

Keeping it Hot

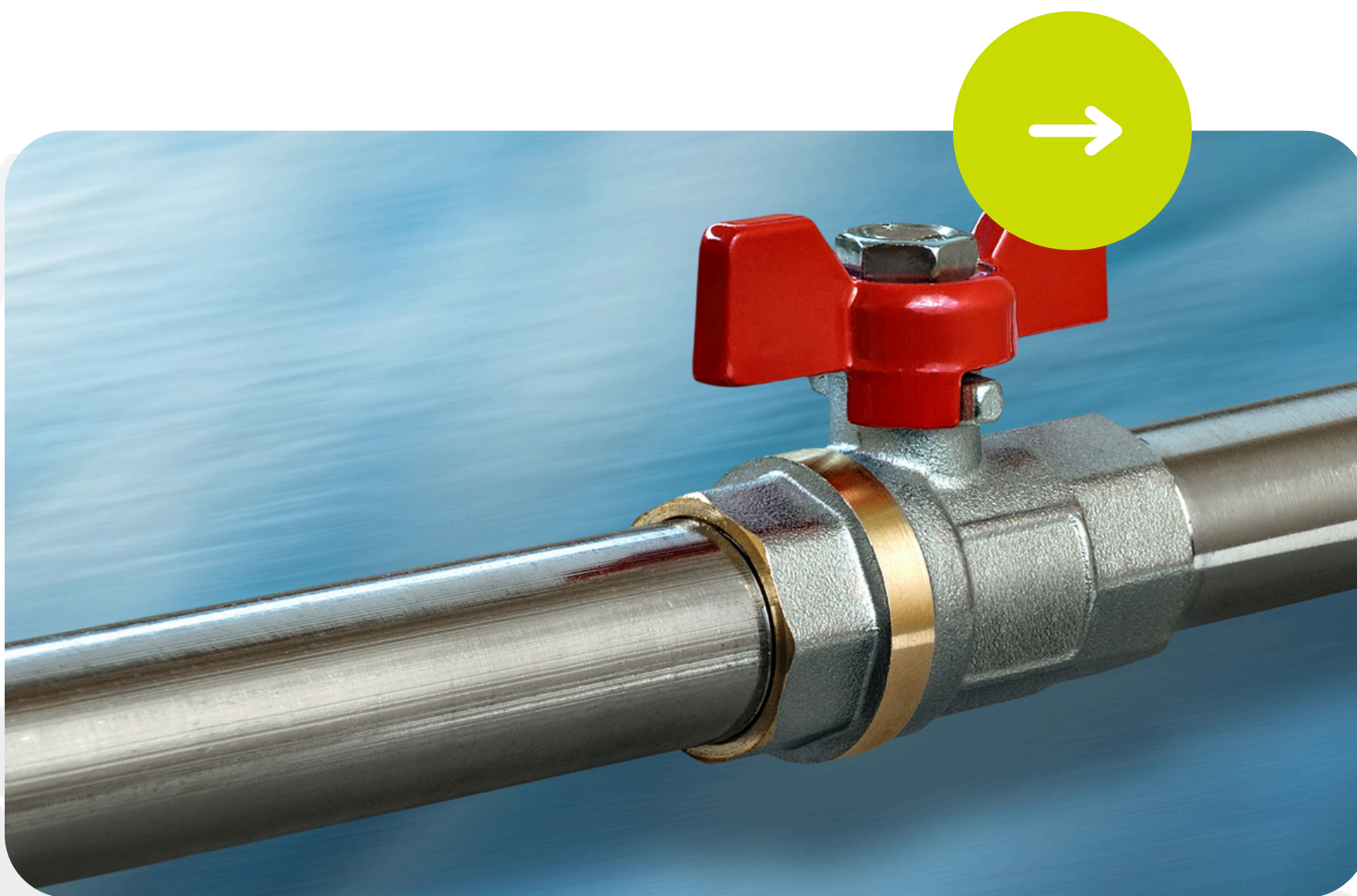
An engineered solution to heat
pump hot water

Presented by:

Evan Hallas, Senior Energy Analyst
Brendan Mangino, Project Engineer II



Agenda



1

Heat Pumps in NYS

If you haven't heard, electrification is HOT water

2

Informed Design

We'll look at the M&V data collected from our multifamily all-electric ASHP DHW system project at Ithaca Arthaus and how it can inform future projects

3

Ironworks Case Study

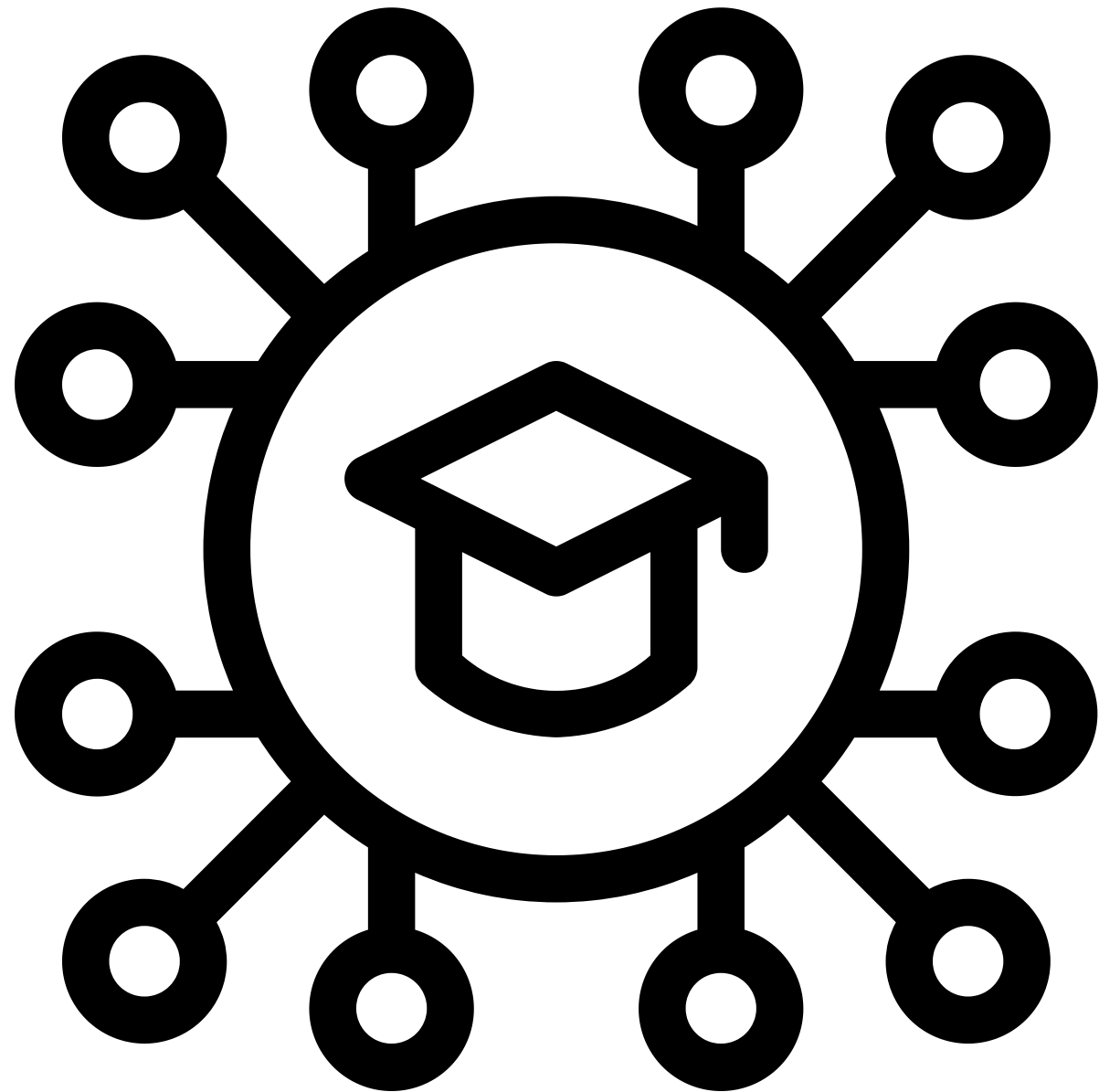
We'll share the story of one of our most recent urban infill projects which includes an all electric ASHP DHW systems

4

Q&A

Discussion

Learning Objectives



1

Understand the importance of commissioning and M&V and how these processes can help inform design

2

Understand challenges with central domestic hot water ASHP designs

3

Review design solutions to further improve future designs



If you haven't heard,
ELECTRIFICATION IS HOT!



Heat pumps are the primary path to building electrification

Replacing fossil fuel-powered systems with electric and other fossil fuel-free, zero-carbon alternatives is a necessary step to achieve statewide energy and carbon emission reduction goals.

Building electrification also provides substantial cost savings as well as increased efficiency and overall safety.





INFORMED DESIGN

We'll look at the M&V data collected from Ithaca Arthaus. One of our first all-electric ASHP DHW system designs and how it is informing future designs.

