COMMERCIAL HEAT PUMP WATER HEATING:

DESIGN & MAINTENANCE

Colin Grist & Evan Green
Ecotope, Inc.

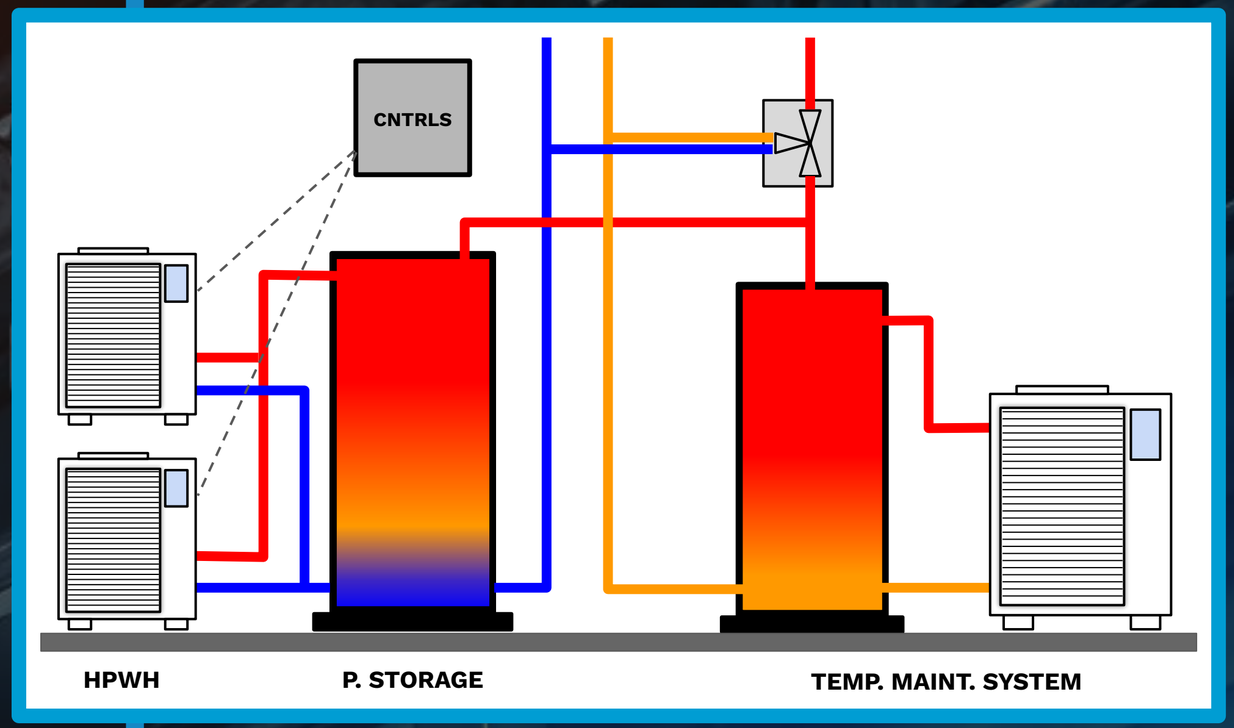
ECOTOPE

D+R LEARN

SCOPE & **SEQUENCE**

- **Session 1:** (Oct 26th)
  - What is a CHPWH system?
- **Session 2**: (Nov 3rd)
  - What key design considerations are essential for success?
- **Session 3**: (Nov 10th)
  - From design to implementation
- **Session 4**: (Nov 17th)
  - How to maintain CHPWH system operation?

REVIEW:
CHPWH SYSTEMS



EXAMPLES OF **SYSTEMS**

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

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)

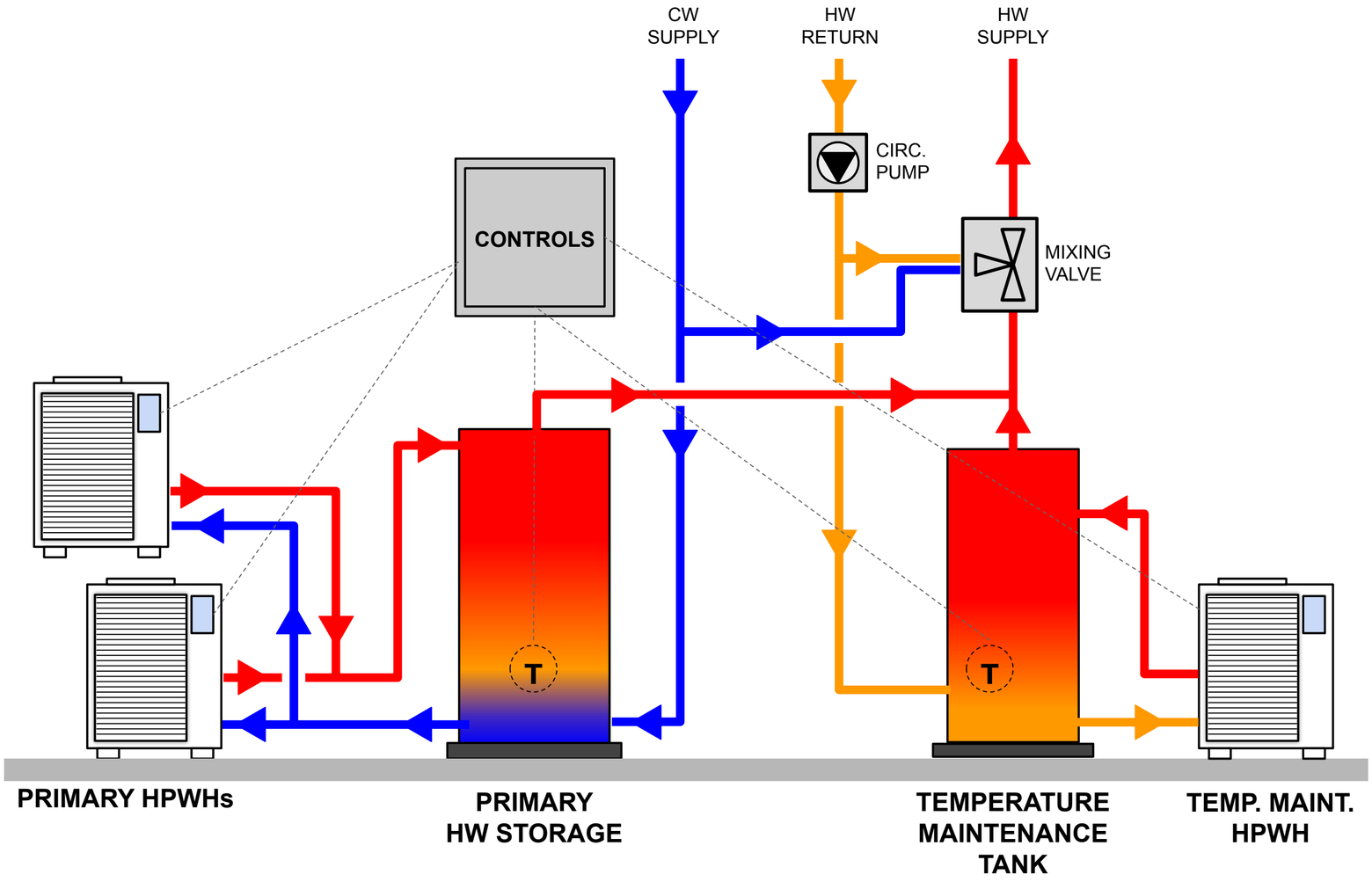
Single-Pass
CO_2/R-744

Colmac
(10 - 30 ton)

Nyle
(10 - 30 ton)

Single- or Multi-Pass
R-134a

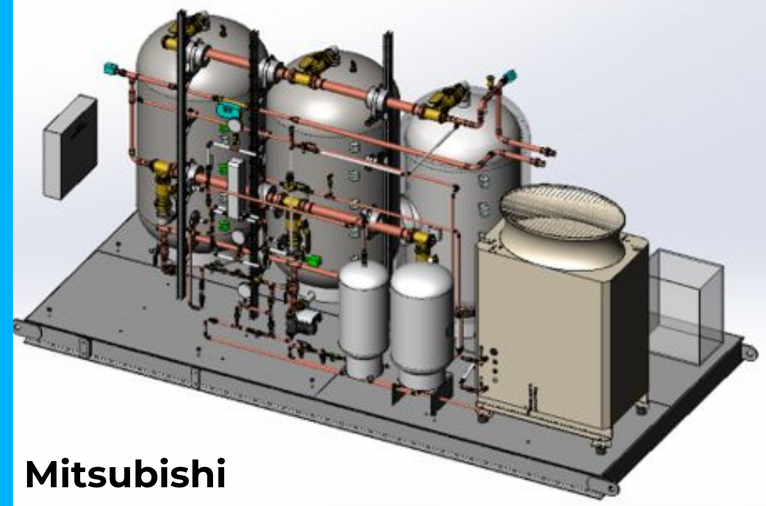
FOUR CHPWH SYSTEM **COMPONENTS**



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

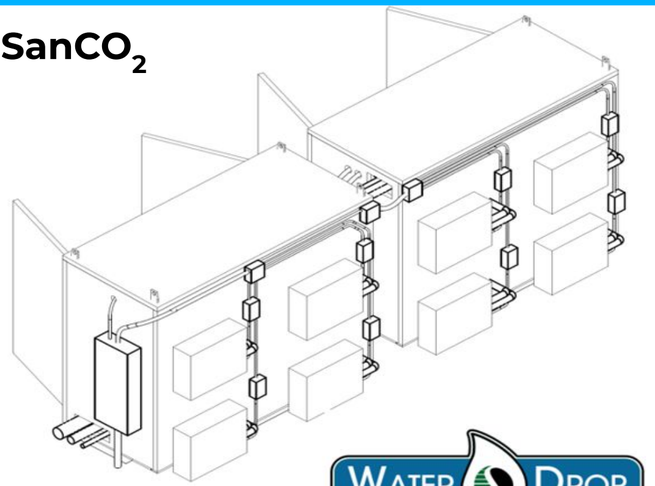
COMMERCIAL HPWH SKID **EQUIPMENT**

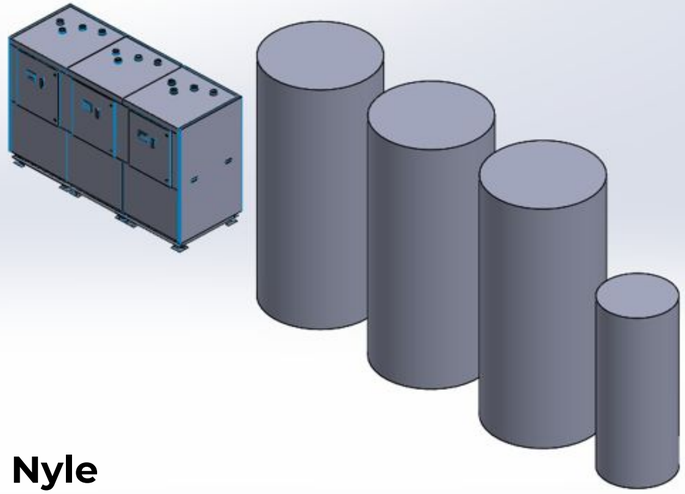
Manufacturers are working to provide skid options that are **easy to install**, **reliable** and result in **energy savings**.



Mitsubishi

SanCO$_2$





Nyle

Joining as a participant?

No account needed.

Enter event code

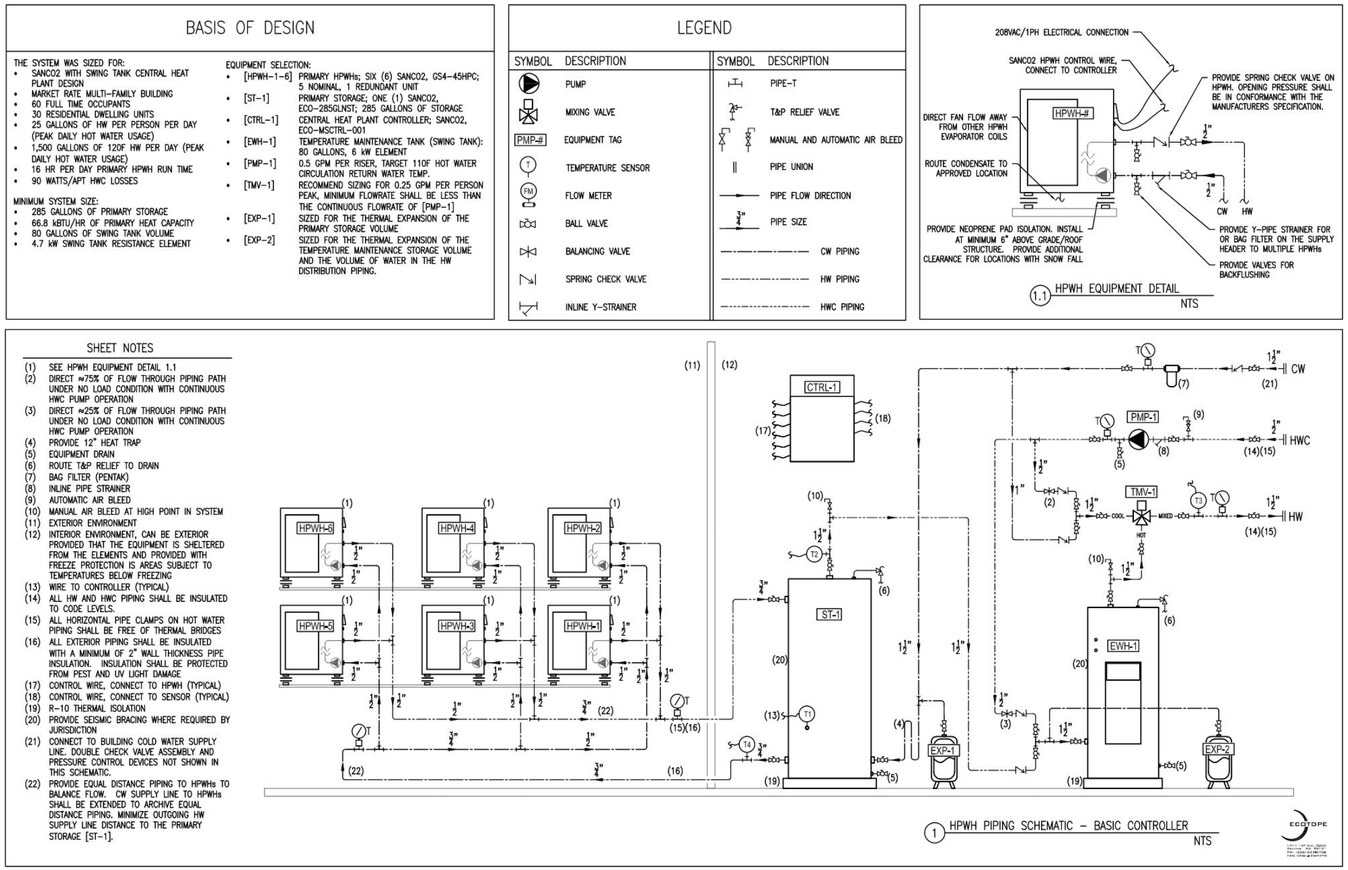
We want to hear from you!

