



# Save Water . . . Save Energy With Efficient Hot Water Delivery



# Presentation Overview



## Typical Systems

- in-unit electric or natural gas storage or tank-less
- heat pump water heaters per floor or cluster of apartments
- central recirculation
- central on demand

## Energy Savings

- modeling predictions
- real world results

## Water Savings

- tools for analysis
- continued monitoring
- the real cost of water

## Common Practice vs. Good Design

- typical distribution design
- efficient layout
- pipe insulation, fixtures

## Further Exploration On-Demand Recirculation

- in practice: Title 24; IECC; DOE ZERH, Passive House
- examples projects & results

## Moving Forward

- additional research, monitoring, measuring and qualifying results
- emerging technologies & controls





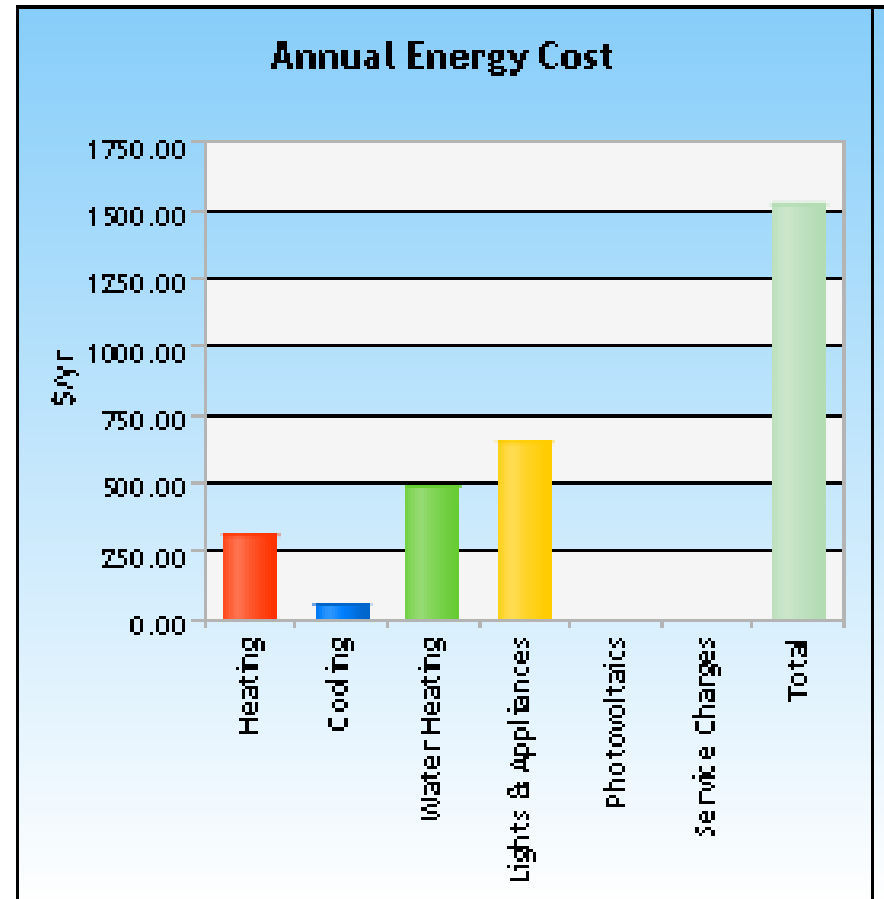
# Learning objectives

- Identify opportunities in layout, design and specifications
- Analyze tools to predict water and energy savings
- Explore alternative equipment and controls
- Evaluate success stories; verify, measure and qualify savings





