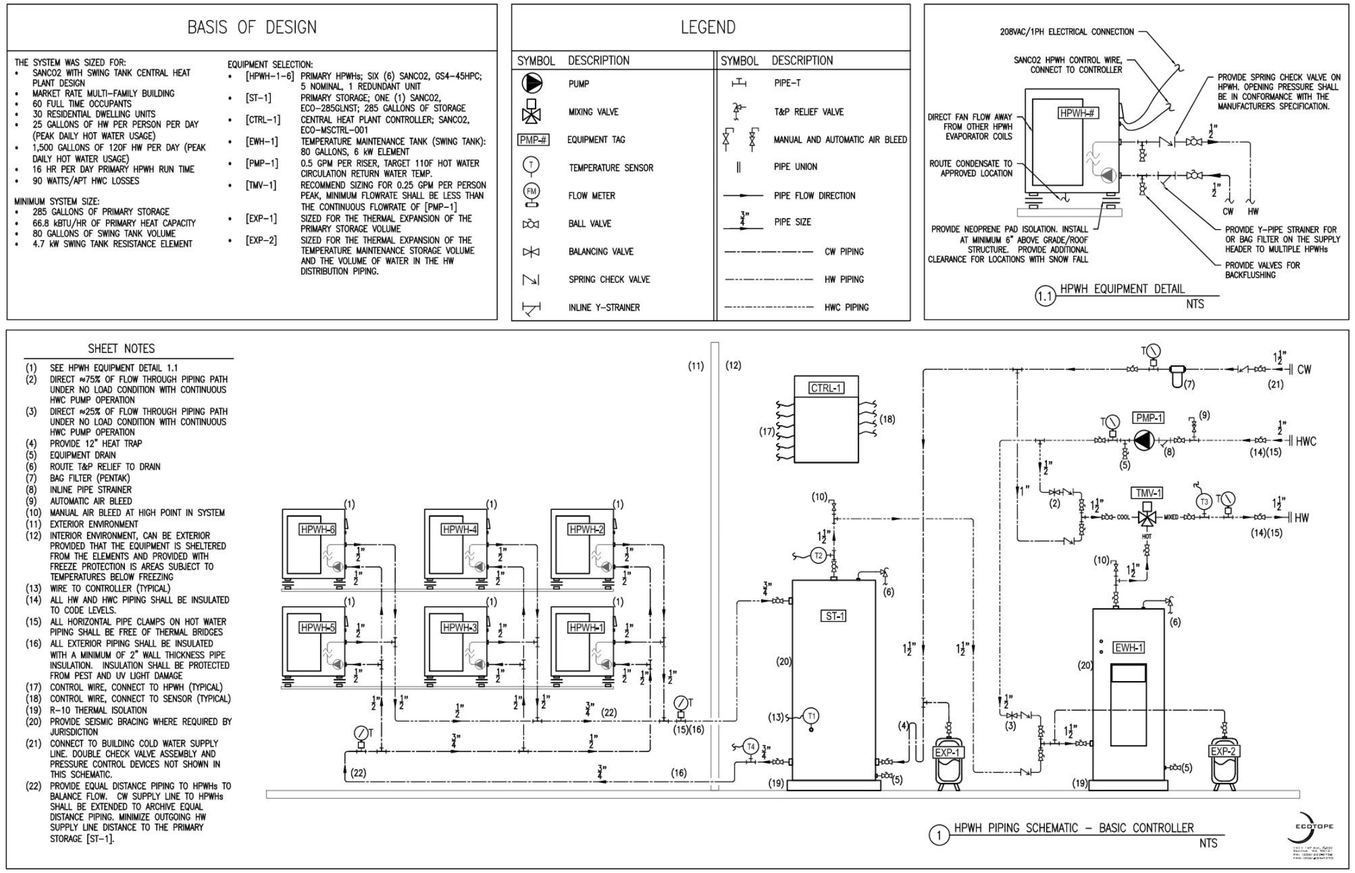
COMMERCIAL HEAT PUMP WATER HEATING:

ENGINEERING DEEP DIVE

Colin Grist, PE,
Ecotope, Inc.



OBJECTIVES

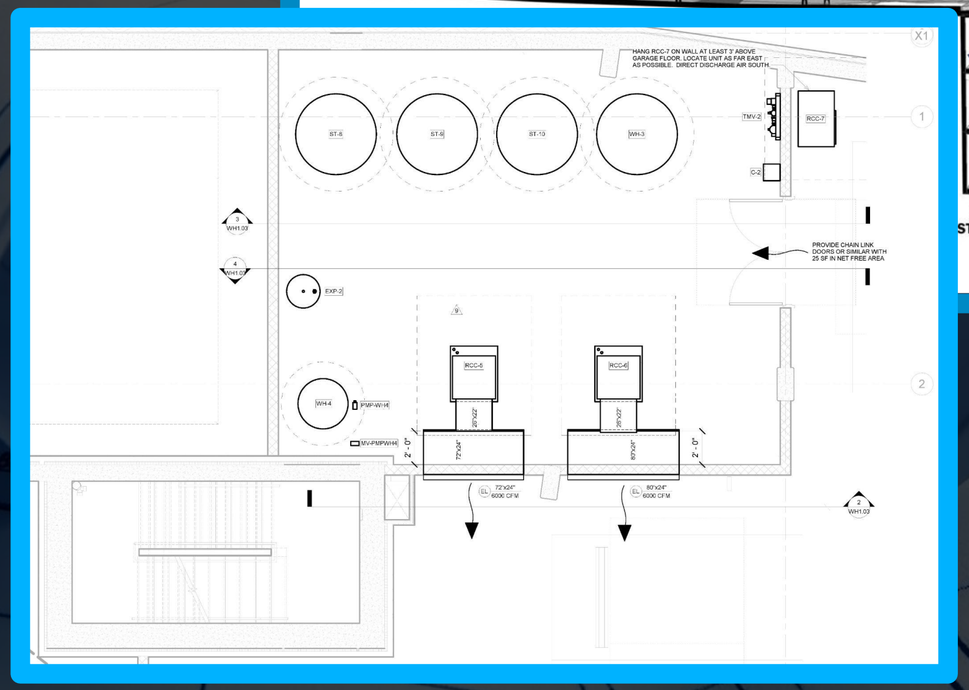
- Let's explore a case study
- Deep dive into design considerations
- Ecosizer: size effectively
- Refrigerant & equipment selection

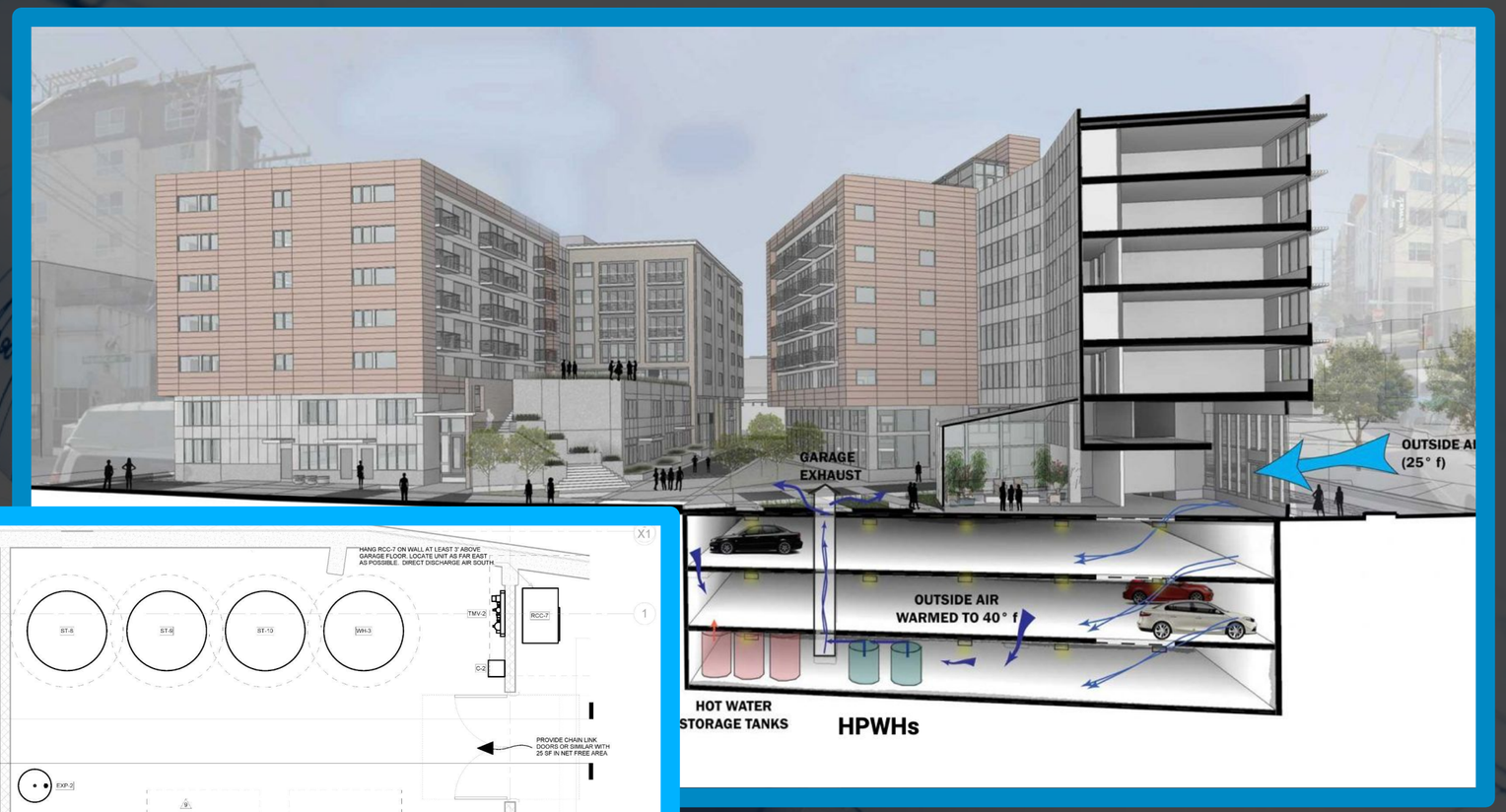
CASE STUDY:
JACKSON APTS

JACKSON **APARTMENTS**

BUILDING INFO**:**

- 7 Stories, 2 Buildings
  - East - 163 units
  - West - 369 units
  - *Total - 532 units*
- Mid-rise; Multi-Family
- 2 Central HPWH systems
- Seattle, WA





AVAILABLE **PRODUCTS**

AO Smith
(2.5 ton)

Rheem
(> 1 ton)

Multi-Pass Unitary
Residential/Small Commercial
R-134a

SanCO$_2$
(1.25 ton)

Mitsubishi
(10 ton)

Single-Pass
CO_2/R-744

Nyle
(10 - 30 ton)

Colmac
(10 - 30 ton)

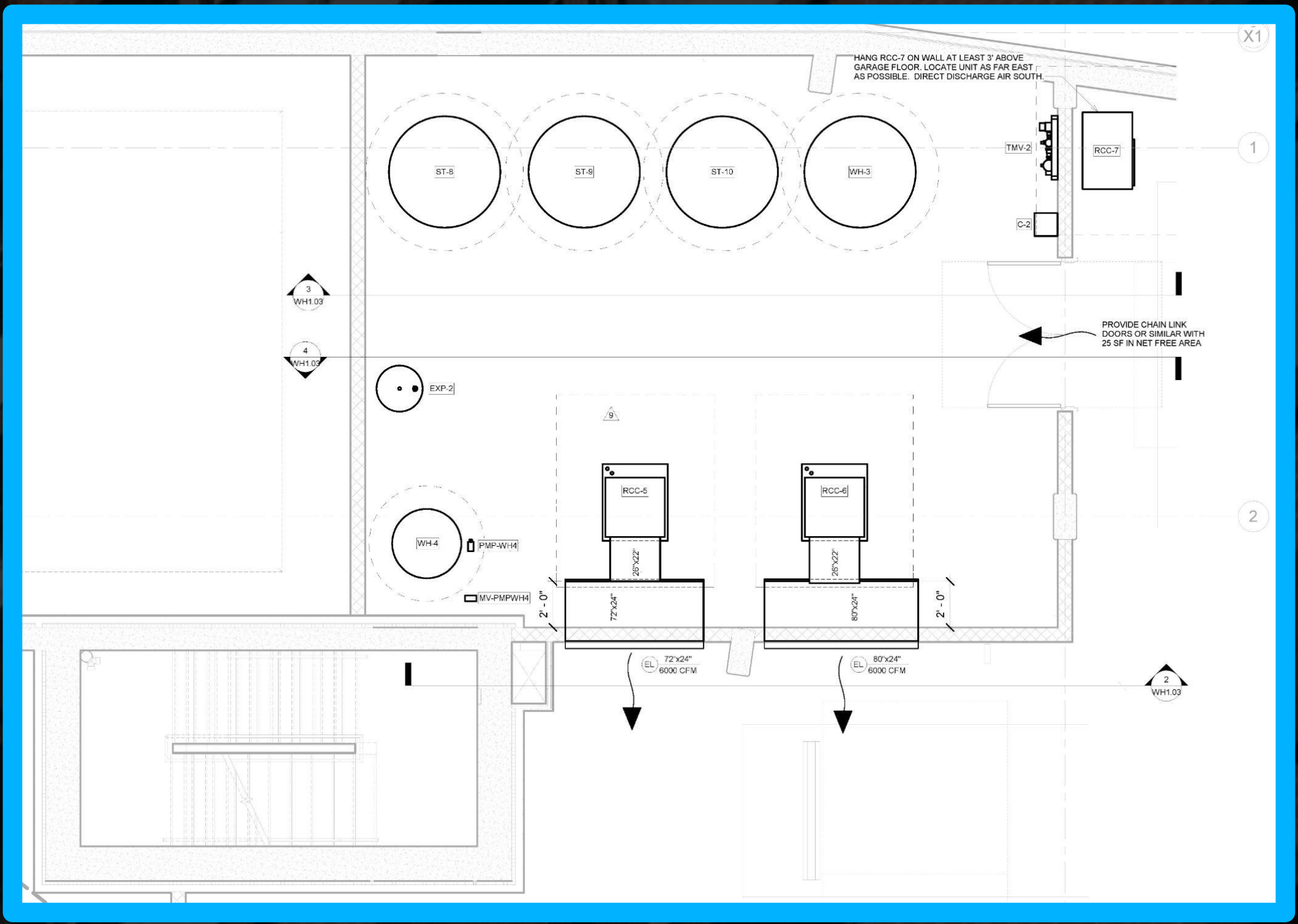
Single- or Multi-Pass
R-134a

JACKSON **APARTMENTS**

BUILDING INFRASTRUCTURE**:**

- DHW Room:
  - 740 ft^2
  - ventilated enclosed parking garage
    - 26 ft^2 exhaust air louver
    - 36 ft^2 intake air opening (door)

- Electrical capacity for HPWH system
  - **w/** electric backup: **87.85 kW** (540 W/apt)
  - **w/out** electric backup: **30.85 kW** (190 W/apt)



