Zero Place:
Showcasing a Road Map to Electrification in Multifamily

Presented Live at the NY-GEO 2023 Conference Albany, New York on April 27, 2023

Moderator:

John Thomas / *WaterFurnace*

Panel:

Pasquale Strocchia / *Integral Building + Design*

Hugh Henderson / *Owahgena Consulting*

Jens Ponikau / *Buffalo Geothermal*

ZerOPlace

Case Study of New Construction Multifamily

Presented by:
Pasquale Strocchia, Hugh Henderson and Jens Ponikau

NY-GEO Conference

April 27, 2023

ZerOPlace

- Mixed use, Net-Zero Energy Building: 63,320sf
  - 46 Residential Apts (55,780 sf)
    - 41 Market-Rate / 5 Affordable
    - 21 One-Bdrm / 25 Two-Bdrm
    - Amenity Spaces including Fitness Center and Tenant Storage
  - 6 Retail spaces at Ground Flr (7,540sf)

- Timeline:
  - Dec 2018: Ground-breaking
  - March 2022: Completed
  - June 2022: Full Apt Occupancy
  - Jan 2023: Retail Occupancies 2 of 6 Spaces


ZerOPlace
Apartment Layouts
Inspired by These Energy Pioneers


ZerOPlace

Importance of Zero Place

- Zero Place was a winner of NYSERDA's first-ever Buildings of Excellence Award in 2019
- Reference project for the State of New York to assess the effectiveness of combining space heating/cooling and domestic hot water (DHW) in a single building-wide geothermal system.
- NYSERDA independently monitoring the Geothermal system.
- Will inform policy regarding means to achieve NY state's aggressive goal of economy-wide carbon neutrality by 2050.

NEW YORK STATE OF OPPORTUNITY. Buildings of Excellence Award Winner

Carbon-Neutral Building Strategies

Key Features at Zero Place

1. Electrify all systems
2. Make the building efficient
3. De-carbonize the production of electricity

- High-performance Thermal Enclosure
- Ultra-efficient Geothermal System
- Optimized Solar PV System

High-performance Thermal Enclosure

Features

- Insulated-concrete form (ICF) walls (R-22)
- Thermal Bridge-Free Construction strategies
- Triple-paned fenestration (0.17 U-Value)
- High-R Slab (R-25)
- Fully-insulated roof assemblies (R-62)
- Air-tight construction Results:
  - Leakage to Outside: 0.6 - 1.0 ACH-50
  - Compartmentalization: 0.07 – 0.18 CFM-50/SF

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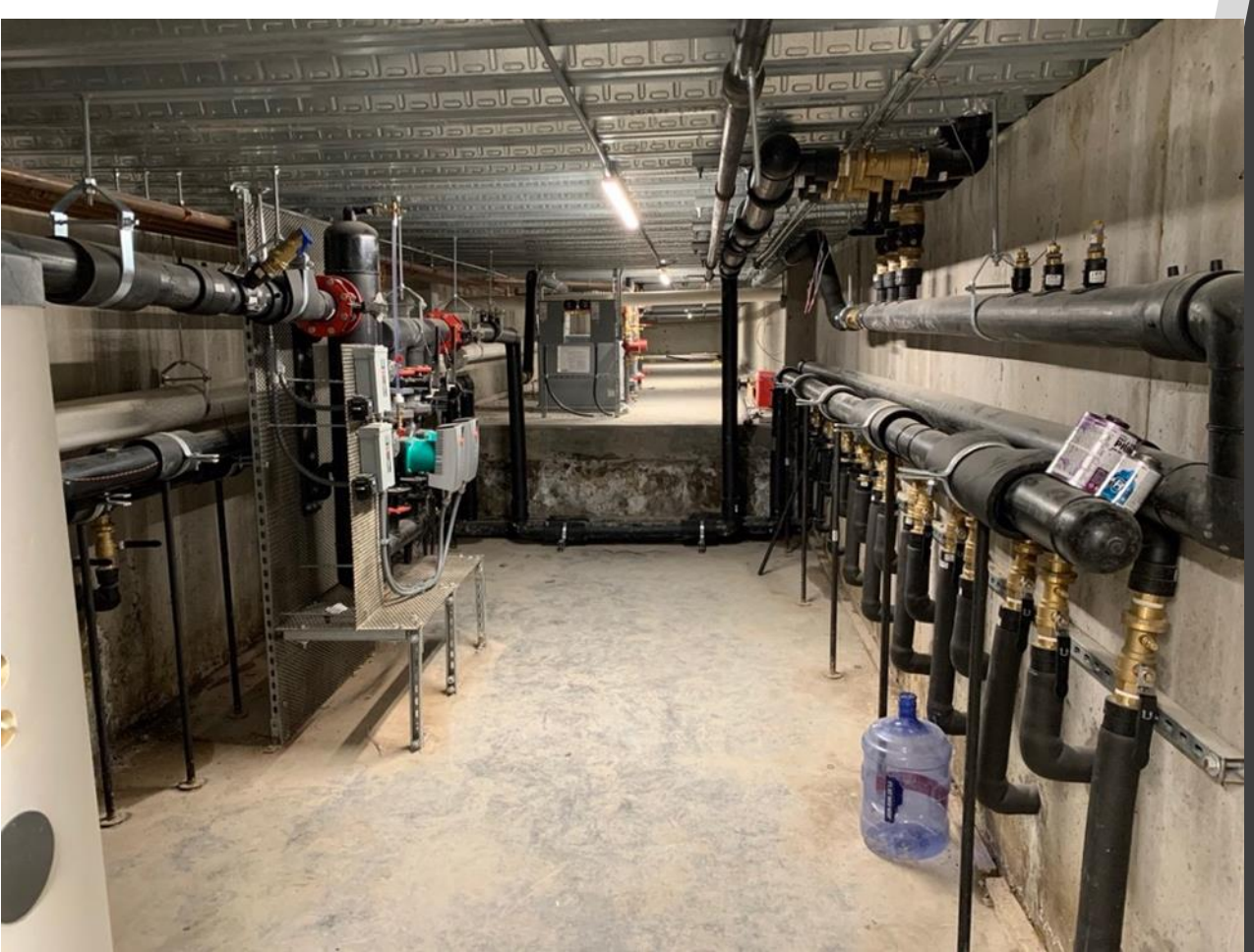


Geothermal System: Integrated HVAC and DHW

- The heart of Zero Place's pioneering innovations
- Ground-source Heat Pump (GSHP) System provides 100% Space Heating, Cooling and Domestic Hot Water (DHW)
- Summary
  - Vertical wells all located within building footprint
  - Common Loop Field for all Space Conditioning and DHW, utilizing a central flow station with variable speed, high-efficiency pumps
  - Unitary Heat Pumps for each Dwelling, Retail Space and Common Area
  - Unitary ERV systems for each Dwelling and Retail Space with integrated Demand-Controlled Ventilation systems and manual over-ride controls for all tenants

Bore field

- (15) 400-ft wells - all within the footprint of the building
- Footprint of building would enable up to 28 stories above
- Insulating cap of the building above the bore field will contribute to the efficiency of the system

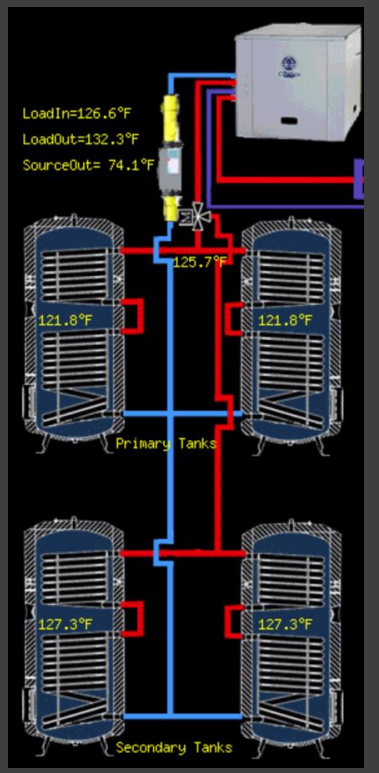
60 Geothermal Heat Pumps

Qty	Description	Capacity (Tons)
53	Single-stage Water-to-Air HP's for Apts and Corridors	0.75 – 1.0
2	Dual-stage Water-to-Air HP's for Common Areas	3.0
7	State of the art, Variable-speed, Water-to-Air HP's for Commercial Spaces	5.0
2	High temperature, Water-to-Water HP's to generate 100% of the Domestic Hot Water for the Building	5.0
64	Total Rated Capacity	94

Domestic Hot Water Design

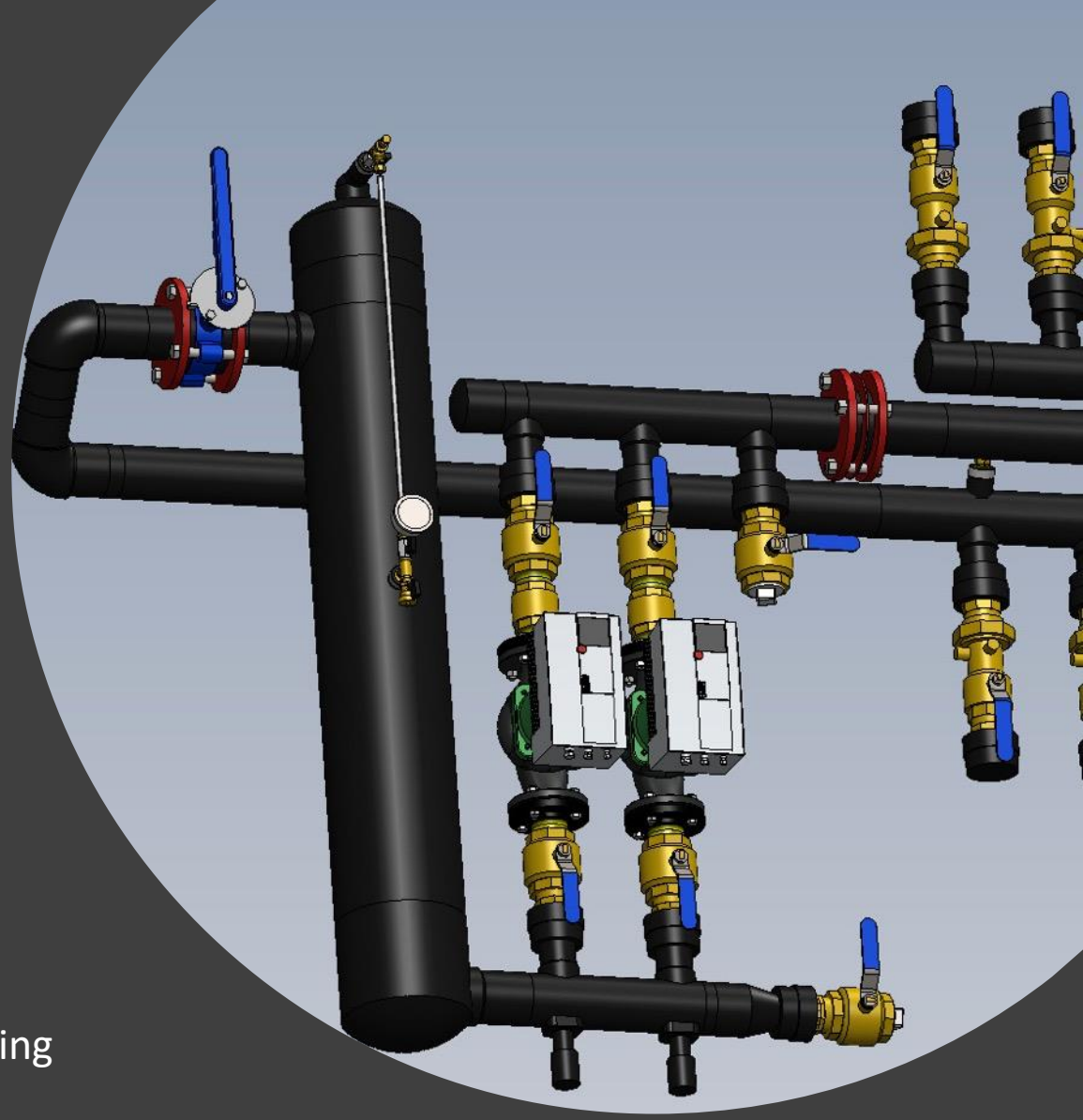
- Zero Place will be only the 2nd multi-family building to make 100% of DHW utilizing a common ground loop strategy in NYS
  - Note: Zero Place demonstrates the concept at scale at 4X the size of the other building.
- Uses rejected heat in apartment A/C mode to make hot water. Even though the building is located in a cold-climate (CZ-6), the building is cooling-dominant.
- The central DHW system is designed to keep the loop field colder, saving substantial well depth (more than 2 wells @ 500')
- The capital cost savings of shorter loop field completely offset the cost of the DHW HP Equipment
- 4x 162-gallon storage tanks to meet the projected peak hot water usage
- 2x Water-to-Water Heat Pumps allows for redundancy (1x would meet the full DHW load)
- Monitored Results:
  - DHW systems is approx 10% of the Total Residential Energy Use of the building

Key Innovation of our Geothermal Design



Other Design Features

- Central adaptive pumping solution
  - Rated Pumping Power: approx. 15 Watts/Ton
  - NYS Clean Heat Limit: ≤ 85 Watts per Ton
    - Best Practice: < 60 Watts per Ton
- Balanced header system
  - No balancing valves
  - No flow restriction, reduced pumping power
- Variable speed pumping
  - Only as much pumping power as needed
  - Revs up and down with the amount of heating and cooling needed and number of heat pumps operating
- No backup heat
  - No gas line in the building, completely emission free



Solar PV

- 248 kW of solar (688 panels @360W)
- 11,978 SF covered
- PROJECTED Total annual generation: 257,940 kWh/yr
- SunPower Helix
- Installed on roof and solar awnings on south wall
- Note: Building-scale energy storage system for peak energy shaving being evaluated

Solar solution provided by: suncommon

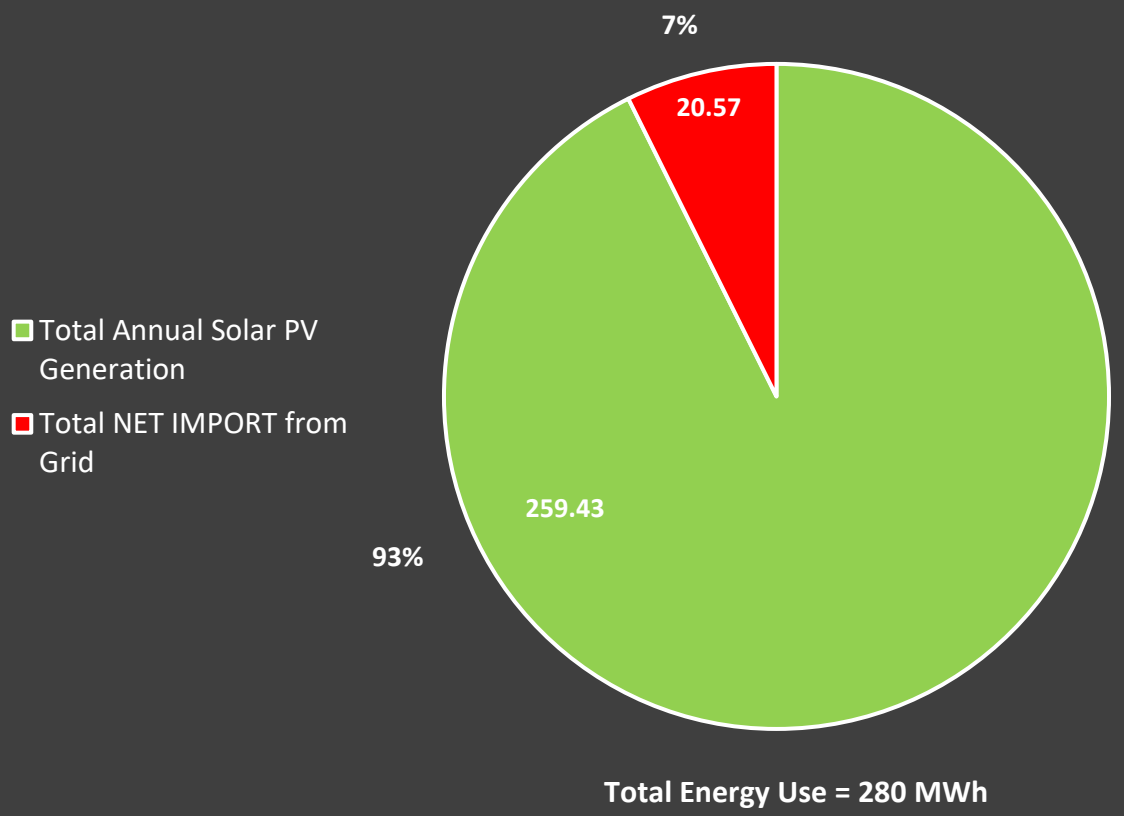
Monitoring Scope: Energy Use + Generation

