Hydronic Space Heating Fluid Additive Field Study

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ICF

Energy Savings in Commercial Hydronic Heating Systems

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STATEWIDE ET PROGRAM

Acknowledgements and Disclaimer

- Acknowledgements:
  - Project developed under Statewide Gas Emerging Technologies Program (GET)
  - Led by SoCalGas as Statewide Lead Program Administrator
  - Conducted by Lincus with guidance from Steven Long, ICF
  - Contact: Steven.Long@ICF.com for more information

- Disclaimer:
  - Prepared by ICF, funded by California utility customers under CPUC
  - No warranties; results representative of tested conditions but may vary

Agenda

- Executive Summary: Overview of key findings
- Technology Description: How the additive works
- Assessment Methodology: Field Study design for savings verification
- Site Descriptions and Installation: Sites, costs, and install process
- Baseline Analysis: Data collection, analysis, and challenges
- Post-Installation Analysis: Post-additive analysis and challenges
- Shift to OAT-Binning Method: Savings alternative due to poor model fits
- Results and Data Analysis: Savings vs claims, and customer feedback
- Surface Tension Results: Compare measured vs claimed
- Discussion, Conclusions, and Recommendations: Findings and next steps

Executive Summary

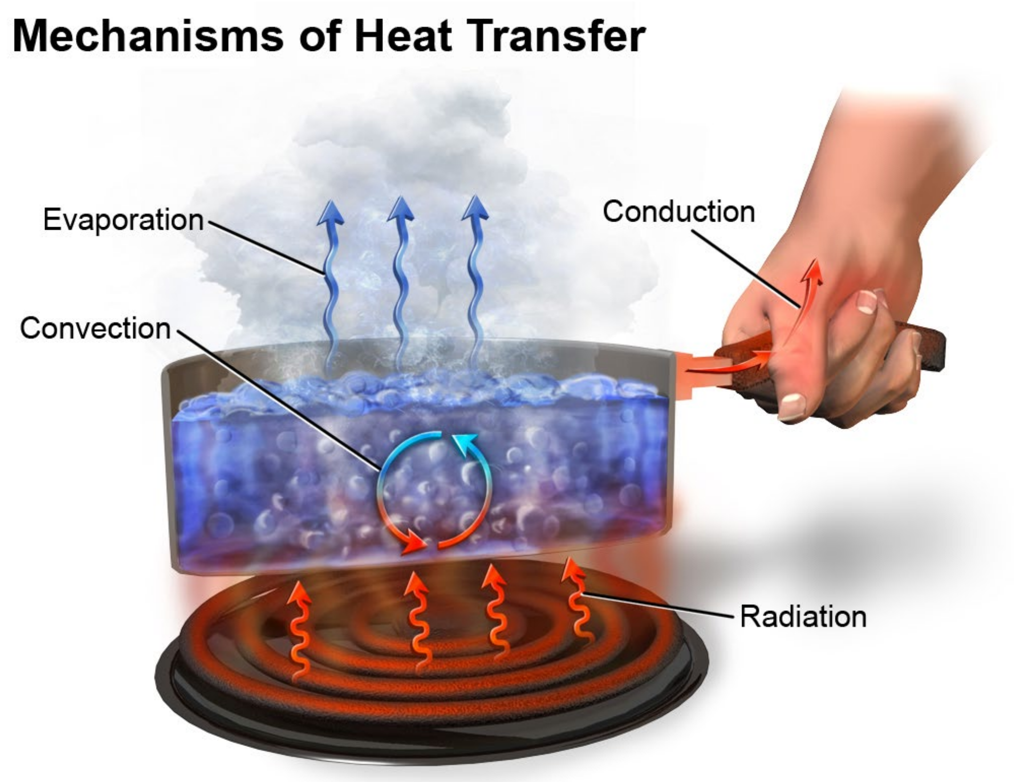
Executive Summary – Key Findings

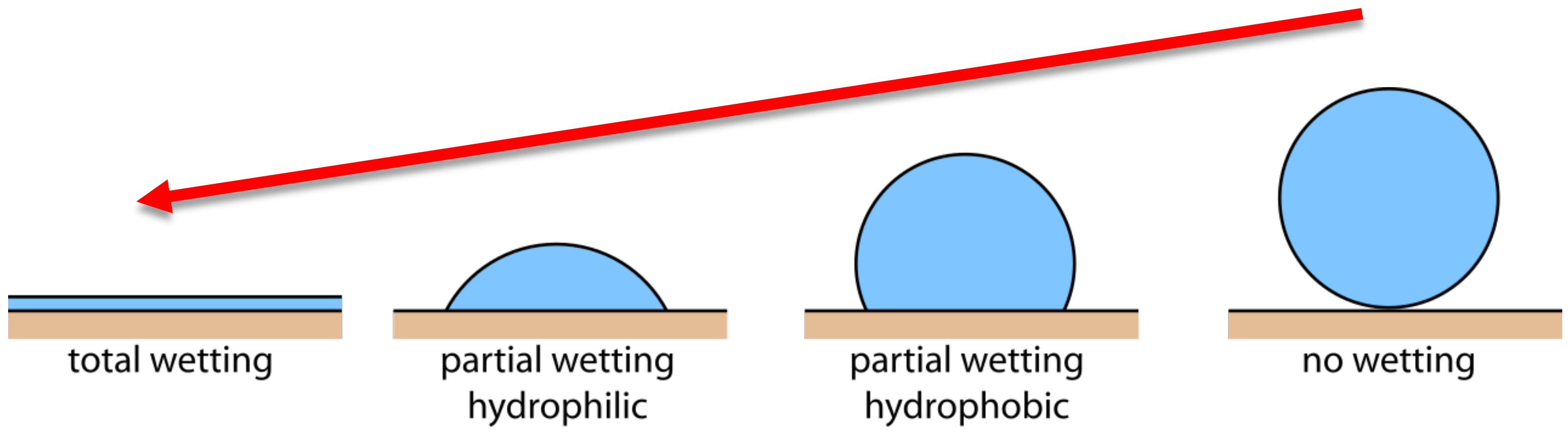
- Energy Savings:
  - Site #1: 10.7% gas savings (Option C, HDD-normalized)
  - Site #2: 19.8% gas savings (Option B, Heating Load normalized)
- Surface Tension Reduction:
  - 40-50% via 3rd party testing
- Cost and Payback:
  - Material costs $5k-$14k
  - Customer prefer <3 years ROI for adoption
- Additional Customer Feedback:
  - Moderate satisfaction
  - No service interruptions
- Overall: Reduces energy consumption; recommend further studies in varying climates