JACKSON **APARTMENTS**

- **Primary:**
  - (2x) Colmac CxA 15-ton
    - Single pass, R-134a
  - (1x) 36 kW Electric WH (backup)
  - (3x) 500g tanks = 1,500 gallons
- **Temperature Maintenance:**
  - Dedicated storage tank
  - (1x) Colmac CxV 5-ton
    - Multi-pass, R-410a
  - (1x) 21 kW Electric WH (backup)
- **Third-party controller**

JACKSON **APARTMENTS**

SHOWN HERE**:**

- Primary heaters:
  - Two Single-pass Colmac HPWH
    - 15-tons each
    - CxA series (R-134A)
  - located in an buffered space (enclosed ventilated below grade parking structure)
  - Full backup due to cool Seattle climate & owner decision

JACKSON **APARTMENTS**

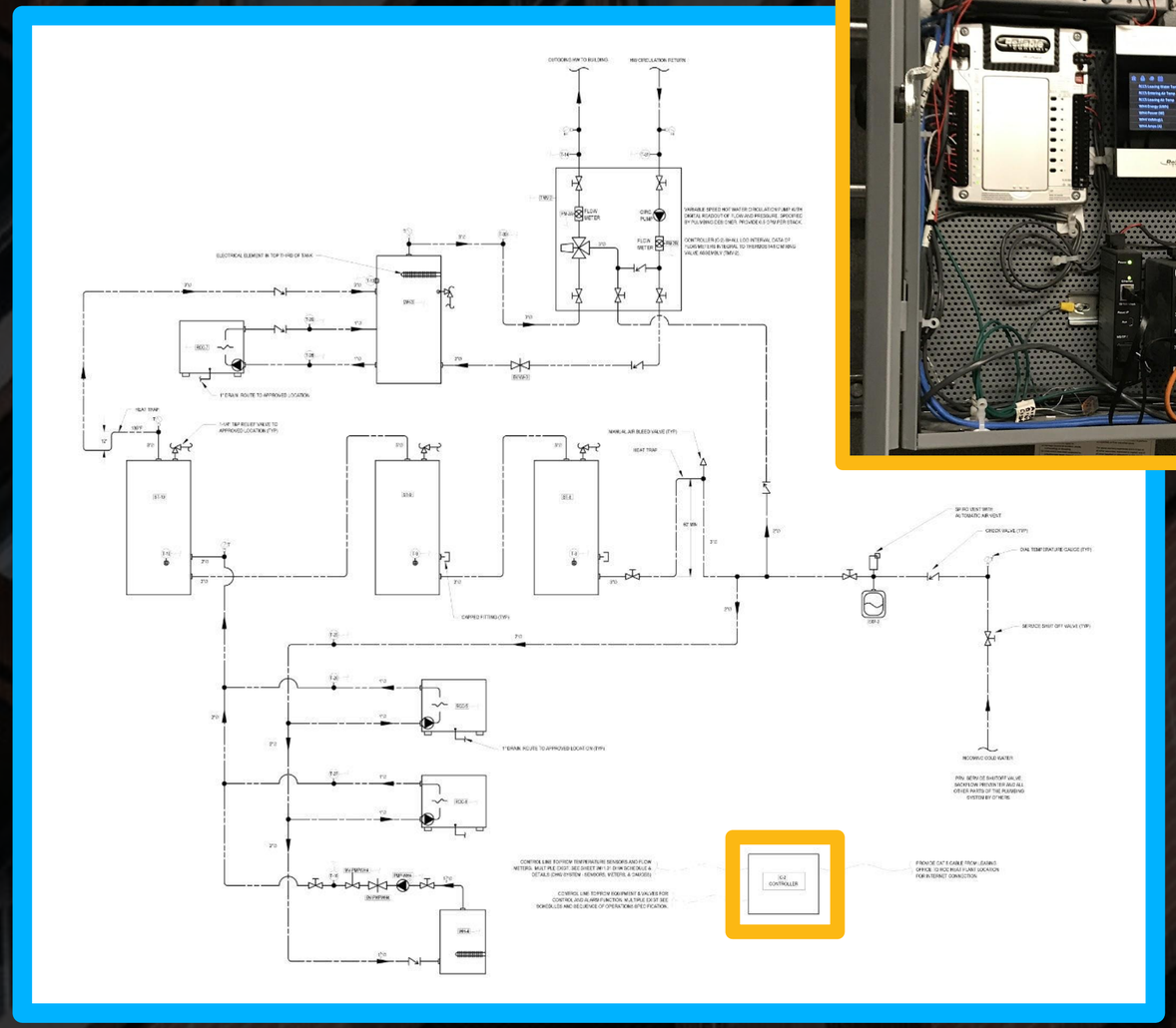
SHOWN HERE:

- Temperature Maintenance:
  - Dedicated storage tank with back-up electric element
  - Multi-pass Colmac 5-ton HPWH
    - CxV series (R-410a)

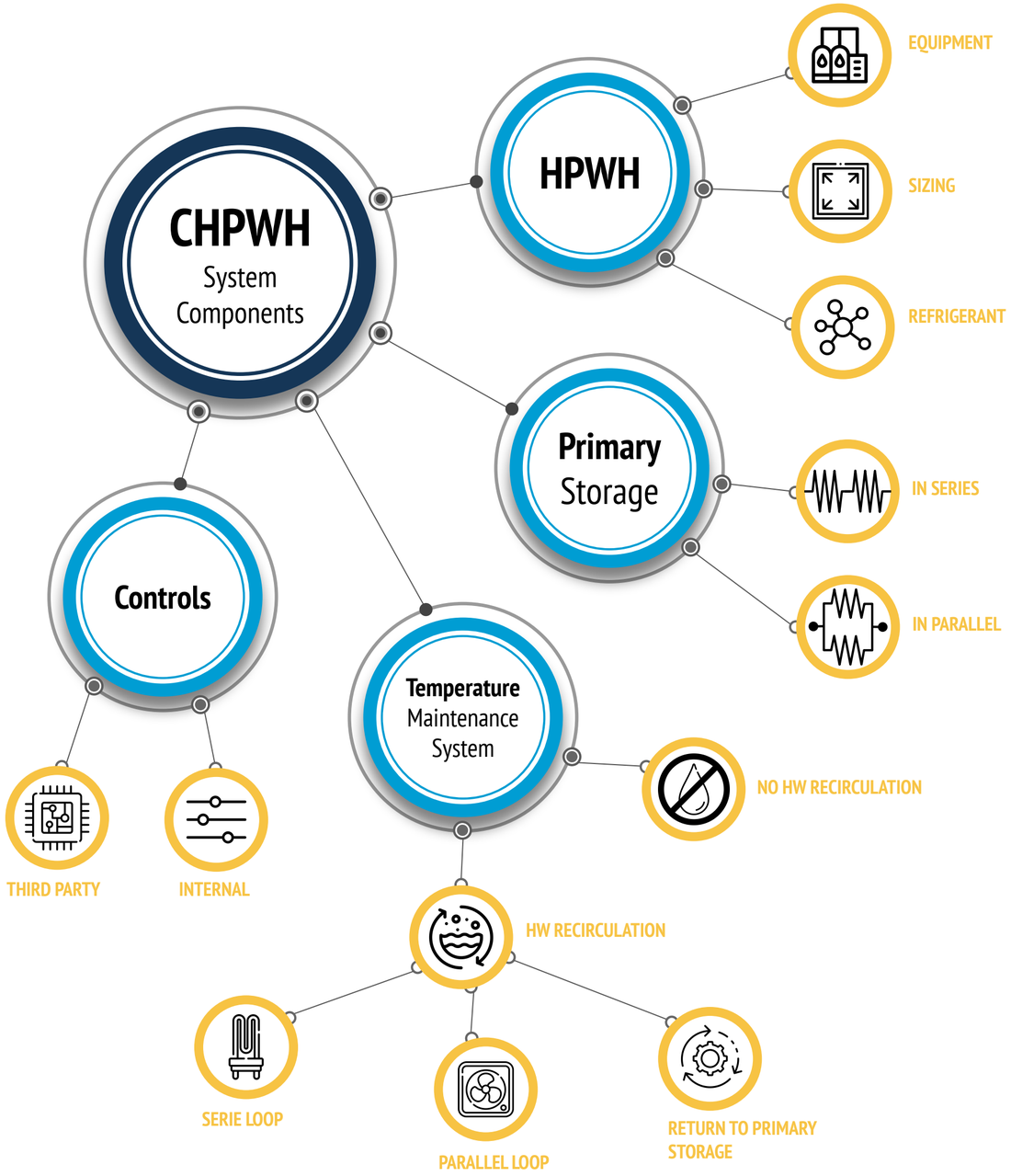
JACKSON **APARTMENTS**

SHOWN HERE:

- Controls:
  - Manages:
    - Primary heaters
    - Temperature maintenance heaters
    - Backup equipment
  - Sends alarms and notifications to building maintenance personal

