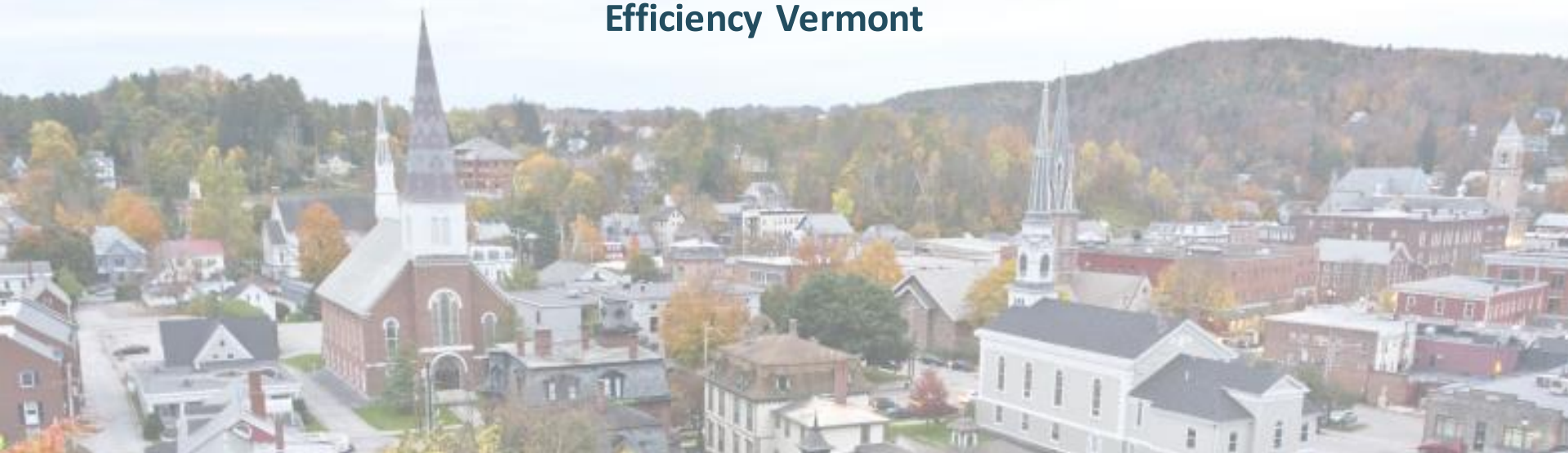
MAY 2020

Heat Pump Showcase Addison County Regional Planning Commission

Matt Sargent
Senior Energy Consultant
Efficiency Vermont



Equipment Types

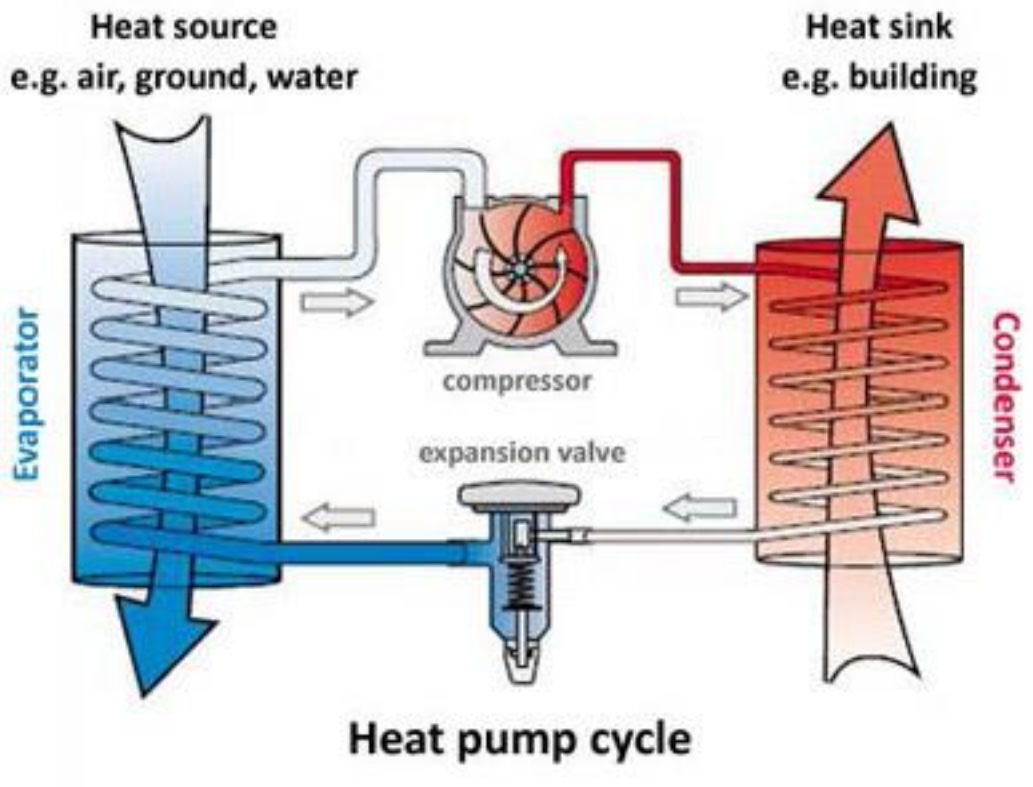
Mini split heat pumps
Ducted heat pumps
Air To Water heat pumps
Ground Source heat pumps
Domestic Hot Water systems

