

# COMMERCIAL HEAT PUMP WATER HEATING:

## DESIGN & MAINTENANCE

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*Colin Grist & Evan Green  
Ecotope, Inc.*

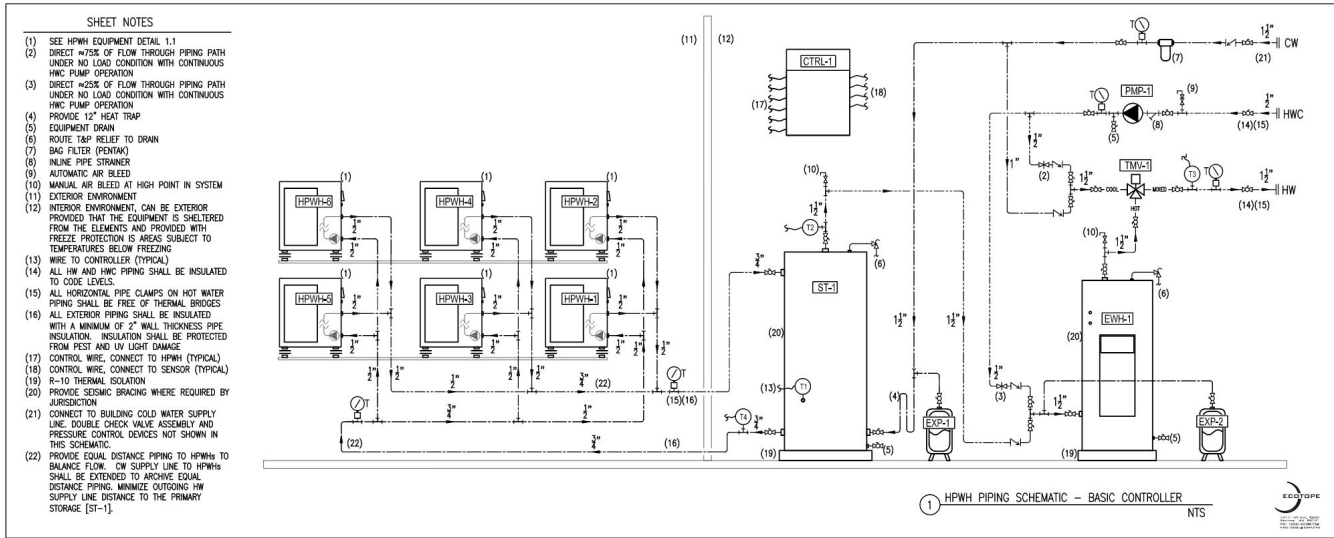
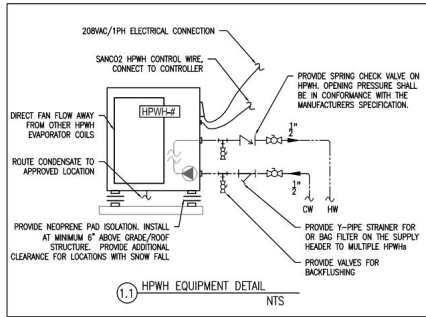


## SCOPE & **SEQUENCE**

- **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?

BASIS OF DESIGN	
<p>THE SYSTEM WAS SIZED FOR:</p> <ul style="list-style-type: none"> <li>SANCOZ WITH SWING TANK CENTRAL HEAT PLANT DESIGN</li> <li>MARKET RATE MULTI-FAMILY BUILDING</li> <li>60 FULL TIME OCCUPANTS</li> <li>30 RESIDENTIAL DWELLING UNITS</li> <li>25 GALLONS OF HW PER PERSON PER DAY (PEAK DAILY HOT WATER USAGE)</li> <li>1,500 GALLONS OF 120°F HW PER DAY (PEAK DAILY HOT WATER USAGE)</li> <li>16 HR PER DAY PRIMARY HPWH RUN TIME</li> <li>90 WATTS/AFW HWC LOSSES</li> </ul> <p>MINIMUM SYSTEM SIZE:</p> <ul style="list-style-type: none"> <li>285 GALLONS OF PRIMARY STORAGE</li> <li>66.8 MBTU/HR OF PRIMARY HEAT CAPACITY</li> <li>80 GALLONS OF SWING TANK VOLUME</li> <li>4.7 KW SWING TANK RESISTANCE ELEMENT</li> </ul>	<p>EQUIPMENT SELECTION:</p> <ul style="list-style-type: none"> <li>[HPWH-1-6] PRIMARY HPWHs; SIX (6) SANCOZ, GS4-45HPC; 5 NOMINAL, 1 REDUNDANT UNIT</li> <li>[ST-1] PRIMARY STORAGE; ONE (1) SANCOZ, ECO-285GAL.NST; 285 GALLONS OF STORAGE</li> <li>[CTRL-1] CENTRAL HEAT PLANT CONTROLLER; SANCOZ, ECO-MESTR-001</li> <li>[DWH-1] TEMPERATURE MAINTENANCE TANK (SWING TANK); 80 GALLONS, 6 KW ELEMENT</li> <li>[PMP-1] 0.5 GPM PER RISER, TARGET 110°F OF HOT WATER CIRCULATION RETURN WATER TEMP.</li> <li>[TMV-1] RECOMMEND SIZING FOR 0.25 GPM PER PERSON PEAK; MINIMUM FLOWRATE SHALL BE LESS THAN THE CONTINUOUS FLOWRATE OF [PMP-1]</li> <li>[EXP-1] SIZED FOR THE THERMAL EXPANSION OF THE PRIMARY STORAGE VOLUME</li> <li>[EXP-2] SIZED FOR THE THERMAL EXPANSION OF THE TEMPERATURE MAINTENANCE STORAGE VOLUME AND THE VOLUME OF WATER IN THE HW DISTRIBUTION PIPING.</li> </ul>

LEGEND	
SYMBOL	DESCRIPTION
	PUMP
	MIXING VALVE
	EQUIPMENT TAG
	TEMPERATURE SENSOR
	FLOW METER
	BALL VALVE
	BALANCING VALVE
	SPRING CHECK VALVE
	INLINE Y-STRAINER
	PIPE-T
	TAP RELIEF VALVE
	MANUAL AND AUTOMATIC AIR BLEED
	PIPE UNION
	PIPE FLOW DIRECTION
	PIPE SIZE
	CW PIPING
	HW PIPING
	HWC PIPING



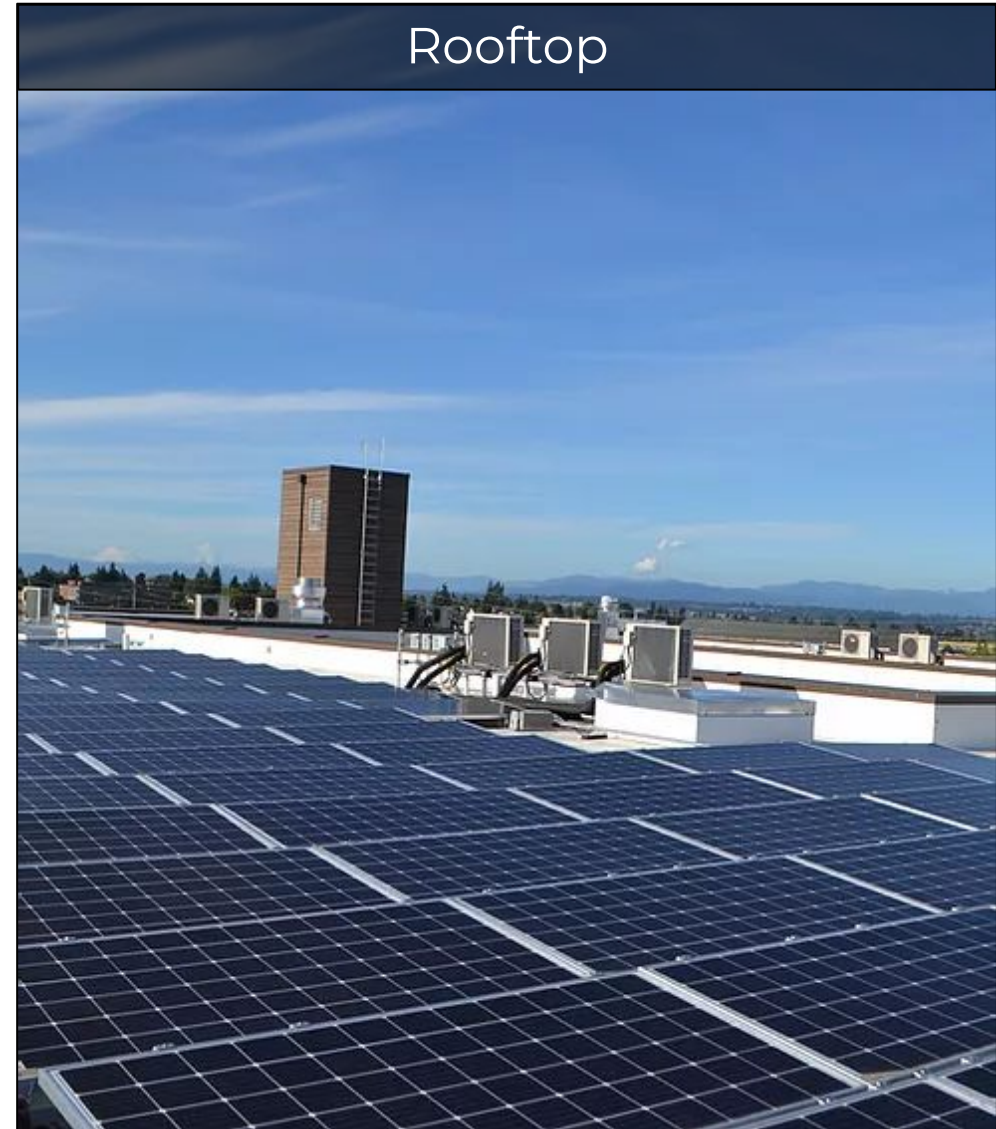
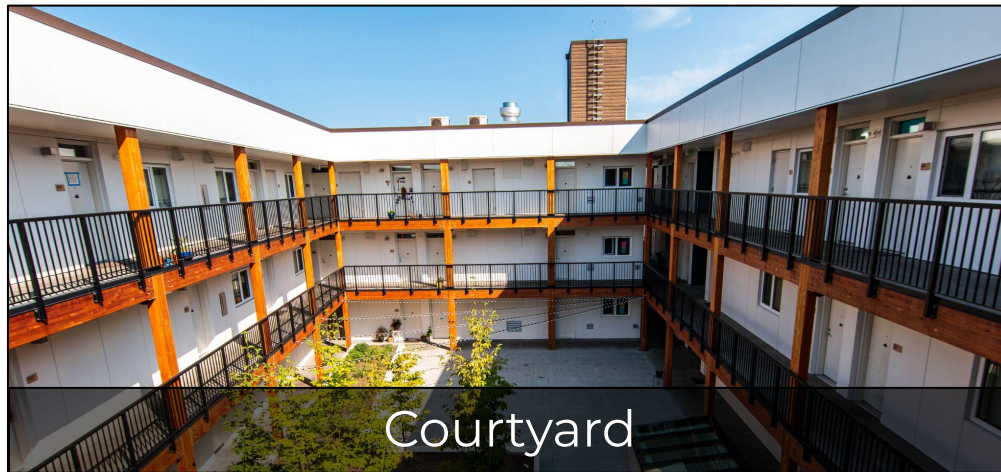
# KEY QUESTION:

Do I want a CHPWH system in my building?

# CASE STUDY: HOPEWORKS STATION

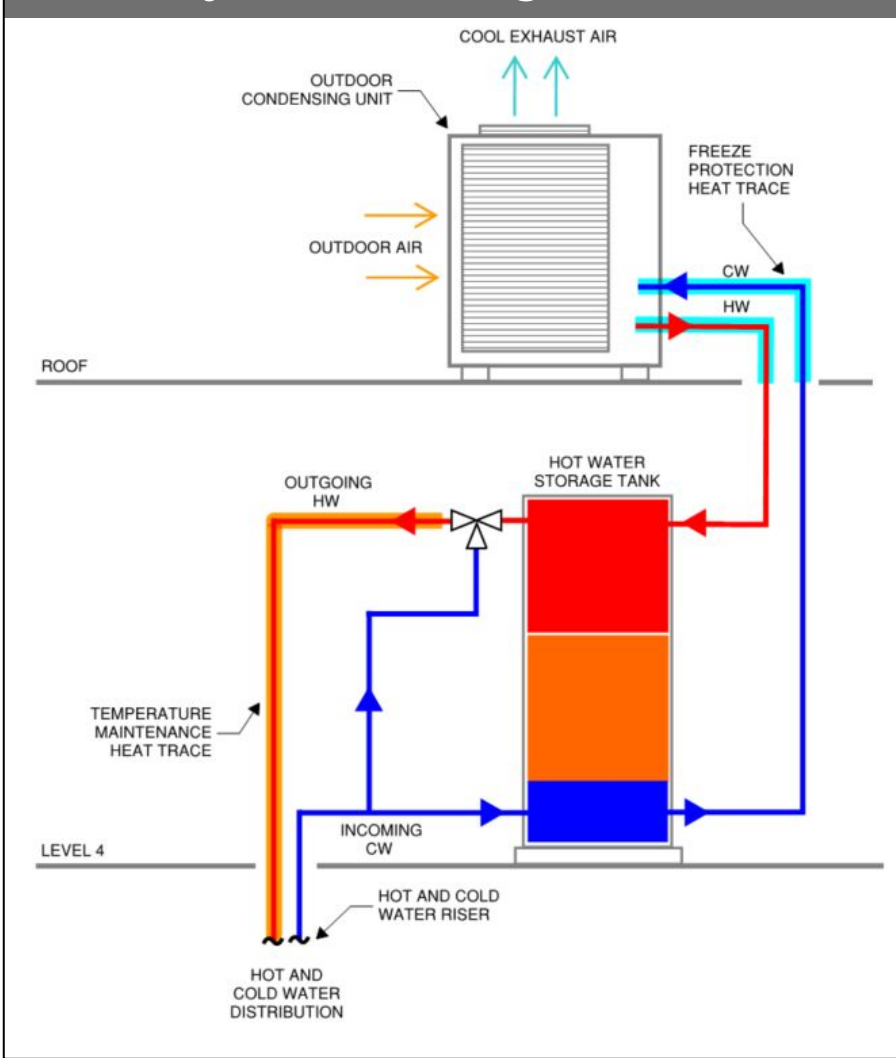


# HOPEWORKS **STATION**



# HOPEWORKS **STATION**

## System Configuration



# HOPEWORKS STATION

New construction



(13) Sanden, single pass  
(11) 120 gal + (2) 84 gal tanks



Heat Trace; no HW recirculation

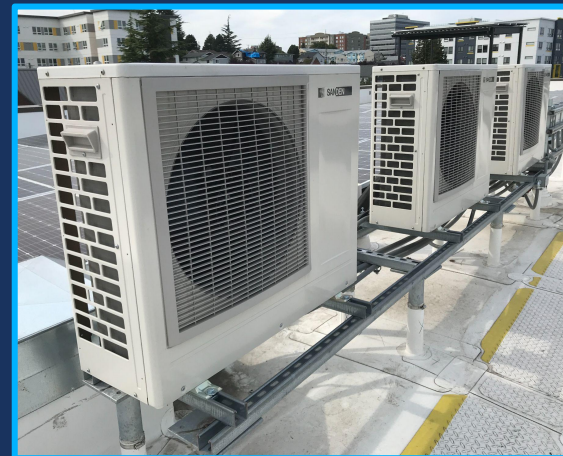


Rooftop




HPWH energy: 76 kWh/day

Total energy: 1.22 kWh/day/person



## **KEY TAKEAWAY:**

Clustered systems with smaller residential equipment can be economical.

The background of the slide is a photograph of industrial machinery, specifically a complex network of pipes and structural beams. The image is split vertically: the left half has a dark red overlay, and the right half has a dark blue overlay. The text is positioned on the left side, over the red area.

