CENTRAL HEAT PUMP WATER HEATING:

Sizing and Modeling

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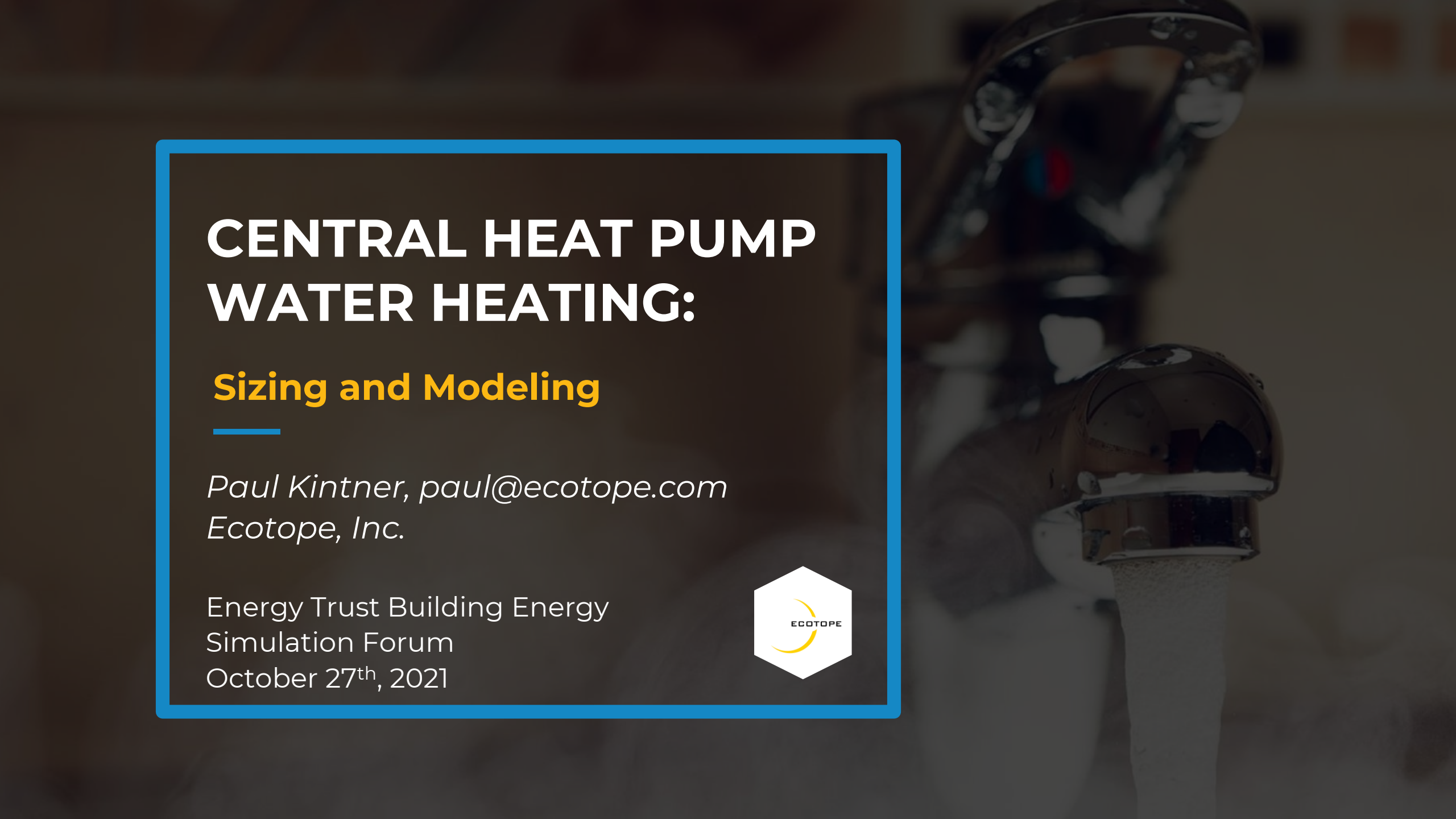
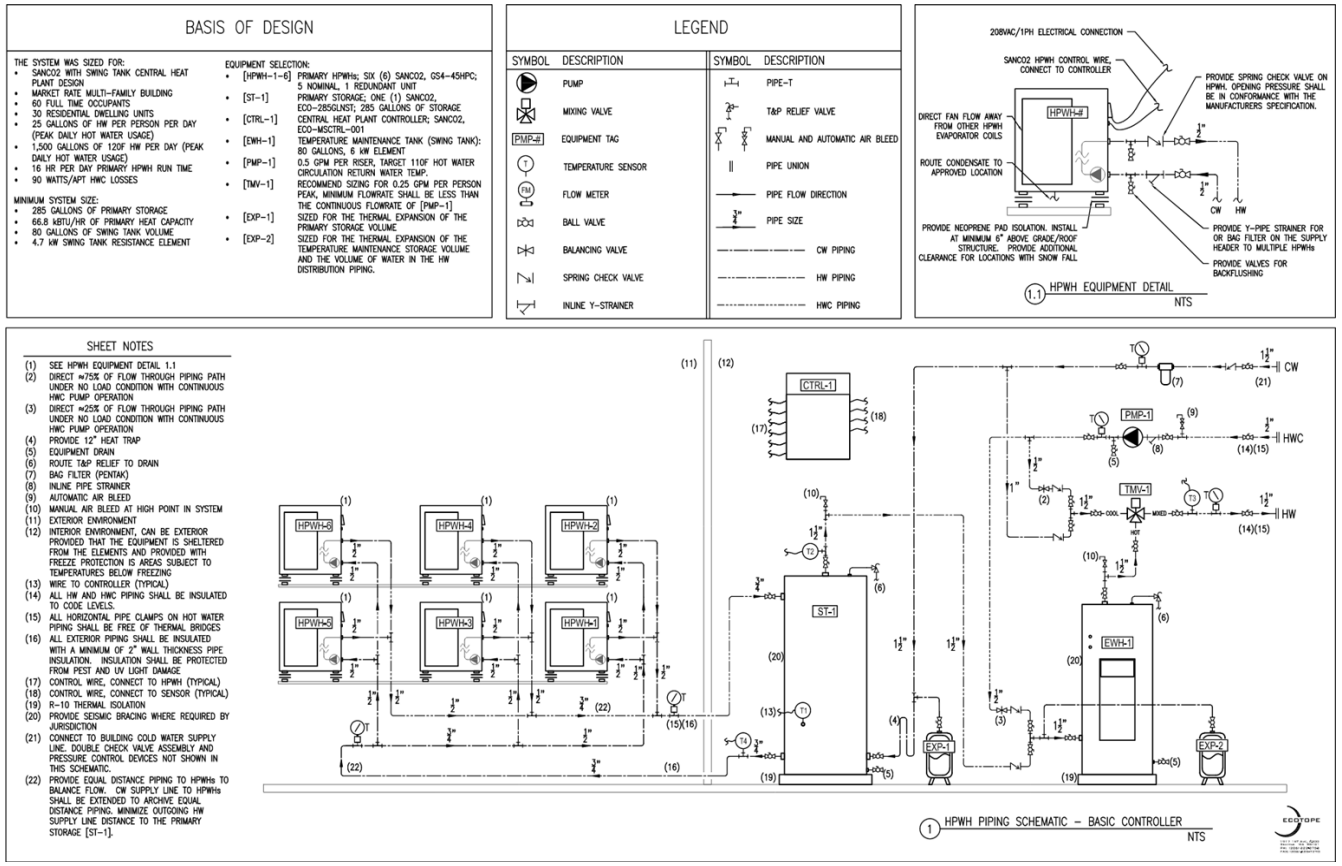
Ecotope, Inc.

Energy Trust Building Energy Simulation Forum
October 27th, 2021





OVERVIEW

- Why CHPWHs
- CHPWH Systems
- Sizing CHPWH Systems
- Modeling

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WHY CHPWH?

- Climate Change
- Global, federal, & state policies
- Codes & standards
- Capture incentives & rebates
- Lower operating costs
- Energy efficiency measures
- Societal changes

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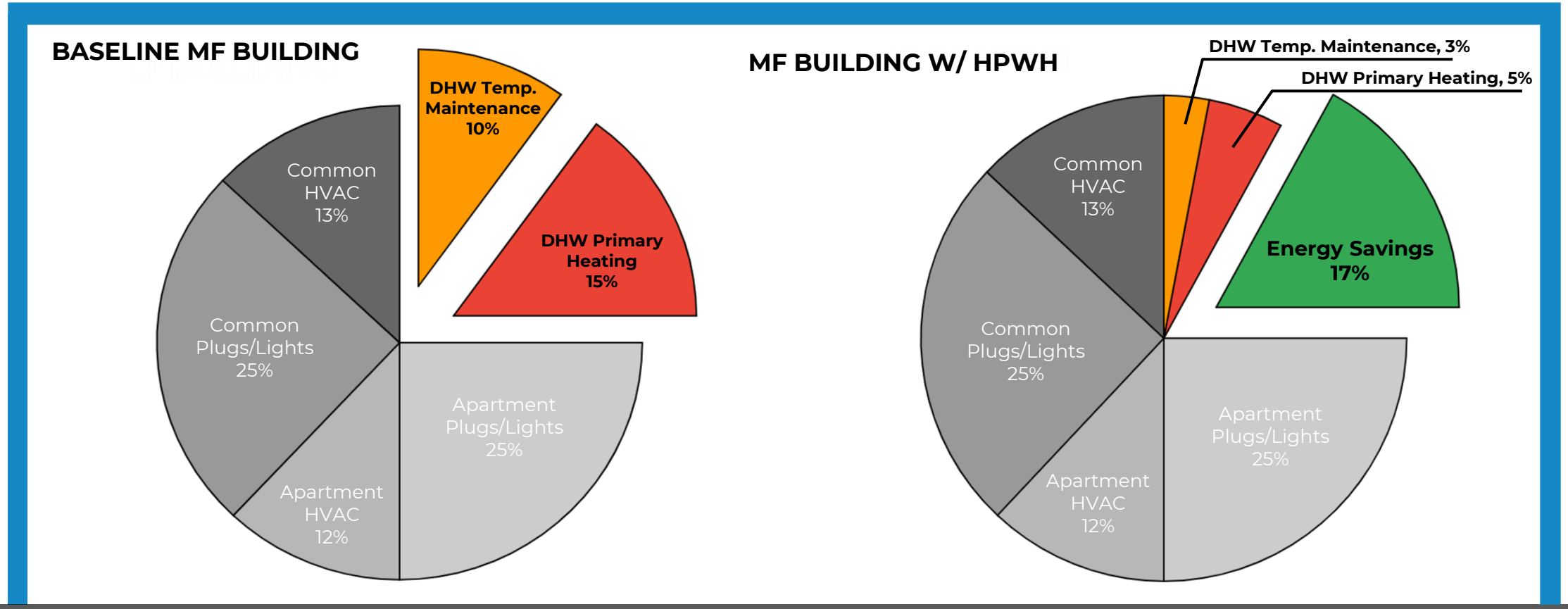
WHY CHPWH?



DHW represents 25% of annual building use

CHPWH systems cut energy usage down by 3x

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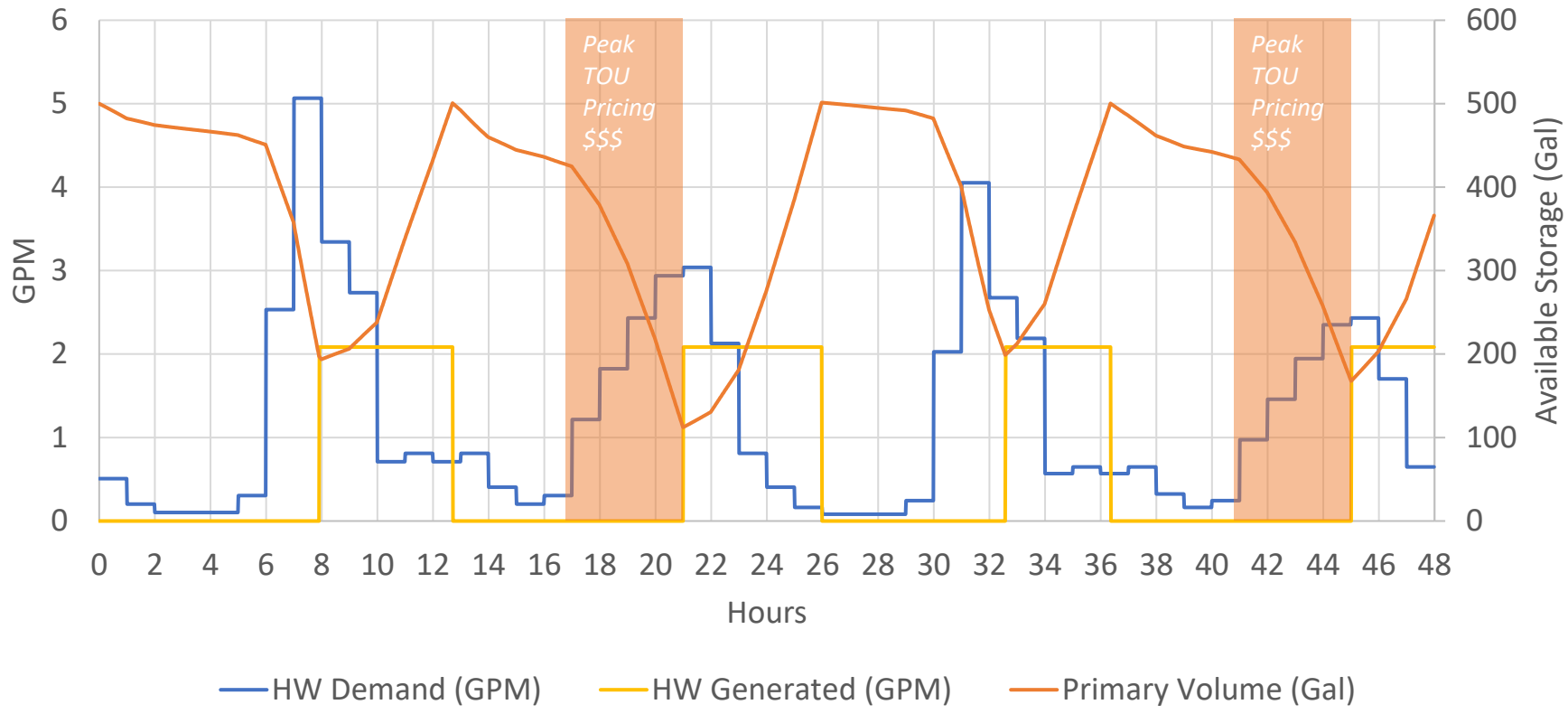
WHY CHPWH: TOU RATES & GRID FLEXIBILITY



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CHPWH SYSTEMs

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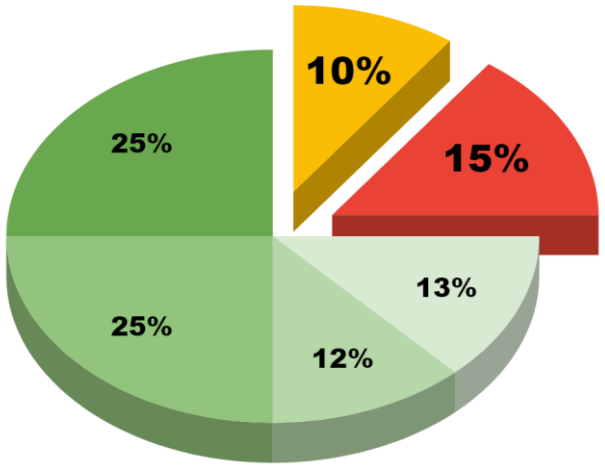
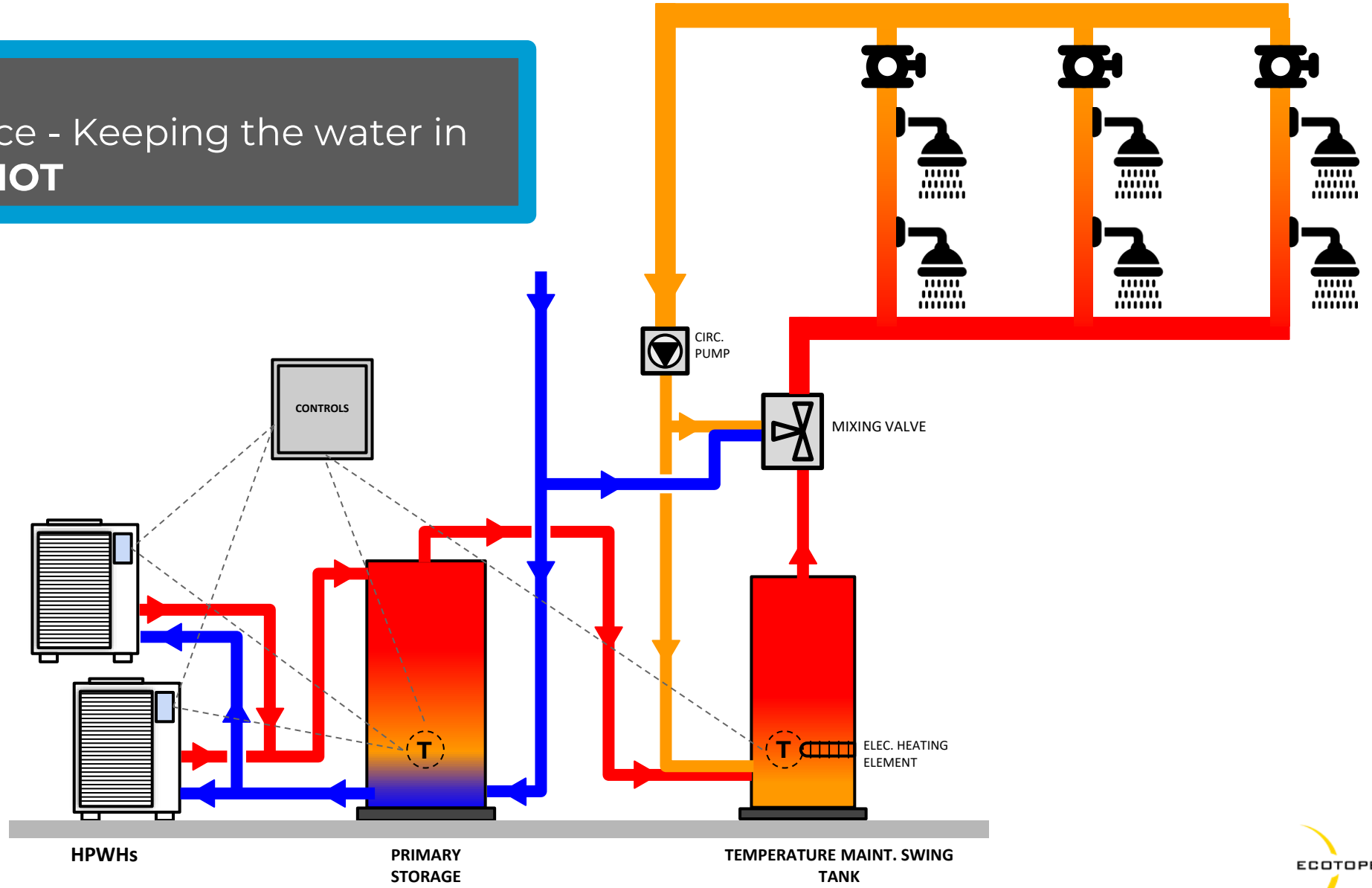
CHPWH **SYSTEM**

