ET Summit 2024

Presented by

Best Practices to Have an Efficient Central Heat Pump Water Heater System in Multifamily Applications: A Laboratory Evaluation

This presentation focuses on evaluating the performance of central heat pump water heaters (HPWHs) for multifamily applications, with an aim to find best practices for integrating hot water storage tanks to enhance system efficiency. Conducted at PG&E's Applied Technology Services Research Laboratories, the project simulated hot water demands for a 44-unit, multifamily building and evaluated various hot water tank configurations and operation modes in a real-life sized, central heat pump water heating setup.

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Agenda

- MF HPWH Testing Project Overview
- Lab Virtual Tour
- Tests Performed
- Findings Highlights
- Questions

Project Tasks

1. Improve the domestic hot water draw schedule to provide accurate results for multifamily buildings.
2. Develop sizing methodology for multifamily Standard Design heat pump water heating systems.
3. Improve distribution system modeling to account for recirculation loops and other multifamily issues.
4. Develop installation criteria for multifamily HPWH systems.
5. Conduct performance testing of multifamily HPWH components.
6. Enhance the CBECC-Res DHW simulation model to enable multifamily HPWH compliance.

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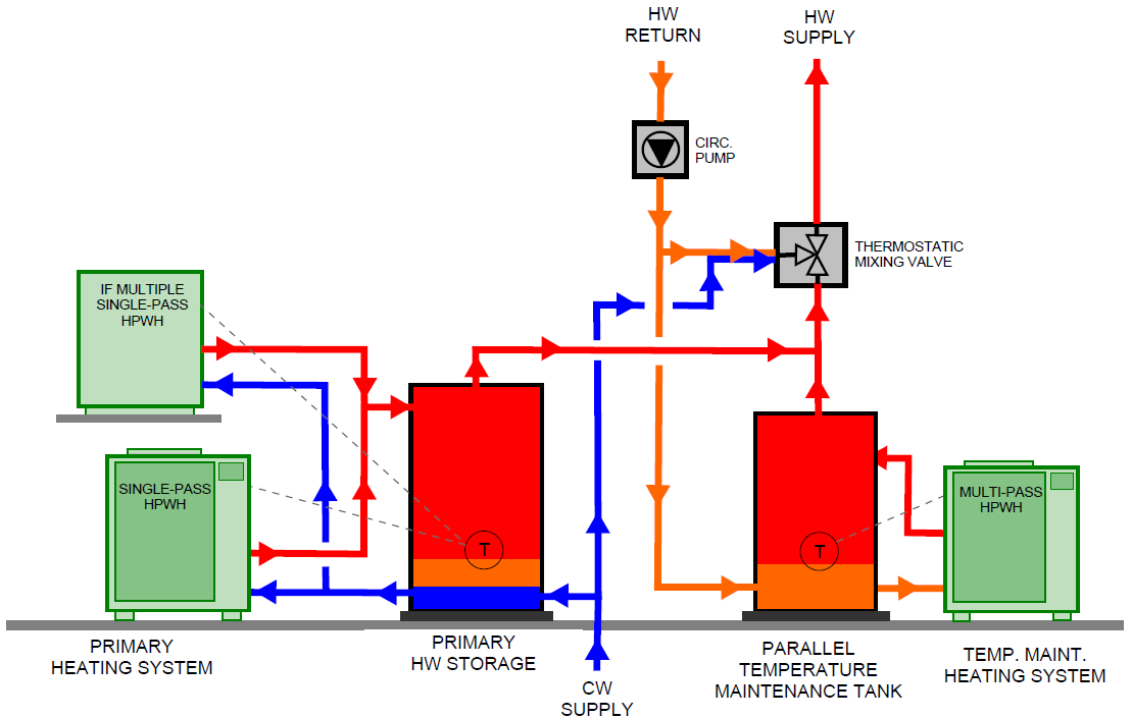
Why Lab Testing

- Unlike the single-family residential market where a one-size-fits-most systems, multifamily HPWH require more detailed designs and operation considerations.

- Also, there was a need for reliable test data to calibrate multifamily HPWH models in building energy simulation software applications such as CBECC-Res (California's Building Energy Code Compliance Software).



Example Schematic: Simplified HPWH system for a multifamily application

Image source: https://neea.org/img/documents/Advanced-Water-Heating-Specification.pdf

Applied Technology Services – PG&E

Advanced Technology Performance Lab (ATPL)

Hosts seven (7) independent, climate-controlled test chambers and a flow loop facility for calibrating flow meters

- Four (4) chambers currently dedicated to testing residential and commercial HVAC systems up to 15 tons
- Three (3) chambers currently dedicated to testing commercial & residential water heaters and hot-water distribution systems

