HOT WATER TEMPERATURE MAINTENANCE PILOT STUDY

ACEEE 2017 - Hot Water Forum

Ecotope, Inc.

Februrary 22, 2017

grow™ community | Bainbridge Island, WA

Bonneville POWER ADMINISTRATION

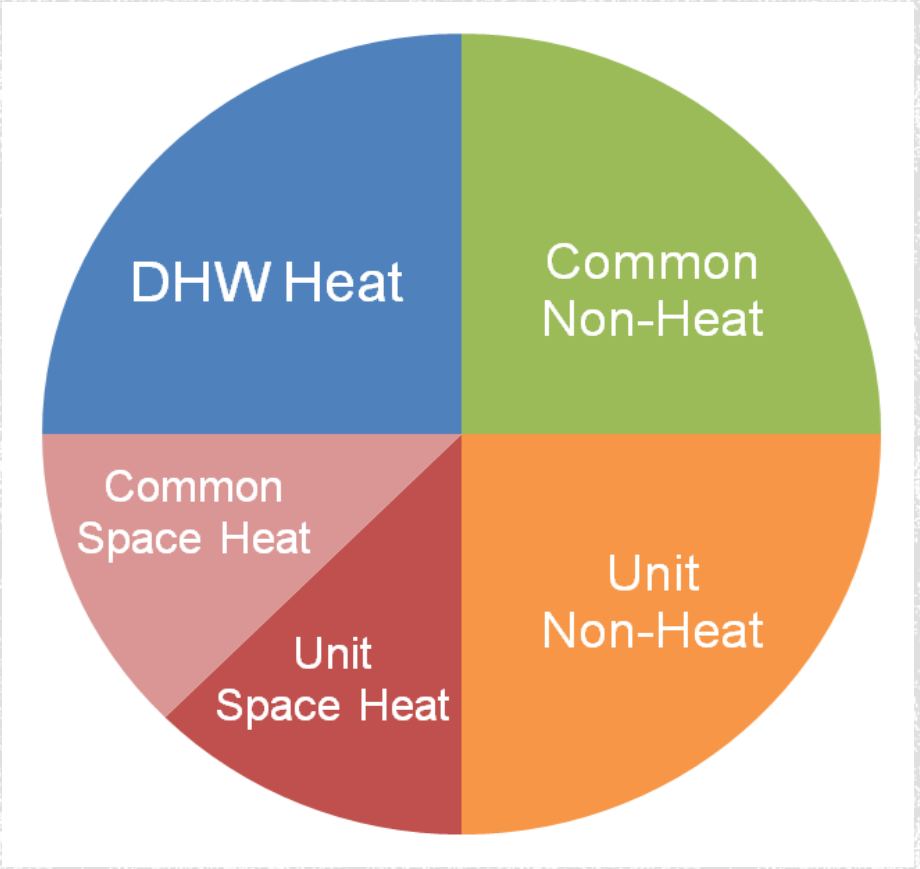
ECOTOPE

AGENDA

- Multifamily Hot Water Load
- Temperature Maintenance Systems
- Pilot Study
- Why Recirculation Flow Measures are Limited.
- High Performance Hot Water Systems

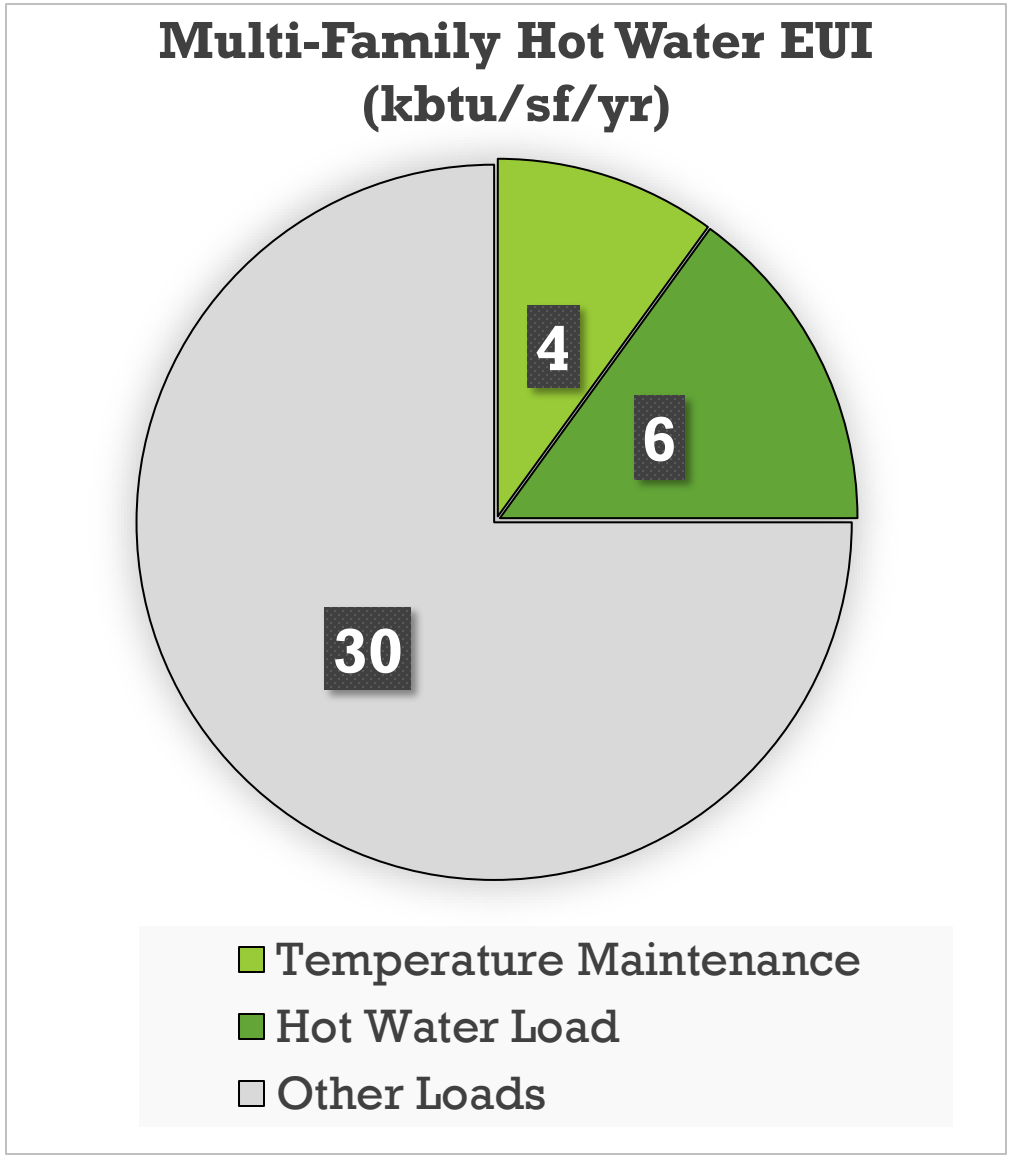
BACKGROUND ON MULTI-FAMILY ENERGY USAGE

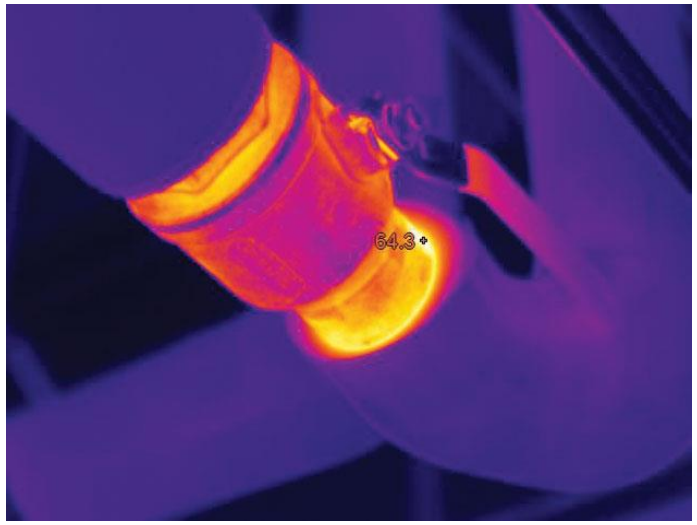
DHW
EUI ~ 10
kbtu/sf/yr



Based on billing analysis of 10 Multi-family Buildings in Seattle
Median Energy Use Index (EUI): 39 kBTU/sf/yr

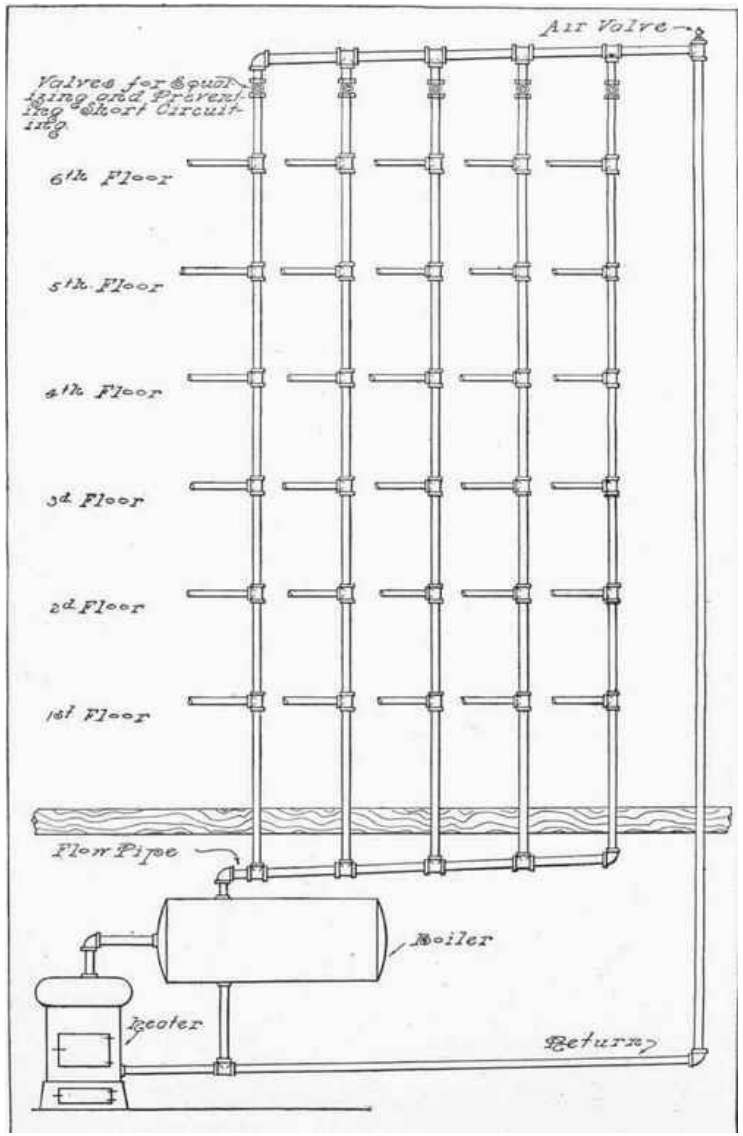
APARTMENT - ANNUAL HOT WATER HEATING LOAD





