Research GAHP Screening Criteria & Design

Gas emerging technologies program (GET)

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Agenda

- Introduction
- Background
- Research objectives
- DHW Sizing Methods
- Subject Matter Expert Interviews
- Comparison with Site Data
- GAHP Site Screening Criteria
- Conclusions

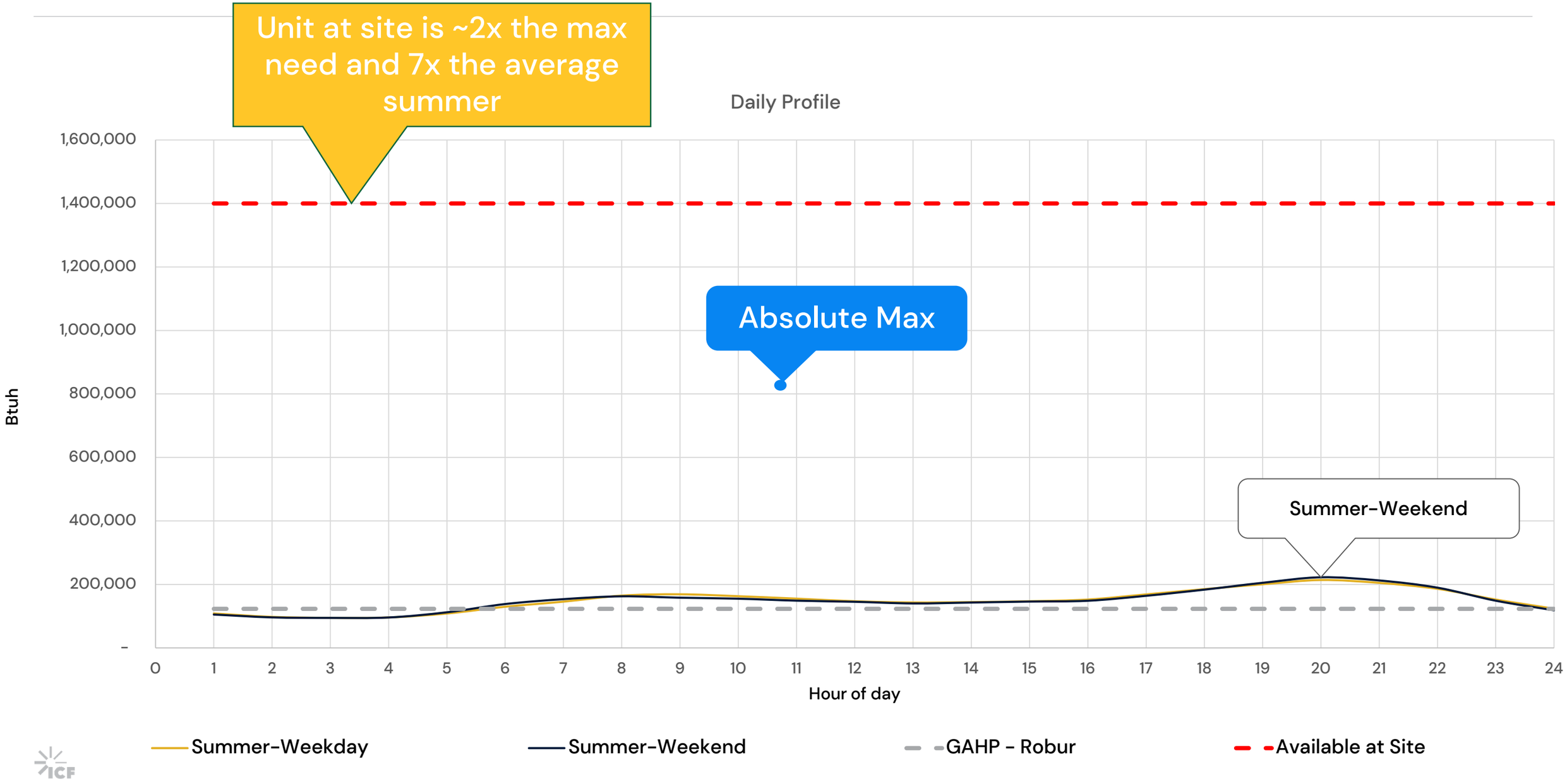
Introduction: Gas Absorption Heat Pump Water Heaters (GAHPs)

- Investigating site screening criteria and sizing methods for GAHPs in domestic hot water (DHW) systems, a novel application with unique challenges.

- Traditional DHW heaters are often oversized, while GAHPs require a minimum load to operate efficiently (recommended at 40-60% of maximum DHW load).

- Many contractors lack the expertise to size GAHPs; the project aims to provide tools for site screening, GAHP sizing, and system design to aid adoption in the multifamily sector.

Background- Site 1 data



Research objectives

Study Objectives:

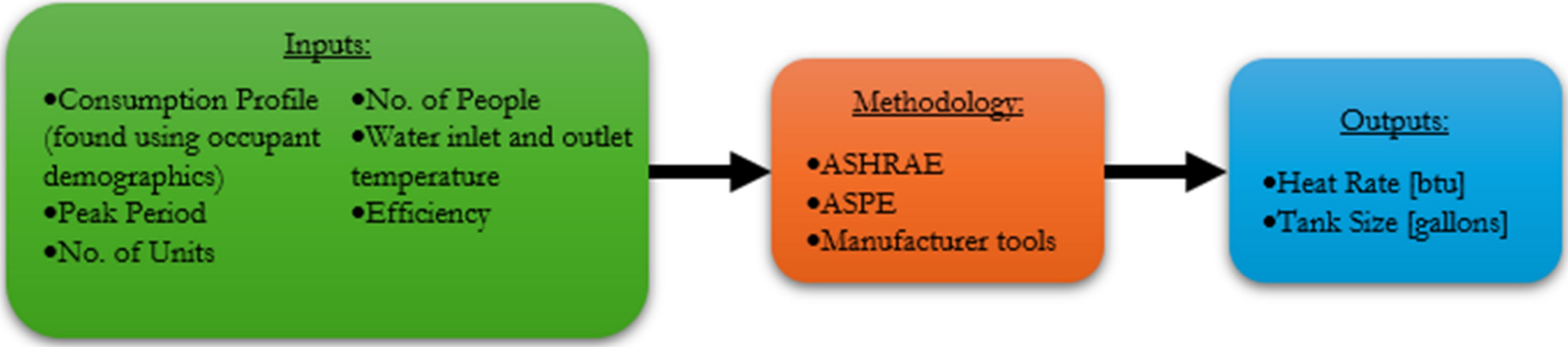
1. Investigate DHW sizing methods in multifamily and hotel buildings in California.
2. Evaluate accuracy of these methods in calculating site-specific minimum DHW loads.
3. Analyze applicability of methods for GAHP systems and provide recommendations for improvement.
4. Develop site screening criteria and GAHP sizing tools tailored for contractors.

Expected Outcomes:

1. Identification of the most-used DHW sizing methods in California's multifamily and hotel/motel buildings.
2. Comparison of expected DHW loads from sizing methods vs. actual natural gas billing and site data.
3. Recommendations for key data points needed for site screening, GAHP sizing, and system design.