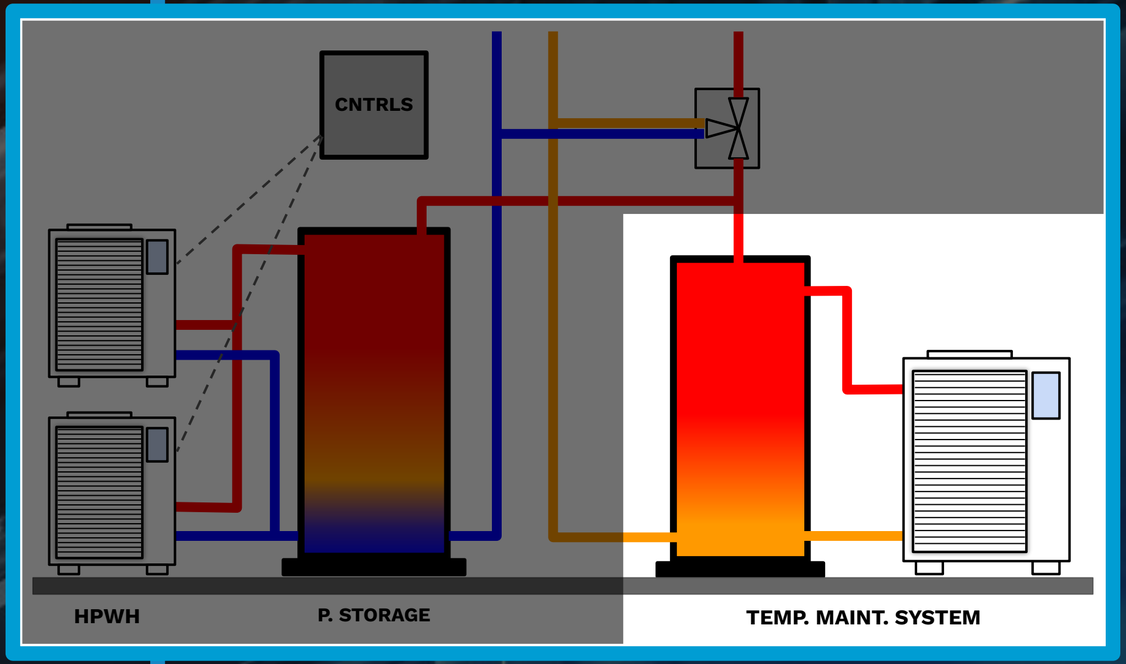


BIRDS EYE REVIEW

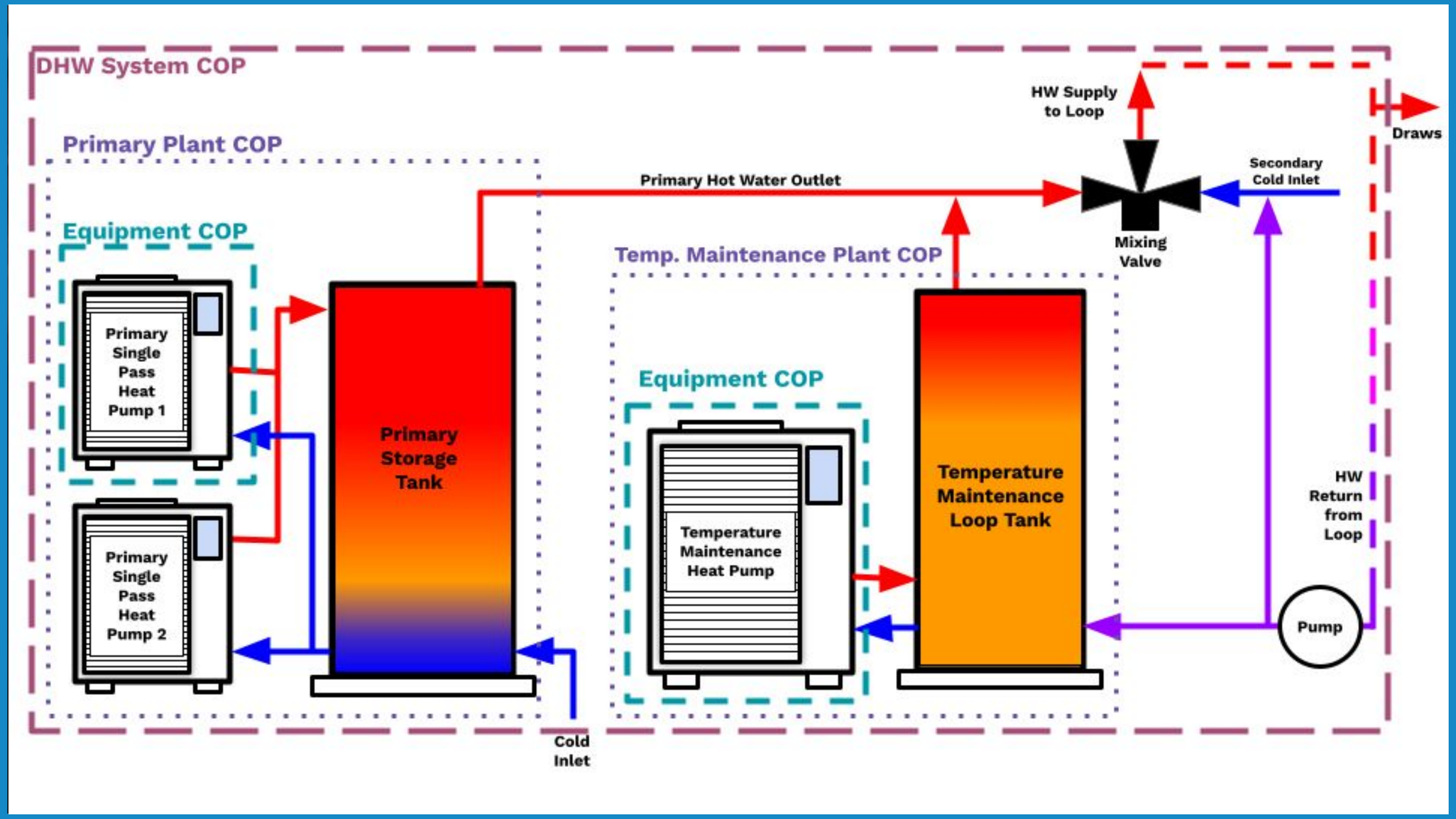


LET’S PAUSE FOR QUESTIONS

HW SYSTEM DESIGN:
A DEEP DIVE



EQUIPMENT EFFICIENCY **BOUNDARIES**



KEY DESIGN CONSIDERATIONS

- HW distribution systems
- System sizing
- Refrigerant & equipment selection

HW DISTRIBUTION SYSTEMS & IMPACT ON **THERMAL STRATIFICATION**

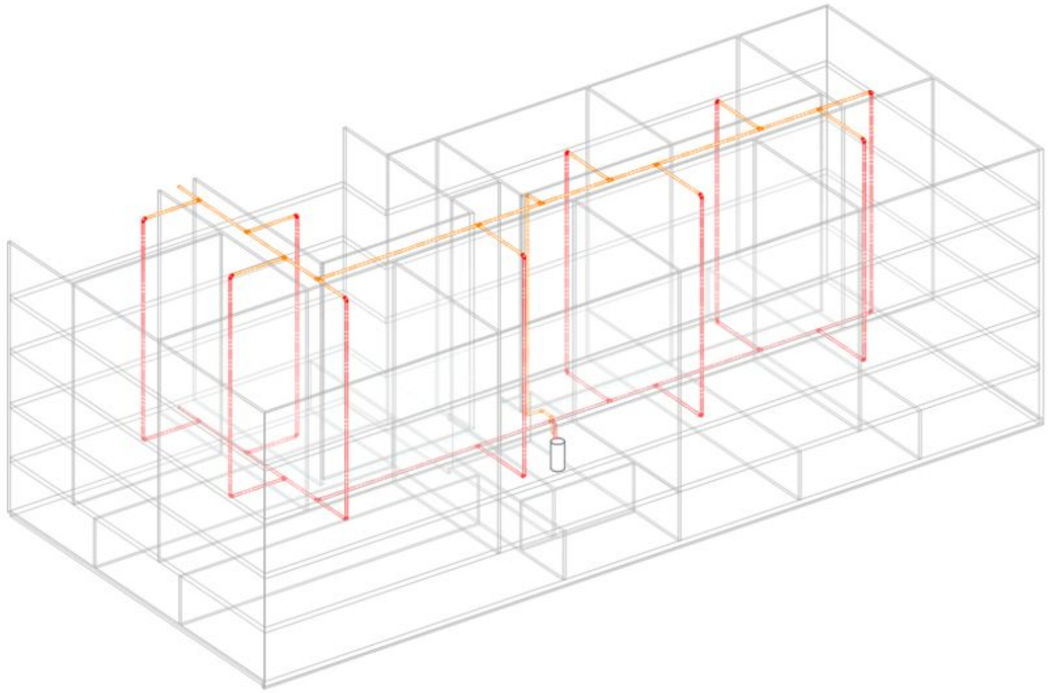
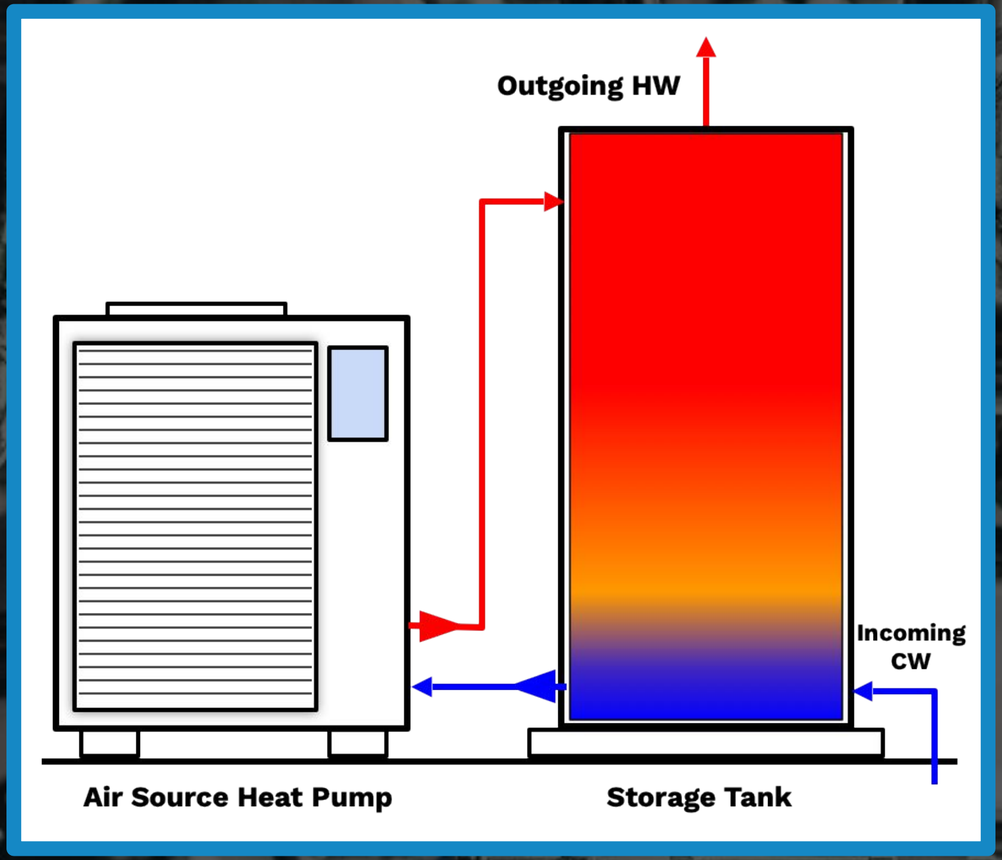
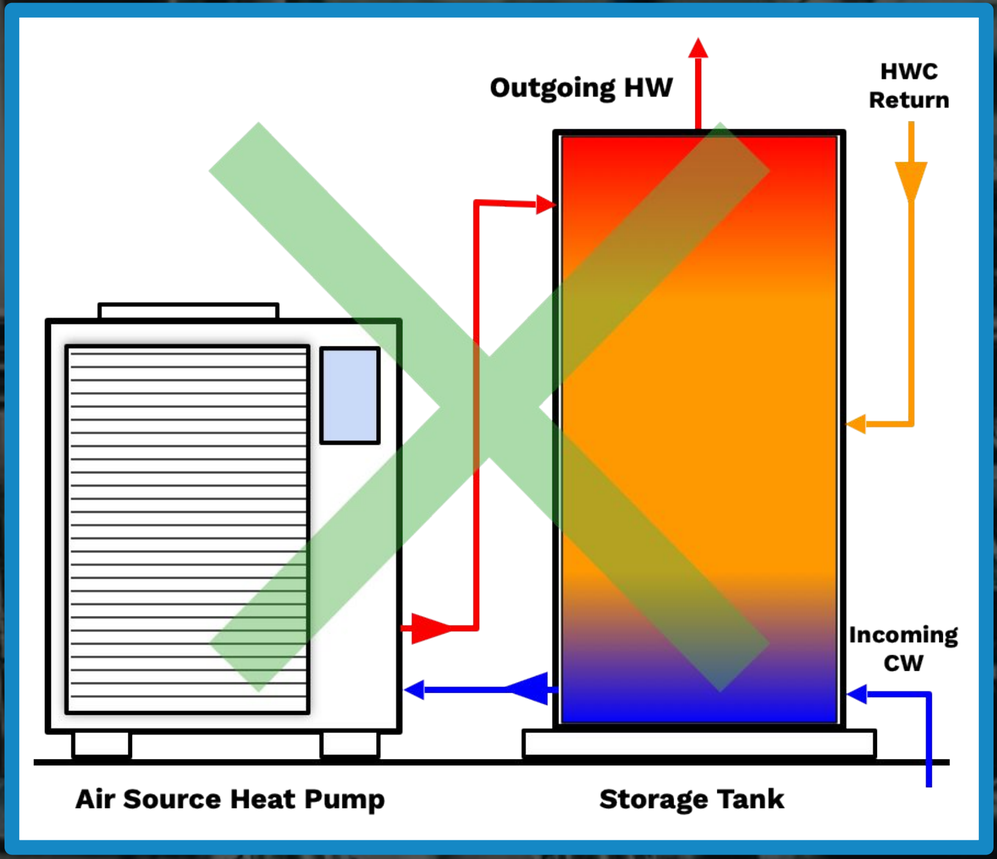


Figure 3: Vertical distribution piping schematic – one riser per apartment stack

HW STORAGE SYSTEMS: **THERMAL STRATIFICATION**





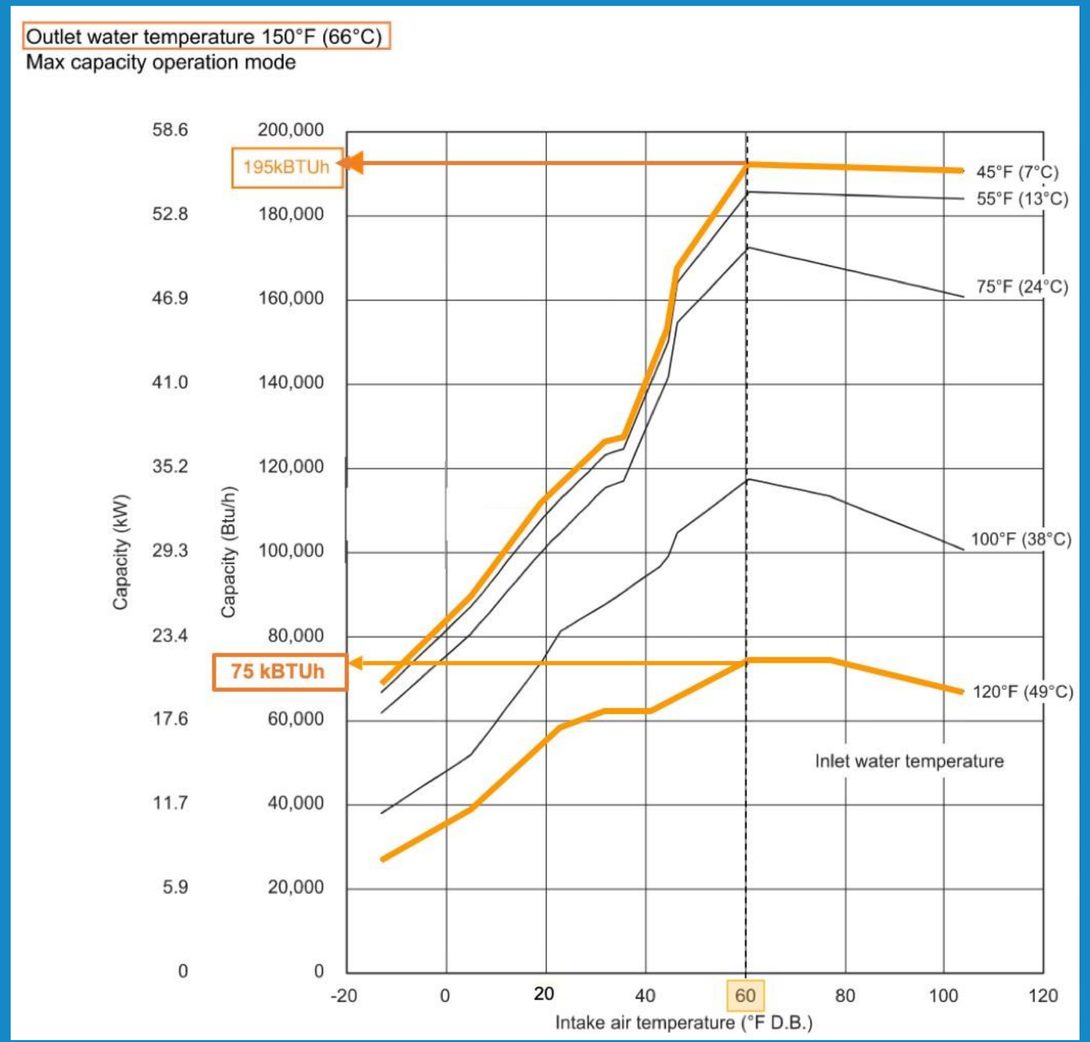
HEAT PUMP **PERFORMANCE**

EFFICIENCY IMPACTS:

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

CAPACITY IMPACTS:

- Limits of Refrigerant
- Lower Air Temperature
- Defrost Effects



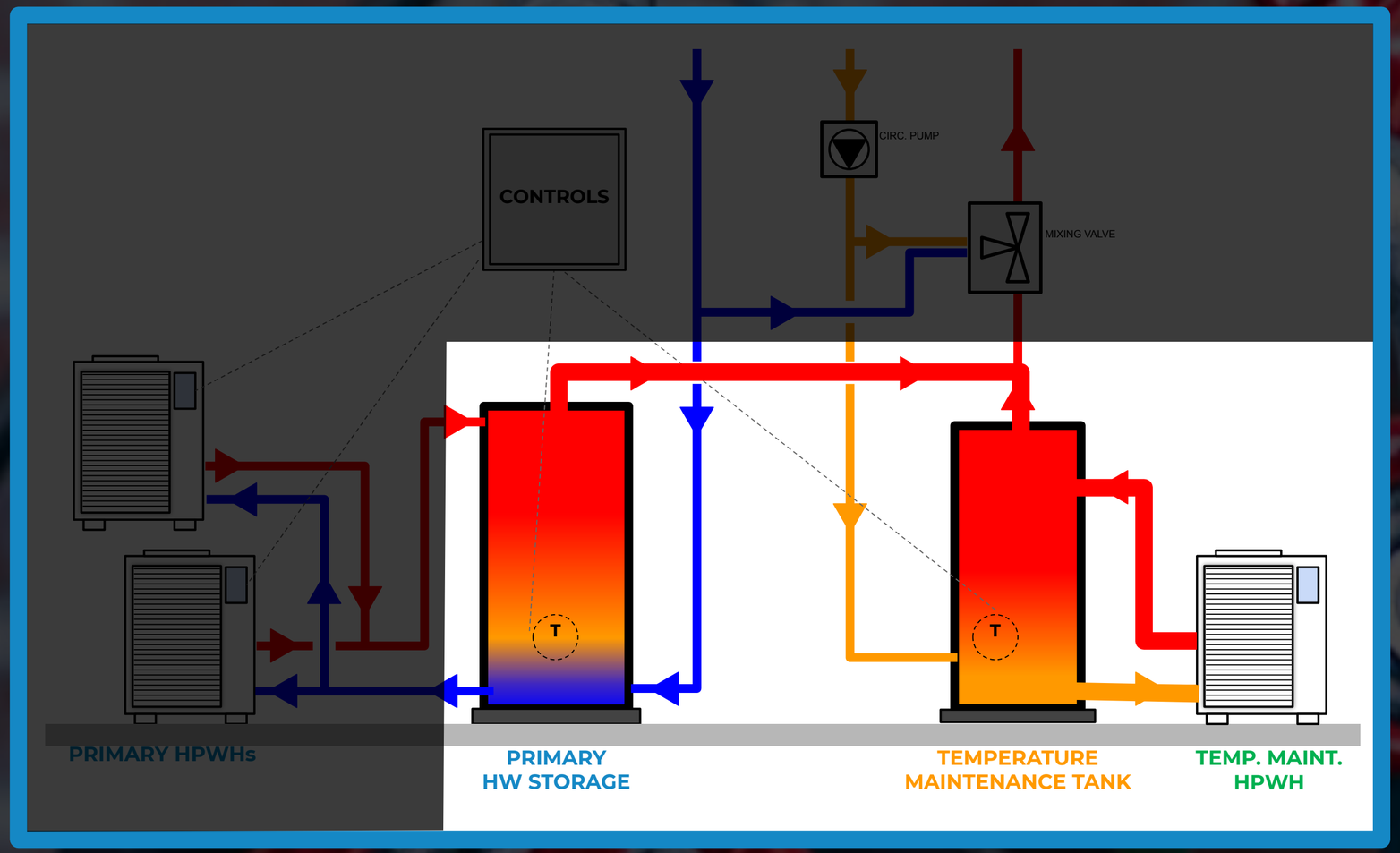
LET’S PAUSE FOR QUESTIONS

TEMPERATURE MAINTENANCE 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

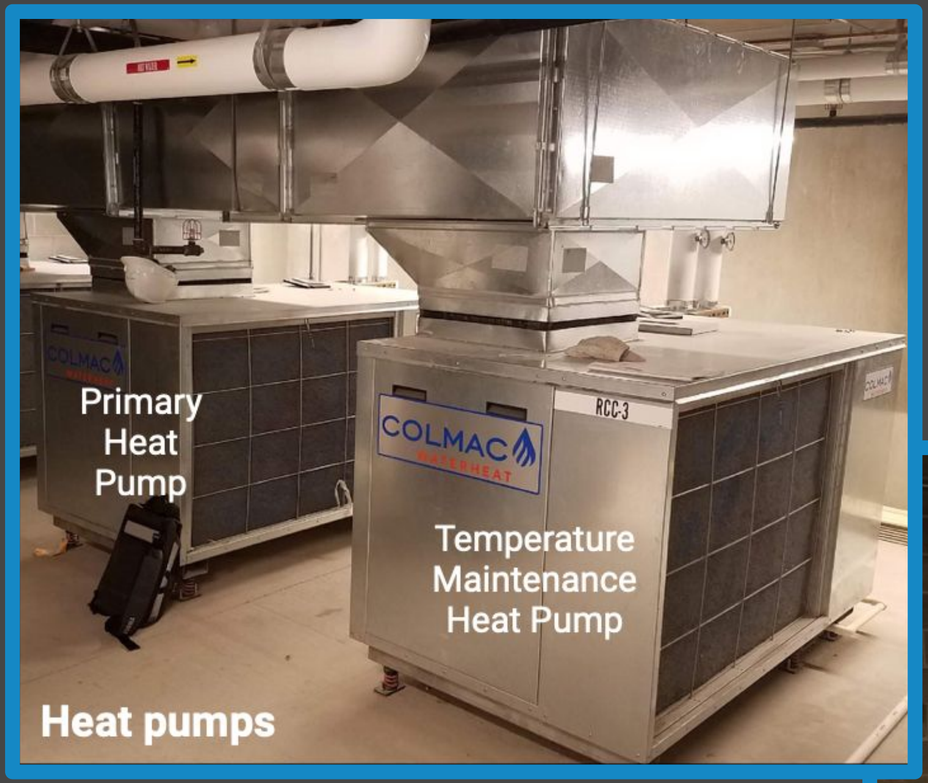
SINGLE-PASS PRIMARY HPWH SYSTEM W/ PARALLEL TEMPERATURE MAINTENANCE TANK & MULTI-PASS HPWH

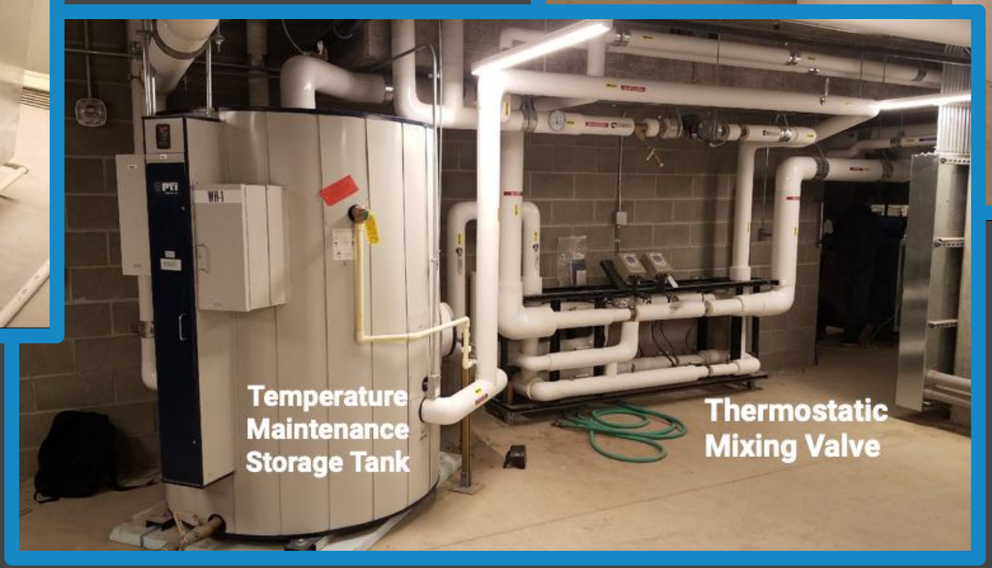


KEY CONSIDERATIONS:

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

SINGLE-PASS PARALLEL EQUIPMENT





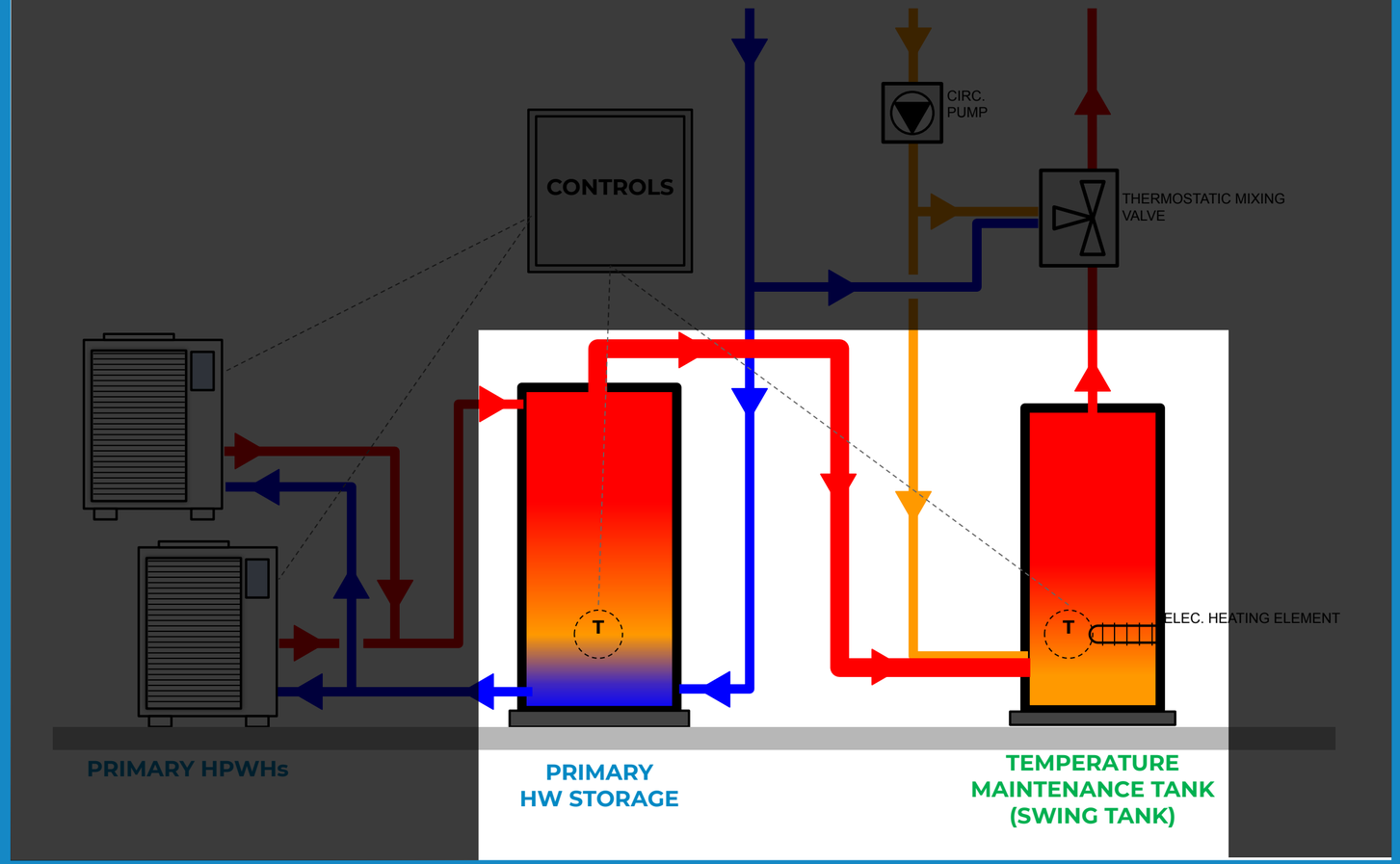
YESLER III:
CYPRESS COLMAC

TEMPERATURE MAINTENANCE 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

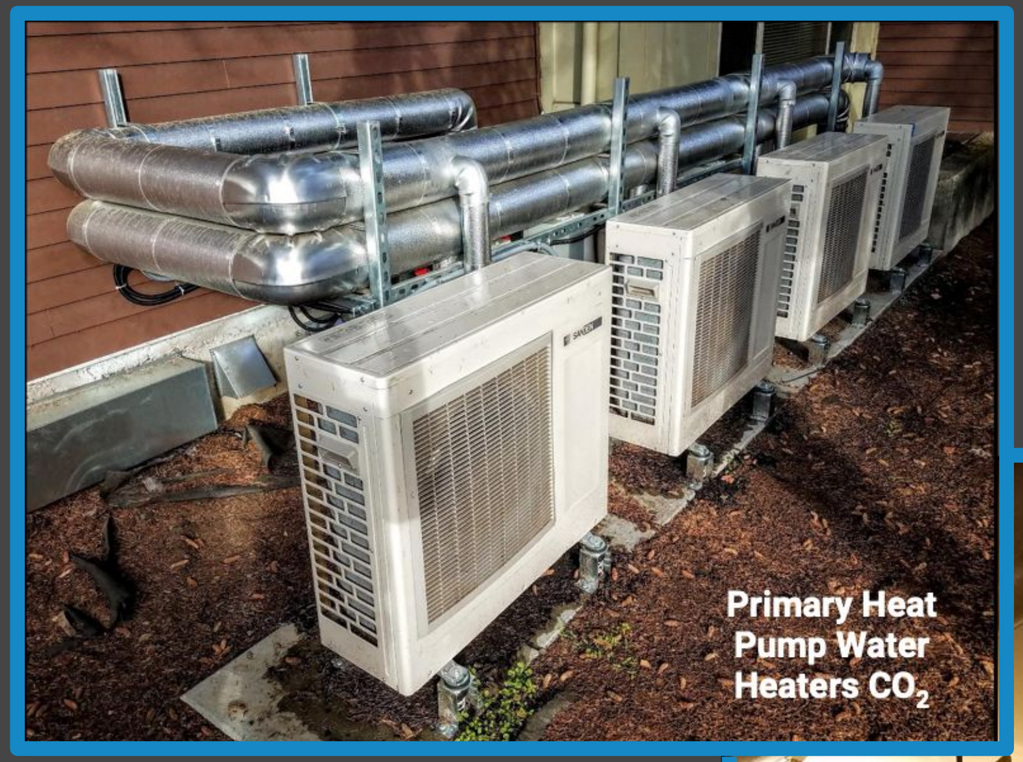
SINGLE-PASS PRIMARY HPWH SYSTEM W/ SERIES TEMPERATURE MAINTENANCE TANK (SWING TANK)

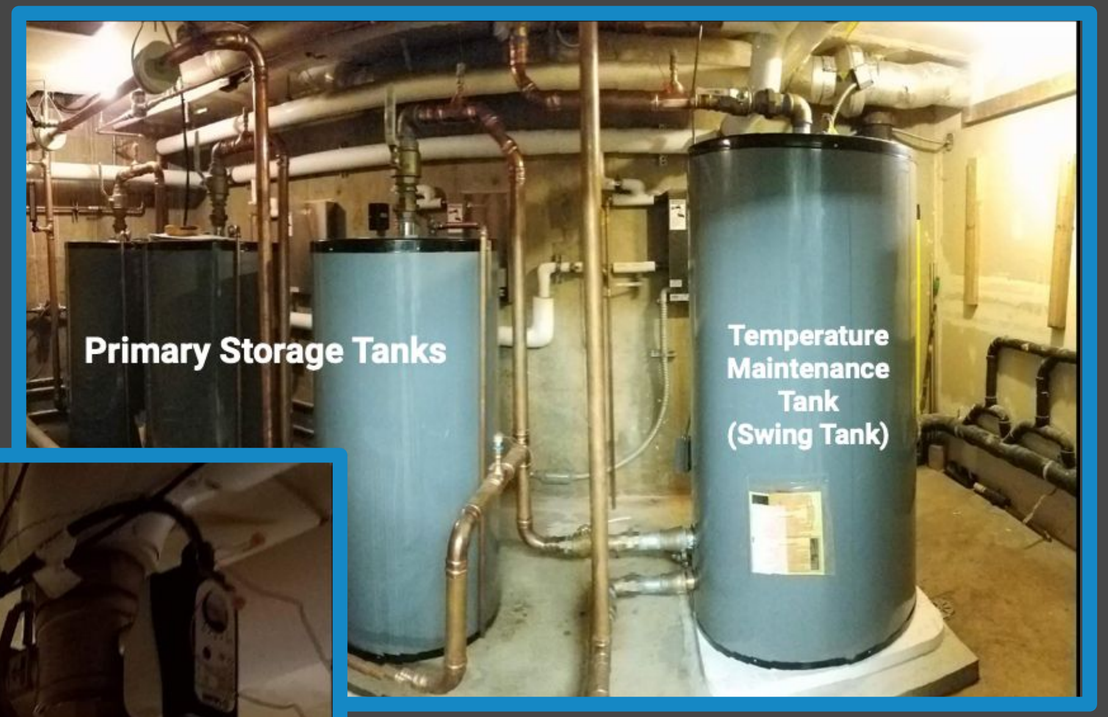


KEY CONSIDERATIONS:

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

SINGLE-PASS SERIES EQUIPMENT

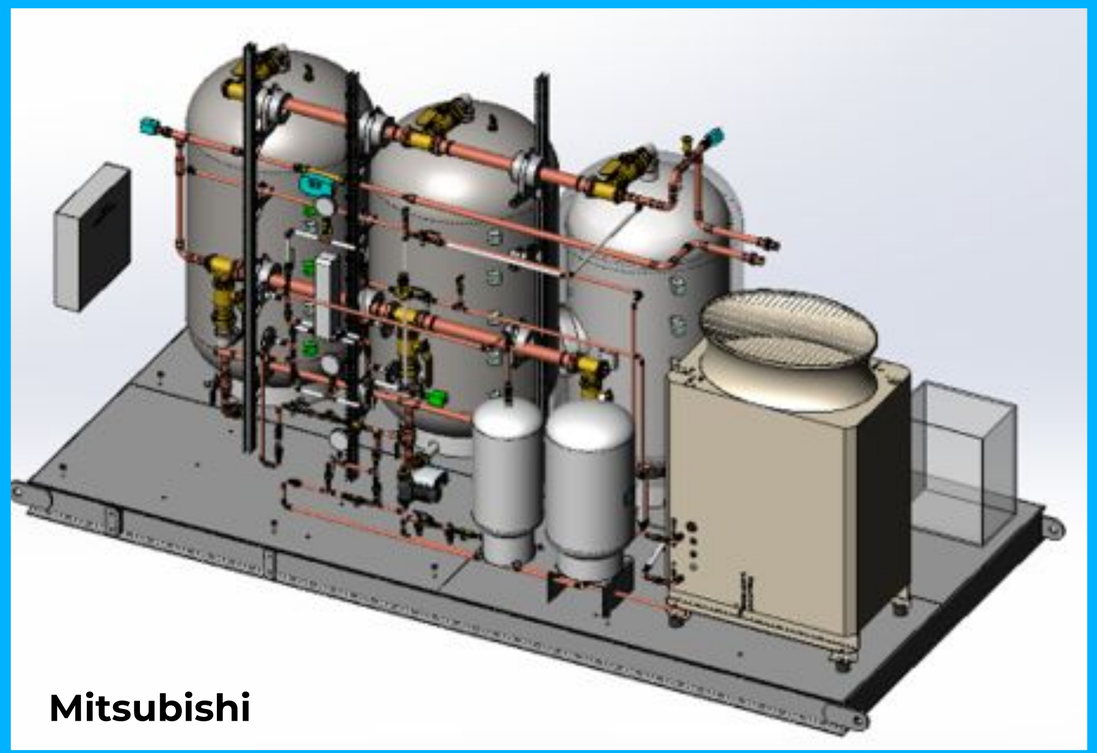




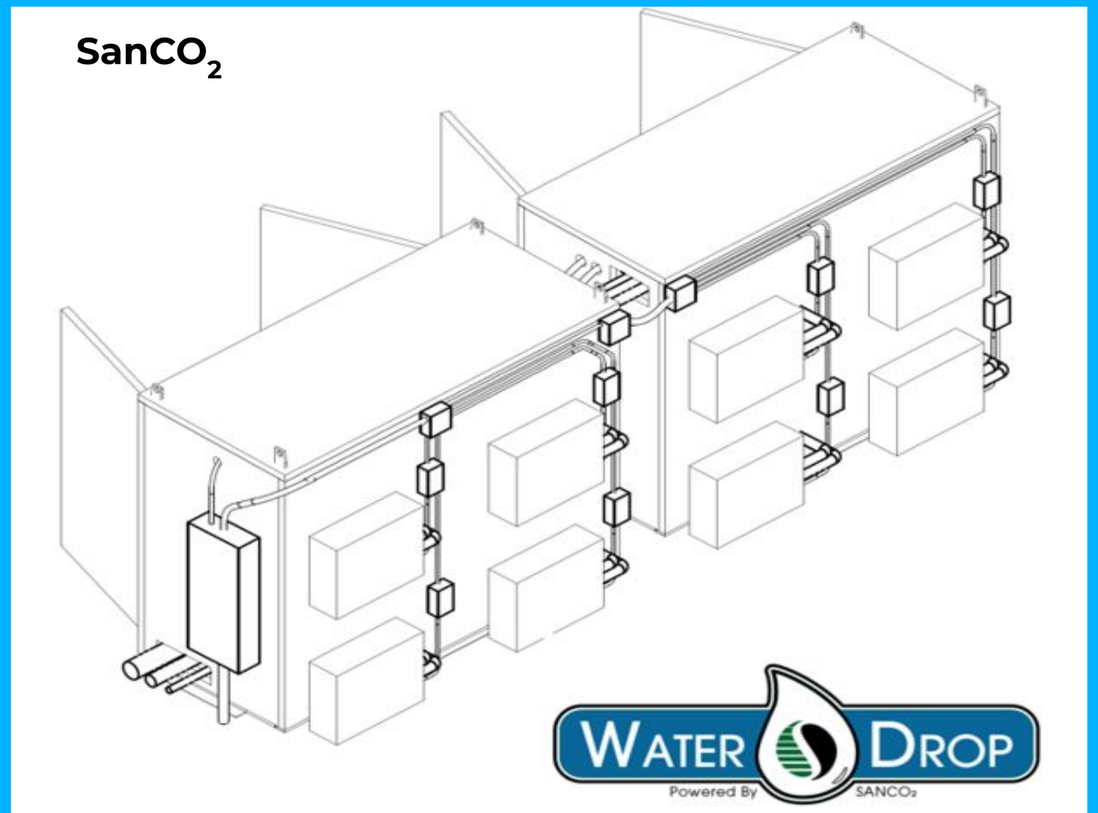
ELIZABETH JAMES
SANDEN GEN3 CO_2

SINGLE-PASS SERIES SKID **EQUIPMENT**

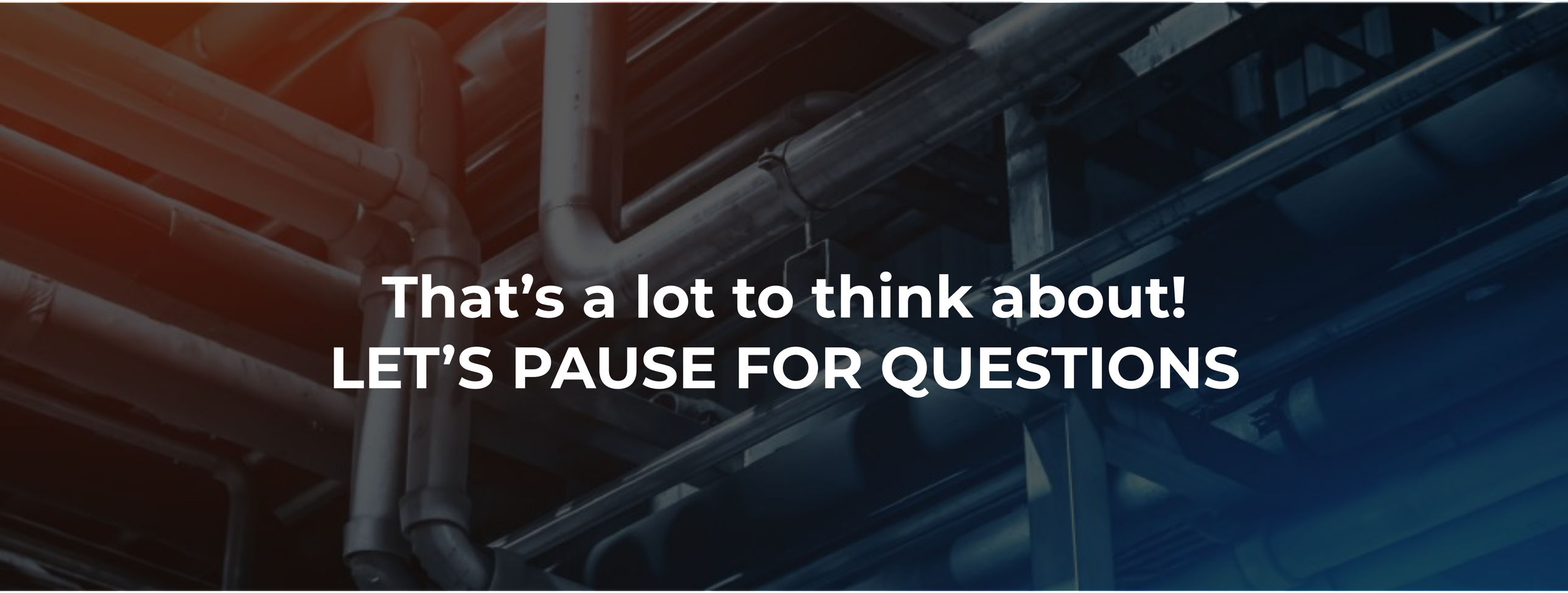
Manufacturers are working to provide skid options that are easy to install, reliable and result in energy savings.