Heating Water + Temperature Maintenance/ Losses

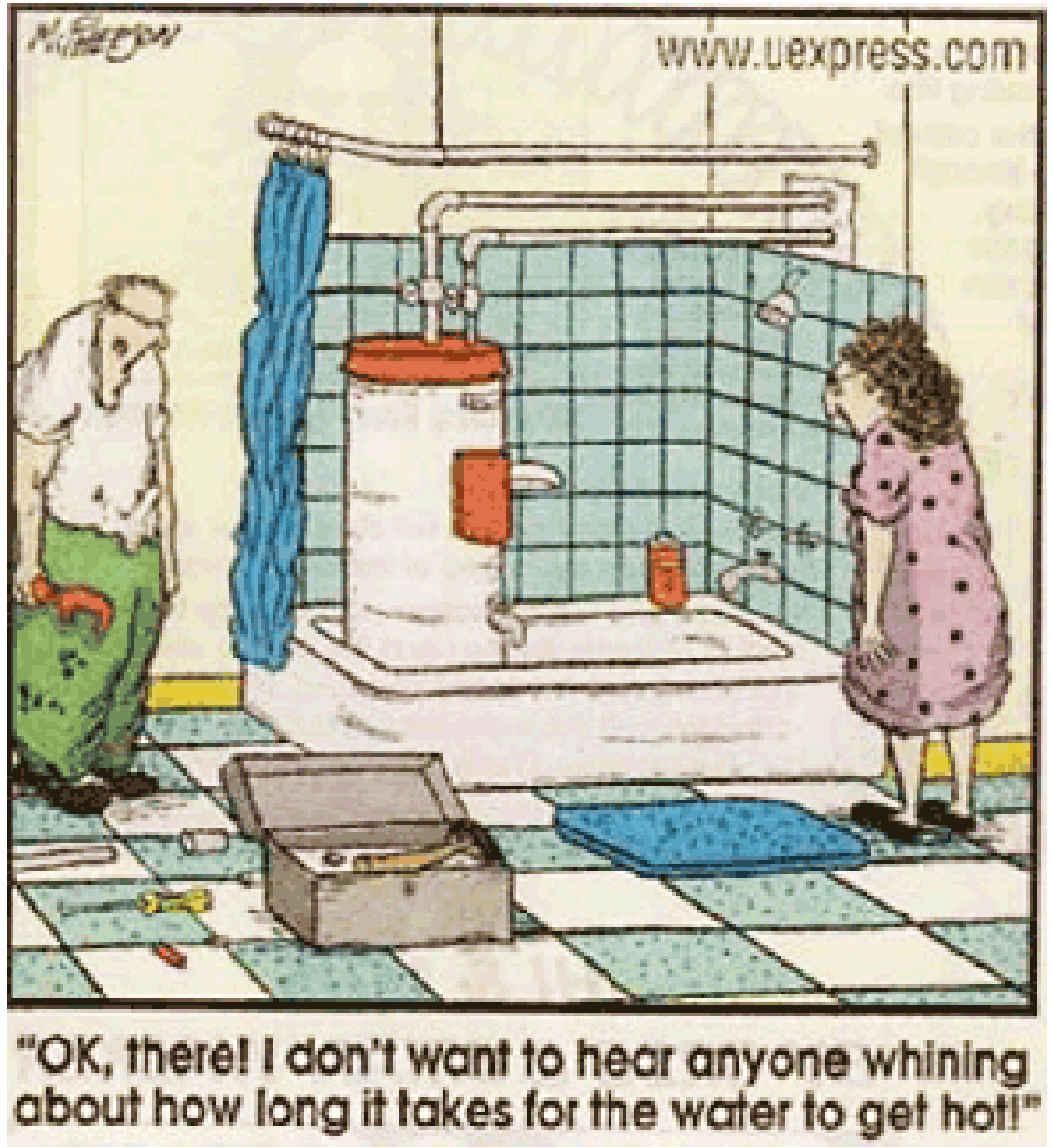
CENTRAL HOT WATER SYSTEM



Parts of a Central Hot Water System

- Central Plant
- Primary Supply
- Risers
- Balancing
- Temperature Maintenance System

TEMPERATURE MAINTENANCE SYSTEMS

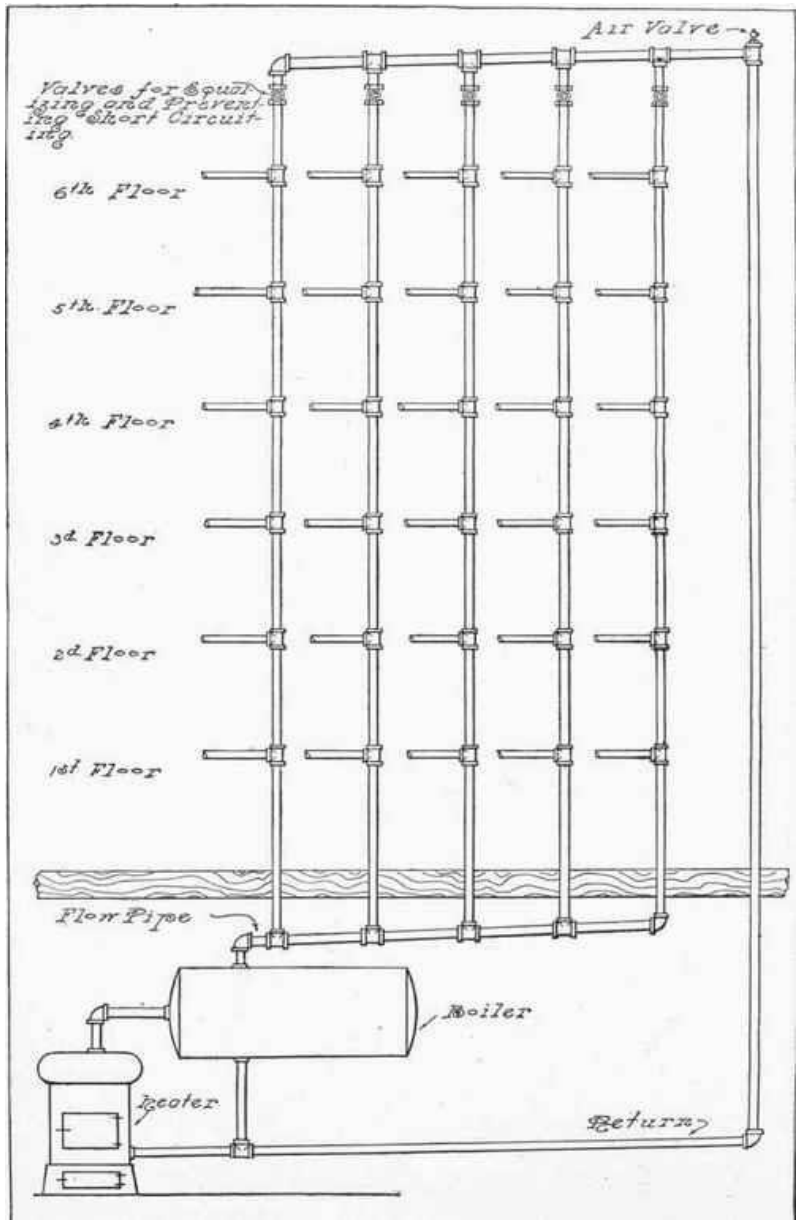


Making Hot Water Available in 20-30 Seconds in a Central Hot Water System

Three Different Approaches

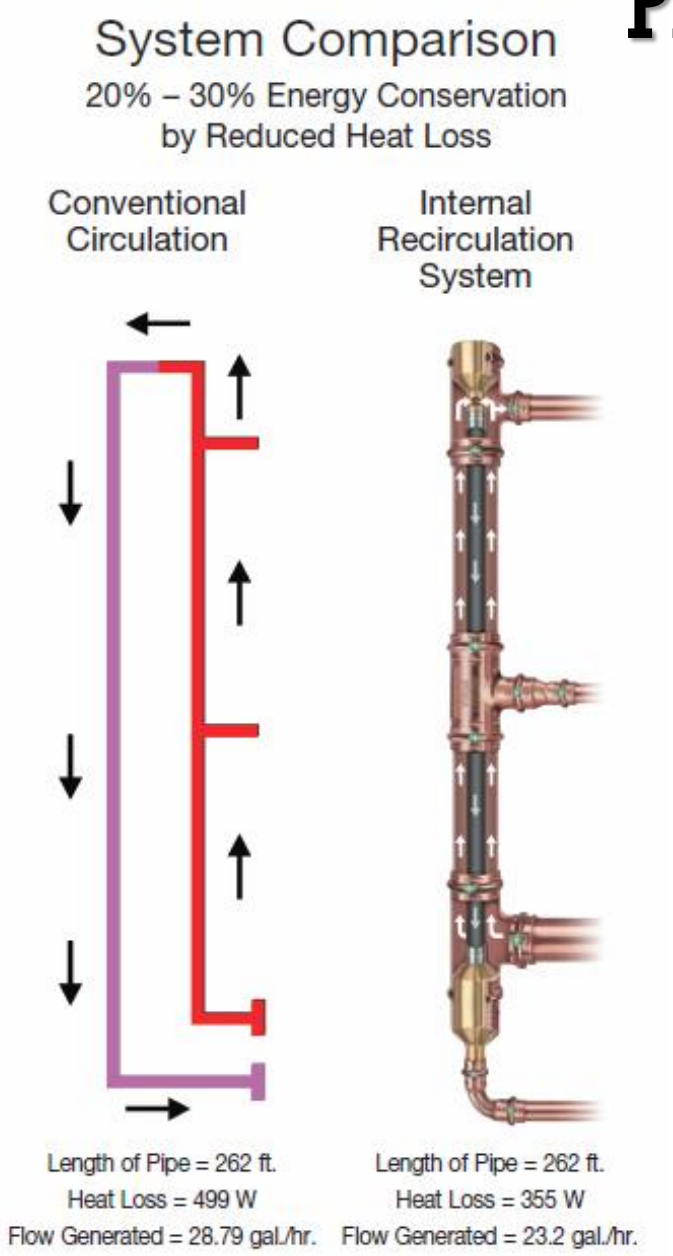
1. Traditional Circulation System
2. Pipe in a Pipe Circulation System
3. Electric Heat Trace and No Circulation

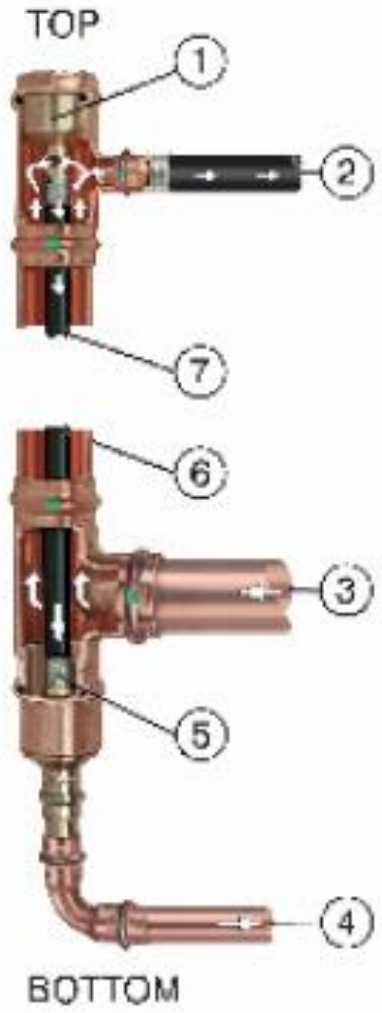
TRADITIONAL CIRCULATION LOOP



- Connects a Return line and Hot Water Circulation Pump to the end of the supply line and circulates hot water to keep supply pipe hot.
- Uses 100-200’ of extra piping and insulation to bring recirc line back.
- Balancing can be tedious
- Pinhole leaks can occur in copper recirculation systems after 20+ years

PIPE IN A PIPE CIRCULATION LOOP





Similar to traditional hot water circulation, except return piping is located inside of supply riser.