GO TO SLIDO.COM

Enter event code:

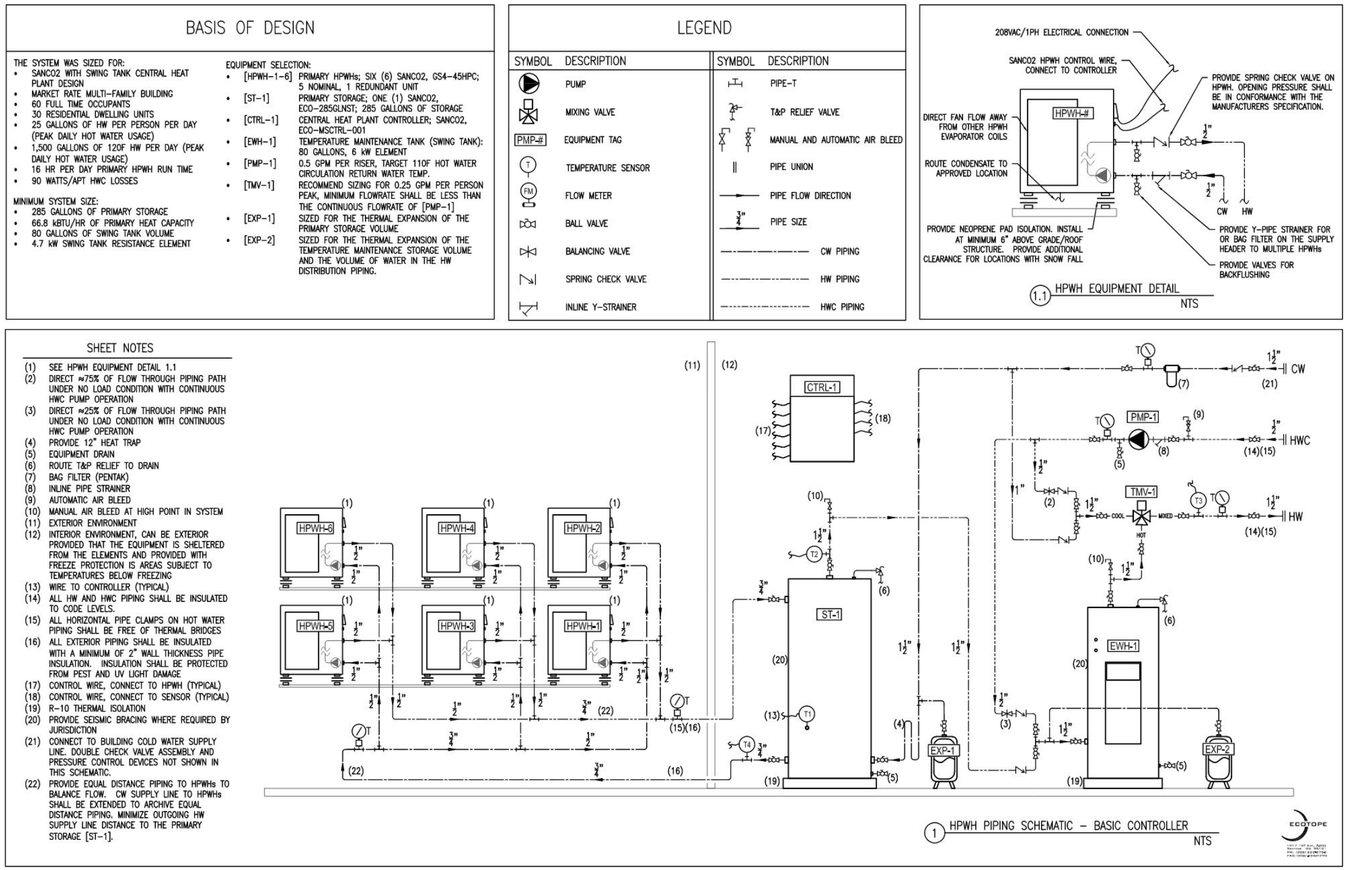
DESIGN2

slido



KEY QUESTION:

What factors are essential for CHPWH system design?

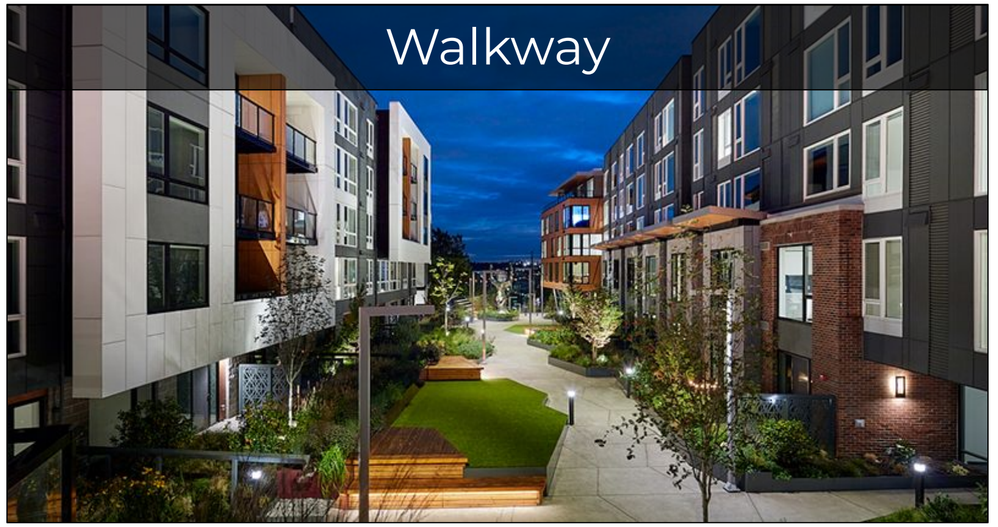


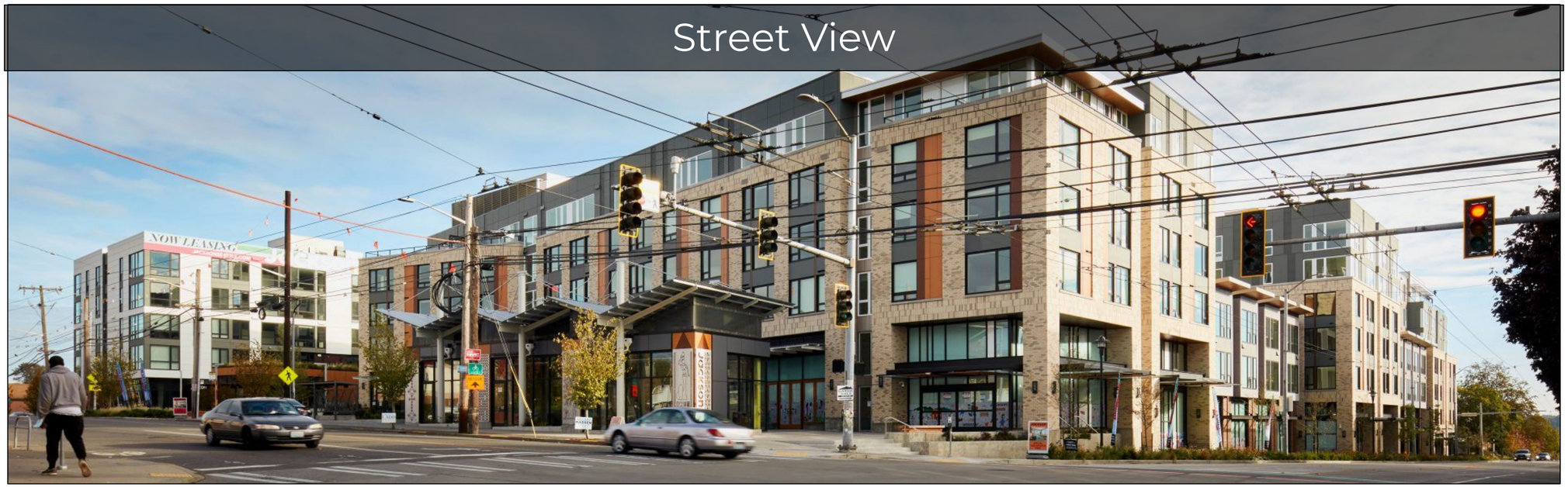
...THE ANSWER:

- Thermal stratification in the storage tanks
- Configuration of the temperature maintenance system
- Managing distribution system losses
- System sizing

CASE STUDY:
JACKSON APARTMENTS

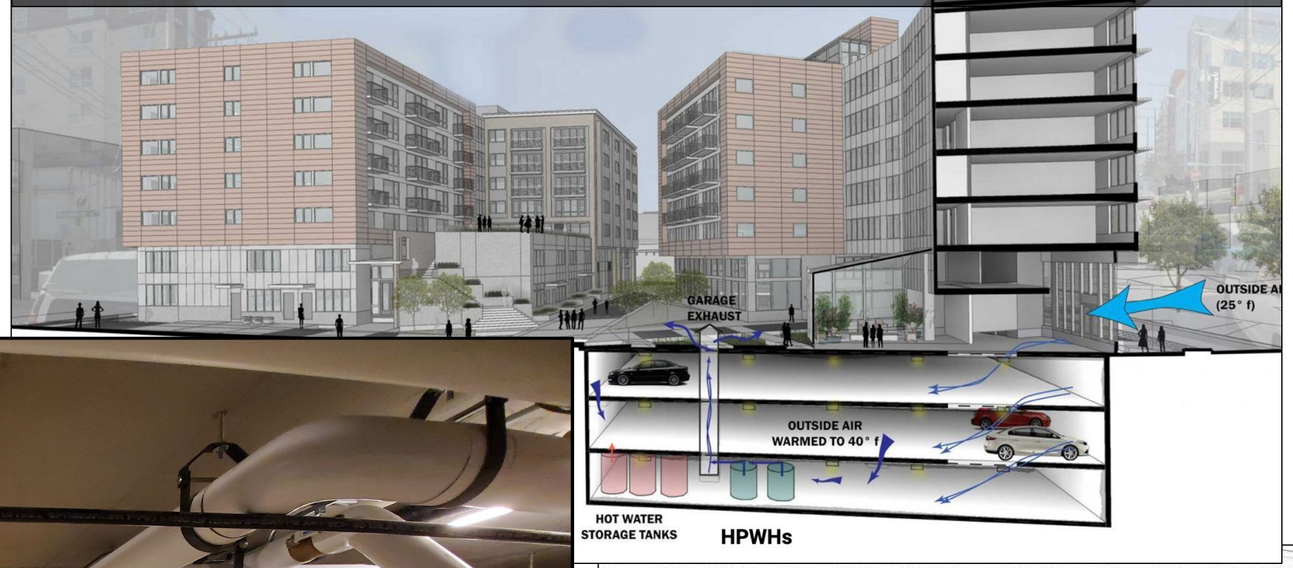
JACKSON **APARTMENTS**



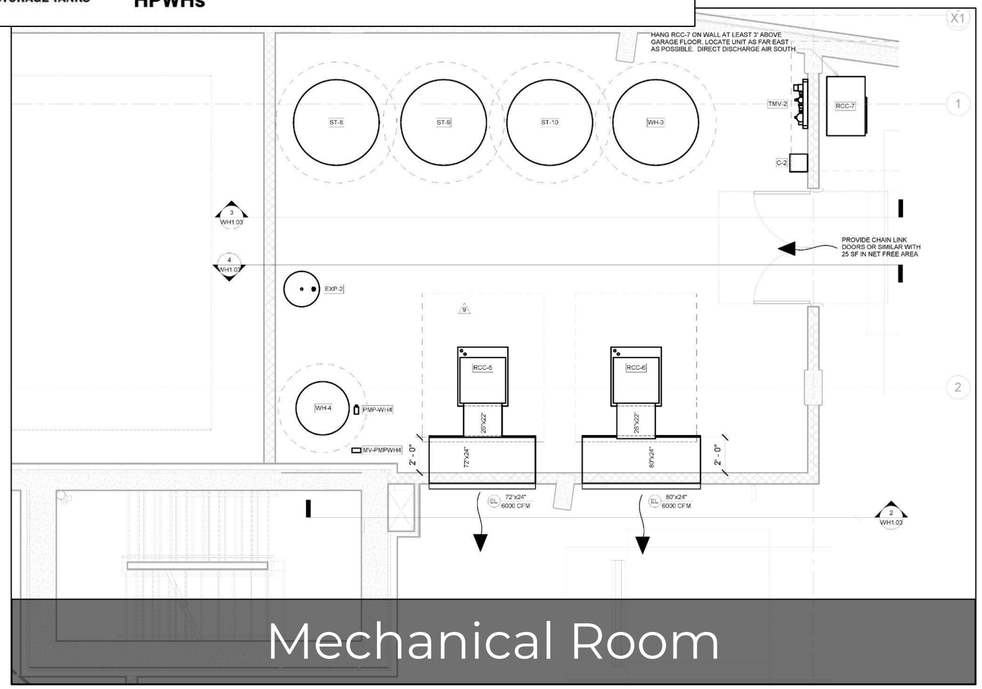


JACKSON **APARTMENTS**

Side/Parking Garage



Building Layout



Mechanical Room

JACKSON
APARTMENTS

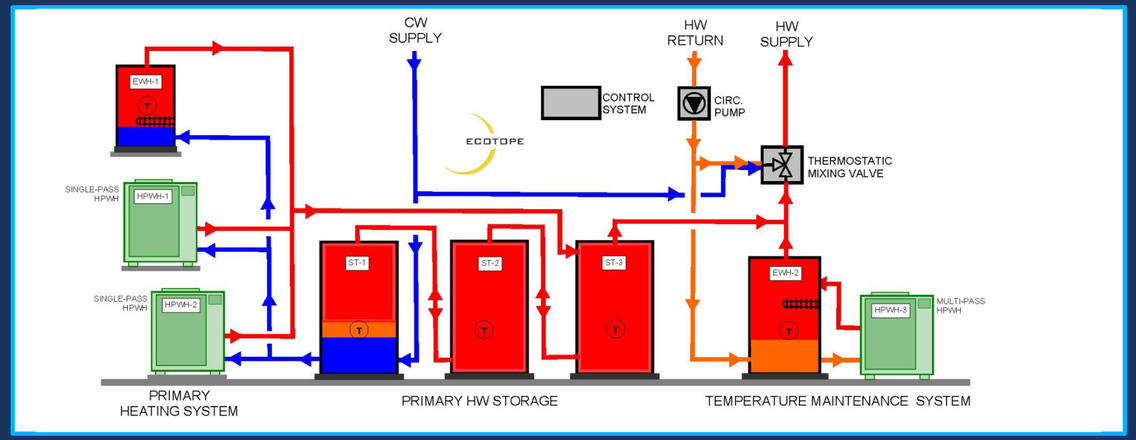
New construction

(2) Colmac CxA-15, single pass
(3) 500 gal tanks

Parallel loop configuration
(1) Colmac CxV-5; (1) 500 gal tank

Garage

15.1 % annual energy savings
(total building)