Hot Water Draws
Temperature Maintenance - Keeping the water in the distribution system **HOT**



ENERGY USAGE IN MULTIFAMILY MIDRISE



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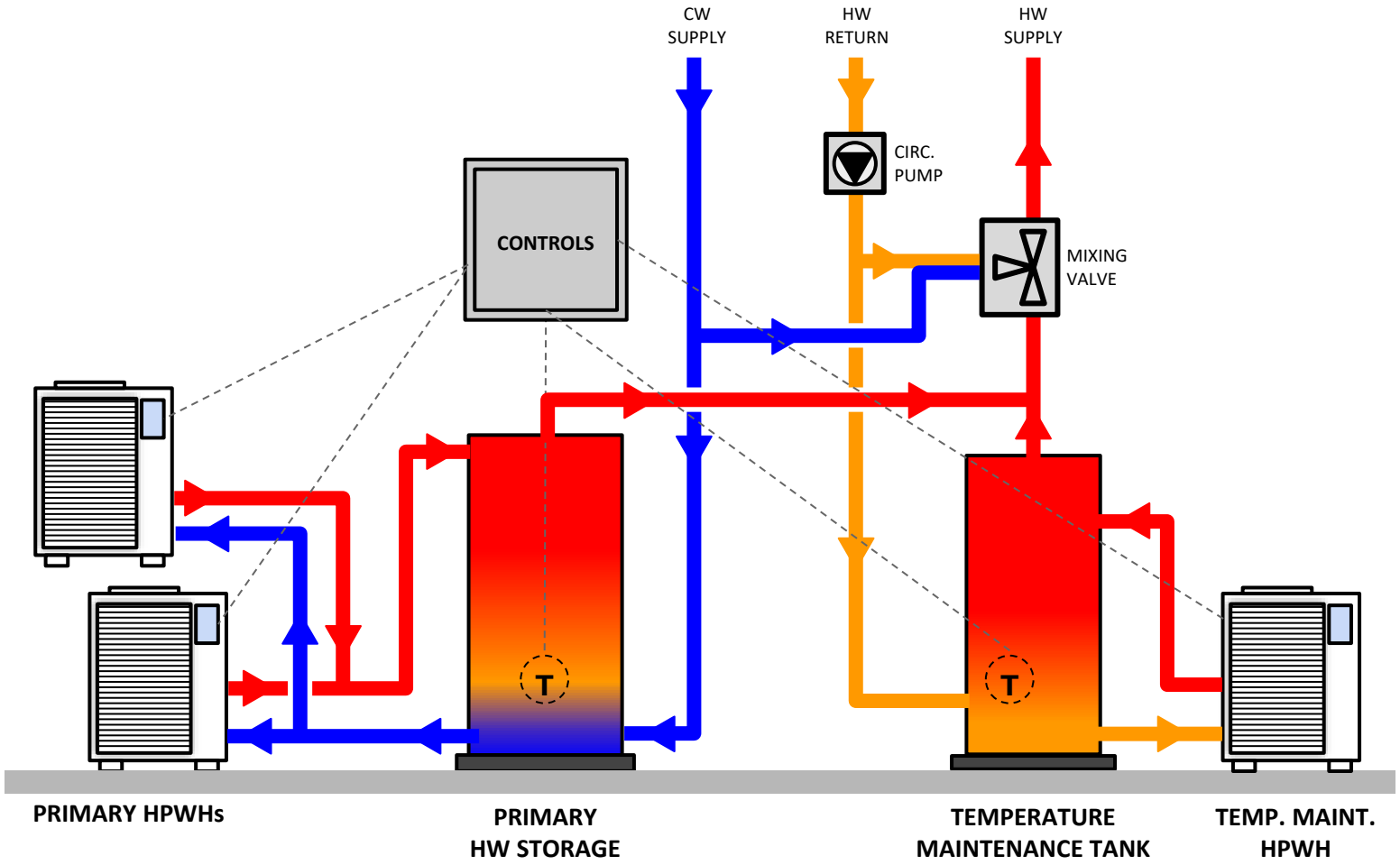
FOUR CHPWH SYSTEM COMPONENTS



- Primary heat pump water heater (HPWH)
- Primary HW storage
- Temperature maintenance system
- Controls

CHPWH SYSTEMS: INTRO

4 OPTIONS

01	**Dedicated Parallel**	Dedicated HPWH connected by parallel piping
02	**Dedicated Series**	Dedicated swing tank connected in series
03	**Combined**	Primary & Temperature Maintenance System are combined
04	**No Recirculation**	Heat Tape

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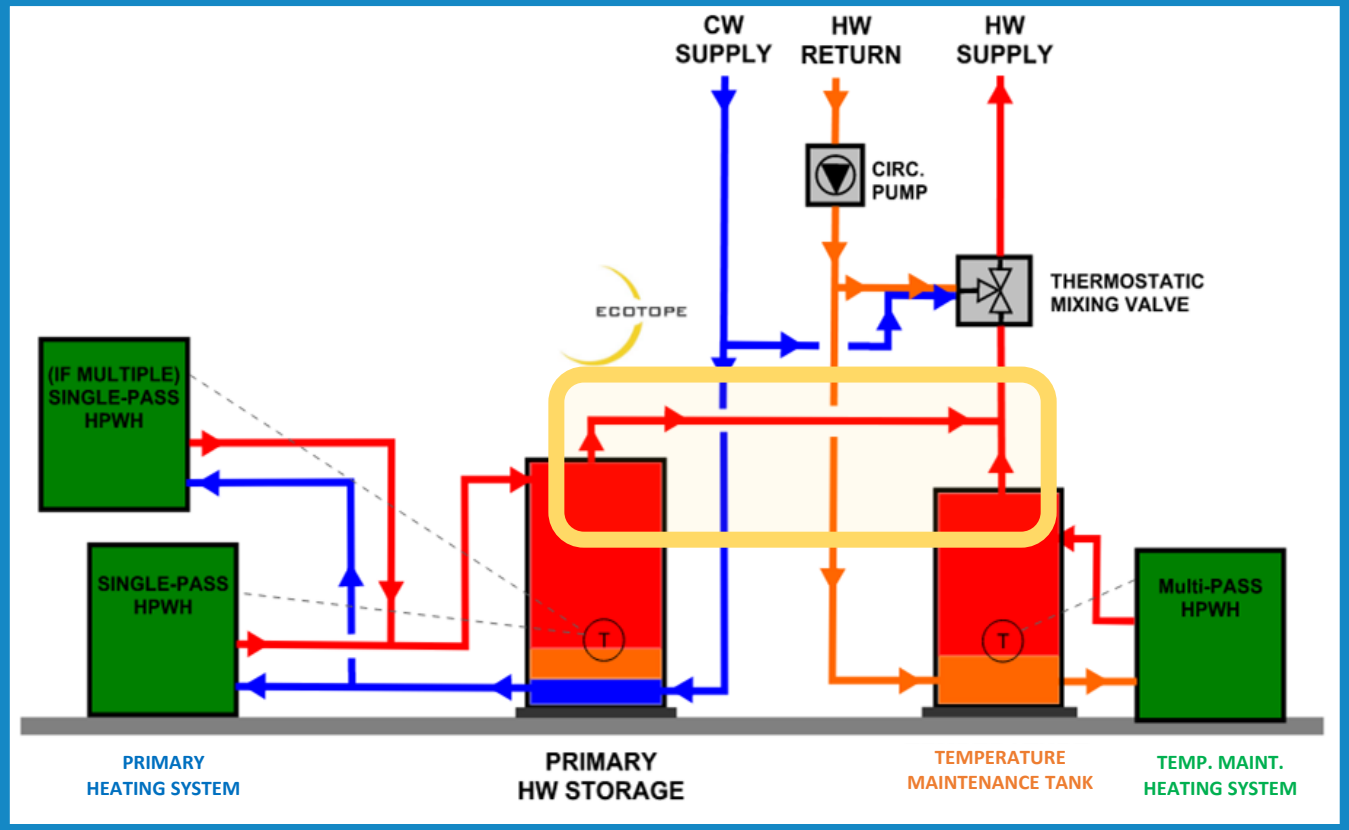
SINGLE-PASS PRIMARY HPWH SYSTEM W/ PARALLEL TEMPERATURE MAINTENANCE TANK & MULTI-PASS HPWH



KEY CONSIDERATIONS:

- Single pass heating system for primary
- Dedicated heating system for temperature maintenance
- Two systems work in parallel

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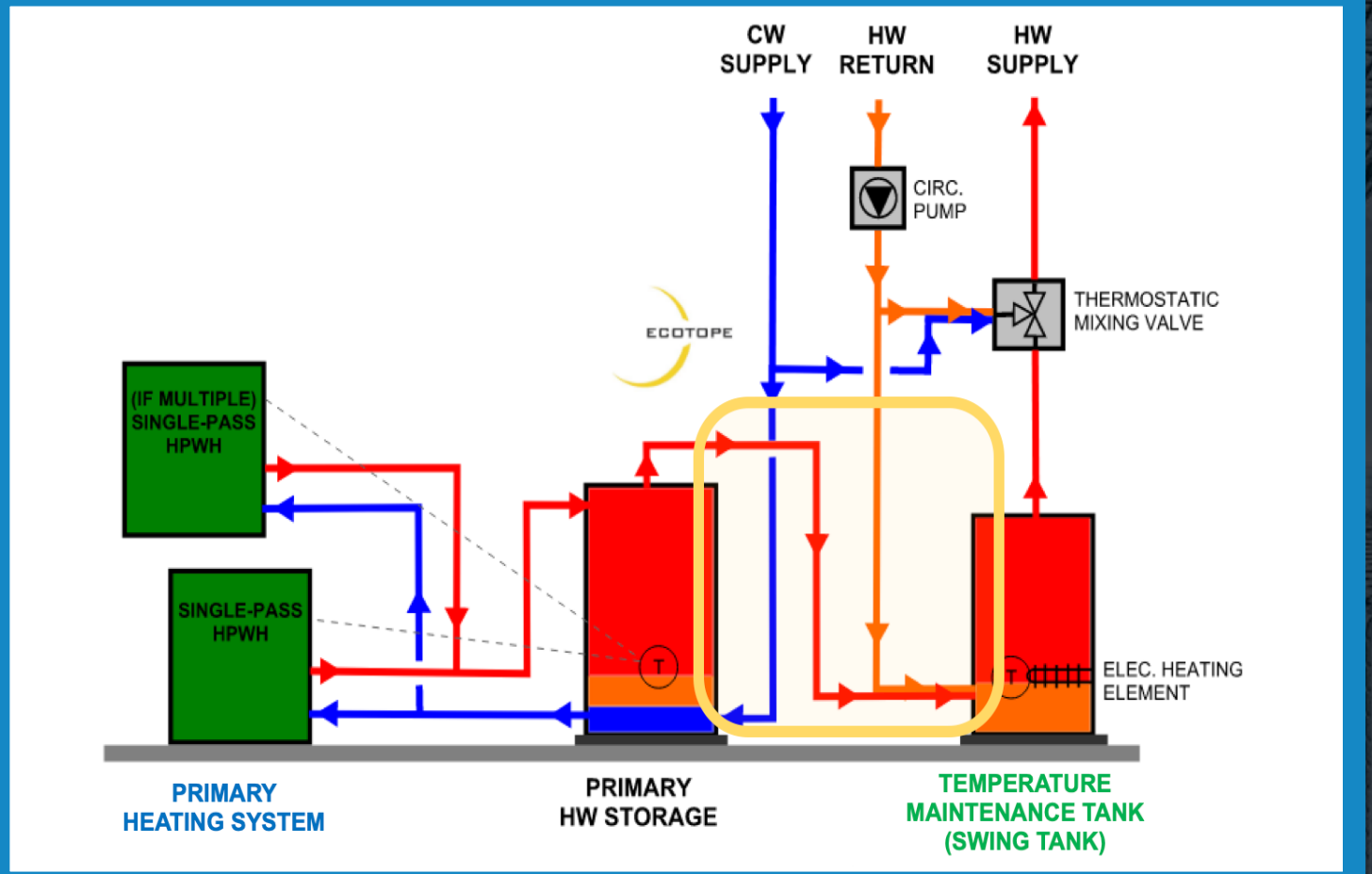
SINGLE-PASS PRIMARY HPWH SYSTEM W/ SERIES TEMPERATURE MAINTENANCE TANK (SWING TANK)



KEY CONSIDERATIONS:

- Single pass heating system for primary
- Dedicated heating system for temperature maintenance
- Two systems work in series

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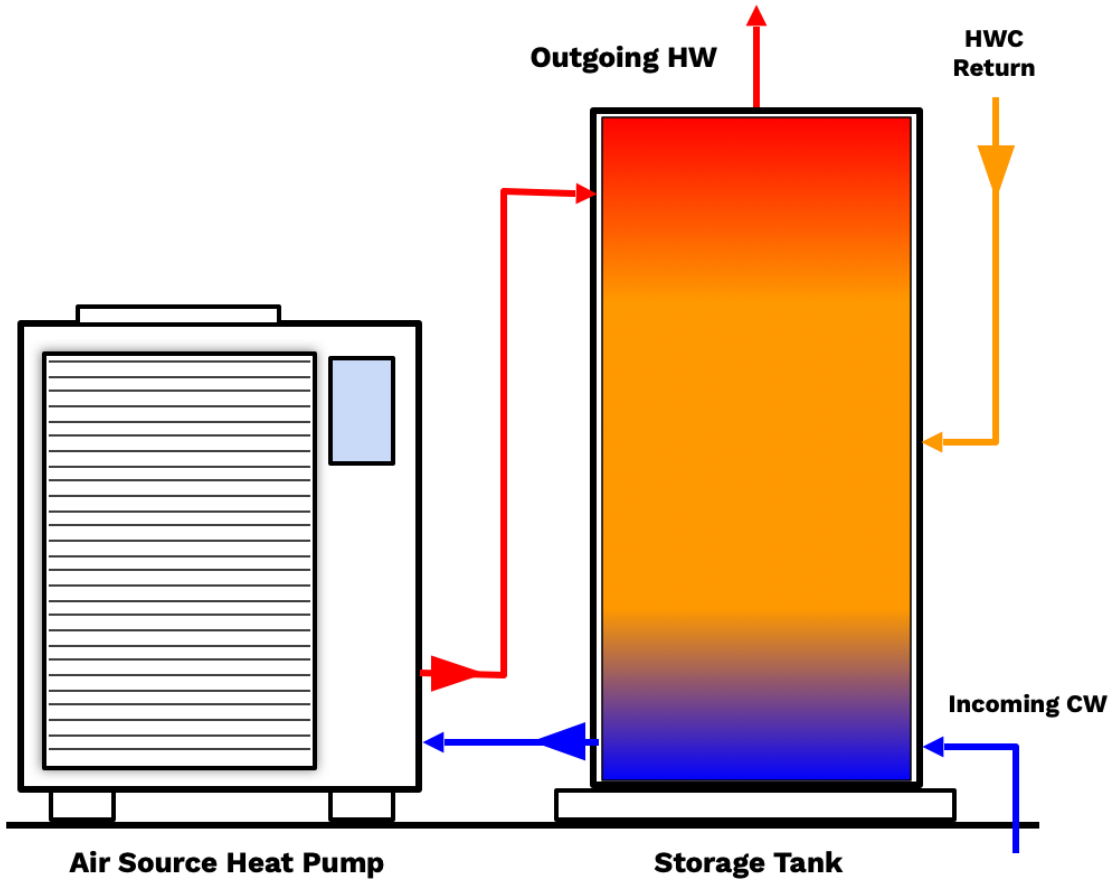
COMBINED SYSTEM



KEY CONSIDERATIONS:

- Both primary & maintenance loads done by one system.