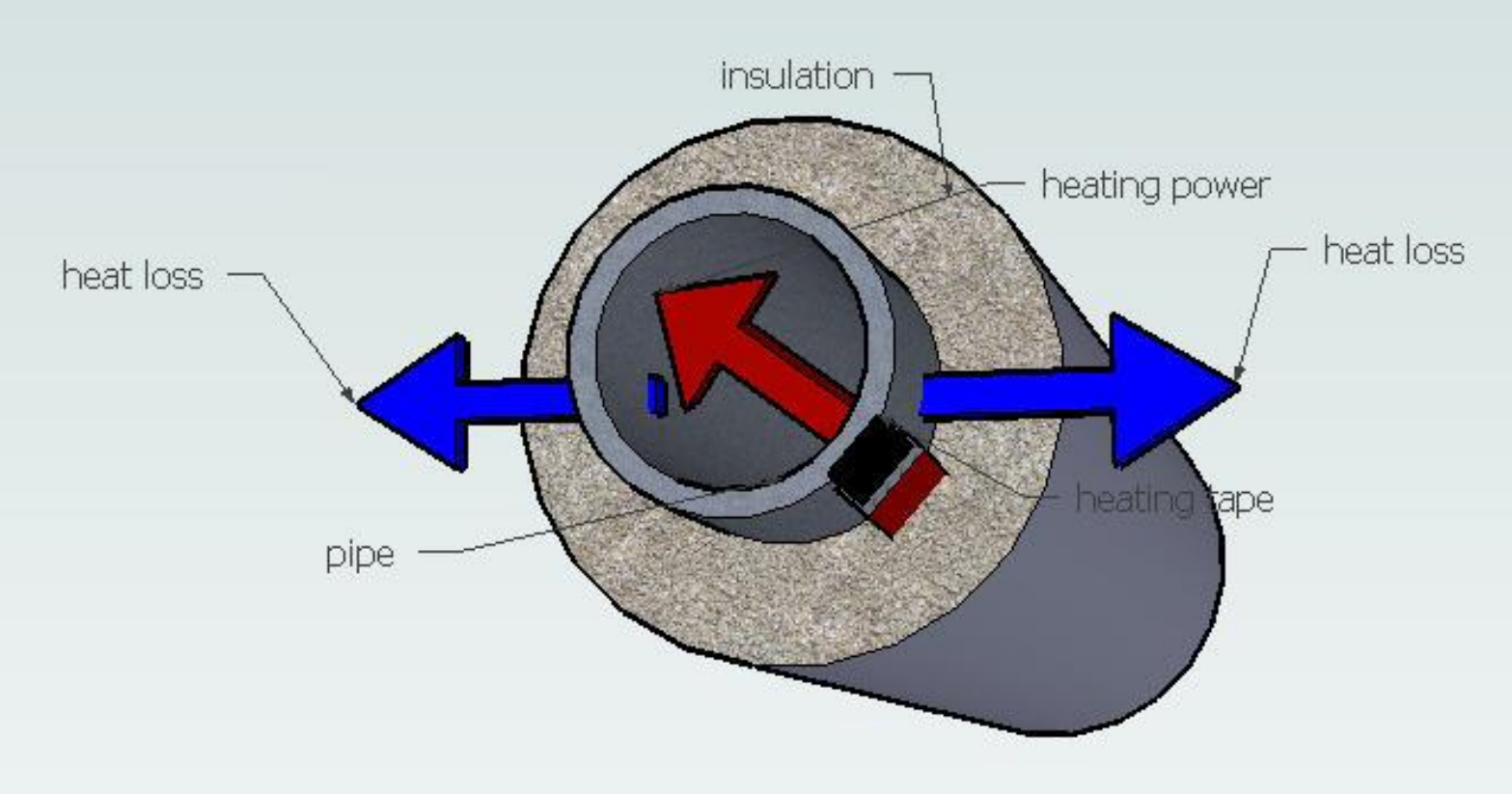
Reduced surface area results in less heat loss

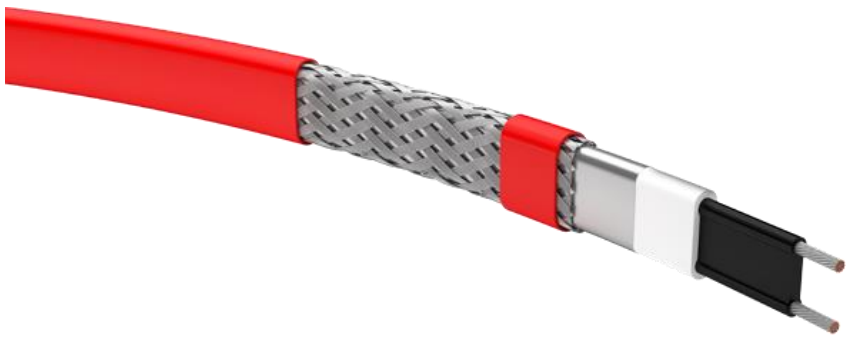
Can still get COP on recirculation load.

Reduced insulation costs trades off with copper risers.

Cost Effective

ELECTRIC HEAT TRACE





Electric controller set to maintain temp

Results in reduced piping length and elimination of pumping energy *(24/7 typ)

Advantage is it is simpler and neutral cost increment over traditional

Disadvantage is no COP on reheating

20 year life, need to locate primary lines in common spaces

Temperature Maintenance Pilot Study

Building A

Traditional Recirculation Loop

12 Units ~ 1450 SF each, 2 Bedroom

Building B

Electric Heat Trace

12 Units ~ 1450 SF each, 2 Bedroom

Building D

Pipe in a Pipe Recirculation Loop

13 Units ~ 1450 SF each, 2 Bedroom

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Temperature Maintenance Pilot Study Objectives

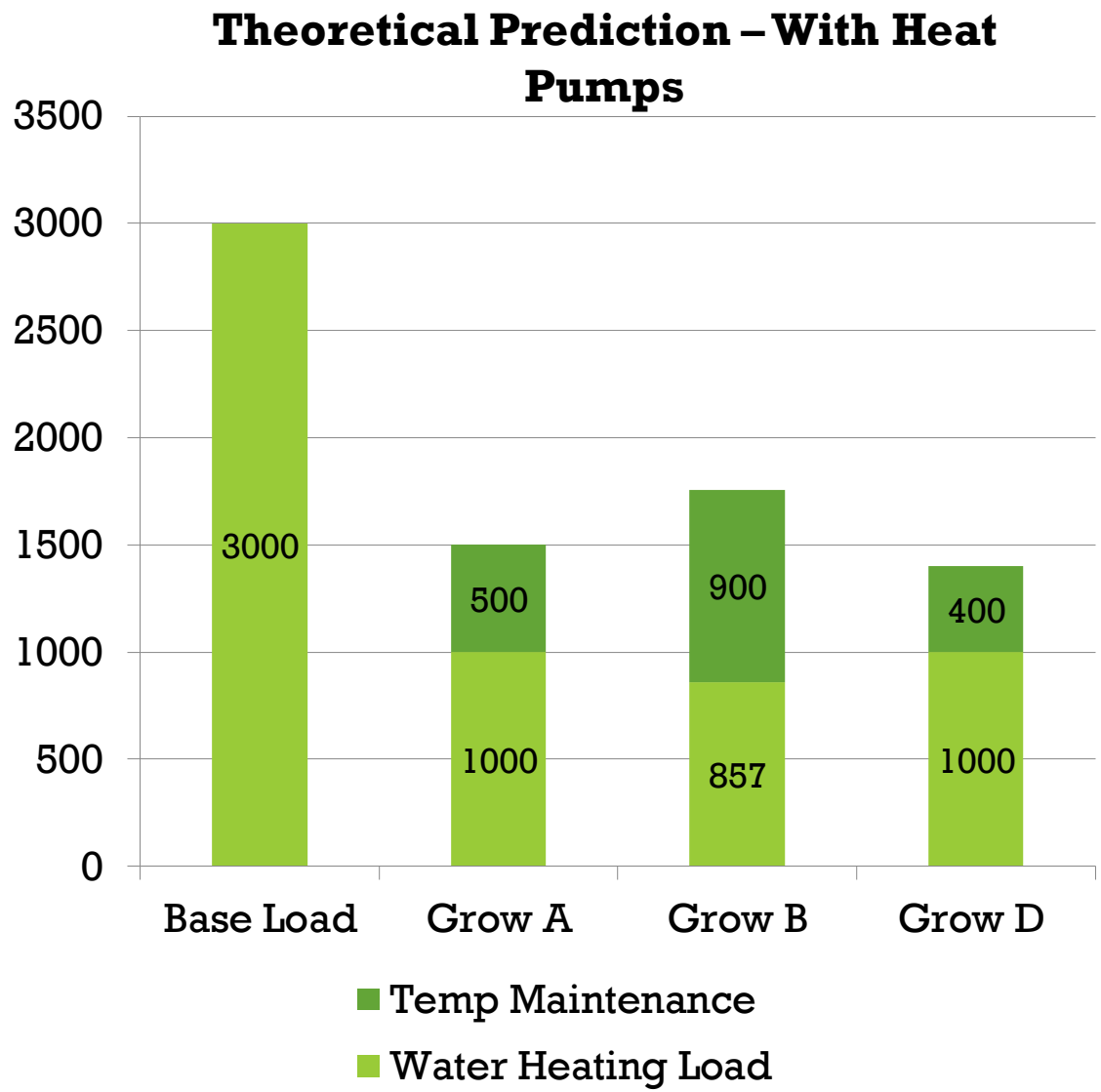
Compare Performance of 3 Different Temperature Maintenance Systems in 3 Similar 12 Unit Multi Family Buildings

Use Hydronic Inverter Driven Heat Pump To Heat Water in a Central Plant.