Technology Description

Emerging Technology: How It Works

- Physics: Alters several thermophysical properties
  - Reduces surface tension → serves as a proxy
  - Enhances heat transfer via several mechanisms (wetting shown below)





Assessment Methodology

Research Objectives and Methodology

Objectives

- Verify mfg. gas savings of 7-15% claim
- Assess costs and barriers

Approach

- Use existing BAS data
- field study over multiple seasons.

Site #1

- IPMVP Option B (retrofit isolation)

Site #2

- Option C supplement for metering issues

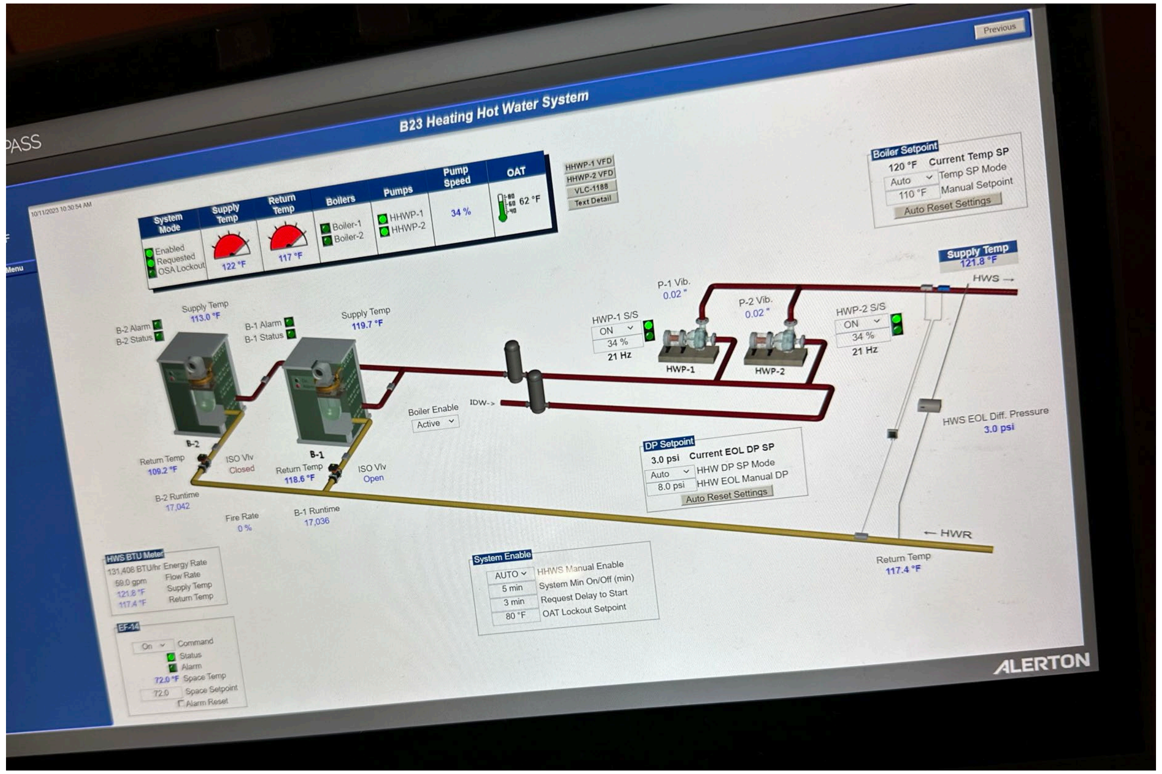
Activities

- Site Recruitment
- Baseline Surface Tension
- Baseline Data Collection
- Post Install Dosing & tests
- Post-monitoring/ Analysis
- Performance Comparison
- Customer Surveys

Site Descriptions and Installation

Site Descriptions and Selection

Project Site	*Location*	Size (sq. ft.)	Building Type	Fire-Tube Boilers[1] (MMBtu/hr, TE)	AHUs	BAS Intervals
Site #1	*San Francisco, CZ03*	251,000 sq. ft, (7) floors	Large office building	2 x 2.0, 92%	8	15-min (gas 24-hr)
Site #2	Menlo Park, CZ03	178,432 sq. ft. (1) floor	Mixed-use office-space	3 x 2.0, 94%	8	15-min



