We will be starting soon!

Thanks for joining us

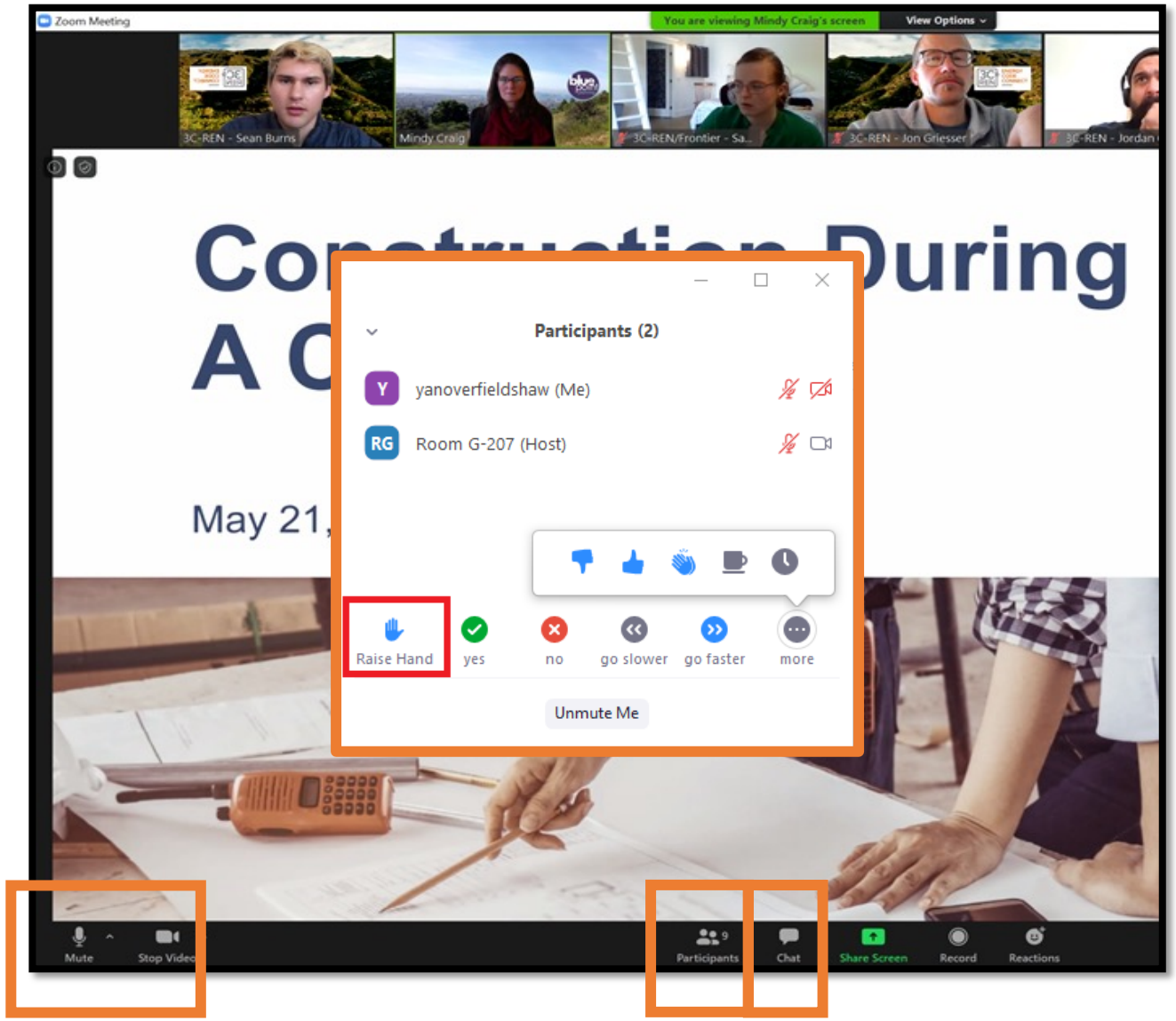
Multi-Family Domestic Hot Water

Albert Rooks and Eva Rooks – Small Planet Supply

March 28, 2024

Zoom Orientation

- Please be sure your full name is displayed
- Please mute upon joining
- Use "Chat“ box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be recorded and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region

3C REN ENERGY CODE CONNECT

3C REN BUILDING PERFORMANCE TRAINING

3C REN HOME ENERGY SAVINGS

3C REN ENERGY CODE CONNECT

- Serves all building professionals
- Three services –
  - **Energy Code Coach**
  - **Training and Support**
  - **Regional Forums**
- Makes the Energy Code easy to follow

Energy Code Coach:
3c-ren.org/codes
805.781.1201

Event Registration:
3c-ren.org/events

BUILDING PERFORMANCE TRAINING

- Serves current and prospective building professionals
- Expert instruction:
  - **Technical skills**
  - **Soft skills**
- Helps workers to thrive in an evolving industry

Event Registration:
3c-ren.org/events

3C REN HOME ENERGY SAVINGS

Multifamily (5+ units)

- No cost technical assistance
- Rebates up to $750/apartment plus additional rebates for specialty measures like heat pumps

Single Family (up to 4 units)

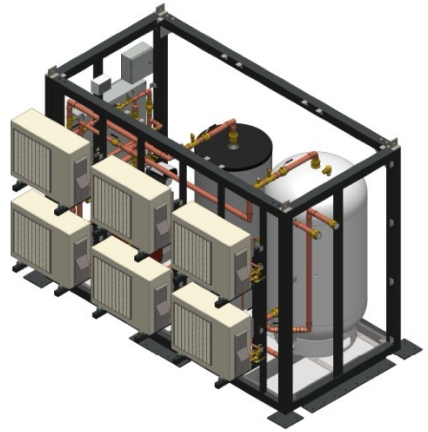
- Sign up to participate!
- Get paid for the metered energy savings of your customers

Enrollment:
3C-REN.org/contractor-participation

WaterDrop Systems

Drop-In - Plug and Play - Central Plants for Domestic Hot Water

Albert Rooks, CEO



Multi Partner – Multiyear Application Study

Ken Eklund – Washington State University

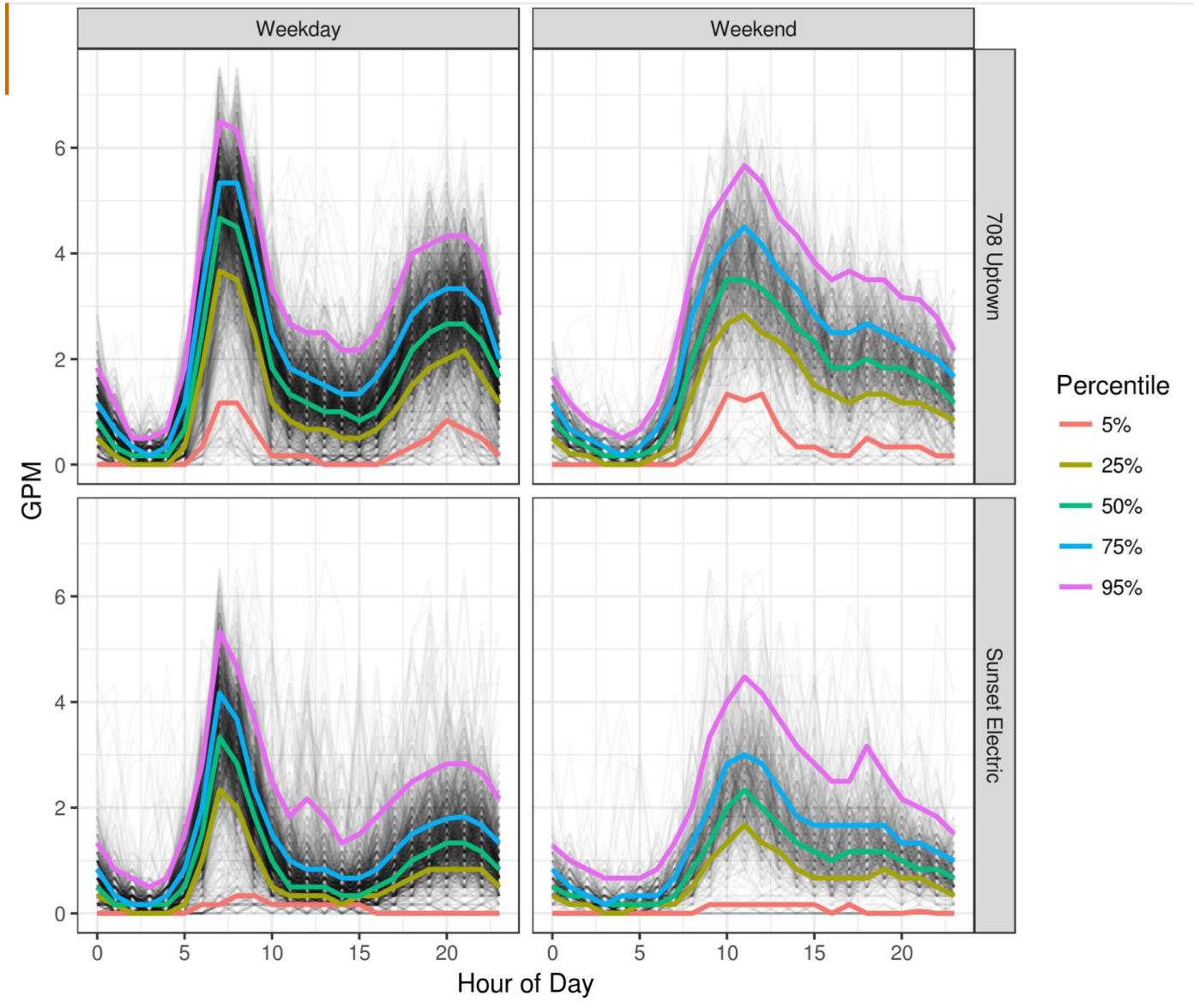
2019 HPWH Training

The Shift

Moving to heat pump DHW - Is moving from ***Recovery*** to ***Storage***

The Load

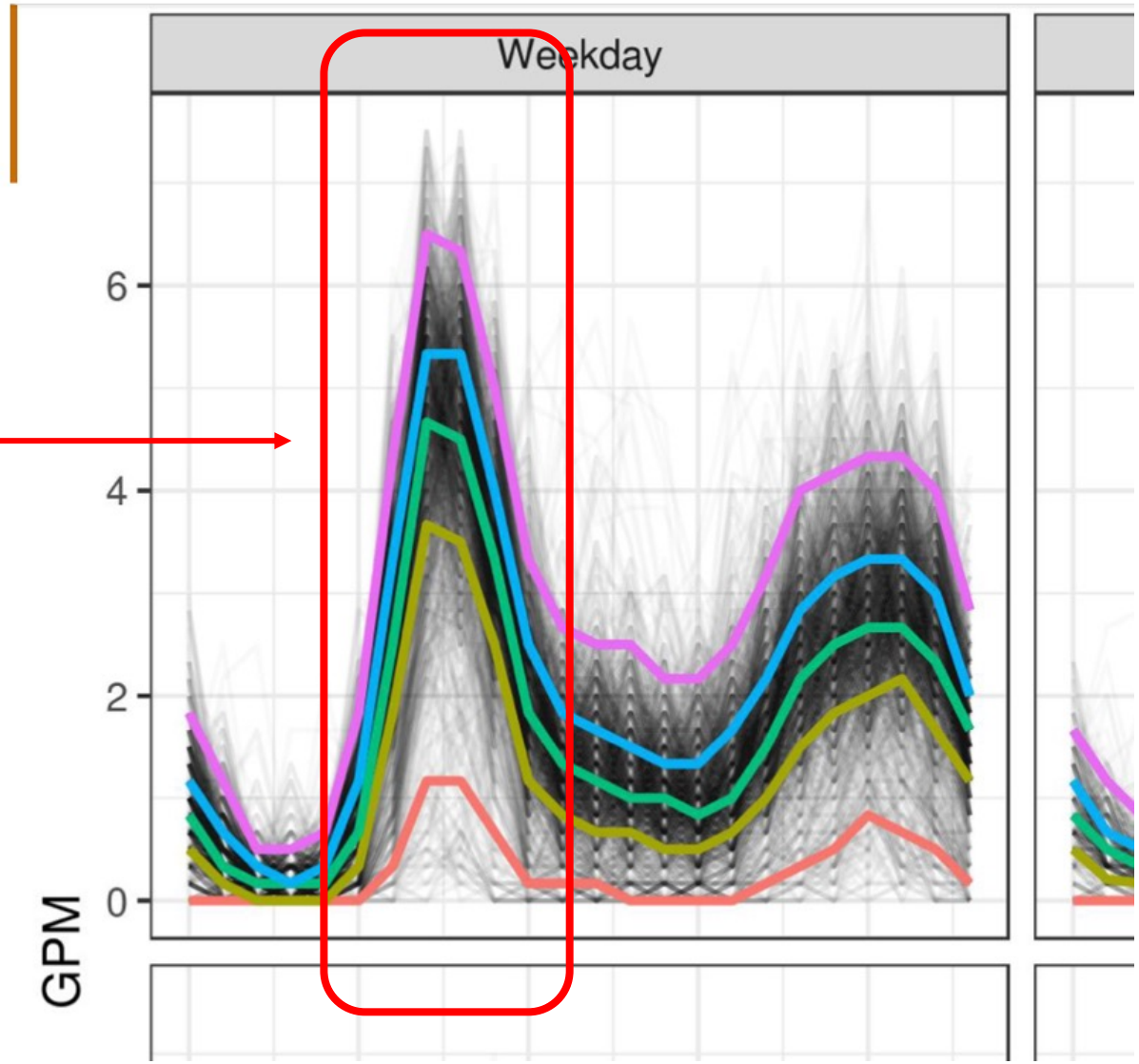
- These are two residential apartment buildings in Seattle WA.
- Normally the gas boiler would be sized to meet the peak flow with very little storage.
- Then there would be the tendency to oversize. Just a little…
- Boilers have high recovery capacity.



Courtesy of Ecotope

Heat Pump Strategy

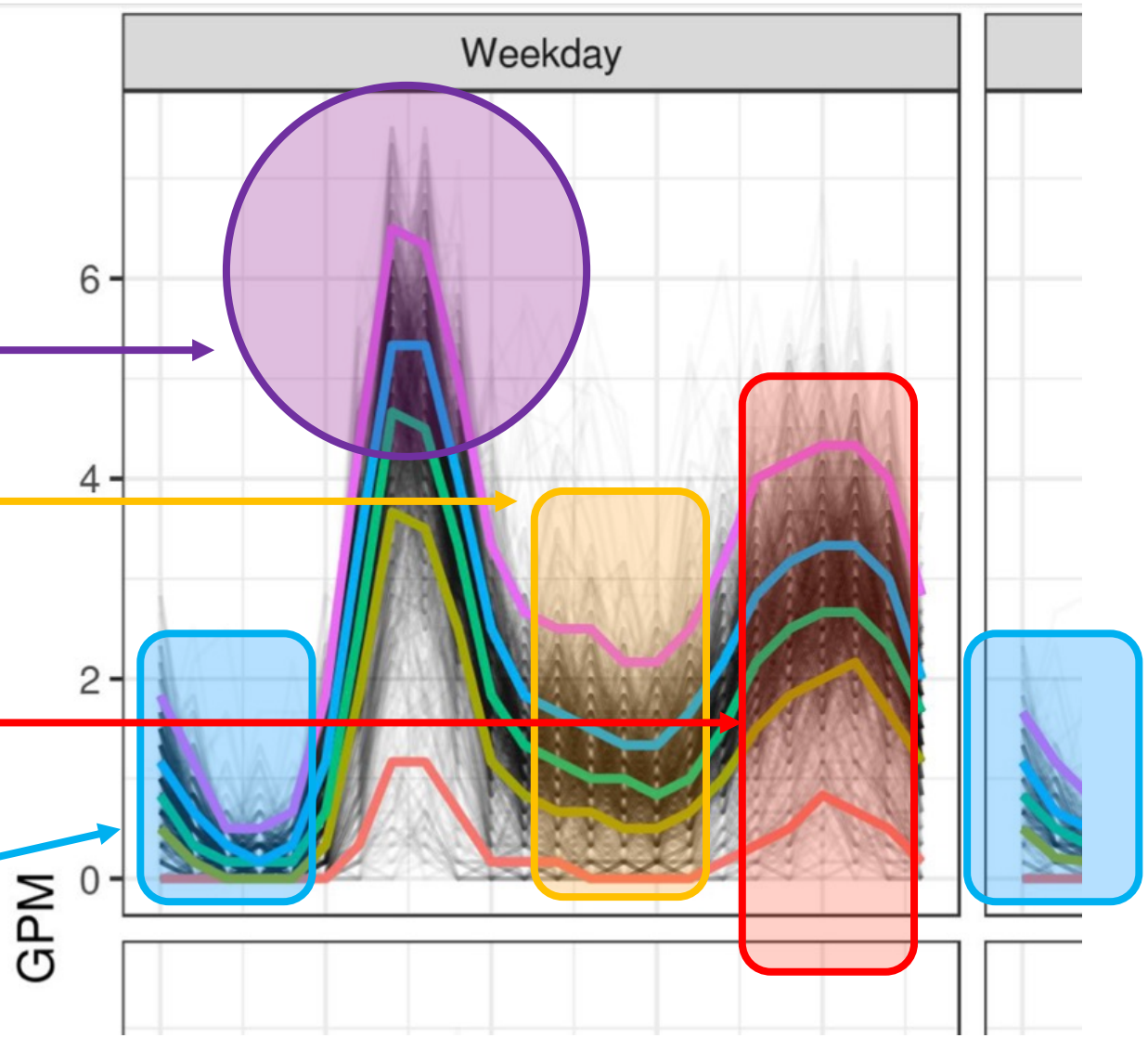
- Build storage ahead of draw.
- Size storage to meet the peak loads. In residential buildings this is the morning peak.
- Heat pump capacity is sized to recover the peak in 4 to 8 hours. The recovery rate is developed by load patterns, renewable energy strategy, and equipment utilizations.