Efficiency Vermont

Refrigeration cycle

Heat Source

Heat Sink



Efficiency Vermont

Gauging energy efficiency

- HSPF – Heating Seasonal Performance Factor
- SEER – Seasonal Energy Efficiency Ratio
- EER – Energy Efficiency Ratio
- COP – Coefficient of Performance
- **NEEP** – Northern Energy Efficiency Partnership

  https://neep.org/ASHP-Specification

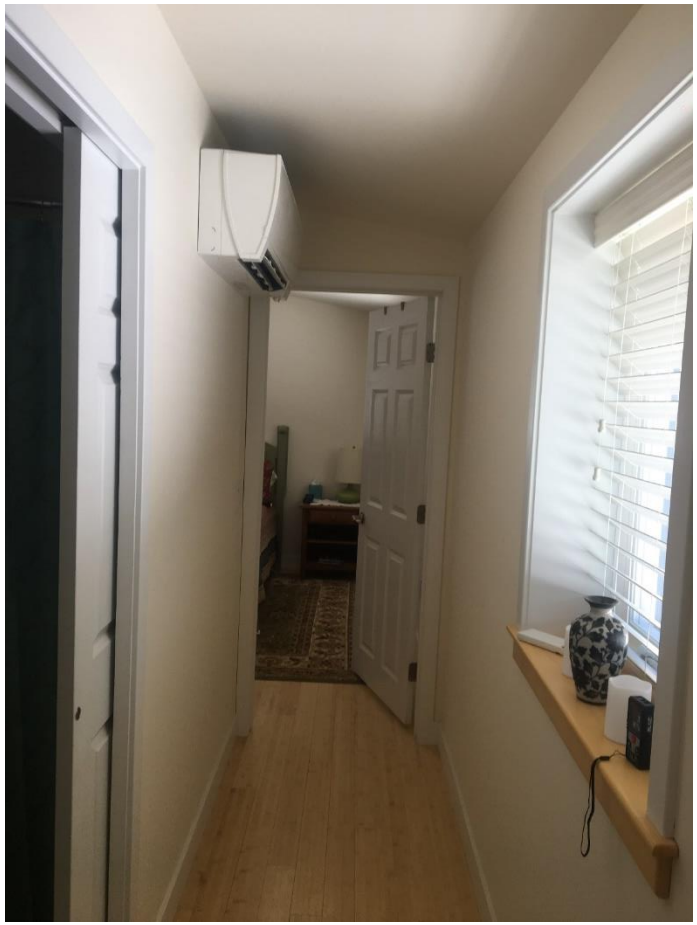
Efficiency Vermont

NEEP ccHP Specification v3.0

- For Non-Ducted systems: HSPF >10
- For Ducted systems: HSPF >9
- COP @5°F >1.75 (at maximum capacity operation)
- SEER > 15

Efficiency Vermont

Single zone mini-split



Good news

- Customers love these things
- Cost effective
- Easy retrofit
- Best efficiency of all air sourced heat pumps
- Great low temp capability
- Indoor unit options

