target Conditions – Part Load (Transient) – Low Draw Testing

- ANESI GAHP 80K system


| Variable | Testing Range | Number of Points within Testing Range |
|---|---|---|
| Outside Air Temperature (OAT) [°F] | 17°F-90°F | 3 |
| Draw Rate [gph] | 12 gph & 24 gph | 2 |
| Aquastat Setpoint [°F] | 120°F & 140°F | 2 |
| City Water Temperature [°F] | 60°F & 80°F | 2 |
| Propylene Glycol [vol%] | 35 vol% | 1 |

Low Draw Testing:

- Unit cycles to its lowest firing rate and then cycles off.

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# Target Conditions – Part Load (Transient) – Draw Pattern Testing

- ANESI GAHP 80K system

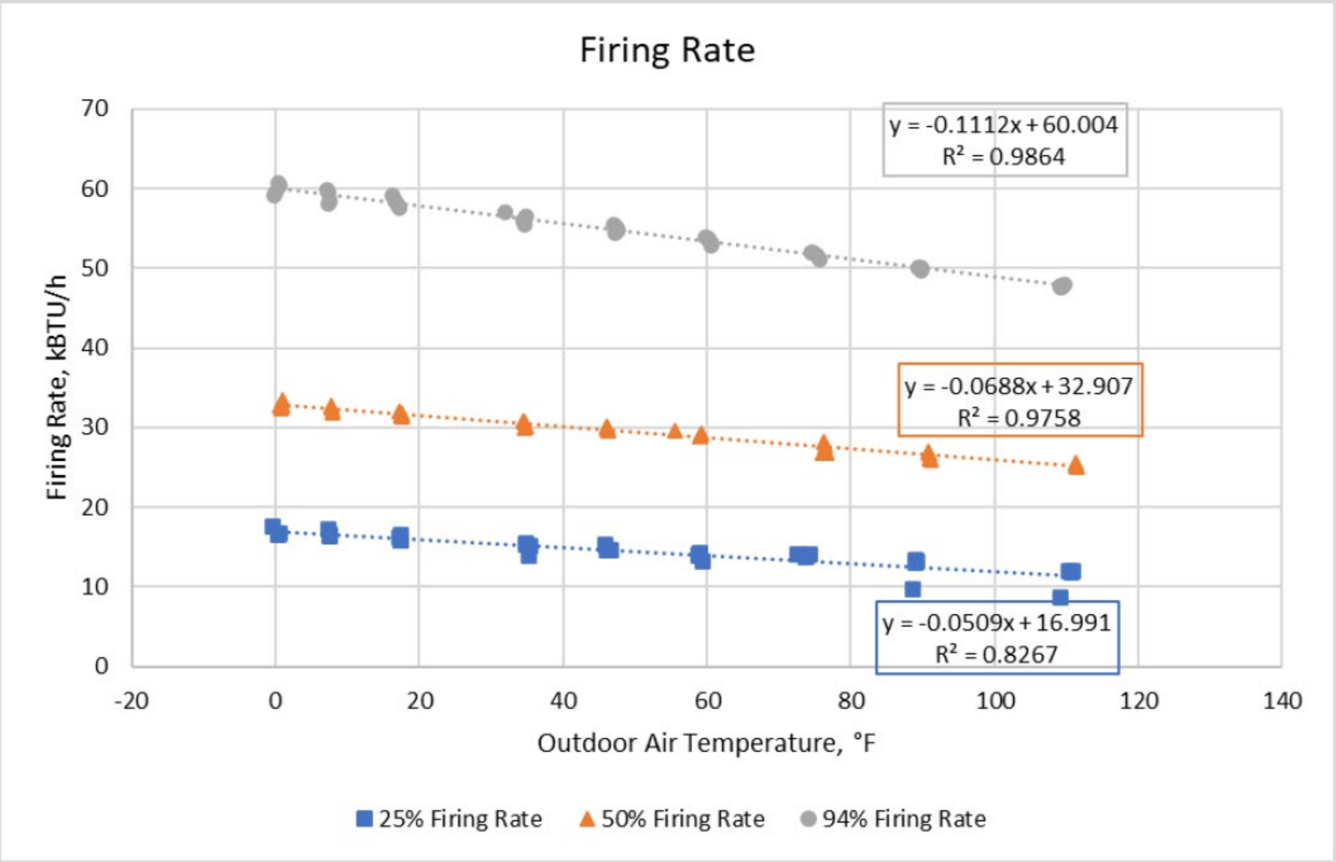

| Variable | Testing Range | Number of Points within Testing Range |
|---|---|---|
| Outside Air Temperature (OAT) [°F] | 47°F | 1 |
| Daily Draw [gal] | 1,000 gal – 5,000 gal | 3 |
| Aquastat Setpoint [°F] | 120°F & 140°F | 2 |
| City Water Temperature [°F] | 60°F | 1 |
| Propylene Glycol [vol%] | 35 vol% | 1 |

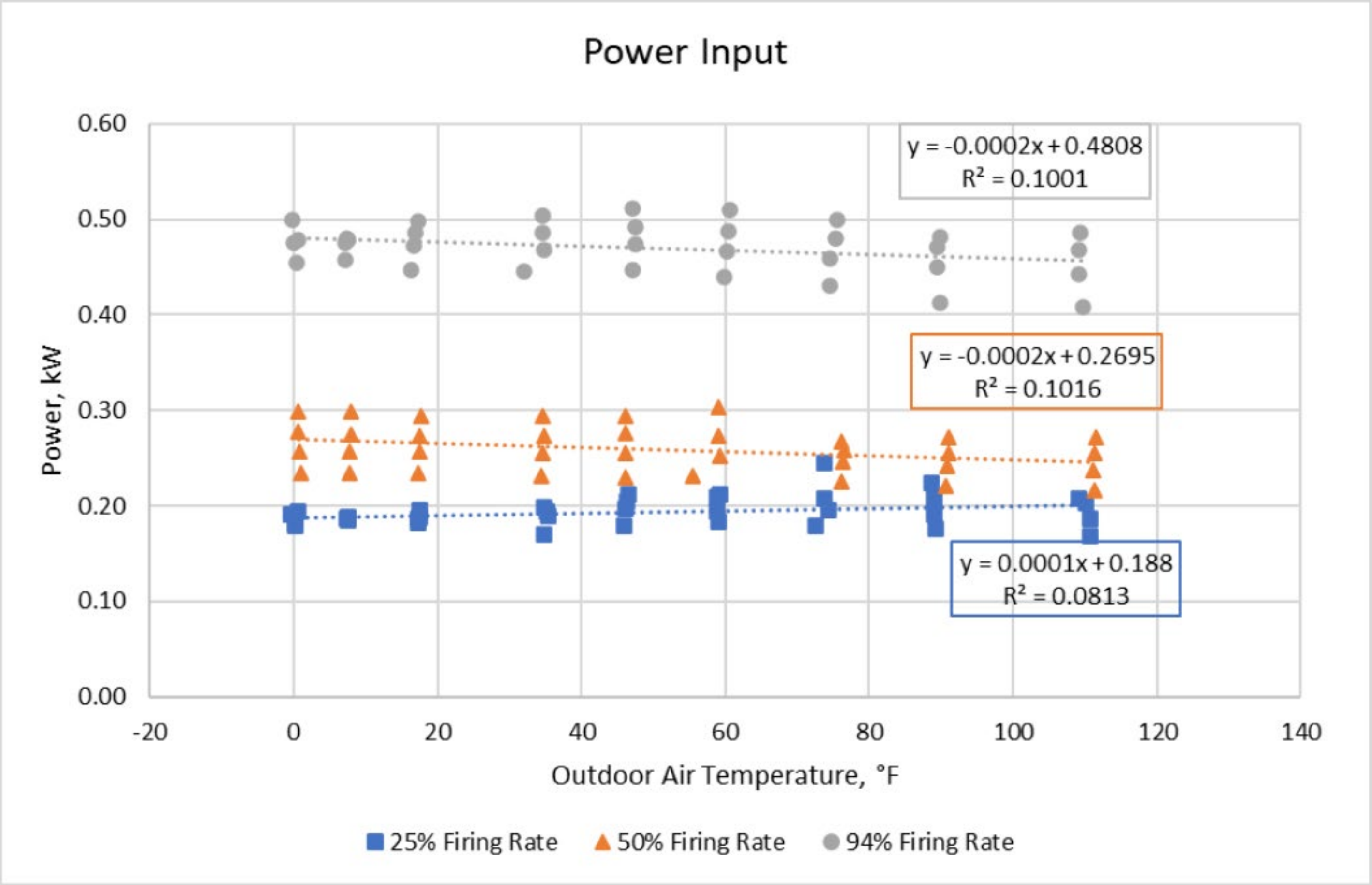
Draw Pattern Testing:

- Based off a load profile from test modeling of Multifamily buildings

# Experimental Results – Steady State

# Steady State Performance Mapping

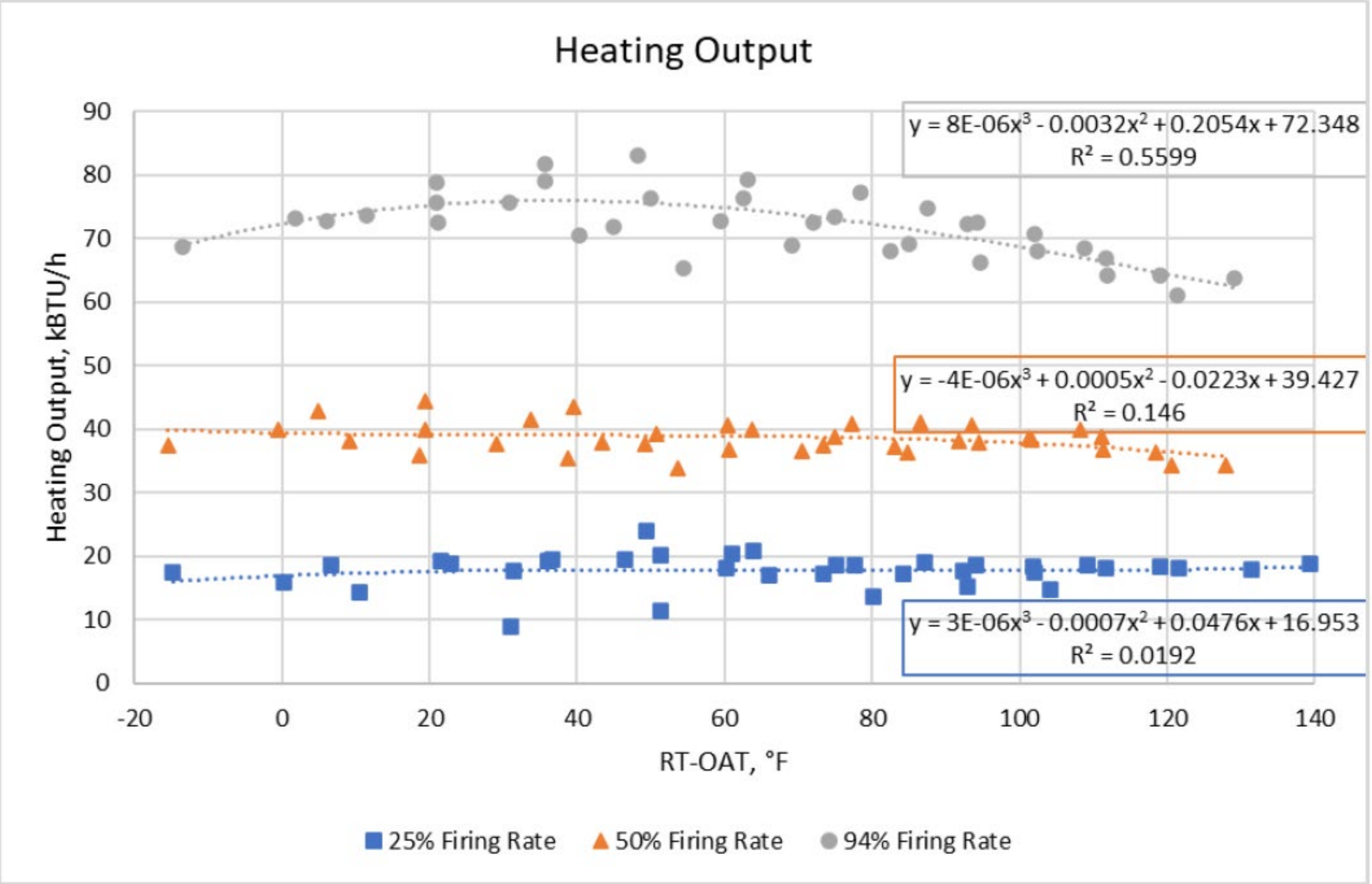


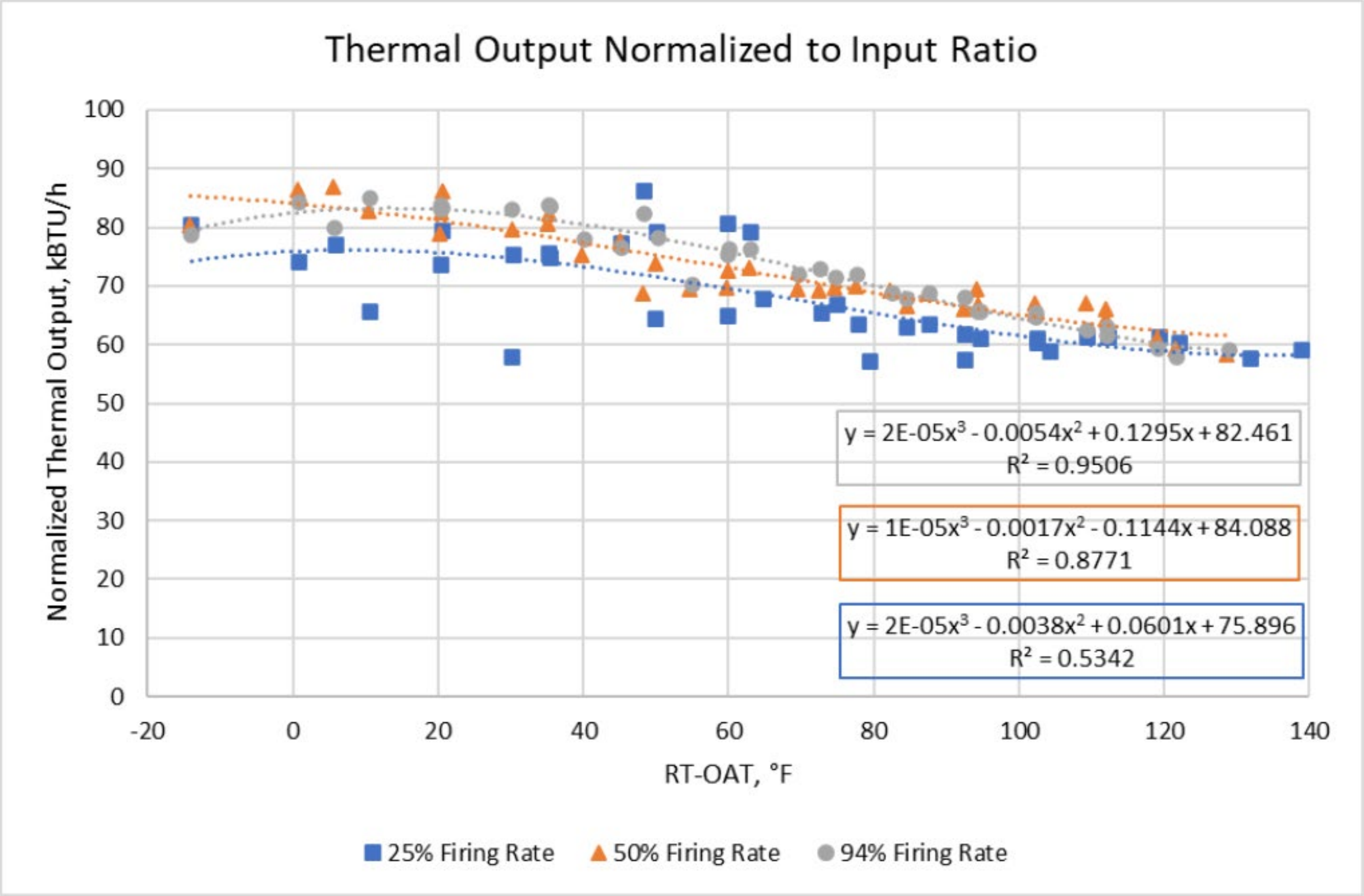




- Firing rate decreases with increasing outdoor air temperature
  - Reduction of 11–18% from 0 to 60 °F