DHW Sizing Methods

- Literature review of DHW Sizing methods
- ASHRAE and ASPE are considered the same
- 3 manufacturer tools were considered, each with different load profiles



Analyzing DHW Sizing methods

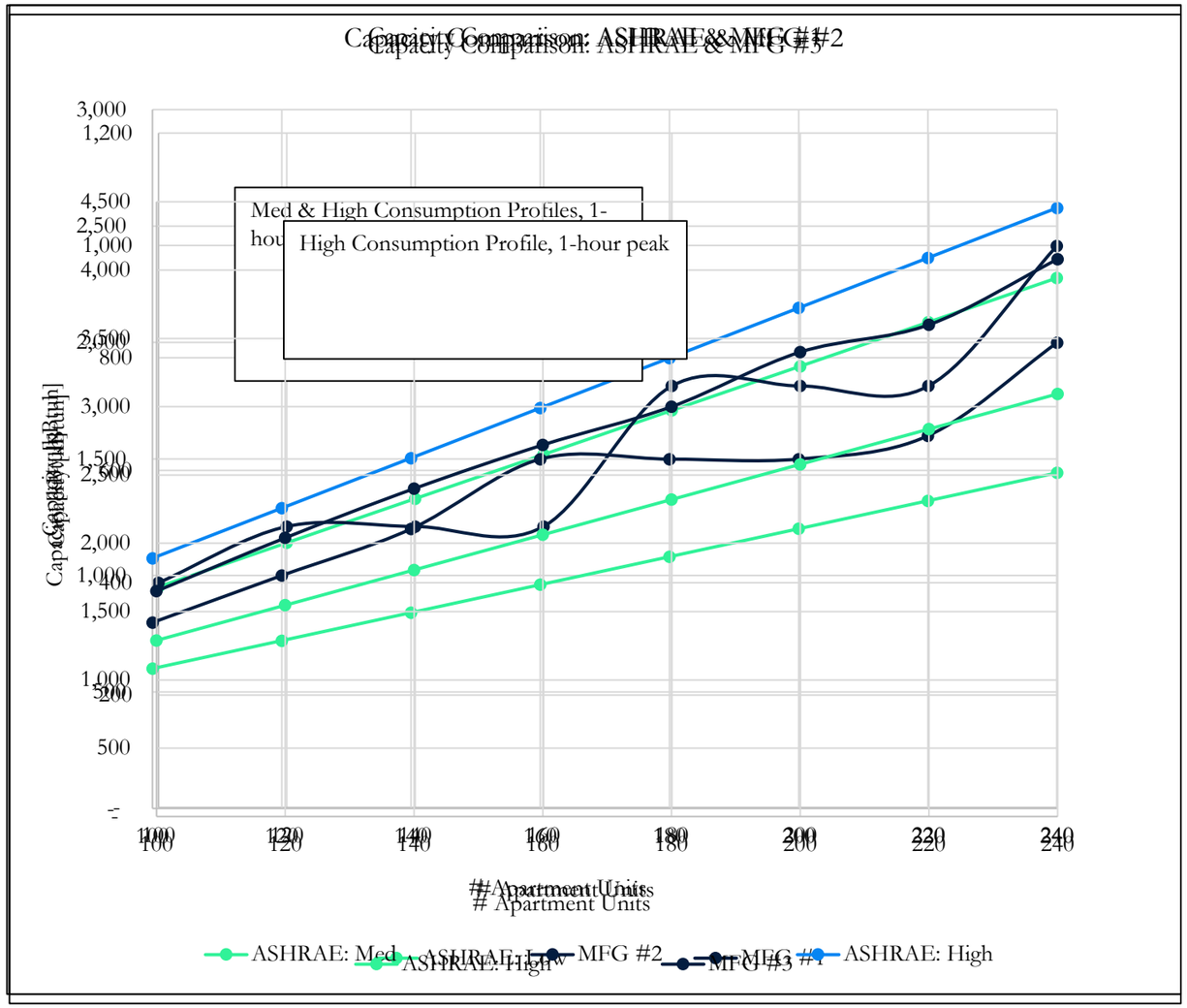
Sizing methods: Handbooks, Codes, and Manufacturer tools.

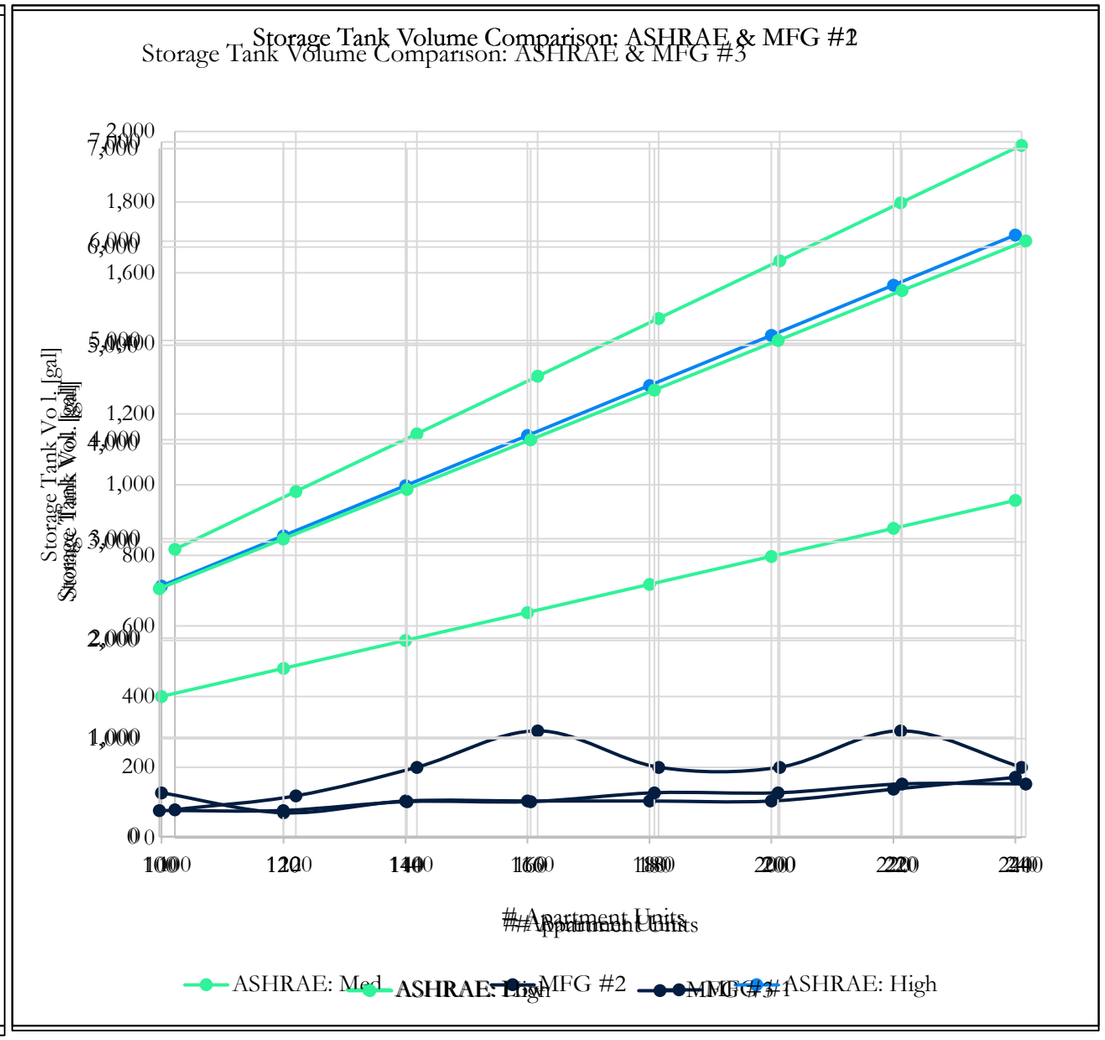
Analyzing DHW Sizing methods

Major Findings:

- The codes have no DHW sizing calculations
- ASHRAE and ASPE share data
- Manufacturer tools & ASHRAE
  - Same demographics
  - match heat rate but not storage volume
- ASHRAE values are from 30-40 years ago

Comparison: ASHRAE v. Manufacturer Tools





Subject Matter Expert Interviews

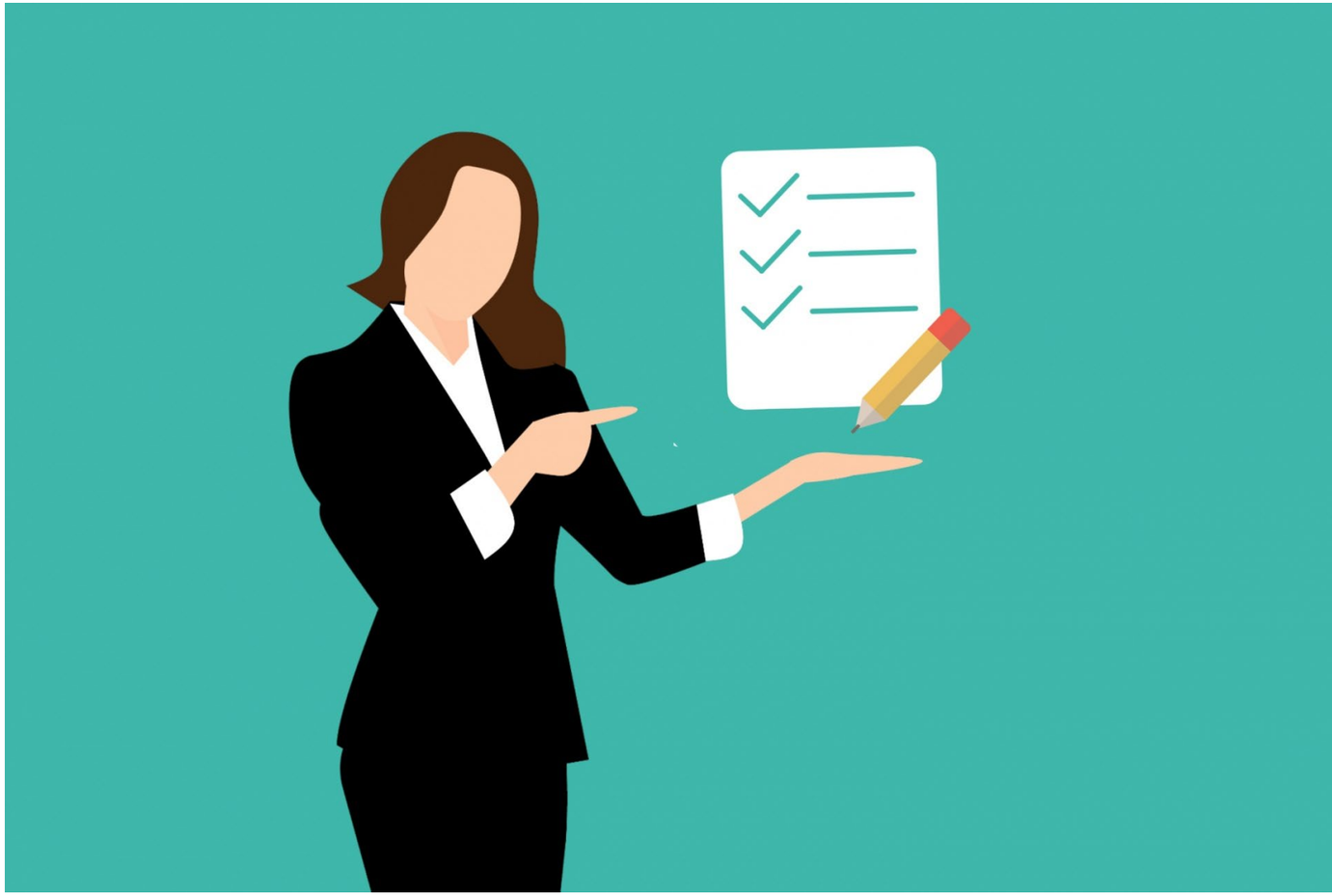
Subject Matter Experts Interviewed

Type of SMEs interviewed

- Contractors
- Manufacturers
- Technical Experts

Questions

- Issues regarding sizing
- Key Components considered for sizing
- Most utilized resources
- Key components considered for selection
- Ways to account for demand increase