RISKS:

- Cycling & Sizing issues
- Low effective storage volume
- Low HPWH COP
- Technology dependent

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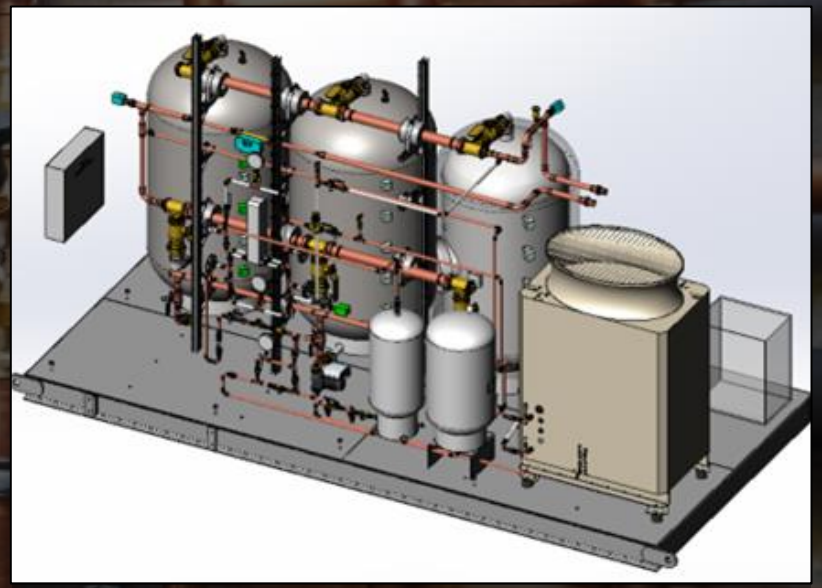
MARKET DELIVERY: LEARN THE LANGUAGE

CUSTOM ENGINEERED SYSTEM

All the pieces are separate & come from multiple distributors and/or manufacturers.

SPECIFIED BUILT-UP SYSTEM

All the pieces are separate but come from a single distributors or manufacturer.



PACKAGED/SKID

Everything is assembled & delivered in a single package.

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HPWH CONSIDERATIONS

- Air source / heat source
- Heating cycle (single pass / multipass)
- Height of control sensor(s)
- Pipe connections, size & location
- Insulation level

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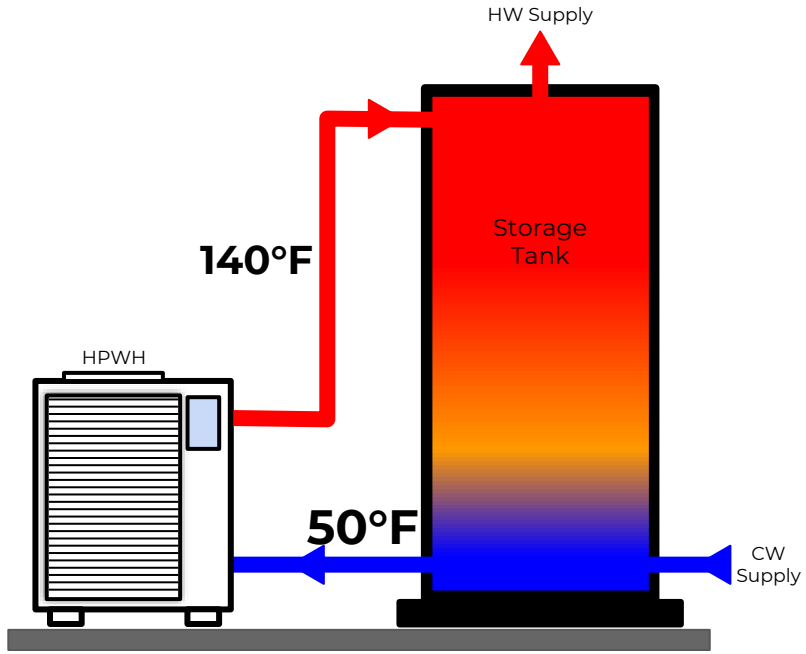
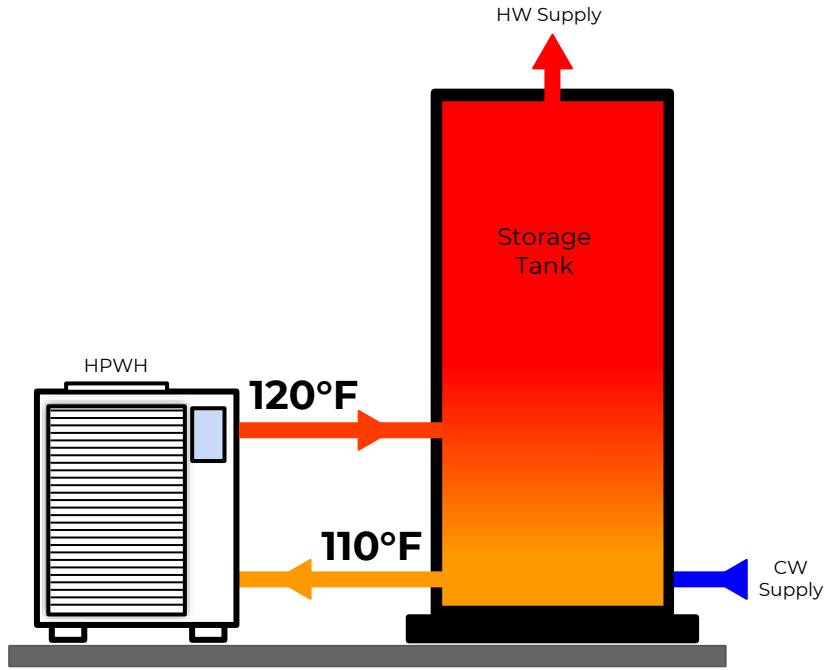
TWO TYPES OF HEATING CYCLES



SINGLE-PASS

Heats water to working temp. in single pass
(*usually for primary heating load*)



MULTI-PASS

Heats water to working temp. in multiple passes
(*typical temperature maintenance systems*)

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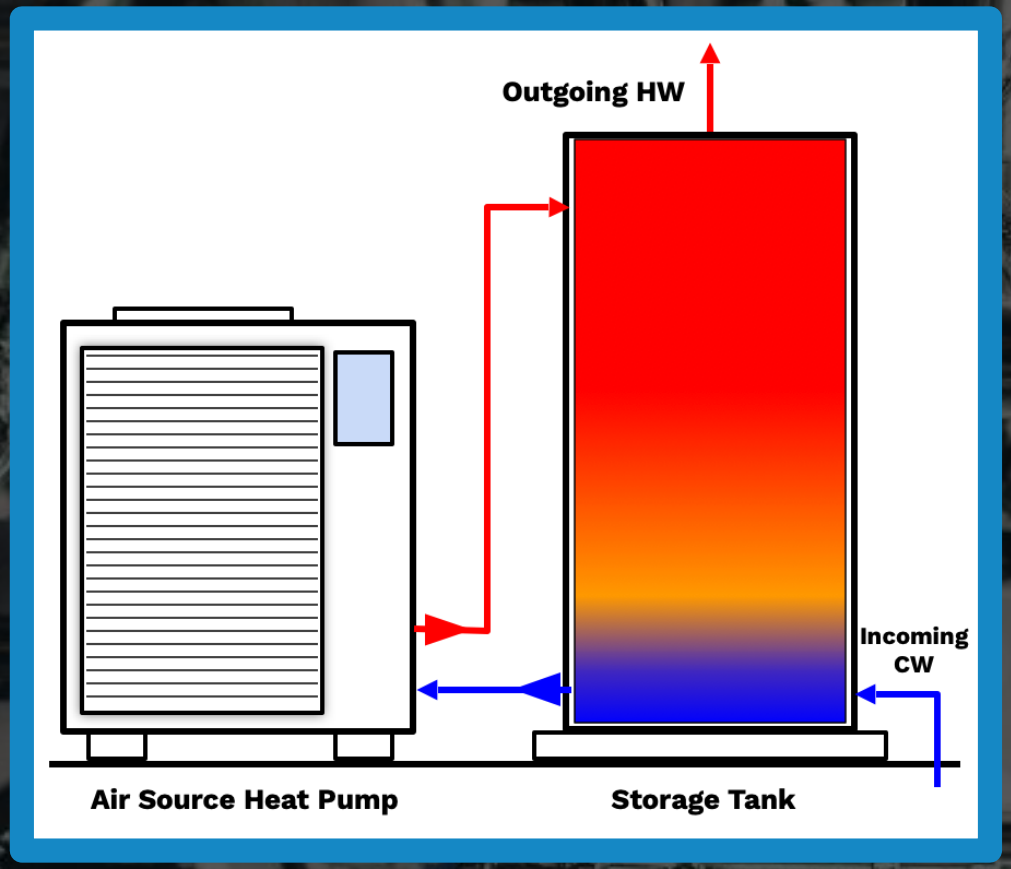
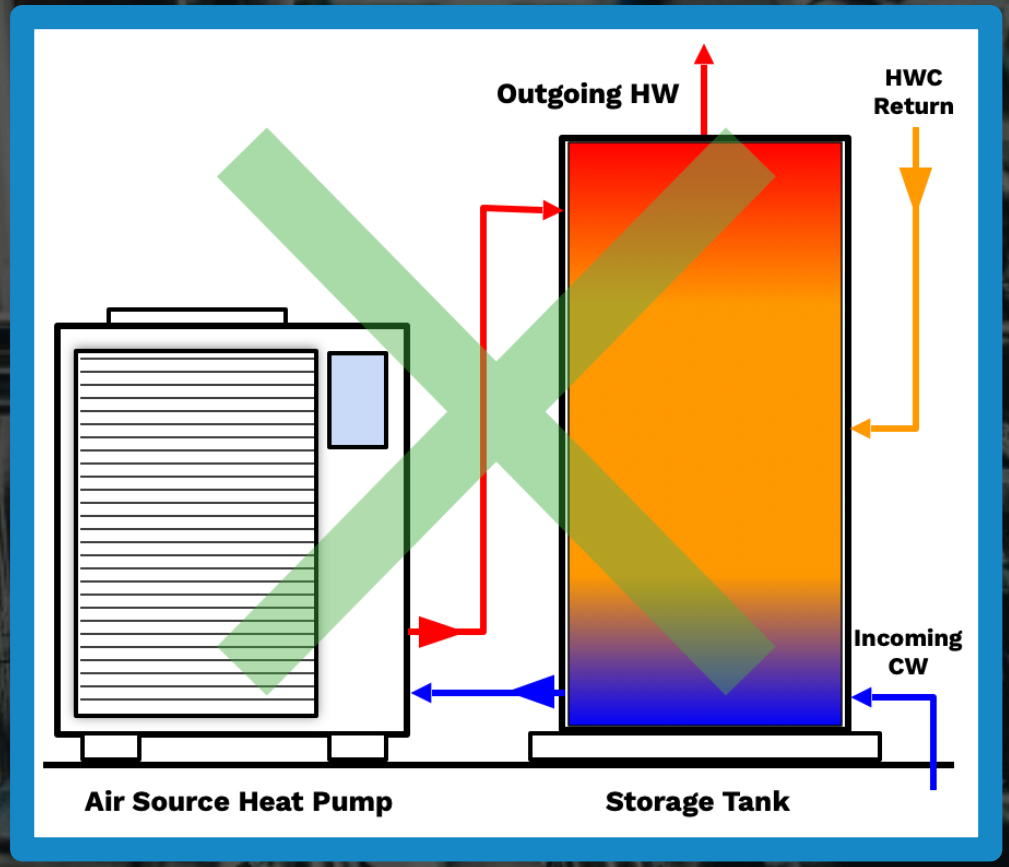
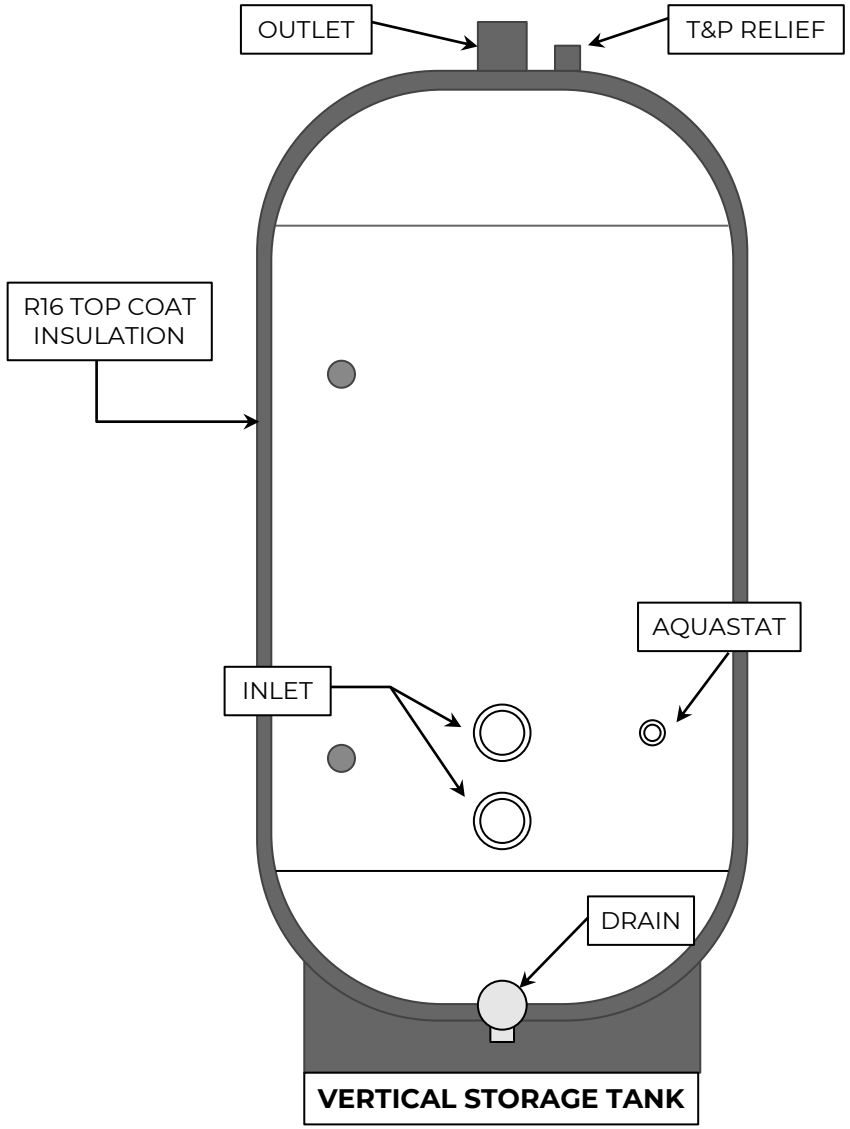
HW STORAGE SYSTEMS: **THERMAL STRATIFICATION**





HW STORAGE CONSIDERATIONS



- Physical space, room & door size
- Multiple tanks, series or parallel?
- Vertical is better than horizontal
- Height of control sensor(s)
- Pipe connections, size & location
- Insulation level

WHAT IS A CHPWH SYSTEM?

