Plumbing Efficiency Workshop:
Forecasting code changes where water meets energy

Fort Collins, Colorado
March 4, 2020

Gary Klein

gary@garykleinassociates.com

916-549-7080

Matthew Harrison

Matthewfrankharrison@gmail.com

678-787-5365

Today's Schedule

Start Time	End Time	Topic	Comments
8:00a	8:30a	Registration/Check-In	
8:30a	8:40a	Introductions (collect questions)	Mariel/Brad
8:40a	10:20a	Session #1 - Overview, Arch Layout & WH Placement, Pressure Compensating Aerators, Pipe Sizing, Hot Water Wait Time, Legionella (including time for questions)	
10:20a	10:30a	Break	
10:30a	11:30a	Session #2 - Interactive Session (2 to 3 demonstrations)	Gary to lead demonstration
11:30a	12:15p	Lunch (potential working lunch to gain more time)	
12:15p	1:15p	Session #3 - Recommended Design & Code Changes	
1:15p	1:30p	Closing Remarks	Mariel/Brad

Topics

- 2015-2021 Code Changes Related to Hot Water
- Architectural Compactness
- Right Sizing Pipe Based on Modern Materials and Flow Rates
- Pressure Drop in Modern Pipe and Fittings
- Time-to-tap and Volume-until-Hot
- Cold Start Function Faucets
- To Insulate (or Not), That is the Question!
- Circulation and Heat Trace Control Strategies
- Drain Water Heat Recovery

How Big is Hot Water?

Water heating is the 1st or 2nd largest residential energy end-use: 15 – 30% of a house's total energy pie.

- What is number 1? Number 3?
- Percentage grows as houses and appliances get more efficient

How does this compare to your:

- Cell phone bill?
- Internet bill?
- Cable or Satellite bill?
- Designer coffee bill?

Why Do I Work on Hot Water?

- Energy Intensity of Indoor Cold Water
  - Range from 5 to 25 kWh per 1000 gallons
- Energy Intensity of Hot Water

	Electric		Natural Gas	
	Resistance (85 % Efficient)	Heat Pump (COP = 2)	(50% Efficient)	(95% Efficient)
kWh/1,000 Gallons	201	85	342	180
Relative Energy Intensity compared to 5 kWh/1,000 gallons	40	17	68	36

- Typically 40-68 times more energy intensive than indoor cold water.

The most valuable water to conserve
is hot water
at the top of the tallest building, with
the highest elevation,
in the area with the greatest
pressure drop.

Issues We Face

- Flow rates have been reduced
- Distances to fixtures have increased
- Potential for simultaneous flow is generally overestimated
- Code requirements for minimum pipe diameters have not been revised since before flow rates were reduced
- Codes and efficiency and green programs generally focus on components, not the hot water system
- Others?

What Are We Aiming For?

- People want the service of hot water, as efficiently as possible.
- It does not make sense to discuss efficiency until the desired service has been provided.

The 2 Key Services…

Hot Water Now = “Instantaneousness”

- Need hot water available before the start of each draw.
  - A tank with hot water
  - Heated pipes
- Need the source of hot water close to each fixture or appliance
- Point of Use is not about water heater size, its about location

Never Run Out in My Shower = “Continousness”

- Need a large enough tank or a large enough burner or element
- Or, a modest amount of both

The Key Components of a Hot Water System

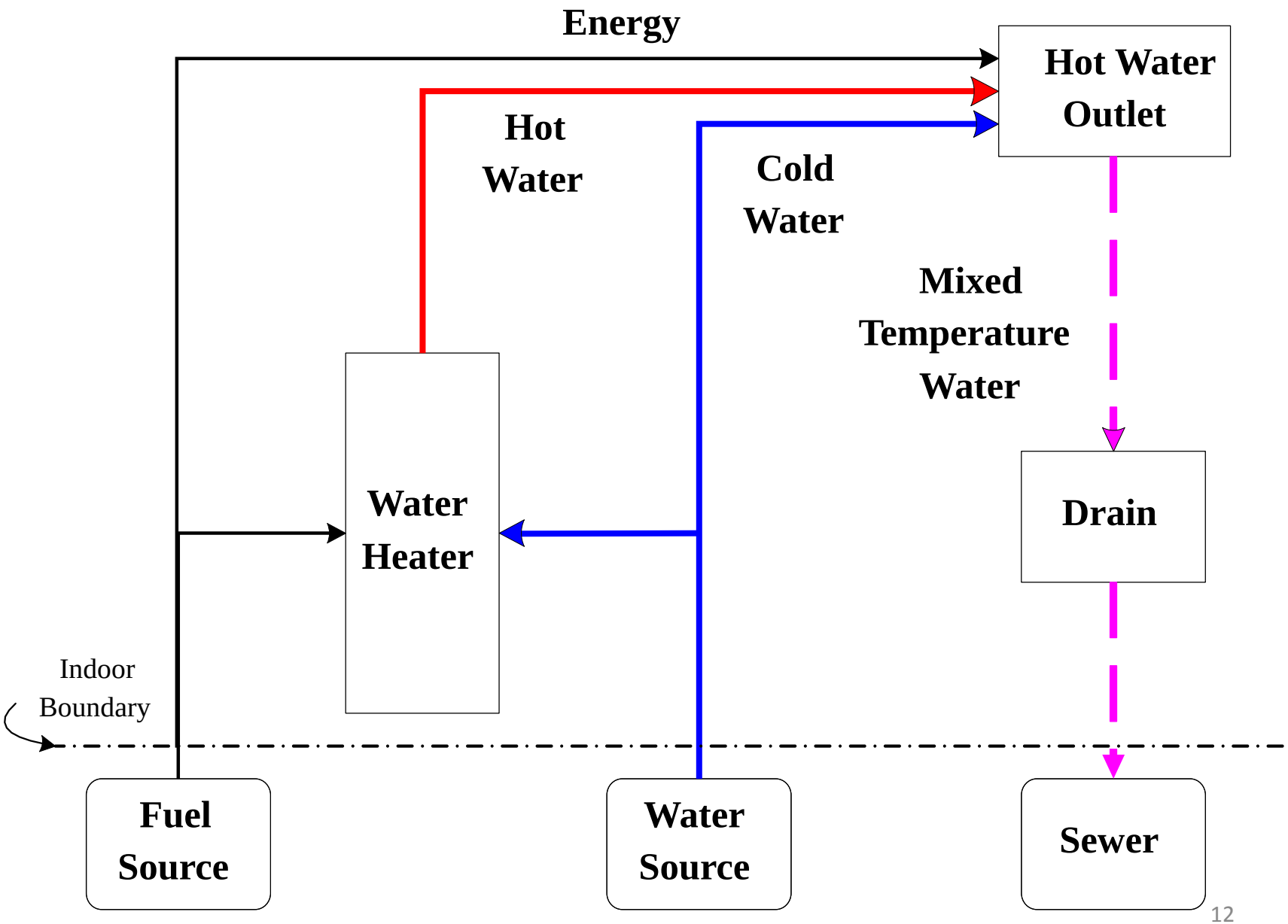
The Hot Water System

- Treatment and Delivery to the Building
- Use in the Building
  - Water Heater
  - Piping
  - Fixtures, Fittings and Appliances
  - Behavior
  - Water Down the Drain
- Waste Water Removal and Treatment