Compare Recirculated Systems with Non-Circulated Systems. Heat Pump Impact

Comparisons with other heat pump buildings

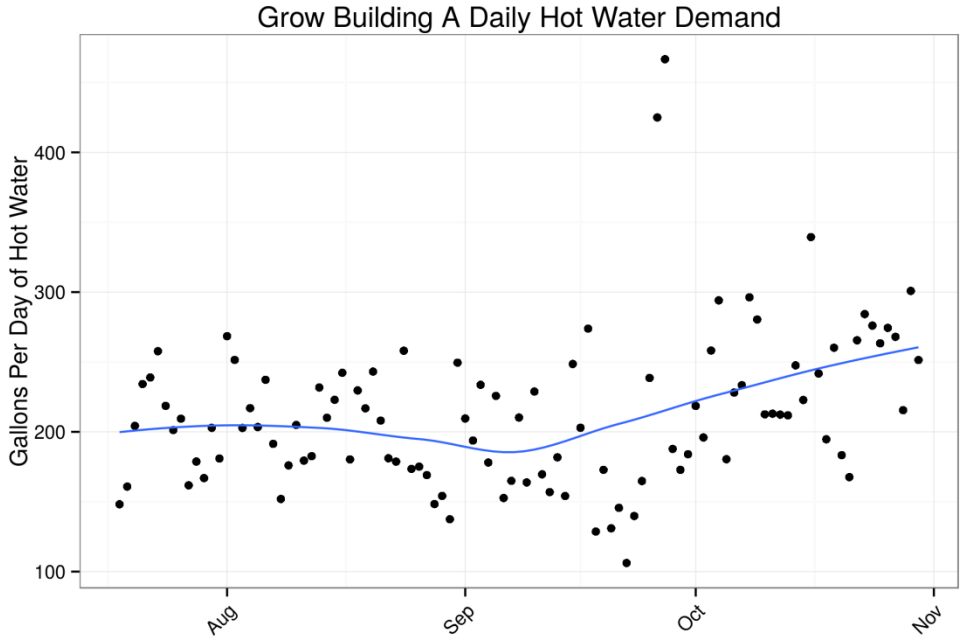
All Buildings used good insulation 2" thick wall for garage and 2x6 cavity, dense pack for risers (R-11)

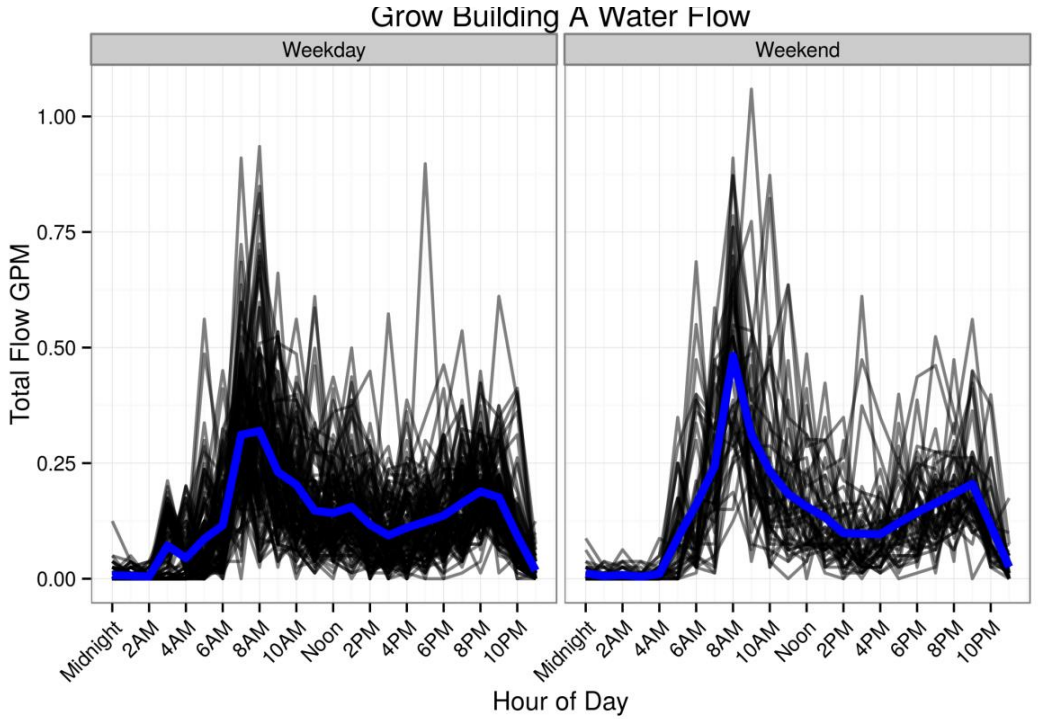


PILOT STUDY HEAT PLANTS

HOT WATER USAGE GROW BUILDING A 12 UNITS

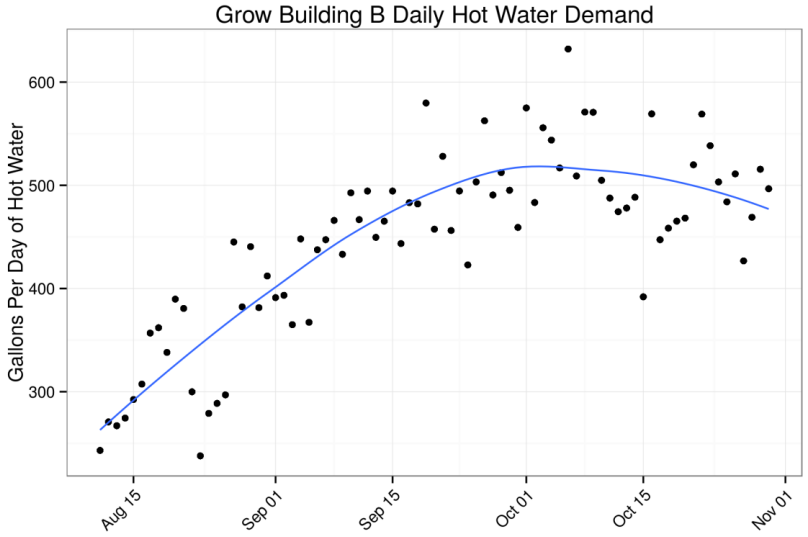
Building	# Occupants	Mean DHW/ Day	Hot Water /pp/day
A	18	250	13.9