- Nearly constant electricity input
  - Electrical power – solution pump, air coil fan, and controls

# Steady State Performance Mapping

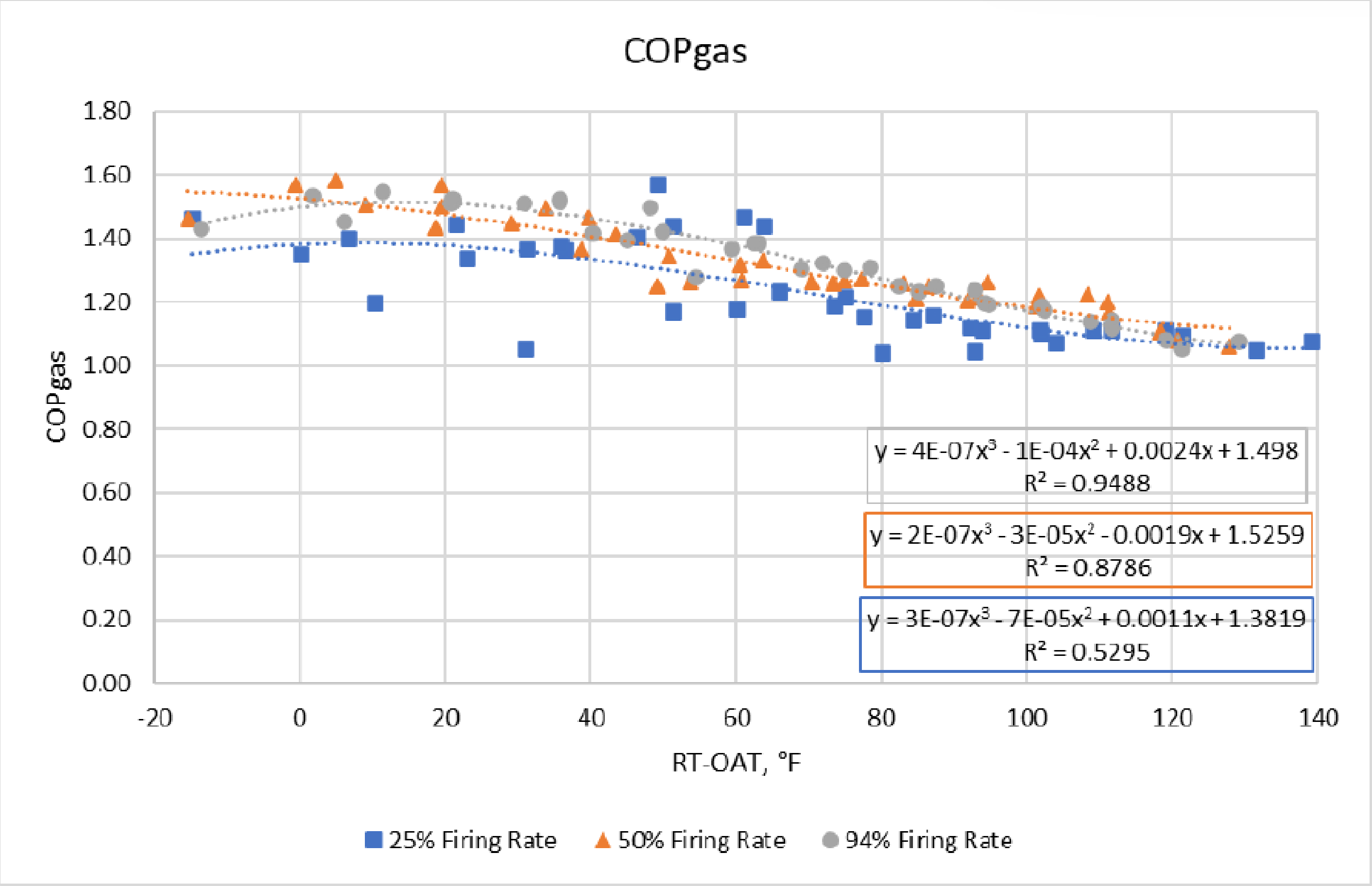


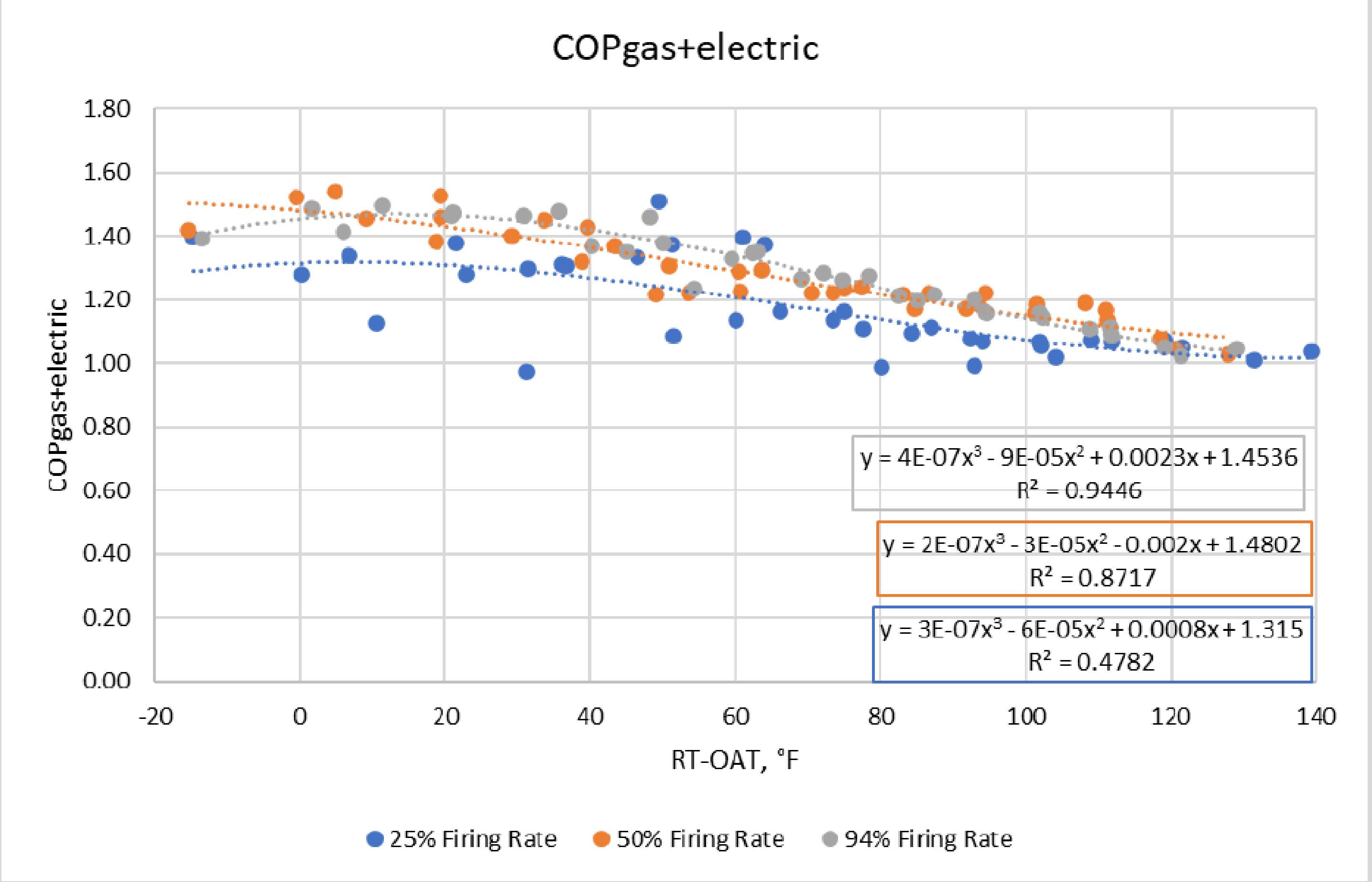




- Heating output peaks at full firing rate and between 40°F - 60°F RT-OAT
- Nearly constant at 50% and 25% firing

- Full and mid firing rate are closely correlated
- Low firing rate has more variation due to occasional cycling at ANESI GAHP 80K boundary limits

# Steady State Performance Mapping




- COP remained above 1.0 over the entire range – more thermal output than energy input. COP is 1.2–1.4 for (RT-OAT) of 40–80 °F (common operating conditions).