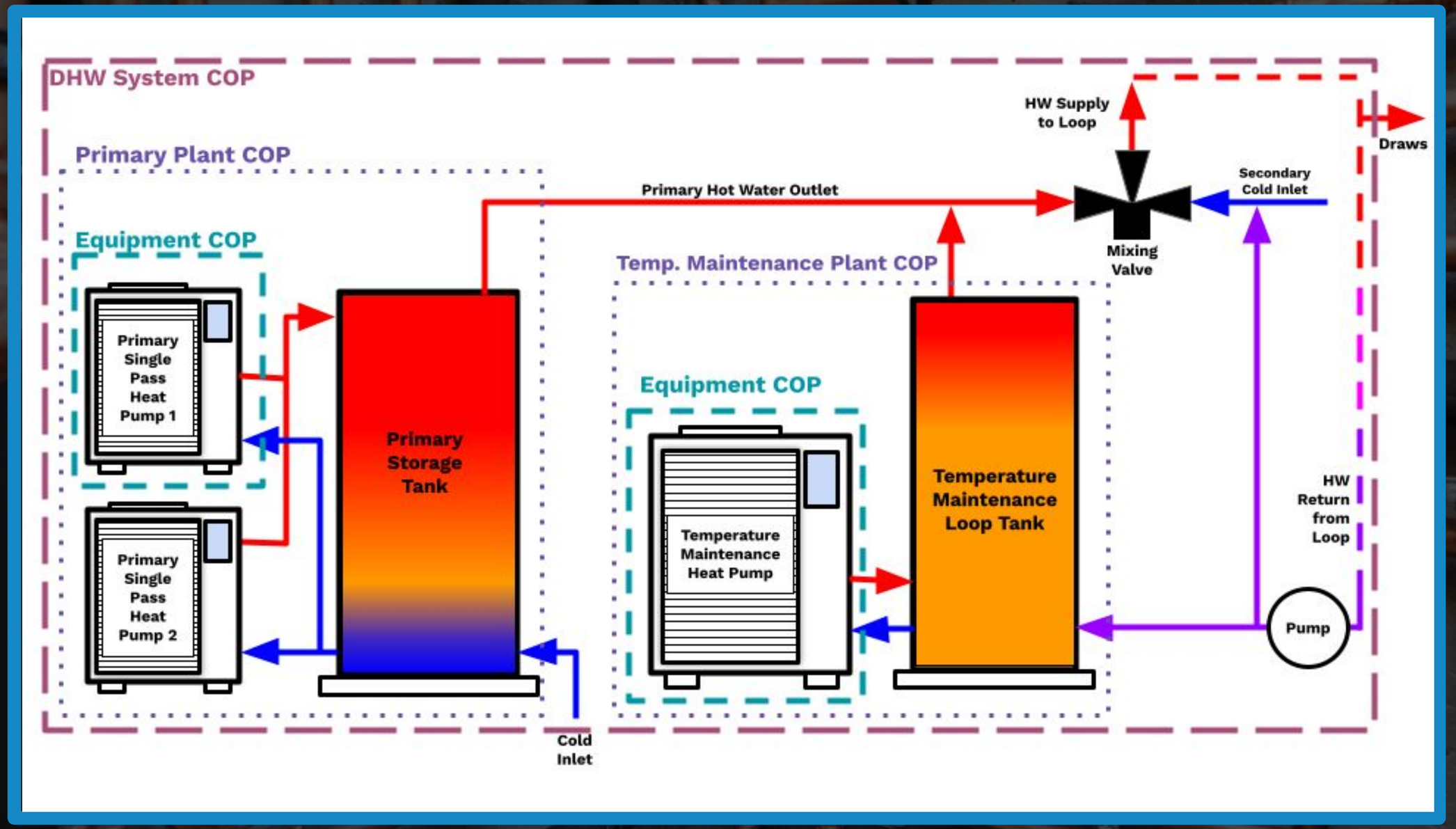


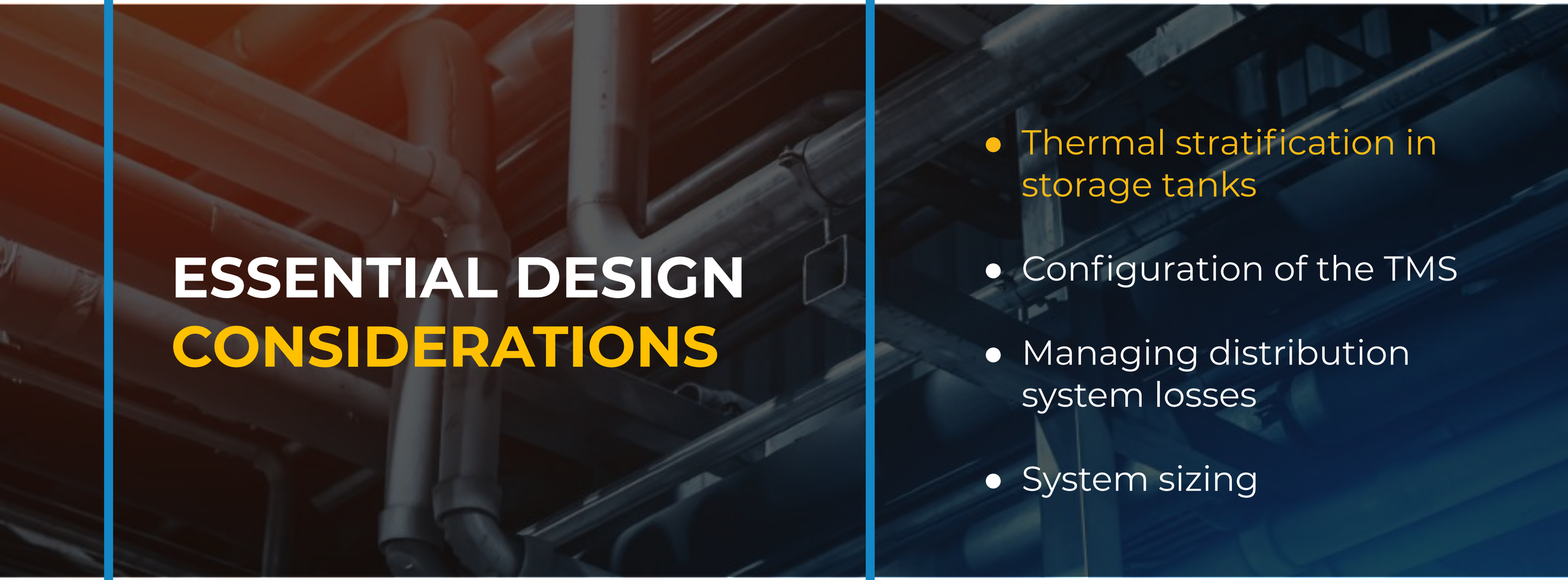
KEY TAKEAWAY:

Large, central systems using commercial equipment can be effectively utilized to deliver high efficiency water heating.


LET’S PAUSE FOR QUESTIONS

EQUIPMENT EFFICIENCY BOUNDARIES

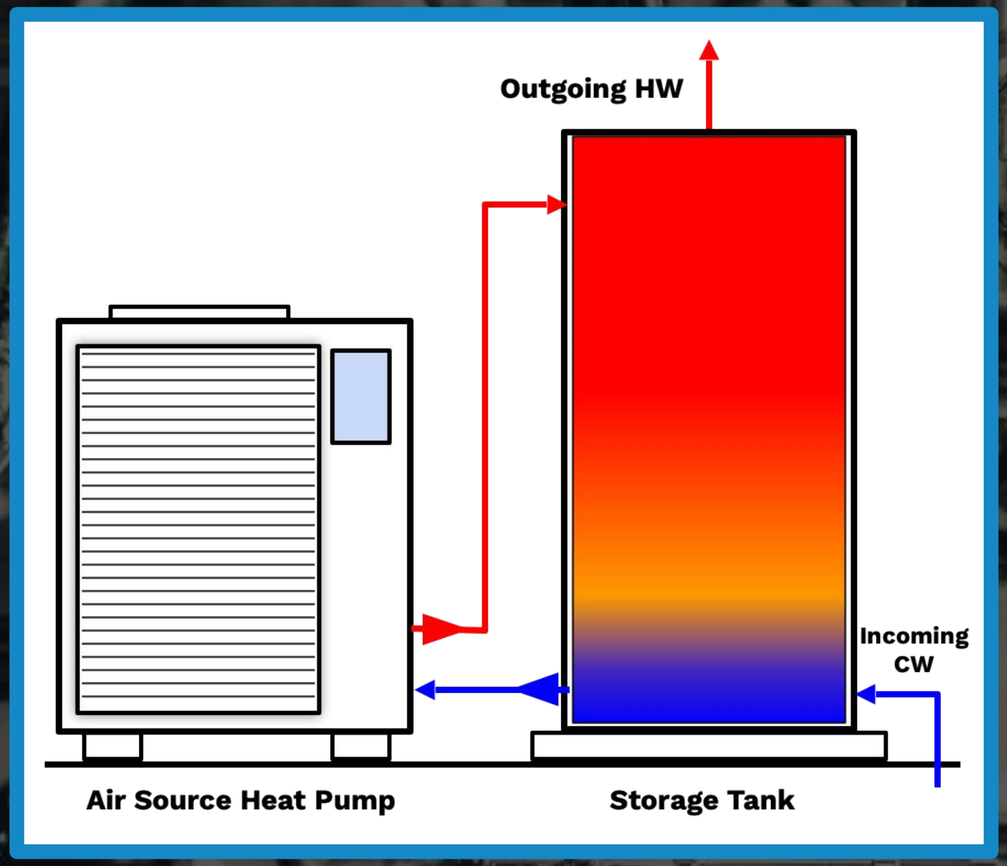


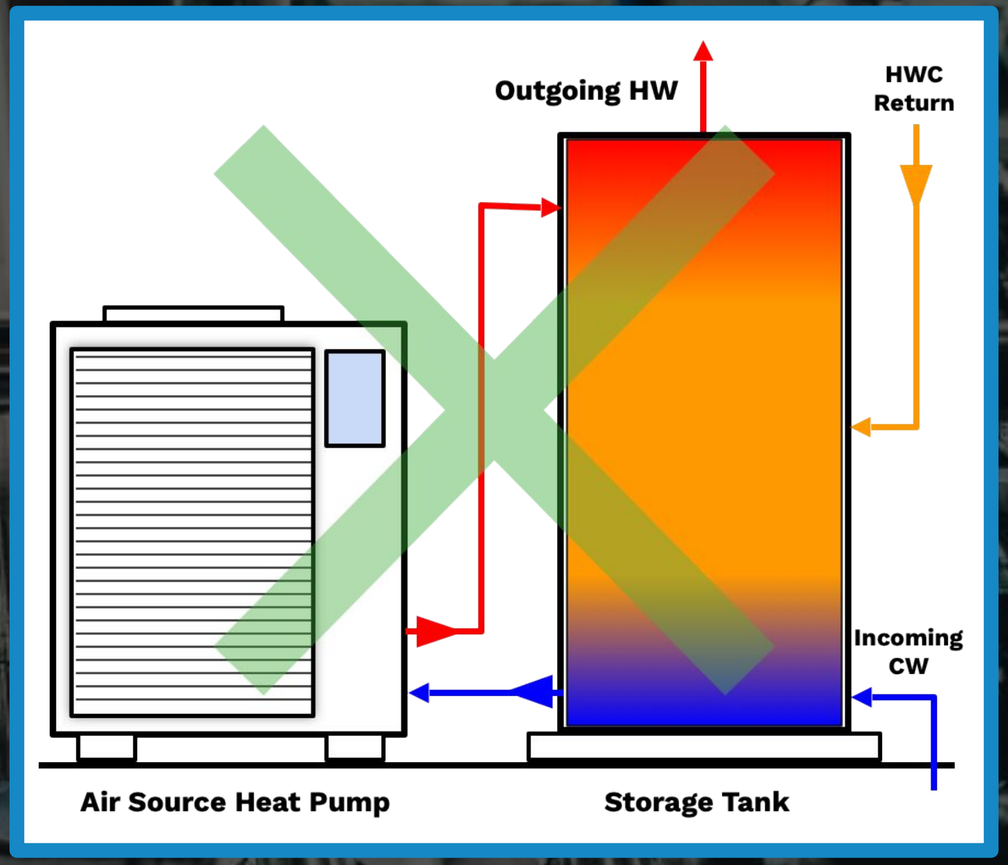


ESSENTIAL DESIGN CONSIDERATIONS

- Thermal stratification in storage tanks
- Configuration of the TMS
- Managing distribution system losses
- System sizing