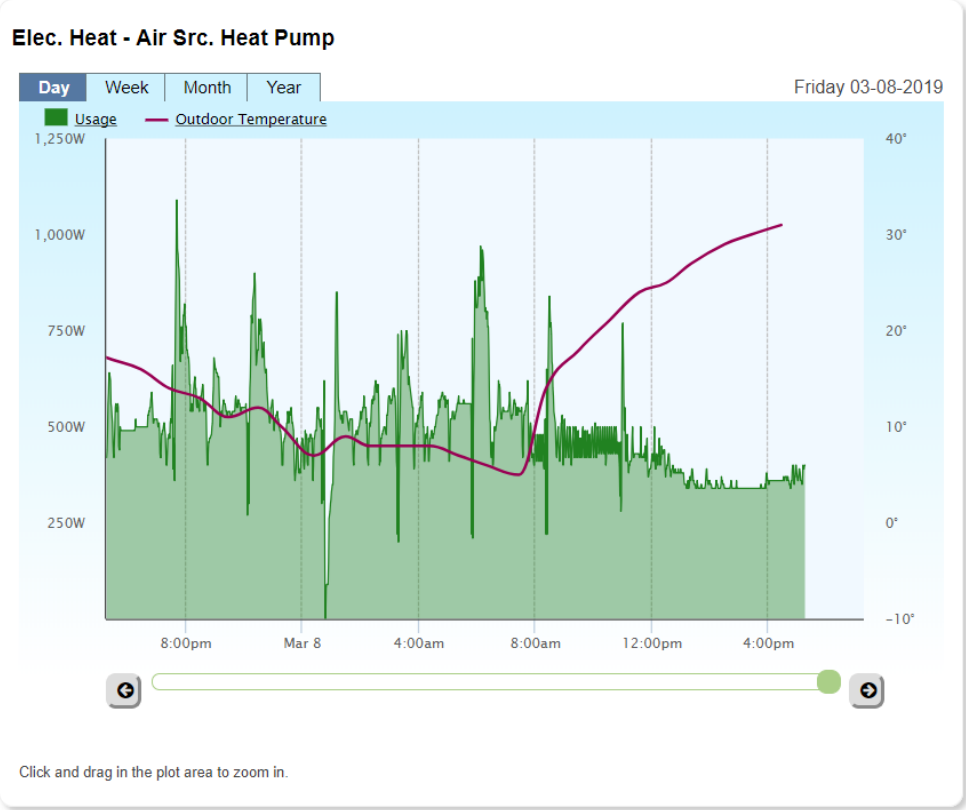
Challenges

- Non-distributed
- Comfort
- Sizing and selecting
- Zoning
- Systems integration

Efficiency Vermont

Single zone ductless mini split

- Up to HSPF 15, SEER 42, highest of all air source heat pumps
- Over 800 systems on NEEP list
- Up to about 30 KBtu at 5F
- Over 100% rated heating capacity at 5F
- Up to 8:1 turndown



Efficiency Vermont

Single zone mini split indoor options

- Compact Duct – still considered mini split
- Ductless Floor – looks like space heater
- Ductless Wall - usually best listed performance
- Ceiling Cassettes – variety of styles, don't install in attic

Efficiency Vermont

Equipment Types

Mini split heat pumps

Ducted heat pumps

Air To Water heat pumps

Ground Source heat pumps

Domestic Hot Water systems

Efficiency Vermont

Multi zone ductless heat pumps

Good News

- Single outdoor unit serves multiple indoor units
- Reduced electric infrastructure
- Indoor options