Heat Pump Water Heater System Testing

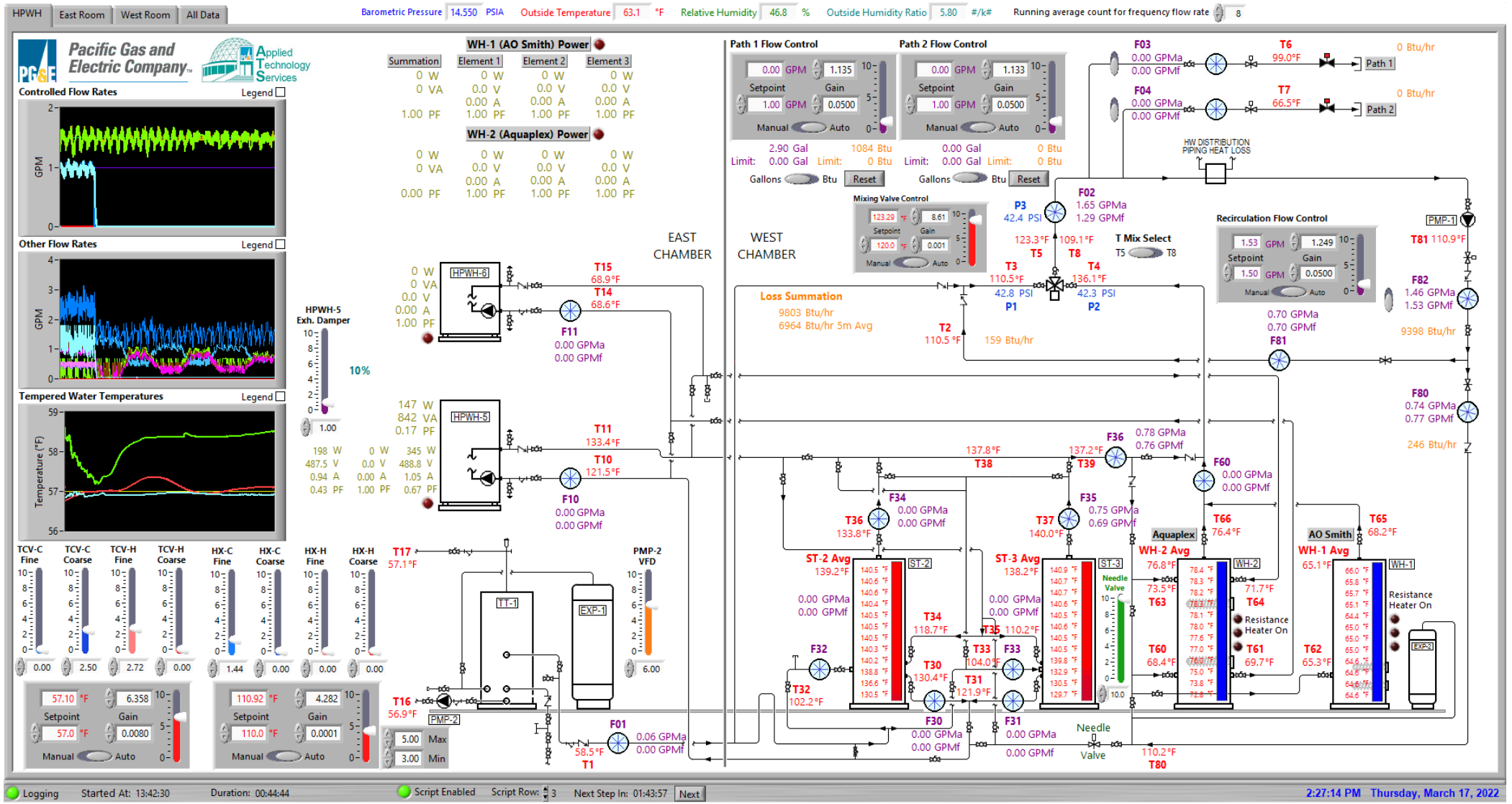
Hot Water Distribution System Testing

Lab Setup

HPWH test chambers were constructed with dimensions of 14.5’ in length 12’ in width and 12’ in height. The chambers sizes and placement of equipment were chosen to adequately accommodate a range of various HPWH sizes.

Placement of equipment in test chambers

Lab Setup


HPWH
East Room
West Room
All Data
Barometric Pressure 14.550 PSIA
Outside Temperature 63.1 °F
Relative Humidity 46.8 %
Outside Humidity Ratio 5.80 #/k#
Running average count for frequency flow rate 8
Pacific Gas and Electric Company
Applied Technology Services
Controlled Flow Rates
Other Flow Rates
Tempered Water Temperatures
Temperature (°F)
WH-1 (AO Smith) Power
WH-2 (Aquaplex) Power
Summation
Element 1
Element 2
Element 3
Path 1 Flow Control
Path 2 Flow Control
Setpoint
Gain
Manual
Auto
Reset
Mixing Valve Control
Recirculation Flow Control
T Mix Select
HW DISTRIBUTION PIPING HEAT LOSS
EAST CHAMBER
WEST CHAMBER
HPWH-6
HPWH-5
HPWH-5 Exh. Damper
10%
Loss Summation
9803 Btu/hr
6964 Btu/hr 5m Avg
159 Btu/hr
9398 Btu/hr
246 Btu/hr
Aquaplex
AO Smith
WH-2 Avg
WH-1 Avg
ST-2 Avg
ST-3 Avg
Needle Valve
Resistance Heater On
TCV-C Fine
TCV-C Coarse
TCV-H Fine
TCV-H Coarse
HX-C Fine
HX-C Coarse
HX-H Fine
HX-H Coarse
PMP-2 VFD
TT-1
EXP-1
PMP-2
PMP-1
EXP-2
Logging
Started At: 13:42:30
Duration: 00:44:44
Script Enabled
Script Row: 3
Next Step In: 01:43:57
Next
2:27:14 PM Thursday, March 17, 2022

Lab Setup

To switch between the plumbing configurations, the lab set up a bank of valves to toggle flows on and off.