- COP drops ~5% at minimum firing rate
- Minimal (3–5%) difference between COP (gas) & COP (gas + electric) due to low electrical usage

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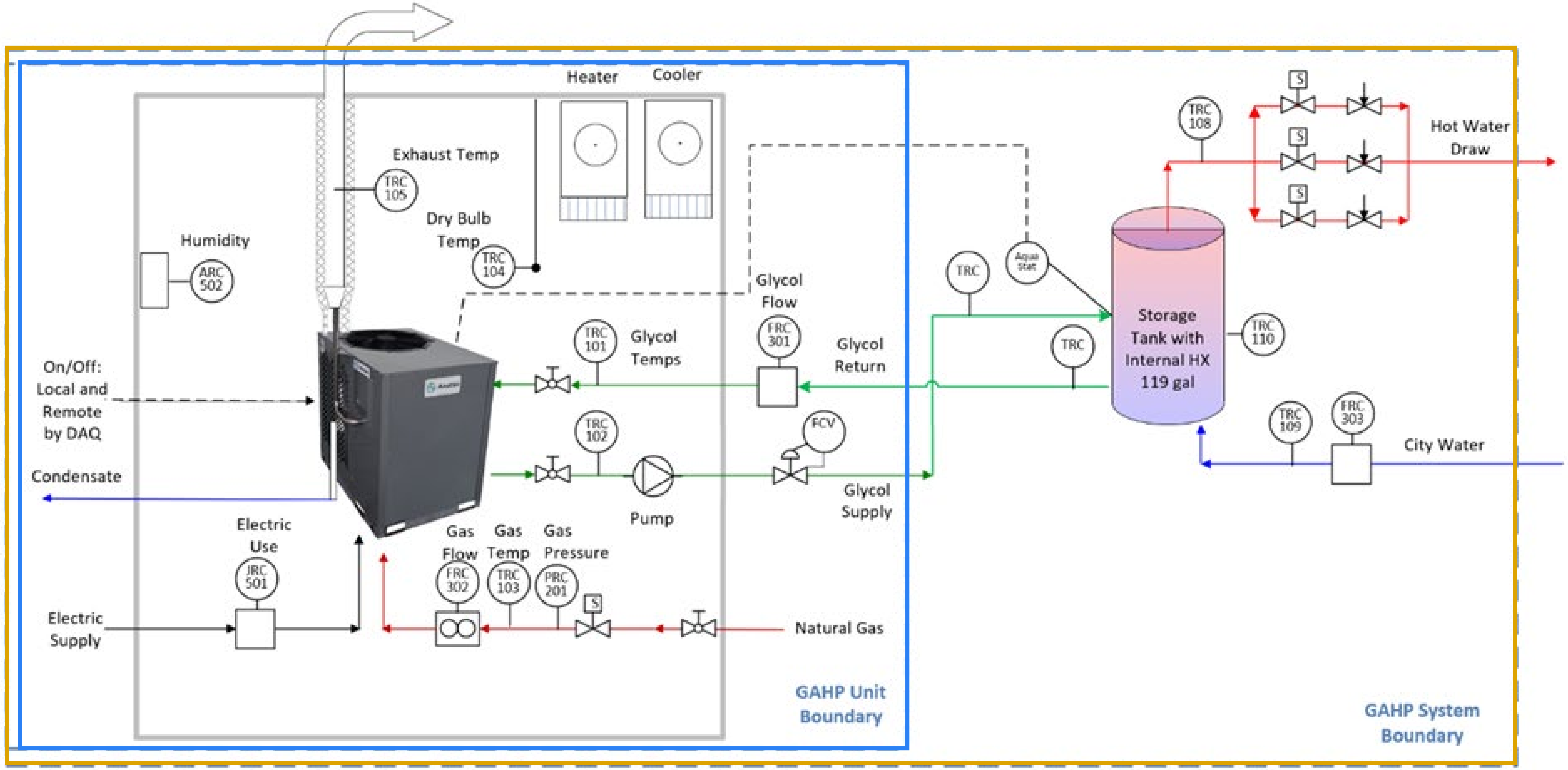
# Experimental Results – Load-Based (Transient)

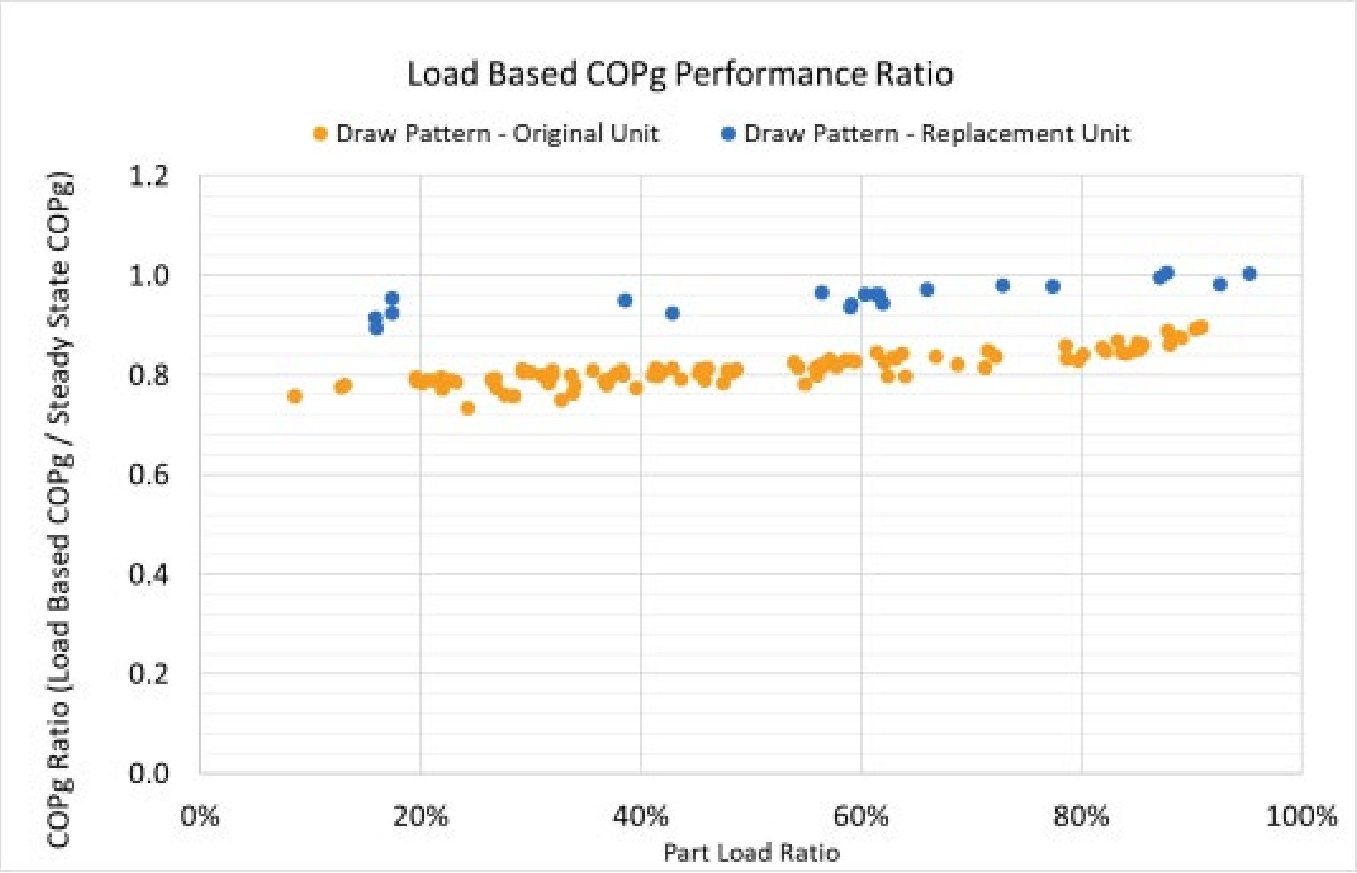
# Test Stand Changes for Standby and Draw Testing