History

new construction

art gallery

community renewal

all-electric 100,000SF on Cayuga inlet

Ithaca Arthaus

5-story

affordable housing

124 units

supportive housing

energy efficient

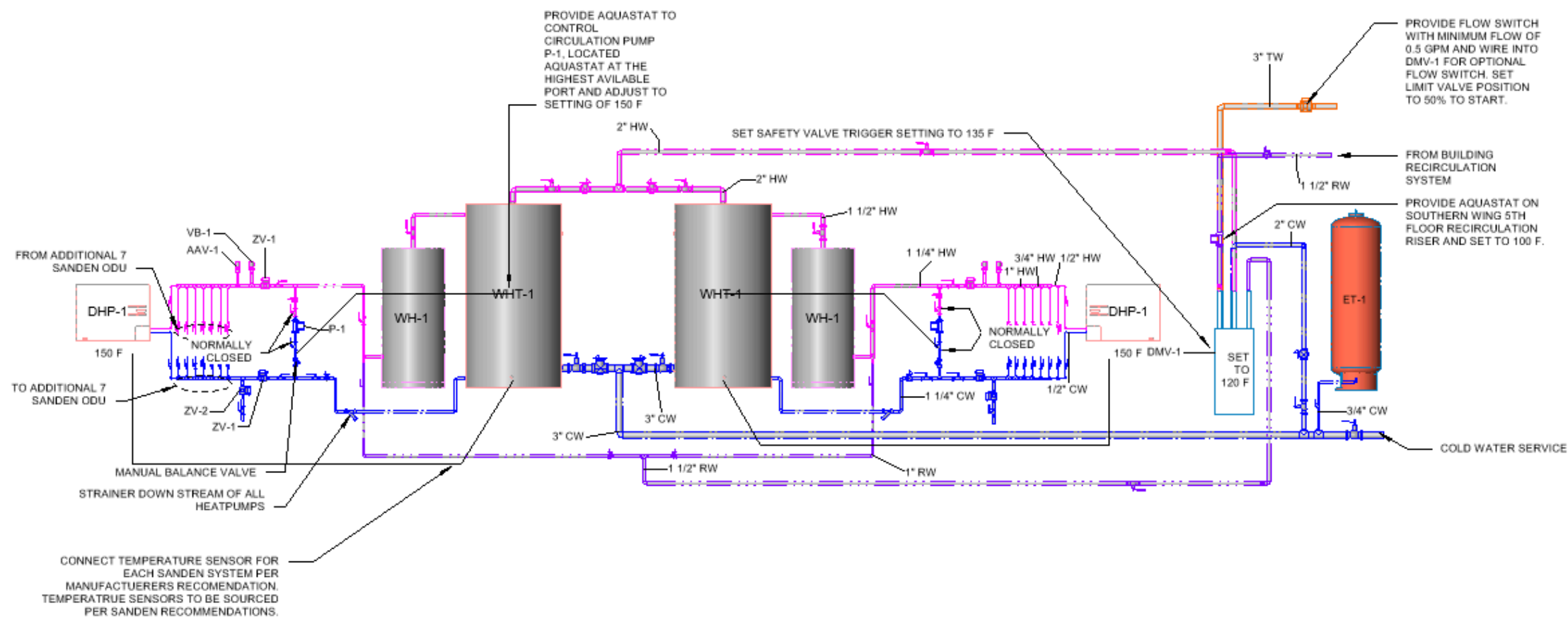
NYSERDA & Energy Star



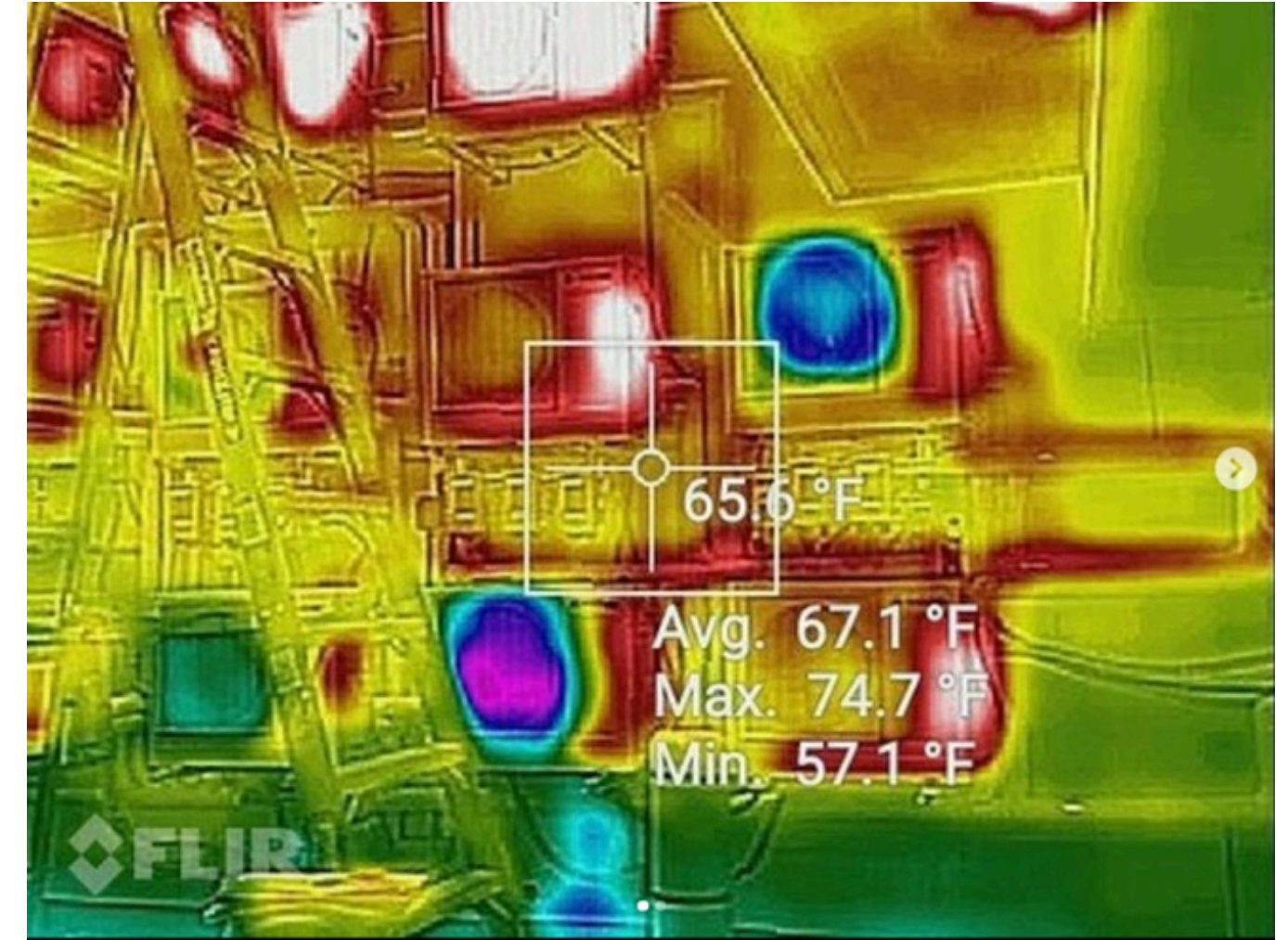
DHW SYSTEM SELECTION

SANCO2 SYSTEM

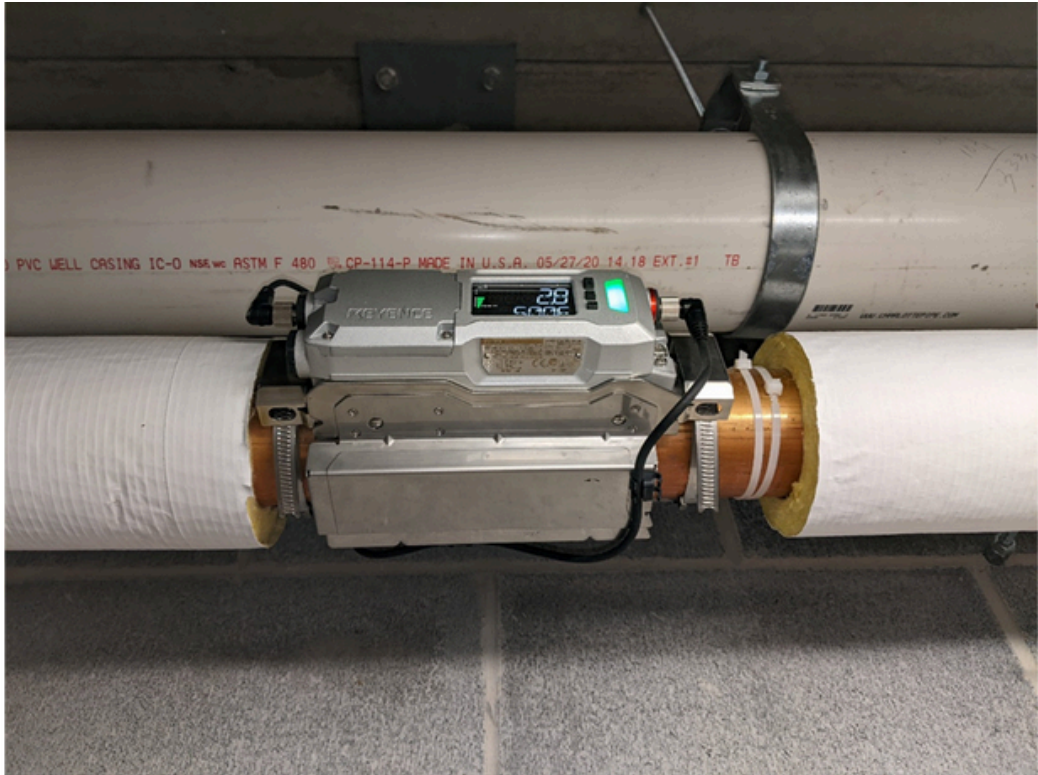
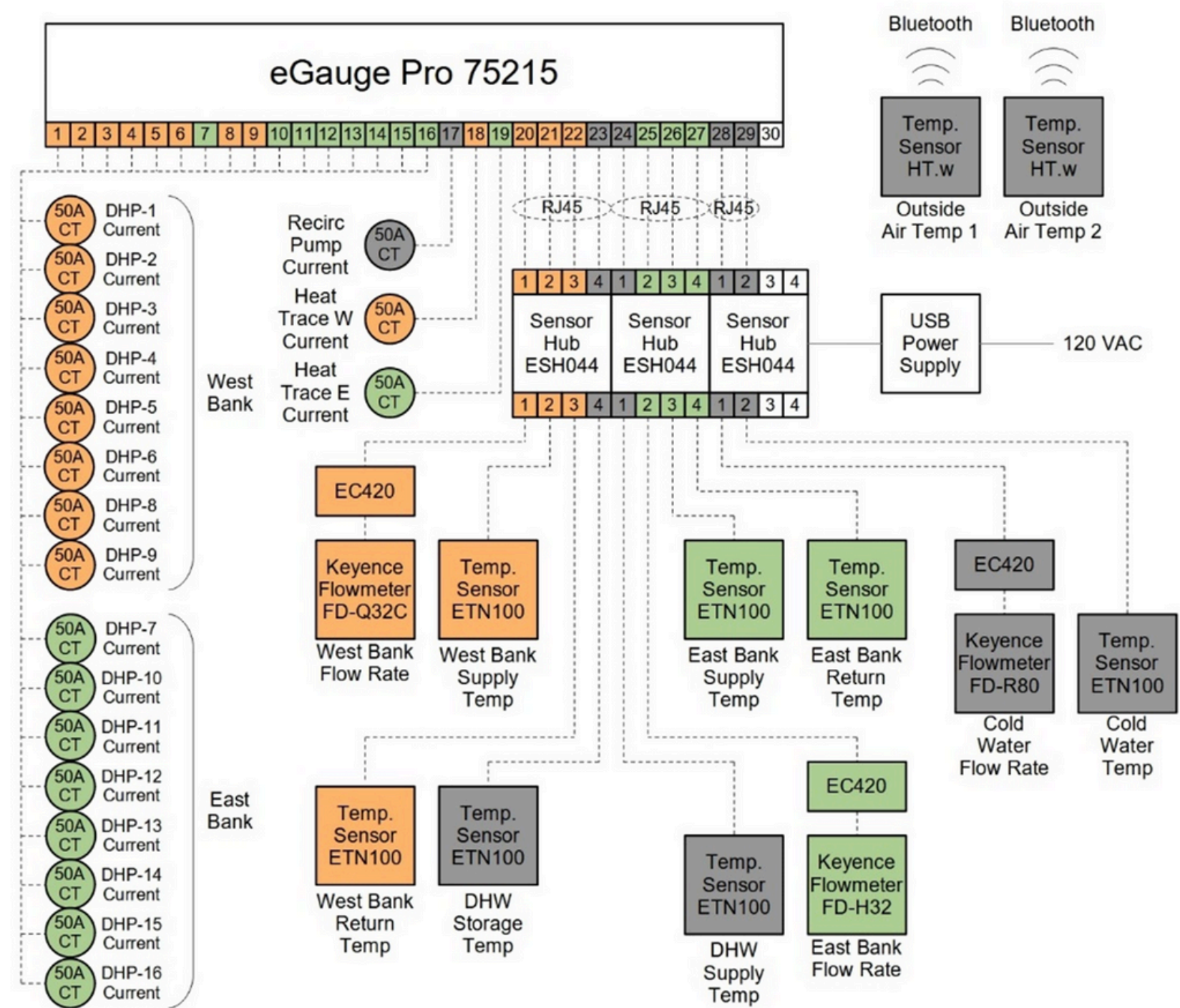
with de-energized emergency
electric resistance back up