Courtesy of Ecotope

Load Shape

- Morning draw served by storage
- Daytime recovery rebuilds storage.
- Evening Draw takes some storage
- Overnight recovers storage.



Courtesy of Ecotope

The nature of CO2

Super Critical – Super Good

Why We Like CO2

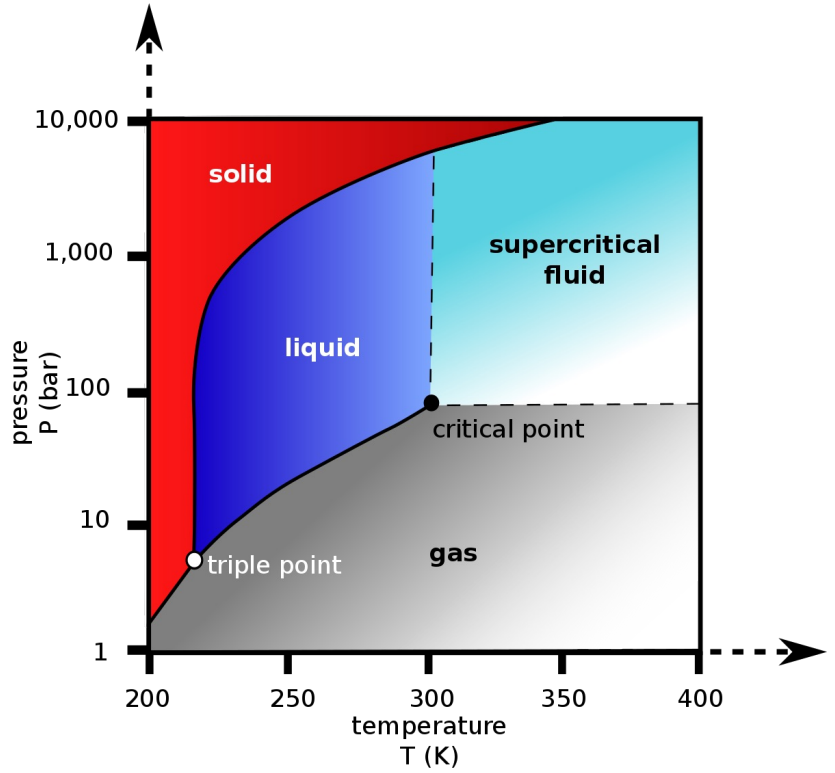
- Minimal Global Warming, approx. 1/1500th compared to “normal” refrigerants
- Non ozone depleting, Safe & secure
- It’s gets hot and crazy under pressure

	Refrigerant	ODP	GWP	Toxicity	Flammability	Notes
Fluorocarbon refrigerant	R134a	0	1,430	No	No	Refrigeration & HPWH
	R410A	0	2,086	No	No	HP, AC & HPWH
	R407C	0	1,800	No	No	HP & AC
Natural refrigerants	CO_2	0	1	No	No	
	Propane Gas	0	20	No	Yes	Flammable
	NH3 Ammonia	0	<1	Yes	Yes	Plume Study required

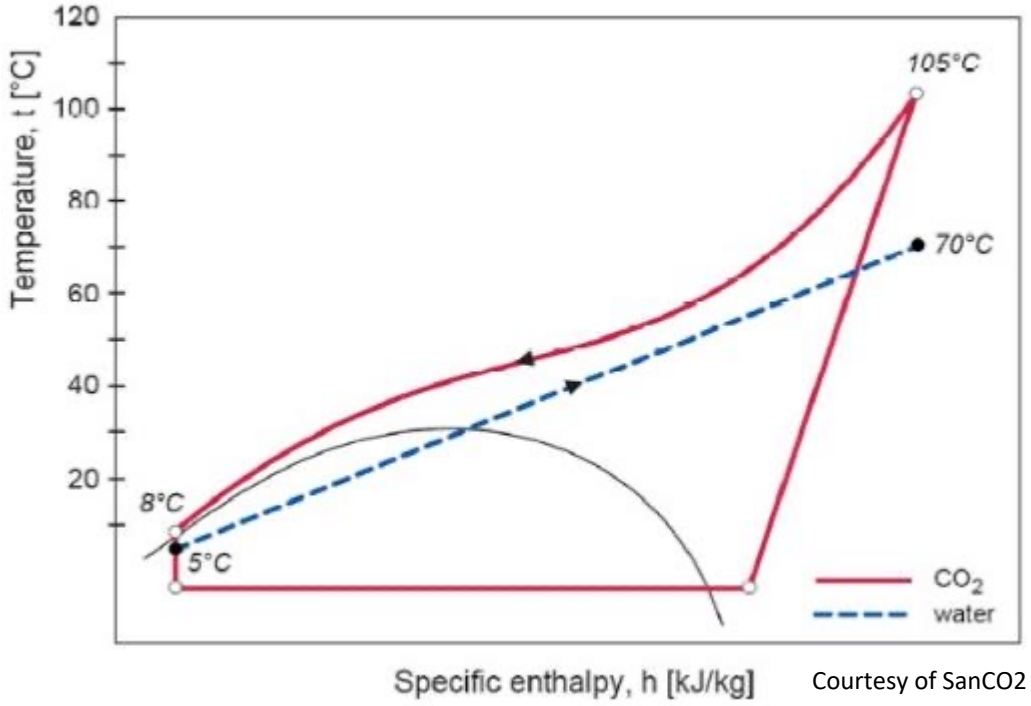
Courtesy of SanCO2

No Phase Change Means More COP

Super Critical Fluid will drop the heat quickly as pressure is released.



Heat drops from the gas/fluid onto the water with no phase change energy



Courtesy of SanCO2

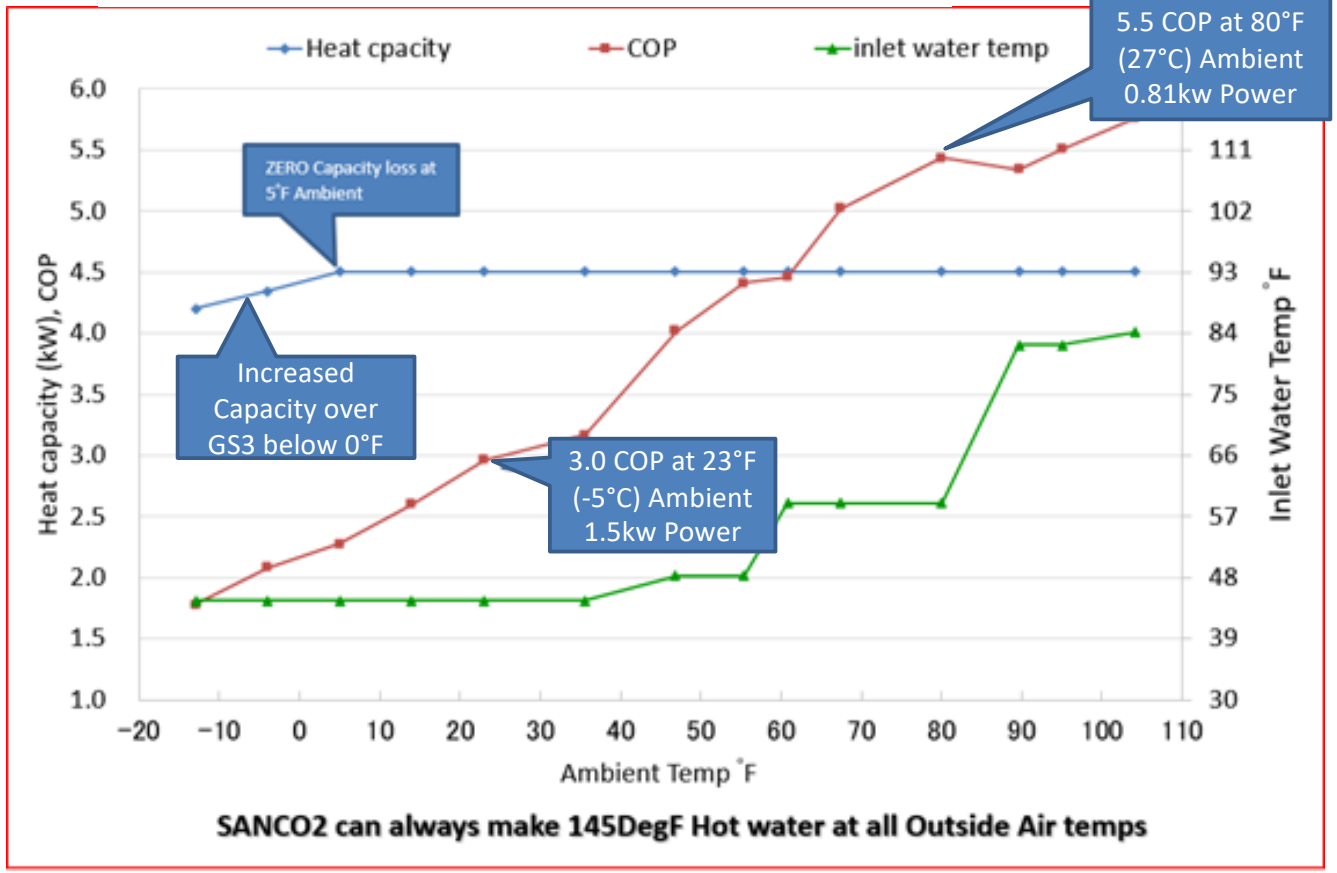
CO2 Works in the Cold

- 5.5 COP at 26C
- 4.5 COP at 15C
- 3.1 COP at freezing!
- 1.75 COP at -25C

Based on inverter driven compressor, fan, & water pump and a double wall heat exchanger.

GS4-45HPC COP

COP is defined as the ratio of Capacity/Power Input



SANCO2 can always make 145DegF Hot water at all Outside Air temps

Questions about the Shift to Heat Pumps or CO2 as a Refrigerant?