Main configuration switching station before and after insulation

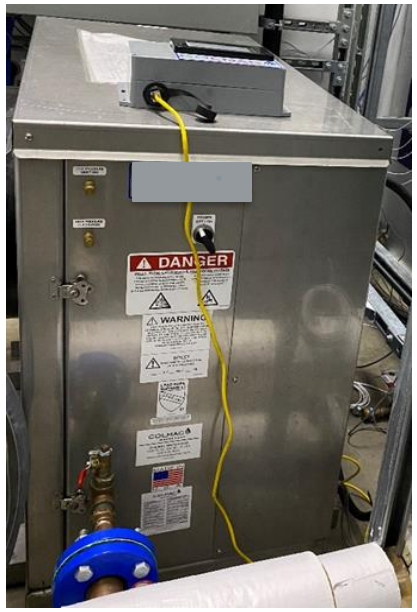
Lab Setup

To simulate a building recirculation loop heat losses water is piped through a water-to-water heat exchanger which can be set to the varying heat loss rates needed in testing

Simulated circulation loop

Lab Setup

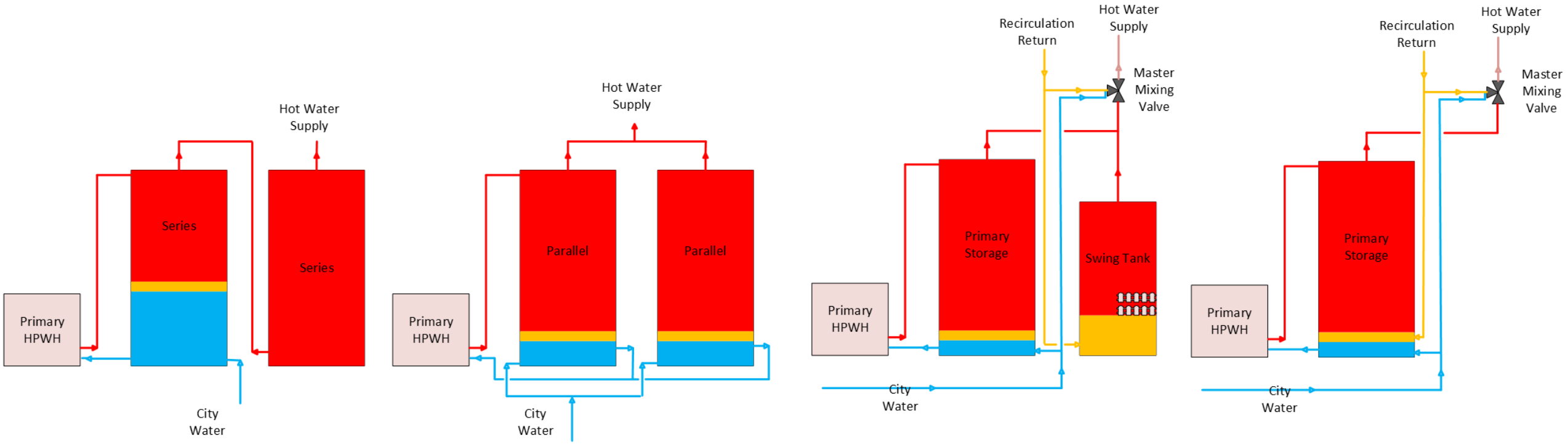
Examined a range of products and refrigerants representative of the central HPWH market today, including split units using CO2, R-134a, R-410a refrigerants, single pass heating, multi-pass heating, as well as integrated tank HPWHs.



