# CENTRAL HEAT PUMP WATER HEATING:

## ENGINEERING DEEP DIVE

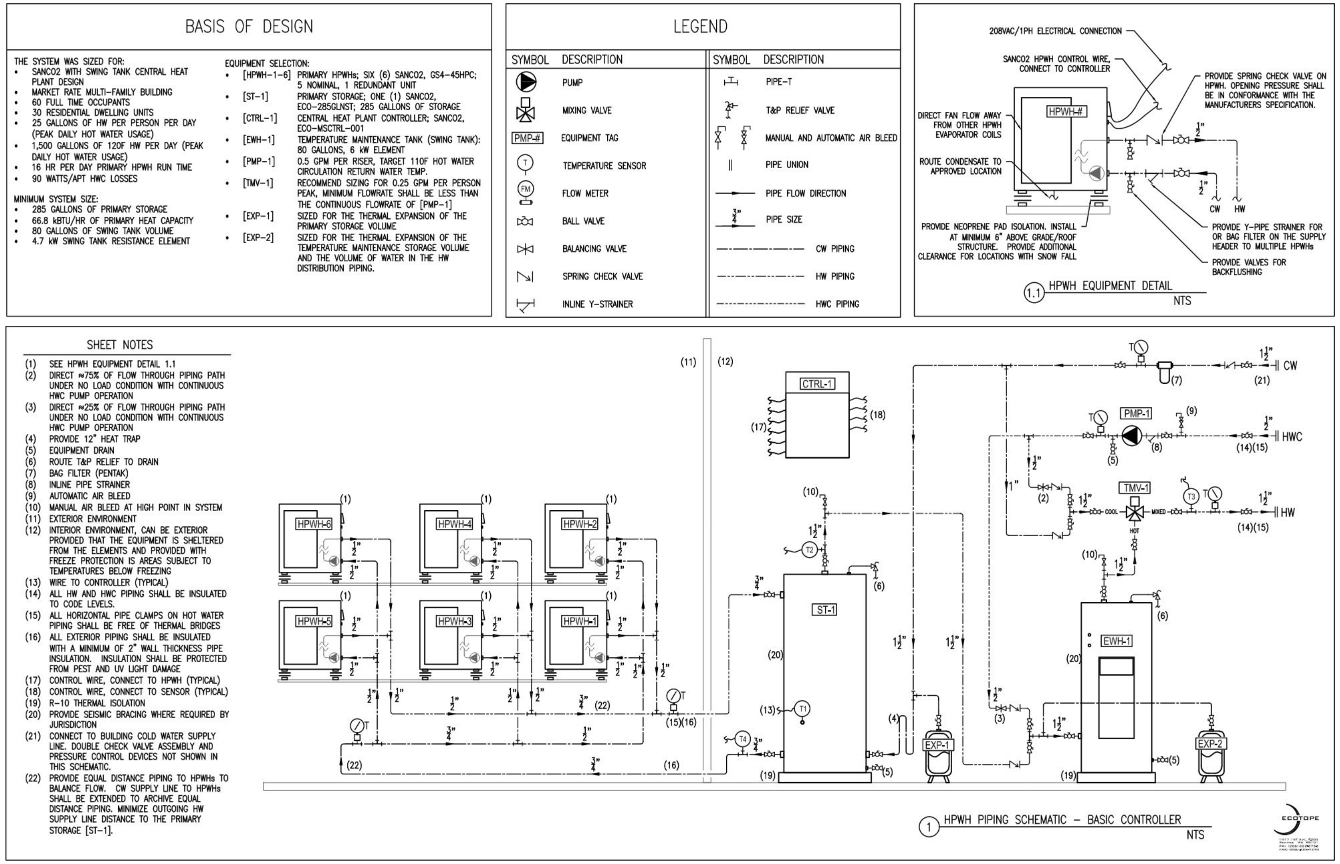
*Colin Grist, PE, Ecotope, Inc.*

D+R LEARN

ECOTOPE

# What professions do we have joining us today?

ⓘ Start presenting to display the poll results on this slide.




# KEY QUESTIONS

- What policy drivers are **pushing for adoption?**
- What makes a **good CHPWH candidate?**
- What are the **key components of CHPWH systems?**

# Joining as a participant?

**No account needed.**

# Enter event code

We want to hear from you!

**GO TO SLIDO.COM**

Enter event code:

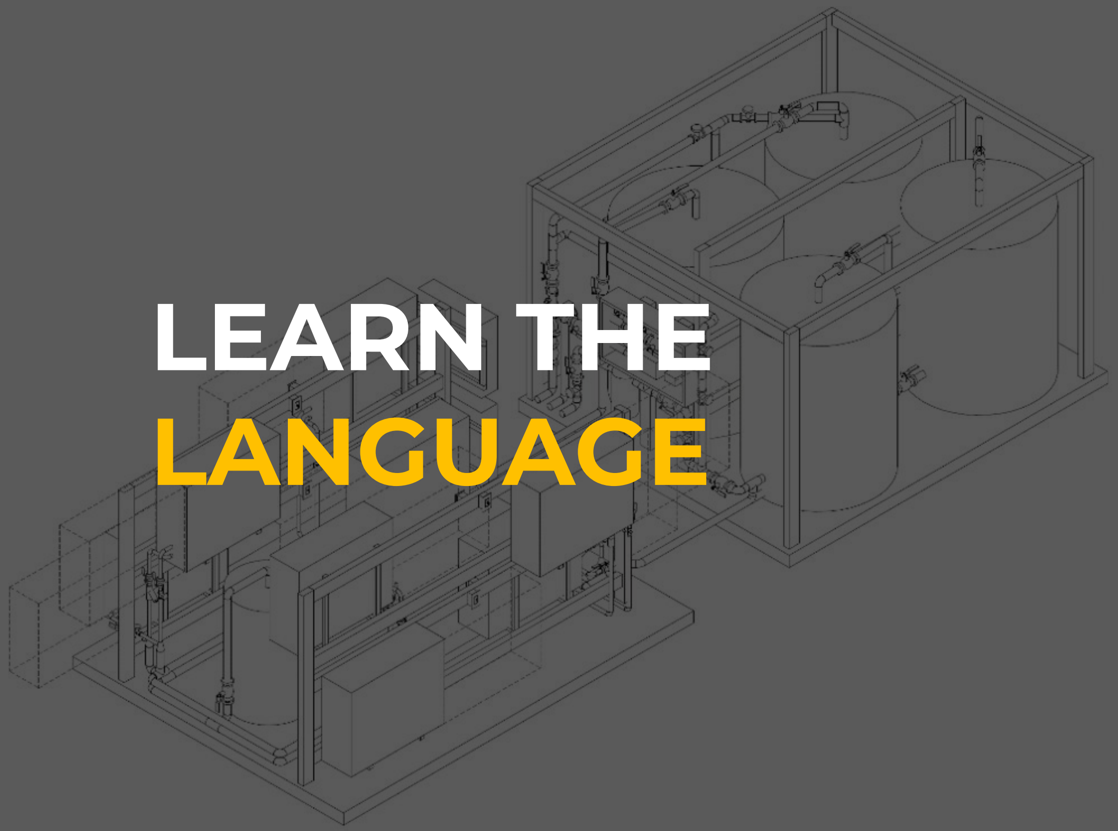
**CHPWH1**

slido

# Introduction Survey

ⓘ Start presenting to display the poll results on this slide.

# LEARN THE LANGUAGE



# PRODUCT **TYPES:** LEARN THE **LANGUAGE**

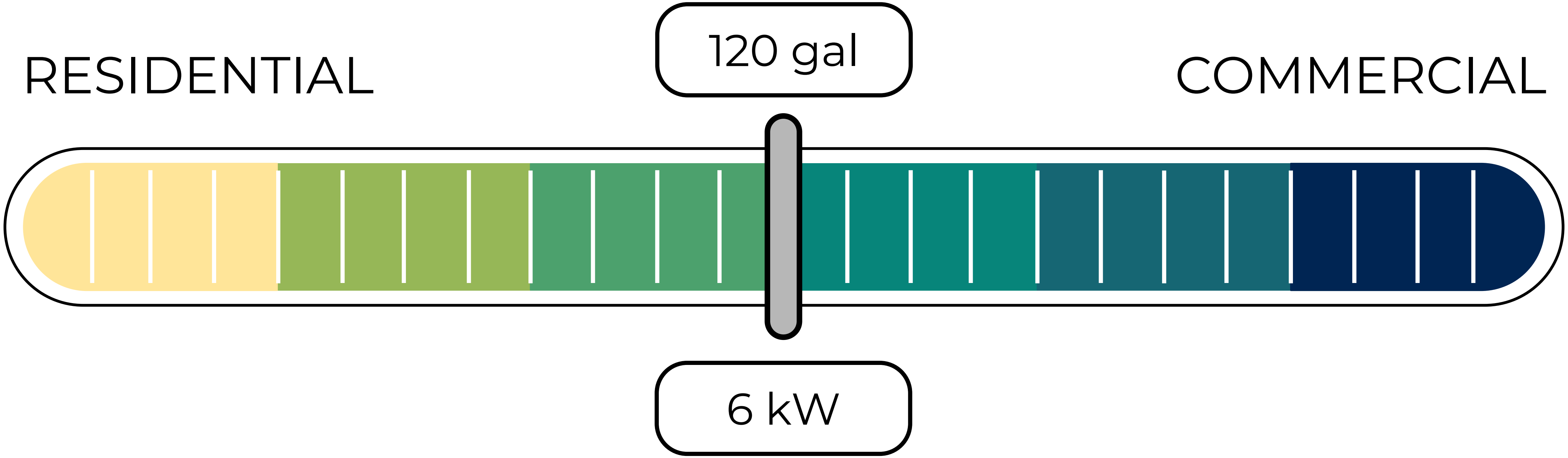
**Unitary**

- Compressor, tank, & controls in a single package.
- Typically small residential product.

**Split System**

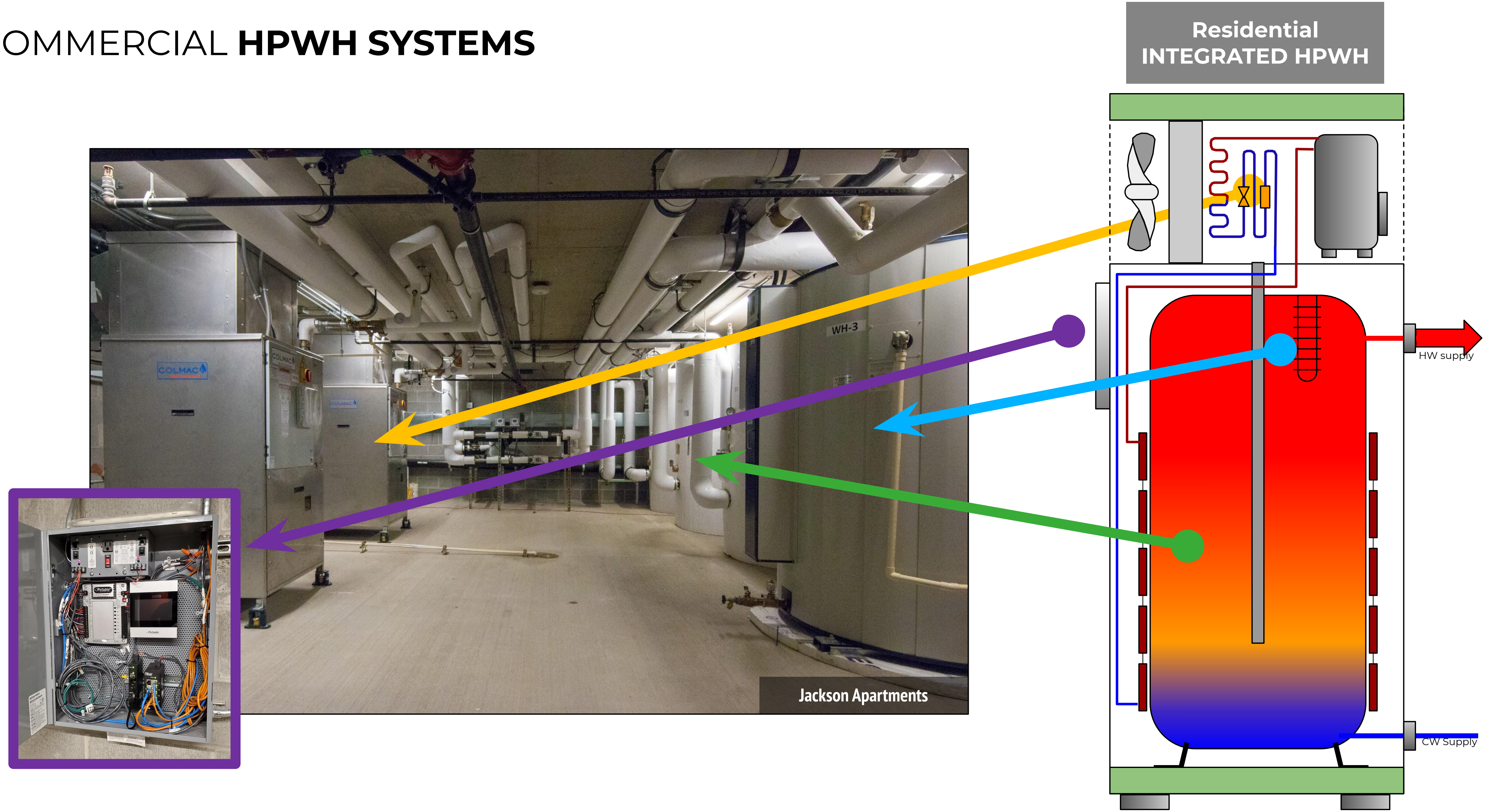
- Compressor, and tank in two separate packages
- Both residential and commercial products available

# RESIDENTIAL vs. COMMERCIAL **SYSTEMS**




A **CHPWH system** serves more than 4 dwelling units or commercial loads requiring **≥ 120 gallons** of storage volume and/or **>6 kW** of input power.