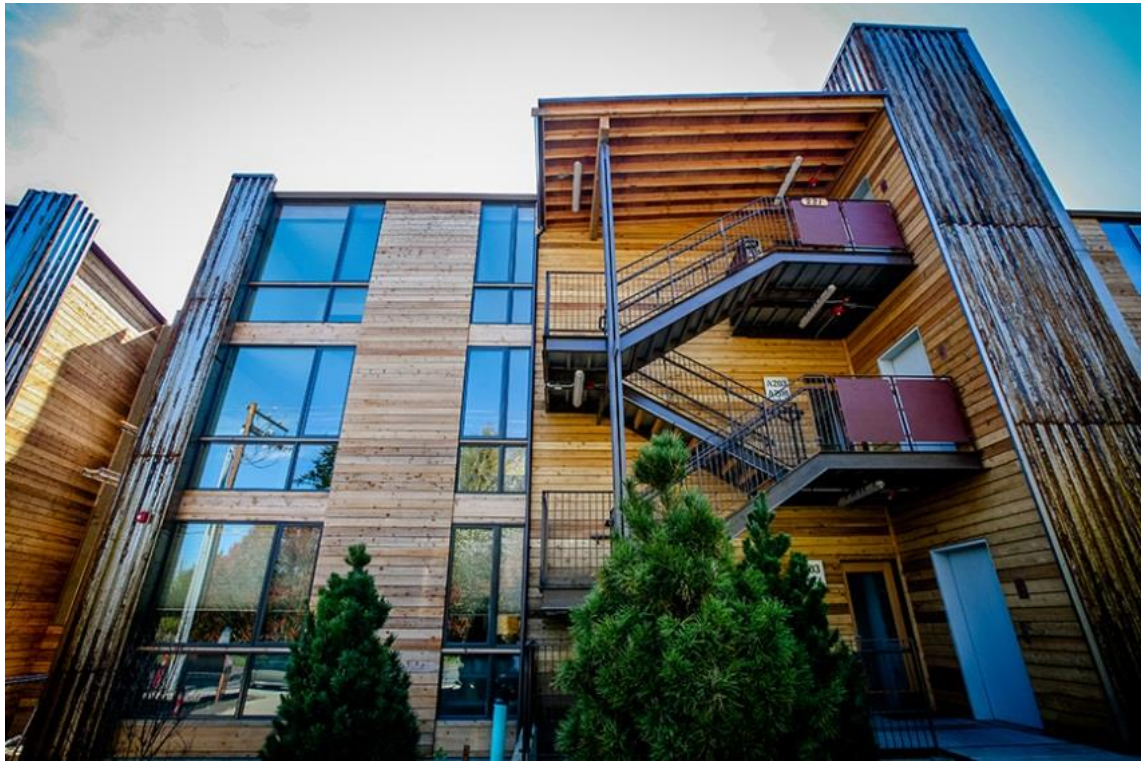


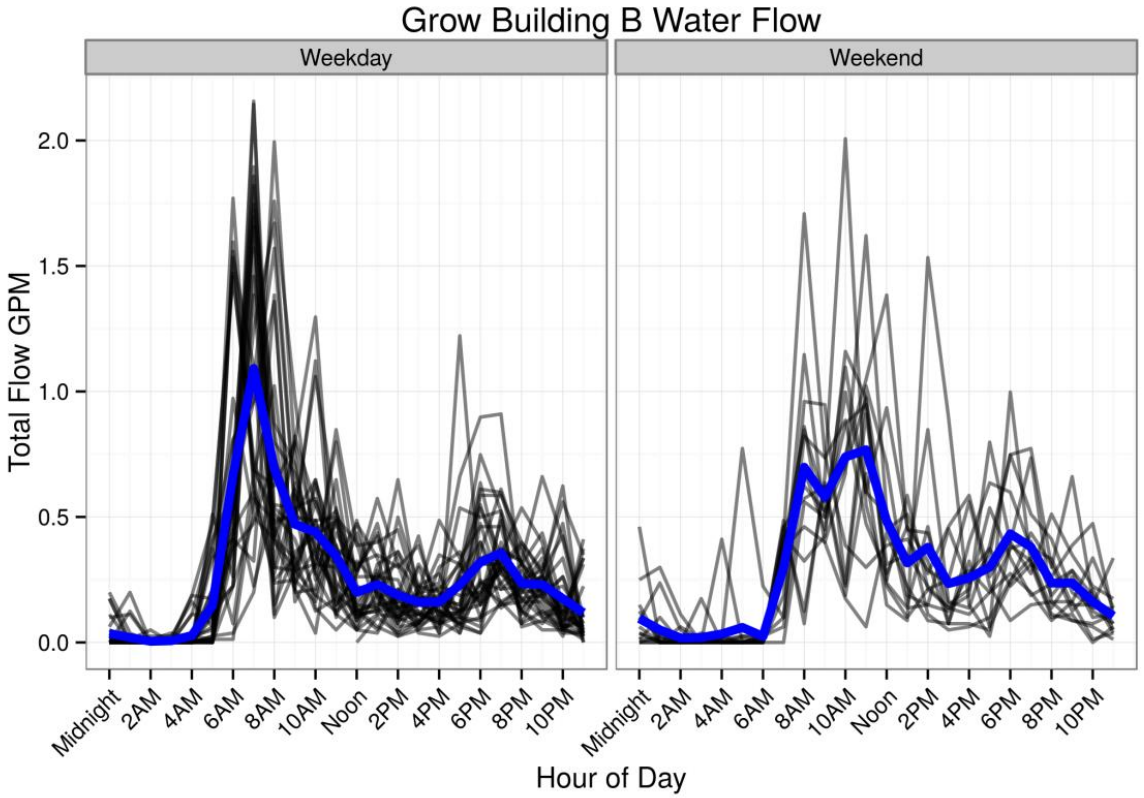


HOT WATER USAGE
GROW BUILDING B
12 UNITS

Building	# Occupants	Mean DHW/ Day	Hot Water /pp/day
B	30	490	16.3

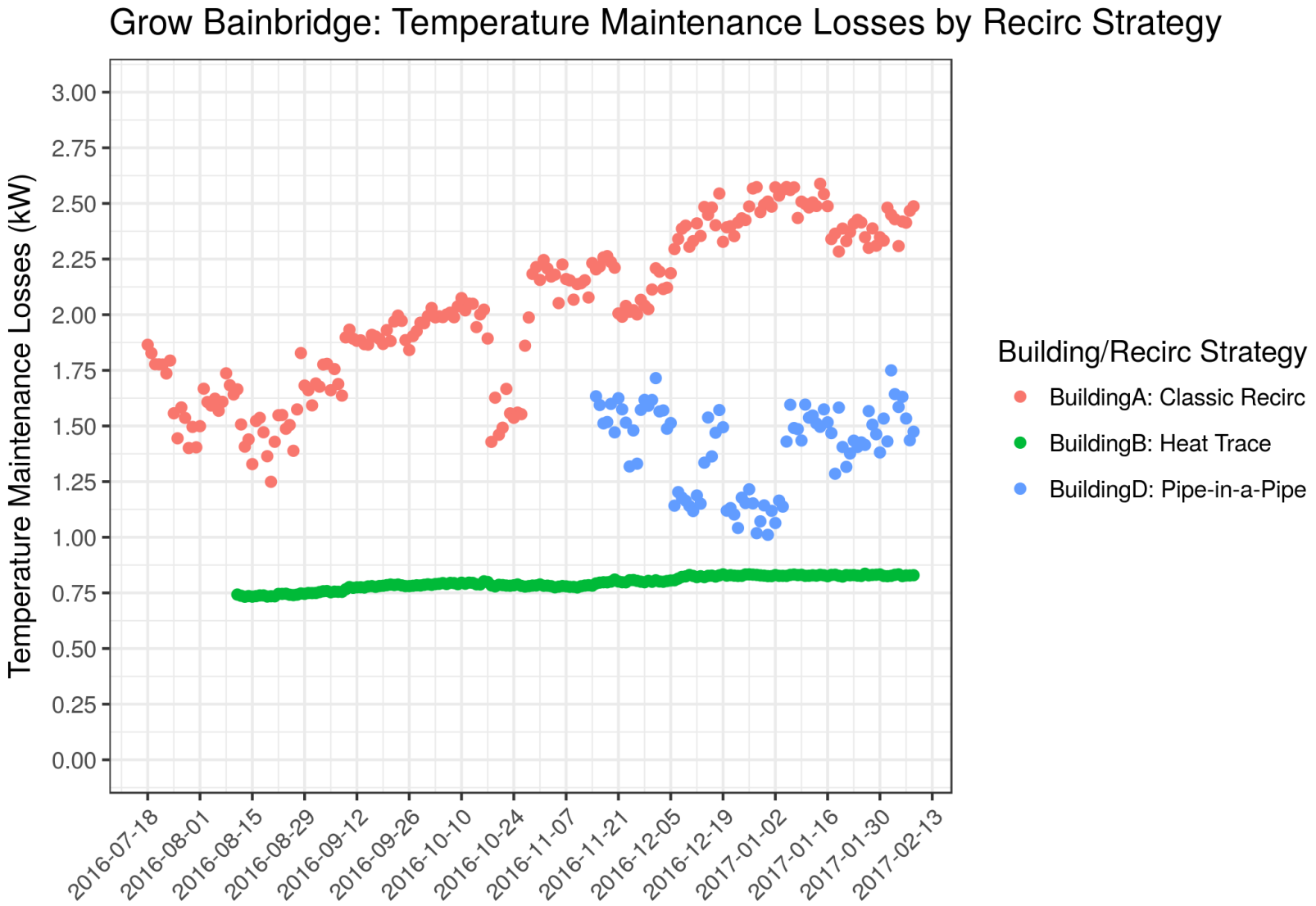


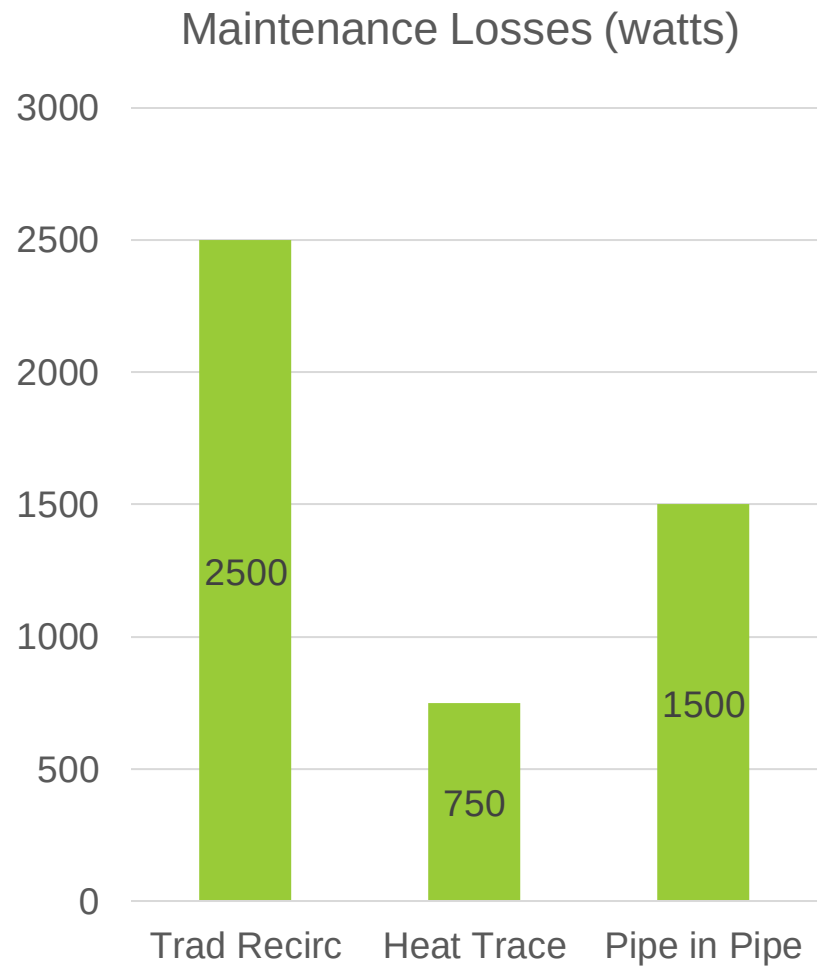


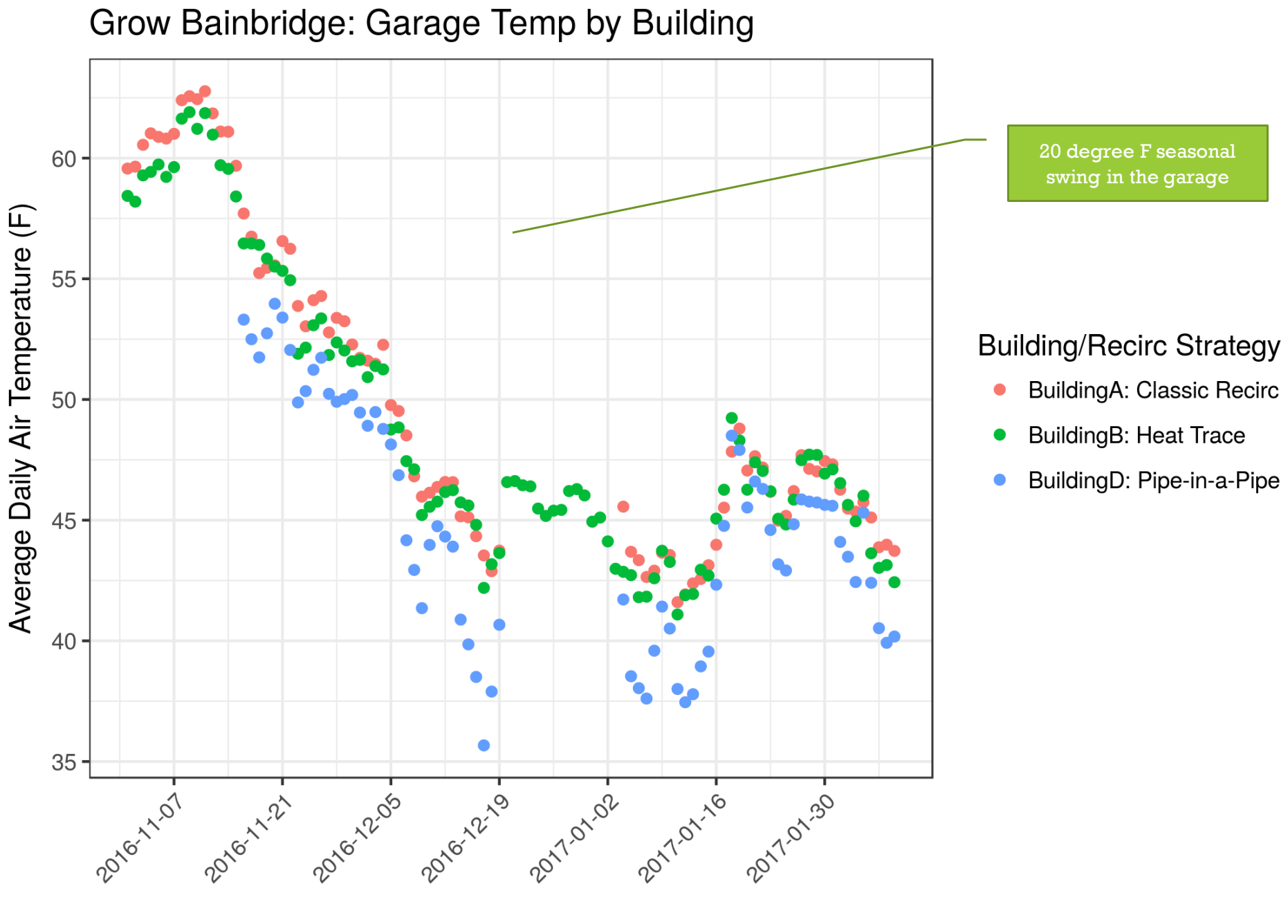


FINDINGS

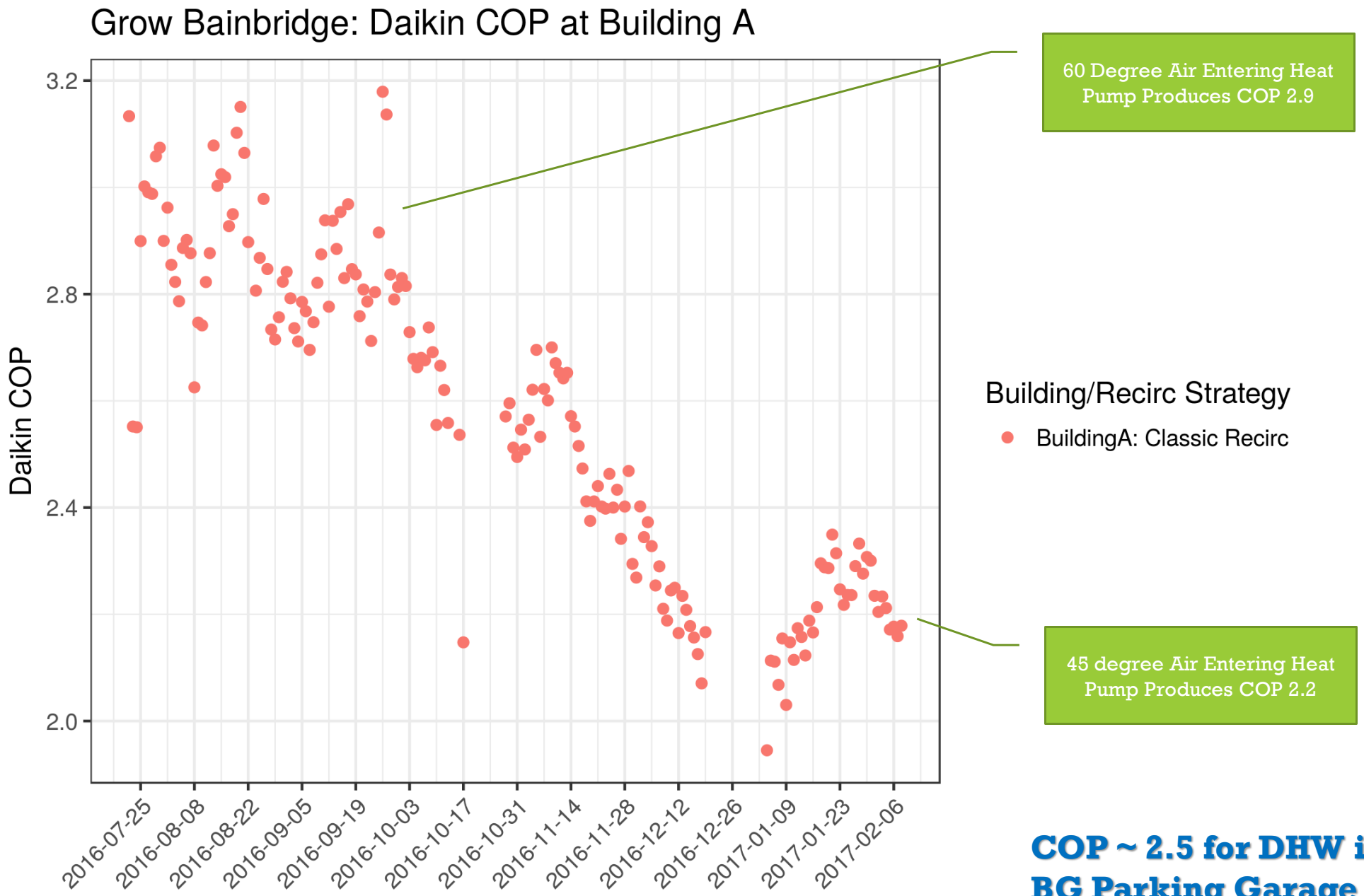
PRELIMINARY FINDINGS






Grow Bainbridge: Garage Temp by Building
Average Daily Air Temperature (F)
60
55
50
45
40
35
2016-11-07
2016-11-21
2016-12-05
2016-12-19
2017-01-02
2017-01-16
2017-01-30
20 degree F seasonal swing in the garage
Building/Recirc Strategy
BuildingA: Classic Recirc