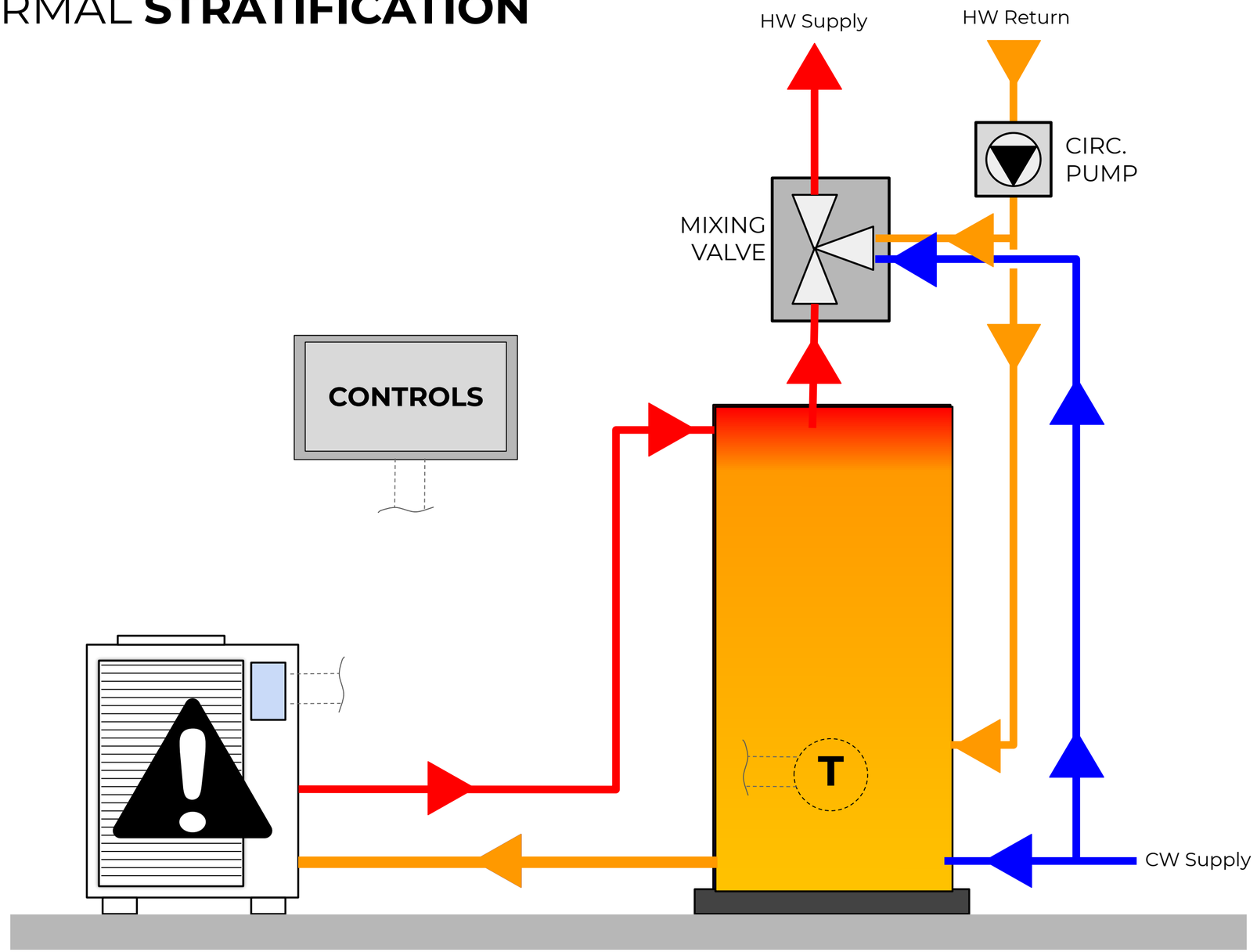
HW STORAGE SYSTEMS: **THERMAL STRATIFICATION**



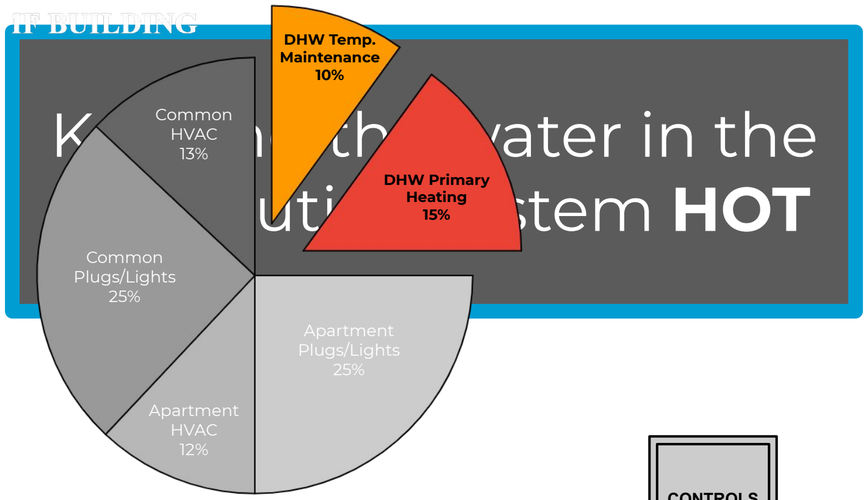


THE IMPORTANCE OF THERMAL **STRATIFICATION**

- HPs are very efficient at making **cold** water **hot**
- HW circulates through the distribution piping
- Water returns from the building slightly cooled
- Return water causes **mixing** & **destratification** in the storage tank
- HPs are not very good at making **warm** water **hot**



TEMPERATURE MAINTENANCE **SYSTEM**



The TMS includes:

- Distribution piping
- Mixing valve
- Circulation pump
- Dedicated storage tank w/heat source


LET’S PAUSE FOR QUESTIONS

ESSENTIAL DESIGN CONSIDERATIONS

- Thermal stratification in storage tanks
- Configuration of the TMS
- Managing distribution system losses
- System sizing

WHAT WILL THE **HW DISTRIBUTION SYSTEM** LOOK LIKE?

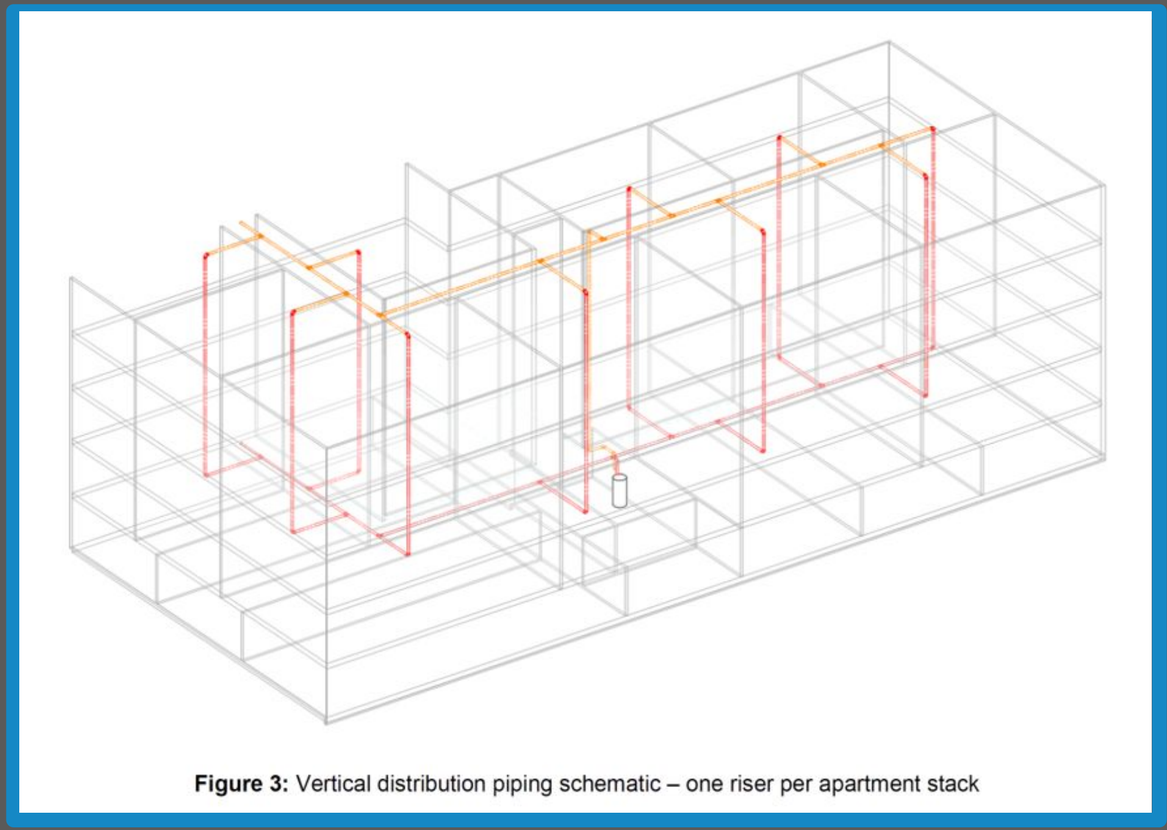


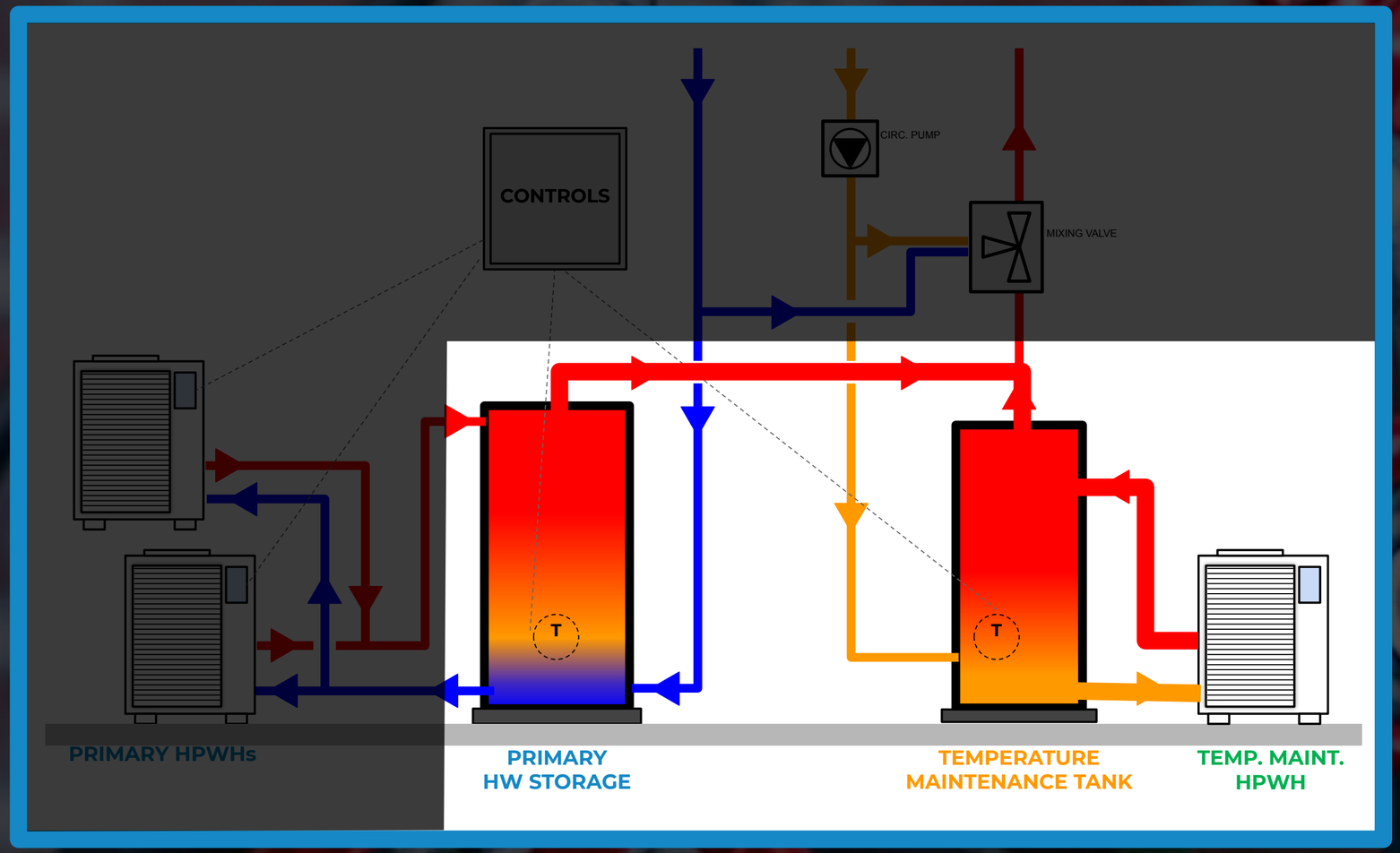
Figure 3: Vertical distribution piping schematic – one riser per apartment stack

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

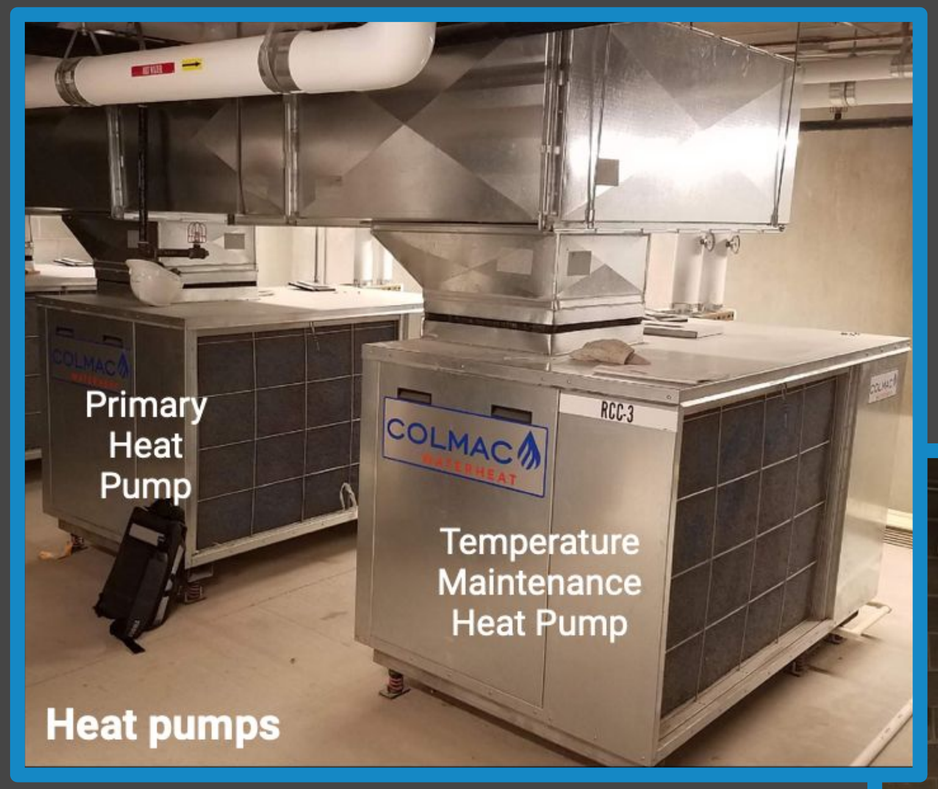
SINGLE-PASS PRIMARY HPWH SYSTEM W/ PARALLEL TEMPERATURE MAINTENANCE TANK & MULTI-PASS HPWH