Small Commercial System

(closet installation serving 5 apts)

Large Commercial System

(basement installation serving 250 apts)

Multiple Commercial Systems

(residential equipment serving 4-5 apts)

Multiple Sizes, Types, & Configurations

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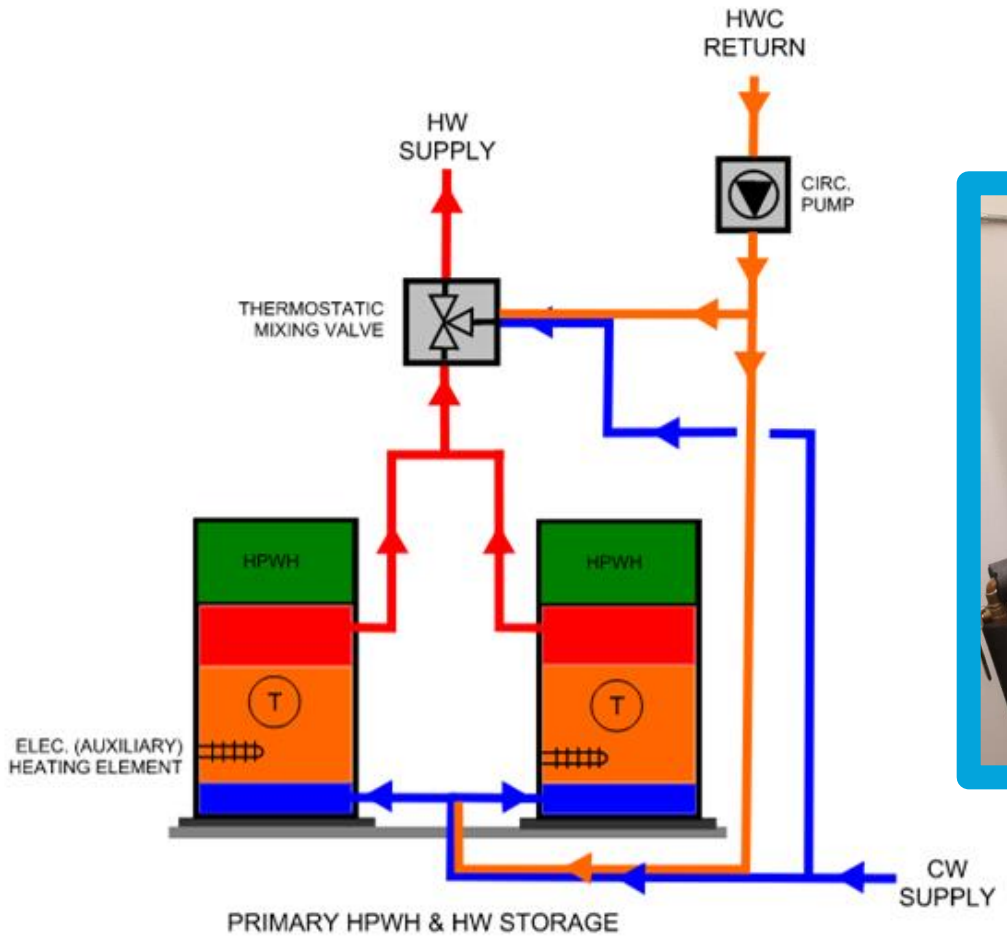
SMALL COMMERCIAL SYSTEM



- Residential unitary equipment in a commercial building?!
- 2-6 units
- Multiple unitary HPs (in parallel)

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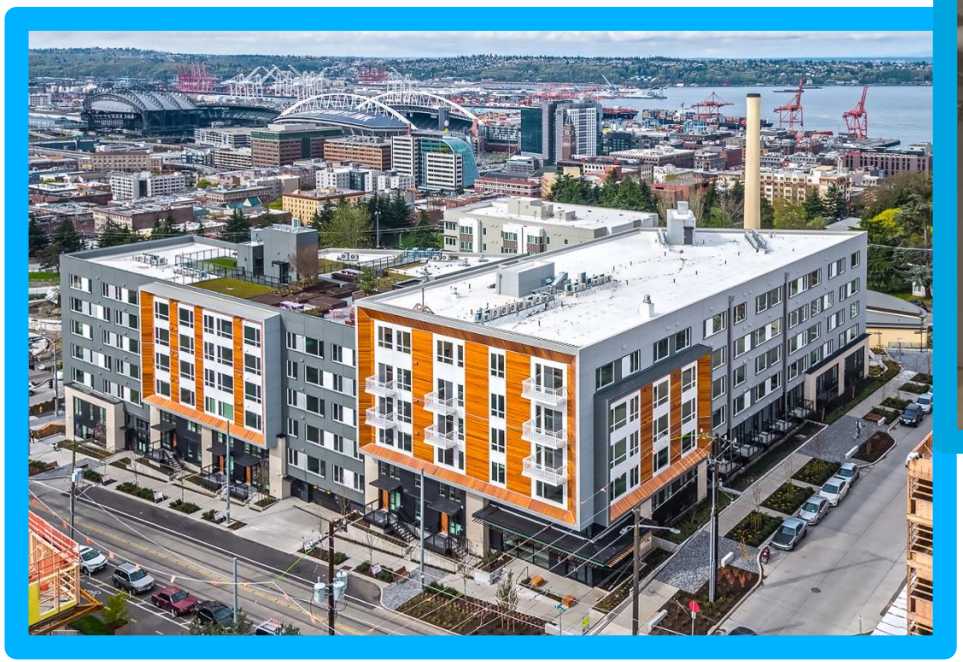
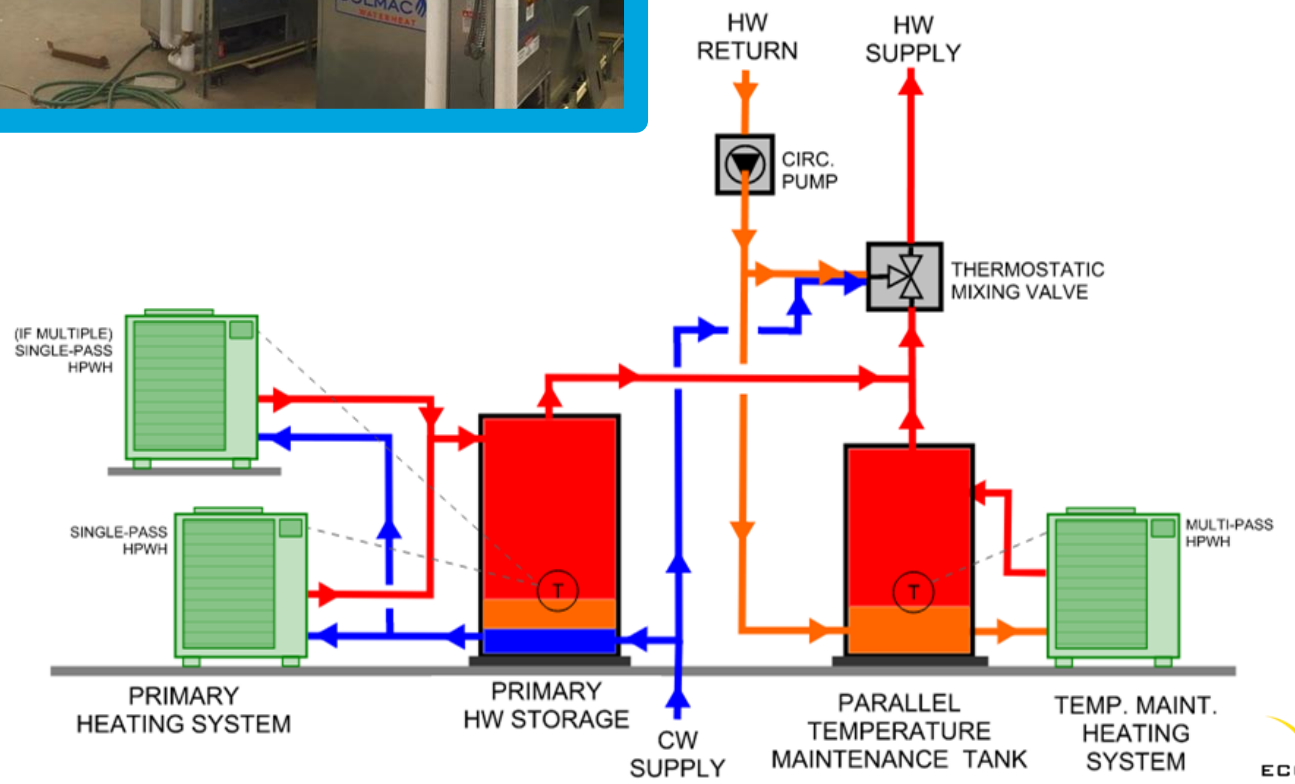
LARGE COMMERCIAL SYSTEM



- Commercial equipment; engineered system
- 200 units
- Dedicated heating system:
  - Single pass primary HPWH
  - Multi pass temperature maintenance system



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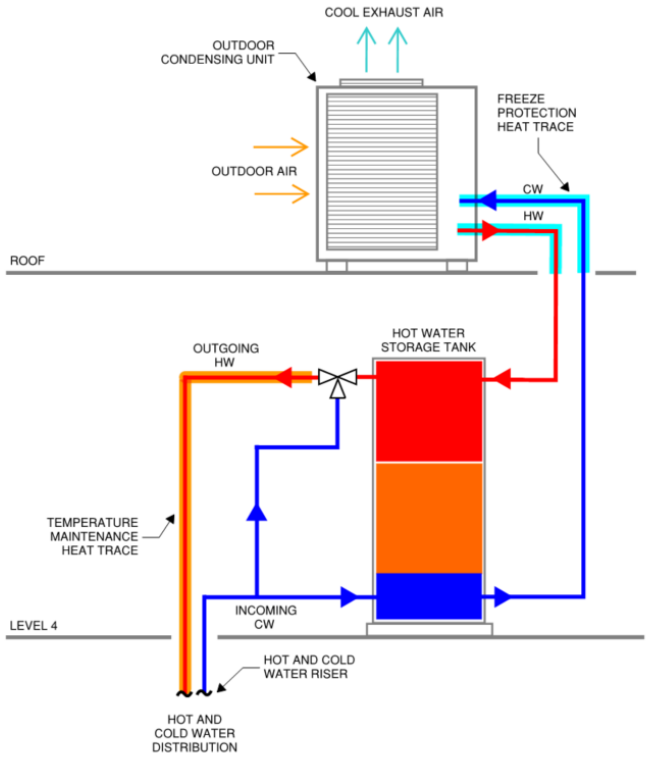
MULTIPLE COMMERCIAL SYSTEMS

- Smaller residential equipment used in a commercial application
- 100 units
- Multiple central/commercial HPWH systems



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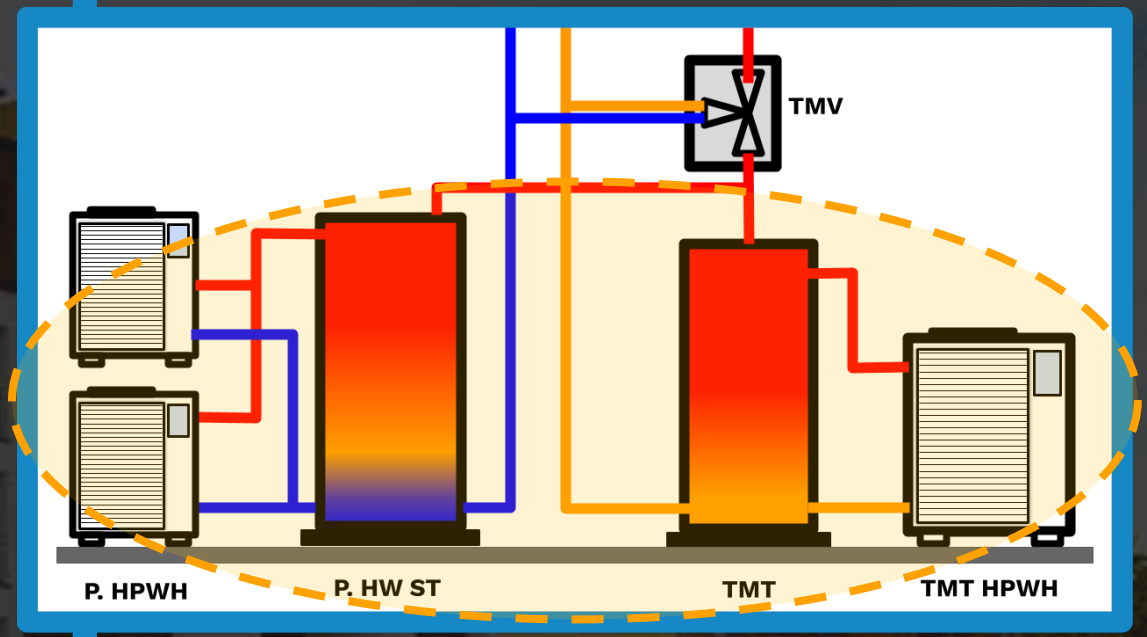
HW SYSTEM DESIGN: SIZING



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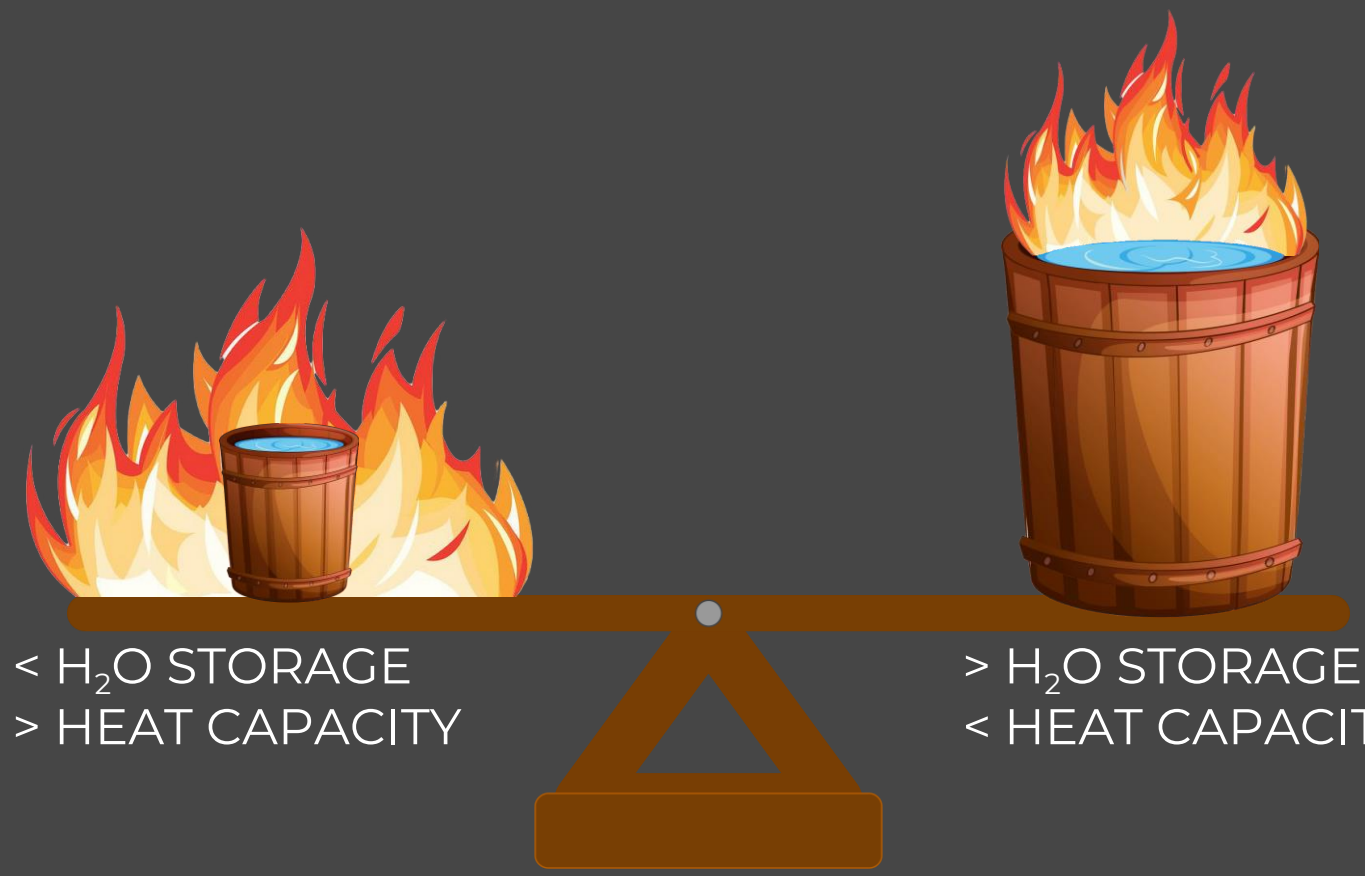
SYSTEM SIZING IMPACTS

55 Tons
1,000 Gallons

5 Tons
520 Gallons

SYSTEM SIZING

- Gas systems are sized w/ low storage and high heat capacity
- HPWH systems are sized w/ high storage and low city



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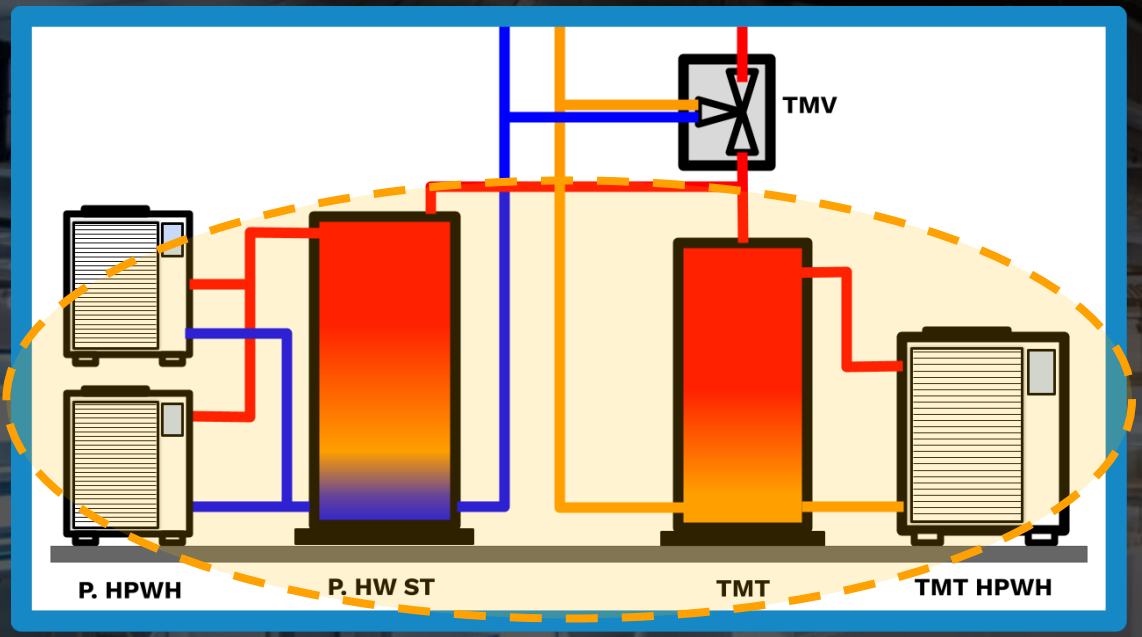
SYSTEM SIZING



