Energy Efficiency Modeling of GAHPs

ET22SWG0009 – Public Dissemination

California Statewide Gas Emerging Technologies Program

SoCalGas
Glad to be of service®

ICF

Madeline Talebi, ICF
Energy Engineer

Jeff Maguire, NREL
Research Engineer

Joseph Robertson, NREL
Research Engineer

10/21/2025

Project Collaborators

ICF

Steven Long, P.E.
Director of Engineering (West)

Alfredo Gutierrez, P.E.
Engineering Manager

Madeline Talebi
Energy Engineer

NREL

Jeff Maguire
Research Engineer

Joseph Robertson
Research Engineer

Ramin Faramarzi, P.E.
Principal Research Engineer

Agenda

- Background & Objective
- Modeling Scenarios
- Assumptions & Results
- Recommendations

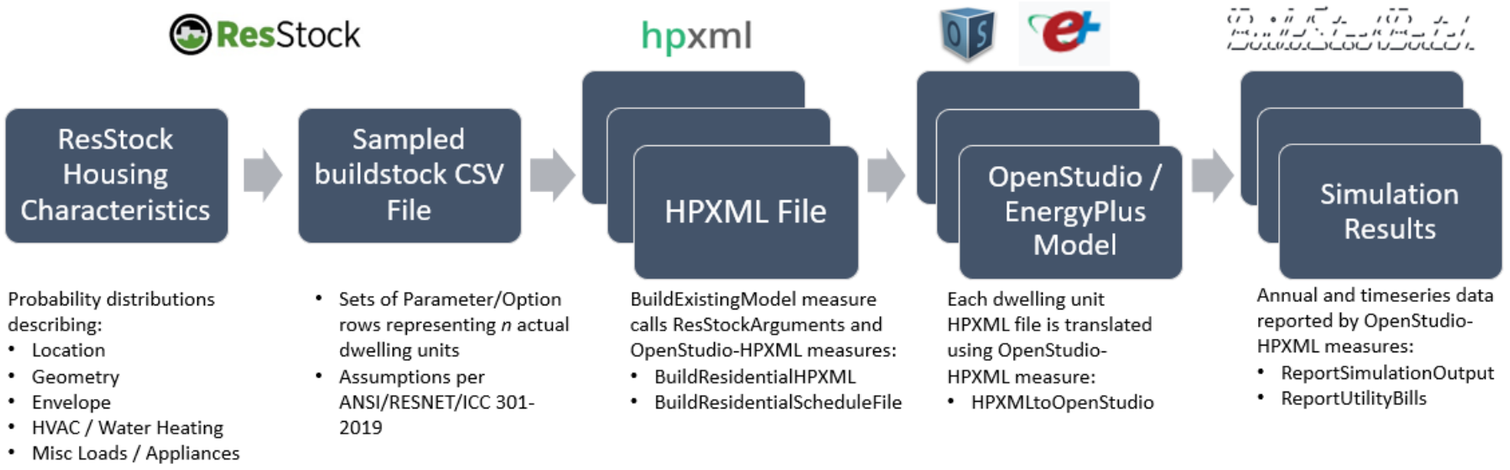
→ Gas Absorption Heat Pumps

Background on GAHPs in the multifamily sector

Emerging Technology – Gas Absorption Heat Pump (GAHP)

- GAHPs – use heat from natural gas combustion (as opposed to electricity) to transfer heat from outdoor air to indoor water
- Water heating is the largest nonindustrial end-use of natural gas in California
- Focus sector: Multifamily
- Modeling workflow:

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)



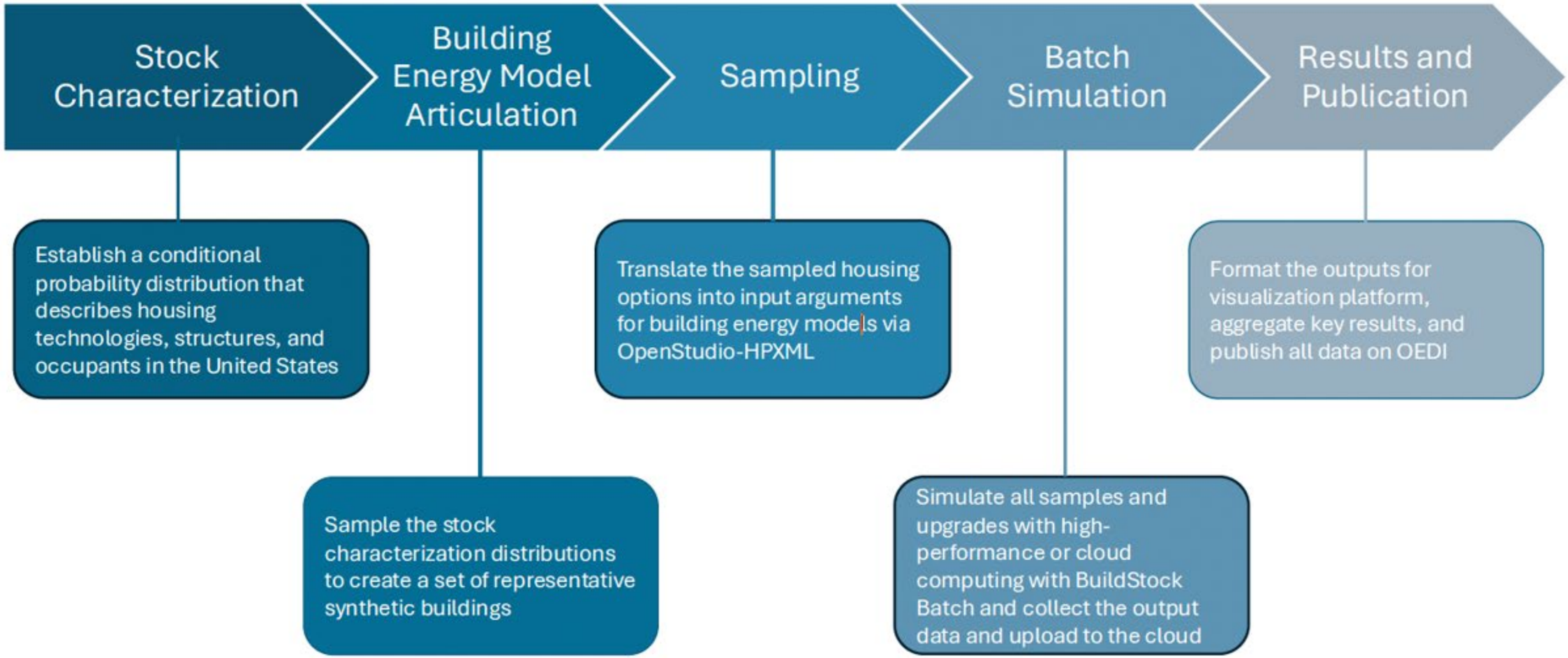
Objectives

- Take previously developed performance mapping curves and integrate into ResStock + EnergyPlus modeling software
  - Based off laboratory study on Robur GAHP-A unit with GTI Energy (ET23SWG0015)[1]
- Leverage ResStock to forecast:
  - Annual energy use
  - Operational costs (i.e., utility bills)
  - Greenhouse gas emissions
- Target sector: California Multifamily (MFm) housing stock in 16 CZs which currently uses large central boilers to satisfy load

1. Guada, Alejandro; Van Dixhorn, Lee; Fridlyand, Alex; Katz, Ari. “Robur GAHP A Performance Mapping.” GTI Energy, 2023.

Modeling Scenarios

ResStock Workflow



ResStock Building Design Scenarios

- Title 24: sets energy efficiency standards for buildings in California to reduce energy use and emissions.
- Title 20: sets minimum efficiency standards for appliances sold in California to save energy and water.

- Adoption rates:

  New construction: 100%

  Existing:
  - Central WHs: 20% every 3 years
  - PV: 1% every 3 years

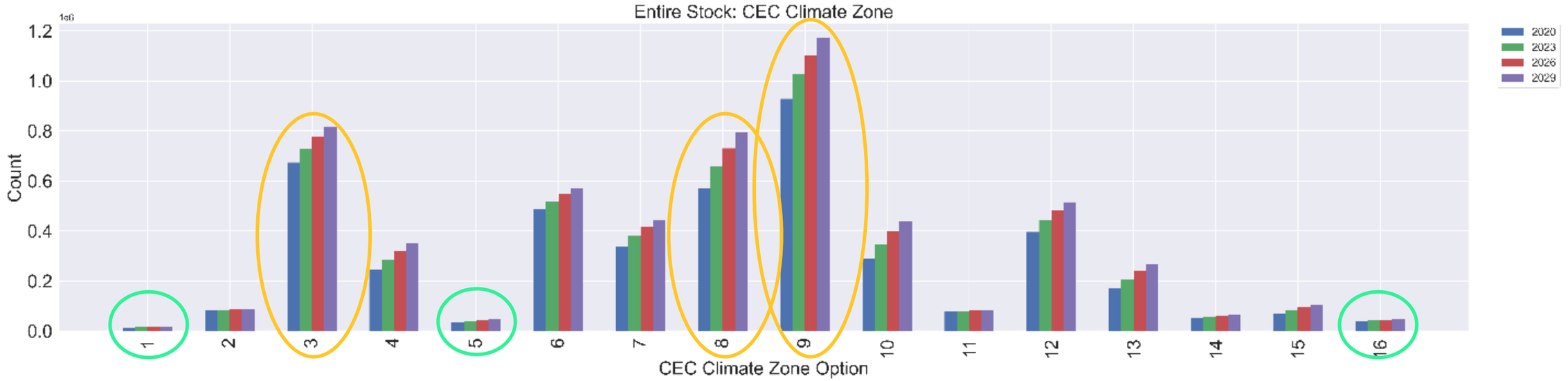
Scenario	Year	Code Basis	Electric Efficiency	Gas Efficiency	Electrification
1	2020	Existing conditions	-	-	-
2	2023	Title 24/ Title 20	Electric heat pumps	Tankless water heaters	-
3a	2026	Title 24/ Title 20 (projected)	Electric heat pumps	Condensing tankless water heaters	Baseline 1.0% by end use; Local policy for new construction (NC)
3b	2026	Title 24/ Title 20 (projected)	Electric heat pumps	Condensing tankless WHs; Condensing furnaces/boilers 50/50 condensing/conventional 0.7% GAHP	Baseline 0.1% by end use; Local policy for NC
4a	2029	Title 24/ Title 20 (estimated)	Electric heat pumps	Condensing tankless water heaters	Baseline 1.0% by end use; Local policy for NC
4b	2029	Title 24/ Title 20 (estimated)	Electric heat pumps	Condensing tankless WH; Condensing furnaces/boilers 100/0 condensing/conventional 6.5% GAHP	Baseline 0.1% by end use; Local policy for NC