# COMMERCIAL **HPWH SYSTEMS**



# EXAMPLES OF **CHPWH SYSTEMS**


**Small Commercial System**

(closet installation serving 5 apts)


**Large Commercial System**

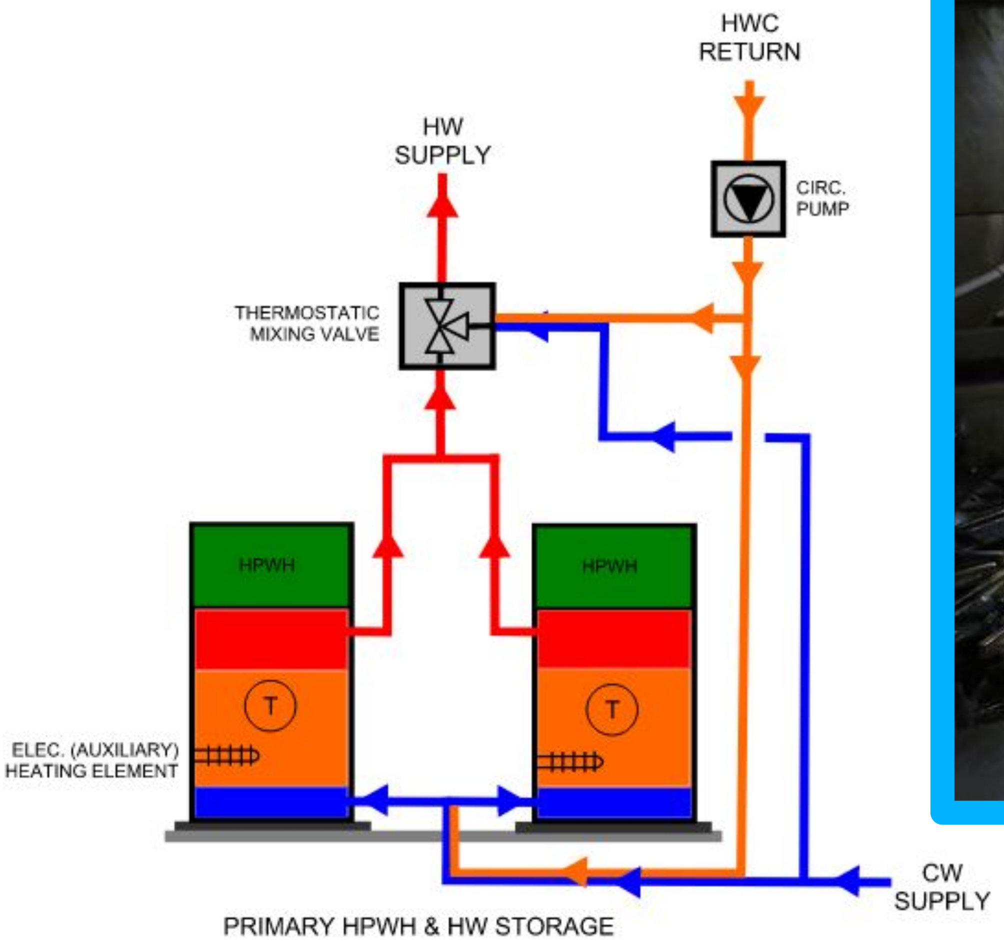
(basement installation serving 250 apts)

**Multiple Commercial Systems**

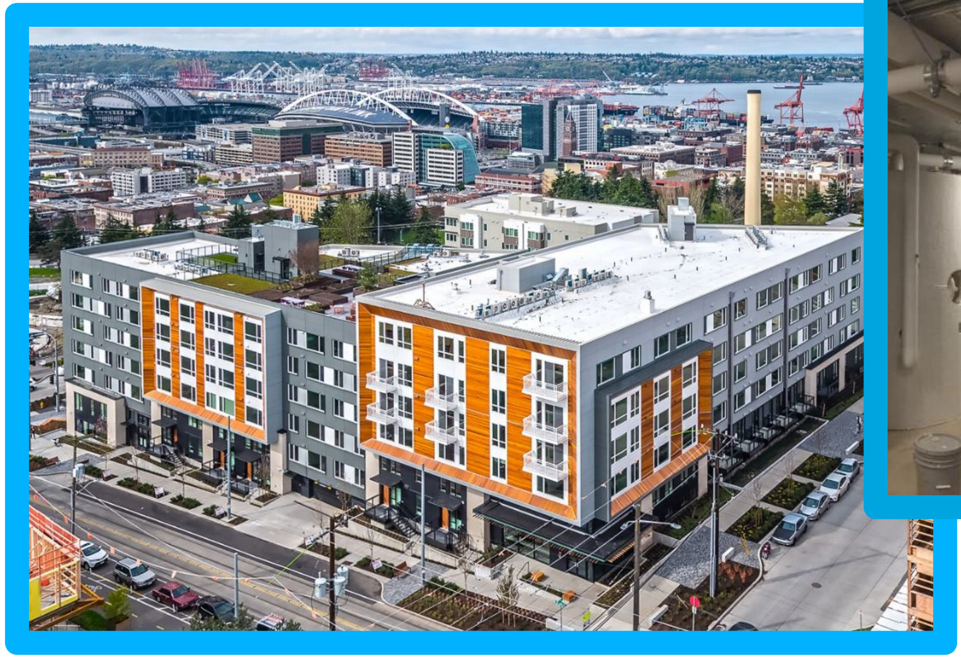
(residential equipment serving 4-5 apts)

**Multiple Sizes, Types, & Configurations**

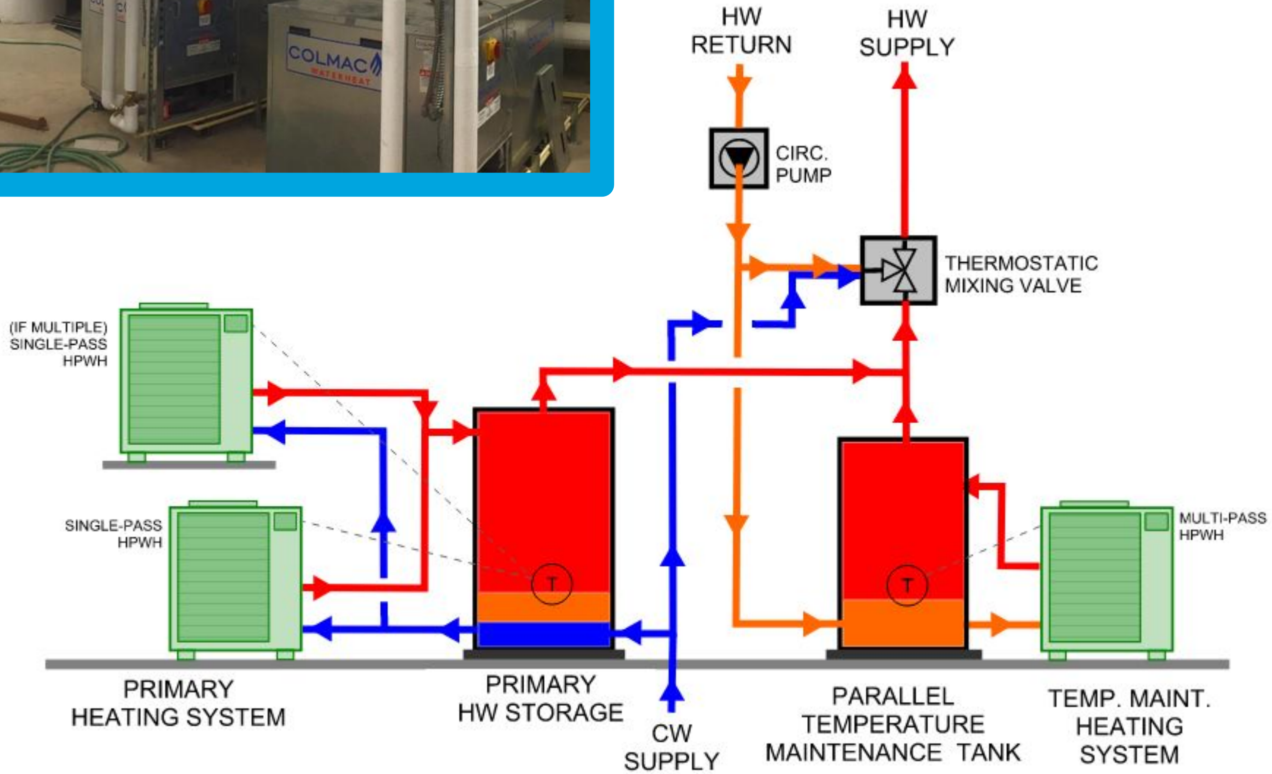
# SMALL COMMERCIAL **SYSTEM**




# LARGE COMMERCIAL **SYSTEM**

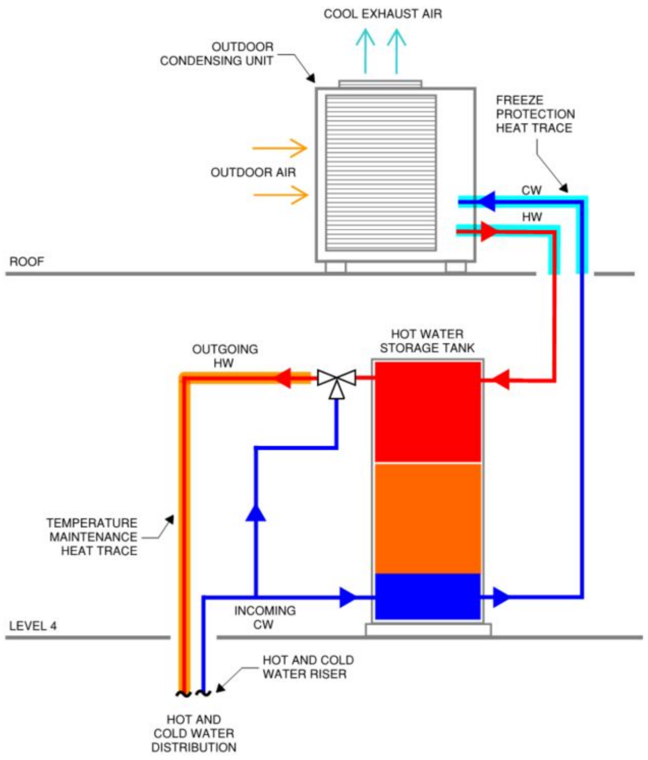


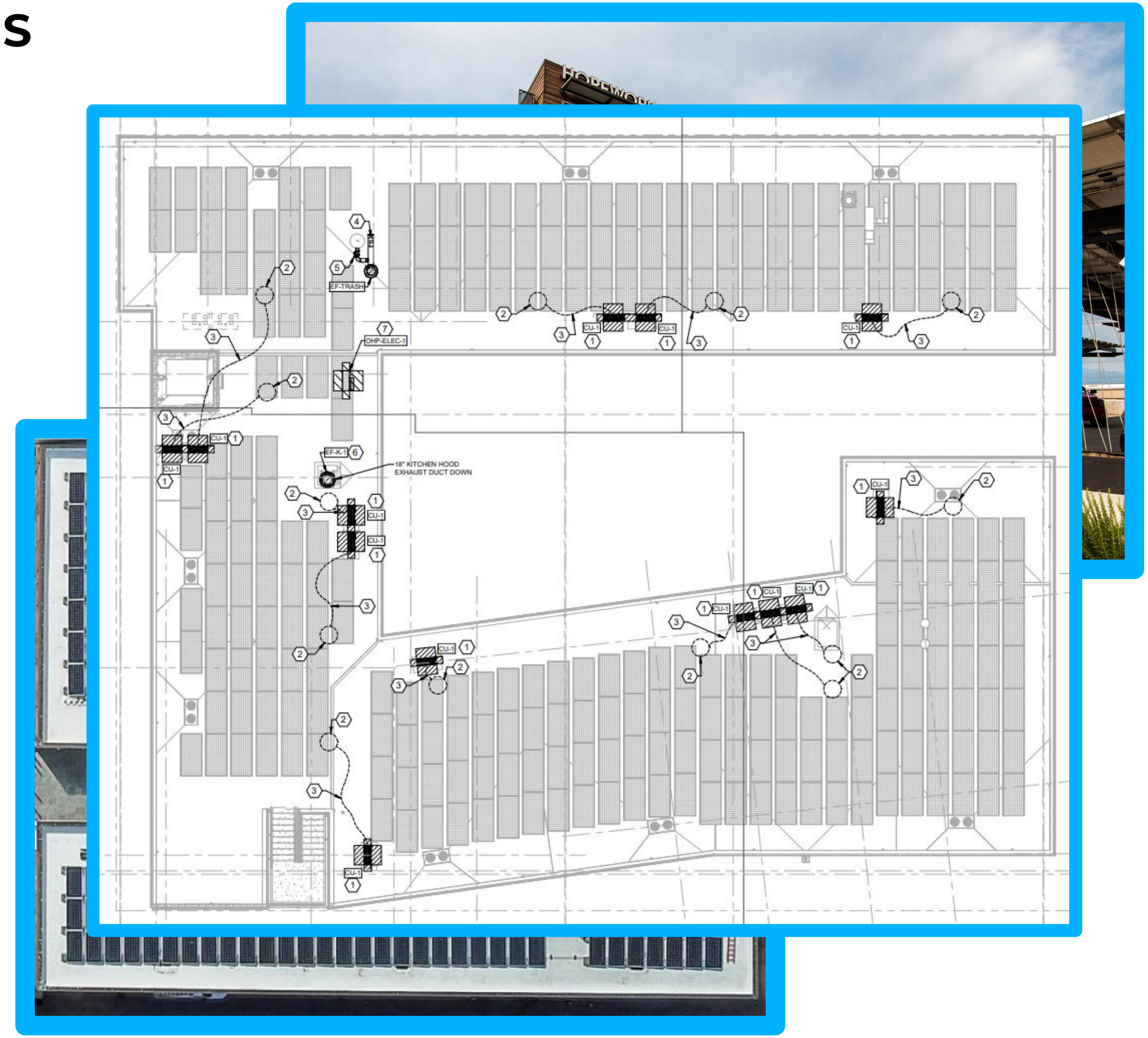

- Commercial equipment; engineered system
- 200 units
- Dedicated heating system:
  - Single pass primary HPWH
  - Multi pass temperature maintenance system



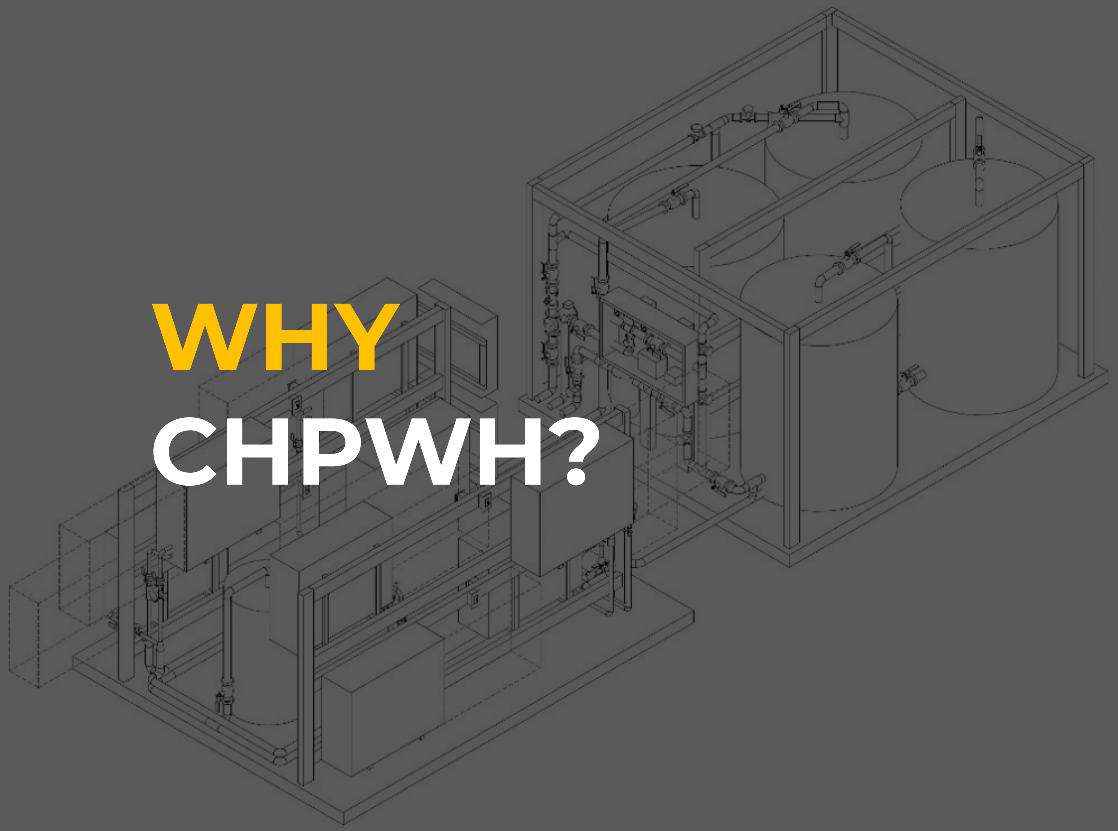
# MULTIPLE COMMERCIAL **SYSTEMS**

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



# WHY CHPWH?



# WHY **CHPWH?**

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE


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

# SEATTLE COMMERCIAL **ENERGY CODE**

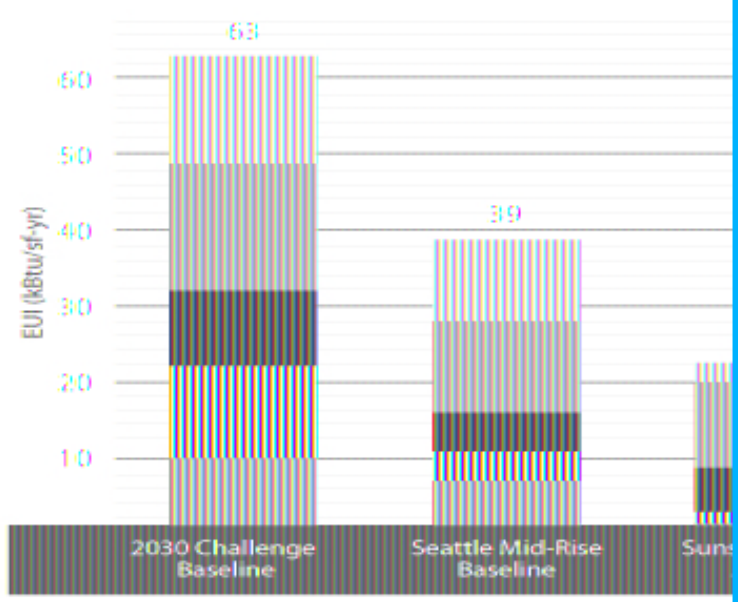
**C404.2.3**
Group R-1 and R-2* occupancies w/ central service water heating systems.

