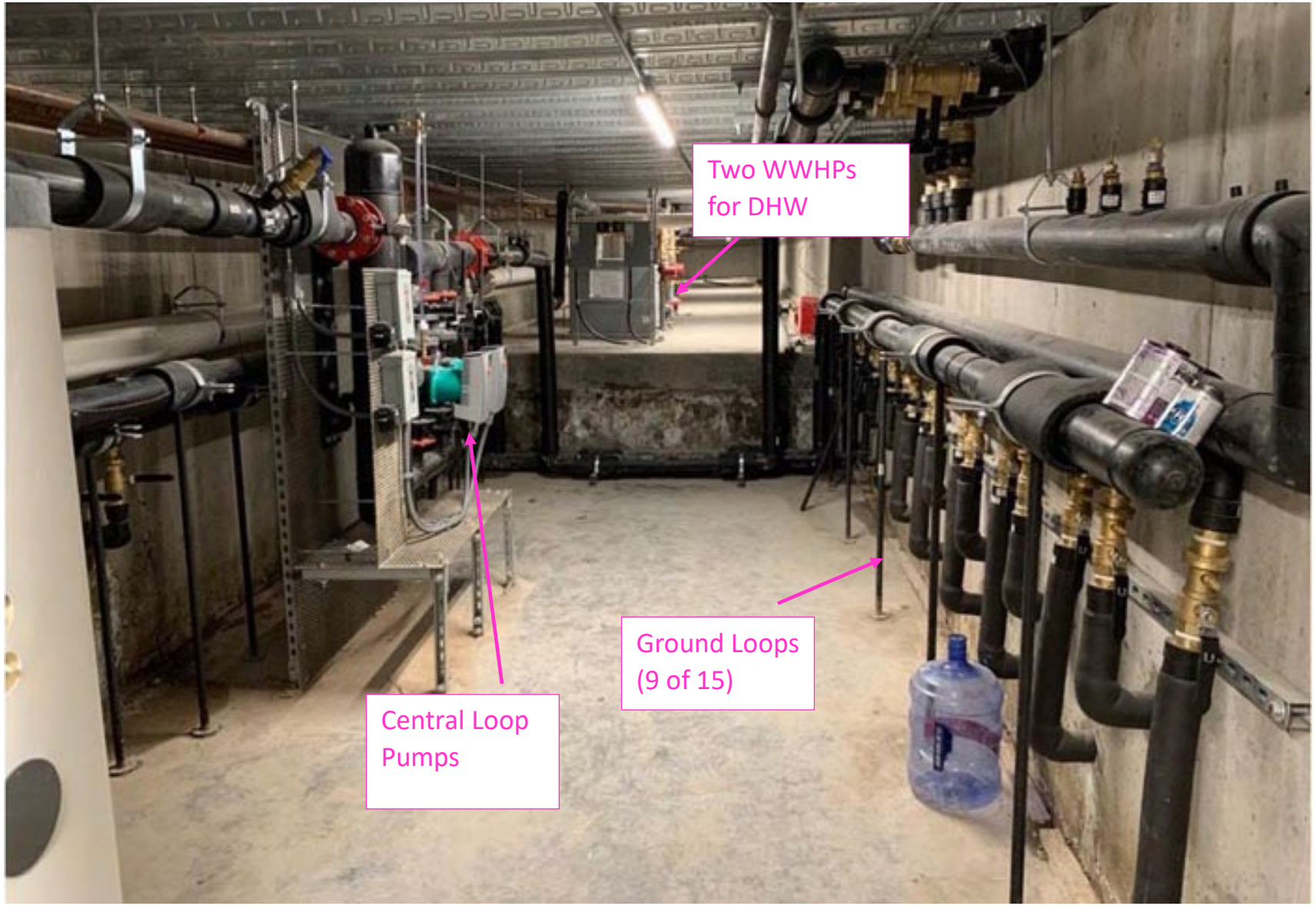
Monitoring Results from Zero Place: A GSHP Multifamily Mixed-Use Building

Speakers: **Hugh Henderson / *OCI***

Jens Ponikau / *Buffalo Geothermal & NY-GEO Board*

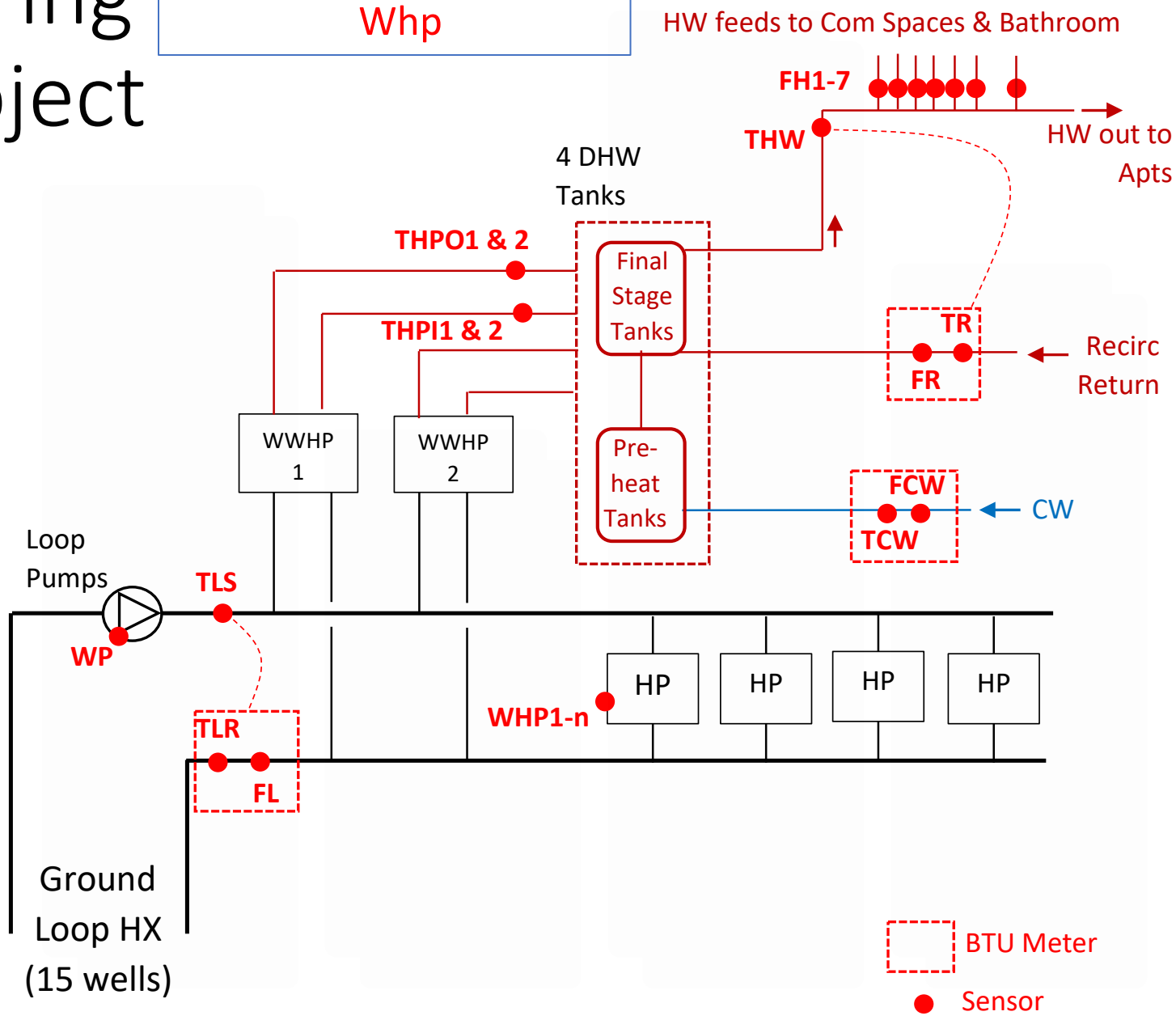
Basement Mechanical Room



Additional Monitoring Installed by for Project

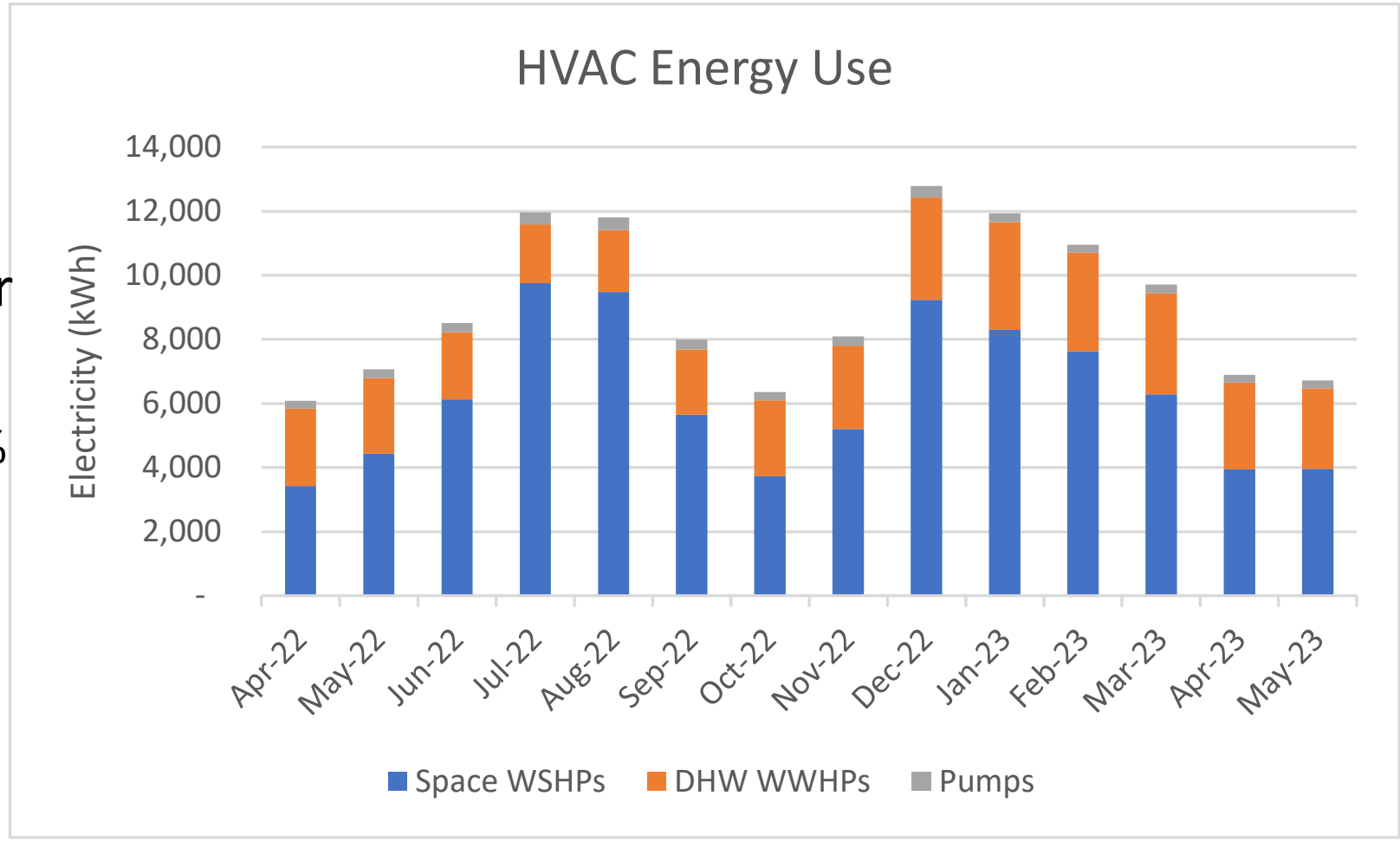
$$COP_{DHW} = \frac{Qrecirc + Qhw}{Whp}$$

- With NYSERDA funding
- 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

- WSHP energy use
  - Monthly kWh and peak kW higher in winter
- Year-round WWHP Use
- Annual loop pumping power is 3.2% of total heat pump power, 18 W/ton peak
  - Best practice is usually 8-10% and 60 W/ton for single family
- Total annual mech energy use is 114 MWh, or 1.8 kWh/sq-ft-yr
- Multifamily space htg & clg is 1.4 kWh/sq-ft-yr