BuildStock Projections

- Estimated total dwelling unit counts across the projection years according to CA CZ:

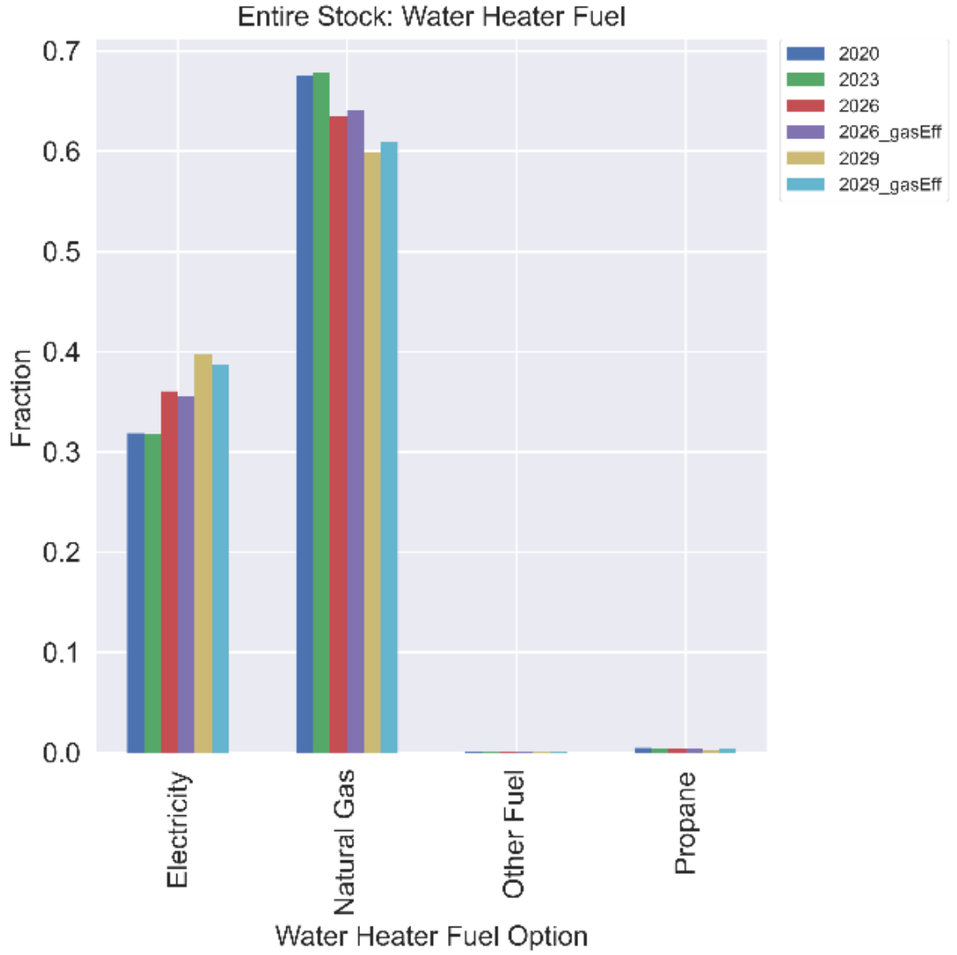
Climate Zone	Location
3	Oakland
8	Fullerton
9	Burbank-Glendale

Climate Zone	Location
1	Arcata
5	Santa Maria
16	Blue Canyon



BuildStock Projections

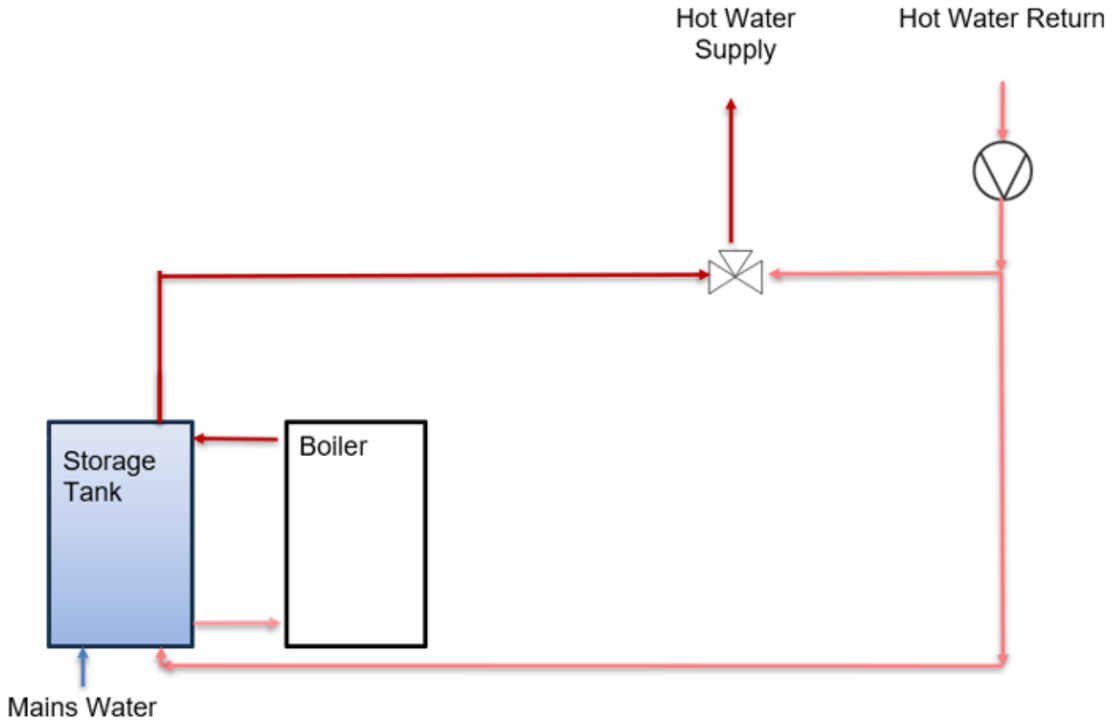
- Distribution of water heater fuel options across projection scenarios for the entire stock:

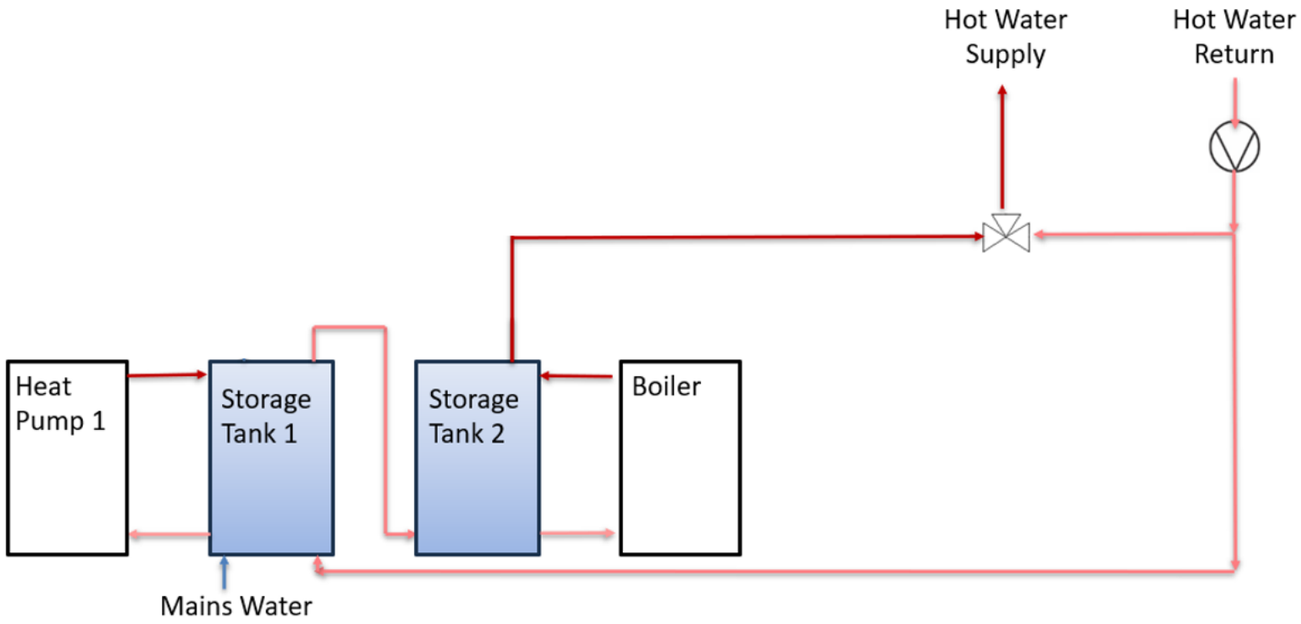


Shared Water Heater Modeling

Boiler vs. GAHP Schematics

- Existing buildings with a boiler used for water heating [left] vs. GAHP retrofit used for water heating [right]