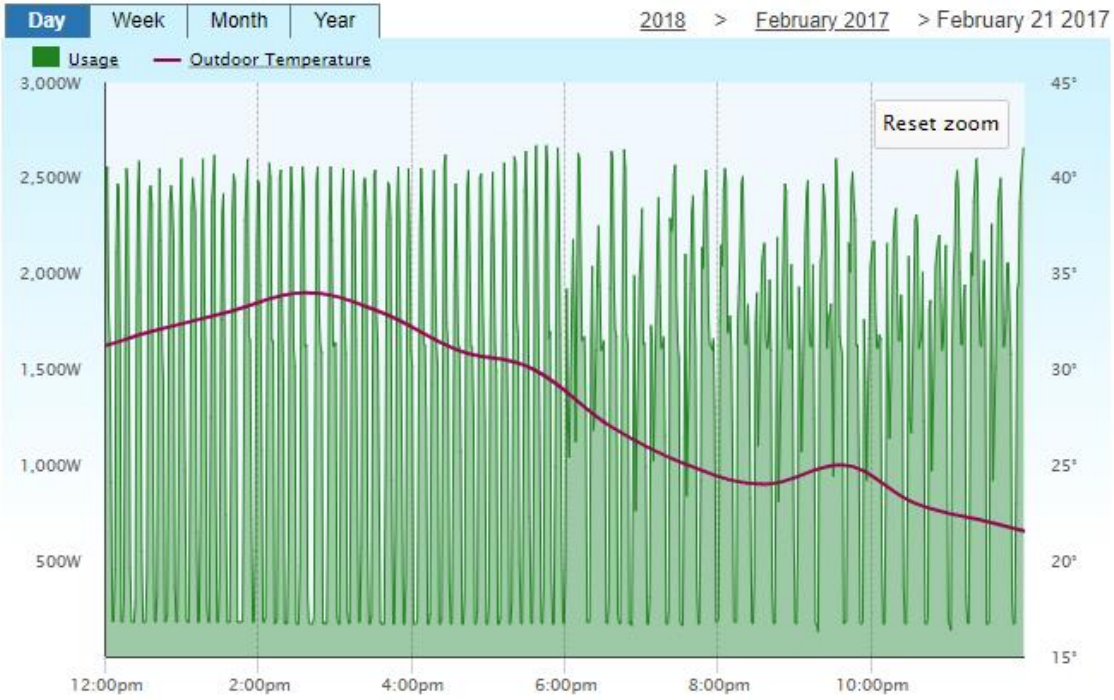
Challenges

- Do not modulate as well as single zones
  - Performance and comfort implications
- Difficulty matching partial loads in small spaces
- Lower listed performance than single zones
- Still need load calcs,
  - block load
  - room by room
  - Sensible and latent

Efficiency Vermont

Multi zone ductless mini split

- Up to HSPF 12.5, SEER 19,
- 208 systems on NEEP list
- Up to about 60 KBtu at 5F
- Over 100% rated heating capacity at 5F
- Up to 4:1 turndown



Efficiency Vermont

Special Bulletin:
Multi Split Heat Pumps

- Single zone systems are recommended over multi zone
- Never oversize multi zone heat pumps, size for partial load offset where possible
- Never size multi zone heat pumps based on number of zones

Efficiency Vermont

One more thing about mini split heat pumps… they need to be cleaned.

Efficiency Vermont

Efficiency Vermont

Equipment Types

Mini split heat pumps

Ducted heat pumps

Air To Water heat pumps

Ground Source heat pumps

Domestic Hot Water systems

Efficiency Vermont

Compact Ducted AKA "ducted mini split"

- Minimal ducting, low static pressure systems
- Good for adjacent rooms
- Slightly lower performance vs single zone mini split
- Connect to HRV? Yes or no?
- 30 Single Zone mini-split compact ducted systems currently on EVT QPL
- EVT rebates found on Mini Split QPL