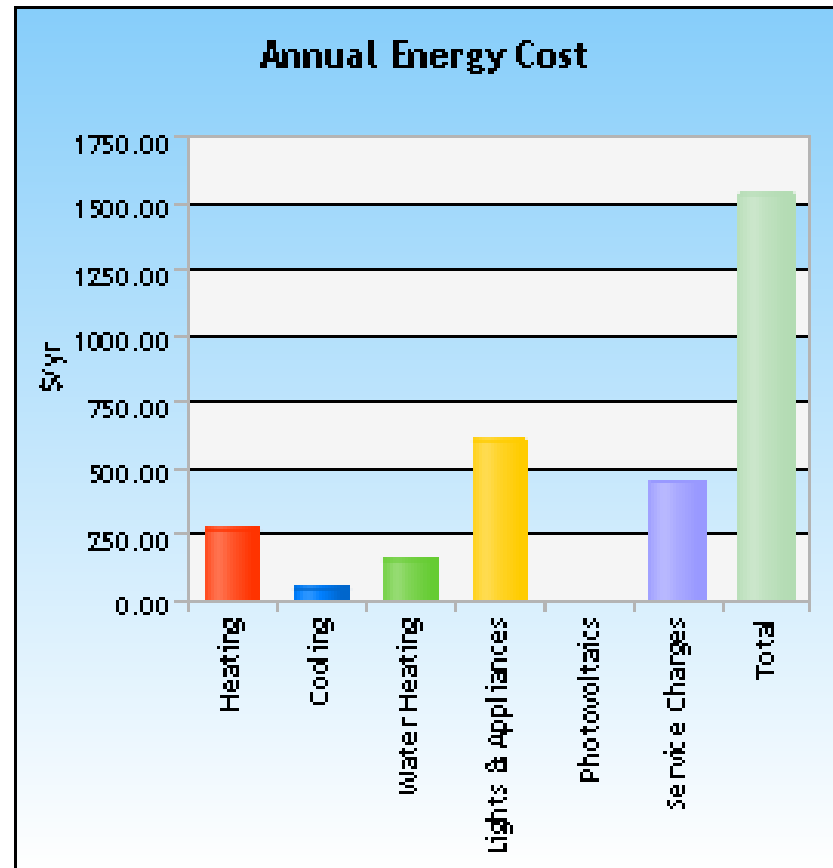
# What's Typical in Unit







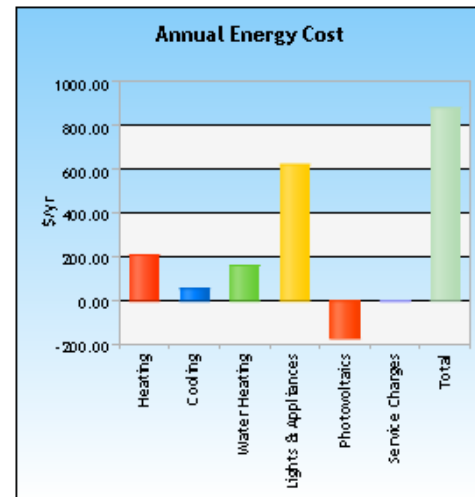
# What's Typical in Unit







# Less Typical







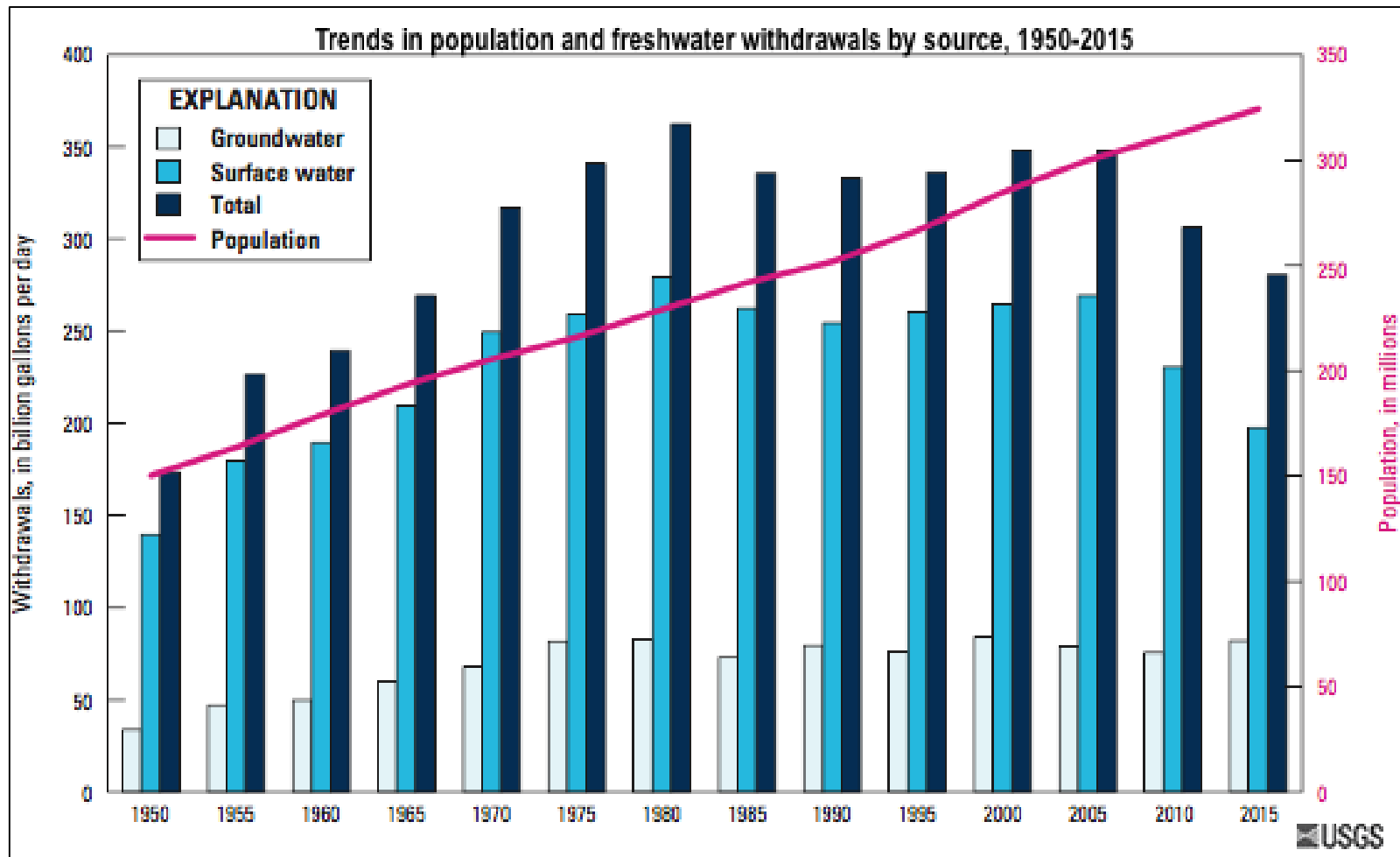
# Not So Typical in Unit







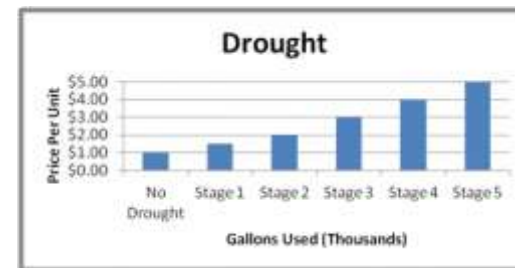
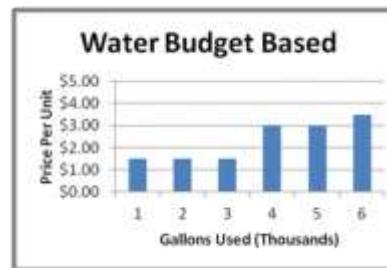
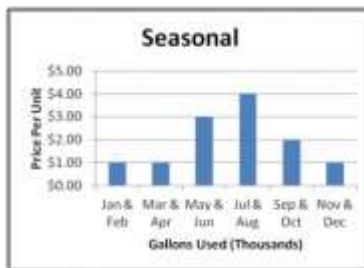
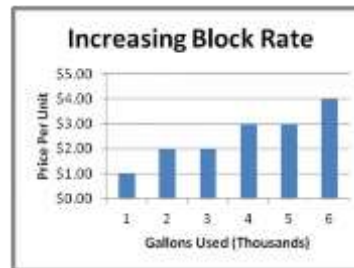
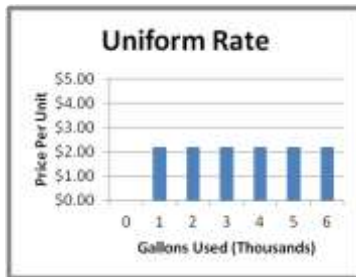
# Water Use vs. Population in the US





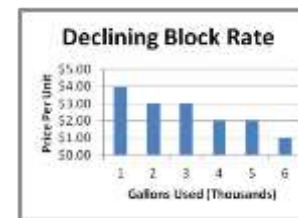
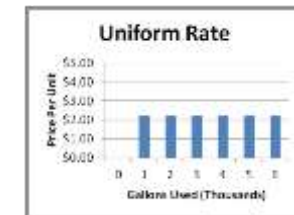
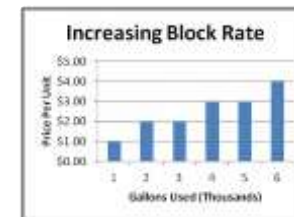
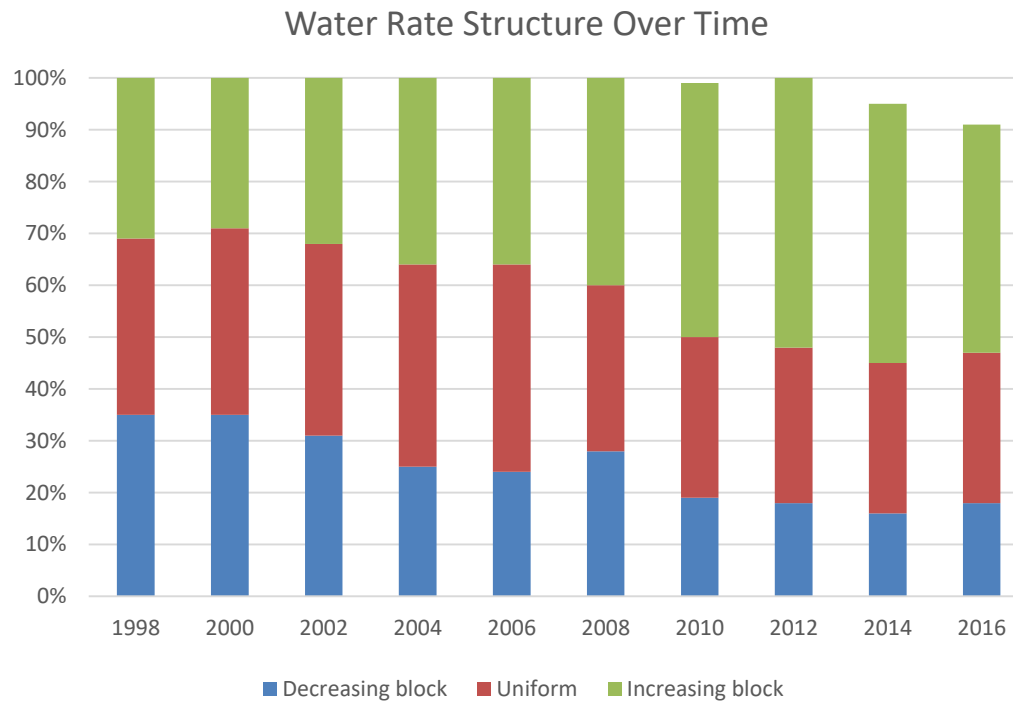


# How Are You Being Charged?



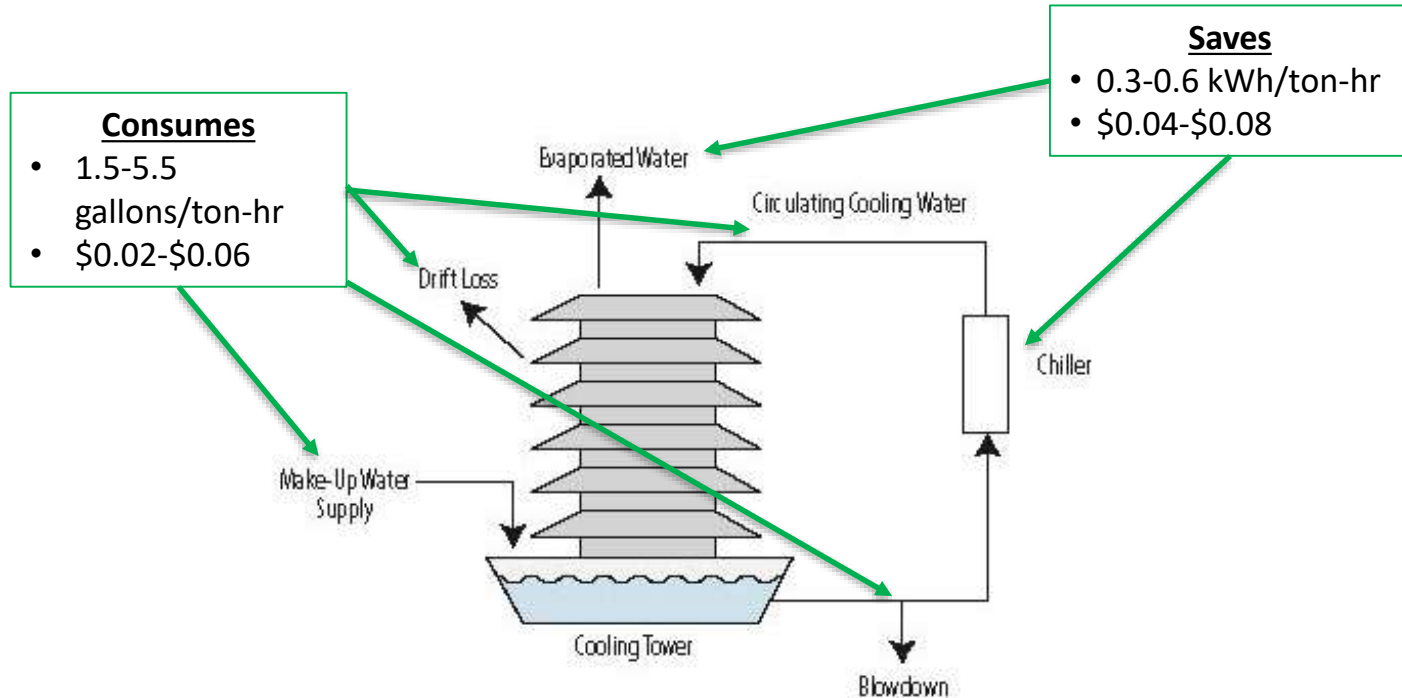


# Be Careful... It Could Change!





# Mechanical Systems: Cooling Towers





# Central DHW







# Certifications

- LEED v4 BD+C Homes & Multifamily Midrise



- PHIUS+



- DOE Zero Energy Ready Homes



- Water Sense Labeled





# Program Requirements



- Store no more than 0.5 gallons (1.9 liters) of water in any piping/manifold between the source and fixture
- For on-demand recirc systems the 0.5 gal storage limit is measured from the point where the branch feeding the fixture branches off the recirculation loop, to the fixture
- MF with central hot water recirculation loop, the storage limit is measured from the point where the branch feeding the apartment meets the loop (more than 1 branch to the central loop may serve an apartment)

Pipe type and distance (ft) required to meet 0.5 US Gallon EPA Water Sense Guideline								
Nominal Diameter Inches (In)	Copper M	Copper L	Copper K	CPVC CTS SDR11	CPVC SCH 40	PEX-Al-PEX ASTM F 1281	PE-Al-PE	PEX CTS SDR 9
3/8	60.38	65.98	76.19	n/a	54.70	101.59	101.59	100.00
1/2	37.87	41.29	44.14	51.20	33.86	48.85	48.85	54.24
3/4	18.66	19.88	22.07	23.97	18.93	18.88	18.88	27.23
1	11.02	11.66	12.38	14.45	11.57	11.51	11.51	16.37
1 1/4	7.36	7.66	7.91	9.68	6.63	7.54	7.54	11.02
1 1/2	5.25	5.41	5.59	6.94	4.85	4.61	4.61	7.91
2	3.04	3.11	3.19	4.05	2.93	2.98	2.98	4.62



# Program Requirements



- Store no more than 0.5 gallons (1.9 liters) of water in any piping/manifold

17. Central hot water delivery systems in multifamily buildings must include on-demand recirculation which operates based on:

- a demand indicator, **and**
- the loop water temperature

Verifiers must confirm:

- pump is installed with flow in the correct direction
- temperature sensors are installed