- Bldg Owner Master Utility Meter
  - Utility Grid Electrical Service
  - Solar PV Generation
  - All Residential Apts
    - Total Energy, Heat Pump, ERV and Induction Range
  - Common Areas
    - Geo Loop Pumps + DHW Heat Pumps, Int and Ext Lighting, Elevator, Fans, Plug Loads, EV Charging Station (1 @ Bldg Entry), etc.
- Commercial/Retail Spaces
  - Individual Utility Electrical Meters
- EXCLUDED:
  - Electric Vehicle (EV) Charging Stations at Parking Lot
    - 9 of 10 Charging Stations installed on distinct utility electrical meter service

Projected Annual Residential Energy Use: June 2022 thru May 2023*

(*Based on 10-mo of Data at Full Occupancy June 2022 thru Apr 2023)

280 MWh/Yr



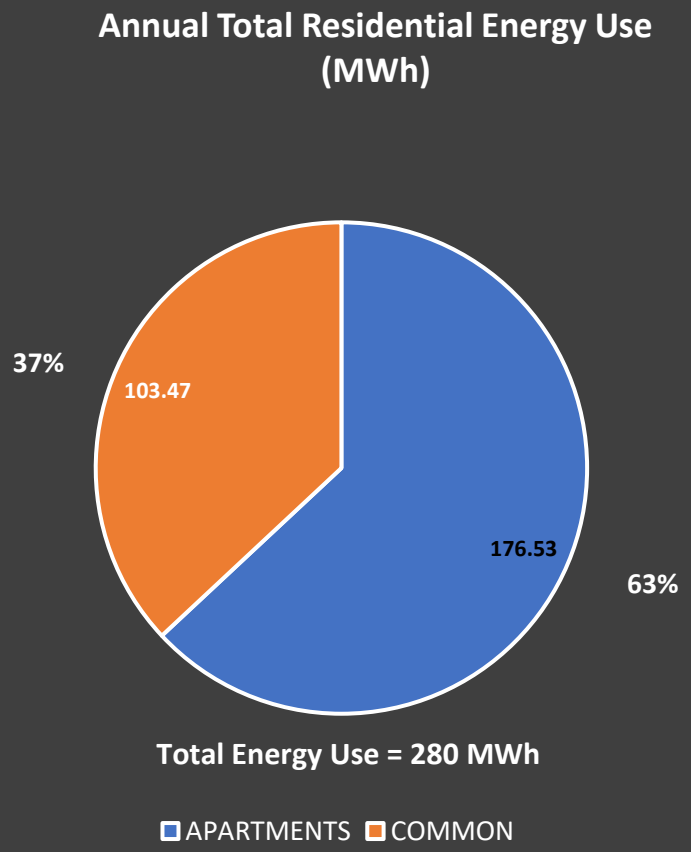
Energy Use Intensity (EUI)
kBTU/SF/Yr

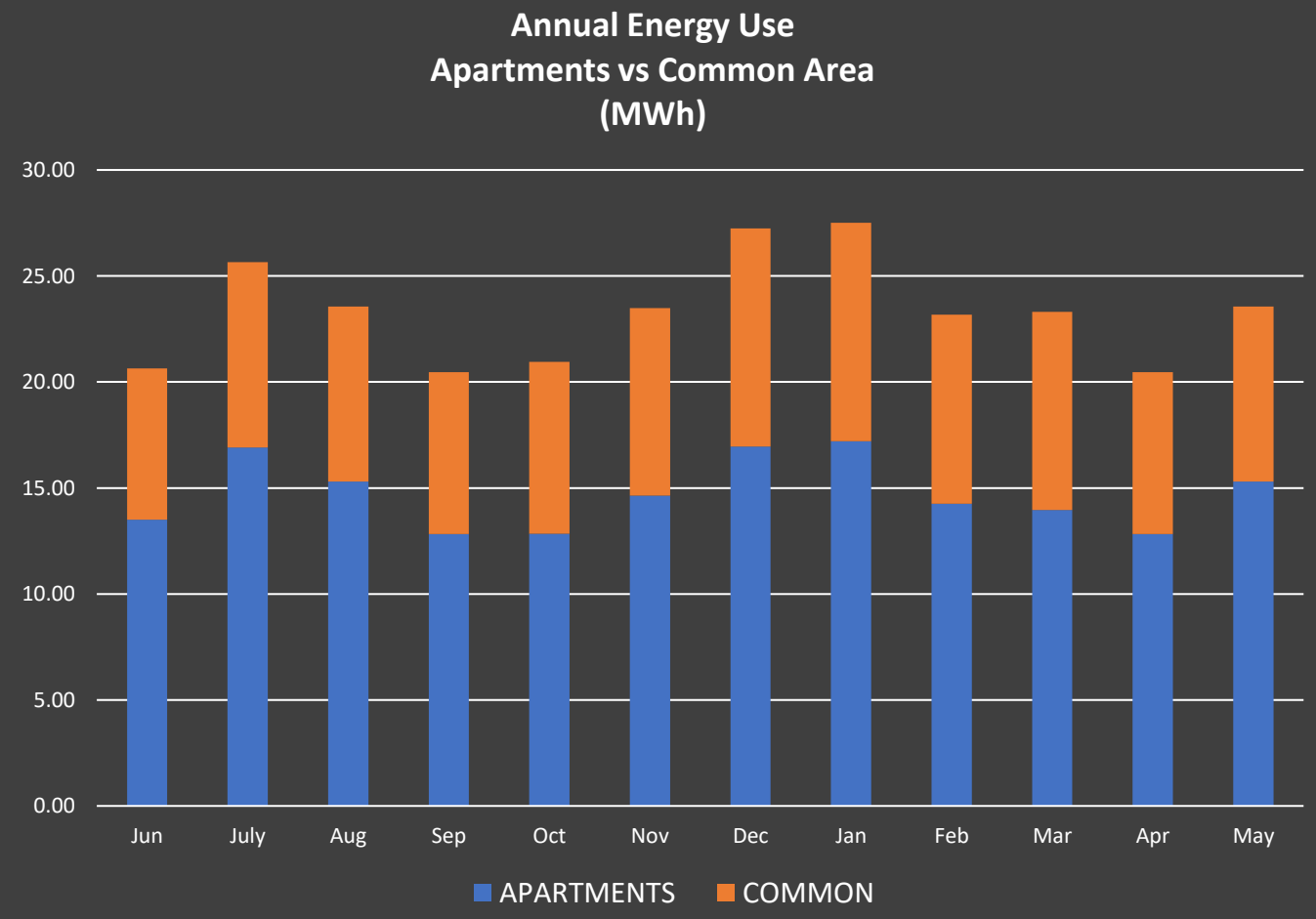
- Building without Solar PV:
  - 275,940 kWh / 55,780sf = 4.95 kWh/SF/Yr
  - EUI = 16.88 kBTU/SF/Yr
- Building with Solar PV:
  - 18,000 kWh / 55,780sf = 0.33 kWh/SF/Yr
  - EUI = 1.16 kBTU/SF/Yr

Projected Annual Energy Use: Total Residential

280 MWh/Yr*

(*Based on 10-mo of Data at Full Occupancy)





Projected Annual Energy Use: Apartments ONLY

176.53 MWh/Yr*

(*Based on 10-mo of Data at Full Occupancy)

Apts: Average Energy Usage (exclusive of Central DHW system)

Measured:

- 1-Bdr Apts
  - 3,169 kWh/Yr (or 264 kWh/Mo)
- 2-Bdr Apts
  - 4,341 kWh/Yr (or 362 kWh/Mo)

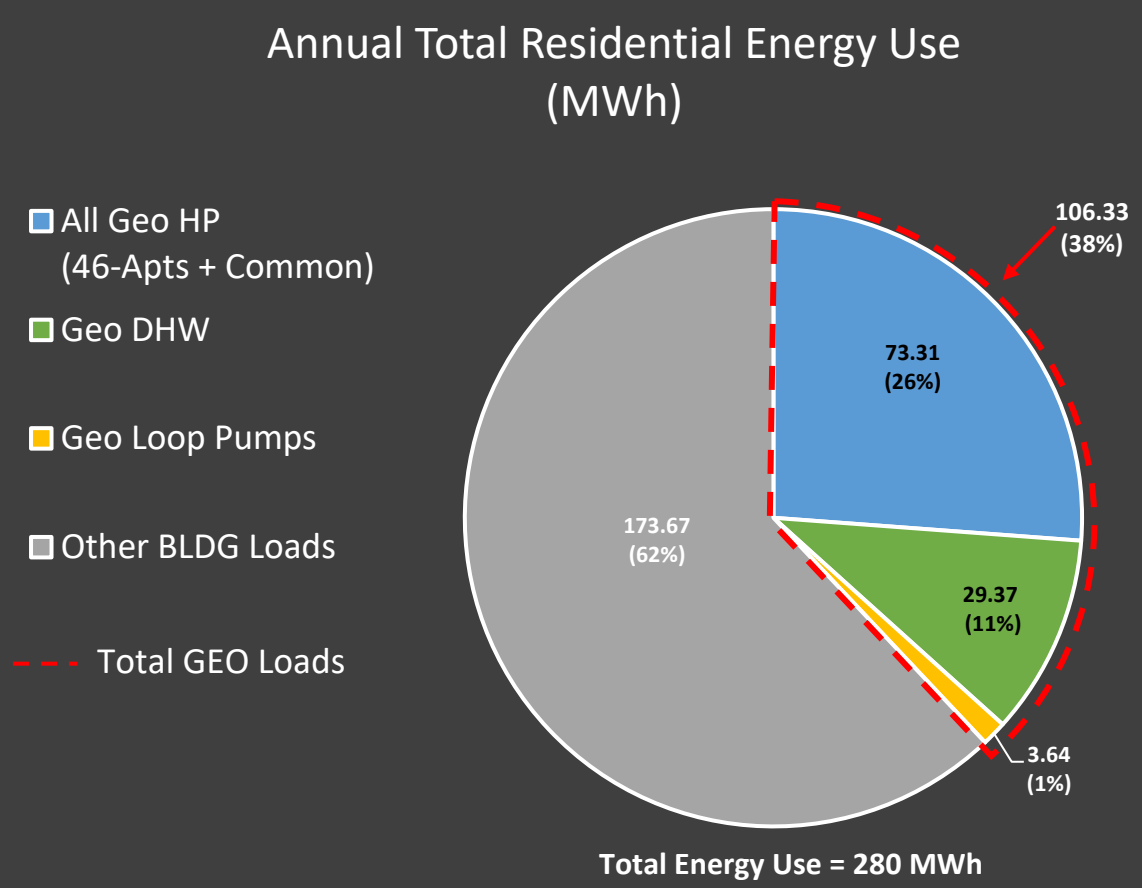
Lease Allowances:

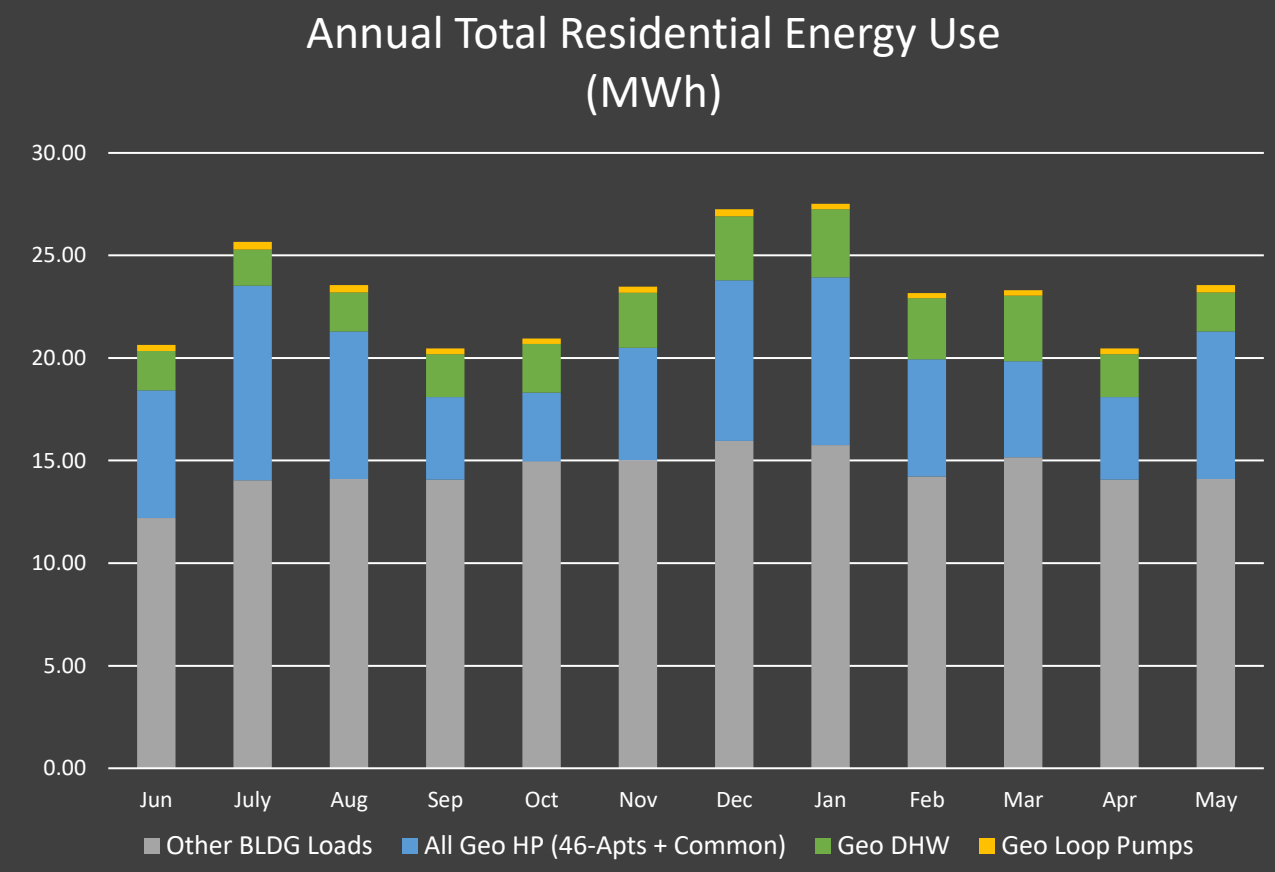
- 1-Bdr Apts
  - 4,300 kWh/Yr (or 358 kWh/Mo)
- 2-Bdr Apts
  - 5,700 kWh/Yr (or 475 kWh/Mo)

