Empowering Meaningful Measurement & Verification with EcoDash:

A Standardized Tool for Assessing Emerging Technology

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June 24, 2025

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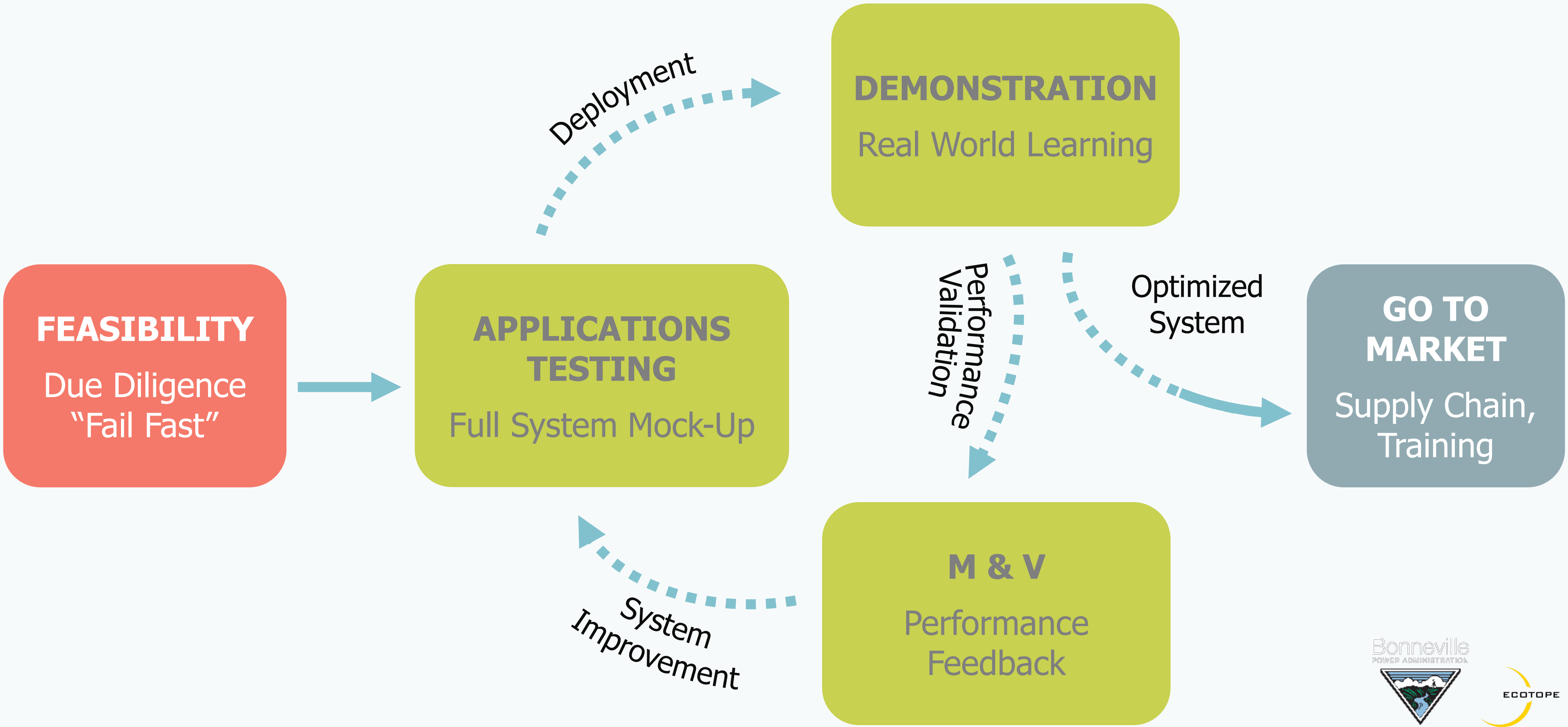
Our Mission

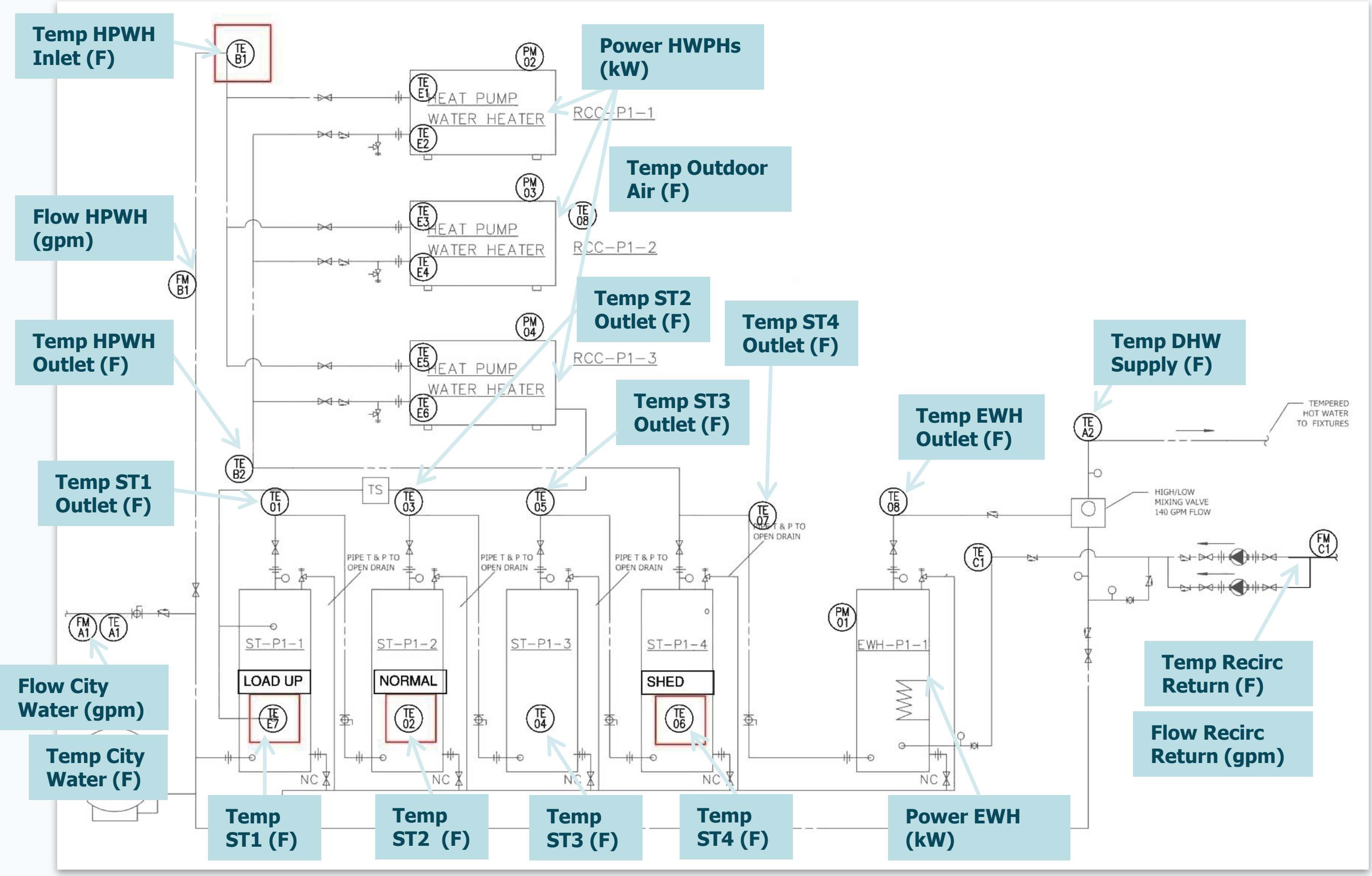
+ **Economic deployment of heat pump water heating systems is critical to building decarbonization**

Technology Innovation Model



Current Monitoring

- ~40 multifamily CHPWH sites
- 7 small Light Commercial HPWH sites
- 30 residential HVAC sites
- 20 commercial HVAC sites



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Goals of EcoDash

+ Validate Savings Potential
+ Support Standard Protocol Measure
+ Identify and solve knowledge gaps
+ Engage manufacturers, contractors, building maintenance, and utilities.

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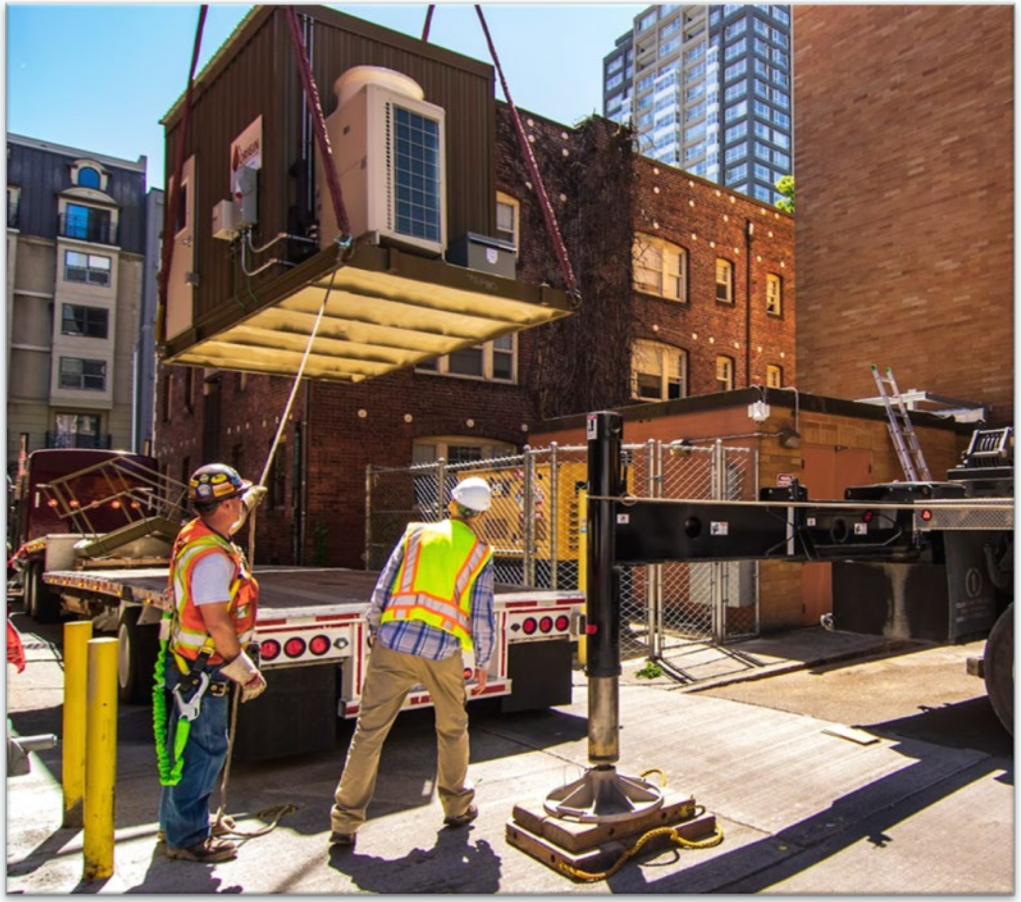
Agenda

+ Data Management, System COP, Appendix H
+ Current EcoDash Features
+ Standard Protocol and Continuous Improvement
+ Flexible Load Management with CHPWHs
+ Next Steps