**WHY CHOOSE A  
CHPWH SYSTEM?**

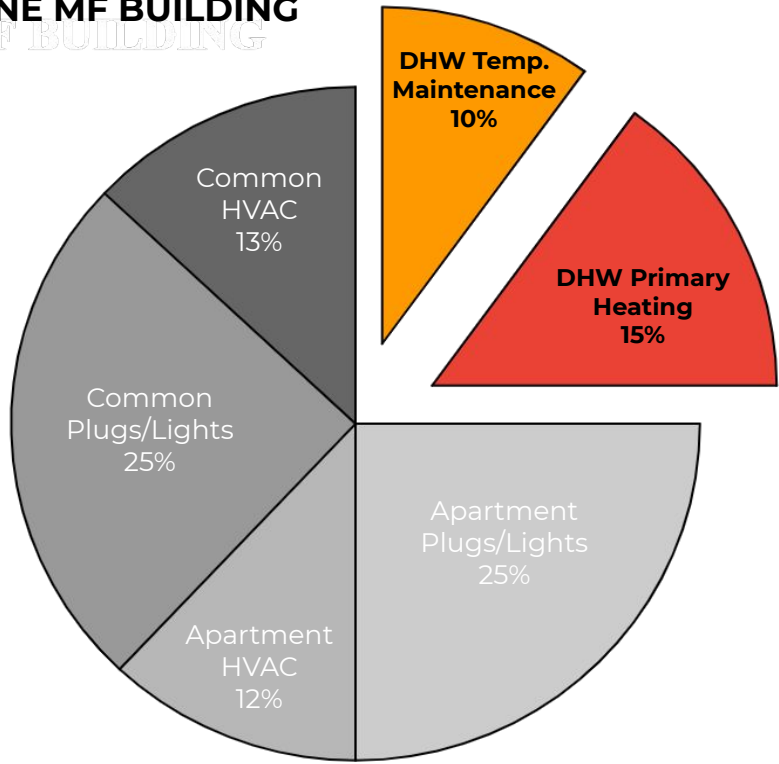
# WHY CHPWH?



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

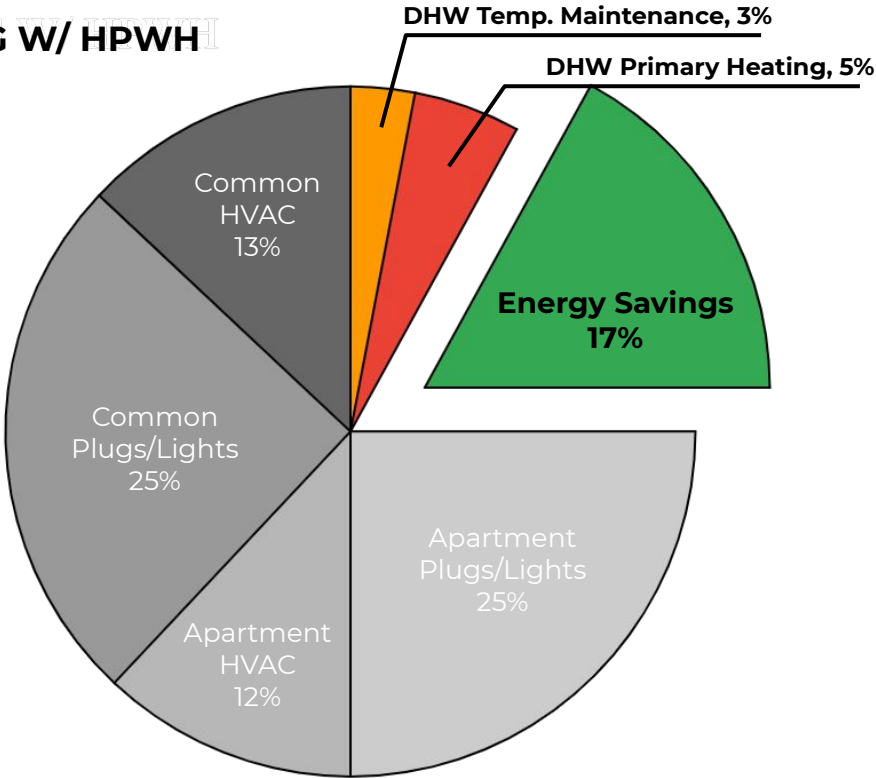
# WHY CHPWH?

BASELINE MF BUILDING



DHW represents 25% of annual building use

MF BUILDING W/ HPWH



CHPWH systems cut energy usage down by 3x

# 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.

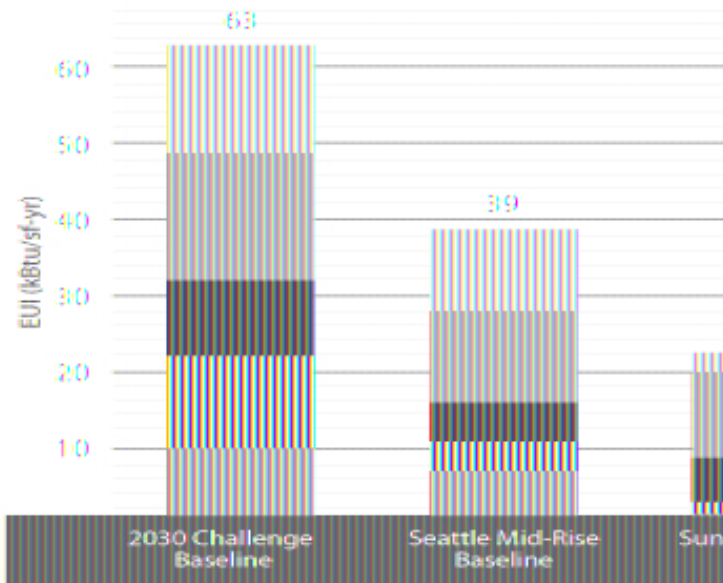


**\*R-1 and R-2:** Multifamily greater than 3 stories; any hotel/motel

# SUNSET ELECTRIC



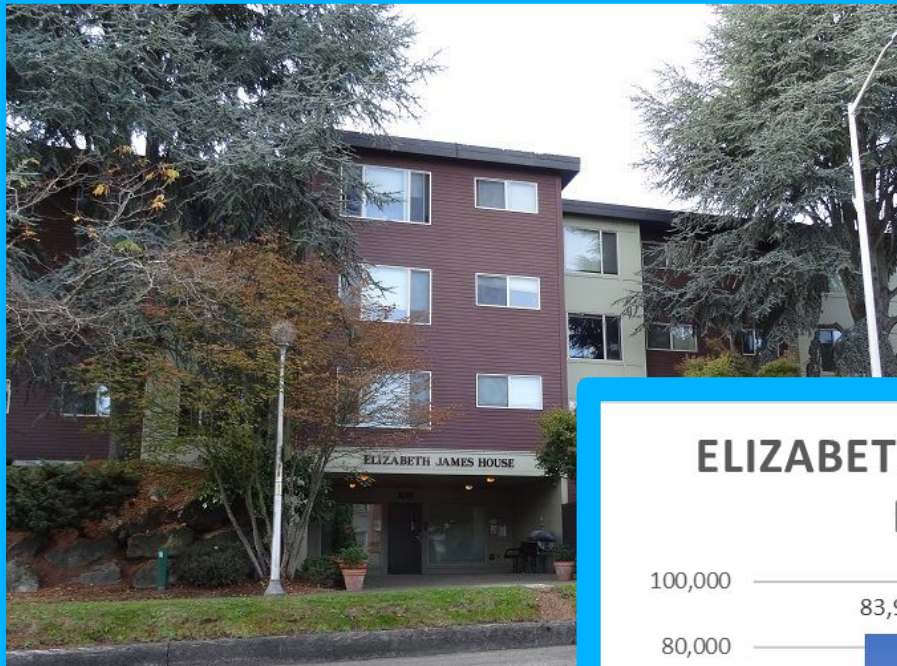
## 70% Reduction in DHW Energy



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

- 67,000 ft<sup>2</sup>
- 92 apartments
- R-134a air-source heat pump water heaters in parking garage

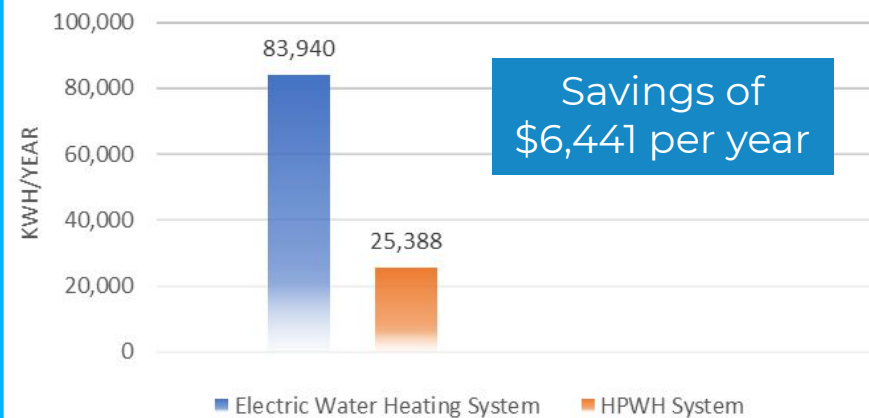
# ELIZABETH JAMES



Elizabeth James House

## 70% Reduction in DHW Energy

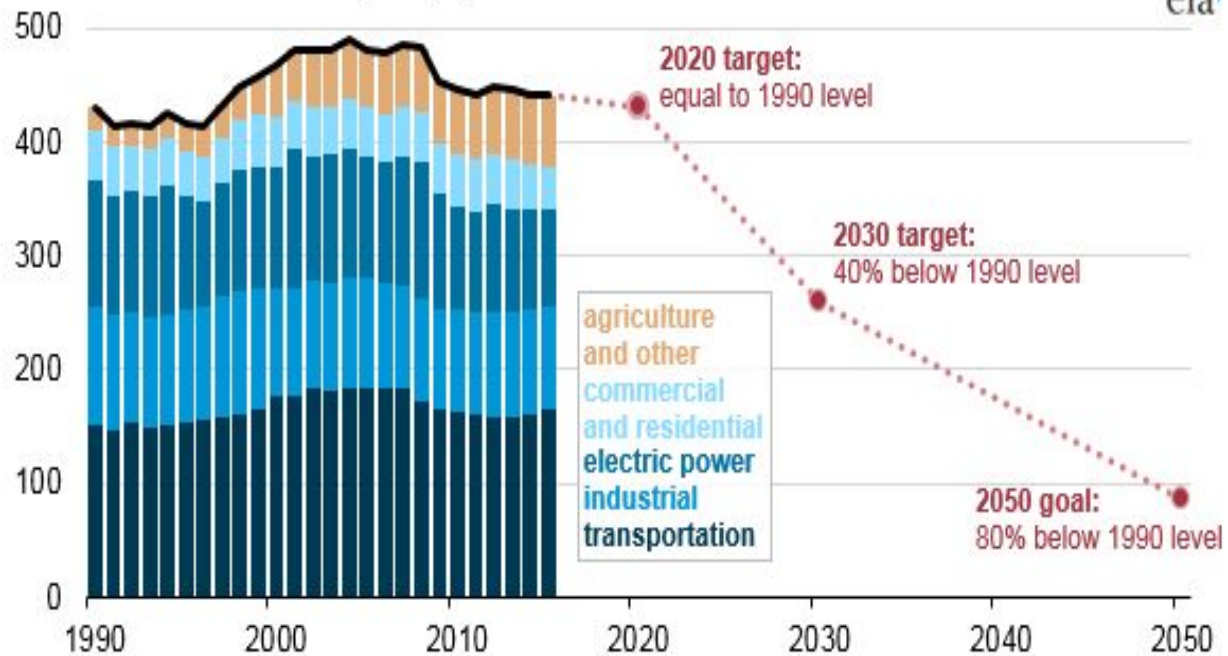
### ELIZABETH JAMES: ENERGY USAGE BY SYSTEM TYPE



- Senior/low income
- 60 apartments
- 4 Sanden CO<sub>2</sub> HPs
- ZERO GHG emissions

# WHY CHPWH?

California greenhouse gas emissions by sector (1990-2015) and targets through 2050  
million tons carbon dioxide (CO<sub>2</sub>) equivalent



## LOWER INSTALLATION COSTS

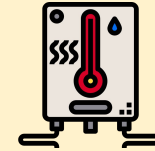
### 965 Weeks Street, East Palo Alto, CA

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

**FOSSIL**  
GAS

**vs**

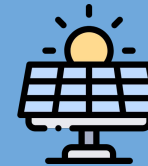
**AIR TO H<sub>2</sub>O**  
HPWH



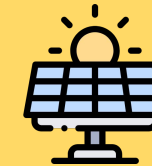
4 hot water plants serve 4 buildings

- Plants contain gas water heaters with integral storage tanks

- Storage tanks on roof
- Outdoor unit on roof or in mechanical room



**Solar thermal collector w/ PV system**



**Solar PV system**

Equipment cost:  
\$192,000

Utility connection cost:  
\$84,800

**Total cost: \$276,800**

Equipment cost:  
\$169,262

Utility connection cost:  
\$27,000

**Total cost: \$196,262**

# OPERATING COST COMPARISON

FOSSIL GAS SYSTEM

VS

AIR TO WATER CO<sub>2</sub> HPWH

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

Average estimated  
cost/therm: \$1.75

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

(no load shifting)

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

PG&E time-of-use rate  
(peak, partial peak, off-peak)

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

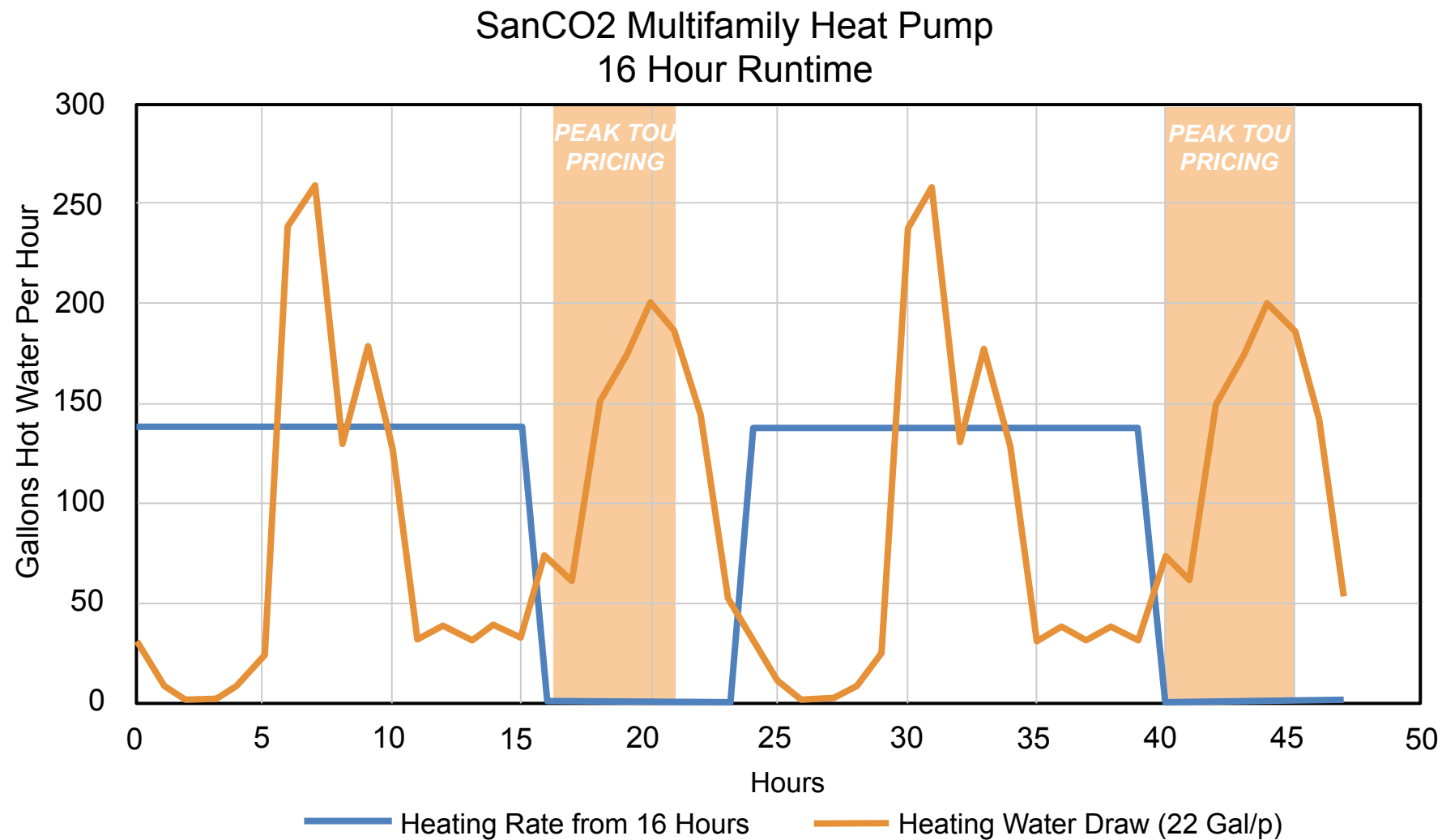
(load shifting)

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

PG&E time-of-use rate  
(peak, partial peak, off-peak)

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

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



The background of the slide is a photograph of industrial machinery, specifically a complex network of pipes and structural beams. The left side of the image is overlaid with a semi-transparent dark red filter, while the right side has a semi-transparent dark blue filter. The text 'WHAT IS A CHPWH?' is positioned on the left side, over the red filter.