Projected Annual Energy Use: Total Residential

280 MWh/Yr*

(*Based on 10-mo of Data at Full Occupancy)





Annual Energy Use:
Summer Utility Grid Energy 15-min Peak Demand

7/19/22

HOTTEST TEMP OF THE YEAR:

@ 7pm: 99.0 F

Utility: 39.40 kW

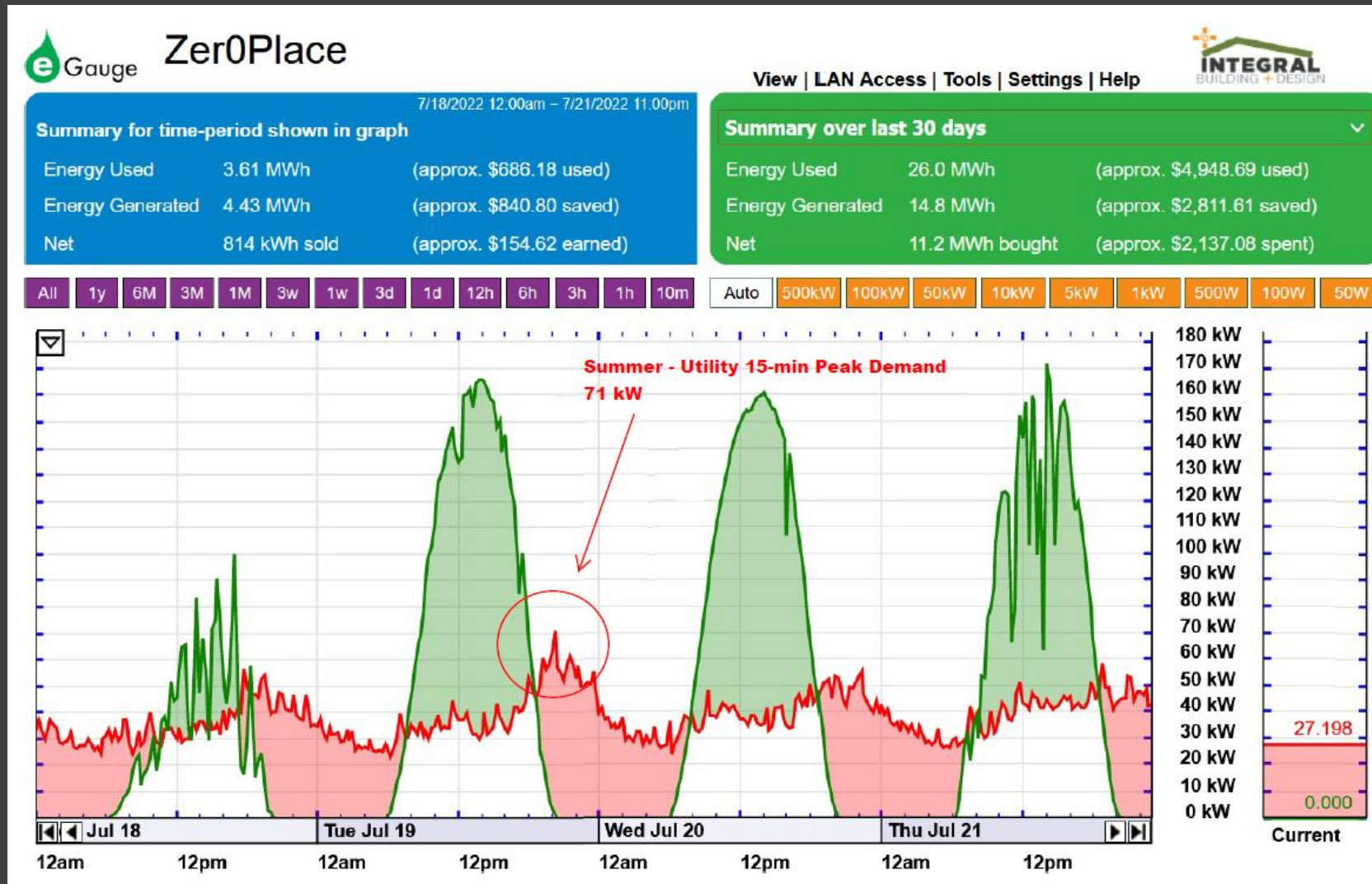
Solar PV: 14.15 kW

GREATEST ANNUAL-PEAK UTILITY DEMAND:

@ 8:15PM: 93.0 F

Utility: 71.26 kW

Solar PV: 0.00 kW



Annual Energy Use:
Winter Utility Grid Energy 15-min Peak Demand

2/4/23

COLDEST TEMP OF THE YEAR:

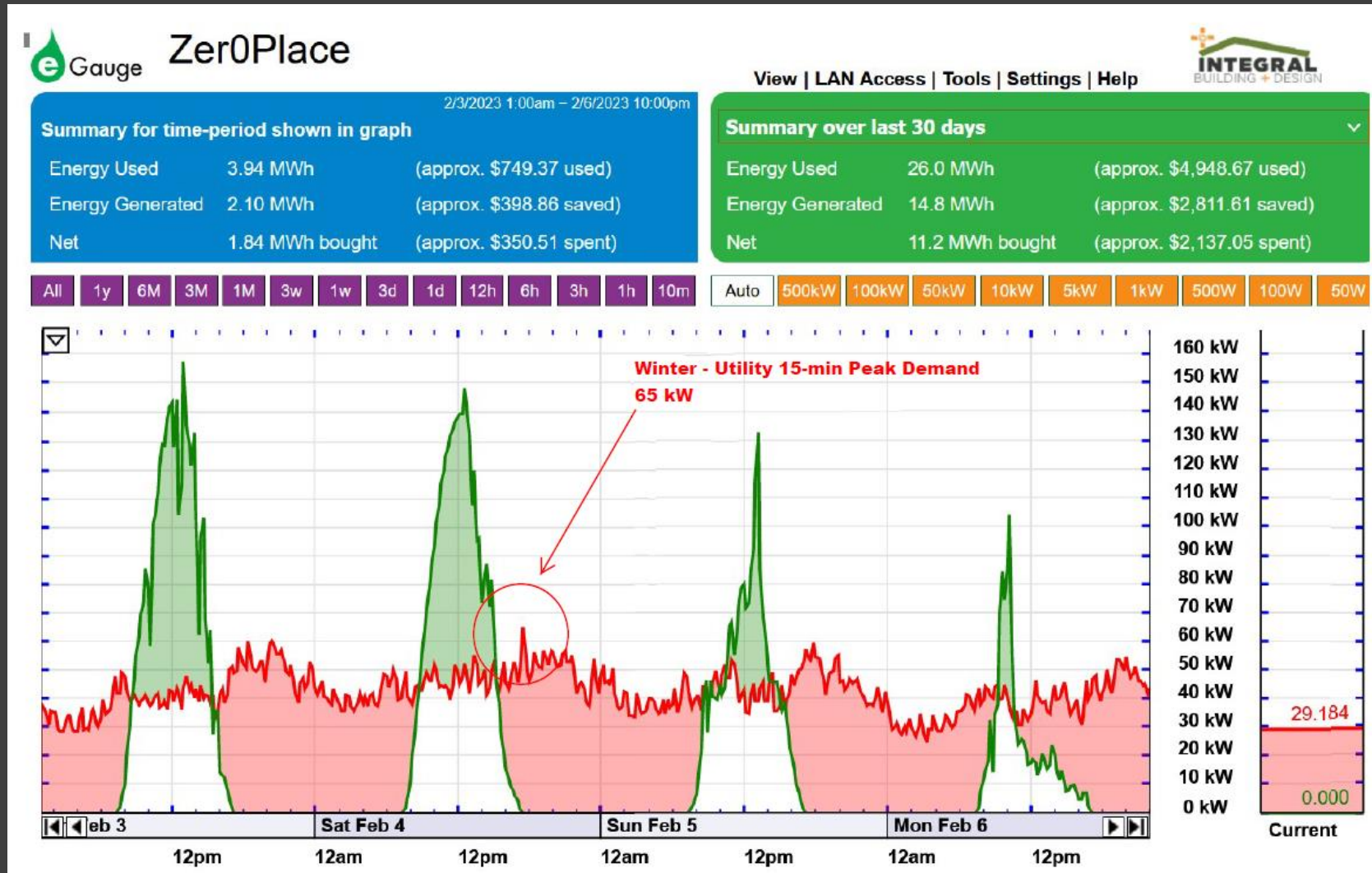
@ 7am: - 6.0 F

Utility: 49.44 kW
Solar PV: 0.00 kW

GREATEST WINTER-PEAK UTILITY DEMAND:

@ 5pm: 16.0 F

Utility: 65.41 kW
Solar PV: 0.00 kW



ZerOPlace

NY-GEO Conference, April 27

Jens Ponikau, CGD

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Buffalo Geothermal

- Specializes in medium and large scale multifamily and commercial projects, especially retrofits
  - Certified Geothermal Designers
- Design-Built only
- Vertically integrated
  - Design
  - Installation
  - Manufacturing
  - Focused on quality and efficiency
  - Fixed cost pricing

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ZerOPlace

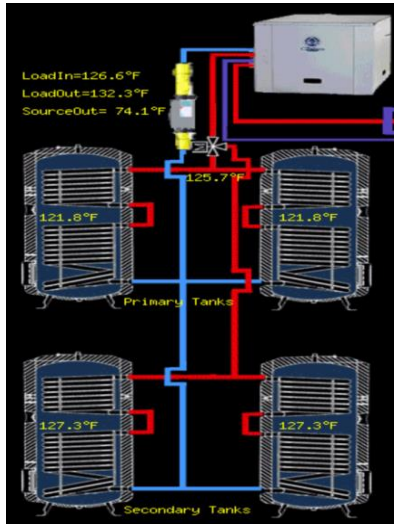
- (15) 400-ft wells - all within 15% Building’s footprint
- Footprint of building would enable up to 30 stories above
- 67 ft/ton

60 Geothermal Heat Pumps

Qty	Description	Capacity (Tons)
50	Single-stage Water-to-Air HP's for Apts and Corridors (Waterfurnace)	0.75 – 1.0
2	Dual-stage Water-to-Air HP's for Common Areas (Waterfurnace)	3.0
6	State of the art, Variable-speed, Water-to-Air HP's for Commercial Spaces (Waterfurnace)	5.0
2	High temperature, Water-to-Water HP's to generate 100% of the Domestic Hot Water for the Building	5.0

DHW Staged Design

- Staged Design with Preheat – Final Heat
- 1st multi-family building to make 100% of DHW With Geo using Preheat Design
- Uses rejected heat in apartment A/C mode to make hot water. Even though the building is located in a cold-climate (CZ-6) the building is cooling-dominant
- The central DHW system is designed to keep the loop field colder, saving substantial well depth (more than 2 wells @ 500')
- The capital cost savings of shorter loop field completely offset the cost of the DHW HP Equipment
- DHW Capital Costs is literally free
- 4x 162-gallon storage tanks to meet the projected peak hot water usage
- 2x Water-to-Water Heat Pumps allows for redundancy (1x would meet the full DHW load)



Key innovation of our geothermal design

Other Design Features

- Central adaptive pumping solution
  - Average Pumping Power to Date: 396 watts
- Balanced header system
  - No balancing valves
  - No flow restriction, reduced pumping power
- Variable speed pumping
  - Only as much pumping power as needed
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    and number of heat pumps operating
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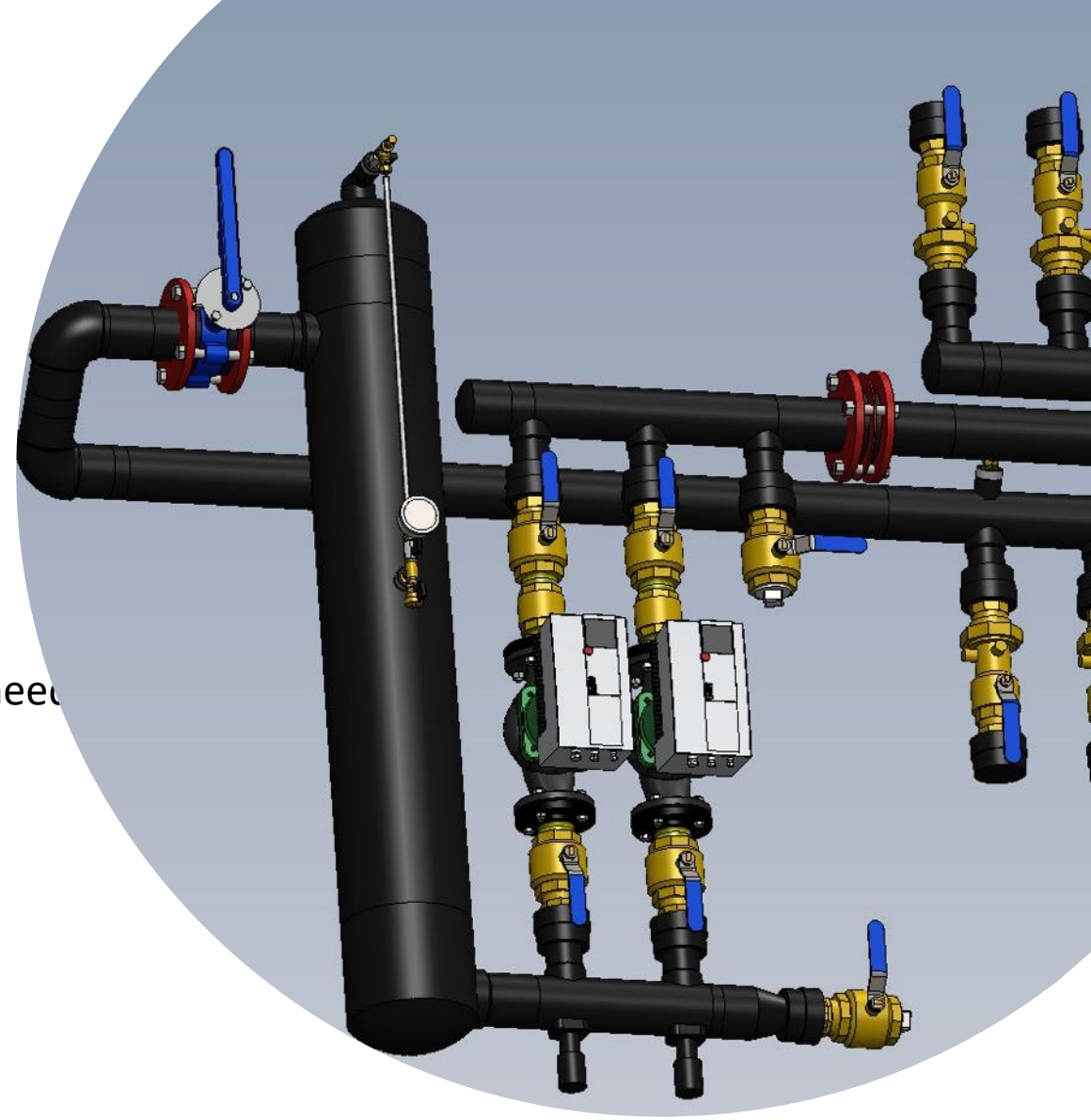
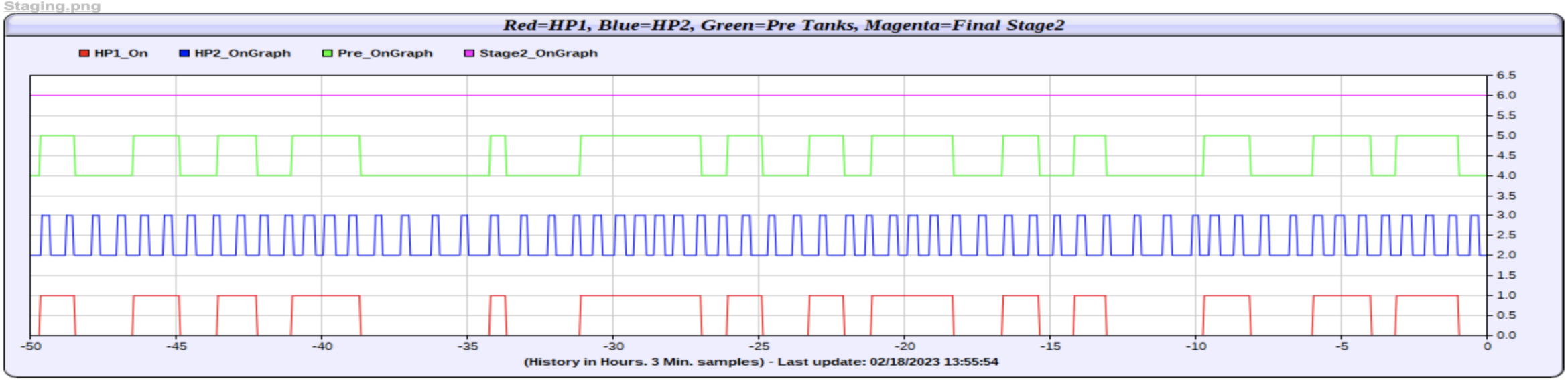