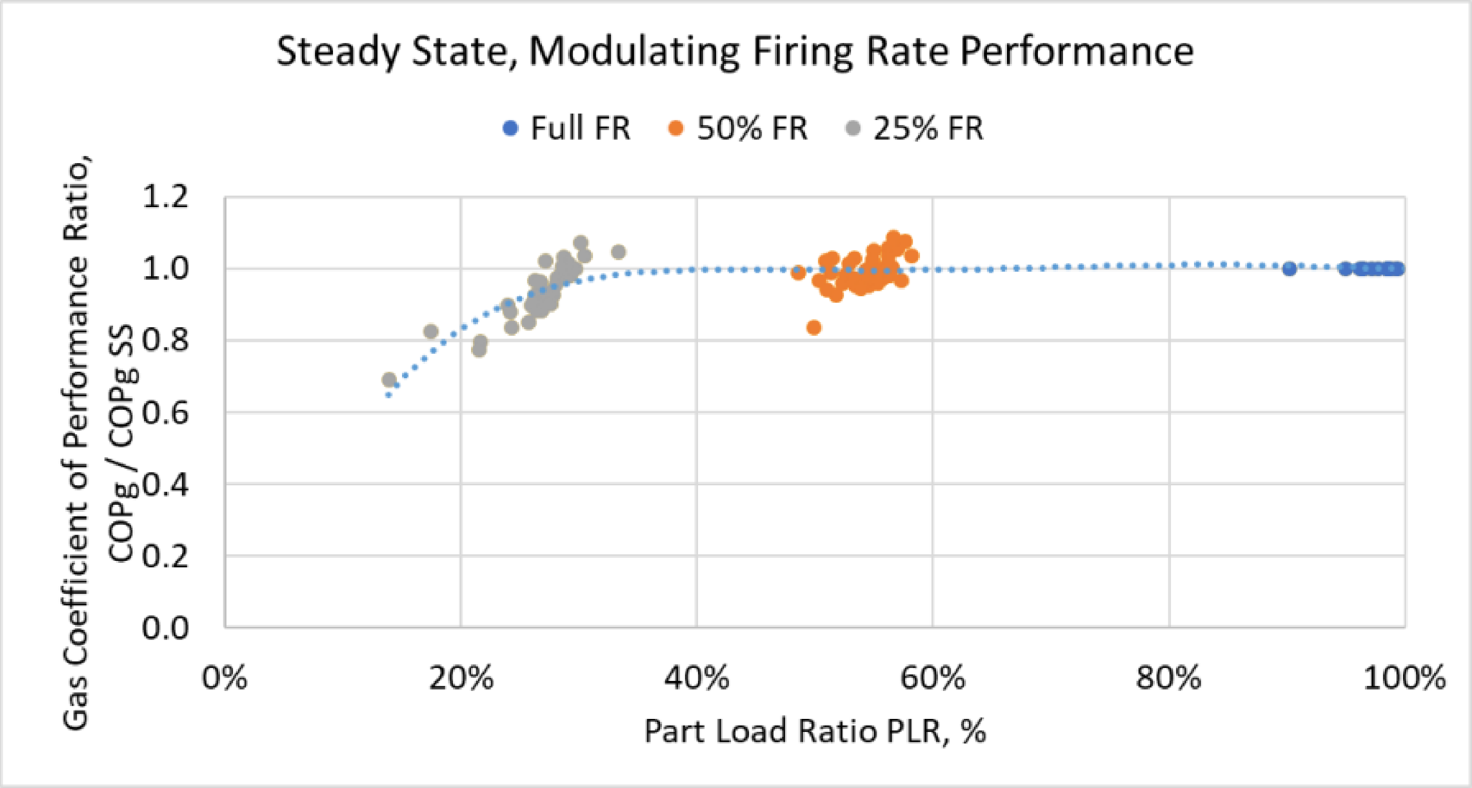

Steady State testing performed on ANESI GAHP 80K unit with controlled RT

Standby, Low Draw and Draw Pattern testing performed on system with indirect tank.

# Load-Based (Transient) Performance Mapping



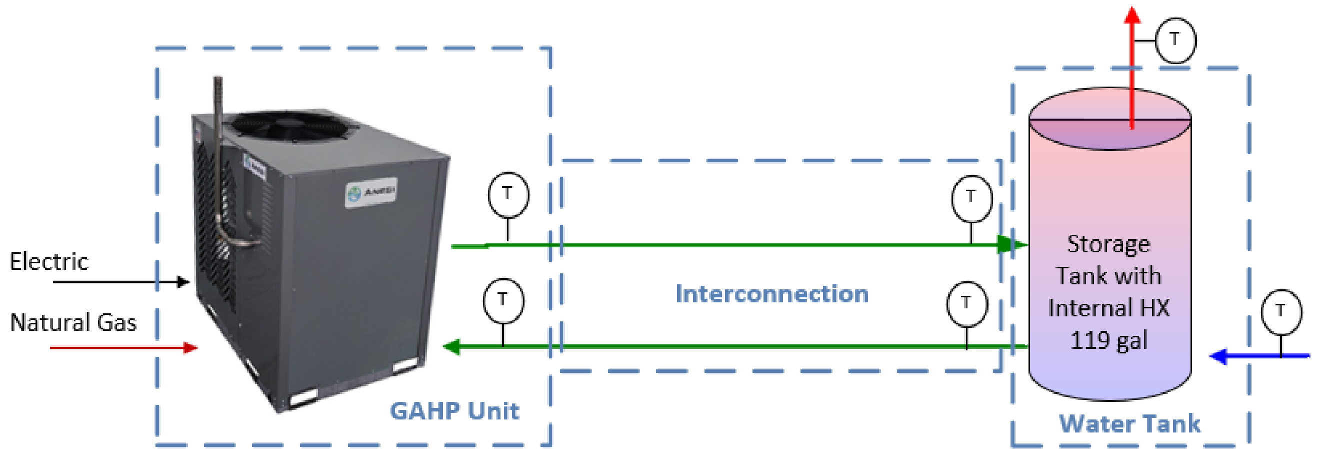

- ANESI GAHP 80K unit was replaced following performance drop (system contamination). After replacement, performance was equal to that of steady state.

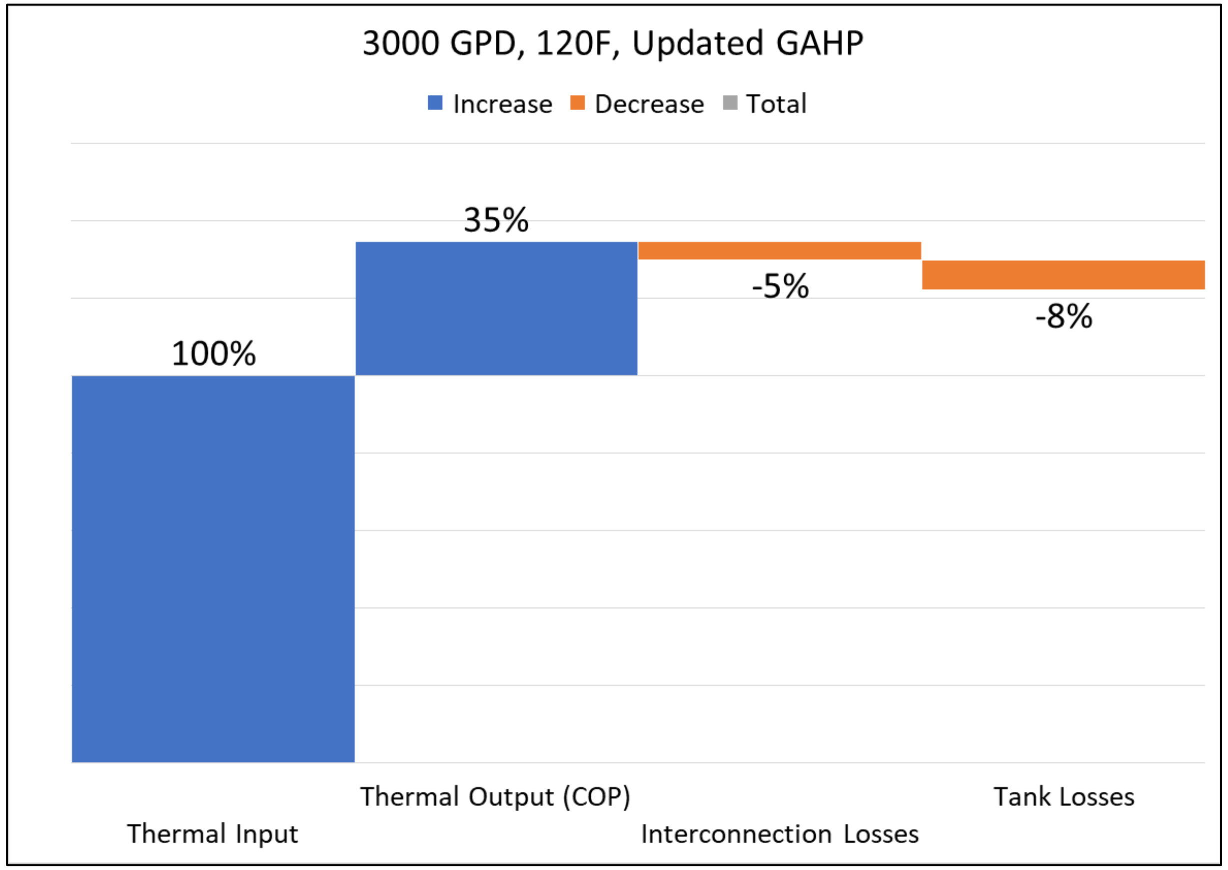



- Part-load unit performance of 25-100% is based on steady state testing at reduced firing.
- Testing of previous unit (non-modulating) was based on cycling on and off.