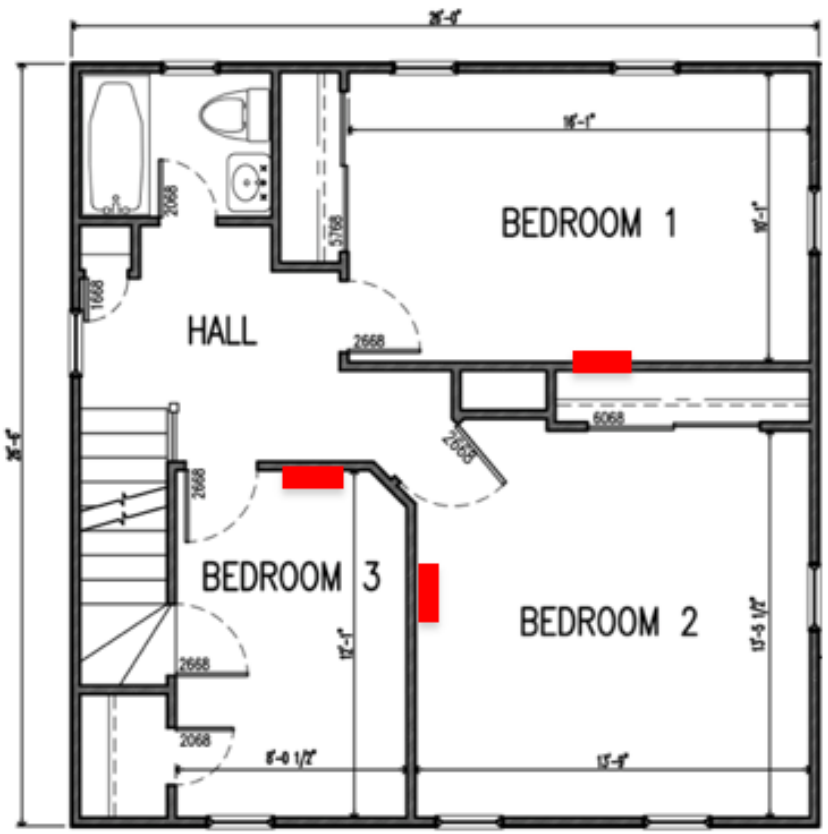
Efficiency Vermont

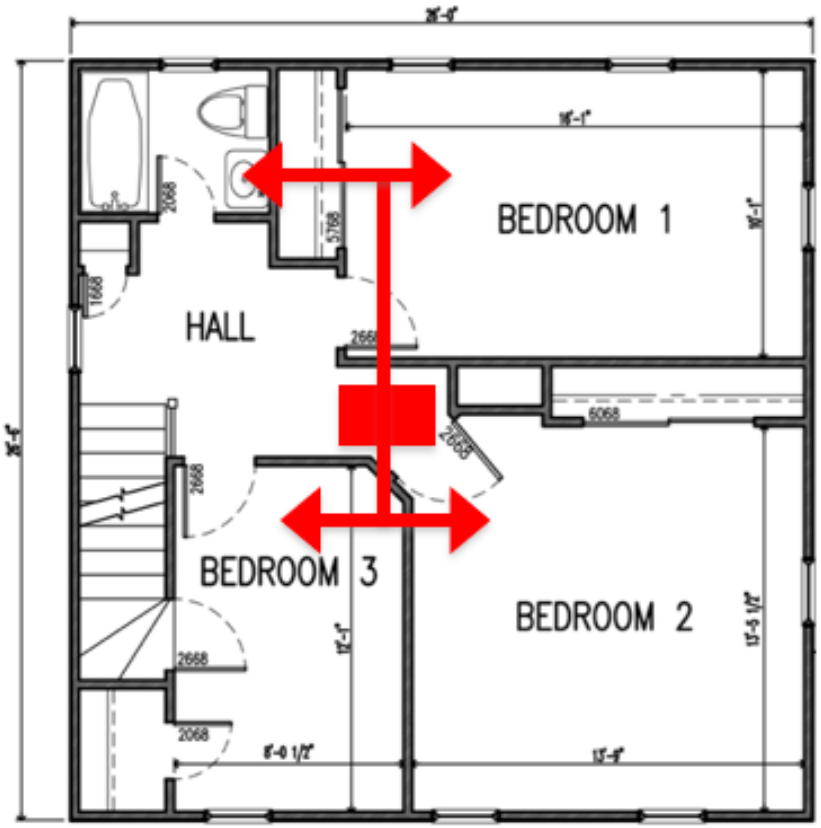
Rules of Thumb for Static pressure in a duct system

- As a rule of thumb, it's not a good idea to use rules of thumb for HVAC design. -John Semmelhack
- Ducts and fittings may need to be larger than you'd think.
- Duct runs should be short, with minimal fittings.
- ACCA Manual D is a good place to start.
- Compact ducted systems range in allowable static pressure from 0.2"-0.6" wg

Efficiency Vermont

Compact Ducted vs Multi Zone





Images courtesy of Mike Duclos, DEAP Energy Group

Efficiency Vermont

Multi Zone vs Compact Ducted

Performance Specs

Heating / Cooling	Outdoor Dry Bulb	Indoor Dry Bulb	Unit	Min	Rated	Max
Heating	5°F	70°F	Btu/h	12,500	-	25,000
			kW	1.6	-	3.82
			COP	2.29	-	1.92
Heating	17°F	70°F	Btu/h	13,100	14,000	25,000
			kW	1.5	1.62	3.56
			COP	2.56	2.53	2.06
Heating	47°F	70°F	Btu/h	11,400	25,000	25,000
			kW	0.93	1.72	1.72
			COP	3.59	4.26	4.26
Cooling	82°F	80°F	Btu/h	15,060	-	23,600
			kW	0.68	-	3.77
			COP	6.49	-	1.83
Cooling	95°F	80°F	Btu/h	12,600	22,000	23,600
			kW	0.53	1.63	3.77
			COP	6.97	3.96	1.83

MXZ-3C24NAHZ2
Multi Zone Ductless

Performance Specs

Heating / Cooling	Outdoor Dry Bulb	Indoor Dry Bulb	Unit	Min	Rated	Max
Heating	5°F	70°F	Btu/h	3,800	-	12,000
			kW	0.25	-	1.22
			COP	4.45	-	2.88
Heating	17°F	70°F	Btu/h	4,900	13,900	13,900
			kW	0.31	1.42	1.42
			COP	4.63	2.87	2.87
Heating	47°F	70°F	Btu/h	8,100	21,600	25,600
			kW	0.43	1.58	2.12
			COP	5.52	4.01	3.54
Cooling	82°F	80°F	Btu/h	6,700	-	18,900
			kW	0.25	-	1.1
			COP	7.85	-	5.04
Cooling	95°F	80°F	Btu/h	6,100	18,000	18,000
			kW	0.32	1.31	1.31
			COP	5.59	4.03	4.03

SUZ-KA18NA2 / SEZ-KD18NA
Compact Duct

Efficiency Vermont

Equipment Types

Mini split heat pumps

Ducted heat pumps

Air To Water heat pumps

Ground Source heat pumps

Domestic Hot Water systems

Efficiency Vermont

Centrally Ducted Heat Pumps

Efficiency Vermont

Centrally Ducted Heat Pumps

- Whole house option, using ducted distribution
- Provide heating and AC
- Replace central AC unit w/Heat Pump
- Keep existing furnace in place
  - Offset dirty and expensive heating fuels used by the furnace
- New construction or retrofit