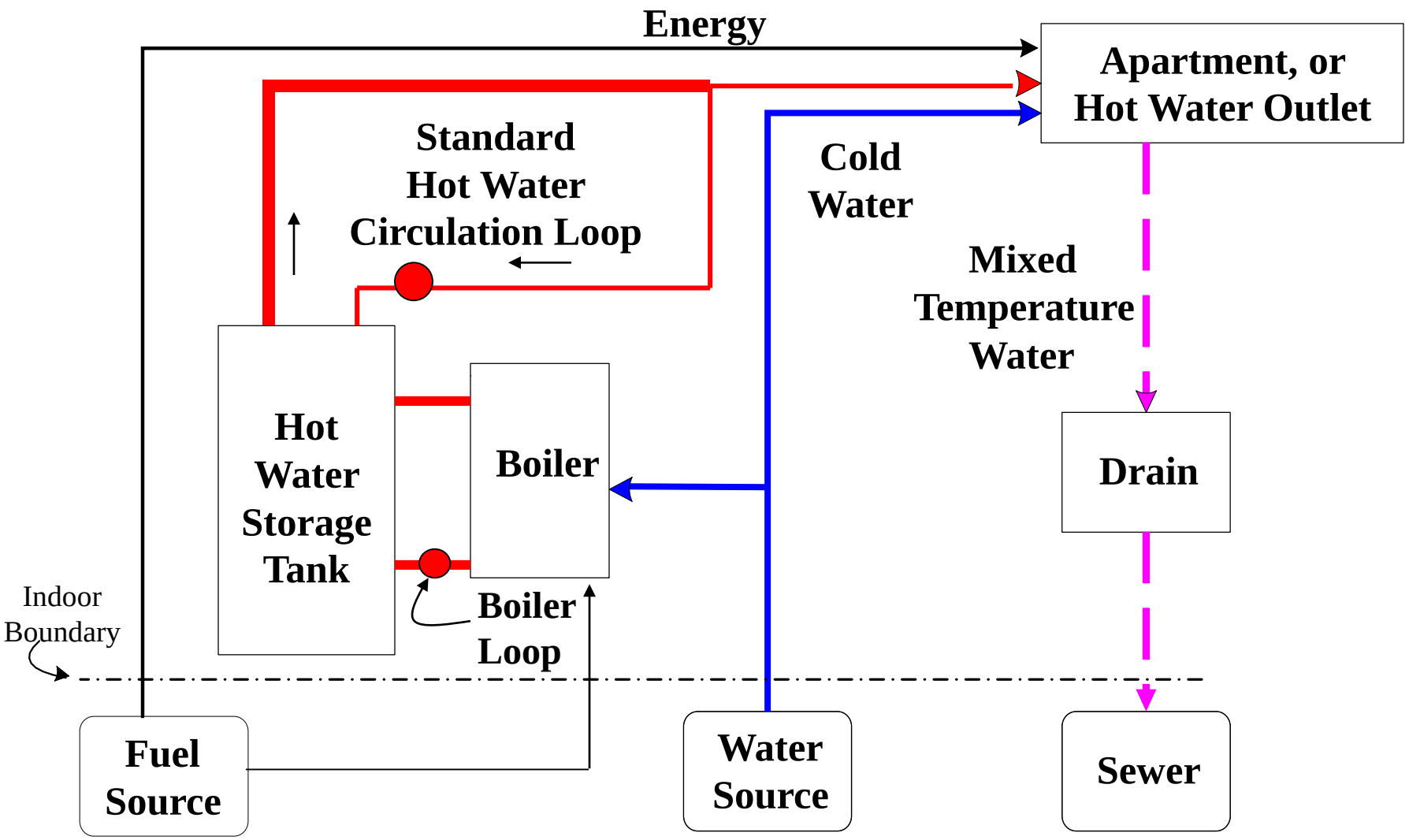
Which is the biggest ***variable*** in determining water and energy use?

How do the ***interactions*** among these components affect ***system*** performance?