Up next – The Single Pass System

Lots of New Heat Pumps are Coming to Market

New HPWH products – Large CO2

> Laars
> Mestek/Transom
> Copeland CO2 compressor

New HPWH product – Synthetic Low GWP

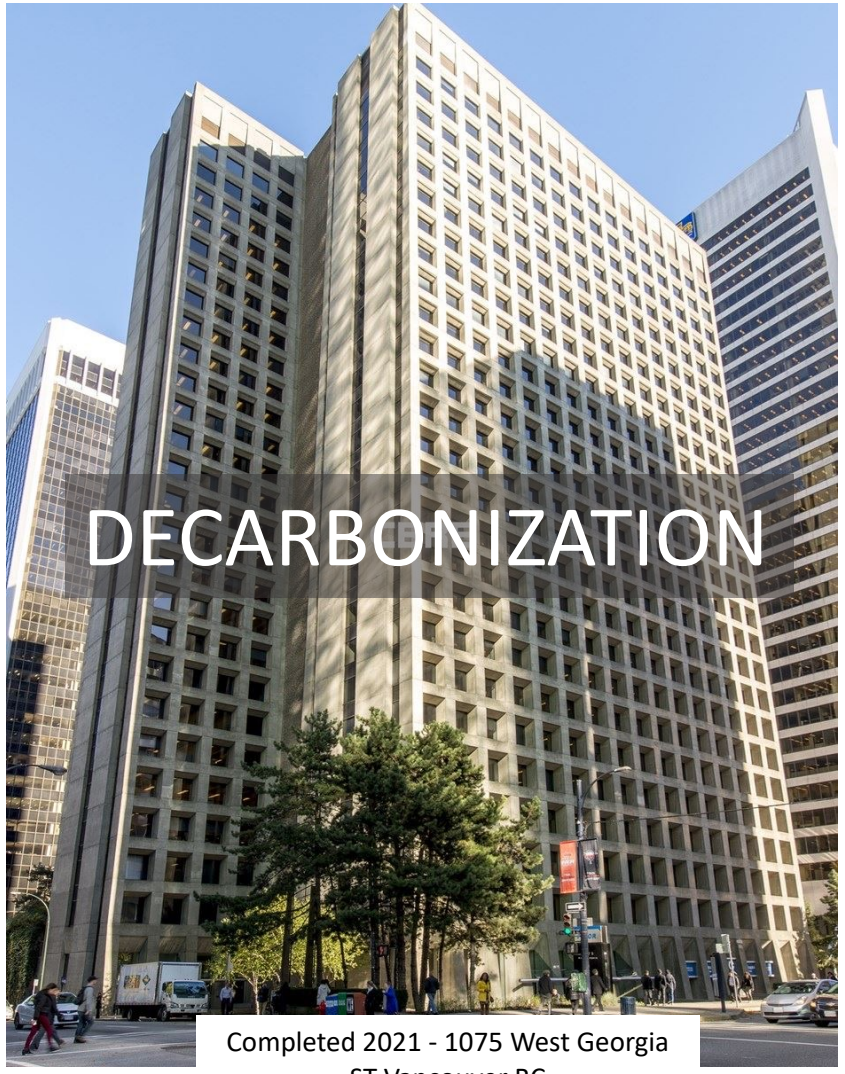
> Nyle R513a
> Colmac R513a

10 Heat Pumps

1 BMS Controller

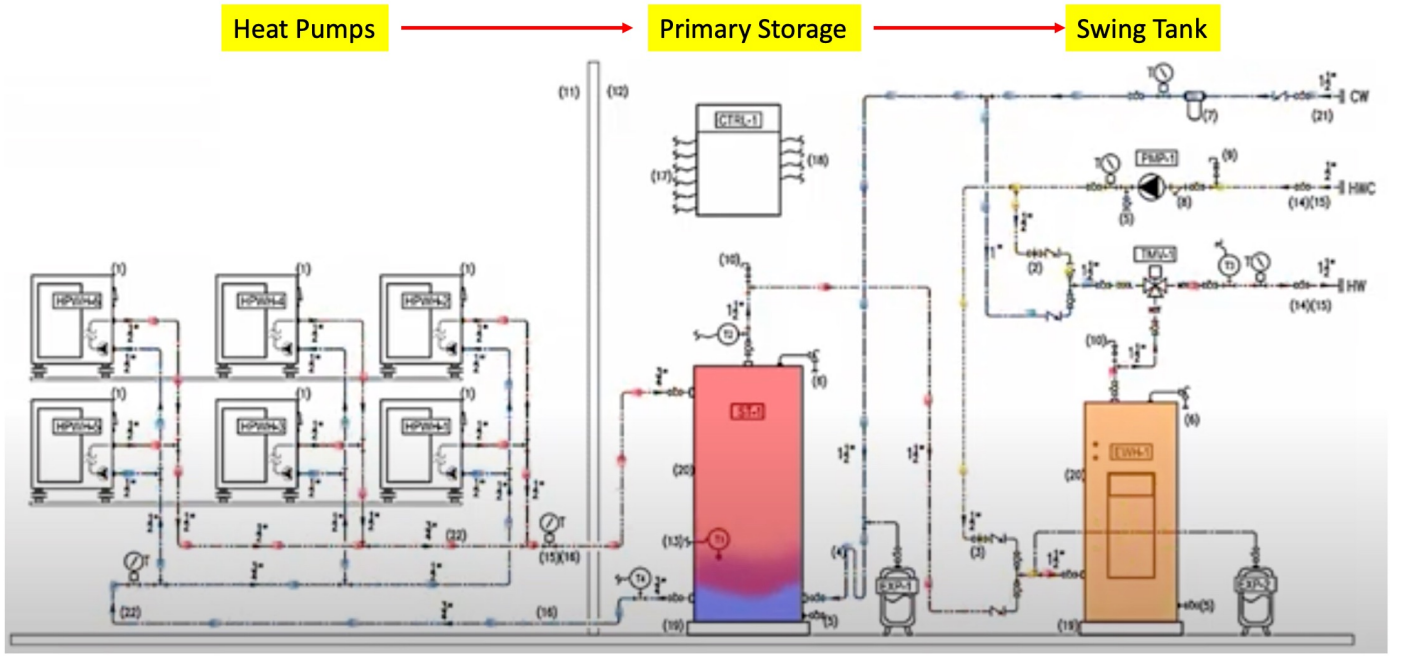
WATER DROP
Powered By SANCO2

DECARBONIZATION



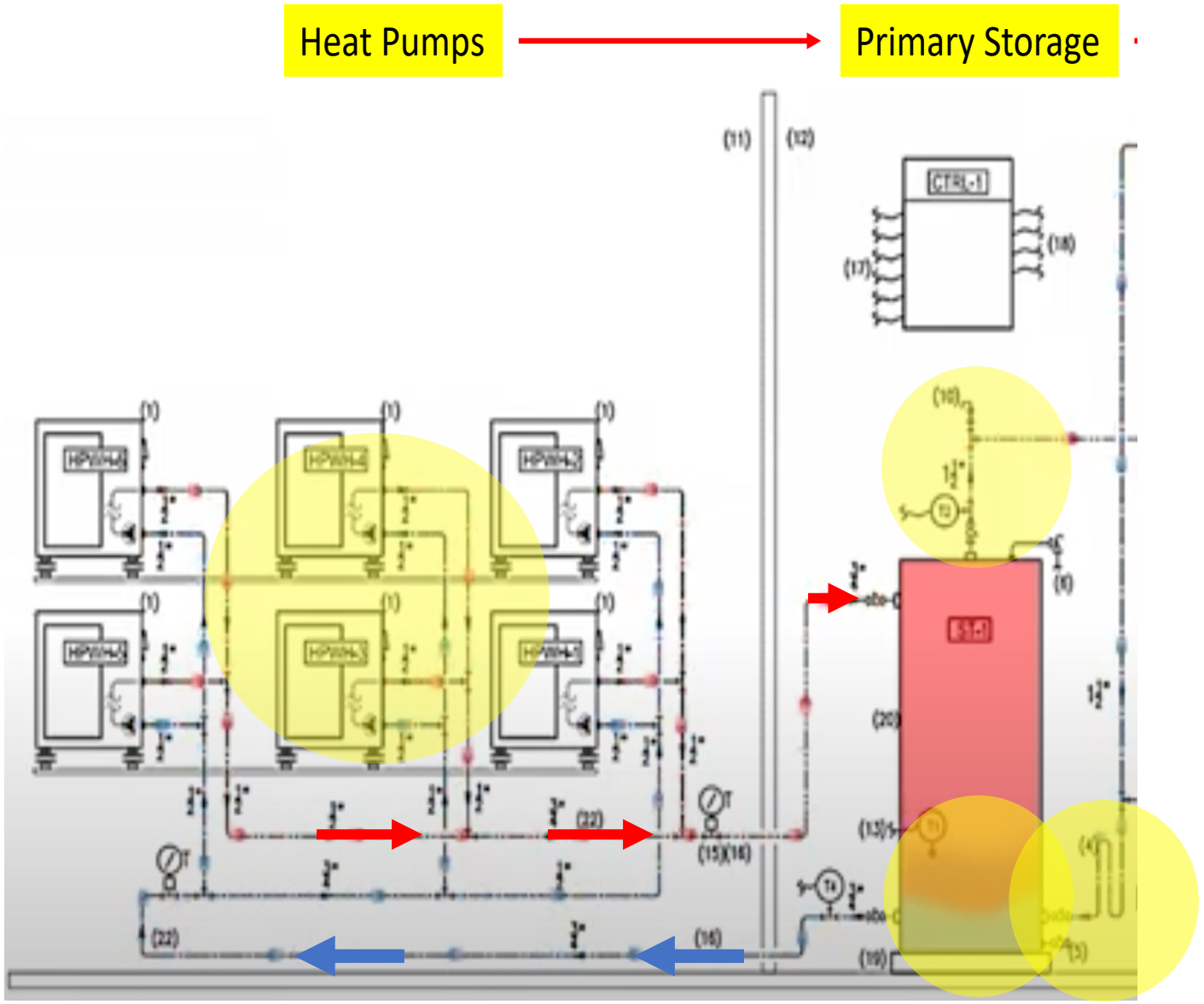
Completed 2021 - 1075 West Georgia ST Vancouver BC

Single Pass System Configuration



Breaking into Functions

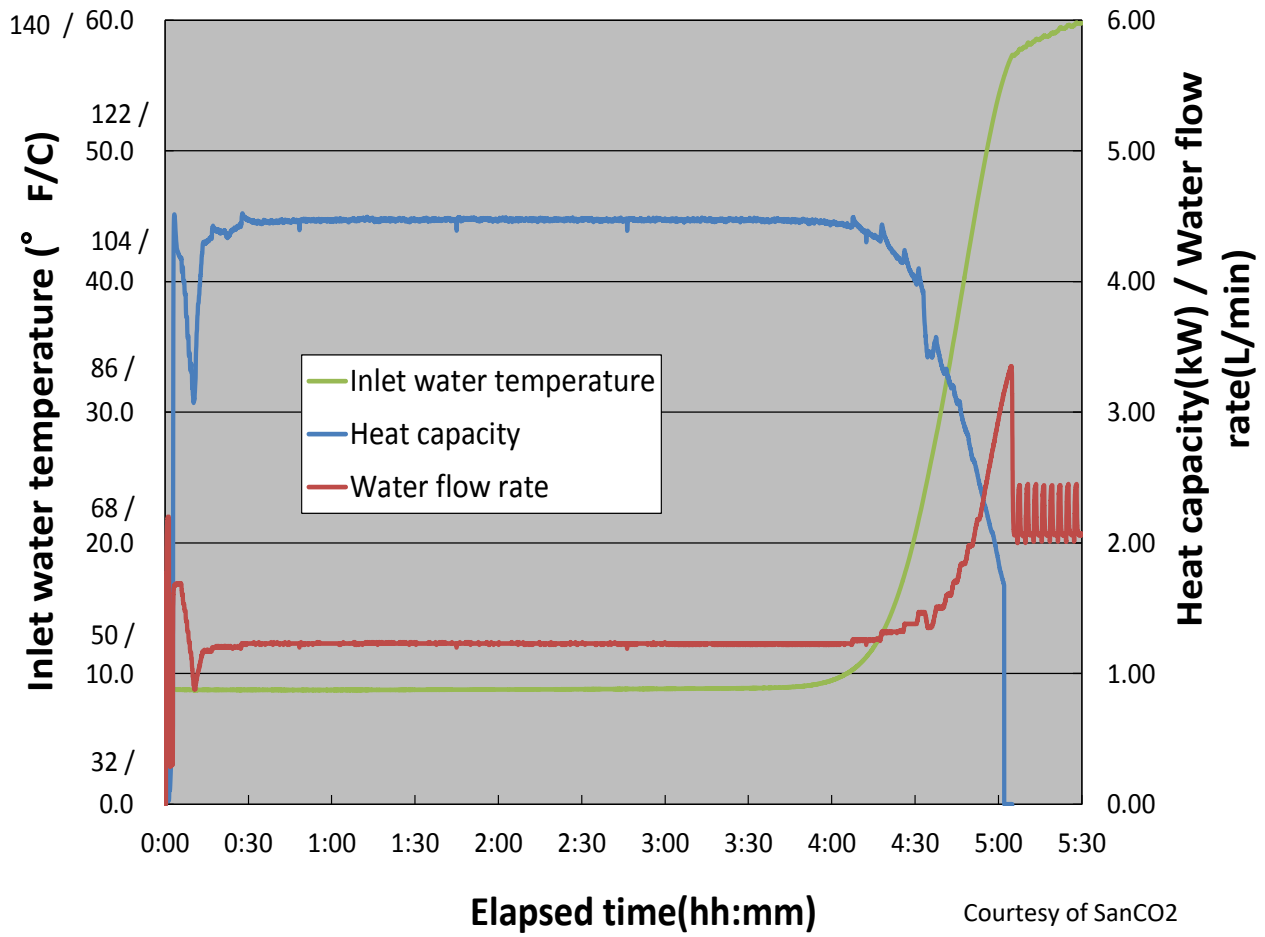
- The primary storage tank(s) are stratified
- The cold municipal water is piped into the bottom of the primary storage tanks(s)
- Heat pump(s) take cold water from the bottom of primary storage tank(s) and provide the 100F lift in a single pass.
- The high temperature (150F-170F) is piped to the top of the primary storage tank(s)
- The hot DHW is piped from the top of the primary storage tank to the load.



CO2 Needs Cold Water

- CO2 Heat pumps loose both capacity and COP when return temperatures increase.
- As the inlet temperature increases, the delta T decreases.
- The water pump try's to compensate by speeding up the flow.
- The overall capacity is reduced as the entering water temperature increases.

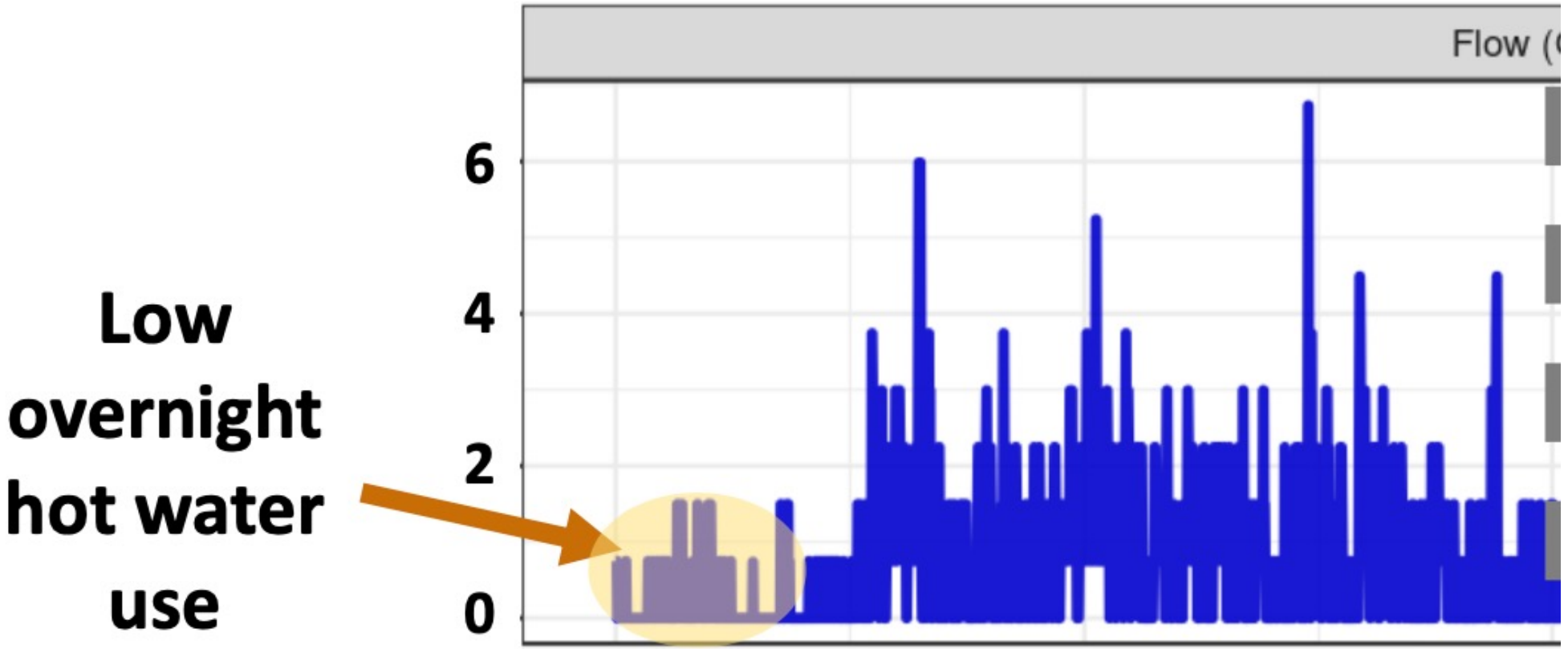
Heating 83 Gallon tank from Cold



Courtesy of SanCO2

Recirculation losses

Happens overnight as the recirc loop pulls heat from the tank and looses it to the building