Installation & Costs

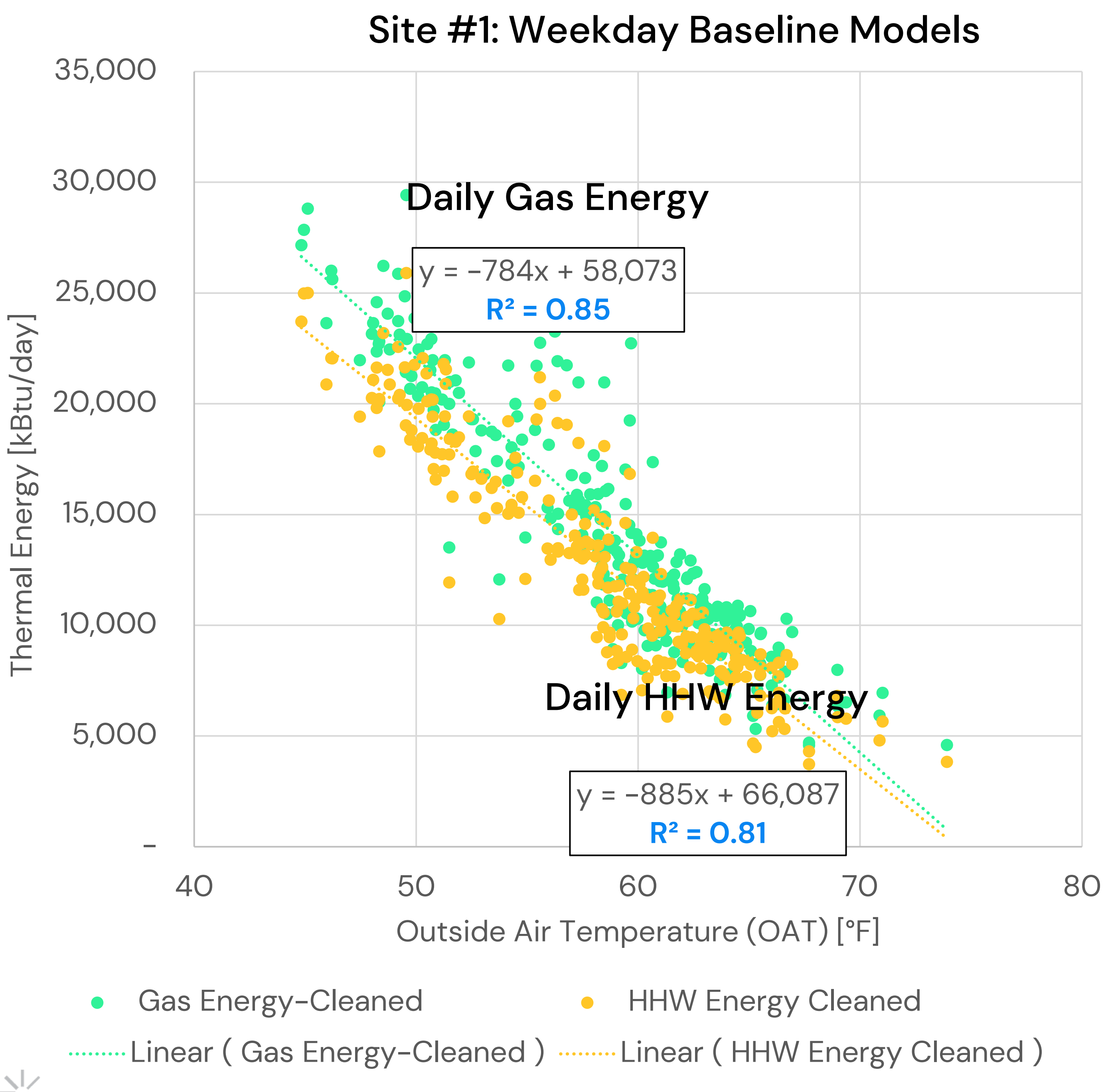
Project Site	Total System Volume (gallons)	Required volume (gallons)	Additive Costs ($)
Site #1	2700	27	$14,165.80
Site #2	Determined by Flow Rate	8	$5,050.00

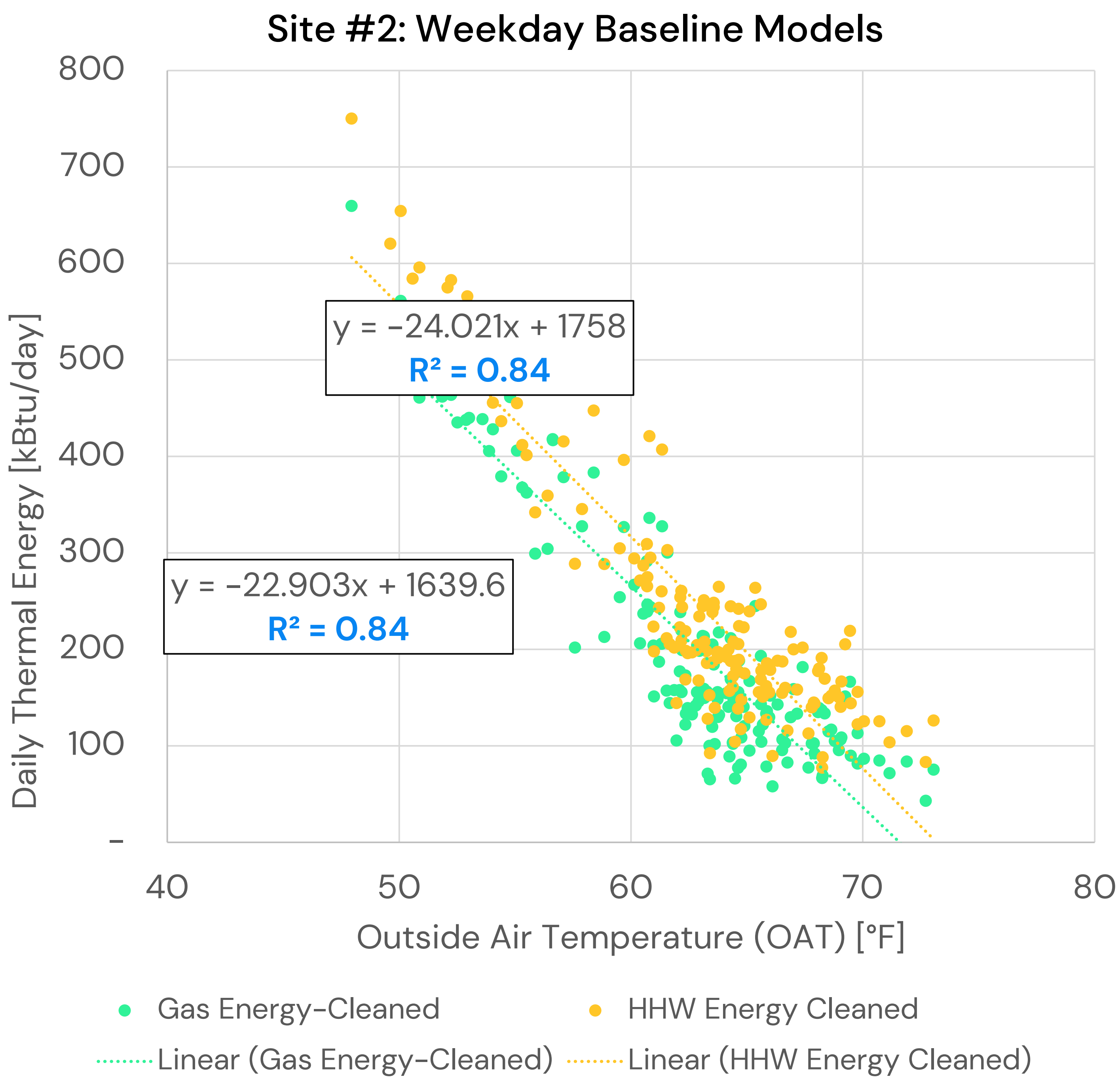
- Process:
  - On-site dosing with flushing; no interruptions.
  - Longer than 10-15 min due to volume; low risk.
- Customer notes:
  - Maximum ROI < 3 for adoption
  - ~$500/gallon reasonable, but need incentives to promote