## Advisories:

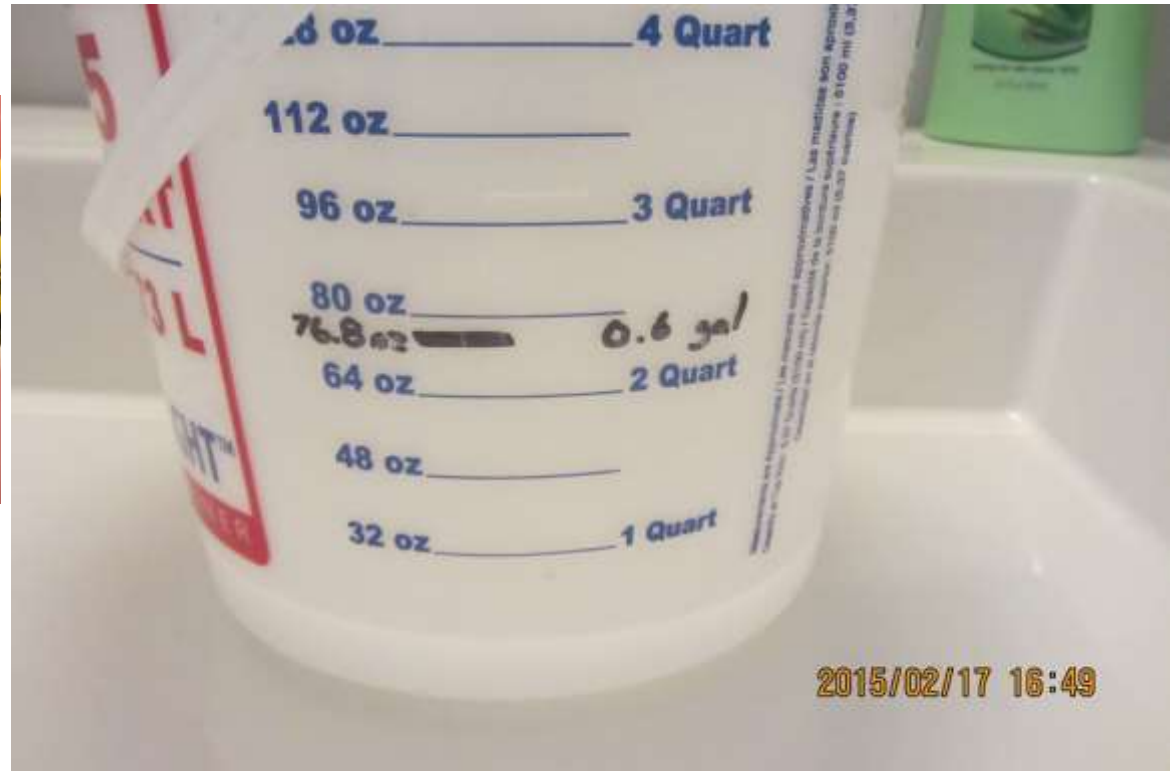
- Stored volume between the recirculation loop and the furthest fixture  $\leq 1.0$  gallon encouraged.
- R-4 pipe insulation encouraged
- Recirculation pump set to operate at a temperature which is at least 5° F less than the water heater set point temperature encouraged



# Program Requirements

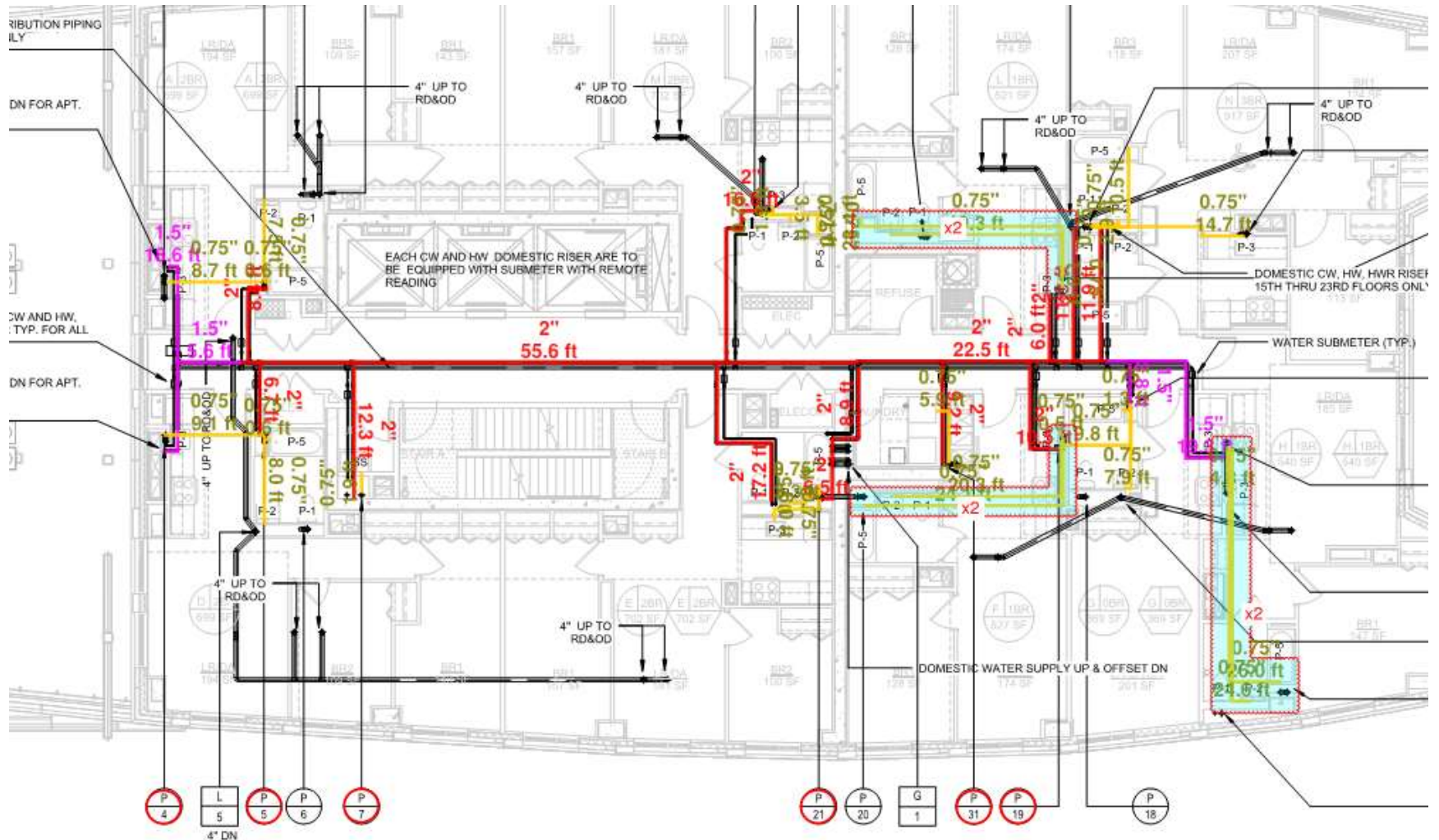


Test that the temperature has changed at least 10°F before 0.6 gallons is collected





# Program Requirements





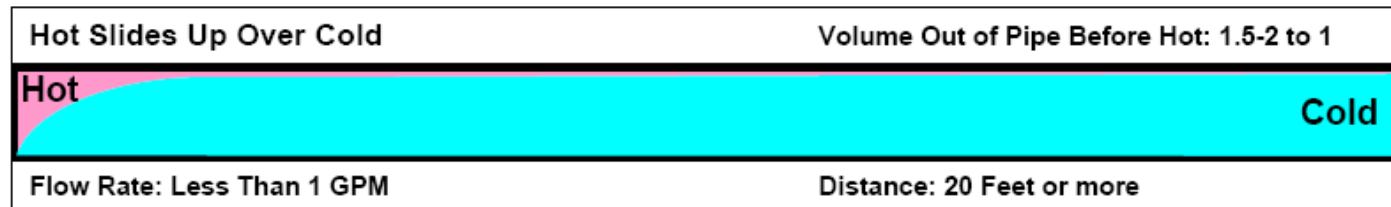
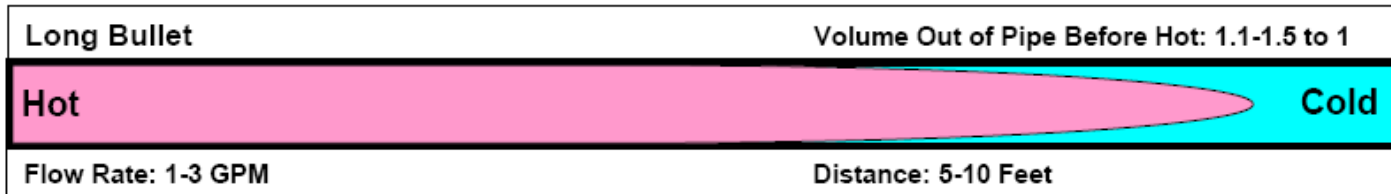
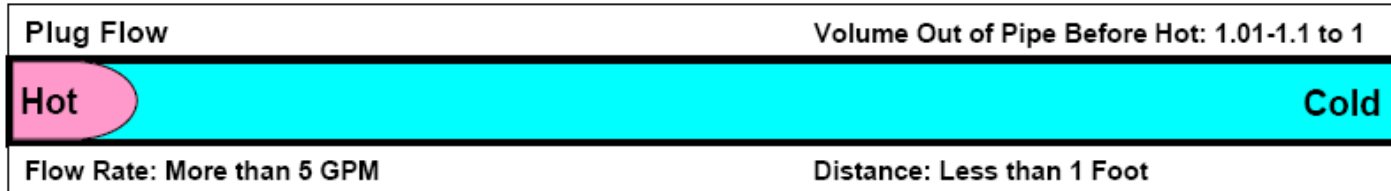
# What Else do we Know About Water?