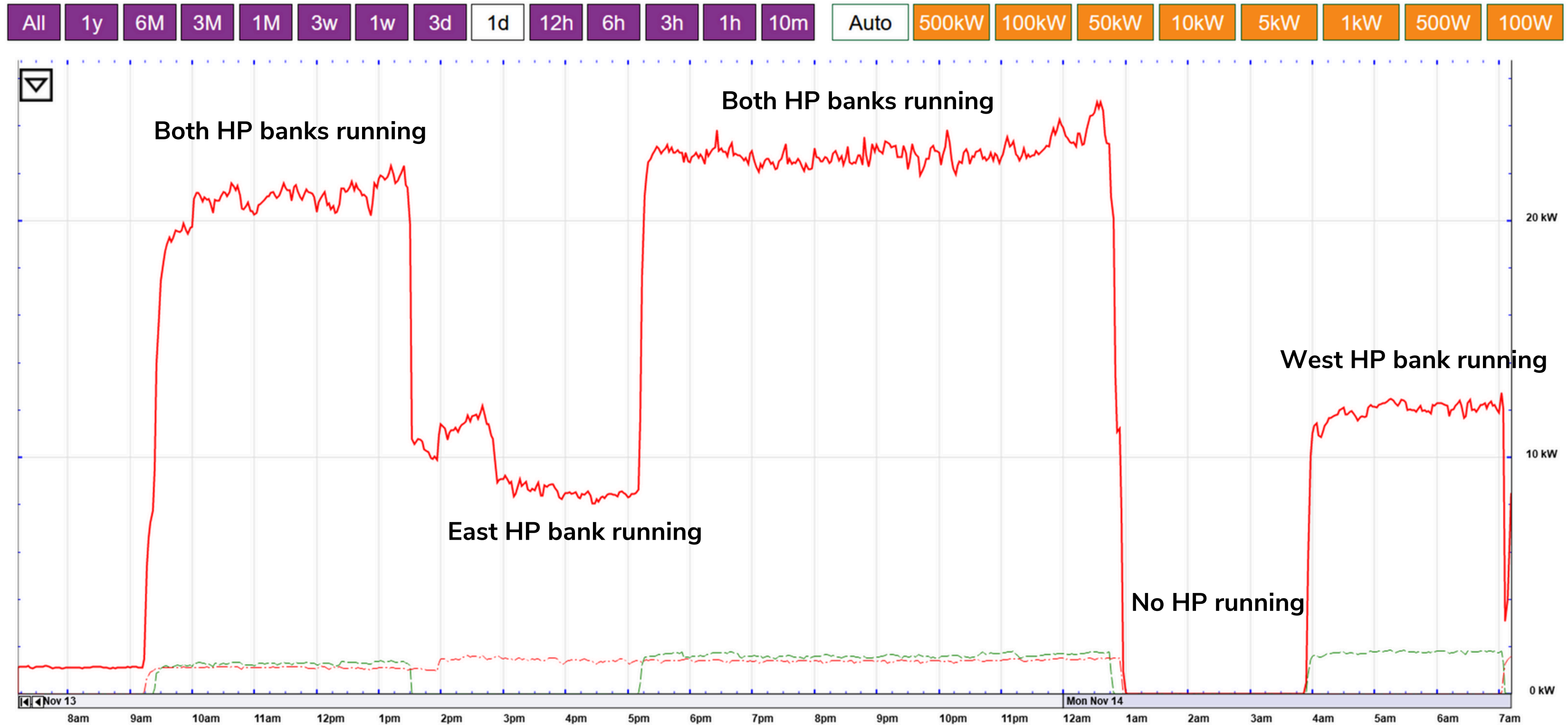
Commissioning



Measurement & Verification

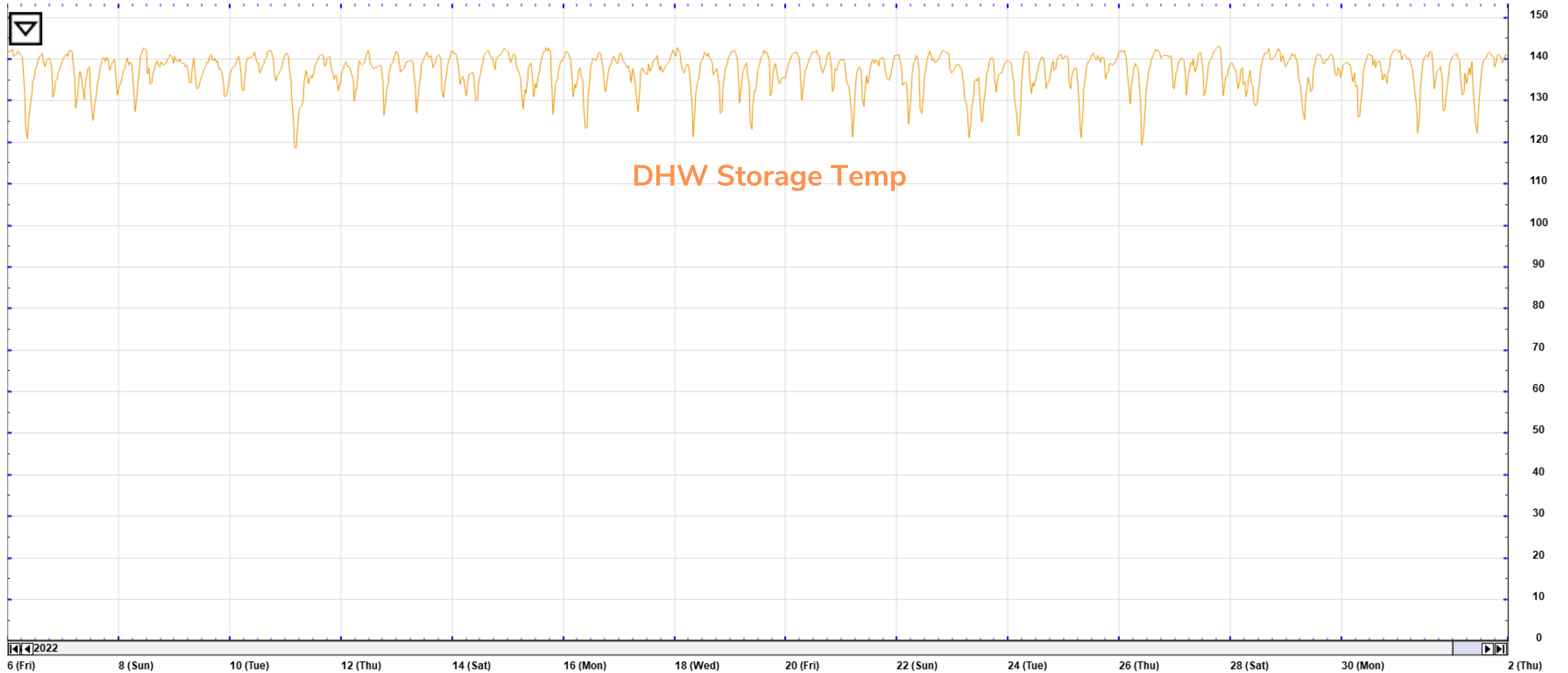


measurement verification



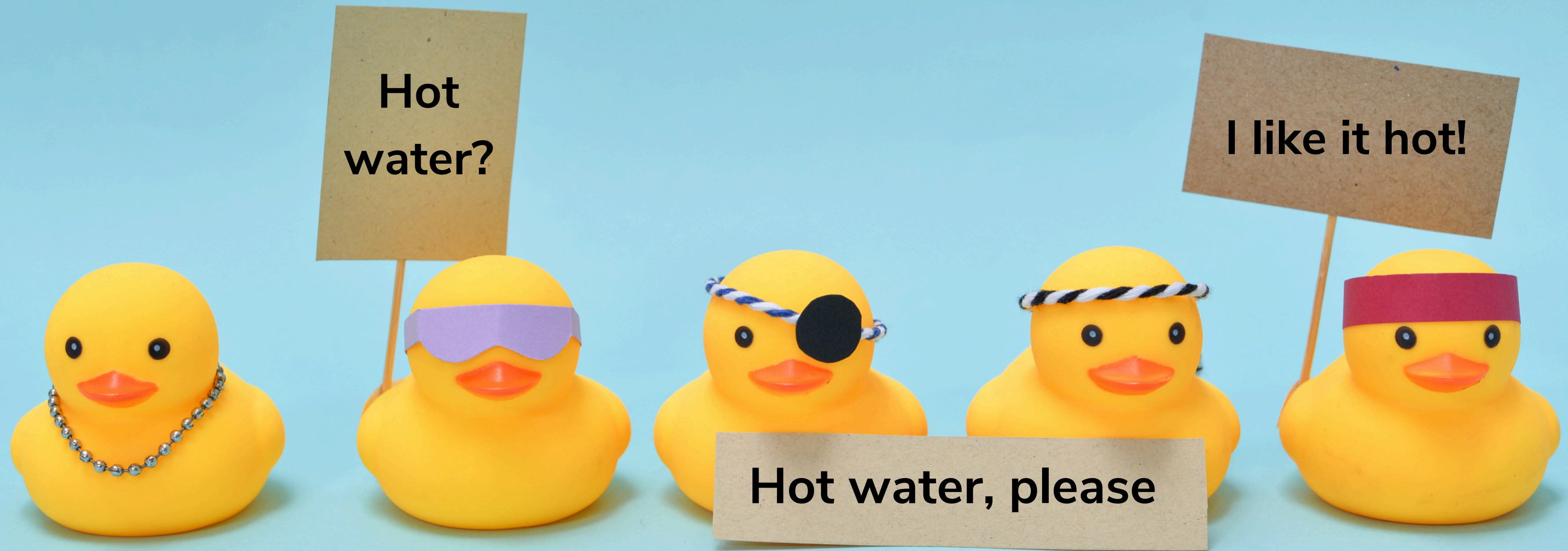
results

measurement verification

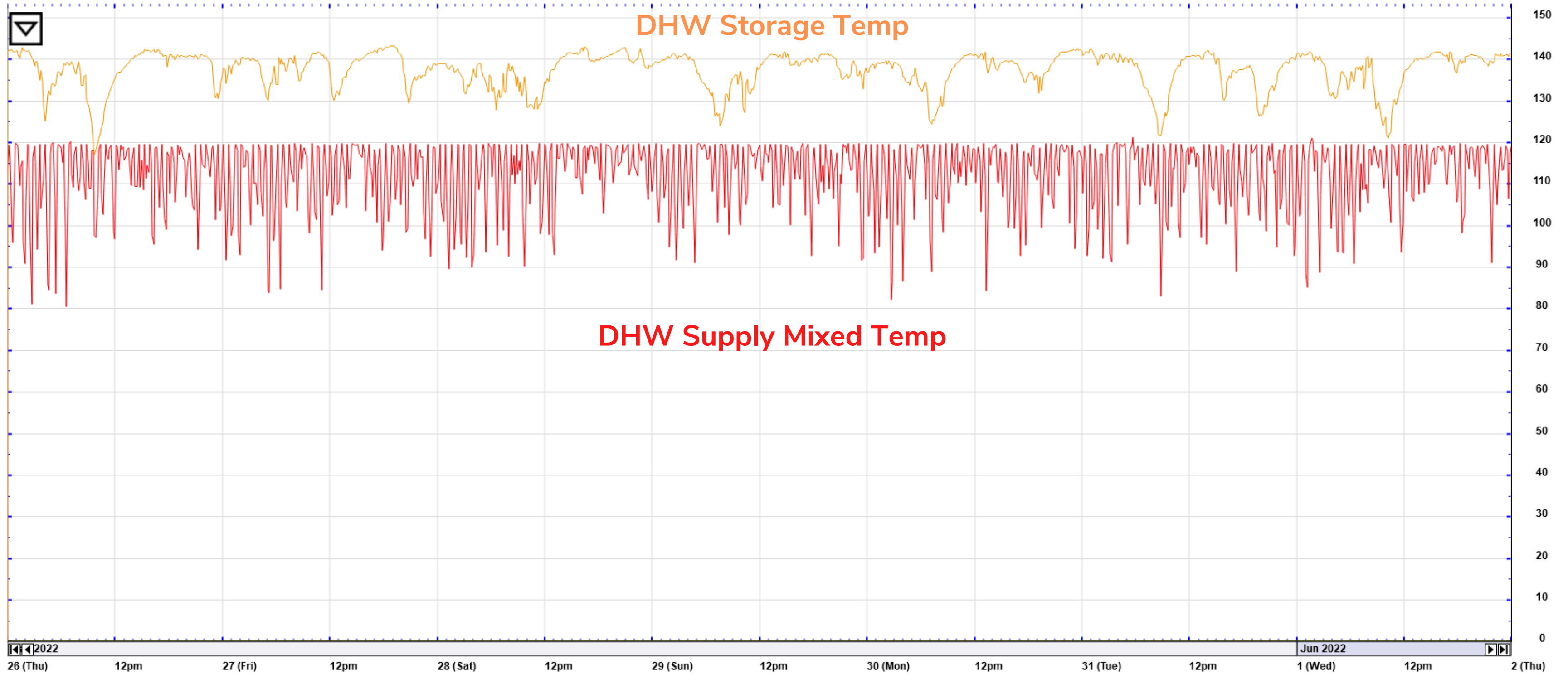


results

Hot water complaints...