Enter chart data sources here.

Baseline Data Analysis

Baseline Energy Models (Energy vs OAT)

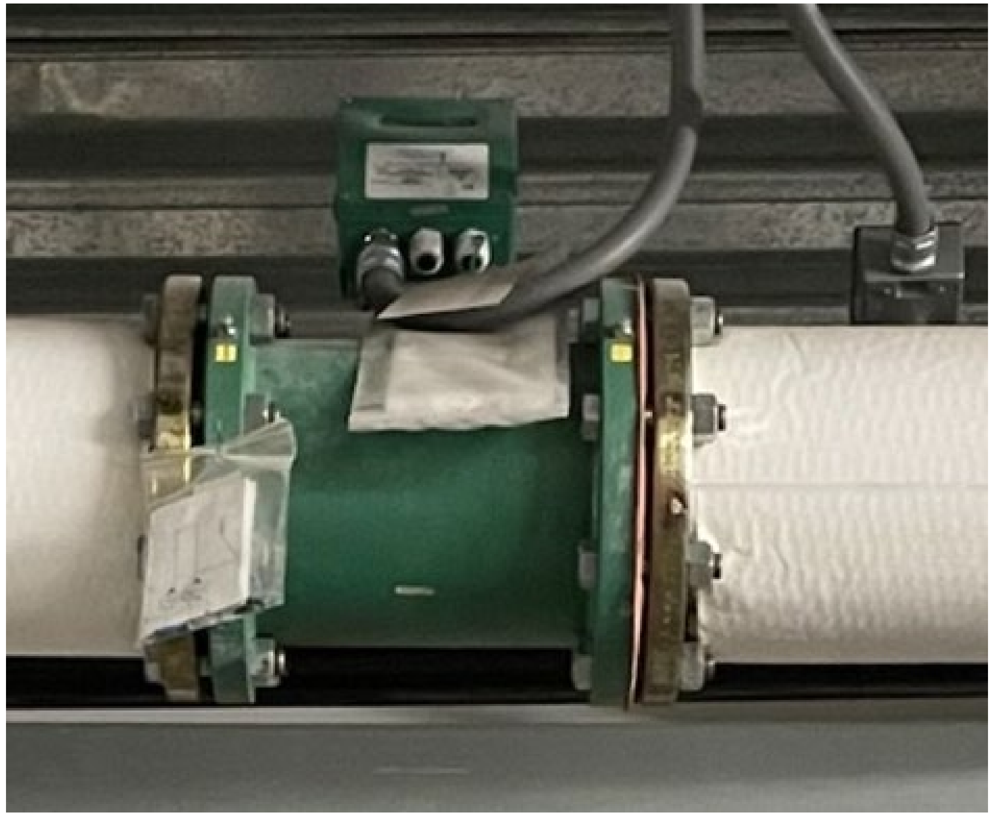




Baseline Period Challenges

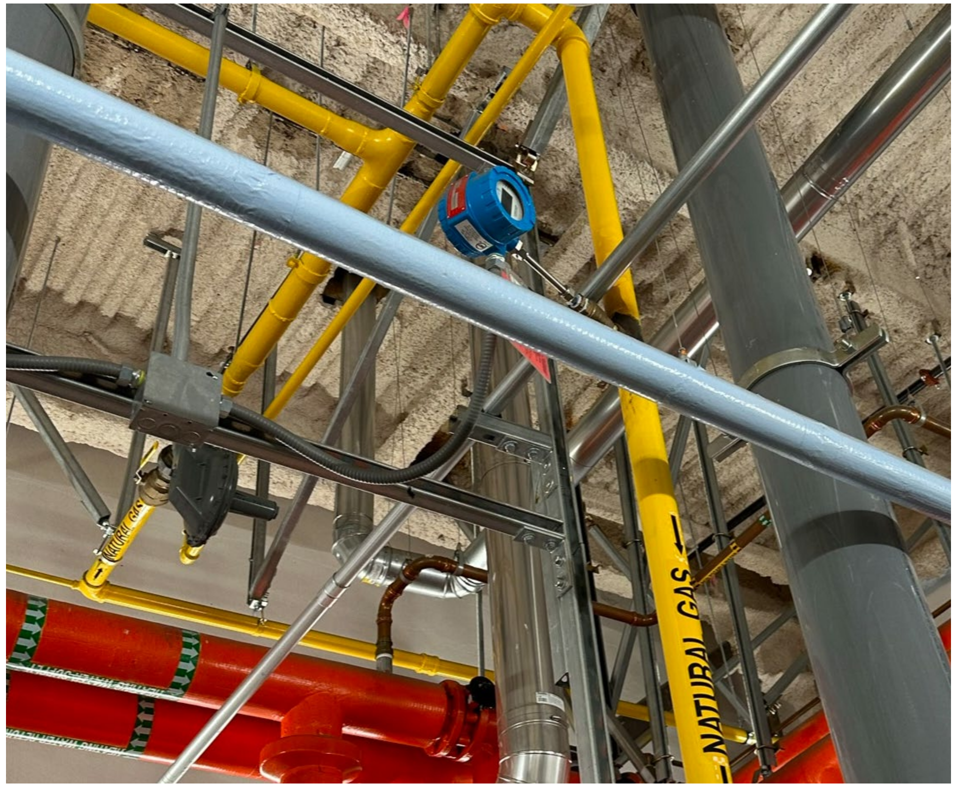
Site #1

- flow meter issues (shown below)
  - Went offline is October 2024
  - Switch to Option C – Whole Building using PG&E gas meter data