HVAC Loads – Compared to Passive House

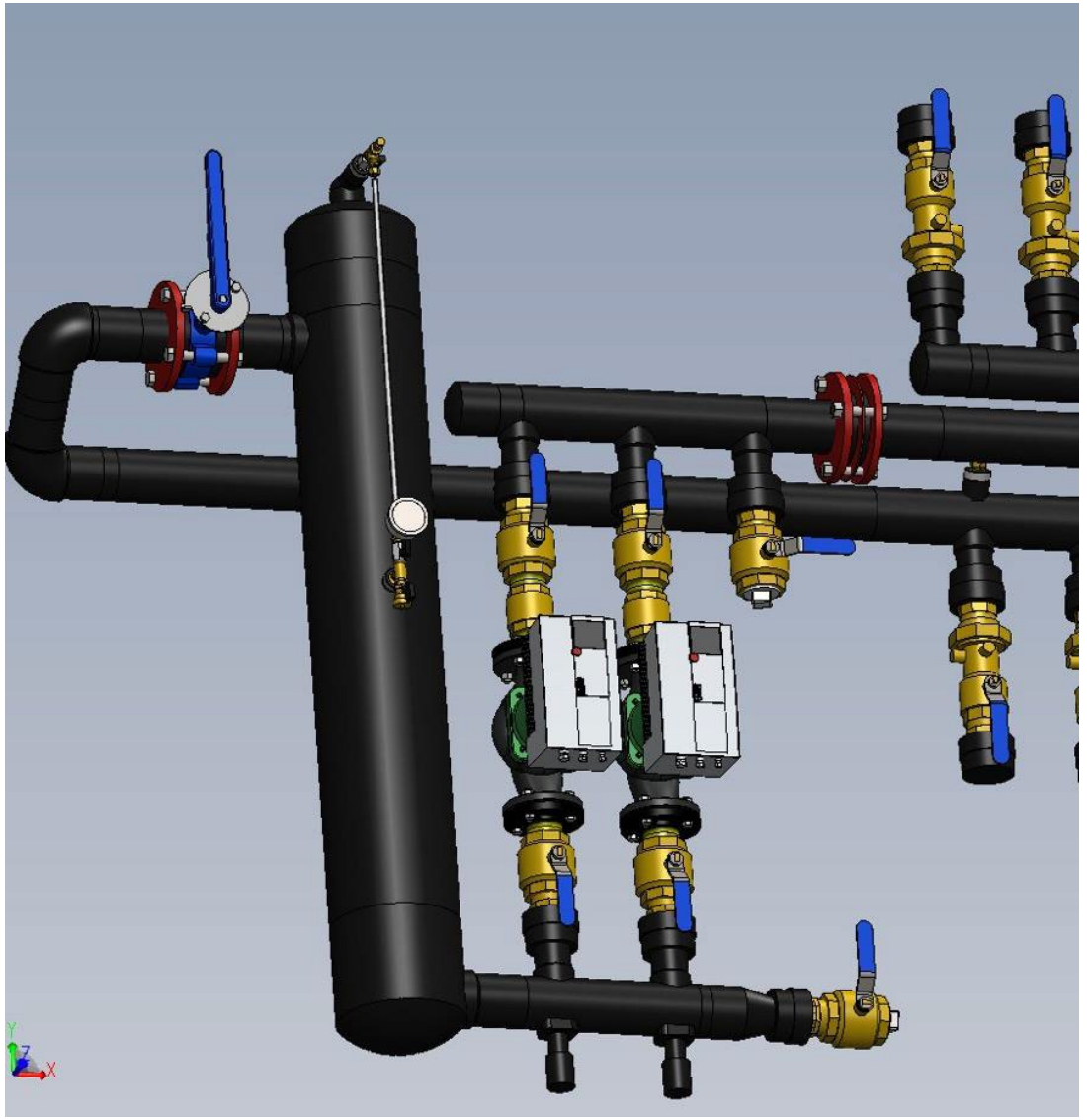
- Reasonably good agreement for HVAC loads
- Multifamily portion of building, energy is 17 kBtu per sq ft per year

	PHIUS Metrics	Measured Values	Difference		Assumed COP(-)	Measured MF Use (kWh/yr)
Total Heating (kBtu/sq ft-yr)	6.2	7.5	21%		3.3	37,251
Total Cooling (kBtu/sq ft-yr)	6.5	8.0	23%		3.6	36,383

Note: Multifamily floor area is 55,780 sq ft

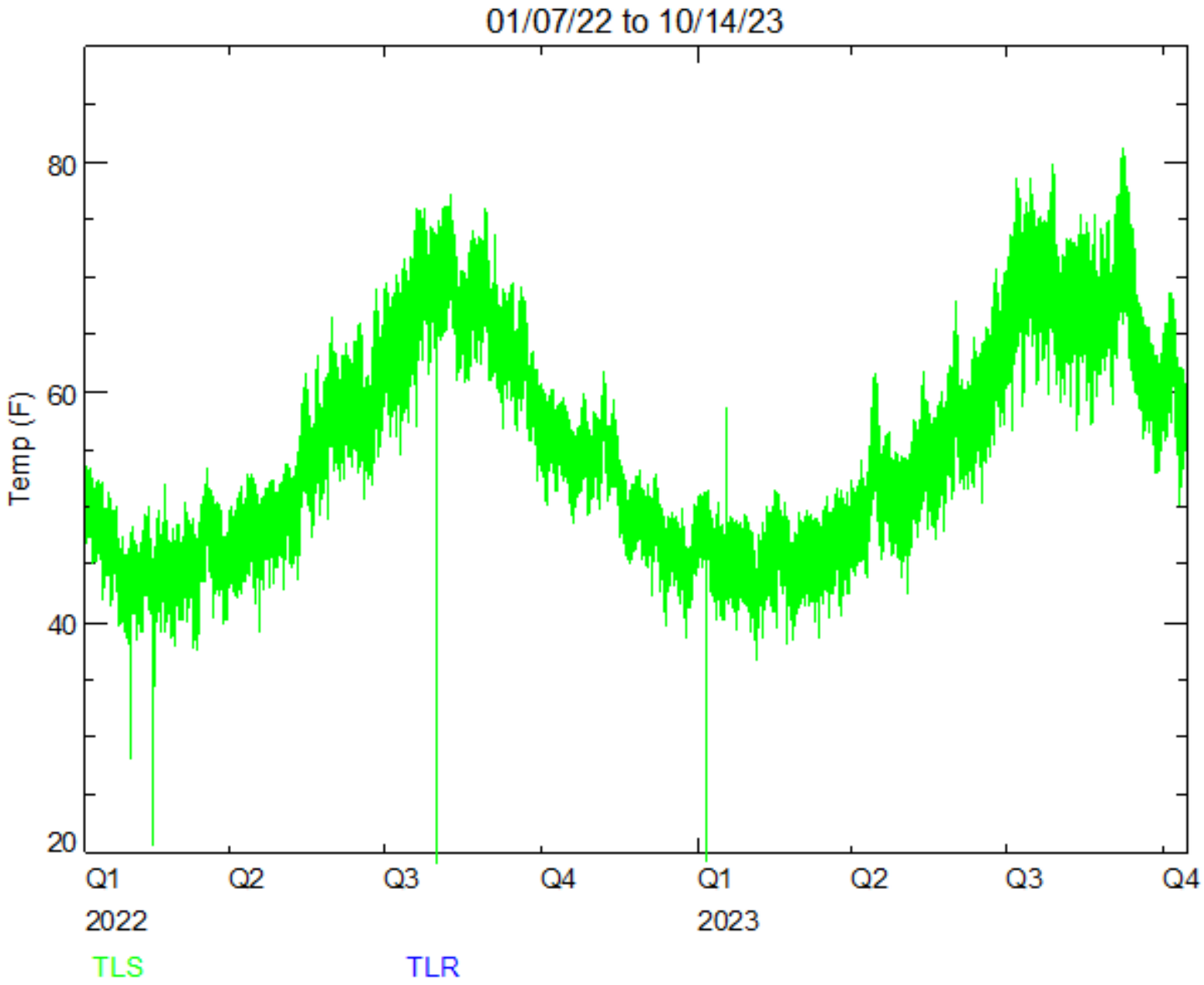
Why is Pumping Energy So Low?

- Pumping energy is extraordinarily low (3% of HPs)
- Loop fluid is methanol
- Variable-speed pumps with “sensorless” control
  - Internal controls maintain pressure across pump (not across the HPs)
  - Pressure control with some “reset”
    - 100% pressure at 100% flow
    - 50% pressure at 0% flow
- No “extra” components to increase pressure requirements
  - No circuit setters, flow limiters, etc. to increase ΔP
  - Use ball valves at HPs to balance (remove handles after balancing)



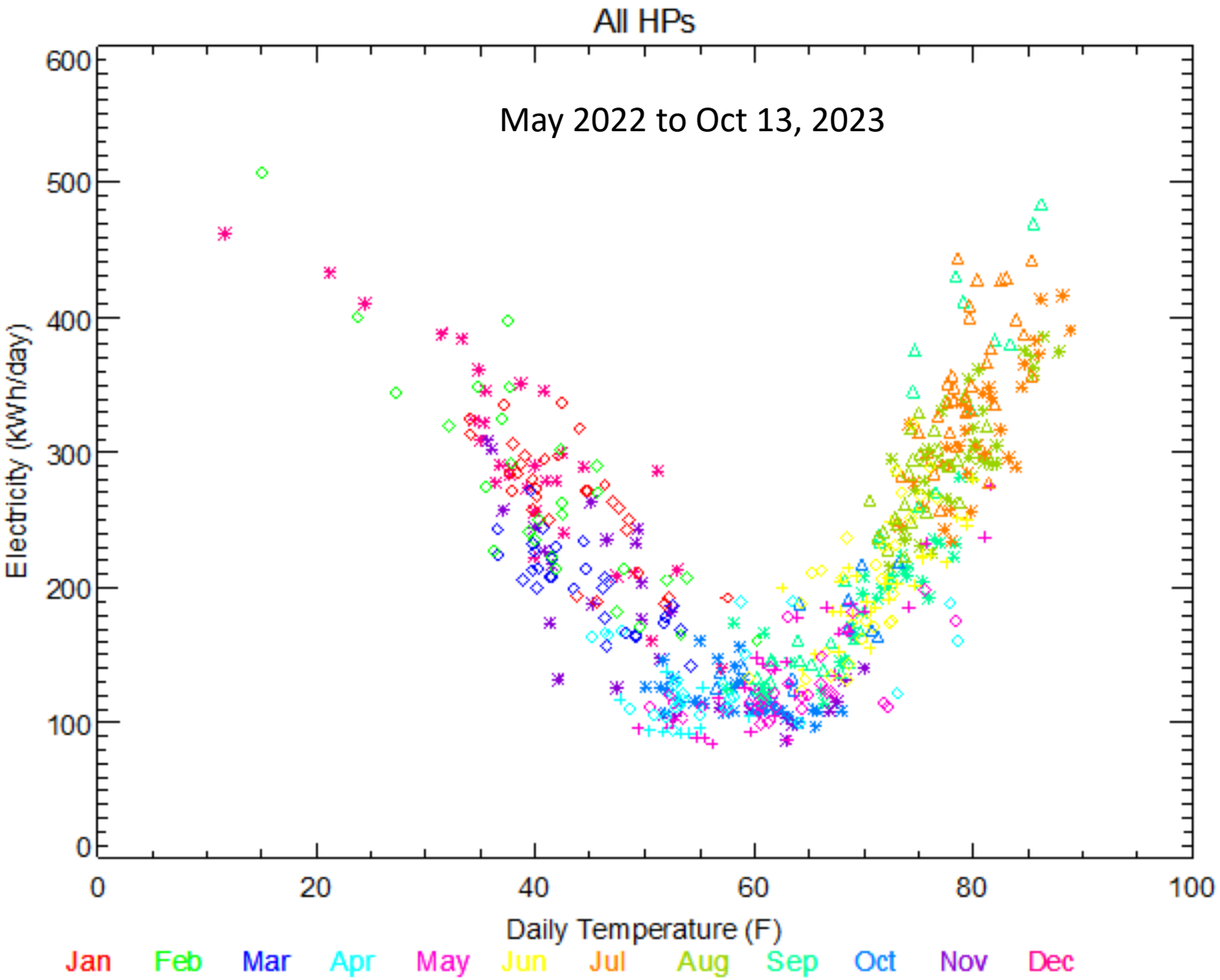
Ground Loop Supply Temps

- Winter loop temps rarely below 40°F
- Summer loop temps rarely above 75°F
- Loop started at near 50°F
  - Expected far-field temp
- Modest loop temperatures for the 1st year
- 2nd summer was warmer



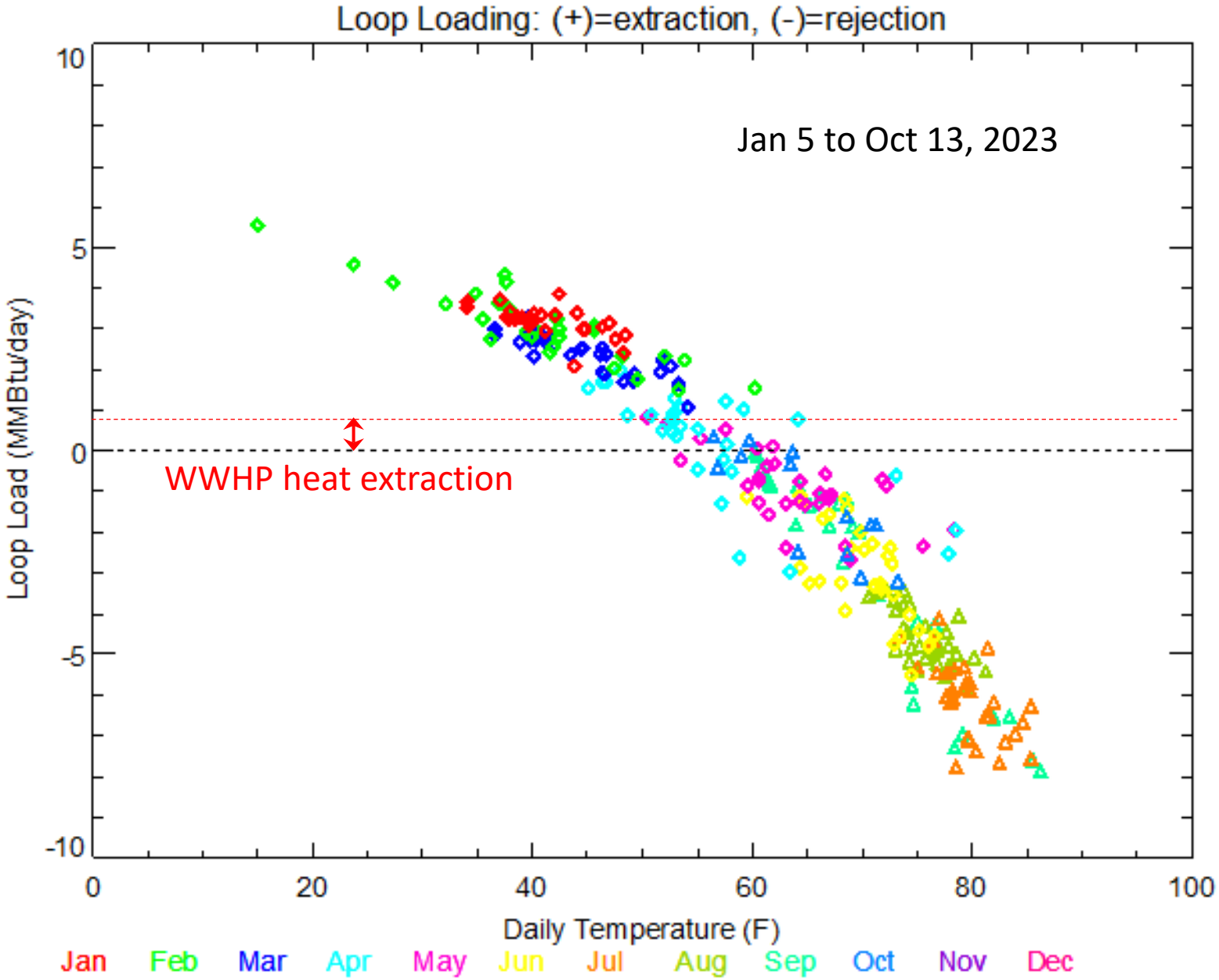
HP Electricity Use Trends

- Strong daily trends with outdoor Temperature
- Energy use higher late in season because of loop temps
  - August > July
  - February > December
- Coldest days have slightly higher use
- Balance Pt near 55-65°F…but lots of simultaneous H & C down below 40°F