BuildingB: Heat Trace
BuildingD: Pipe-in-a-Pipe

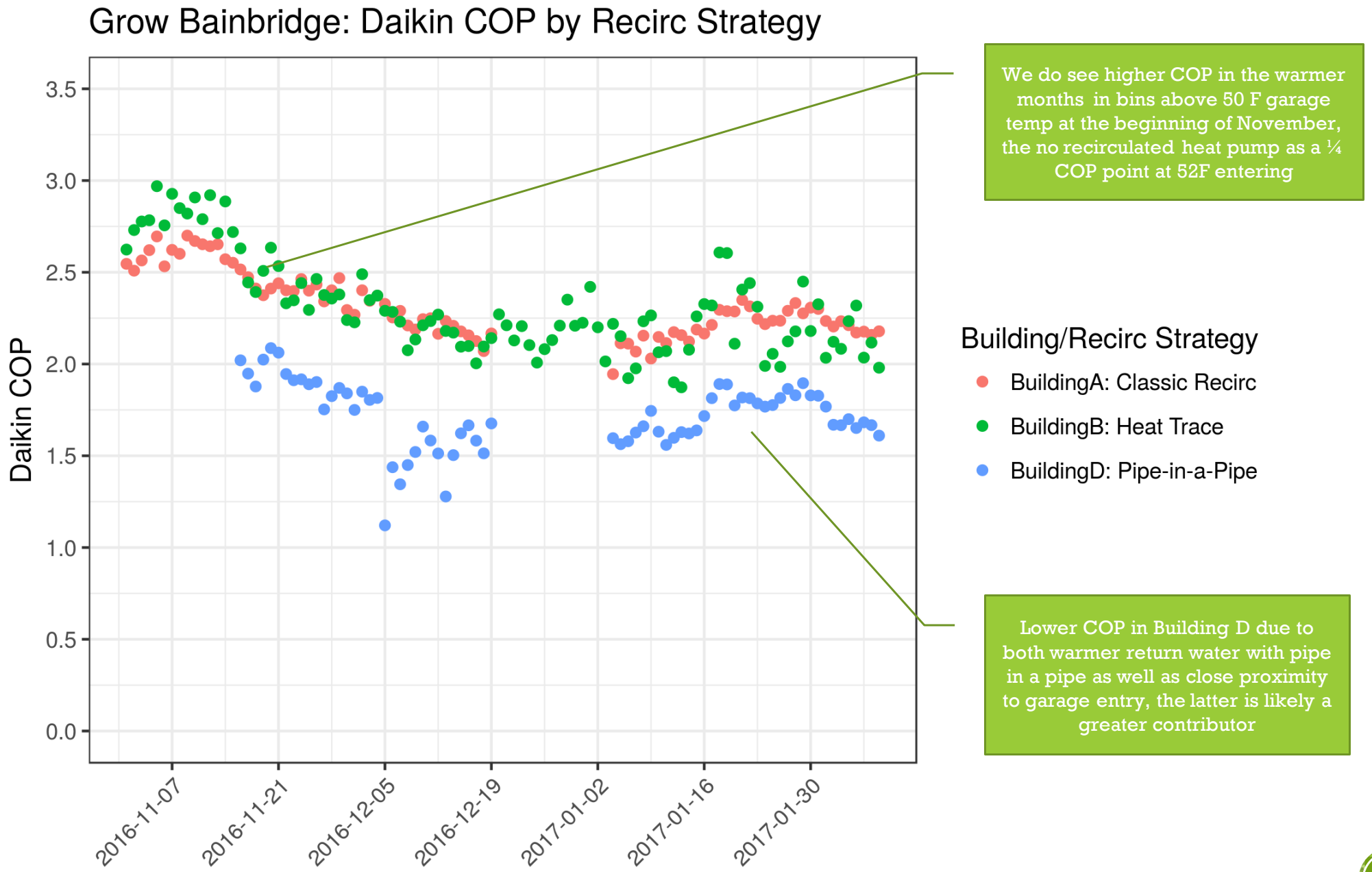
Grow Bainbridge: Smoothed Daily Recirc vs Hot Water Load



60 Degree Air Entering Heat Pump Produces COP 2.9

45 degree Air Entering Heat Pump Produces COP 2.2

COP ~ 2.5 for DHW in BG Parking Garage



We do see higher COP in the warmer months in bins above 50 F garage temp at the beginning of November, the no recirculated heat pump as a ¼ COP point at 52F entering

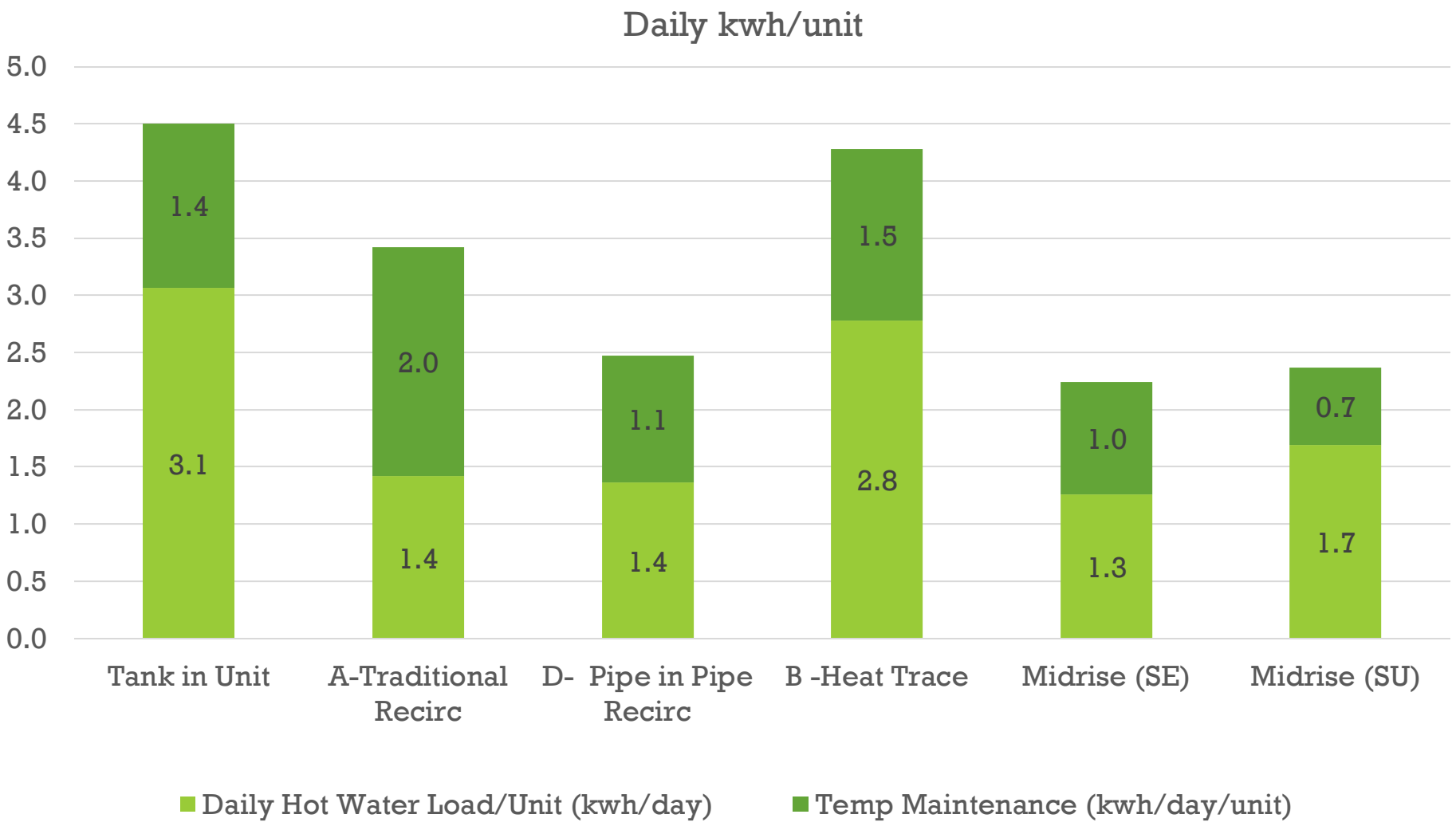
Lower COP in Building D due to both warmer return water with pipe in a pipe as well as close proximity to garage entry, the latter is likely a greater contributor

