BUILDINGENERGY BOSTON

Equitable, Data Driven, Domestic Hot Water Decarbonization

Neil Donnelly (New Ecology)
Charlie Simek (New Ecology)

Curated by Keirstan Field (EPRI)

Northeast Sustainable Energy Association (NESEA) | March 19, 2024

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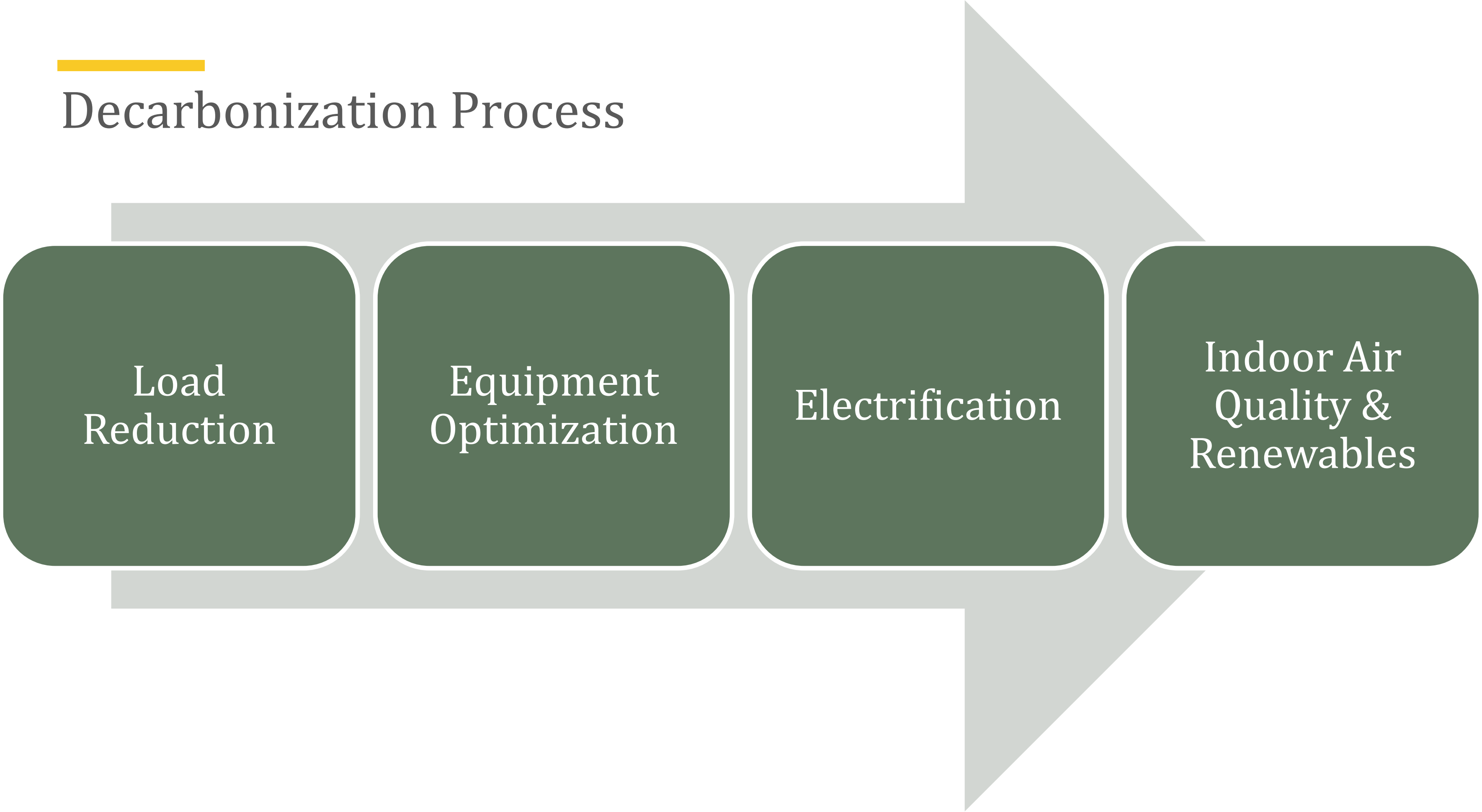
Presented by Charlie Simek
& Neil Donnelly