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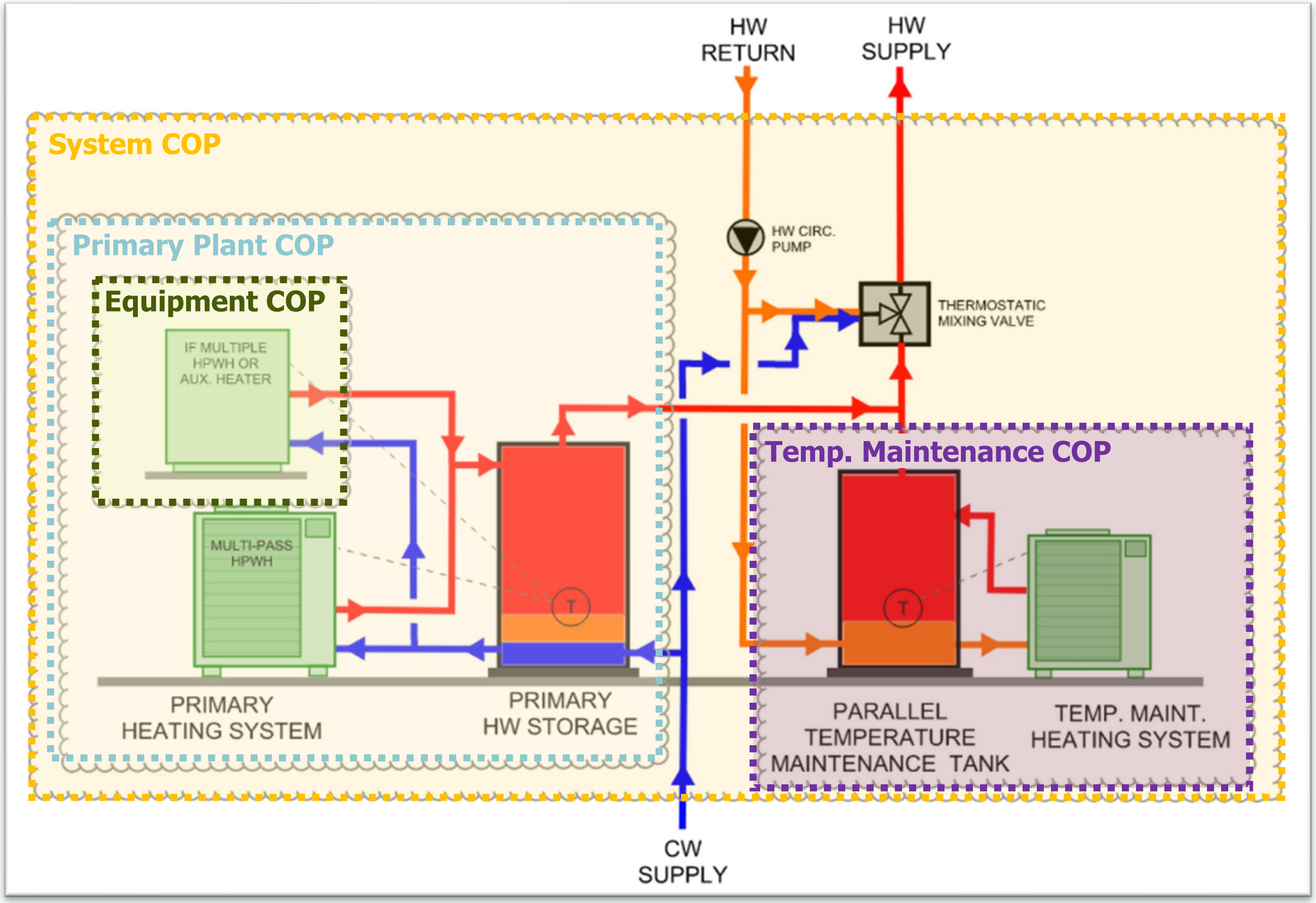
System COP, Appendix H, Data Management

System COP

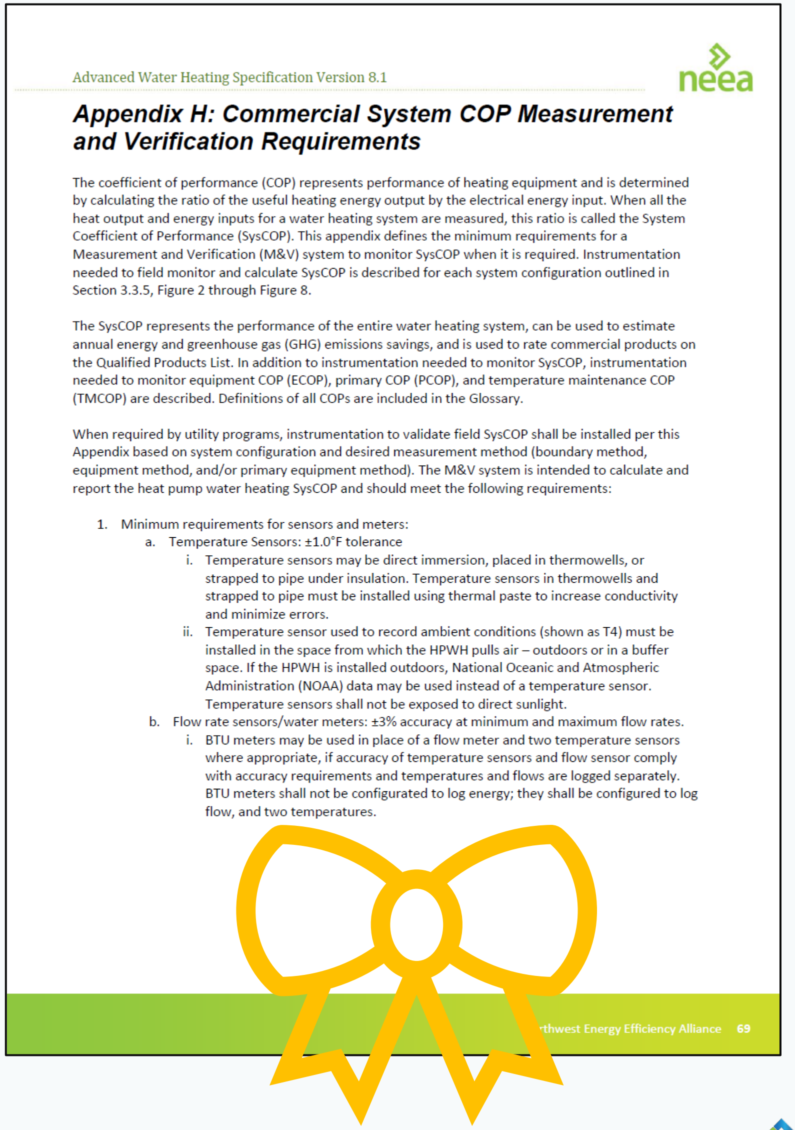
+ **Equipment COP:**
  Heat pump only
+ **Primary Plant COP:**
  Heat pump + storage
+ **Temp. Maintenance COP:**
  Temperature maintenance system
+ **System COP:**
  Accounts for all water heating energy



COP Boundaries: Single-Pass Primary HPWH System with Parallel Temperature Maintenance Tank & Multi-Pass HPWH

AWHS Appendix H

- Methods for Calculating System COP
  - Boundary, Equipment, Primary Equipment
- Data to be logged in 1-minute intervals
- SysCOP to be calculated daily, stored for at least 6 months



Appendix H: Commercial System COP Measurement and Verification Requirements

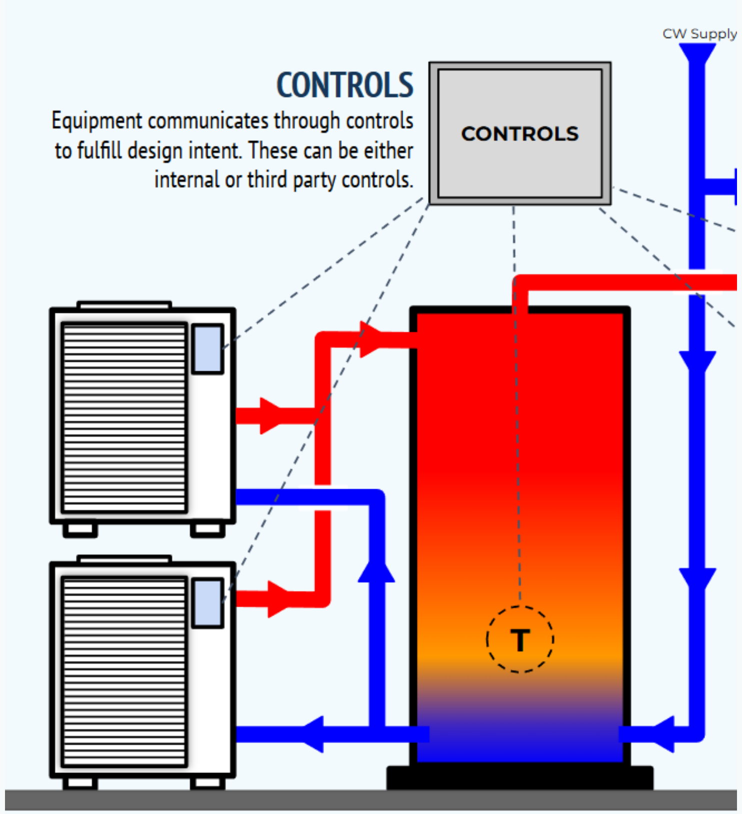
The coefficient of performance (COP) represents performance of heating equipment and is determined by calculating the ratio of the useful heating energy output by the electrical energy input. When all the heat output and energy inputs for a water heating system are measured, this ratio is called the System Coefficient of Performance (SysCOP). This appendix defines the minimum requirements for a Measurement and Verification (M&V) system to monitor SysCOP when it is required. Instrumentation needed to field monitor and calculate SysCOP is described for each system configuration outlined in Section 3.3.5, Figure 2 through Figure 8.

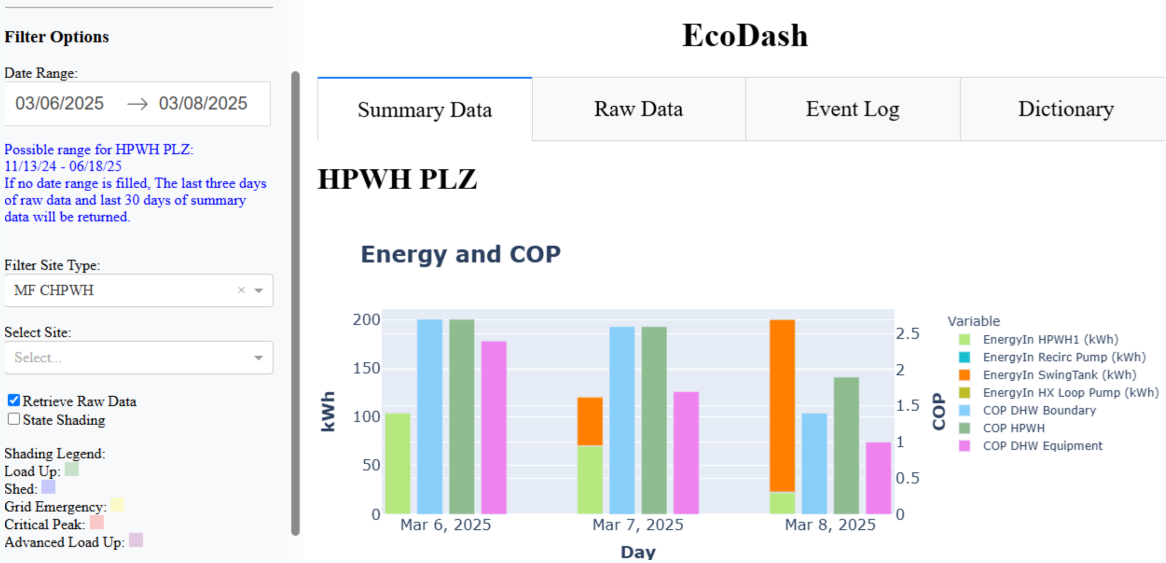
The SysCOP represents the performance of the entire water heating system, can be used to estimate annual energy and greenhouse gas (GHG) emissions savings, and is used to rate commercial products on the Qualified Products List. In addition to instrumentation needed to monitor SysCOP, instrumentation needed to monitor equipment COP (ECOP), primary COP (PCOP), and temperature maintenance COP (TMCOP) are described. Definitions of all COPs are included in the Glossary.

When required by utility programs, instrumentation to validate field SysCOP shall be installed per this Appendix based on system configuration and desired measurement method (boundary method, equipment method, and/or primary equipment method). The M&V system is intended to calculate and report the heat pump water heating SysCOP and should meet the following requirements:

1. Minimum requirements for sensors and meters:
   a. Temperature Sensors: ±1.0°F tolerance
      i. Temperature sensors may be direct immersion, placed in thermowells, or strapped to pipe under insulation. Temperature sensors in thermowells and strapped to pipe must be installed using thermal paste to increase conductivity and minimize errors.
      ii. Temperature sensor used to record ambient conditions (shown as T4) must be installed in the space from which the HPWH pulls air – outdoors or in a buffer space. If the HPWH is installed outdoors, National Oceanic and Atmospheric Administration (NOAA) data may be used instead of a temperature sensor. Temperature sensors shall not be exposed to direct sunlight.
   b. Flow rate sensors/water meters: ±3% accuracy at minimum and maximum flow rates.
      i. BTU meters may be used in place of a flow meter and two temperature sensors where appropriate, if accuracy of temperature sensors and flow sensor comply with accuracy requirements and temperatures and flows are logged separately. BTU meters shall not be configurated to log energy; they shall be configured to log flow, and two temperatures.