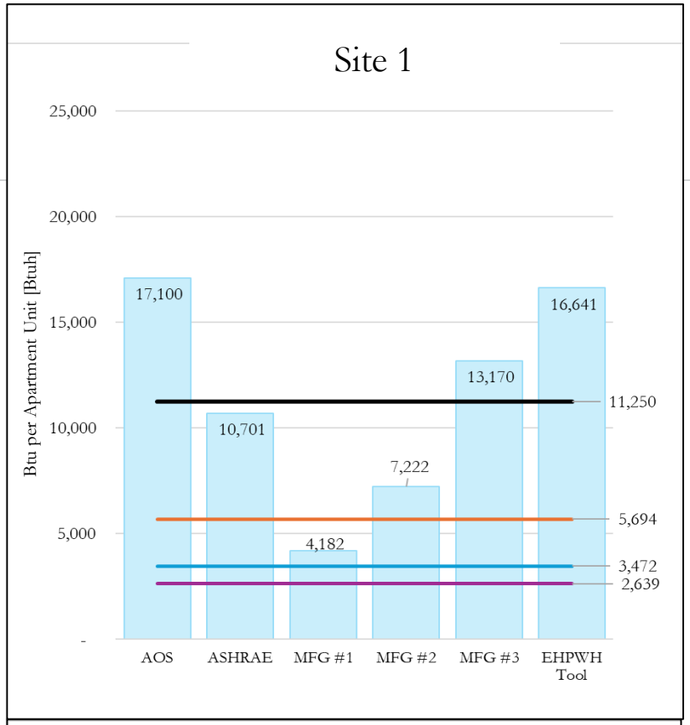
SME interviews

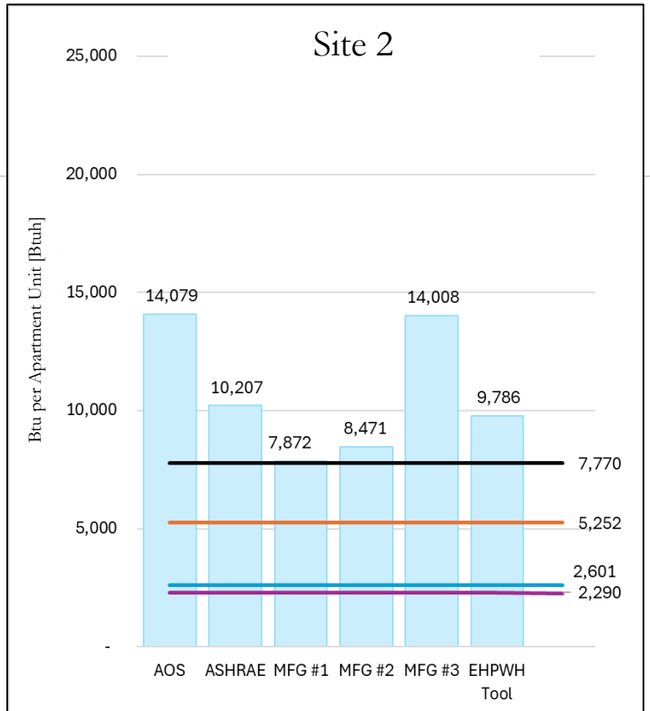
Key Findings

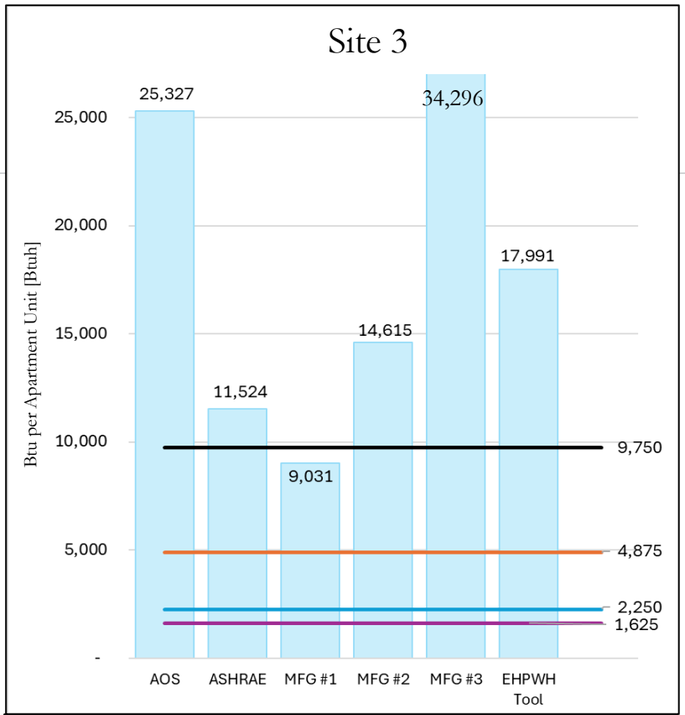
- Water Heater Replacement
  - Primary cause: Failure
  - Primary Issue: Oversizing
- Different SMEs = Different Practices
- Key Sizing Component
  - Number of Occupants
- Preferred Sizing Tool
  - ASHRAE's handbook
- Top Equipment Selection Consideration
  - Heat Rate (Capacity)
- Account for Future Demand
  - Providing space for storage
    - Ensure capacity in gas lines and electrical panels

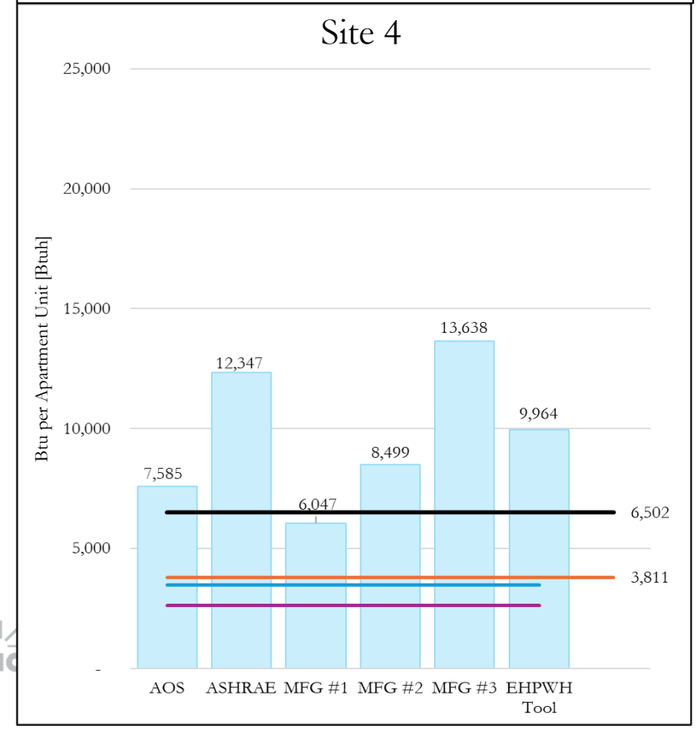
Comparison with Site Data

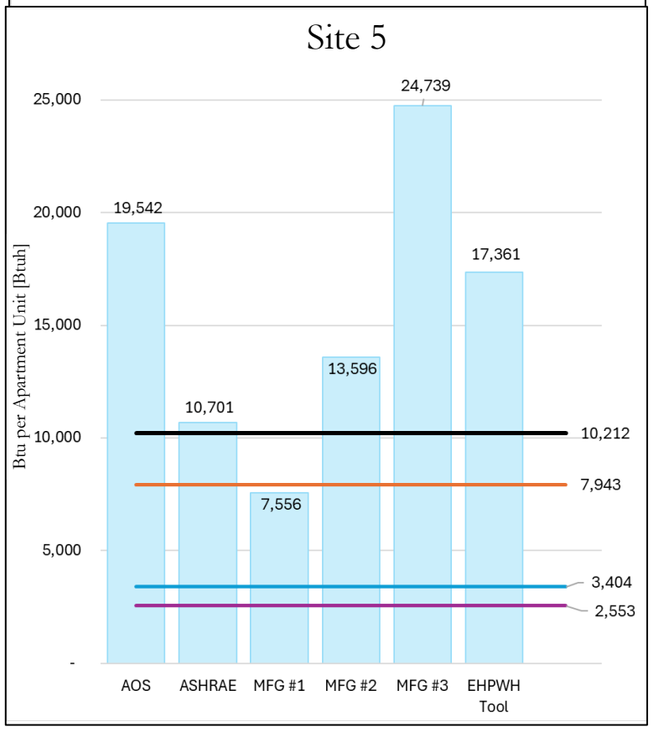
- Data Sources
  - Hourly gas billing data for multifamily properties in California
  - Compared to ASHRAE, Manufacturer tools, and EHPWH sizing tool
- Purpose:
  - Compare max DHW loads to sizing tool recommendations.
  - Highlight inconsistent sizing by DHW tools.