Two Loads

- Occupancy and Hot Water Load
- Temperature Maintenance

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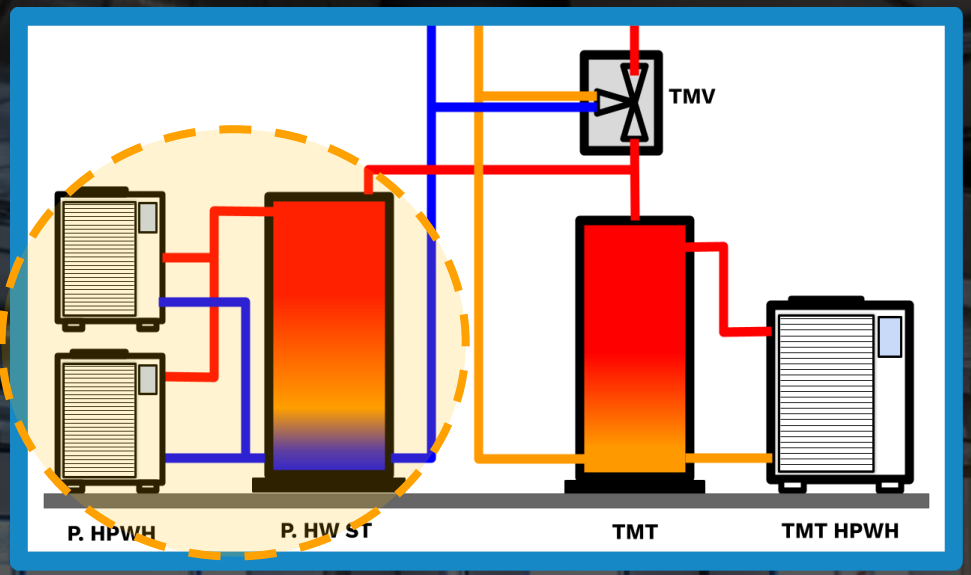
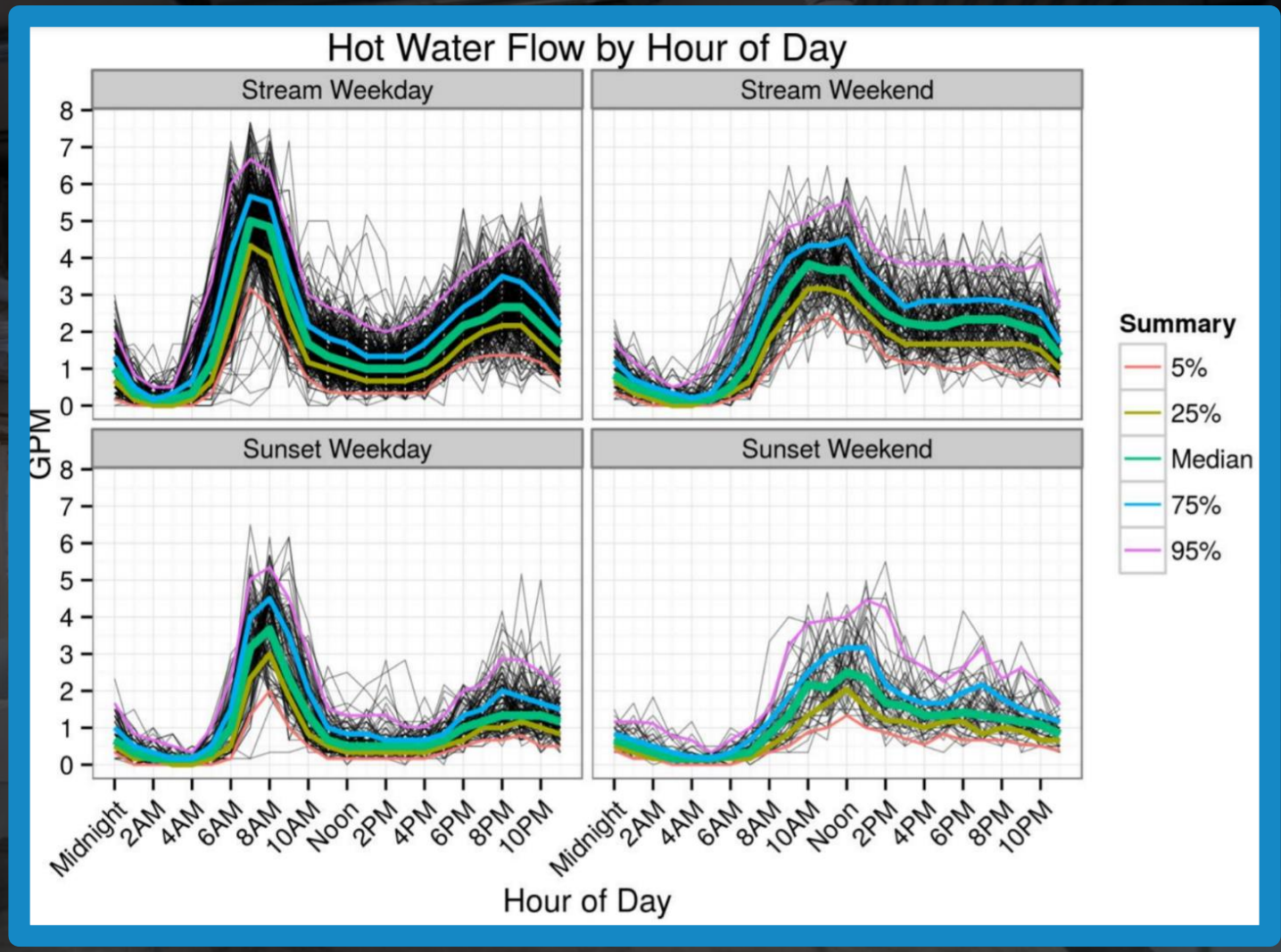
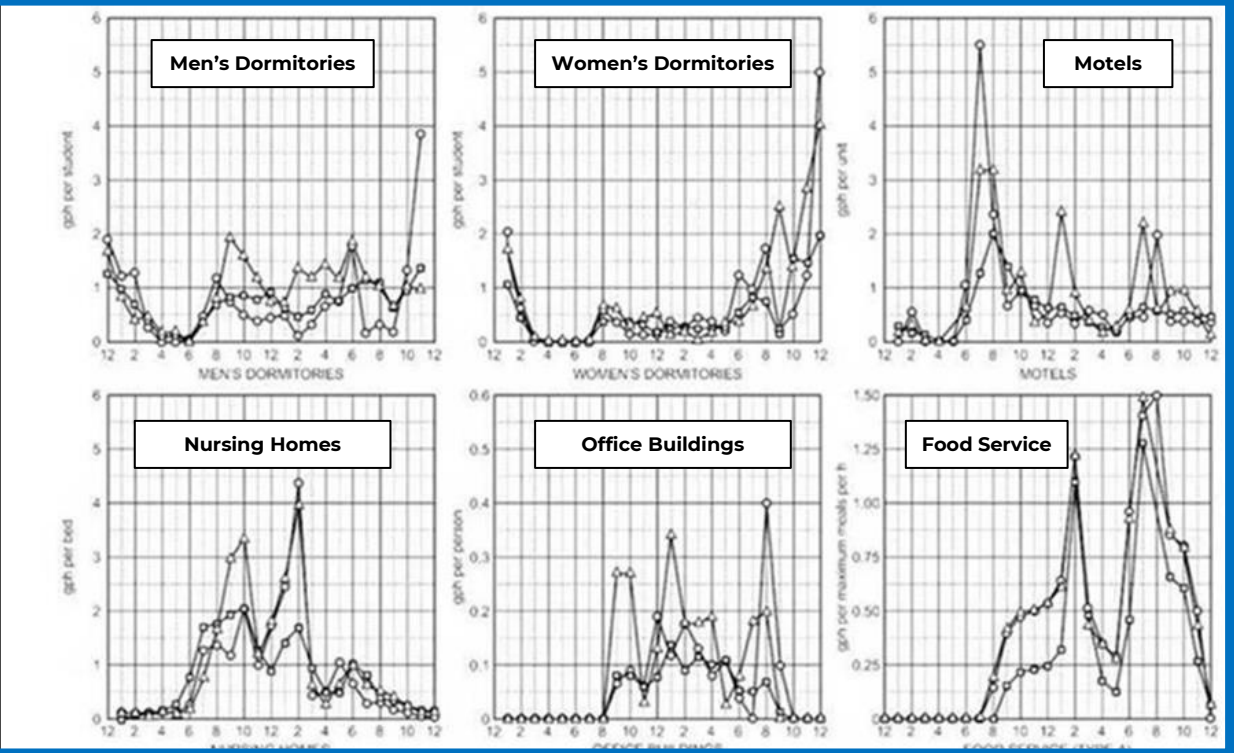
SYSTEM SIZING : Hot Water Load