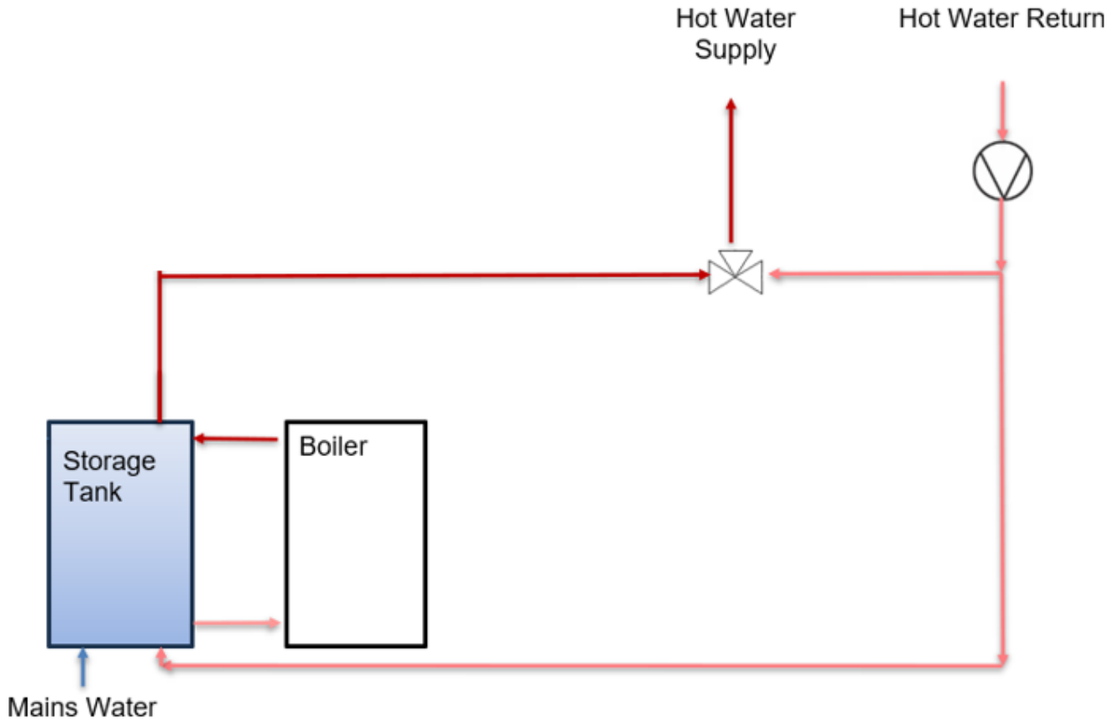


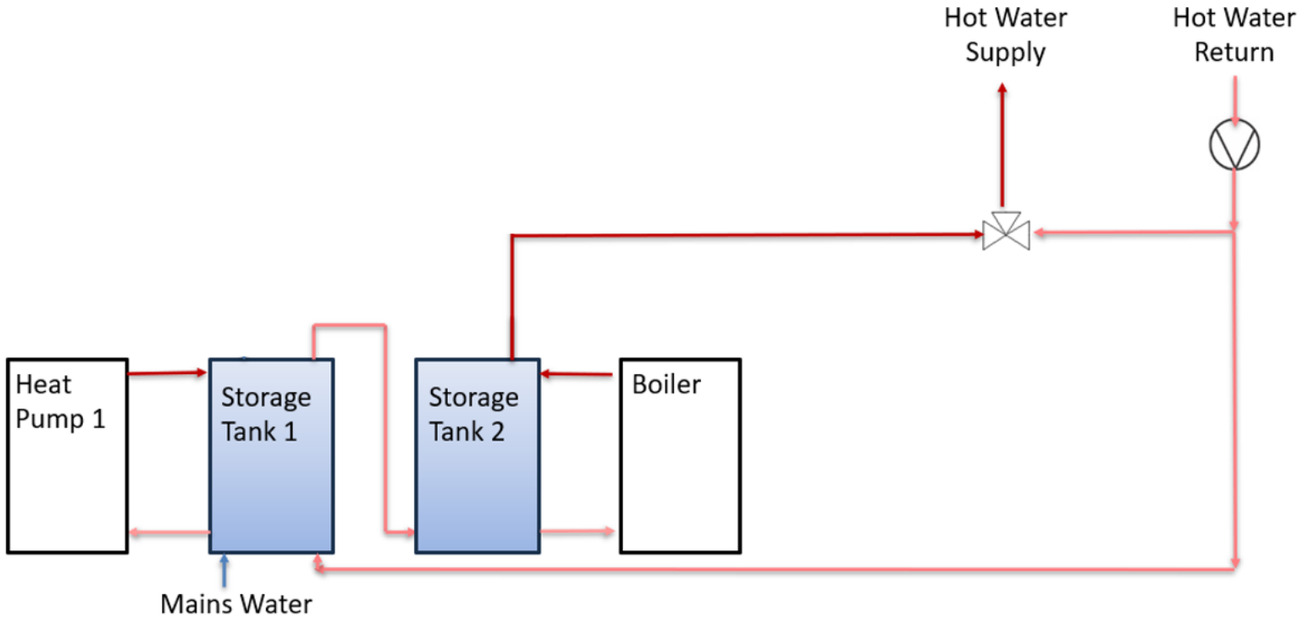


*multiple GAHPs may be modeled based on number of units in multifamily building

Boiler vs. GAHP Schematics

- Existing buildings with a boiler used for water heating [left] vs. GAHP retrofit used for water heating [right]

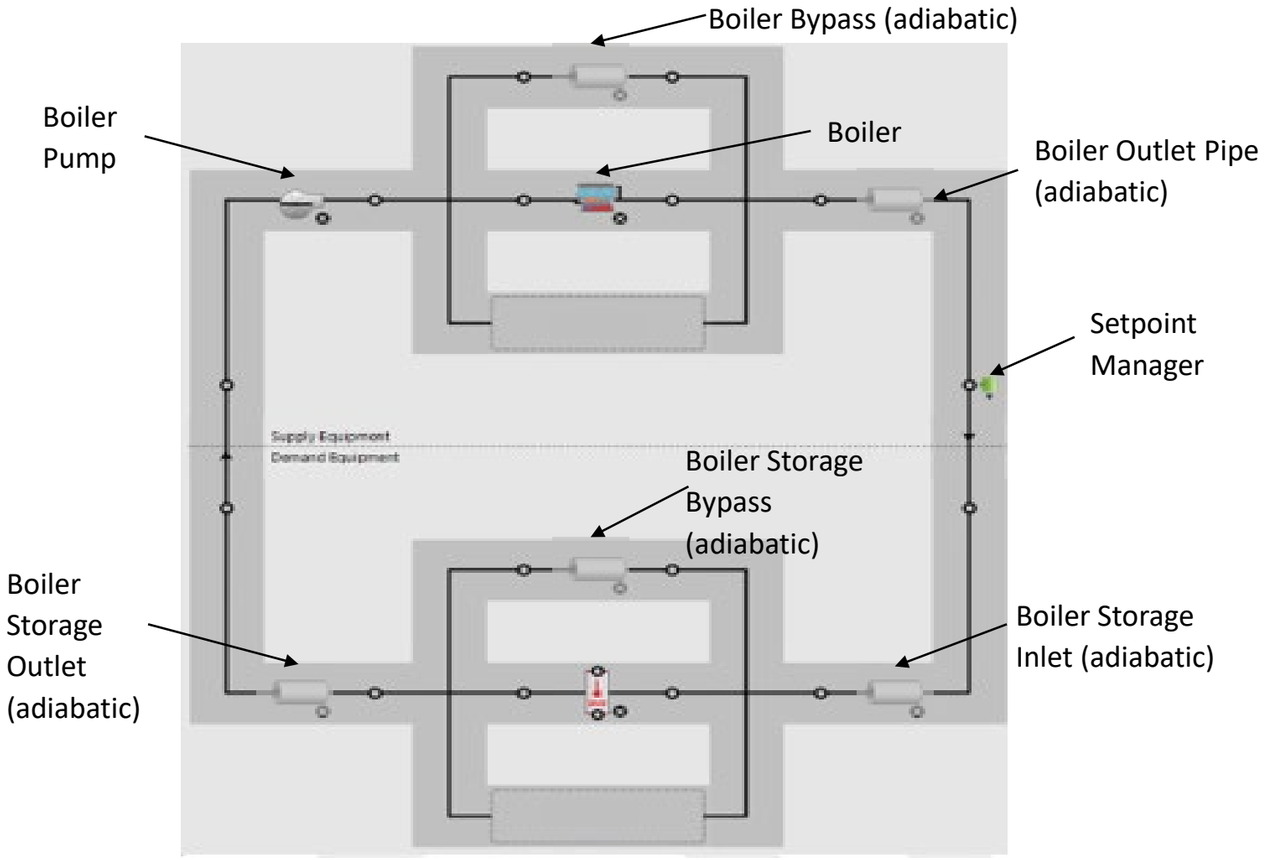




*multiple GAHPs may be modeled based on number of units in multifamily building

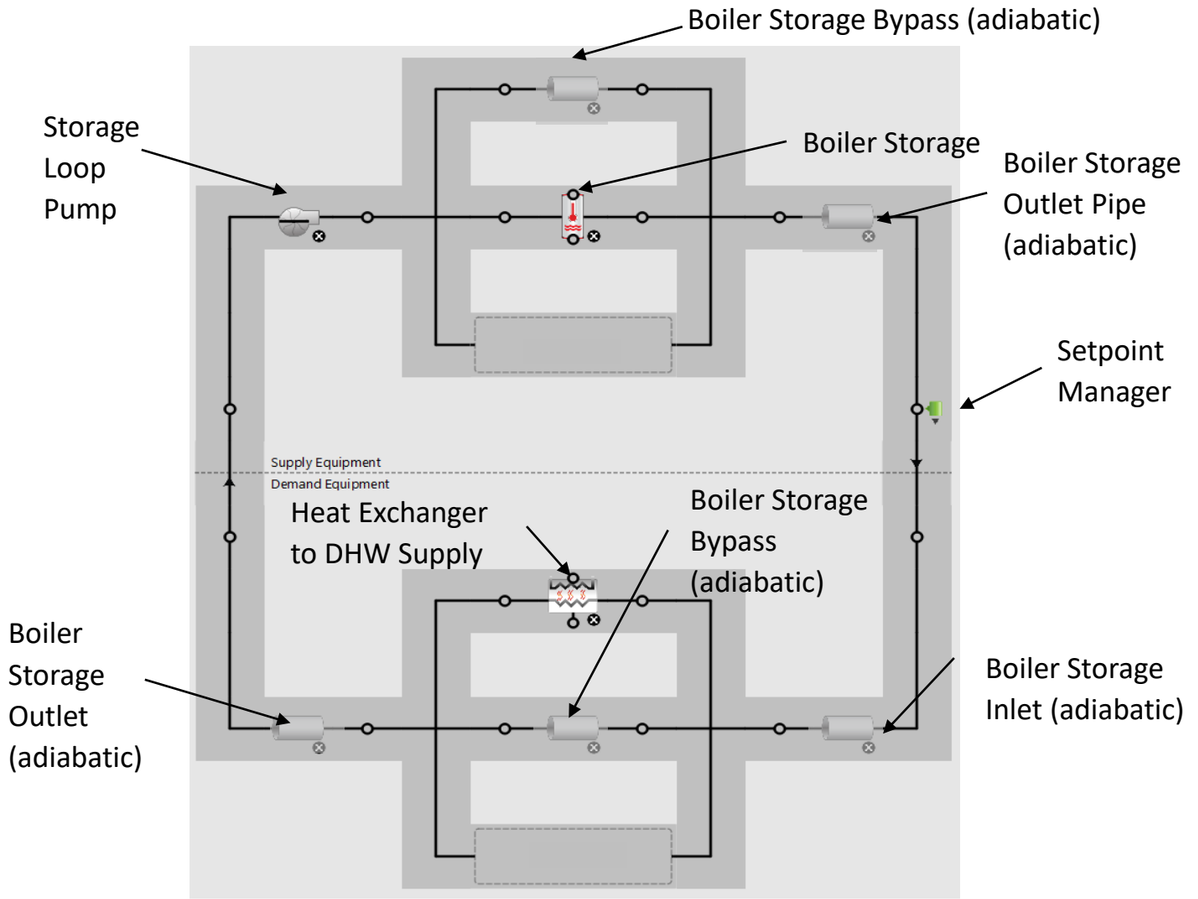
Plant Component Summary – Boiler

Loop	Name	Supply Side	Demand Side
Loop 1	Supply Loop	Boiler	Storage Tank
Loop 2	Storage Loop	Storage Tank	Heat Exchanger
Loop 3	DHW Loop	Heat Exchanger	Hot Water Fixtures