NESEA BuildingEnergy Boston 2024
March 19, 2024

NEW ECOLOGY
Community-Based Sustainable Development

Decarbonization Process

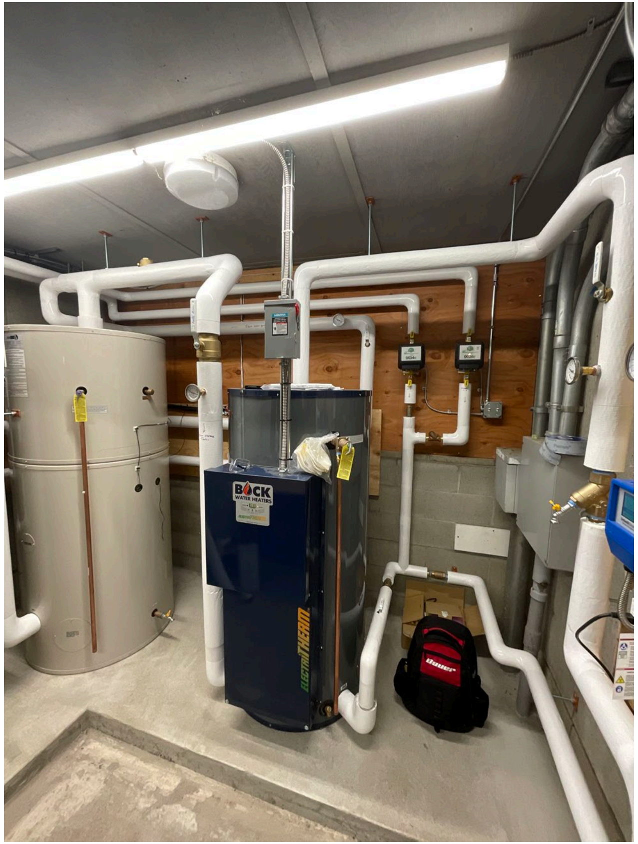


DHW Decarbonization Priorities

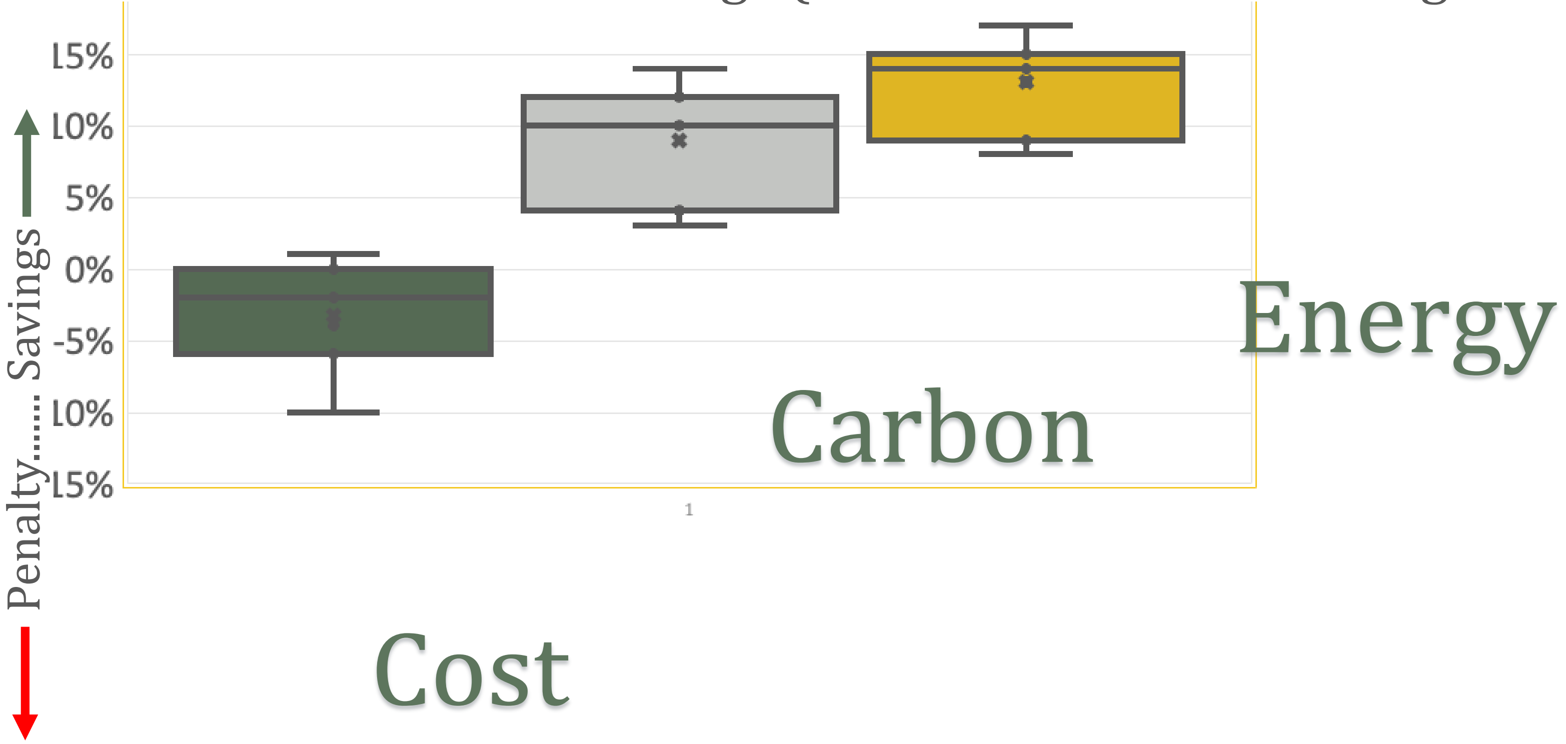
Provide the service

Keep it simple

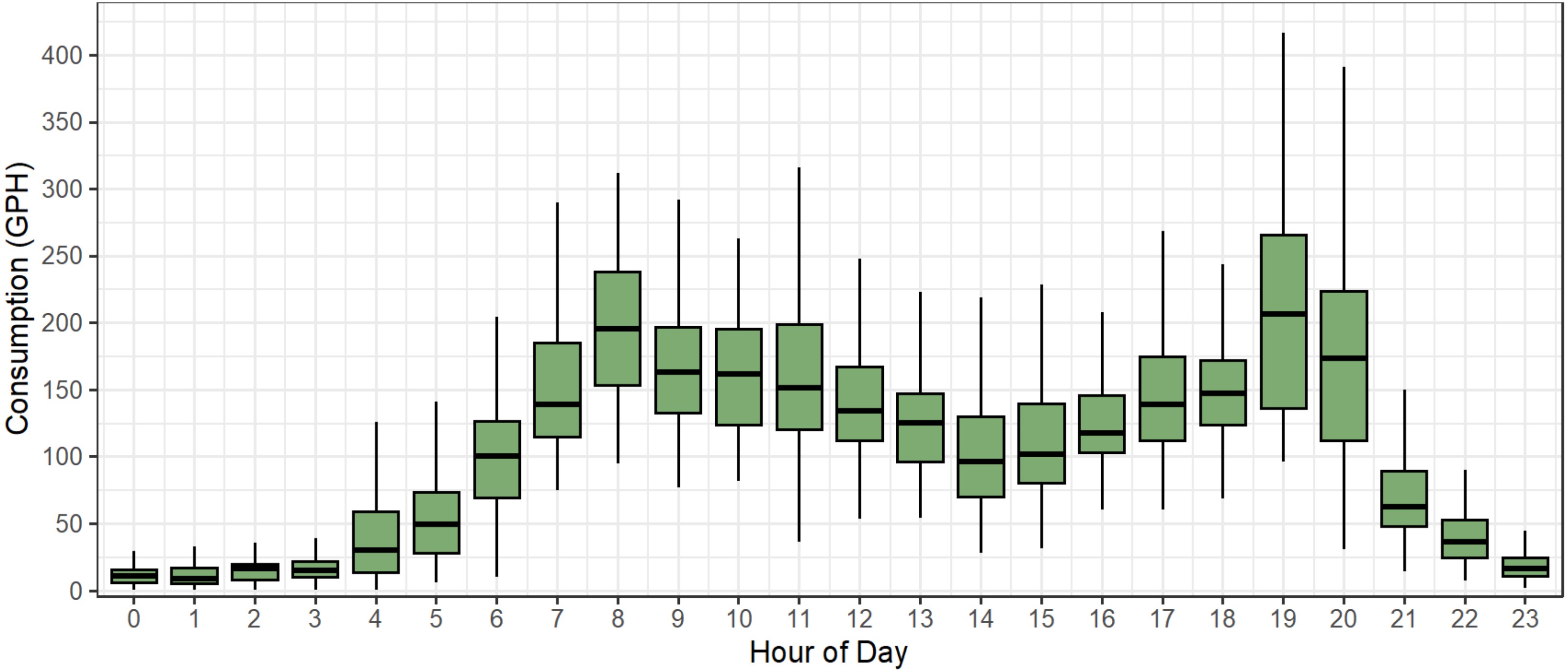
Accessibility, through low costs & support



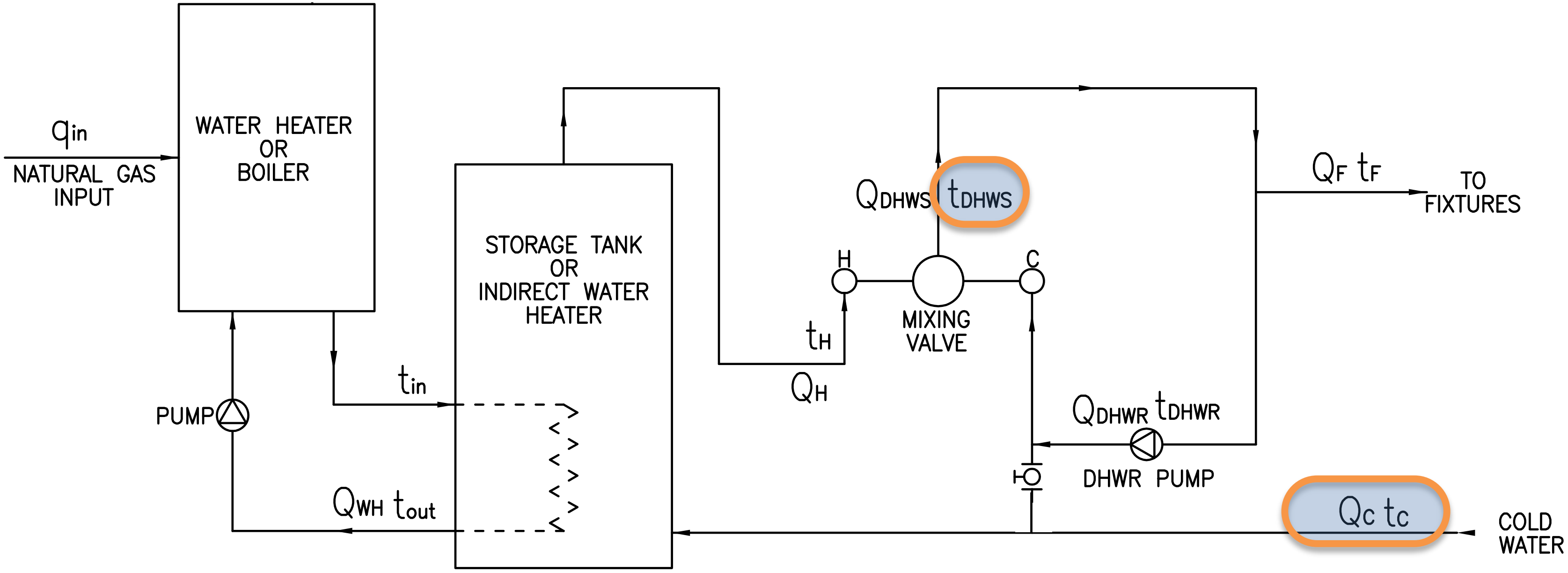
ASHPWH Estimated Savings (relative to whole building annual use)