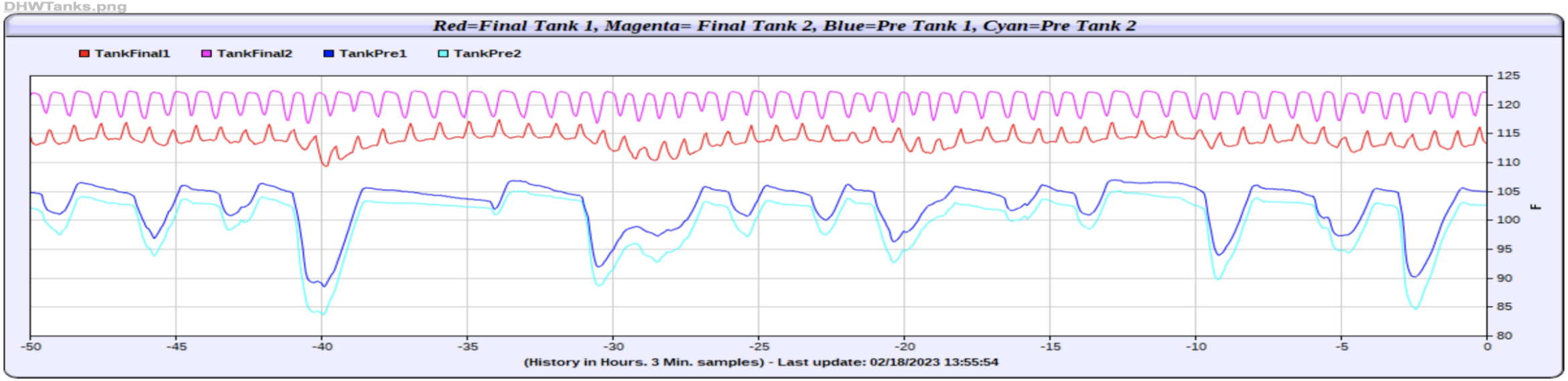
Hot water run time

Pre heating and final heating

Staging.png



DHWTanks.png

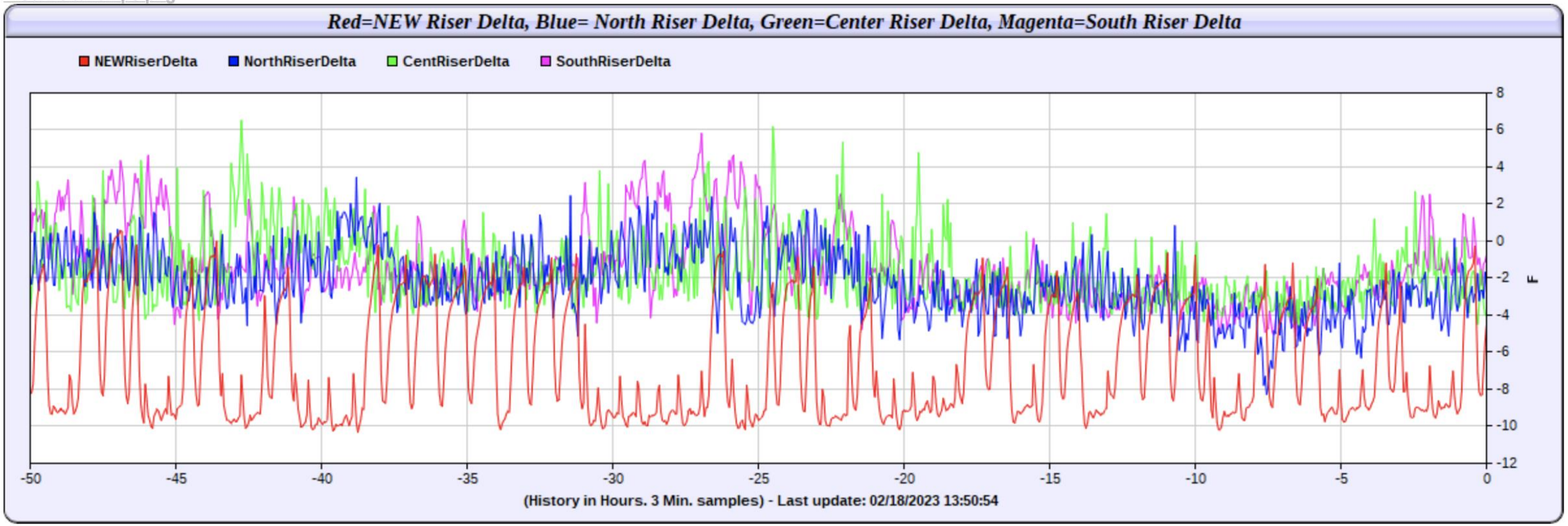


Heat extraction vs heat rejection

Space conditioning vs DHW production 48 hour period

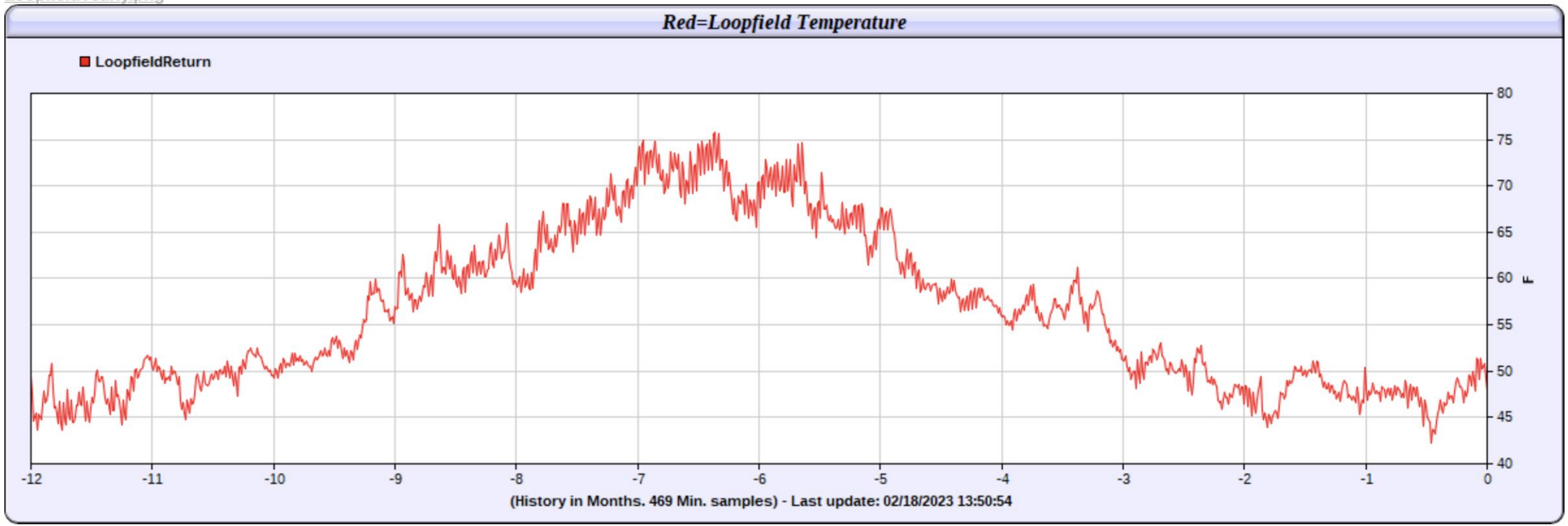
Southern oriented heat pumps operate in A/C mode, sending thermal energy to DHW and northern heat pumps

RiserDeltaTemps.png



12 Month Annual Entering Water Temperatures 2/18/2022 -2/18/2023

LoopfieldYearly.png

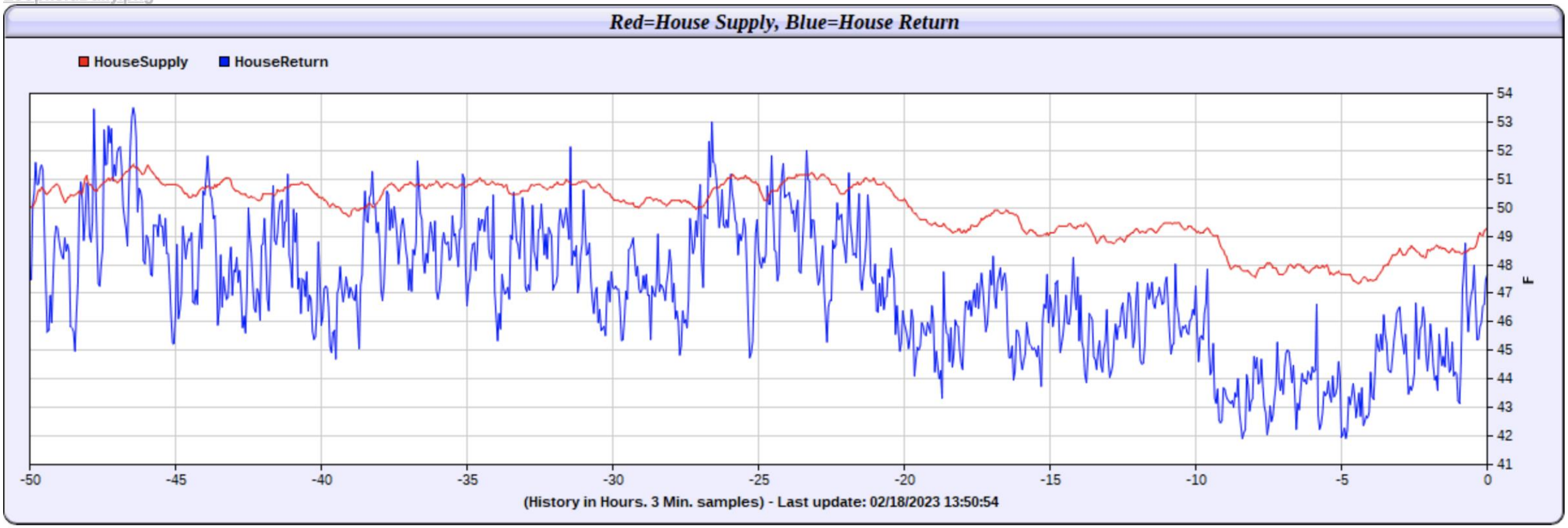


Entering and leaving water temperatures

48 hour period 2/17 -2/18 2023

Loop field increases thermal energy delivery via larger Delta T

LoopfieldDaily.png



ZeroPlace Loop Field Thermal Energy Delivery

Monetary Value

					@ $567/ kWh*
Monthly Thermal Energy (Jan 11 to Feb 10)			31.38	MWh	$ 17,792,460
Peak Day (Feb 4)			1,706.81	kWh	$ 967,762
Peak Hour			90.86	kWh	$ 51,518
Peak Interval (5-min)			106.98	KW	

*"Among projects awarded NYSERDA incentives, average total installed costs for non-residential, retail projects averaged $567/kWh for installations occurring in 2022 and 2023"
Case 18-E-0130 – In the Matter of Energy Storage Deployment Program.
New York's 6 GW Energy Storage Roadmap Policy Options for Continued Growth in Energy Storage.pdf

Support for Our Geothermal System

NYSERDA

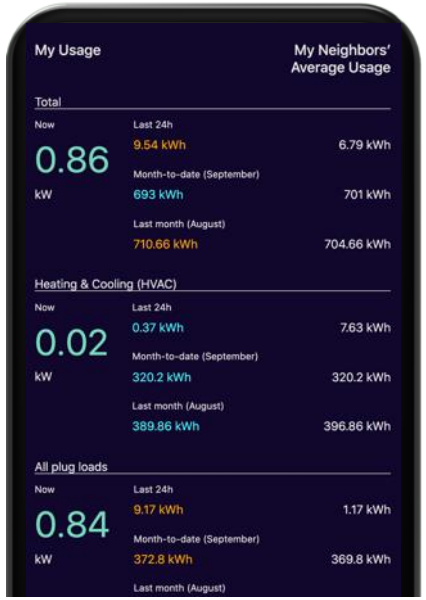
- $109,000 in Geothermal Rebate Incentives
- Performing independent 3rd Party energy monitoring and energy verification
- Zero Place is an important case study / reference project to educate policymakers
  - NY State and beyond
  - Utilities
  - Demonstrate what is possible in the heat dominated Northeast

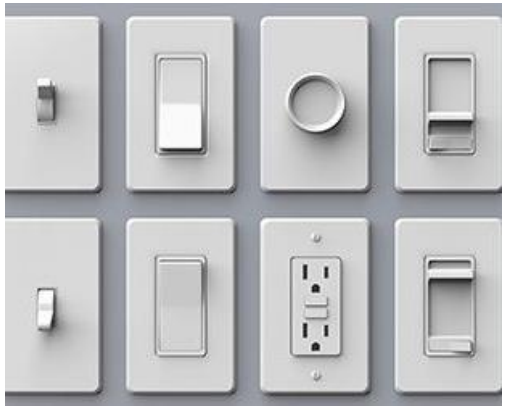
WaterFurnace

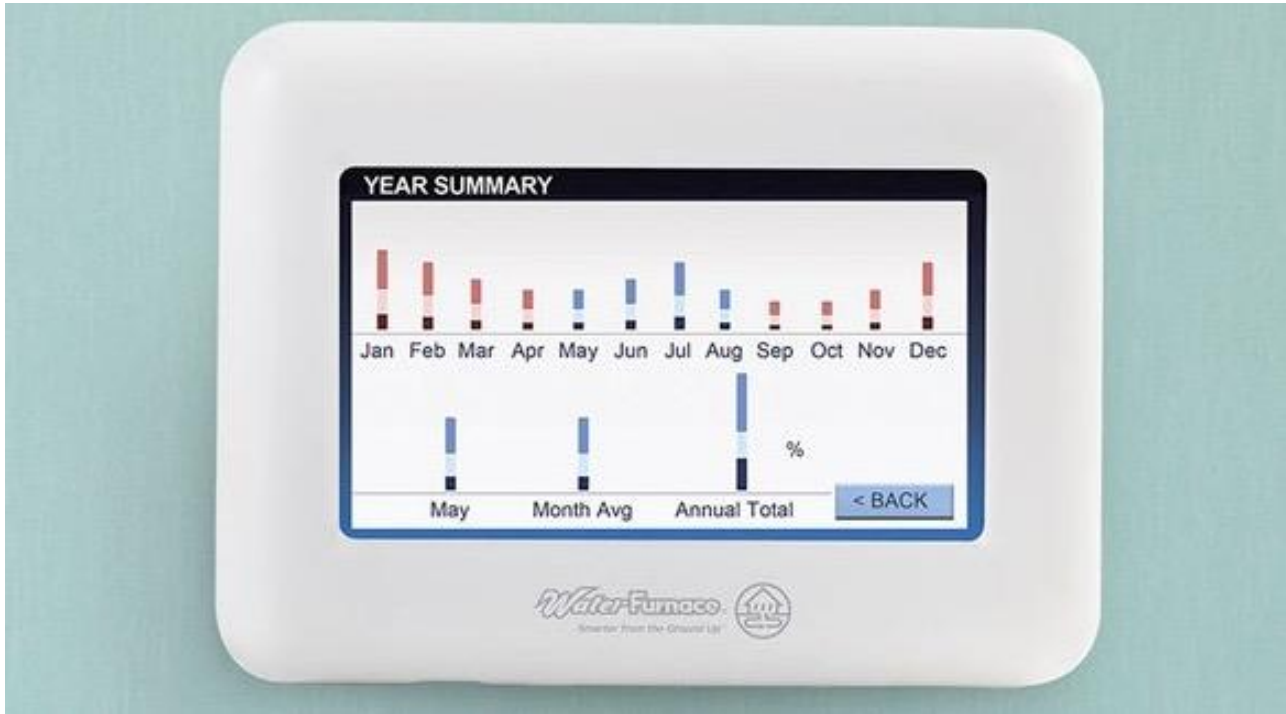
- In-kind support by installing remote control and monitoring systems, each streaming 256 data points every 10 secs
- Remote Thermostat control for Tenants