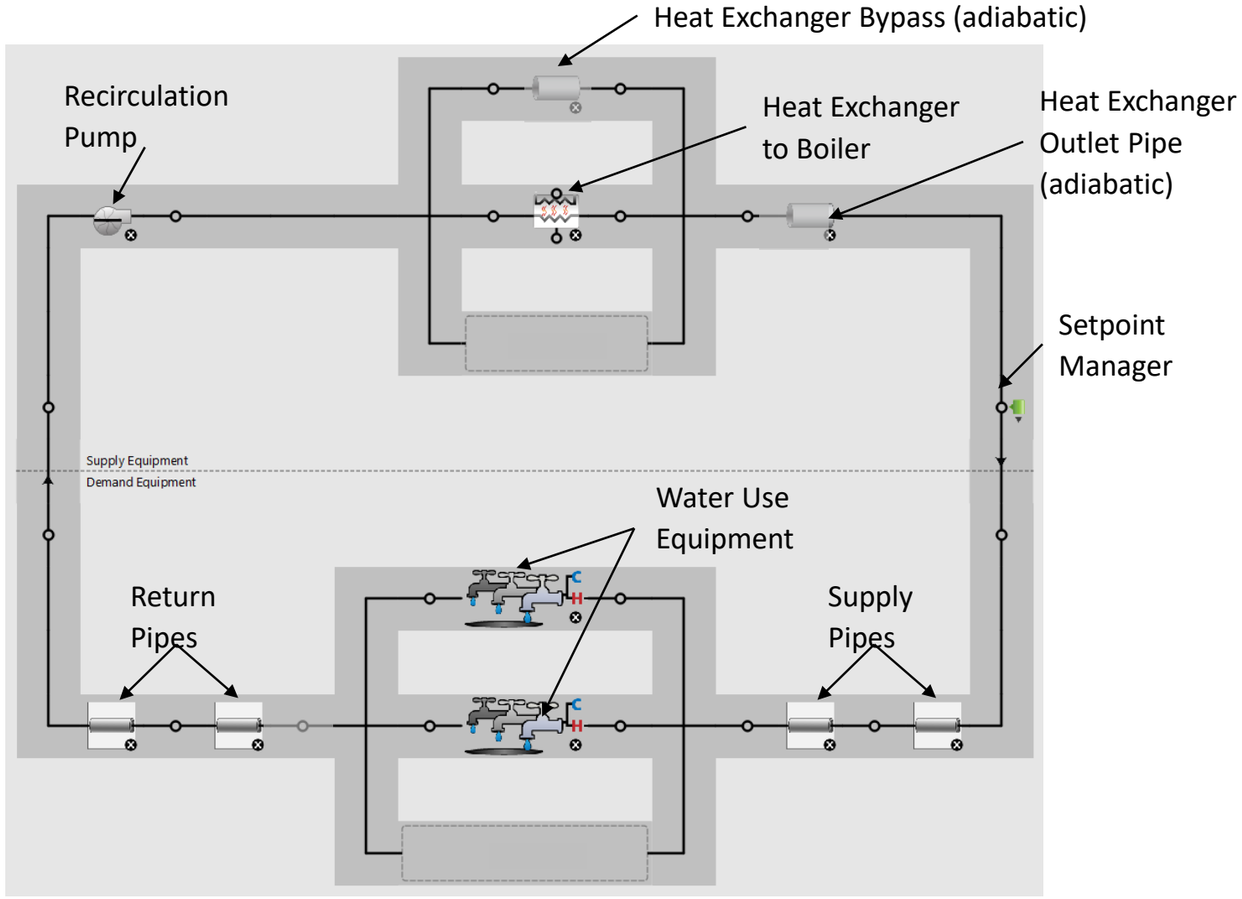
Plant Component Summary – Boiler

Loop	Name	Supply Side	Demand Side
Loop 1	Supply Loop	Boiler	Storage Tank
Loop 2	Storage Loop	Storage Tank	Heat Exchanger
Loop 3	DHW Loop	Heat Exchanger	Hot Water Fixtures



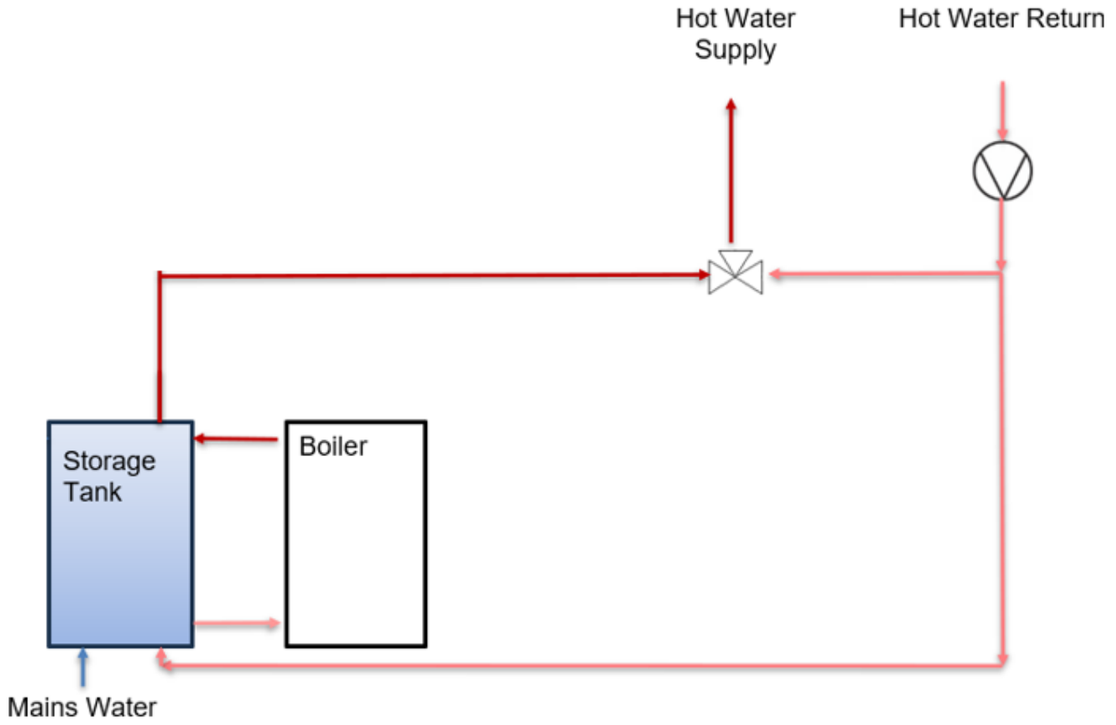
Plant Component Summary – Boiler

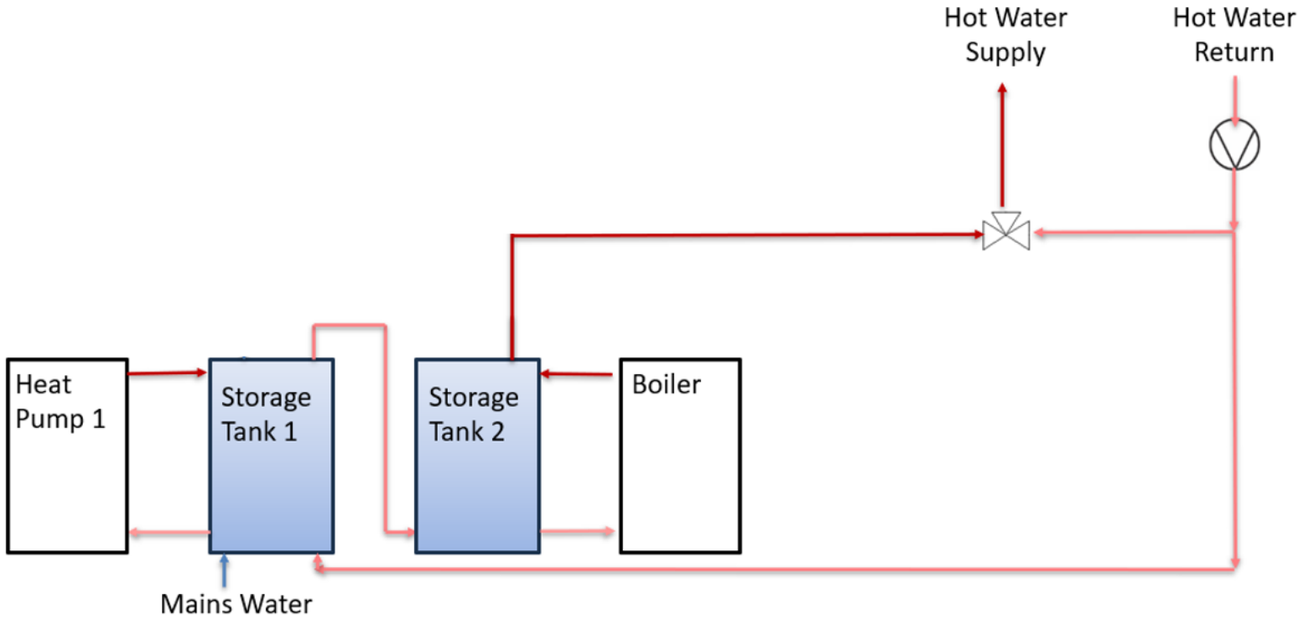
Loop	Name	Supply Side	Demand Side
Loop 1	Supply Loop	Boiler	Storage Tank
Loop 2	Storage Loop	Storage Tank	Heat Exchanger
Loop 3	DHW Loop	Heat Exchanger	Hot Water Fixtures