Understand Demand → Size the System

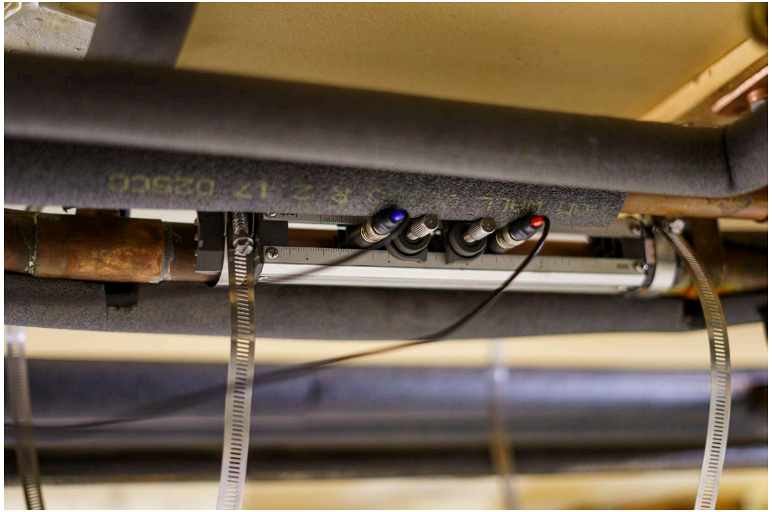


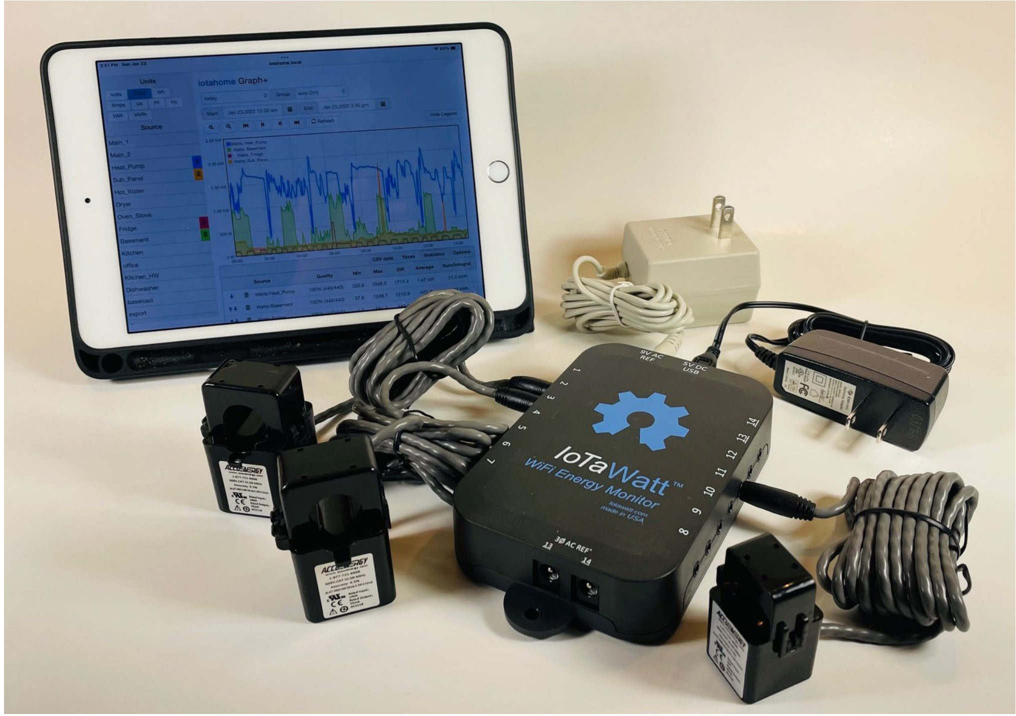
DHW Systems



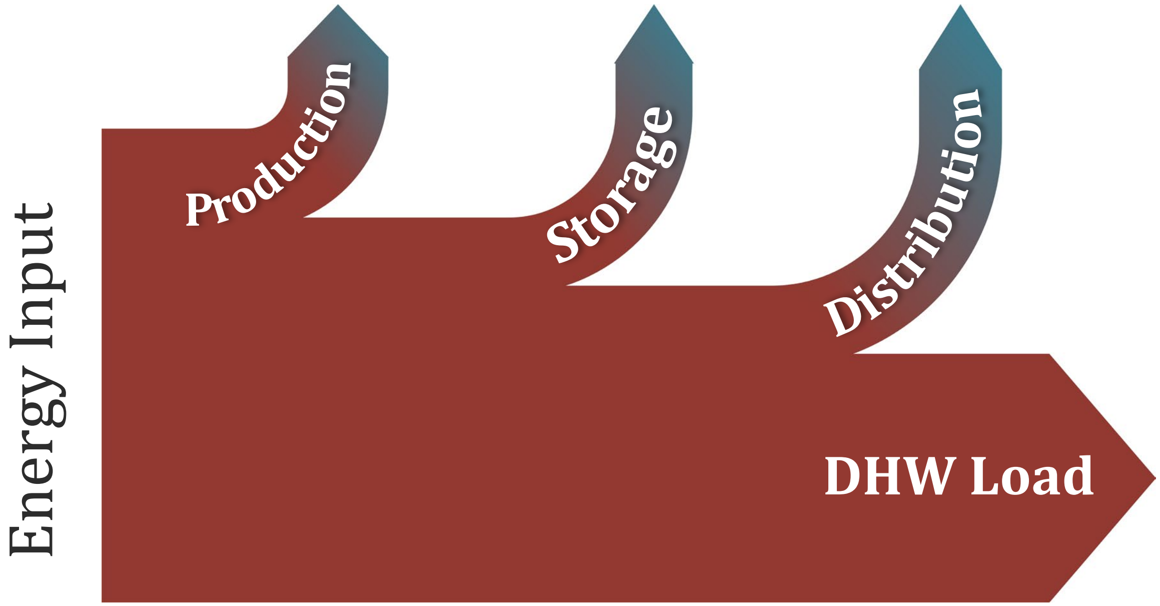
qin
NATURAL GAS INPUT
WATER HEATER OR BOILER
STORAGE TANK OR INDIRECT WATER HEATER
PUMP
tin
QWH tout
tH
QH
H
C
MIXING VALVE
QDHWS tDHWS
QF tF
TO FIXTURES
QDHWR tDHWR
DHWR PUMP
Qc tc
COLD WATER

Methods & Data

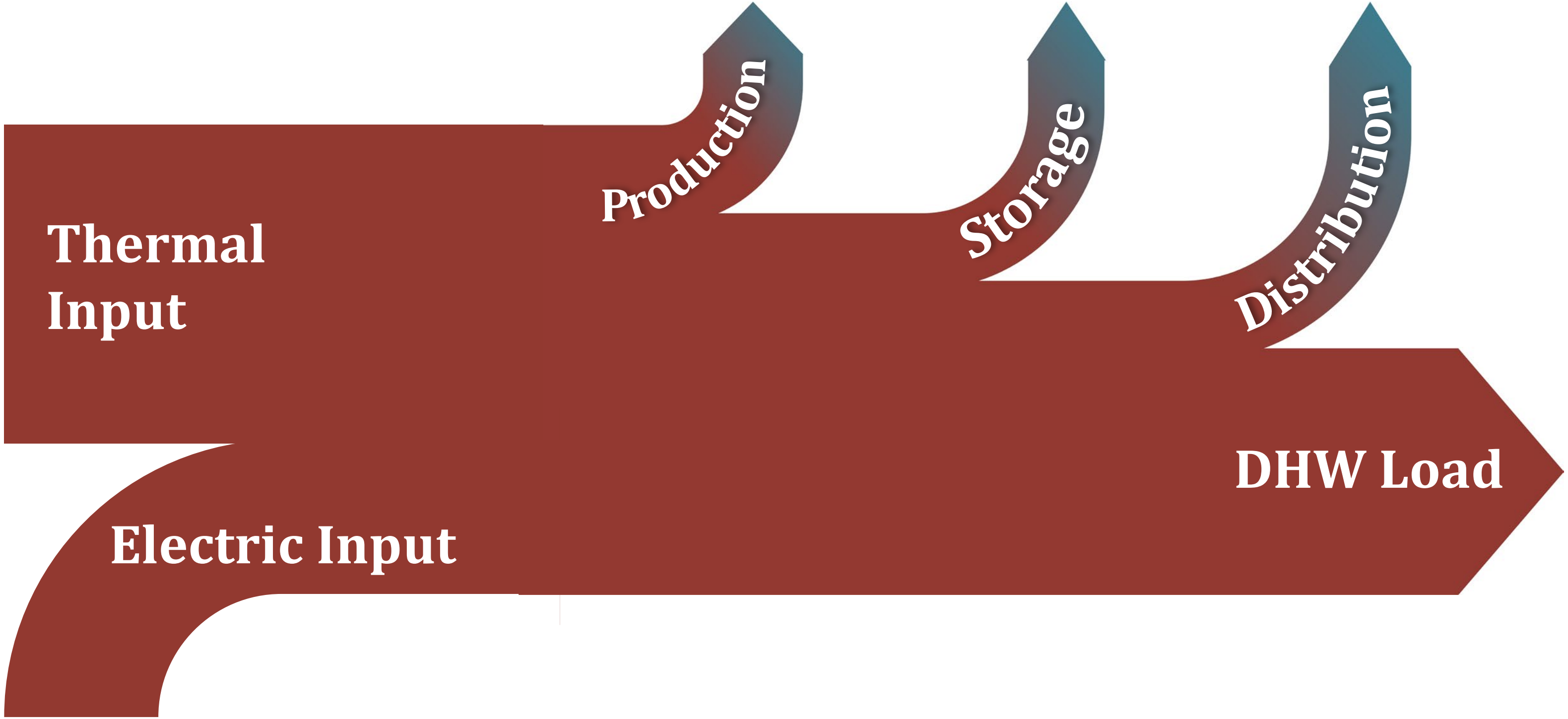




Hot Water Energy Flow Diagram- Gas Fired



Hot Water Energy Flow Diagram- Heat Pump



Goals

1. What Measured Loads Look Like
2. Efficiency Impacts of System Sizing
3. First Cost Impacts of System Sizing

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ASHRAE Sizing

Low:
- Working
- Elderly
- Couples
- Middle Income

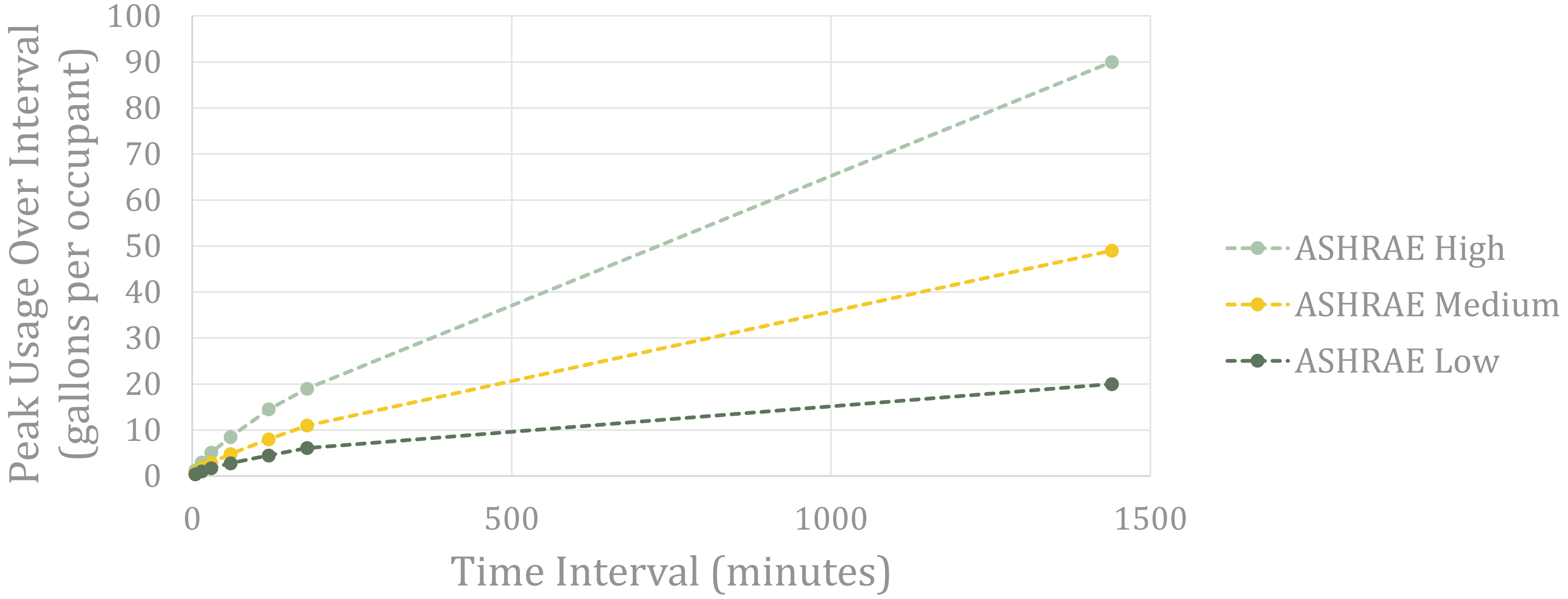
Medium:
- Singles
- Families
- Single-parent households