Site #2

- gas meter issues (shown below)
  - Communication issues with BAS

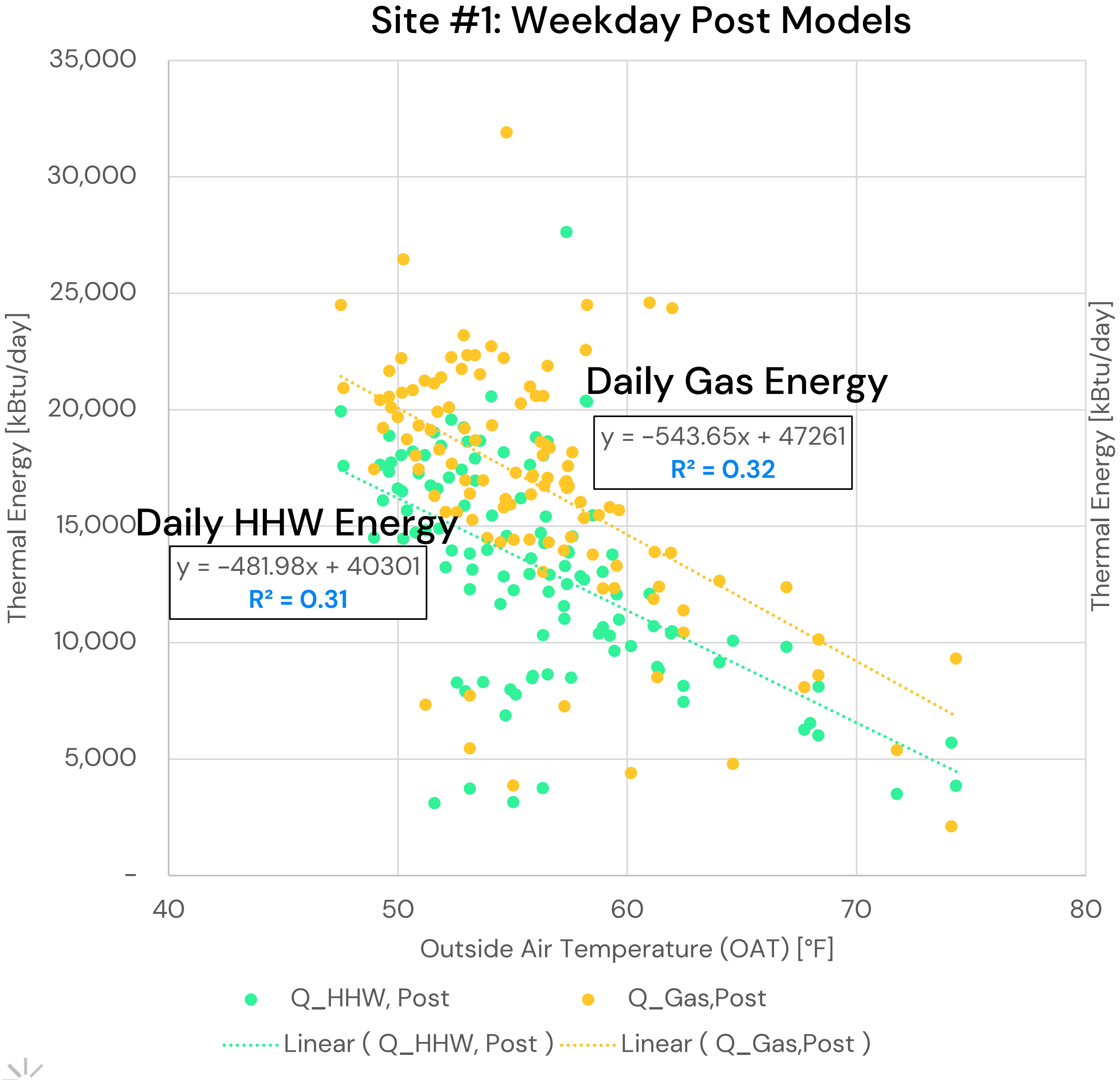


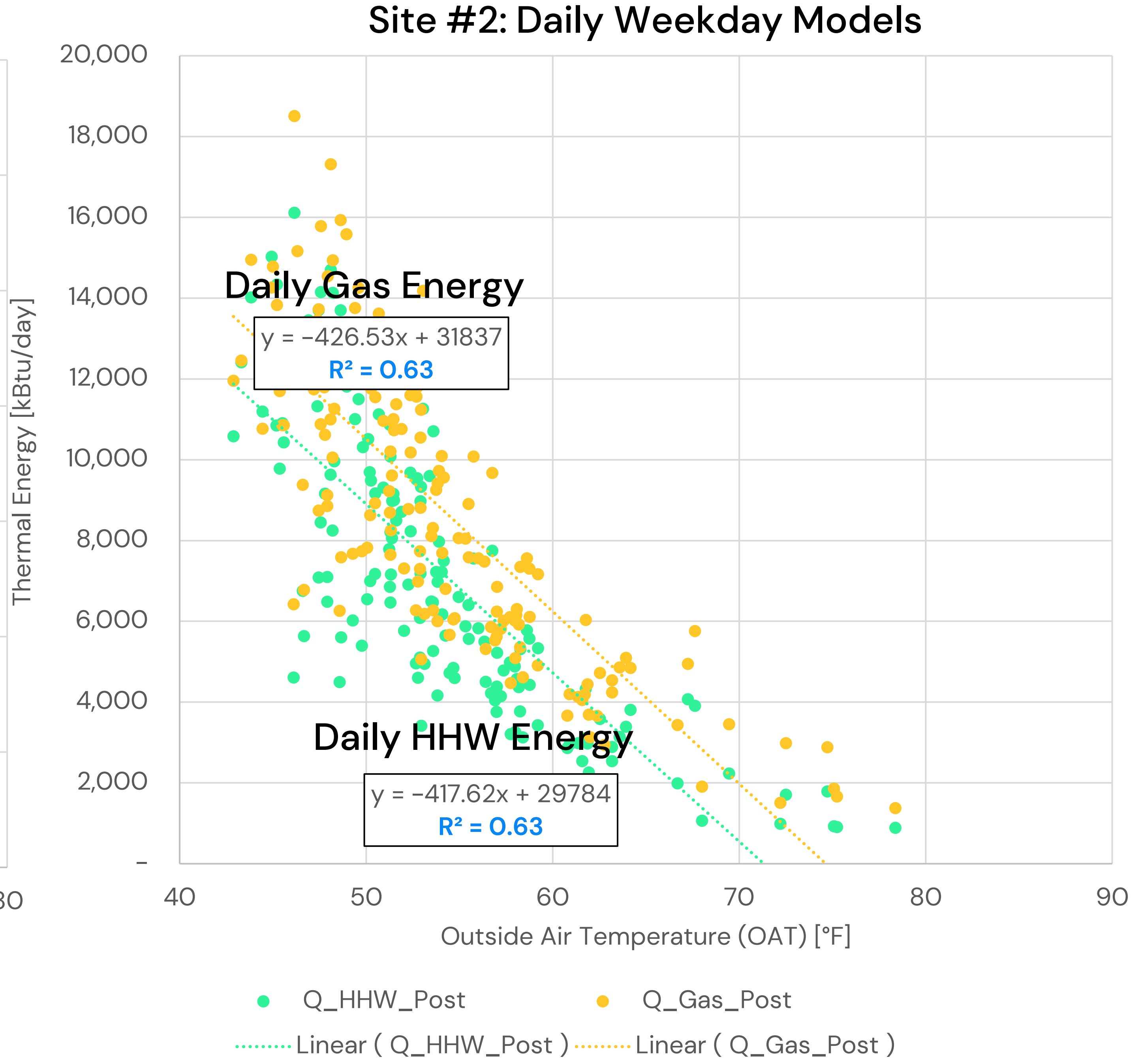
- Gas Flow regression using firing rate

R2	CV(RMSE)	NMBE
0.97	23%	-0.027%

Post-Install Data Analysis

Post-Install Energy Models vs OAT





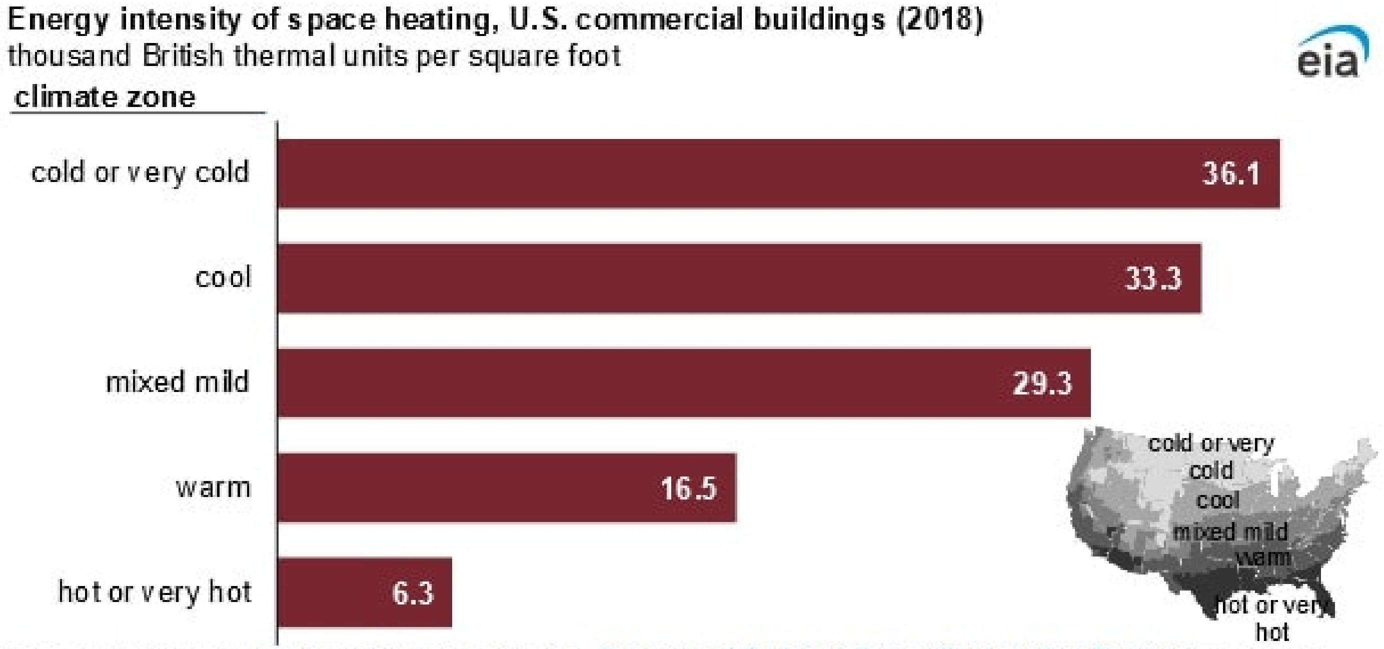
Shift to OAT-Binning Method

Shift to OAT-Binning Method

- Why shift: Post-models poor fits
  - (R^2 ~0.18-0.63) vs baseline (0.81-0.85)
  - System more dynamic (occupancy, setpoints)
- OAT-binning: alternative approach:
  - Uses daily "bins"
  - Allows for comparisons
- Benefits:
  - Verifies claims in similar conditions
  - Identify patterns

Why OAT-Binning?