Boiler vs. GAHP Schematics

- Existing buildings with a boiler used for water heating [left] vs. GAHP retrofit used for water heating [right]

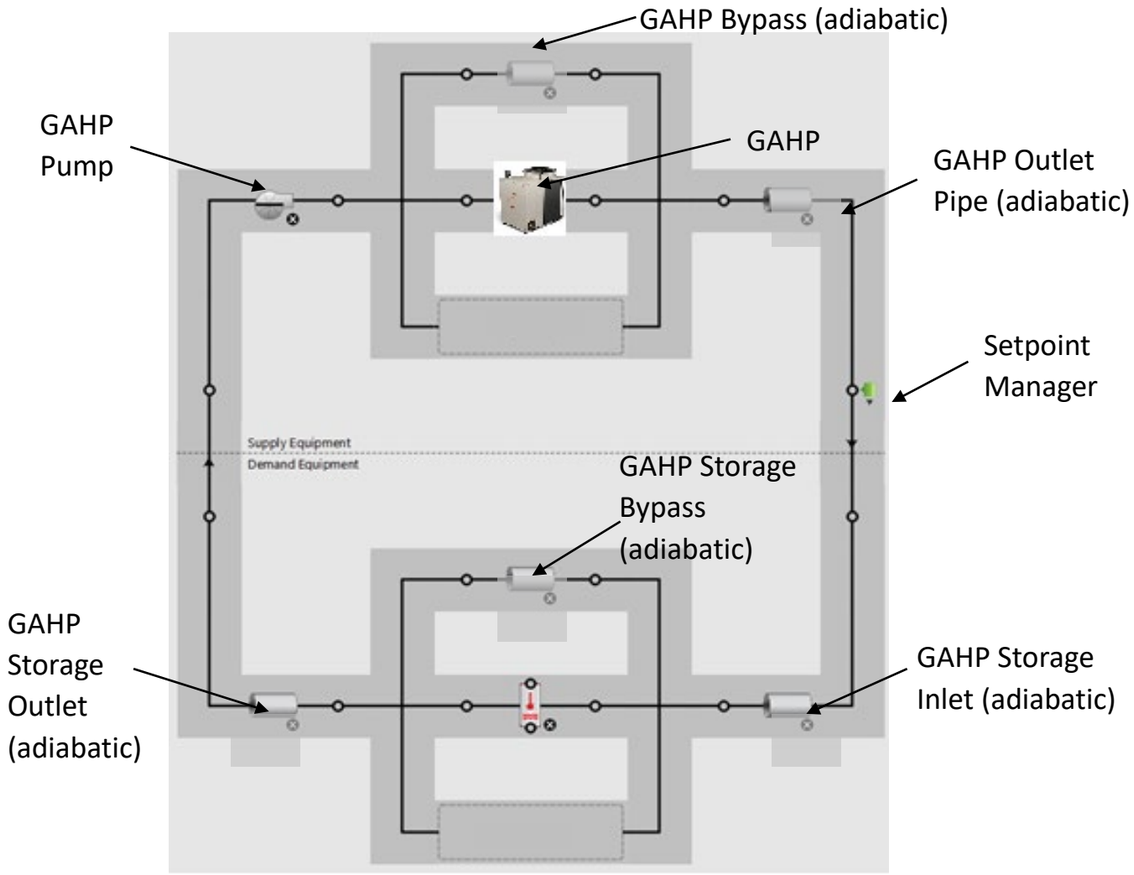




*multiple GAHPs may be modeled based on number of units in multifamily building

Plant Component Summary – GAHP

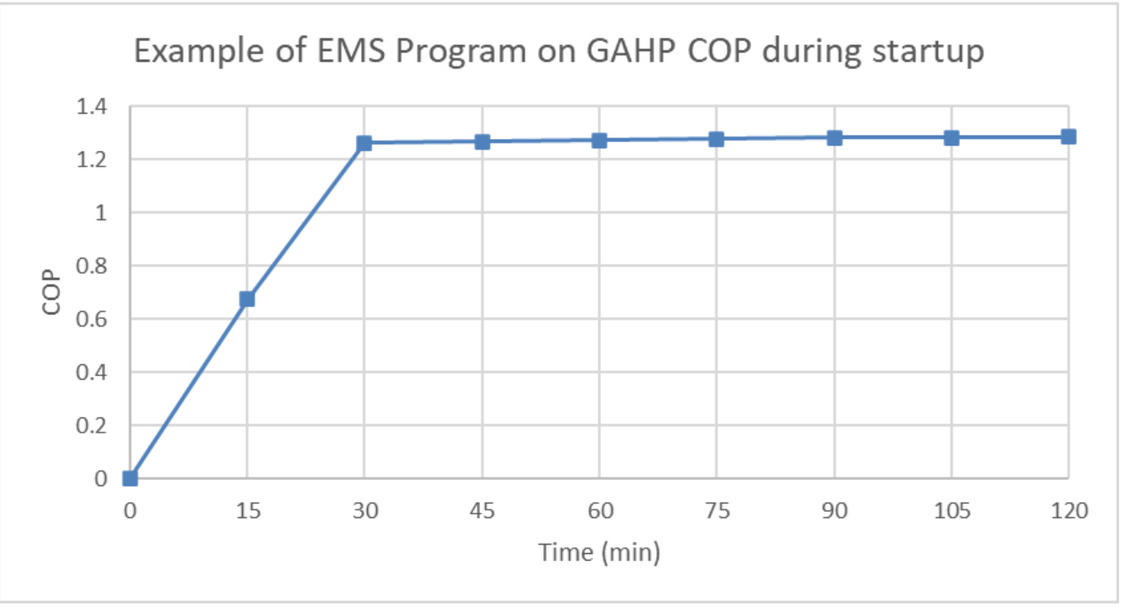
Loop	Name	Supply Side	Demand Side
Loop 1	Supply Loop 1	GAHP	Storage Tank 1
Loop 2	Supply Loop 2	Boiler	Storage Tank 2
Loop 3	Storage Loop	Storage Tank 1, Storage Tank 2	Heat Exchanger
Loop 4	DHW Loop	Heat Exchanger	Hot Water Fixtures



GAHP Model

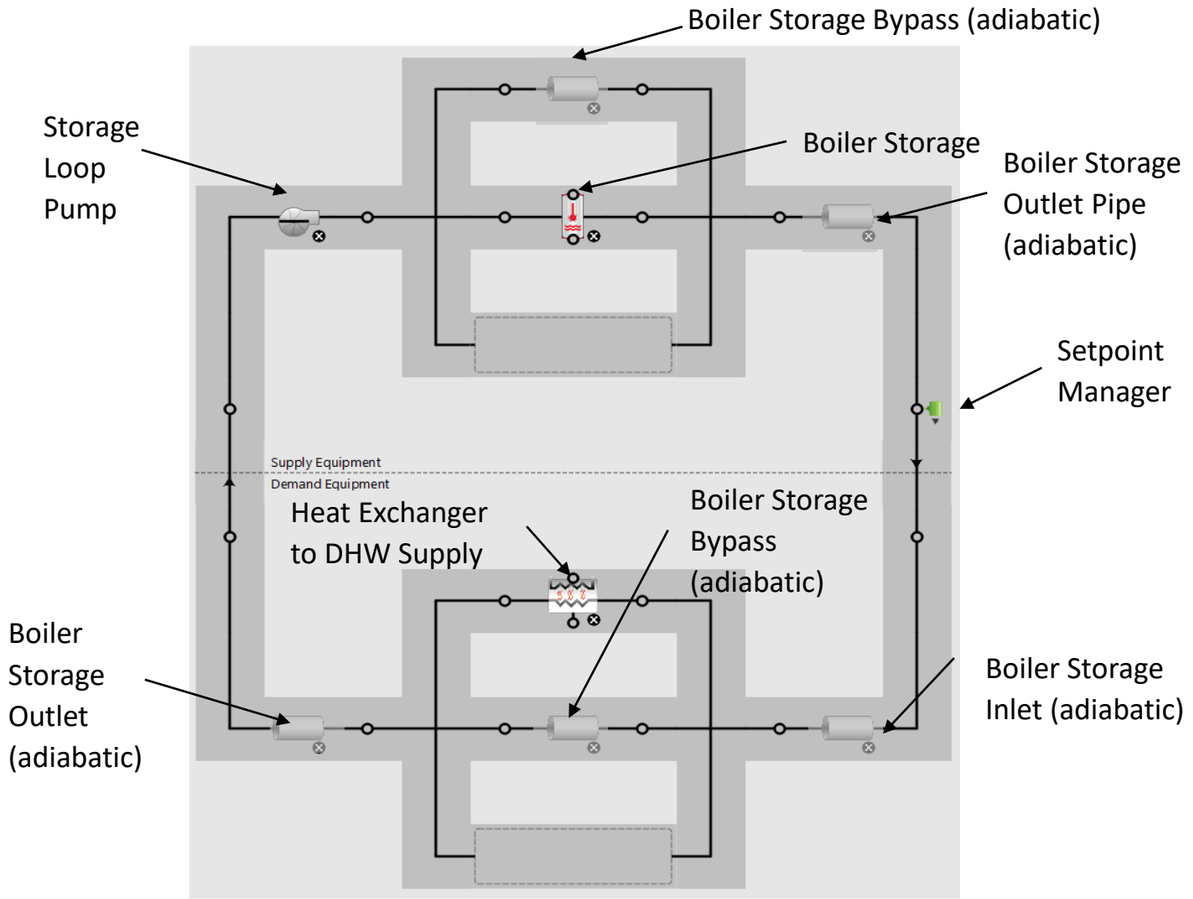
- Implemented a model in EnergyPlus using the relatively new GAHP object
  - Found and got a fix merged for the GAHP object for this and future efforts
- Using performance map based on data taken at GTI for capacity and COP
- Implemented a custom EMS routine for cycling losses for the GAHP at the start of a cycle
  - Lab and field testing showed GAHP takes time to reach steady state efficiency
  - Model configured to try to ensure long cycles for GAHPs