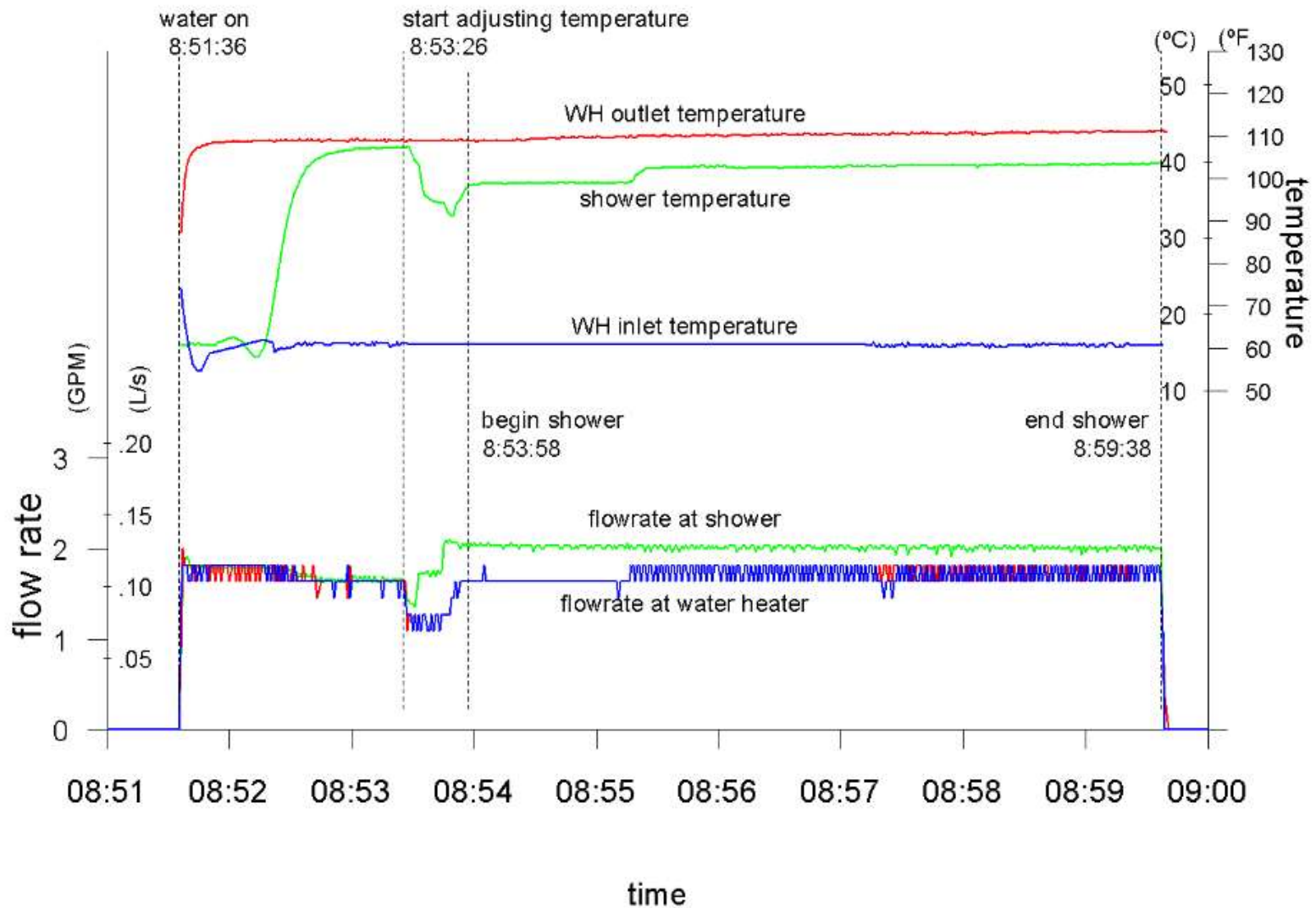
- Speed and temperature will impact how it moves in a building



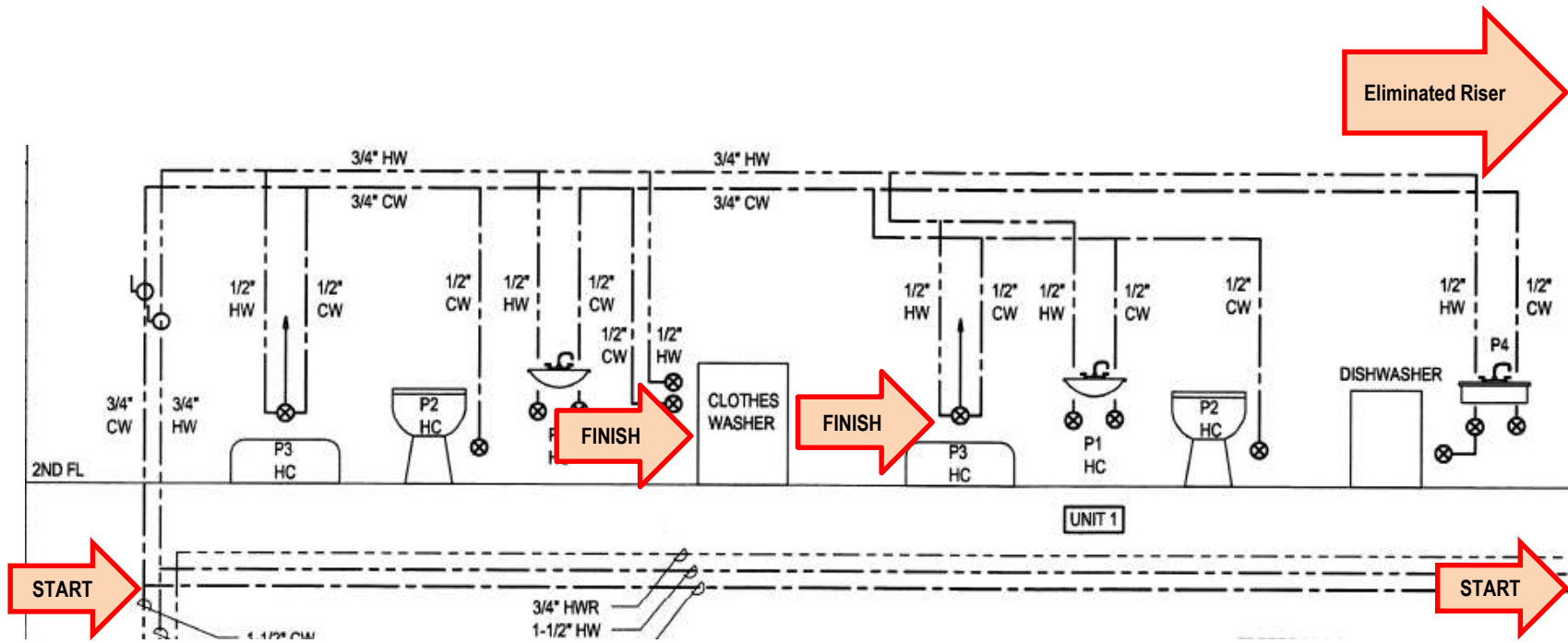
# Air Doesn't Move the Same Way at all Speeds, Why Should Water?



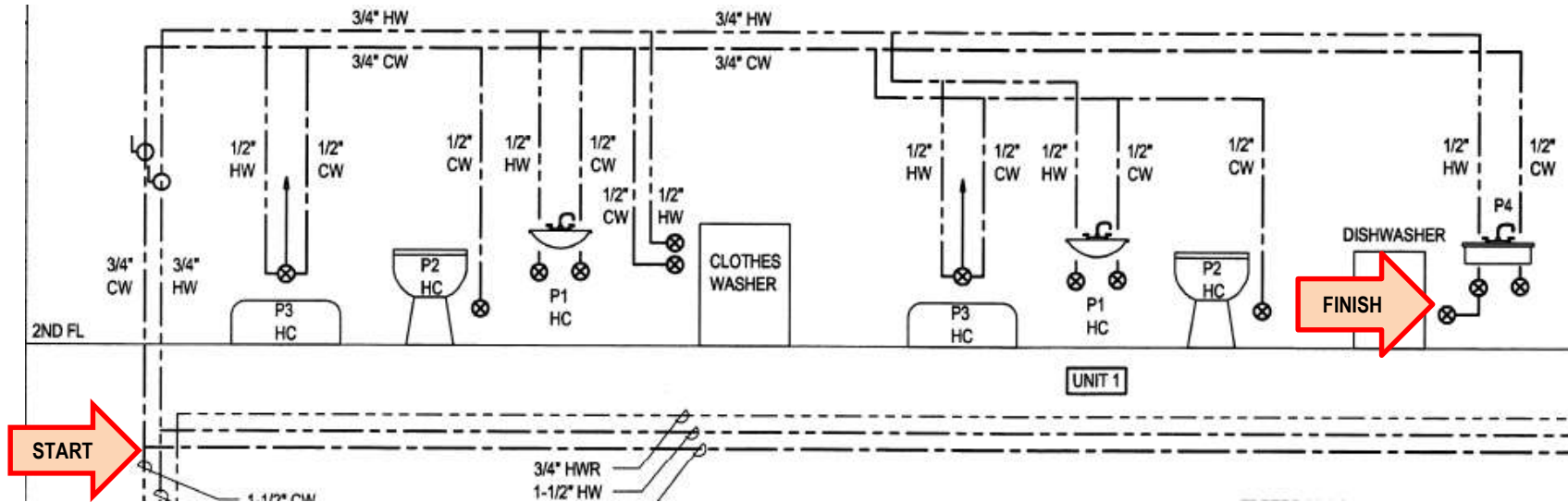












### Volume Calculations

3/4" Copper M piping: 3.43 oz/foot

58 foot run:  $3.43 \times 58 = 198.94$  oz

1/2" Copper M piping: 1.69 ounces/foot

5 foot run:  $1.69 \times 5 = 8.45$  oz

Total volume:  $198.94 + 8.45 = 207.39$  oz or  
1.62 gallons

### Wait Time/Waste Calculations

Total flow: 1.2 GPM

Hot/Cold mix: 50%

Hot water flow: 0.6 GPM

Total expelled volume:  $1.62 \times 2 = 3.24$

Total wait time:  $3.24 \text{ gal} / 0.6 \text{ gpm} = 5.4 \text{ min}$



# Performance & Safety Can be Impacted



Onsite pathogens harmful to human beings typically thrive

- In conditions that are similar to the human body
  - Ex legionella

< 20°C	Dormant
20-45°C	Can multiply
> 60°C	Can not survive

- Where age of water has increased and chlorine residual may be gone
- Scale or sediment exists to provide optimal environments for colonization

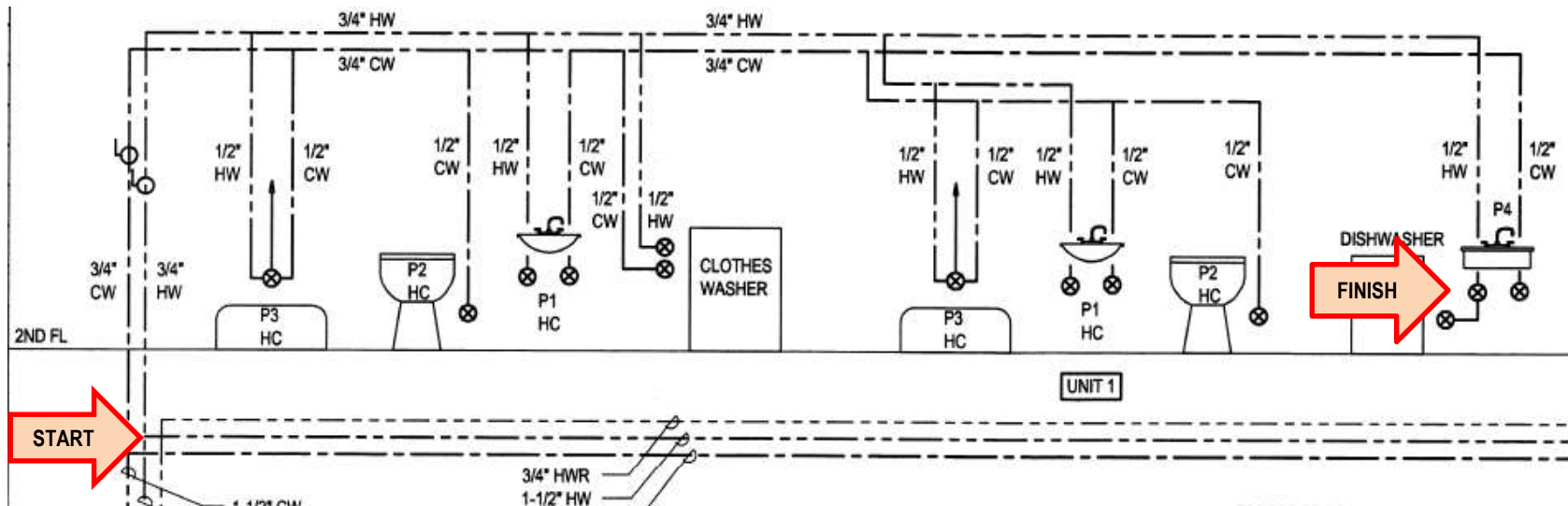


# Performance & Safety Can be Impacted



We're looking for

- Old water sitting around for long periods of time between 20 and 45°C (68-113°F) with an opportunity to colonize
- Residential buildings typically do not fall into this category because use is high and water is hot, nor does it diminish the benefits
- Does require a responsible approach