Operations

- Zero-Energy Living
  - Zero Place Includes Eall Energy Costs with the with rent for all residential tenants
  - annual power generation meets annual Consumption For Apartments and Commons
- Monitoring infrastructure installed
  - For Each Dwelling
  - Custom mobile software for each tenant energy and emission
- Encouraging Energy Savings by Tenants
  - Creating a community with a shared vision
  - Display of overall building consumption and relation to NZE goal







Zero Place Project Team

- Founder: David Shepler
- Anthony Aebi – ZeroNetNow Inc.
- Keith Libolt - Affordable Housing Concepts

- Architect – Bolder Architecture
  - David Toder, RA

- Builder – Affordable Housing Concepts
  - Keith Libolt - Owner
  - Mike Scirbona – Construction Manager

- Energy Modeling & Consulting – Integral Building & Design
  - Pasquale Strocchia

- Geothermal System and DHW
  - Jens Ponikau – Buffalo Geothermal

- Solar PV & Energy Storage
  - Jeff Irish - SunCommon

Zero Place Monitoring Results

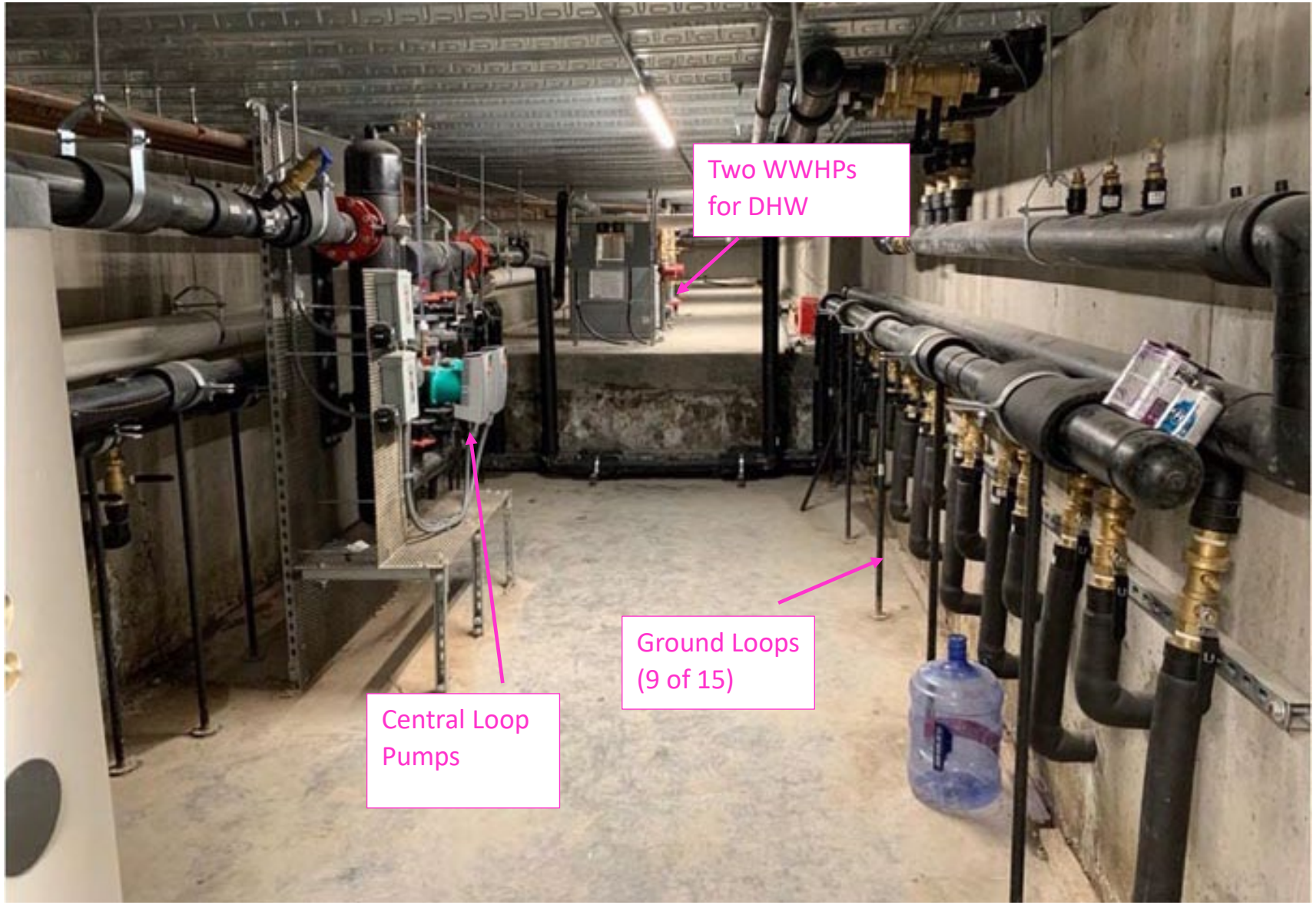
Hugh I. Henderson, Jr., P.E.

Owahgena Consulting Inc.

Zero Place Mixed Use Building

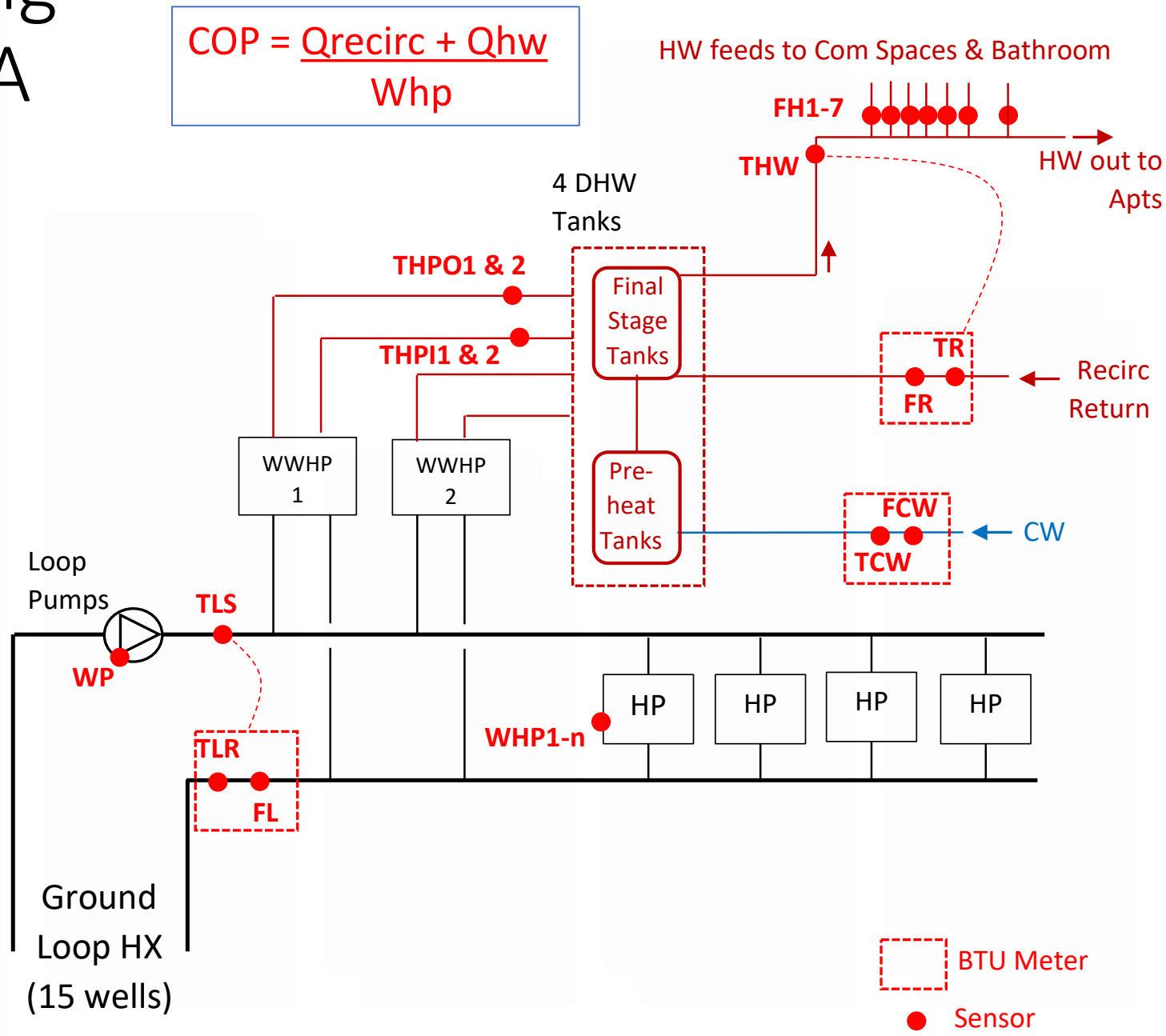
- Four story, 63,320 sq ft, retail on 1st floor, Apartments on floors 2-4
- 46 Apartments, 71 Bedrooms, 6 retail spaces
- Very efficient building envelope
- Ground source heat pumps for space conditioning **AND** water heating
  - 15 400-ft vertical bores
  - 64 WSHP heat pumps, mostly 1-ton HPs, 87 tons total
  - Two WWHPs for DHW, ~ 10 tons total
  - Variable speed loop pumps
  - Year-round heat extraction loads from DHW WWHPs made ground loop size smaller (because of smaller summertime heat rejection loads)

Basement Mechanical Room



Additional Monitoring Installed by NYSERDA Project

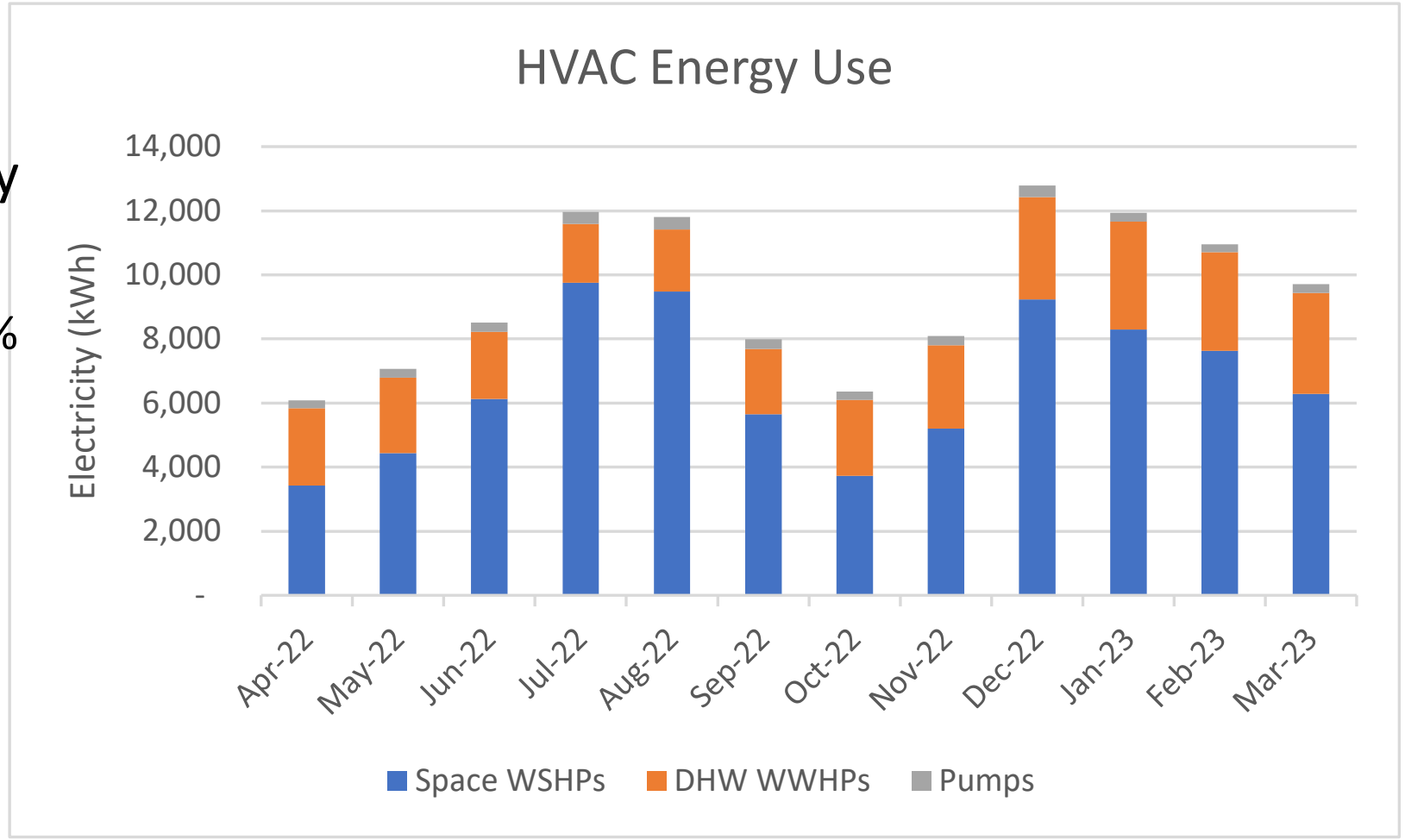
- Added BTU Meters to measure flows, temperatures, and energy use for:
  - Ground loop heat exchanger
  - DHW HW use
  - HW Recirculation loop
- Power use for all heat pumps and pumps
- Various other system temperatures
- Collecting 5-min and 1-min data since April 2022