COP						
Tamb (F)↓Tret (F)→	90	100	110	120	130	140
0	0.869868	0.820008	0.775555	0.73567277	0.69969214	0.667067
10	0.954994	0.904653	0.859353	0.81837347	0.78112453	0.747119
20	1.044357	0.994821	0.949772	0.90862635	0.87089746	0.836177
30	1.135332	1.088226	1.044874	1.00484415	0.96776791	0.93333
40	1.224072	1.181252	1.141327	1.10401304	1.06906136	1.036255
50	1.305544	1.268868	1.234196	1.2013686	1.17024215	1.140688
60	1.3739	1.34488	1.317061	1.2903692	1.26473799	1.240105
70	1.423246	1.402663	1.382667	1.36323285	1.34433754	1.325959
80	1.448738	1.436347	1.424167	1.41219162	1.40041587	1.388835
90	1.447669	1.442162	1.436697	1.43127367	1.42589075	1.420548
100	1.420156	1.41943	1.418705	1.41798114	1.41725766	1.416535
110	1.369107	1.370755	1.372408	1.37406426	1.37572473	1.377389



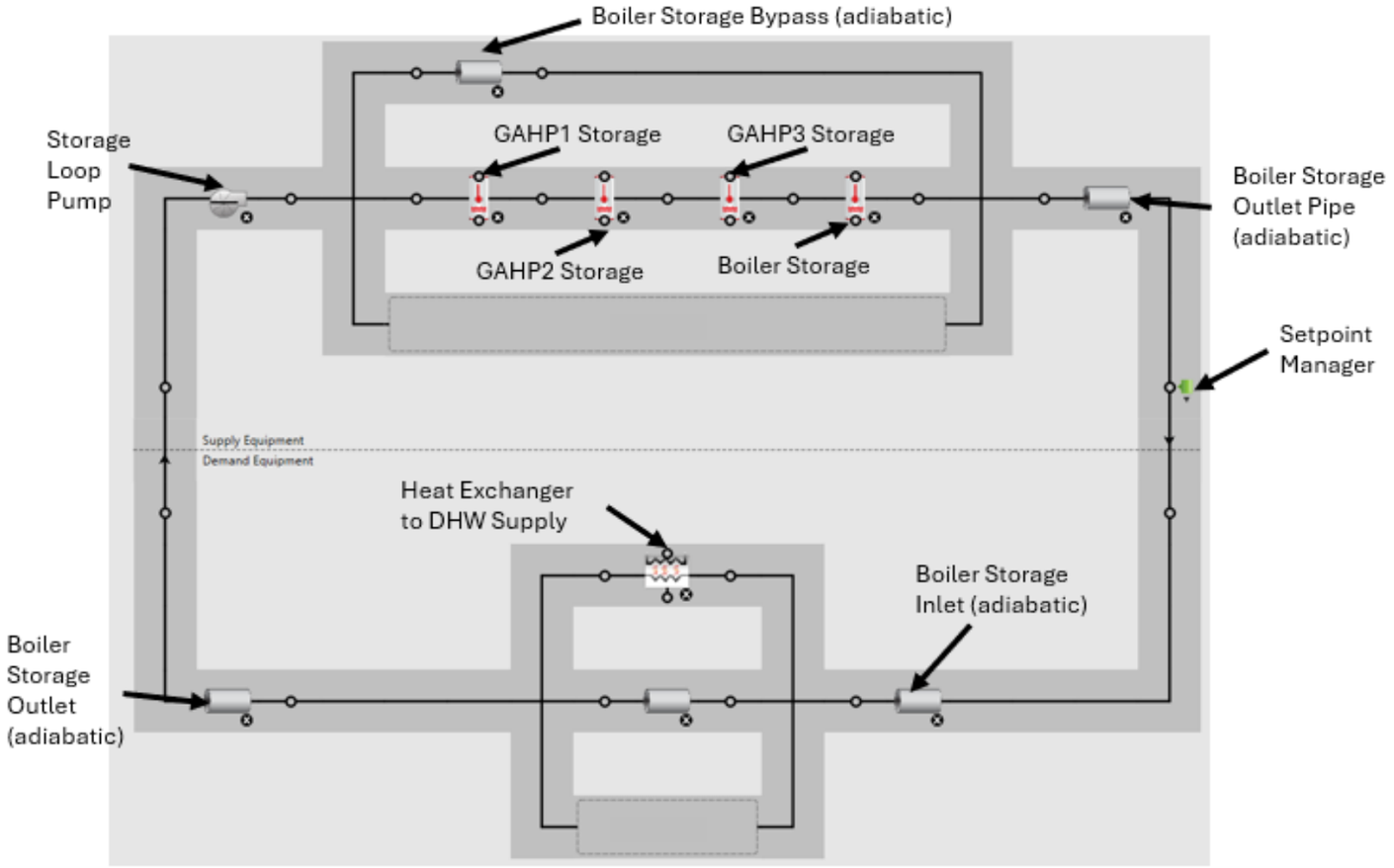
Plant Component Summary – GAHP

Loop	Name	Supply Side	Demand Side
Loop 1	Supply Loop 1	GAHP	Storage Tank 1
Loop 2	Supply Loop 2	Boiler	Storage Tank 2
Loop 3	Storage Loop	Storage Tank 1, Storage Tank 2	Heat Exchanger
Loop 4	DHW Loop	Heat Exchanger	Hot Water Fixtures



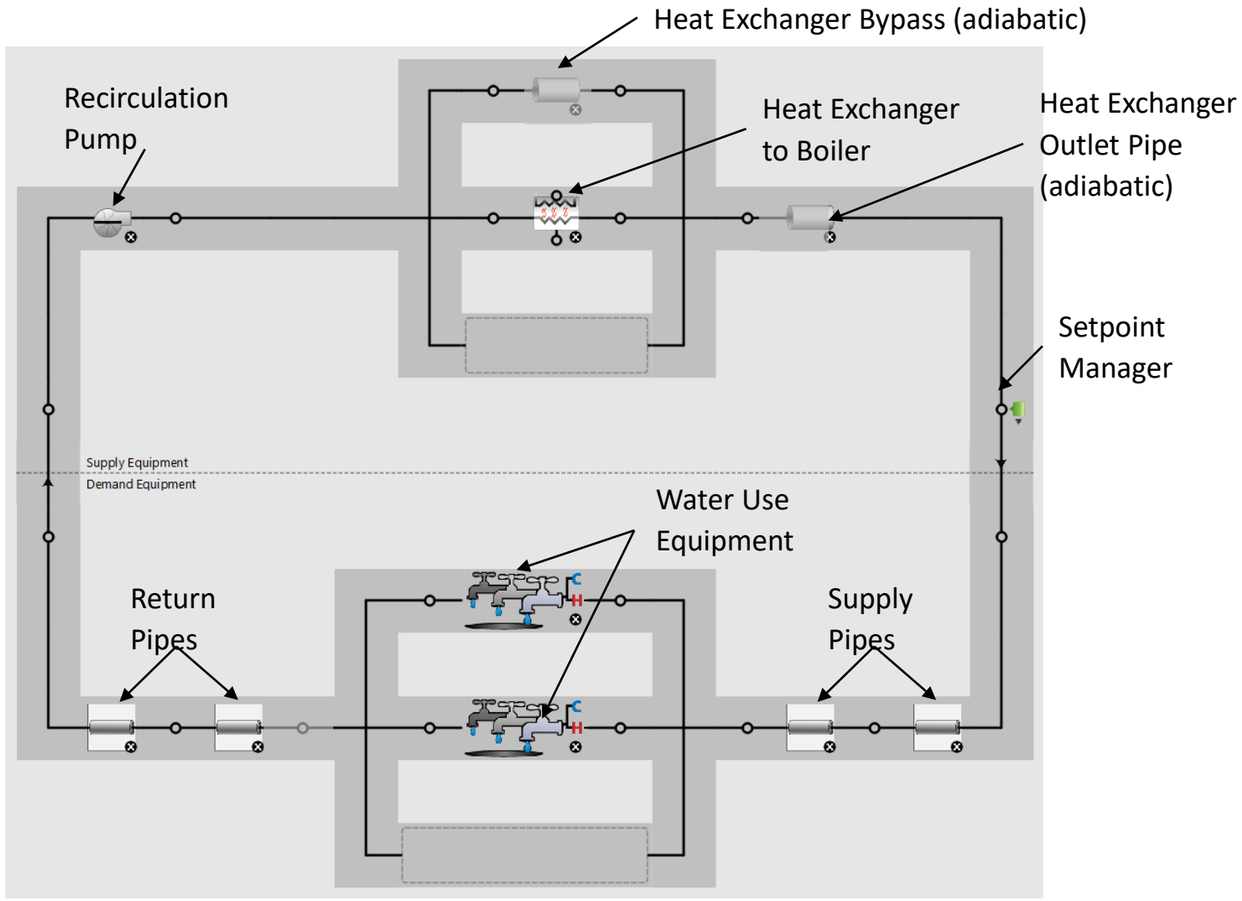
Plant Component Summary – GAHP

Loop	Name	Supply Side	Demand Side
Loop 1	Supply Loop 1	GAHP	Storage Tank 1
Loop 2	Supply Loop 2	Boiler	Storage Tank 2
Loop 3	Storage Loop	Storage Tank 1, Storage Tank 2	Heat Exchanger
Loop 4	DHW Loop	Heat Exchanger	Hot Water Fixtures