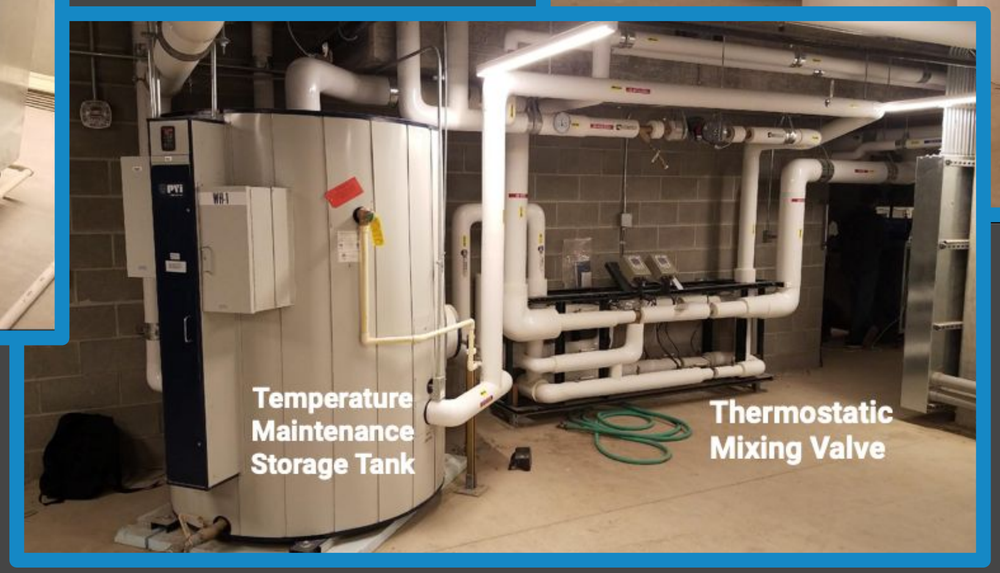


KEY CONSIDERATIONS:

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

SINGLE-PASS PARALLEL EQUIPMENT





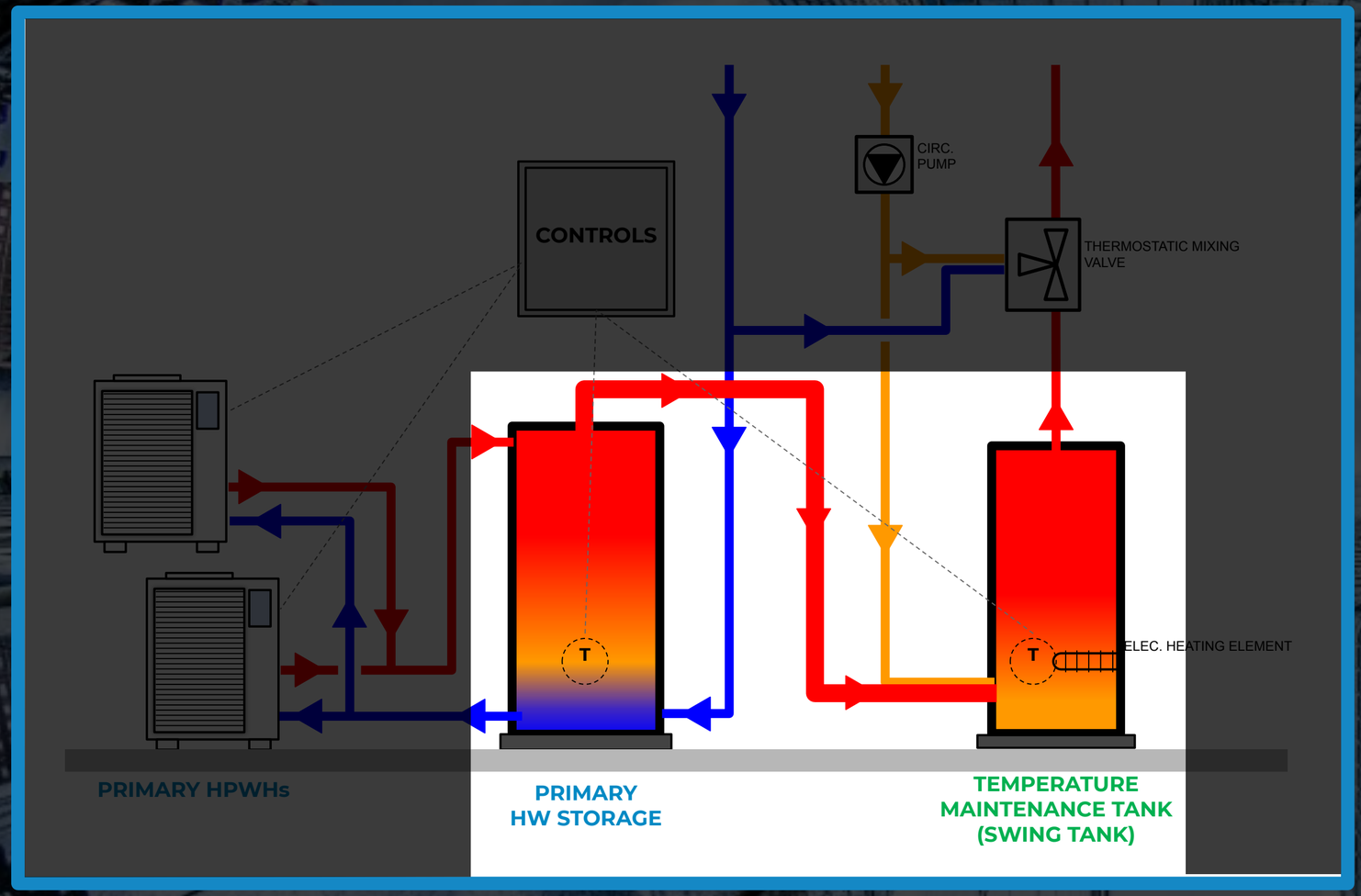
YESLER III:
CYPRESS COLMAC

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

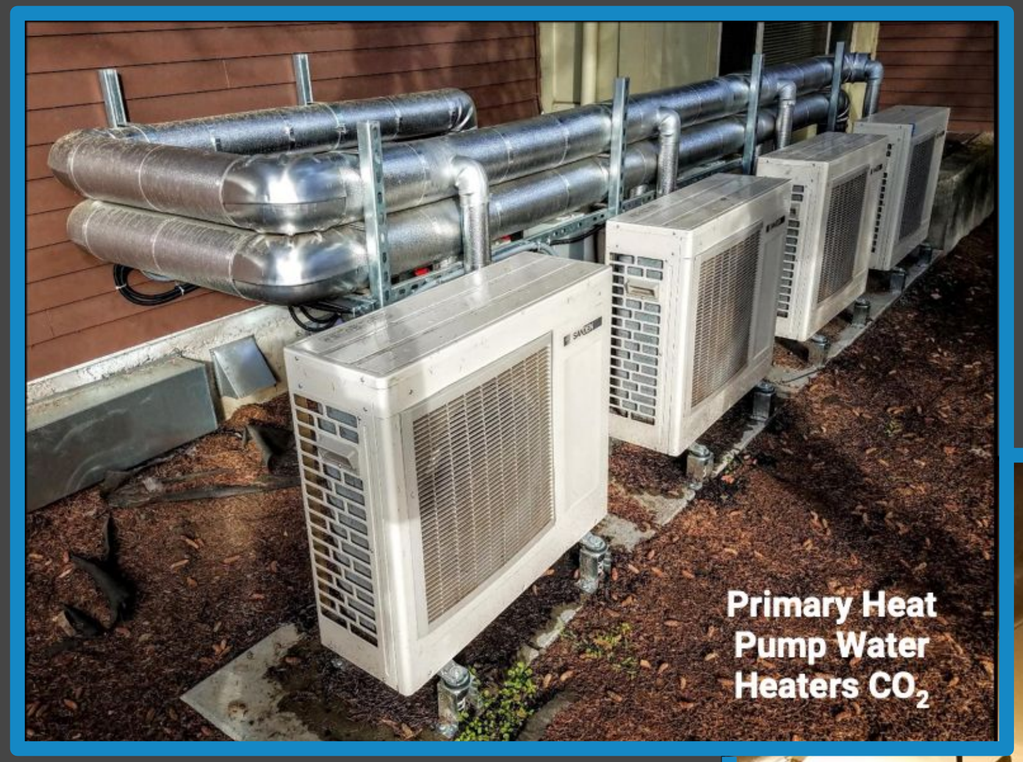
SINGLE-PASS PRIMARY HPWH SYSTEM W/ SERIES TEMPERATURE MAINTENANCE TANK (SWING TANK)



KEY CONSIDERATIONS:

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

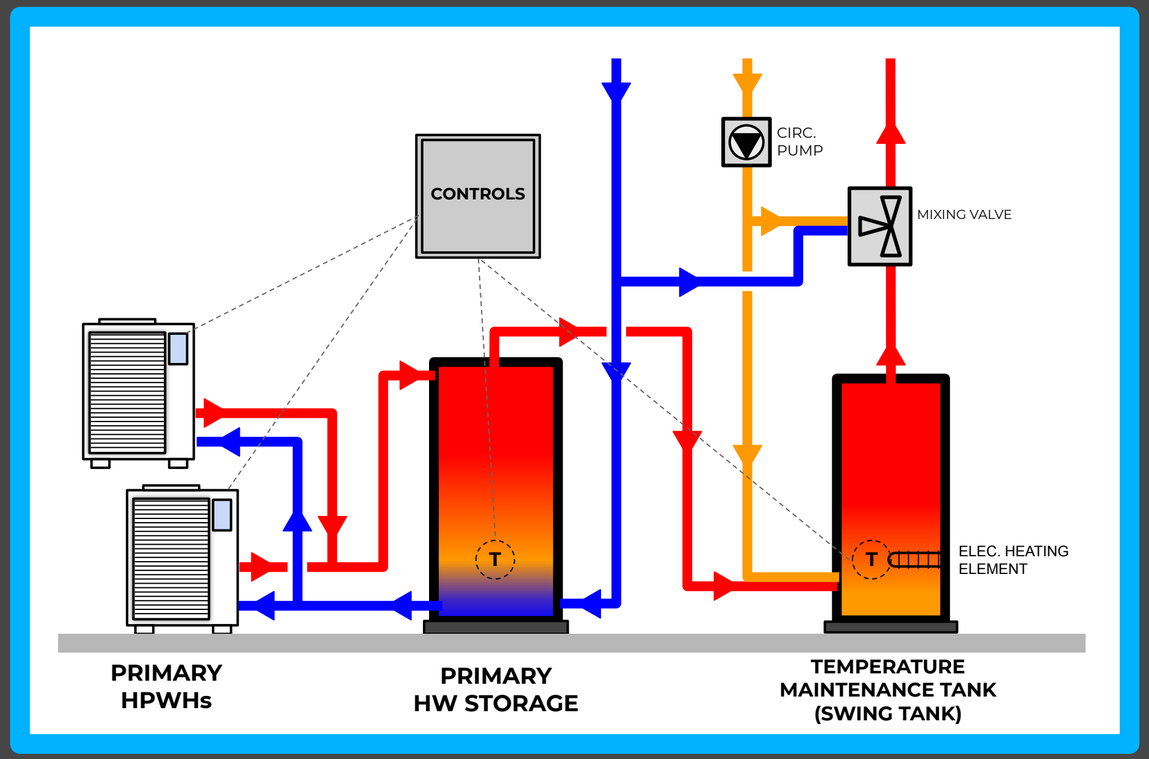
SINGLE-PASS EQUIPMENT



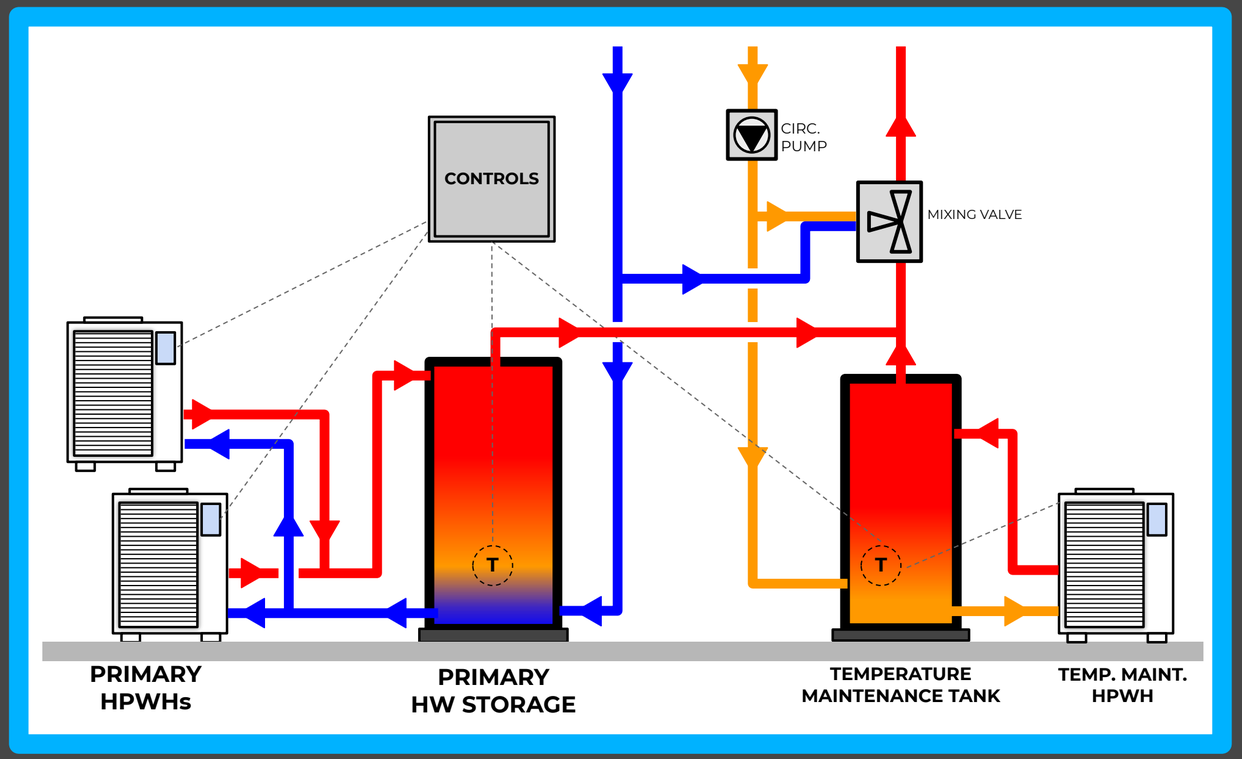
ELIZABETH JAMES
SANDEN GEN3 CO_2


LET’S PAUSE FOR QUESTIONS

RECAP: DEDICATED **HPWH SYSTEMS**



IN SERIES **SWING TANK**



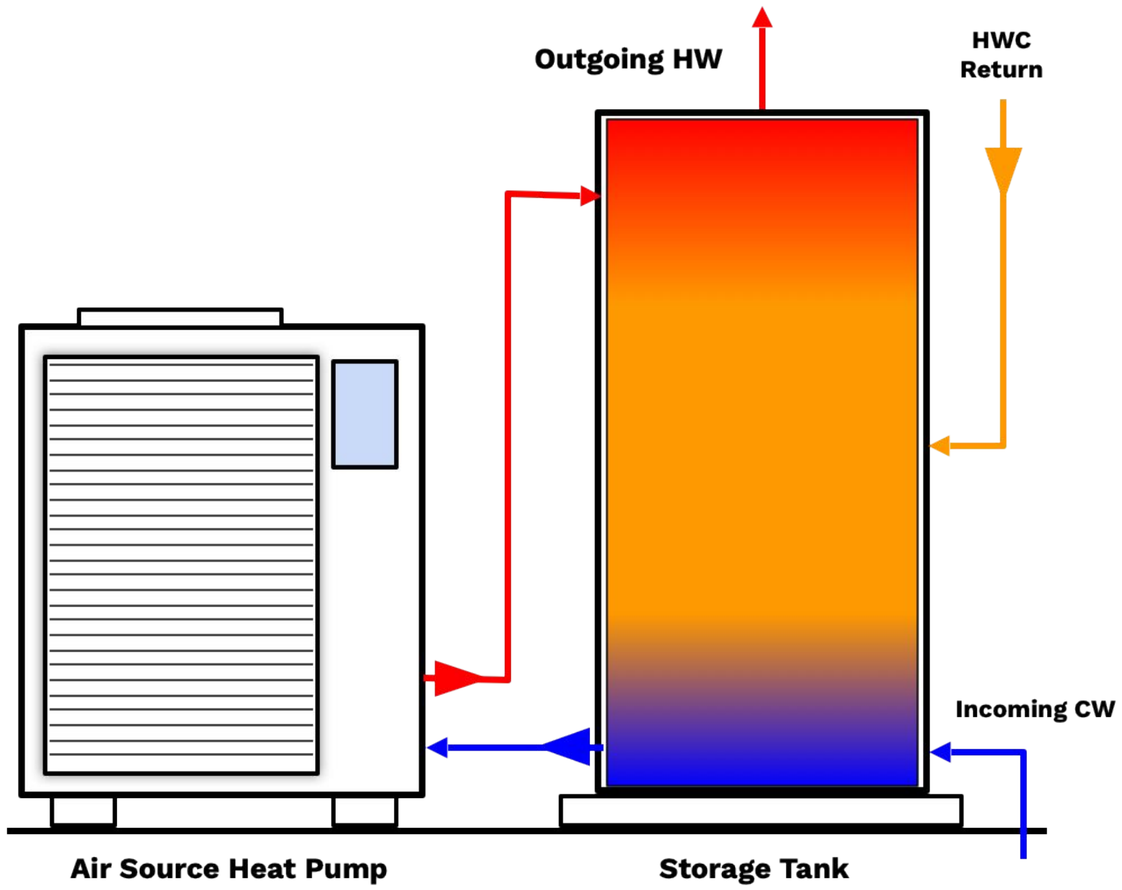
IN PARALLEL **MULTI-PASS HPWH**

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**

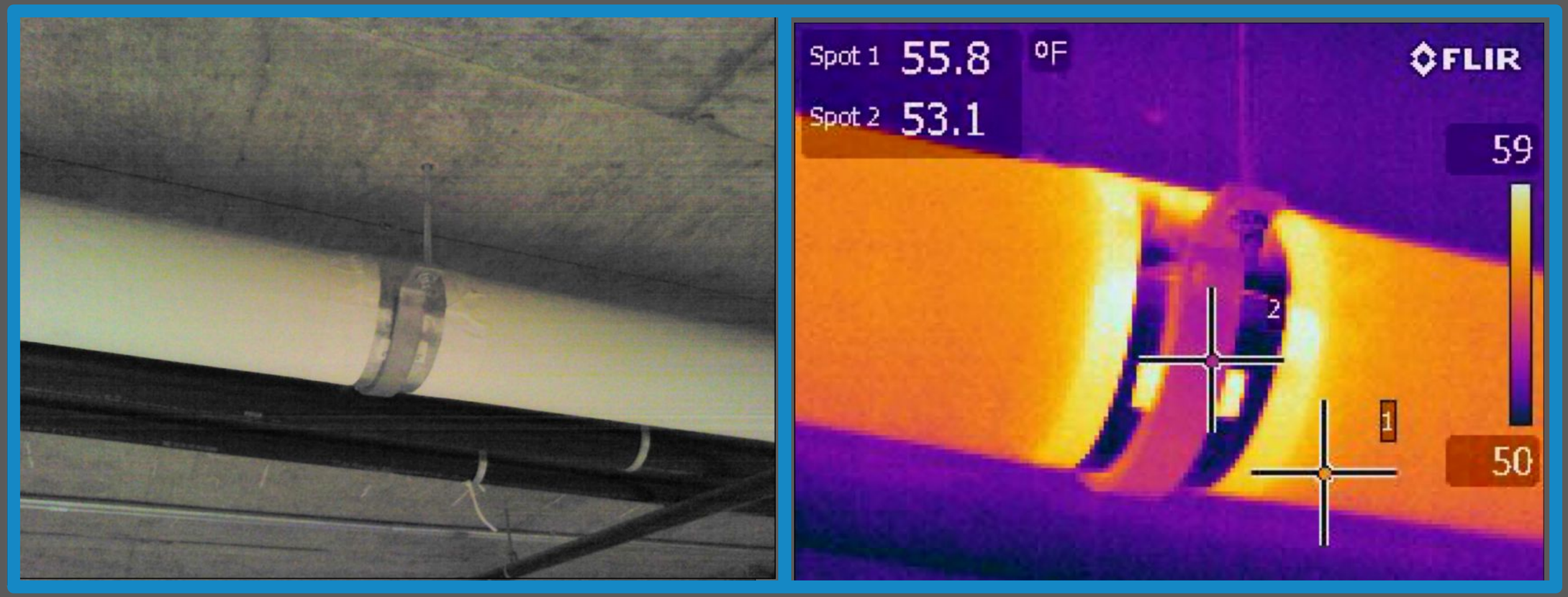
- Lack of recirculation system is uncommon
- Heat tape/trace is an option


LET’S PAUSE FOR QUESTIONS

ESSENTIAL DESIGN CONSIDERATIONS

- Thermal stratification in storage tanks
- Configuration of the TMS
- Managing distribution system losses
- System sizing

OPTIONS FOR REDUCING THE **TEMPERATURE MAINTENANCE LOSSES**



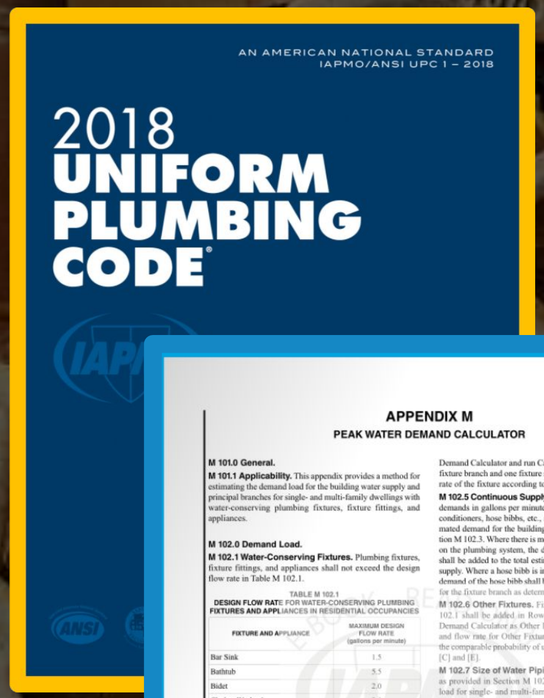
GOOD EXAMPLE: PIPE CLAMP ACTS AS A THERMAL BREAK

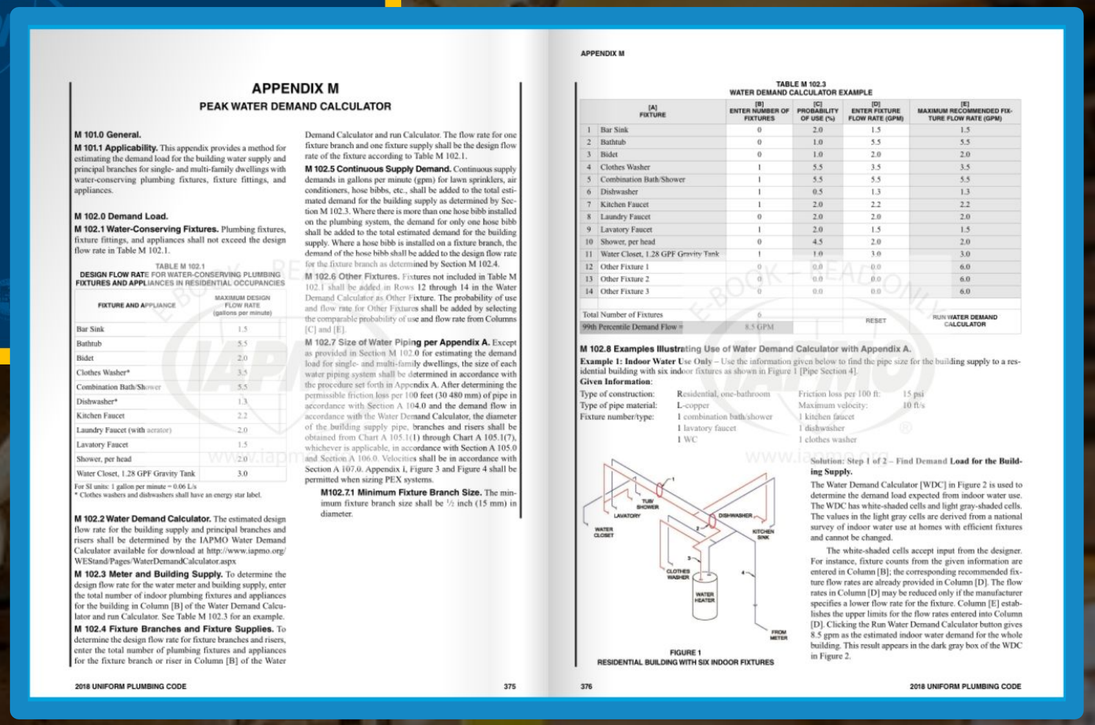
HIGH EFFICIENCY **PLUMBING DISTRIBUTION SYSTEMS**

APPENDIX M SIZING (UPC 2018)

- Reduces pipe size in building
- Reduces volume of water & associated losses
- Jurisdiction dependent in CA

Sizing Method	Flowrate (GPM)	CW main
Appendix A	260	4"
Appendix A + C	205	3.5"
Appendix M	**54**	**2"**





APPENDIX M

PEAK WATER DEMAND CALCULATOR

M 101.0 General.

M 101.1 Applicability. This appendix provides a method for estimating the demand load for the building water supply and principal branches for single- and multi-family dwellings with water-conserving plumbing fixtures, fixture fittings, and appliances.

M 102.0 Demand Load.

M 102.1 Water-Conserving Fixtures. Plumbing fixtures, fixture fittings, and appliances shall not exceed the design flow rate in Table M 102.1.

TABLE M 102.1
DESIGN FLOW RATE FOR WATER-CONSERVING PLUMBING FIXTURES AND APPLIANCES IN RESIDENTIAL OCCUPANCIES

FIXTURE AND APPLIANCE	MAXIMUM DESIGN FLOW RATE (gallons per minute)
Bar Sink	1.5
Bathtub	5.5
Bidet	2.0
Clothes Washer*	3.5
Combination Bath/Shower	5.5
Dishwasher*	1.3
Kitchen Faucet	2.2
Laundry Faucet (with aerator)	2.0
Lavatory Faucet	1.5
Shower, per head	2.0
Water Closet, 1.28 GPF Gravity Tank	3.0

For SI units: 1 gallon per minute = 0.06 L/s
* Clothes washers and dishwashers shall have an energy star label.

M 102.2 Water Demand Calculator. The estimated design flow rate for the building supply and principal branches and risers shall be determined by the IAPMO Water Demand Calculator available for download at http://www.iapmo.org/WEStand/Pages/WaterDemandCalculator.aspx

M 102.3 Meter and Building Supply. To determine the design flow rate for the water meter and building supply, enter the total number of indoor plumbing fixtures and appliances for the building in Column [B] of the Water Demand Calculator and run Calculator. See Table M 102.3 for an example.

M 102.4 Fixture Branches and Fixture Supplies. To determine the design flow rate for fixture branches and risers, enter the total number of plumbing fixtures and appliances for the fixture branch or riser in Column [B] of the Water Demand Calculator and run Calculator. The flow rate for one fixture branch and one fixture supply shall be the design flow rate of the fixture according to Table M 102.1.

M 102.5 Continuous Supply Demand. Continuous supply demands in gallons per minute (gpm) for lawn sprinklers, air conditioners, hose bibbs, etc., shall be added to the total estimated demand for the building supply as determined by Section M 102.3. Where there is more than one hose bibb installed on the plumbing system, the demand for only one hose bibb shall be added to the total estimated demand for the building supply. Where a hose bibb is installed on a fixture branch, the demand of the hose bibb shall be added to the design flow rate for the fixture branch as determined by Section M 102.4.

M 102.6 Other Fixtures. Fixtures not included in Table M 102.1 shall be added in Rows 12 through 14 in the Water Demand Calculator as Other Fixture. The probability of use and flow rate for Other Fixtures shall be added by selecting the comparable probability of use and flow rate from Columns [C] and [E].

M 102.7 Size of Water Piping per Appendix A. Except as provided in Section M 102.0 for estimating the demand load for single- and multi-family dwellings, the size of each water piping system shall be determined in accordance with the procedure set forth in Appendix A. After determining the permissible friction loss per 100 feet (30 480 mm) of pipe in accordance with Section A 104.0 and the demand flow in accordance with the Water Demand Calculator, the diameter of the building supply pipe, branches and risers shall be obtained from Chart A 105.1(1) through Chart A 105.1(7), whichever is applicable, in accordance with Section A 105.0 and Section A 106.0. Velocities shall be in accordance with Section A 107.0. Appendix i, Figure 3 and Figure 4 shall be permitted when sizing PEX systems.

M102.7.1 Minimum Fixture Branch Size. The minimum fixture branch size shall be ½ inch (15 mm) in diameter.