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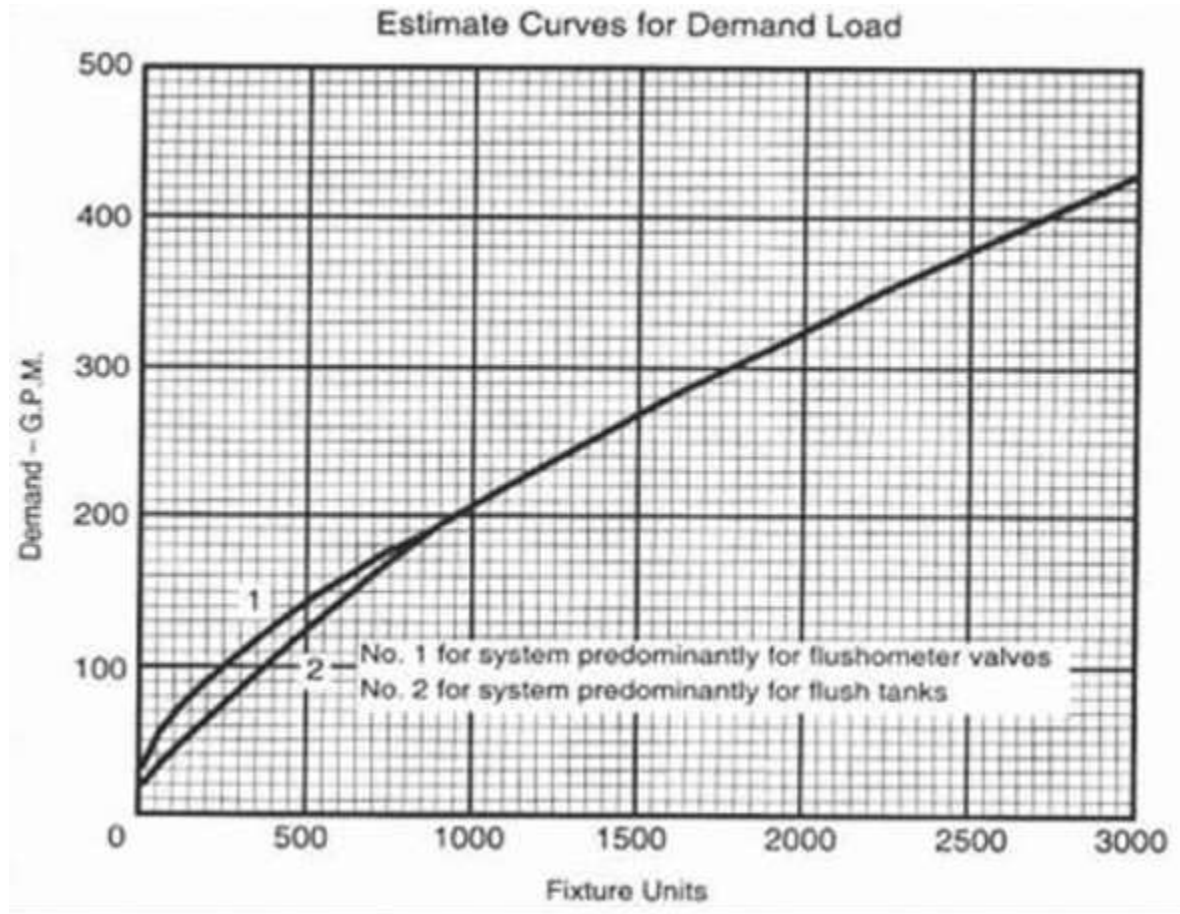
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# How Are Plumbing Systems Sized?



Hunter curves have been the basis for system sizing for decades.



# How Are Plumbing Systems Sized?

Hunter simplified a complicated probability calculation by converting everything to a standard “fixture unit” weighted for use probability before converting back to GPM.

Fixture	Fixture Units
Water closet (tank)	3
Lavatory faucet	1
Showerhead	2
Bath	2
Kitchen sink	2
Laundry tray	3
<b>Total</b>	<b>13</b>

13 fixture units would require about 10 GPM!



↓ Select Units ↓

Wednesday, October 10, 2018 3:14 PM

PROJECT NAME :

XXX-XXX

GPM

LPM

LPS

FIXTURE GROUPS	[A] FIXTURE		[B] ENTER NUMBER OF FIXTURES	[C] PROBABILITY OF USE (%)	[D] ENTER FIXTURE FLOW RATE (GPM)	[E] MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.0	5.5	5.5
	2	Bidet	0	1.0	2.0	2.0
	3	Combination Bath/Shower	0	5.5	5.5	5.5
	4	Faucet, Lavatory	0	2.0	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.5	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	0	1.0	3.0	3.0
Kitchen Fixtures	7	Dishwasher	0	0.5	1.3	1.3
	8	Faucet, Kitchen Sink	0	2.0	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	0	5.5	3.5	3.5
	10	Faucet, Laundry	0	2.0	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.0	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.0	0.0	6.0
	13	Fixture 2	0	0.0	0.0	6.0
	14	Fixture 3	0	0.0	0.0	6.0

Total Number of Fixtures 0

99<sup>th</sup> PERCENTILE DEMAND FLOW = GPM

RESET

RUN WATER  
DEMAND  
CALCULATOR

↑ CLICK BUTTON ↑





# The Water Demand Calculator

Wednesday, October 10, 2018 3:23 PM

PROJECT NAME :

Select Units

GPM LPM LPS

FIXTURE GROUPS	[A] FIXTURE	[B] ENTER NUMBER OF FIXTURES	[C] PROBABILITY OF USE (%)	[D] ENTER FIXTURE FLOW RATE (GPM)	[E] MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1 Bathtub (no Shower)	0	1.0	5.5	5.5
	2 Bidet	0	1.0	2.0	2.0
	3 Combination Bath/Shower	0	5.5	5.5	5.5
	4 Faucet, Lavatory	1	2.0	1.5	1.5
	5 Shower, per head (no Bathtub)	0	4.5	2.0	2.0
	6 Water Closet, 1.28 GPF Gravity Tank	1	1.0	3.0	3.0
Kitchen Fixtures	7 Dishwasher	0	0.5	1.3	1.3
	8 Faucet, Kitchen Sink	1	2.0	2.2	2.2
Laundry Room Fixtures	9 Clothes Washer	1	5.5	3.5	3.5
	10 Faucet, Laundry	0	2.0	2.0	2.0
Bar/Prep Fixtures	11 Faucet, Bar Sink	0	2.0	1.5	1.5
Other Fixtures	12 Fixture 1	1	4.5	1.5	6.0
	13 Fixture 2	0	0.0	0.0	6.0
	14 Fixture 3	0	0.0	0.0	6.0

Total Number of Fixtures 5

99<sup>th</sup> PERCENTILE DEMAND FLOW = 5.7 GPM

RESET

RUN WATER  
DEMAND  
CALCULATOR

The calculator yields a flow rate of 5.7 GPM for the same combination of fixtures.



# The Heights at Darien

## Darien, CT



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# HVAC Options



REM/Rate v 14.5.1 - 3A Allen O'Neill\_v14.4.blg

File Building View Extras Libraries Reports Tools Help

Mechanical Equipment Properties Summary

#	Type	Htg Eff	Clg Eff	Dhw Eff
1	18K,8.2 HSPF,14.2SEE*	8.2 HSPF	14.2 SEER	
2	Elec, ST, 40gal, 92%			0.92 EF

New Delete Copy

Mechanical Equipment Properties

Library Type: Air-Source Heat Pump Number of Units: 1

Equipment: 18K,8.2 HSPF,14.2SEE\* Location: Conditioned area

Performance Adj. (%): 100.0 Load Served (%): Heating 100.0 Cooling 100.0 DHW 0.0

System-Wide Properties

Setpoint Temperature (F): Heating 68.0 Cooling 78.0 DHW

Programmable Thermostat: ☒ Heating ☒ Cooling

Capacity Weight % of Load Served: ☒ Heating ☒ Cooling ☒ DHW

Total Load Served (must total 100%): Heating 100 Cooling 100 DHW 100

Errors/Warnings

Analysis

Updated: 07:01:30 AM

Programs

V2.0 ENERG...	Passes
V2.5 ENERG...	Fails
V3.0 ENERG...	Passes
V3.0* ENER...	Fails
V3.1 ENERG...	Fails
Tax Credit	Fails
DOE Zero En...	Fails
HERS Index	75
NY HERS Sc...	N/A

Code

IECC 2012 E...	Fails
IECC 2009 E...	Passes
IECC 2006 E...	Fails
IECC 2004 E...	Passes
IECC 2003 E...	Passes
IECC 2001 E...	Passes
IECC 2000 E...	Passes
IECC 1998 E...	Passes
ECCCNYS-2...	Fails
ECC of South...	Passes
MEC 1995 E...	Passes
MEC 1993 E...	Passes
MEC 1992 E...	Passes
ASHRAE 90...	Passes