Plant Component Summary – GAHP

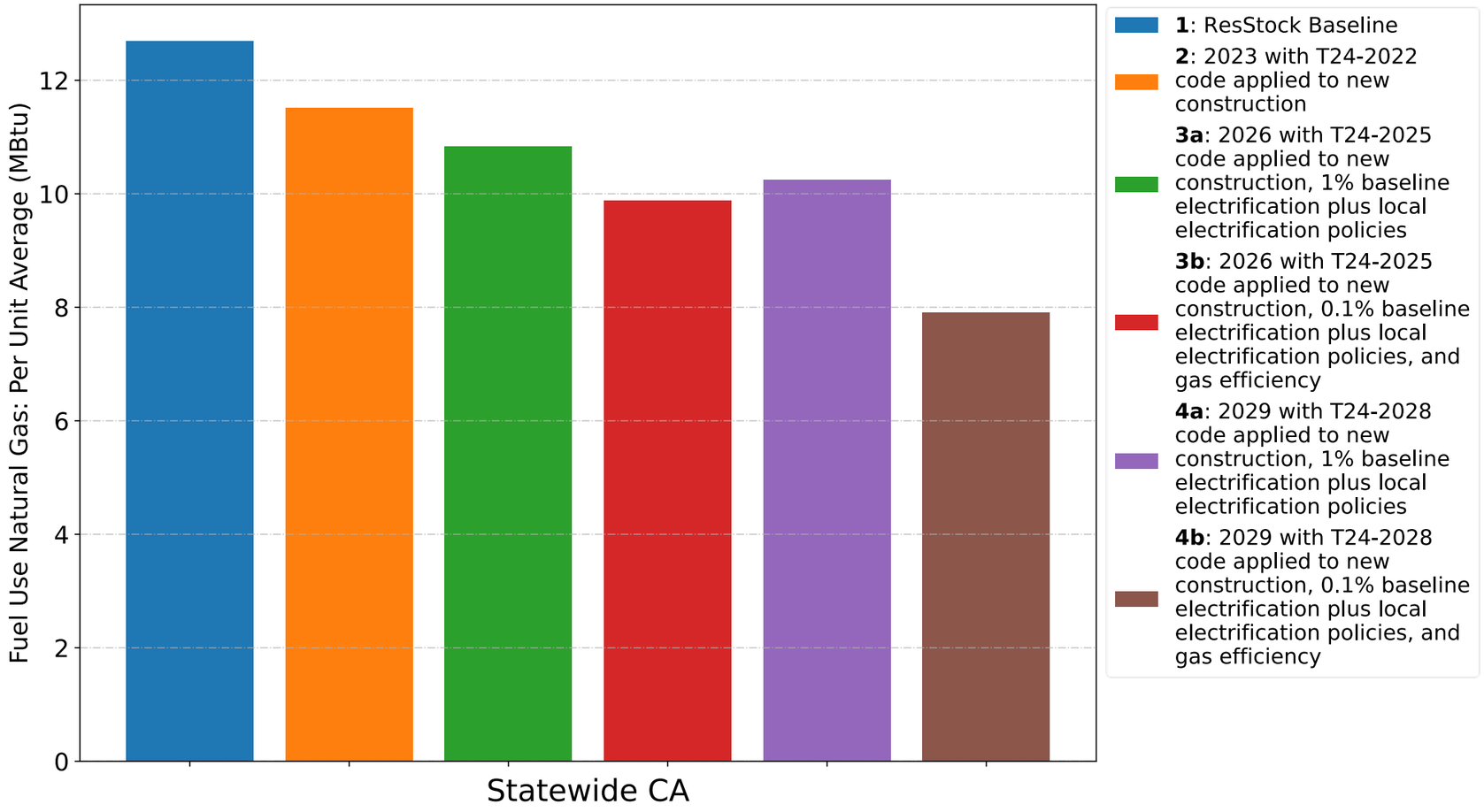
Loop	Name	Supply Side	Demand Side
Loop 1	Supply Loop 1	GAHP	Storage Tank 1
Loop 2	Supply Loop 2	Boiler	Storage Tank 2
Loop 3	Storage Loop	Storage Tank 1, Storage Tank 2	Heat Exchanger
Loop 4	DHW Loop	Heat Exchanger	Hot Water Fixtures



Results

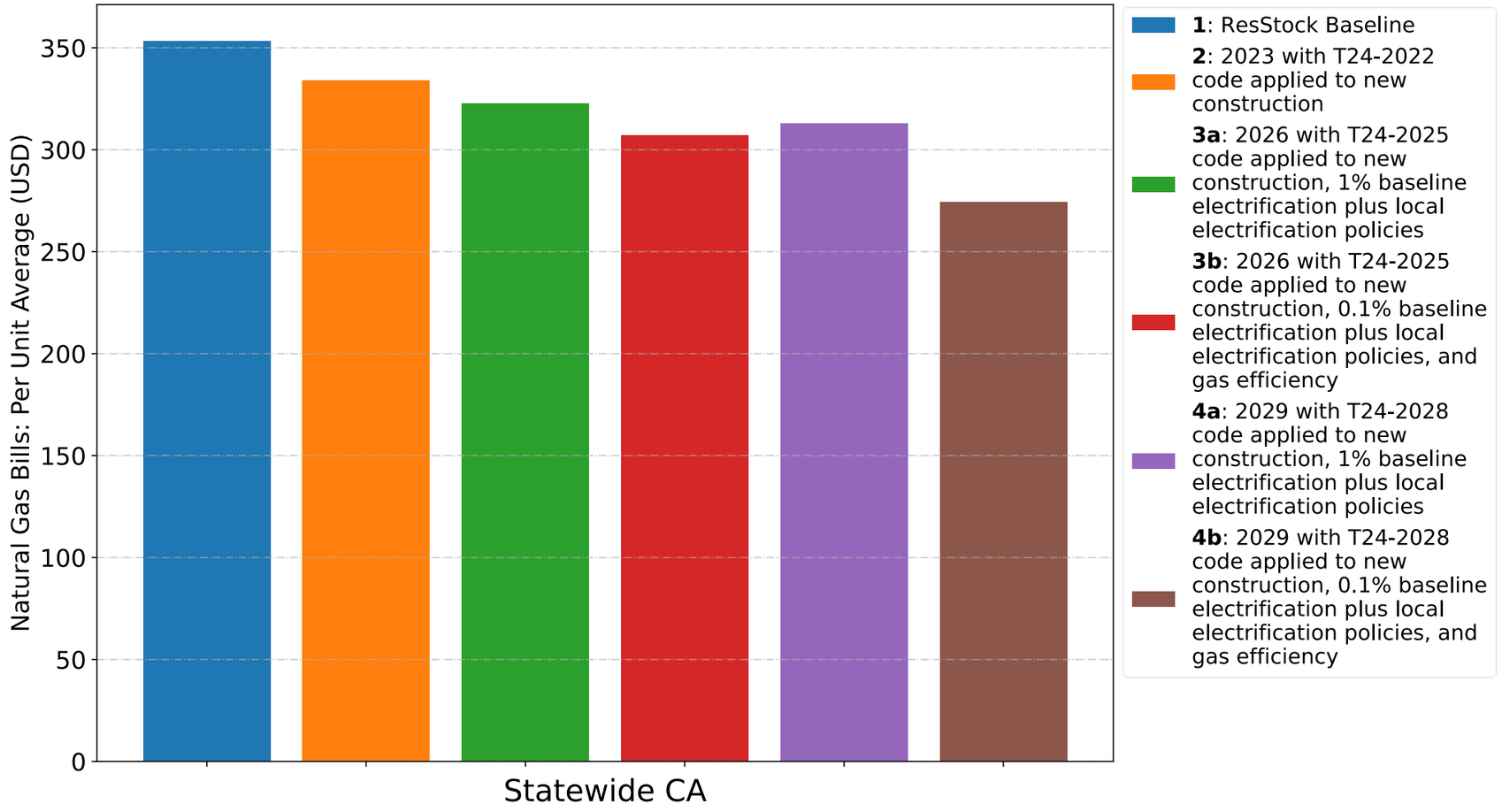
Scenario Results –Natural Gas Usage

- Per-unit average hot water natural gas use across projection scenarios for 16 CA CZs



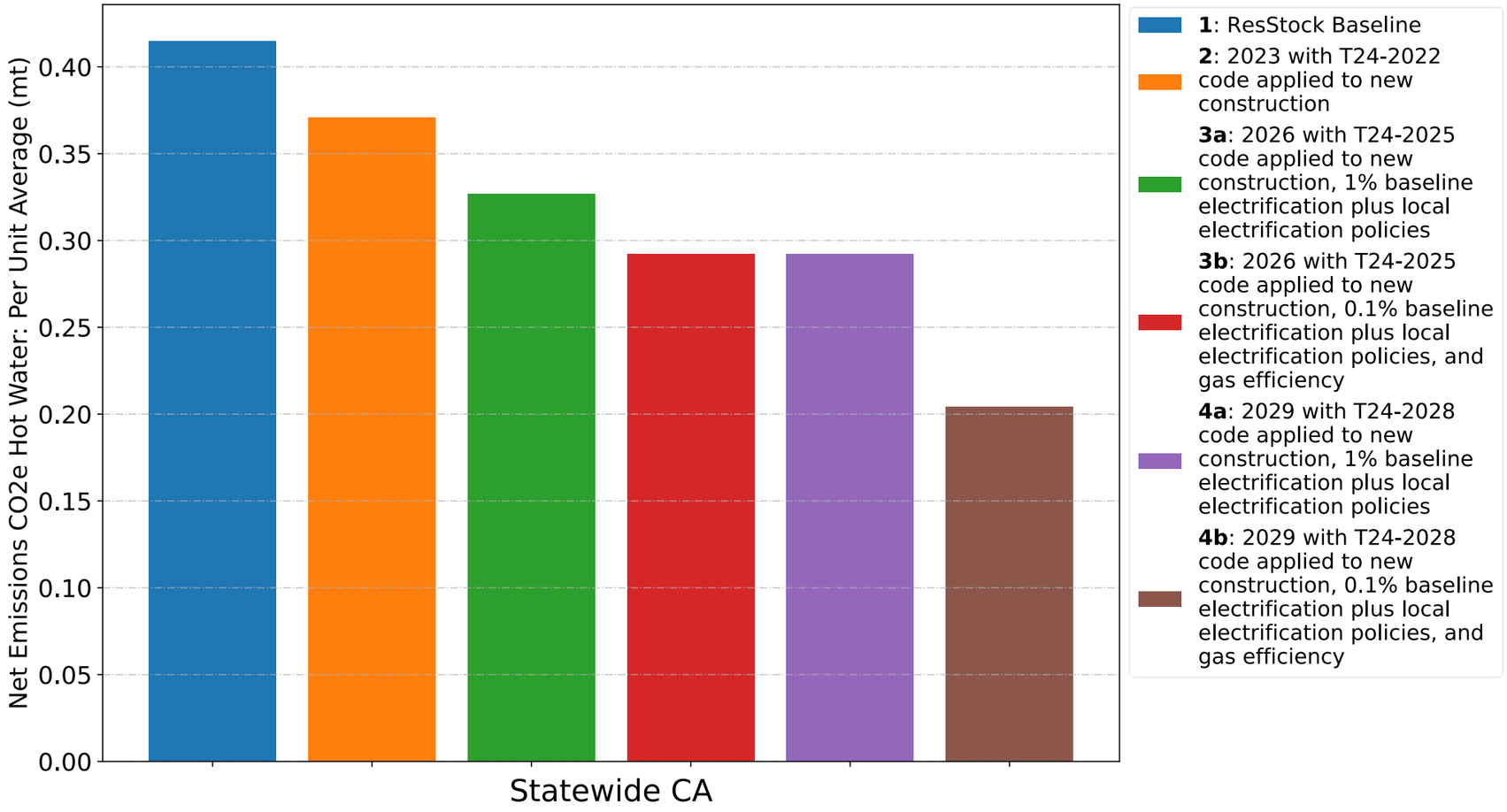
Scenario Results – Utility Bills

- Per-unit average natural gas bills across projection scenarios for 16 CA CZs



Scenario Results – Emissions (gas and electricity)