EcoDash Data Flow



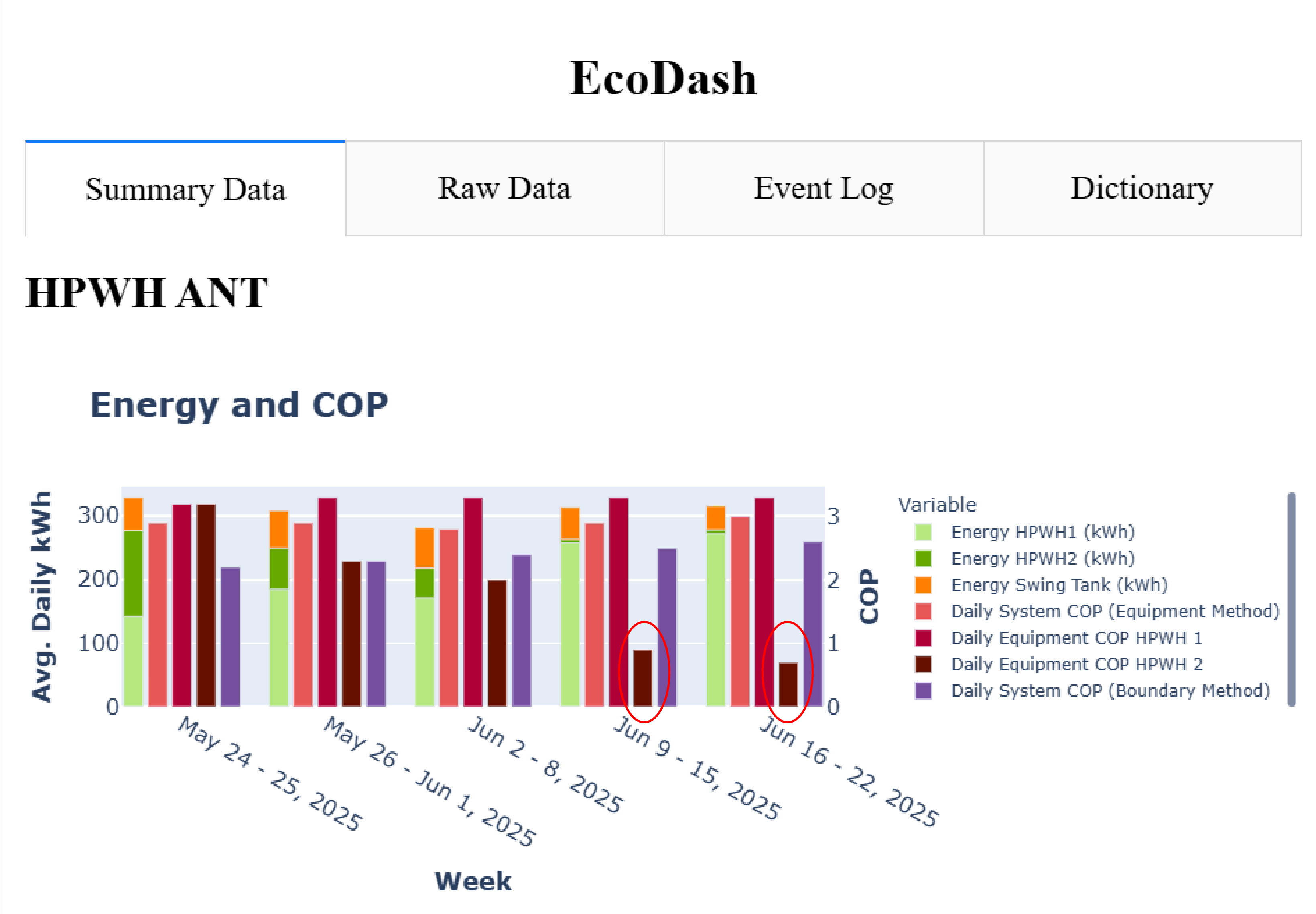


Shareable user interface for cleaned, processed M&V data.

Current EcoDash Features

EcoDash – Summary Data

- System COP Performance Tracking
- OAT Regression
- Usage or HP and ER
- Water Usage



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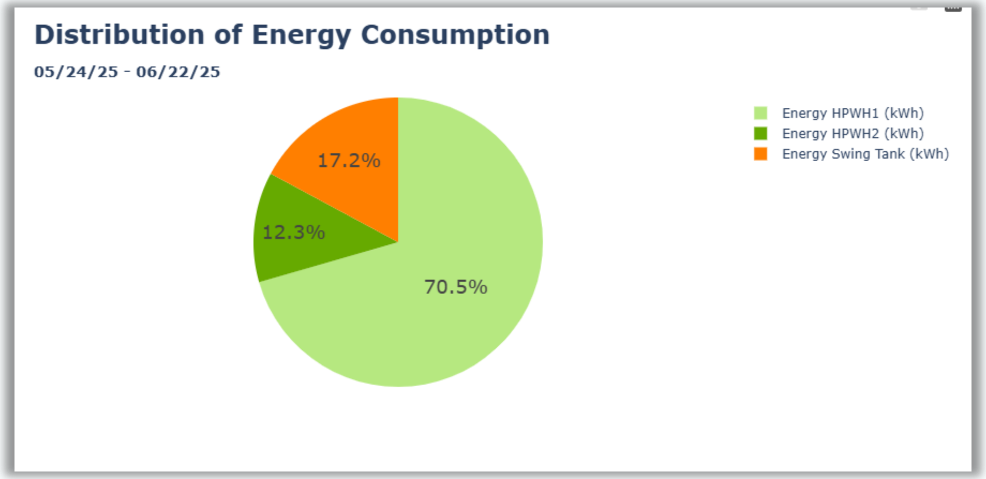
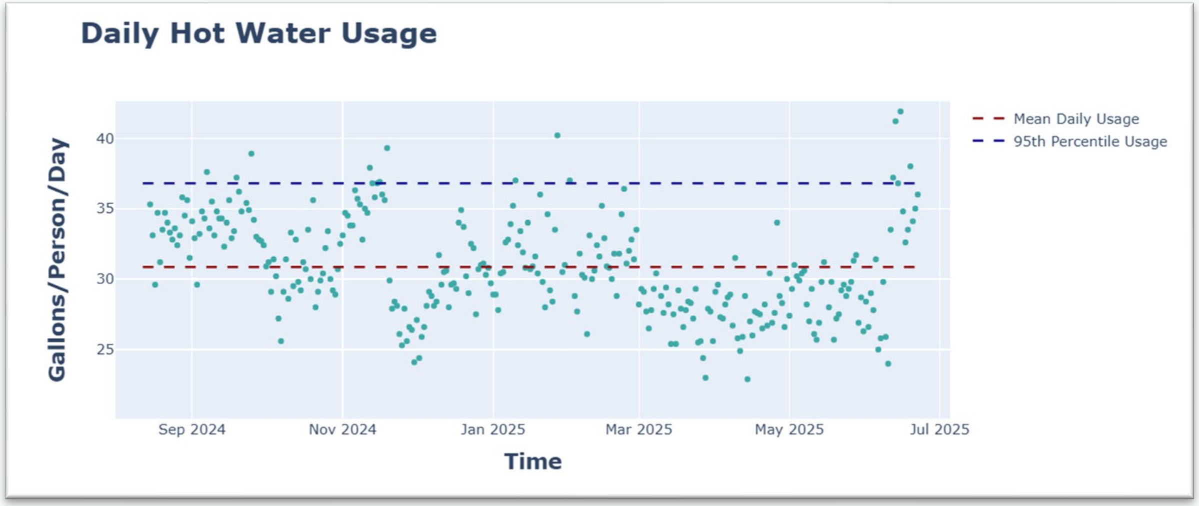
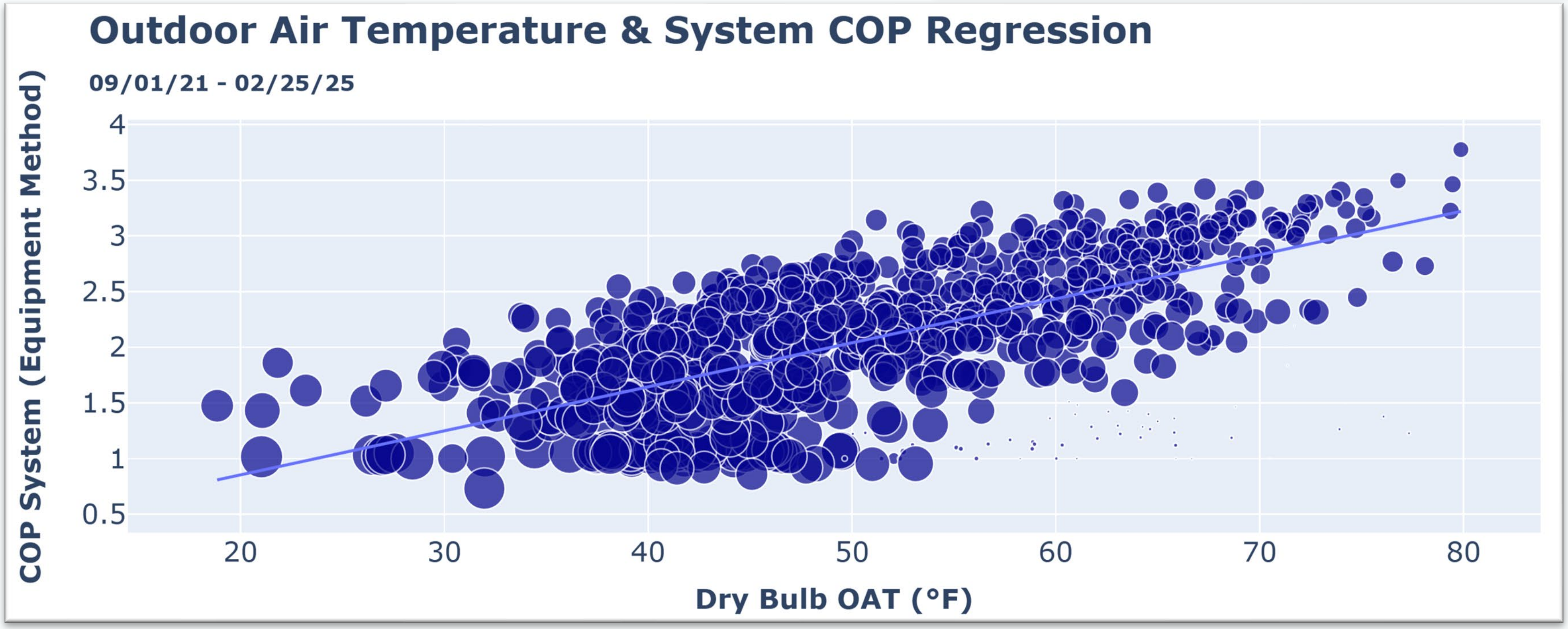
EcoDash – Summary Data







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EcoDash – Raw Data

+ **Troubleshooting**
+ **Zooming, Hovering, Filtering Data**
+ **System Schematic to align points**