Mitsubishi

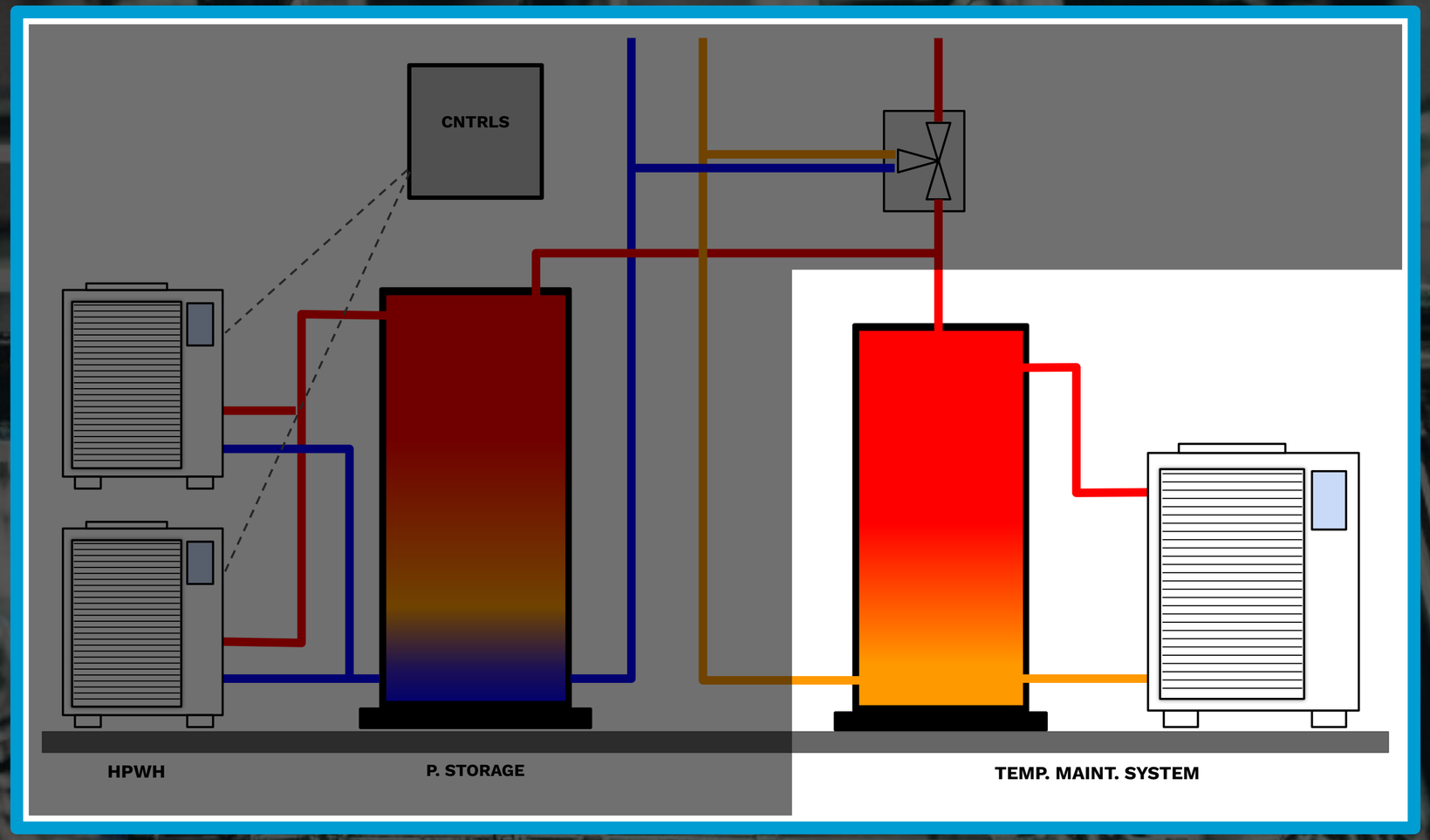


SanCO$_2$

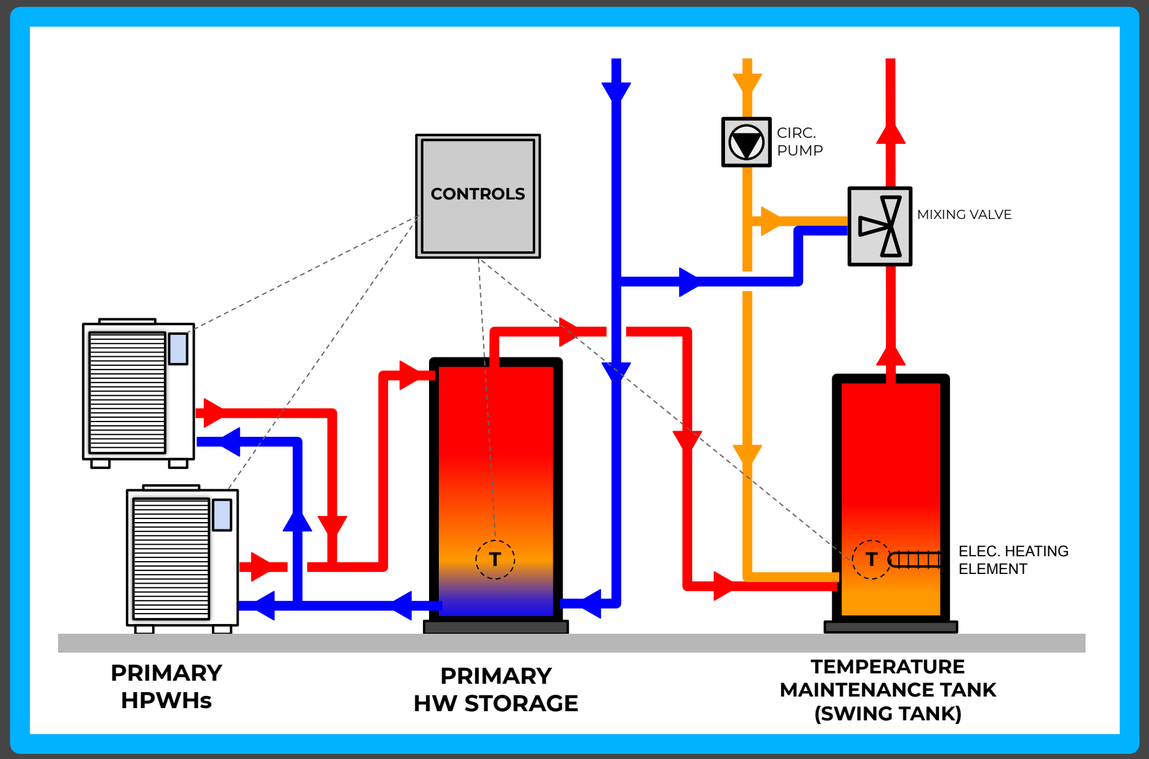


That’s a lot to think about!
LET’S PAUSE FOR QUESTIONS

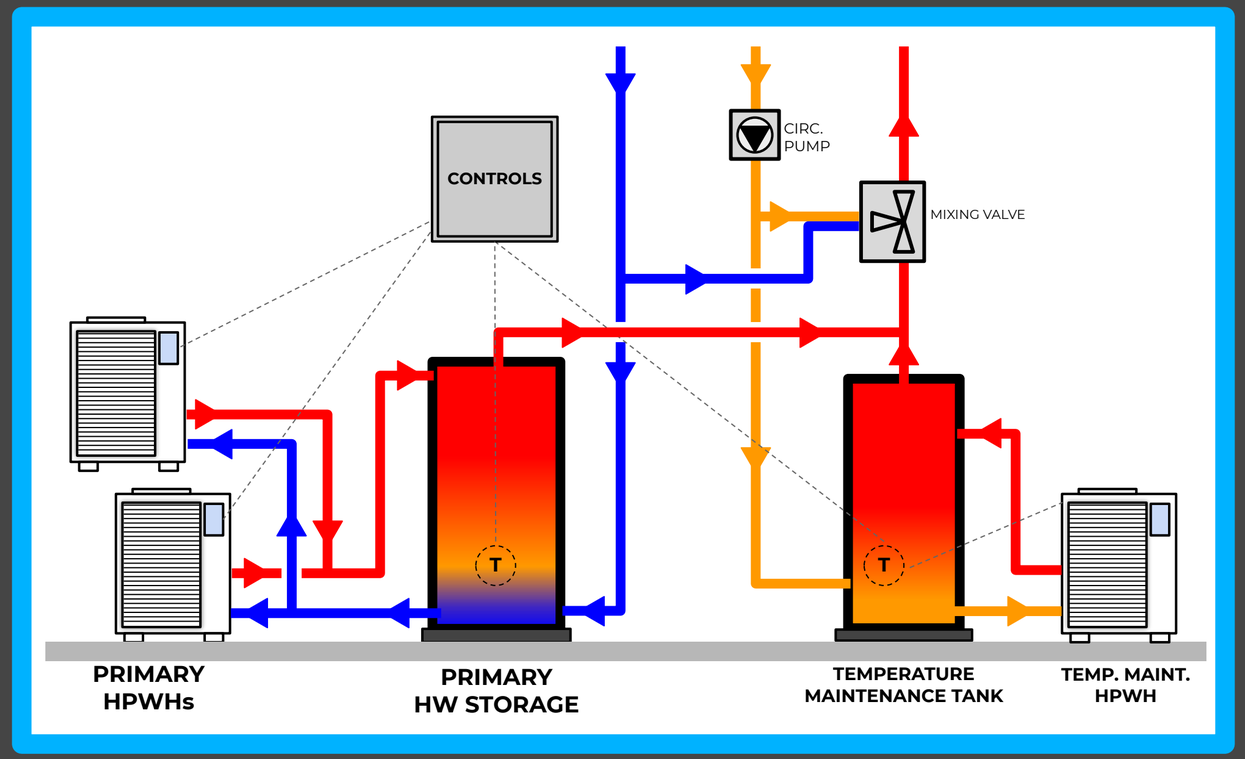
BIRDS **EYE VIEW**



RECAP: DEDICATED **HPWH SYSTEMS**



IN SERIES **SWING TANK**



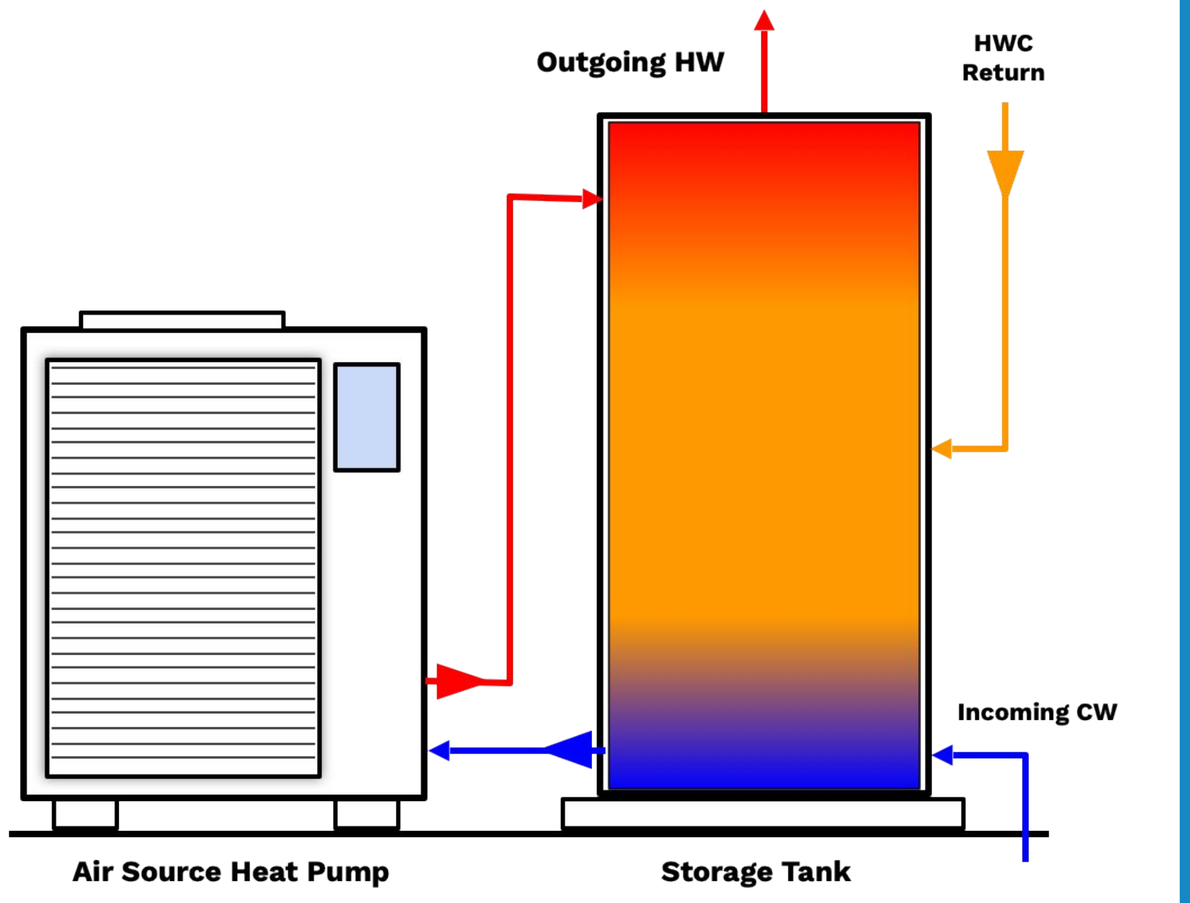
IN PARALLEL **MULTI-PASS HPWH**

TEMPERATURE MAINTENANCE 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

COMBINED **SYSTEM**



KEY CONSIDERATIONS:

- "All eggs in one basket."
- Both primary & maintenance loads done by one system.

RISKS:

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

TEMPERATURE MAINTENANCE SYSTEMS: **INTRO**

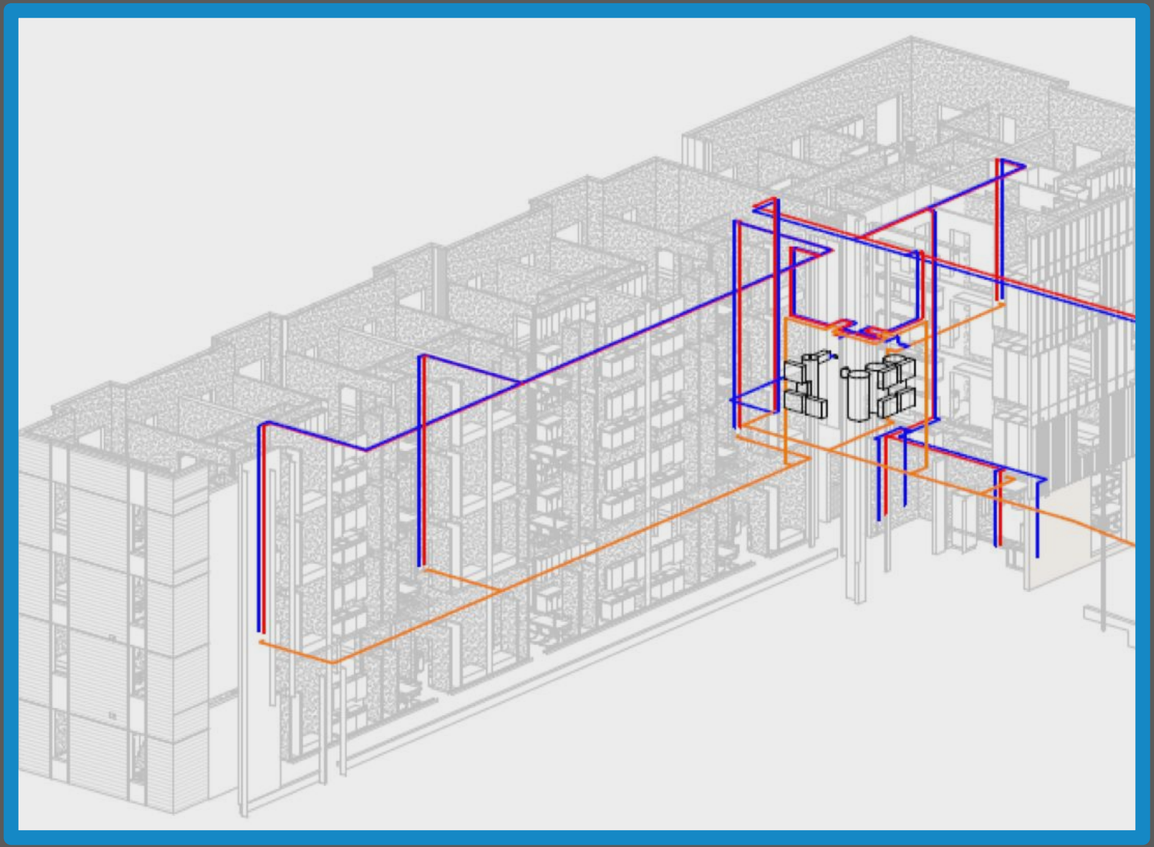
4 OPTIONS

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

TEMPERATURE MAINTENANCE SYSTEM: **NO RECIRCULATION**

- Lack of Recirculation System is uncommon
- Heat tape/trace is an option

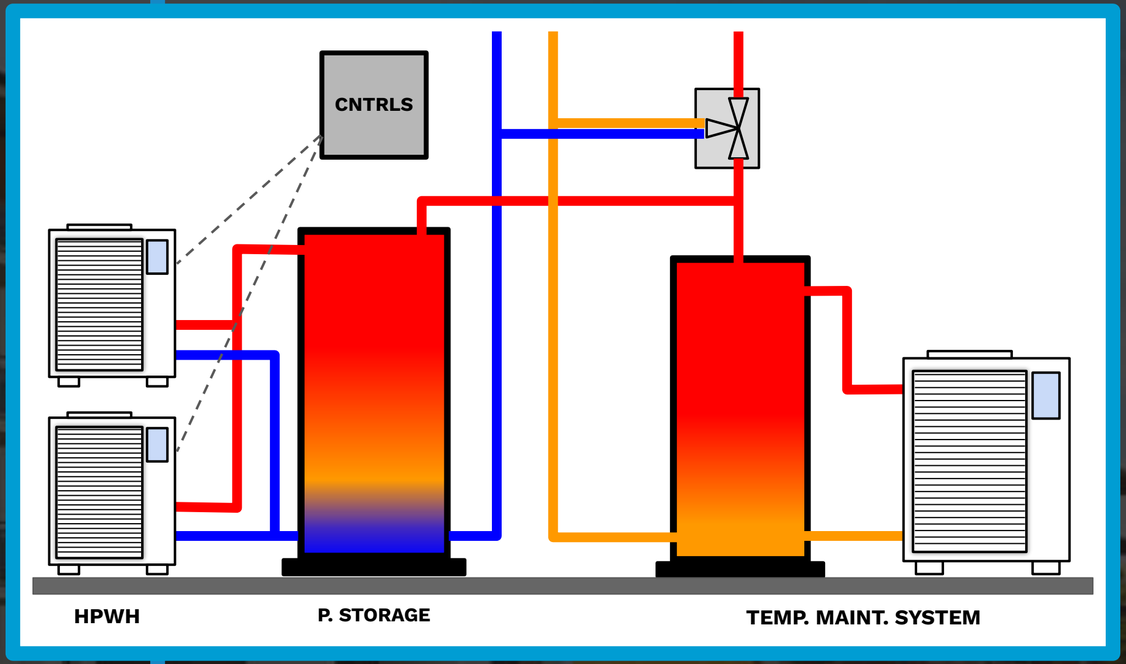
TEMPERATURE MAINTENANCE SYSTEMS: **REVIEW**