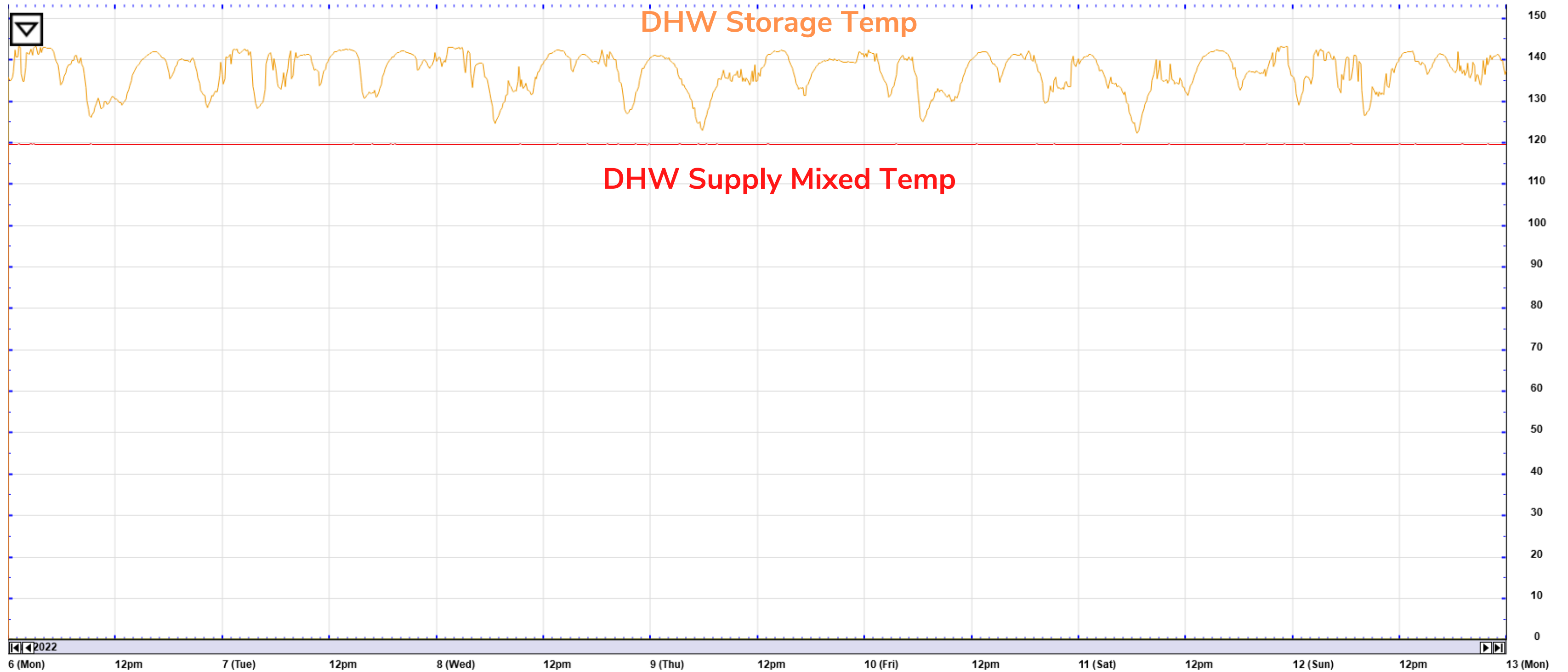


measurement verification



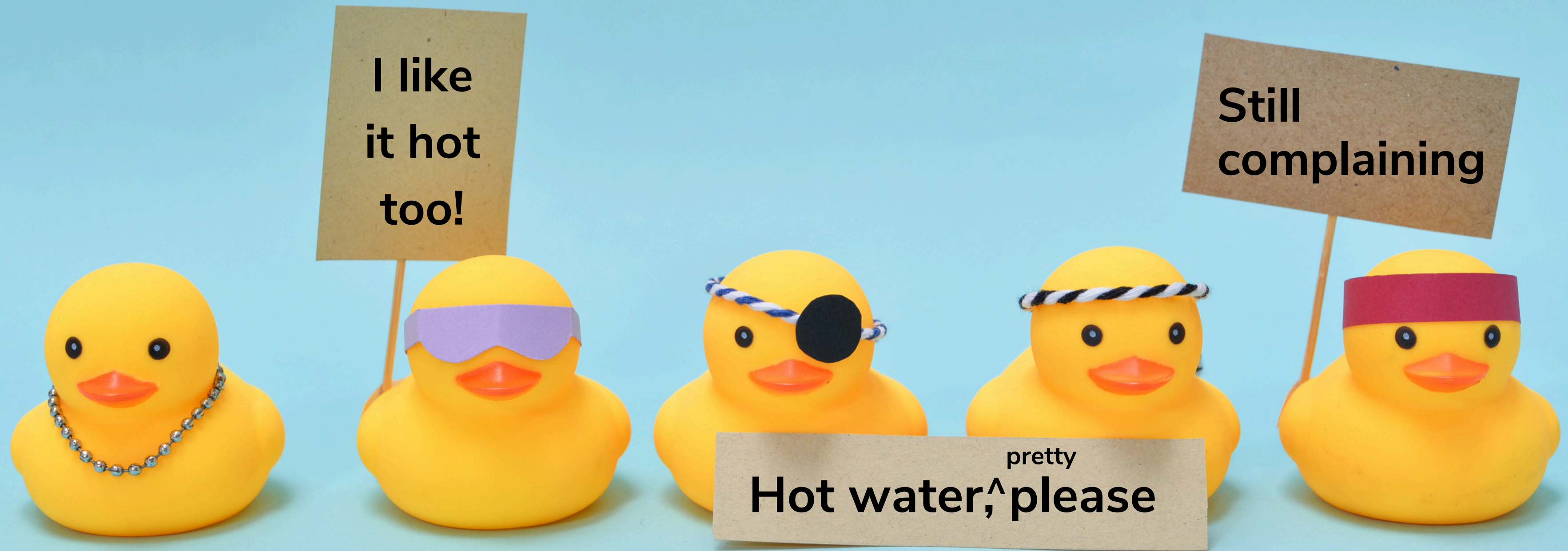
results

measurement verification



results

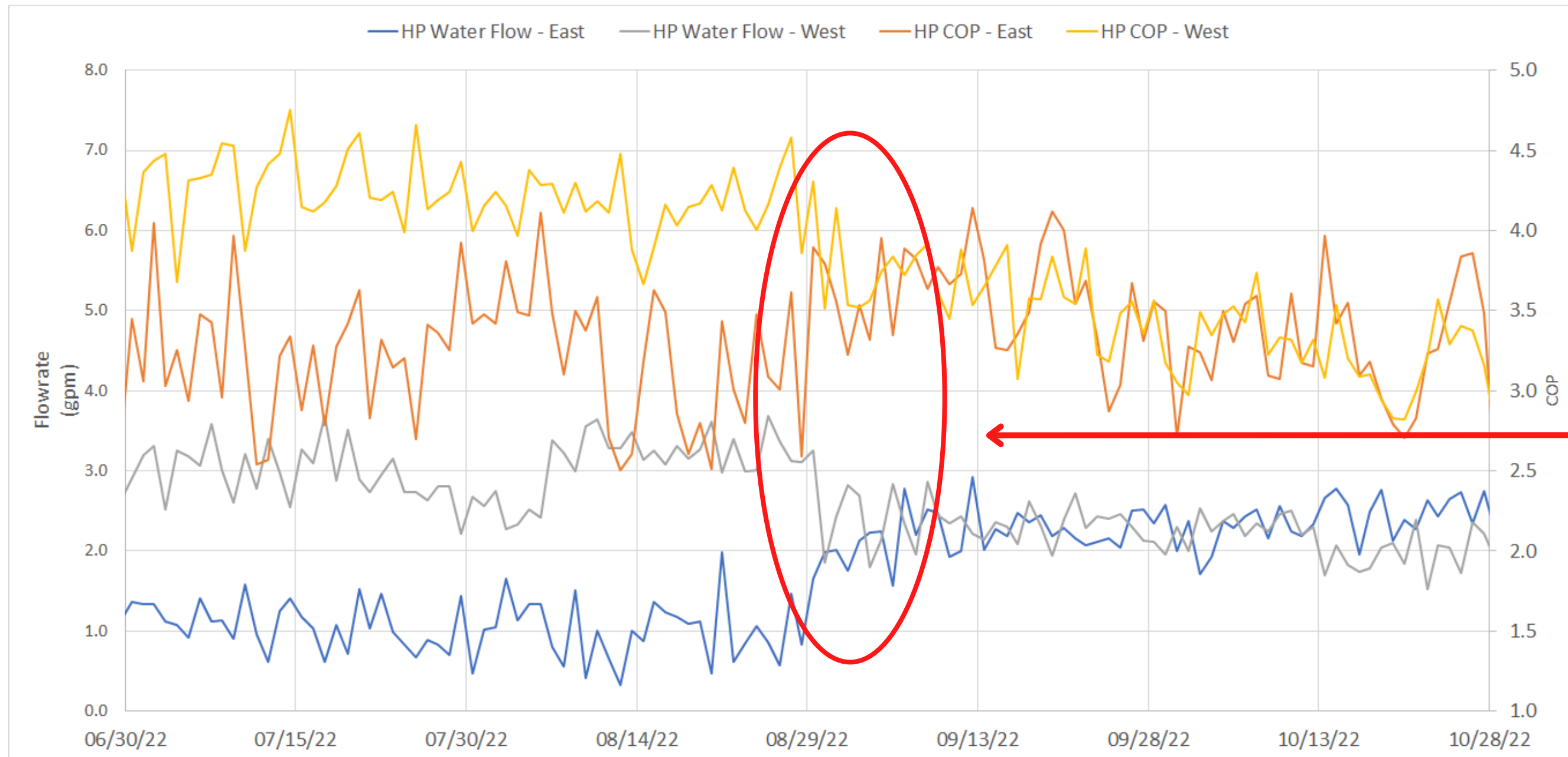
Hot water complaints continue...



More Commissioning...



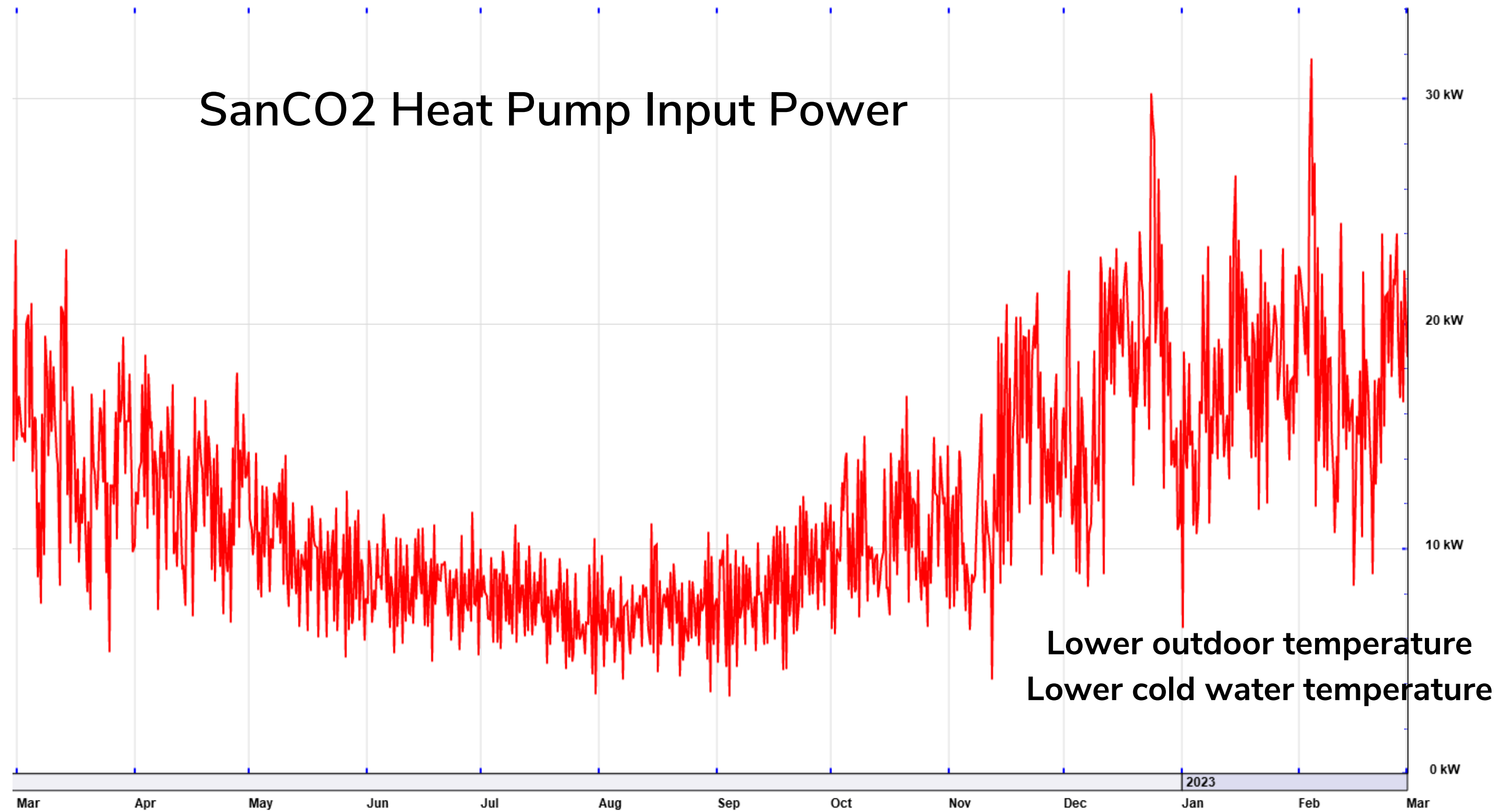
measurement verification



More commissioning...