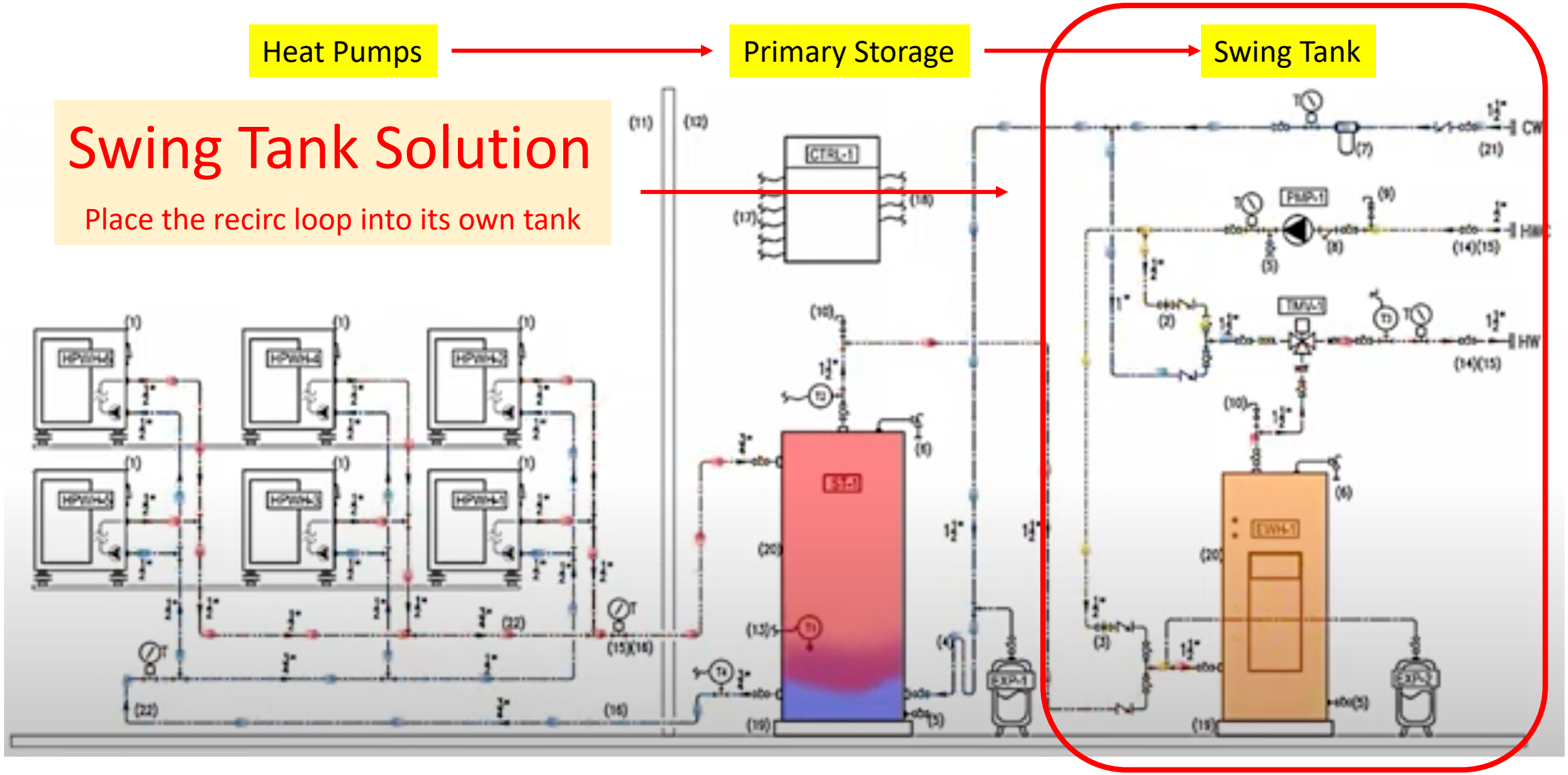


Courtesy of Ecotope

Heat Pumps → Primary Storage → Swing Tank

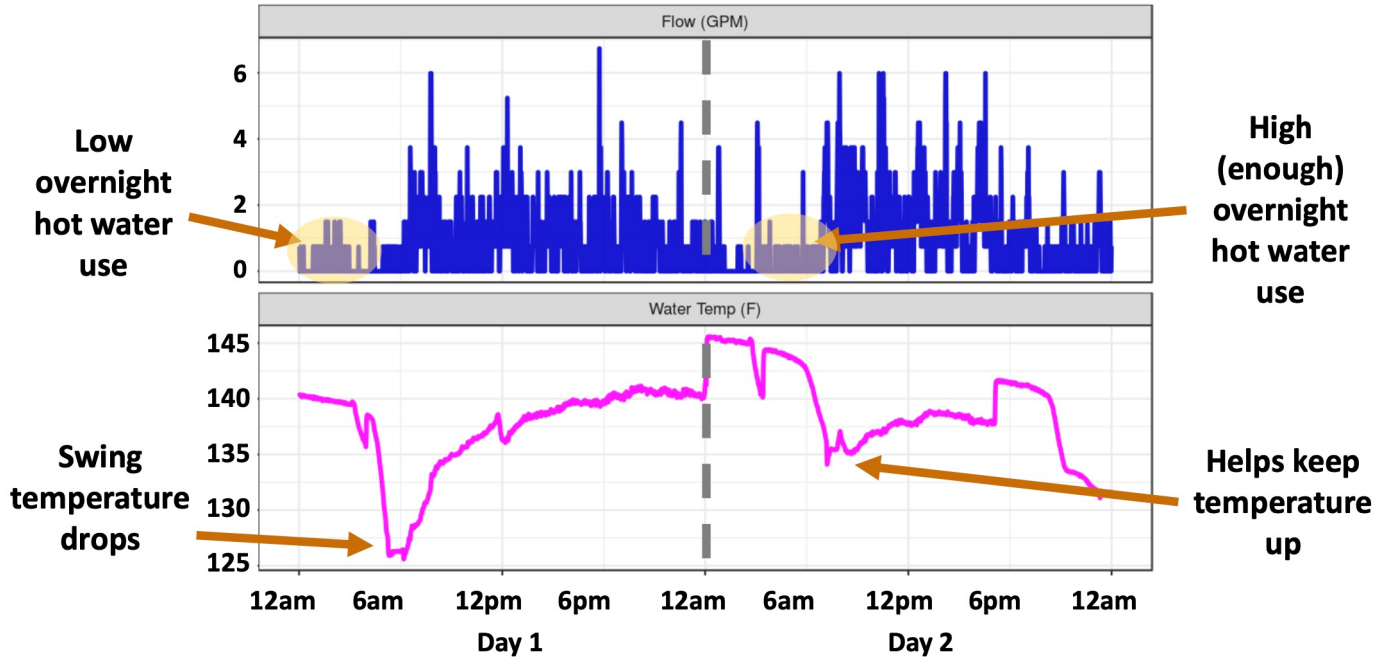
Swing Tank Solution

Place the recirc loop into its own tank



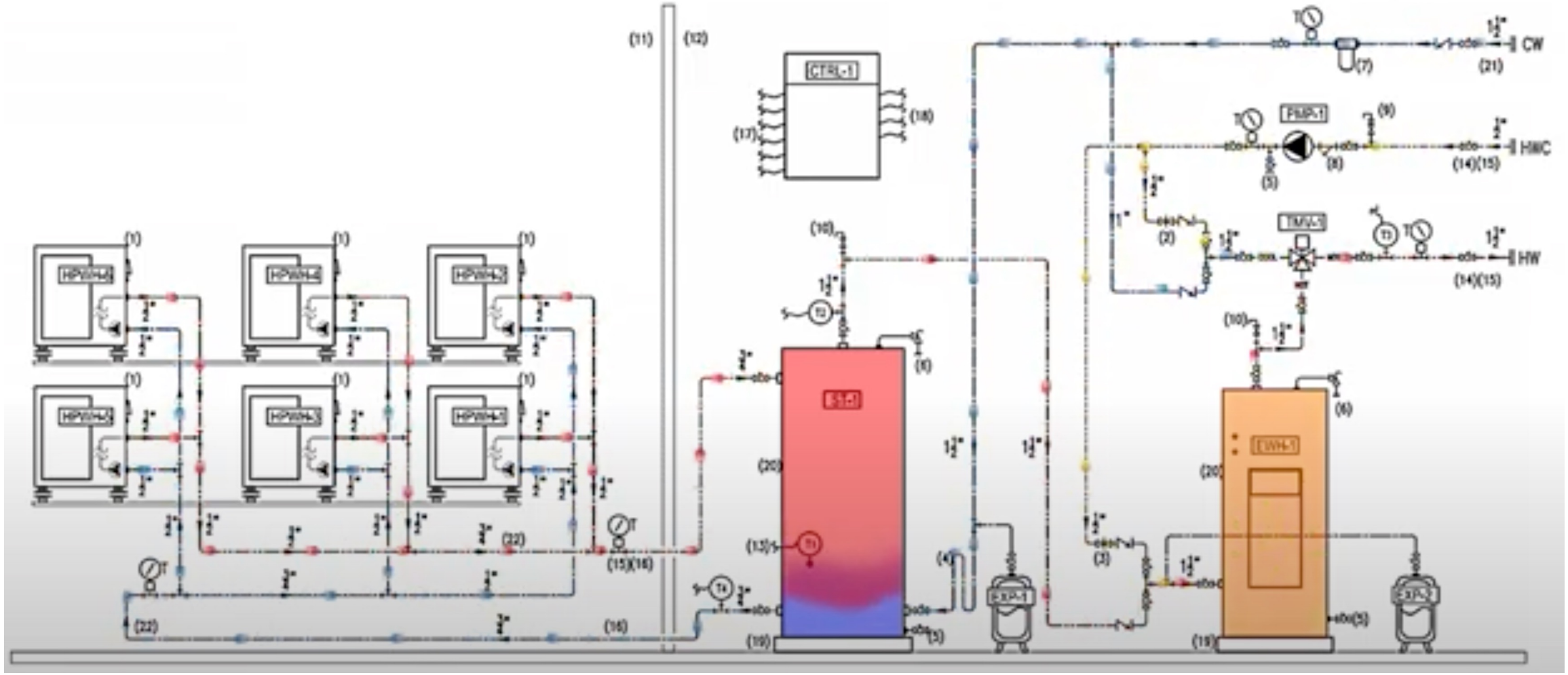
How it works

- Recirculation losses are isolated from primary storage
- Overnight tank temperature can often cool below set point (120F)
- Add electric resistance to provide a short lift back to set point.
- Can also use a multi-pass heat pump.

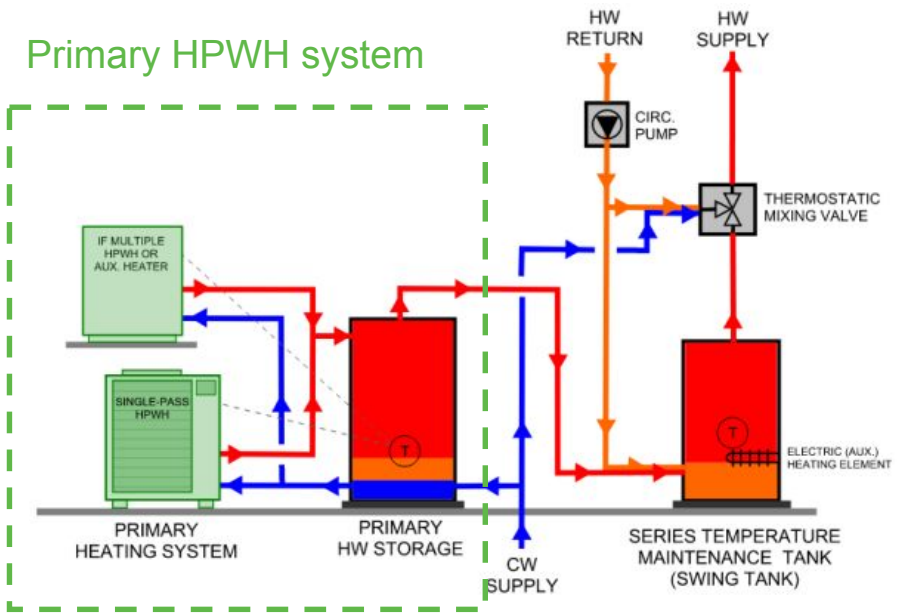


Courtesy of Ecotope

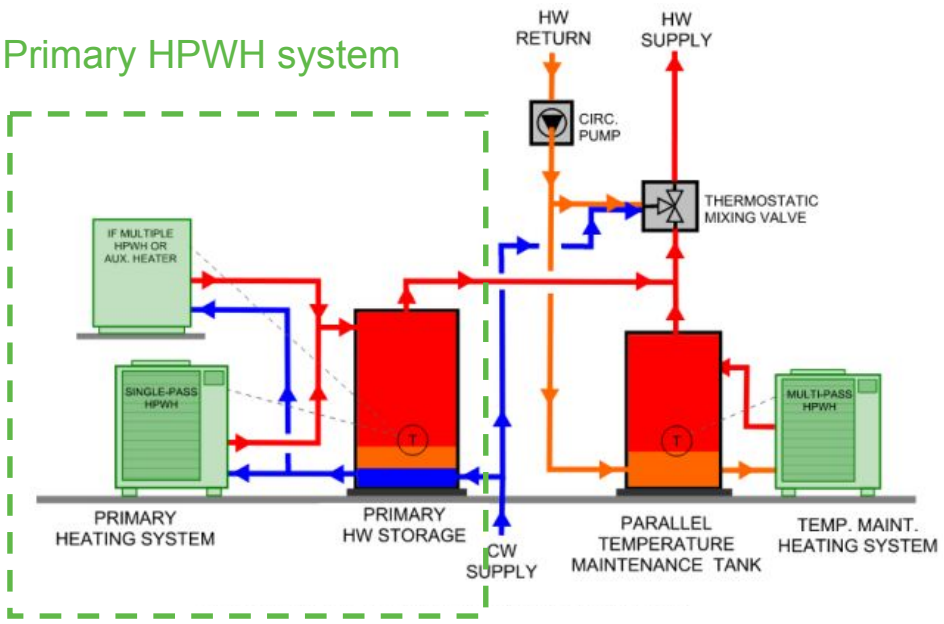
Heat Pumps → Primary Storage → Swing Tank



Swing Tank can be both Electric Resistance or a Multipass Heat Pump

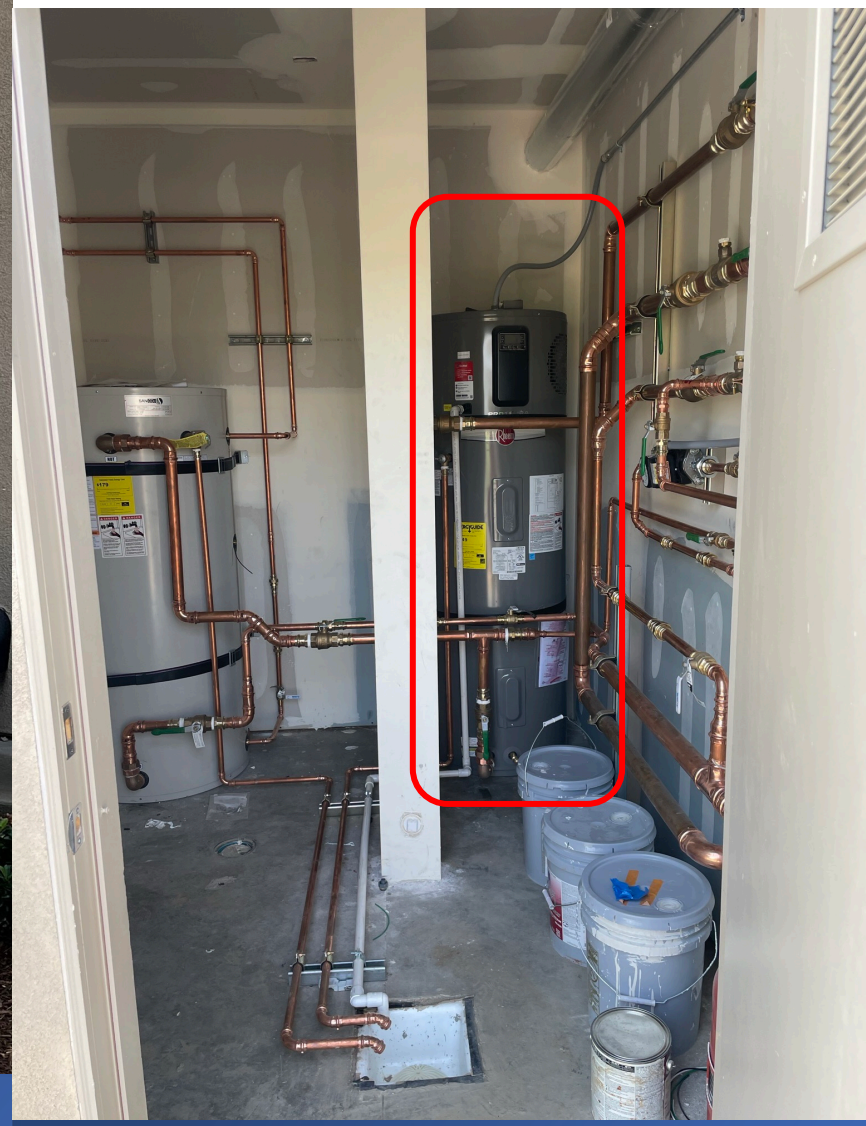


Single-pass primary with electric resistance water heater in series for temperature maintenance system **(HPWH_SPST)**



Single-pass primary with multi-pass in parallel for temperature maintenance system (**HPWH_SPwMPTM**)

Source: NEAA, Dec 2022, https://neea.org/img/documents/advanced-water-heating-specification-v8.0.pdf



Multipass Swing Tank Delano California

Control & Visibility

The WaterDrop Controller Functions: Basic, Communication Package, BMS, Full M&V.

Questions about “The Single Pass System”?

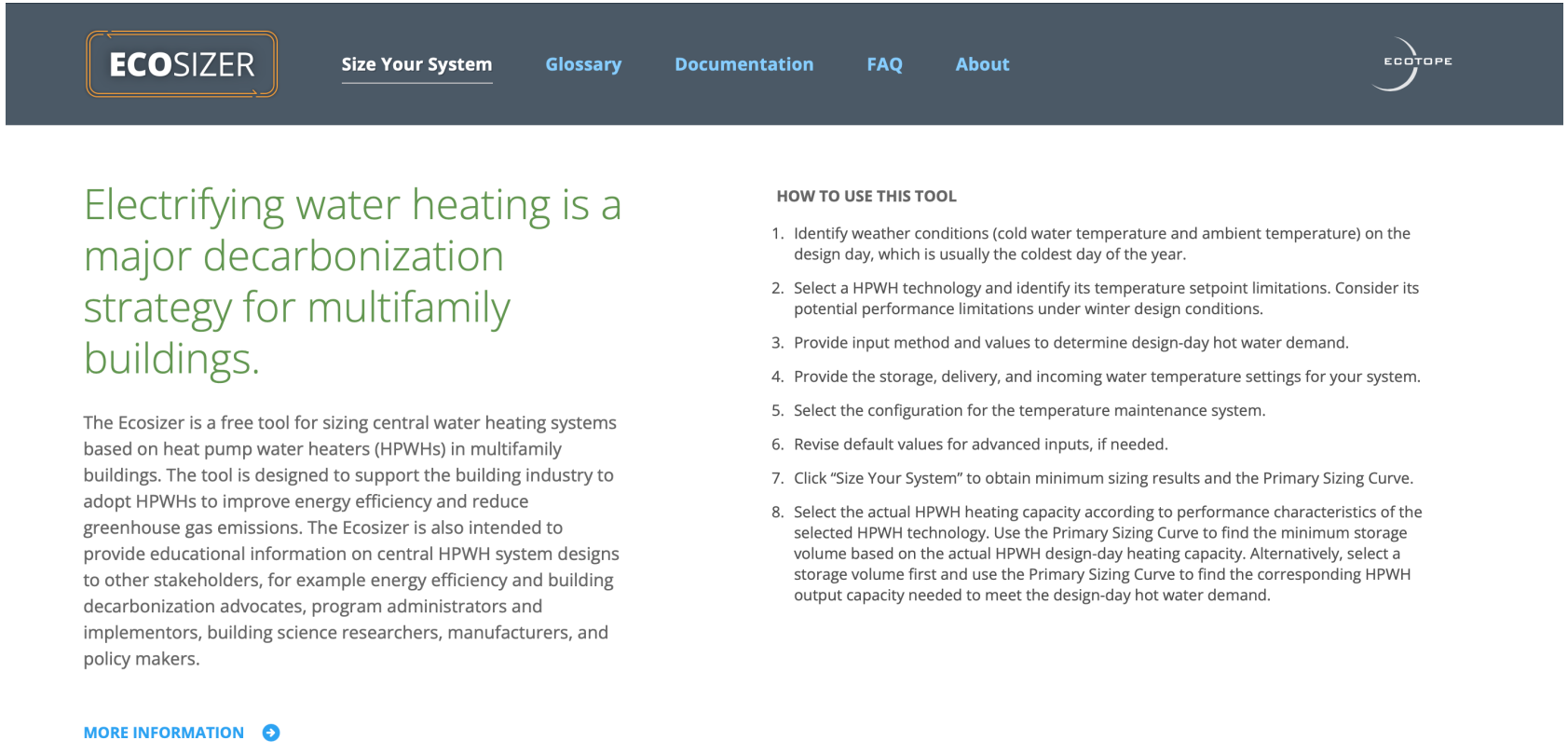
Up next – Sizing a Plant

Sizing a Building

New tools!