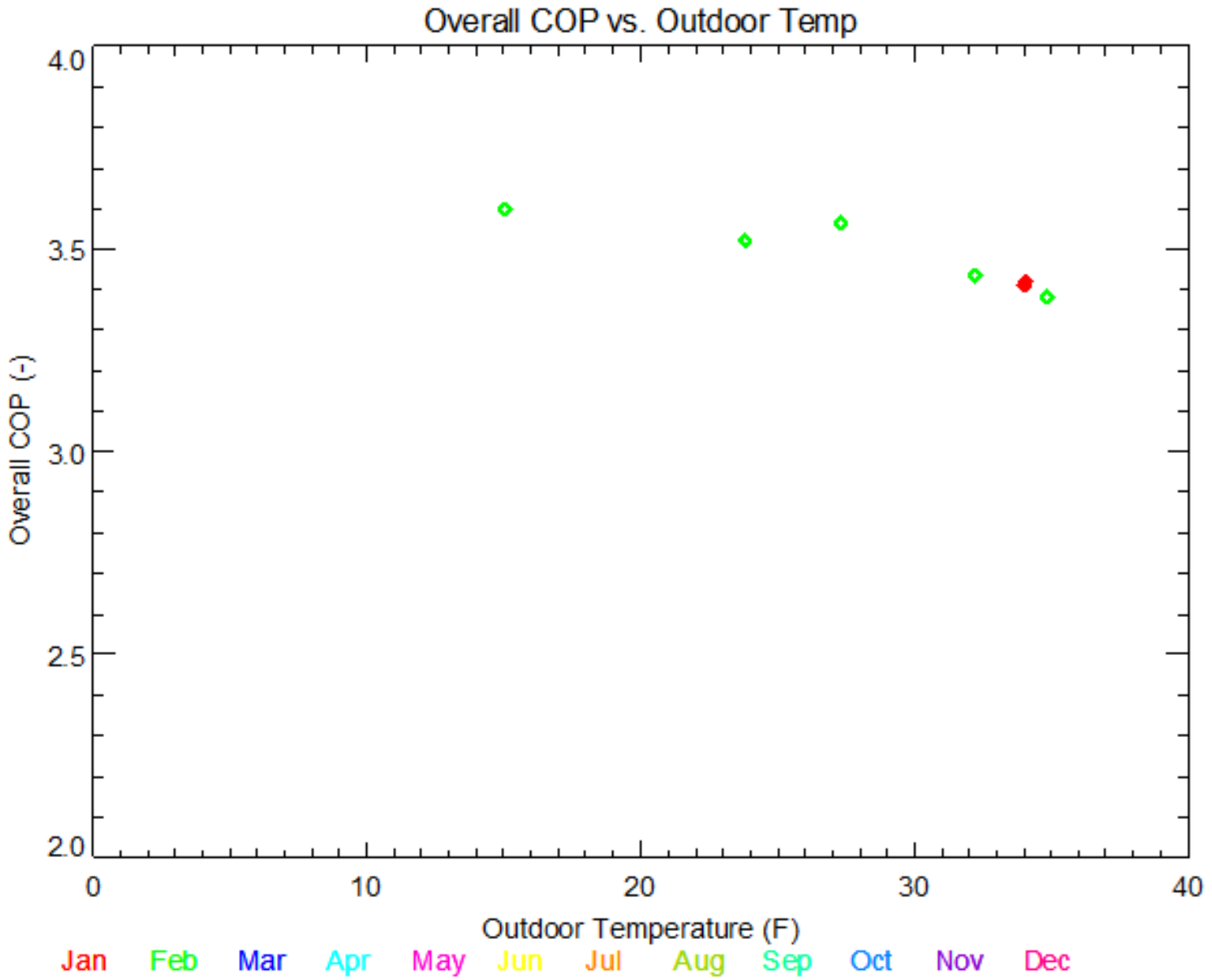
Ground Loop Heat Transfer

- 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
  - 5.7 MMBtu/day in Winter
  - 8 MMBtu/day in Summer



Implied COP

- Can calculate Overall COP from all HP power and loop heat
- Calculation only works when all HPs are in Heating
  - So only show data below 35°F
- Even on the coldest day the combined WSHP and WWHP COP is 3.6



DHW Performance

Both GSHP DHW Related

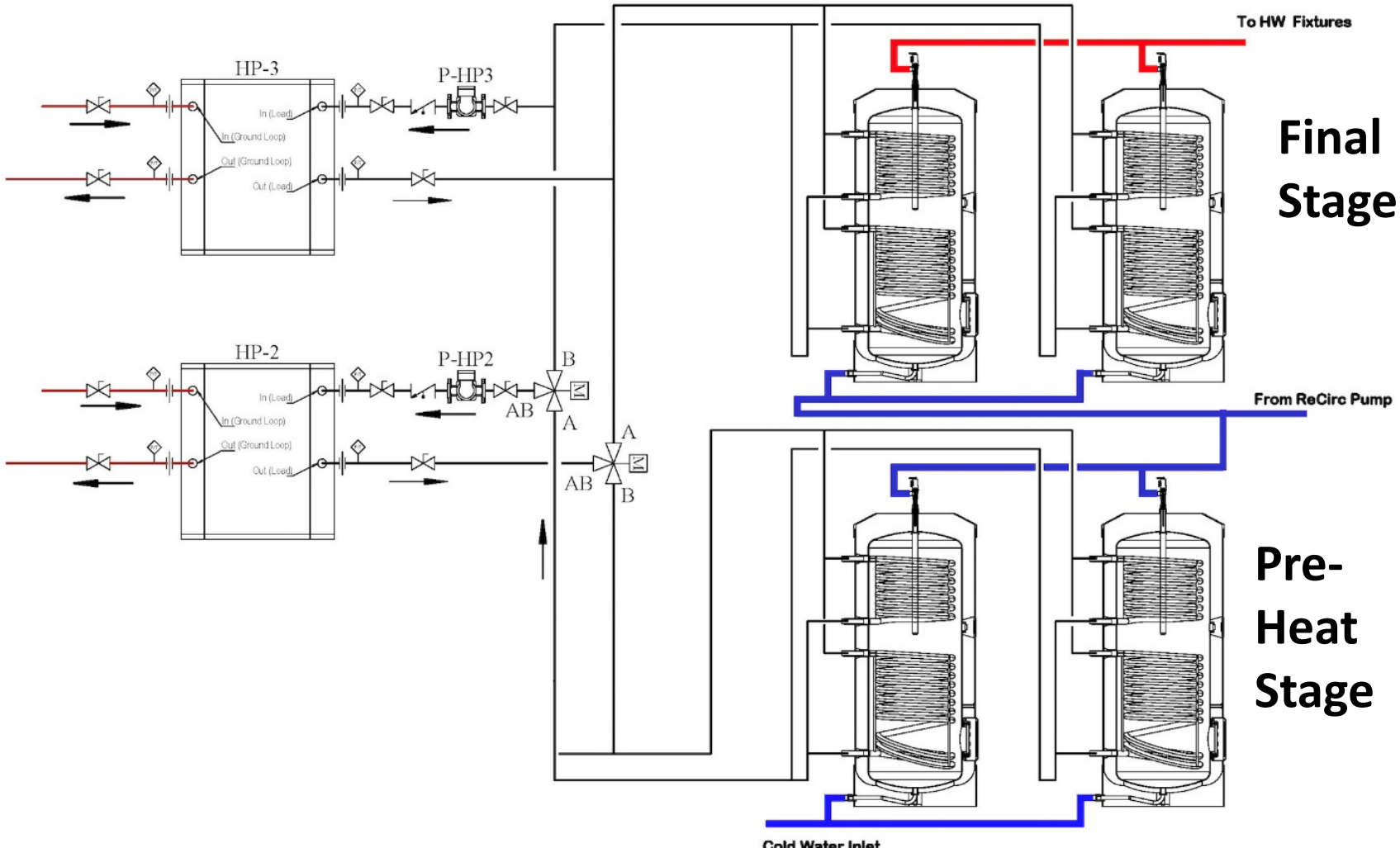
and

General DHW

WWHPs and Storage Tanks

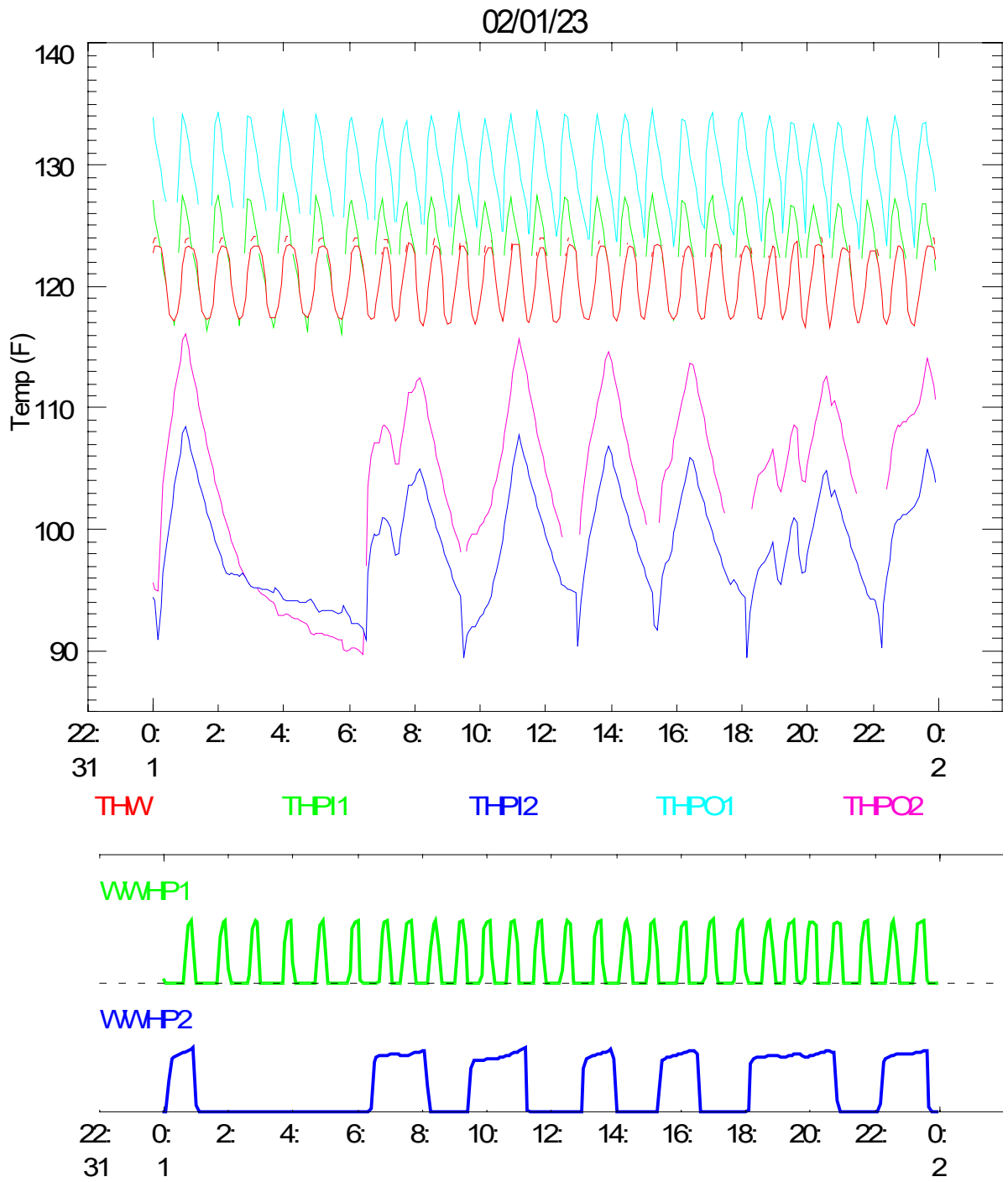
Designer: **Adding DHW HPs to ground loop was FREE!**
Reduced loop cost = WWHPs & tanks