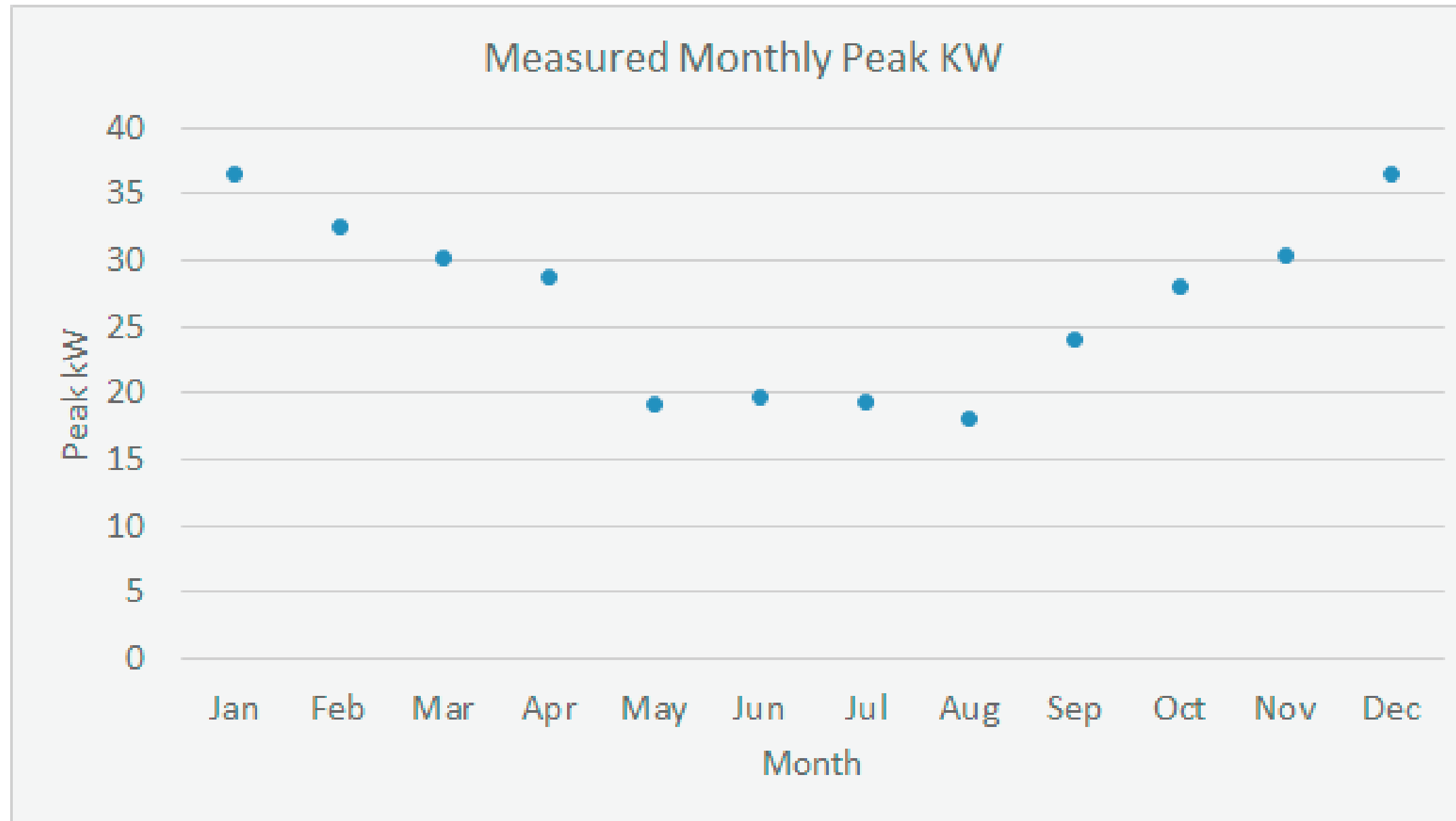
results

measurement verification



results

measurement verification



Central Heat Pump System

Peak Input Power: 37 kW

~0.3 kW/apartment

Individual Electric Resistance Tanks

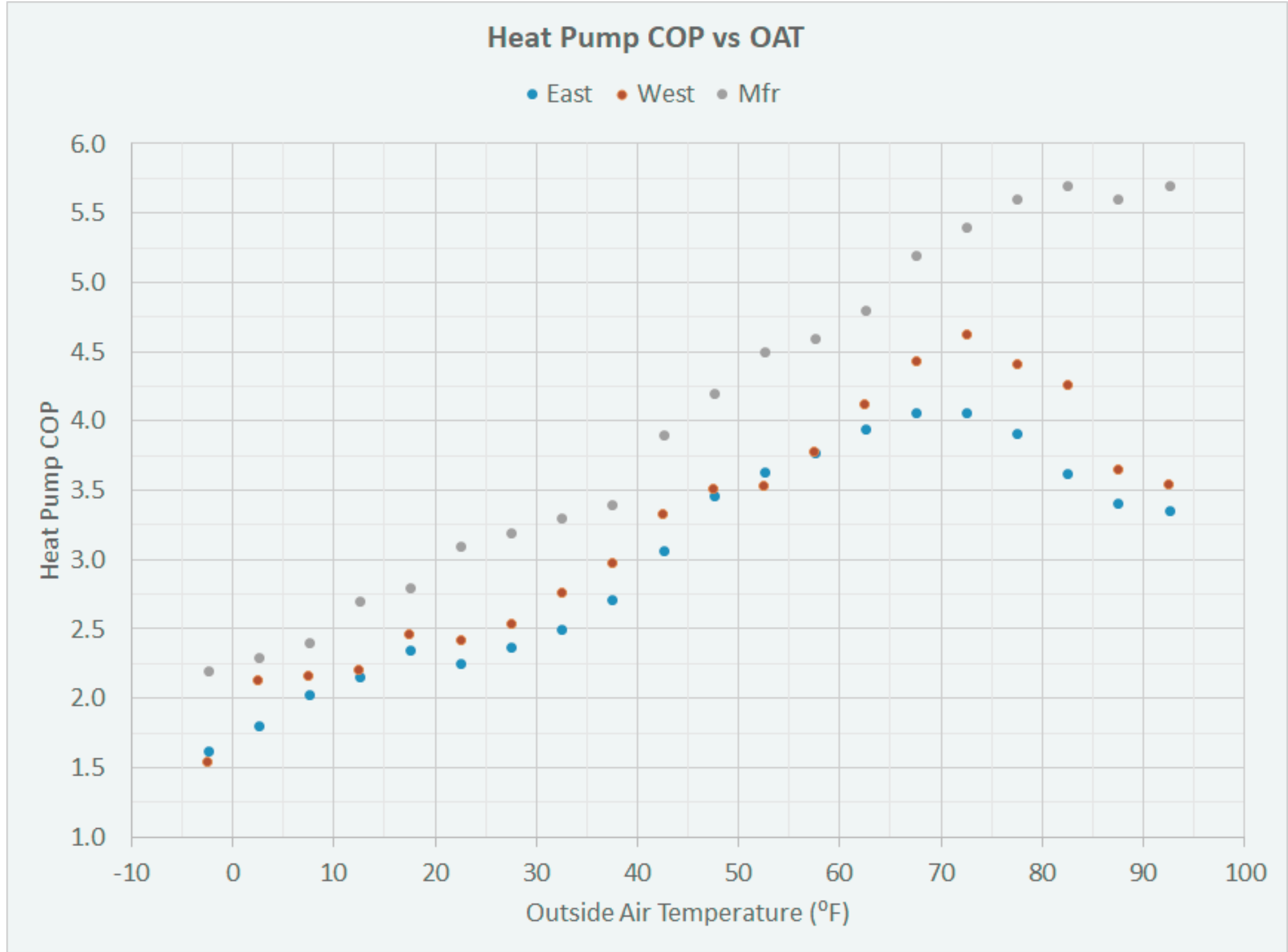
$4.5 \text{ kW} * 124 = 558 \text{ kW} * \text{NEC}$

$220.84 \text{ demand factor } 23\% = 128.3$

kW or ~1.0 kW/apt

results

measurement verification



June 4, 2022 - February 27, 2023

East HP Bank COP: 3.17

West HP Bank COP: 3.62

Measured Heat Pump COP: 3.41

- System COP: 2.01
- System Losses: 37%
Includes Standby Losses + Recirc Losses

measurement verification

Total DHW Energy Usage and Costs February 15, 2022 - February 14, 2023

105,403 kWh/yr

850 kWh/yr/apartment

\$15,969/yr

\$129/yr/apartment



Based on Current Commercial Utility Rates

\$12.38/kW and \$0.114/kWh

measurement verification

Assuming Electric Resistance In-Unit Water Heaters

$$\frac{\sim 227,625 \text{ kWh/yr}}{1,836 \text{ kWh/yr/apartment}} = \frac{\$30,502/\text{yr}}{\$246/\text{yr/apartment}}$$

Based on Current Residential Utility Rates \$0.134/kWh

~\$14,533 yearly energy cost savings from going with central heat pump DHW

measurement verification

Summary

- System is meeting load and temperature requirements
- No electric resistance needed!
- Delivered hot water issues were distribution related
- Balancing of systems very important
- Heat pumps operating efficiently
- System losses are high, needs more attention
- Cost effective solution over electric resistance



construction costs

System	Equipment Costs	Equipment Install Costs	Central Distribution System Costs	Total Cost ¹	Total Cost/SF	Cost Premium ²
Central SanCO2	\$86,000	\$107,000	\$45,000	\$238,000	\$2.33	\$125,800
Central LG Hydro Kit	\$91,000	\$77,000	\$45,000	\$213,000	\$2.09	\$100,800
Central Electric Resistance	\$25,000	\$42,200	\$45,000	\$112,200	\$1.10	-
Individual Electric Resistance	\$60,000	\$192,200	\$0	\$252,200	\$2.47	-

Pricing Assumptions

- Pricing based on 2021 costs
- Pricing based off the Ithaca Arthaus, 124 Unit Building, ~102,000sf in Ithaca, NY
- Costs exclude apartment distribution which would be the same in each scenario
- Cost premium is calculated off of central electric resistance system

<10 year payback

results installed costs



IRONWORKS CASE STUDY

Our most recent all-electric ASHP DHW system



History

new construction

mixed-use

urban infill

113,000SF

all-electric

Downtown Revitalization

Ironworks

5-story

129 units

NYSERDA & Energy Star





Design Goals

1

Efficient

Provide an energy efficient all electric central DHW system.

2

Smart

Minimize electric resistance with a focus on minimizing demand charges.

3

Consistent

Durable and reliable system in all operation conditions.

4

Constructable

A system that was as simple as possible to reduce cost and complexity while still achieving our design and energy goals.





General Contractor



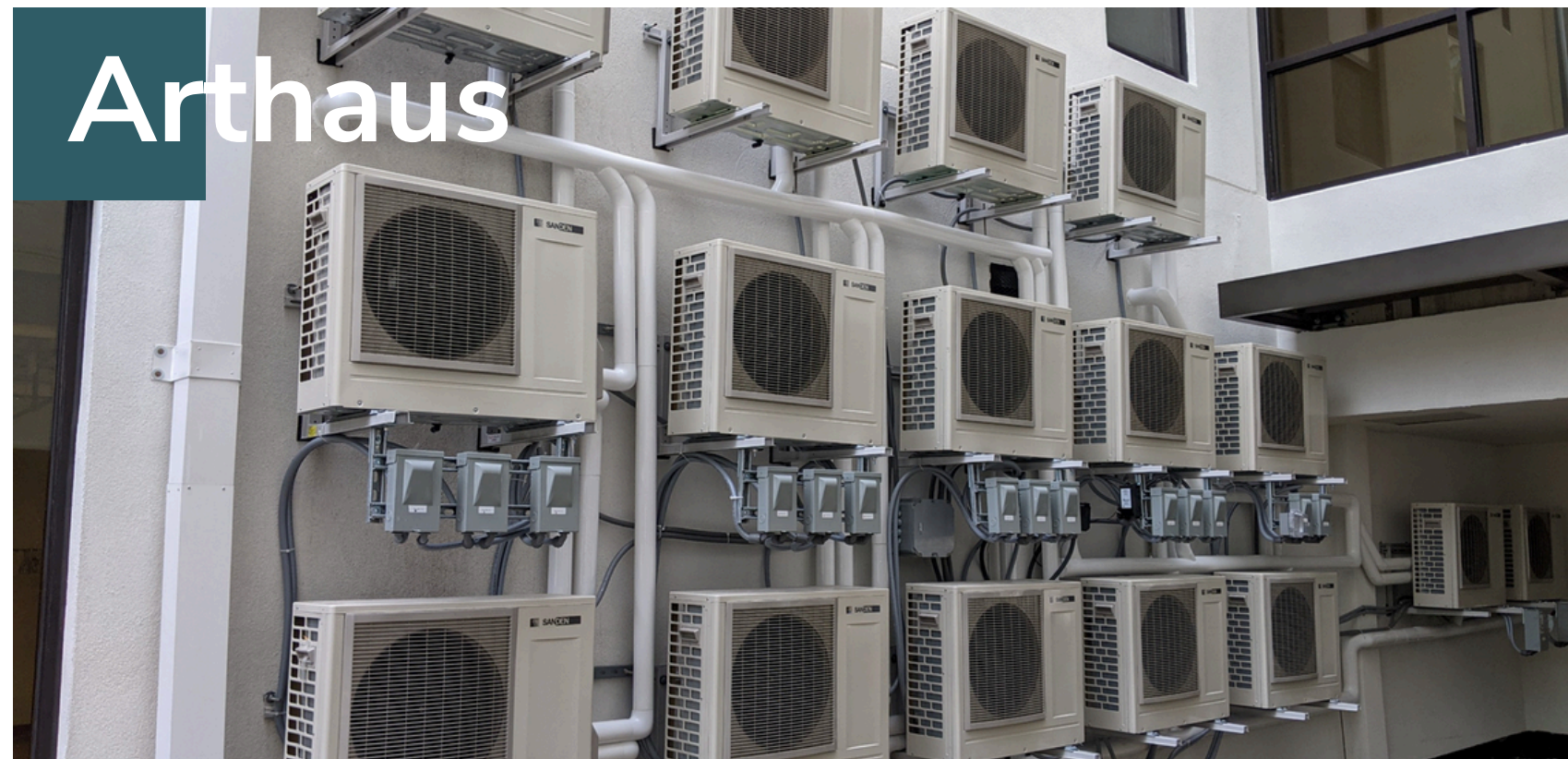
250 North Genesee Street
Montour Falls, NY 14865
Ph: (607) 535-5400
Fax: (607) 535-9254
Email: shartsing@buildwelliver.com

Plumbing SubContractor



85 Main Street
Johnson City, NY 13790
Ph: (607) 354-1234
Email: info@slavikandco.com

Construction team



Arthaus

Lessons Learned From Original Design

We applied lessons learned from our first generation SanCO2 central heat pump domestic hot water system at Arthaus and applied to the Iron works project with the goal to develop a more consistent second generation design.

1

Ice build up

SanCO2 heat pumps produce excessive amounts of ice during defrost cycles causing ice build up.

2

Automatic drain back design complications

The first generation of our automatics drain back system design presented problems during refill.



Ironworks

Challenges **Ice build up**

ORIGINAL ISSUE

Heat pumps at Arthaus were stacked directly above each other. during a defrost operation the heat pumps would drip water on the units below causing large amounts of ice build up.

SOLUTION

We staggered the heat pumps and added a small flexible PVC drain hose directly behind the units to drain water away from the equipment below.