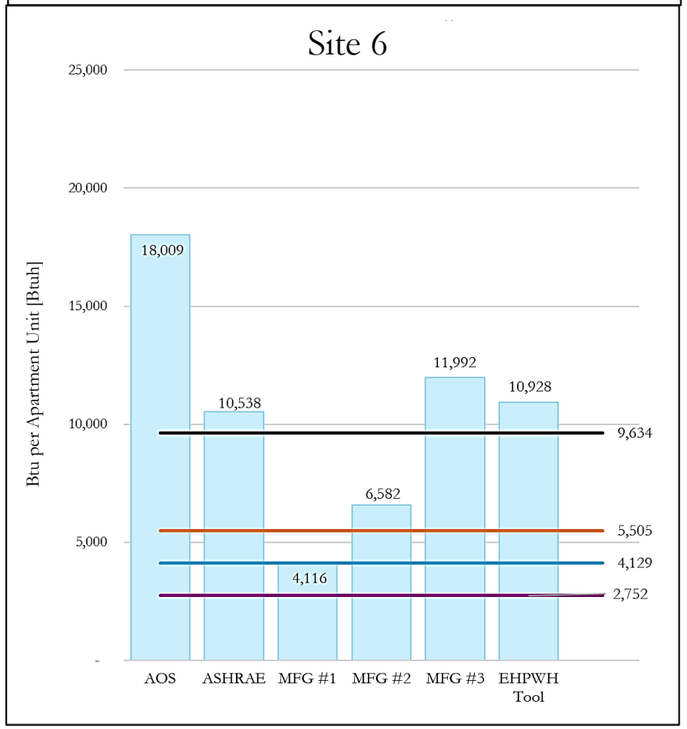












Sizing Tools Equivalent Peak Capacity

100th Percentile

99th Percentile

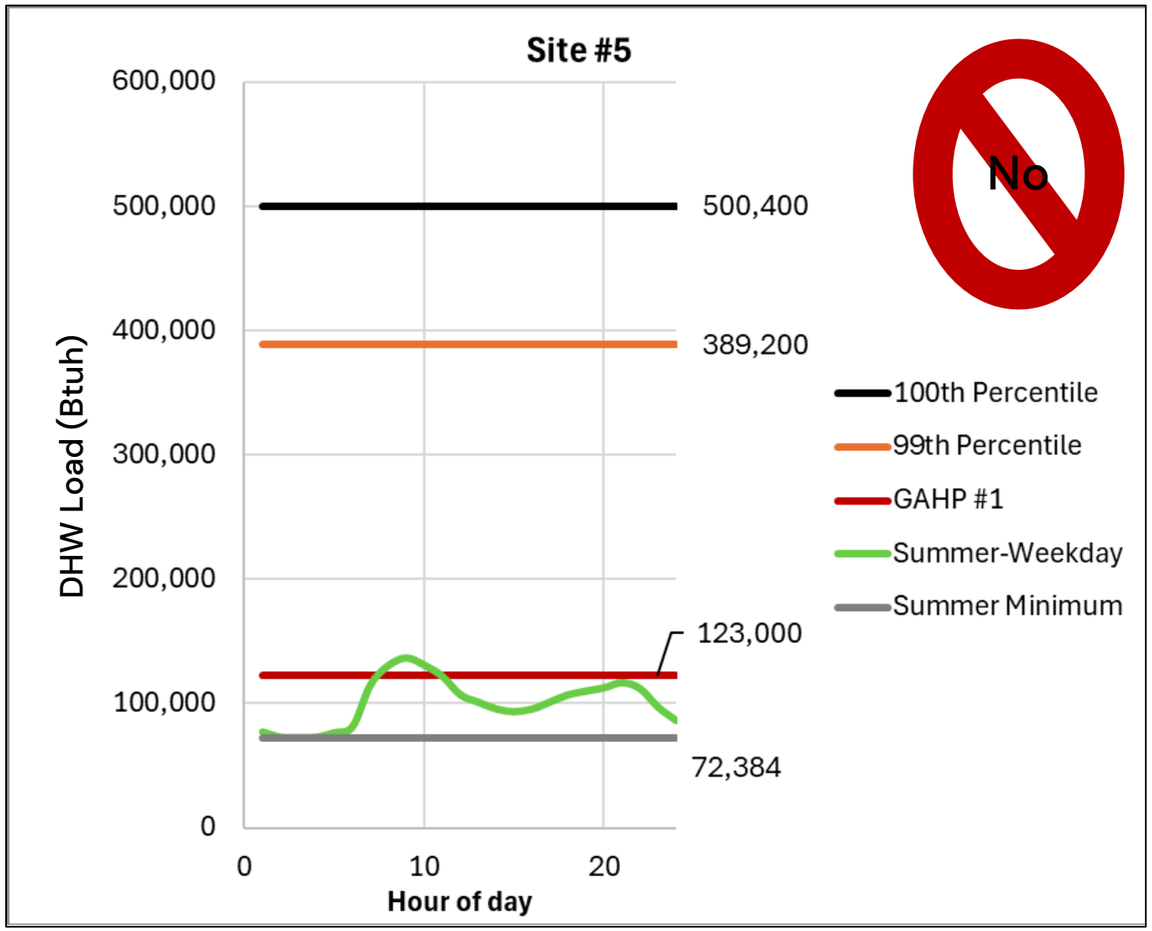
75th Percentile

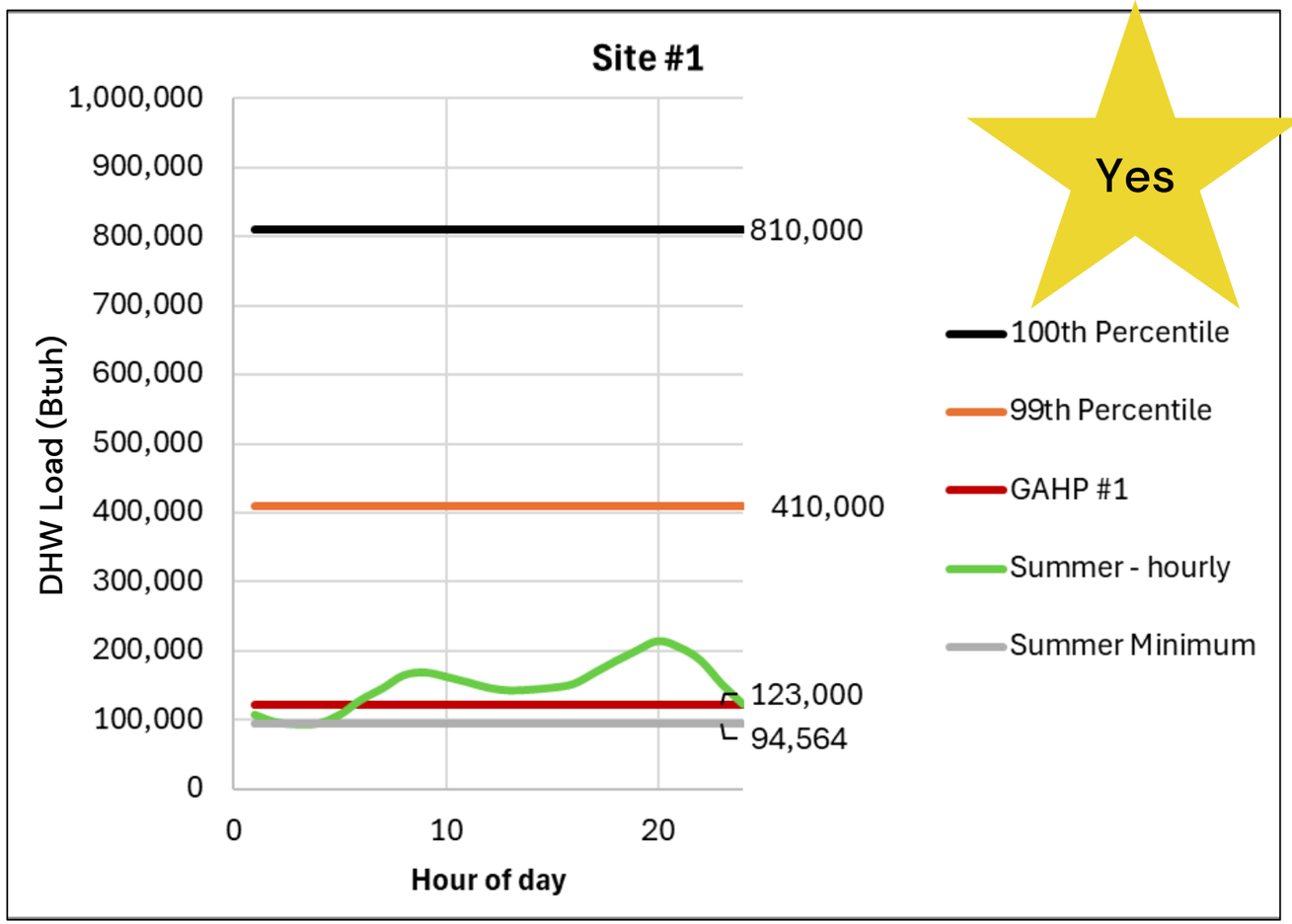
50th Percentile

Comparing Actual Water Heating Loads to Manufacturer Recommendations

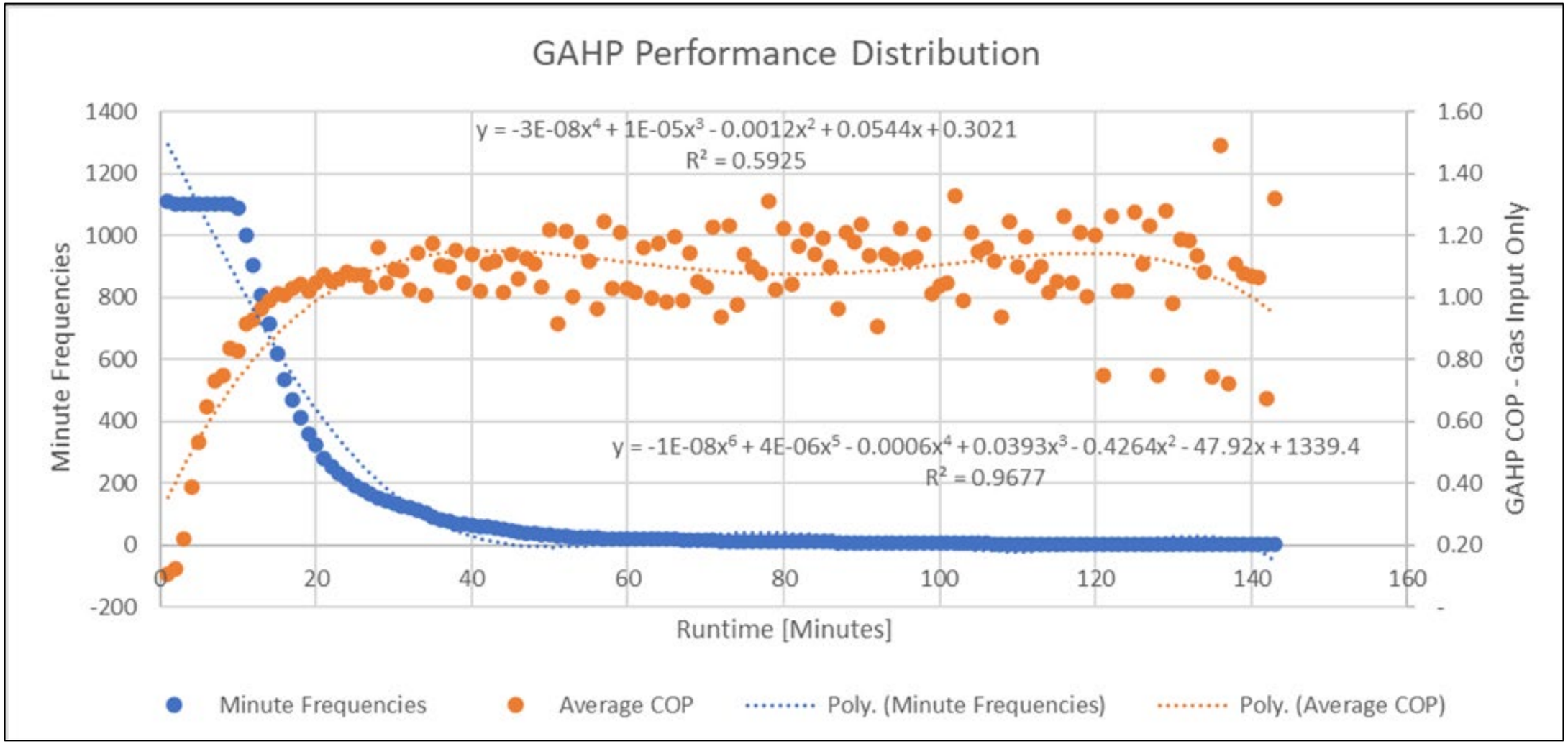
- Site Capacity Oversizing:
  - Existing systems are oversized except at Site #4.
- ASHRAE Tool:
  - Most consistent, accurately predicts 100th percentile at most sites.
  - The team assumes 2.6 people/unit, which can overestimate usage for studios.
- Manufacturer Tools:
  - MFG #1: Usually under sizes to the 100th percentile
  - MFG #2: Closer to 99th percentile but inconsistent.
  - MFG #3: Consistently over sizes to the 100th percentile
- EHPWH Tool:
  - Consistently over sizes but aligns better at Sites #2 and #6.
- Overall Trend:
  - Tools are inconsistent; ASHRAE is the most reliable.