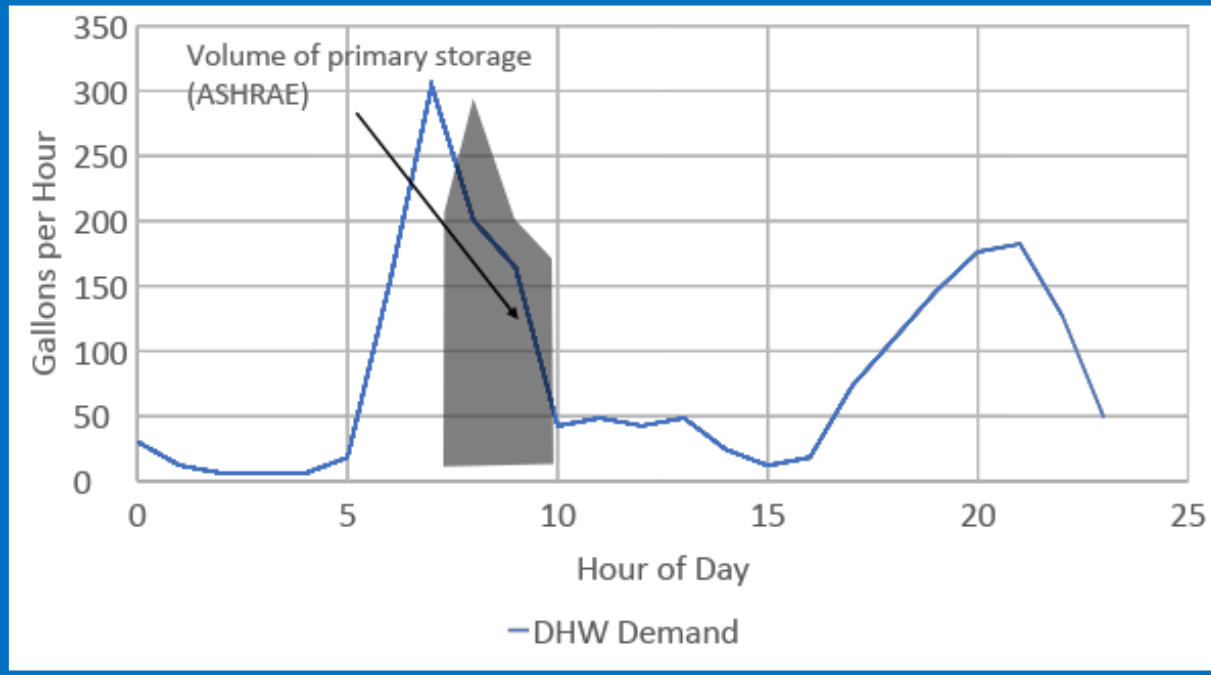




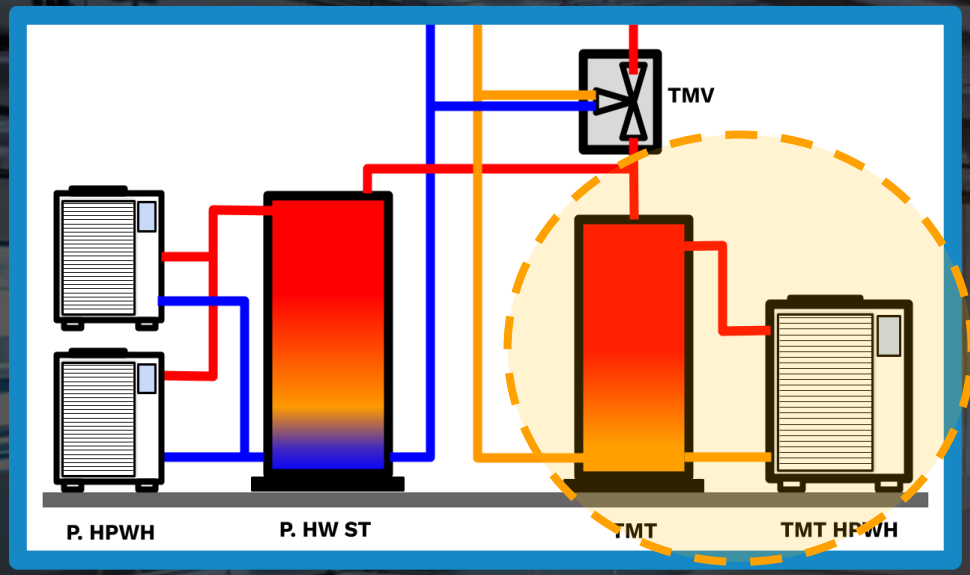
SYSTEM SIZING

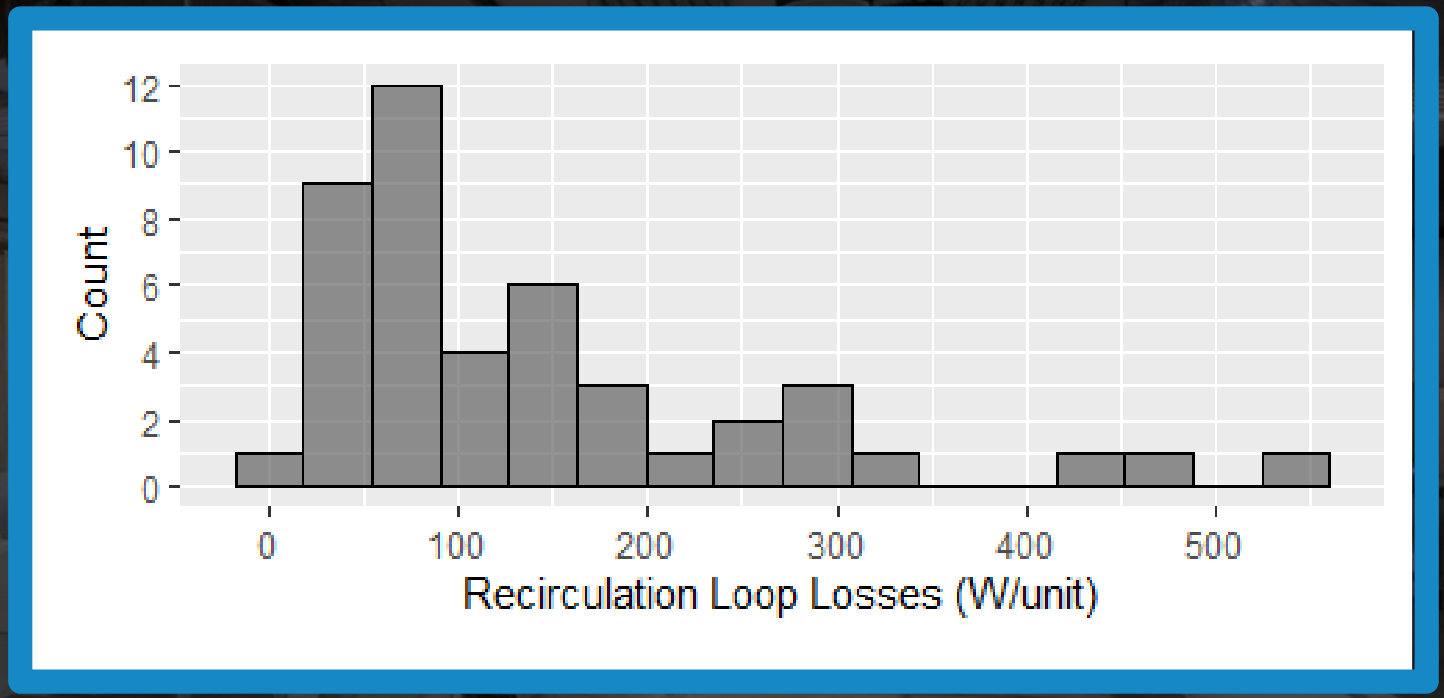


Multi Family **Domestic Hot Water (DHW)** Demand

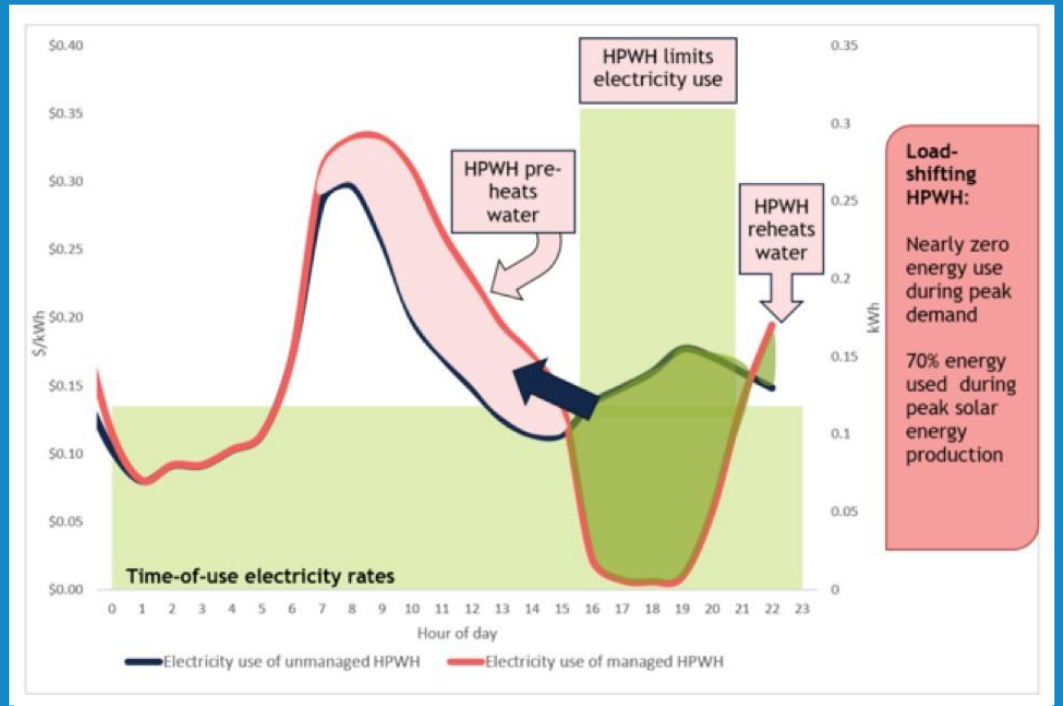


SYSTEM SIZING : Temperature Maintenance





SIZING FOR LOAD SHIFT



	What's changing?	Details
Starting January 1, 2021	Longer winter season:	October 1 to May 31 (currently November 1 to April 30)
	Shorter summer season:	June 1 to September 30 (currently May 1 to October 31)
Starting June 1, 2021 Summer Hours Changes (Winter Hours do not change)	Peak Hours:	3–8 p.m. weekdays
	Partial Peak Hours:	12–3 p.m. and 8–10 p.m. weekdays; 5–8 p.m. weekends
	Off-Peak Hours:	All other hours including most holidays
Starting January 1, 2022 Summer Hours Changes (Winter Hours do not change)	Peak Hours:	4–9 p.m. weekdays
	Partial Peak Hours:	2–4 p.m. and 9–10 p.m. weekdays 5–8 p.m. weekends
	Off-Peak Hours:	All other hours including most holidays

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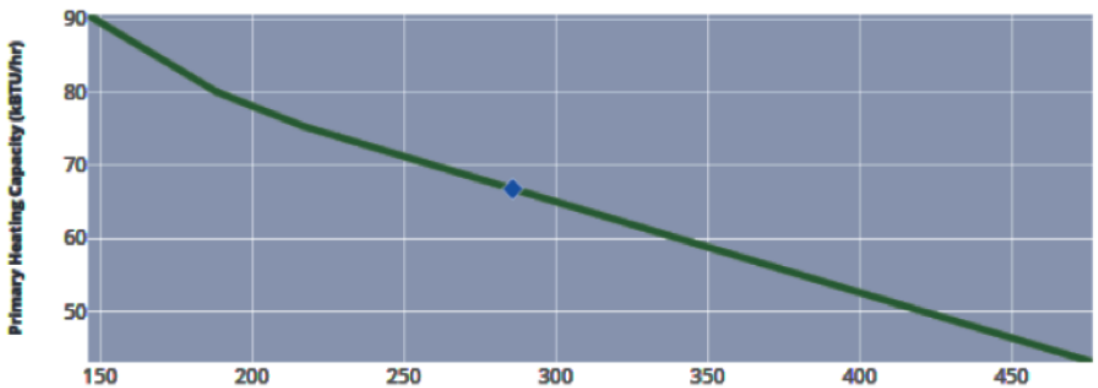
ECOSIZER

https://calbem.ibpsa.us/resources/ecosizer/



Primary System Size, Storage: 286 Gal, Capacity: 66.8 kBTU/hr

THIS SYSTEM WAS SIZED FOR

Occupancy
60.0 People

Apartments
30.0 Units

Daily Hot Water Usage
25.0 Gallons per Day per Person

Total Hot Water
1500 Gallons per Day

Tank Volume
285 Gallons

Heating Capacity
66.8 kBTU/hr

Swing Tank Volume
80 Gallons

Swing Resistance Element
4.7 kW · **15.9** kBTU/hr

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MODELING CHPWH SYSTEMS

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HEAT PUMP PERFORMANCE

Residential Ratings

Constant COP

Outdoor Unit (Heat Pump) Model No. GUS-A45HPA

Performance	43-gal. system	83-gal. system
Energy Factor	2.65	3.35
First Hour Rating	69 gallons	97 gallons
Specifications		
Water Temperature Setting	149”F	
Ambient Air Operating Temperature	-15”F to +110”F	
Heat Pump Capacity	15,400 Btu/h	
Heat Pump Capacity	4.5 kW	
Heat Pump COP	4.5	
Refrigerant Type	R744 (CO_2)	
Compressor Type	Inverter	
Power Voltage	208/230v –1Ph – 60Hz	
Breaker Size	15 Amps	
MCA	7.7 Amps	
Outdoor Operating Noise Level	38 dB	
Weight	123 lbs	
Pipe Size (Tank to Heat Pump)	½" (Cold & Hot)	
Max Length Inc Vertical	25 ft	
Max Vertical Separation	10 ft	
Max Water Pressure	95 Psig	

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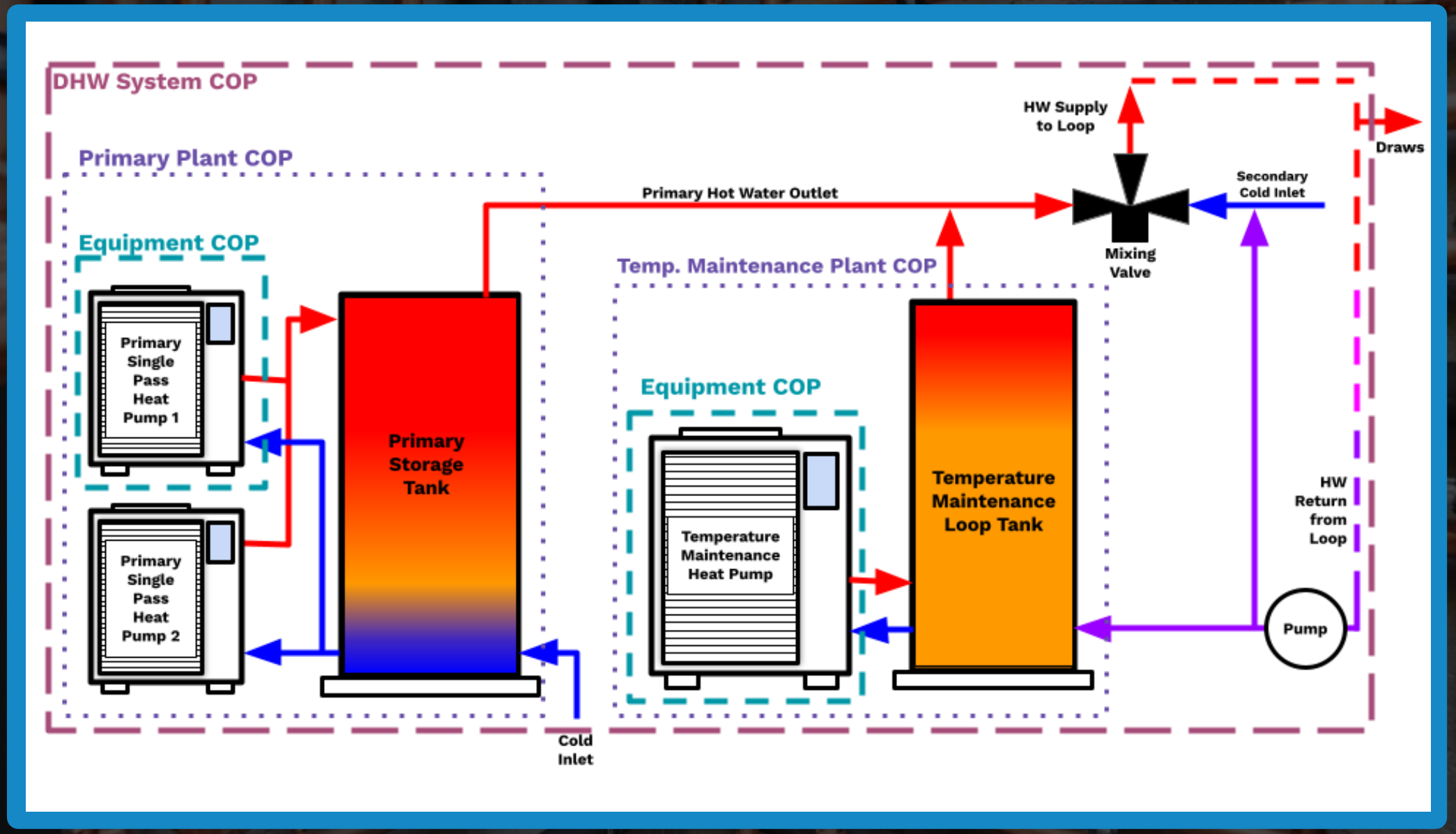
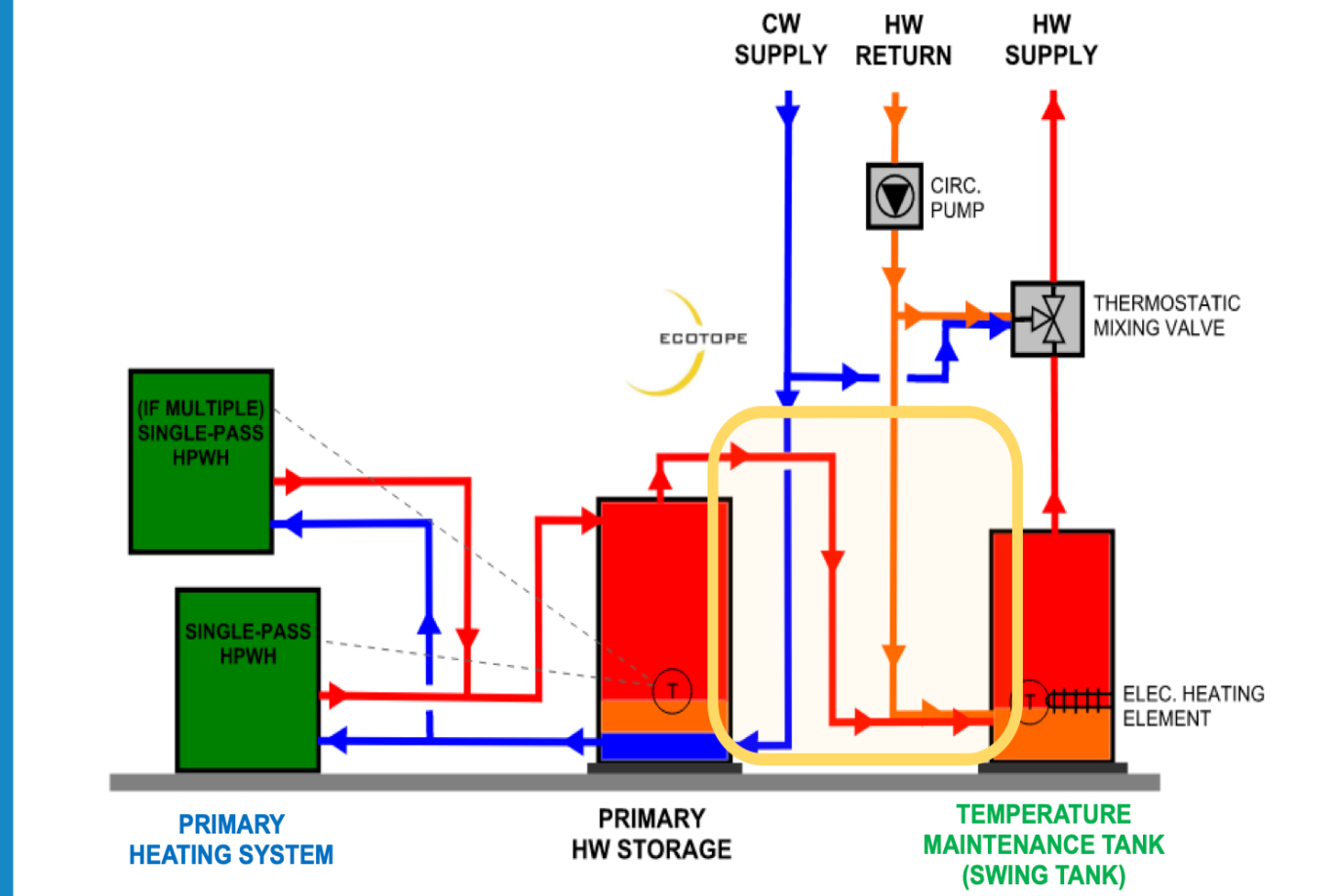
EQUIPMENT EFFICIENCY BOUNDARIES



What goes into a HPWH model

- Climate Zone
- Hot Water Draws
- Specific HPWH Equipment
- Schematic
- Temperature Maintenance System



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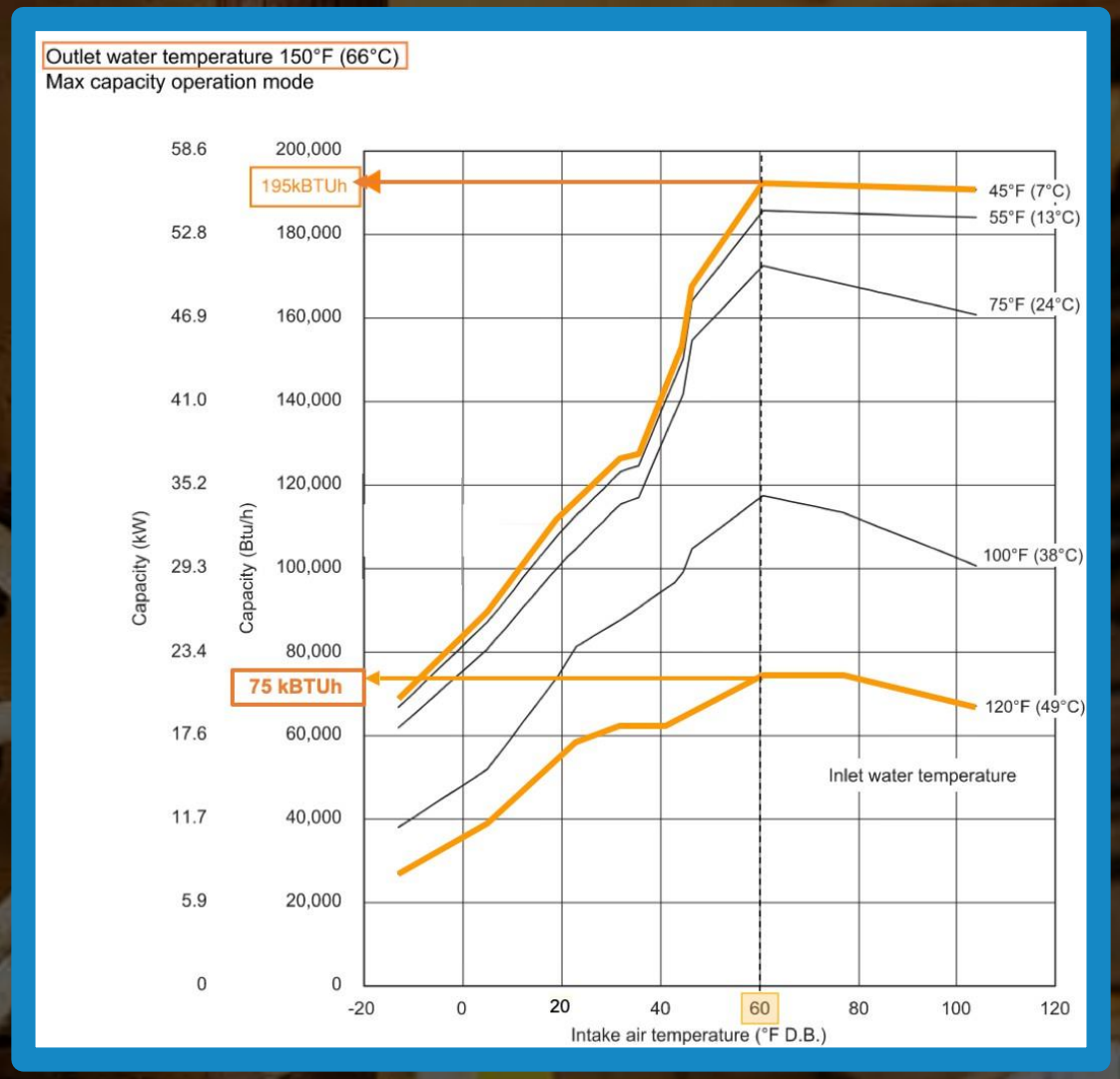
HEAT PUMP PERFORMANCE