# ANESI GAHP 80K with Tank System Performance

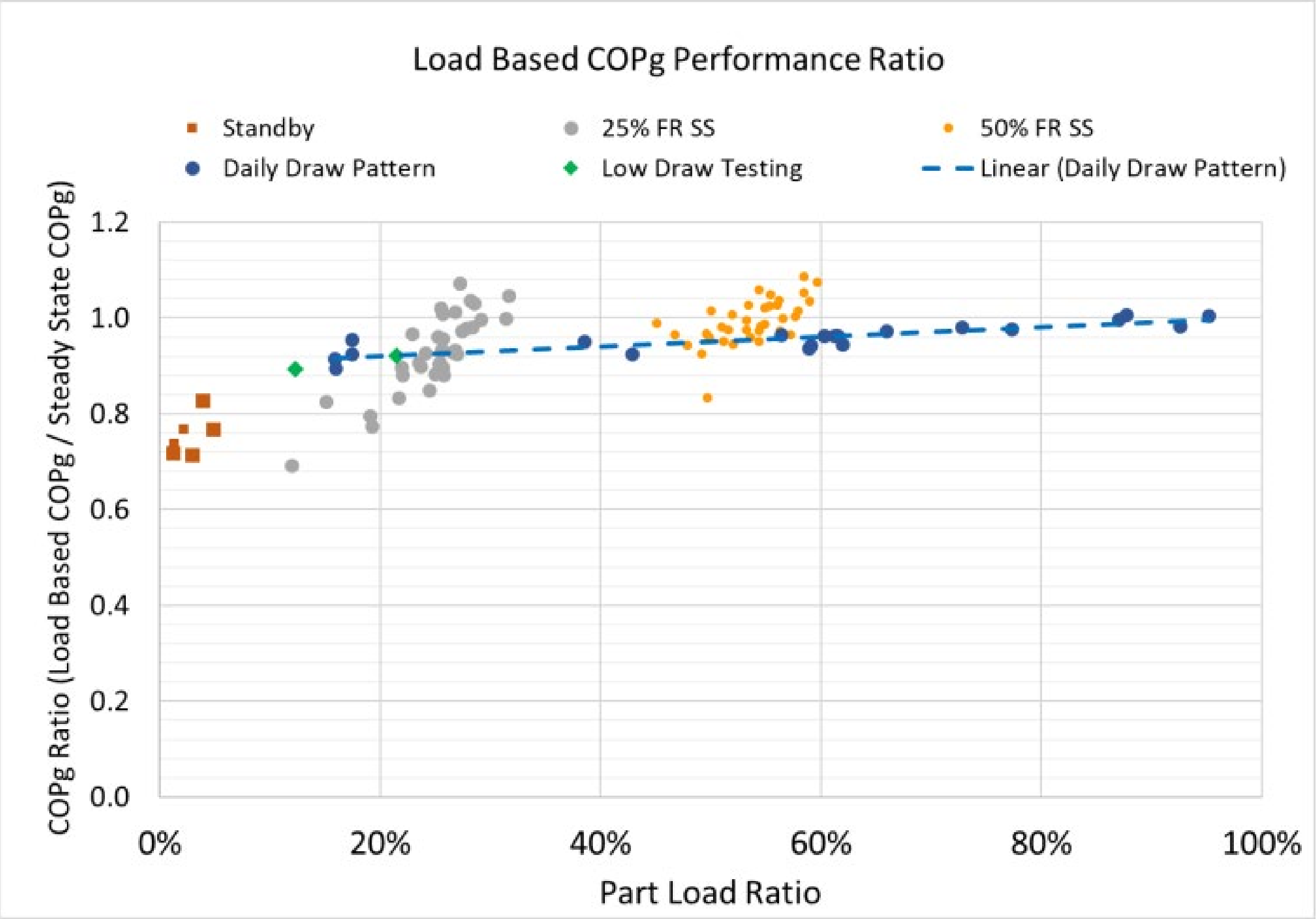
- Testing using draw pattern at low, medium and high draws was performed.
- COP benefit, along with interconnection losses and tank losses were identified.
  - Example shown for one operating condition in the laboratory (each field installation will vary).



# Load-Based (Transient) Performance Mapping

- ANESI GAHP 80K Load-Based System Performance:
  - 50% Firing Rate: minimal performance drop
  - 25% Firing Rate: COP ~10% lower than steady state
  - At very low usage (standby conditions): COP ~0.8



# EnergyPlus Modeling

# 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

# EnergyPlus Modeling Integration

- Modeling parameters developed and plotted with experimental data
  - Modeling parameters can be predicted within ±5% at full load and ±10% at lower part load ratios
- Key parameters (simplified below):
  - Heating Capacity = Rated Capacity x CAPFT

    CAPFT = correction factor based on ambient and return temperature
  - Gas Use = [(Load/$COP_{nom}$) x EIRFT x EIRFPLR x EIRDEFROST]/CRF

    $COP_{nom}$ = Rated GAHP capacity / Rate Gas input

    EIRFT = correction factor based on ambient and return temperature

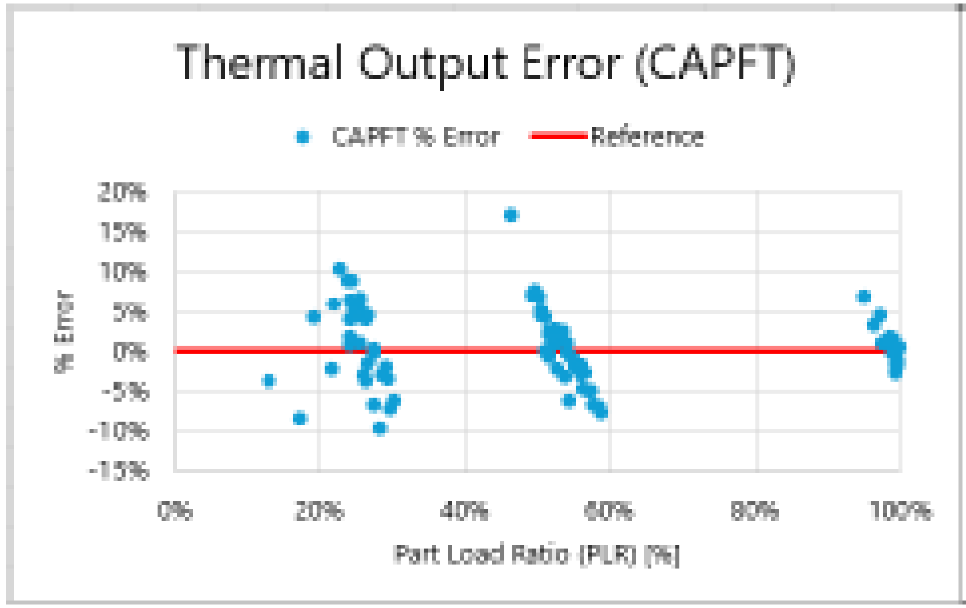
    EIRFPLR = correction factor for cycling (part load)