# The Heights at Darien

## Darien, CT





# Crescent Crossings Bridgeport, CT

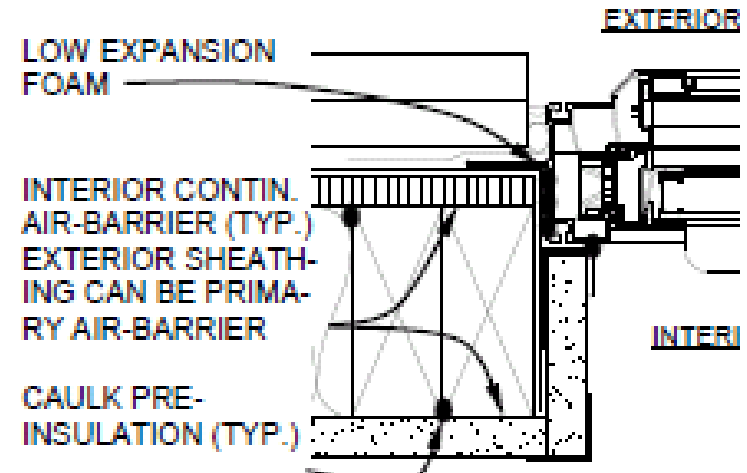
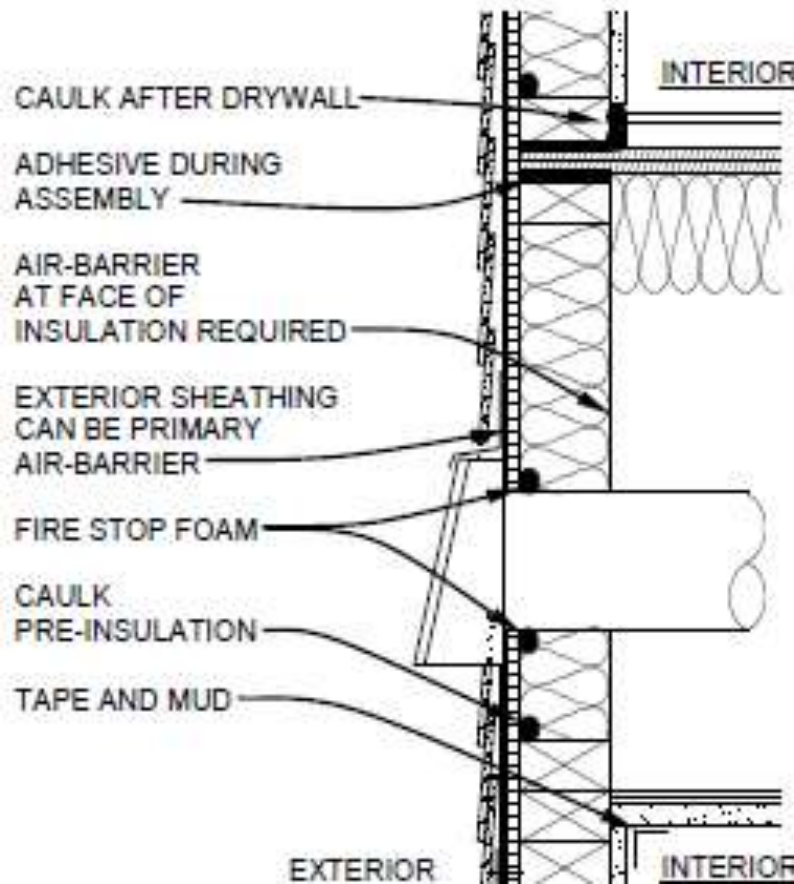


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# Construction Details



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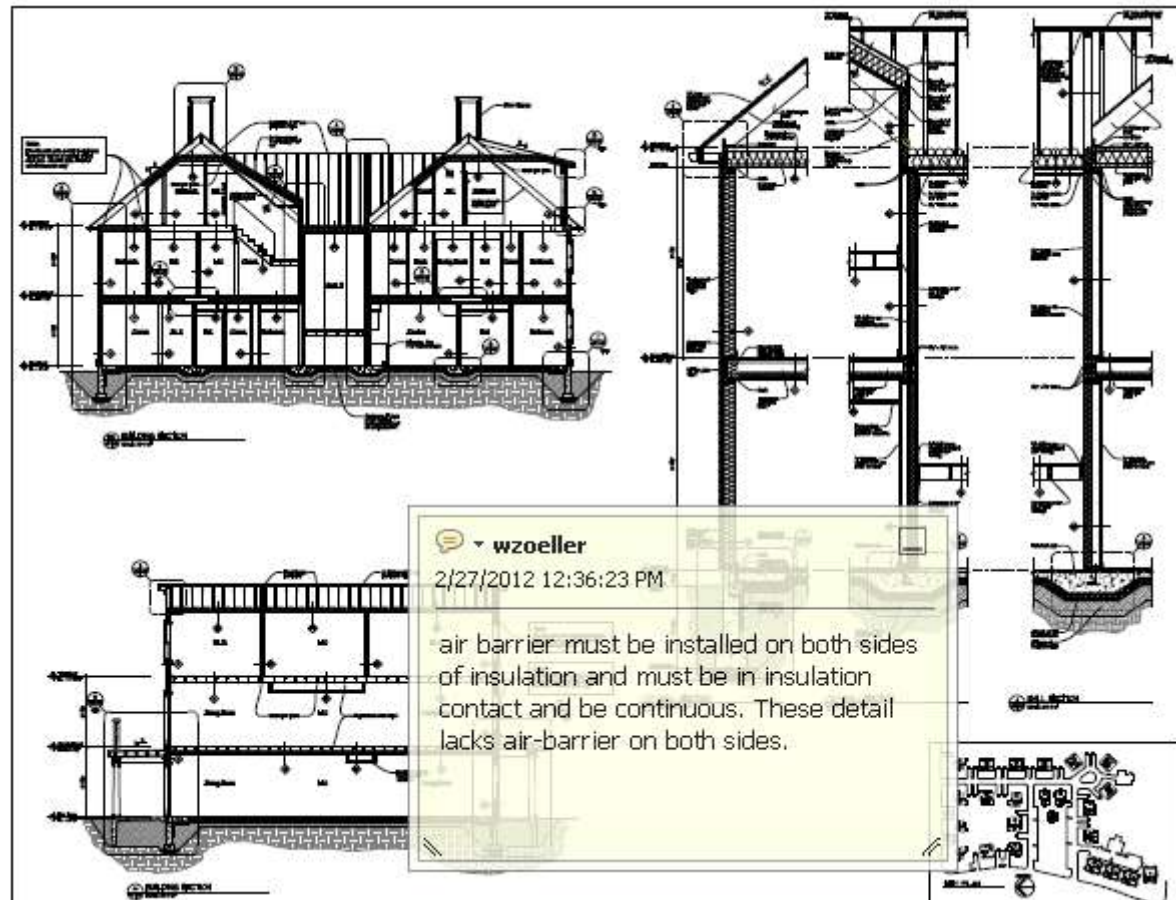
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# Construction Details





# Construction Details



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# Certifications

## Home Energy Rating Certificate

### Property

Bldg 8 Crescent Crossing  
Crescent Crossing, LLC  
160 Church St. Bldg 8 #101  
Bridgeport, CT 06604

### HERS

Rating Type: Confirmed  
Rating Date: 12/2/2016  
Registry ID: 254468779

Certified Energy Rater: Matt Slattery  
Rating Number:

HERS Index: 57

Efficient Home Comparison: 43% Better

### General Information

Conditioned Area	698 sq. ft.	House Type	Apartment, inside unit
Conditioned Volume	5584 cubic ft.	Foundation	Slab
Bedrooms	1		

### Mechanical Systems Features

Heating:	Fuel-fired air distribution, Natural gas, 96.1 AFUE.
Cooling:	Air conditioner, Electric, 16.0 SEER.
Water Heating:	Instant water heater, Natural gas, 0.96 EF, 0.0 Gal.
Duct Leakage to Outside	40.00 CFM25.
Ventilation System	Exhaust Only: 23 cfm, 5.0 watts.
Programmable Thermostat	Heat=Yes; Cool=Yes

### Building Shell Features

Ceiling Flat	NA	Slab	R-10.0 Edge, R-10.0 Under
Sealed Attic	NA	Exposed Floor	NA
Vaulted Ceiling	NA	Window Type	U-Value: 0.290, SHGC: 0.290
Above Grade Walls	R-27.5	Infiltration Rate	Htg: 736 Clg: 736 CFM50
Foundation Walls	NA	Method	Blower door test

### Lights and Appliance Features

Percent Interior Lighting	100.00	Range/Oven Fuel	Electric
Percent Exterior Lighting	100.00	Clothes Dryer Fuel	Electric
Refrigerator (kWh/yr)	415	Clothes Dryer EF	3.01
Dishwasher Energy Factor	0.78	Ceiling Fan (cfm/Watt)	0.00

### Estimated Annual Energy Cost

Use	MMBtu	Cost	Percent
Heating	4.2	\$151	12%
Cooling	3.0	\$46	4%
Hot Water	2.4	\$137	11%
Lights/Appliances	11.0	\$495	39%
Photovoltaics	-0.0	\$-0	-0%
Service Charges		\$453	35%
Total	20.6	\$1282	100%

### Criteria

This home meets or exceeds the minimum criteria for the following:  
EPA ENERGY STAR Version 3 Home  
EPA ENERGY STAR Version 3.1 Home



### HERS Provider:

Steven Winter Associates, Inc.  
61 Washington Street  
Norwalk, CT 06854  
203.857.0200

### Certified Energy Rater:

REM/Rate - Residential Energy Analysis and Rating Software v14.6.4

This information does not constitute any warranty of energy cost or savings. © 1985-2016 Noresco, Boulder, Colorado.  
The Home Energy Rating Standard Disclosure for this home is available from the rating provider.