Typical “Simple” Hot Water System



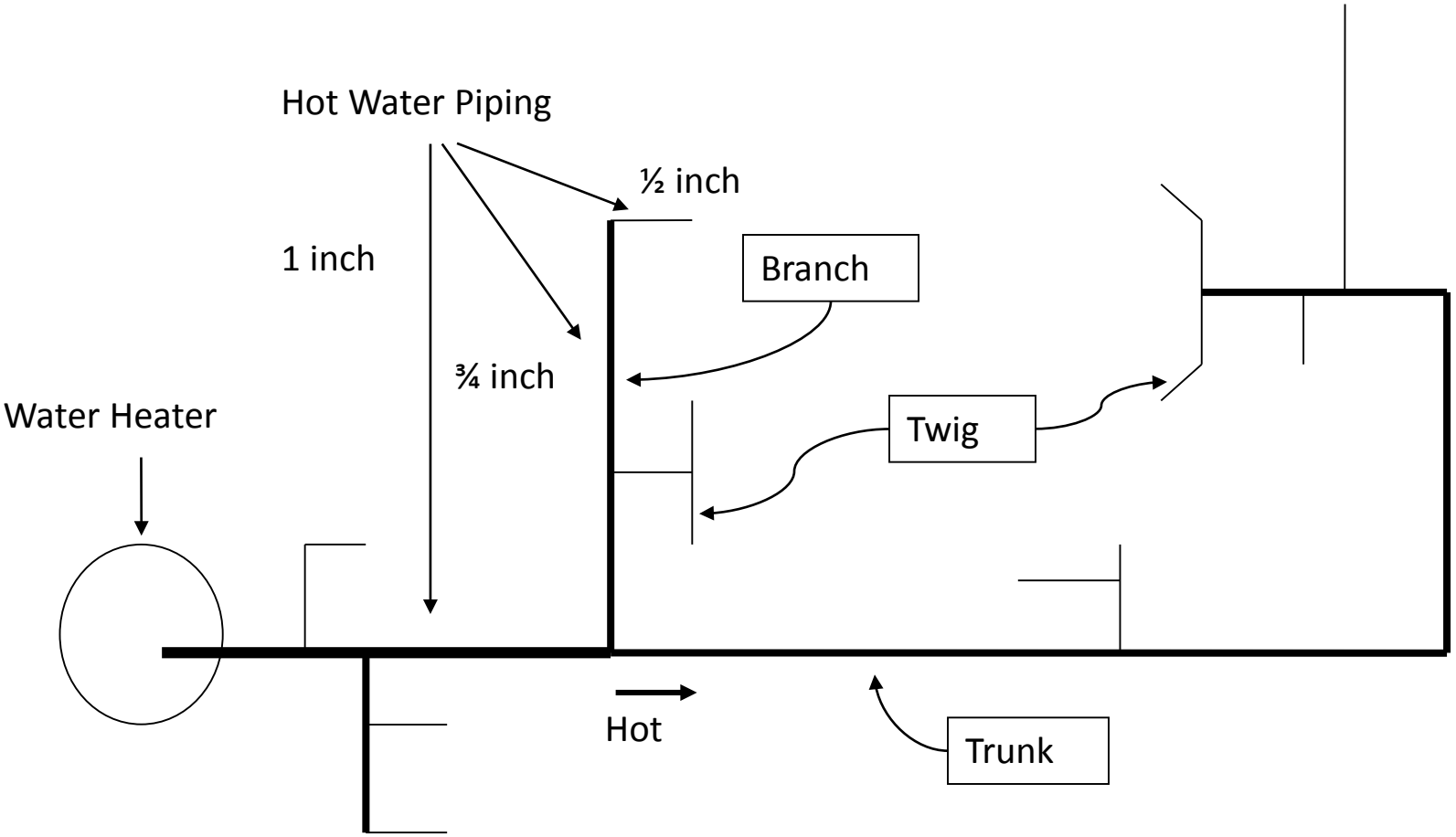
Typical Central Boiler Hot Water System



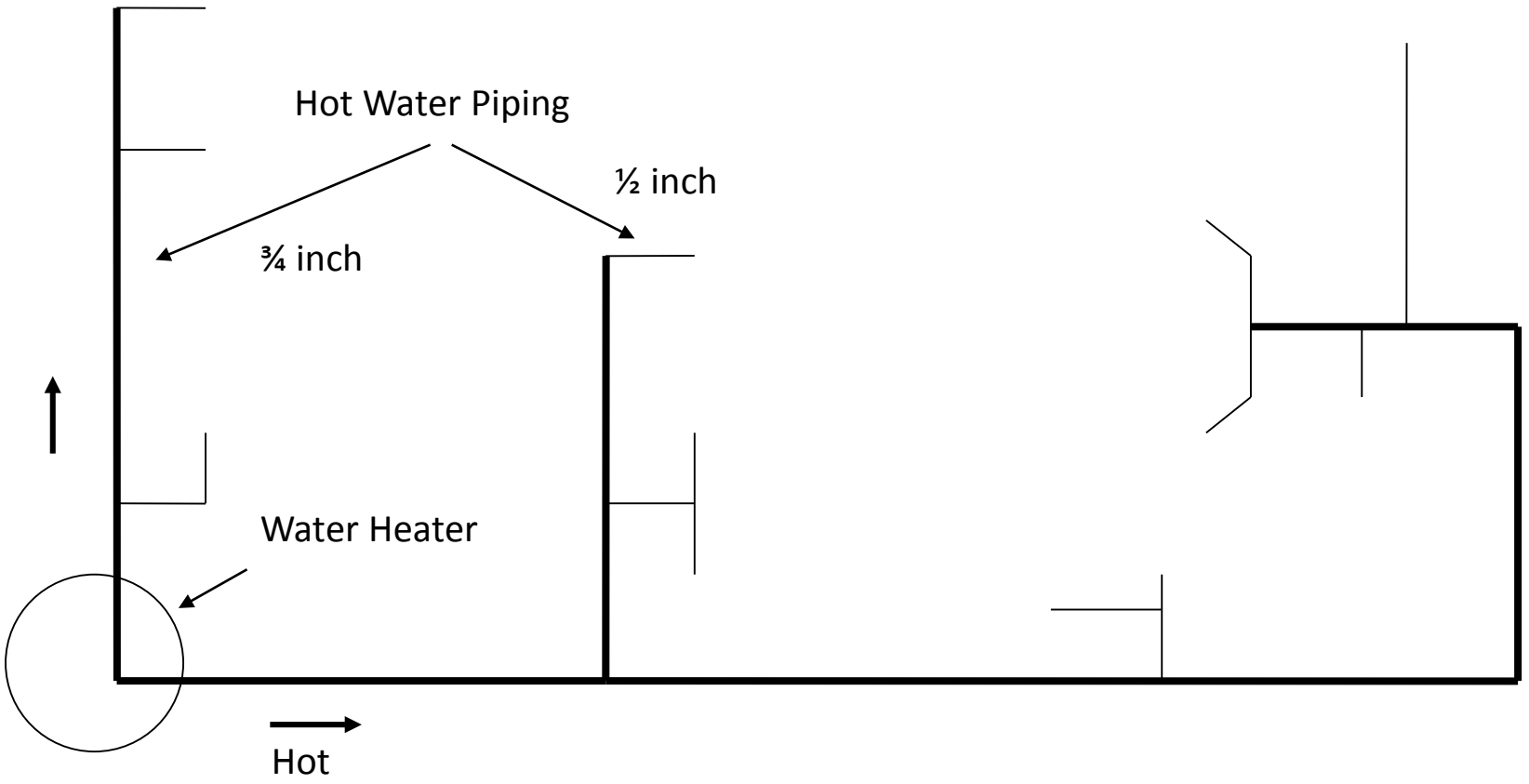
Definitions for Water Supply Piping

1. A Twig line serves one outlet or appliance.
   - The diameter of the twig should be determined by the flow rate of the outlet or appliance it serves and the pressure drop that will occur due to length, velocity and restrictions to flow (e.g. elbows and tees).
2. A Branch line serves more than one twig.
3. A Trunk line serves branches and twigs.
4. A Main line serves the building.
5. A hot water location contains one or more hot water outlets. Some cold ones too.