High:
- Families
- Low Income
- Not Working
- High percentage of children

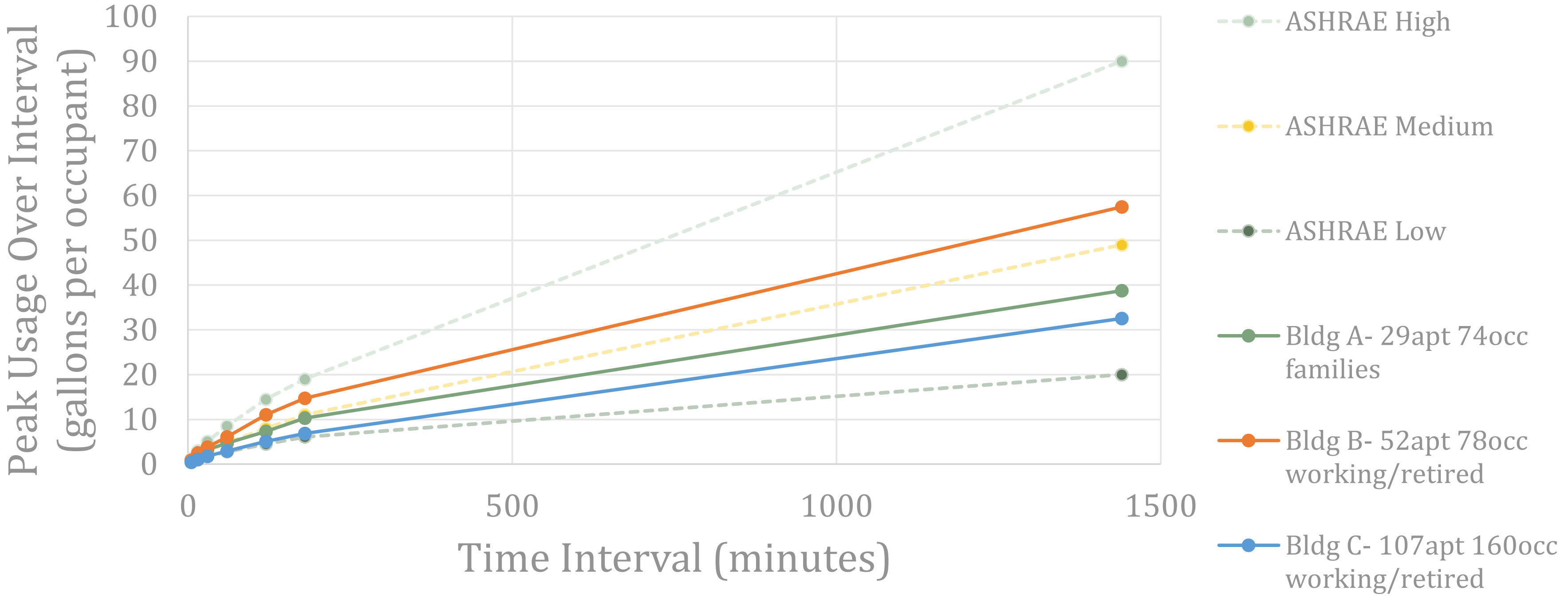
	Peak Minutes							
Guideline (Min)	**5**	**15**	**30**	**60**	**120**	**180**	**Max Daily**	**Avg Daily**
Low (GPP)	0.4	1.0	1.7	2.8	4.5	6.1	20	14
Medium (GPP)	0.7	1.7	2.9	4.8	8.0	11.0	49	30
High (GPP)	1.2	3.0	5.1	8.5	14.5	19.0	90	54

Gallons consumed per person (GPP) at 120°F over the time interval

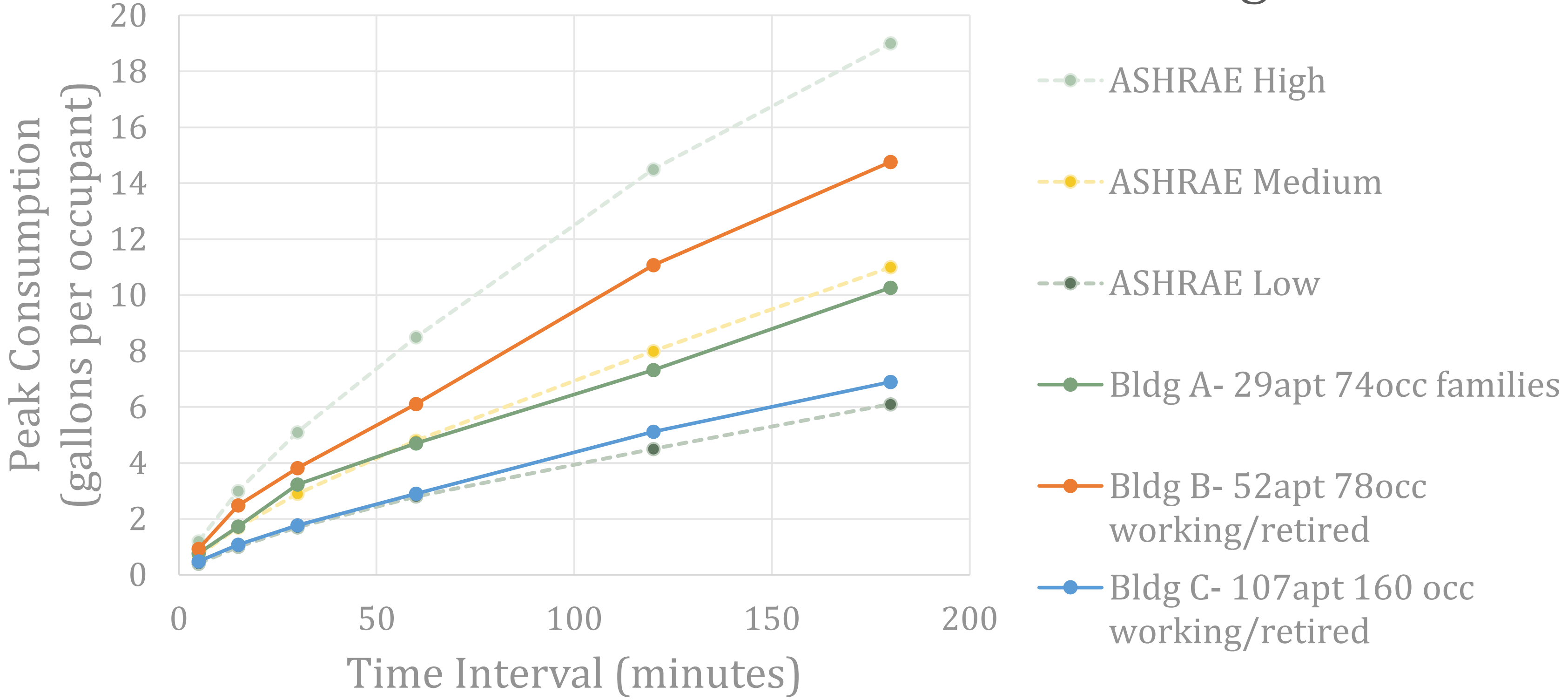
ASHRAE Standards vs. Measured Peak DHW Usage



ASHRAE Standards vs. Measured Peak DHW Usage



ASHRAE Standards vs. Measured Peak DHW Usage



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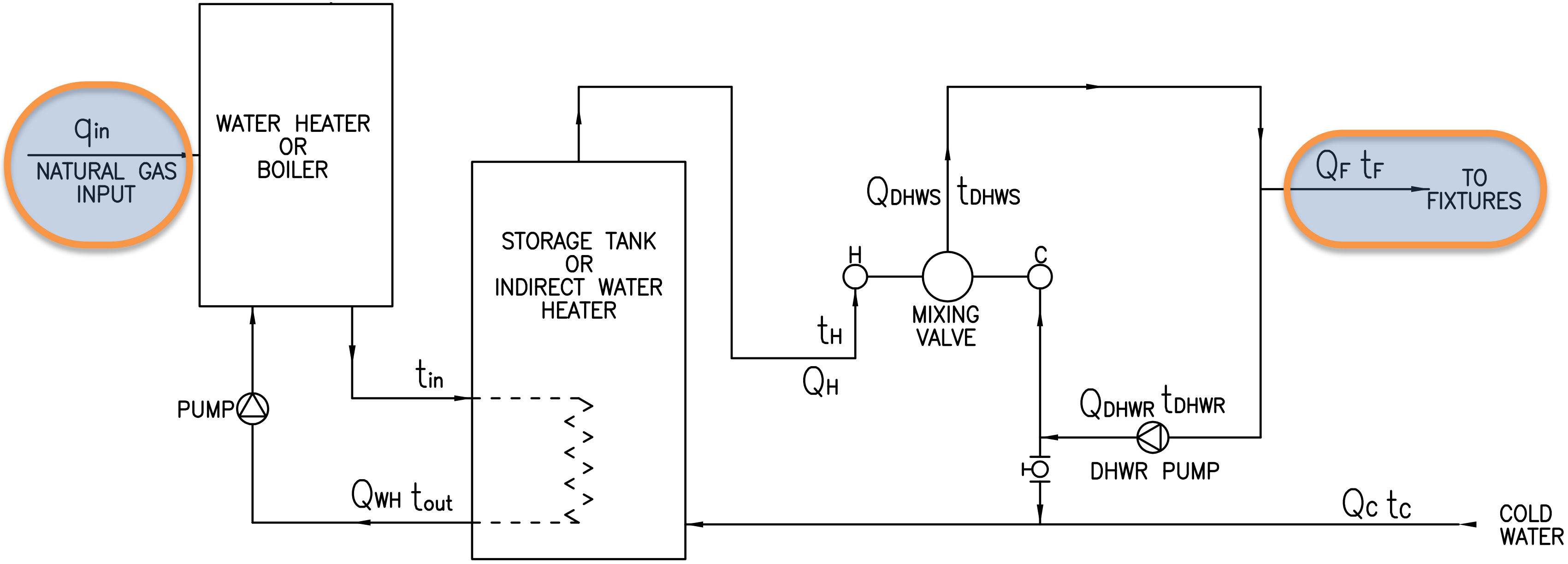
Gas-fired Hot Water Heater System Diagrams