Various commercial sized HPWHs tested

Application Tests

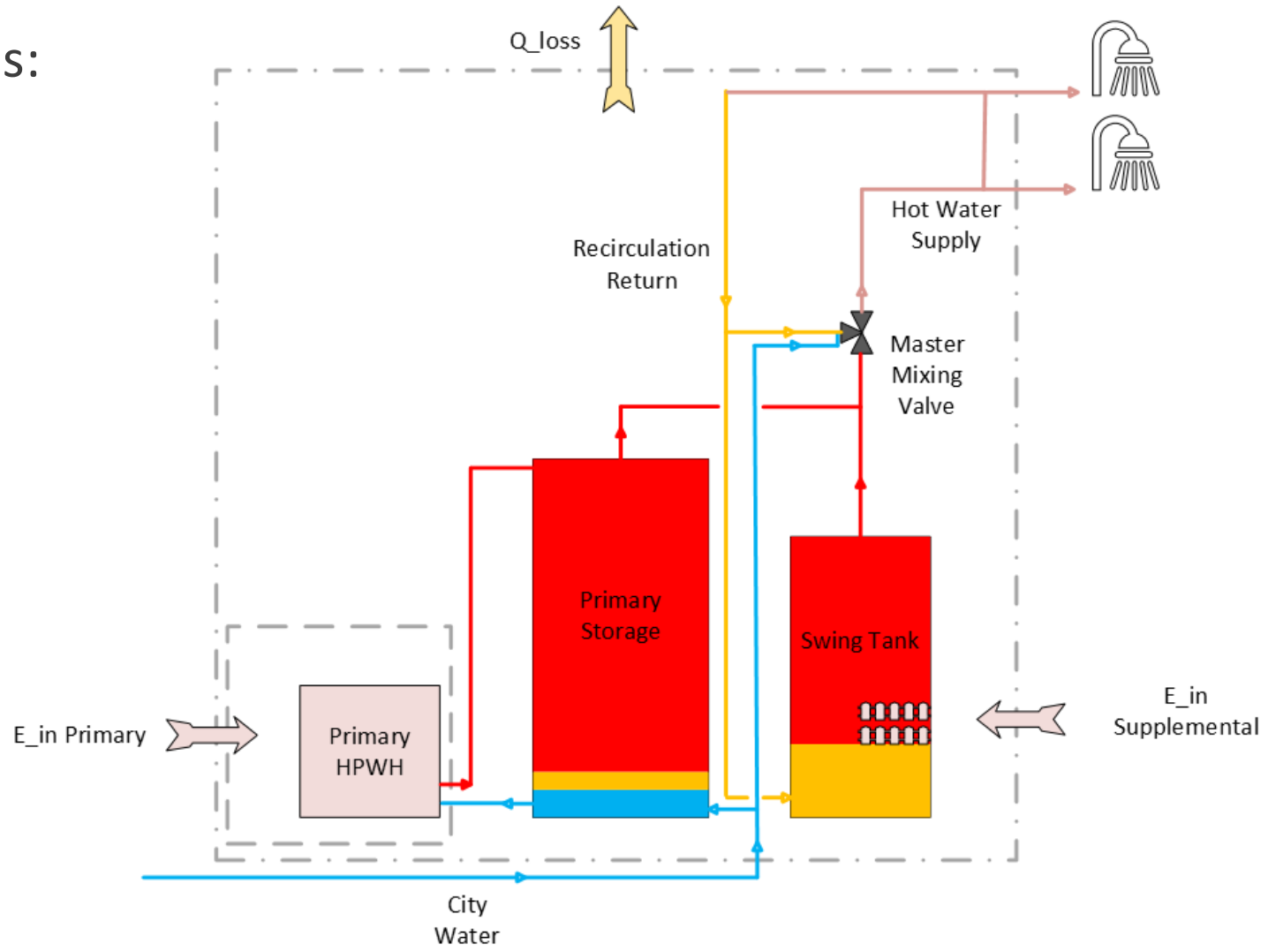
24-h application tests were conducted to measure the performance of various design configurations under similar operation conditions (~300 tests).



Application Tests

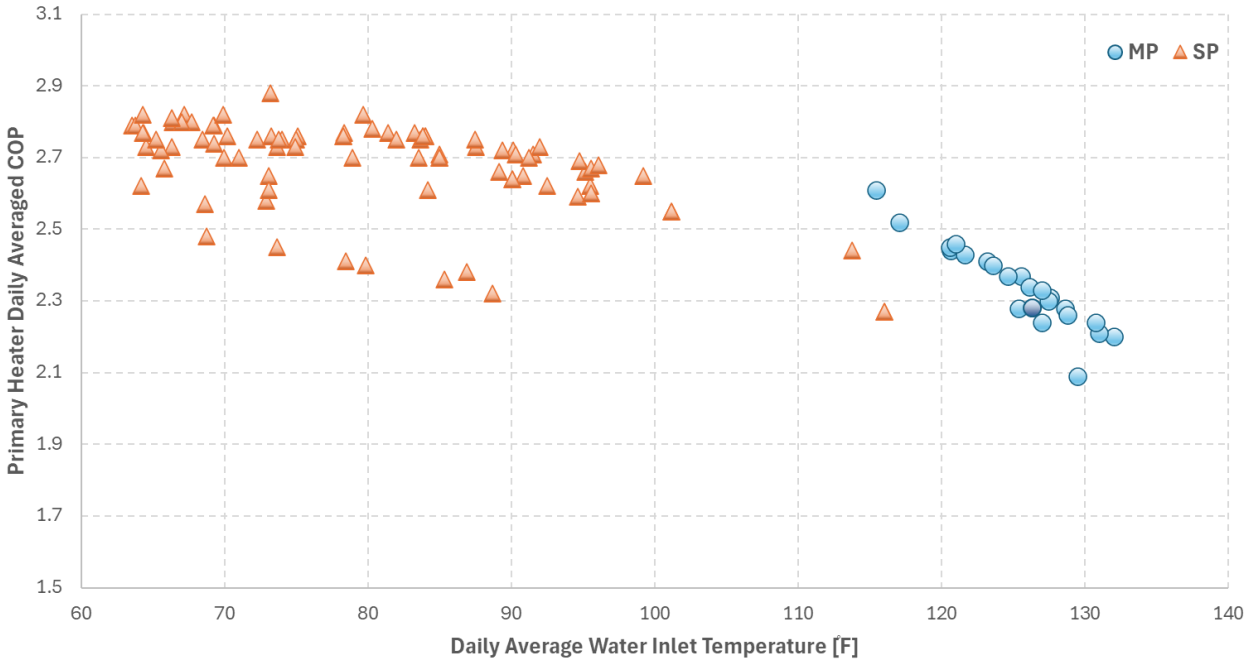
Energy Balance Boundaries:

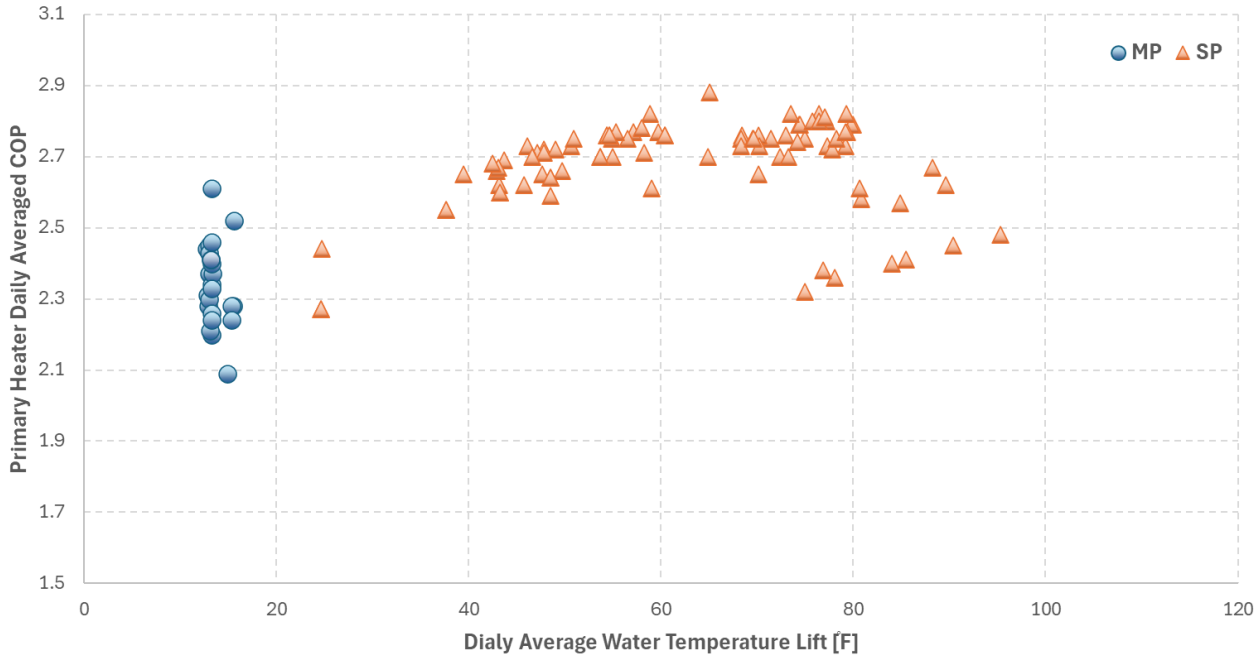
- Primary heater COP
- System COP



Observations

Single Pass Vs. Multi Pass





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