The Ecosizer

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



Occupancy Inputs

ECOSIZER

TOTAL PEOPLE & APARTMENTS | APARTMENT SIZE & OCCUPANCY RATES

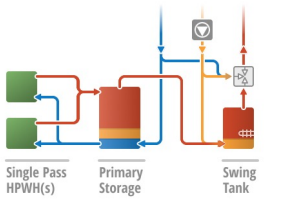
	Number of Apartments	Occupancy Rate: ASHRAE Market Rate	Peak Gallons per Day per Person: Ecotope Market Rate with Low Flow Fixtures		
Studio	50	1.49	1	25	49
1 Bedroom	0	1.93	1	25	49
2 Bedroom	0	2.39	1	25	49
3 Bedroom	0	2.84	1	25	49
4 Bedroom	0	3.29	1	25	49
5 Bedroom	0	3.74	1	25	49

Water Temperatures

Water Temperature

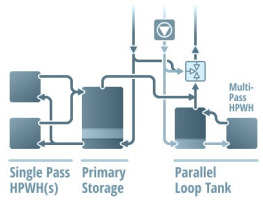
Design Cold	Supply	Hot Storage
50 °F	120 °F	150 °F

Temperature Maintenance System



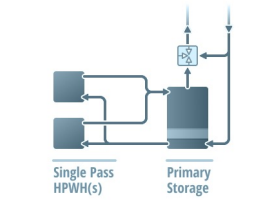
SWING TANK

Primary plant with a temperature maintenance plant in series



PARALLEL LOOP TANK

Primary plant with a temperature maintenance plant in parallel



PRIMARY - NO RECIRCULATION

Just the primary plant without a temperature maintenance load

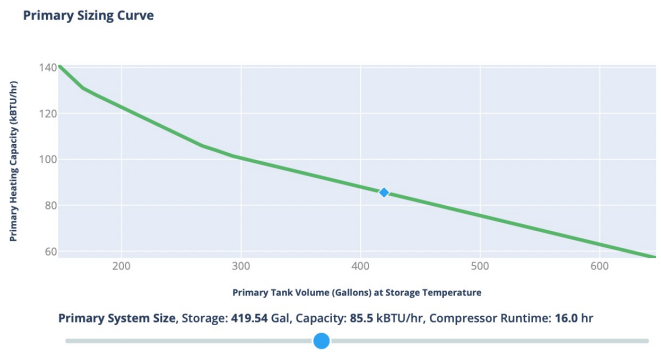
Results

ECOSIZER

Results

The graph below represents the trade off between storage volume and heating capacity. The Ecosizer method result is the green curve in the graph. The system sized from user inputs is the blue diamond. Users should pick any point above the green curve to determine their system sizing.

Use the slider bar below the plot to select a different size system.



Primary System Size, Storage: **419.54** Gal, Capacity: **85.5** kBTU/hr, Compressor Runtime: **16.0** hr

RECOMMENDATIONS

The recommended minimum heating capacity shown below is the **minimum** needed average output capacity of the selected equipment at the design cold air temperature in your climate zone. Note that you must also account for manufacturer specific defrost penalty.

Primary Storage →

Tank Volume
420.00 Gallons

Heating Capacity
85.50 kBTU/hr

← Heat Pump Capacity

Swing Tank →

Swing Tank Volume
120 - 300 Gallons

→ Swing Resistance Element
8.7 kW · **29.9** kBTU/hr

CA Title 24 Swing Tank Volume
288 Gallons

THIS SYSTEM WAS SIZED FOR

Occupancy
74.5 People

Apartments
50.0 Units

Daily Hot Water Usage
25.0 Gallons per Day per Person

Total Hot Water
1,862.50 Gallons per Day

Recirculation Loop
Heat Loss
100.0 Watts per Apartment

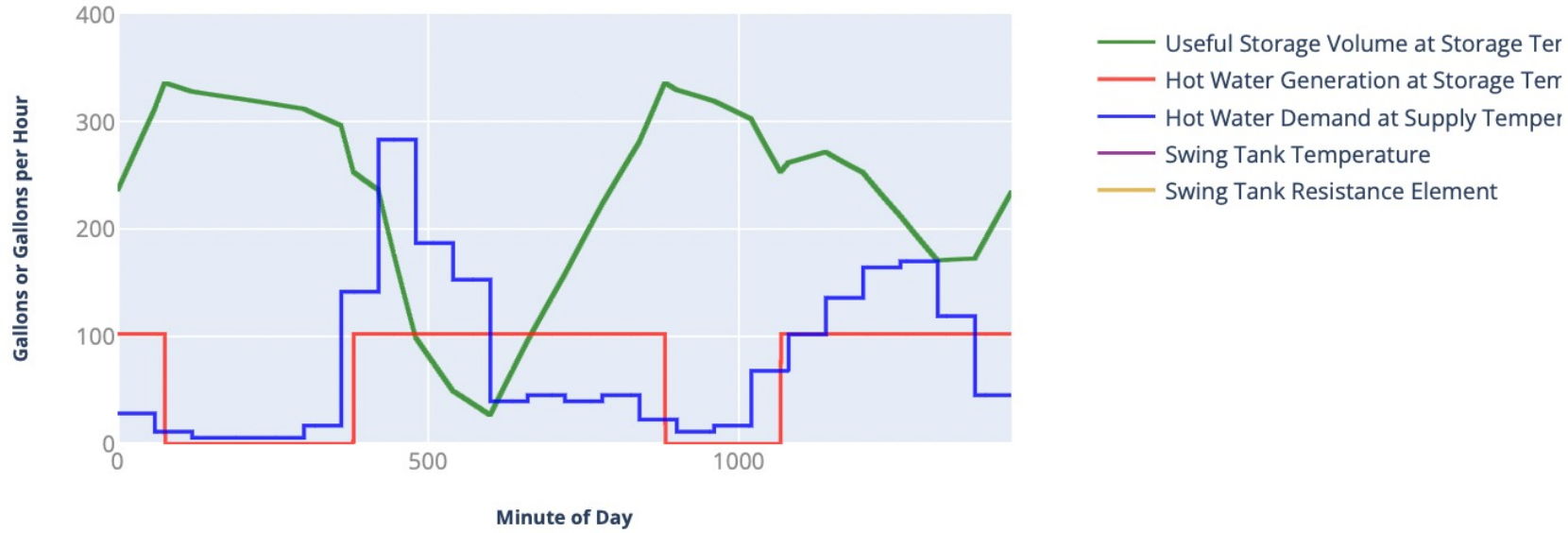
Details

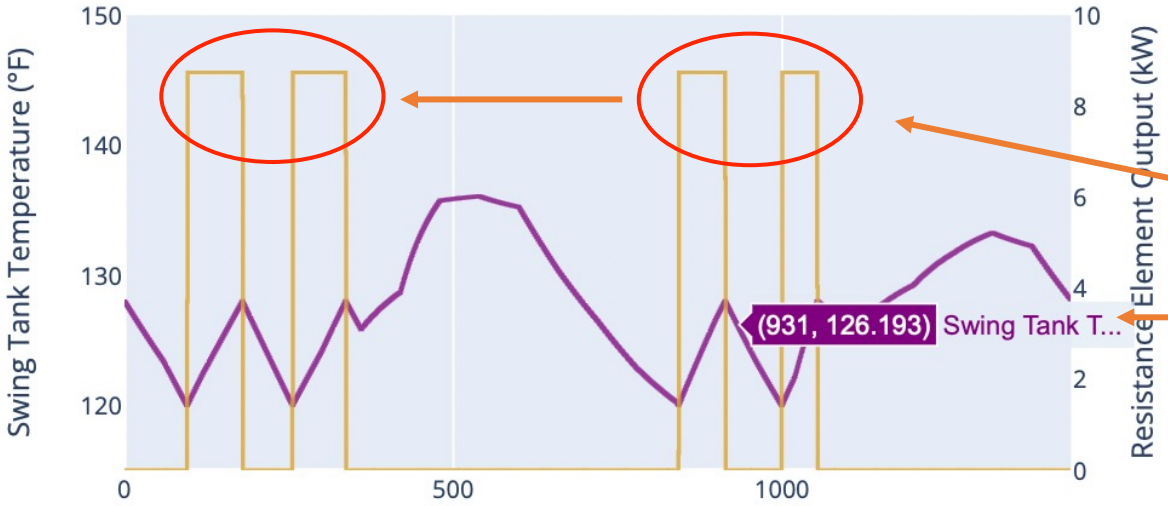
SAVE RESULTS TO PDF

SEND US YOUR FEEDBACK

ECOSIZER

Hot Water Simulation





Swing Tank EWH Used

Swing Tank Temperature

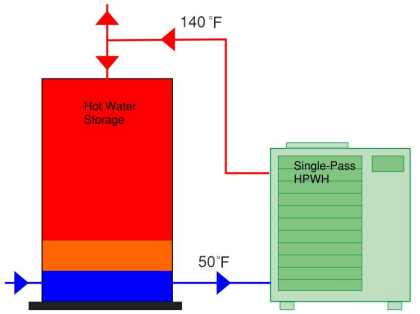
Questions about “Sizing a Plant”?

Up next – California Codes

Central HPWH System Approach

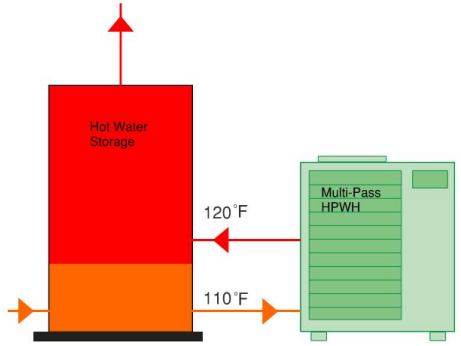
System performance and applications vary by:

- Primary HPWH equipment types
  - Single-pass vs. Multi-pass
  - Refrigerant type
  - Capacity
- Temperature maintenance system (TMS) for maintaining hot water temperature in recirculation loop
  - Decoupled from primary system
  - Direct return to primary system



Single-Pass

Heats up water to working temperature in single pass

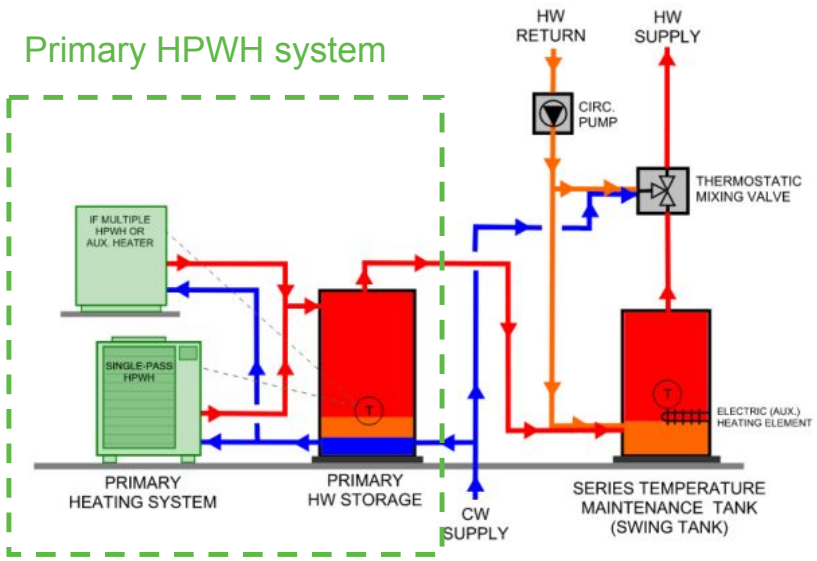


Multi-Pass

Heats up water to working temperature in multi pass

Source: TRC CASE Proposal - Central Heat Pump Water Heater Code Clean-up JingJuan “Dove” Feng

Recirculation Loop Decoupled from Primary System



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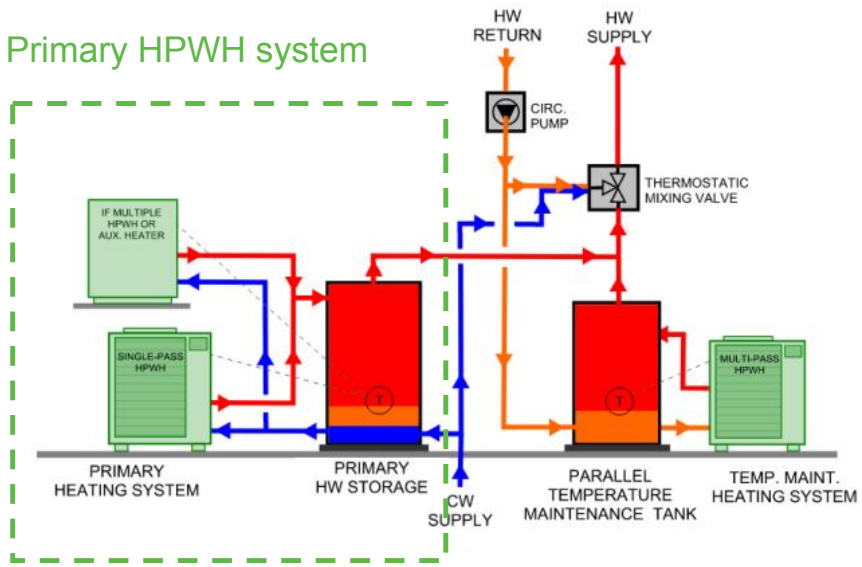

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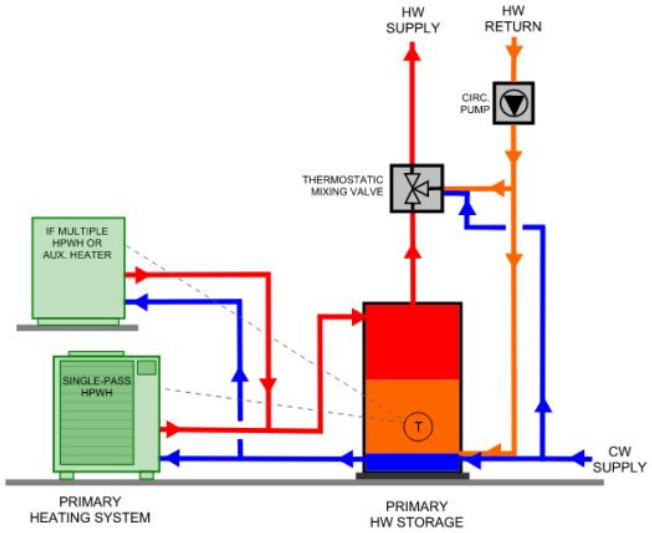
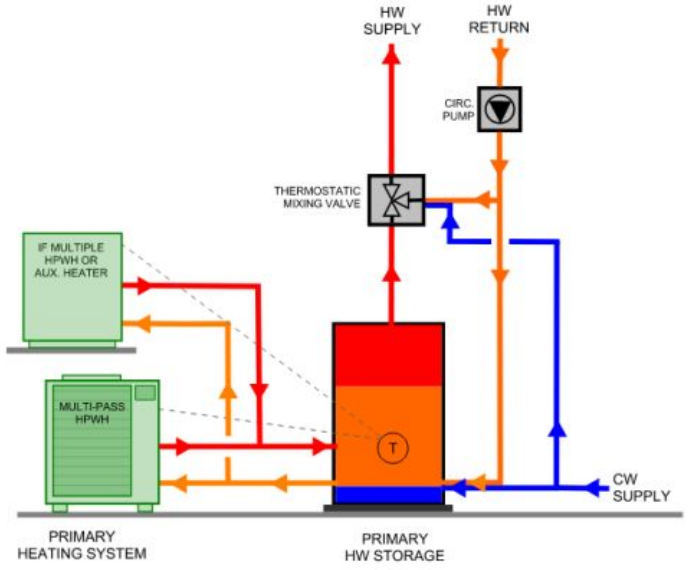
Source: TRC CASE Proposal - Central Heat Pump Water Heater Code Clean-up JingJuan “Dove” Feng