Break

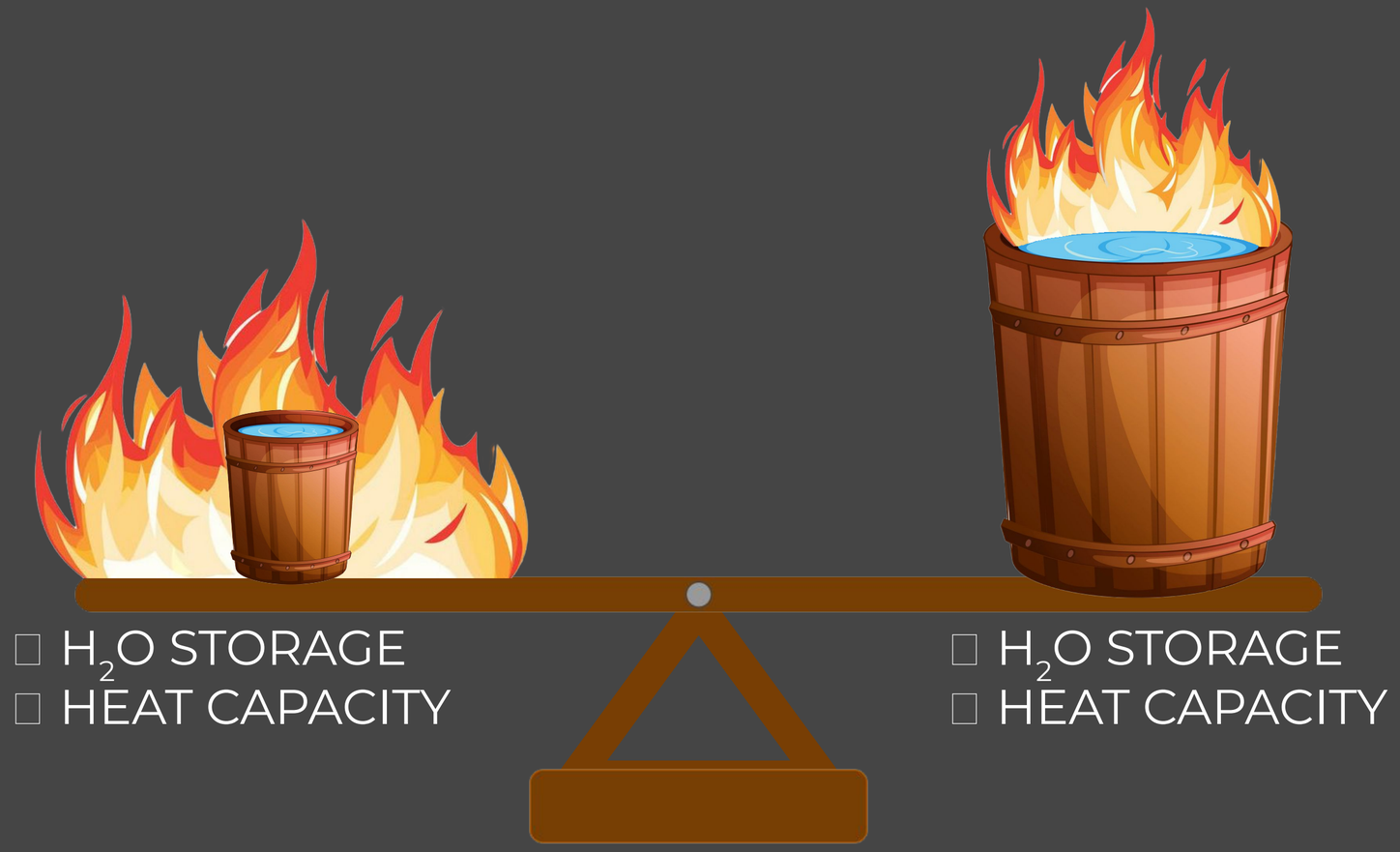
LET’S PAUSE FOR QUESTIONS

HW SYSTEM DESIGN: SIZING

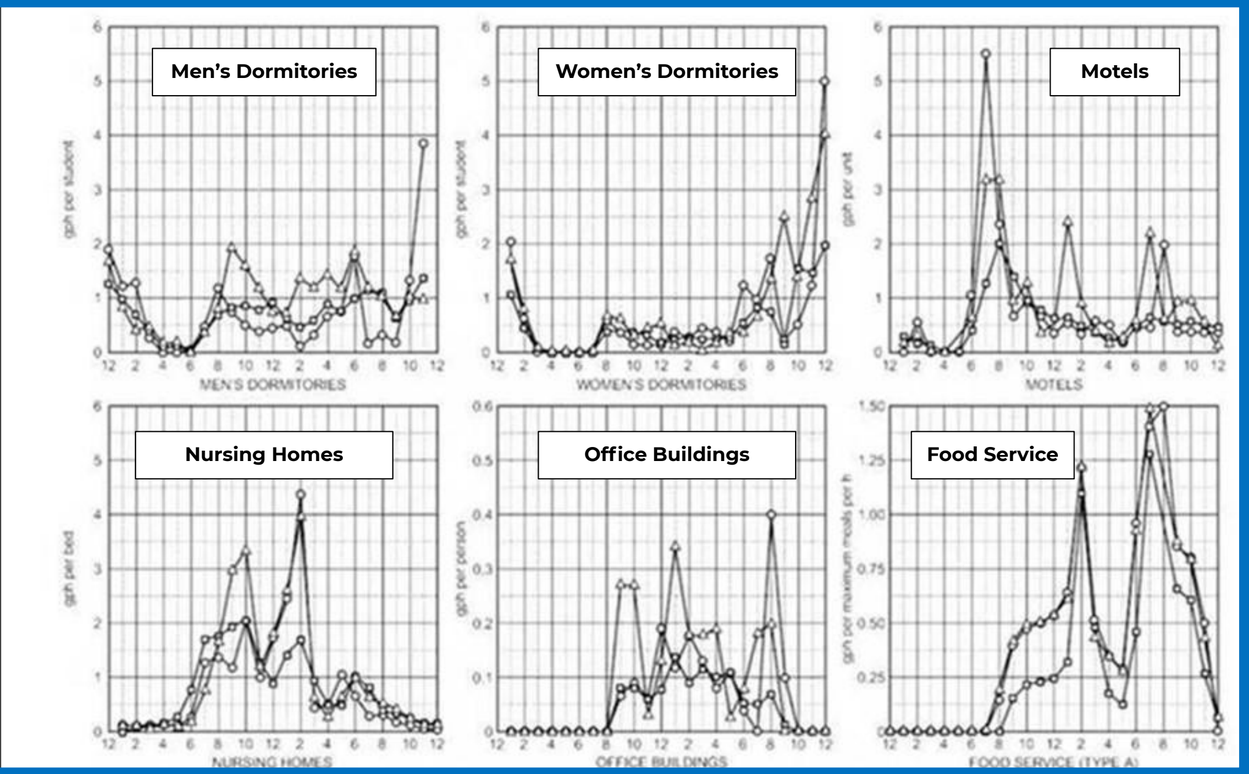


SYSTEM **SIZING**

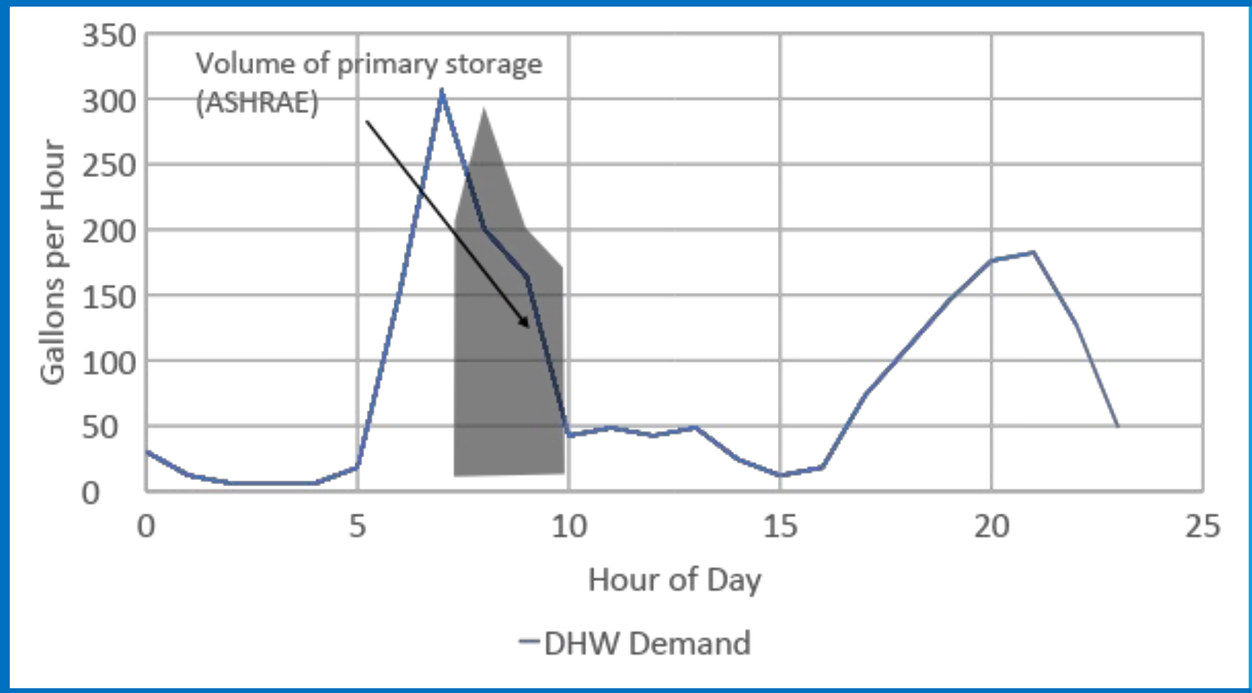
- Gas systems are sized w/ low storage and high heat capacity
- HPWH systems are sized w/ high storage and low heat capacity