TABLE M 102.3
WATER DEMAND CALCULATOR EXAMPLE

	[A] FIXTURE	[B] ENTER NUMBER OF FIXTURES	[C] PROBABILITY OF USE (%)	[D] ENTER FIXTURE FLOW RATE (GPM)	[E] MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
1	Bar Sink	0	2.0	1.5	1.5
2	Bathtub	0	1.0	5.5	5.5
3	Bidet	0	1.0	2.0	2.0
4	Clothes Washer	1	5.5	3.5	3.5
5	Combination Bath/Shower	1	5.5	5.5	5.5
6	Dishwasher	1	0.5	1.3	1.3
7	Kitchen Faucet	1	2.0	2.2	2.2
8	Laundry Faucet	0	2.0	2.0	2.0
9	Lavatory Faucet	1	2.0	1.5	1.5
10	Shower, per head	0	4.5	2.0	2.0
11	Water Closet, 1.28 GPF Gravity Tank	1	1.0	3.0	3.0
12	Other Fixture 1	0	0.0	0.0	6.0
13	Other Fixture 2	0	0.0	0.0	6.0
14	Other Fixture 3	0	0.0	0.0	6.0
	Total Number of Fixtures	0		RESET	RUN WATER DEMAND CALCULATOR
	99th Percentile Demand Flow =	8.5 GPM			

M 102.8 Examples Illustrating Use of Water Demand Calculator with Appendix A.

Example 1: Indoor Water Use Only – Use the information given below to find the pipe size for the building supply to a residential building with six indoor fixtures as shown in Figure 1 [Pipe Section 4].

Given Information:

Type of construction: Residential, one-bathroom
Type of pipe material: L-copper
Fixture number/type: 1 combination bath/shower, 1 lavatory faucet, 1 WC
Friction loss per 100 ft: 15 psi
Maximum velocity: 10 ft/s
1 kitchen faucet
1 dishwasher
1 clothes washer

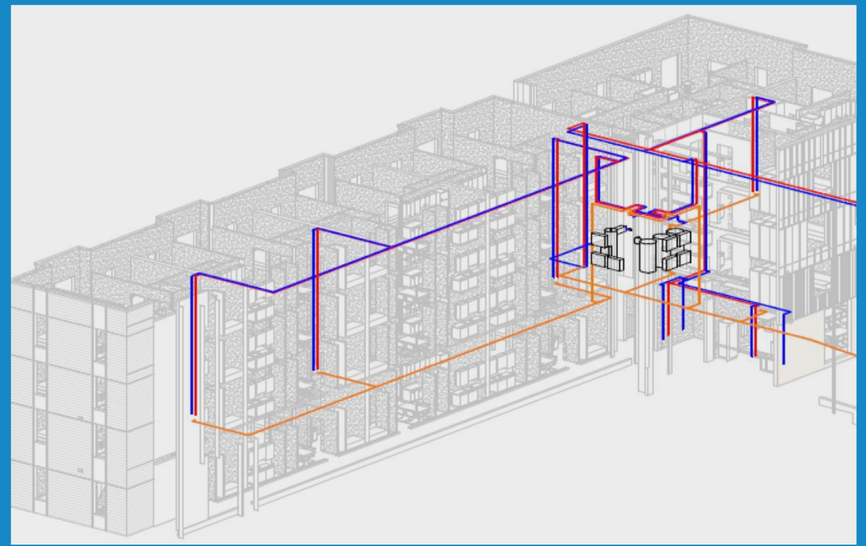
FIGURE 1
RESIDENTIAL BUILDING WITH SIX INDOOR FIXTURES

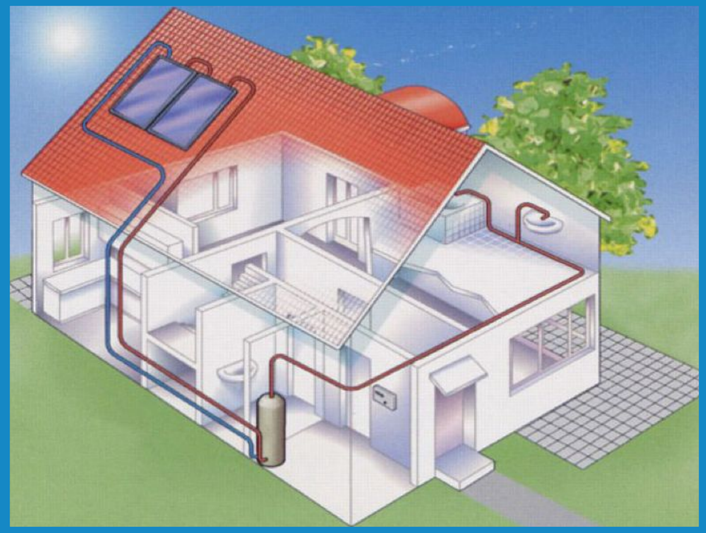
Solution: Step 1 of 2 – Find Demand Load for the Building Supply.

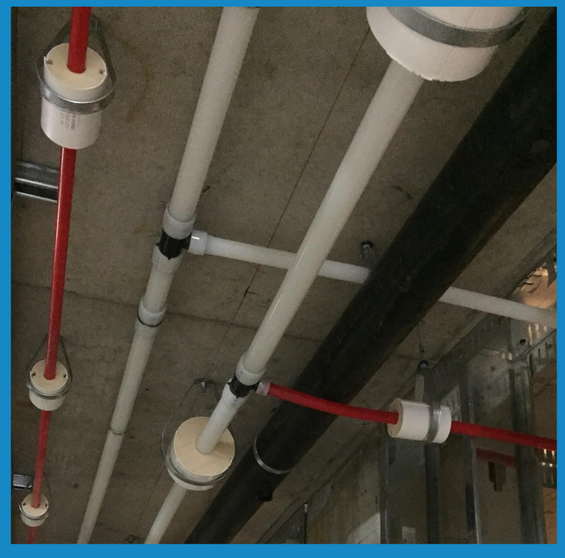
The Water Demand Calculator [WDC] in Figure 2 is used to determine the demand load expected from indoor water use. The WDC has white-shaded cells and light gray-shaded cells. The values in the light gray cells are derived from a national survey of indoor water use at homes with efficient fixtures and cannot be changed.

The white-shaded cells accept input from the designer. For instance, fixture counts from the given information are entered in Column [B]; the corresponding recommended fixture flow rates are already provided in Column [D]. The flow rates in Column [D] may be reduced only if the manufacturer specifies a lower flow rate for the fixture. Column [E] establishes the upper limits for the flow rates entered into Column [D]. Clicking the Run Water Demand Calculator button gives 8.5 gpm as the estimated indoor water demand for the whole building. This result appears in the dark gray box of the WDC in Figure 2.

TEMPERATURE MAINTENANCE SYSTEMS: **REVIEW**







CONSIDERATIONS:

- Scale of the distribution system and associated losses
- Drive the temperature maintenance HW distribution losses down
  - Piping insulation and thermal bridges
  - UPC Appendix M
- Understand the equipment: Single-pass or Multi-pass HPWH
- Dedicated systems are more reliable
- Reheat with losses efficiently, often 30% of the annual DHW load

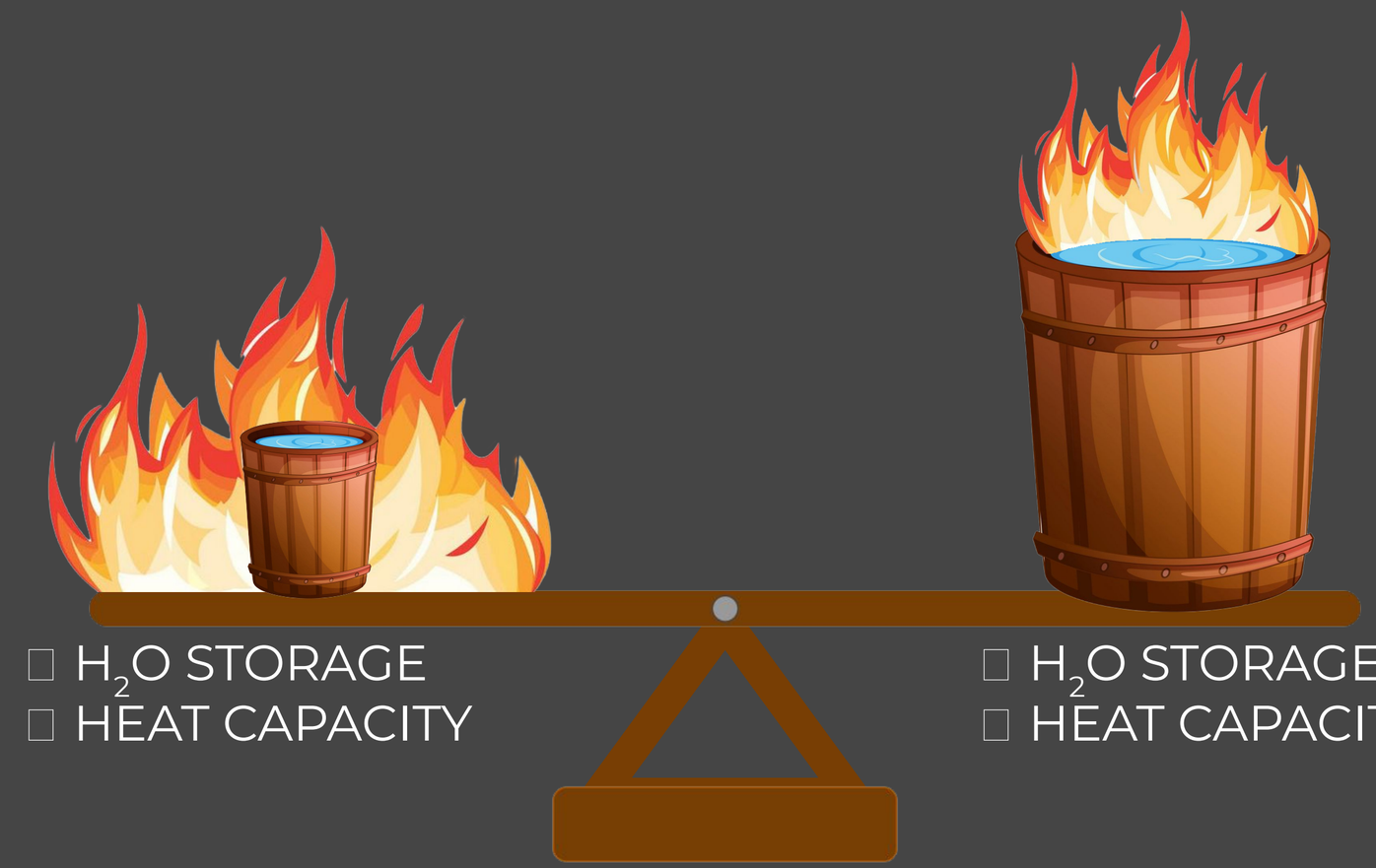

LET’S PAUSE FOR QUESTIONS

ESSENTIAL DESIGN CONSIDERATIONS

- Thermal stratification in storage tanks
- Configuration of the TMS
- Managing distribution system losses
- System sizing

SYSTEM **SIZING**

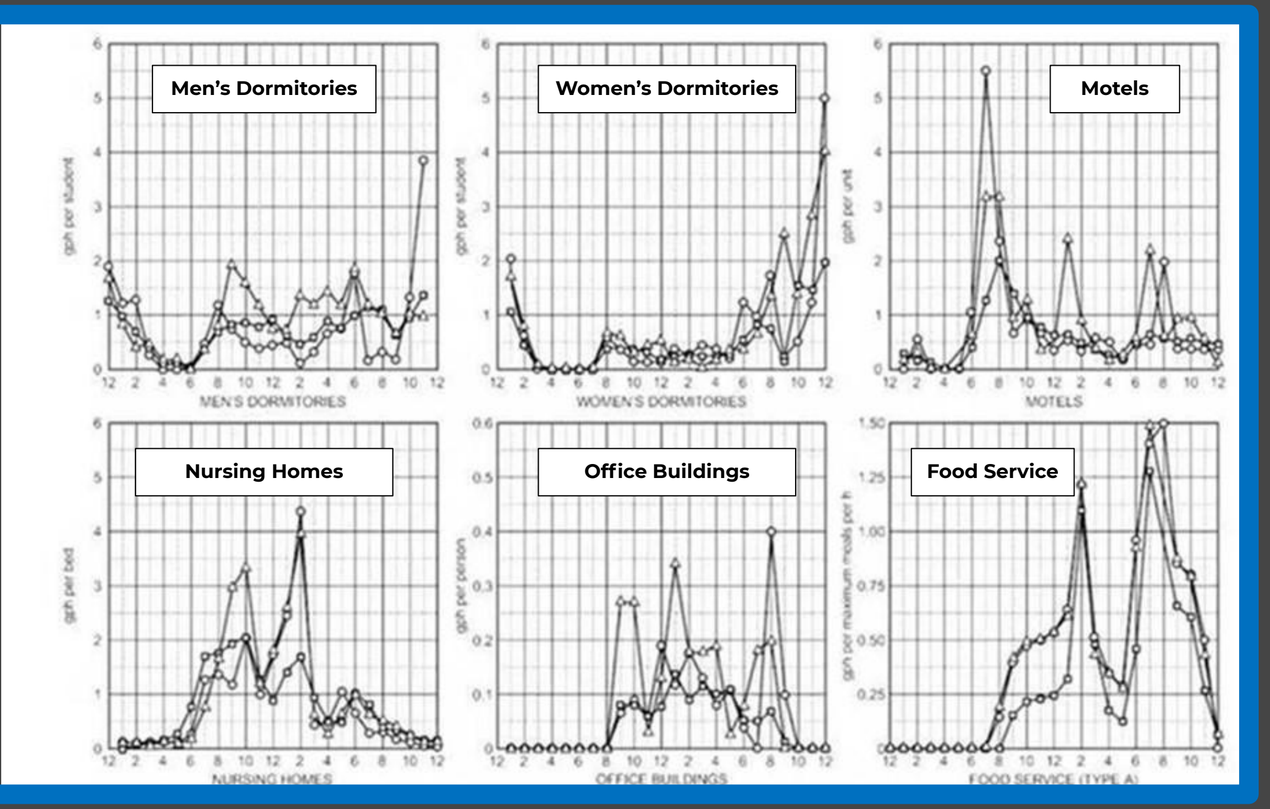
- Gas systems are sized w/ low storage and high heat capacity
- HPWH systems are sized w/ high storage and low heat capacity