- Per-unit average hot water emissions across projection scenarios for 16 CA CZs

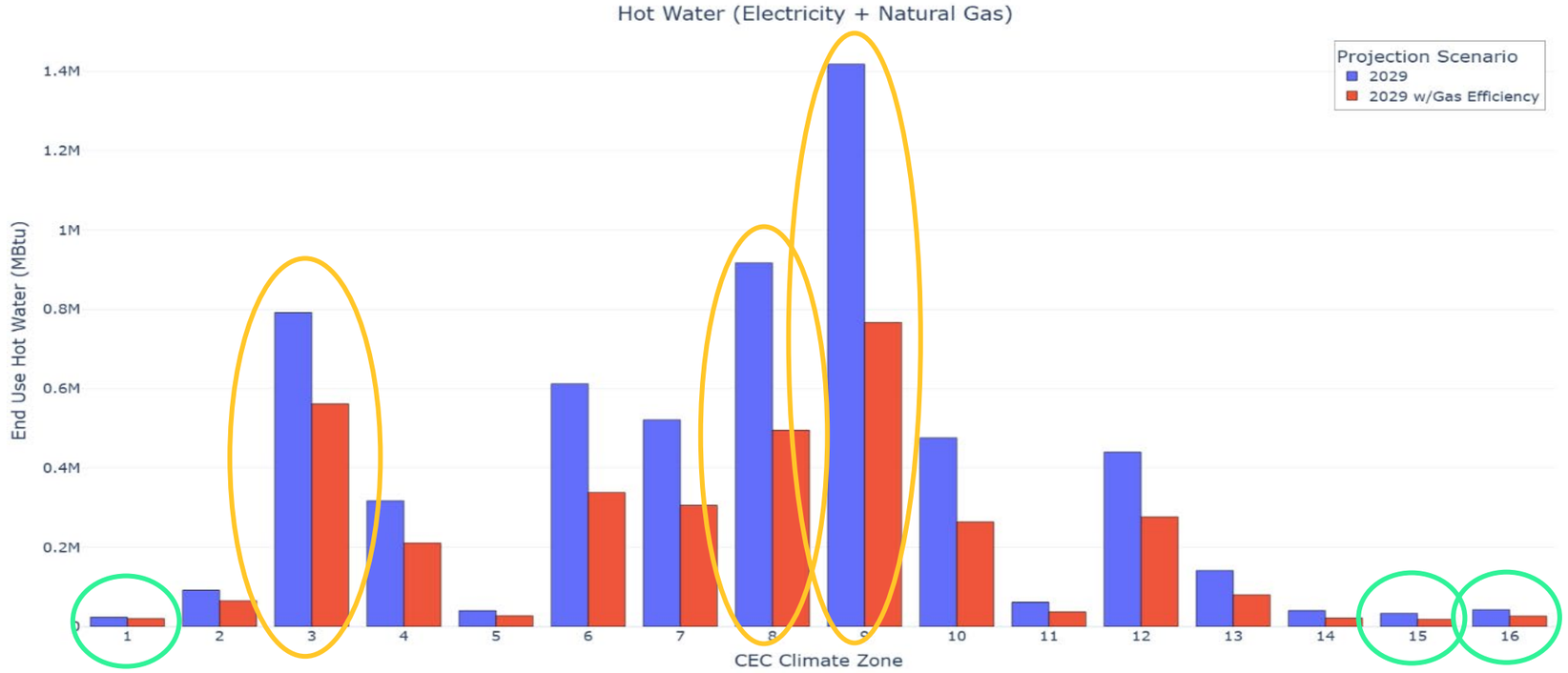


GAHP Upgrade Results – 2029

- Total hot water (electricity + natural gas) energy consumption across baseline/upgrade scenarios, according to 16 CA CZs.

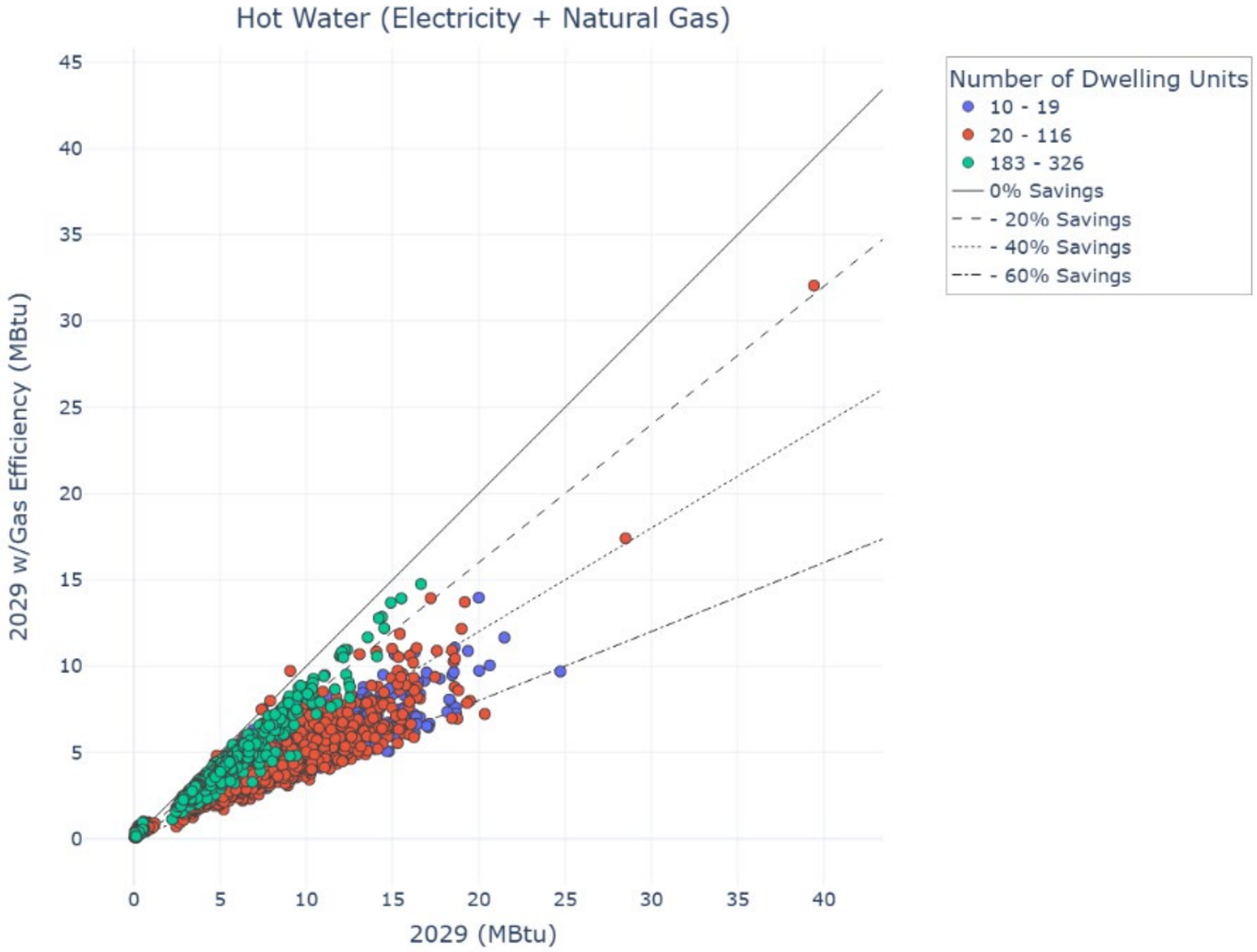
Climate Zone	Location
3	Oakland
8	Fullerton
9	Burbank-Glendale

Climate Zone	Location
1	Arcata
15	Palm Springs
16	Blue Canyon



GAHP Upgrade Results - 2029

- Per-unit hot water (electricity + natural gas) energy consumption across baseline/upgrade scenarios, in year 2029.



Key Takeaways & Recommendations for Future Studies

Key Takeaways

1. Substantial updates to ResStock for whole building shared water heating system simulations
2. Bug fix in EnergyPlus
3. Performance mapping curves from GTI Energy lab testing were incorporated into the model (~20 min for GAHP to reach steady state)
4. Energy consumption, utility bills, and emissions decrease across Scenarios 1-4b for the 16 CA CZs

Future Studies

1. Series vs. Parallel tank configuration exploration
2. ResStock updates to reflect year over year changes to local electrification policies
3. Comprehensive GAHP Design Tool which factors in several OEM GAHP performance mapping data

SoCalGas™

Glad to be of service®

ICF

Get in touch with us:
Ava Donald

Program Manager
Ava.Donald@icf.com

Follow GET on LinkedIn: linkedin.com/cagastech

Visit: cagastech.com

---

icf.com

linkedin.com/company/icf-international/

twitter.com/icf

https://www.facebook.com/ThisIsICF/

About ICF

ICF (NASDAQ:ICFI) is a global consulting and digital services company with over 7,000 full- and part-time employees, but we are not your typical consultants. At ICF, business analysts and policy specialists work together with digital strategists, data scientists and creatives. We combine unmatched industry expertise with cutting-edge engagement capabilities to help organizations solve their most complex challenges. Since 1969, public and private sector clients have worked with ICF to navigate change and shape the future.