Temperature Maintenance System Return to Primary Configurations



Single-pass return to primary (**HPWH_SPRetP**)



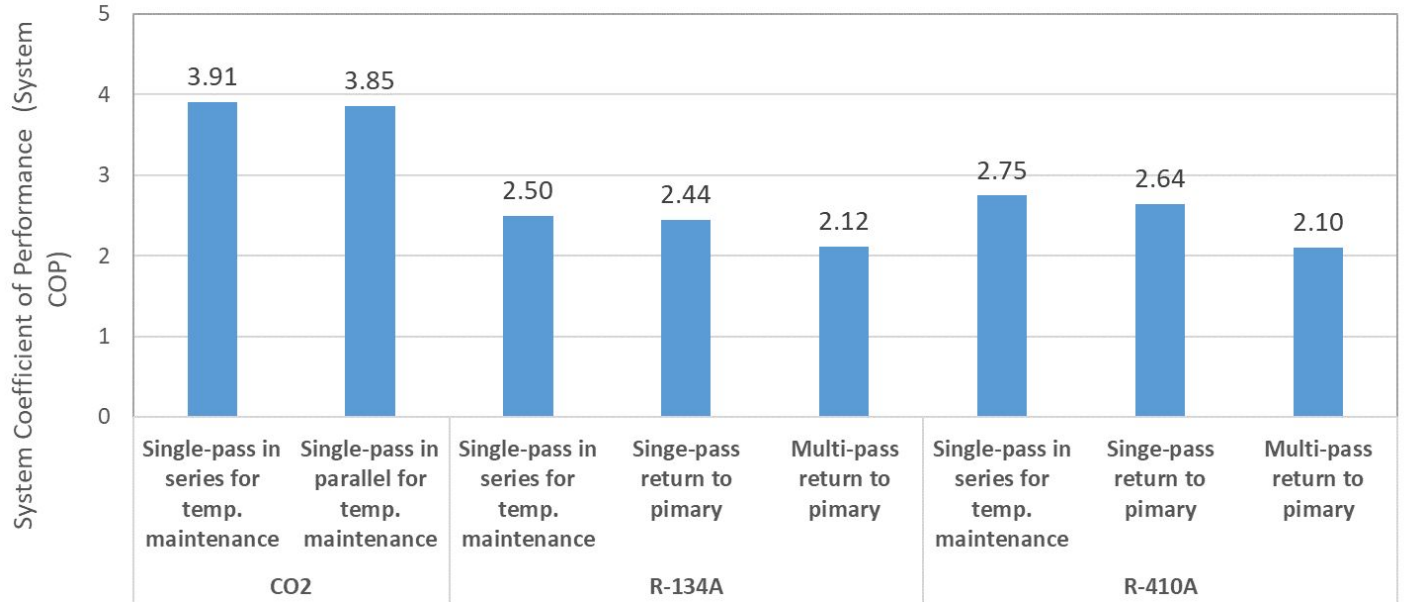
Multi-pass return to primary **(HPWH_MPRetP)**

Source: NEAA, Dec 2022, https://neea.org/img/documents/advanced-water-heating-specification-v8.0.pdf

Source: TRC CASE Proposal - Central Heat Pump Water Heater Code Clean-up JingJuan “Dove” Feng

Central HPWH System Energy Performance

Example: Annual System COP for Climate Zone 12



NEEA Tier 3 System COP = 2.5 for most CA climate zones

Source: the DHW CASE Team

Source: TRC CASE Proposal - Central Heat Pump Water Heater Code Clean-up JingJuan “Dove” Feng

Current Code Requirements

Existing requirements in Title 24, Part 6 **Section 170.2(d)2**

- Allows both single-pass and multi-pass primary equipment
- Requires recirculation loop decoupled from primary HPWH systems
- Plumbing configurations to ensure stratification in primary tanks
- Control requirements to achieve minimal efficiency
- Design documentation of specified operating conditions of the system according to Joint Appendix 14.4

Performance Requirements: Joint Appendix 14

- Qualification requirements for a performance pathway for central HPWH
- Includes product performance testing requirements, as well as design documentation requirements

Source: 2022 Building Efficiency Standards for Residential and Nonresidential Buildings

Source: TRC CASE Proposal - Central Heat Pump Water Heater Code Clean-up JingJuan “Dove” Feng

Draft Proposed Code Change Language

- **Updates prescriptive requirements in Section 170.2(d)2 to include two compliance paths**:

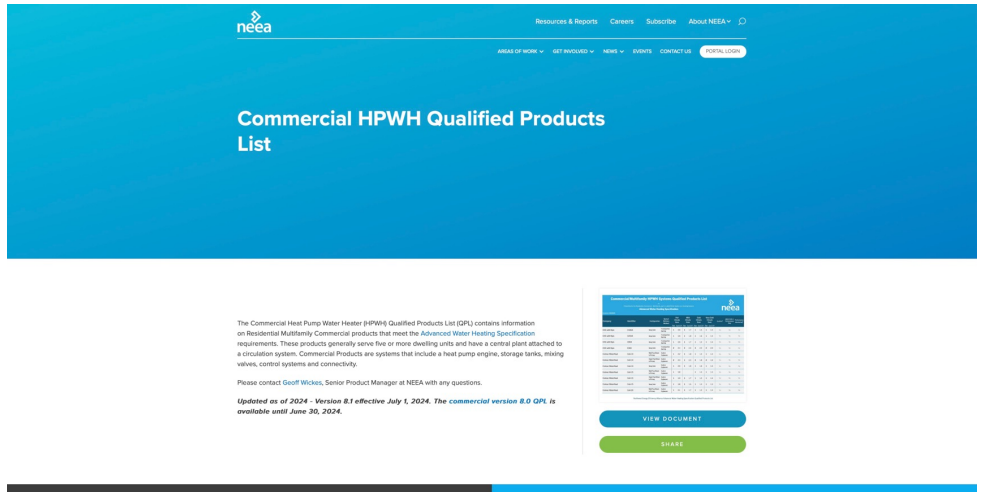
  (a) Single-pass primary HPWH meeting prescriptive requirements. Summary of revisions highlighted in red:

  - ~~Either single-pass and multi-pass primary equipment~~ → Single-pass primary HPWH equipment
  - Requires recirculation loop decoupled from primary HPWH systems
  - Plumbing configurations to ensure stratification in primary tanks
  - Control requirements to achieve minimal efficiency
  - Requires heat pump compressor cut-off to be 40° F or lower
  - Design documentation of specified operating conditions of the system according to Joint Appendix 14.4

  (b) A system that meets requirement of NEEA Advanced Water Heating Specification for commercial HPWH system Tier 3 o higher.

Source: TRC CASE Proposal - Central Heat Pump Water Heater Code Clean-up JingJuan “Dove” Feng

NEEA CHPWH Qualified Products List



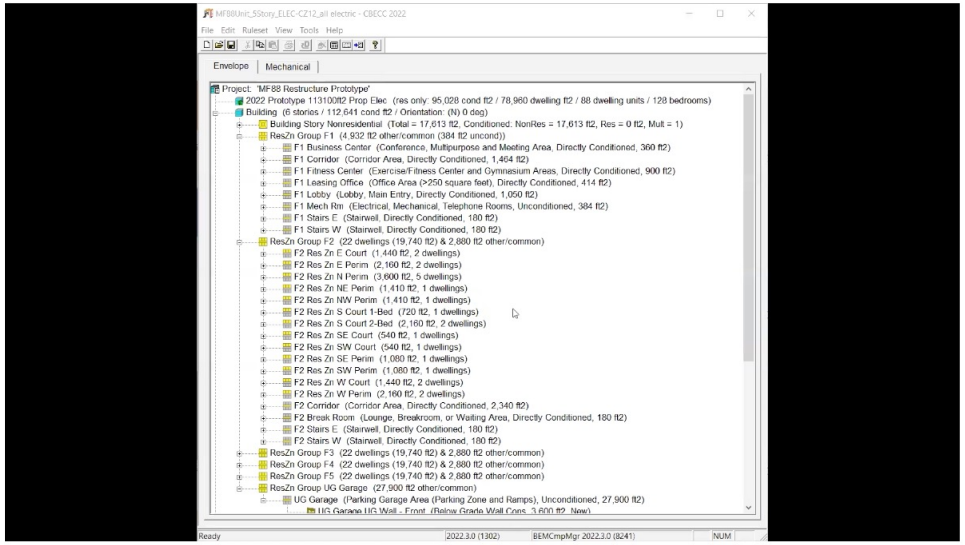
Rheem	HPHD-60HNU-201 (HORIZONTAL)	Multi Pass Return to Primary	Custom Engineered	1	2.2	1	1.7	1	1.5	1	1.4	No	No	No
Rheem	HPHD-60HNU-201 (VERTICAL)	Multi Pass Return to Primary	Custom Engineered	1	2.2	1	1.7	1	1.5	1	1.4	No	No	No
Small Planet Supply	Small Planet Supply SanCO2 System	Swing Tank	Fully Specified Built-Up	2	2.7	3	2.6	3	2.4	2	2.0	No	No	No
Small Planet Supply	WD1S-60-300-119-09	Swing Tank	Full Packaged Skid-Mounted	2	2.7	3	2.6	3	2.4	2	2.0	No	No	No
Small Planet Supply	WD1S-75-430-119-09	Swing Tank	Full Packaged Skid-Mounted	2	2.7	3	2.6	3	2.4	2	2.0	No	No	No
Small Planet Supply	WD1T-90-500-119-12	Swing Tank	Full Packaged Skid-Mounted	2	2.7	3	2.6	3	2.4	2	2.0	No	No	No
Small Planet Supply	WD2S-120-650-119-12	Swing Tank	Full Packaged Skid-Mounted	2	2.7	3	2.6	3	2.4	2	2.0	No	No	No
Small Planet Supply	WD2S-150-800-200	Swing Tank	Full Packaged Skid-Mounted	2	2.7	3	2.6	3	2.4	2	2.0	No	No	No
Small Planet Supply	WD2S-180-1000-200	Swing Tank	Full Packaged Skid-Mounted	2	2.7	3	2.6	3	2.4	2	2.0	No	No	No
Steffes Origin with Nyle	C125A	Swing Tank	Full Packaged Skid-Mounted					1	1.3	1	1.3	Yes	No	Yes
Steffes Origin with Nyle	C185A	Swing Tank	Full Packaged Skid-Mounted	1	1.8			1	1.4	1	1.3	Yes	No	Yes

https://neea.org/resources/commercial-hpwh-qualified-products-list

Engineering Resources

Drop-In • Plug & Play • Central Plants for Domestic Hot Water

California Title 24 CBECC Modeling



A quick demonstration on how to enter a WaterDrop System into California Title 24 software using CBECC modeling software.

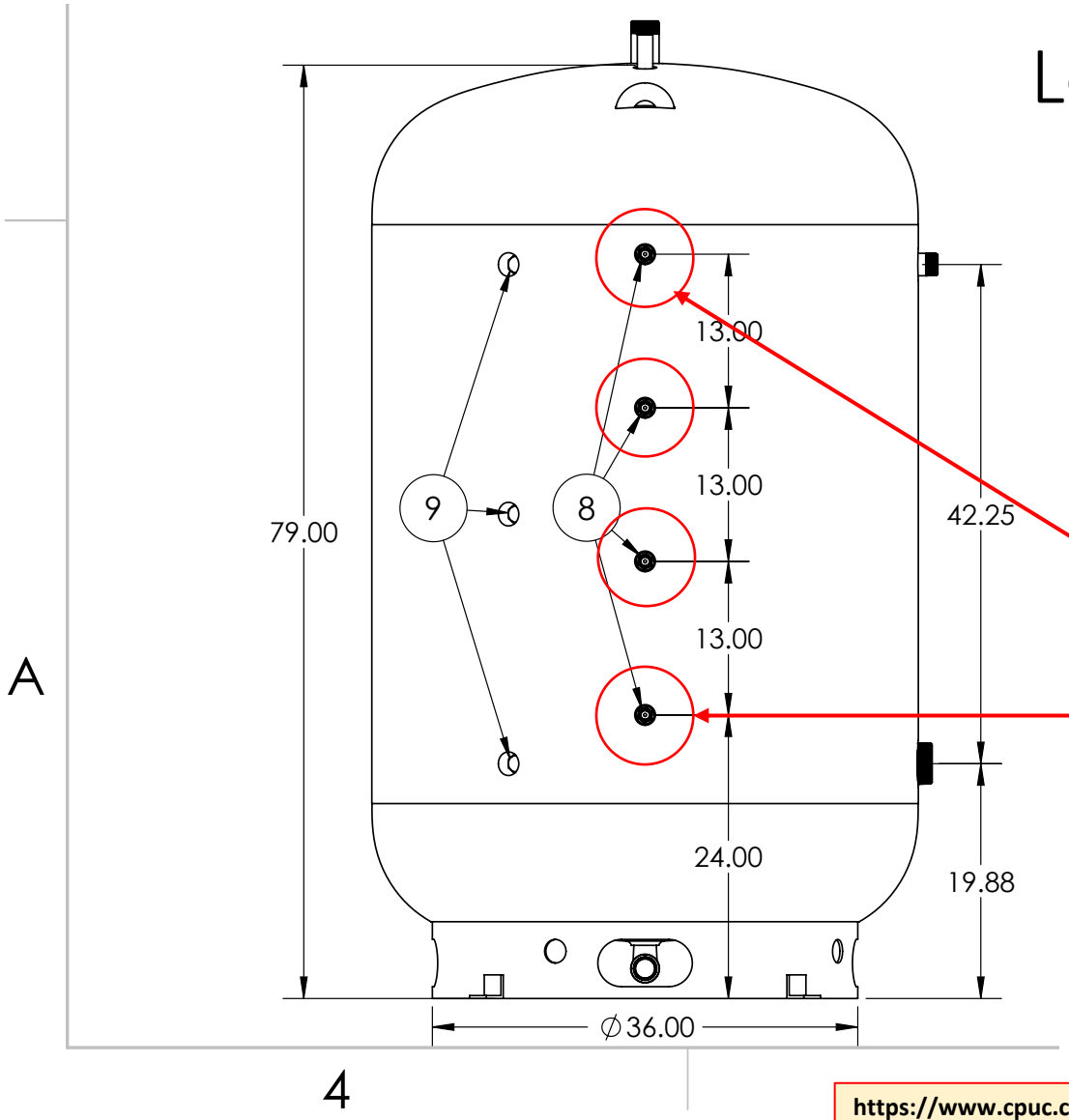
Proposed Code Change

System Configurations		Prescriptive Compliance Pathway		
		2022	2025	
			Primary path	Alternative path
Single-Pass Primary	with HW Circulation Returned to Primary Storage	No	No	NEEA AWHS Commercial HPWH Tier 3 or higher
	with Series Temperature Maintenance Tank System (Swing Tank)	Yes	Yes	
	with Parallel Temperature Maintenance Tank System with multi-pass HPWH	Yes	Yes	
Multi-Pass Primary	with HW Circulation Returned to Primary Storage	No	No	
	with Series or Parallel Temperature Maintenance Tank System (Swing Tank)	Yes	No	

All configurations can use the performance pathway

Source: TRC CASE Proposal - Central Heat Pump Water Heater Code Clean-up JingJuan “Dove” Feng