Service hot water shall be provided by an **air-source heat pump water heating system**, not fossil fuel or electric resistance.

***R-1 and R-2**: Multifamily greater than 3 stories; any hotel/motel

# SUNSET **ELECTRIC**

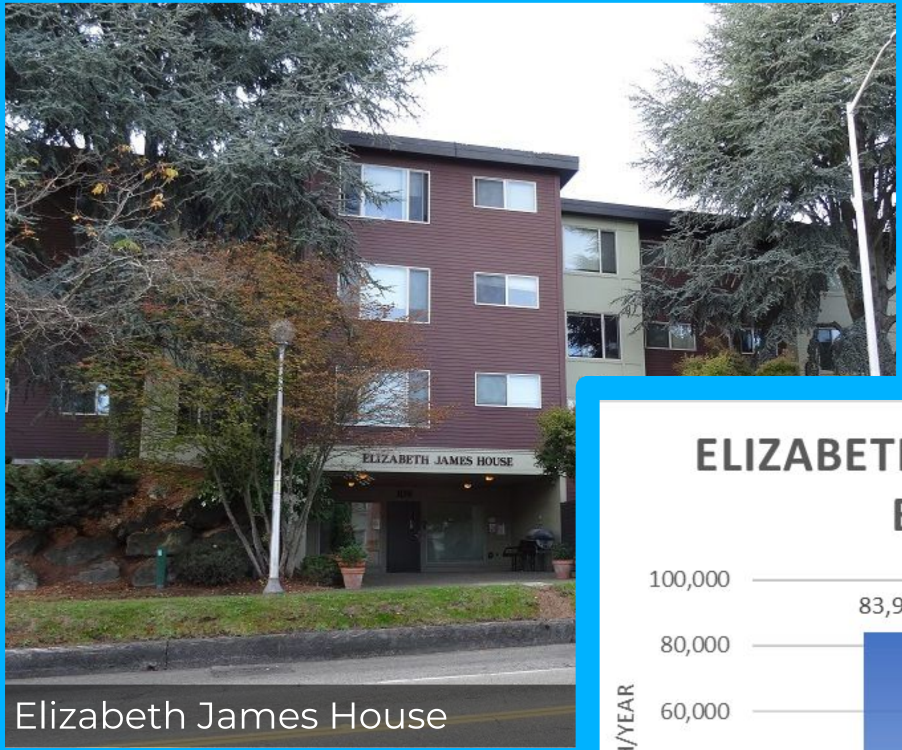
## **70% Reduction** in DHW Energy




**EUI=** Energy Use Intensity
(Energy Use/Total Building Area)

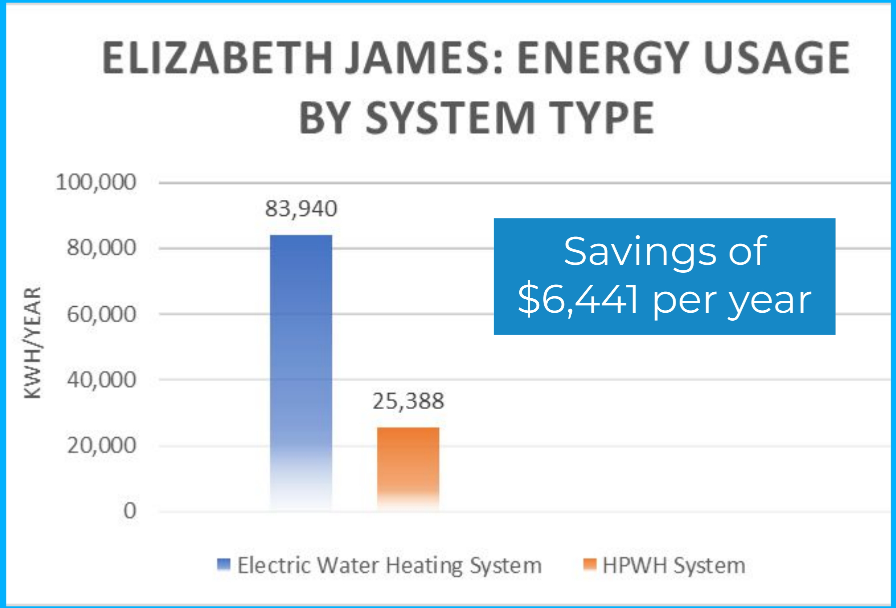
- 67,000 $ft^2$
- 92 apartments
- R-134a air-source heat pump water heaters in parking garage

# ELIZABETH JAMES



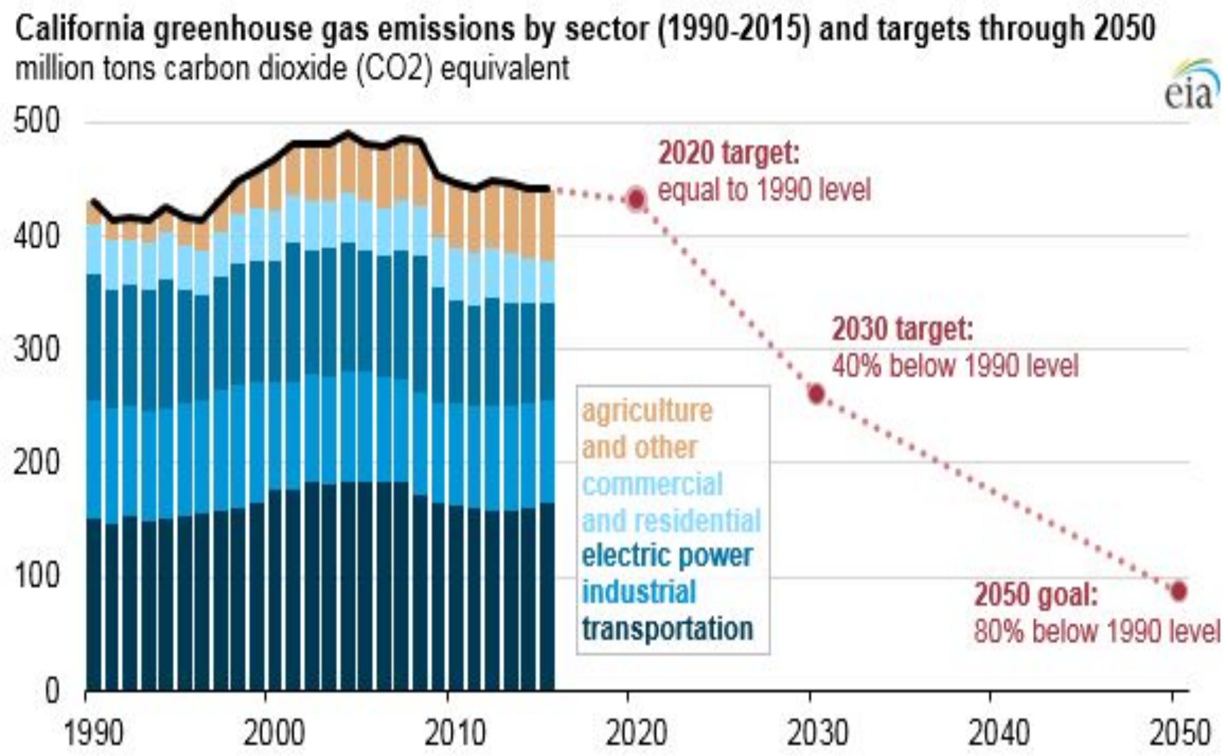
Elizabeth James House

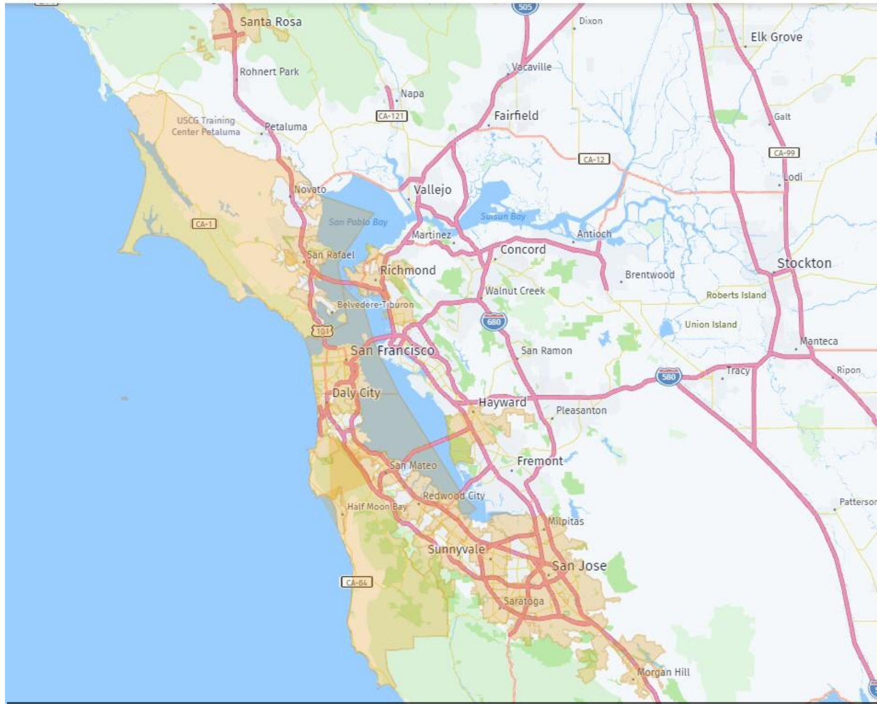
**70% Reduction** in DHW Energy




- Senior/low income
- 60 apartments
- 4 Sanden $CO_2$ HPs
- ZERO GHG emissions

# WHY **CHPWH?**




Interactive REACH Codes Map:
*https://localenergycodes.com/content/map*

# LOWER FIRST **COSTS**

## 965 Weeks Street, East Palo Alto, CA

Affordable apartment homes that include at least 30% extremely low-income units and 50% low-income units

| **FOSSIL** GAS | vs **AIR TO $H_2O$** HPWH |
| --- | --- |
| **4 hot water plants serve 4 buildings** | |
| • Plants contain gas water heaters with integral storage tanks | • Storage tanks on roof<br>• Outdoor unit on roof or in mechanical room |
| **Solar thermal collector w/ PV system** | **Solar PV system** |
| Equipment cost: $192,000<br>Utility connection cost: $84,800<br>**Total cost: $276,800** | Equipment cost: $169,262<br>Utility connection cost: $27,000<br>**Total cost: $196,262** |

# OPERATING COST **COMPARISON**

FOSSIL GAS SYSTEM **vs** AIR TO WATER $CO_2$ HPWH

**FOSSIL GAS SYSTEM**

Gas usage/year:
**18,722 therms**

Average estimated cost/therm: $1.75

Estimated gas cost/year: **$32,829**

**AIR TO WATER $CO_2$ HPWH (no load shifting)**

Electricity usage/year:
**130,154 kWh**

Time-of-use rate
(peak, partial peak, off-peak)

Estimated electric cost/year: **$33,065**

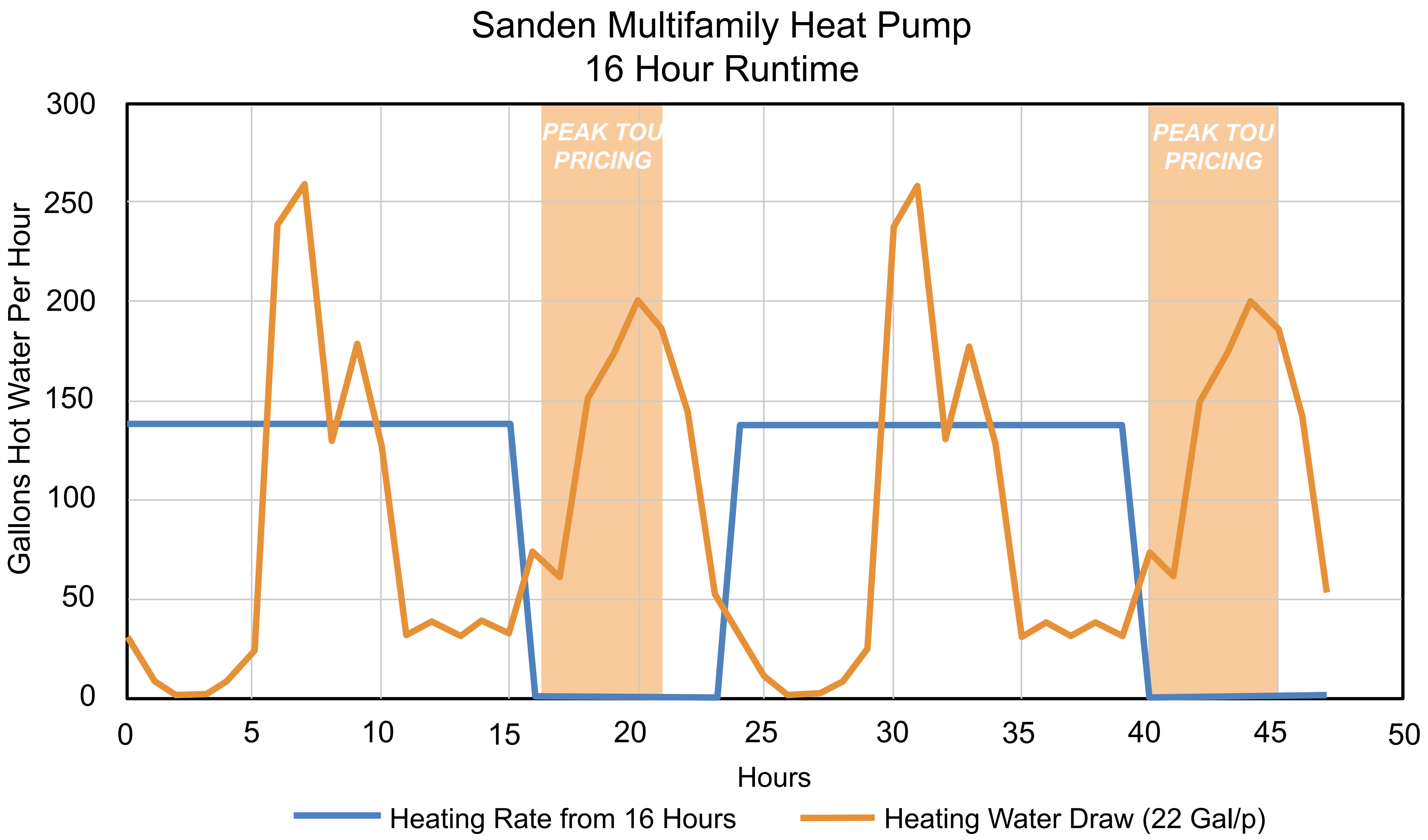
**AIR TO WATER $CO_2$ HPWH (load shifting)**