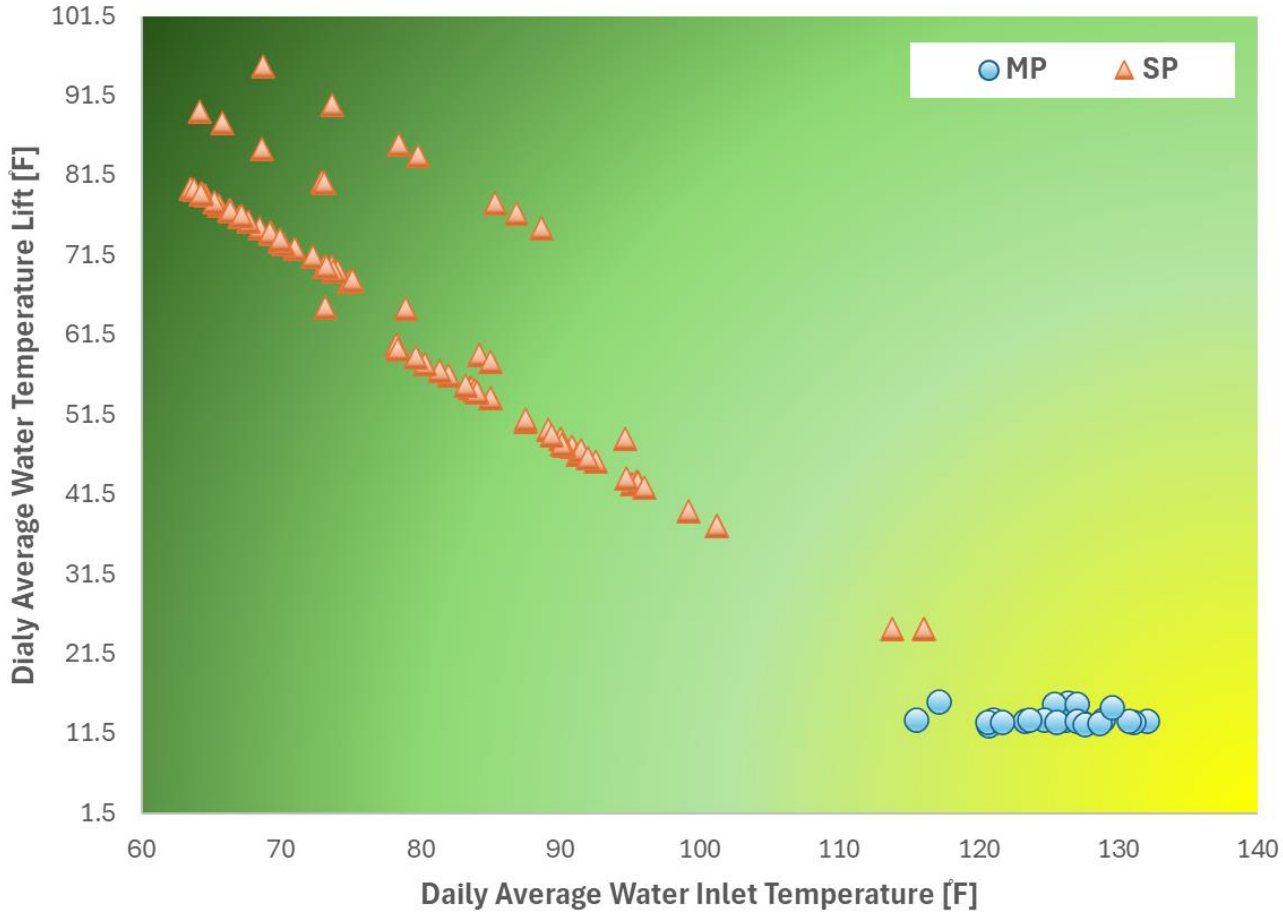
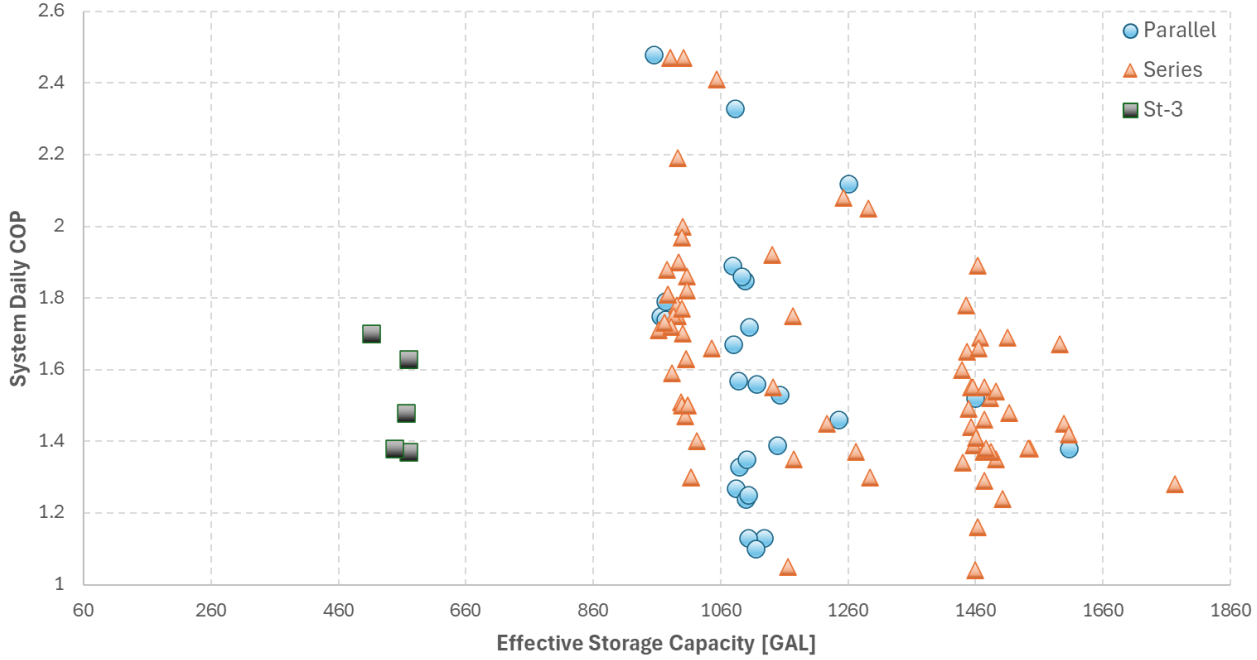
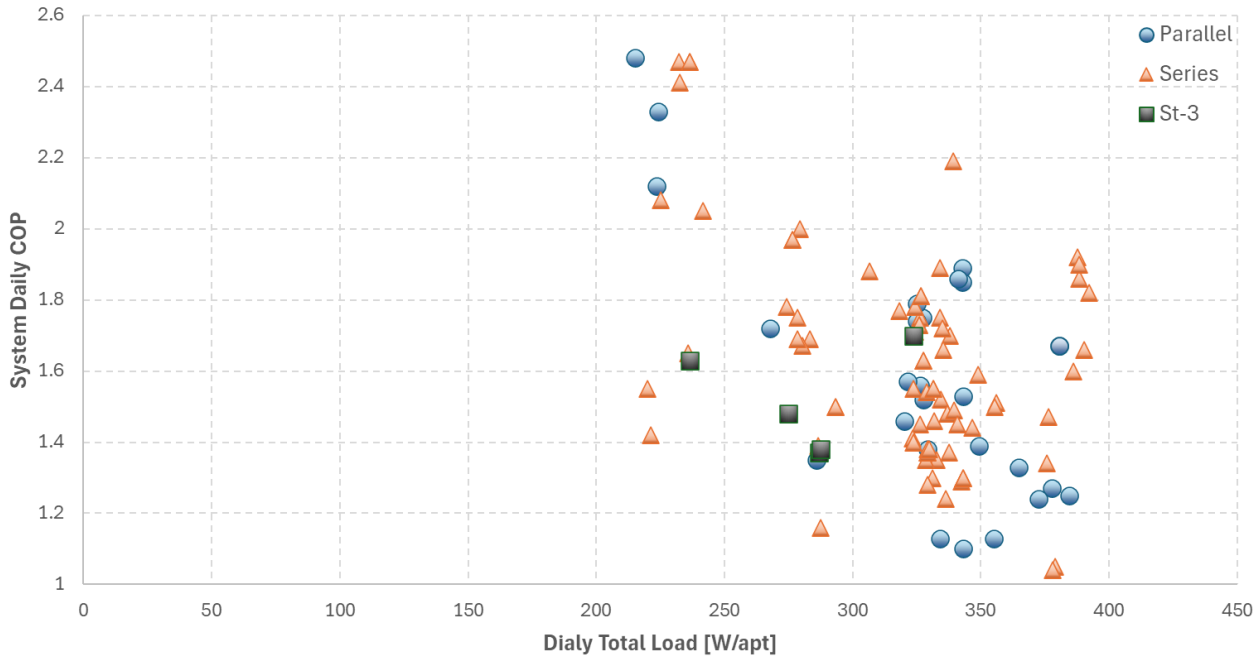