Challenges Auto drain back complications

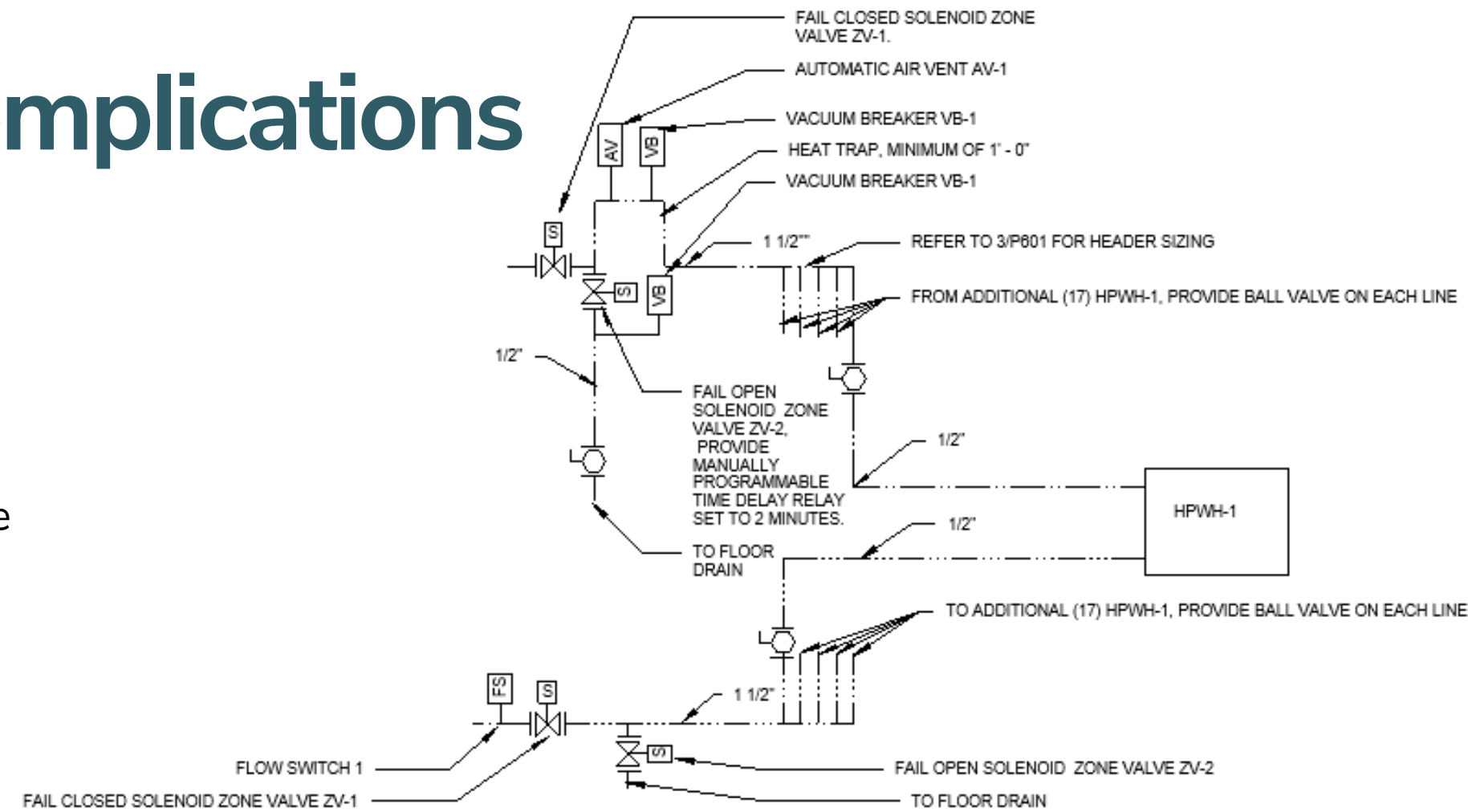
ORIGINAL ISSUE

At the Arthaus project the automatic drain back system would operate properly during a power outage event but upon re-energizing the system wouldn't purge all air from the heat pumps causing airlock error code at the water circulator.

SOLUTION

We added a an automatic air vent at the high point of the system with a fourth solenoid valve that will revert to an open state when de-energized with a 2 minute time delay when the system regained power.

During a system restart after a drain back operation water will flow through the system to a drain allowing for air to be trapped at the air vent high point which will slowly purge over time.



DESIGN PARAMETERS

Studios: 66

1 Bedrooms: 16

2 Bedrooms: 47 (2 Bathrooms)

Clothes washers in each apartment

Common space fixtures: (2) Lavatories, (8) Sinks

Peak demand: 1900 Gallons for 1-3 hour peak at 120 F delivery temperature.

FINAL SYSTEM SIZING

1500 gallons of water stored at 140 F with
81 KW (276 kBTU/hr) of recovery rate

SIZING CALCULATIONS

1

Store for peak demand, recover after

The system is designed to meet peak DHW demand with storage and recover following the peak usage period in 4 hours at rated capacity or 6 hours at derated capacity.

2

Recover maximum daily usage

The system is designed to meet peak daily usage of 21 gallons of tempered water per person per day.

Challenges during design

Design challenges specific to this buildings needs

1

System recovery rate

The building required a recovery rate larger then the heat pump array was able to produce in de-rated conditions.

2

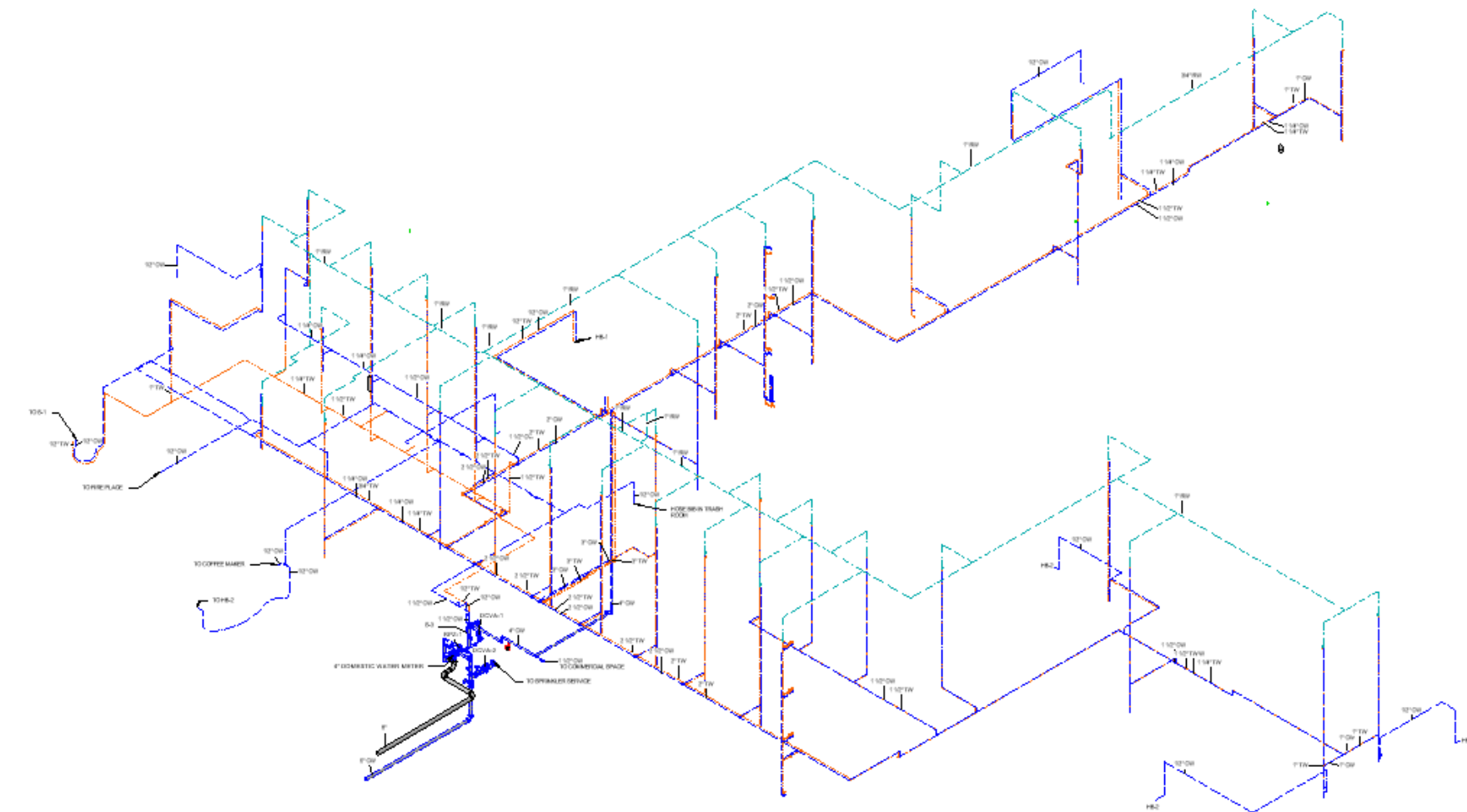
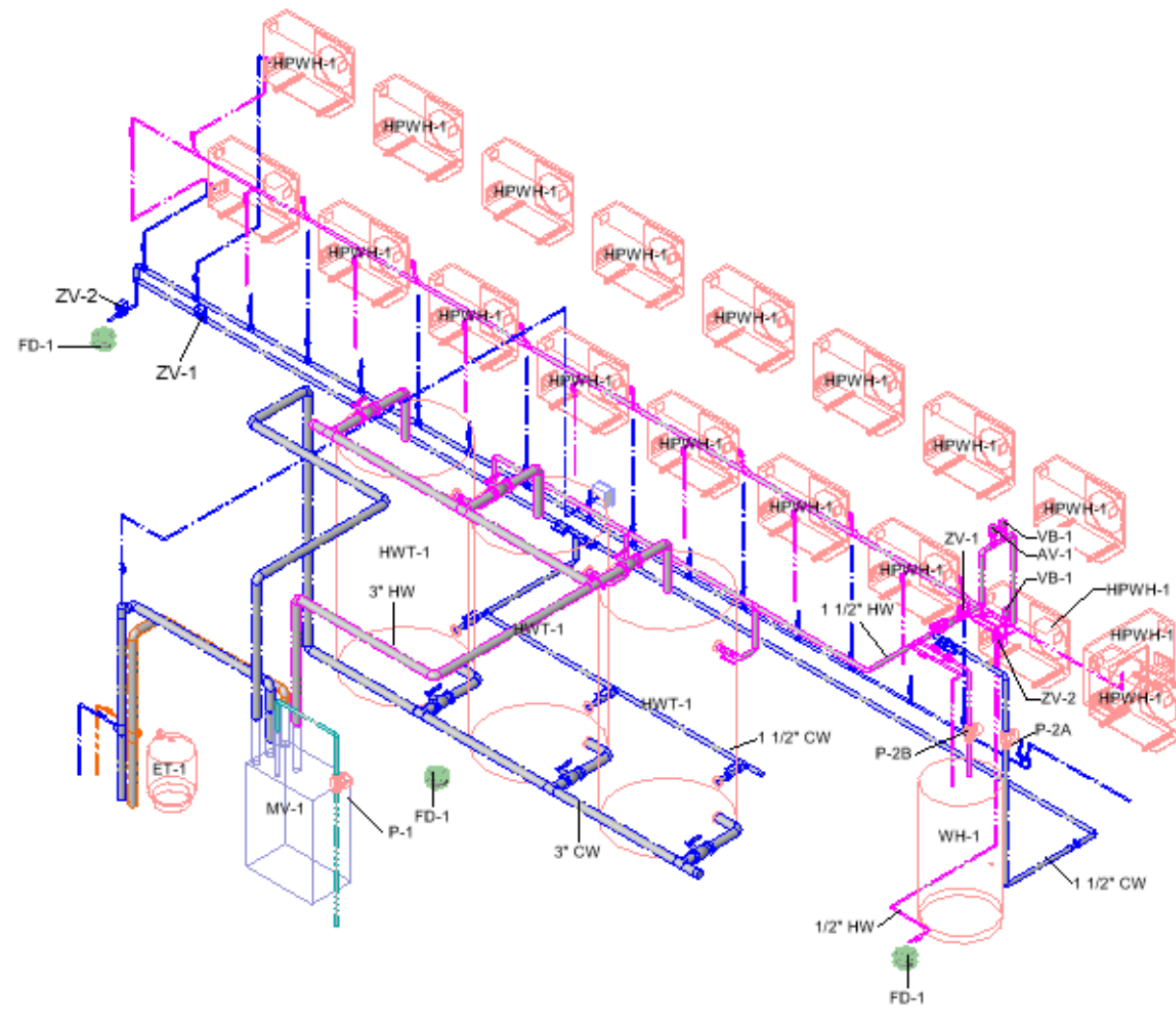
Automatic electric resistance

To address system recovery rate we decided to include automatic supplemental electric resistance and back up electric resistance when required in emergencies.

3

Pipe length

The total pipe length of the heat pump array exceeded the manufacturers allowable pipe length per heat pump.