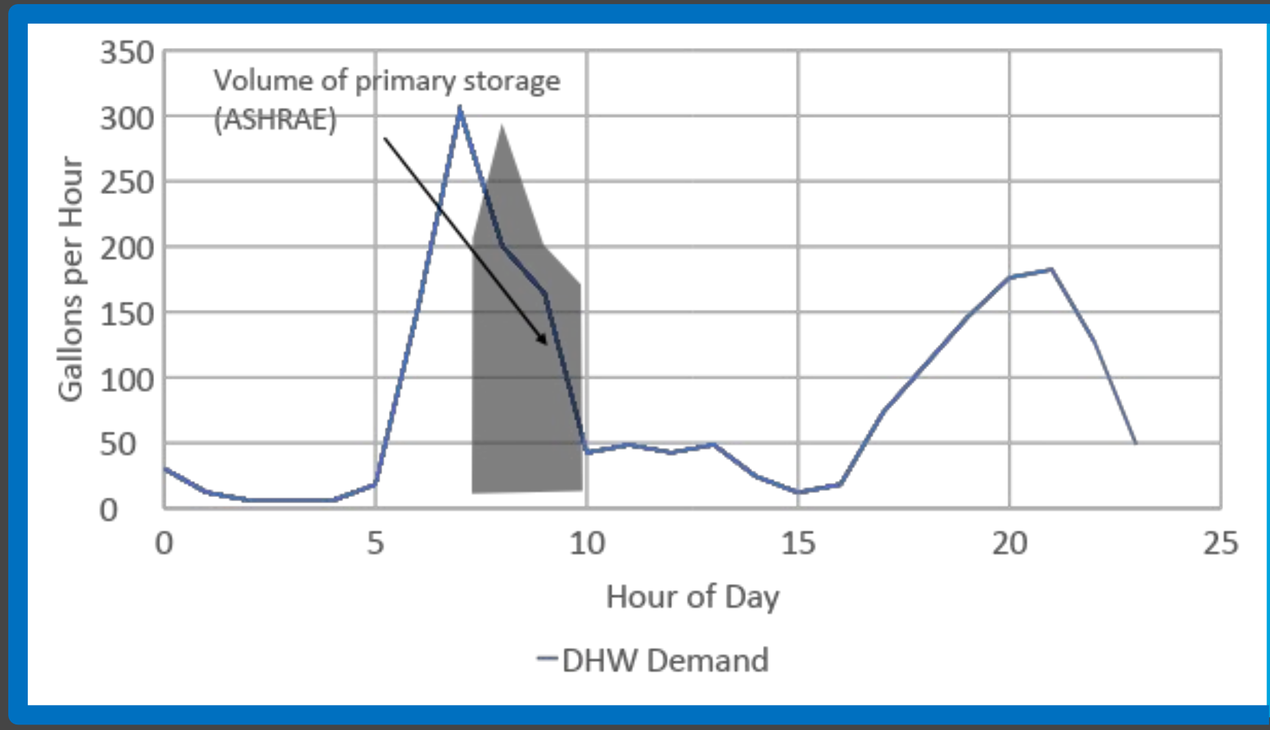
H_2O STORAGE
HEAT CAPACITY

H_2O STORAGE
HEAT CAPACITY

SYSTEM **SIZING**

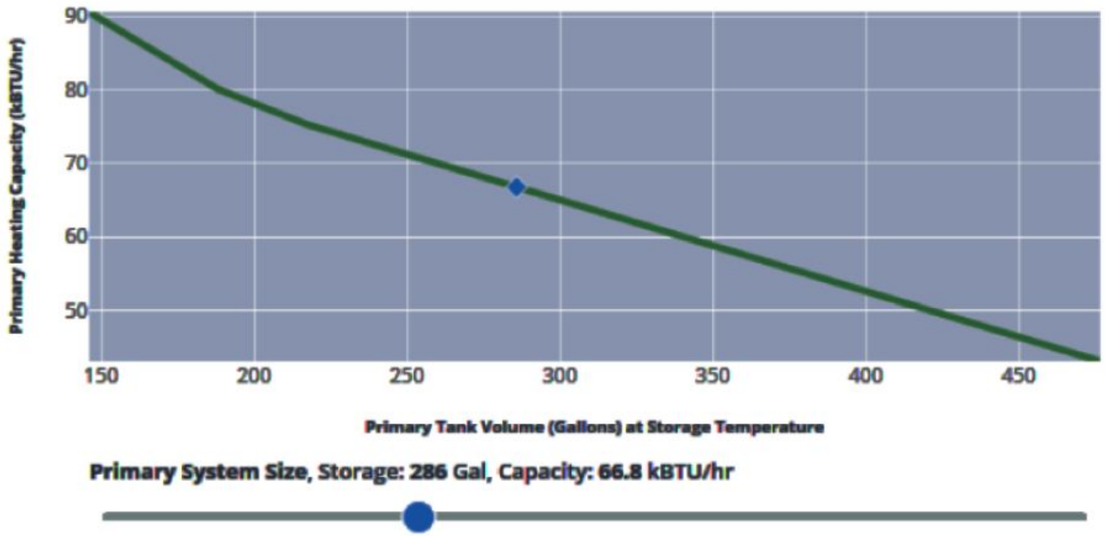


Multi Family **Domestic Hot Water (DHW)** Demand



ECOSIZER

ecosizer.Ecotope.com



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

Try it!

- Turn off CA mode
- 60 people
- 30 apartments
- 25 gallons per day

						
	Rheem	**SanCO2**	**AO Smith**	**Mitsubishi**	**Colmac**	**Nyle**
Size	> 1 ton	1.25 tons	2.5 tons	10 tons	10 - 30 tons	10 - 30 tons
Market delivery	unitary	split	unitary	split	split	split
System design	multi pass	single pass	multi pass	single pass	single or multi pass	single or multi pass
Refrigerant	R-134a	CO_2 / R-744	R-134a	CO_2 / R-744	R-134a	R-134a
Minimum ambient air temperature	37 °F	-20 °F	45 °F	-15 °F	40 °F	40 °F
Maximum outlet water temperature	145 °F	149 °F	145 °F	165 °F	165 °F	165 °F

* some generalizations

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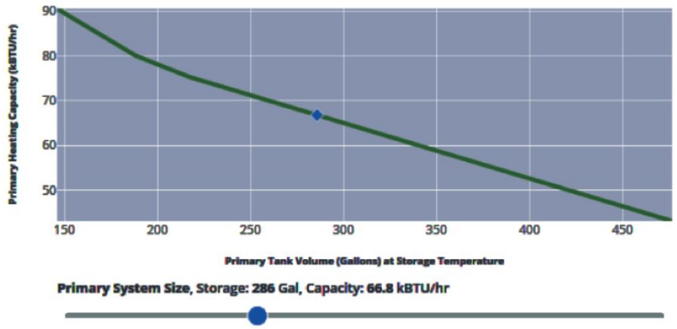

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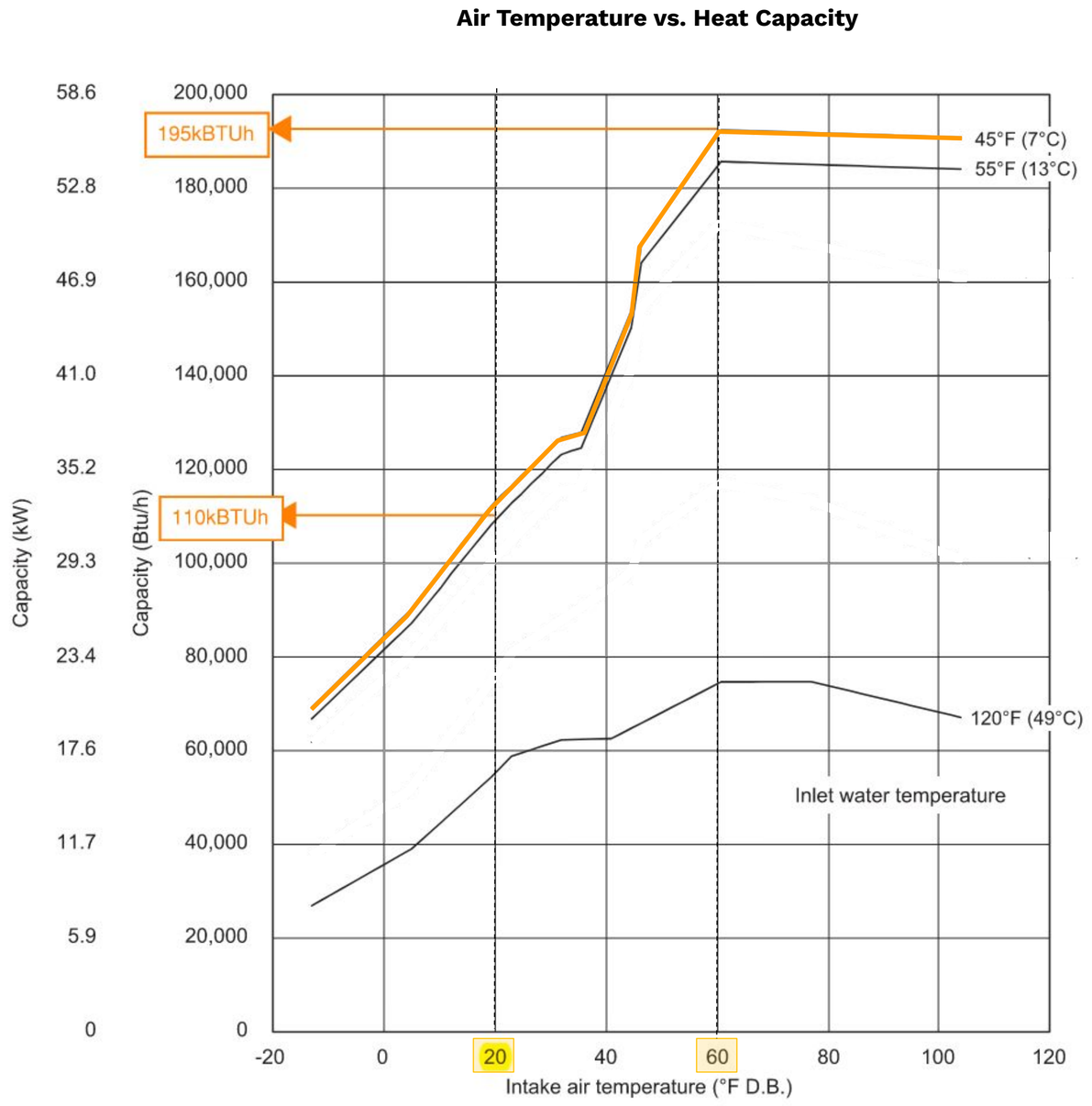
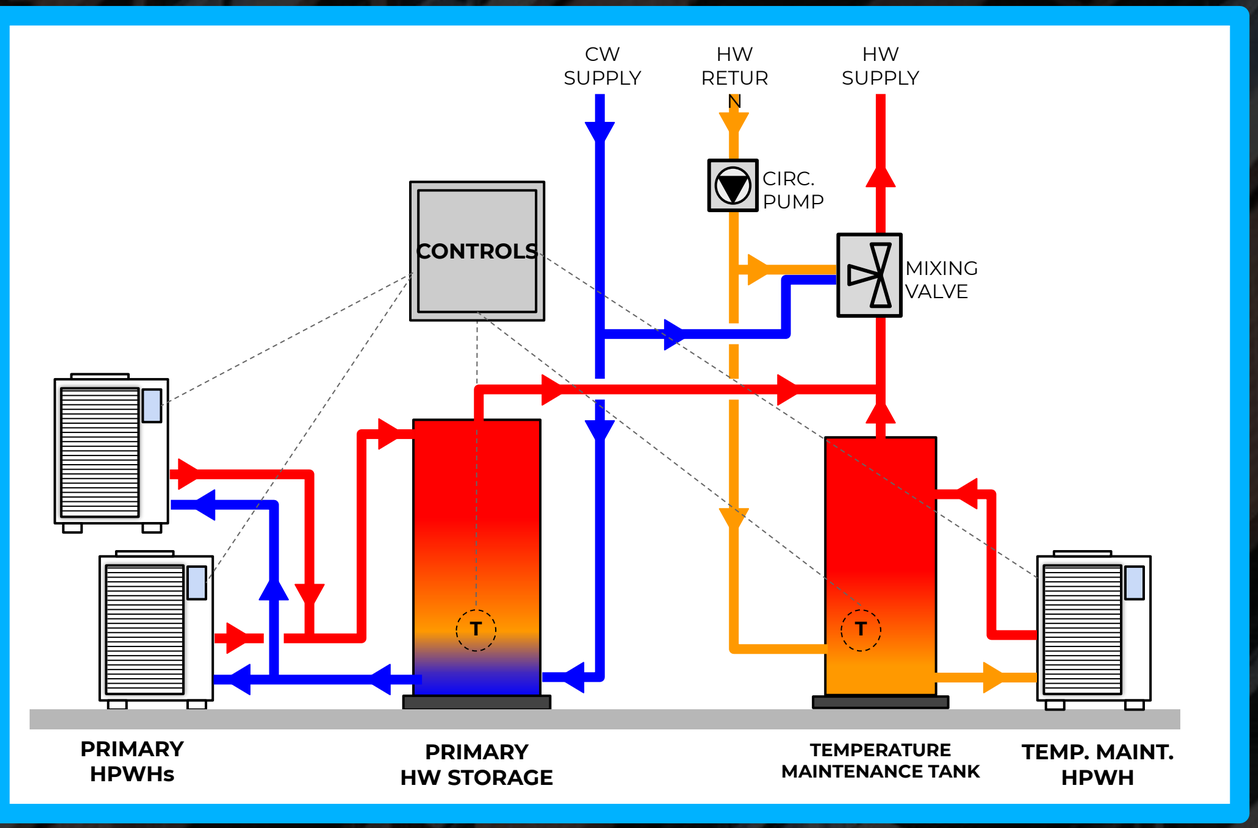


PUTTING THE PIECES TOGETHER

PUTTING THE PIECES **TOGETHER**



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**

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UPCOMING **TRAINING & RESOURCES**

SDGE 2021

(SDGE.COM/ENERGY-INNOVATION-CENTER/EDUCATION-TRAINING)

CHPWH: Design & Maintenance (8-hour seminar)

Oct 5, 7, 12 & 14

CHPWH ONLINE EDUCATION -
launches October 11th!

- *CHPWH System Components, Sizing, and Design*
- *Measurement and Verification: A Unified Approach to CHPWH Performance Data*
- *CHPWH: Manufacturer Training and Resources*
- *CHPWH: Maintenance and Operations*
- *Installation of CHPWHs in New Construction*

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THANK YOU
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