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EcoDash – Event Log

EcoDash

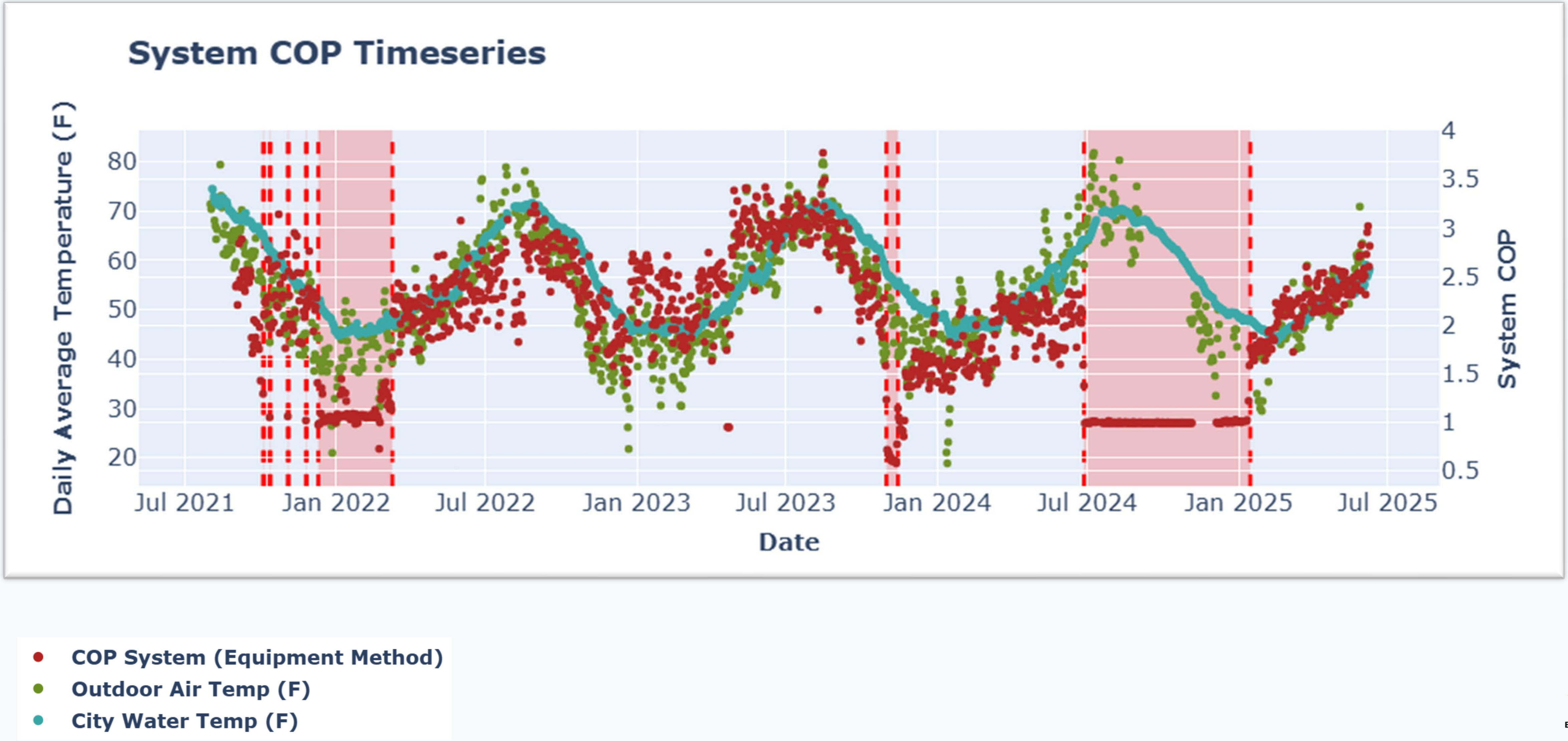
Summary Data	Raw Data	Event Log	Dictionary

HPWH HTN

Event Log

id	Start Date	End Date	Event Type	Details	Filtered from Summary Graphs	Filtered from Optimized COP
706	2025-03-18	2025-03-18	SITE_VISIT	Initial Installation	NO	NO
707	2025-04-09	2025-04-09	SITE_VISIT	Repair 1 temperature sensor, reconfigure HPWH flow meter	NO	NO
651	2025-03-03	2025-04-10	DATA_LOSS_COP	HPWH Flow rate not accurate. Adjusted 4/9/25 on site and updated in Aquisuite 4/10/25.	YES	YES
686	2025-03-18	2025-04-23	SOO_PERIOD_COP	Swing tank setpoint 135F. Lowered to 130F on site visit 4/23/25.	NO	YES
685	2025-03-18	2025-04-23	DATA_LOSS	DHW supply temperature configured incorrectly. Fixed during site visit 4/23/25. Supply temperature adjusted in TM and DHW usage calculations prior to correction.	NO	NO
708	2025-04-23	2025-04-23	MV_COMMISSIONED	Final site visit, including adjustments to swing tanks.	NO	YES

EcoDash – Event Log



EcoDash – Event Log

Event Log

id	Start Date	End Date	Event Type	Details
241	2024-06-27	2025-01-14	EQUIPMENT_MALFUNCTION	HPWH non functional due to a leak on the flex joint at the QAHV unit causing the system to lose pressure.
512	2025-01-13	2025-01-13	SITE_VISIT	Broken flex connection replaced with high temperature flex connection. Coil Cleaned. System filled with water. QAHV is operational again! Repairs made by . Dustin (METUS) walks site with to finalize.
242	2023-10-31	2023-11-14	HW_LOSS	Based on data there appears to be a problem with the secondary loop pump resulting in a HW loss
71	2023-10-31	2023-11-14	EQUIPMENT_MALFUNCTION	Based on data there appears to be a problem with the secondary loop pump resulting in a HW loss
597	2023-04-21	2023-04-23	EQUIPMENT_MALFUNCTION	Heat exchanger failure and replacement

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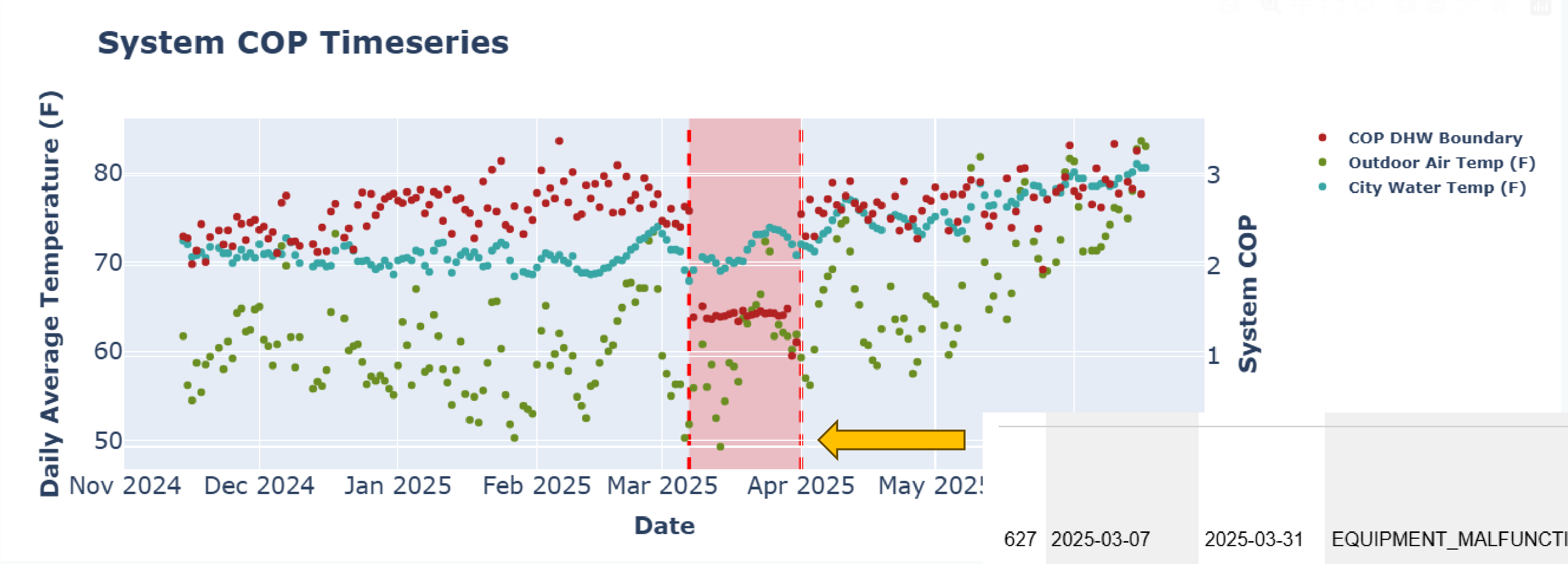
EcoDash – Event Log

+ **Issues identified as valve closed that should be open using raw data. Data logged in Event Log.**



627	2025-03-07	2025-03-31	EQUIPMENT_MALFUNCTION	Blus closes wrong valve during cite visit resulting in HP short cycling and ER heating. Contractor installed thermostatic balancing valves. Shut system down to install.

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Standard Protocol and Continuous Improvement

Standard Protocol Measure

+ Pay for performance approach recommended in the March 18th RTF Meeting
+ Appendix H M&V Standard Protocol Measure for CHPWHs
+ Current market maturity, achieving high long term SysCOP requires monitoring
+ EcoDash can be used to help RTF determine a baseline

- Most promising way to achieve savings

Simple Example: 2.5 SysCOP "commissioned" system vs an assumed 1.2 long-term SysCOP for the baseline

- **UES $\approx$ 46,000 kWh/yr**
  - Assume 1,700 gallons/day hot water, 50°F inlet, 120°F outlet
  - $UEC_{baseline} = \frac{(1700)\times(120-50)\times(365\times 8.34\times 1\div 3412)}{1.2} = 88{,}500\ kWh/yr$
  - $UEC_{efficientcase} = \frac{(1700)\times(120-50)\times(365\times 8.34\times 1\div 3412)}{2.5} = 42{,}500\ kWh/yr$
- **Cost ≈ $5k to $30k** (initial) **$4k** (recurring)
  - Monitoring equipment installation and initial commissioning cost (does not include HPWH equipment cost)
    - Assume $5,000 where "installed" at time of manufacturer
    - Assume $30,000 if installed after-the-fact
  - Recurring (every 3 years) commissioning and reporting
    - Assume $4,000
- **Benefit/Cost Ratio ≈ 0.59 to 1.5**
  - Assumes 15-year life, with commissioning and reporting costs recurring every 3 years, flat load shape

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Qualified Products List

SystemCOP ≠ Manufacturer's published COP or DOE Test COP

Company	Identifier	Configuration	Market Delivery Method	Hot Climate Zone		Mild Climate Zone		Cold Climate Zone		Very Cold Climate Zone	
				Tier	SysCOP	Tier	SysCOP	Tier	SysCOP	Tier	SysCOP
Manufacturer A	Model A	Multi Pass Return to Primary	Custom Engineered	1	2.1	1	1.6	1	1.4	1	1.3
Manufacturer A	Model B	Multi Pass Return to Primary	Custom Engineered	1	2.1	1	1.6	1	1.4	1	1.3
Manufacturer A	Model C	Multi Pass Return to Primary	Custom Engineered	1	2.2	1	1.7	1	1.5	1	1.4
Manufacturer A	Model D	Multi Pass Return to Primary	Custom Engineered	1	2.2	1	1.7	1	1.5	1	1.4
Manufacturer B	Model AA	Swing Tank	Fully Specified Built-Up	2	2.7	3	2.6	3	2.4	2	2.0

Fault Detection/Data Quality

HPWH SUMMARY

Site	ASHRAE CZ	Equipment	Expected COP	Average COP	Ongoing Events	Details
HPWH 02	3C		2.5	2.4	No ongoing events.	N/A
HPWH 03	4C		2.5	2	No ongoing events.	N/A
HPWH 04	3C		2.5	2.9	No ongoing events.	N/A
HPWH 05	3C		2.5	2.6	No ongoing events.	N/A
HPWH 06	4C		3.2	1.6	INSTALLATION_ERROR	Missing balancing valve on the recirculation return branch to the swing tank causes more recirculation water flow back through the swing tank and less is directed to the mixing valve. When more recirculation water flows to the swing tank, less water from the primary storage flows into the swing tank during hot water draws. As a result, the swing tank does a higher percentage of the overall heating.
HPWH 08	3C		3.2	1.1	PARTIAL_OCCUPANCY, MISC_EVENT	Partial occupancy. Swing tank setpoint set to 140F instead of 122-125F at start up.
HPWH 09	3C		3.2	1.4	PARTIAL_OCCUPANCY, MISC_EVENT	Partial occupancy. Swing tank setpoint set to 140F instead of 122-125F at start up. Swing tank handling majority of TM load.
HPWH 10	3C		2.4	1.1	DATA_LOSS	Broken recirc return BTU meter. Recirc losses estimated with redundant flow metering.
HPWH 18	3B		1.7	1.4	PARTIAL_OCCUPANCY	Building is not fully occupied: estimated 52 occupants as of 11/5/24.