Challenges

System recovery rate & Automatic electric resistance

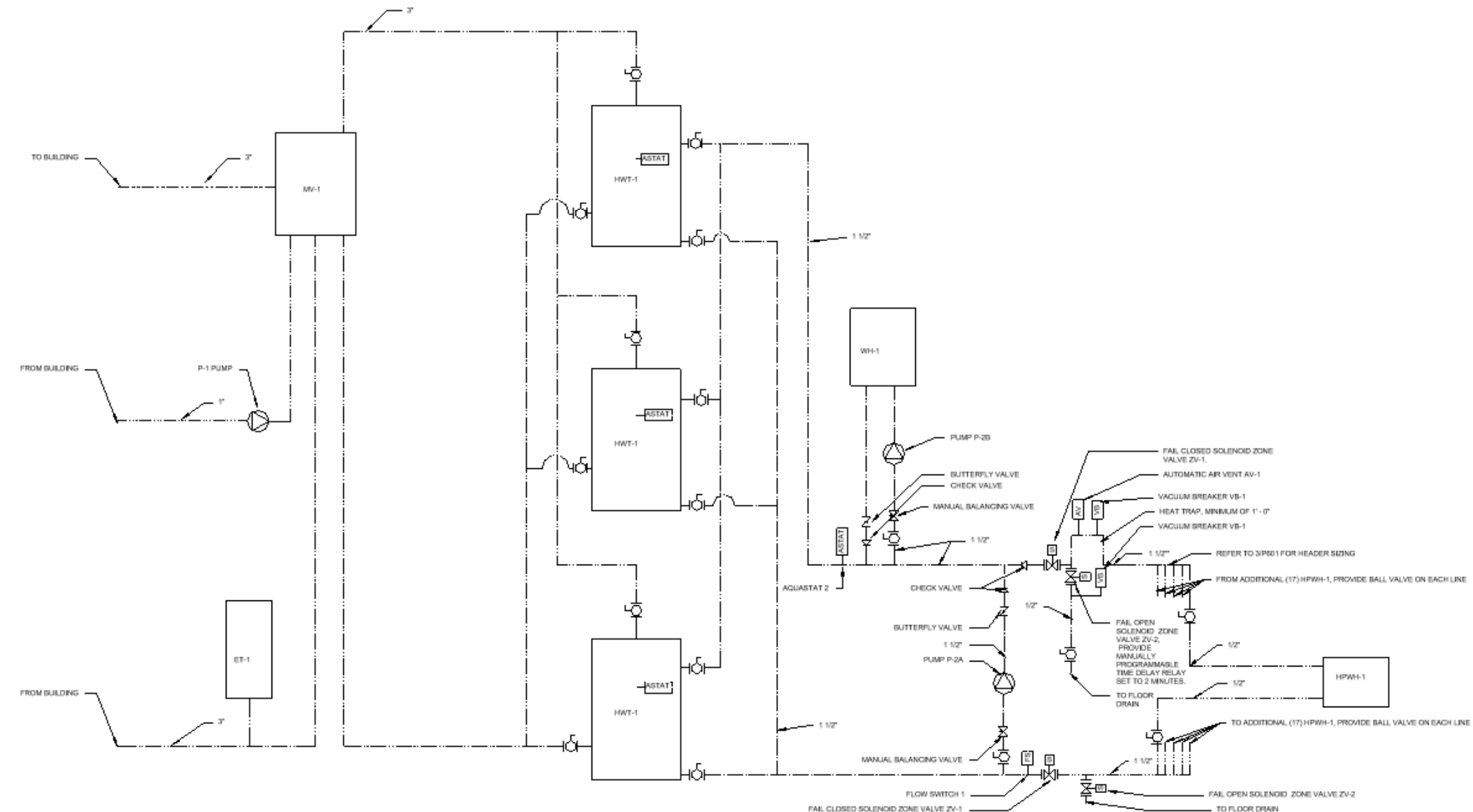


ISSUE

The system required 81 KW of heating capacity, but due to wall space and pipe length limitations we were only able to fit 18 SanCO2 heat pumps in the system without increased complexity. During extreme cold weather events the heat pump system was rated to produce ~77% of required capacity.

SOLUTION

We designed in a multi stage electric resistance boiler with a controller to coordinate sequence of operations. The boiler will act as supplementary and 100% back up depending on the capacity and operation of the primary heat pump plant.



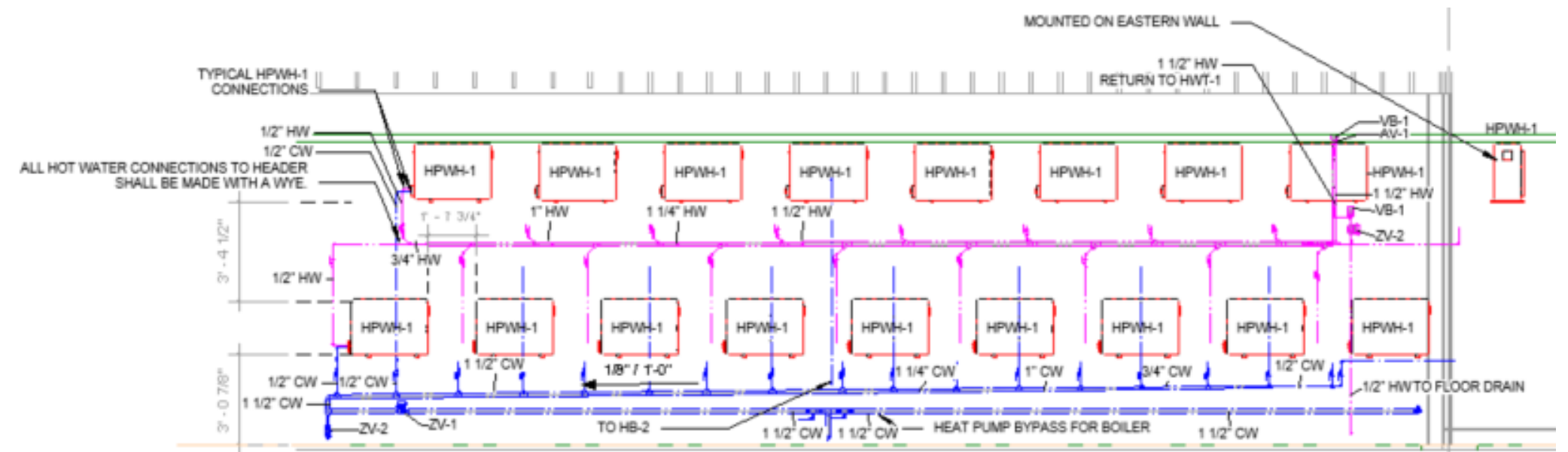
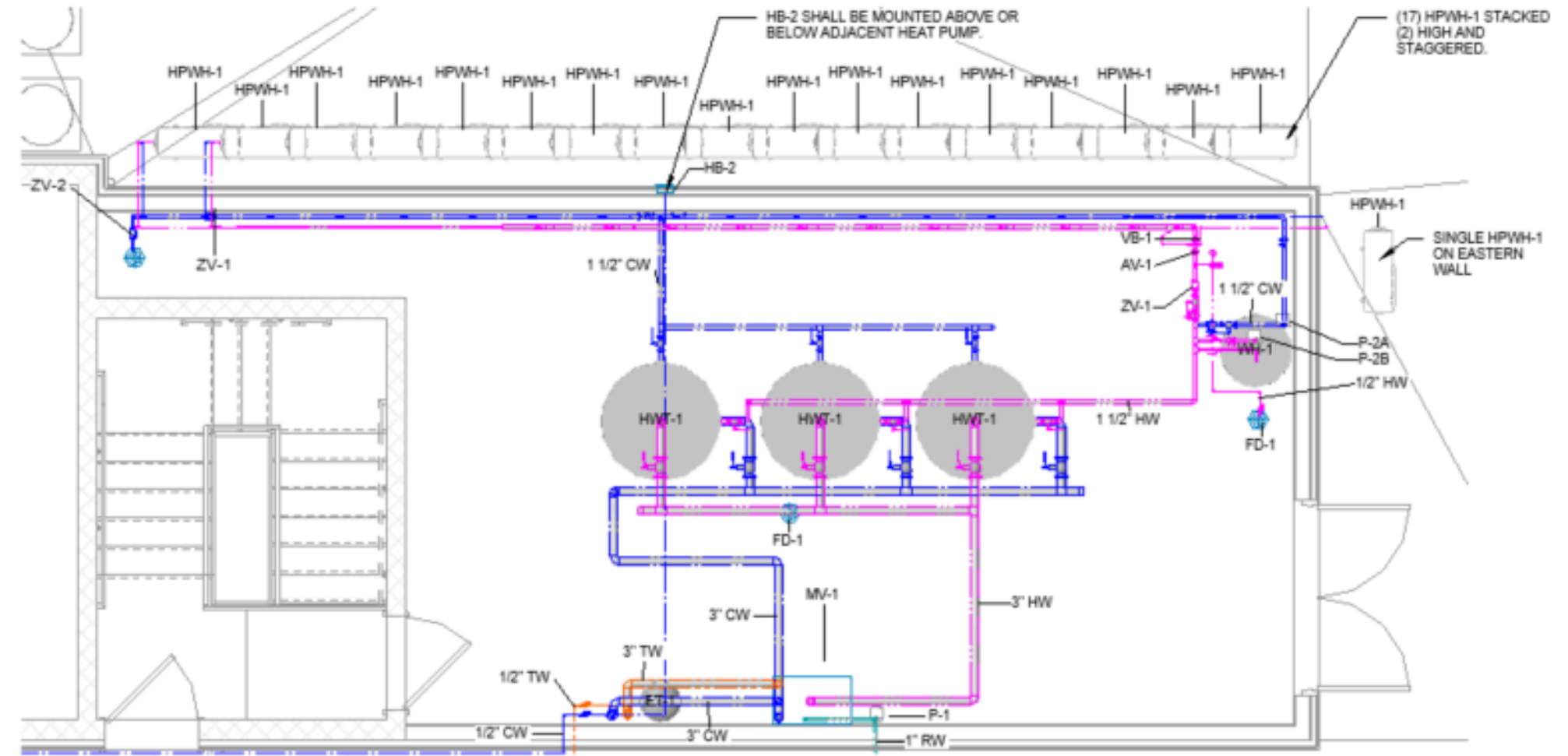
Challenges Pipe length

ORIGINAL ISSUE

The SanCO2 system allows for roughly ~70' of combined hot and cold piping between the tanks and the heat pump. With the large central system the maximum pipe length exceeded 140'.

SOLUTION

We worked with SanCO2 engineers directly. This lead to an approved piping layout that oversized the main distribution piping to 1 1/2" to minimize head loss through the piping at peak flow.