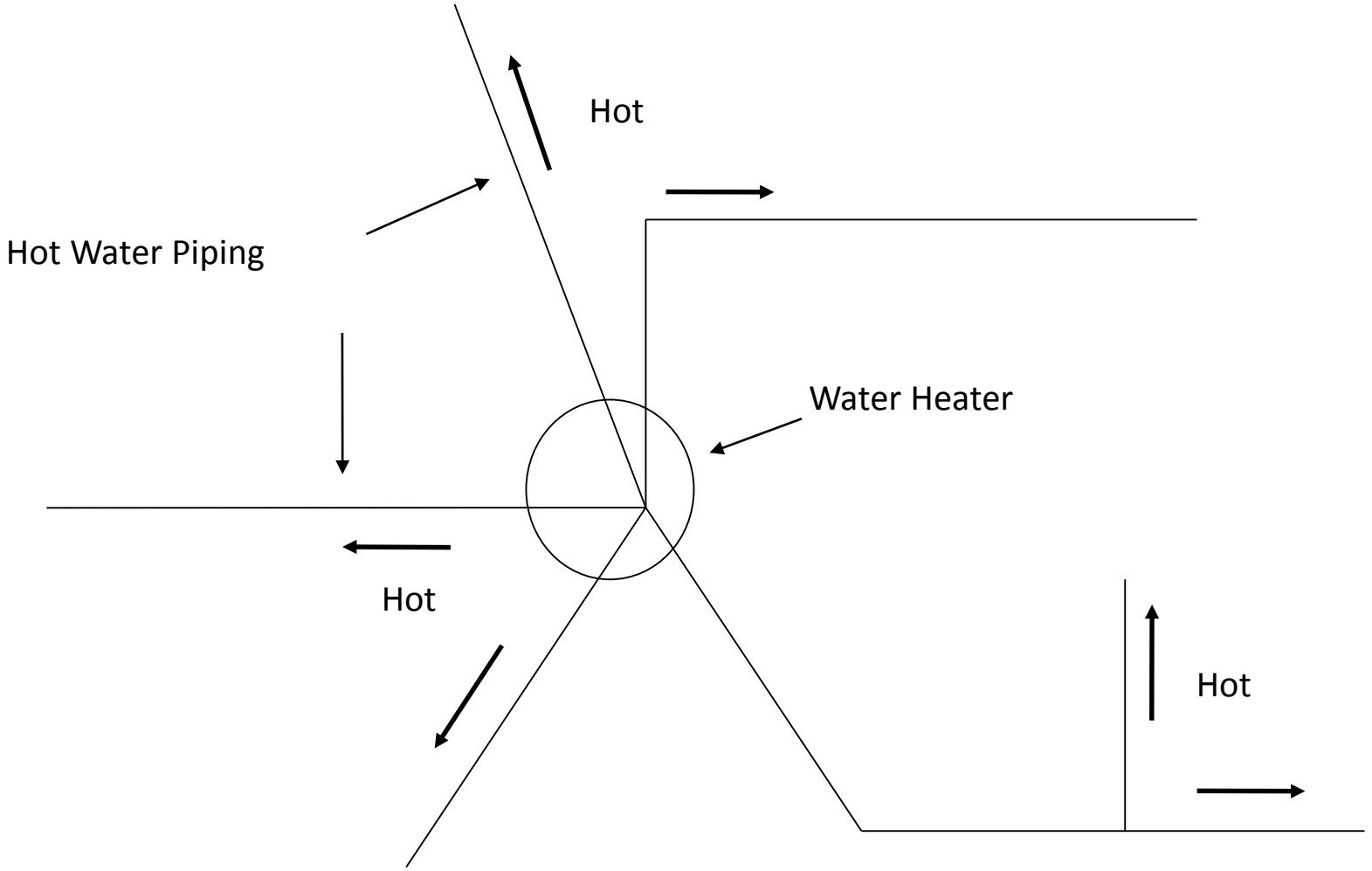
Single Trunk, Branch and Twig



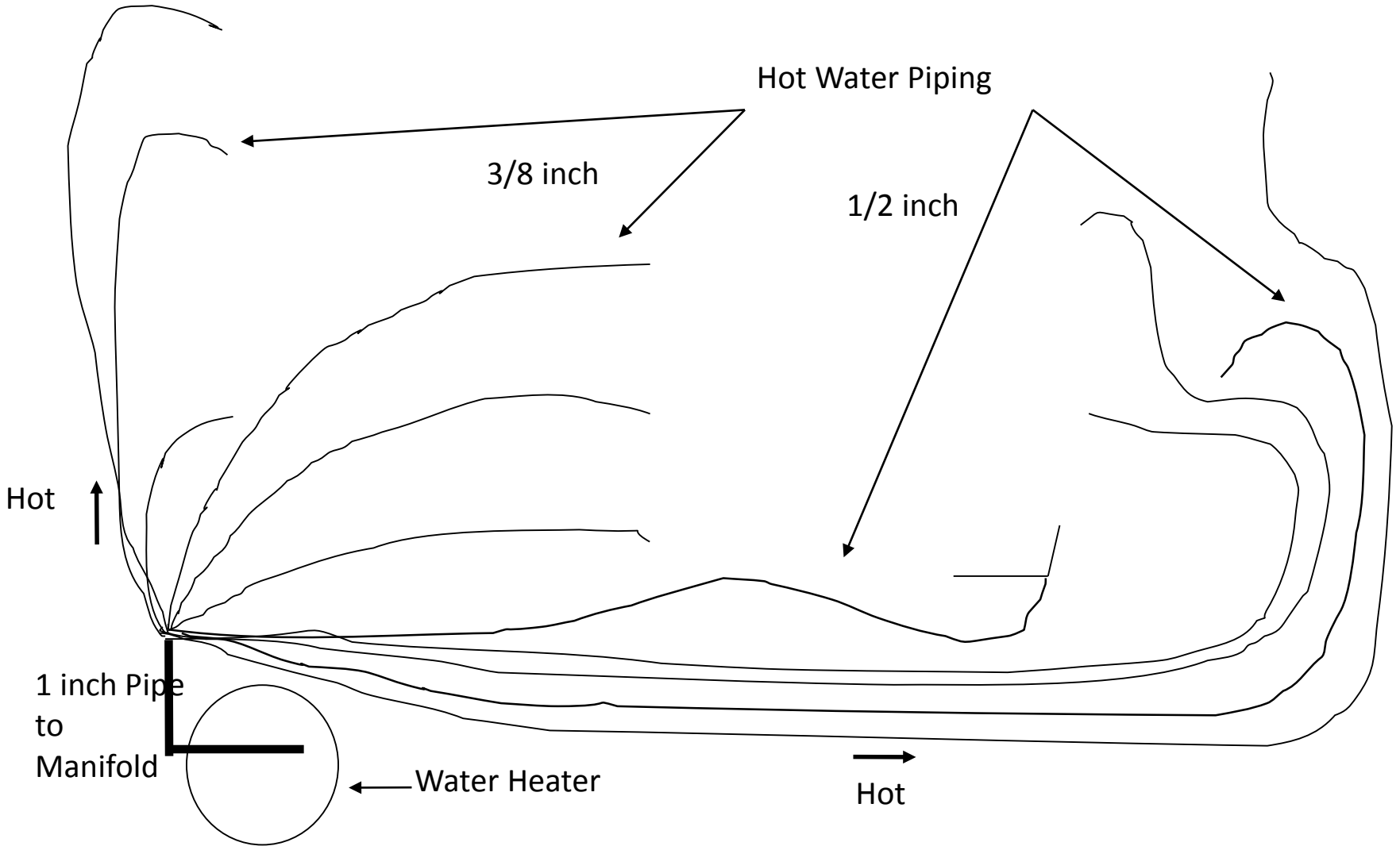
Multiple Trunk, Branch and Twig



Radial, Manifold, Parallel Pipe-
Central Core

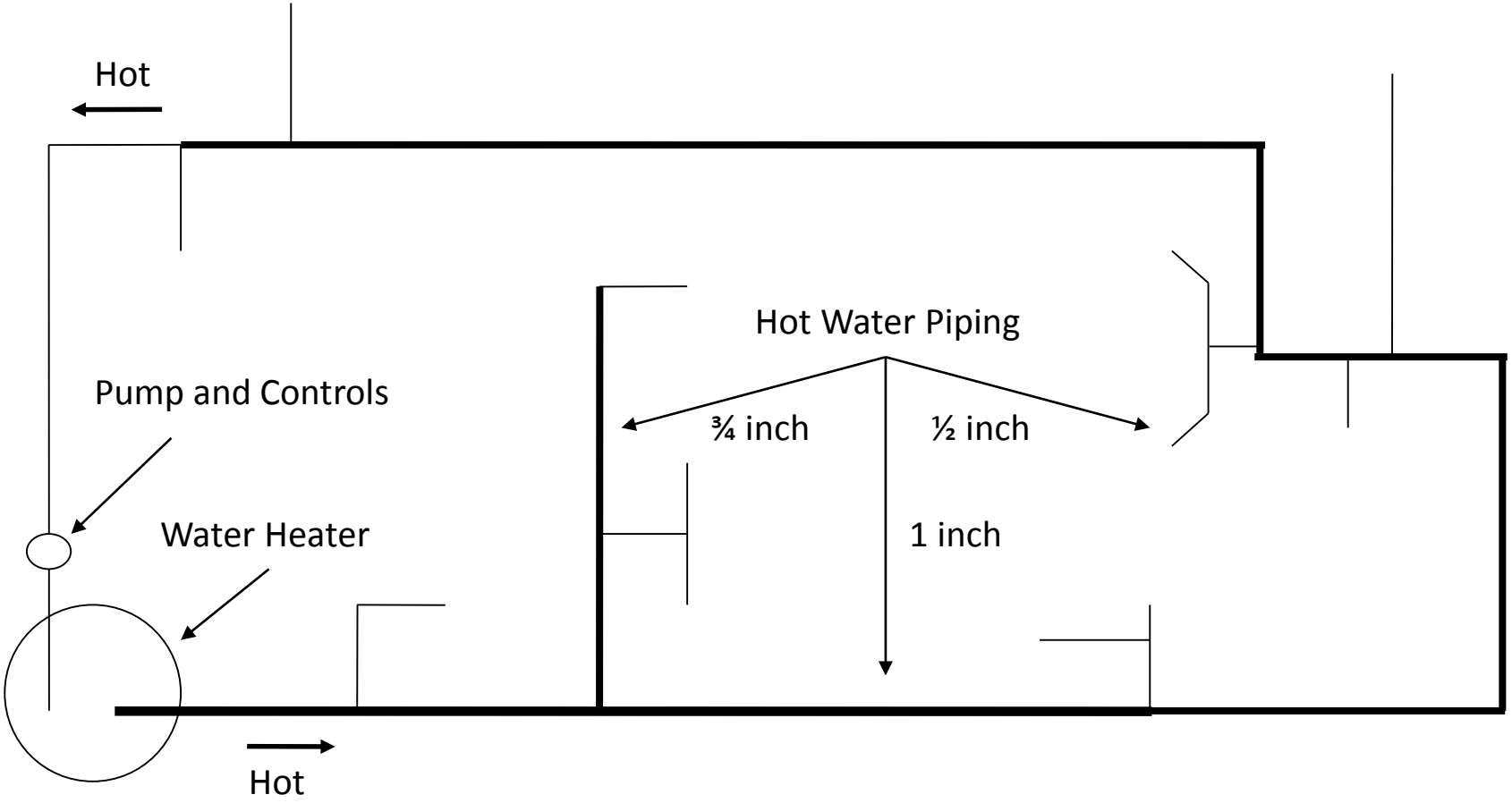


Radial, Manifold, Parallel Pipe-Distributed



Standard Recirculation

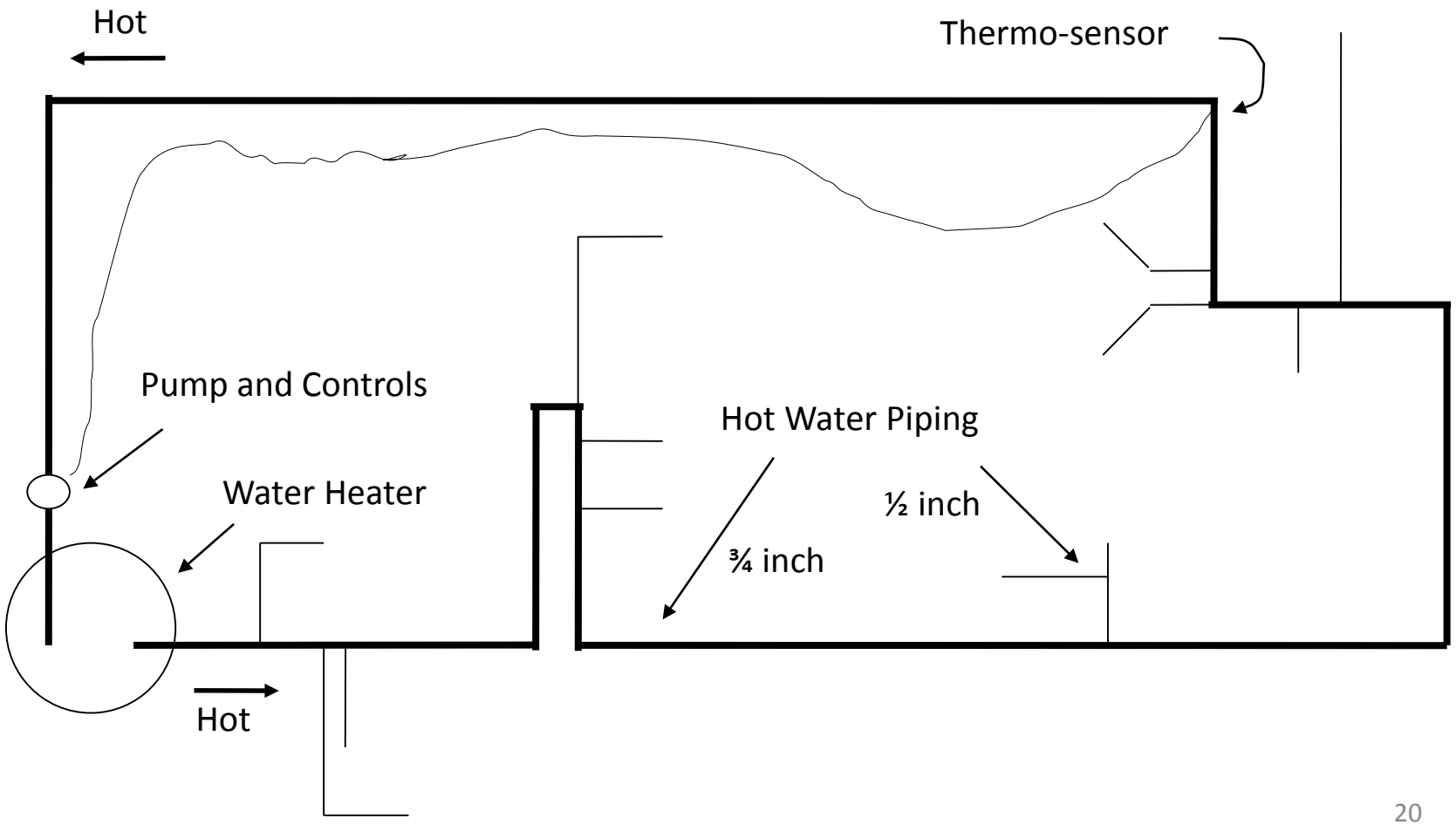
Fully Heated Loop



Standard Recirculation

Half Heated Loop

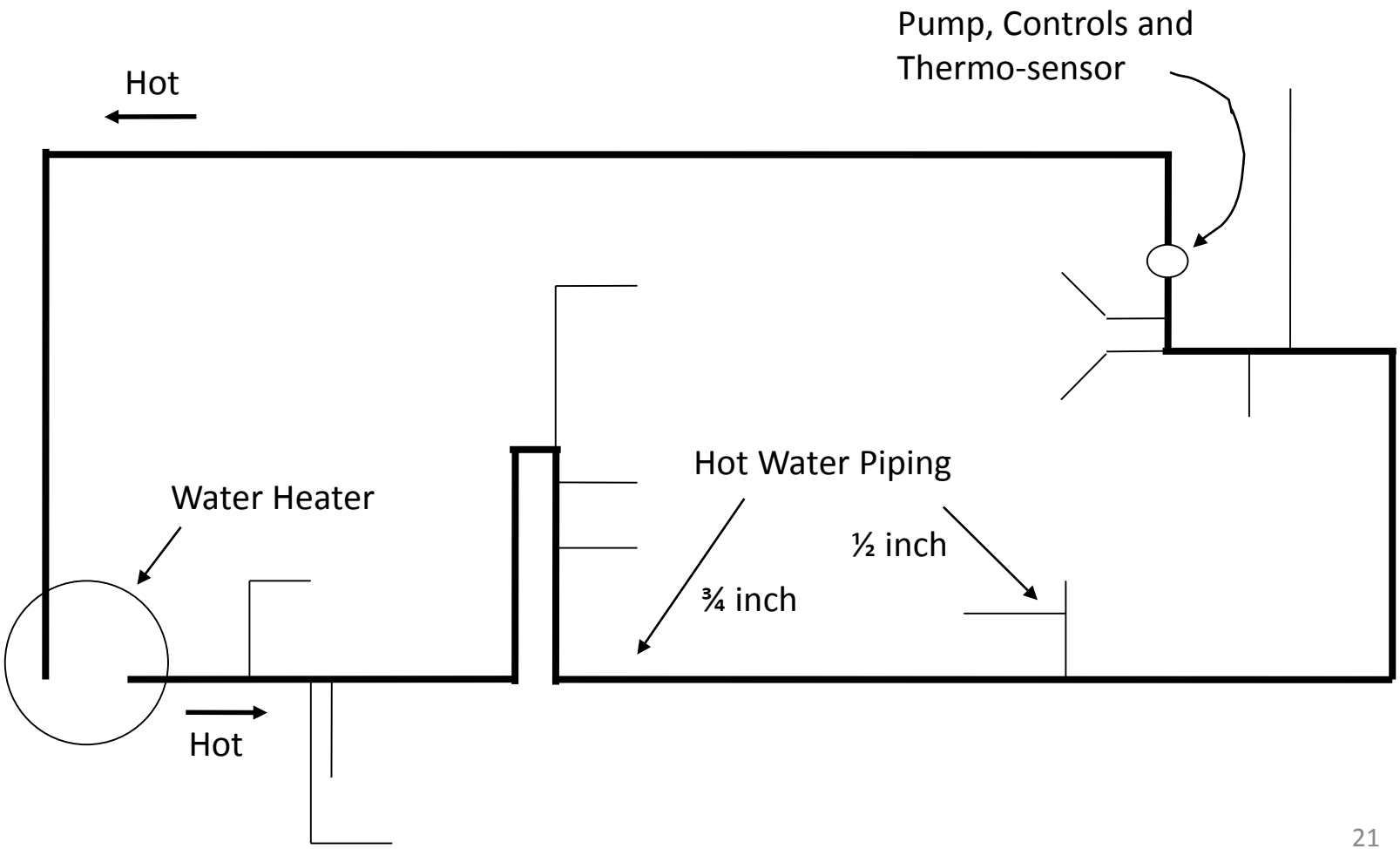
Pump Separated from Thermo-sensor



Standard Recirculation

Half Heated Loop