**WHAT IS A  
CHPWH?**

## HPWH PRODUCT TYPES



**Unitary/Integrated**

- 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

# CHPWH SYSTEM MARKET DELIVERY



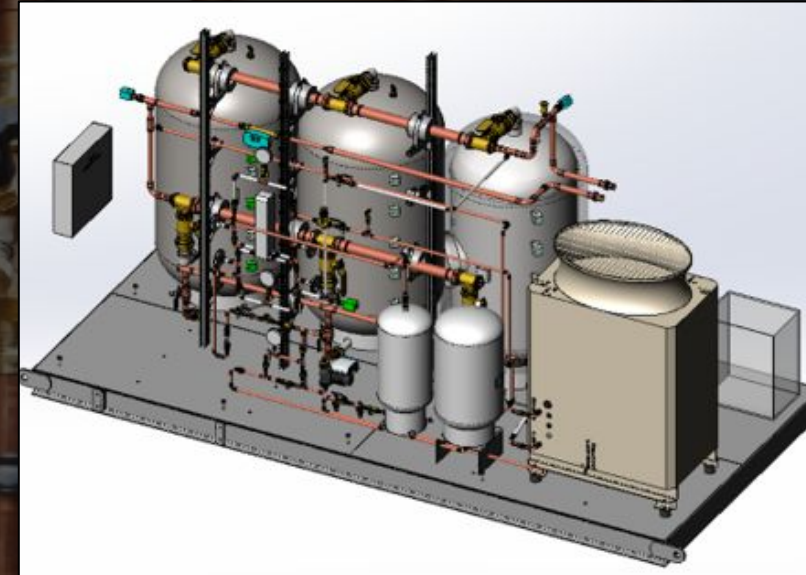
## CUSTOM ENGINEERED SYSTEM

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



## SPECIFIED BUILT-UP SYSTEM

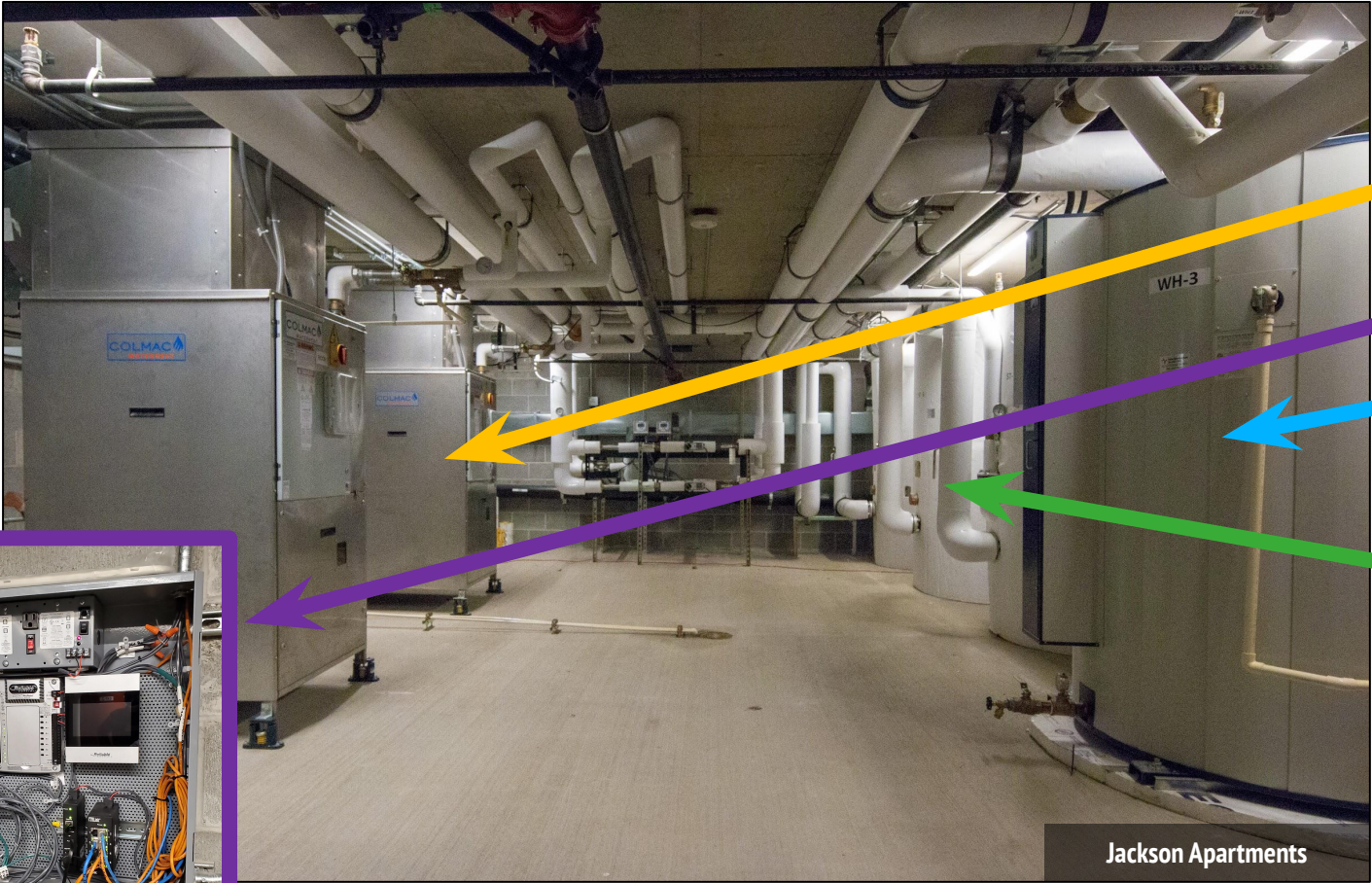
All the pieces are separate but come from a single distributors or manufacturer.



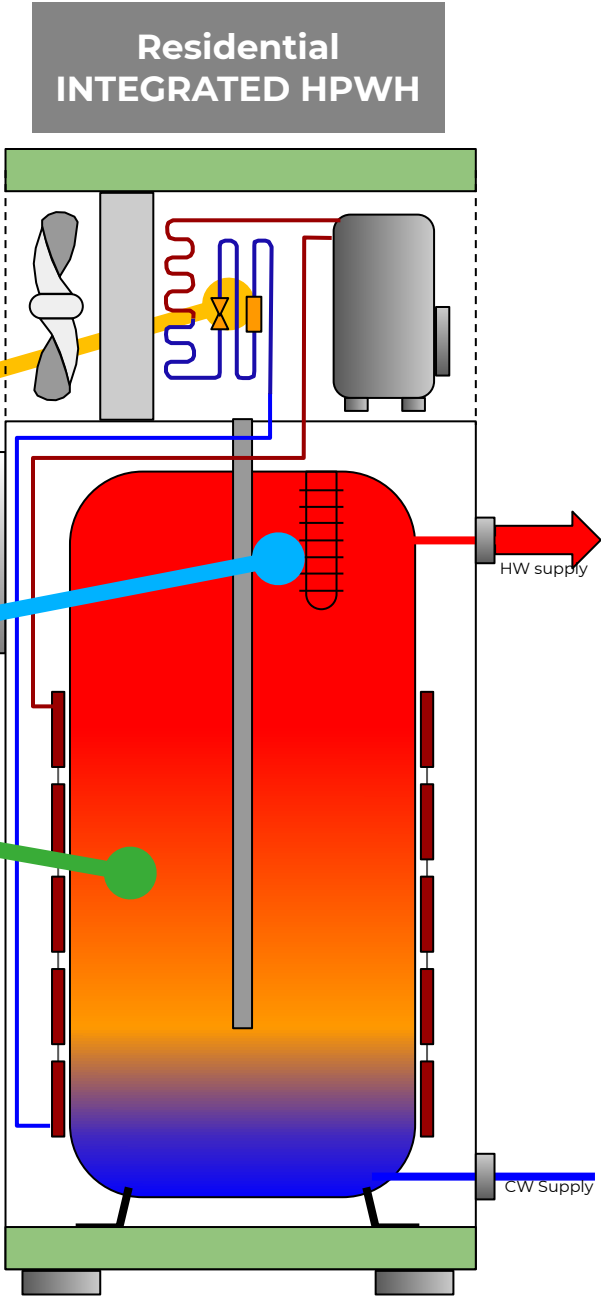
## PACKAGED/SKID

Everything is assembled & delivered in a single package.

# COMMERCIAL HPWH SYSTEMS



Jackson Apartments



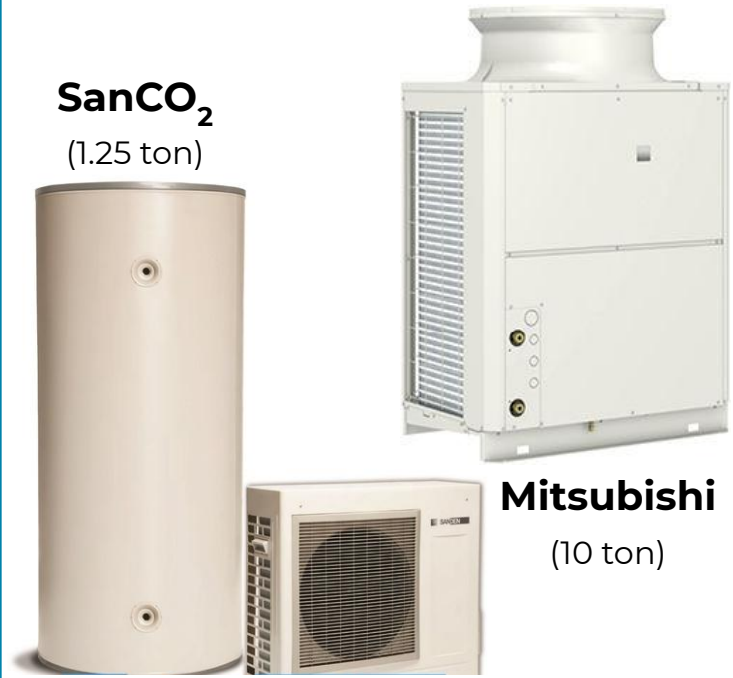
# AVAILABLE PRODUCTS



**AO Smith**  
(2.5 ton)

**Rheem**  
(> 1 ton)

Unitary/Integrated  
Residential/Small Commercial  
R-134a



**SanCO<sub>2</sub>**  
(1.25 ton)

**Mitsubishi**  
(10 ton)

Split System  
Single-Pass  
CO<sub>2</sub>/R-744



**Colmac**  
(10 - 30 ton)

**Nyle**  
(10 - 30 ton)

Split System  
Single- or Multi-Pass  
R-134a



# EXAMPLES OF CHPWH SYSTEMS



**Small Commercial System**

(closet installation serving 5 apts)



**Large Commercial System**

(basement installation serving 250 apts)

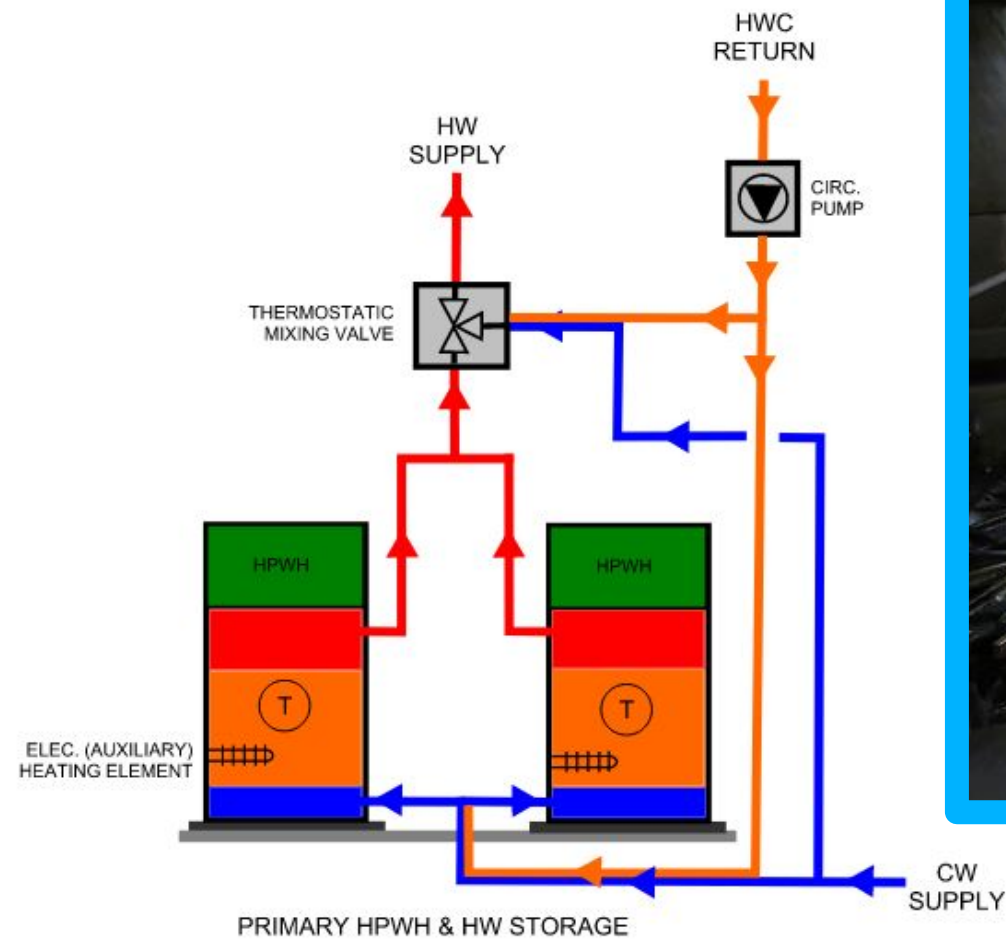


**Multiple Commercial Systems**

(residential equipment serving 4-5 apts)