TABLED COMPARISON (6 BUILDINGS)

Temperature Maintenance (units).	Total Hot Water Use/day (gal/day)	Hot Water Use (kwh/day)	Daily Hot Water Usage Load/Unit (kwh/day)	Total Temp Maint. Heat Loss Rate (watts)	Daily Temp Maint. Load (kwh/day)	Temp Maint. (kwh/day/ unit)	% Temp Maint. To Hot Water Use Load	% Temp Maint. over Total DHW Load	TM Heat Loss Rate (Watts/unit)
N/A (Electric Tank In Unit)	18	3	3	60/unit	1.44	1.44	47%	32%	60
A-Traditional HWC	250	43	4	2500	60	5.00	141%	59%	208
D-Pipe in Pipe Recirc	260	44	3	1500	36	2.77	81%	45%	115
B-Heat Trace	490	83	7	750	18	1.50	22%	18%	63
Traditional HWC(92)	1530	260	3	8500	204	2.22	78%	44%	92
Traditional HWC(118)	2640	449	4	7500	180	1.53	40%	29%	64

DAILY DHW ENERGY/UNIT WITH COP

(ACTUAL USAGE AND LOSS/UNIT (NOT NORMALIZED)



Tank In Unit: Assumes Electric Resistance (ER) Tank in Unit, Approximate Losses, "Base-Case"

A-Traditional Recirc: Grow A, Traditional Recirc, Daikin Primary Water Heat to 120F, Electric Trim Included but hardly needed, 24/7 HWC Pump for TM. Losses are hidden when heat pump COP is applied. Low Hot Water Usage makes TM a larger fraction of the total load

D-Pipe In a Pipe Recirc: Grow D, Pipe in a Pipe Recirc, Daikin Primary Water Heat to 120F, Electric Trim Included but only used if Daikin has Error, 24/7 HWC Pump for TM. 45% Savings in Pipe in a Pipe for this install includes the garage horizontal runs (60%)

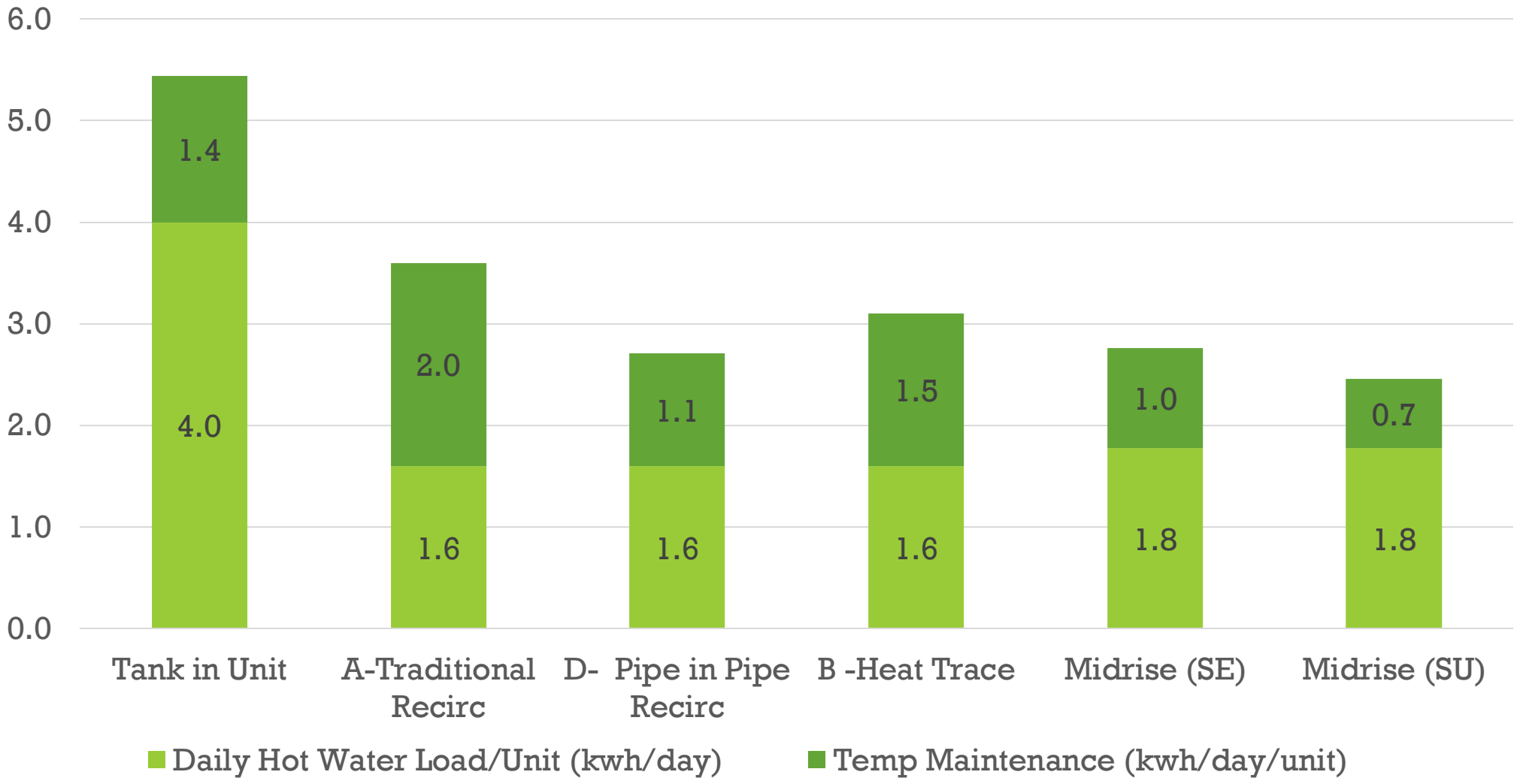
B- Heat Trace: Grow B. High Hot Water Usage compared to other buildings, Only a supply pipe used and heat tarce under insulation.

Midrise (SE): 92 Unit 6 story apartment in Seattle with a garage located Colmac Heat Pump Water Heating System, Traditional Recirc

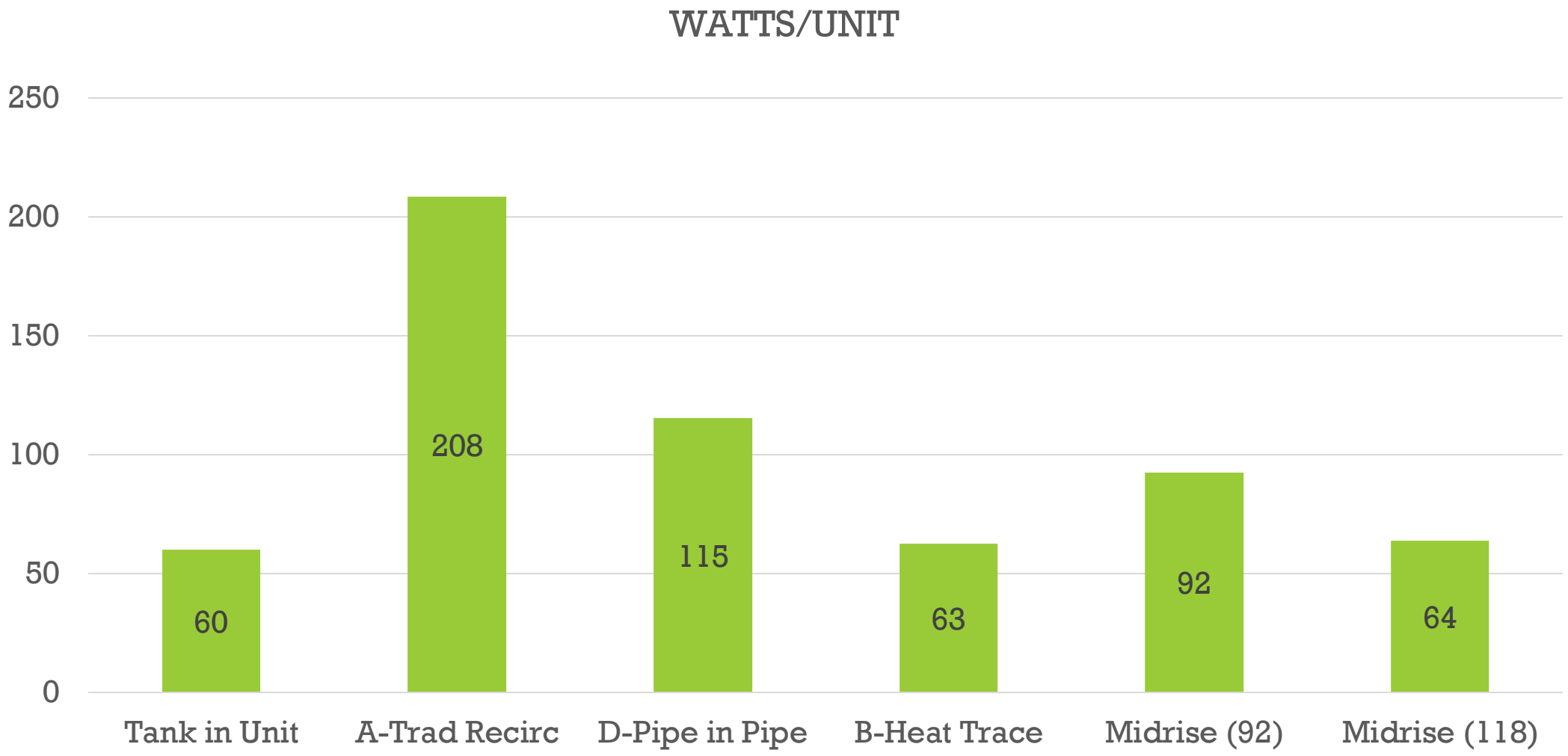
Midrise (SU): 118 Unit 6 story apartment in Seattle with a garage located Colmac Heat Pump Water Heating System, Traditional Recirc