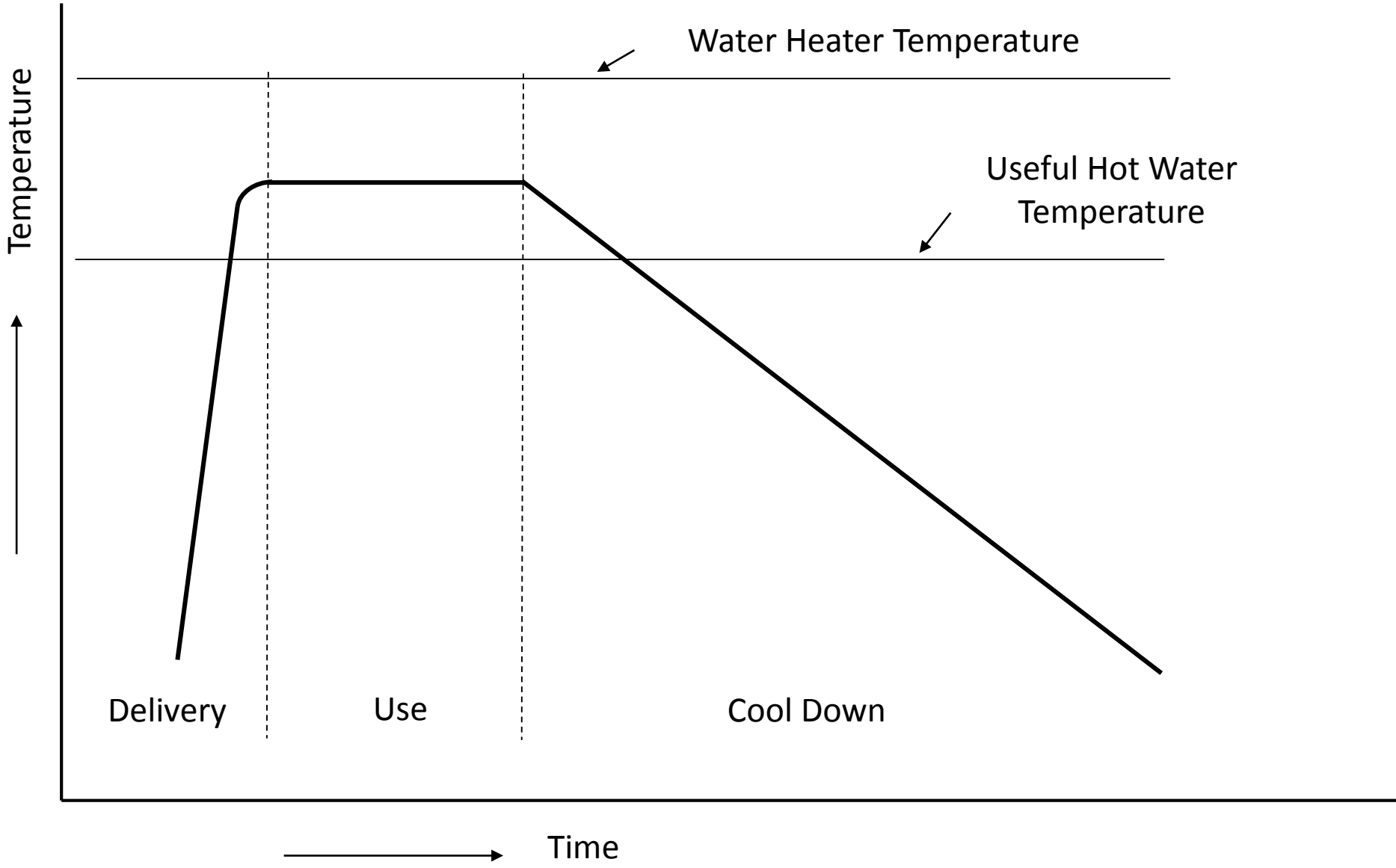
Pump Located with Thermo-sensor



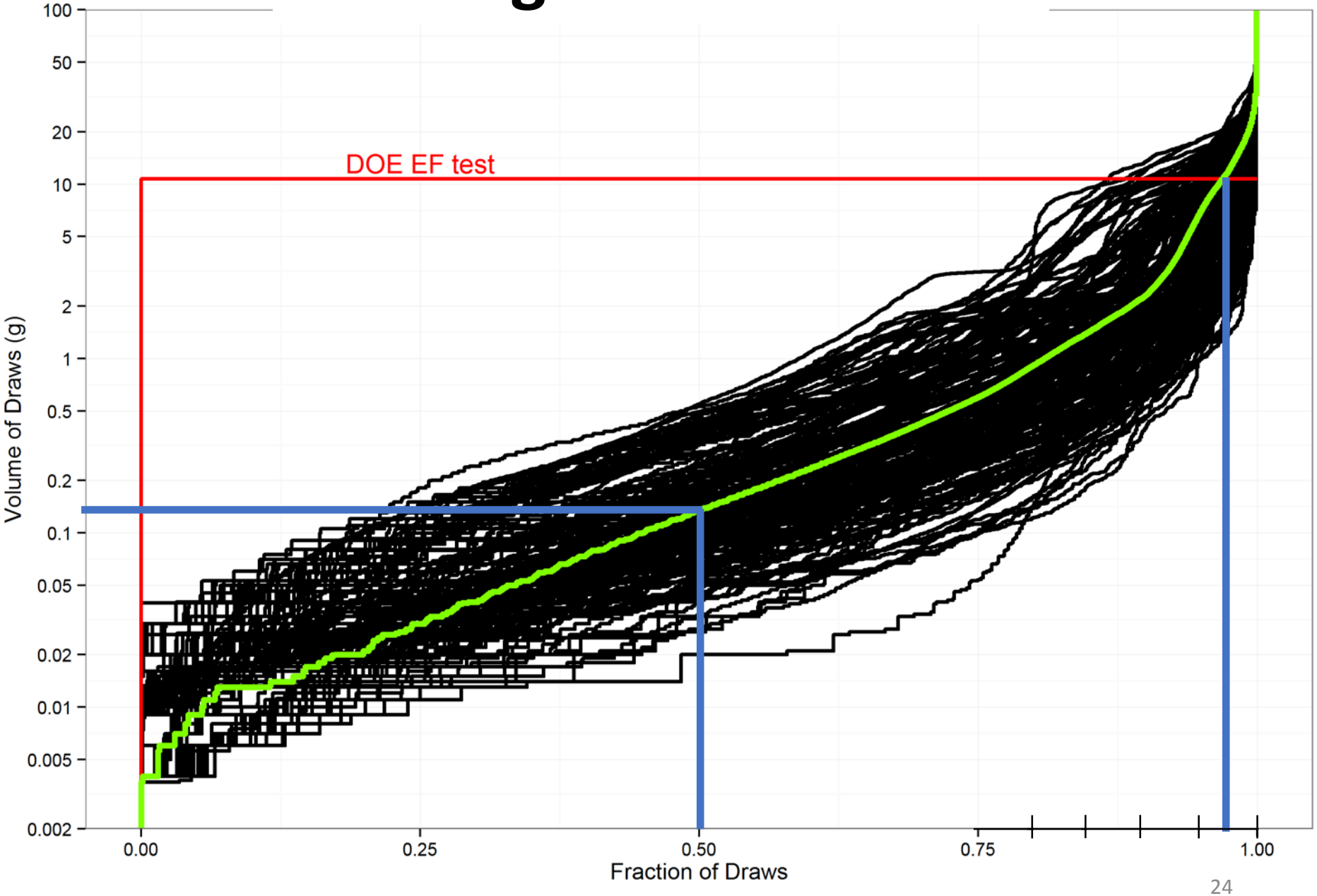
Do You Know:

- *Anyone who waits a long time to get hot water somewhere in their house? At their job? In their favorite restaurant?*
- Someone who has ever run out of hot water?
- *Any Communities that have a "you can't build unless you can guarantee a long term supply of water" ordinance?*
- Someone who has a "routine"' that they do while waiting for hot water to arrive at their shower? At the kitchen sink? For the dishwasher?
- *Anyone who wants instantaneous hot water?*
- Someone who thinks that a tankless water heater is instantaneous?
- *Anyone who thinks that a whole-house manifold plumbing system will save water?*
- Someone who is confused about how to implement the LEED, NAHB, Water Sense, Build-it-Green or other hot water distribution system credits?
- *Anyone who would like to learn how to get hot water to every fixture wasting no more than 1 cup waiting for the hot water to arrive?*
- Someone who wants to know "the answer"?