**Multiple Sizes, Types, & Configurations**

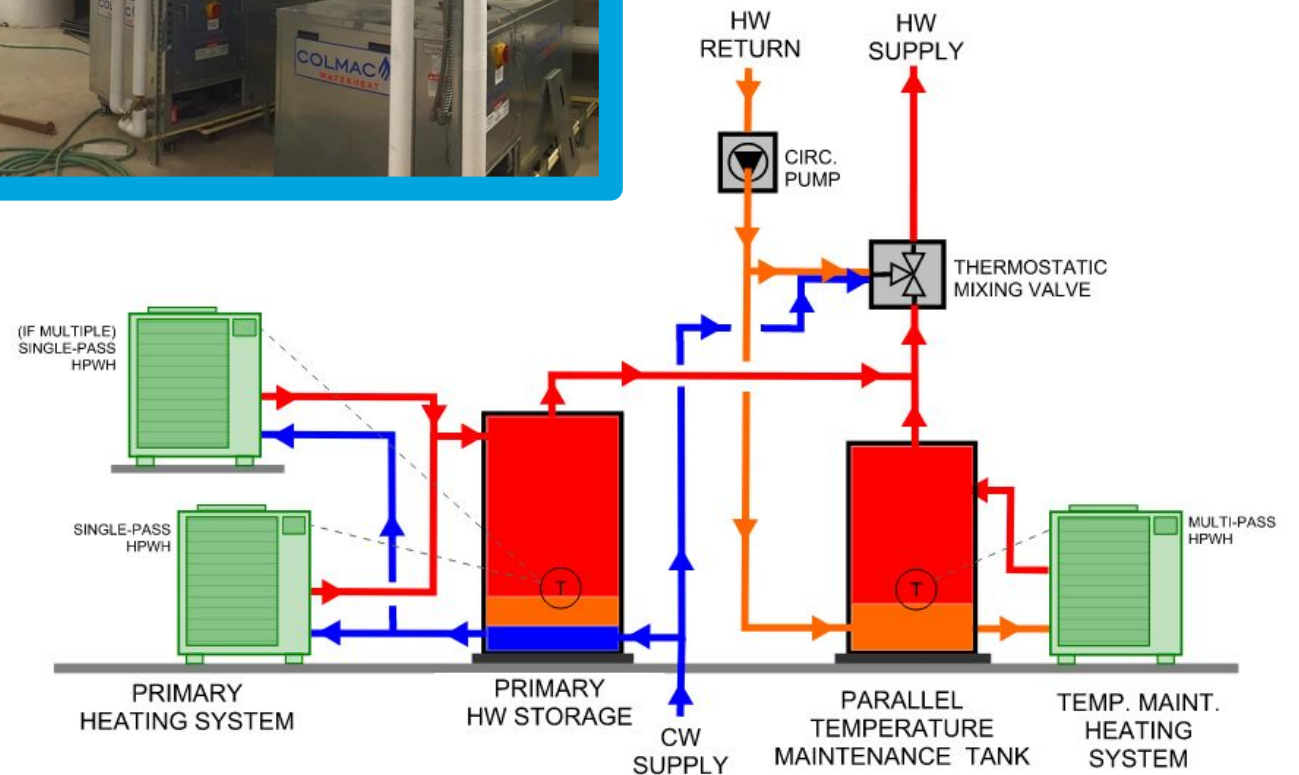
# SMALL COMMERCIAL SYSTEM



# LARGE COMMERCIAL SYSTEM

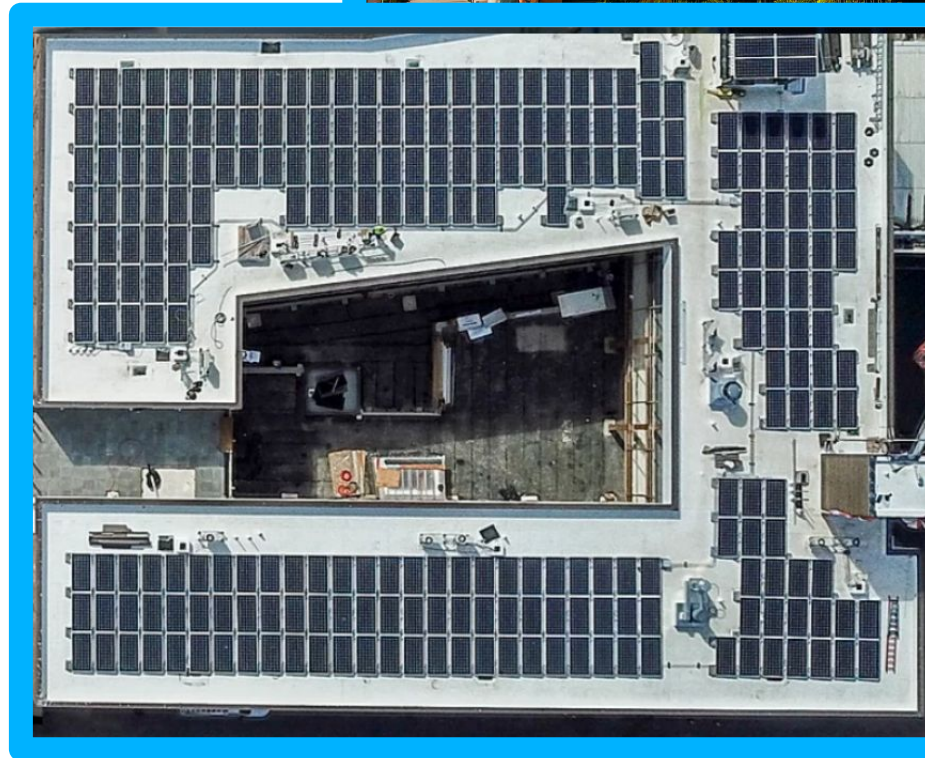
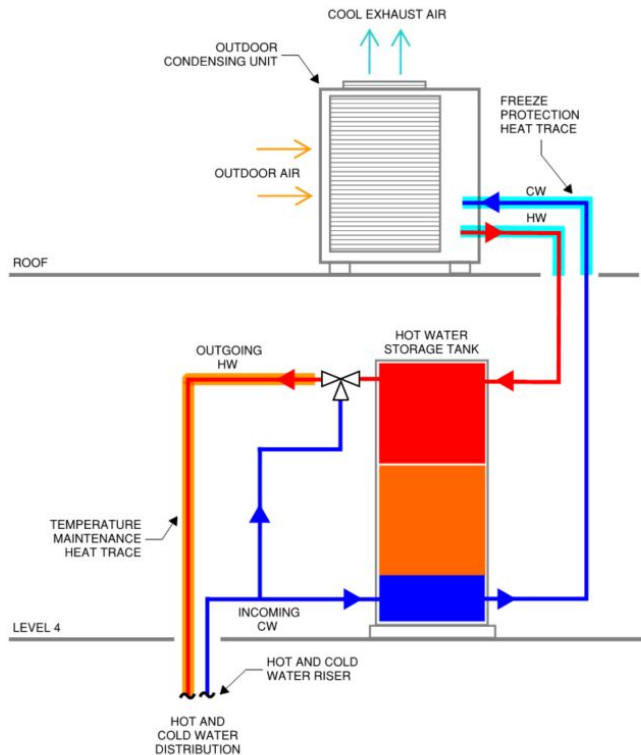


- Commercial equipment; engineered system
- 200 units
- Dedicated heating system:
  - Single pass primary HPWH
  - Multi pass temperature maintenance system



# MULTIPLE COMMERCIAL **SYSTEMS**

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

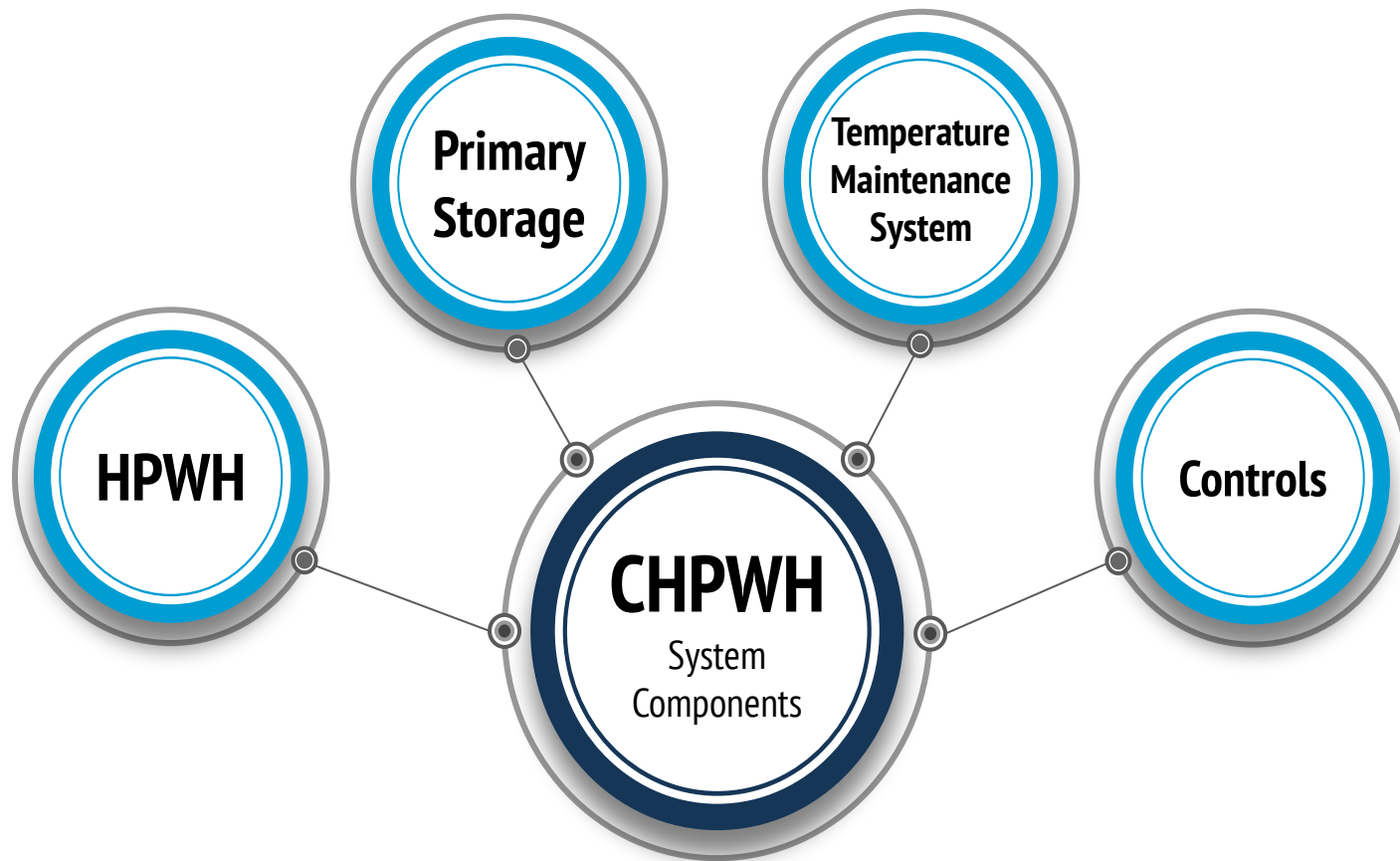


The background of the slide is a photograph of an industrial facility, likely a refinery or chemical plant. It features a complex network of large, dark-colored pipes and structural steel beams. The lighting is somewhat dim, with a blueish-grey tint overall, and a darker, reddish-brown gradient overlay on the left side. The text "LET'S PAUSE FOR QUESTIONS" is centered in a bold, white, sans-serif font.

**LET'S PAUSE FOR QUESTIONS**

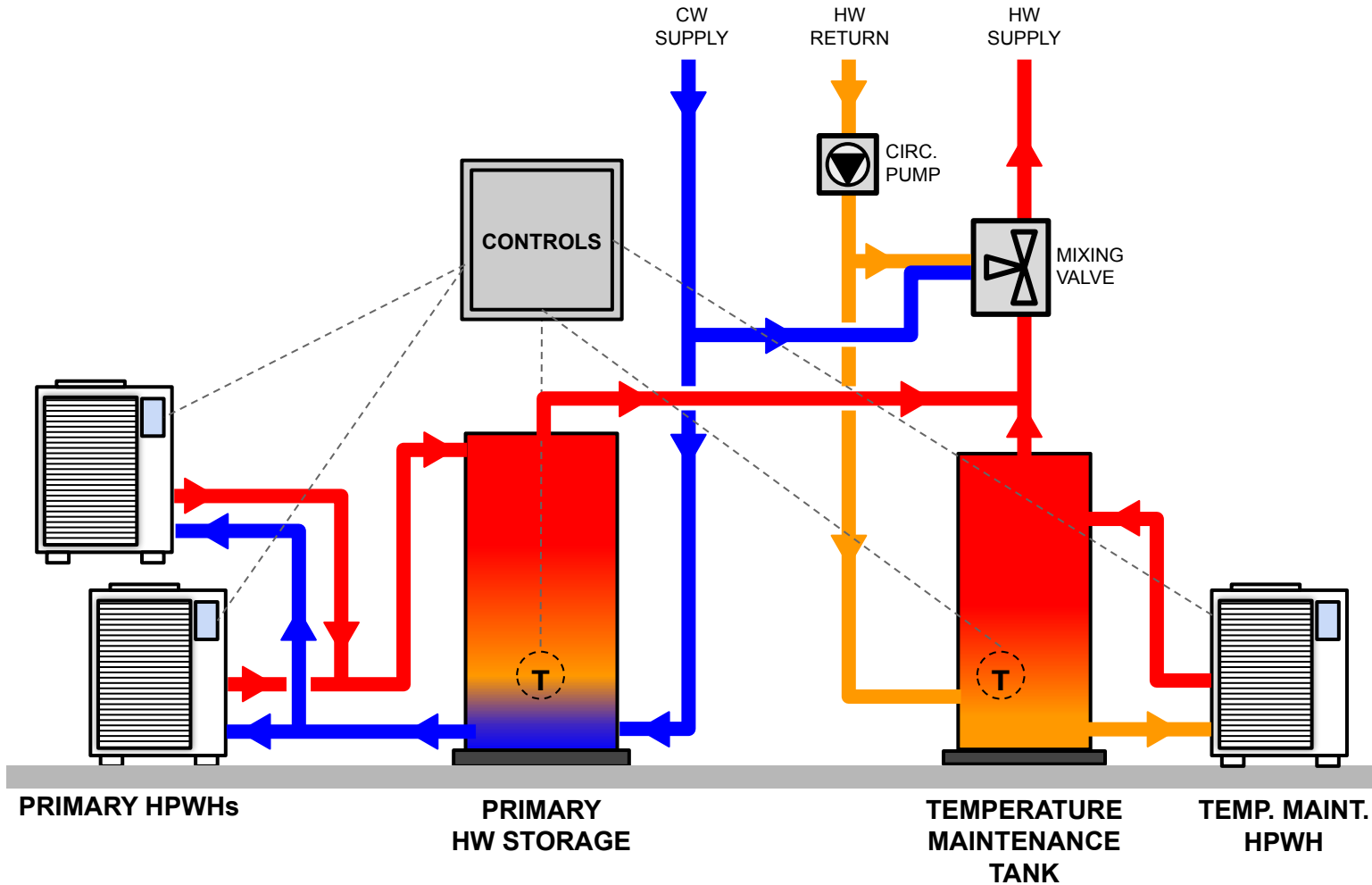
The background of the slide is a photograph of industrial piping and structural elements, likely from a power plant or refinery. The image is dark and has a blue tint. A thick blue border frames the left and top portions of the slide. The text "CHPWH SYSTEM COMPONENTS" is overlaid on the left side of the image.

# **CHPWH SYSTEM COMPONENTS**



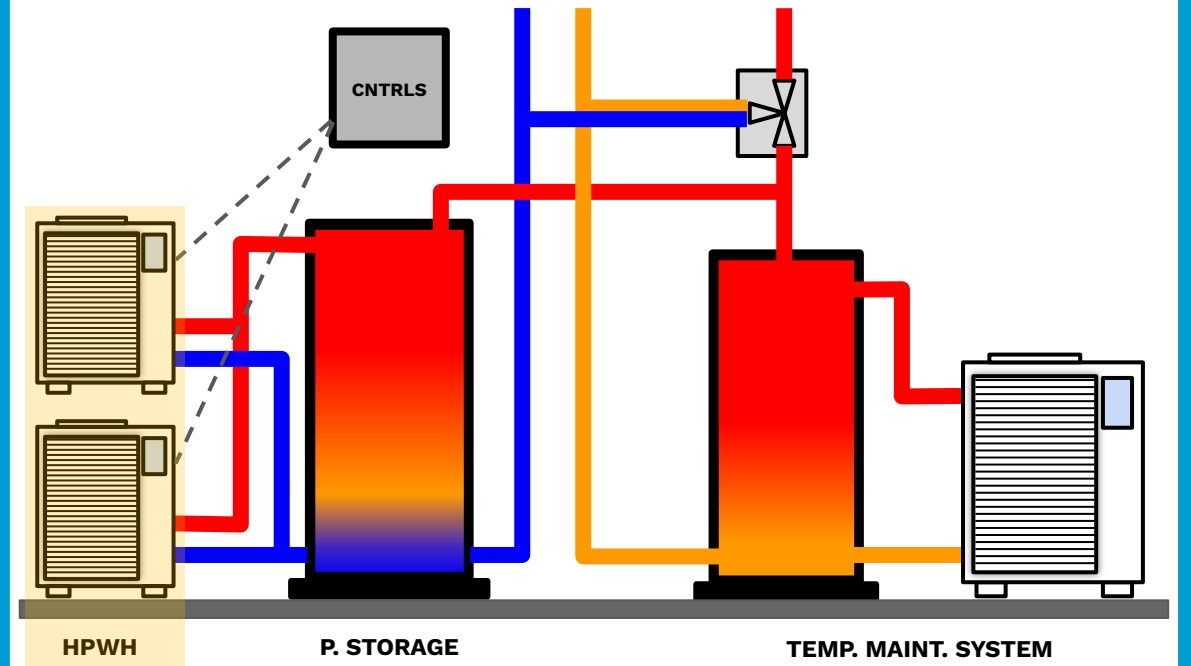
Not a gas  
water heater!