GAHP Capacity & Minimum Flowrate

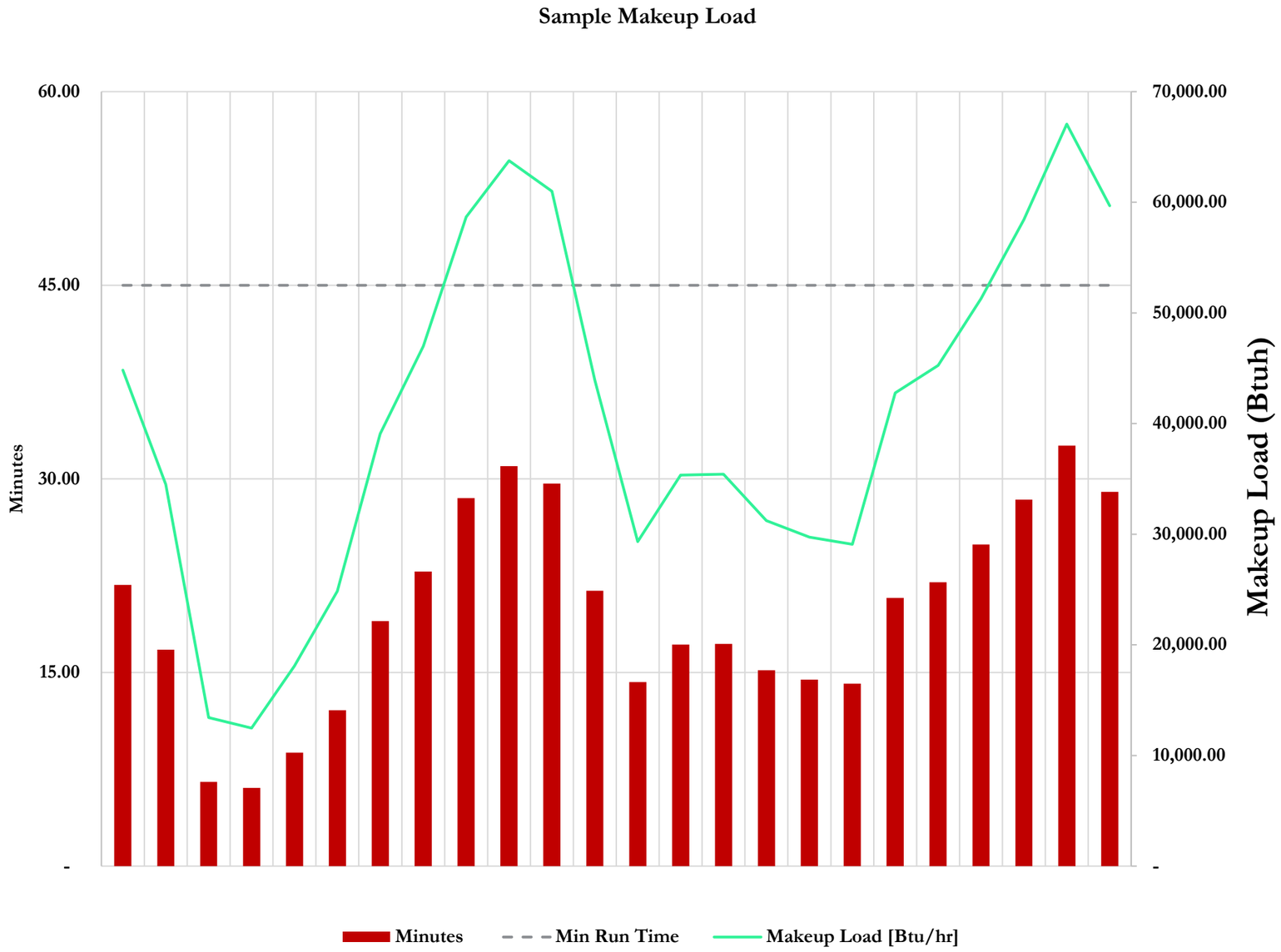




COP vs Run Time



GAHP Example



Site Screening Recommendations

- Pre-Heat Configuration:
  - GAHP handles average load, gas boiler supports peak demand.
- Hot Water Demand:
  - Minimum flowrate required, based on GAHP capacity and temperature difference.
- Operational Efficiency:
  - Continuous heating loads preferred; avoid short cycling with minimum flow rates.
  - GAHP performance varies by run time and cycle time.
- Temperature Limitations
- Storage Tank Needs:
  - Indirect storage tank for GAHP + boiler system.
  - Buffer tank with certain MFG

Cycle Time and Tank Charge time

Site 1 Example:

-
  - 45-minute GAHP run time achieves 94% efficiency, comparable to a condensing boiler.
  - Minimum flow rate for 12 cycles/day: 2.68 gal/min (3,866 gal/day).

- Feasibility of GAHP systems must be evaluated site by site using similar calculations.

- $Tank\ charge\ time\ [min] = Cycle\ Time\ [\mathrm{min}] - GAHP\ run\ time\ [min]$

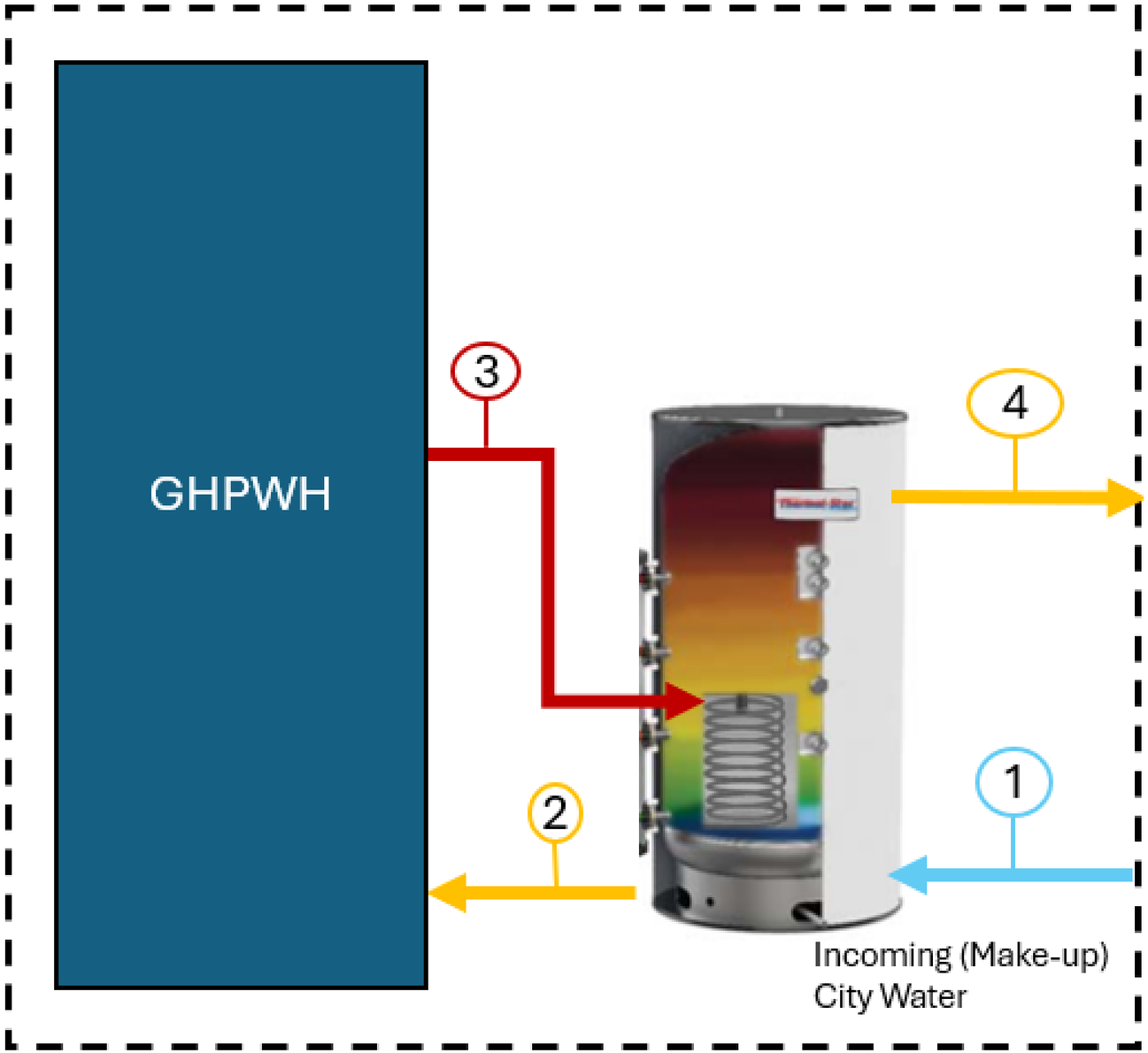
- $$Min\ Flow\ Rate\ for\ 12\ cycles\ per\ day\left[\frac{gal}{min}\right] = \frac{GAHP\ Capacity\ [Btuh] * GAHP\ Run\ Time\ [hr]}{\rho\left[\frac{lbm}{gal}\right] c_p\left[\frac{Btu}{°\mathrm{F}-lbm}\right] \Delta T\ [°\mathrm{F}]\ (Tank\ Charge\ Time\ [min]}$$