1. Increased Heat Demand at lower OATs
2. Usage Patterns: increase behavior at lower OATs



Data source: U.S. Energy Information Administration, *Commercial Buildings Energy Consumption Survey* (CBECS), and ANSI/ASHRAE Standard 169-2021, *Climatic Data for Building Design Standards*

Energy Savings Results

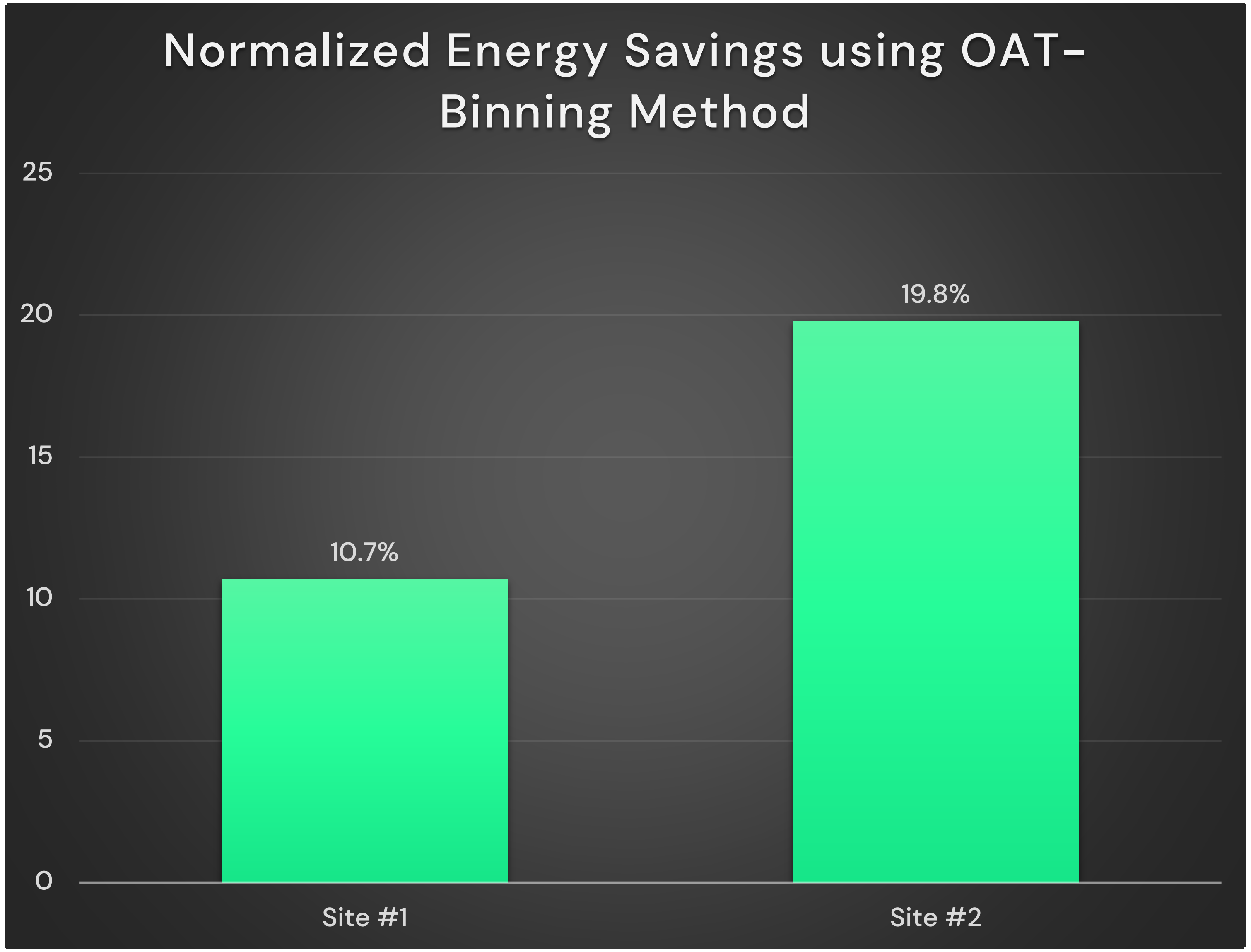
Normalized Energy Saving Summary

Site #1:

- 10.7% gas savings
- Option C method
- Heating Degree Day (HDD) normalization

Site #2:

- 19.8% gas savings
- Option B method
- Heating Load output normalization



Customer Survey Results

Adoption Likelihood

- Site #1 unlikely to adopt without incentives due to 10.7% savings
- Site #2 likely to expand use with 19.8% savings

Installation Experience

- Both sites found installation easy, no disruptions
- Site #1 installed in-house without issue
- Site #2 used a water treatment company

ROI and Cost

- Site #1 requires 3-year ROI
- Site #2 $500/gallon cost is reasonable, self payback

Recommendations

- Both sites recommend for low risk and higher savings in mild to colder climates

Occupant Impact

- No occupant complaints or service interruptions at either site

Concerns

- Site #1 seeks savings confidence via deemed incentives
- Site #2 wants multi-site verification, reliability

Surface Tension Results

Measured Surface Tension Results

- Method:
  - Wilhelmy Plate by third-party lab. (shown to the right)
- Results:
  - 40-50% reduction measured