# FOUR CHPWH SYSTEM **COMPONENTS**



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

# CHPWH COMPONENTS: HP WATER HEATER



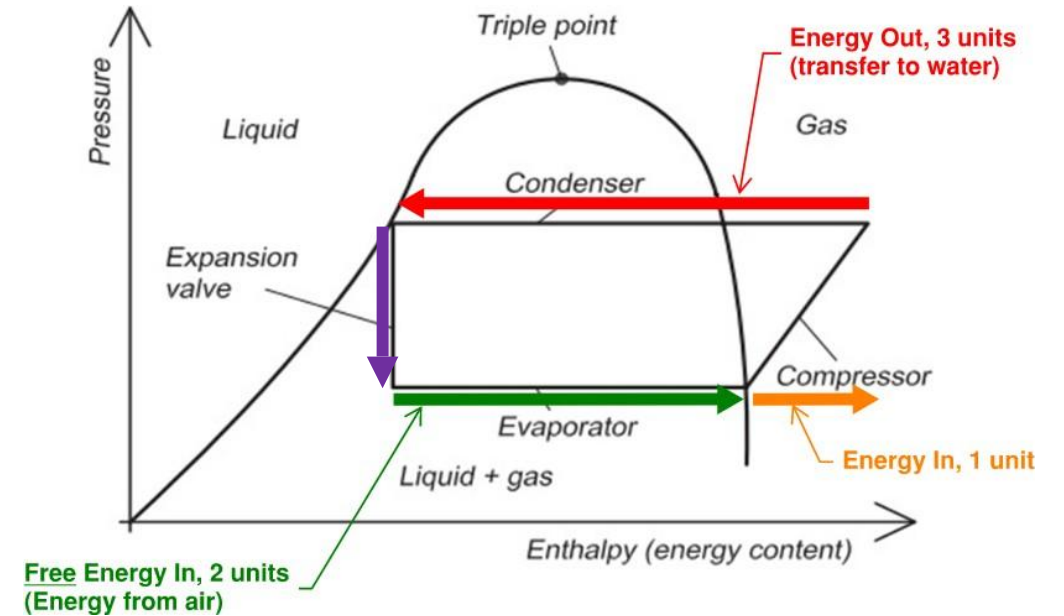
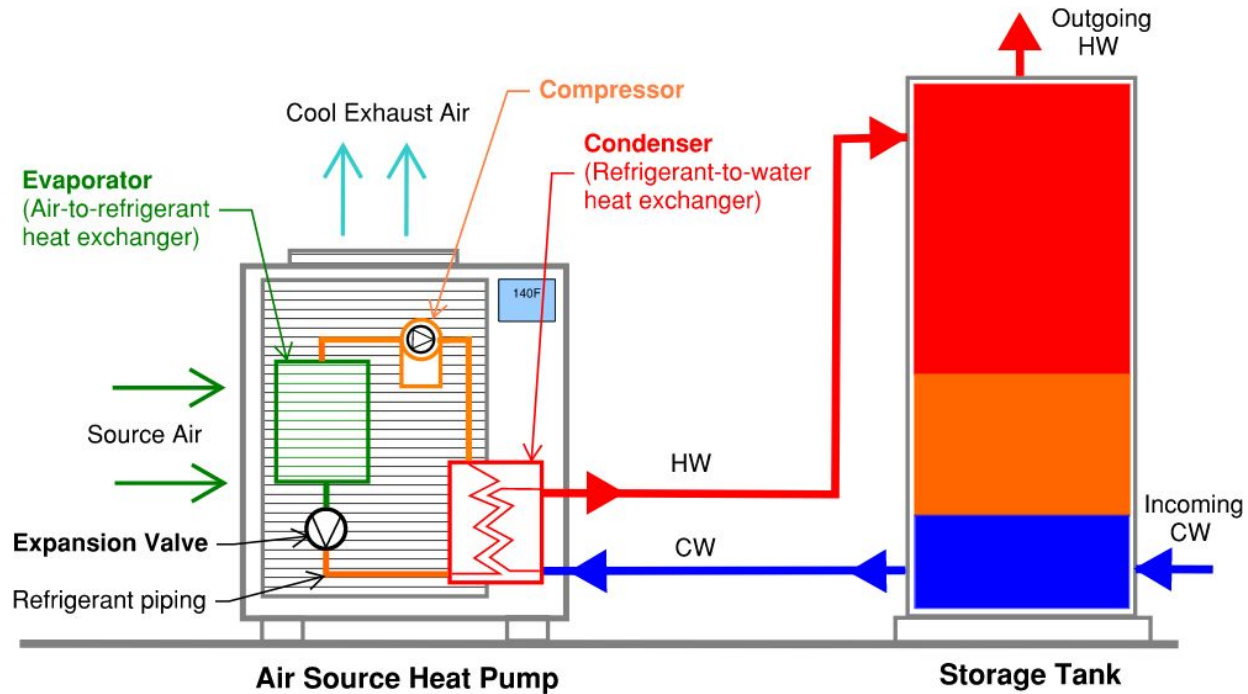
# PRIMARY HEAT PUMP



PRIMARY HP = ENGINE

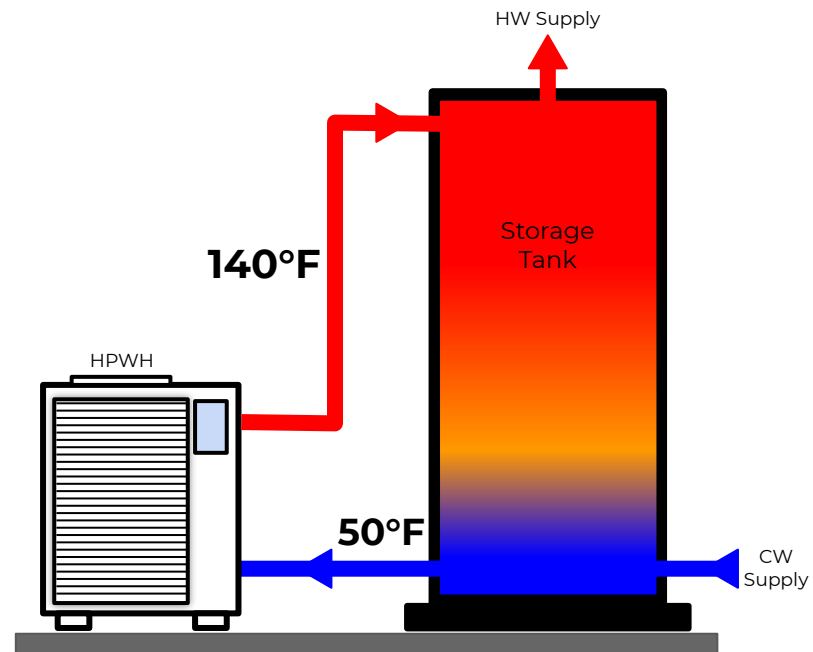
# HOW HEAT PUMPS WORK

Air Source Heat Pump with Storage Tank



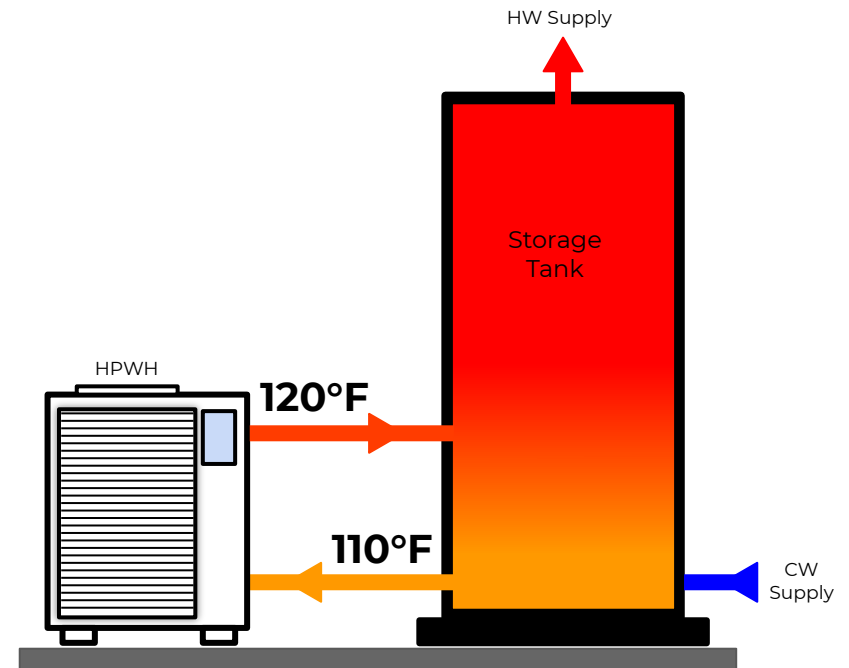
**Moving HEAT**  
(not making heat)

## 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)*

# HEAT PUMP PERFORMANCE

## EFFICIENCY IMPACTS:

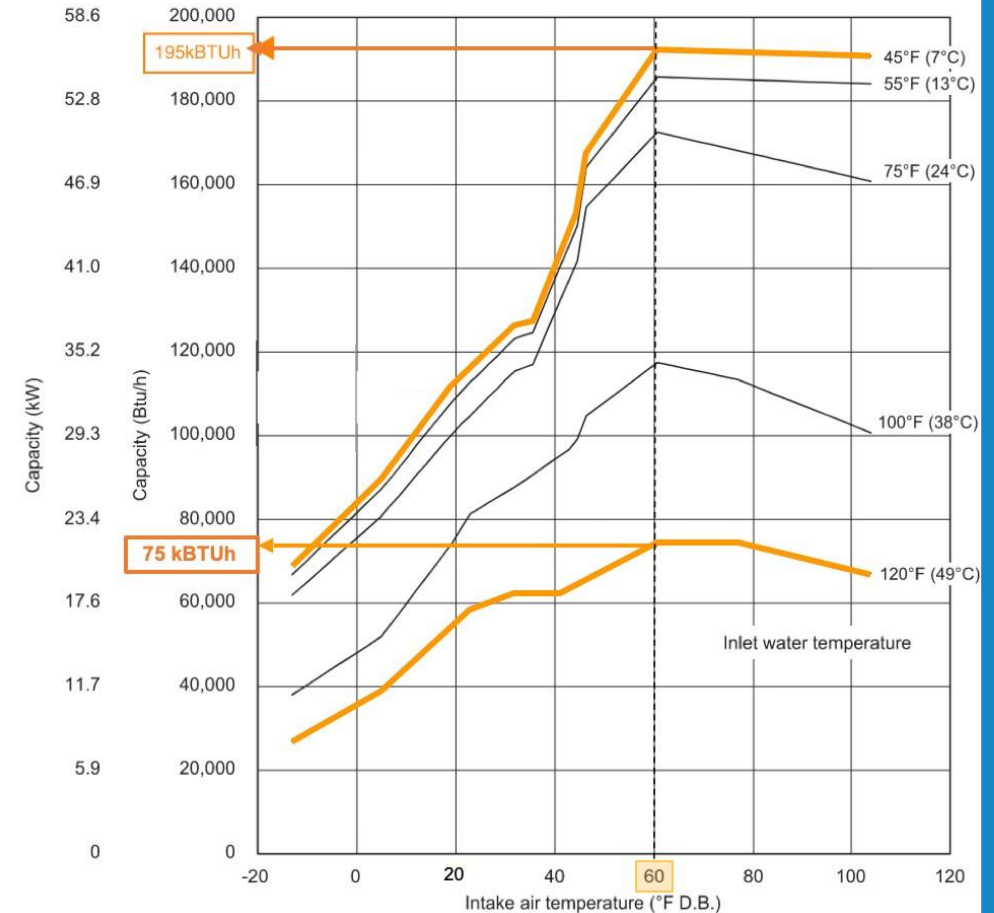
- Lower Air Temperature
- Warmer Entering Water
- Warmer Leaving Water

## CAPACITY IMPACTS:

- Limits of Refrigerant
- Lower Air Temperature
- Defrost Effects
- Warmer Entering Water

Outlet water temperature 150°F (66°C)

Max capacity operation mode

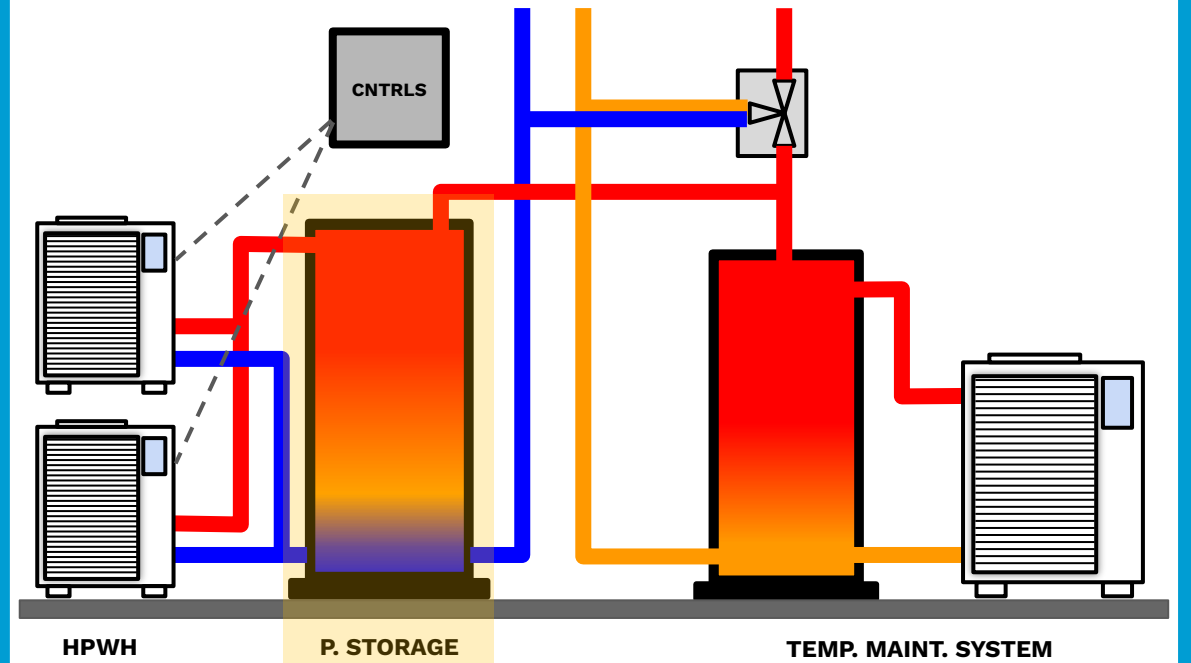


# HPWH **CONSIDERATIONS**



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

# CHPWH COMPONENTS: PRIMARY STORAGE



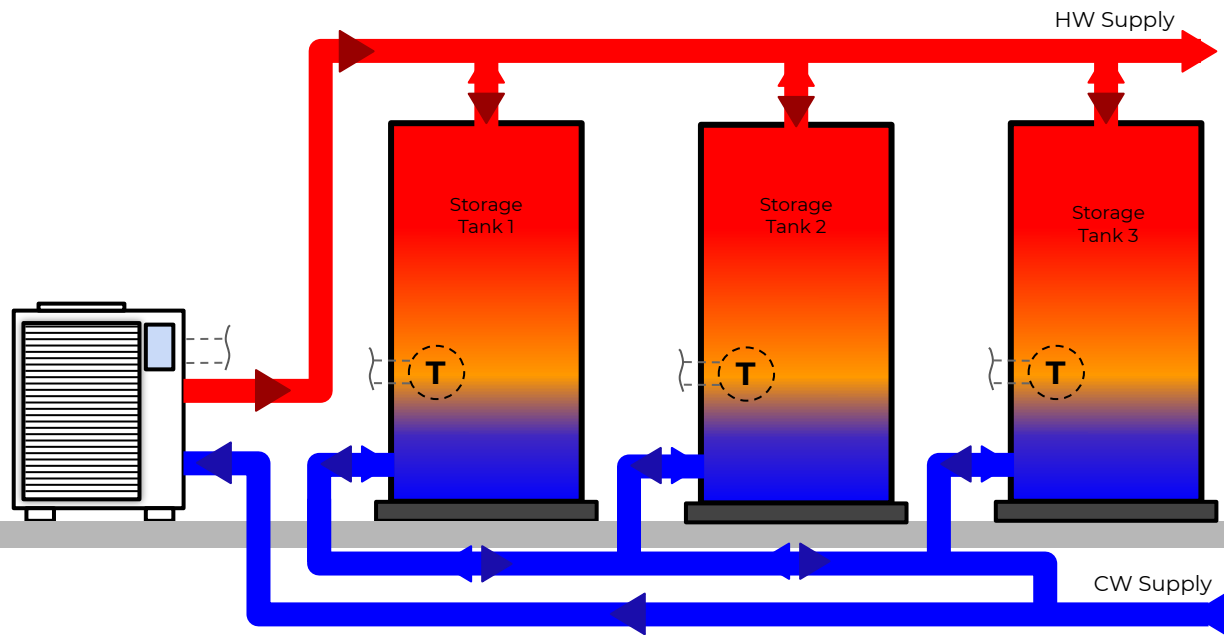
## PRIMARY STORAGE TANK(S)