DAILY ENERGY USAGE/UNIT

NORMALIZED TO EQUAL WATER USAGE

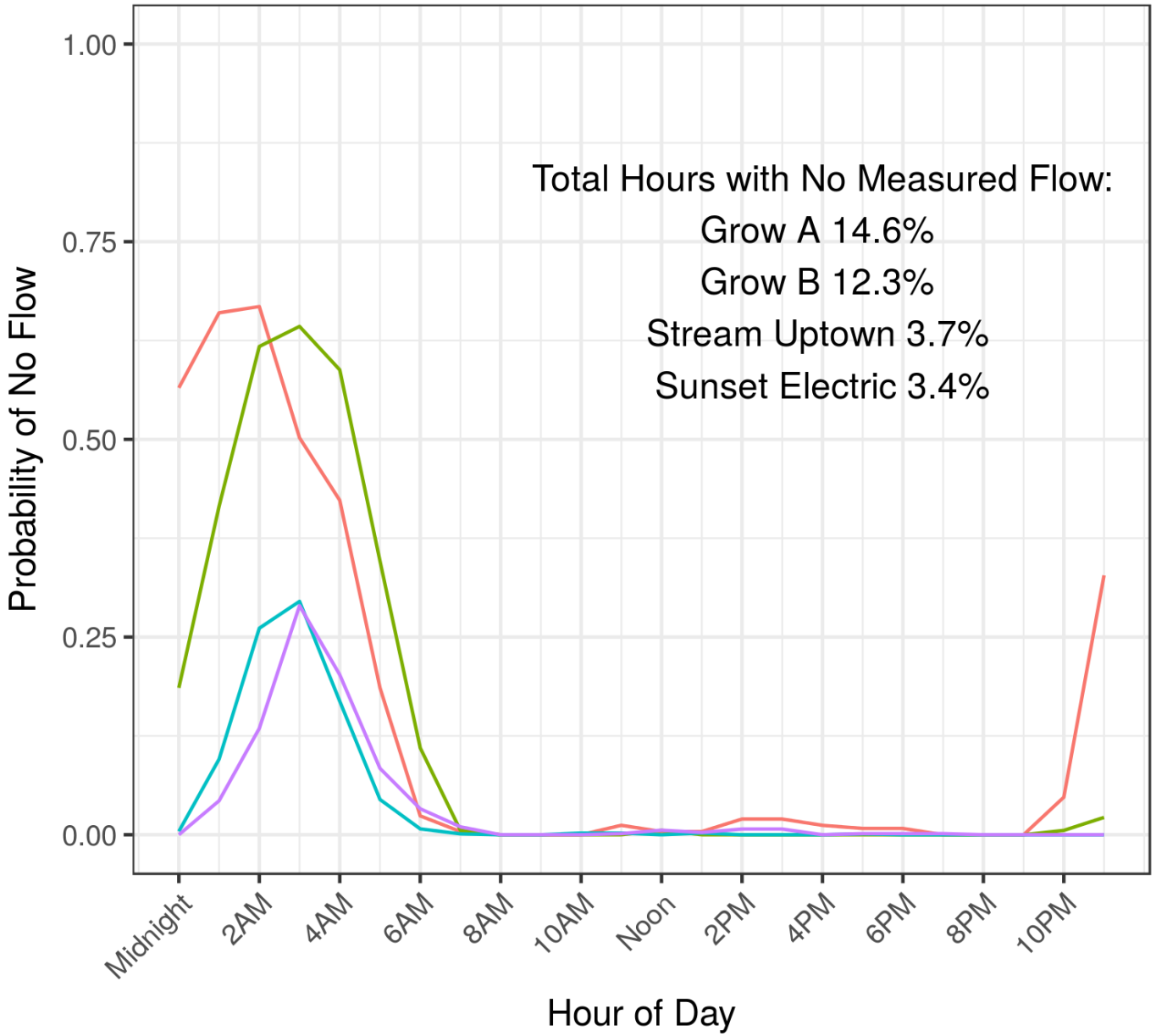


TEMPERATURE MAINTENANCE HEAT LOSS COMPARISONS



TEMPERATURE MAINTENANCE CONSIDERATIONS

- Recirculation Systems and Heat Pumps Can be Tricky, don't under-estimate simple.
- Heat Trace is a 20 year life will likely need to be replaced, good design can make this replacement simpler.
- Hot water recirculation systems built out of copper do develop pinhole leaks due to constant circulation and abrasive forces of water.
- Single Pass heat pump systems should consider heat trace and extra insulation as these systems work best without warm return water.
- Multi-pass heat pump systems should consider pipe in a pipe technology over traditional recirculation, cost effective.



PUMP CONTROL MEASURES ARE LIMITED

DESIGN APPROACH TO HIGH PERFORMANCE HOT WATER SYSTEMS

DESIGN CONSIDERATIONS
PROGRAMMING AND DESIGN

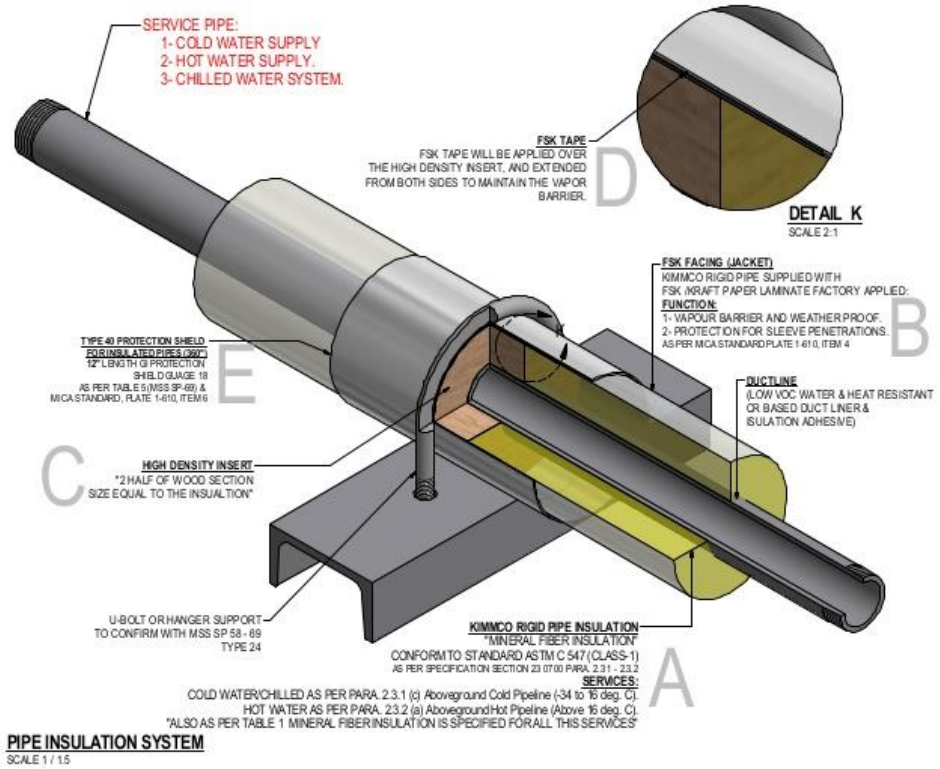
- Back to back bathrooms sharing a single stack reduces UA by factor of 2
- Locate hot water storage and primary distribution in heated space to capture losses for ½ the year
- Plan for super-insulated hot water piping runs, Risers- 2x8 studbays, Adequate room for insulated pipe clamps
- Consider Distributed Plants versus Single Central Plant. (closer to use, smaller piping)
- Use heat pumps when heating with utility provided power, lowest carbon

DESIGN CONSIDERATIONS

CONTINUOUS INSULATION – 2-3" THICK WALL, W/VB

DESIGN CONSIDERATIONS

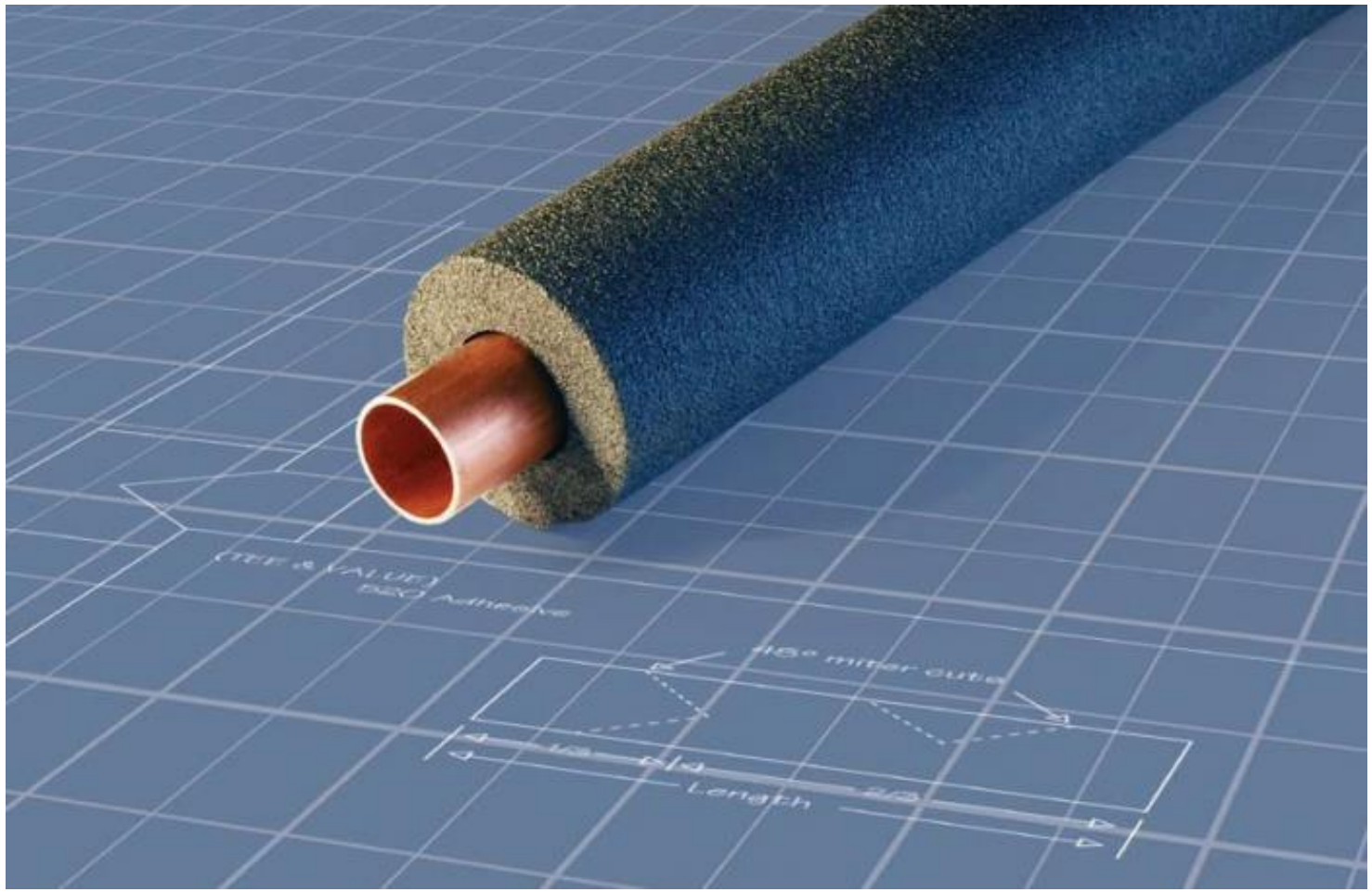
FULL PIPING INSULATION MOUNTS



DESIGN CONSIDERATIONS

INSULATION JACKETS ON TANKS AND VALVES

PIPING INSULATION REQUIREMENTS – TOO LOW



Delta T of 50-70 degrees year round
We insulate houses to R-20 and 30 for 1 week of 47F delta T
Pipe Insulation is Cost Effective, Need More

PASSIVLOOP

Super-Insulated Hot Water Storage and Distribution System that reduces losses from 75 Watts to 15 watts per unit. Increase U value by factor of 5

PassivLoop

- R-25 Insulation on central hot water piping
- R-25 jackets around storage tanks
- Eliminate Thermal Bridging on Pipe Mounts and Penetrations
- Hot Water Storage Tanks located inside heated space
- Insulated Valves and Pumps.
- 1 hot water stack per 2 back to back apartment stacks (1/2 UA)
- Consider small plant on each riser
- No Recirculation Systems (Use Heat Trace)

- Targeted losses are less than 15 Watts/apartment

ECOTOPE

Questions/Comments:

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