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Identification and Tracking of Common Issues

+ Missing balancing valve
+ Swing tank setpoint is too high
+ Feedback to AWHS QPL Diagrams
+ Event log tracking to allow FDD in Progress

Identifier	Configuration	Market Delivery Method
AHPA060	Multi Pass Return to Primary	Custom Engineered System
AHPA060	Single Pass Return to Primary	Custom Engineered System
AHPA060	Swing Tank	Custom Engineered System
AHPA140	Multi Pass Return to Primary	Custom Engineered System

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RECOMMENDED CHPWH SYSTEM CONTROLS

TABLES BELOW INDICATE RECOMMENDED CONTROL MODES, POINTS, ALARMS, AND RESPONSES TO ECOPORT (CTA-2045-B) UTILITY REQUESTS. ALL ALARMS ARE RECOMMENDED TO BE AUDIBLE AND/OR EMAIL ALERTS. CONTROLS ARE DESIGNED TO ACHIEVE LOAD SHIFTING WHILE MAINTAINING HOT WATER DELIVERY TO TENANTS. THE CONTROLLER SHALL RECEIVE ECOPORT REQUESTS THROUGH THE ECOPORT UNIVERSAL COMMUNICATION MODULE (UCM), CONVERT SIGNALS TO OPERATIONAL ADJUSTMENTS, AND BE CAPABLE OF ENABLING/DISABLING THE ELECTRIC RESISTANCE EQUIPMENT.

DEMAND RESPONSE CONTROL

SWT RECOMMENDED CONTROL CHANGES	ECOPORT COMMAND					
	NORMAL OPERATION	SHED	CRITICAL PEAK EVENT	GRID EMERGENCY	LOAD UP	ADV. LOAD UP
OPERATING MODE	1	3	3	DISABLED	2	2
HPWH OUTLET TEMPERATURE SETPOINT	150°F	150°F	150°F	DISABLED	150°F	180°F
SWING TANK SETPOINT (DEADBAND)	130°F (10°F)	130°F (10°F)	DISABLED	DISABLED	130°F (10°F)	130°F (10°F)

POINTS AND ALARMS

TAG	CONTROL PANEL INPUT/OUTPUT	LOCATION
DEVICES		
ENABLE/DISABLE	DIGITAL OUTPUT	SWING TANK
TEMPERATURE SENSORS		
TE-01	ANALOG INPUT	ST-1 LOW (10-25%)
TE-02	ANALOG INPUT	ST-1 MID (30-45%)
TE-03	ANALOG INPUT	ST-1 HIGH (65-85%)
TE-04 (1)	ANALOG INPUT	MXV OUTLET
HEAT PUMP WATER HEATER INTERNAL POINTS		
HPWH(S) FAULT (2)	DIGITAL OUTPUT	HPWH(S) (INTERNAL)
HPWH(S) INLET TEMP	ANALOG INPUT	HPWH(S) (INTERNAL)
HPWH(S) ON/OFF	DIGITAL OUTPUT	HPWH(S) (INTERNAL)
HPWH(S) OUTLET TEMP	ANALOG OUTPUT	HPWH(S) (INTERNAL)

(1) ALARM WHEN MIXING VALVE OUTLET DROPS BELOW SETPOINT MINUS 5°F FOR MORE THAN 15 MINUTES.
(2) ALARM WHEN HPWH IS IN A FAULT CONDITION. (AUDIBLE , TEXT, OR EMAIL)

OPERATING MODES

OPERATING MODE 1	
ON SENSOR	TE-02
OFF SENSOR	TE-01
ON TEMPERATURE	120°F
OFF TEMPERATURE	140°F
OPERATING MODE 2	
ON SENSOR	TE-01
OFF SENSOR	INLET TEMP
ON TEMPERATURE	120°F
OFF TEMPERATURE	125°F
OPERATING MODE 3	
ON SENSOR	TE-03
OFF SENSOR	TE-02
ON TEMPERATURE	120°F
OFF TEMPERATURE	140°F
OPTIONAL EWH CONTROL	
INSTANTANEOUS WATER HEATER USED FOR BACKUP HEATING AND/OR COLD CLIMATE TRIM HEATING. ENGINEER SHALL SPECIFY CONTROLS ACCORDINGLY.	

GENERAL NOTES

A. THIS SHEET PROVIDES A DETAILED GENERIC REPRESENTATION OF THE SWING TANK CONFIGURATION DEFINED IN NORTHWEST ENERGY EFFICIENCIES ALLIANCE'S ADVANCED WATER HEATING SPECIFICATION. PLEASE ALSO REFER TO MANUFACTURE LITERATURE WHEN DESIGNING AND INSTALLING SPECIFIC PRODUCTS.
B. SIZE SYSTEM WITH MANUFACTURER APPROVE SIZING TOOL. REFERENCE MANUFACTURER DOCUMENTATION TO DETERMINE CAPACITY AT VARIABLE OUTDOOR AIR TEMPERATURES. IF NO DEFROST DERATE IS PROVIDED BY MANUFACTURER, A MINIMUM 20% DERATE IS RECOMMENDED.
C. MOUNT ALL EQUIPMENT PER MANUFACTURER DOCUMENTATION AND LOCAL CODES. CONSULT STRUCTURAL ENGINEER IF NEEDED. PROVIDE SEISMIC STRAP AS REQUIRED BY LOCAL CODE. PROVIDE VIBRATION ISOLATION WHERE REQUIRED ON HPWHS AND PUMPS.
D. ROUTE ALL T&P RELIEF VALVES TO APPROVED DRAIN LOCATION.
E. REFER TO AWHS APPENDIX I FOR MINIMUM M&V INSTALLATION GUIDELINES.

SHEET NOTES

1. FOLLOW MANUFACTURERS GUIDANCE ON EQUIPMENT CONNECTIONS - PLUMBING, ELECTRICAL STRUCTURAL, CONDENSATE, AND COMMUNICATION. INCLUDE A CHECK VALVE ON HEAT PUMP INLET IF THERE IS NO INTERNAL CHECK VALVE TO PREVENT BACKFLOW THROUGH THE HEAT PUMP WHEN NOT OPERATING. STRAINER MAY BE LOCATED AT EACH HEAT PUMP OR, AS DEPICTED, BEFORE ALL HEAT PUMPS. ROUTE CONDENSATE OUTLET TO NEAREST ACCEPTABLE DRAIN LOCATION - FLOOR DRAIN OR CONDENSATE DRAIN WELL. PROVIDE HEAT TRACE OR HEATING PAD ON BOTTOM OF CONDENSATE PAN AND DRAIN LINE FOR FREEZE PROTECTION IN CLIMATES WHERE FREEZING IS POSSIBLE. INSULATE CONDENSATE DRAIN LINE OVER HEAT TRACE IF INSTALLED.
2. THERMAL STORAGE TANKS MAY BE PIPED IN PARALLEL OR SERIES, BUT A COMBINATION OF PARALLEL AND SERIES IS HIGHLY DISCOURAGED. STORAGE SYSTEMS ARE RECOMMENDED TO HAVE NO MORE THAN 3 TANKS AND STRONGLY RECOMMENDED TO HAVE NO MORE THAN 5 TANKS.
3. PROVIDE AUTOMATIC AIR VENT WITH SERVICING CHECK VALVE AT HIGH POINT.
4. SET BALANCING VALVE TO MINIMUM POSSIBLE FLOW THAT MAINTAINS STABLE MIXING VALVE OPERATION WHEN SYSTEM HAS NO HW DRAW.
5. ADD HEAT TRACE TO ALL EXTERNAL PIPING IN CLIMATES WHERE FREEZING IS POSSIBLE. HEAT TRACE SHALL BE ON UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM CAPABLE OF PROVIDING 24 HRS OF HEATING IN CASE OF POWER OUTAGE. INSTALL METHOD FOR ISOLATION AND DRAINING OUTDOOR WATER LOOP WHEN POWER OUTAGES OF MORE THAN 24-HRS ARE POSSIBLE DURING FREEZING CONDITIONS.
6. PROVIDE HEAT TRAP AT PRIMARY AND SWING TANK OUTLETS. HEAT TRAP MAY BE FABRICATED BY DROPPING OUTLET PIPING A MINIMUM OF 12 INCHES BELOW TANK CONNECTED POINT.
7. PROVIDE HEAT TRAP OR SPRING CHECK VALVE TO PREVENT THERMOSYPHONING.
8. MIXING VALVE SETPOINT TEMPERATURE IS RECOMMENDED TO BE NO LOWER THAN 120°F. RECIRCULATION RETURN WATER TEMPERATURE IS RECOMMENDED TO BE NO LOWER THAN 110°F AND NO HIGHER THAN 120°F.
9. INCLUDE BALANCING VALVE IF PUMP IS CONSTANT SPEED. VARIABLE SPEED PUMPS ARE RECOMMENDED TO BE CONTROLLED TO CONSTANT/PROPORTIONAL PRESSURE OR CONSTANT TEMPERATURE. PRESSURE CONTROL IS RECOMMENDED WHEN THERMOSTATIC BALANCING VALVES ARE USED FOR BRANCH BALANCING (HIGHLY RECOMMENDED IN LARGER BUILDINGS). TEMPERATURE CONTROL IS RECOMMENDED WHEN MANUAL BRANCH BALANCING IS USED. PUMP MUST BE CONTROLLED TO PROVIDE THE MINIMUM REQUIRED FLOW FOR THE SELECTED MIXING VALVE. THE MINIMUM RECOMMENDED RECIRCULATION RETURN WATER TEMPERATURE IS 118°F.
10. FOLLOW MANUFACTURERS GUIDANCE WHEN PIPING MULTIPLE HPWHS. HPWHS MAY BE REQUIRE PIPING IN REVERSE RETURN OR USE COMMON HEADERS. MAXIMUM PIPE LENGTH BETWEEN HPWHS AND STORAGE MAY APPLY. SOME HPWHS MAY BE ABLE TO USE BOOSTER PUMPS.

LEGEND

PIPING COMPONENTS AND VALVES

- MIXING VALVE
- SHUT-OFF VALVE (BALL, GATE, OR BUTTERFLY)
- CHECK VALVE
- FULL-PORT BALL VALVE
- BALANCING VALVE
- DRAIN VALVE
- STRAINER
- PRESSURE GAUGE
- TEMPERATURE GAUGE
- PRESSURE RELIEF VALVE
- PUMP

INSTRUMENTS

- FM XX — FLOW METER
- TE XX — TEMPERATURE SENSOR

GENERAL SHEET SYMBOLS

- # — PLAN NOTE REFERENCE SYMBOL

ABBREVIATIONS

CW	COLD WATER
HW	HOT WATER
HWC	HOT WATER RECIRCULATION
ST	STORAGE TANK
P	PUMP
EWH	ELECTRIC WATER HEATER
HPWH	HEAT PUMP WATER HEATER