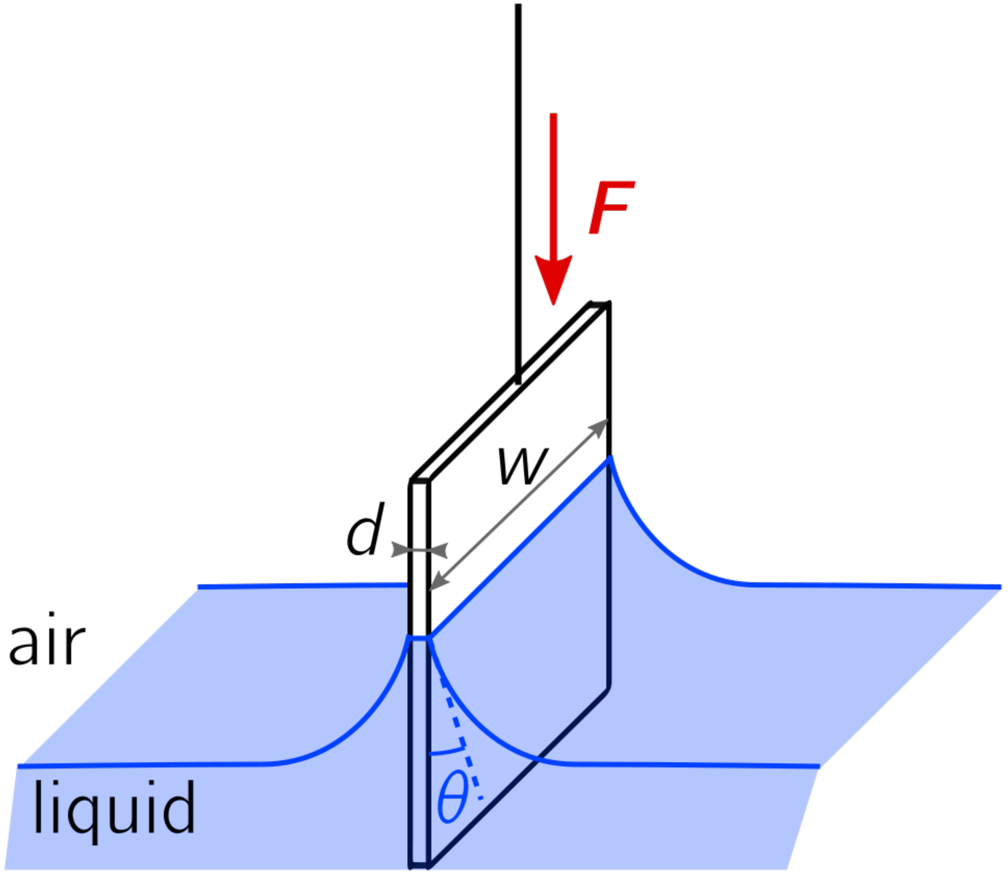
Used as a proxy to confirm heat transfer increase

-55%

- Site #1:
  - 65 mN/m to 29 mN/m

-49%

- Site #2:
  - 71 mN/m to 34.5 mN/m



Discussion

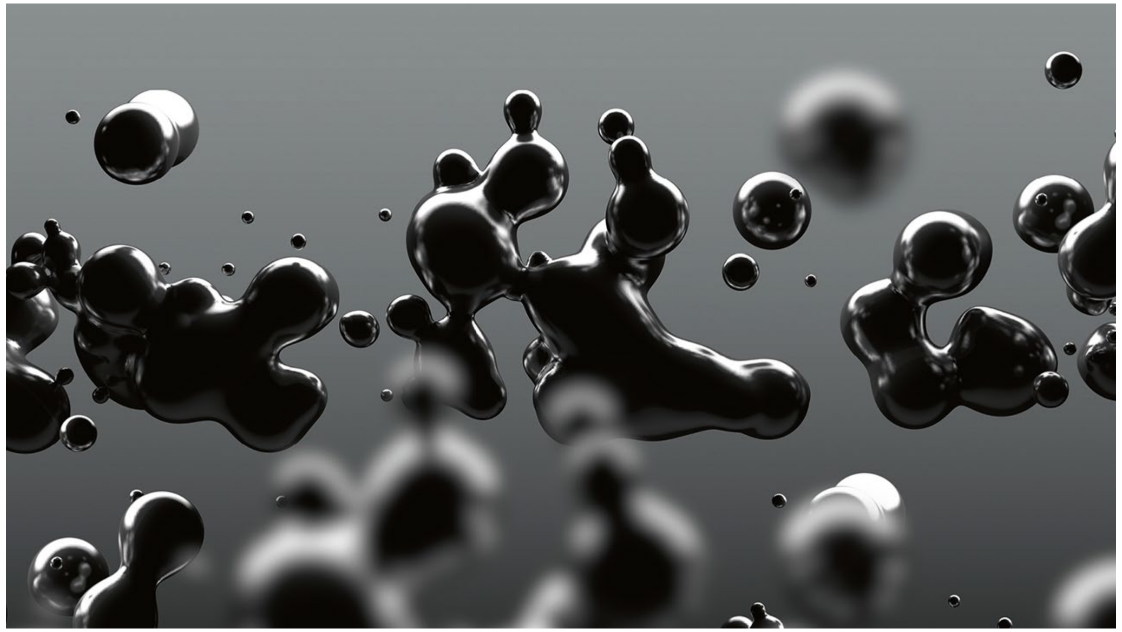
Discussion

- Site #1
  - 10.7% (metering issues masking impacts)
- Site #2
  - 19.8% adjusted from reduced HHW
- Higher savings in lower OAT bins (<60°F)
- Aligns with manufacturer studies but lacks source data
- No system thermal efficiency improvement
  - Inconclusive due to system boundaries (i.e., boilers)
- Poor post fits sue to dynamic response of hydronic fluid additive
- Vs. incumbent: Reduced energy consumption

Key Takeaways

Recommendations

- Further studies:
  - Varied climates (milder/cold)
  - 5-10 sites, 2+ seasons to capture variations
  - Verify higher savings at lower OATs
- Data transparency:
  - Cross-validate with manufacturer source data
  - address product lifetime concerns over multiple years
- Related work:
  - Compare similar nanoparticle fluids for multi-year performance



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