Electricity usage/year:
**130,154 kWh**

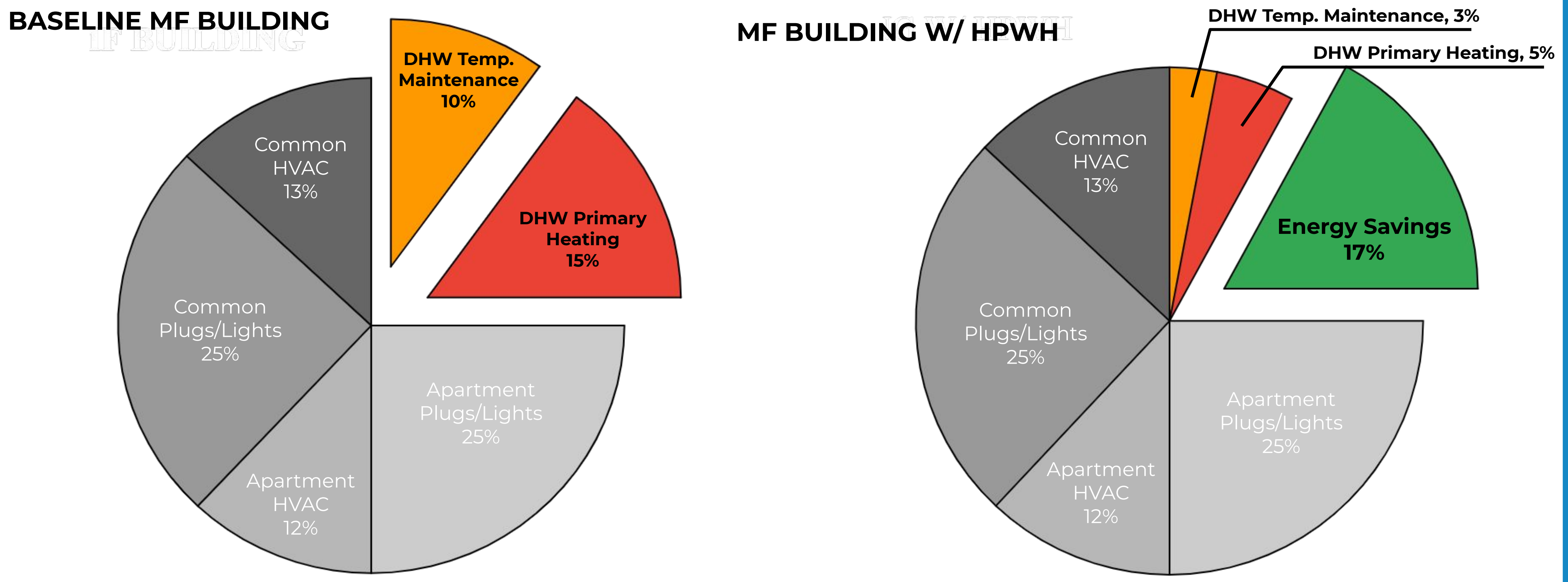
Time-of-use rate
(peak, partial peak, off-peak)

Estimated electric cost/year: **$31,672**

# WHY **CHPWH:** TOU RATES & GRID **FLEXIBILITY**



# WHY **CHPWH?**



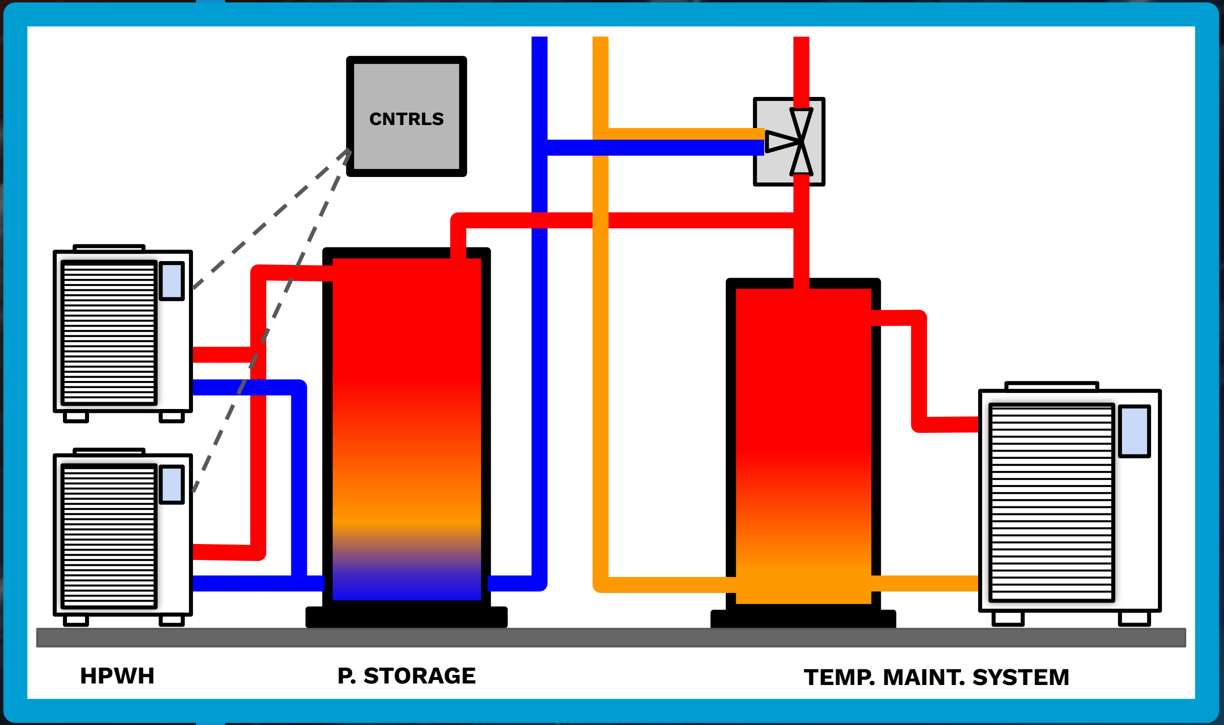

- DHW represents 25% of annual building use
- CHPWH systems cut energy usage down by 3x

slido

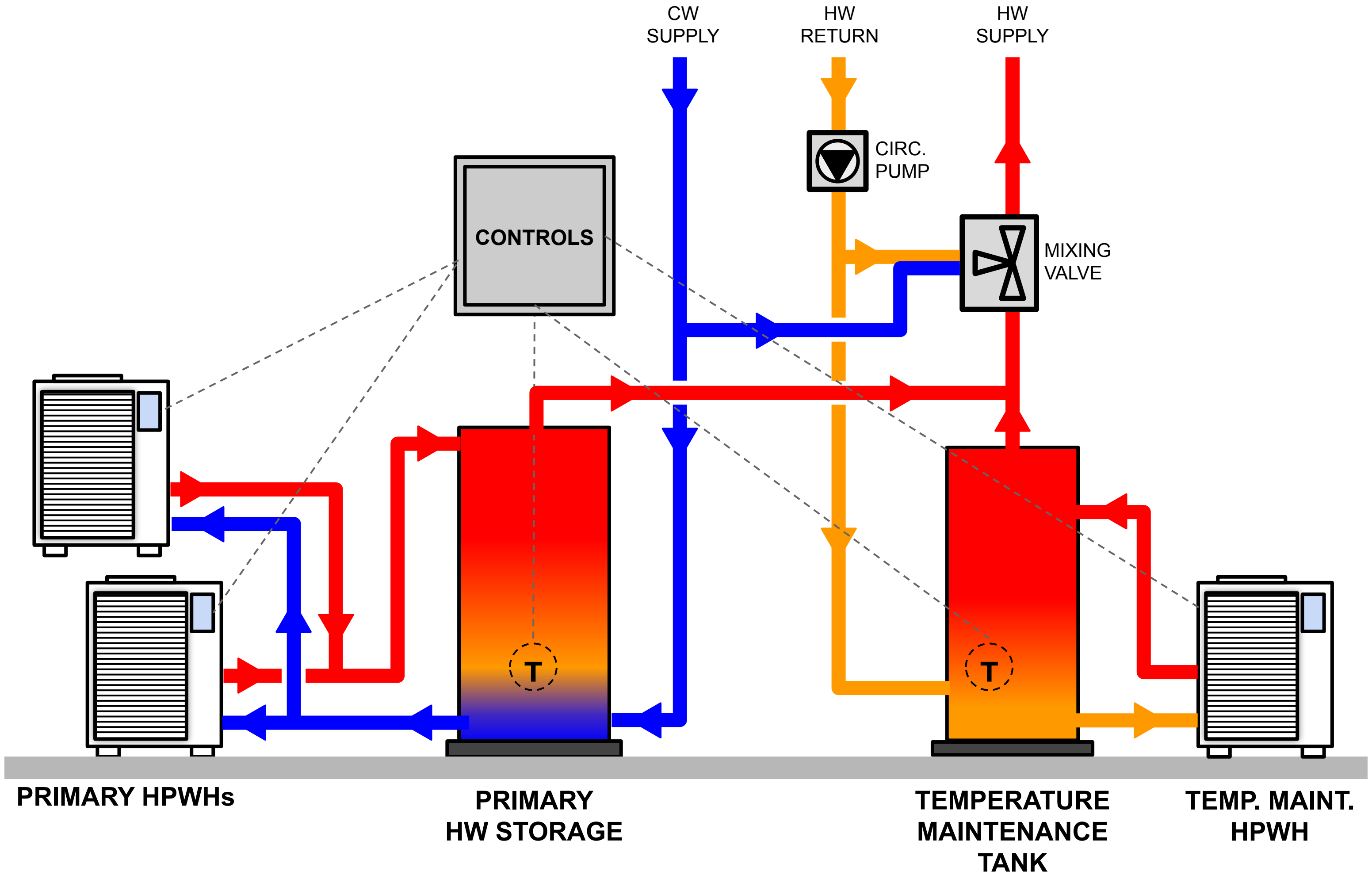
# What aspects of CHPWH systems are most appealing to you?

ⓘ Start presenting to display the poll results on this slide.