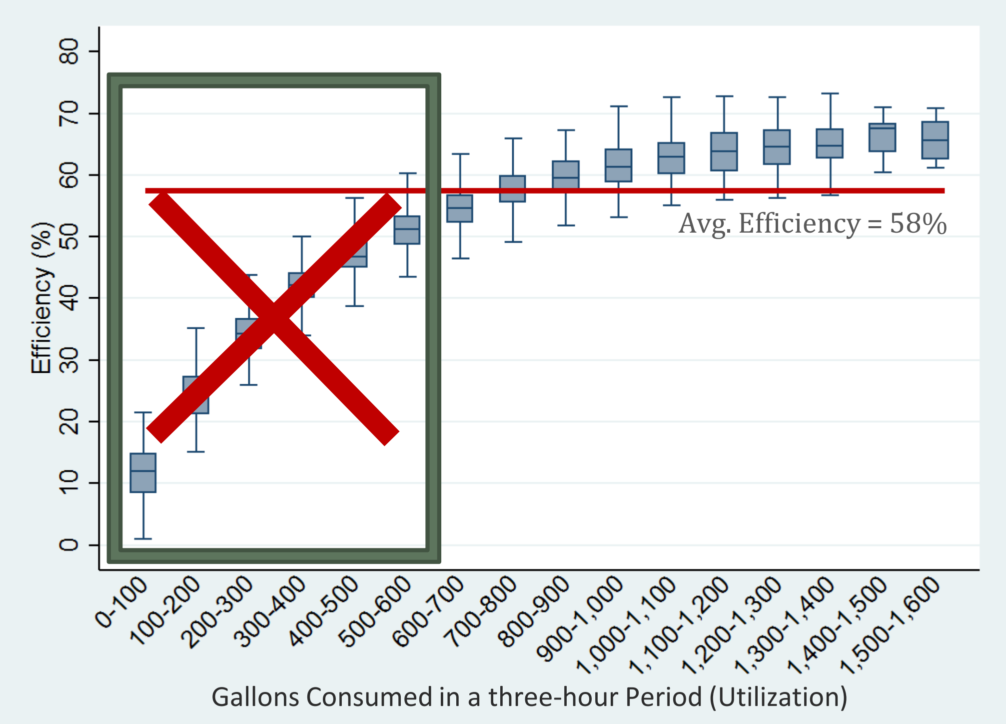


188-Unit Elderly Housing

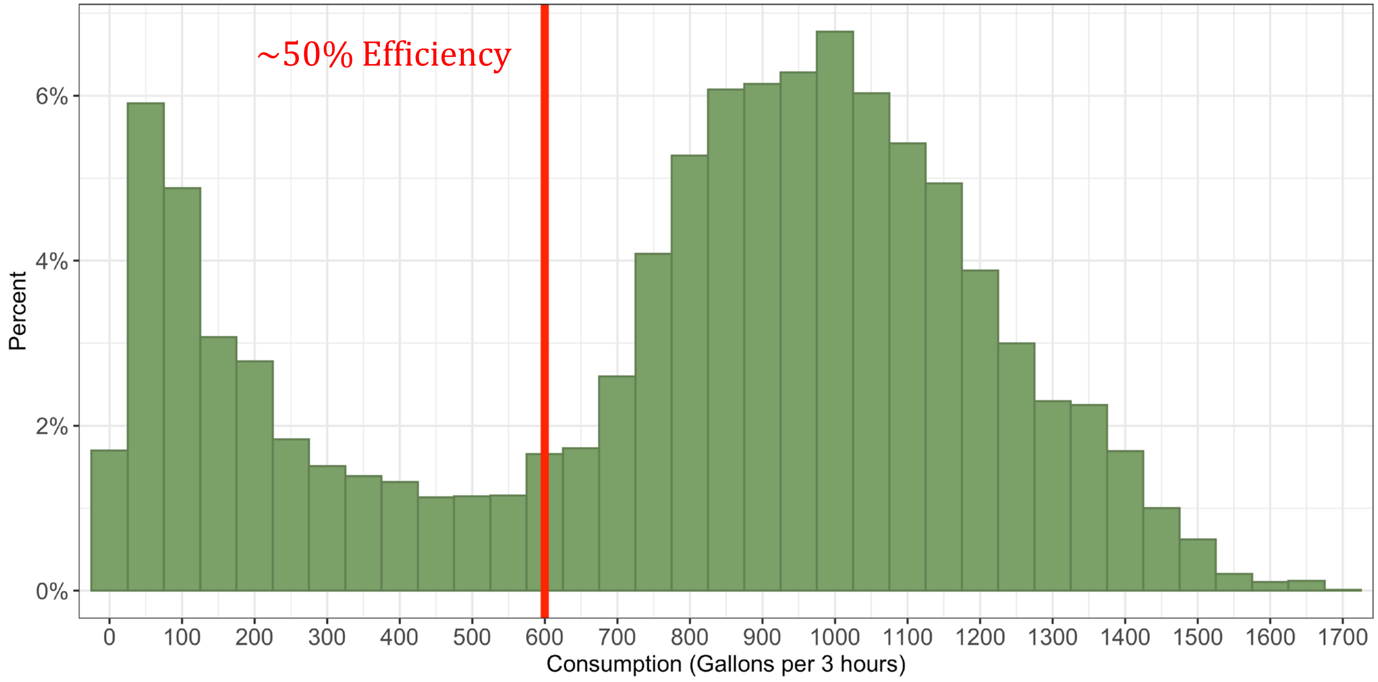
Direct-Fired gas boilers with Storage

- *201 Bedrooms*
- *2x 500 Kbtu boilers*
- *4x 120 gal storage tanks*
- *Constant recirculation*