Energy Use Results

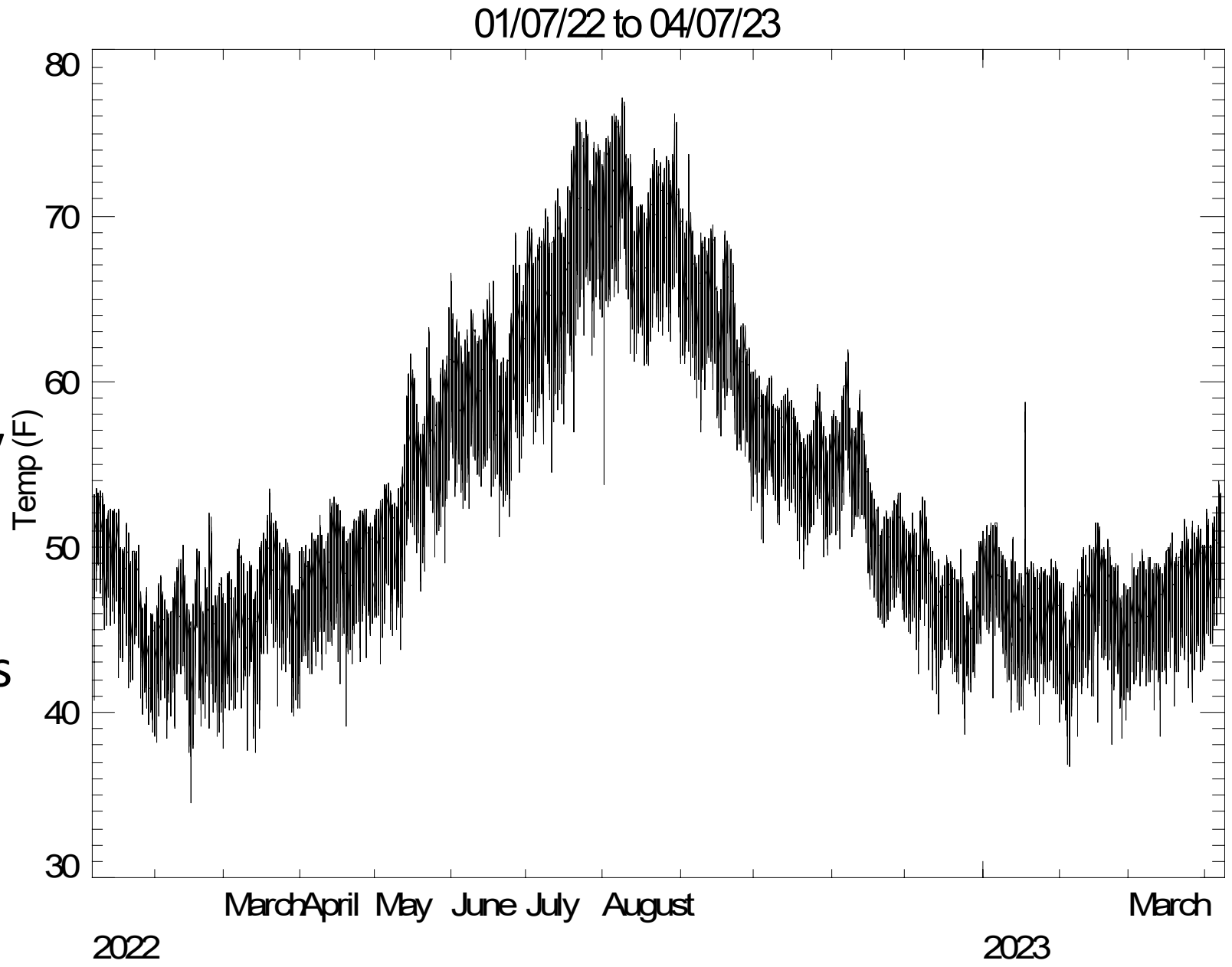
Baseline for New Construction (from NYSERDA BEEM)	
Space heating & DHW:	17,135 therms
Space Cooling:	22,175 kWh

- WSHP energy use
  - Monthly kWh and peak kW higher in winter
- Year-round WWHP Use
- Loop pumping power is only 2-4% of total heat pump power, 15 W/ton peak
  - Best practice is usually 8-10% and 60 W/ton for single family
- Total annual mech energy use is 113 MWh, or 1.8 kWh/sq-ft-yr
- Multifamily space htg & clg is 1.4 kWh/sq-ft-yr



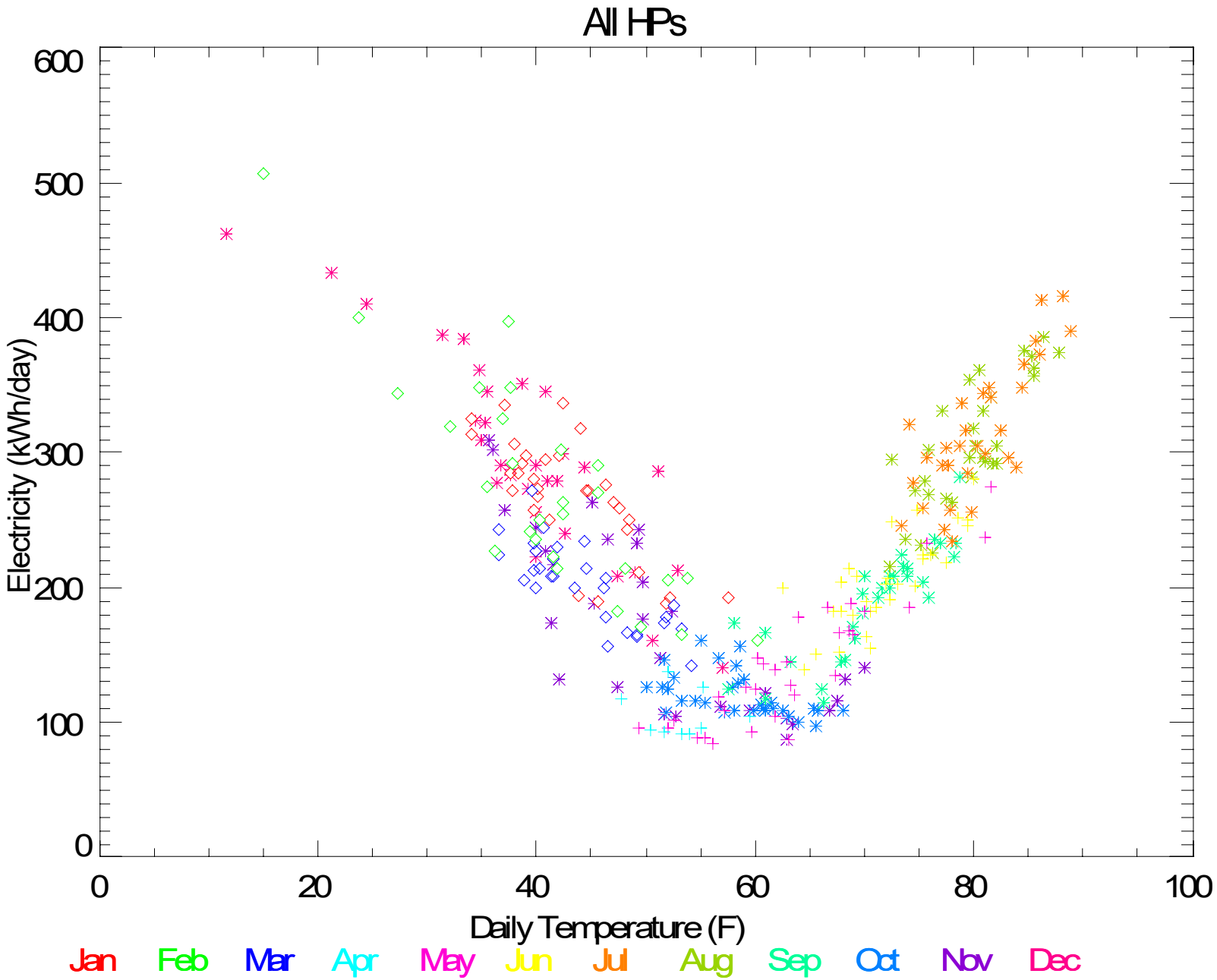
Ground Loop Supply Temps

- Winter loop temps rarely below 40°F
- Summer loop temps rarely above 75°F
- Loop started at near 50°F
- Modest loop temperatures for the 1st year



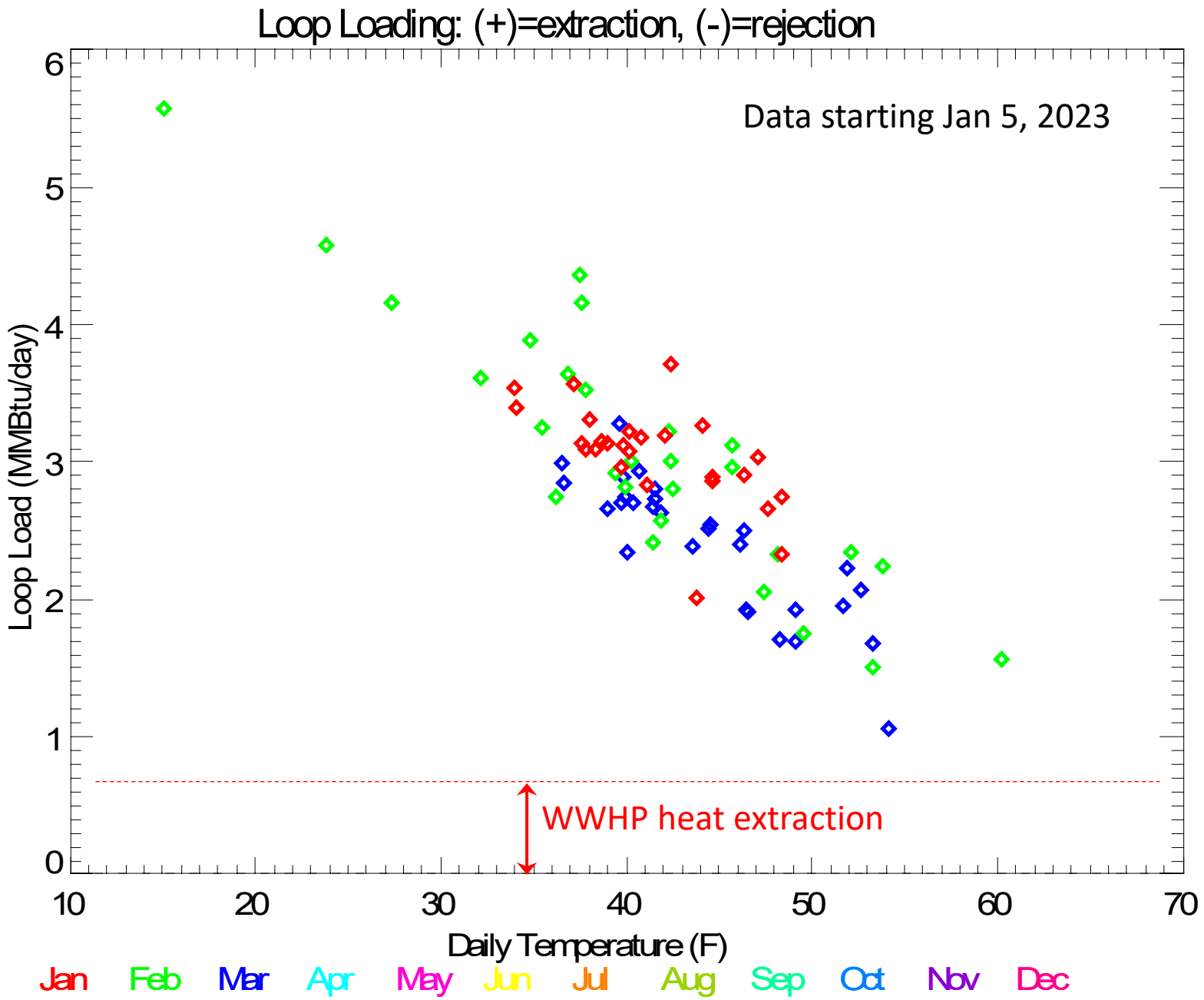
HP Electricity Use Trends

- Strong daily trends with outdoor Temperature
- Energy use higher late in season because of loop temps
  - August > July
  - February > December
- Coldest days have highest use
- Balance Pt near 55-65°F…but lots of simultaneous H & C



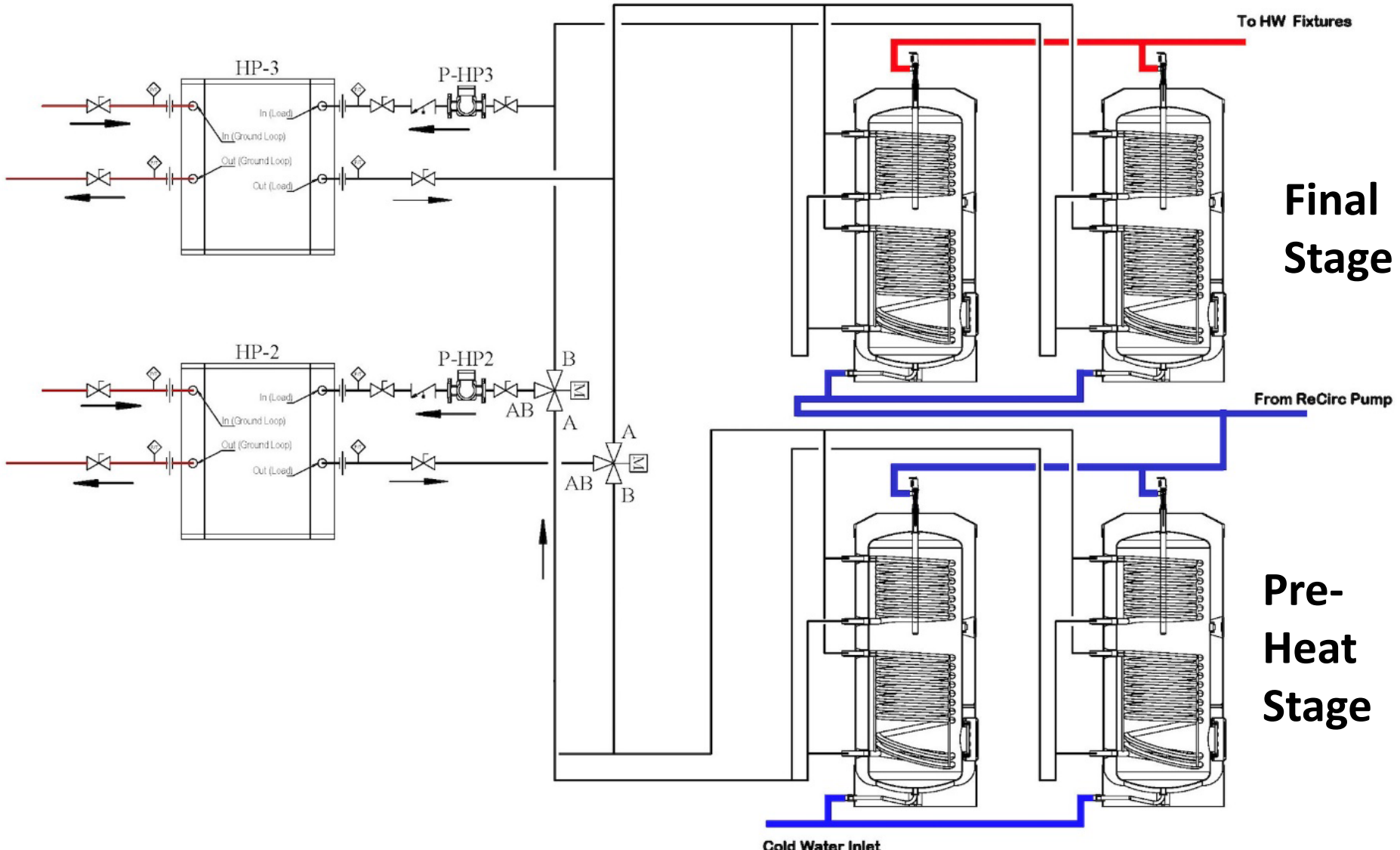
Ground Loop Heat Transfer

- Implied balance point is near 60-65°F
- Avg WWHP heat extraction is ~0.7 MMBtu/day
  - the space heating / cooling balance point is near 55°F
- Peak daily GHX loop load is 5.7 MMBtu/day at 15°F avg
- Implied overall heating COP is 3.5 for WSHPs & WWHPs combined