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



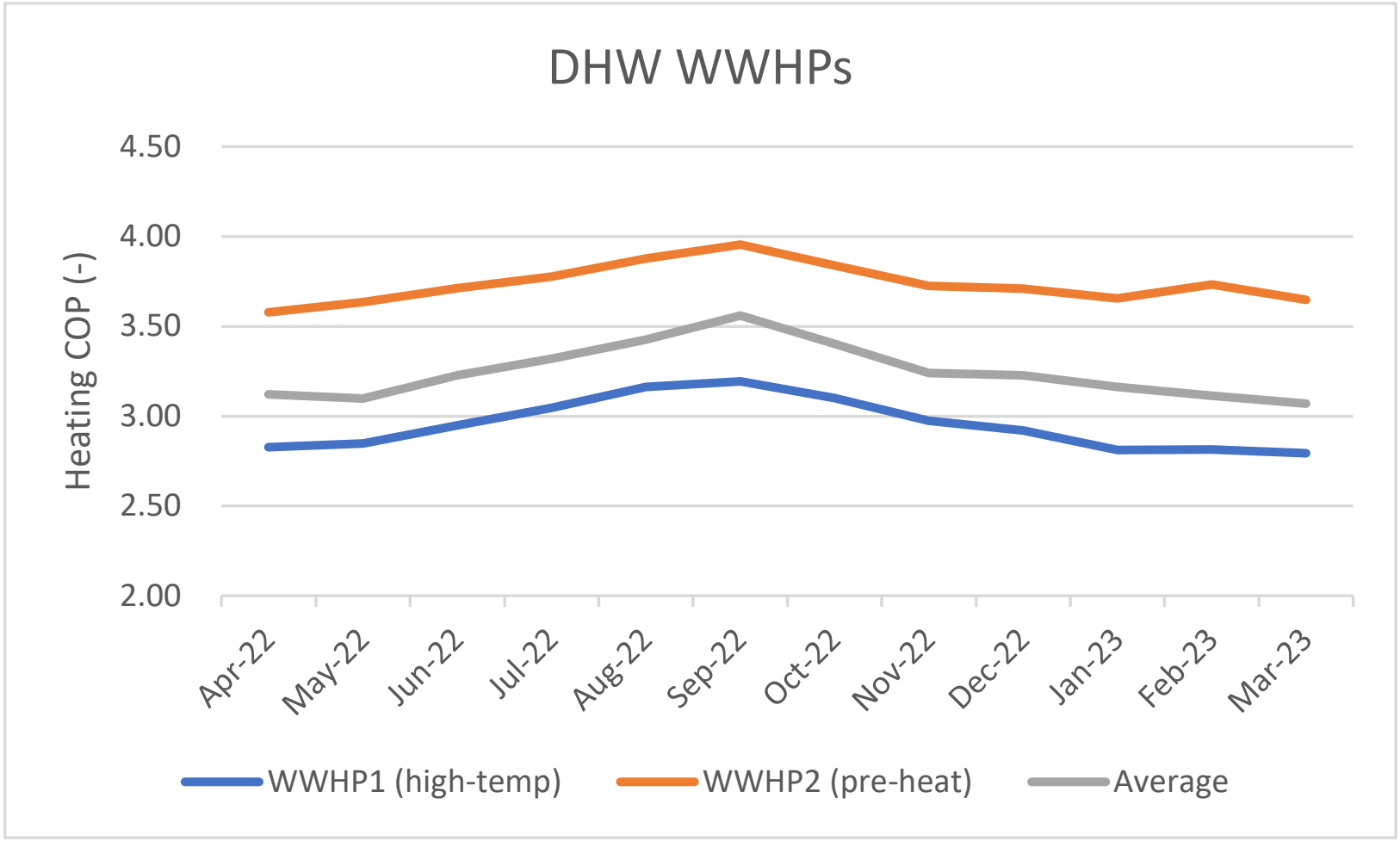
WWHP Operation

- 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

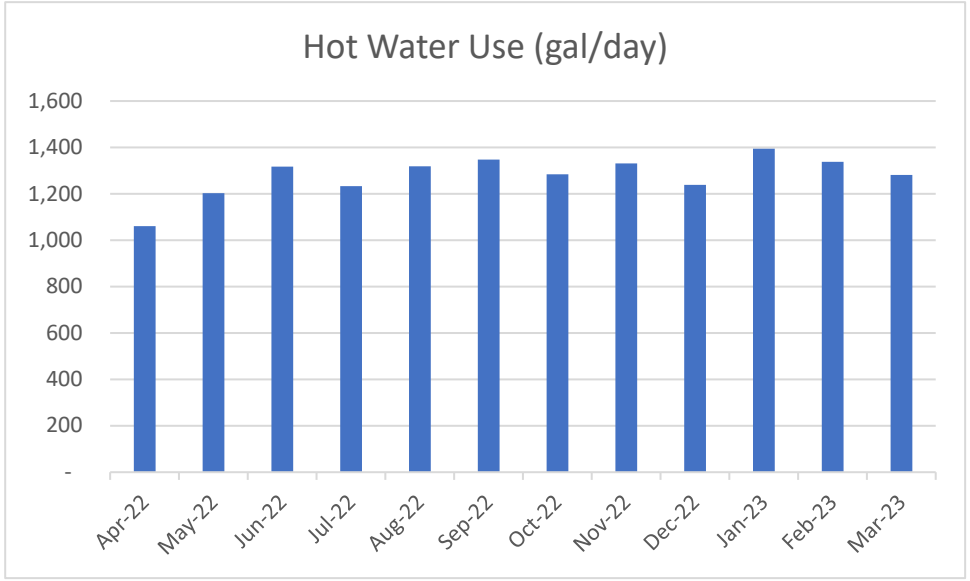
- Heating COPs
  - high-temp is 3.0
  - Pre-heat is 3.7
- COPs are higher in the summer than in the winter
- Annual average COP is 3.3

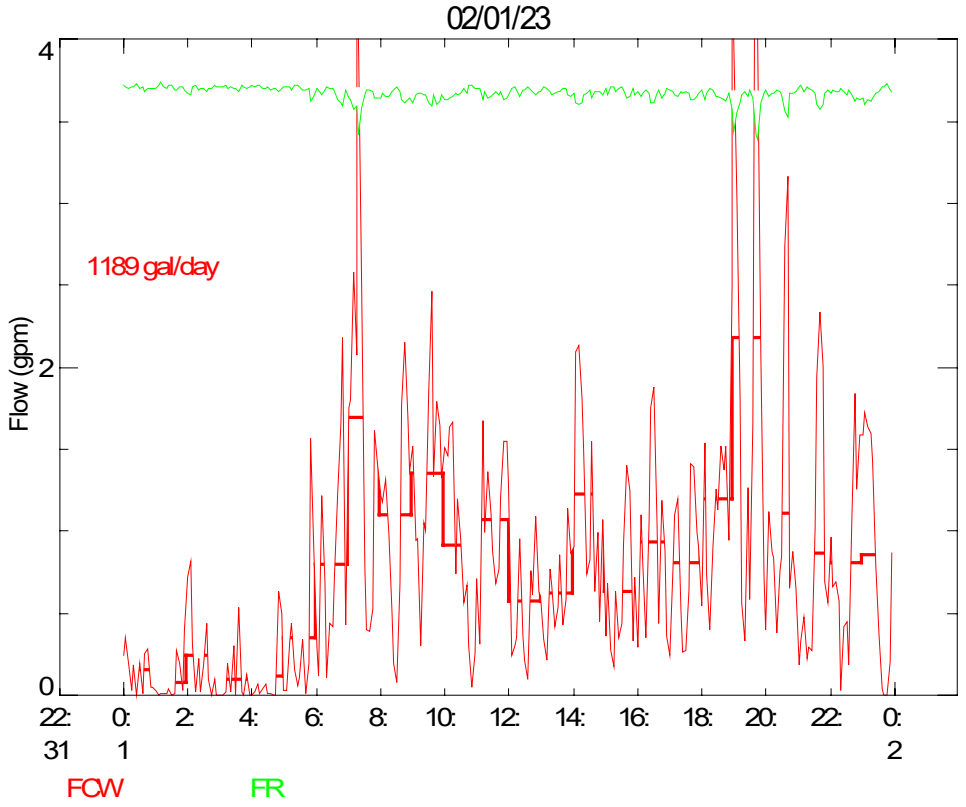


DHW Use Trends

- HW water use 1285 gal/day, or 18 gal per bedroom per day (near TRM's 17)
- 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 recirc rates

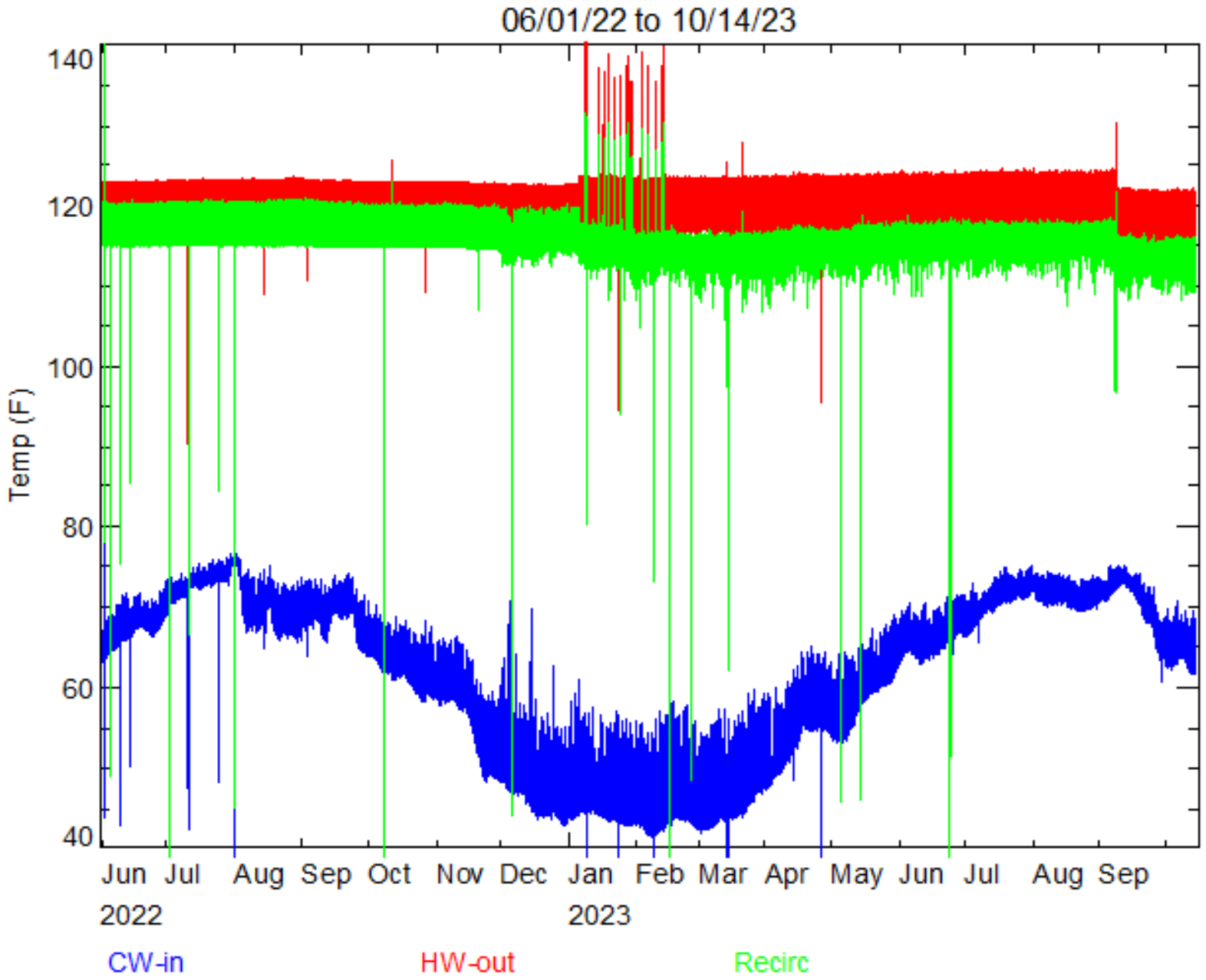
Pipe sizes were 4-inch at this site!





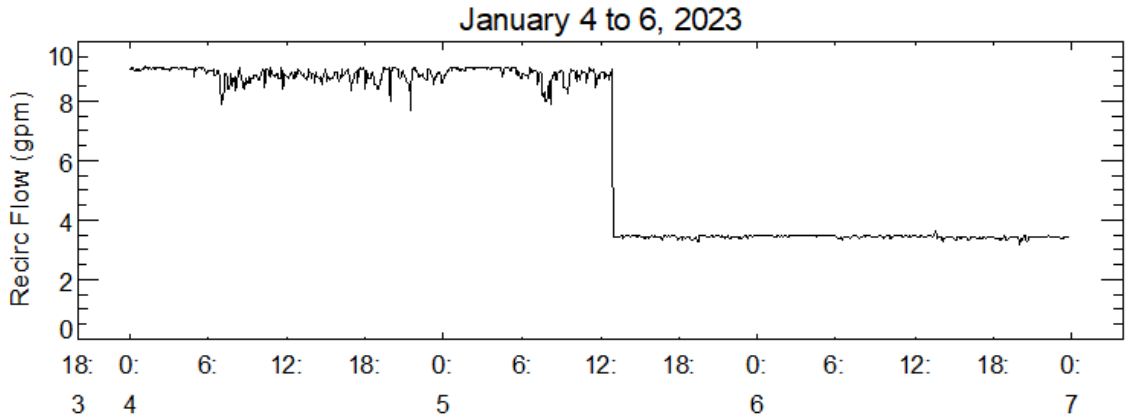
DHW Temperatures

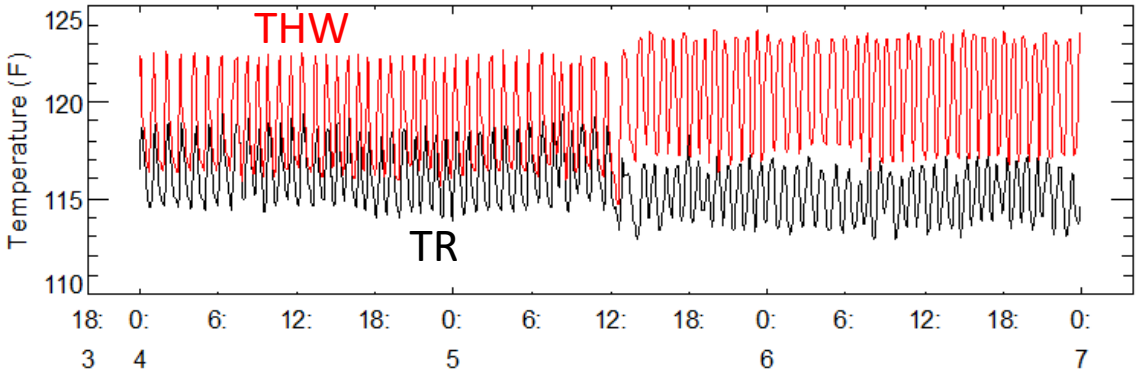
- Delivered HW 120-125°F
- City Water ranges from 40-45°F in winter to 70°F in summer
- Recirculation changes in January 2023