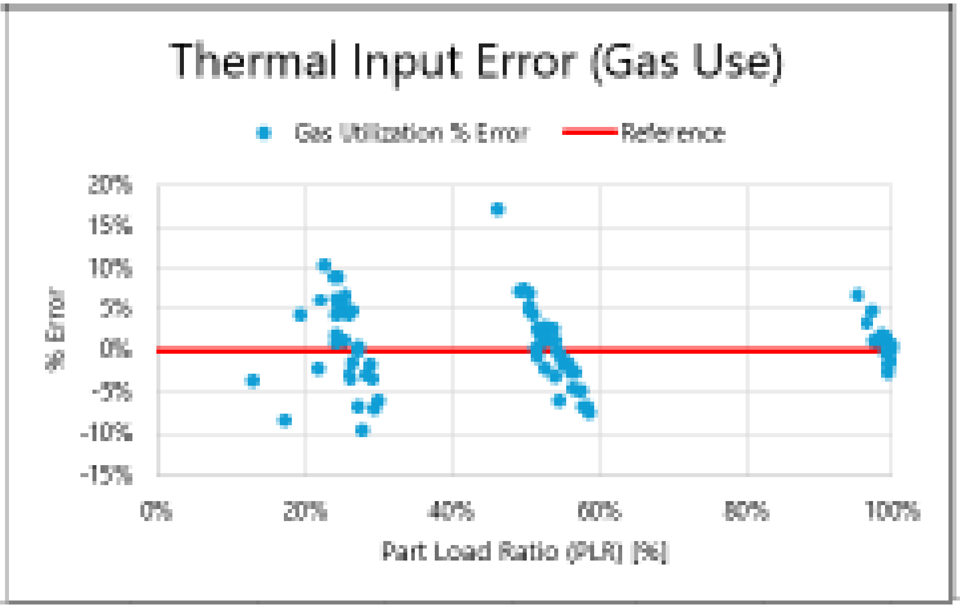
    EIRDEFROST = correction factor for defrost

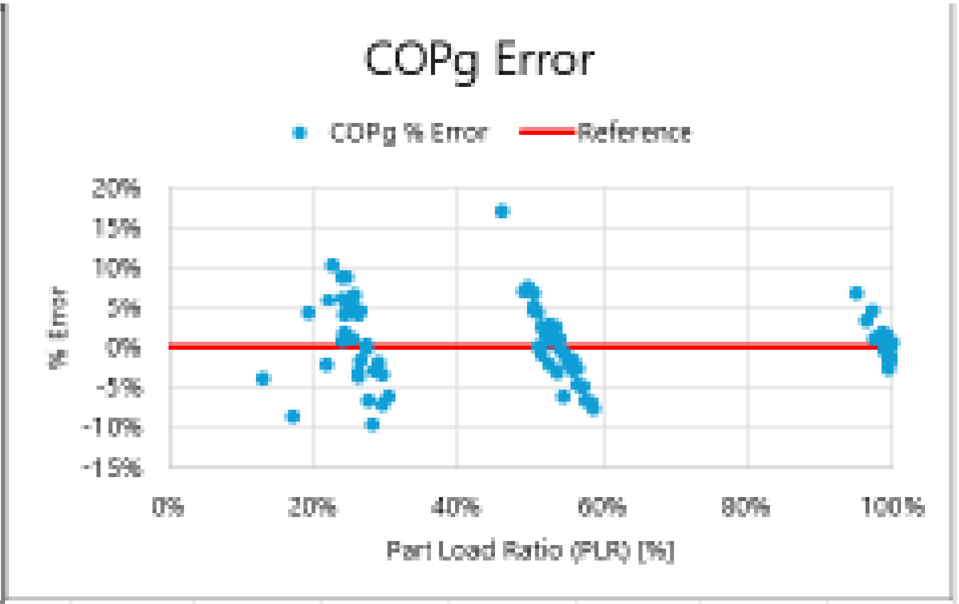
    CRF = correction factor for cycling operation

# EnergyPlus Modeling Integration

- Parameter error between measured and modeled data
  - Parameter prediction within ±5% at full load
  - Parameter prediction within ±10% at lower part load ratios



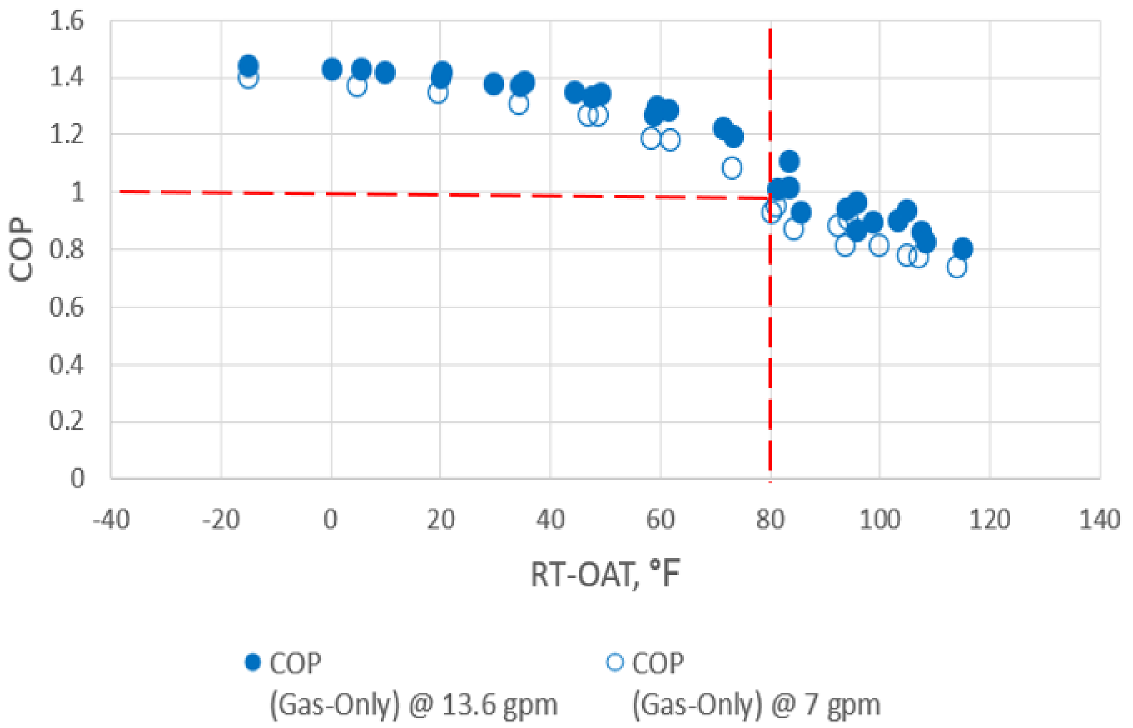



# Robur GAHP-A vs. ANESI GAHP 80K Comparison

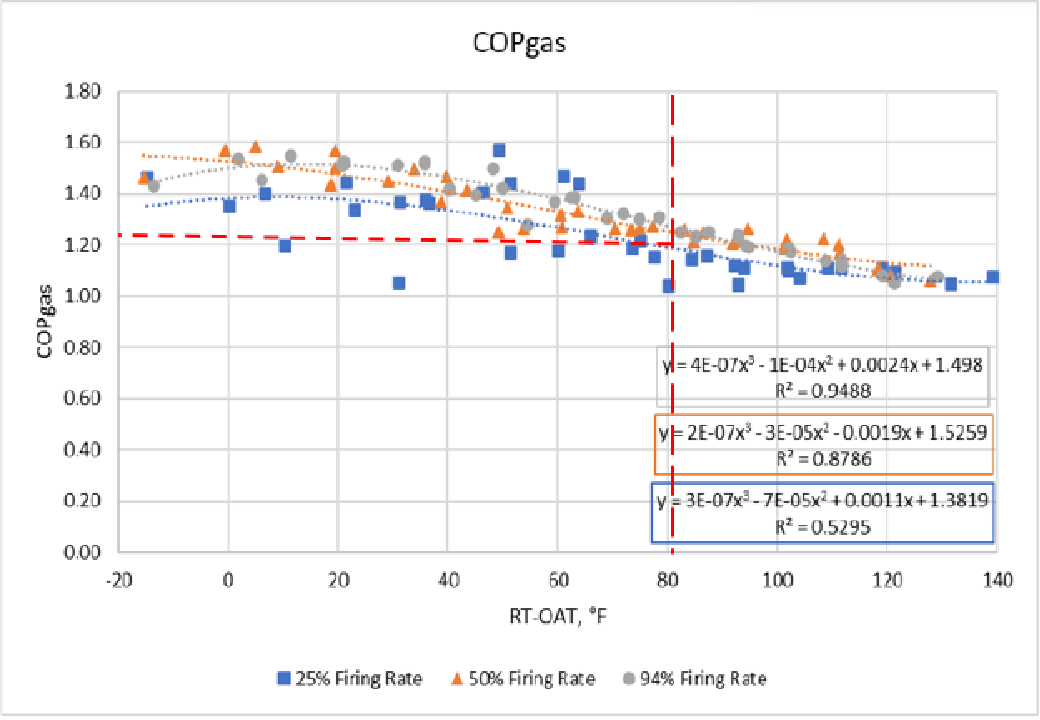
# Steady State Comparison

- Similar performance characteristics resulted for Robur GAHP-A (no modulation) and ANESI GAHP 80K (25-100% modulation) over the operating conditions
- ANESI GAHP 80K unit was ~7-10% higher over tested range.
  - Example shown below at (RT-OAT) of 80°F : Robur GAHP-A = 1.0-1.1; ANESI GAHP 80K – 1.2