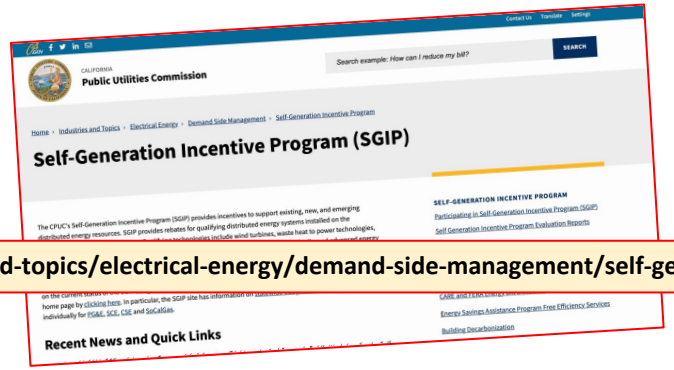
Load Shifting & Demand Response



Single Pass

Temperature Setpoints

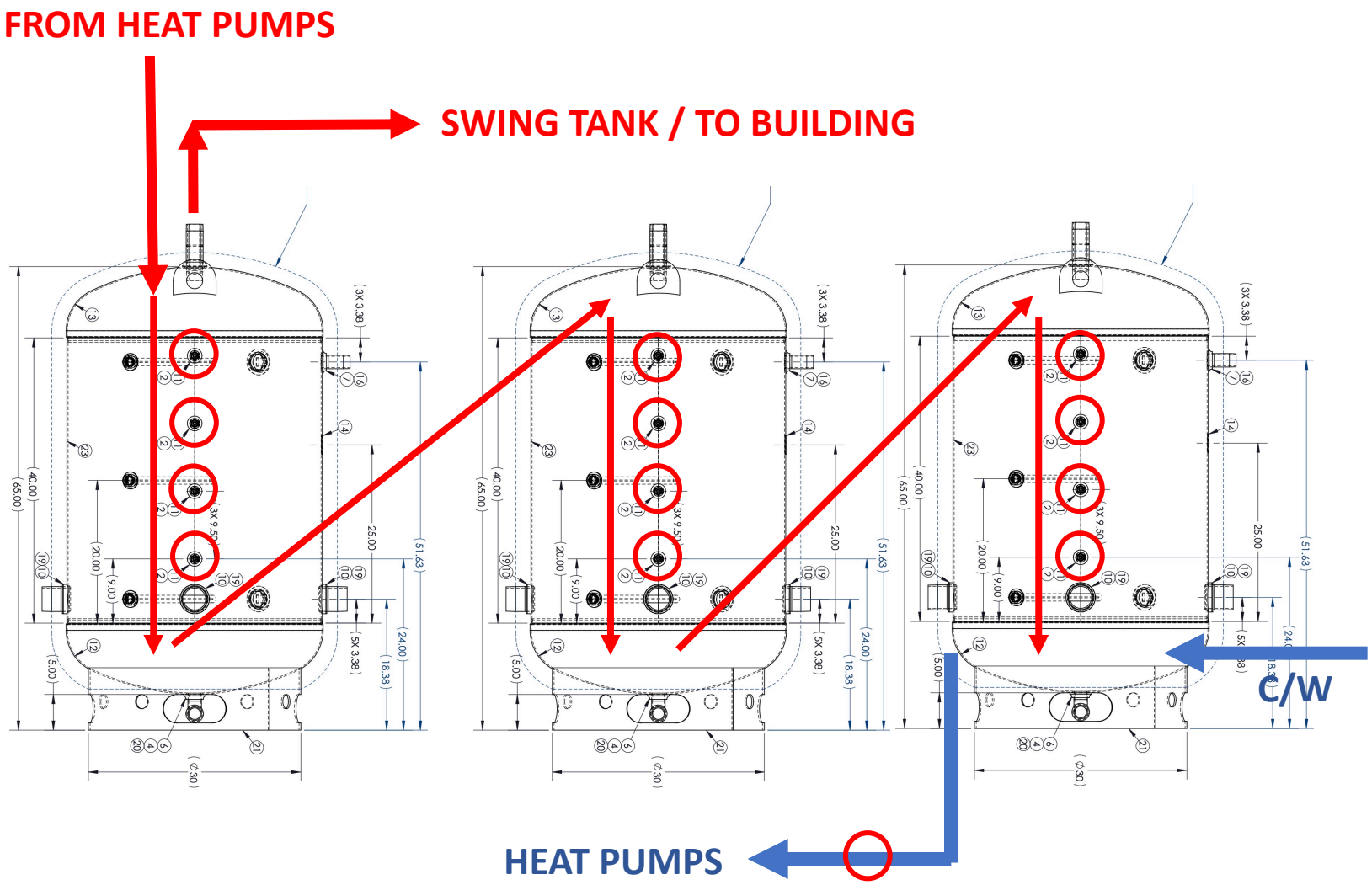
EcoPort Command	Aquastat Fraction	ON-Trigger	OFF-Trigger	HPWH Outlet
Normal	40 %	115 °F	135 °F	145 °F
Load Up	10 %	115 °F	135 °F	145 °F
Shed	85 %	115 °F	135 °F	145 °F



https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/self-generation-incentive-program

Measure Everything

- Stage recovery based on charge condition
- Optimization of Time Of Use Rates
- Total System COP
- Total Energy Usage
- Total Water Usage
- Optimization of Demand Response
- Additional programing can be pushed



Questions about “California Codes”?

Up next – Types of CHPWH Deliveries

Site built plants have been successful but…

Space and complexity can be reduced into a package

Major Components of Laars Heat Pump System

Heat Pump

I/O Panel

Storage Tanks

Temperature Maintenance Tank

Diffuser

- Heat Pump pulls heat from air to transfer to domestic water. Main heat source for DHW system.
- I/O panel allows for remote installation of tanks far from the heat pump, neatly houses wiring.
- Storage tanks hold required hot water to meet daily demand, sized for daily load vs. peak load.
- Temperature maintenance tanks provide hot water for recirculation loop needs. Minimizes likelihood of stored hot water to be depleted.
- Diffusers are placed into the storage tanks to help maintain temperature stratification. Tank temperature stratification helps to maximize installed efficiency.

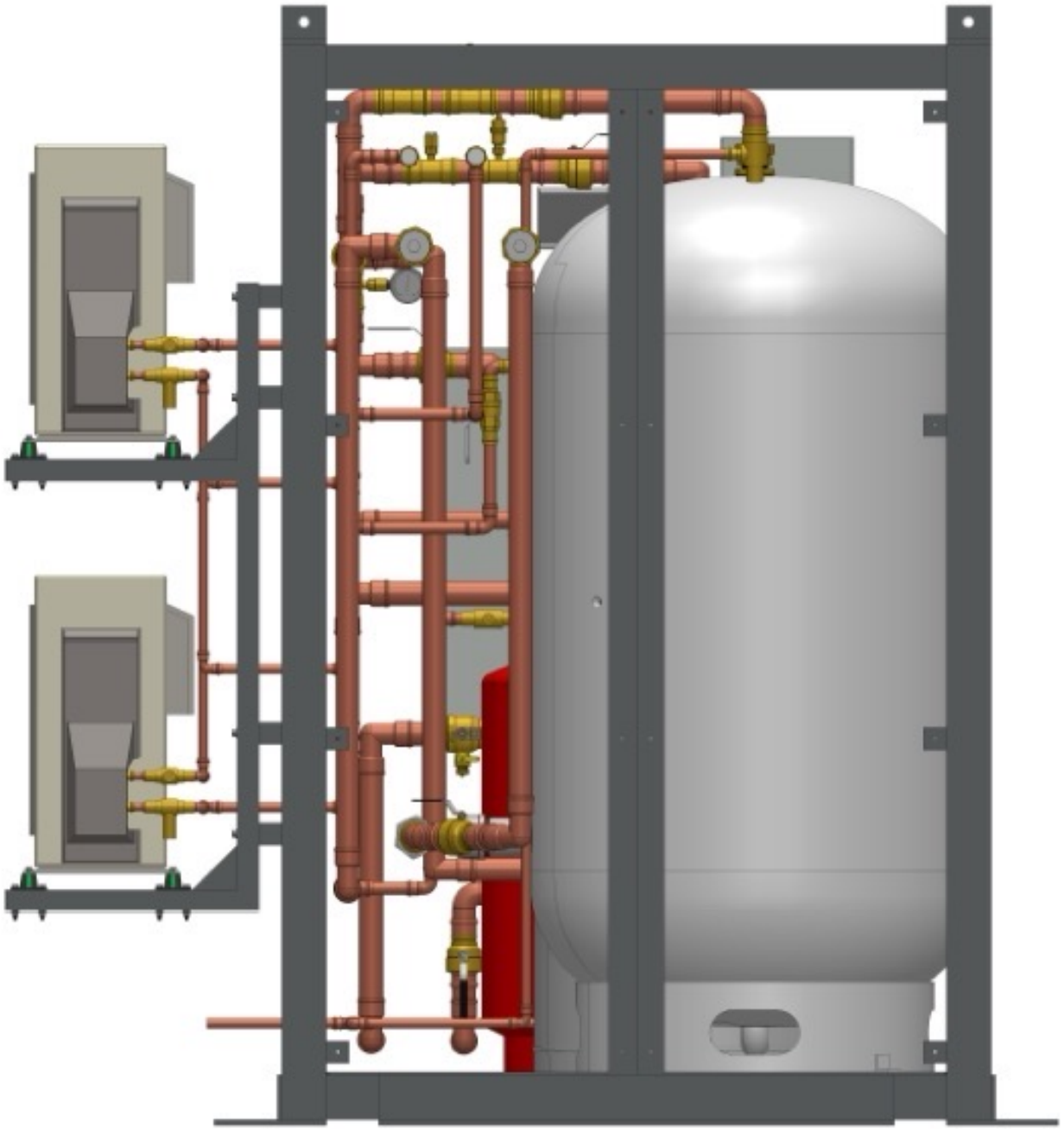
Packaged would be faster, better, and with less risk

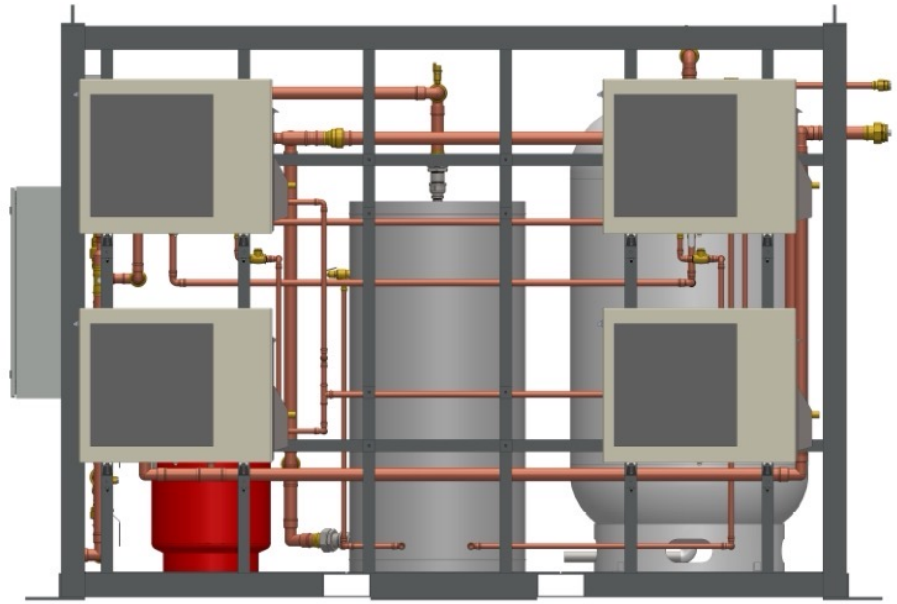
Deliveries

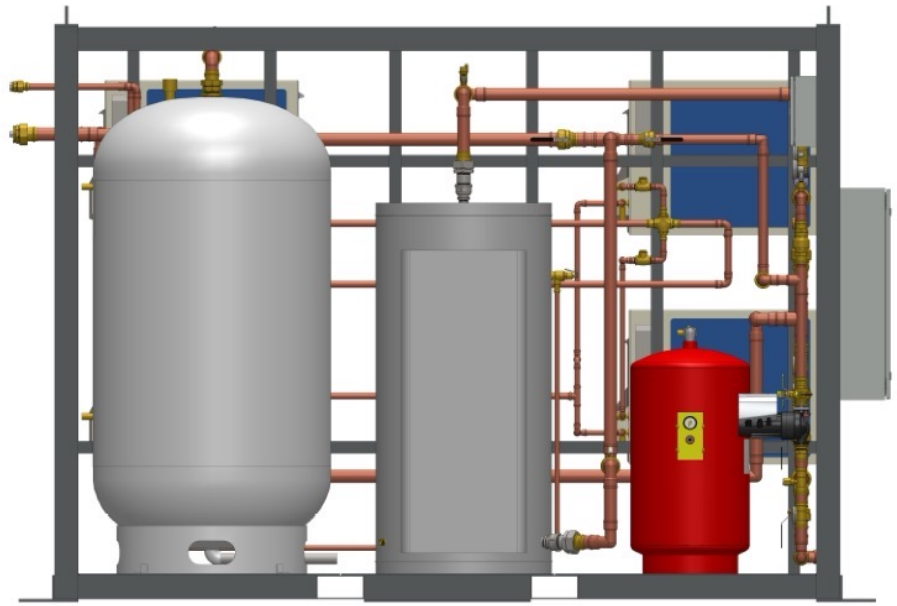
Parts, Pumps and Skids

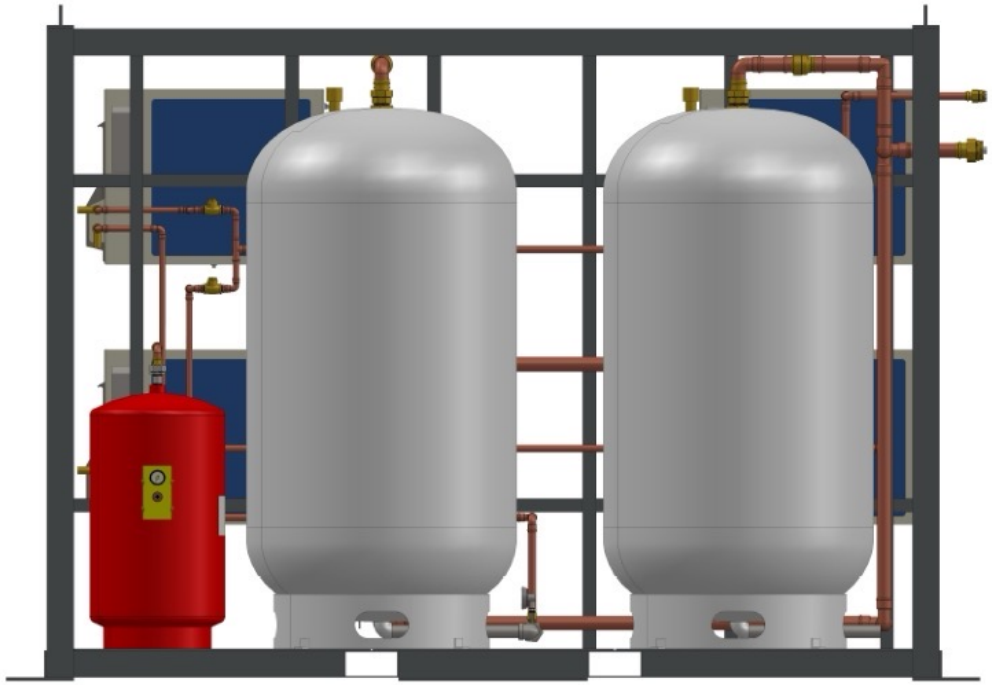
Eklund Innovation Center

Factory Assembled Plug & Play









Extend the heat pumps and storage


BOCK
WATER HEATERS
ELECTRATHERM


WATER DROP
Powered By R290

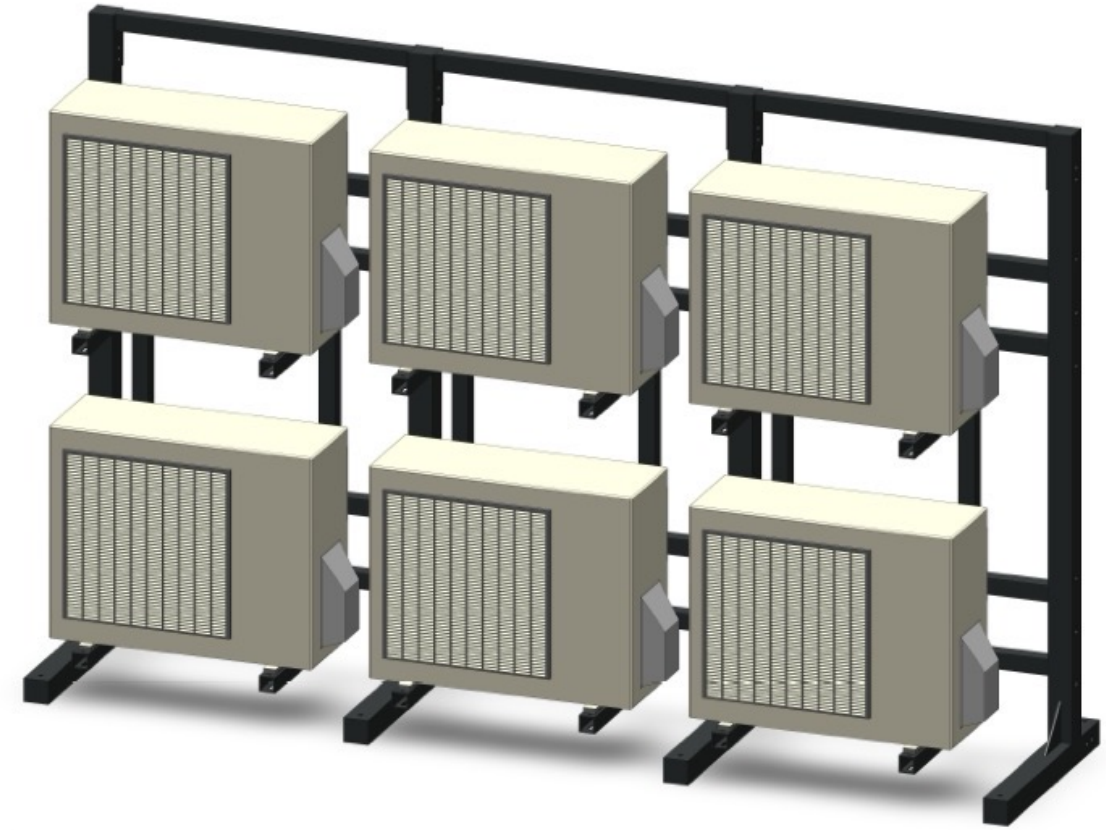

Controller
R-8 Insulated Enclosure
Heat Pump
Electronic Mixing Valve
R-12 Primary Storage
9kw Swing Tank
Expansion
Recirc pump
BUILDING CONNECTIONS
BOCK
WATER HEATERS
ELECTRITHERM