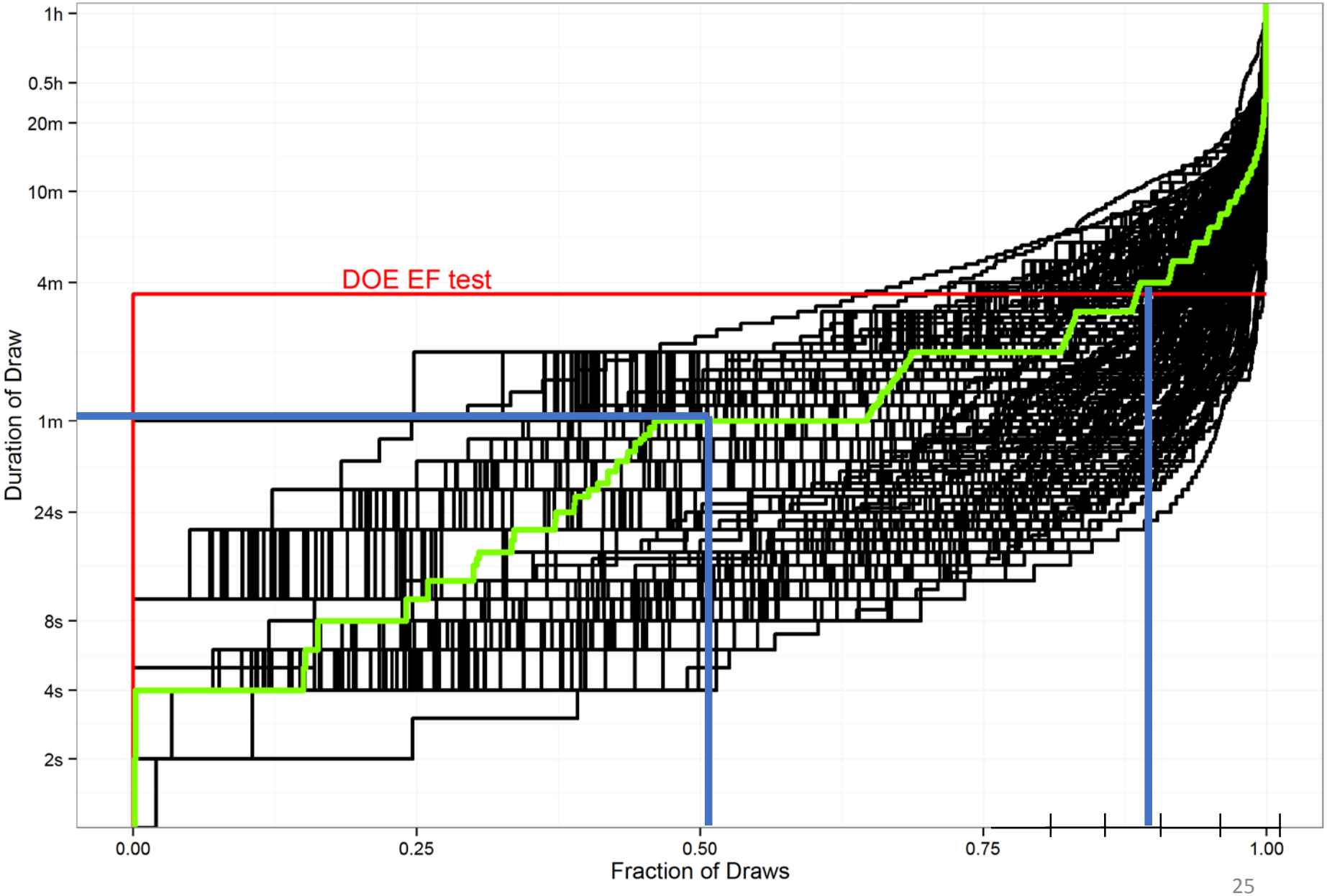
Typical Hot Water Event



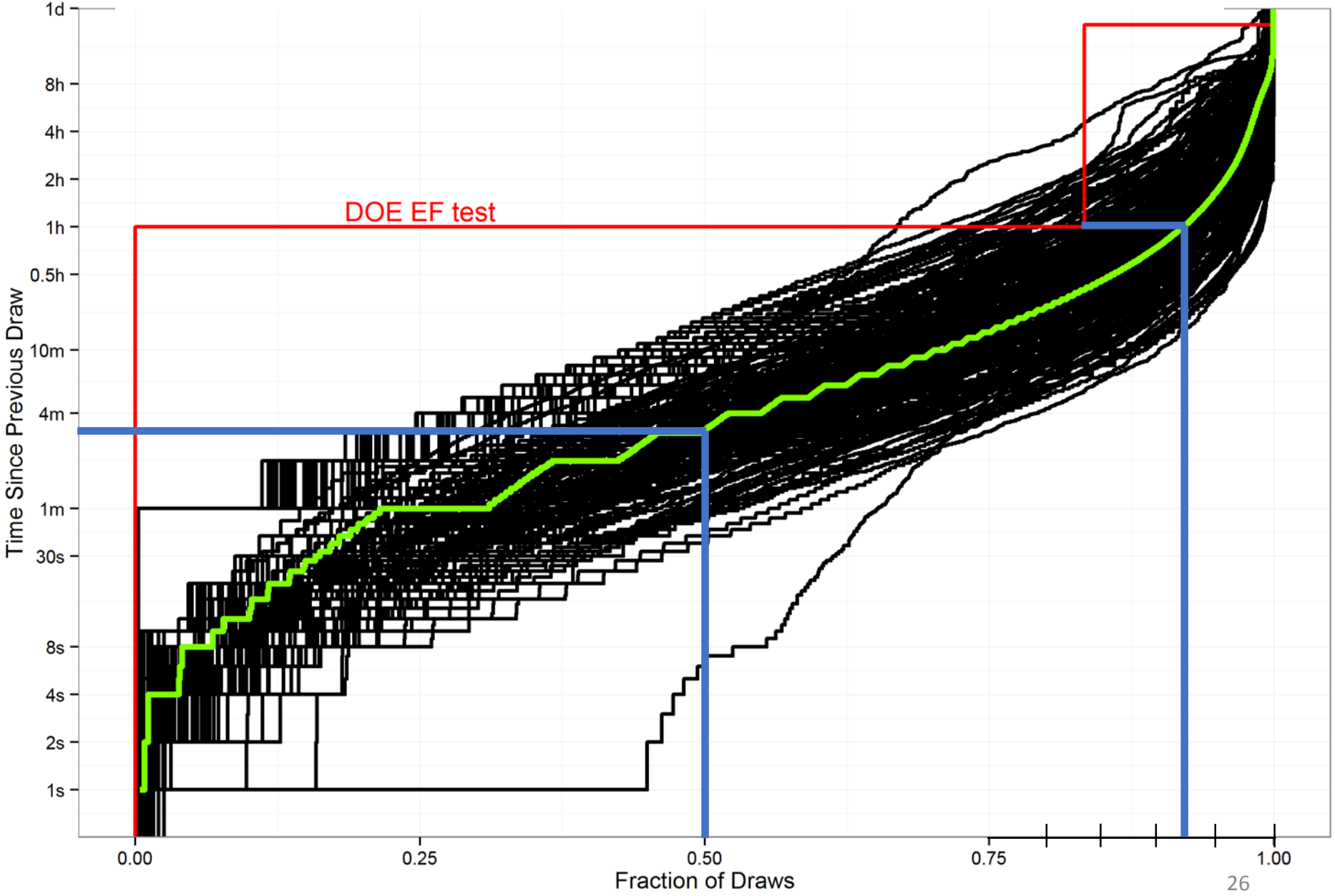
How Big are the Draws?