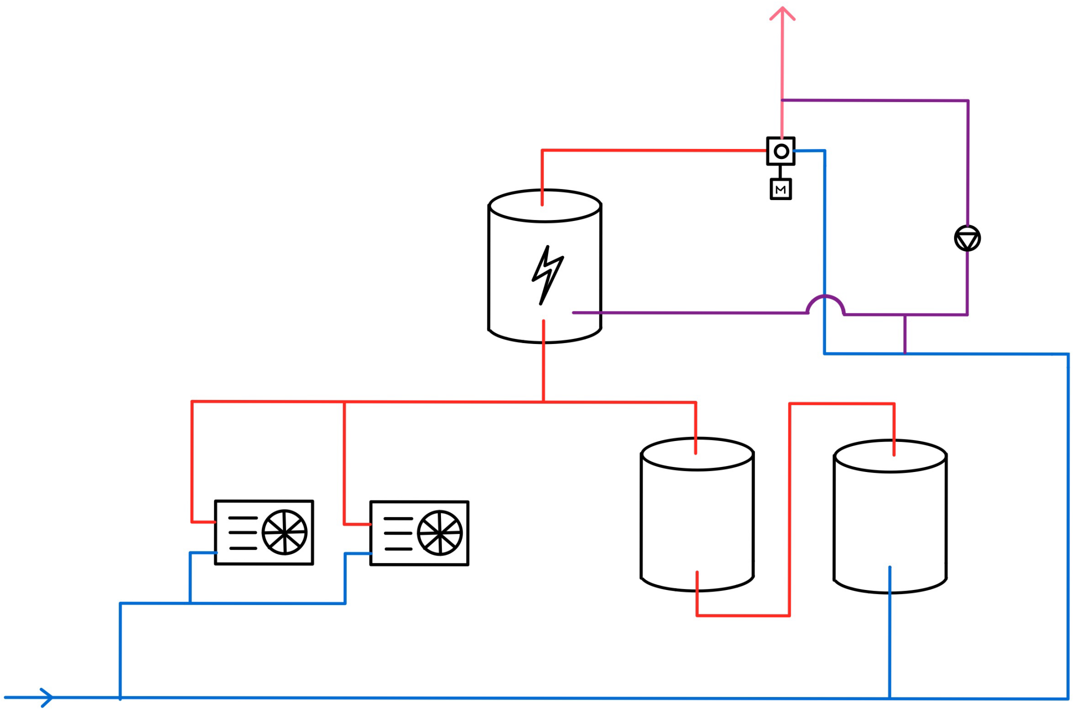
Total System Efficiency vs. Utilization



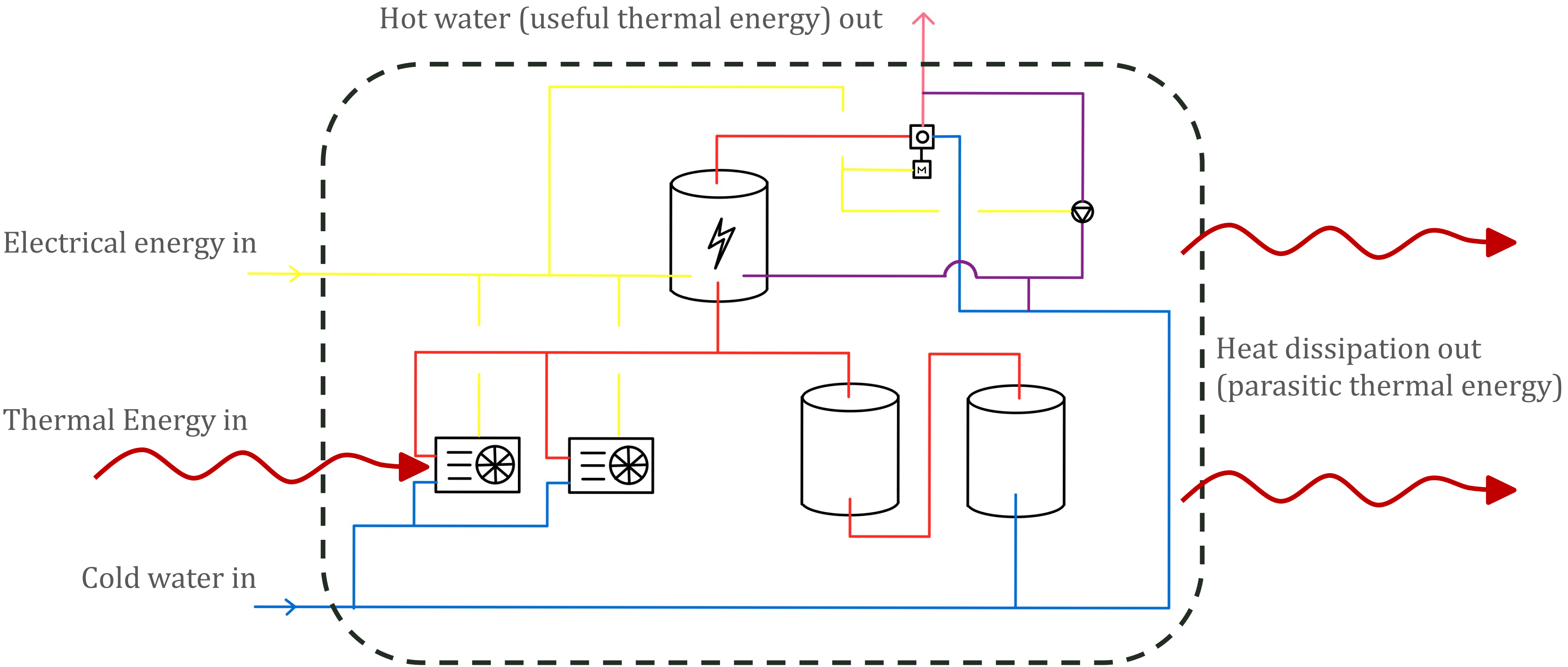
Histogram – Rolling 3 Hour Consumption Rate



Air Source Heat Pump Hot Water Heater System Diagrams



Air Source Heat Pump Hot Water Heater System Diagrams

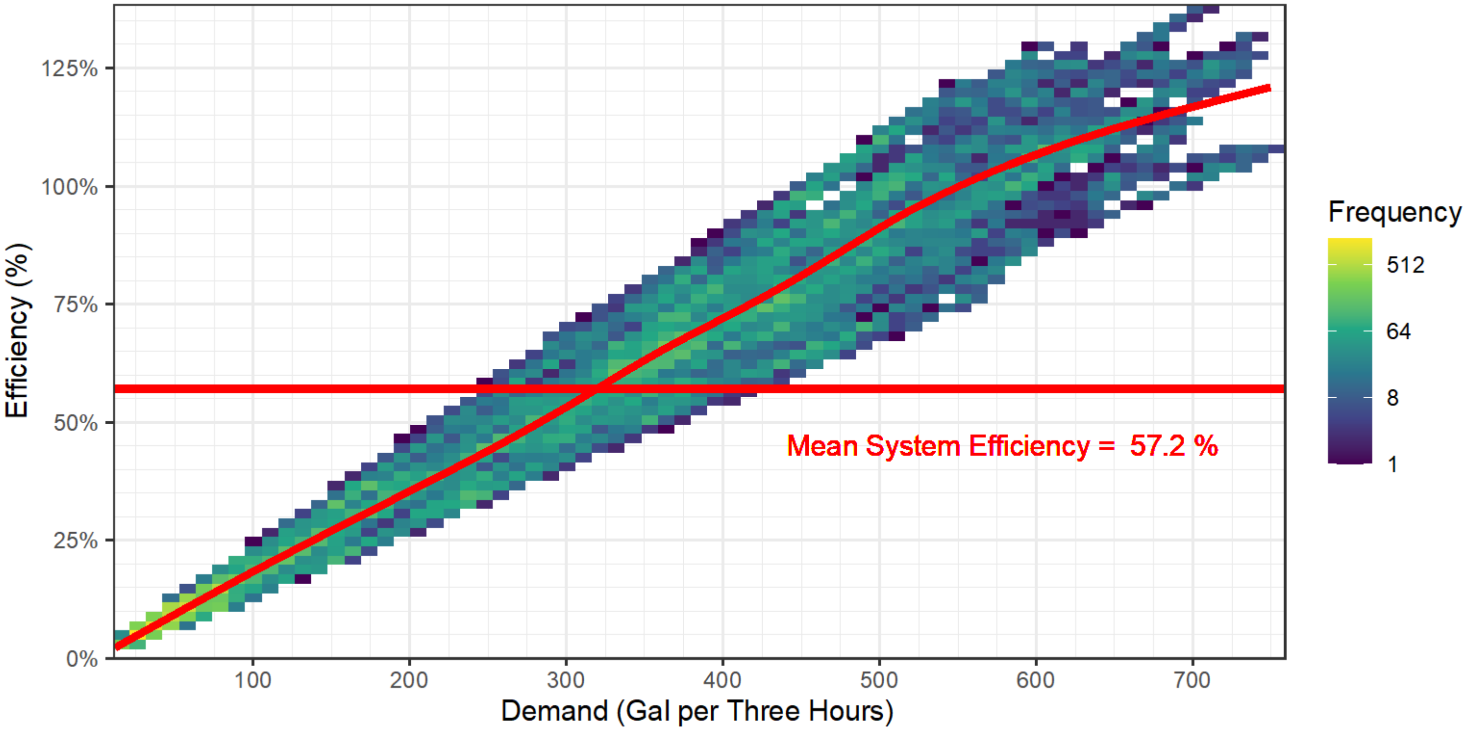


132 Unit Building Description

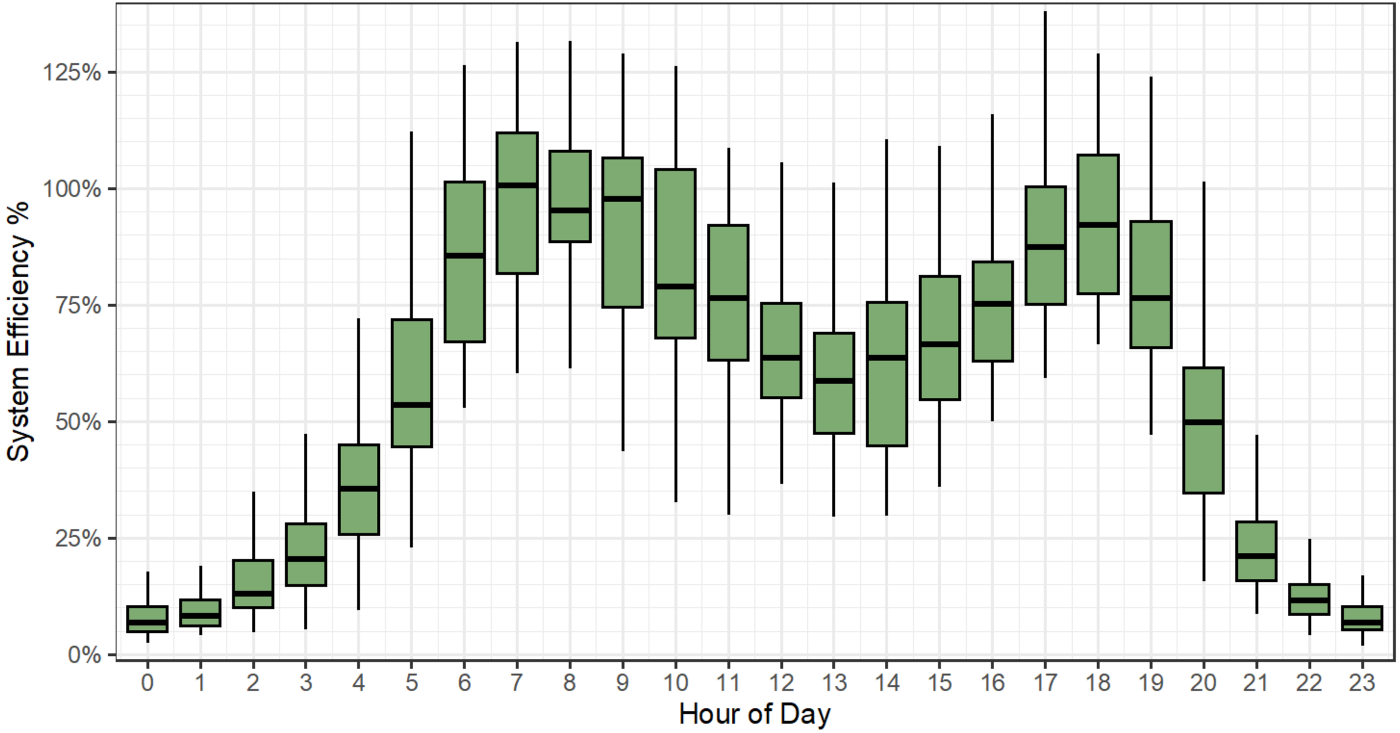
Ganged Sanco HPWHs with Storage

- *132 one bedroom units, 132 occupants*
- *10x Sanco heat pump water heaters*
- *1000 gallons of storage (at 160°F)*
- *120 gallon swing tank with 13.5 kW elements*