# CHPWH SYSTEM COMPONENTS

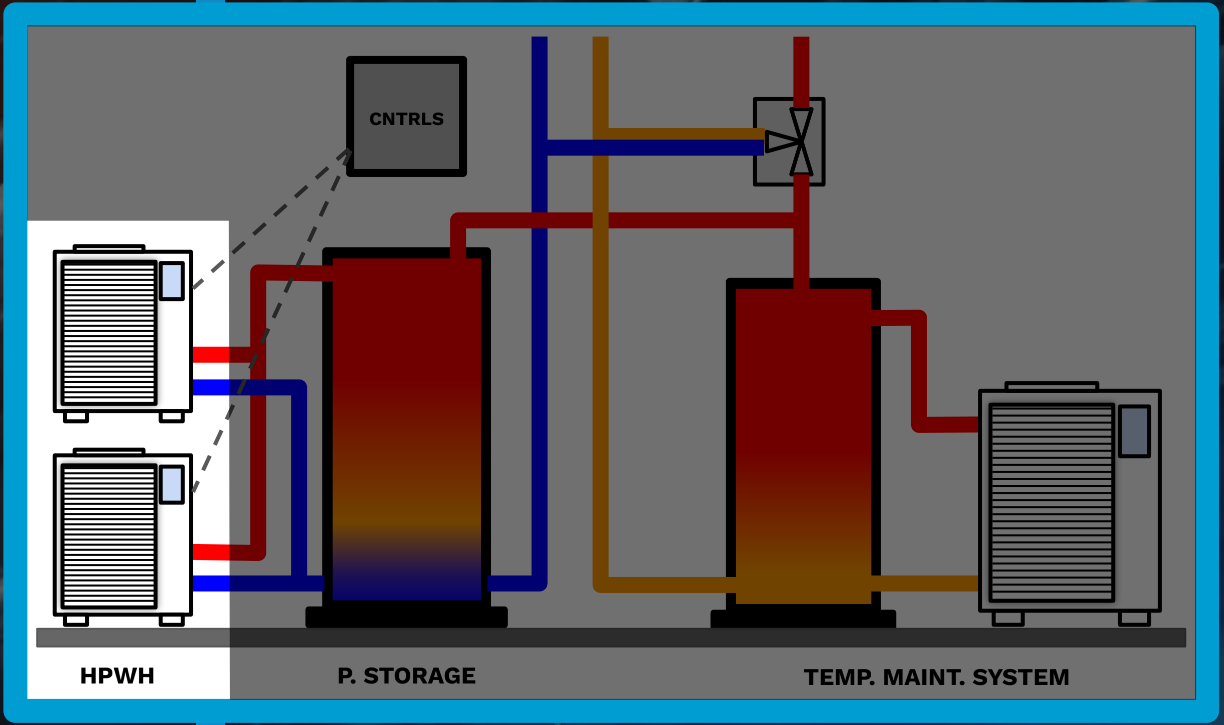


# FOUR **CHPWH SYSTEM COMPONENTS**




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

# COMPONENTS:
# HPWH

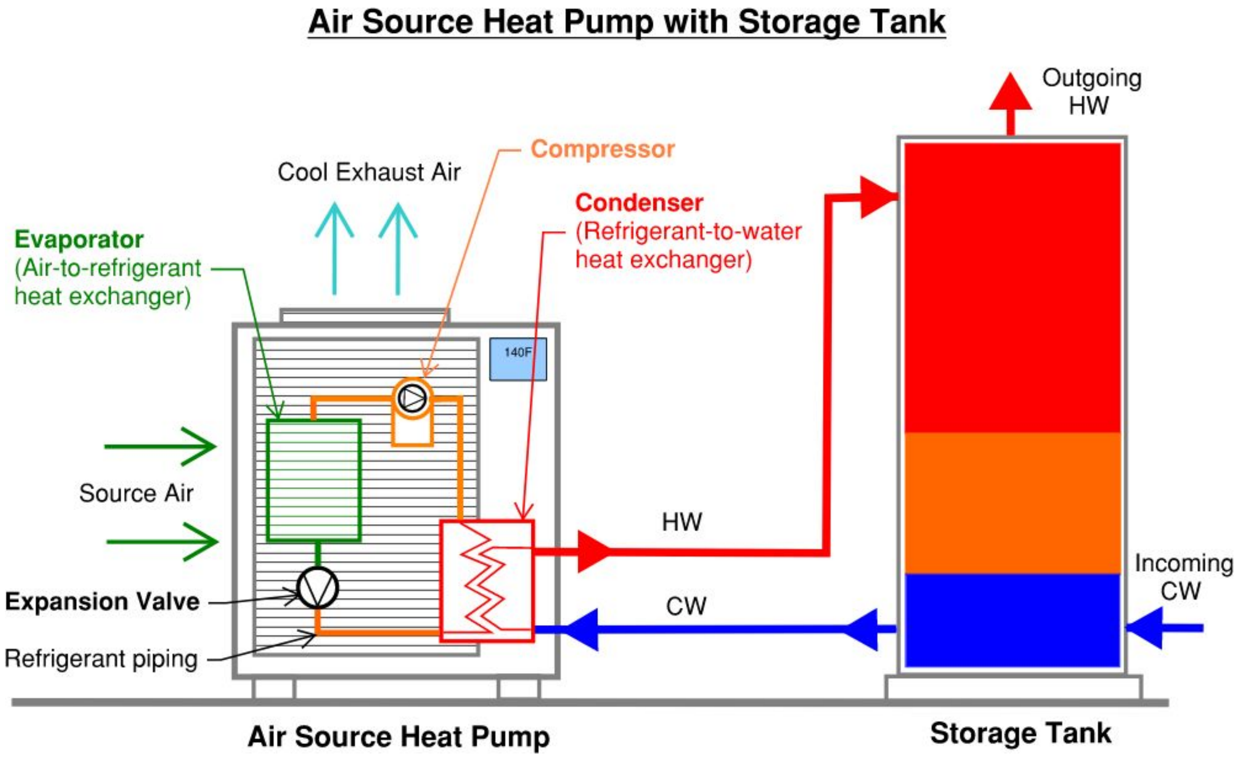


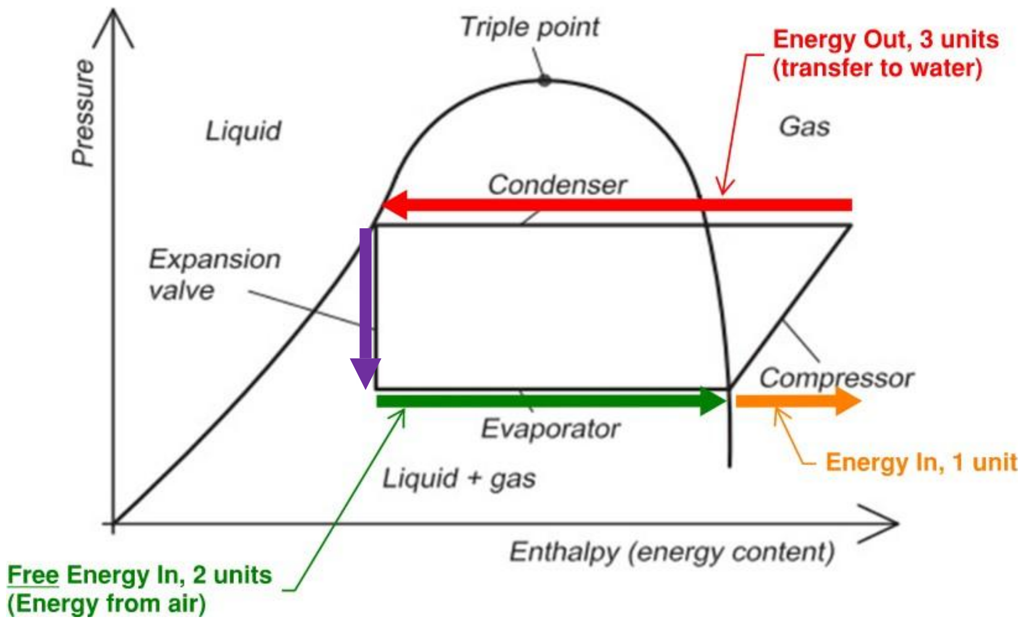
## **PRIMARY** HEAT PUMP



PRIMARY HP = ENGINE

# HOW **HEAT PUMPS** WORK

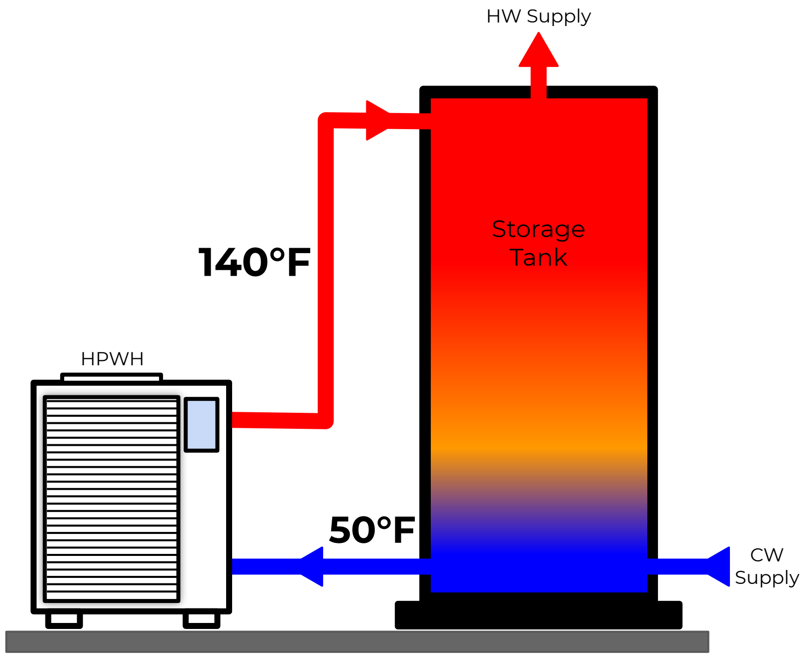



**Moving HEAT**

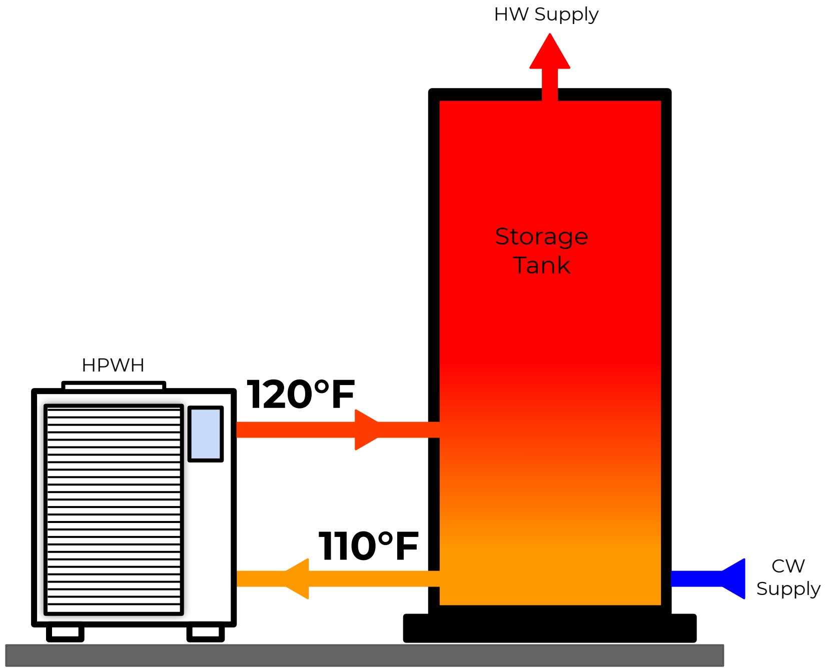
(not making heat)

# 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*)

# AVAILABLE PRODUCTS




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

Single-Pass
$CO_2$/R-744

Single- or Multi-Pass
R-134a

# HPWH **CONSIDERATIONS**

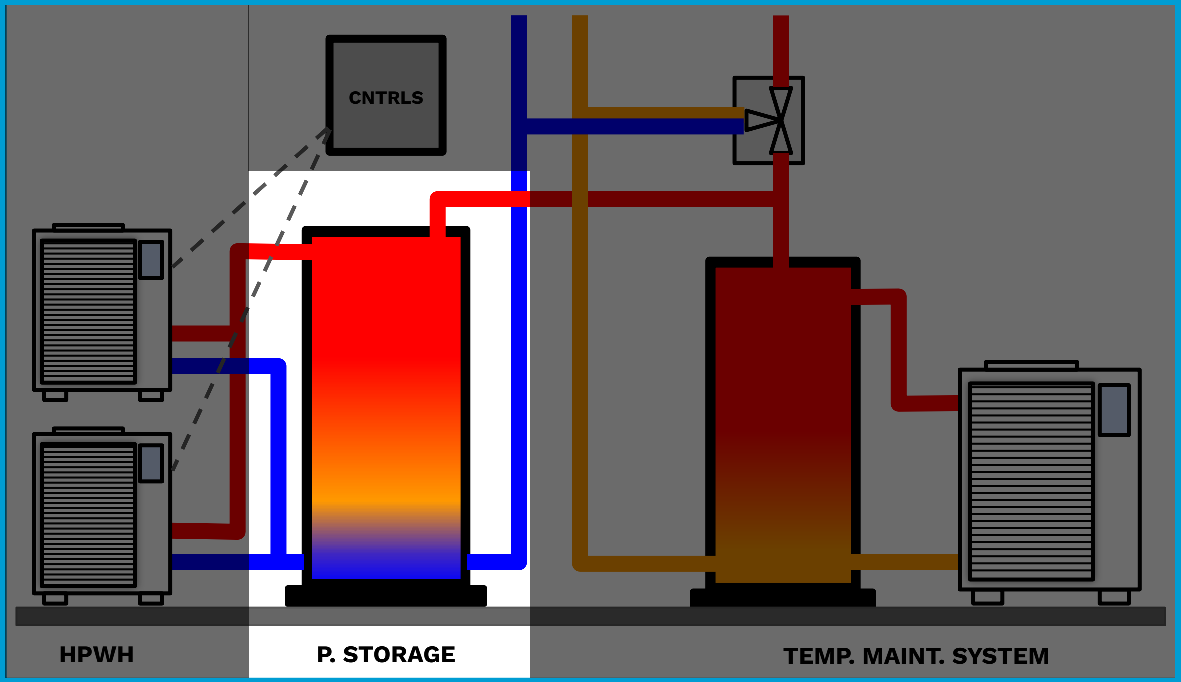

**Nyle**
(10 - 30 ton)


**Rheem**
(> 1 ton)

- Air source / heat source
- Heating cycle (single pass / multipass)
- Electrical connection
- Water connections
(freeze protection required?)
- Condensate management
- Maintenance and access
- Sound level, noise considerations