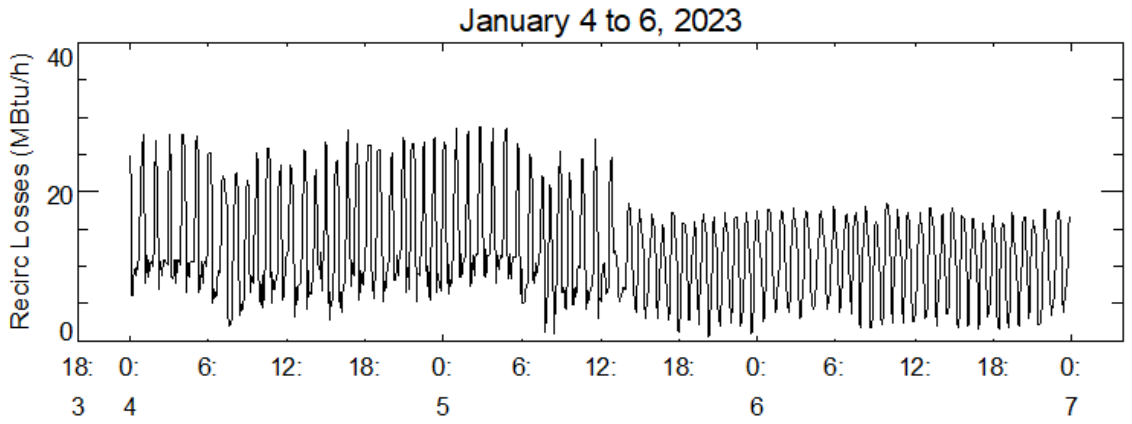


Reducing Recirculation Losses

- 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 25%
  - Savings not just from lower thermal losses from piping – but from less disruption to in thermocline in final tank







Impact of Recirculation Flow Changes

COP_net = Q_delivered / Pwr

COP_gross = (Q_delivered + Q_loss) / Pwr

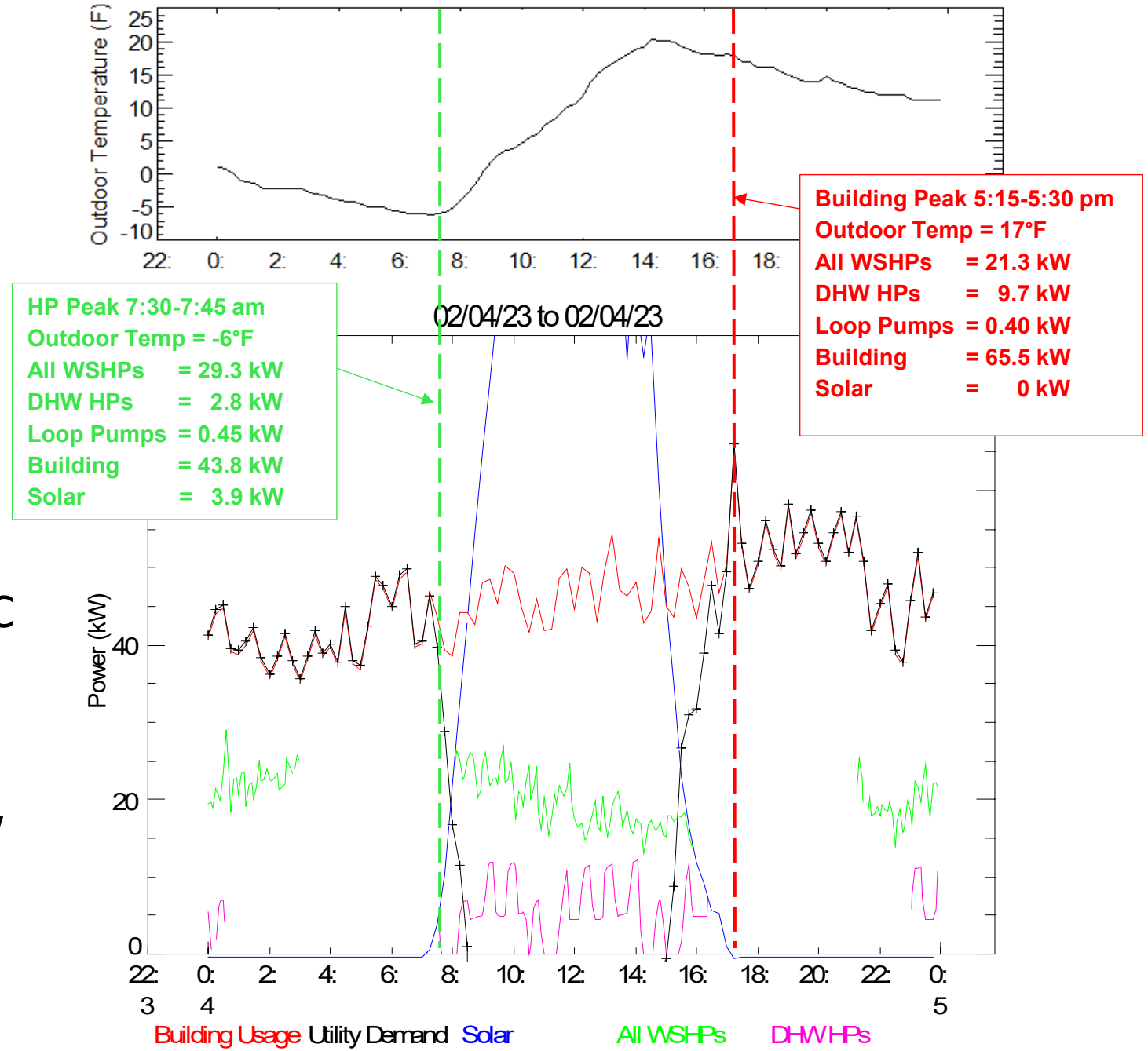
- System Changes
  - Lowered recirc flow on Jan-5-2023
  - Expanded the recirc loop to Café on Jan-24-2023
- Recirc heat losses lower by 25%
- Less tank disruption, etc. increases net COP by 11% → ~11% energy savings

Period	Recirc Flow	Recirc Losses	Recirc Losses (MBtu/h)	Net COP (-)	Gross COP (-)
Before Change (Dec 1 to Jan 4)	10 gpm	32%	350	2.15	3.16
After Change (Jan 6 to Jan 23)	4 gpm	23%	262	2.39	3.09
Café Recirc Changes (Jan 25 to Feb 28)	4 gpm	26%	300	2.28	3.07
Impact of Lower Recirc (Before-After)			-25%	+11%	-2%

Peak Demand Impacts

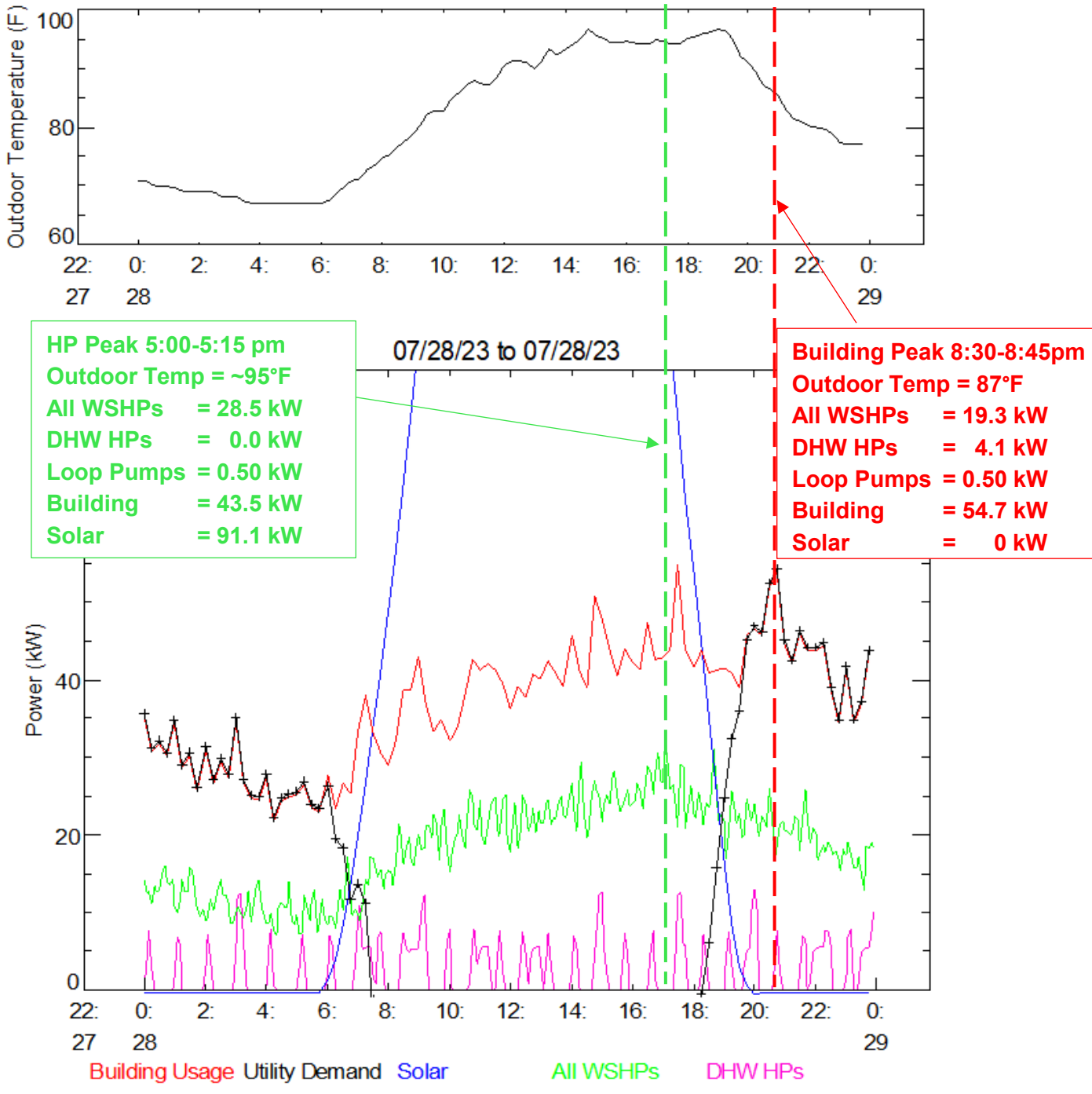
Peak Winter Day

- WSHP Peak on Feb 4 at 7:45 am (hourly avg)
- The building utility demand peaks later in the evening when people come home
  - Driven by appliances not HVAC
- Solar has less impact in the winter
  - Peaks outside of solar window



Peak Summer Day

- WSHP Peak on July 28 at 5:15 pm (hourly avg)
- The building utility demand peaks later in the evening when people come home
  - Driven by appliances not HVAC
- Solar has no impact summer building peak
  - Peaks outside of solar window



Summary and Lessons

- Overall energy use for HVAC very low
  - Heating and cooling energy about same
- Pumping energy is very low, at 3% of HP energy
  - Low-cost “Sensorless” variable speed pumping is effective
  - Methanol as well as no extra hydronic components
- Combined heating COP is 3.6 on the coldest day (low of -6°F)
  - ccASHP COP would have been near 1.0
- Heat pumps did not drive building peak in summer or winter
- Solar PV supplied 95% of annual building energy – but did not eliminate building peak demand impacts

Summary and Lessons - 2

- WWHPs on the ground loop successfully met the DHW loads
  - Also reduced loop size from 18 to 15 bores
  - Therefore design-build contractor provided DHW HPs and tanks for “free”
- Annual gross COP for DHW was 3.3
  - Air-source HP options (e.g., Sanden) for DHW have annual COPs of 2.0 to 2.5
- In general, DHW Systems can be better designed
  - Codes and ASHRAE tend to promote oversized piping; codes are changing
  - Excessive recirculation flows can increase energy use
  - Seemingly small tweaks have big impacts

Monitoring Results from Zero Place a GSHP a Multifamily Mixed Use Building

Speakers: **Hugh Henderson, P.E. / *OCI***

Jens Ponikau / *Buffalo Geothermal*

ZerOPlace

Case Study of New Construction Multifamily

Presented by
Pasquale Strocchia, Integral Building + Design
to the
NYS Public Service Commission
July 27, 2023

87 N. Chestnut St
New Paltz NY

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)

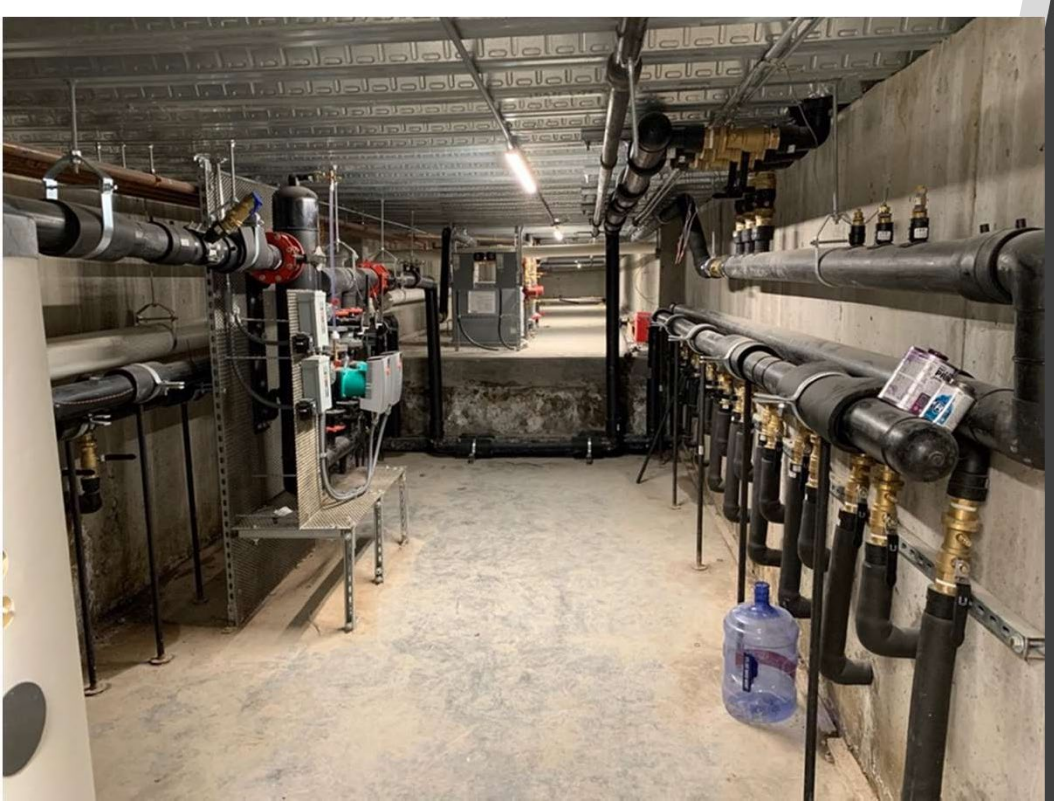
- Timeline:
  - March 2022: Construction Completed
  - June 2022: Full Apt Occupancy
  - Jan 2023: Retail Occupancies 2 of 6 Spaces

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.