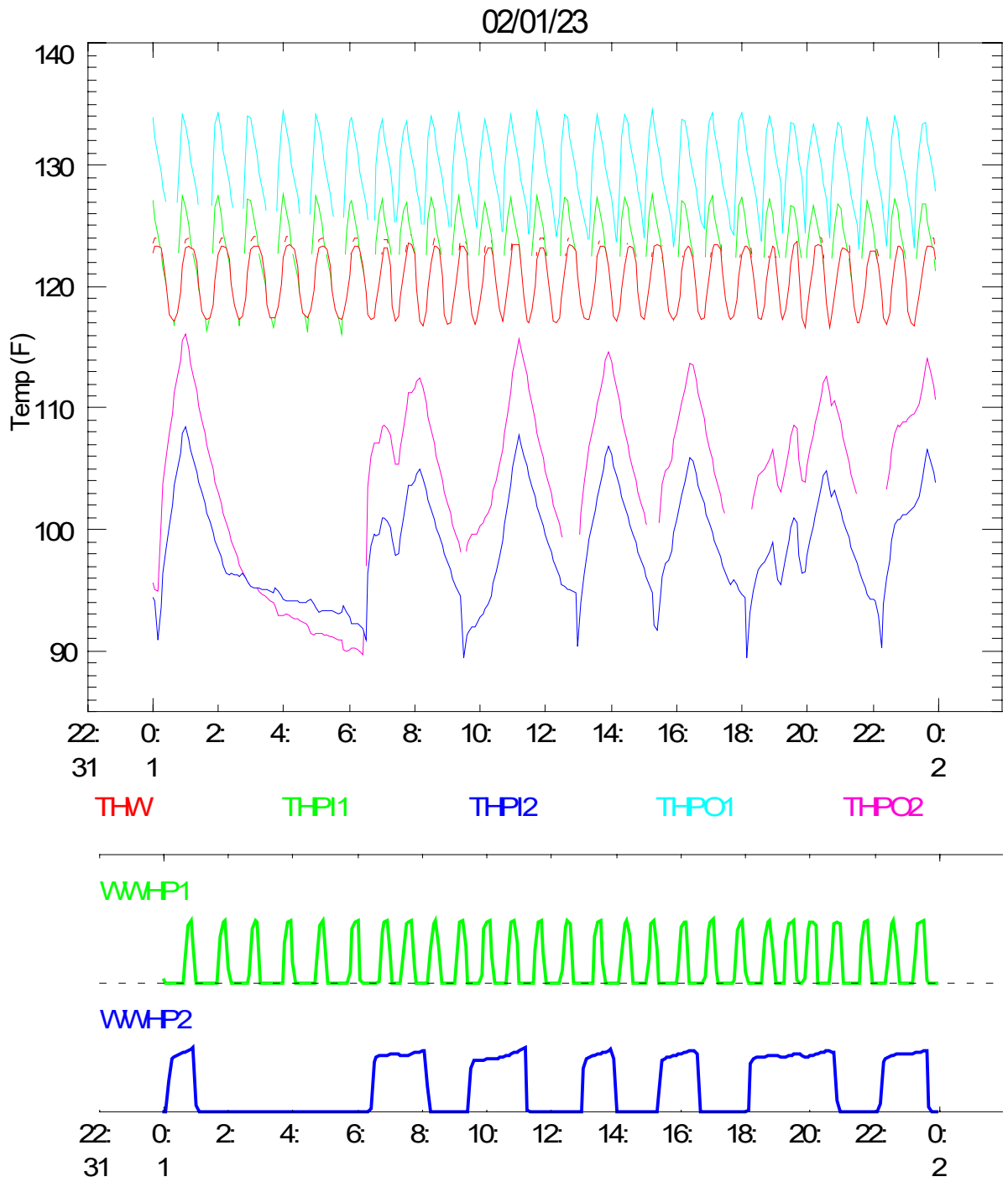
WWHPs and Storage Tanks

- Two WWHPs
  - One serves final-stage tank
  - One HP serves pre-heat tank
- Tanks operate at different temperatures……. SO heat pump COPs are different



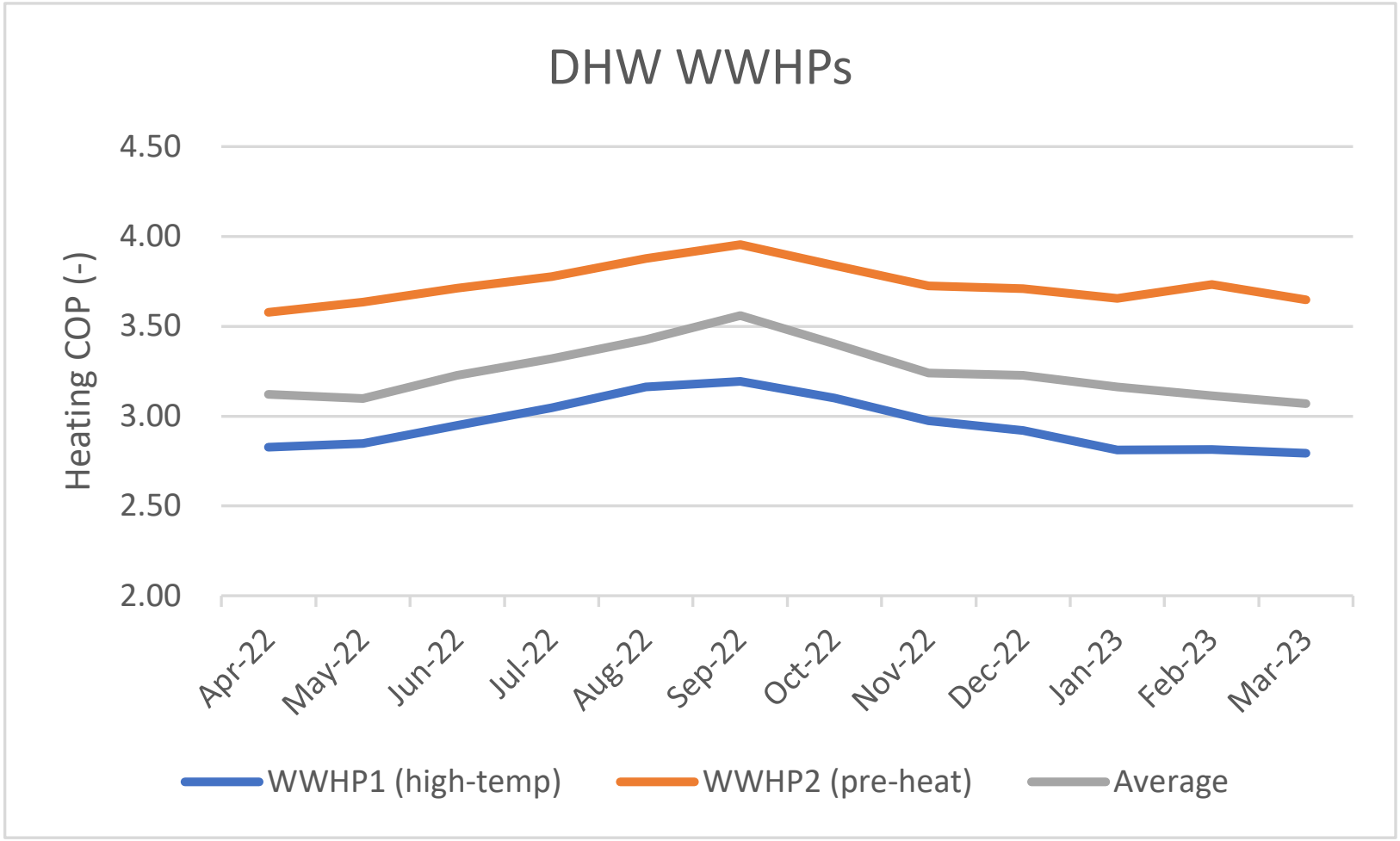
WWHP Operation

- WWHP2 serves pre-heat
  - Cycles less often
  - Inlet is around 90-105°F
- WWHP1 serves final stage
  - Cycles frequently
  - Inlet is 120°F



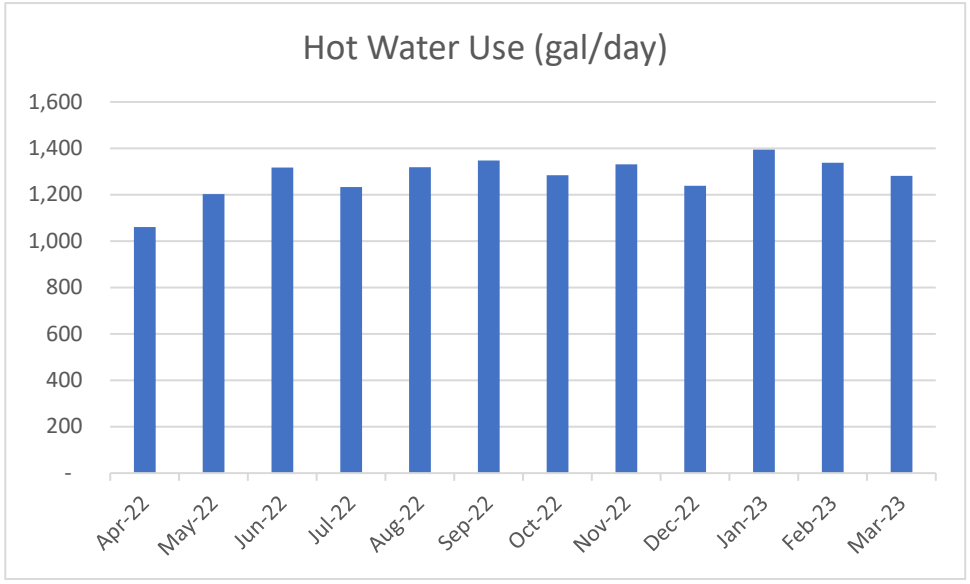
DHW Heat Pumps

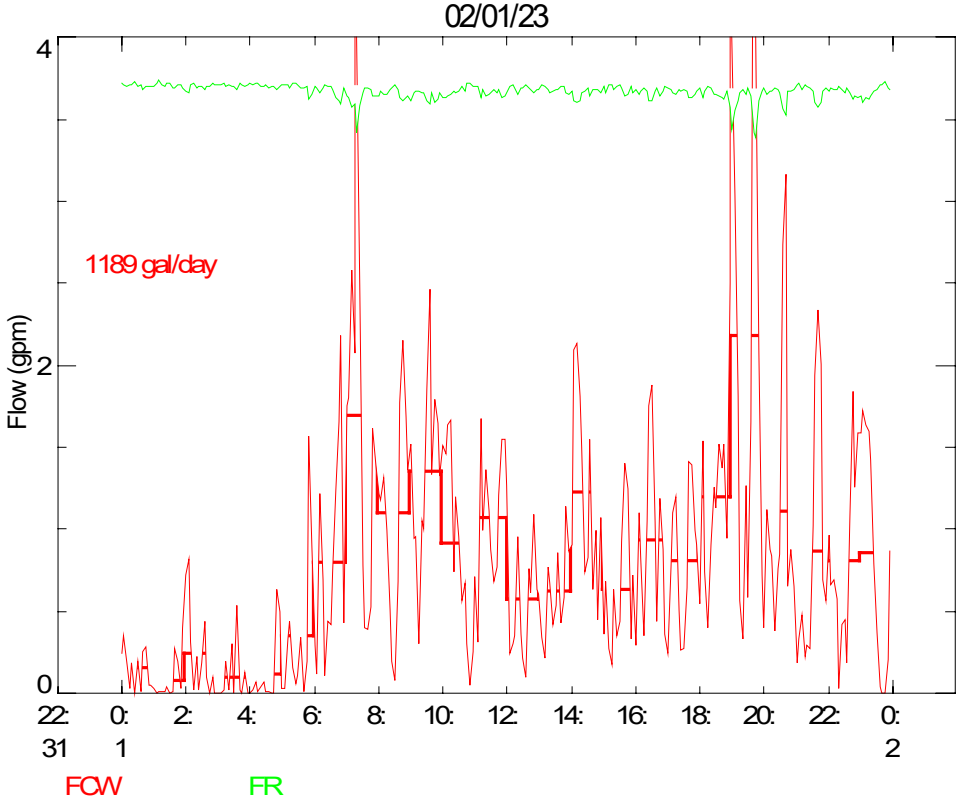
- Heating COPs
  - high-temp is 3.0
  - Pre-heat is 3.7
  - Average is 3.3
- COPs are higher in the summer than in the winter
- Annual average is 3.25



DHW Use Trends

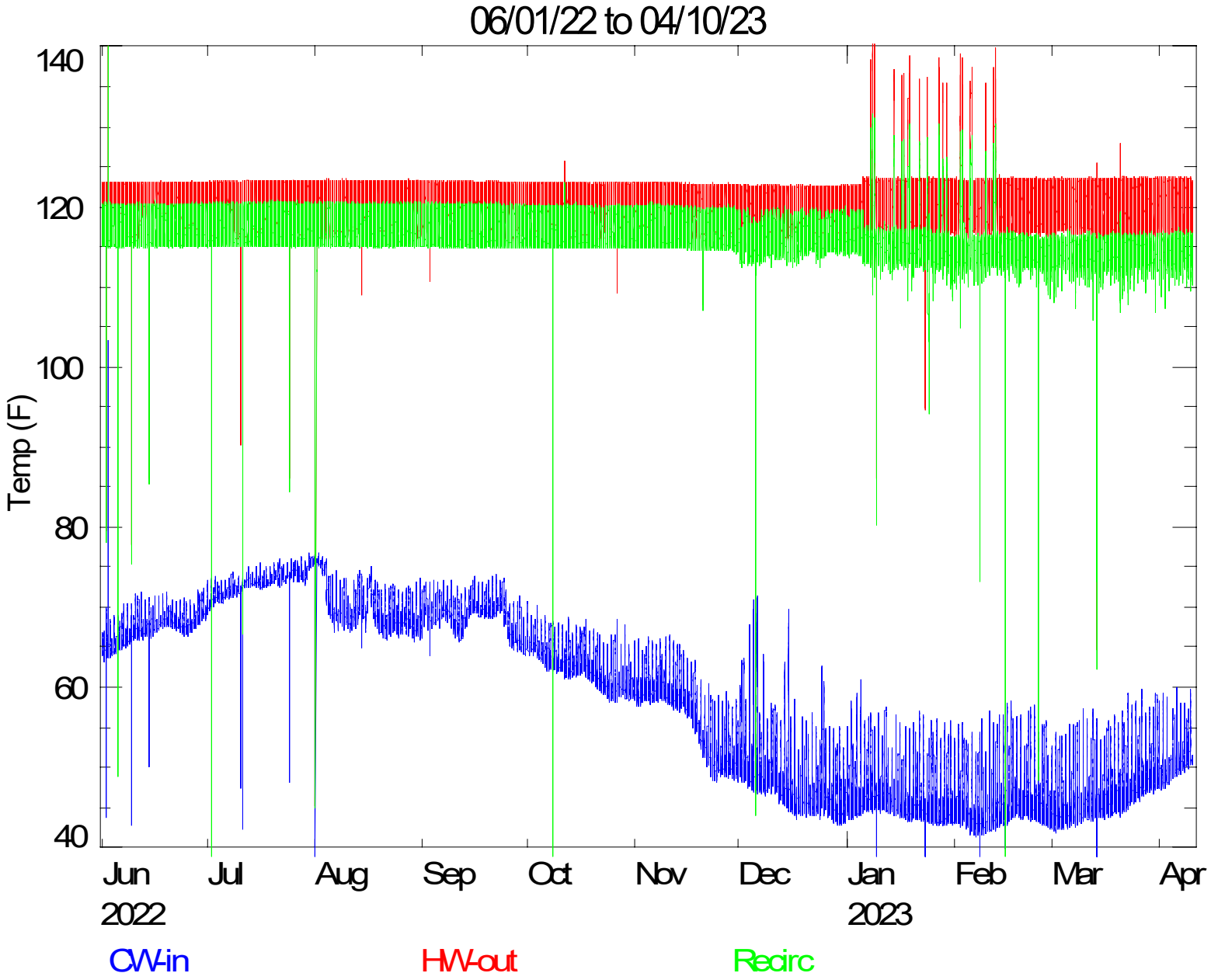
- HW water use 1200-1300 gal/day, or 17-18 gal per bedroom per day (near TRM)
- Daily profile shows peaks in morning and afternoon, maximum observed 1-minute flow is 9 gpm. 99.9% flow is 6.2 gpm
  - Current plumbing codes assume much-much larger flows (and therefore piping sizes)
  - Plumbing codes are being modified based on these types of measurements
- Measured recirculation losses are 30% of total heat output
  - Increases load on final-stage tank
  - Better designs can reduce these losses
  - OR… lower flow rates