Robur GAHP-A



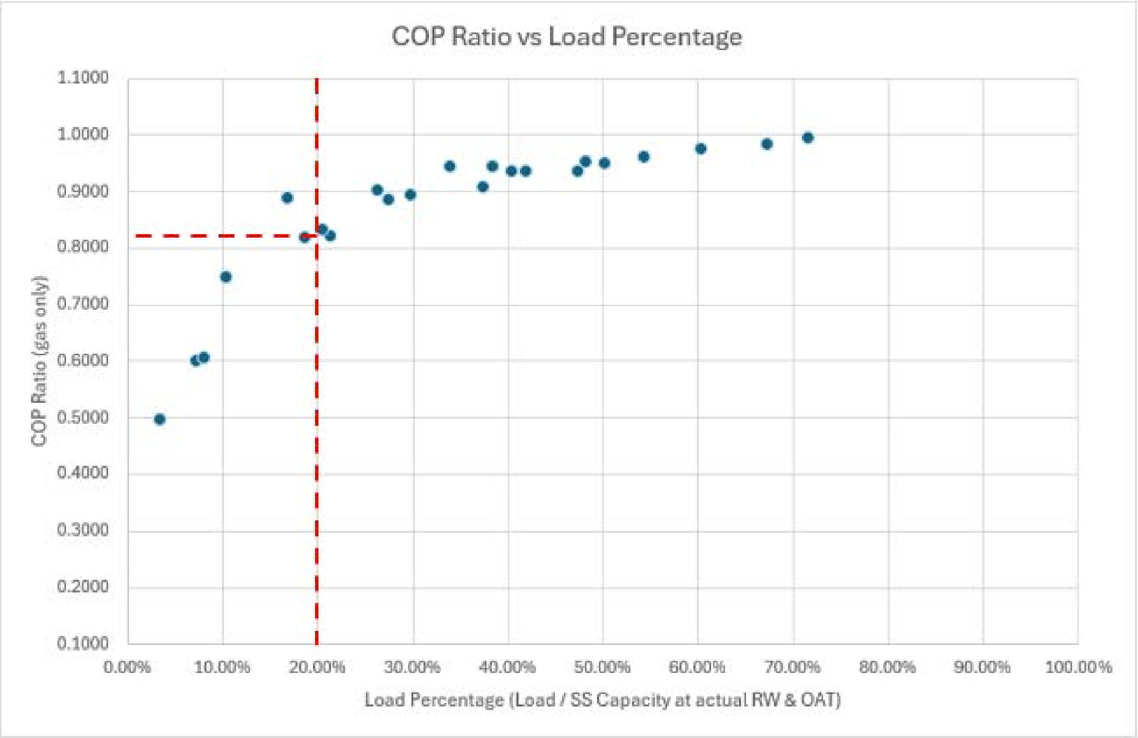

ANESI GAHP 80K



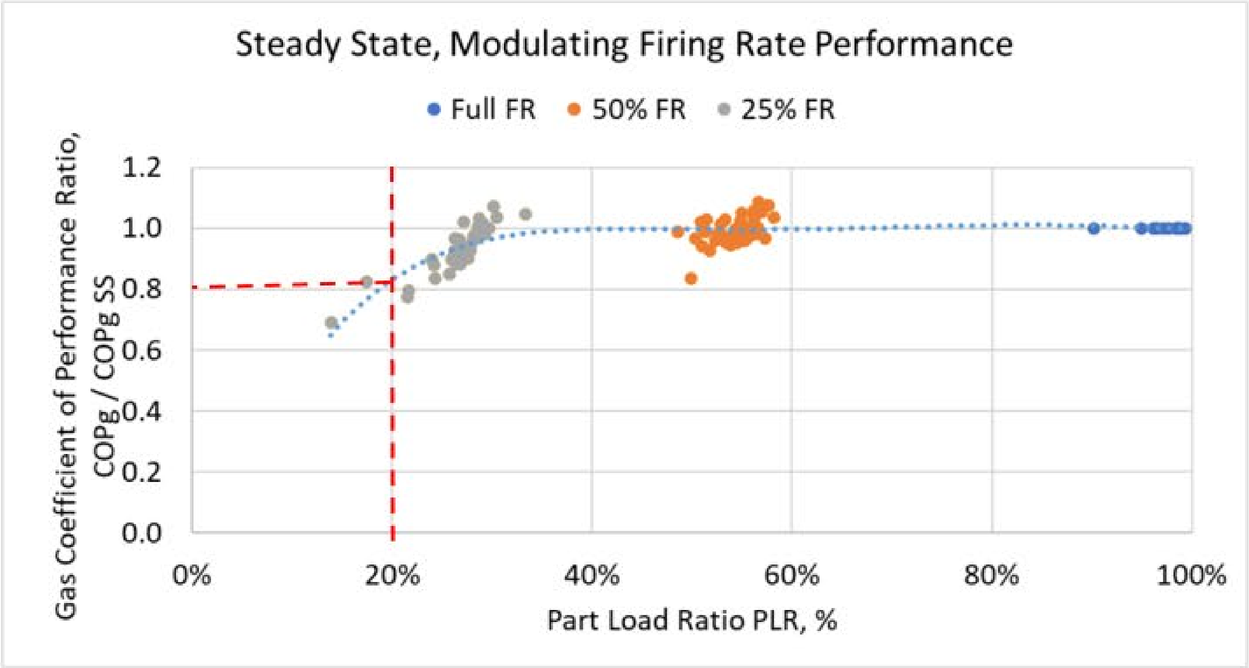
# Load-Based (Transient) Comparison

- Part load performance of the ANESI GAHP 80K is marginally higher in the 25-75% range due to modulating capability.
- Differences are independent of flowrate (Robur GAHP-A) or firing rate (ANESI GAHP 80K)

Robur GAHP-A




ANESI GAHP 80K



# EnergyPlus Modeling Comparison

- The EnergyPlus factors are in close alignment with the tested data (within 5-10%), therefore signifying good mapping data was developed from both tests

<table>
<tr><th>Variable</th><th>Robur GAHP-A % Error</th><th>ANESI GAHP 80K % Error</th></tr>
<tr><td>Thermal Output</td><td rowspan="2">±5%</td><td rowspan="3">±5% (at full load)<br>±10% (at lower PLRs)</td></tr>
<tr><td>Thermal Input</td></tr>
<tr><td>COP (gas only)</td><td>±6%</td></tr>
</table>

# Key Takeaways & Recommendations for Future Studies

## Key Takeaways

1. ANESI GAHP 80K closely aligns with manufacturer's rated conditions
2. System experience clogging at the filter-dryer (before the expansion valve). Replacement resolved issue.
3. Large draws/longer cycle times – optimal steady state ANESI GAHP 80K performance
4. ANESI GAHP 80K should be configured according to application
5. Normalized data suggests experimental data is sufficient for modeling integration (±5-10%)

## Future Studies

1. Hydrogen blend testing and performance curve development
2. Additional "market-ready" GAHP experimental and field testing for EnergyPlus modeling integration and/or GAHP installation tool development
3. Overall system enhancements (i.e., varying heat exchanger configurations, more temperature sensors, inclusion of a tankless water heater)

## FOR MORE INFORMATION

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

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