BUFFALO GEOTHERMAL HEATING™

www.BuffaloGeothermalHeating.com



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

jponikauoid
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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

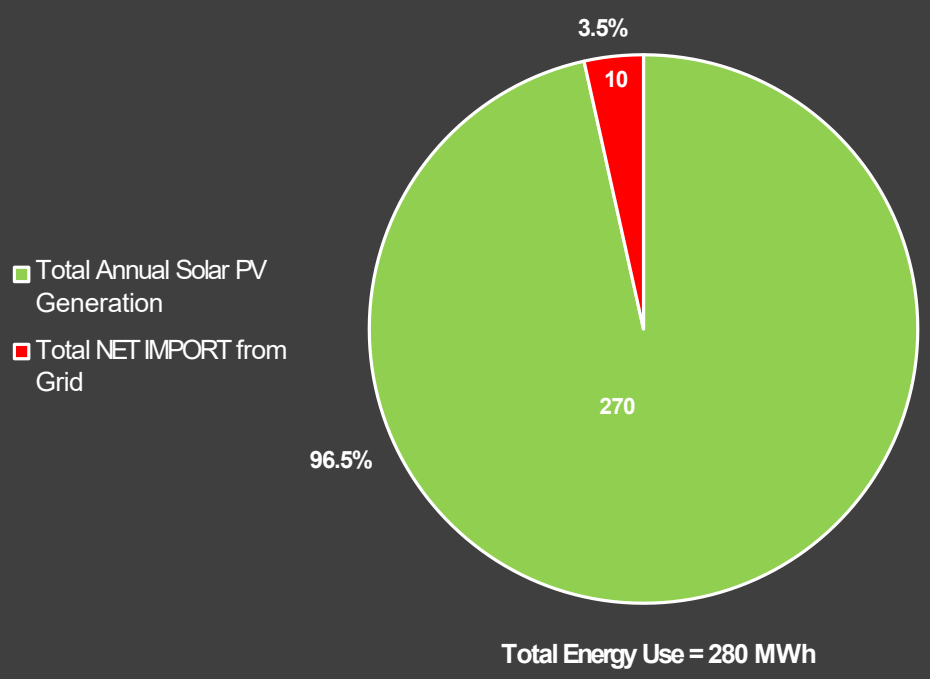
Solar solution provided by: suncommon

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.

- EXCLUDED:
  - Commercial/Retail Spaces
    - Individual Utility Electrical Meters
  - Electric Vehicle (EV) Charging Stations at Parking Lot

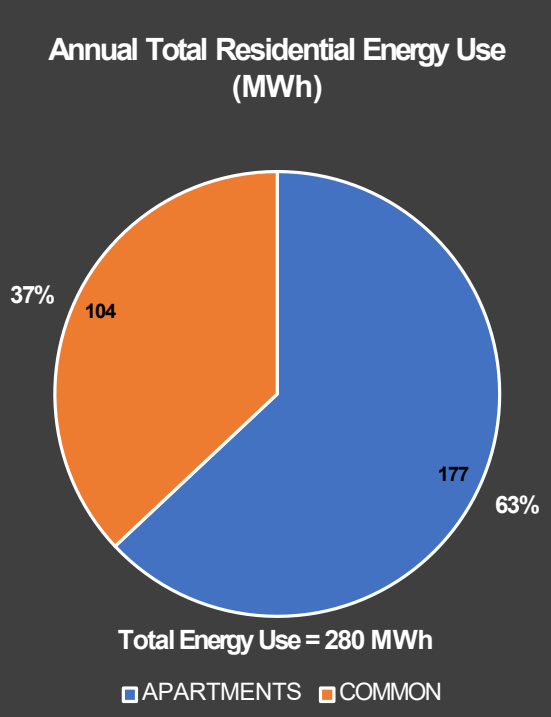
Actual Annual Residential Energy Use: June 2022 thru May 2023
280 MWh/Yr

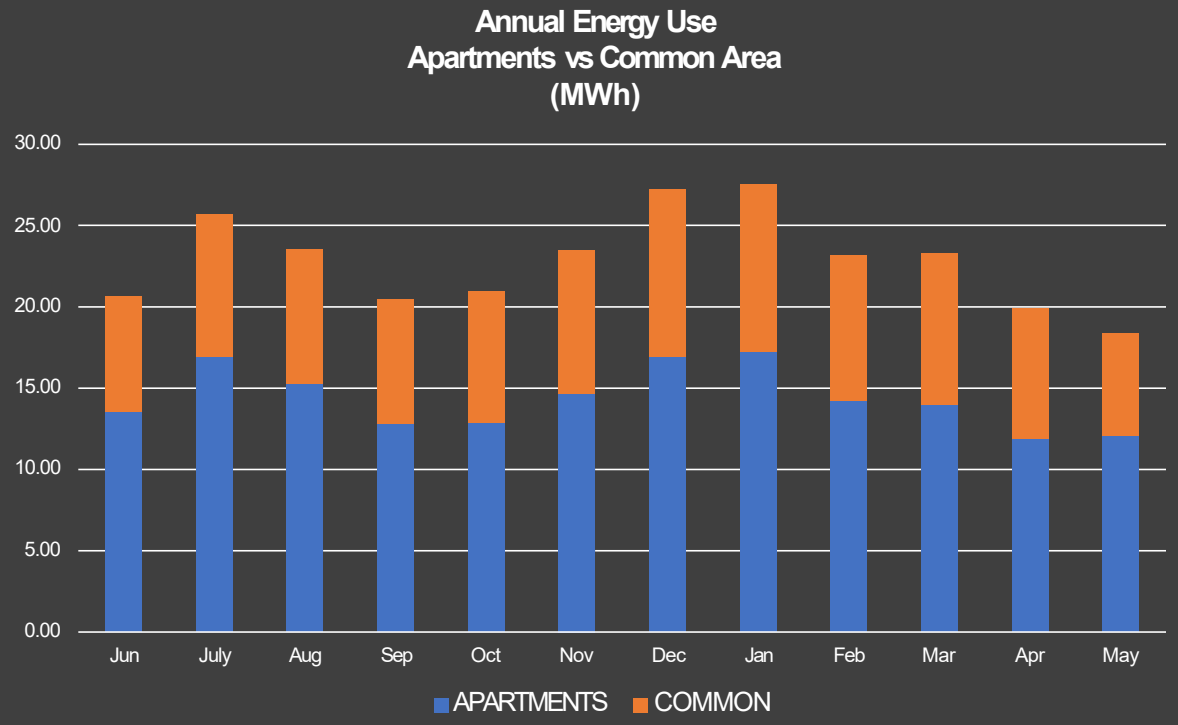


Energy Use Intensity (EUI)
kBTU/SF/Yr

- Building without Solar PV:
  - 280,421 kWh / 55,780sf = 5.03 kWh/SF/Yr
  - EUI = 17.17 kBTU/SF/Yr
- Building with Solar PV:
  - 9,749 kWh / 55,780sf = 0.17 kWh/SF/Yr
  - EUI = 0.58 kBTU/SF/Yr

Actual Annual Residential Use: June 2022 thru May 2023 **280 MWh/Yr**





Annual Residential Energy Use:
206 MWh/Yr
(177 MWh/Hr APTS + 29 MWh/Yr DHW)

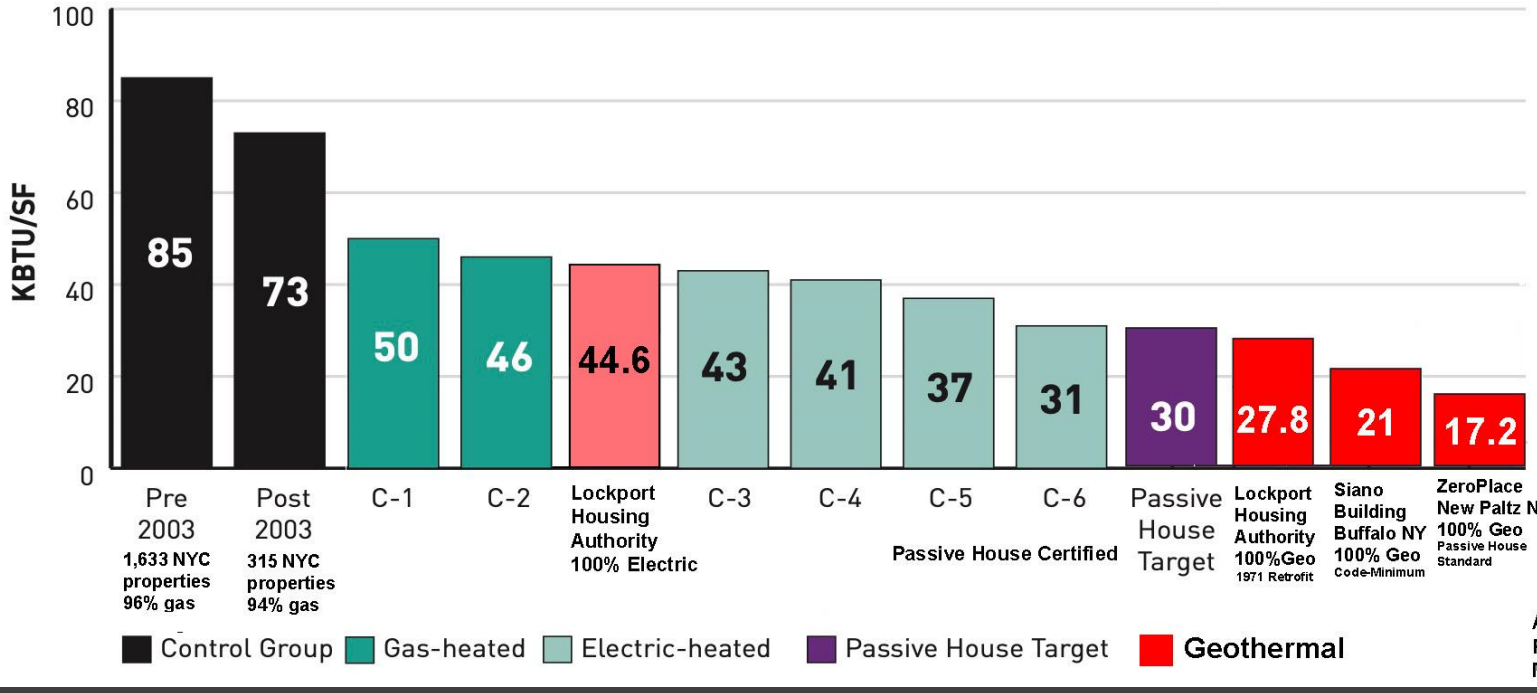
Average Energy Usage per Apt
(inclusive of all space conditioning and central DHW)

Measured Results:

- 1-Bdrm Apts
  - 3,744 kWh/Yr (or 312 kWh/Mo)

- 2-Bdrm Apts
  - 5,096 kWh/Yr (or 424 kWh/Mo)

New York City Department of Housing Preservation and Development (NYC HPD)



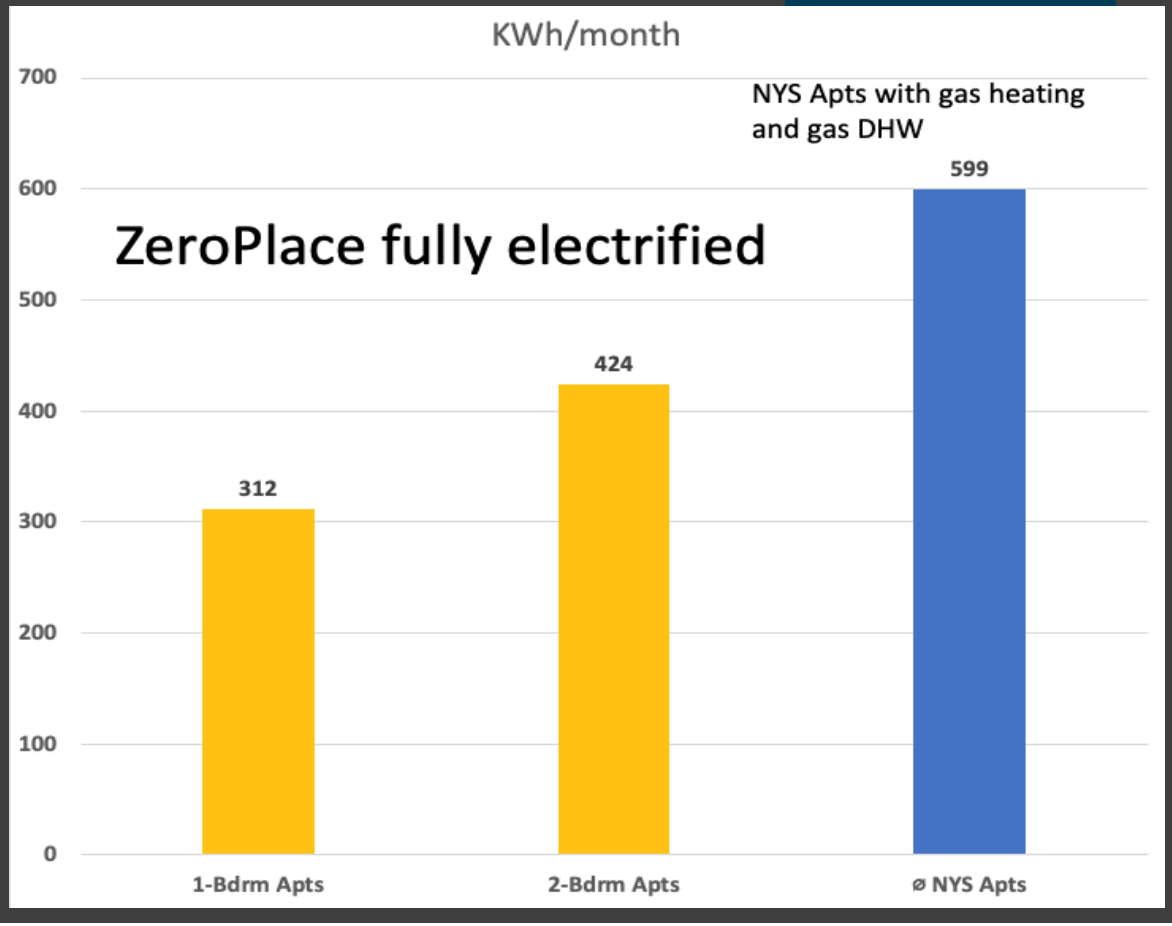
Energy Use Intensity (EUI)

Passive House case study buildings C1-C6 consume signifcantly less energy than the buildings in the post-2003, conventionally-built control group. Electrically heated Cerified Passive House Buildings with gas domestic hot water consume the least energy, but still do not reach the Passive House Target.