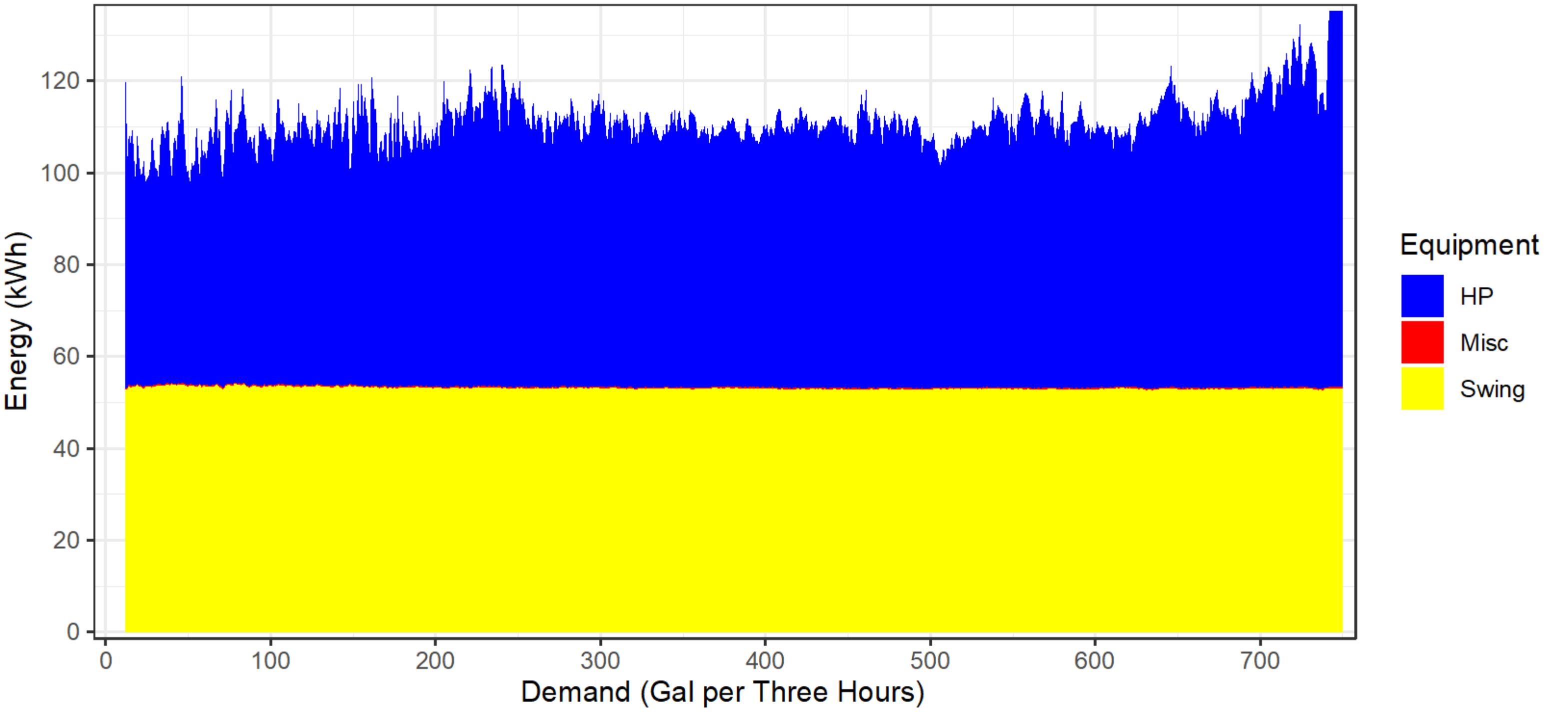
Total System Efficiency vs. Utilization



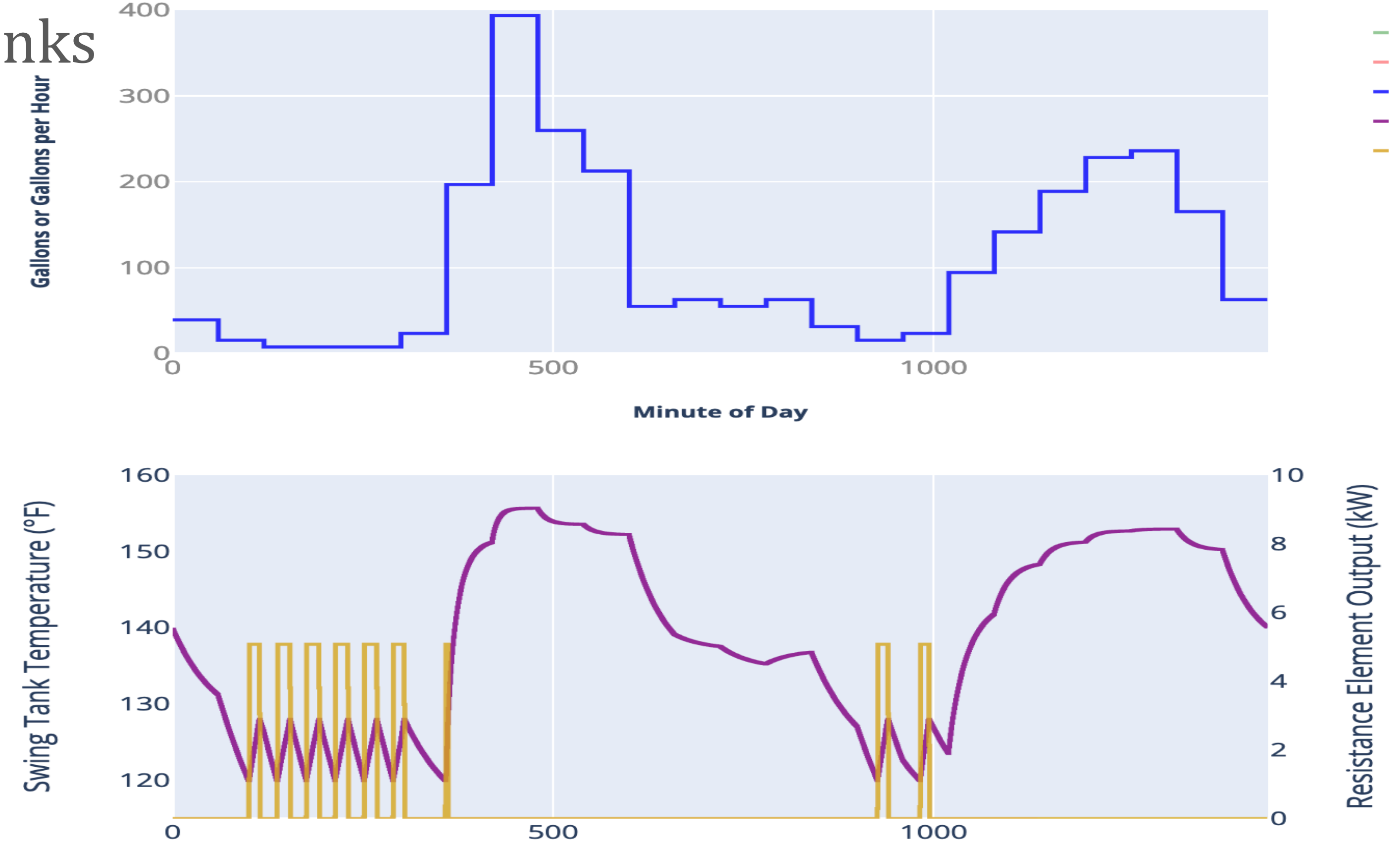
Daily System Efficiency



Energy Use Breakdown



Swing Tanks



Gallons or Gallons per Hour
400
300
200
100
0
0
500
1000
Minute of Day
Swing Tank Temperature (°F)
160
150
140
130
120
0
500
1000
Resistance Element Output (kW)
10
8
6
4
2
0

Recirculation Loads

	Bldg A	Bldg B	Bldg C	Bldg D
Recirc gpm	2.5	5.8	18.7	7.2
DHWS	117.5	134.6	132.1	127.1
DHWR	115.1	126.7	125.5	117.1
Btu/h Recirc	3,100	22,870	61,391	35,750
# apts	29	52	107	92
Watts/apt	**31**	**129**	**168**	**113**
Btu/h/apt	107	440	574	387

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ASHRAE More Accurate Method					Resultant Systems	
Interval (minutes)	Total Gallons	Local Slope of Incremental Gallons Per Minute	Ideal Heating Rate (Btu/h)	Storage Volume (gallon)	# of Sancos (15,400 Btu/h each)	Installed System Cost
5	52	7.4	298,368	74	20	$250,000
15	126	5.92	238,694	180	16	$218,000
30	215	4.69	189,101	307	13	$199,000
60	355	3.95	159,264	507	11	$200,000
120	592	3.7	149,184	846	10	$228,000
180	814	2.23	89,914	1163	6	$221,000
1440 (day)	3626				13 (@12 hour runtime)	