LET’S PAUSE FOR QUESTIONS

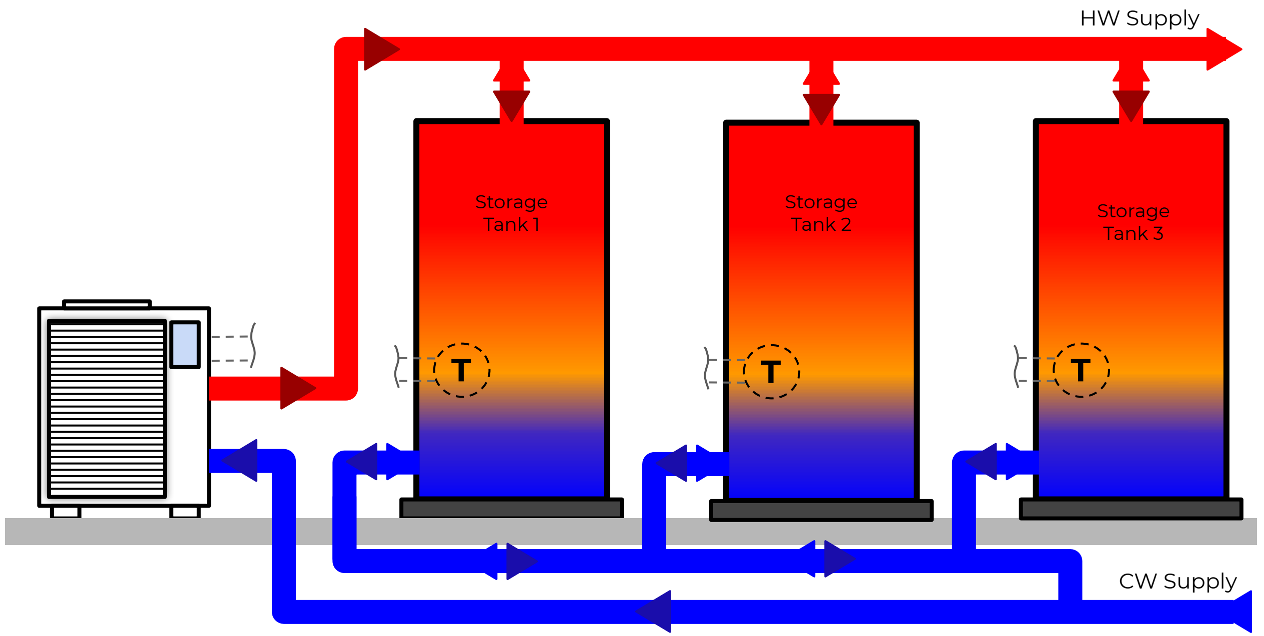
# COMPONENTS:
# PRIMARY STORAGE



PRIMARY **STORAGE TANK(S)**

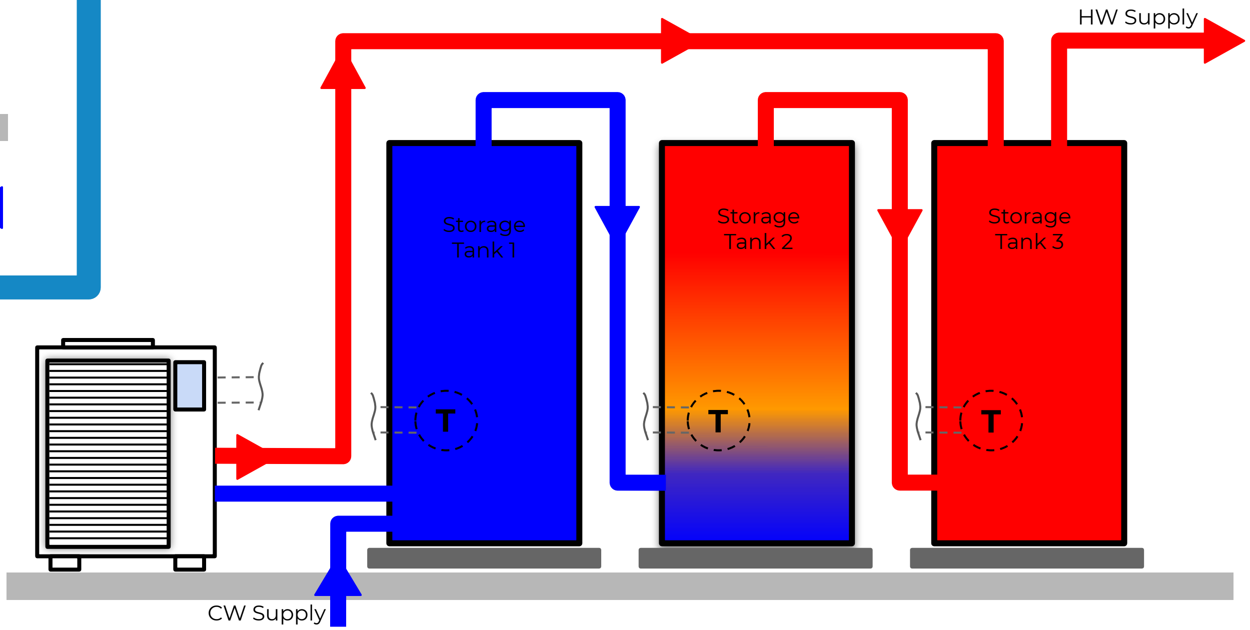
**A BATTERY BANK**

# PRIMARY STORAGE **PLUMBING**

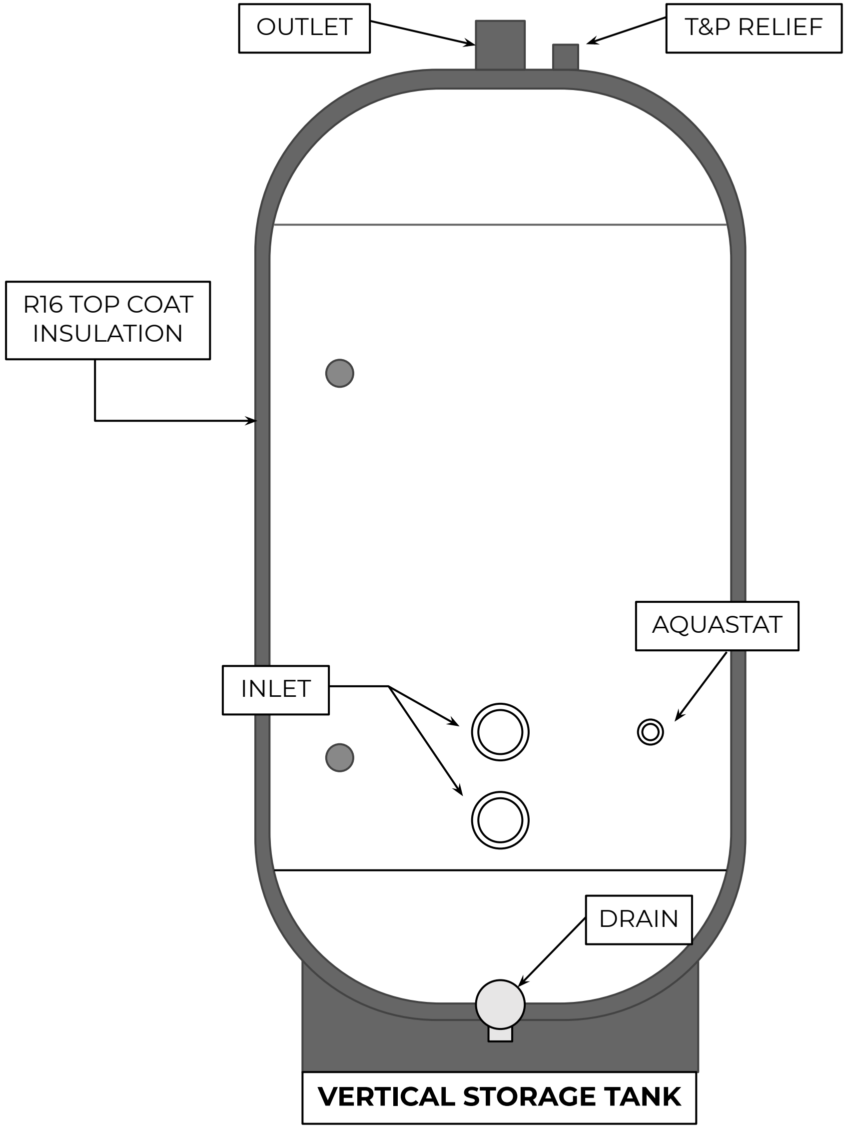



**IN PARALLEL**

**IN SERIES**



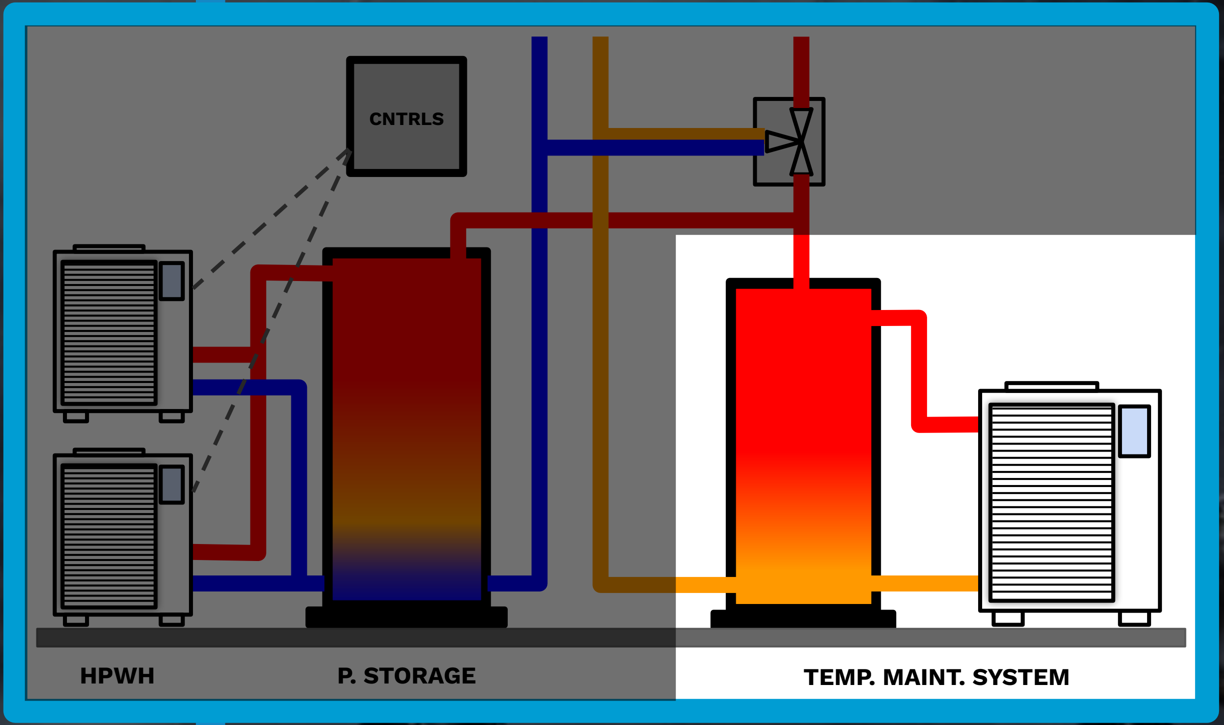
# HW STORAGE **CONSIDERATIONS**




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

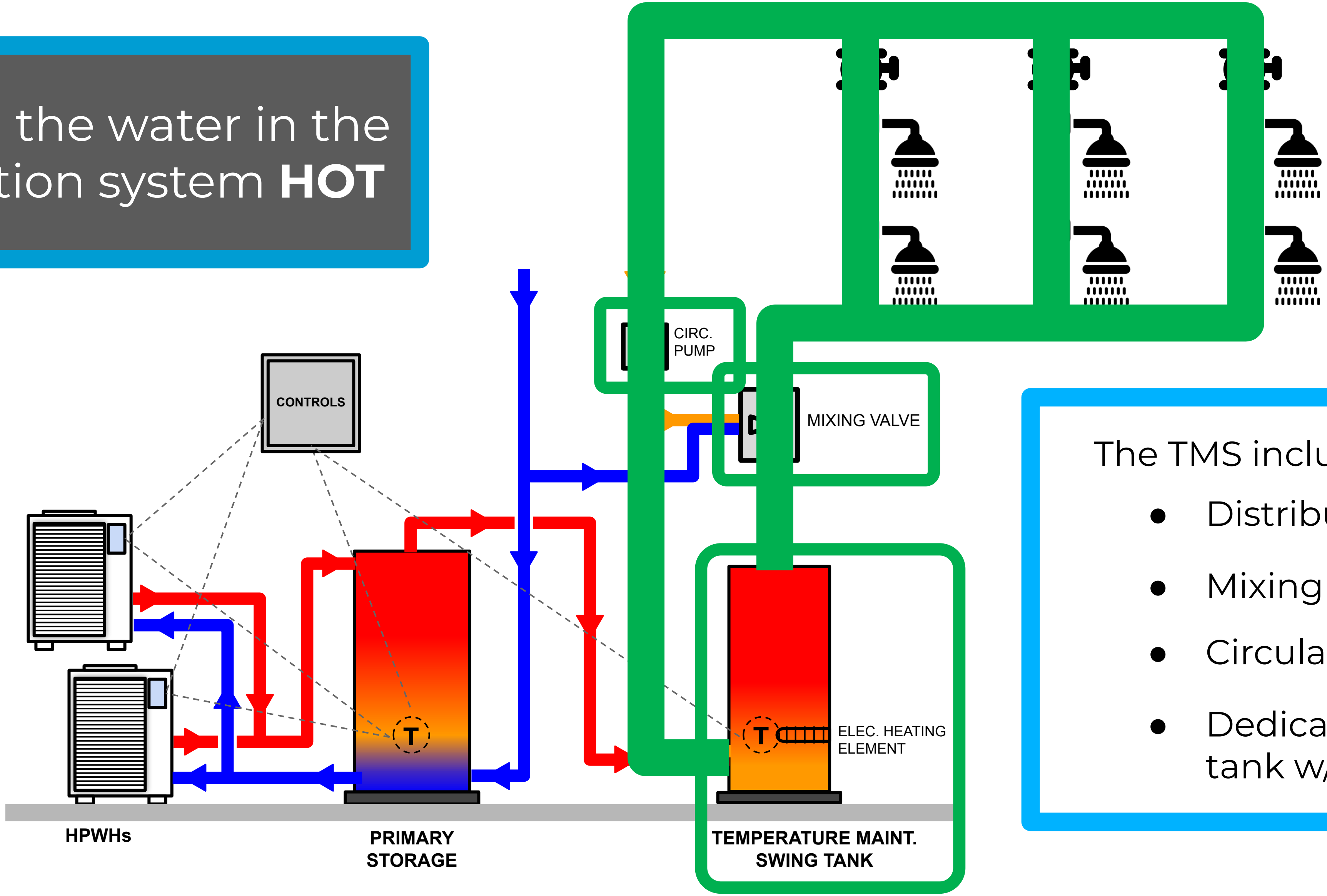
# LET’S PAUSE FOR QUESTIONS

# COMPONENTS:
# TEMPERATURE MAINTENANCE



# TEMPERATURE MAINTENANCE **SYSTEM**

Keeping the water in the distribution system **HOT**

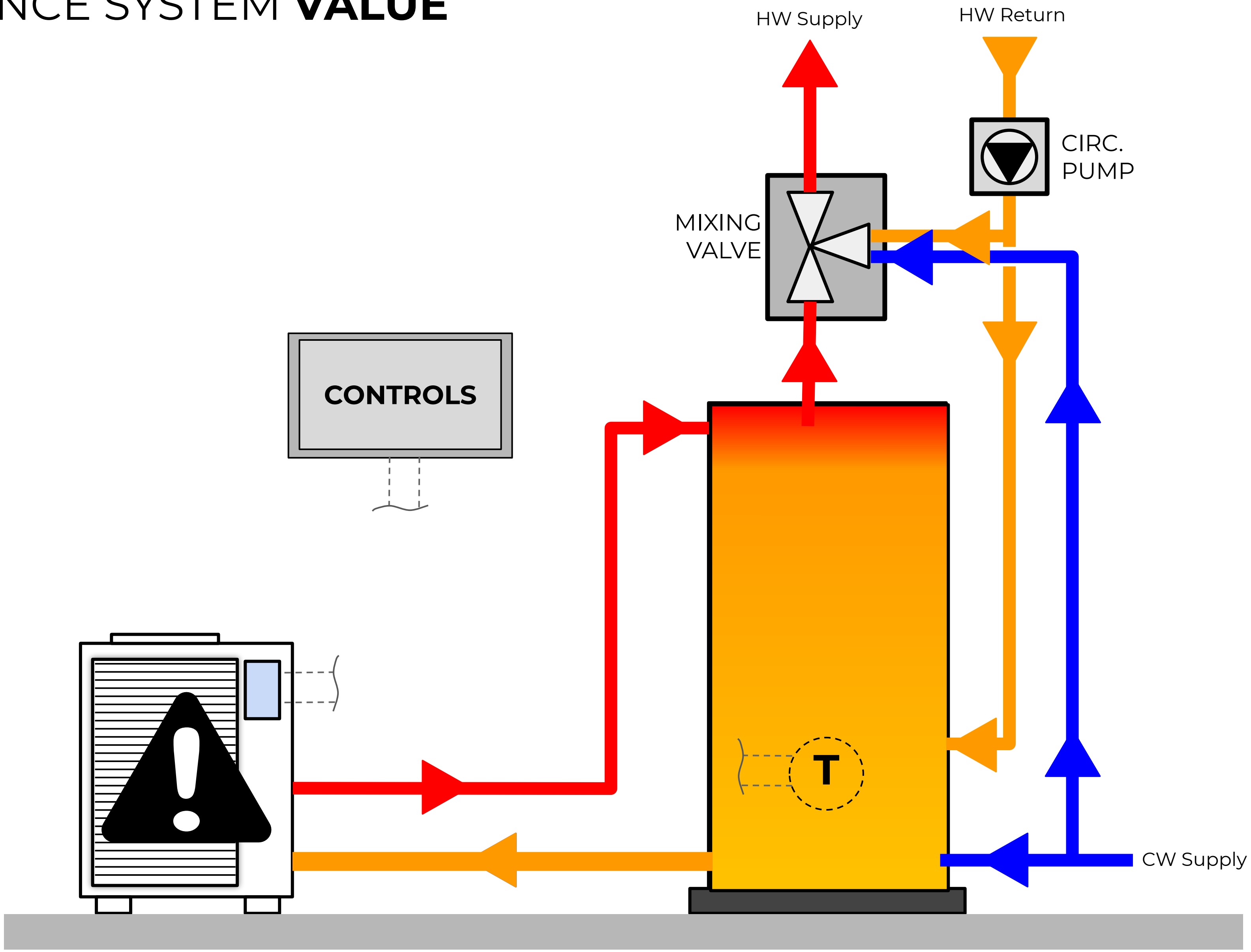



The TMS includes:

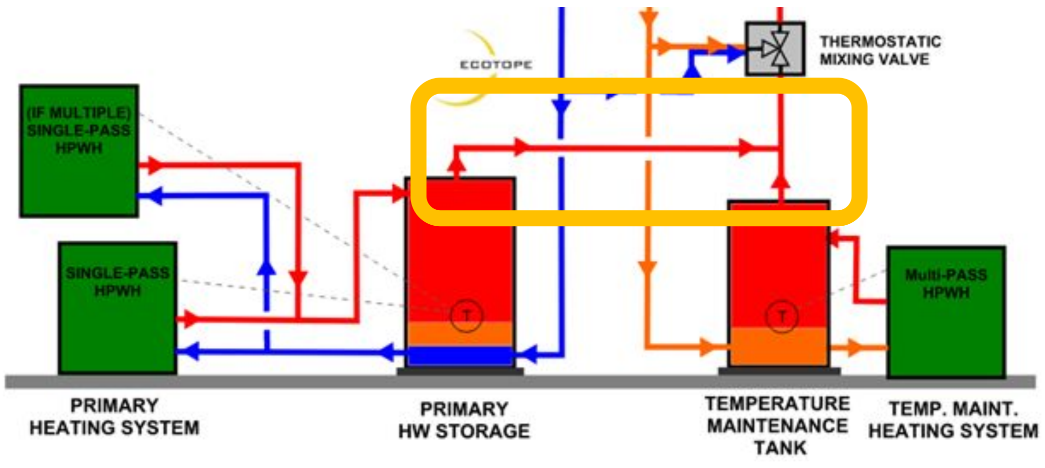
- Distribution piping
- Mixing valve
- Circulation pump
- Dedicated storage tank w/heat source