All Geothermal heated (incl geo DHW) exceed Passive House Target, whether retrofits without envolope upgrades (Lockport), 2014 code minumum new built (Siano), or passive house new built 2017 (ZeroPlace).

Adapted from:
Passive House: Connecting Performance to Financing
March 2021

Average electricity usage per Apartment (inclusive of all space conditioning and central DHW)

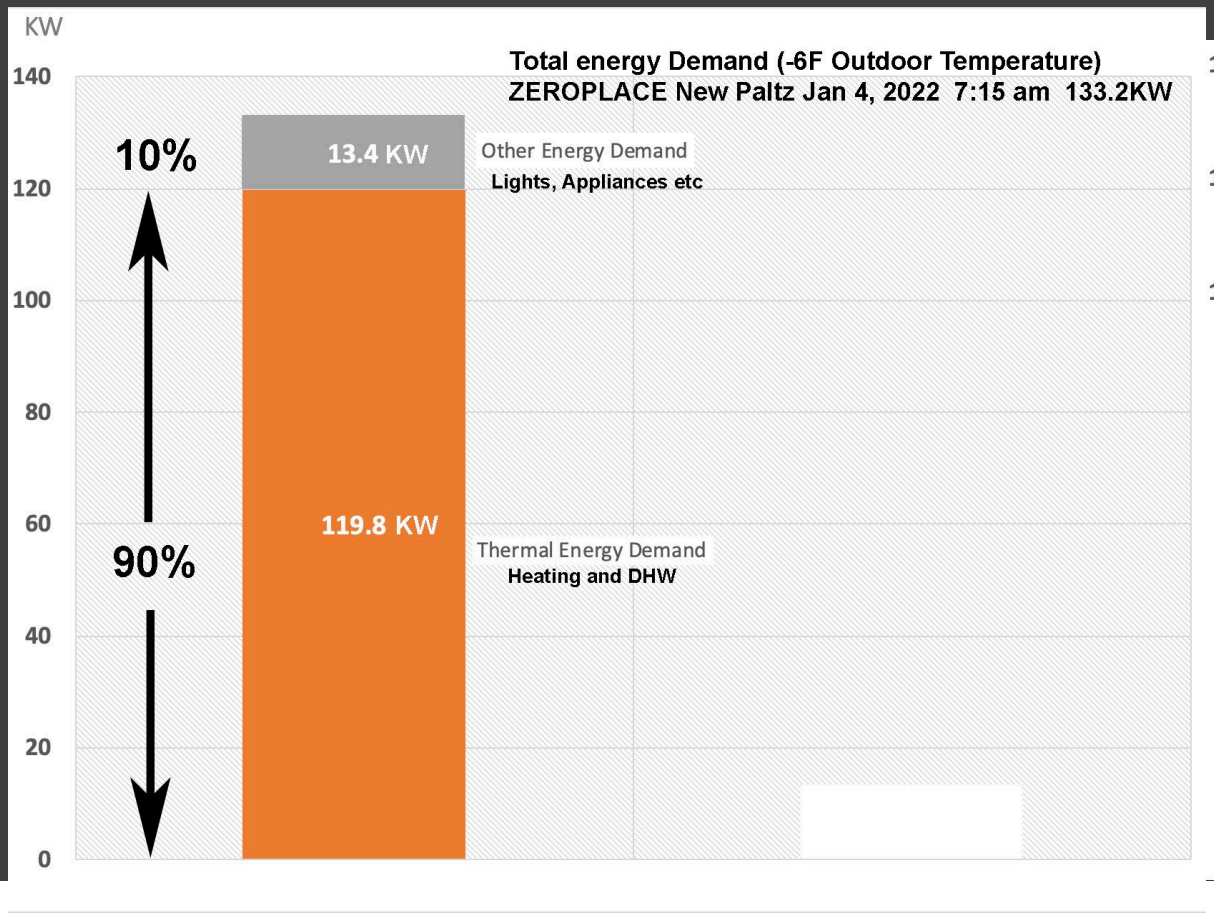


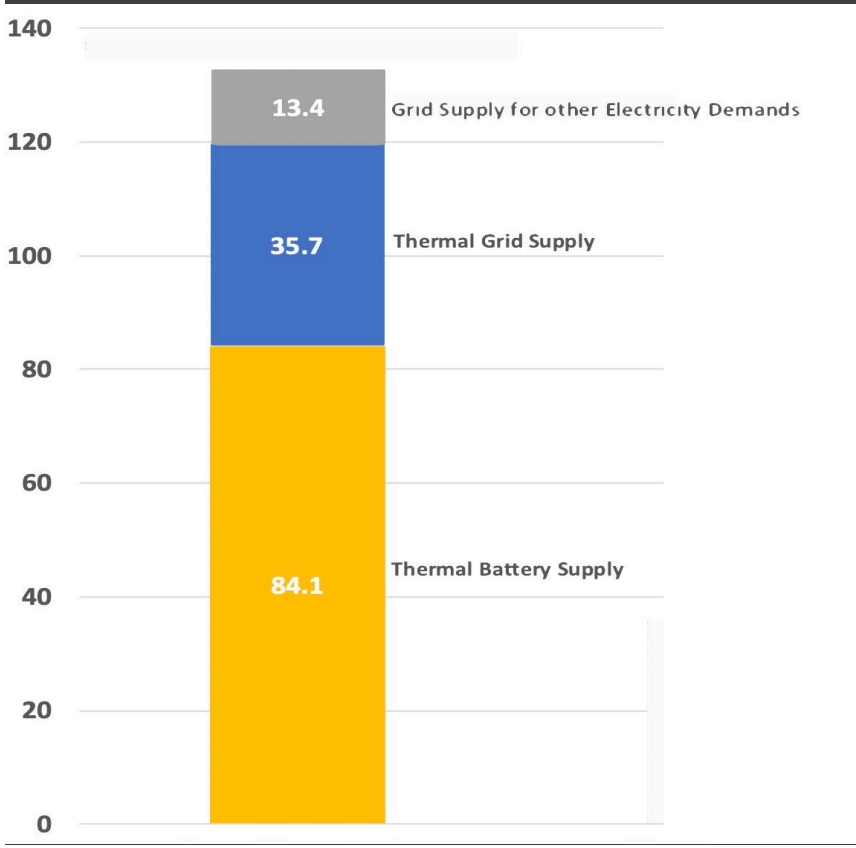
Heating Peak
Feb 4th 2023, 7:30-7:45 am
- *Outdoor Temp = -6°F*
- *All WSHPs = 29.3 kW*
- *DHW HPs = 2.8 kW*
- *Loop Pumps = 0.45 kW*
- *Building = 43.8 kW*

Cooling Peak
July 28th, 2022 5:00-5:15 pm
Outdoor Temp = ~95°F
All WSHPs = 28.5 kW
DHW HPs = 0.0 kW
Loop Pumps = 0.50 kW
Building = 43.5 kW

Peak 15 min Energy Use

90% of the entire energy load of the building was DHW and heating (Thermal Load)





ZeroPlace Loop Field

Thermal Energy Delivery

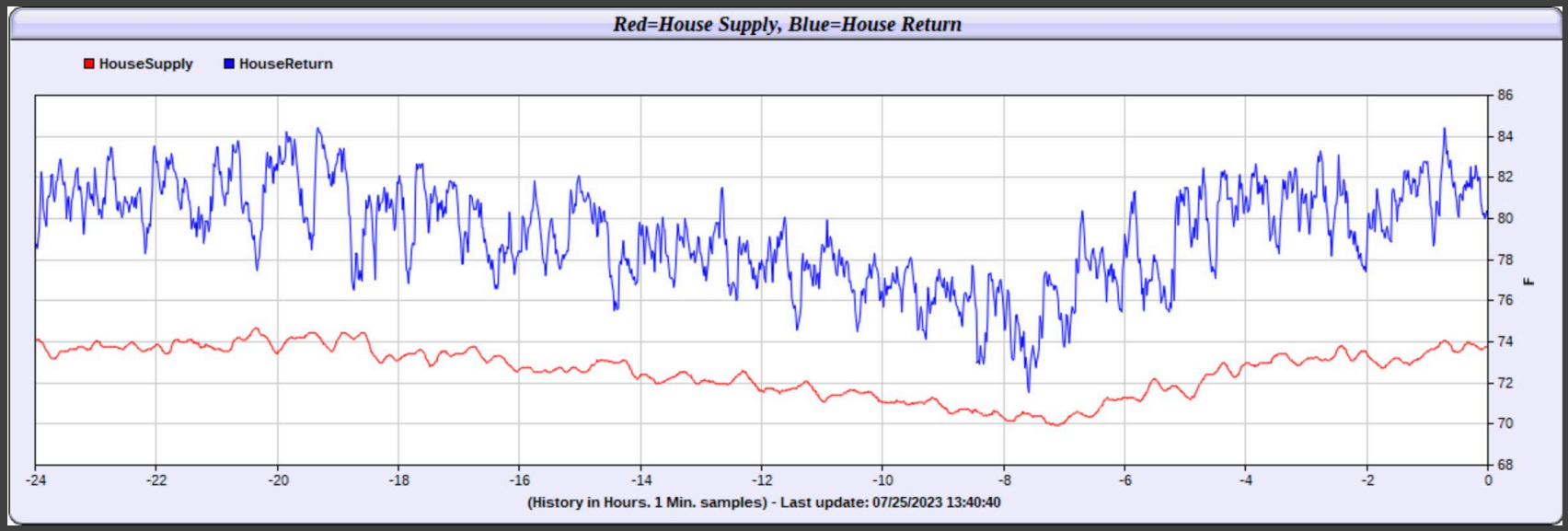
Monetary Value @567/kWh*

Peak Day (Feb 4, 2023):

- **1,706.81 kWh**
- **$967,762**

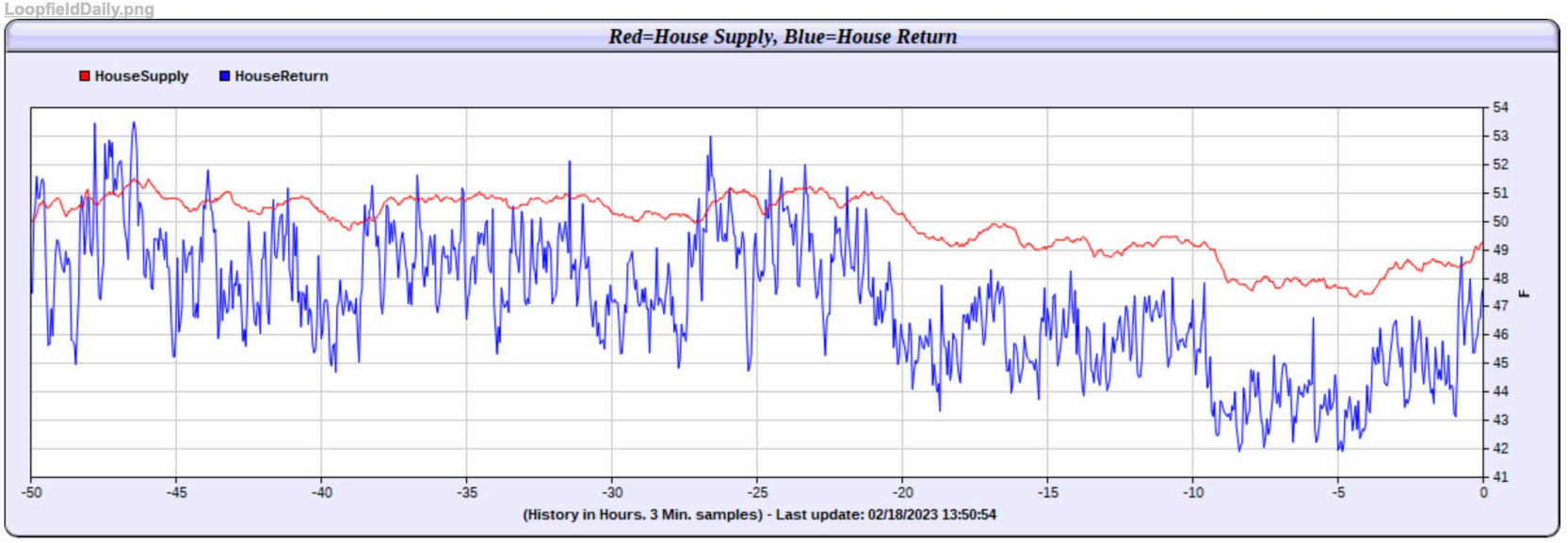
*"Among projects awarded NYSERDA incentives, average total installed costs for non-residential, retail projects averaged
$567/kWh for installations occurring in 2022 and 2023"
Case 18-E-0130 – In the Matter of Energy Storage Deployment Program.
New York's 6 GW Energy Storage Roadmap Policy Options for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