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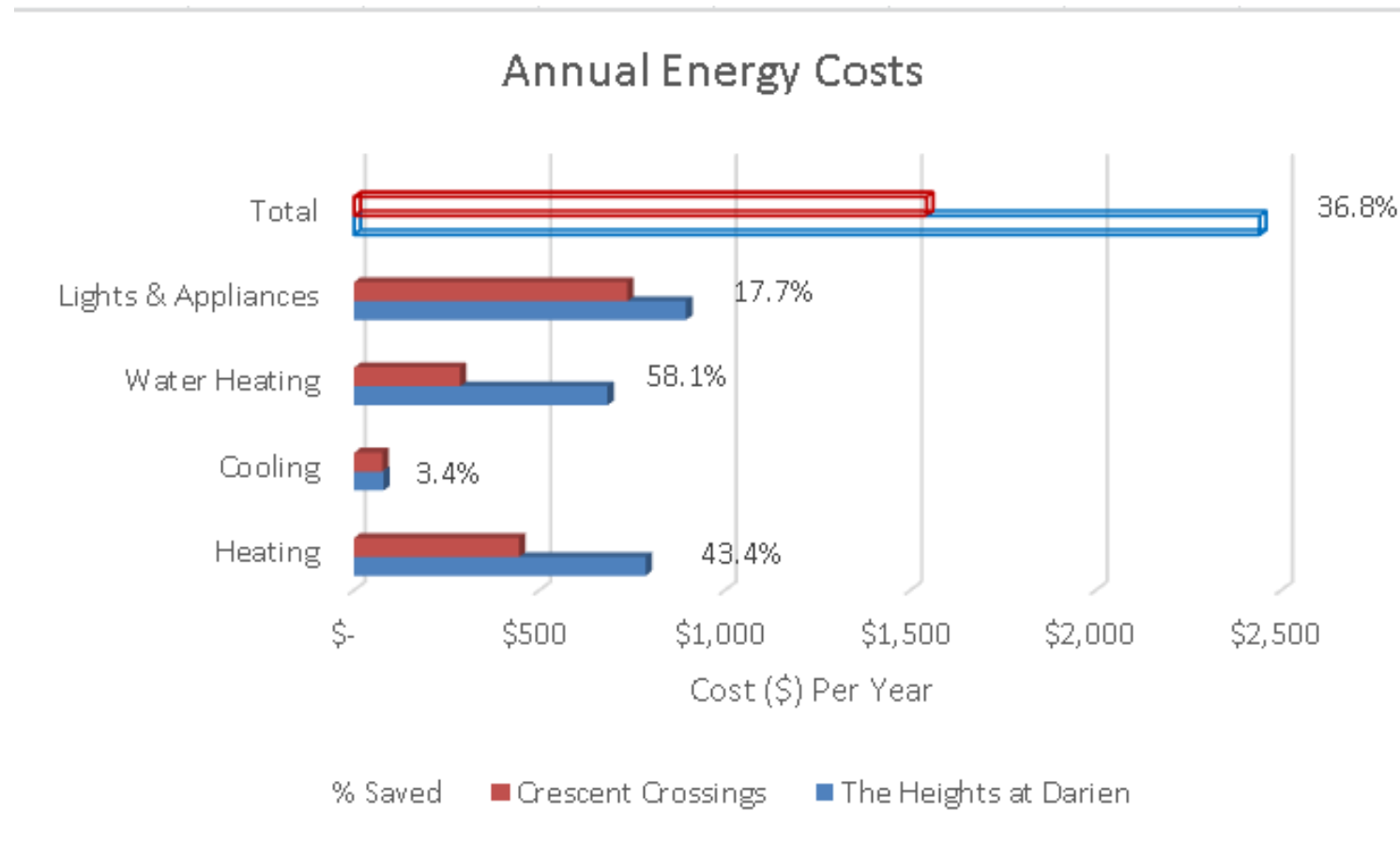
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# Energy Comparison





# Old Town Hall Homes Darien, CT



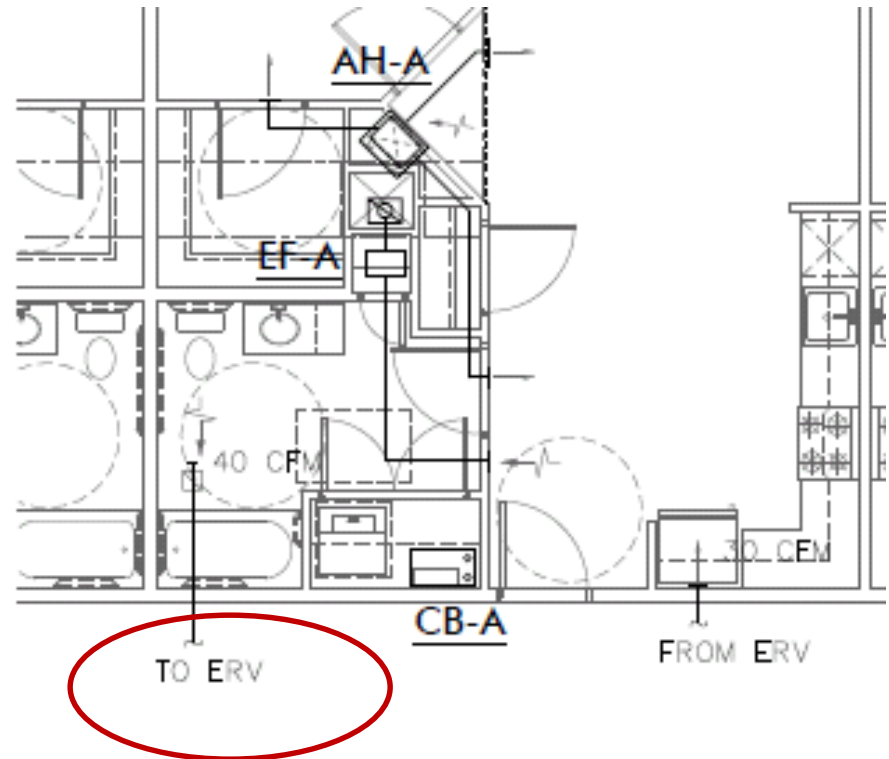
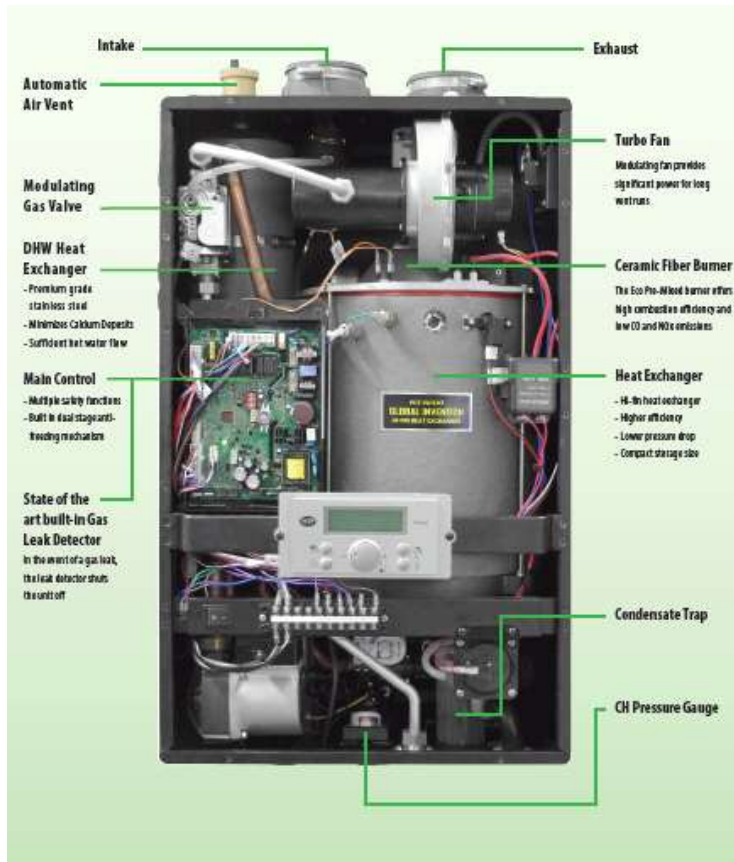
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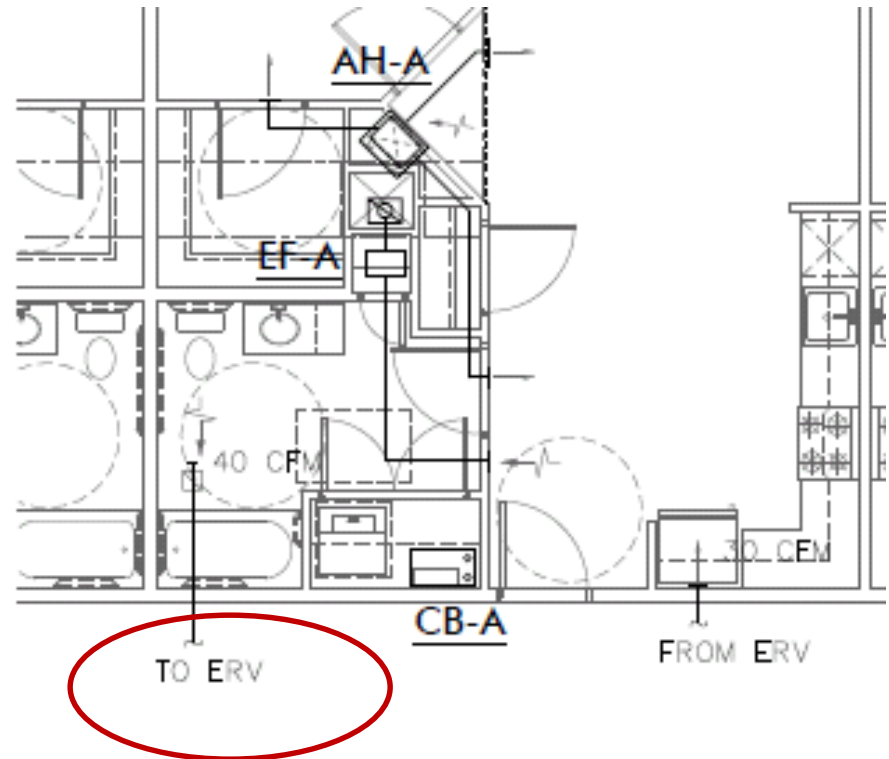
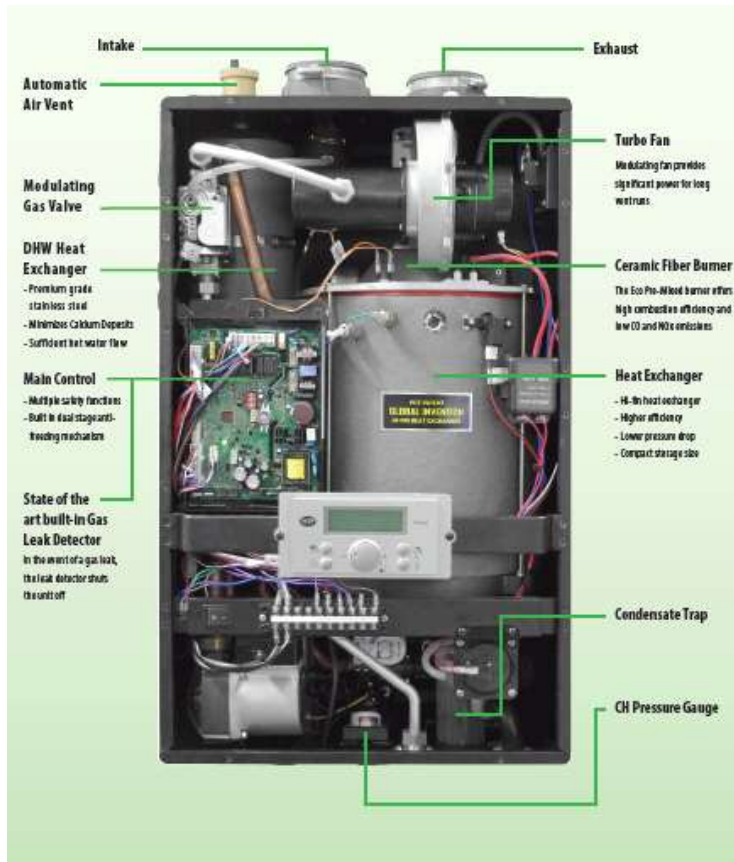
# HVAC