Observations

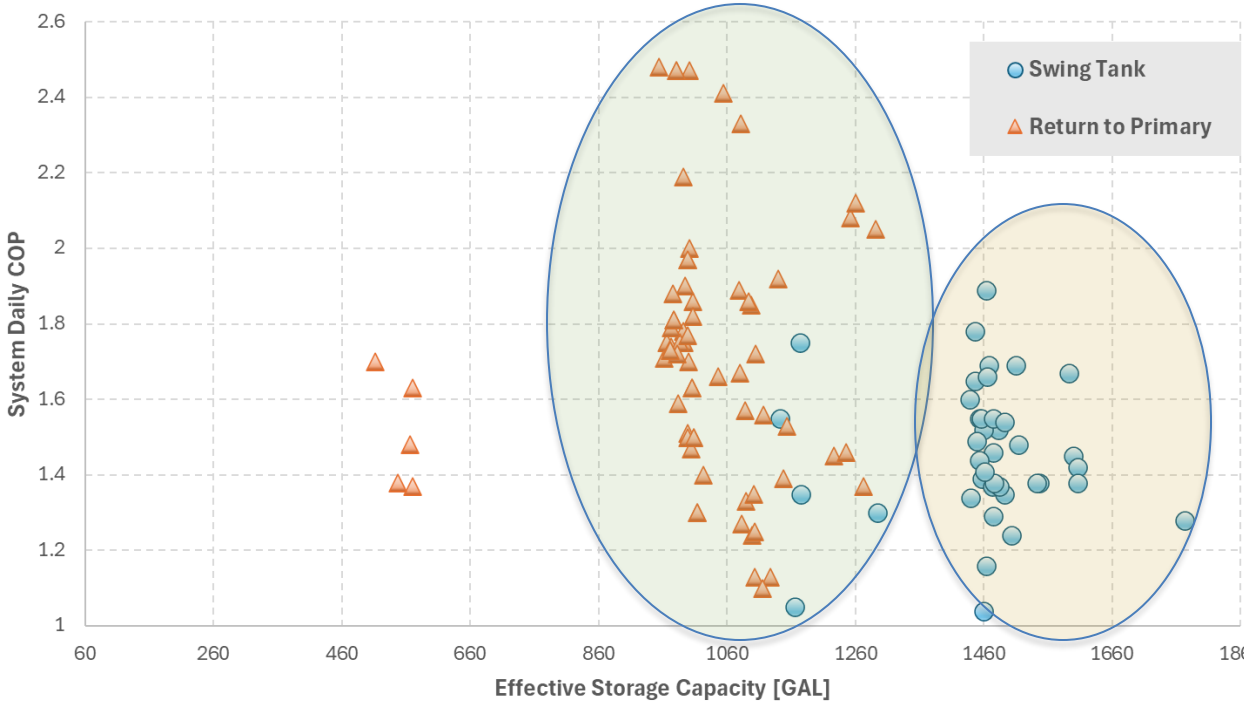
Water Storage Tanks in Series Vs. Parallel Water Storage Tanks