Summer versus Winter Ground loop
Heat Rejection versus Heat Extraction



Summer

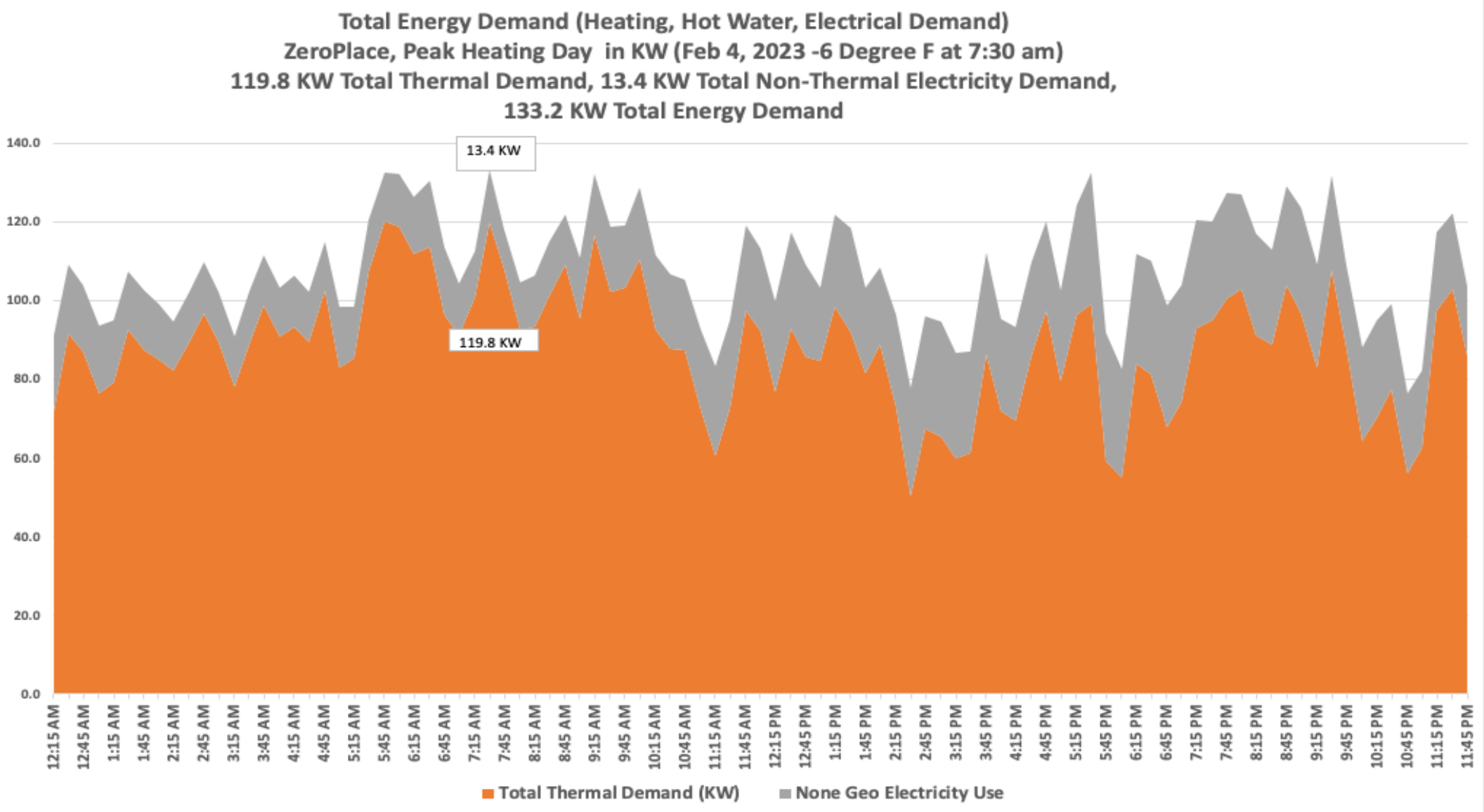
LoopfieldDaily.png



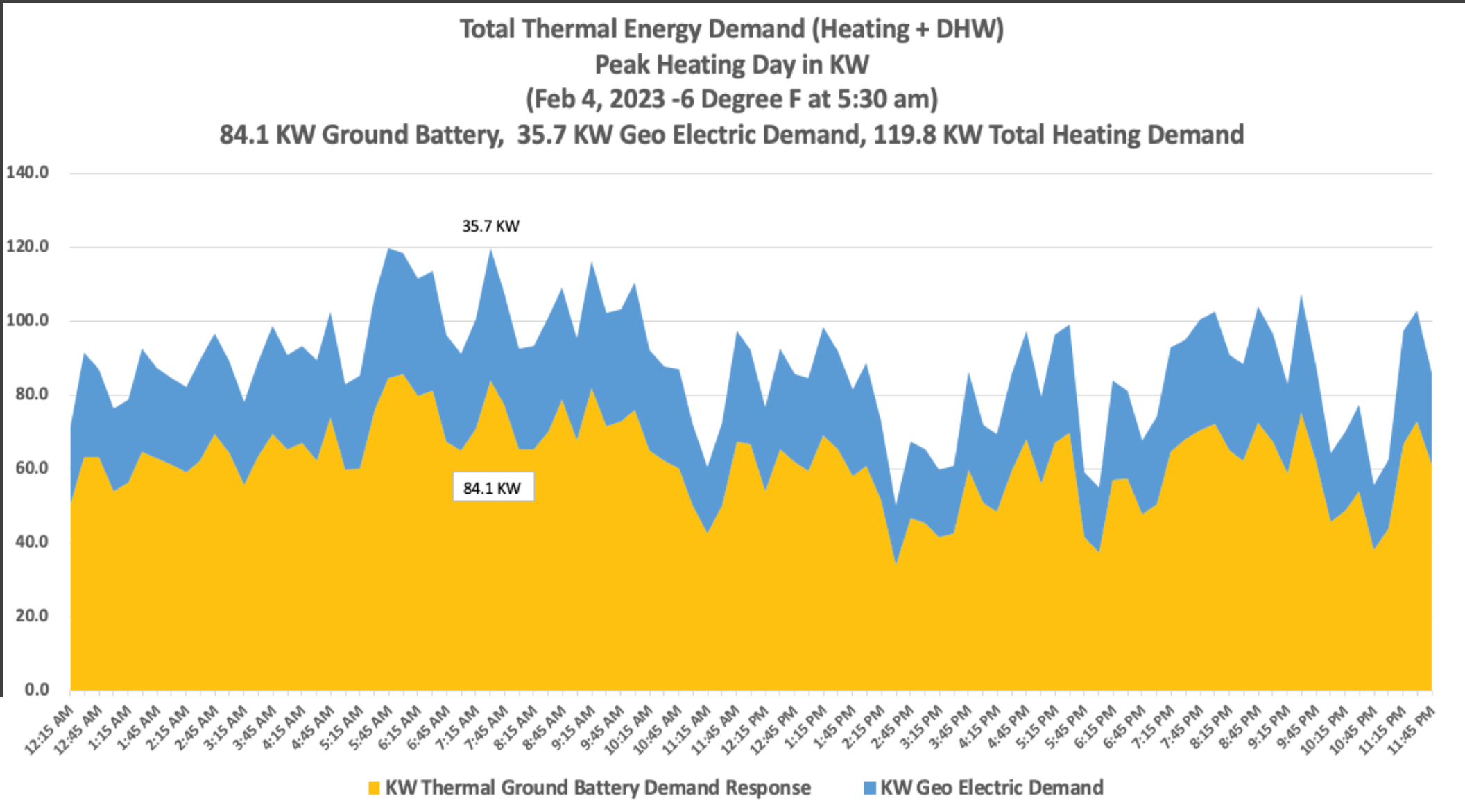
Winter

Total Energy

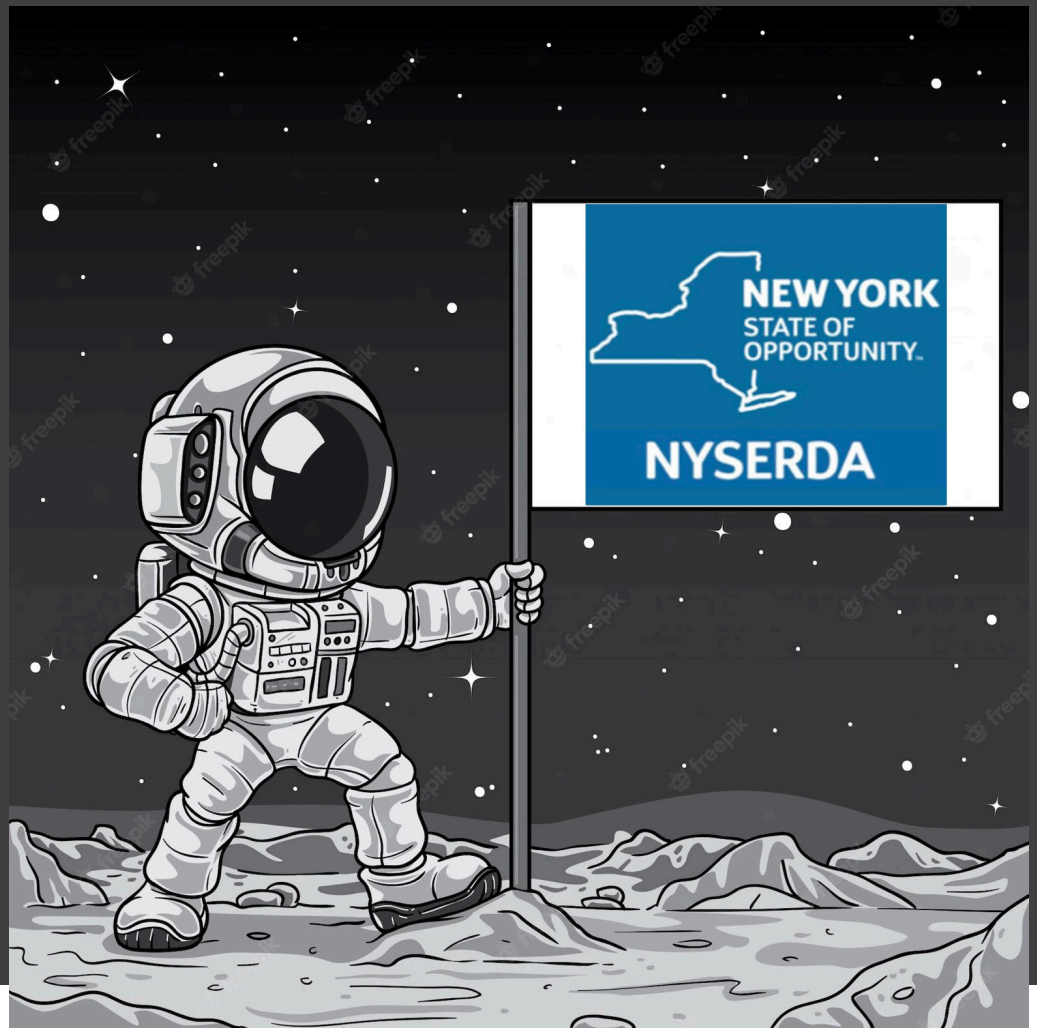
Demand Winter Peak



Total HeatingDemand versus Heat Extraction



Took NYSERDA along to monitor and verify



Buffalo News

EDITOR'S PICK TOPICAL

Gaps in electrical distribution create disruptions for construction of new housing projects

Jonathan D. Epstein Jun 12, 2024

Buffalo News

Pan Am Building

-150 units affordable housing project

- 3 x 50 units

-Buffalo NY

-Passive House standard

Buffalo News

Pan Am Building

“But there wasn’t enough electrical capacity in that immediate area to power the three four-story buildings that are under construction.”

“Hungry for electricity

The problem is partly about the electric capacity in the overall power grid,
but also about where and how that power is distributed.”

Buffalo News

Pan Am Building

“it took six months of study and planning to come up with a solution.

National Grid will be running an extra 23-kilovolt power distribution line into the site to deliver the needed electricity from elsewhere.

And it isn’t cheap: The power upgrade will cost DePaul more than $5 million in additional costs, on top of the $30 million construction project.

“Who would have thought there was not enough power on Delaware Avenue?” Fuller said.”

Buffalo News

Pan Am Building

“And the problem may only worsen with the state’s push toward full electrification of buildings and rising demand from electric vehicles.

The winter demand for electricity statewide will roughly double by 2040, according to a study released this month by the New York Independent System Operator, which manages the state’s power grid.”

Utility Load Letter

ZeroPlace Load application
New Paltz NY

46 Apartment Units (diversified) 263 Kw, 56,000 sqf
Common (House Panel - diversified) 80 Kw
Total 343 Kw 1200 Amps at 208Y/120V, 3Phase

Measured Peak
Summer 71.26 KW
Winter 65.41 KW

ASHP Load application Pan-Am Building Buffalo NY

Load Information

Fill section below with new load for any 3ph service or 1ph greater than 200 amps
For each line below provide connected load in Total kW or HP (do not duplicate)
Note: If there are multiple buildings, please submit a separate Load Sheet for each.

SERVICE SIZE 3000 amps 208 volts 3 phase

SQUARE FOOTAGE* 61,480

Equipment Type	kW		Usage
INSIDE LIGHTING	20	for	4380 hrs/year
OUTSIDE LIGHTING	5	for	4000 hrs/year
ELECTRIC HEATING	150	for	4380 hrs/year
AIR CONDITIONING	150	for	4380 hrs/year
WATER HEATING	69	for	8000 hrs/year
REFRIGERATION	30	for	8000 hrs/year

Additional Equipment	kW	# of Units		Usage
PLUMBING	48		for	8000 hrs/year
APARTMENTS	450		for	8000 hrs/year
MISCELLANEOUS	46		for	3000 hrs/year
KITCHEN	100		for	3000 hrs/year
			for	hrs/year
			for	hrs/year
			for	hrs/year

Motors**	HP	# of Units		Usage
ELEVATOR	30	1	for	200 hrs/year
			for	hrs/year
			for	hrs/year
			for	hrs/year

Total Connected Load	1100	kW
Total Diversified Load	1000	kW

*Square Footage is required to size service correctly
**Complete next page w/ NEMA code for 3 ph motors >15 HP & 1 ph motors > 6 HP

Job Description
Provide new service to three new four story housing apartment buildings. Buildings are ALL electric.

Buffalo News

Pan Am Building

Buffalo Geothermal Bid

- $3.5M before incentives
- $1.9M after incentives

Developers choice

- $2M for ASHP system

Conclusion

- ZeroPlace shows as a clear path forward how to avoid the grid collapse in the winter due to increased peak demand
- Tapping in the the ground as a thermal battery will avoid the winter grid demand on the grid
- “What you get from the Ground you do not have to get from the Grid”
- Ground KW = Grid KW

Questions?

Thank you

Monitoring Results from Zero Place a GSHP a Multifamily Mixed Use Building

Speakers: **Hugh Henderson, P.E. / *OCI***

Jens Ponikau / *Buffalo Geothermal*