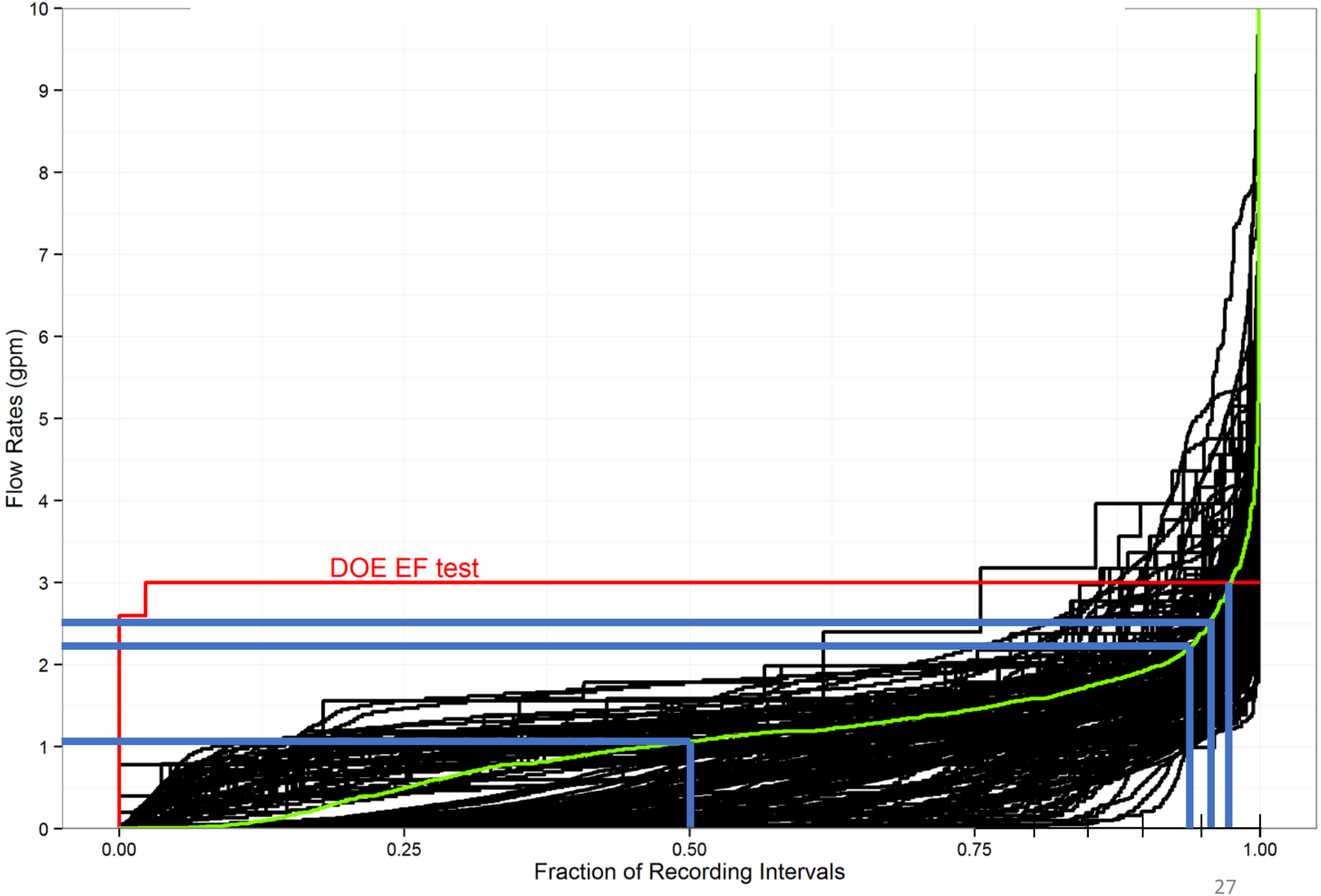
How Long is Each Draw?



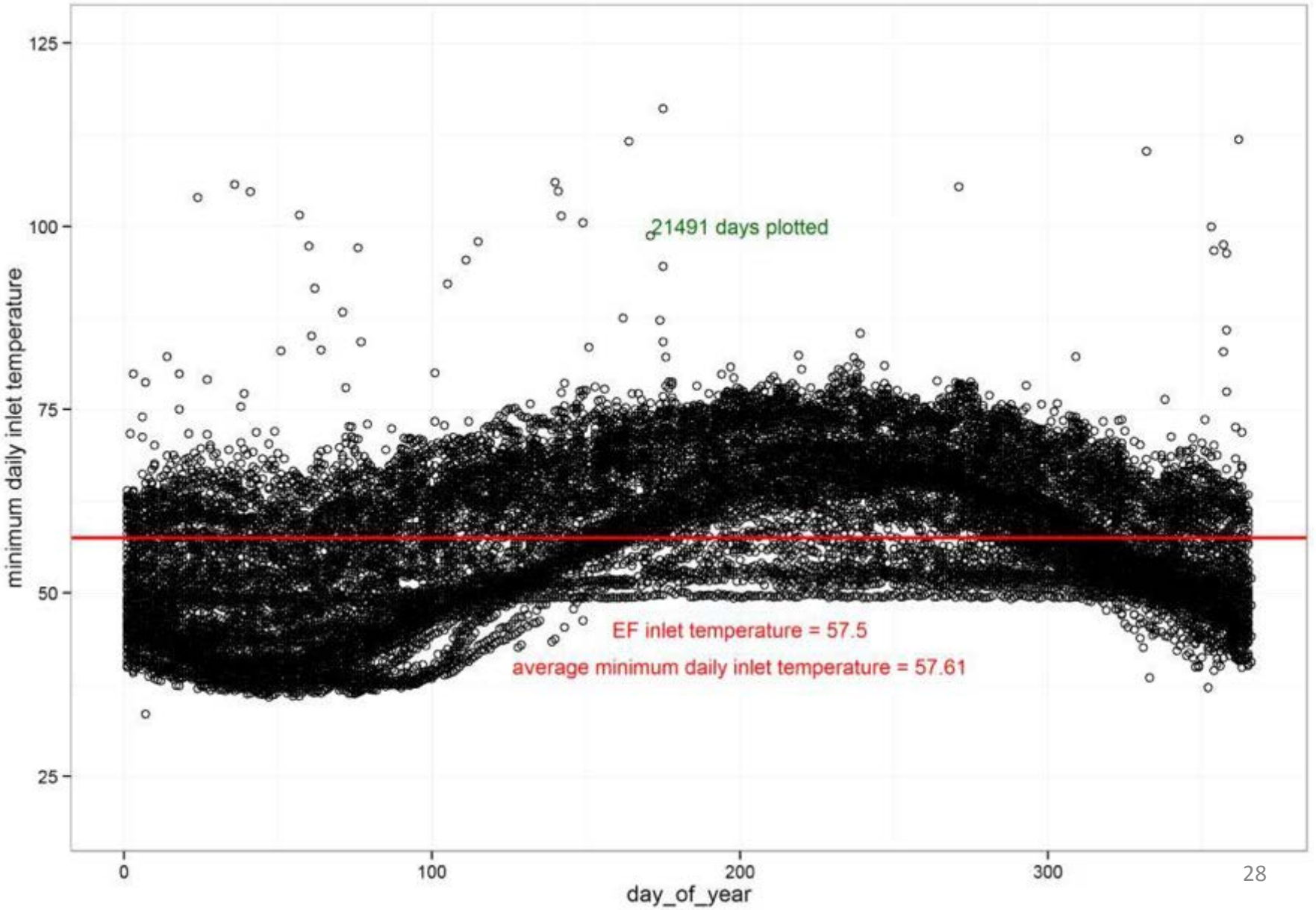
How Much Time Between Draws?



What are the Flow Rates?



Inlet Water Temperatures



How do we use hot water?

- Frequent short, low flow-rate draws
- Occasional long draws at low flow-rates
- High flow-rate and high volume draws are rare
- Draws are highly clustered

The Ideal
Hot Water Distribution System

- Has the smallest volume (length and smallest "possible" diameter) of pipe from the source of hot water to the hot water outlet.
- Sometimes the source of hot water is the water heater, sometimes a trunk line.
- For a given layout (floor plan) of hot water locations the system will have:
  - The shortest buildable trunk line
  - Few or no branches
  - The shortest buildable twigs
  - The fewest plumbing restrictions
  - Insulation on all hot water pipes, minimum R-4

The Challenge

Deliver hot water

to every hot water outlet

wasting no more energy

than we currently waste running water down the drain and

wasting no more than 1 cup

waiting for the hot water to arrive.

Question:

If you want to waste no more than 1 cup
while waiting for hot water to arrive,
what is the maximum amount of water
that can be in the pipe that is not usefully hot?

Answer:

1 cup = 8 ounces = 1/16th gallon = 0.0625 gallon

Question:

If you want to waste no more energy than you would have wasted waiting for hot water to arrive while running water down the drain, how much energy can any alternative consume?

Answer:

No more than was originally wasted!

Length of Pipe that Holds 8 oz of Water

	3/8" CTS	1/2" CTS	3/4" CTS	1" CTS
	ft/cup	ft/cup	ft/cup	ft/cup
"K" copper	9.48	5.52	2.76	1.55
"L" copper	7.92	5.16	2.49	1.46
"M" copper	7.57	4.73	2.33	1.38
CPVC	N/A	6.41	3.00	1.81
PEX	12.09	6.62	3.34	2.02
Ave	**8 feet**	**5 feet**	**2.5 feet**	**1.5 feet**

Given human nature,

it is our job

to provide the infrastructure

that supports efficient behaviors.

Questions?

Thank you!

2015-2021 Code Changes Related to Hot Water

Architectural Compactness

Right Sizing Pipe in the 21st Century

Pressure Drop in Modern Pipe and Fittings

Time-to-tap and Volume-until-Hot

Cold Start Function Faucets

To Insulate (or Not), That is the Question!

Circulation and Heat Trace Control Strategies

Drain Water Heat Recovery