WaterDrop Systems

WATERDROP STANDARD SKID MODEL DATA

Model Number[1]	Pcs, Height	Total HPs	HP Recovery[2] (kBtuh)	HP Recovery[2] (Gal/Hr)	Max Output[3] (Gal/Day)	Storage (Gallons)	Swing Tank (Gallons)	Swing Tank (kW)	Dimensions L (in)	Dimensions W (in)	Dimensions H (in)	Dry Weight (lbs)	Wet Weight (lbs)
WD1S-30-0175-119-F-G-H-I-J-K	1 Piece, Std	2	31	37	592	175	119	6	149	94	101	4,800	7,500
WD1S-60-0300-119-F-G-H-I-J-K	1 Piece, Std	4	62	74	1,183	318	119	9	149	94	101	4,900	9,250
WD1S-75-0430-119-F-G-H-I-J-K	1 Piece, Std	5	77	92	1,479	432	119	9	149	94	101	5,250	10,400
WD1T-90-0500-119-F-G-H-I-J-K	1 Piece, Tall	6	92	111	1,775	500	119	12	149	94	123	5,350	11,000
WD2S-120-0650-119-F-G-H-I-J-K	2 Piece, Std	8	123	148	2,366	660	119	12	2 x 149	2 x 94	101	8,900	16,800
WD2S-150-0800-200-F-G-H-I-J-K	2 Piece, Std	10	154	185	2,958	795	200	18	2 x 149	2 x 94	101	9,500	19,300
WD2S-180-1000-200-F-G-H-I-J-K	2 Piece, Std	12	185	222	3,550	954	200	18	2 x 149	2 x 94	101	10,000	21,000

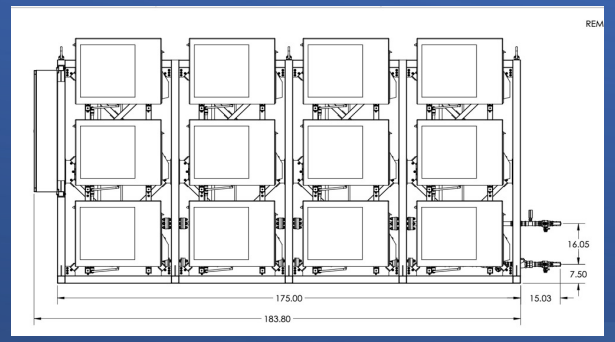
HP Capacity + Storage = Sizing

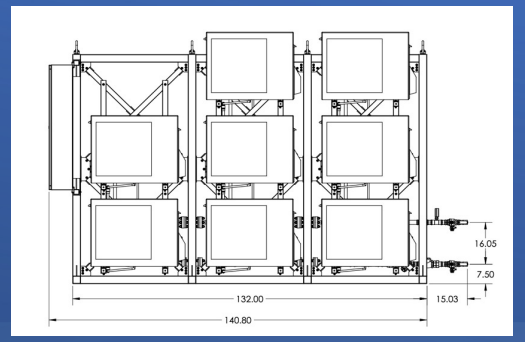


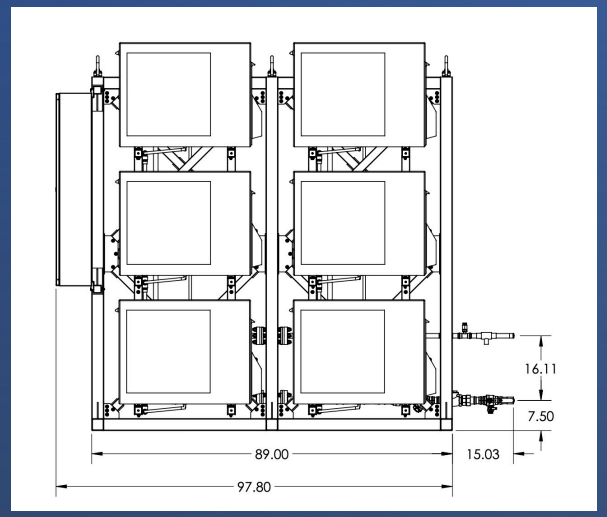
Droplet Racked Heat Pump Array

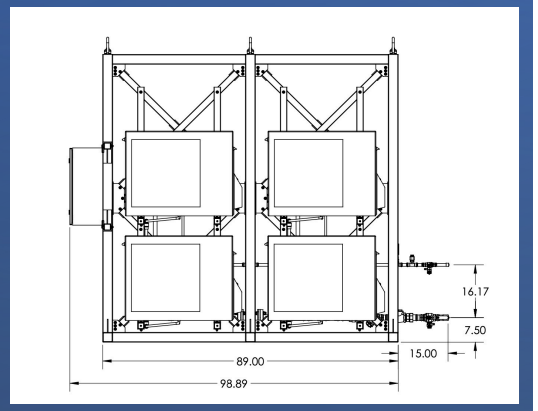
Heat pumps Outside – Tanks Inside

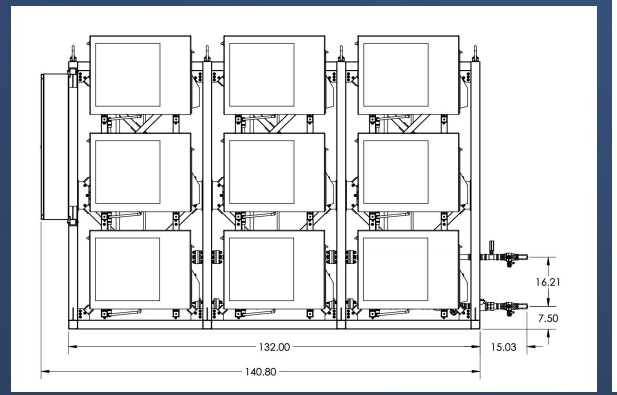
Available Droplet Configurations: 2/3/4/6/8/9/12

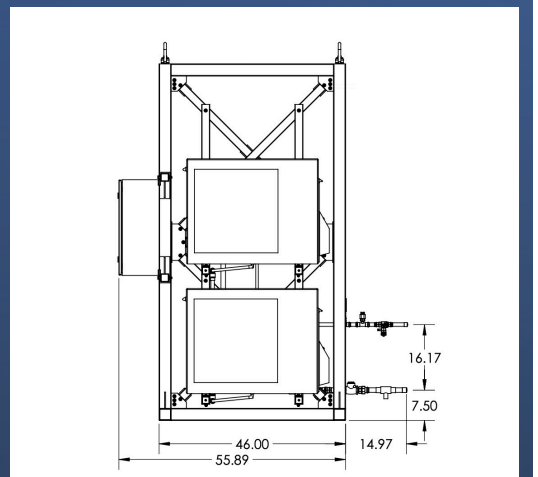


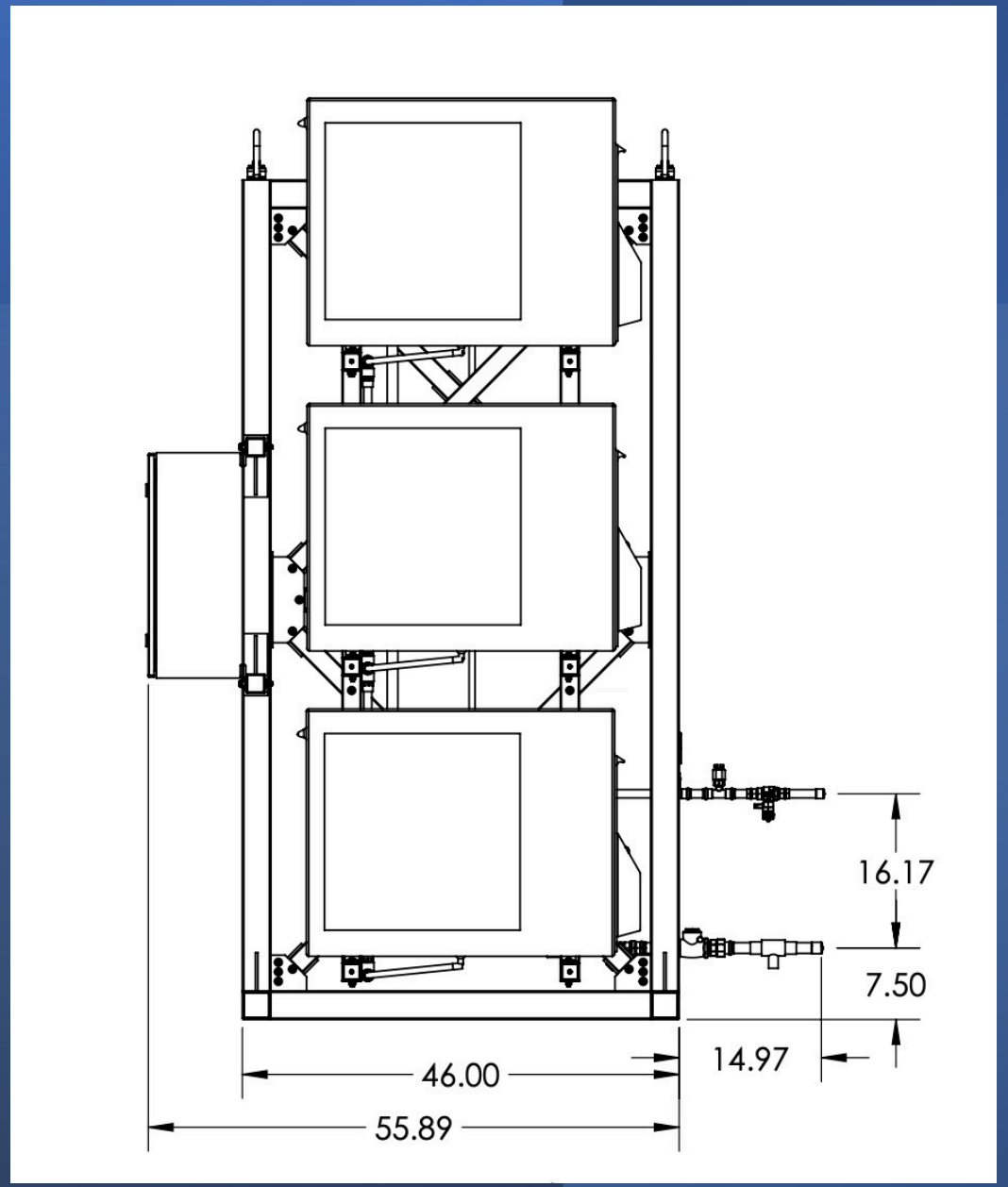












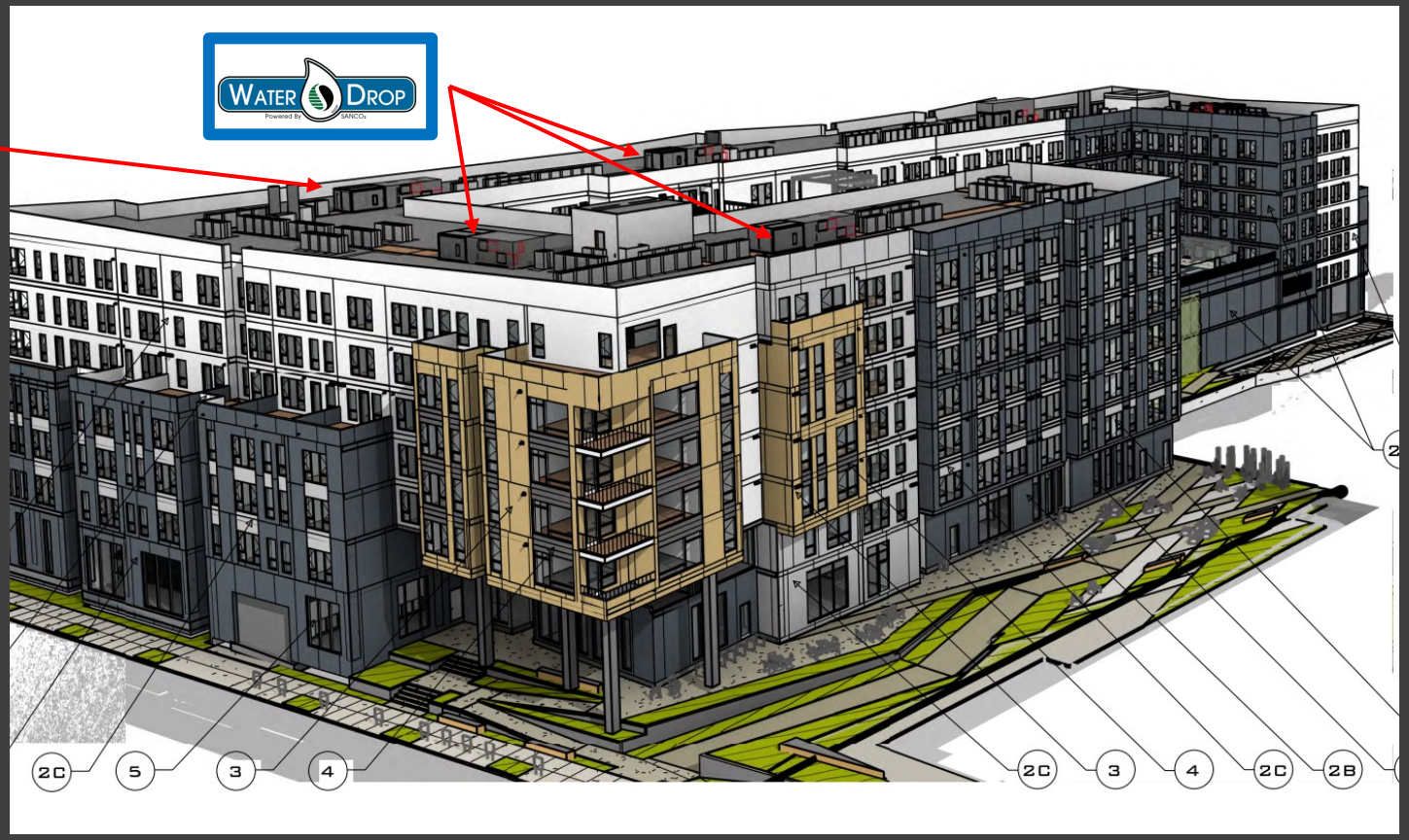

EXIT

DROPLET HEAT PUMP RACK MODEL DATA

Model	Total HPs	HP Recovery[1] (kBtuh)	HP Recovery[1] (Gal/Hr)	Max Output[2] (Gal/Day)	Dimensions[3] L (ft)	Dimensions[3] W (ft)	Dimensions[3] H (ft)	Dry Weight[3] (lbs)	Wet Weight[3] (lbs)
Droplet 2	2	31	37	592	60	45	80	400	550
Droplet 4	4	62	74	1,183	96	45	80	800	1,075
Droplet 6	6	92	111	1,775	135	45	80	1,200	1,600
Droplet 8	8	123	148	2,366	175	45	80	1,600	2,150
Droplet 10	10	154	185	2,958	135	90	80	2,150	2,850
Droplet 12	12	185	222	3,550	135	90	80	2,400	3,200

Big Buildings

Zone out and keep it tight



Break it into zones

- Compact distribution systems use less pump energy
- Shorter runs have less loss with a smaller swing tank lifts
- Multiple plants offer better security and lower power drops.

Questions?

(It’s safe to to wake up now…)

Questions about Title 24?

3C-REN offers a *free* Code Coach Service

Online:
3c-ren.org/codes

Call:
805.781.1201

Energy Code Coaches are local experts who can help answer your Title 24 questions. Coaches have decades of experience in green building and energy efficiency improvements. They can provide citations and offer advice for your project to help your plans and forms earn approval the first time.

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  - April 9th - Blower Door Basics and Beyond
  - April 11th – Is A Heat Hump Water Heater Right for Me?
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Thank you!

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For questions:
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