## A BATTERY BANK

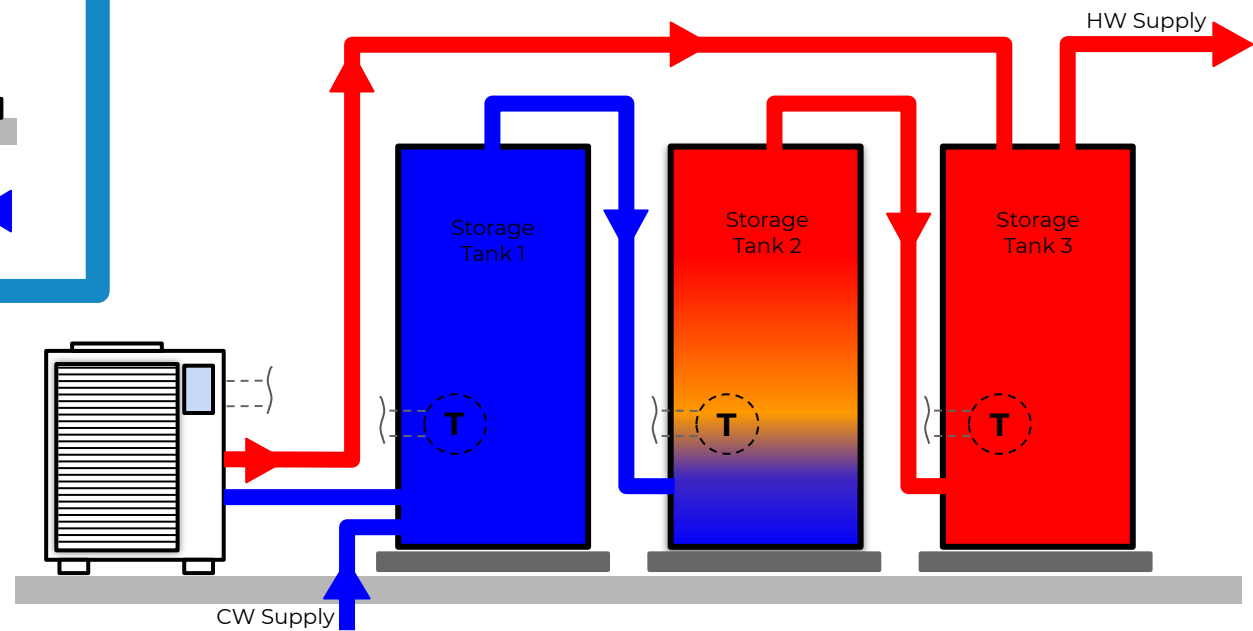


# PRIMARY STORAGE PLUMBING

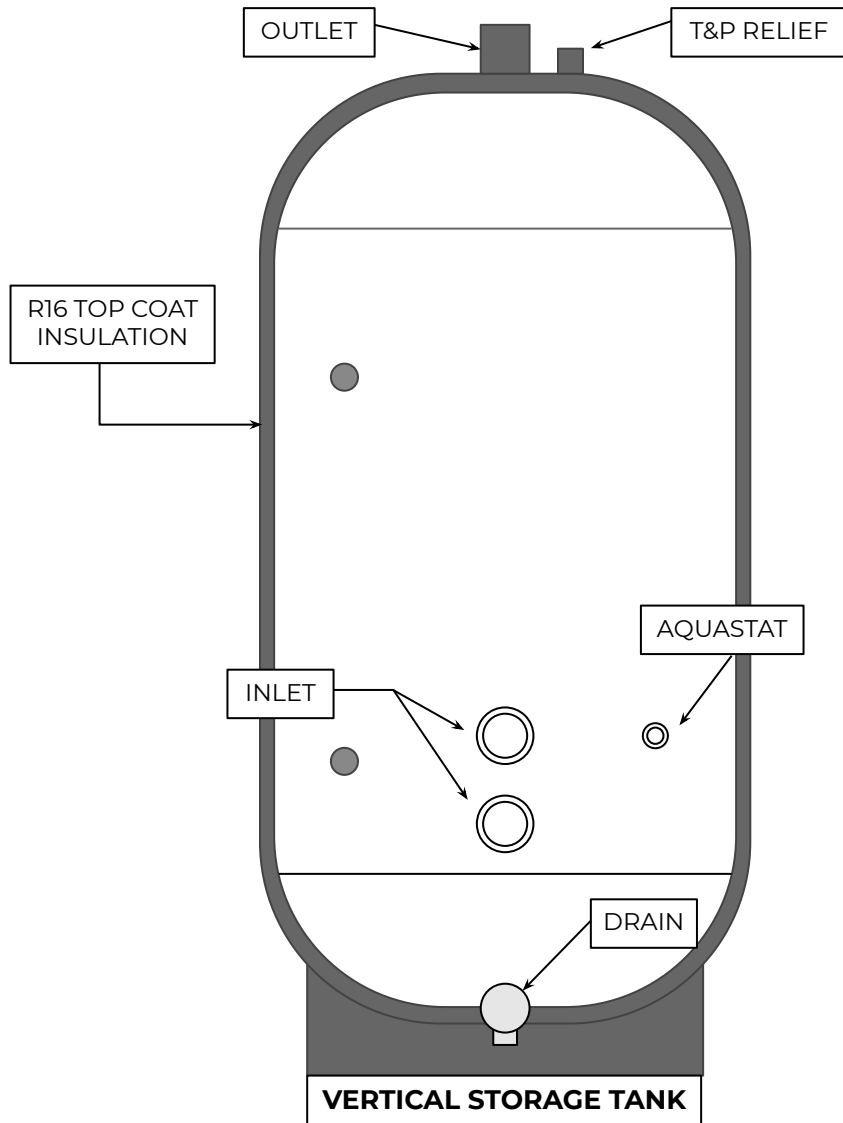


IN SERIES

IN PARALLEL



# HW STORAGE **CONSIDERATIONS**

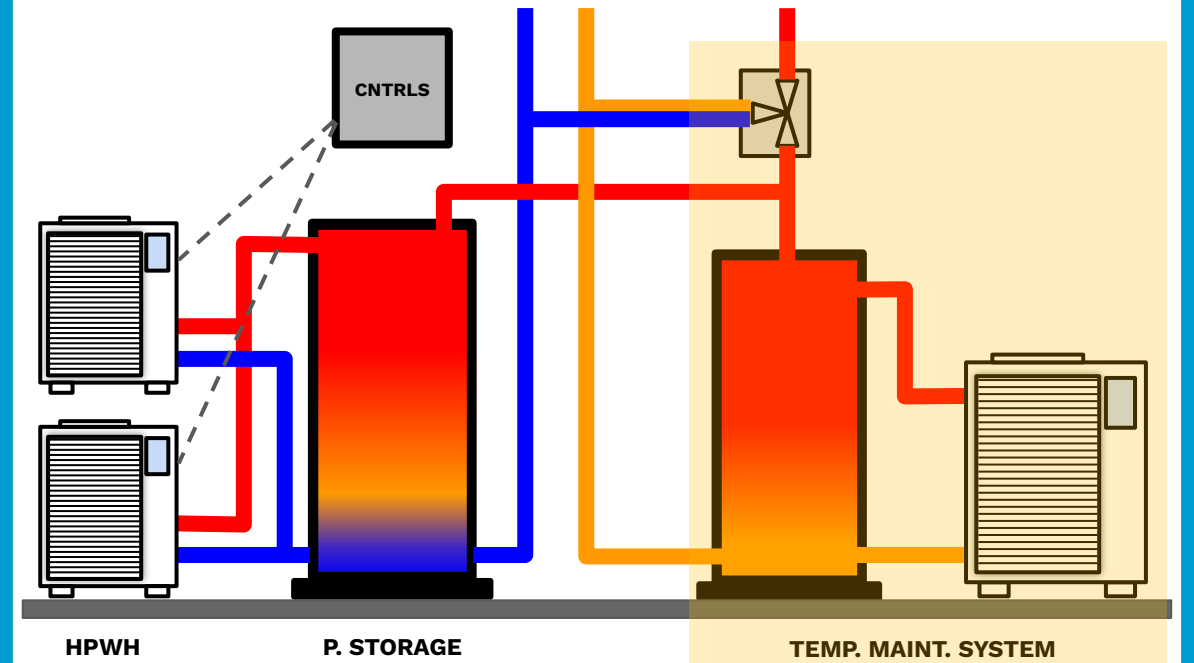


- Physical space, room & door size
- Vertical is better than horizontal
- Multiple tanks, series or parallel?
- Height of control sensor(s)
- Pipe connections, size & location
- Insulation level
- Thermal isolation
- Maintenance & access

The background of the slide is a photograph of an industrial facility, likely a refinery or chemical plant. It features a complex network of large, dark-colored pipes and structural steel beams. The lighting is somewhat dim, with a blueish-grey tint overall, and a darker, reddish-brown gradient overlay on the left side. The text "LET'S PAUSE FOR QUESTIONS" is centered in a bold, white, sans-serif font.