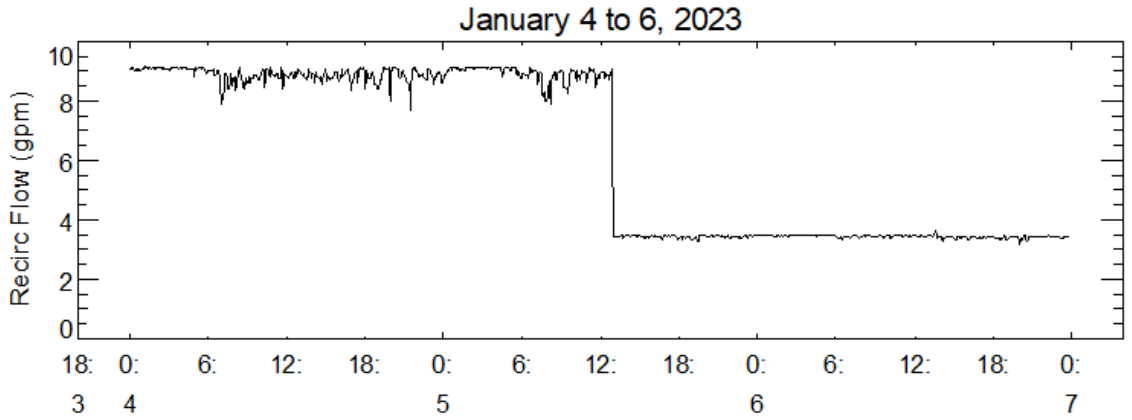
DHW Temperatures

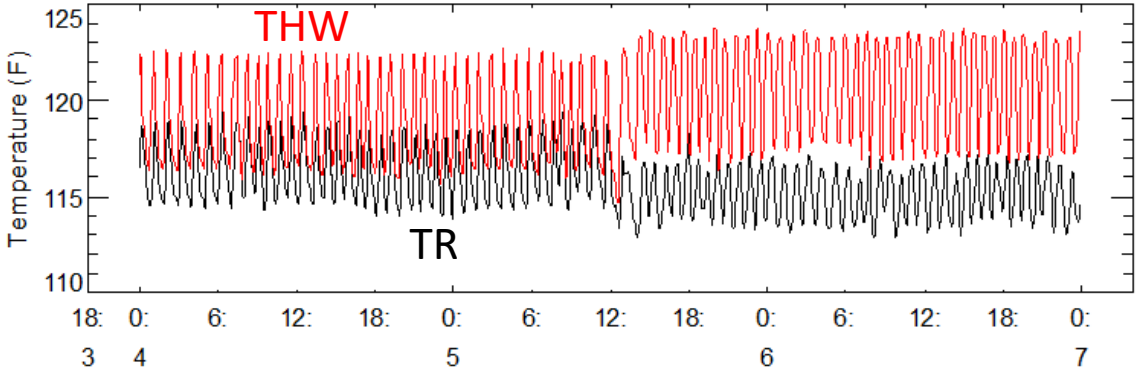
- Delivered HW 120-125°F
- City Water ranges from 40-45°F in winter to 70°F in summer
- Recirculation changes in January 2023

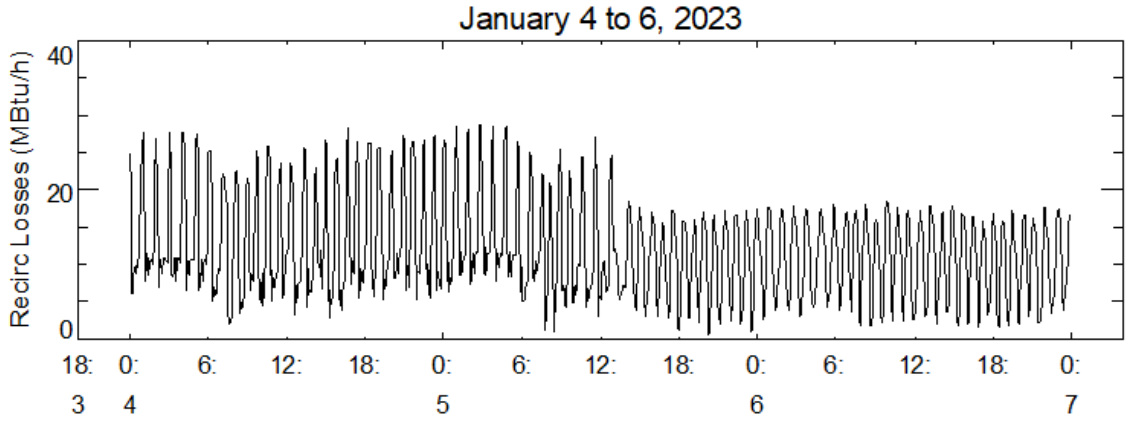


Reducing Recirculation Losses

- Decreased recirculation flow from 9 to 4 gpm on Jan 5, 2023
  - Reduced tank mixing increased HW out (THW) and decreased recirculation return (TR)
  - Thermal losses dropped by more than 20%
  - Savings not just from lower thermal losses from piping – but from less disruption to in thermocline in final tank



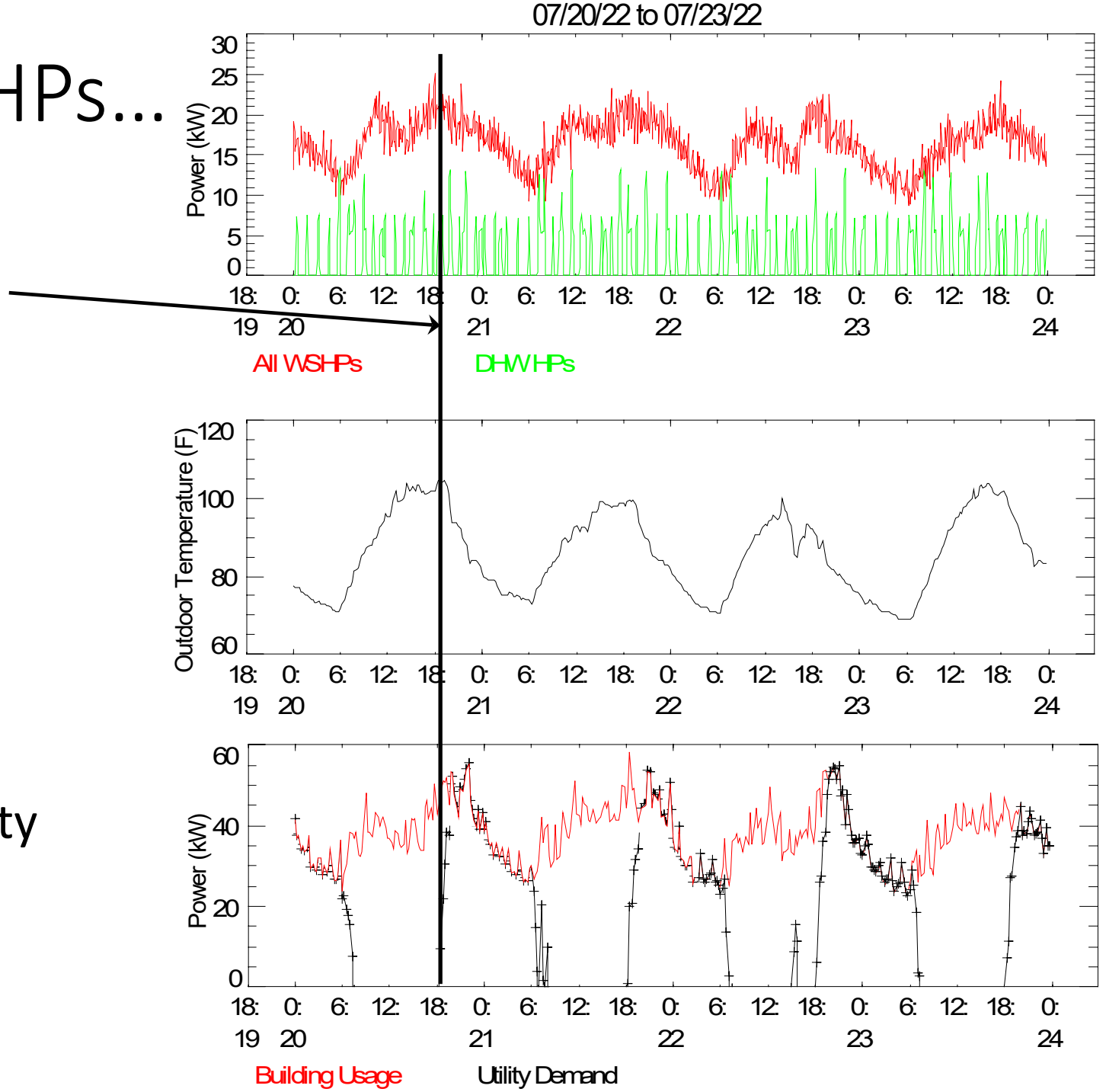




Combining Solar and HPs…

A Hot Summer Day

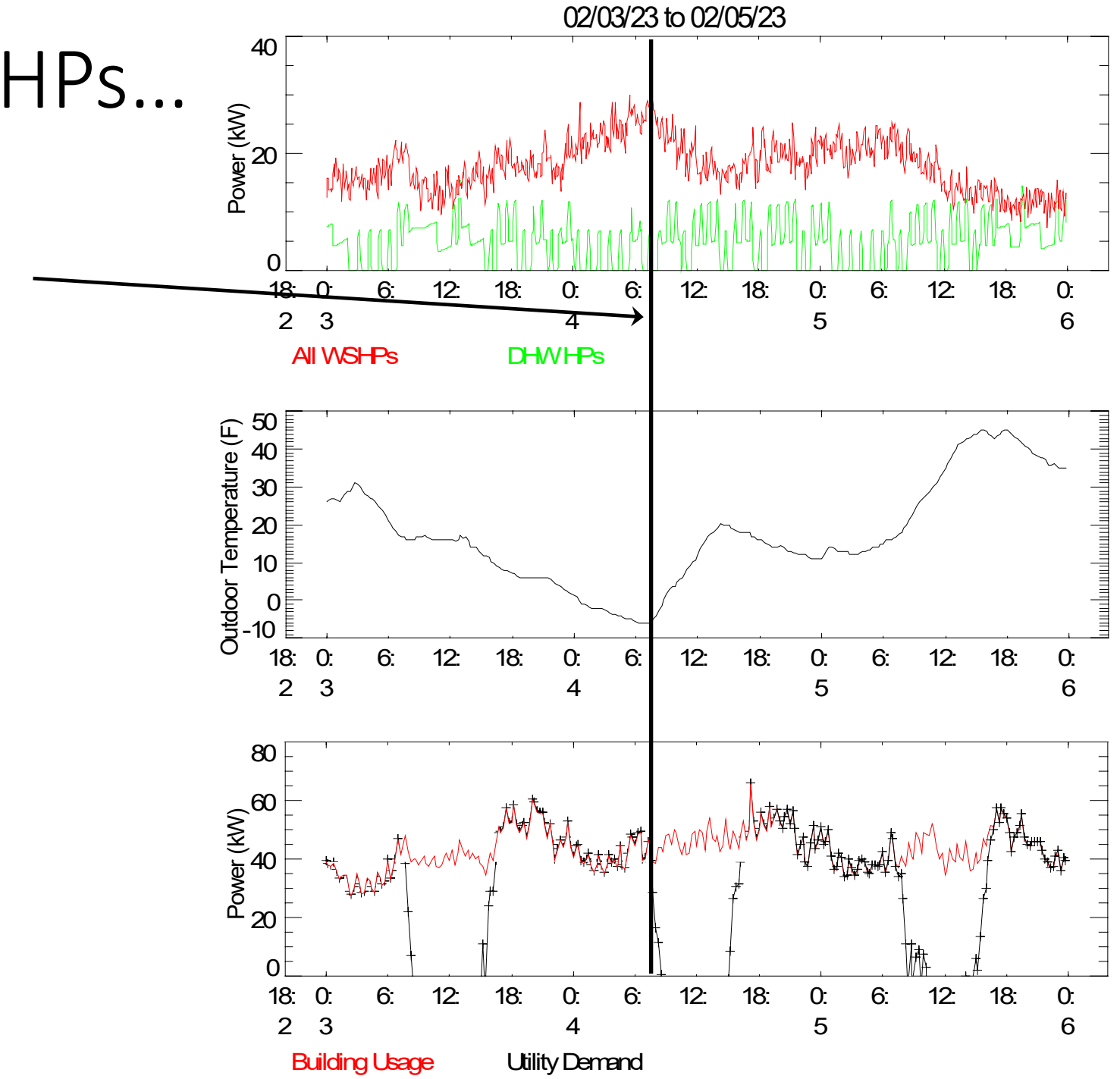
- HP Peak on July 20 at 6-7 pm (hourly avg)
  - Outdoor Temp = ~90°F
  - All WSHPs = 18.0 kW
  - DHW HPs = 3.0 kW
  - Loop Pumps = 0.6 kW
  - Building = 44.3 kW
  - Solar = 29.4 kW
- The building utility demand peaks later at 7-8 pm
- Solar PV does not significantly change the building's peak utility demand



Combining Solar and HPs…

Coldest Day

- HP Peak on Feb 4 at 7-8 am (hourly avg)
  - Outdoor Temp = -6°F
  - All WSHPs = 28.4 kW
  - DHW HPs = 1.9 kW
  - Loop Pumps = 0.4 kW
  - Building = 42.5 kW
  - Solar = 3.6 kW
- The building utility demand peaks later in the evening when people come home
- Solar has less impact in the winter



M&V Summary

- Ground loop is working well, temperatures ranging from 40°F to 75°F across the year
- Heat pump system (space & DHW) energy use is using 1.8 kWh per sq ft per year; pumping energy is only 2-4% of heat pump energy
- Adding in DHW for multifamily does not increase the size of the ground loop heat exchanger…year-round heat extraction decreases summer peaks.
- WWHPs used for DHW meet HW load of 1300 gal/day, with an overall heating COP of 3.25 (better than air source heat pump options)
- 30% of DHW load is recirculation losses, initial recirc flow reduction has reduced significantly
  - Current codes drive oversized DHW piping….but code changes are coming (IAPMO)