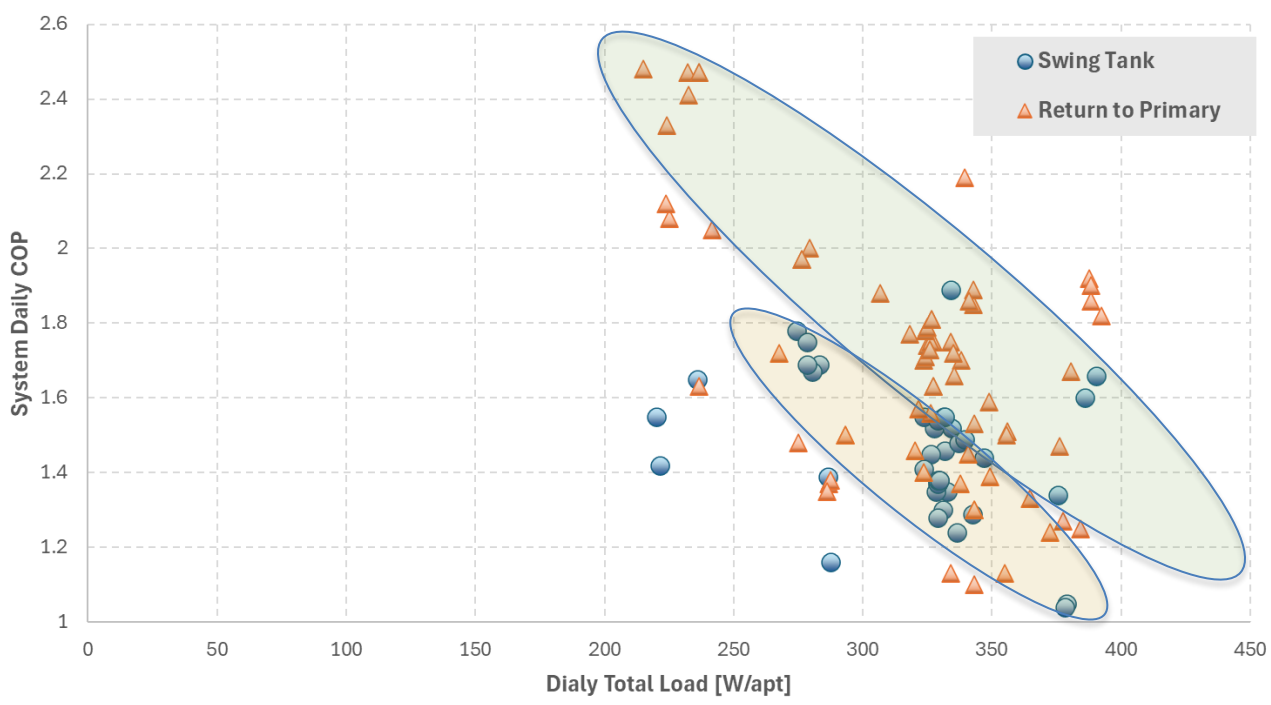




Observations

Return to Primary Vs. Swing Tank





Findings Highlights

- There is no **“one size fits all”** configuration. The specific system configuration to use for a given building depends on multiple factors ranging from climate and building size to equipment and space availability as well as cost.
- Single-pass return to primary configurations performed well for the split heat pump products. They produced the highest efficiency of all the tested configurations for these type of equipment.
- As a general note, the system with lowest average water inlet and relatively high lift temperature across the heat pump water heater will result in highest primary heater daily performance.
- Adequate storage capacity is necessary for high system performance.
- Parallel hot water storage tank configuration can provide reliability as well as high system performance.

Acknowledgement:

This project is supported by PG&E's Codes and Standards program, with the intention of providing data for the development of Statewide Building Codes Advocacy and codes and standards enhancement (CASE) proposals for consideration by the California Energy Commission to advance the California Energy Code (Title 24, Part 6). CASE proposals can be found at title24stakeholders.com

Questions?

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