Efficiency Vermont

Control Strategy

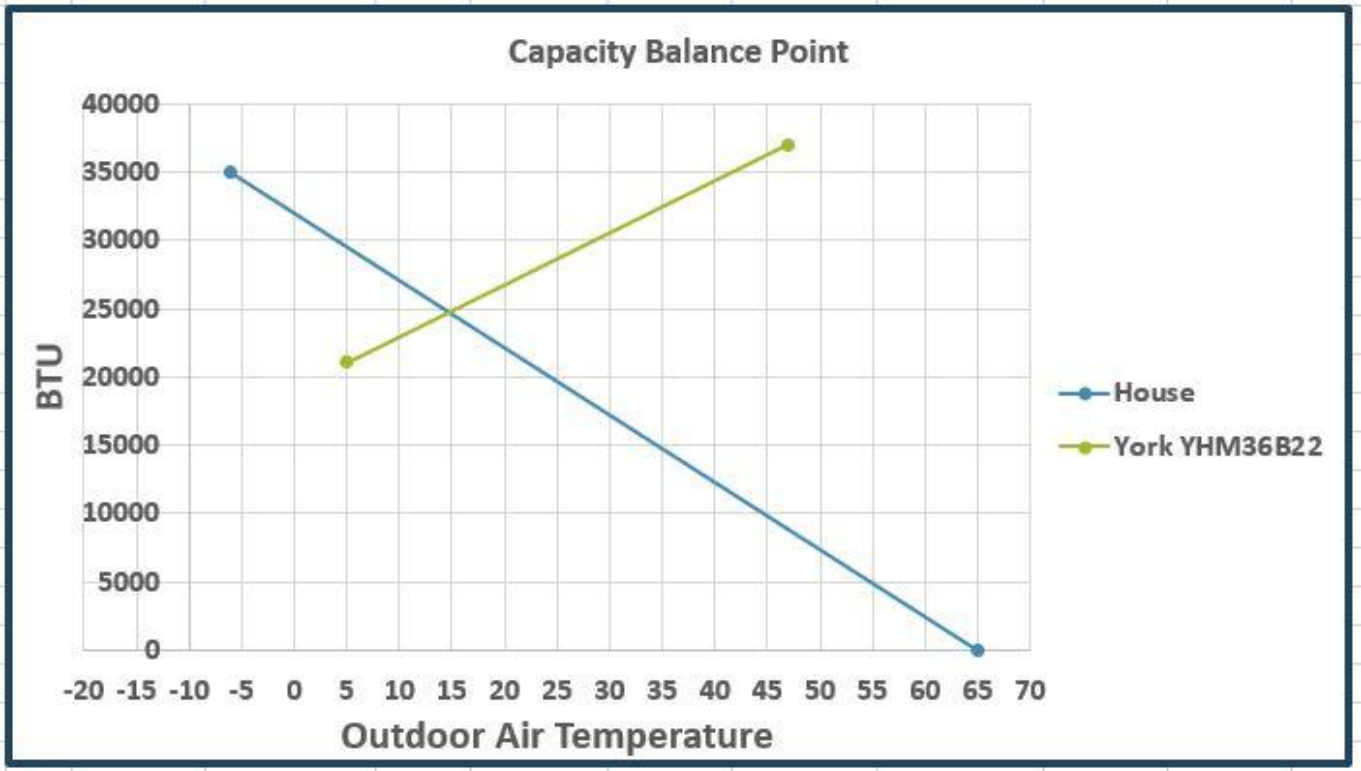
- Capacity Balance Point:
  - outdoor temperature at which the capacity of a heat pump equals the heating load in the house.

- Economic Balance Point:
  - Outdoor temperature at which cost to operate heat pump equals cost to operate backup heat

Efficiency Vermont

Balance Point, Capacity

Heat Pump Make Model		
York YHM36B22		
Building Design		
Heat Load	35000	
	Temp	Btu
House	-6	35000
House	65	0
York YHM36B22	5	21100
York YHM36B22	47	37000