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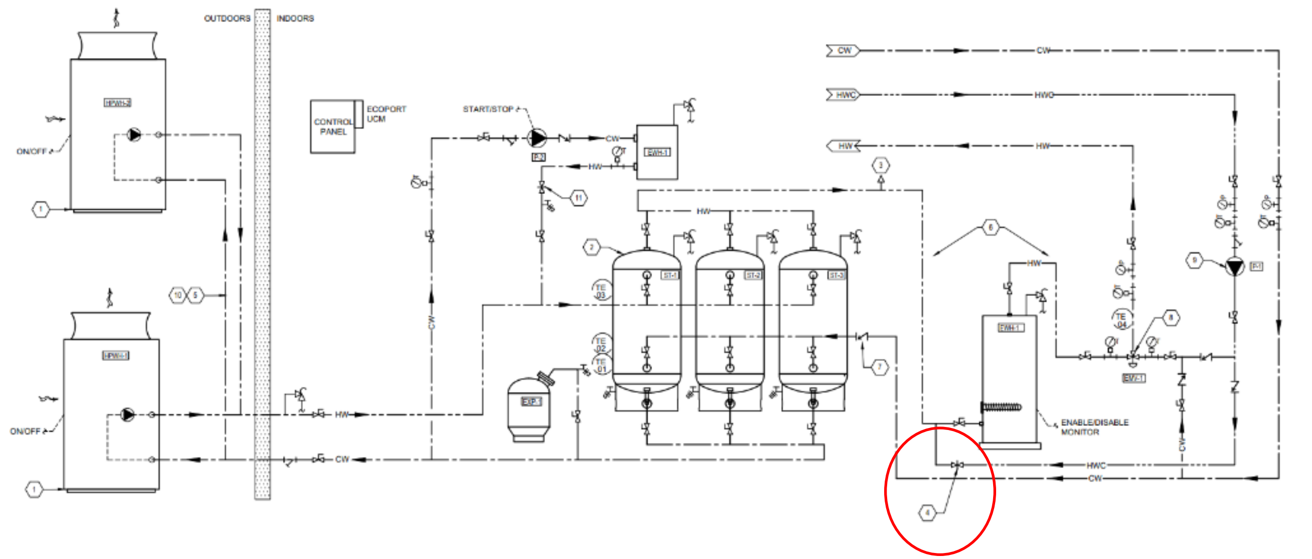

1 WATER HEATING PLANT P&ID

Scale: NTS

PROJECT
COMMERCIAL HPWH - SWING TANK
NORTHWEST ENERGY EFFICIENCY ALLIANCE
ADVANCE WATER HEATING SPECIFICATION

DATE 06/11/2024

REVISIONS

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Flexible Load Management with CHPWHs

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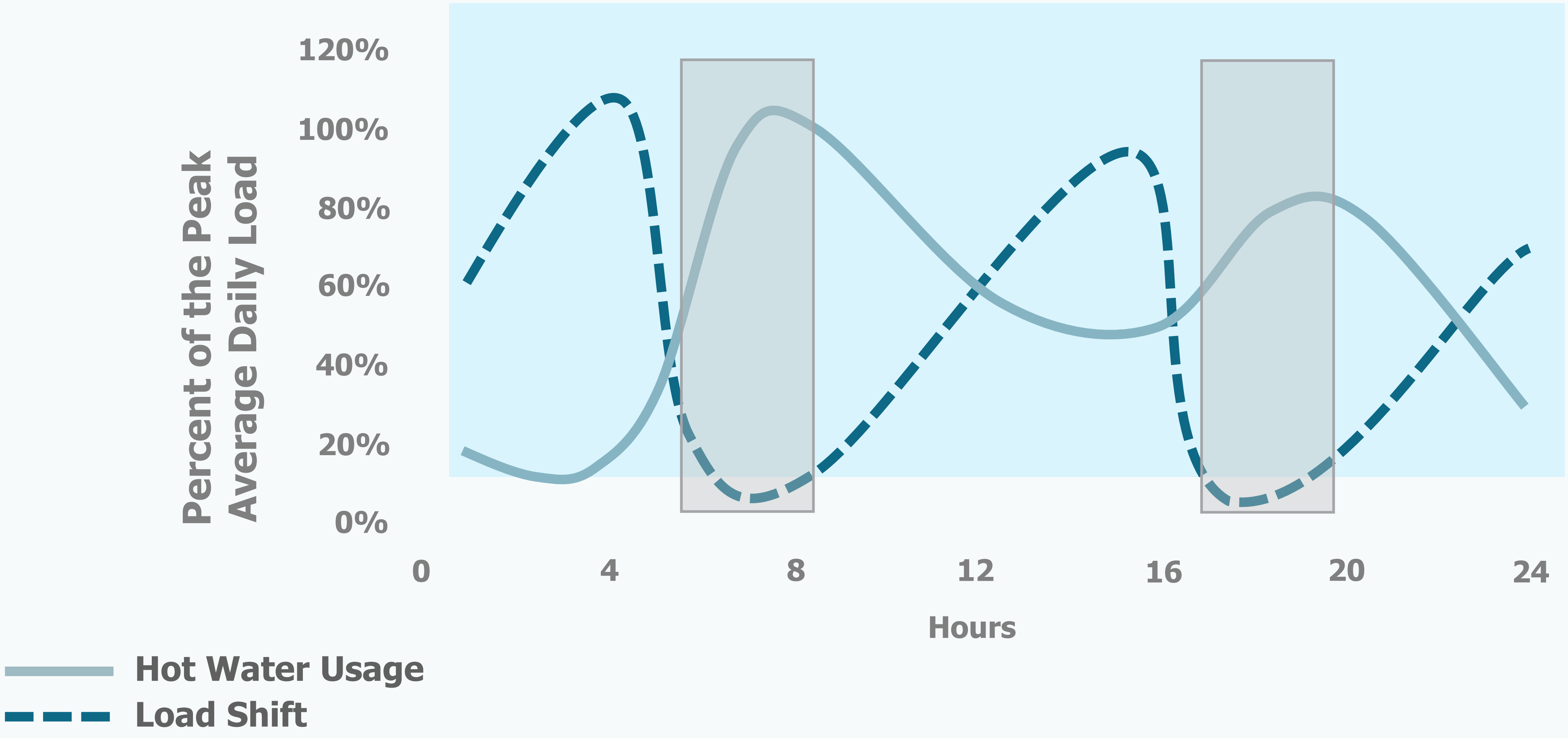
HPWH systems are a valuable utility resource for load shifting

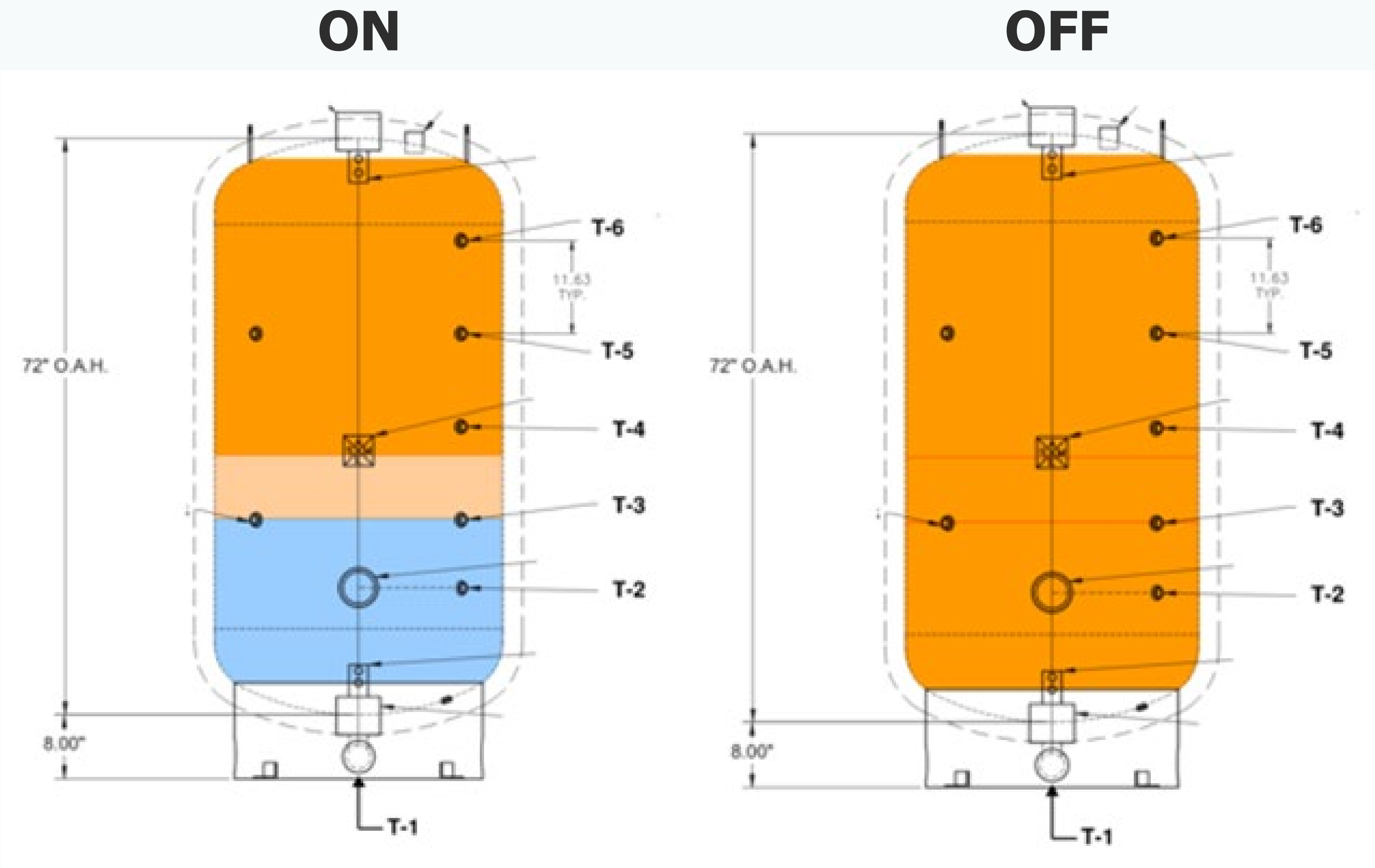


Controls

+ 4 modes of operation sent via EcoPort (CTA-2045) requests
    - Normal
    - Load up
    - Shed
    - Critical Peak
+ Load shift strategies
    - Storage staging
    - Increase water temperatures
    - Increase capacity

HPWH normal operations

- + ~40% Aquastat Fraction
- + Simple on/off logic
- + Long compressor cycles



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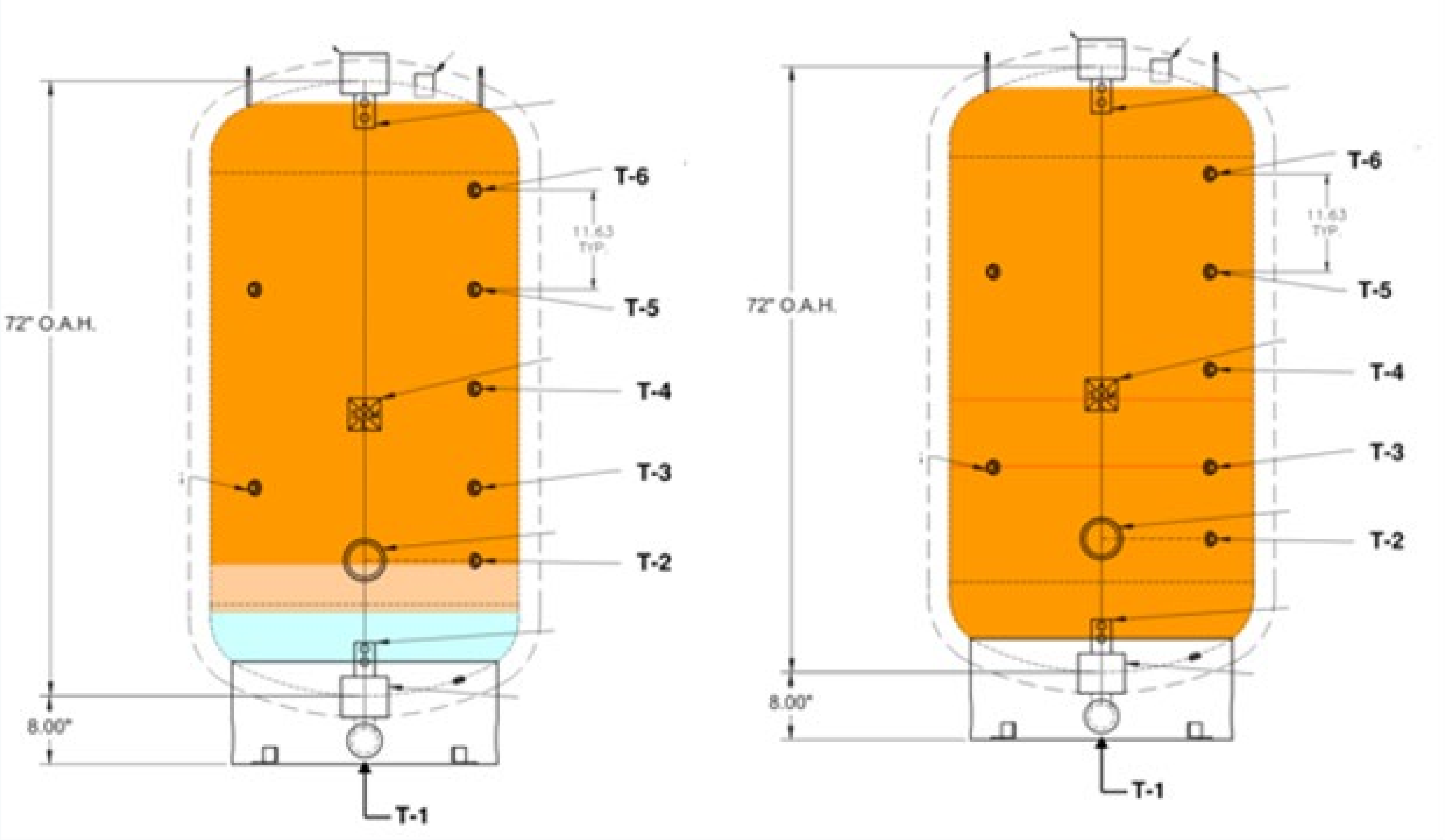
Load-up controls