First Cost Implications

	Peak Minutes								
Guideline	**5**	**15**	**30**	**60**	**120**	**180**	**Max Daily**	**System**	**Cost**
Low	0.4	1.0	1.7	2.8	4.5	6.1	20	6s+300	$119,000
Medium	0.7	1.7	2.9	4.8	8.0	11.0	49	13s+300	$198,000
High	1.2	3.0	5.1	8.5	14.5	19.0	90	24s+500	$346,000
Measured	.71	1.58	2.95	4.30	6.69	9.37	35.4	10s+300	$164,000

Gallons per person at 120°F

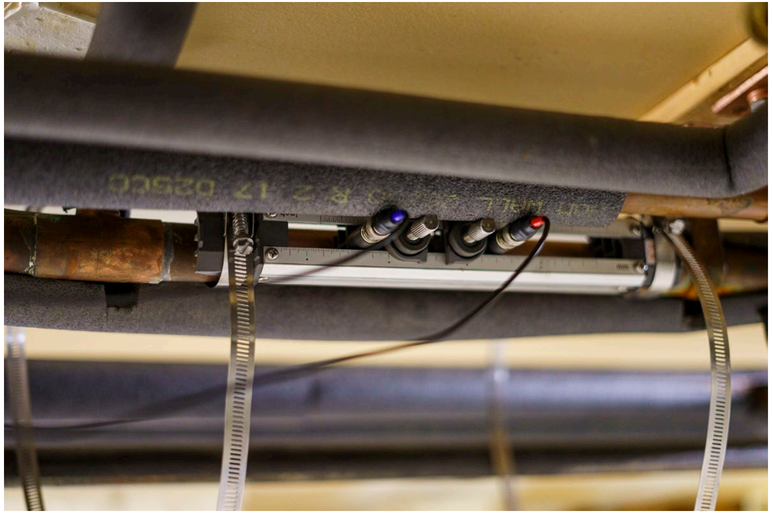
What's Next for You

Owners

Engineers

Program Administrators

Equipment Reps

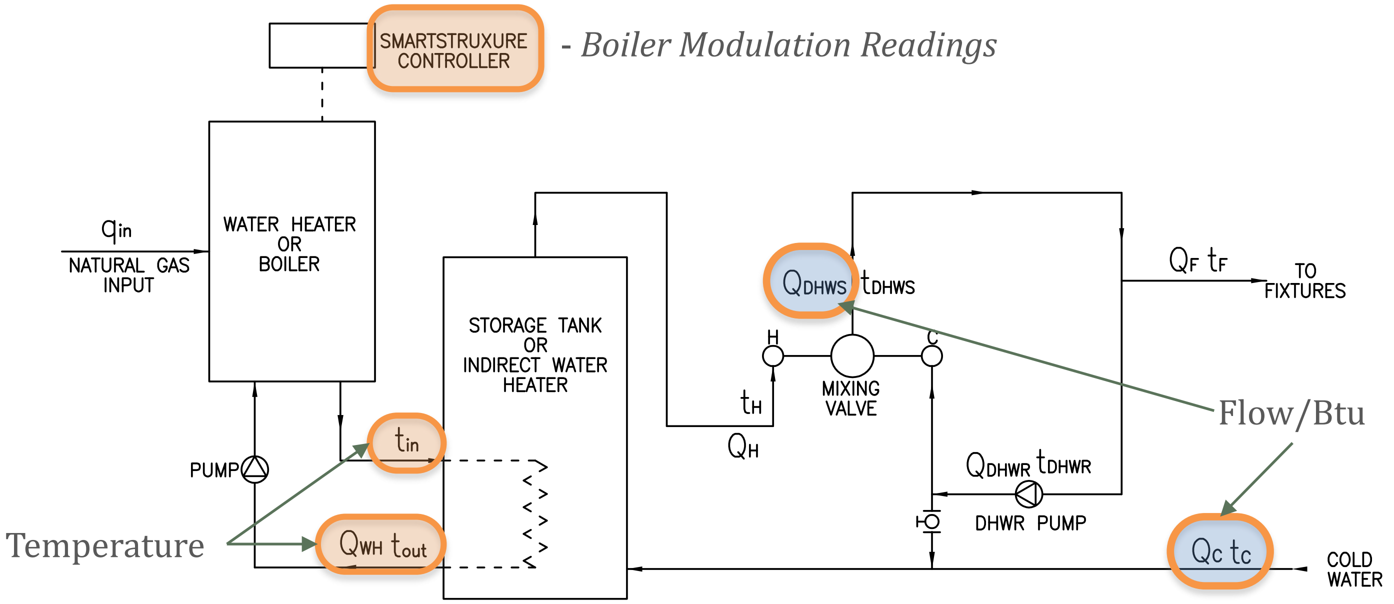


Charlie Simek
Energy Engineer
charles.simek@newecology.org
617-557-1700 x7095

Neil Donnelly
Senior Energy Engineer
neil.donnelly@newecology.org
617-557-1700 x7095

www.newecology.org

A.1 - System Schematic, Temperature, and Flow/Btu Sensor Locations

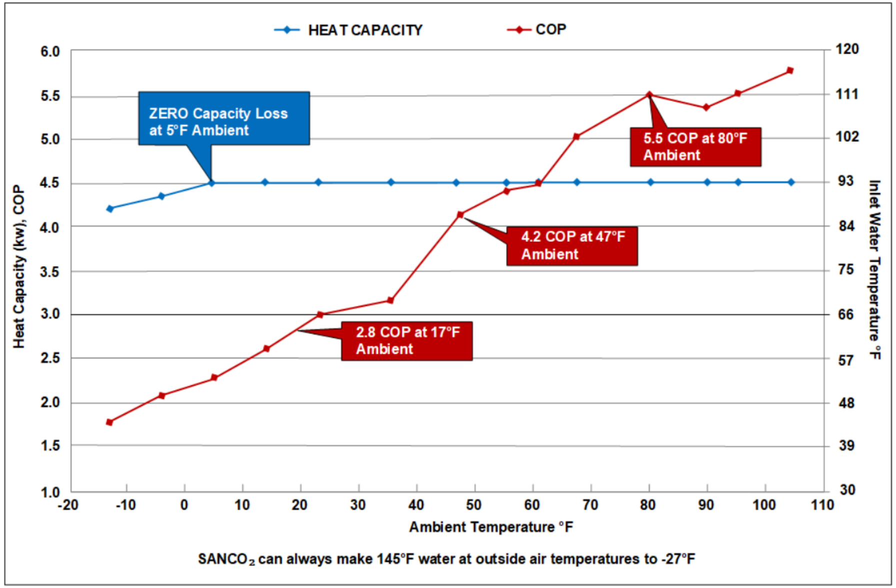


A.2 - Data Accuracy & Error Checking

- Ultrasonic flow meter accuracy:
  - *±1 gpm for the range of flow rates encountered*
- Temperature Sensor accuracy: ±1% temp reading
- Temperature sensor transient response
- Consumption below or above expected values
- Checking measured energy and water consumption against utility meters

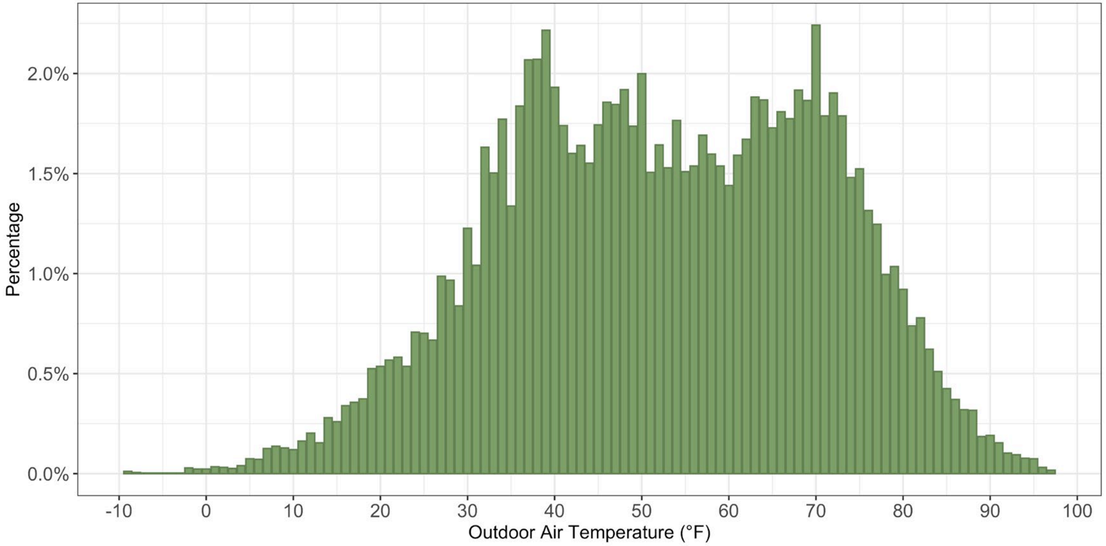
A.3 - Outdoor Air Temperatures and Heat Pump Capacity

- As outdoor air temperatures decrease ASHPs that are extracting heat from the ambient air must work harder to output the same amount of heat
- At a certain threshold the heat pump's capacity will begin to decrease as well
- Heat pumps using CO_2 as their refrigerant can operate down to colder temperatures than other refrigerants without losing capacity
- CO_2 has the added benefit of only having a global warming potential (GWP) of 1.0 compared to other refrigerants with GWPs in the 1000s



https://www.eco2waterheater.com/_files/ugd/e88920_b4075b5329fe46edb29044ae9b7116bf.pdf

A.4 - Outdoor Air Temperature Histogram (Boston)



- Supplement the capacity of the hot water system with electric resistance or boilers to meet the load when heat pumps lose capacity

A.5 - Sizing for the Majority of Runtime