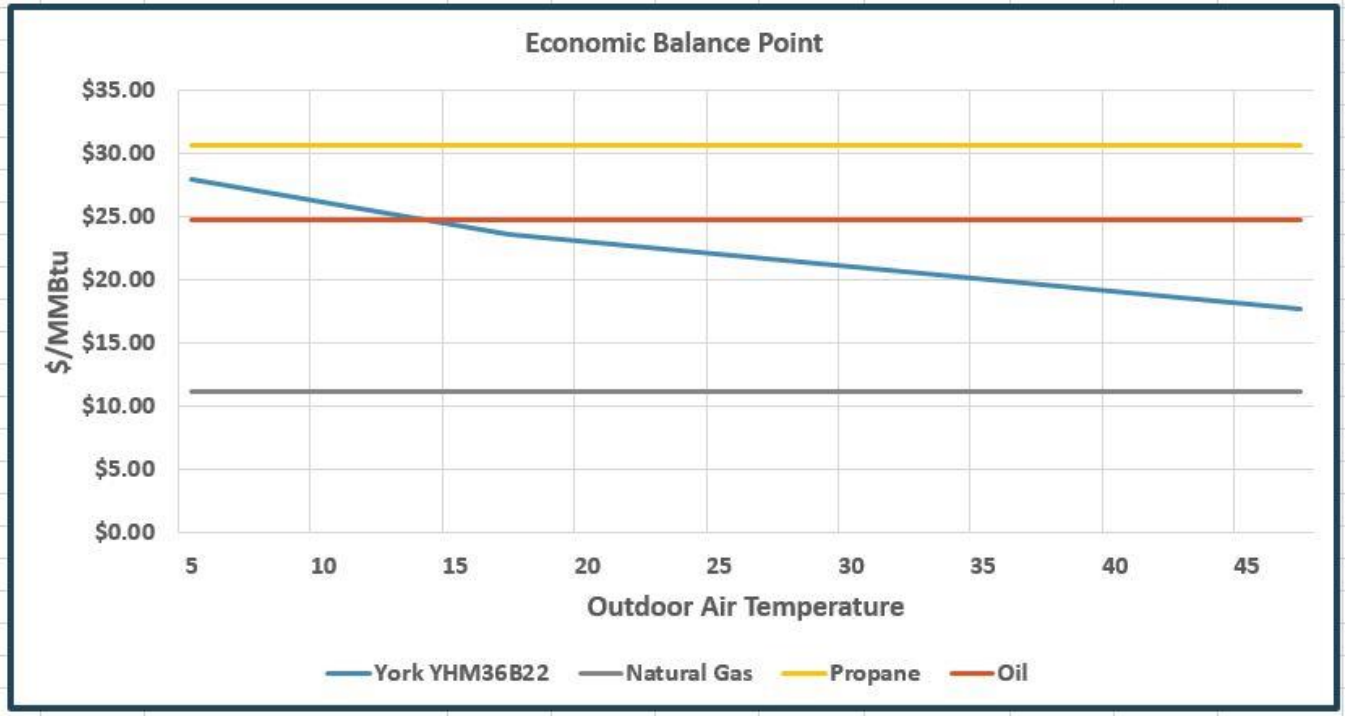
Efficiency Vermont

Balance Point, economic

NEEP Rated COP at OAT			Heat Pump make model	Heat Pump $/MMBtu		
5 F	17 F	47 F		5	17	47
1.78	2.11	2.82	York YHM36B22	$27.98	$23.61	$17.66

	Fuel $/MMBtu		
Natural Gas	$11.11	$11.11	$11.11
Propane	$30.61	$30.61	$30.61
Oil	$24.81	$24.81	$24.81

Fuel	Fuel cost	Unit	Fuel system Efficiency
Natural Gas	$1.14	/CCF	90.0%
Propane	$2.65	/Gallon	90.0%
Oil	$2.84	/Gallon	82.0%
Electric	$0.17		