# TEMPERATURE MAINTENANCE SYSTEM **VALUE**

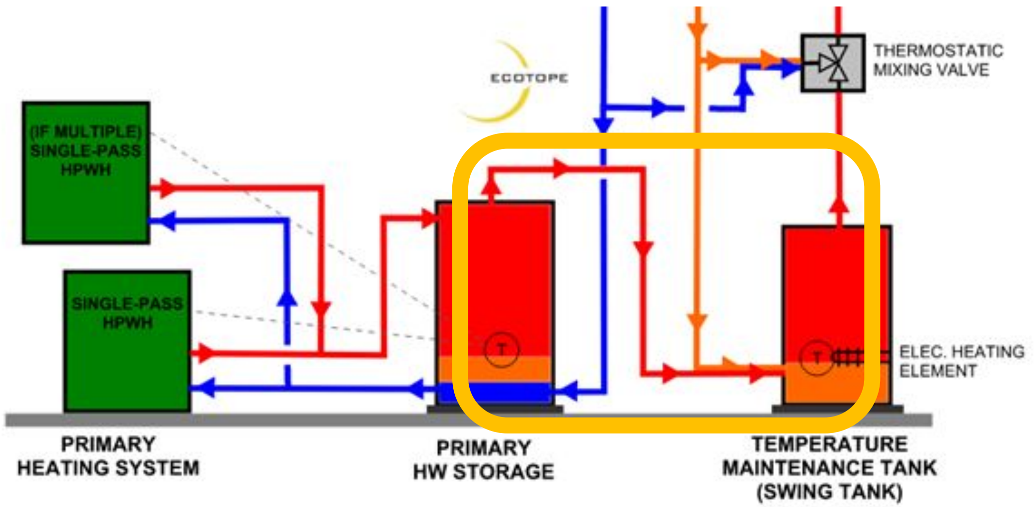
- HPs are very efficient at making **cold** water **hot**
- HW circulates through the distribution piping
- Water returns from the building slightly cooled
- Return water causes **mixing** & **destratification** in the storage tank
- HPs are not very good at making **warm** water **hot**



# TWO RELIABLE TEMPERATURE MAINTENANCE REHEAT STRATEGIES

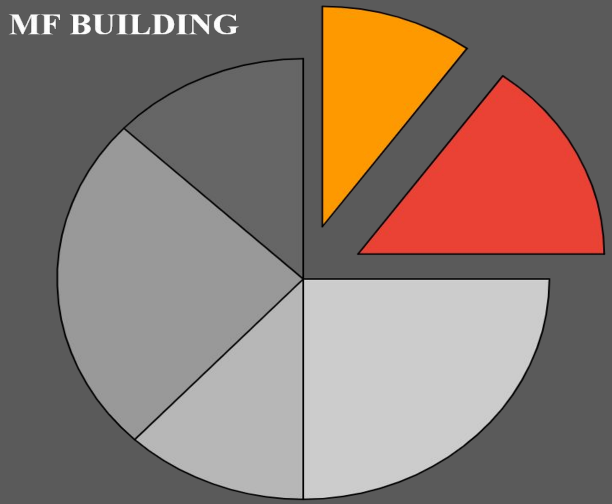



**"Parallel Loop Tank"**



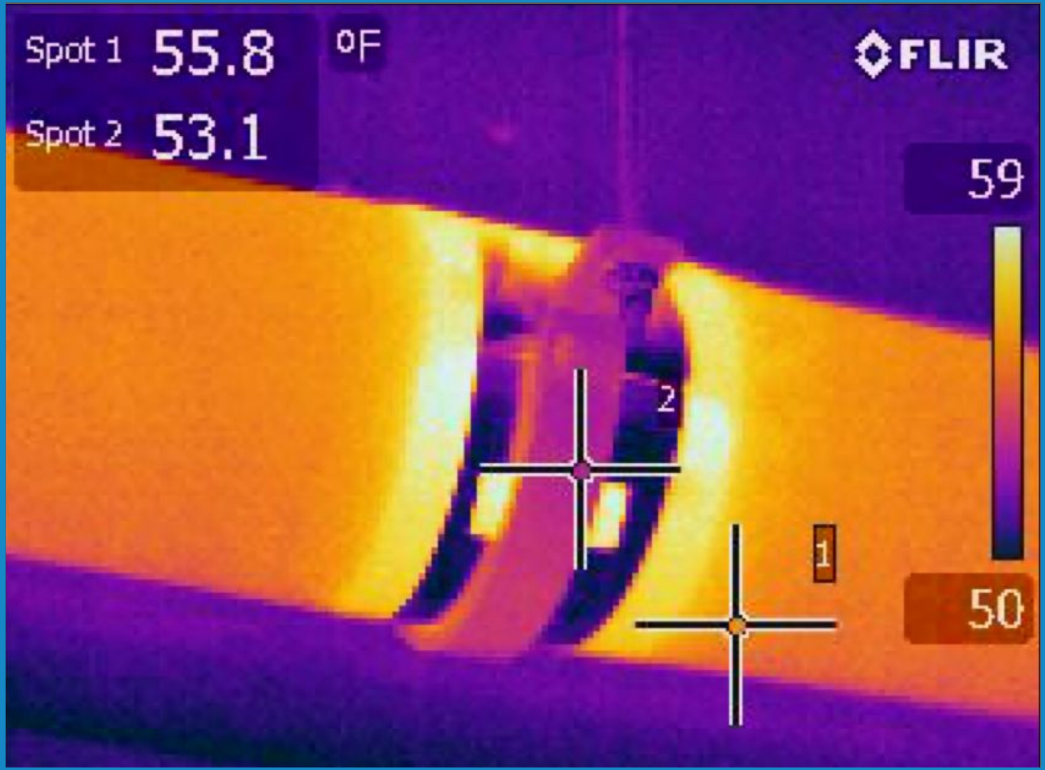

**"Series Loop Tank" or "Swing Tank"**

# TEMPERATURE MAINTENANCE: **HW CIRCULATION**




A SMALL CONSTANT LOAD THAT **ADDS UP**

# OPTIONS FOR REDUCING THE **TEMPERATURE MAINTENANCE LOSSES**




**GOOD EXAMPLE:** PIPE CLAMP ACTS AS A THERMAL BREAK

# OPTIONS FOR REDUCING THE **TEMPERATURE MAINTENANCE LOSSES**

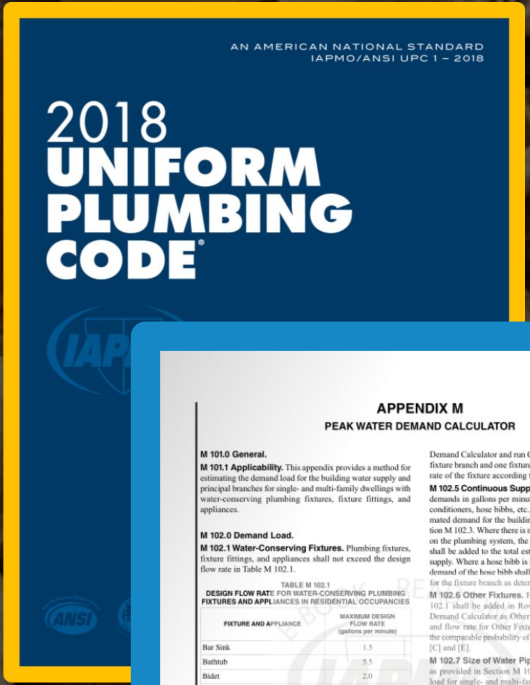
**GOOD**

**BAD**

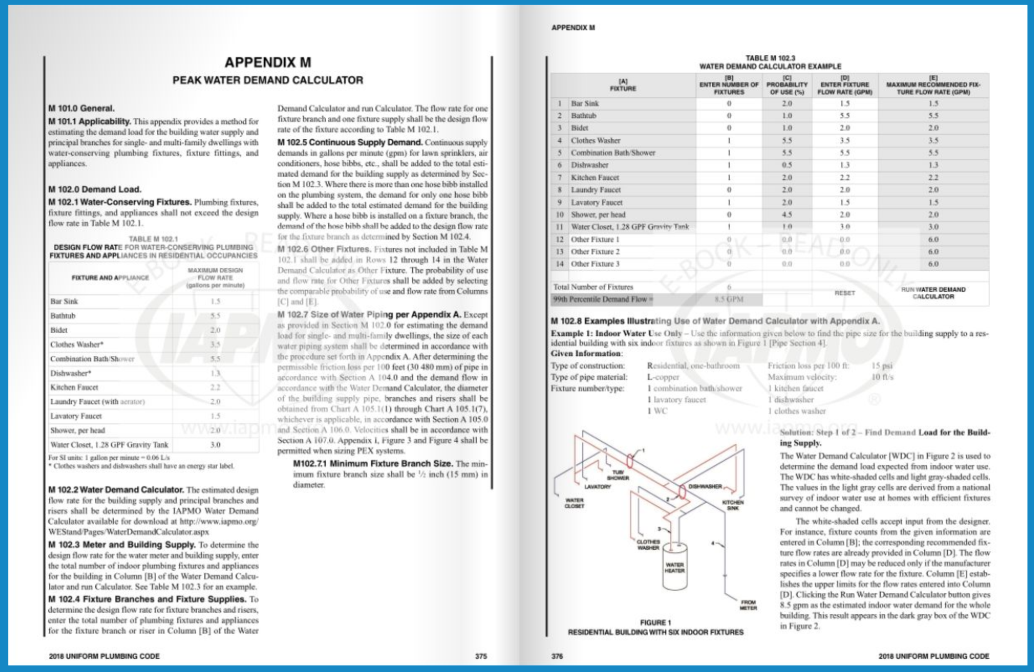
# HIGH EFFICIENCY **PLUMBING DISTRIBUTION SYSTEMS**

## APPENDIX M SIZING
(UPC 2018)

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

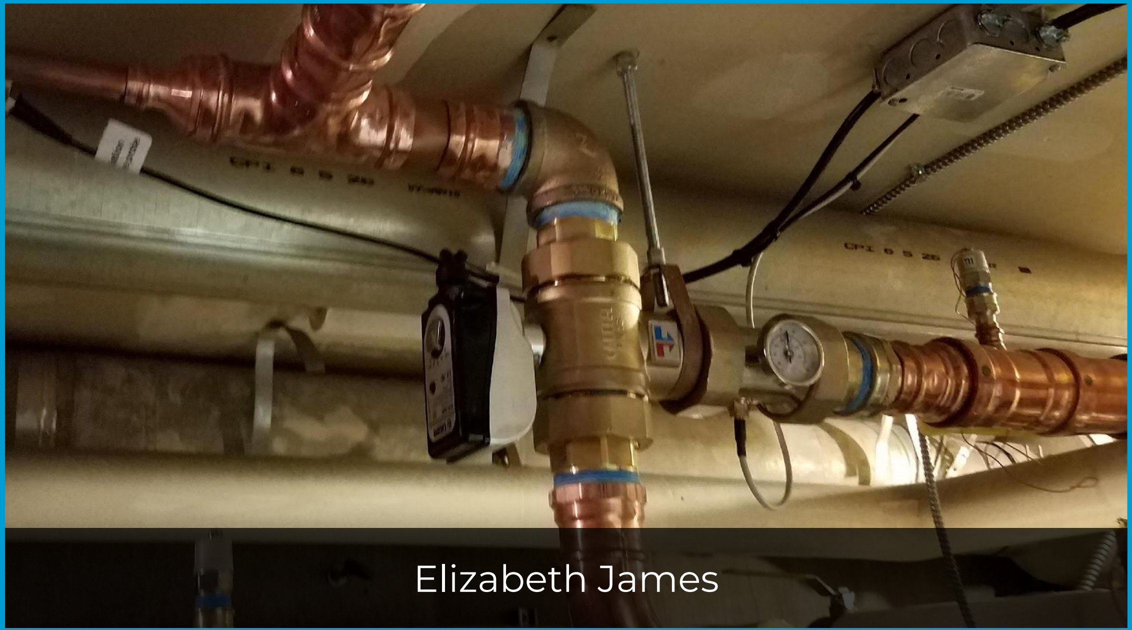



| Sizing Method | Flowrate (GPM) | CW main |
|---|---|---|
| Appendix A | 260 | 4" |
| Appendix A + C | 205 | 3.5" |
| Appendix M | 54 | 2" |



# THERMOSTATIC MIXING VALVE **SIZING**

Jackson Apartments



Elizabeth James

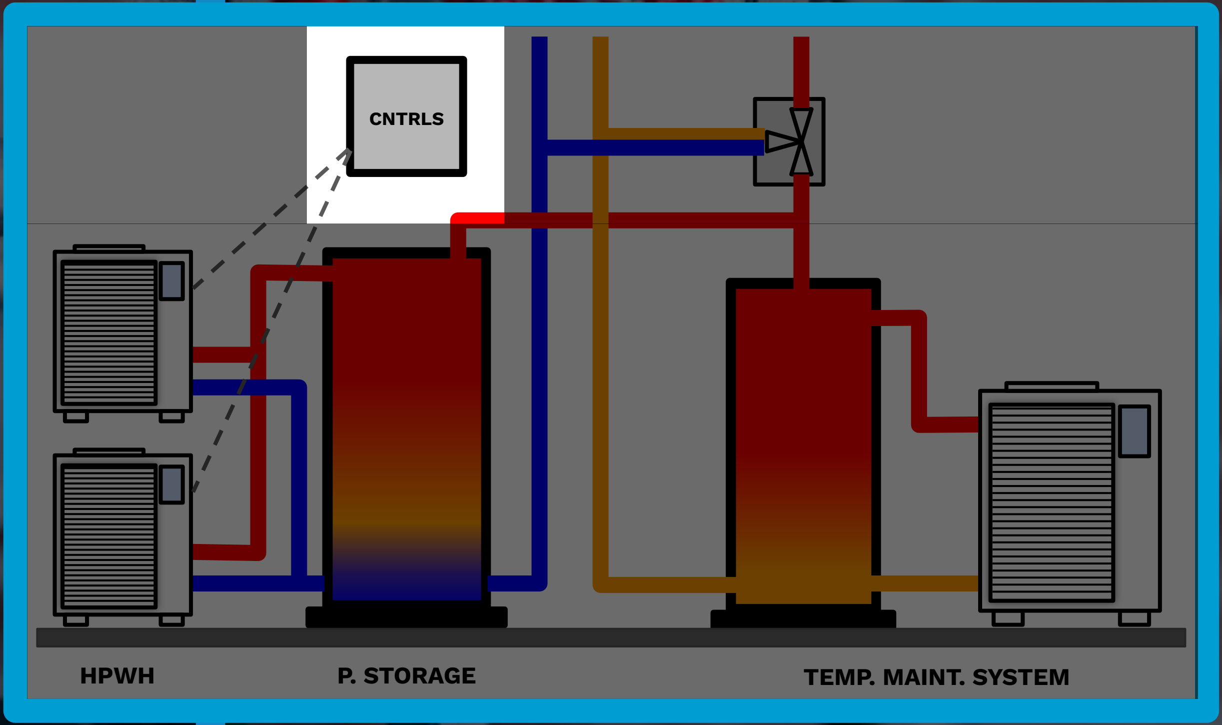
Requires **accurate sizing** for DHW load.
Response time is **essential**.

slido

# There will be A LOT more on this next time, but what questions do you have now?

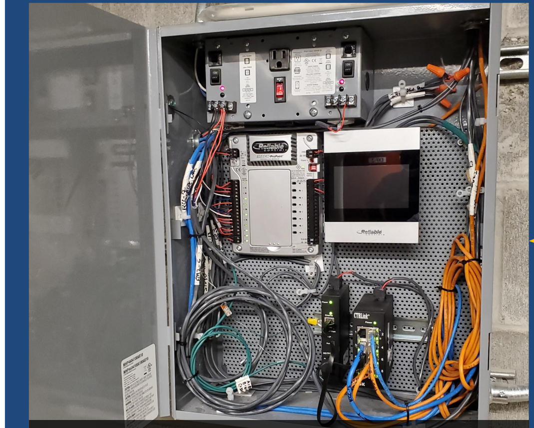
ⓘ Start presenting to display the poll results on this slide.