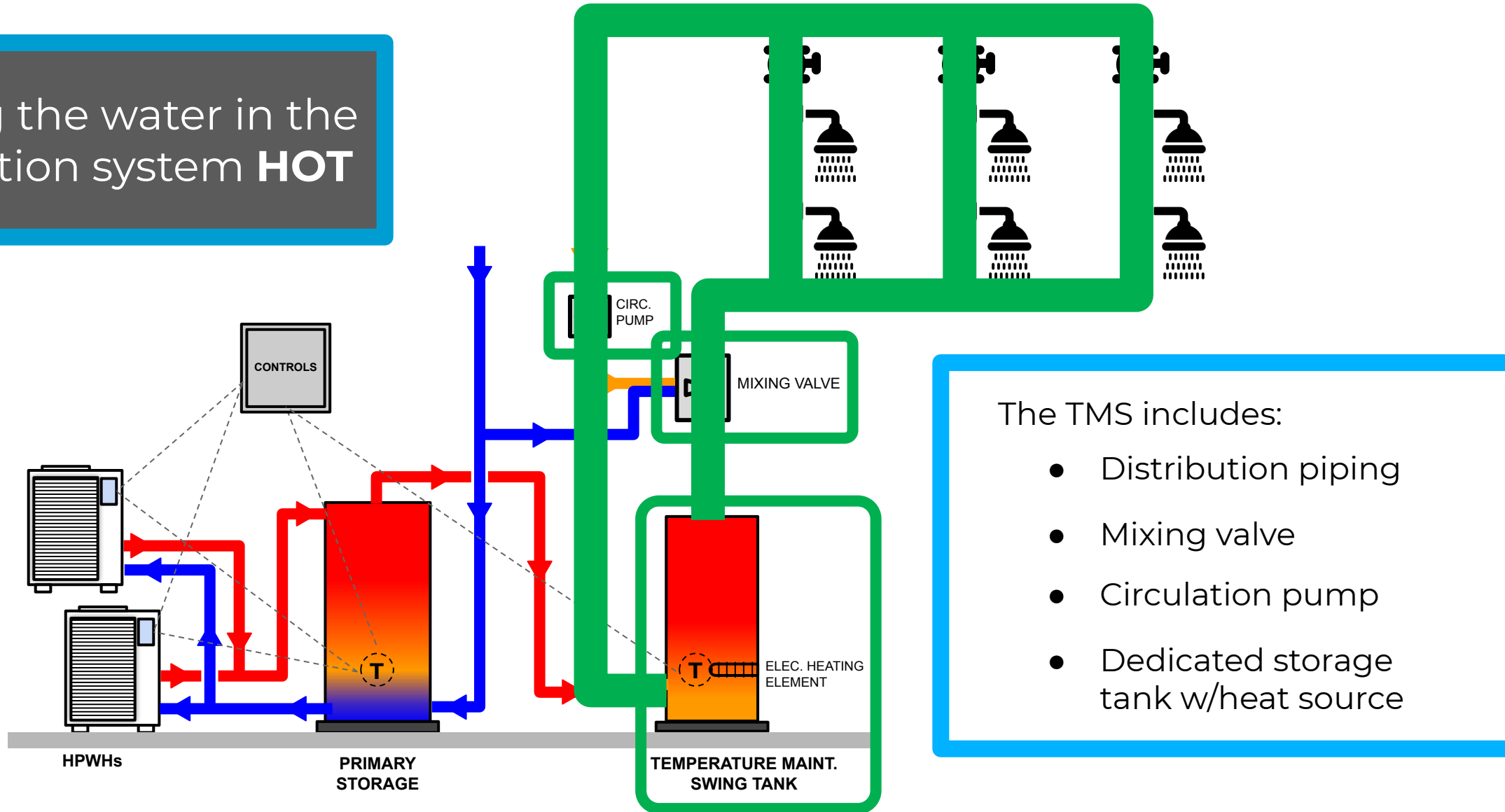
**LET'S PAUSE FOR QUESTIONS**

# CHPWH COMPONENTS: TEMPERATURE MAINTENANCE SYSTEM



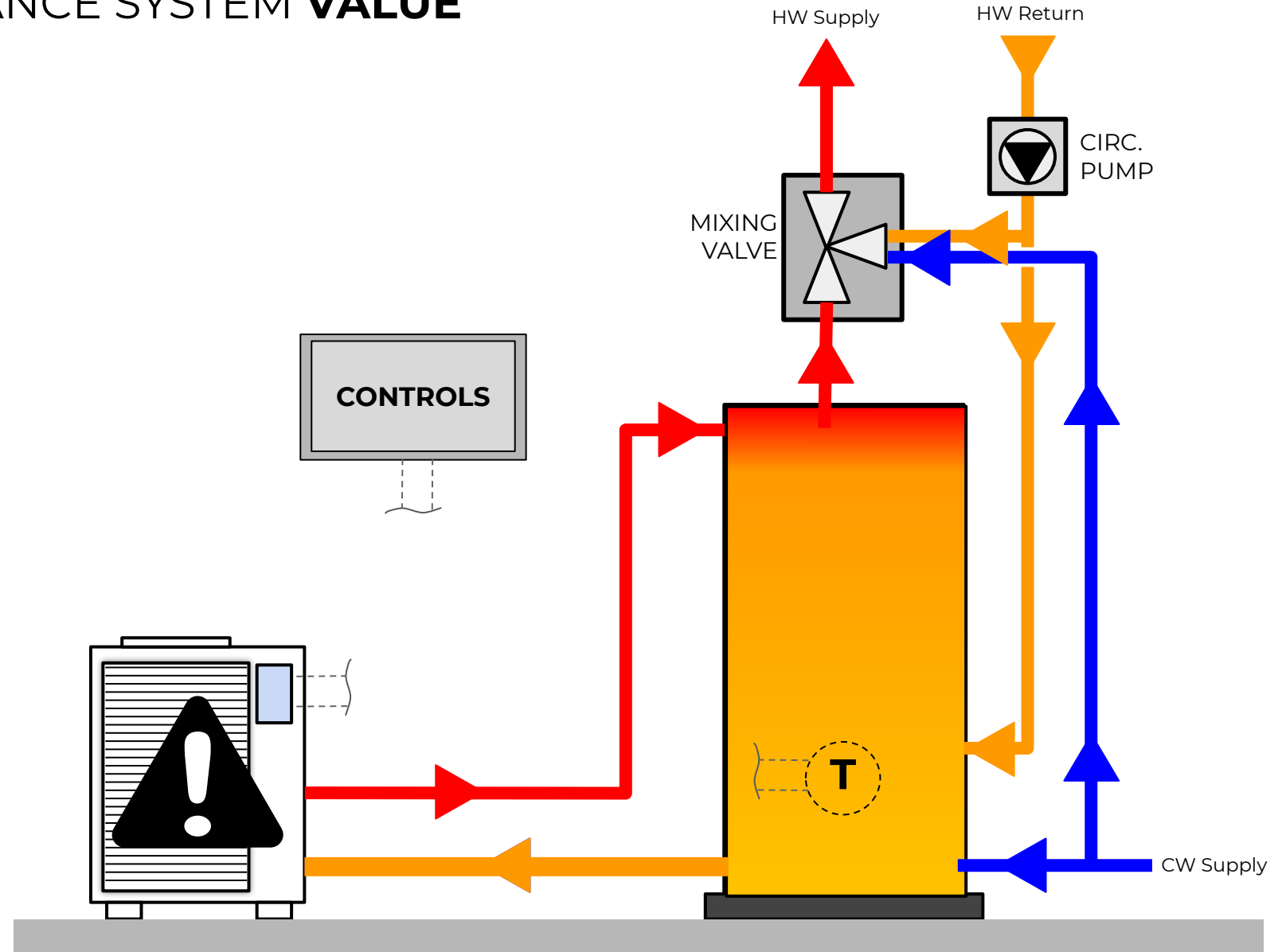
# TEMPERATURE MAINTENANCE SYSTEM

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



# TEMPERATURE MAINTENANCE SYSTEM **VALUE**

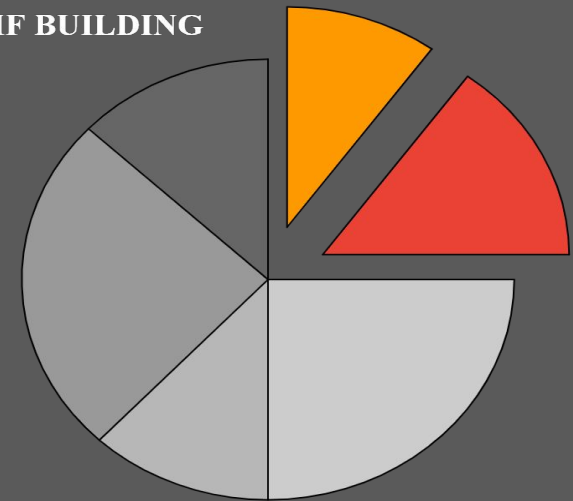
- HPs are very efficient at making **cold** water **hot**
- HW circulates through the distribution piping
- Water returns from the building slightly cooled
- Return water causes **mixing & destratification** in the storage tank
- HPs are not very good at making **warm** water **hot**



## TEMPERATURE MAINTENANCE: **HW CIRCULATION**



MF BUILDING

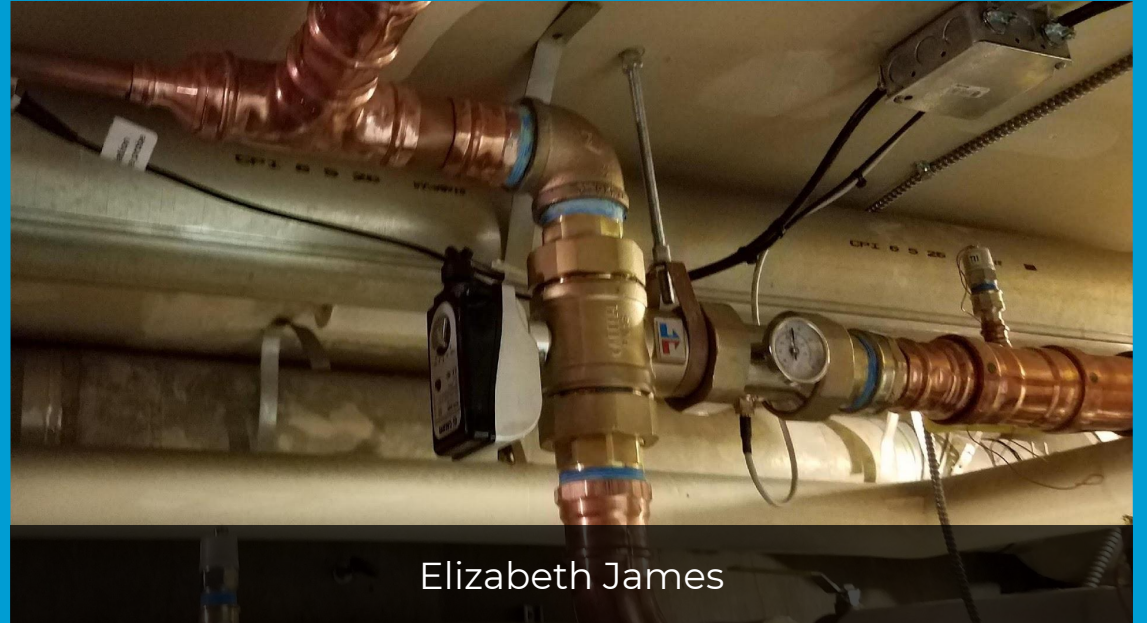


A SMALL CONSTANT LOAD THAT **ADDS UP**

# THERMOSTATIC MIXING VALVE **SIZING**



Jackson Apartments



Elizabeth James

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

The diagram illustrates a district heating system architecture. It features three main components: HPWH (Heat Pump Water Heater) on the left, P. STORAGE (Primary Storage) in the center, and TEMP. MAINT. SYSTEM (Temperature Maintenance System) on the right. A central CNTRLS (Control) unit is shown at the top. The system is connected by a network of red, blue, and yellow pipes. The HPWH and P. STORAGE are connected by red and blue pipes. The P. STORAGE and TEMP. MAINT. SYSTEM are connected by red and blue pipes. The TEMP. MAINT. SYSTEM is also connected to a yellow pipe network. The CNTRLS unit is connected to the red and blue pipes of the P. STORAGE and the yellow pipe network of the TEMP. MAINT. SYSTEM.