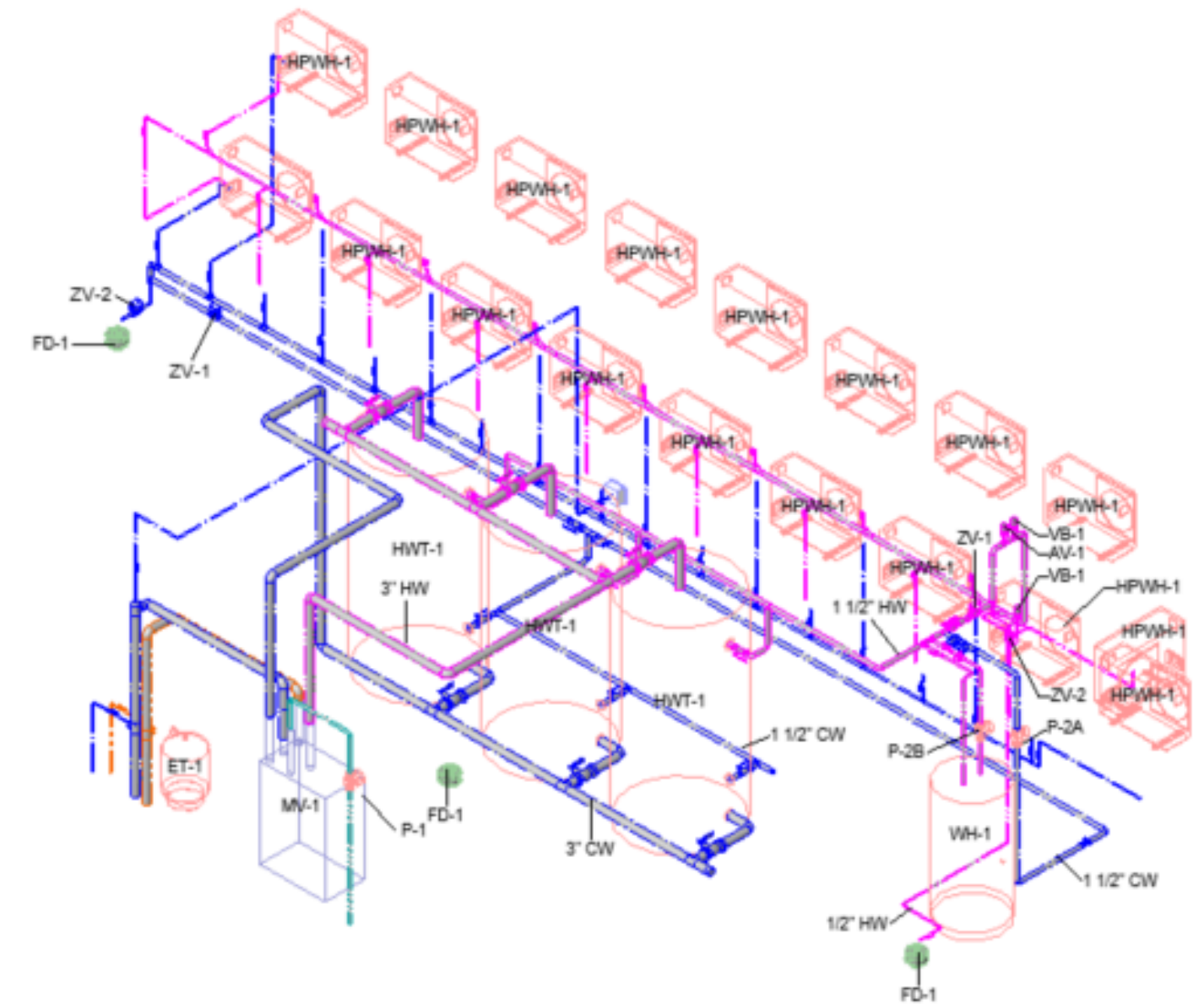
Final System Selection



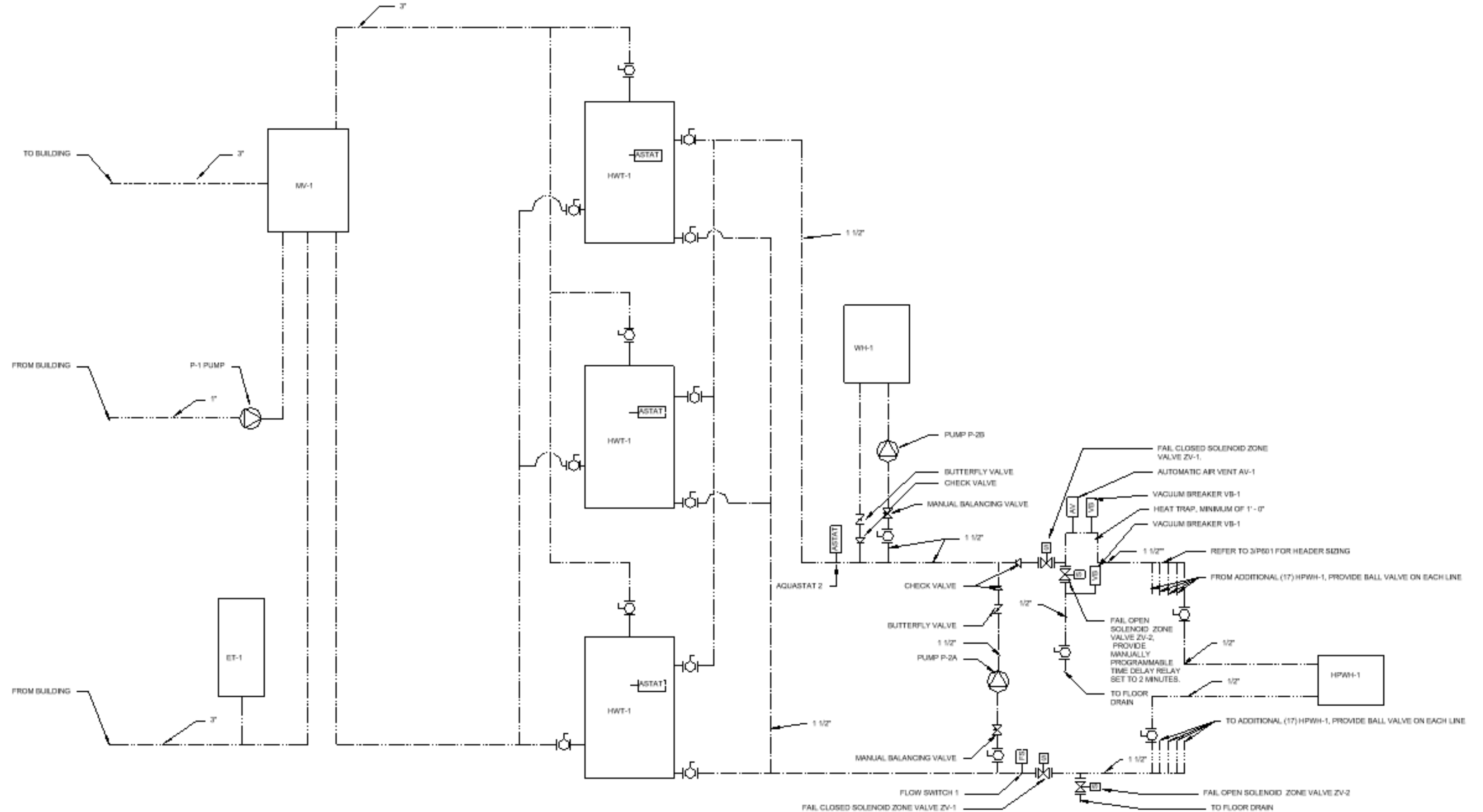
Storage: (3) 505 gallon hot water storage tanks stored at 140 F
Primary heating system: (18) SanCO2 GS4-45HPA-US heat pump water heaters.

Secondary/ back up heating system: (1) 72 KW Electric resistance boilers.

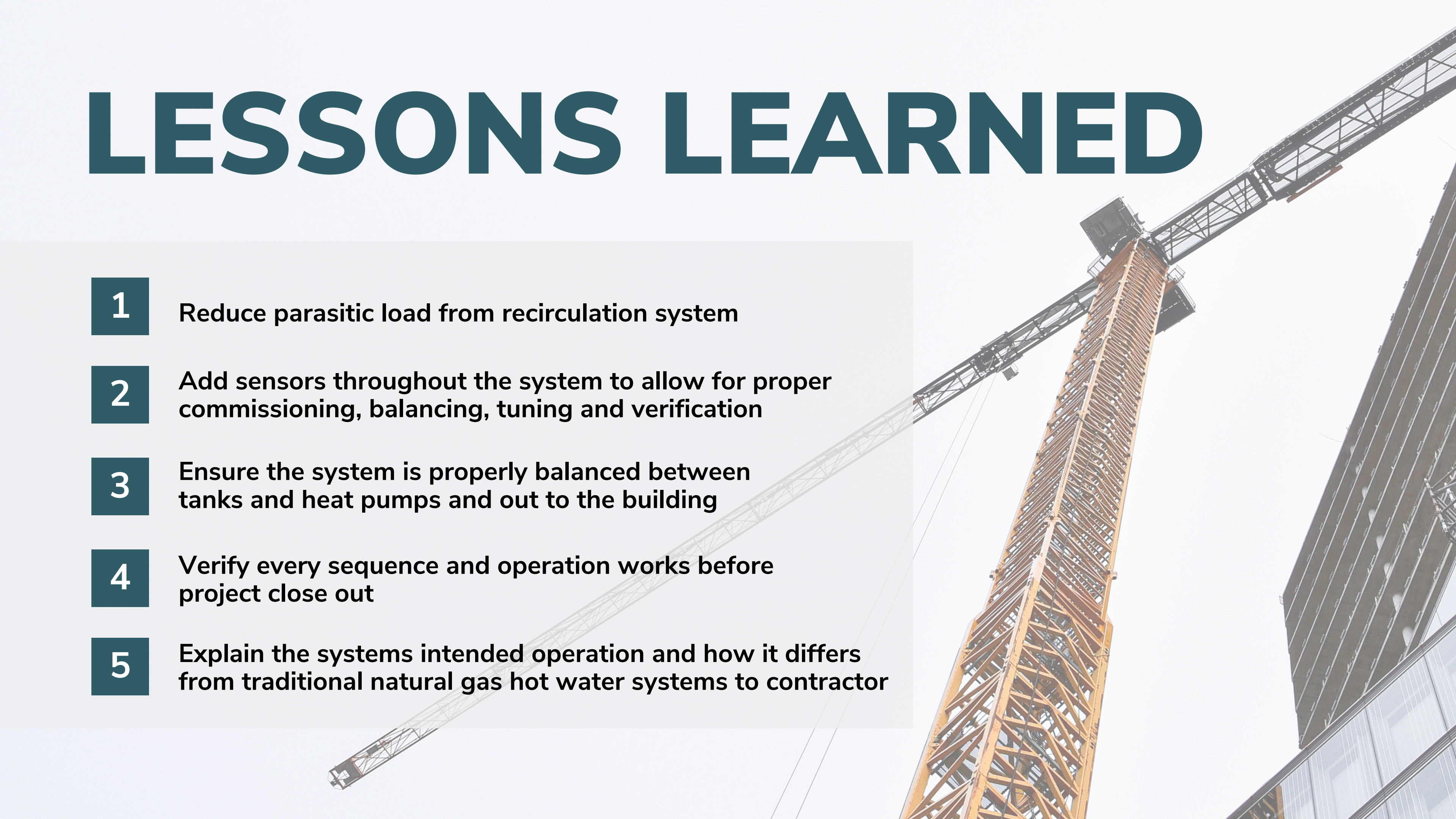
Digital mixing valve: (1) 2 1/2" Heat-Timer digital mixing station.



Final system



LESSONS LEARNED

The background of the slide features a low-angle photograph of a construction site. A tall, yellow lattice boom crane is the central focus, extending from the bottom left towards the top right. To the right of the crane, a modern building with a glass facade is visible, showing multiple floors. The sky is a pale, overcast blue.

1

Reduce parasitic load from recirculation system

2

Add sensors throughout the system to allow for proper commissioning, balancing, tuning and verification

3

Ensure the system is properly balanced between tanks and heat pumps and out to the building

4

Verify every sequence and operation works before project close out

5

Explain the systems intended operation and how it differs from traditional natural gas hot water systems to contractor

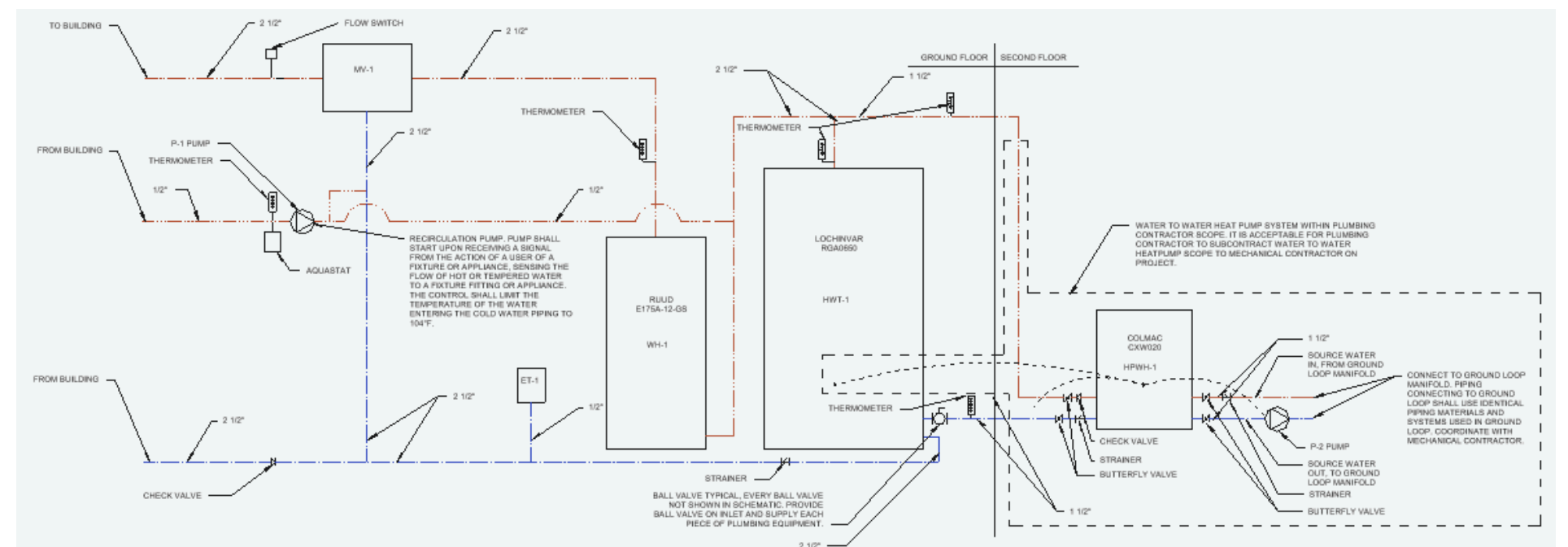
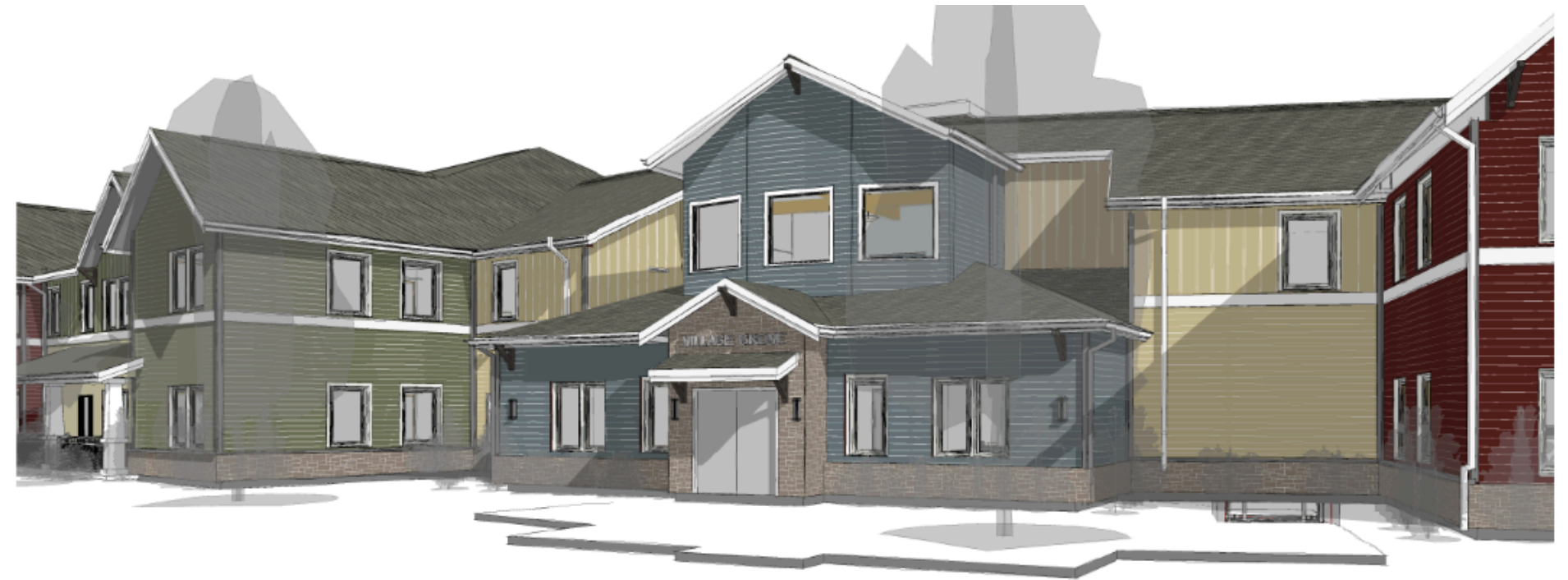
INFORMED DESIGN

1

Reduce parasitic load from recirculation system

2

Add sensors to allow for proper Cx, balancing, tuning and verification



DISCUSSION



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