# COMPONENTS:
# CONTROLS



# CONTROLS **OPTIONS**

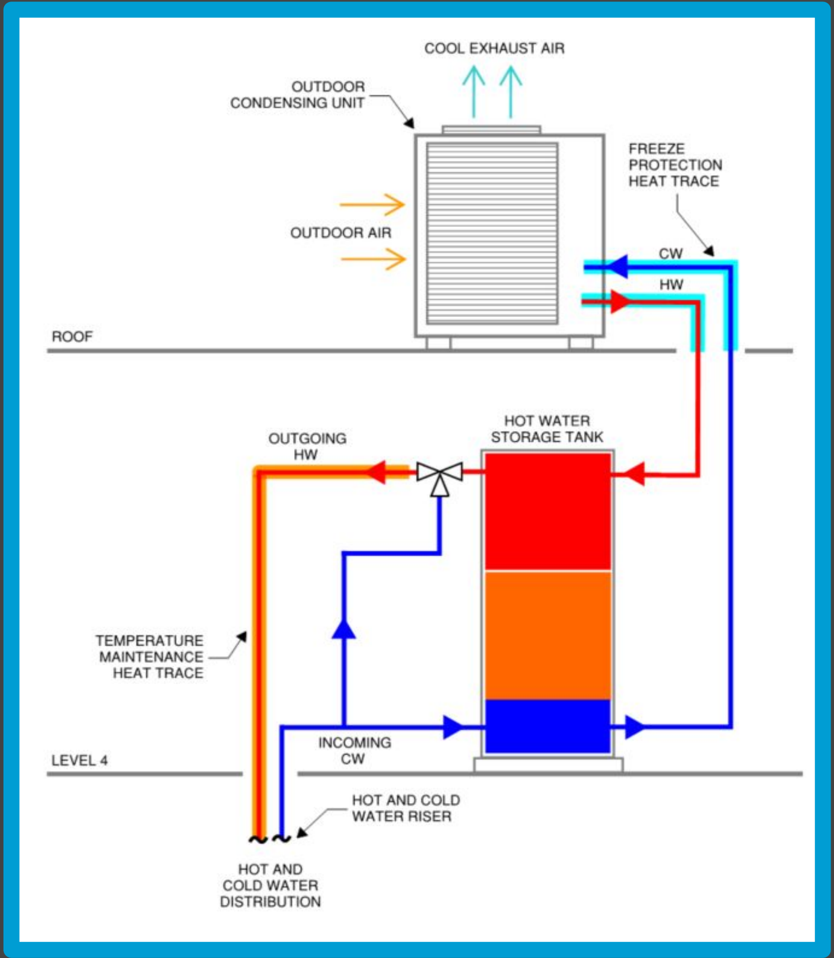
Equipment communicates through **CONTROLS** to fulfill design intent.



Third Party Controls


Internal Controls

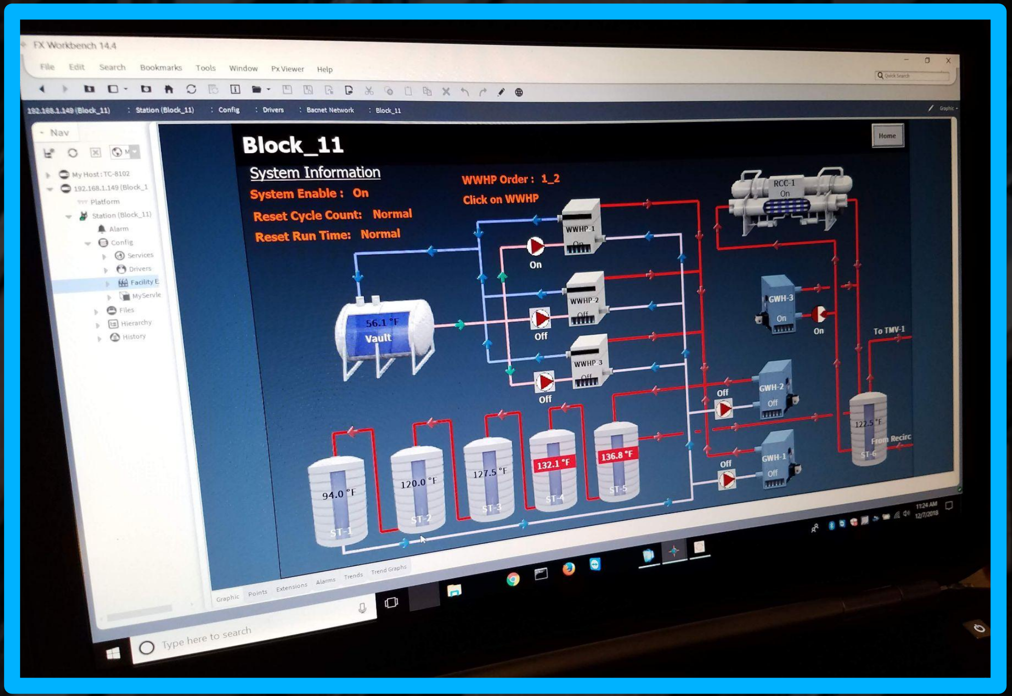
# CHPWH CONTROL SYSTEM: **INTERNAL**

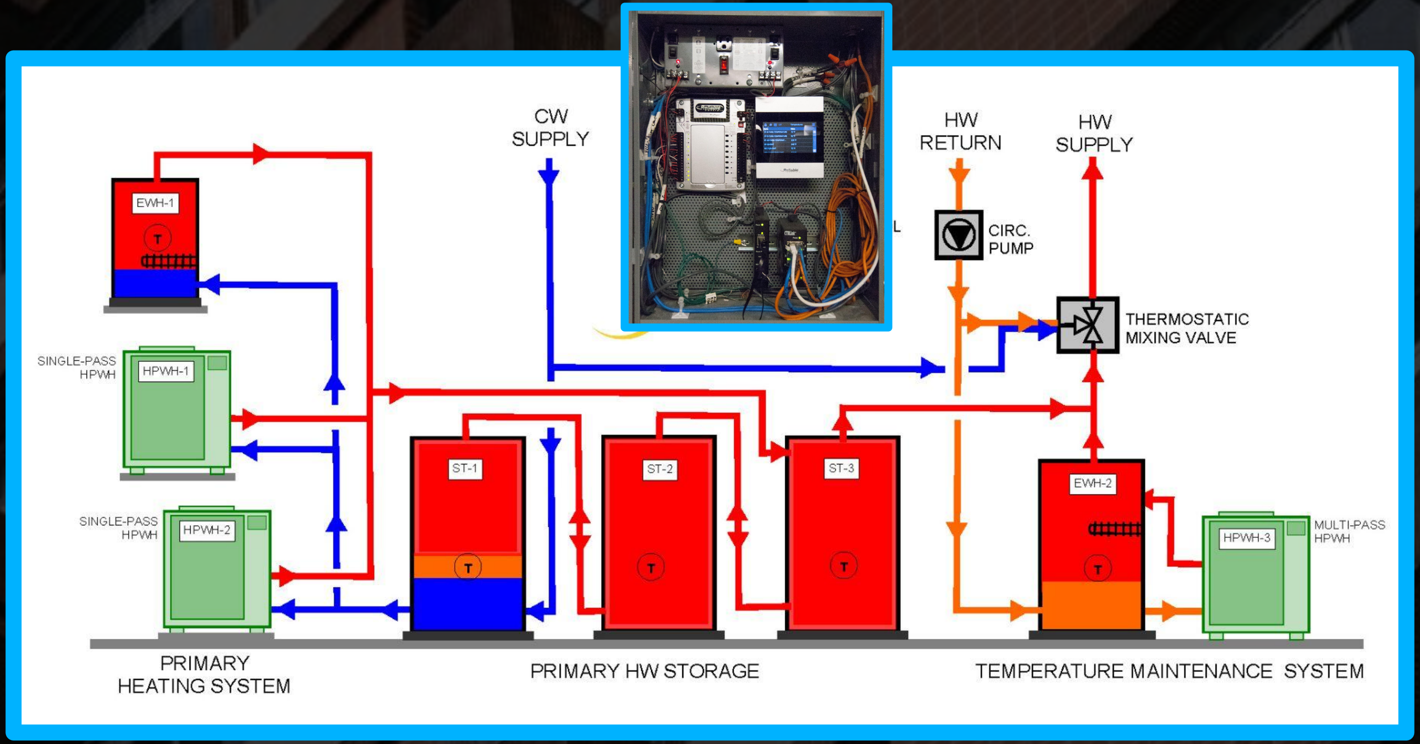



INTERNAL



# CHPWH CONTROL SYSTEM: **THIRD PARTY**




THIRD PARTY

slido

# Take a moment to reflect!

ⓘ Start presenting to display the poll results on this slide.

# RECAP:

- Why choose a CHPWH system?
- What is a CHPWH system?
- What makes a good CHPWH system candidate?
- CHPWH system components

# RECAP:

## CHPWH COMPONENTS:

- Heat pump
- Primary storage tank
- Temperature maintenance system
- Controls

slido

## What questions remain for you? Write them here so we know to tackle them next time!

ⓘ Start presenting to display the poll results on this slide.

# NEXT **TIME**

- HW System Designs
- Sizing
- Refrigerant Types & Equipment Selection
- Case Studies

## UPCOMING **TRAINING & RESOURCES**

**Seattle City Light, in collaboration w/ the Lighting Design Lab 2022**

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

### CHPWH: Engineering Deep Dive (Pt 2)

January 18th, 10AM-12PM

### CHPWH: Design, Maintenance & Operation

January 25th, February 1st, 8th, 15th
10AM - 12PM

To host a training session, or for more information, contact:
Thomasena Philen at: **TPHILEN@DRINTL.COM**

lighting design lab

Seattle City Light

D+R LEARN

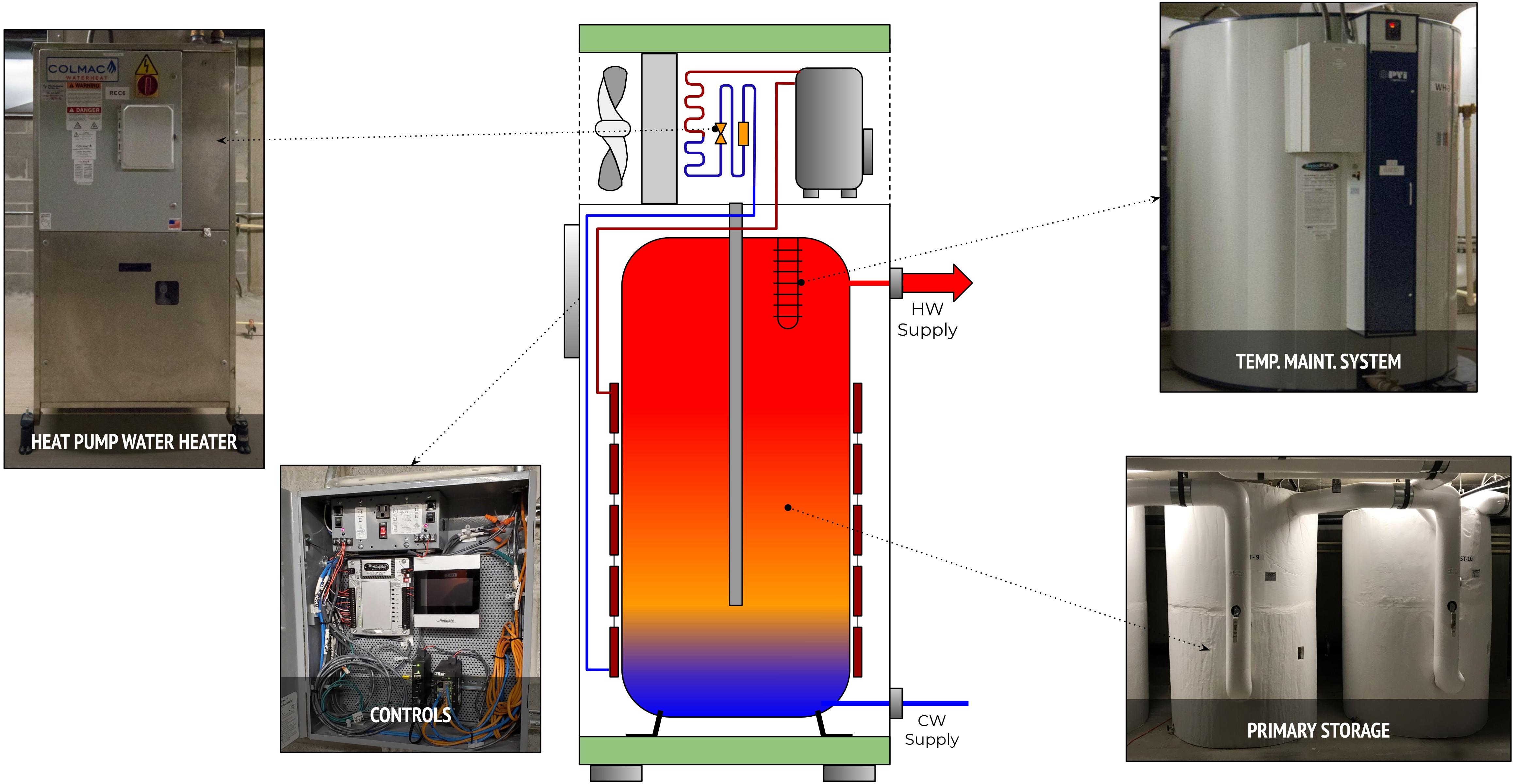
ECOTOPE

# THANK YOU

D+R LEARN

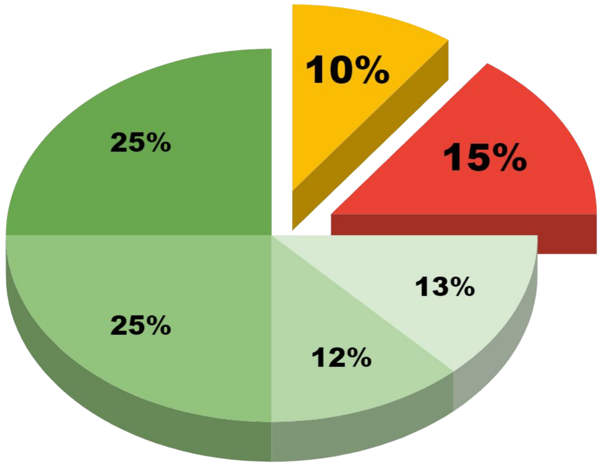
ECOTOPE

# HOW DOES IT **COMPARE?**



# TEMPERATURE MAINTENANCE **SYSTEM**

Keeping the water in the distribution system **HOT**




**ENERGY USAGE IN MULTIFAMILY MIDRISE**