- ~20% Aquastat Fraction
- Forces heat pump on
- Short compressor cycles

ON

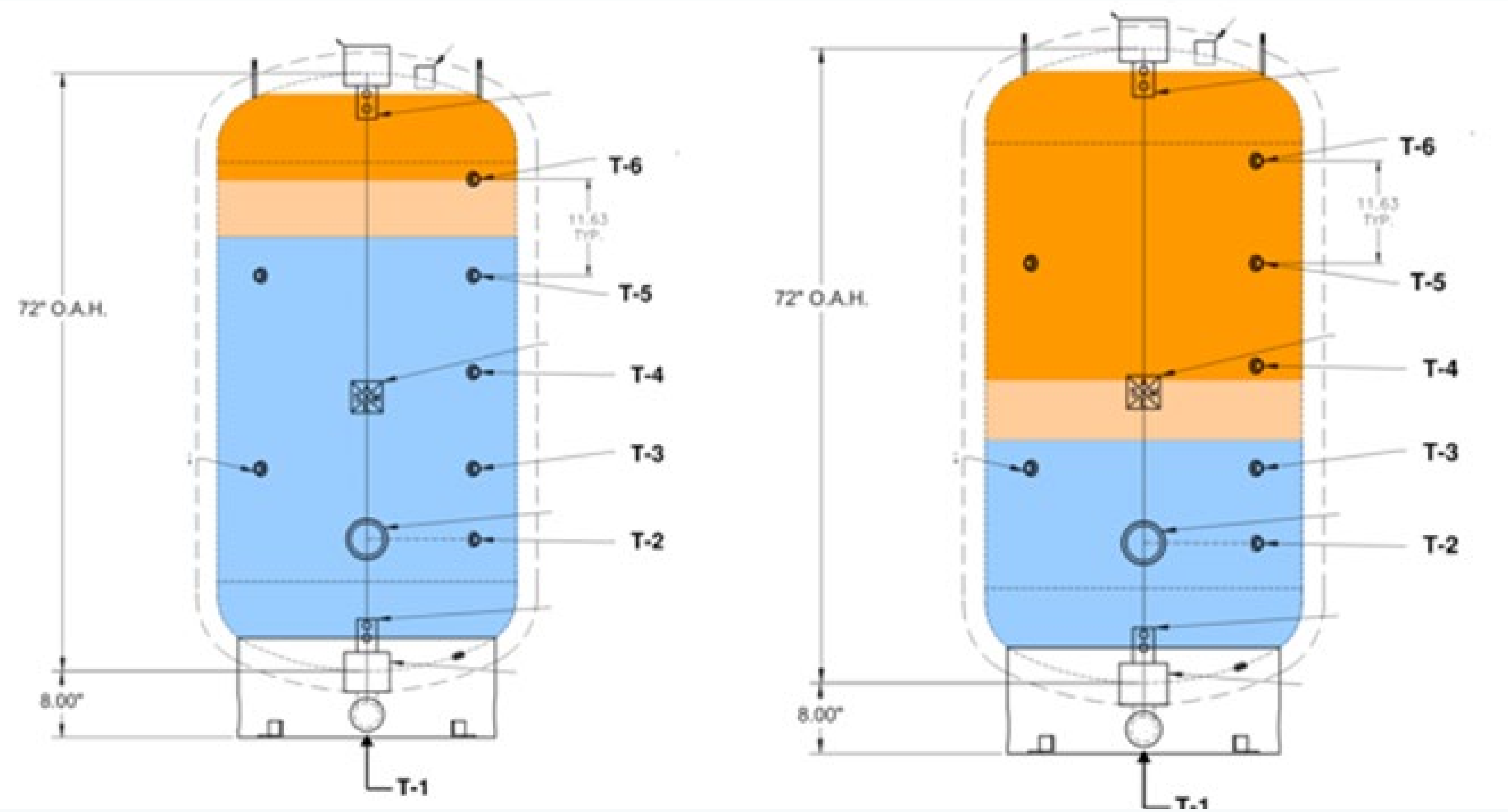
OFF



Shed controls

ON

OFF



+ ~85% Aquastat Fraction
+ Keeps heat pump off
+ Prevents hot water loss

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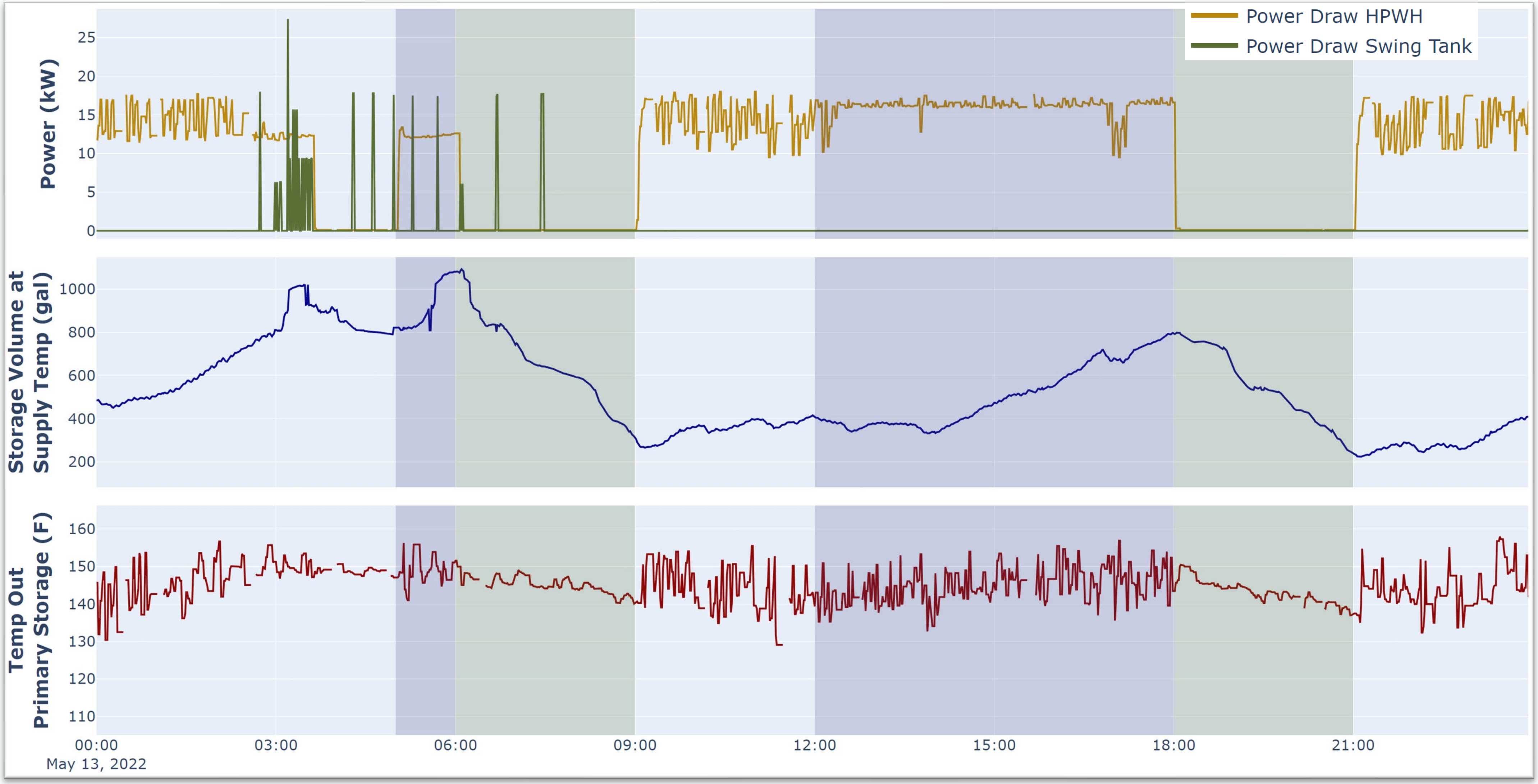
Load shifting with CHPWHs



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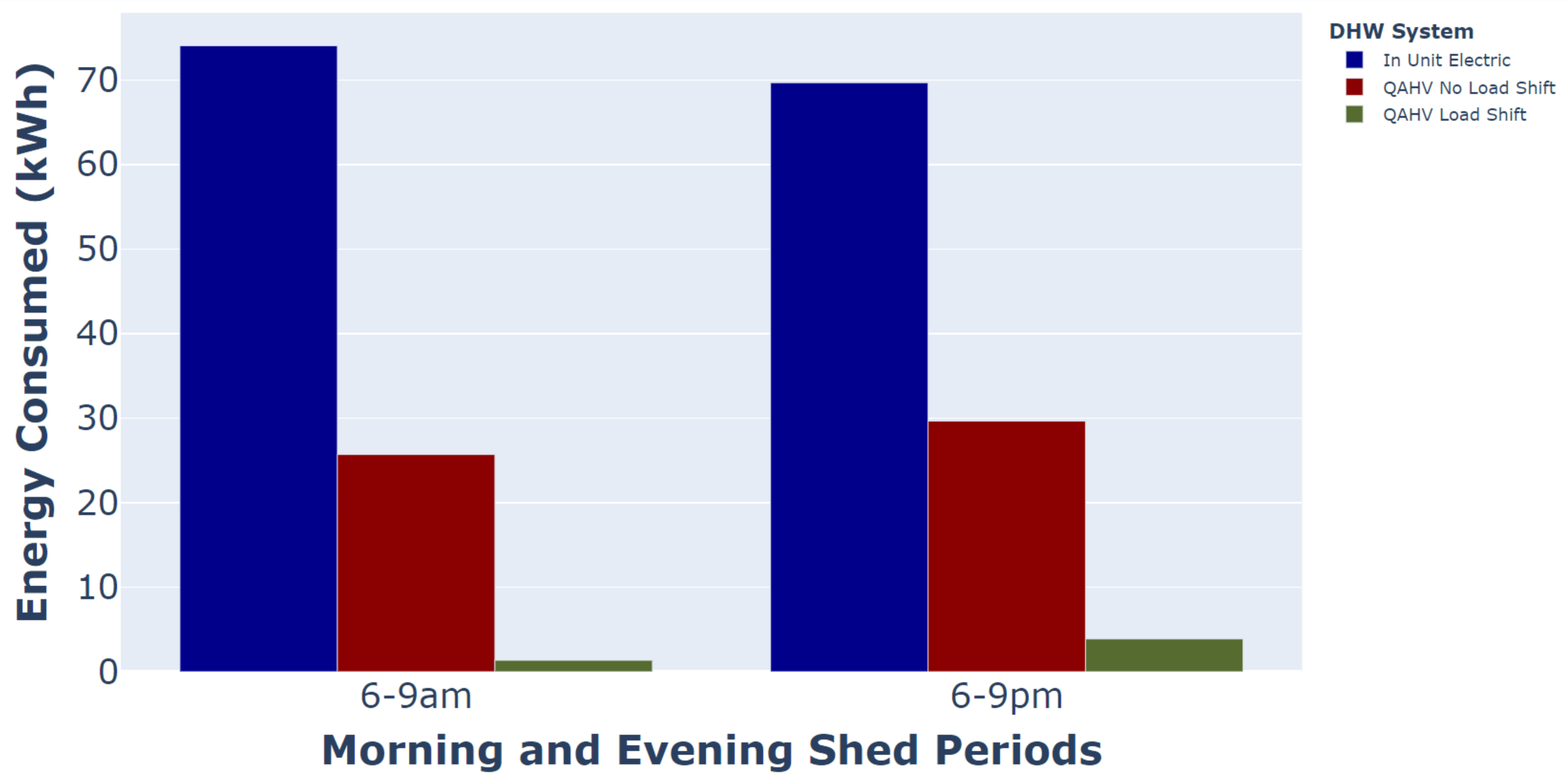
Bayview M&V data – Summer demand reduction