SYSTEM **SIZING**

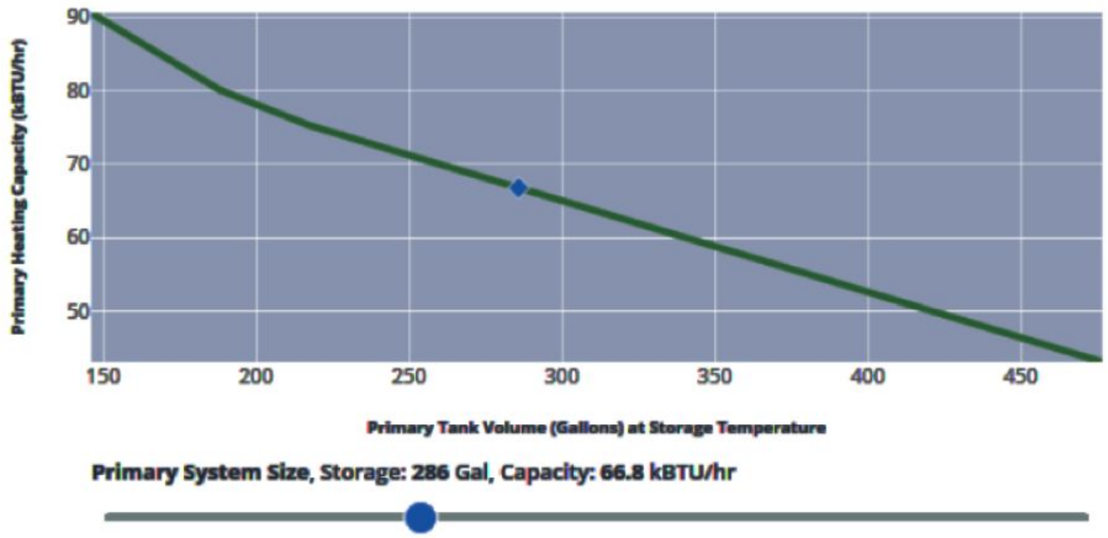


Multi Family **Domestic Hot Water (DHW)** Demand



ECOSIZER

ecosizer.Ecotope.com



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

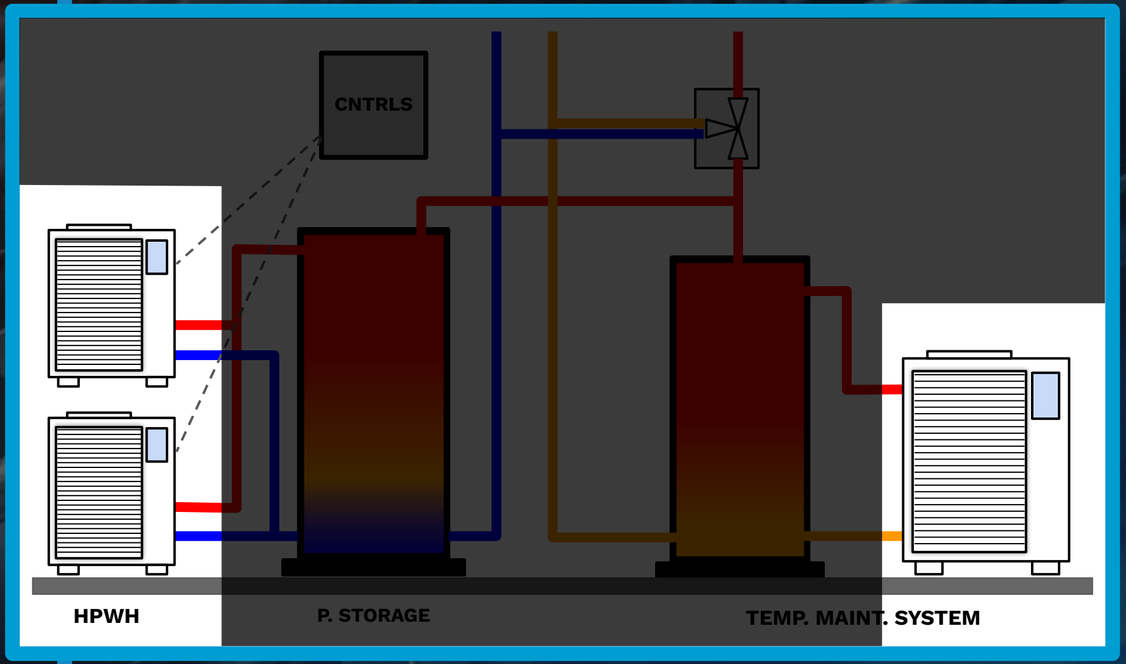
Tank Volume
285 Gallons

Heating Capacity
66.8 kBTU/hr

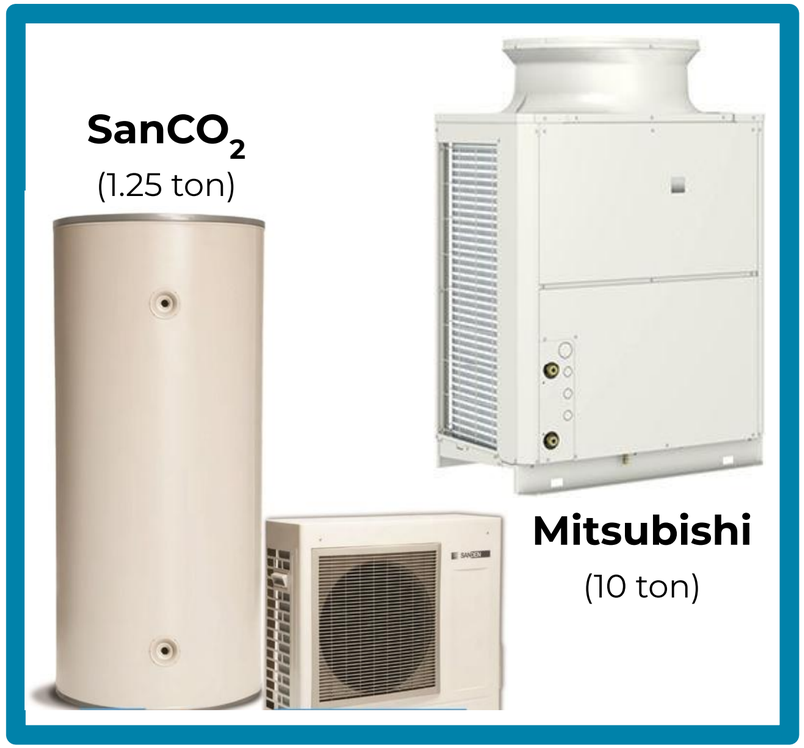
Swing Tank Volume
80 Gallons

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

HW SYSTEM DESIGN: REFRIGERANT & EQUIPMENT



AVAILABLE PRODUCTS



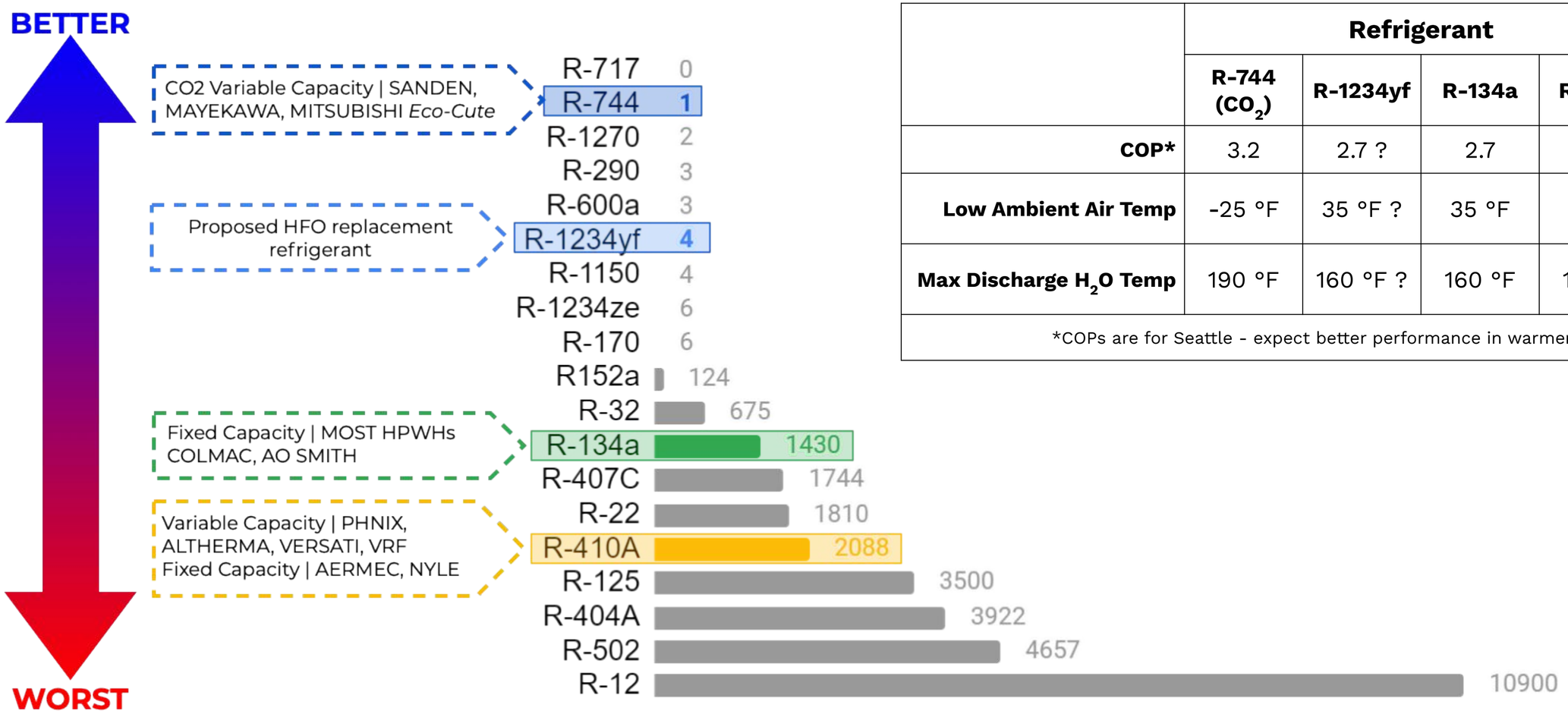
Single Pass
CO_2/R-744

Single or Multi-Pass
R-134a

Single Pass Unitary
Residential/Small Commercial
R-134a

REFRIGERANTS: **GWP OF SELECTED REFRIGERANTS**

(CARBON DIOXIDE EQUIVALENTS, CO_2e)

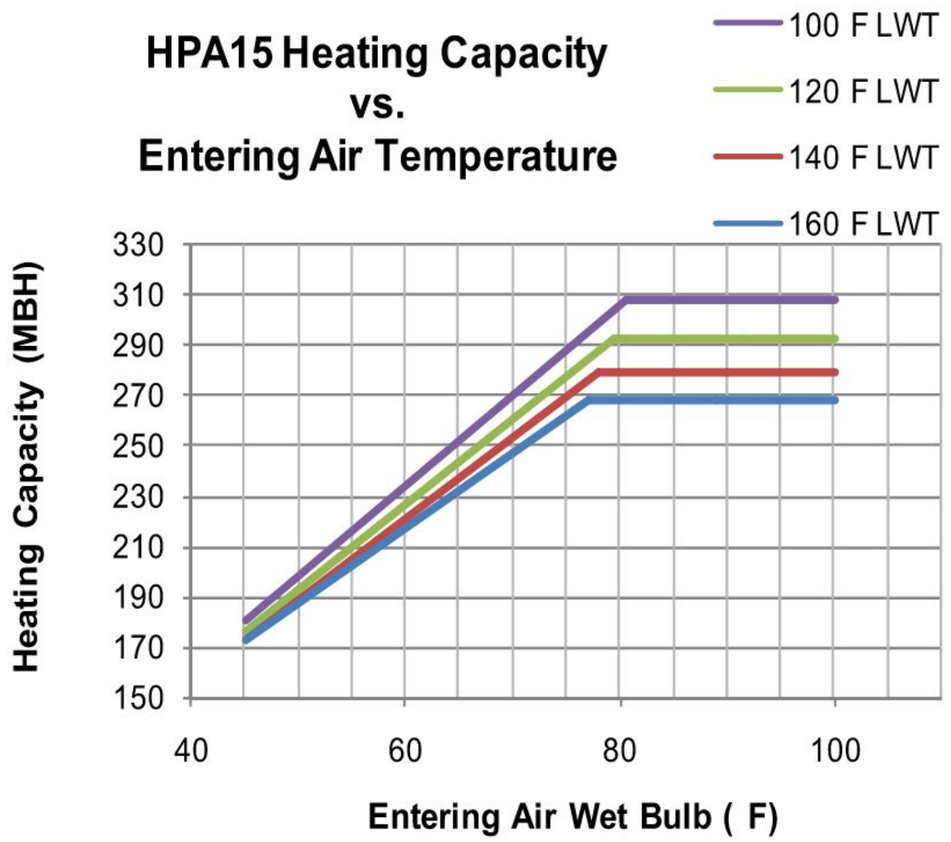


	Refrigerant			
	R-744 (CO_2)	**R-1234yf**	**R-134a**	**R-410A**
COP*	3.2	2.7 ?	2.7	2.5
Low Ambient Air Temp	-25 °F	35 °F ?	35 °F	-5 °F
Max Discharge H_2O Temp	190 °F	160 °F ?	160 °F	140 °F

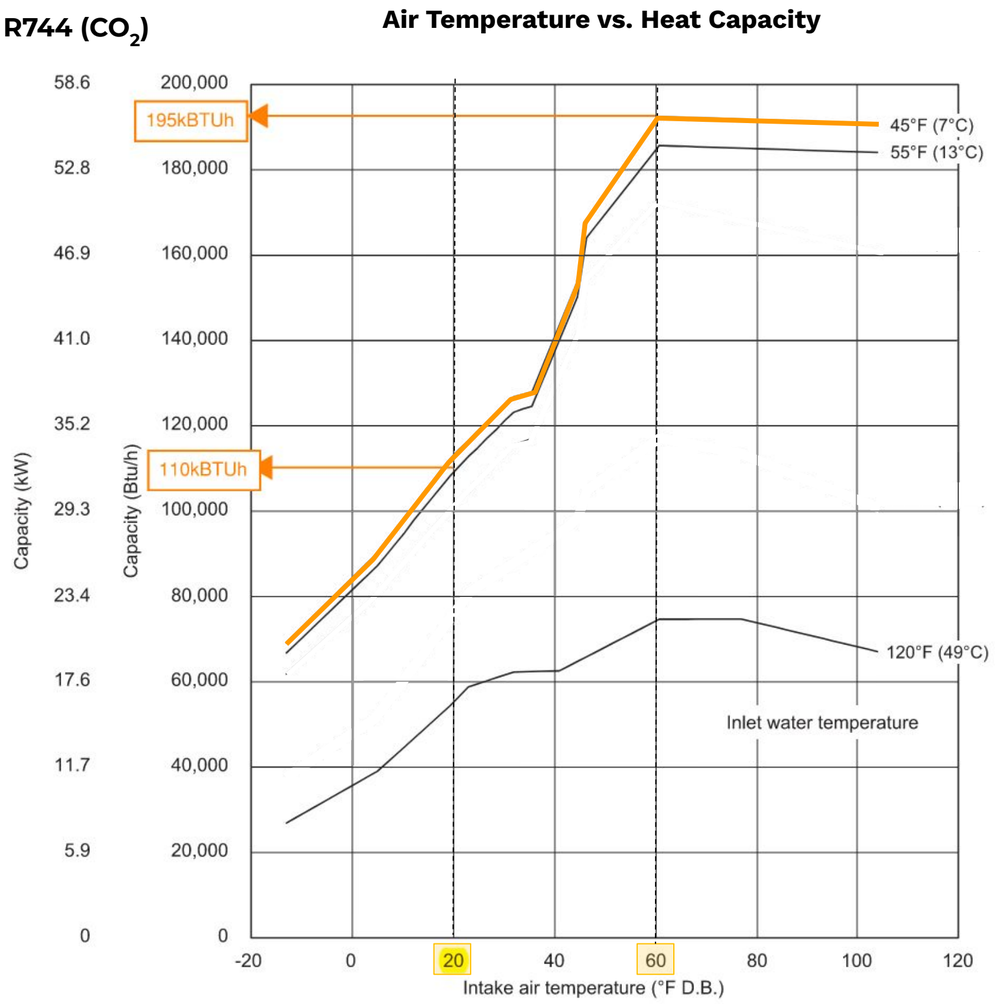
*COPs are for Seattle - expect better performance in warmer climates

REFRIGERANT & EQUIPMENT **SELECTION**

R134a



R744 (CO_2)



REFRIGERANT & EQUIPMENT: **DEFROST**

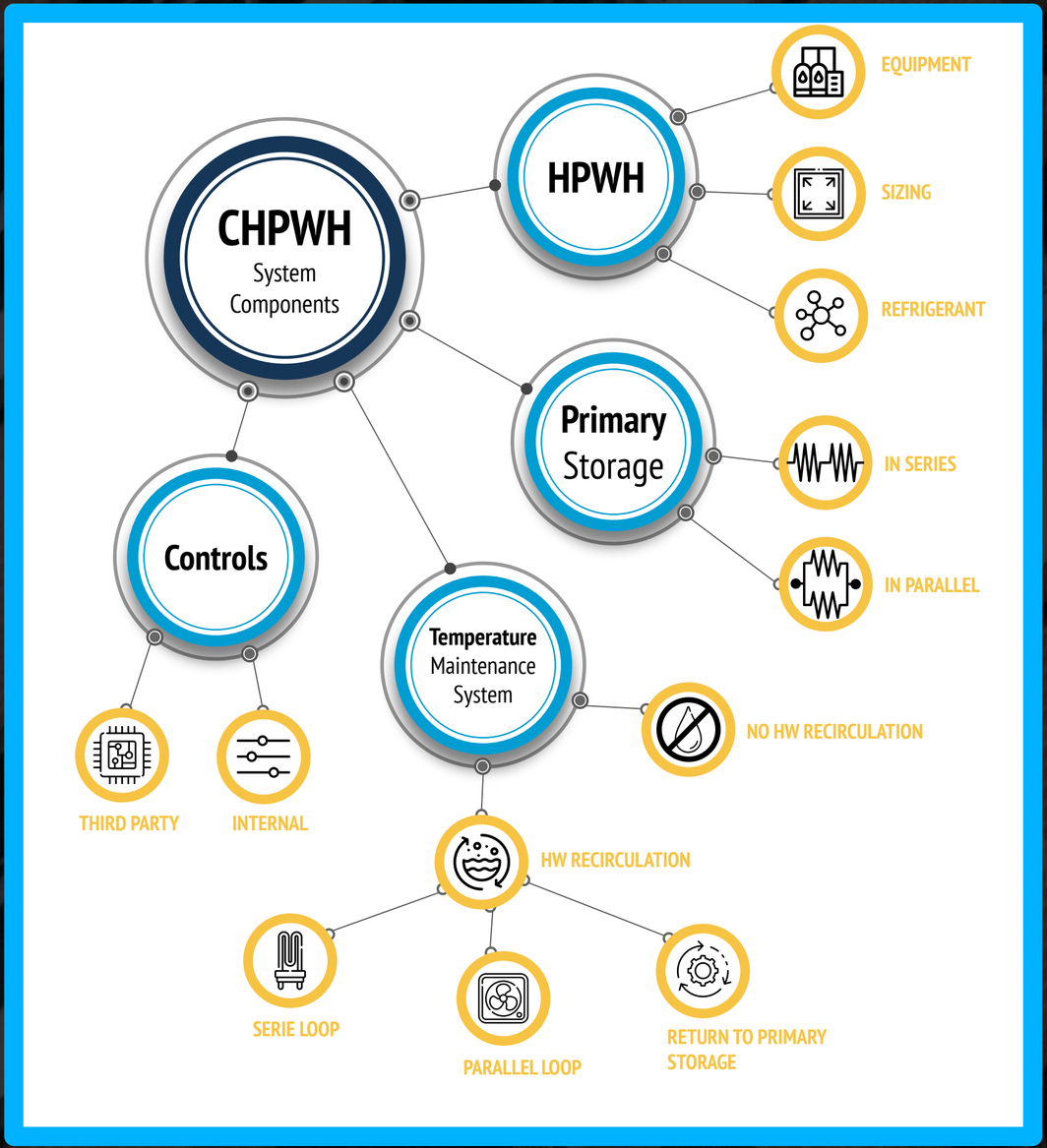
CONSIDERATIONS:

- During defrost, HPs typically don't provide heat
- Defrost cycles vary depending on MFGs. and refrigerant used
- Active vs Passive:
  - Active: unit operates in reverse
  - Passive: fan is used to melt frost/ice

PUTTING THE PIECES TOGETHER

PUTTING THE PIECES **TOGETHER**

- Components of a CHPWH system
- How HPWHs work
- Primary Storage
- Temperature Maintenance System
- Controls



UPCOMING **TRAINING & RESOURCES**

Seattle City Light, in collaboration with the Lighting Design Lab 2021

(https://www.lightingdesignlab.com/education)

CHPWH: Design, Operations, and Maintenance

(8-hour seminar)

Oct 26, Nov. 3, 10, 17

10am-12pm

To host a training session, or for more information, contact:
Lauren Bhaskar at: **LBHASKAR@DRINTL.COM**

lighting design lab

Seattle City Light

D+R LEARN

ECOTOPE

THANK YOU

AWHi

ADVANCED WATER HEATING INITIATIVE

et

Emerging Technologies

Bonneville

POWER ADMINISTRATION

THANK YOU TO OUR COLLABORATORS