EFFICIENCY IMPACTS:

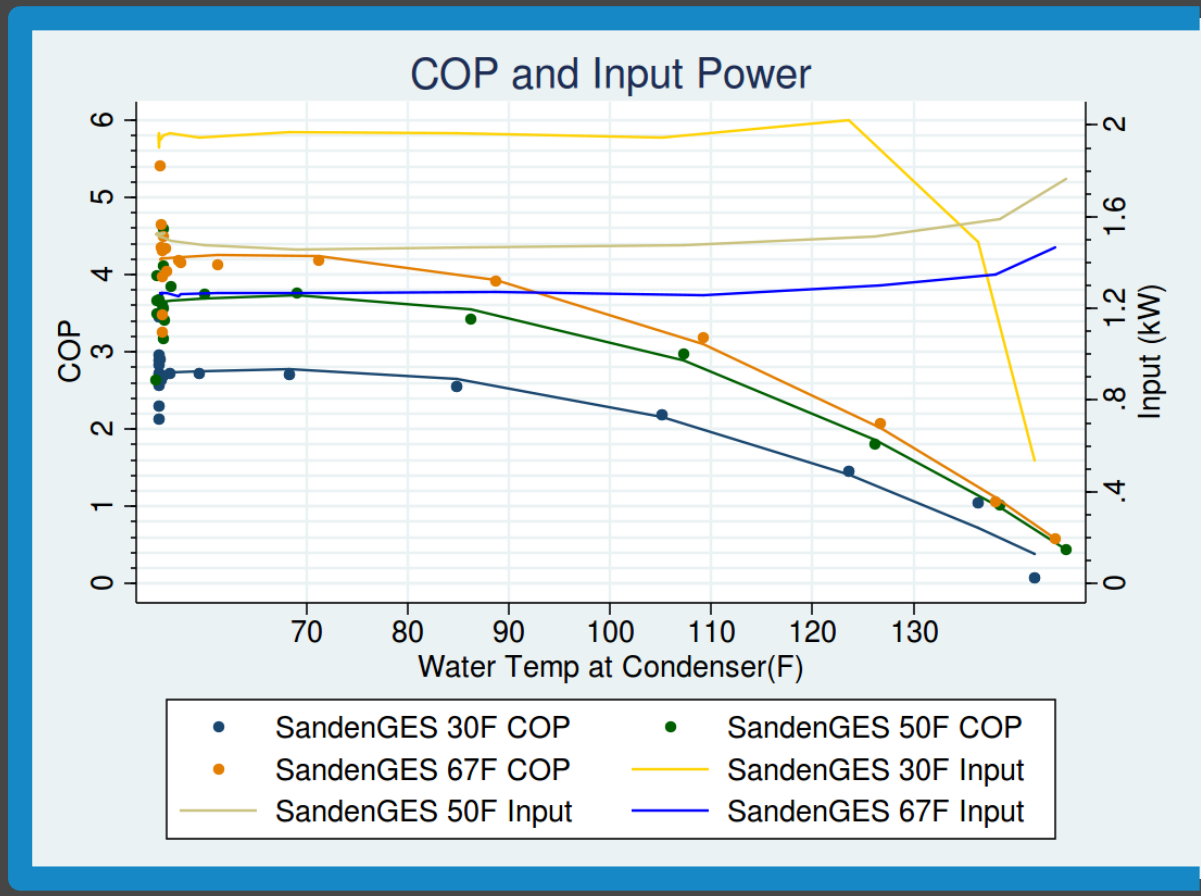
- Lower Air Temperature
- Warmer Entering Water
- Warmer Leaving Water

CAPACITY IMPACTS:

- Limits of Refrigerant
- Lower Air Temperature
- Defrost Effects



HEAT PUMP PERFORMANCE



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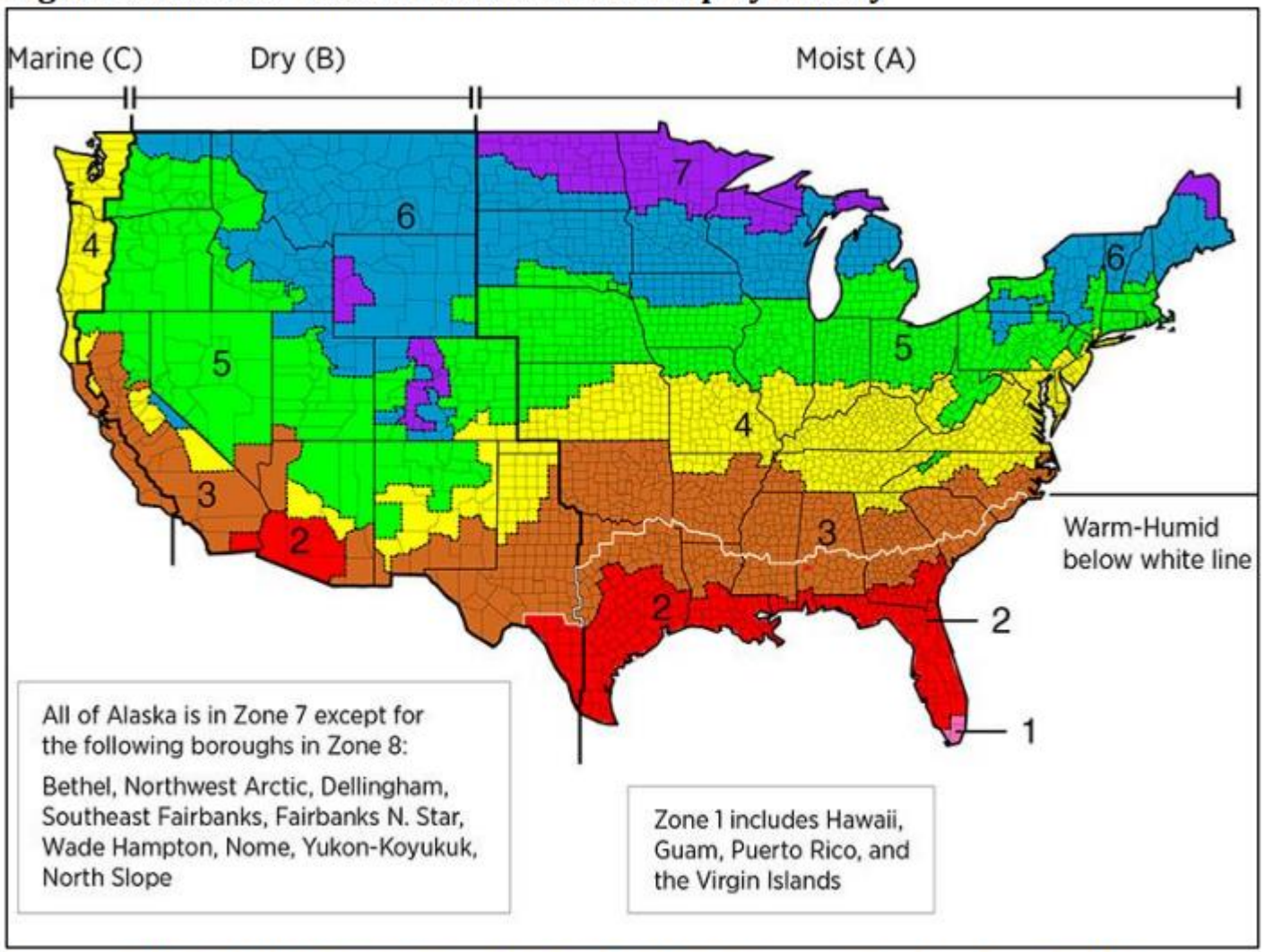
Climate Zone

Figure 1. ASHRAE 90.1 U.S. Climate Zone Map by County



Source: *ANSI/ASHRAE/IES Standard 90.1-2019 -- Energy Standard for Buildings Except Low-Rise Residential Buildings*

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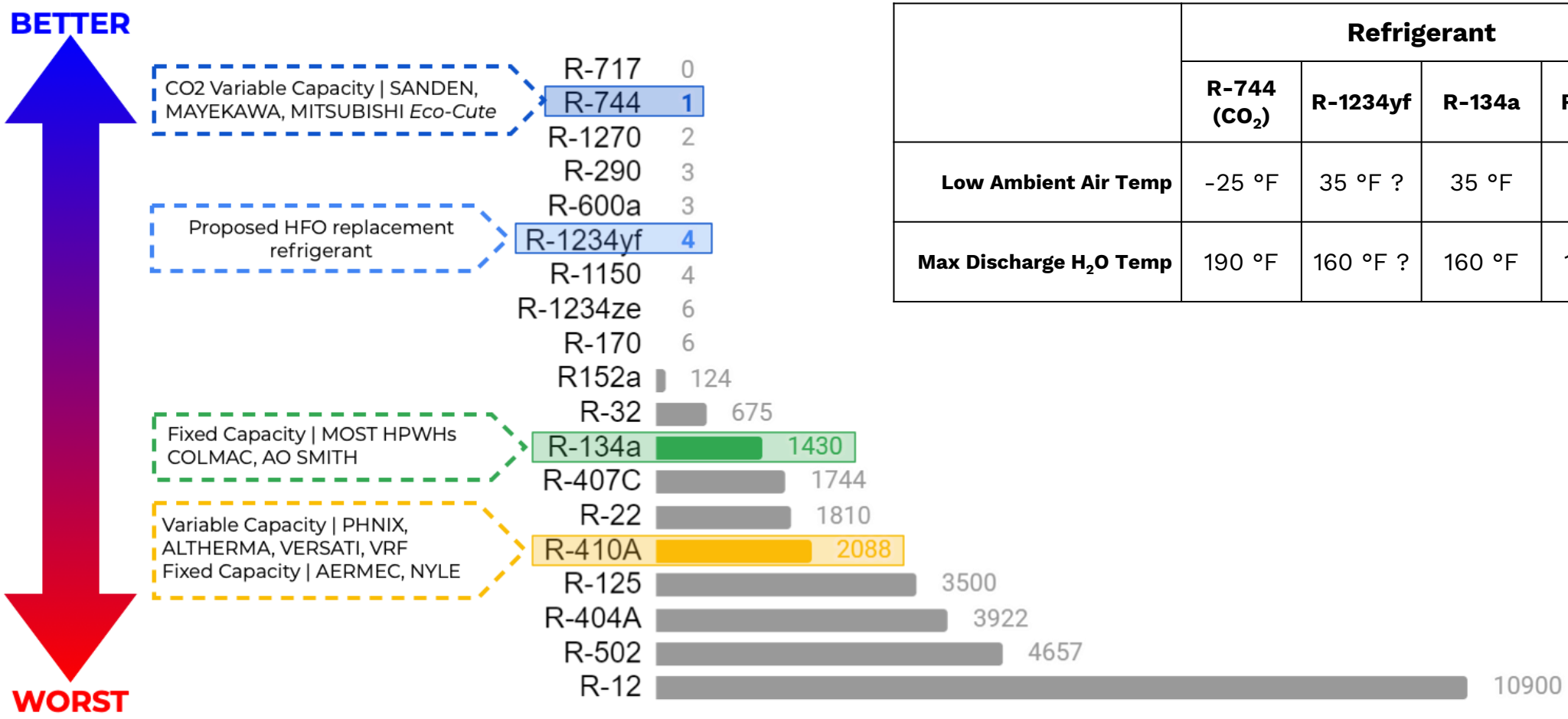
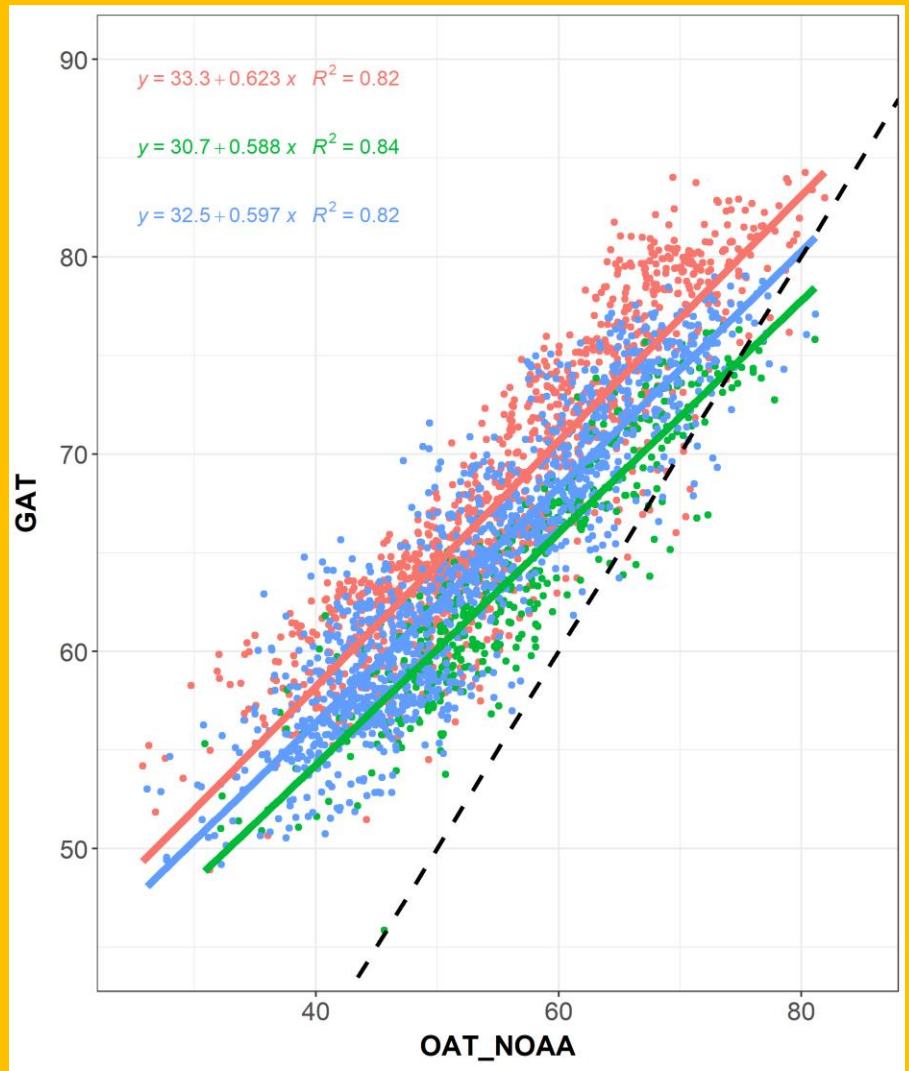
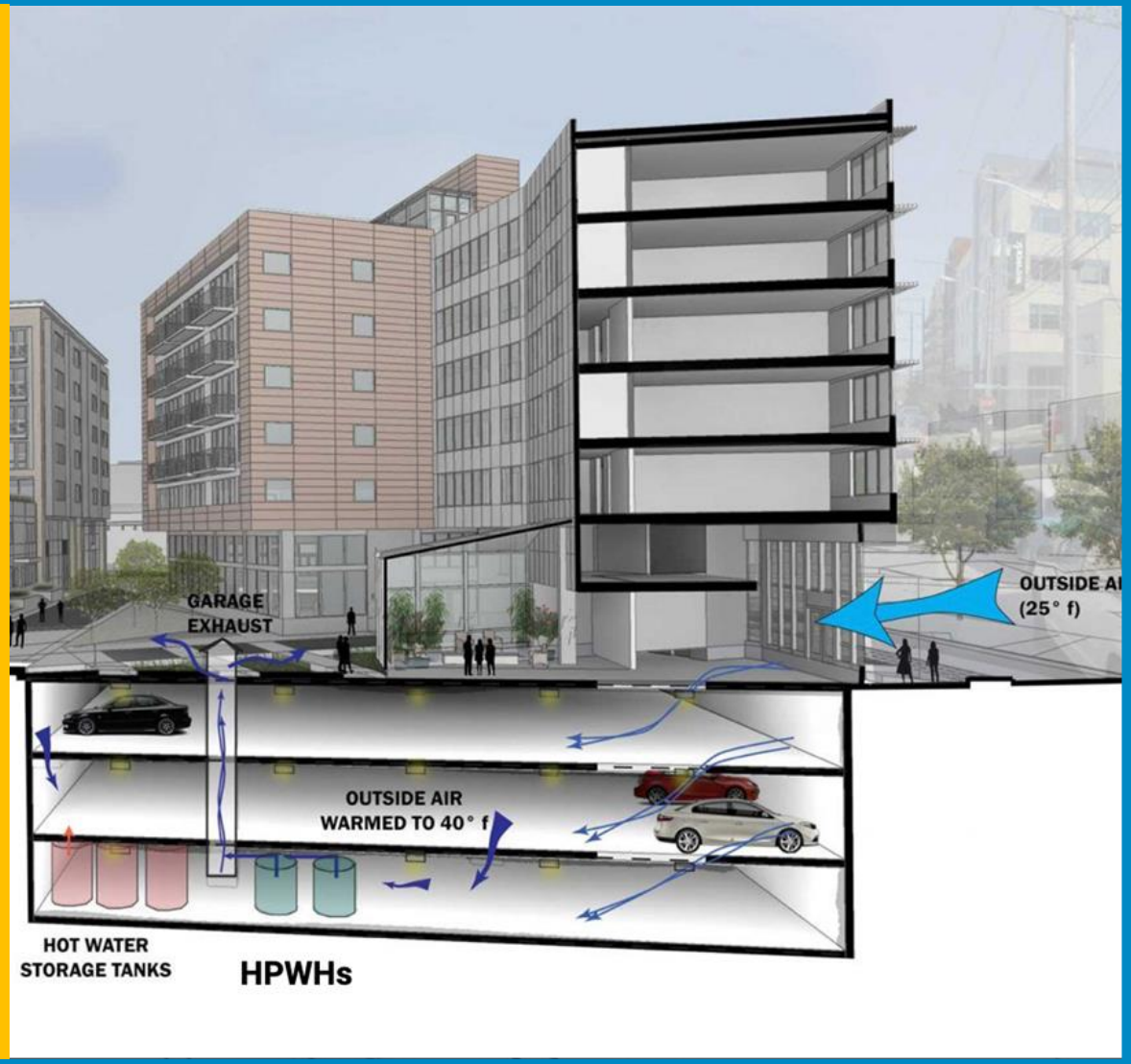
REFRIGERANTS | GWP OF SELECTED REFRIGERANTS (CARBON DIOXIDE EQUIVALENTS, CO_2e)



	Refrigerant			
	R-744 (CO_2)	**R-1234yf**	**R-134a**	**R-410A**
Low Ambient Air Temp	-25 °F	35 °F ?	35 °F	-5 °F
Max Discharge H_2O Temp	190 °F	160 °F ?	160 °F	140 °F

Garage Air Temperatures





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Bonneville
POWER ADMINISTRATION

Ecosim

Wireframes · Version 1.8

Website Coming Soon...