(testing 5/2/2022 – 7/28/2022)

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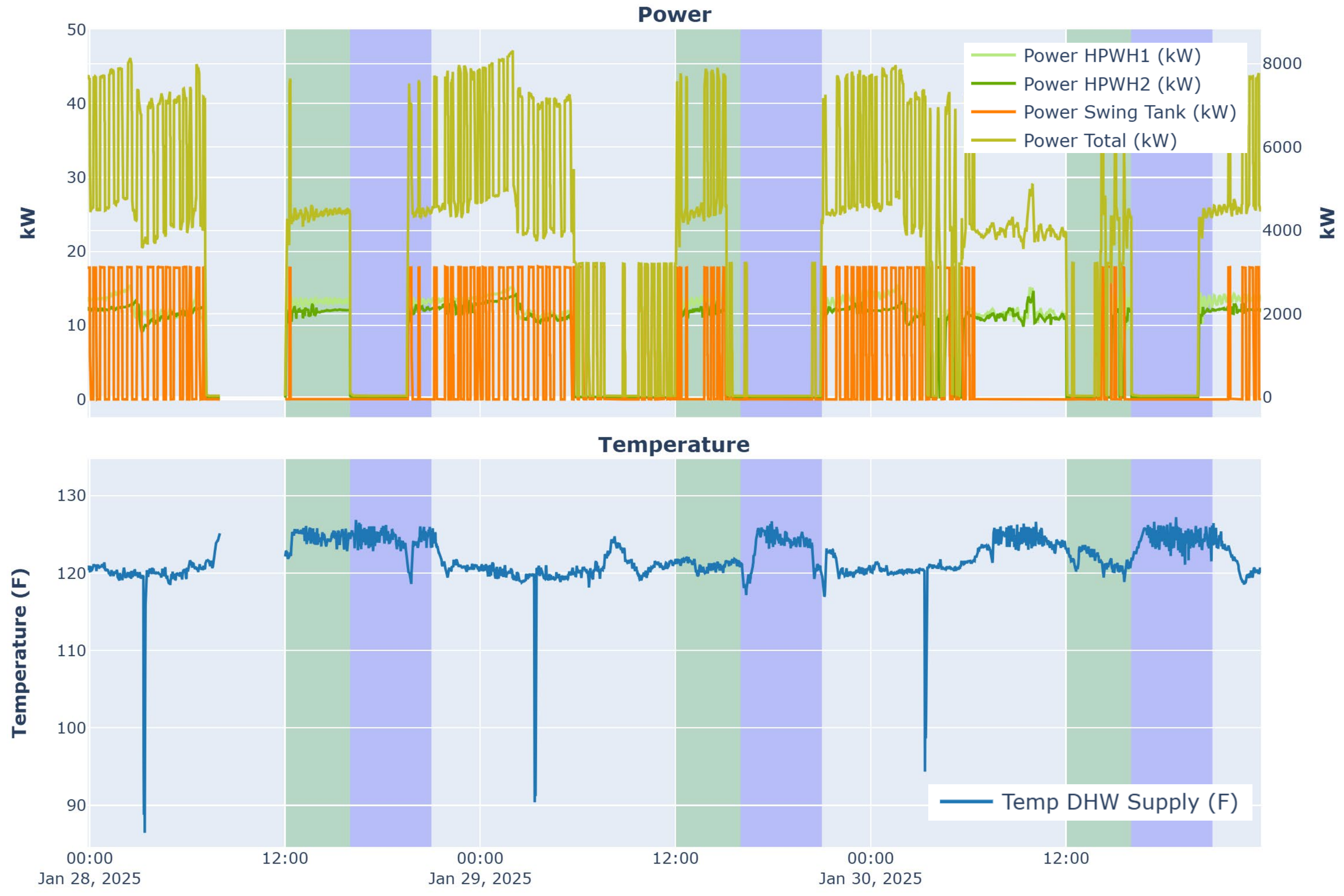
Controls Optimization



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Preliminary Results

	Site 1	Site 2
Monitoring length (days)	214	153
Baseline energy (kBtu)	617,360	683,127
CHPWH energy (kBtu)	195,214	210,778
Energy savings (kBtu)	422,145 (68%)	472,348 (69%)
Baseline GHG emissions (tons CO_2e)	33.7	37.3
CHPWH GHG emissions (tons CO_2e)	3.2	3.7
GHG emissions savings (tons CO_2e)	30.5 (90%)	33.6 (90%)
Baseline customer utility costs	$8,009 ($6,407*)	$8,702 ($6,962*)
CHPWH customer utility costs	$25,879 ($18,116*)	$23,114 ($16,180*)

*with CARE discount

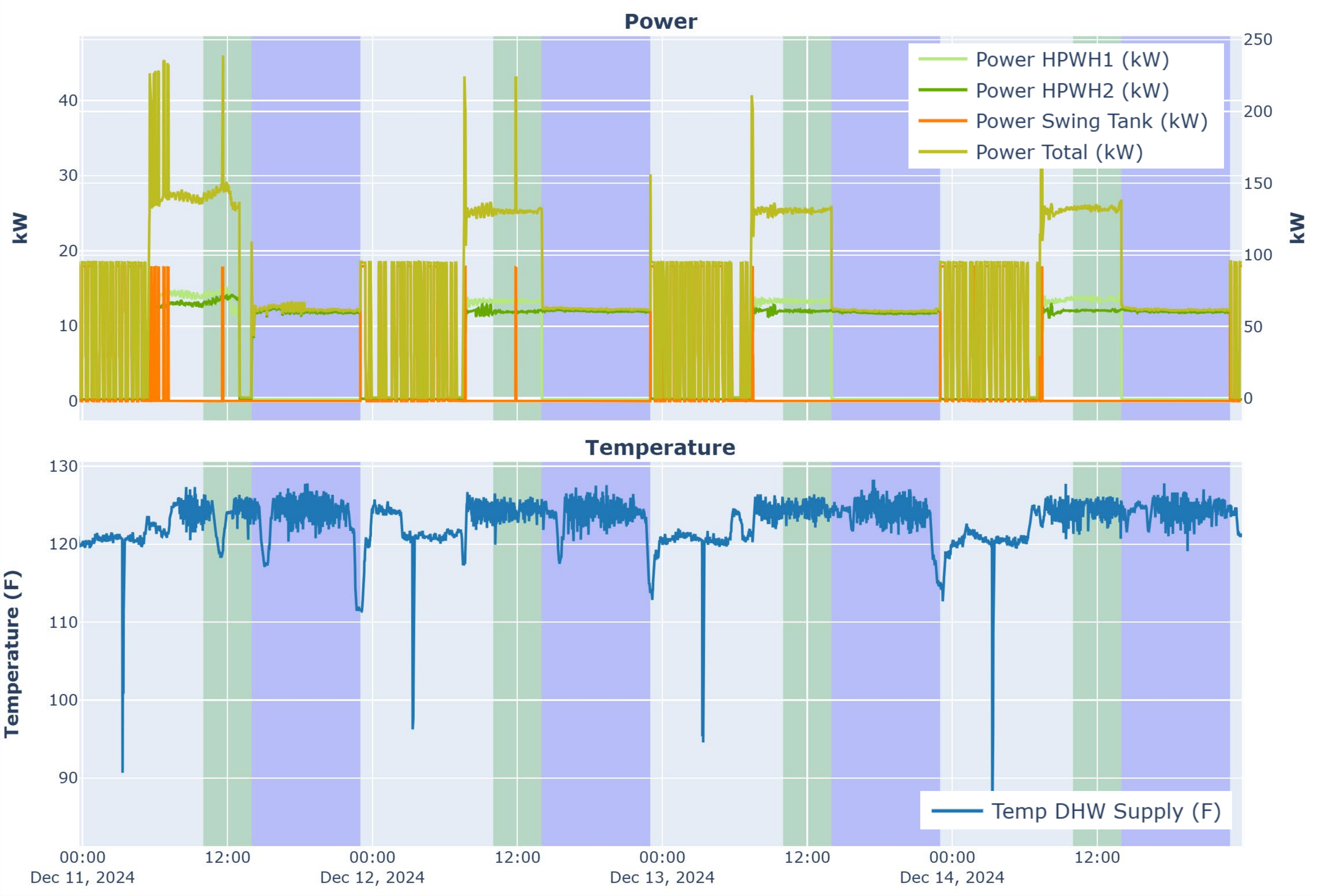
Solution: Critical Peak

+ **HPWH staging**
+ **Swing tank lock out**

	Mode per hour of day														*Part Peak*				*Peak*			*Part Peak*		
Schedule	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***
Baseline	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Schedule 1	N	N	N	N	N	N	N	N	LU	LU	LU	LU	LU	LU	LU	LU	S	S	S	S	S	N	N	N
Schedule 2	N	N	N	N	N	N	N	N	N	N	N	N	LU	LU	LU	LU	S	S	S	S	S	N	N	N
Schedule 3	N	N	N	N	N	N	N	N	N	N	LU	LU	LU	LU	LU	LU	CP	CP	CP	CP	CP	N	N	N
Schedule 4	N	N	N	N	N	N	N	N	N	N	N	N	LU	LU	LU	LU	CP	CP	CP	CP	CP	N	N	N
Schedule 5	N	N	N	N	N	N	N	N	LU	LU	LU	LU	LU	LU	CP	CP	CP	CP	CP	CP	CP	N	N	N
Schedule 6	N	N	N	N	N	N	N	N	LU	LU	LU	LU	LU	LU	CP	CP	CP	CP	CP	CP	CP	CP	CP	N
Schedule 7	N	N	N	N	N	N	N	N	N	N	LU	LU	LU	LU	CP	CP	CP	CP	CP	CP	CP	CP	CP	N

Normal	Load Up	Critical Peak	Shed

Solution: Critical Peak



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Results

Load Shift Schedule	On-Peak Energy Shift (kWh/day)	On-Peak and Part-Peak Energy Shift (kWh/day)	Net Daily Energy Savings (kWh/day)	On-Peak Demand Reduction (kW)	Utility Cost Savings ($/yr)	GHG Impacts (tons CO_2e/yr)	TSB Impacts ($/yr)
1	39.5 (58%)	-1.0 (-1%)	-37.5 (-13%)	4.9 (11%)	$2,428 (5 %)	-0.36 (-4%)	$1,539 (15%)
2	37.0 (55%)	-2.2 (-2%)	-50.8 (-18%)	-0.7 (-2%)	-$1,754 (-3%)	-0.90 (-10%)	$728 (7%)
3	23.7 (35%)	22.6 (21%)	-18.9 (-7%)	12.9 (29%)	$2,884 (6%)	0.71 (8%)	$867 (9%)
4	22.9 (34%)	22.3 (20%)	-21.4 (-8%)	14.6 (33%)	$3,335 (7%)	0.74 (8%)	$755 (7%)
5	10.3 (15%)	27.5 (25%)	-27.9 (-10%)	29.1 (65%)	$9,713 (19%)	0.09 (1%)	$162 (2%)
6	10.3 (15%)	28.3 (26%)	-15.9 (-6%)	29.2 (65%)	$8,558 (17%)	0.14 (1%)	$314 (3%)
7	9.5 (14%)	26.0 (24%)	-9.3 (-3%)	29.0 (65%)	$7,860 (16%)	0.47 (5%)	$360 (4%)

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Next Steps

+ Continue collaboration with Manufacturers and Distributors to facilitate ease of setup.
+ Engage with facilities staff on Event Logging and refine Event Types.
+ Develop Automated Fault Detection and notification System.

Questions?

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