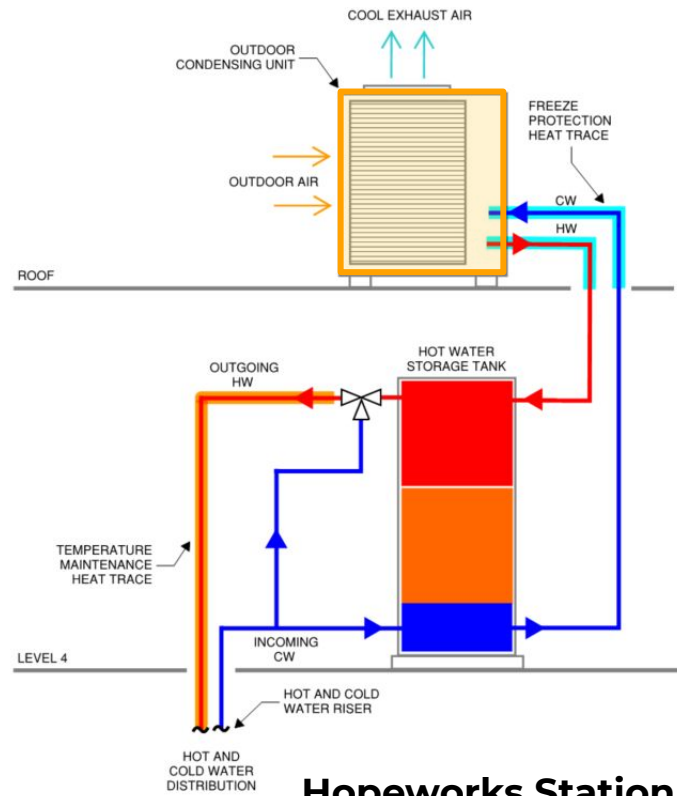
# CONTROL OPTIONS

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

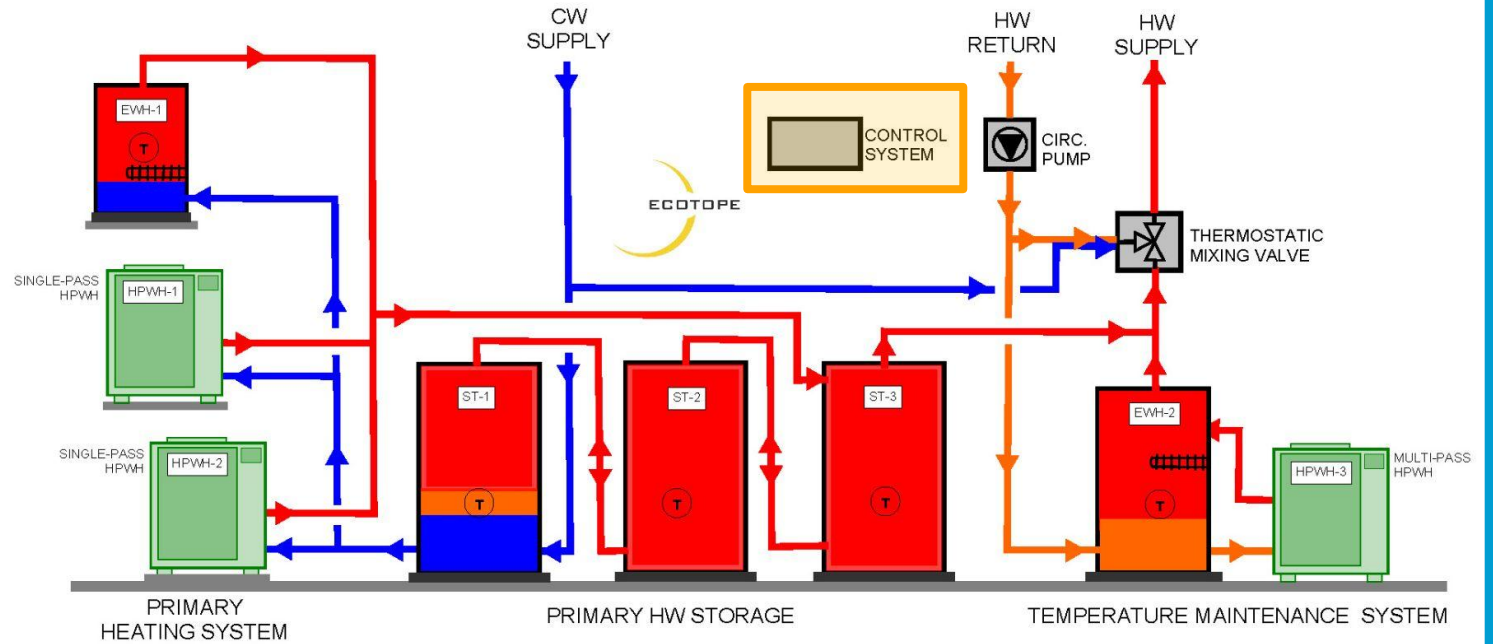


# CONTROL OPTIONS

Controls can be **INTERNAL** or **THIRD PARTY**



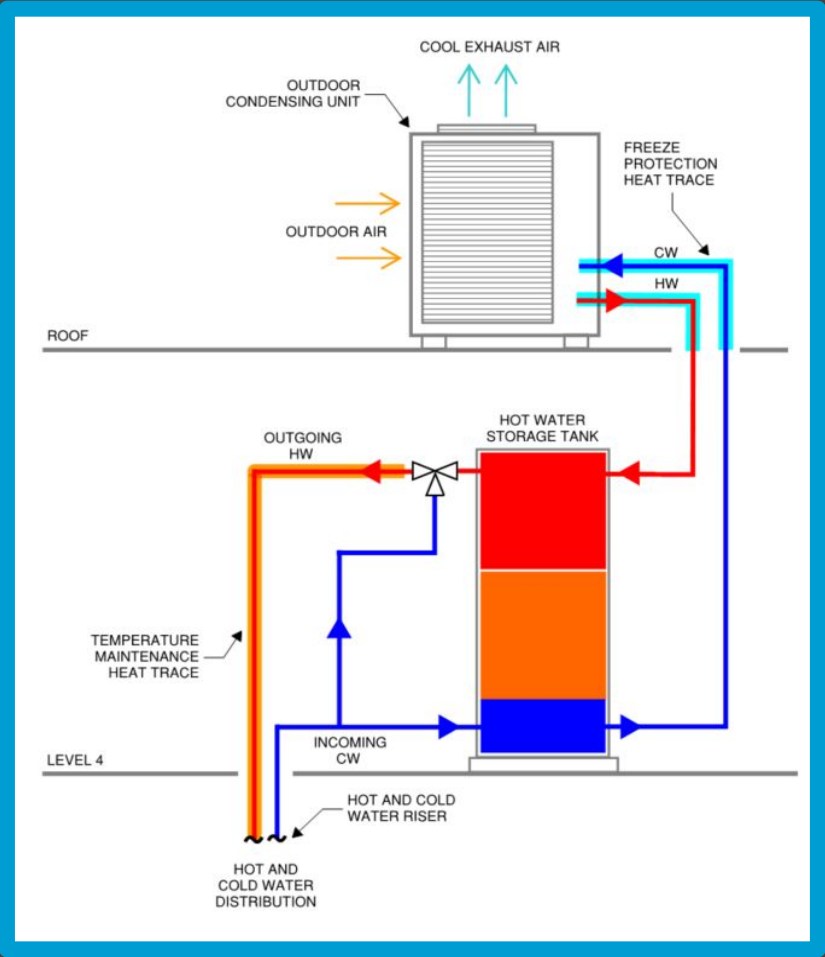
INTERNAL



**JACKSON APARTMENTS  
HEAT PUMP WATER HEATING SYSTEM**

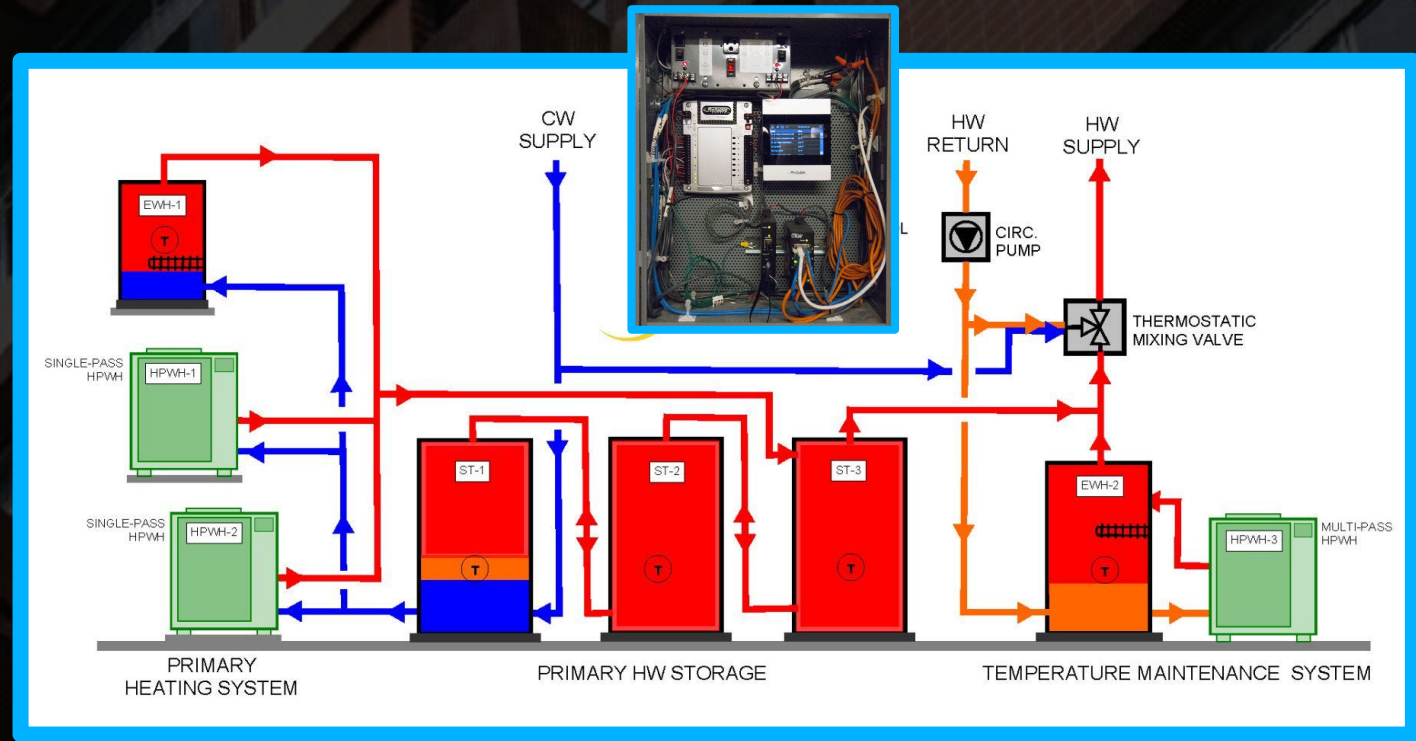
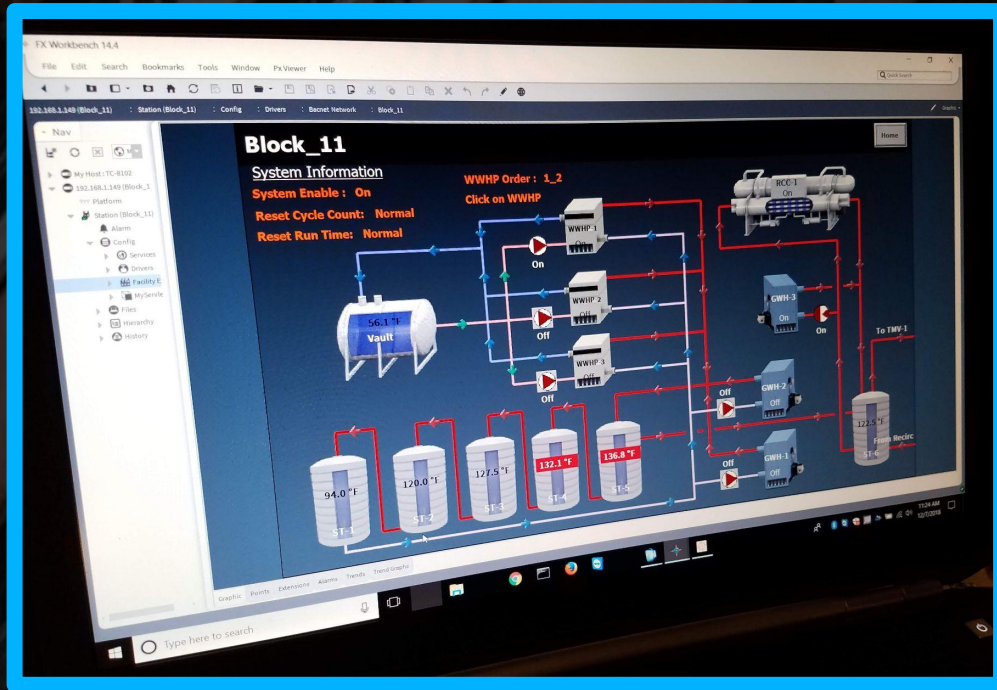
THIRD PARTY

# CHPWH CONTROL SYSTEM: **INTERNAL**



INTERNAL


# CHPWH CONTROL SYSTEM: **THIRD PARTY**



THIRD PARTY

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**LET'S PAUSE FOR QUESTIONS**

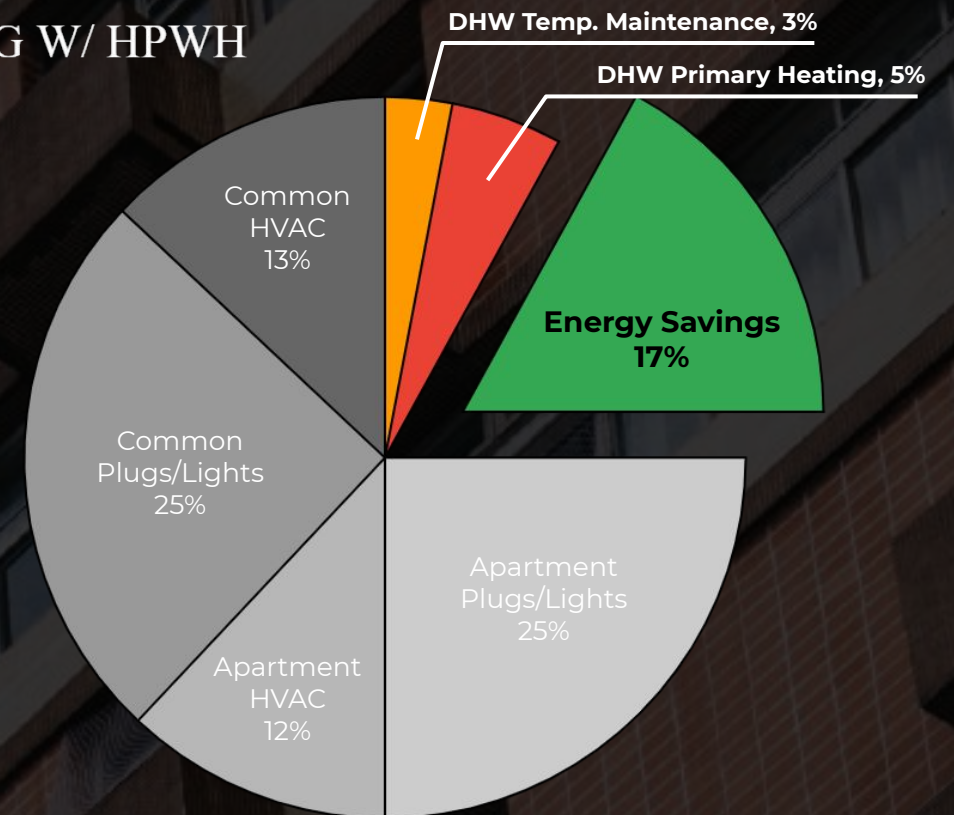
The background image shows an industrial facility with various pipes, valves, and structural elements. A blue border is overlaid on the left side of the image. The text is centered on the left side of the image.

**IS THIS PROJECT A  
CANDIDATE FOR A  
CHPWH SYSTEM?**

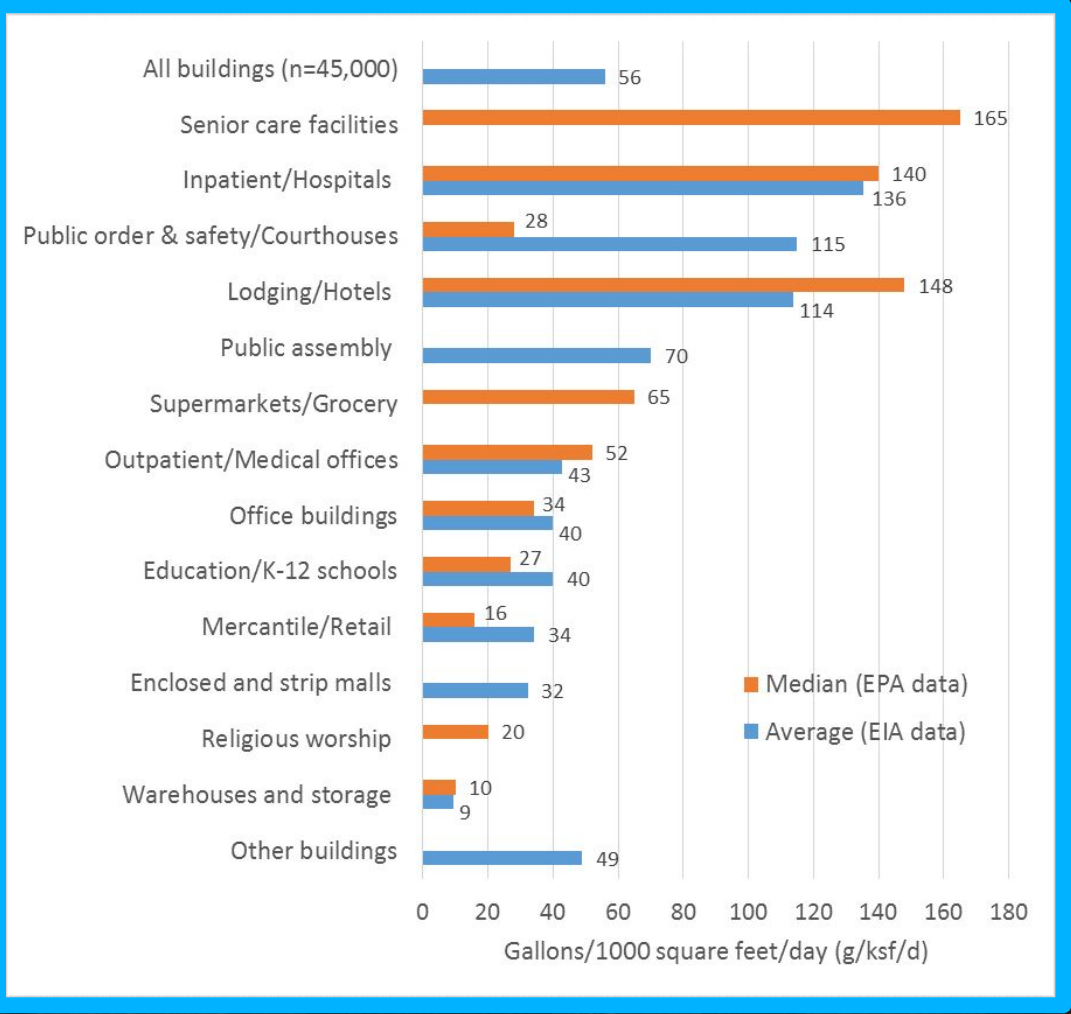
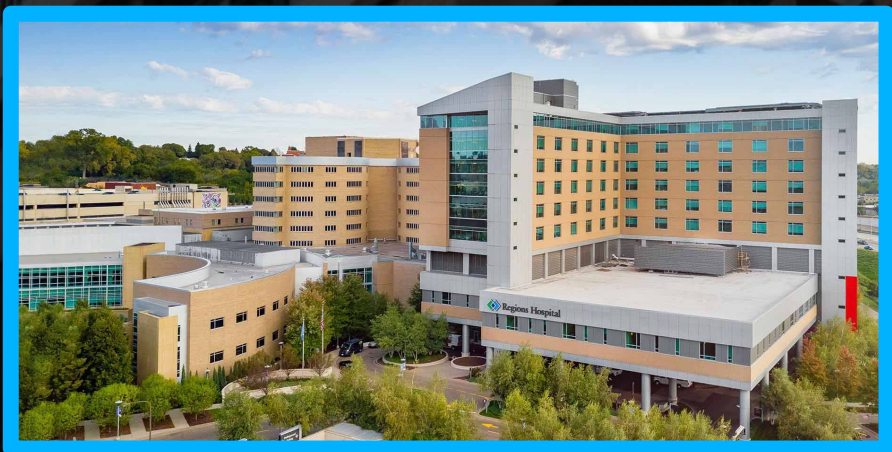
# HOT WATER USAGE



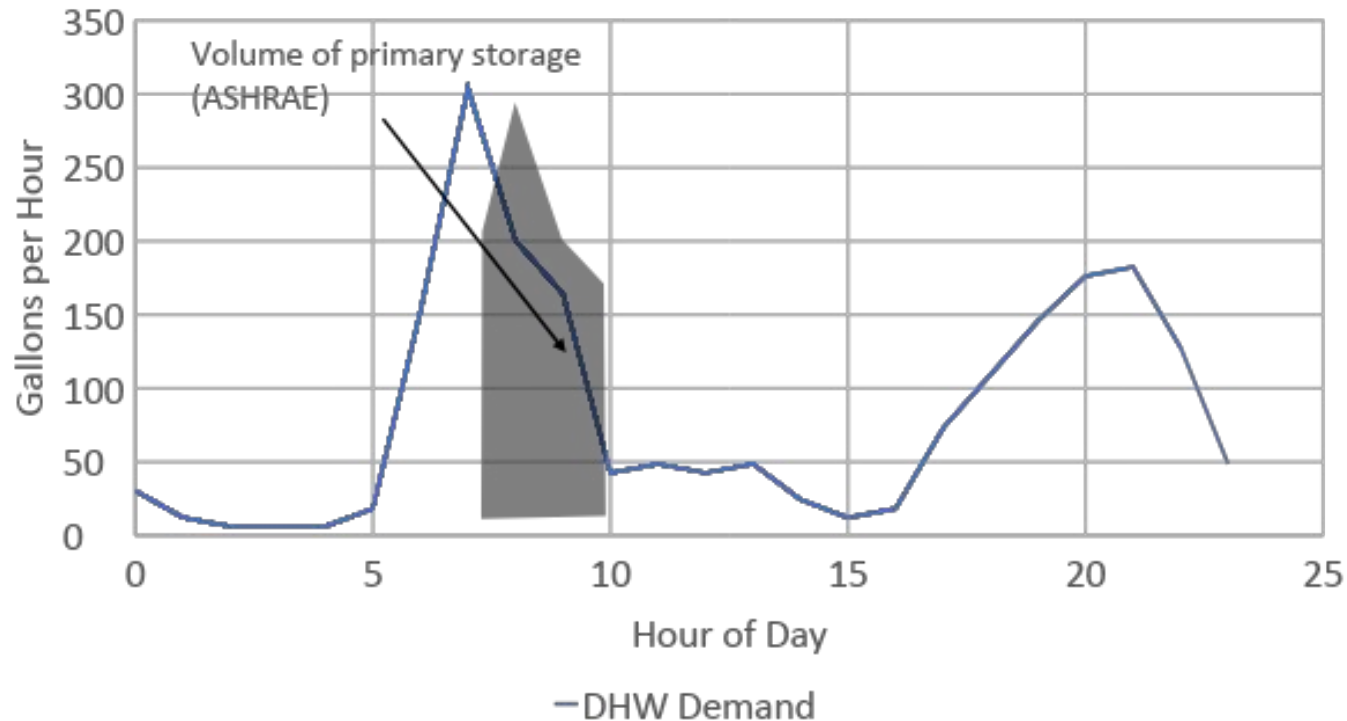
MF BUILDING W/ HPWH



# HOT WATER USAGE



# OCCUPANCY & DHW LOAD



## IS IT A CANDIDATE?

- ◆ It makes sense for all **building applications**
- ◆ Biggest payback if:
  - ◆ **24/7** occupancy
  - ◆ High **DHW Load**

**ECOSIZER**

<https://ecosizer.ecotope.com/sizer/>

## RECAP:

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



## 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?

## 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](mailto:LBHASKAR@DRINTL.COM)



**Seattle City Light**



# UPCOMING TRAINING & RESOURCES

## SDGE 2021

([SDGE.COM/ENERGY-INNOVATION-CENTER/EDUCATION-TRAINING](https://sdge.com/energy-innovation-center/education-training))



### CHPWH ONLINE EDUCATION - *launched October 15th!*

- *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*

To host a training session, or for more information, contact:  
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THANK YOU