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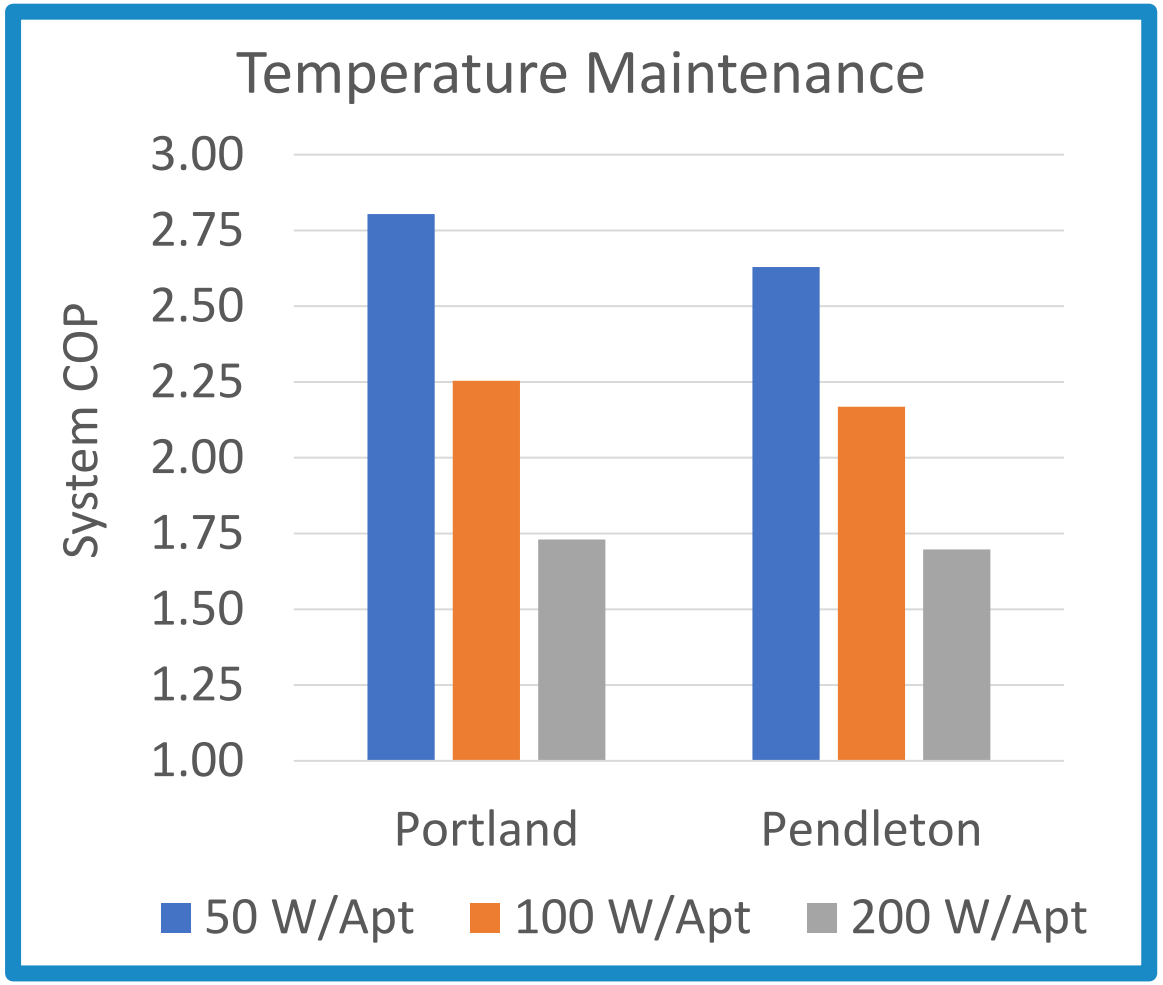
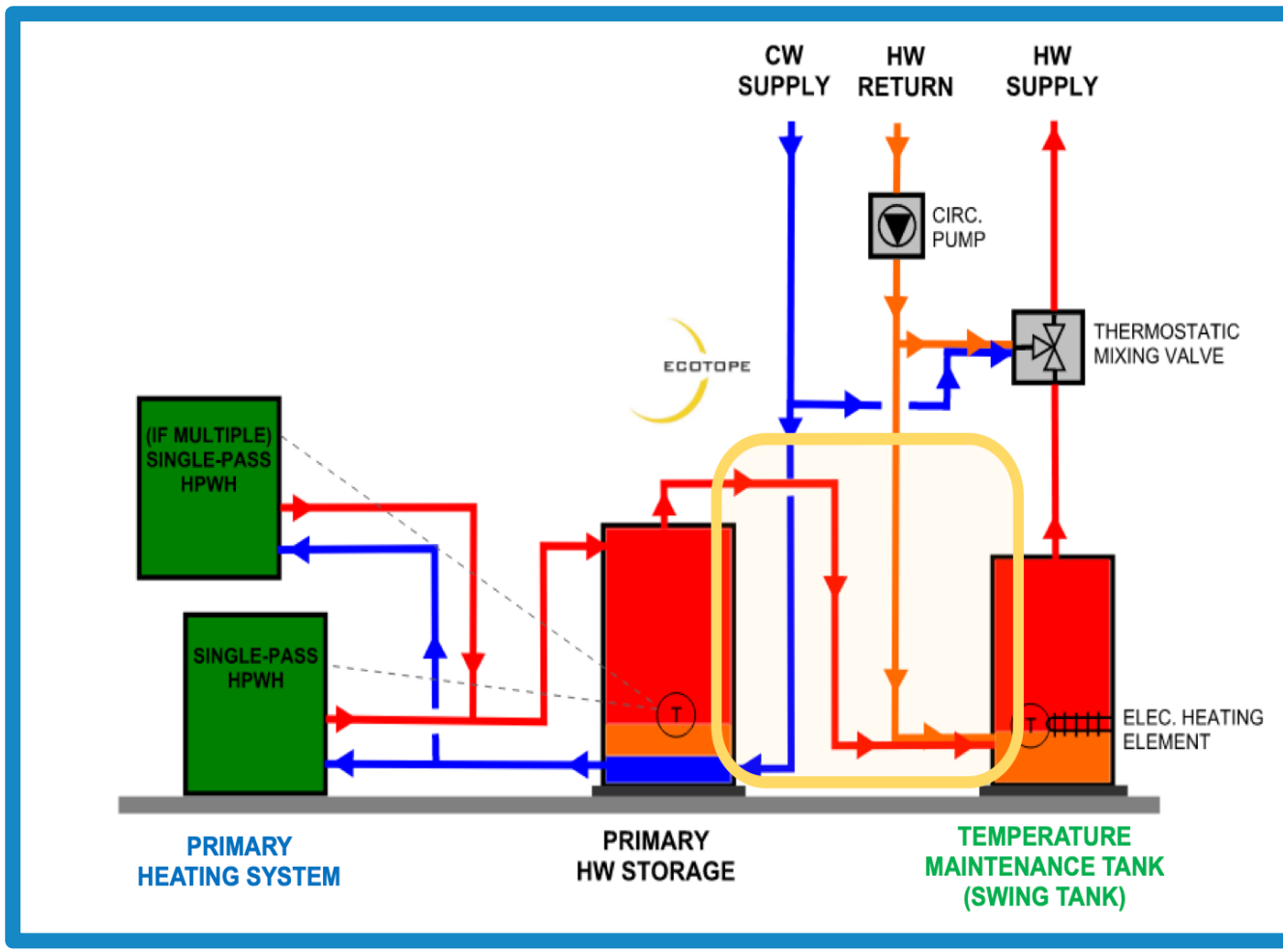
System COP





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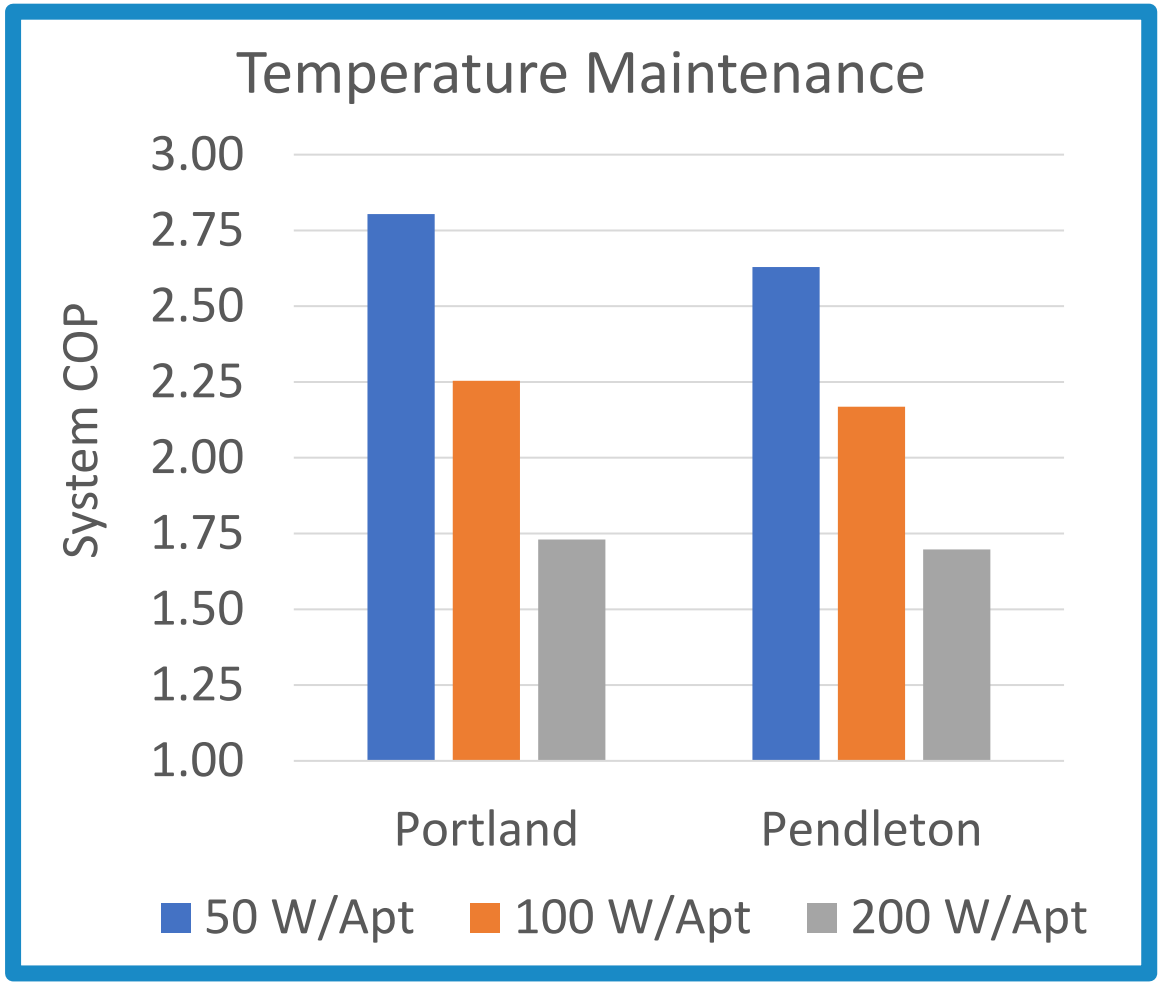
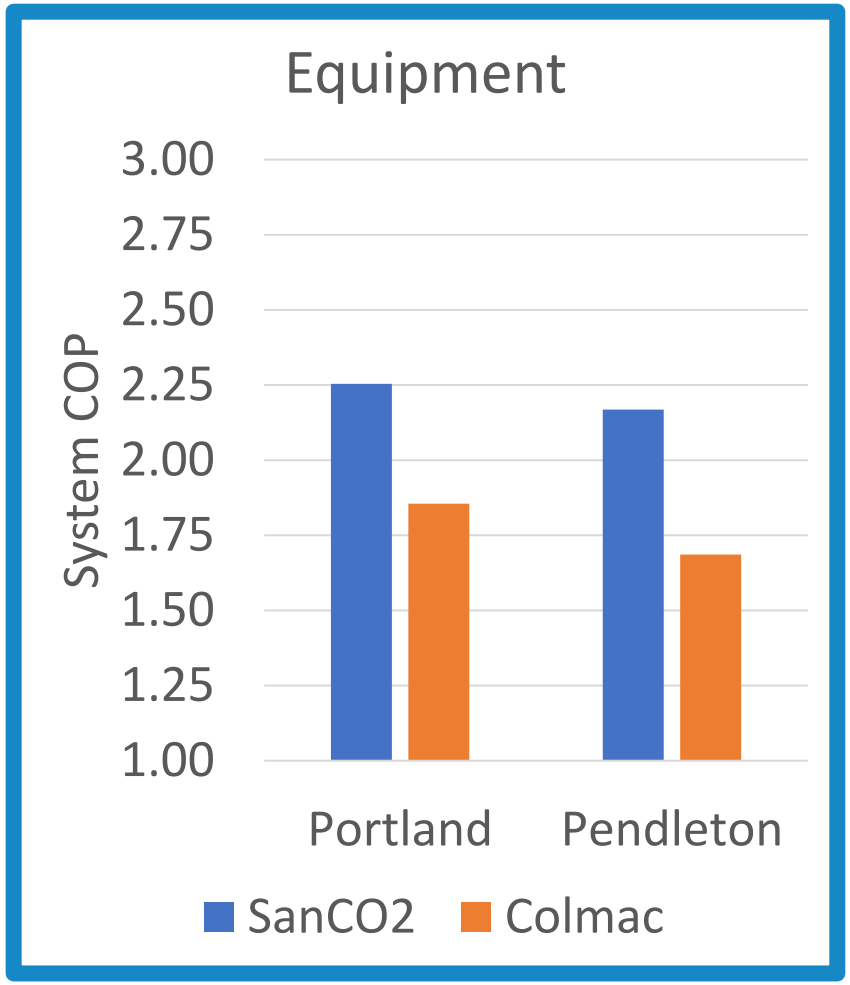
System COP





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Advanced Water Heater Specification

- Characterize standardized systems across **Climates** by **Schematics** and **Equipment**
- Draft Version 8 - https://neea.org/our-work/advanced-water-heating-specification

	Minimum System Efficiency (SysCOP)				Other Requirements	
	Hot Climates (IECC Zones 1-2)	**Mild Climates (IECC Zones 3-4)**	**Cold Climates (IECC Zones 5-6)**	**Extremely Cold Climates (IECC Zones 7-8)**	**Demand Response (CTA-2045- B)**	**M&V Points**
Tier 1	2.25	2.0	1.5	1.25	Optional	Optional
Tier 2	3.0	2.5	2.0	1.5	Required*	Required
Tier 3	3.5	3.0	2.5	2.0	Required*	Required
Tier 4	3.75	3.5	3.0	2.75	Required*	Required
*Demand response requirements are suspended through July 1, 2022.						

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