Minimum Flowrate, Indirect Storage & Buffer Tank Volume

- Minimum Flowrate

  - $Min\ Flow\ Rate\ \left[\frac{Gal}{hr}\right] = \frac{GAHP\ Capacity\ \left[\frac{Btu}{hr}\right]}{\rho\left[\frac{lbm}{gal}\right] c_p\left[\frac{Btu}{lbm-°F}\right] \Delta T\ [°F]}$

- Indirect Storage Tank Vol
  - $Indirect\ Storage\ Tank\ Vol\ [Gal] = \frac{GAHP\ Capacity\ [Btuh] * GAHP\ run\ time\ [hr]}{\rho\left[\frac{lbm}{gal}\right] c_p\left[\frac{Btu}{°F-lbm}\right] \Delta T\ [°F]}$



Conclusion

Key Takeaways:

- Inconsistent Sizing and Oversizing:
  - DHW systems often oversized.
  - Tools vary widely in predicting peak loads.
- GAHP Challenges:
  - GAHP sizing lacks a tool for predicting summer minimum load.
- ASHRAE & SME Insights:
  - ASHRAE most reliable; sizes based on occupancy.
  - Contractors rely heavily on manufacturer recommendations.
- Future Research Needs:
  - Summer load prediction methods.
  - Development of a GAHP screening and sizing tool.

Presentations at conferences

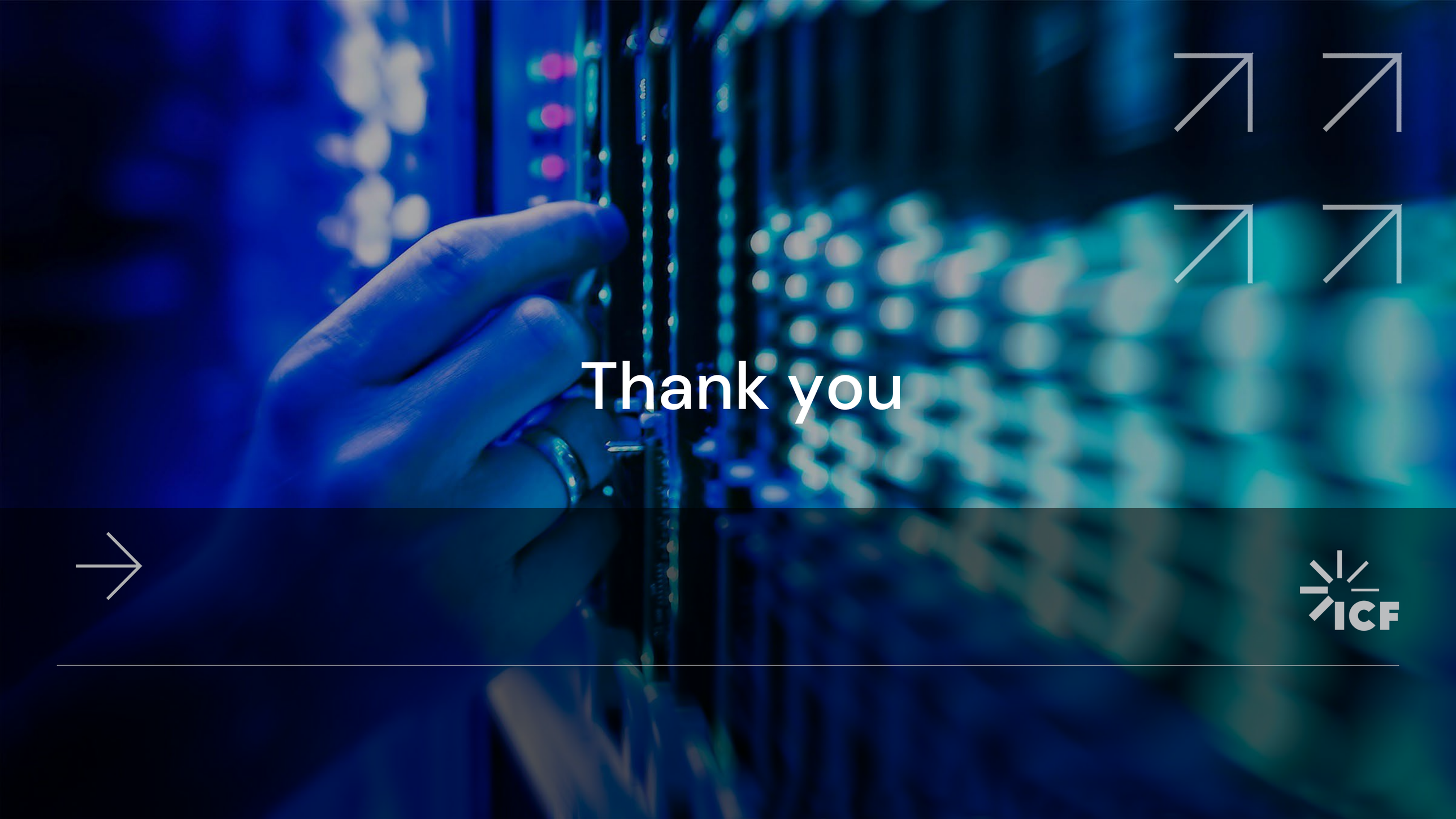
This research was presented at the following conferences:

2024 ETCC, California

ACEEE Hot Water and Hot Air Forum, Atlanta

ACEEE Hot Water and Hot Air Forum, Portland

Approved paper for 2025 Winter ASHRAE Conference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