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# HVAC

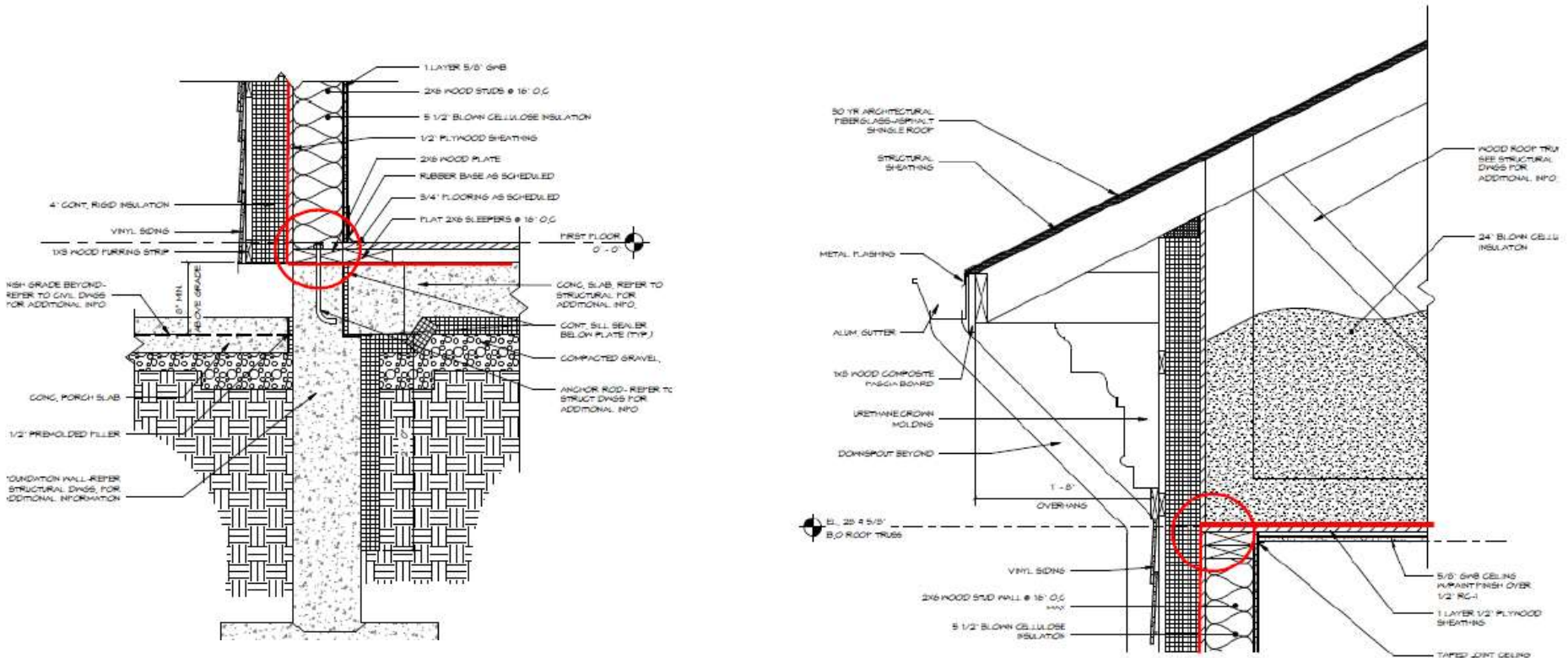


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# On the Drawing Board



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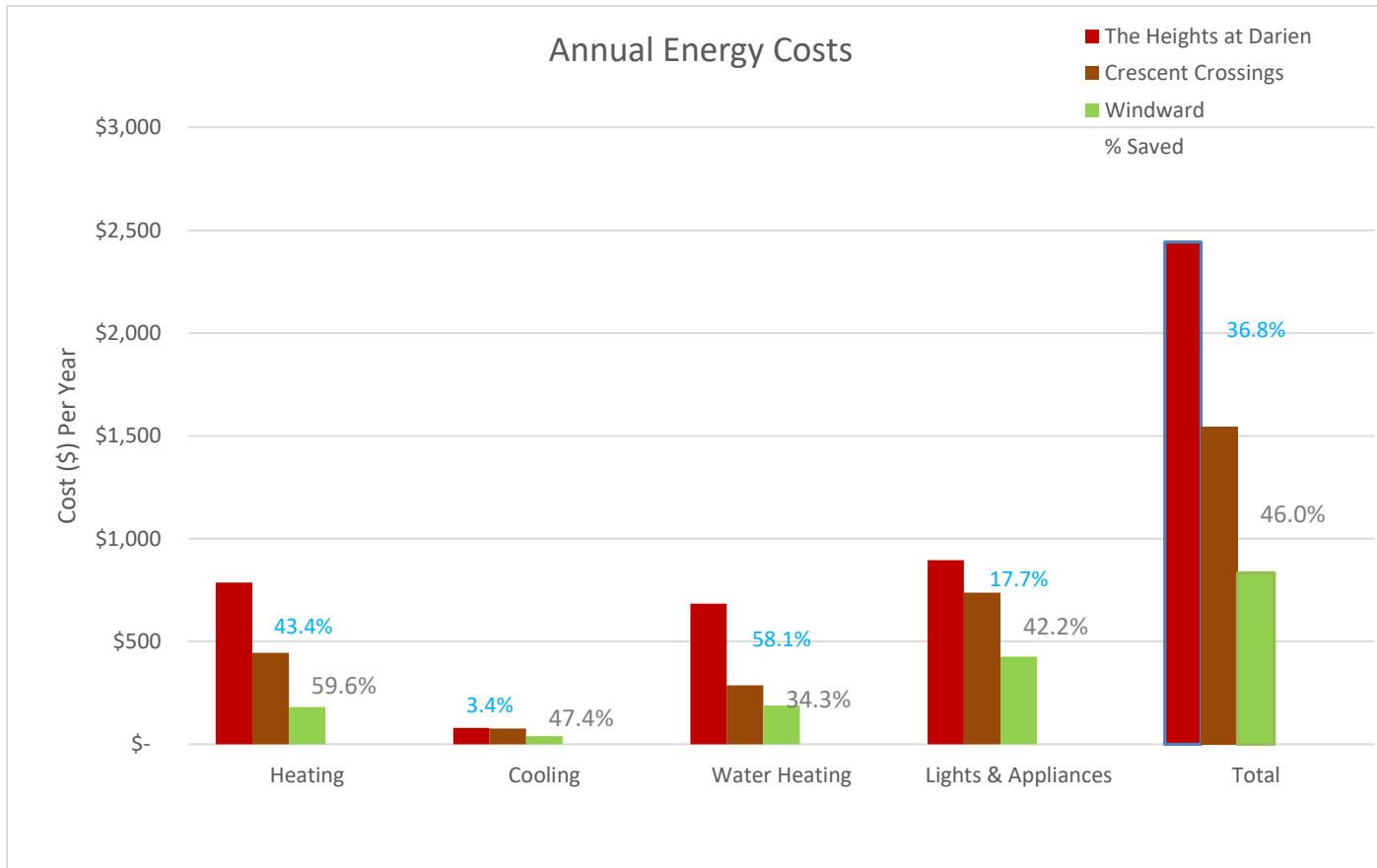
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# Energy Savings Predicted



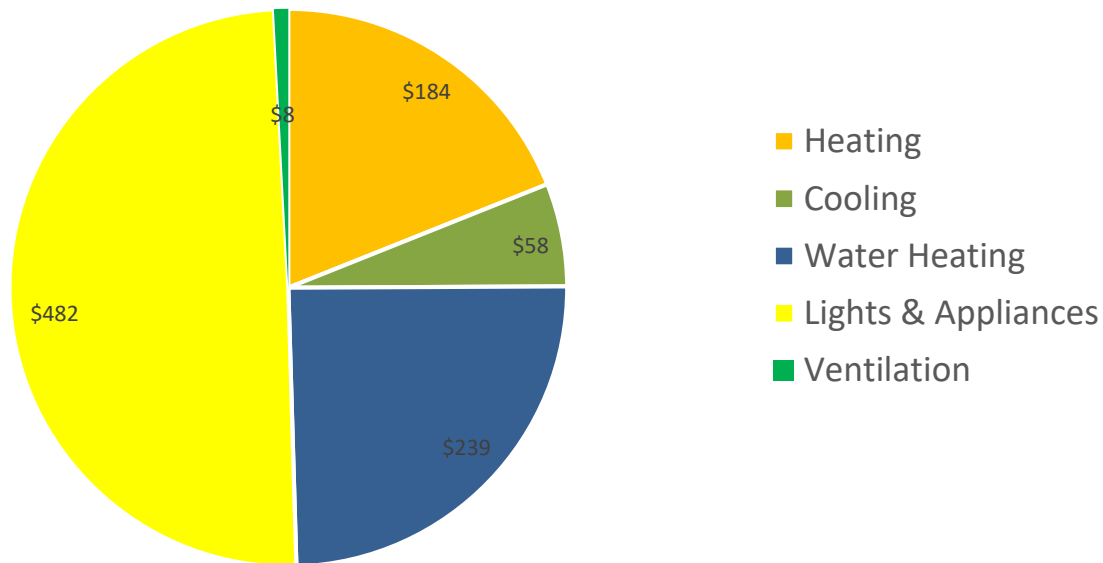
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# Energy Use

Marina Village 2 bedroom: Annual Energy Cost







# In Summary

## Solutions Are Everywhere

- Always first . . . high efficiency fixtures, appliances & equipment
- Efficiently delivering domestic hot water in central recirc systems requires an efficient layout
- Temperature and flow sensors placed at the source and furthest fixtures means less wasted water in the pipes
- Quantifying savings can help building owners make informed decisions





# Thank You

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## Questions?

**Karla Butterfield**

Sustainability Director

LEED AP, BD+C Homes · LEED Green Rater · HERS Rate · NGBS Master Verifier · PHIUS+ Rater & MF Verifier

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**Jonah Schein**

Water Infrastructure Division, US EPA

[Schein.Jonah@epa.gov](mailto:Schein.Jonah@epa.gov)