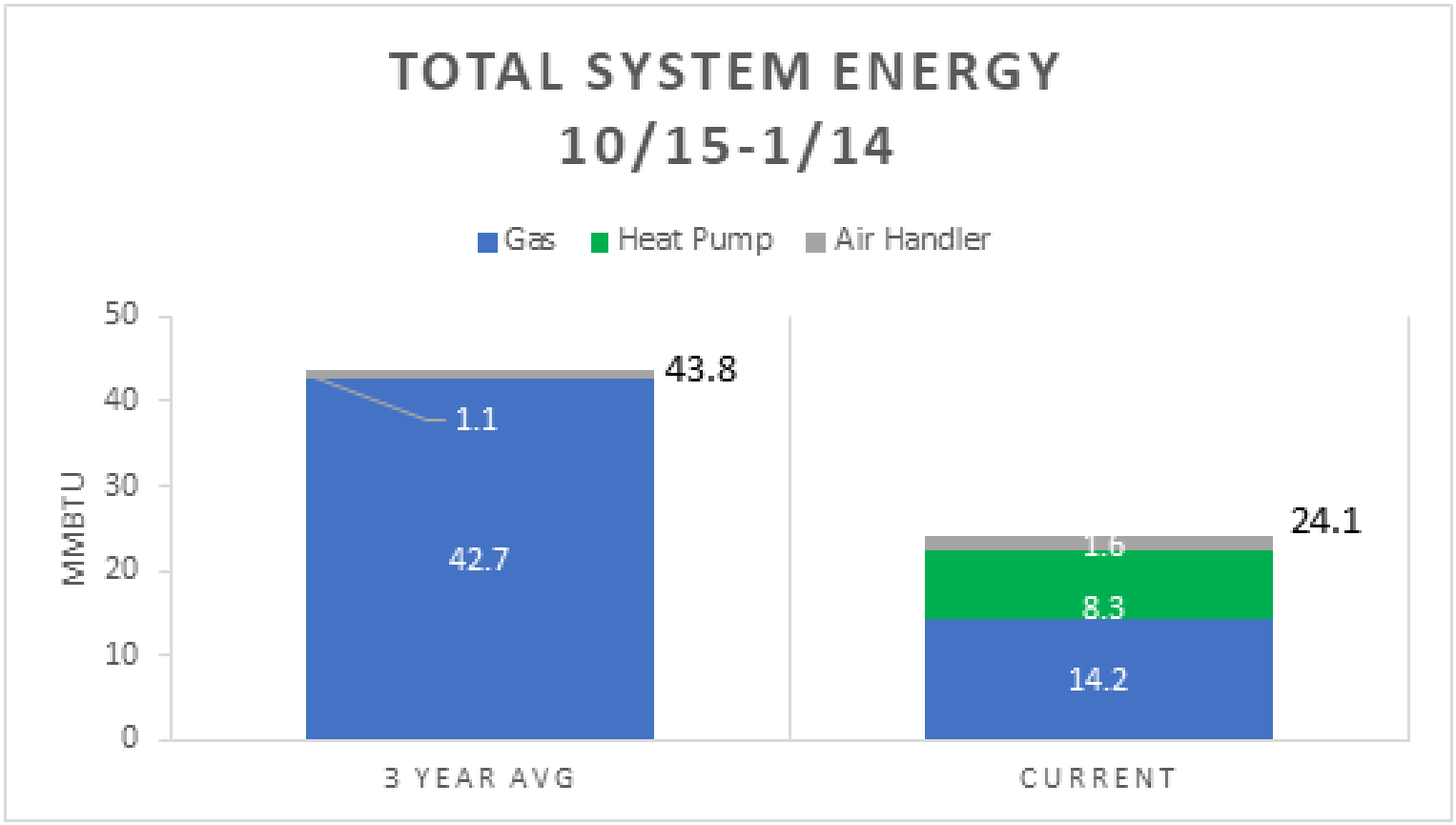


Efficiency Vermont

Control Strategy Goals

- Reduce emissions
  - Reduce Loads, Weatherize the Building
  - Install unit sized close to design heating load
  - Use capacity balance point
- Save money
  - Use economic balance point to operate system
  - Caution this will change with fuel prices
- Have this conversation with customer and show them how to set the balance point
- Use Dual Fuel capable thermostat

Efficiency Vermont


TOTAL SYSTEM ENERGY
10/15-1/14
Gas
Heat Pump
Air Handler
MMBTU
50
40
30
20
10
0
43.8
1.1
42.7
24.1
1.6
8.3
14.2
3 YEAR AVG
CURRENT

Equipment Types

Mini split heat pumps

Ducted heat pumps

Air To Water heat pumps

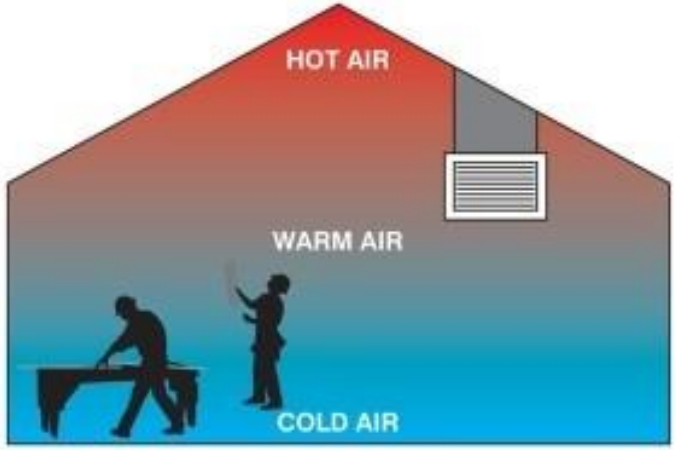
Ground Source heat pumps

Domestic Hot Water systems

Efficiency Vermont

Benefits of ATW

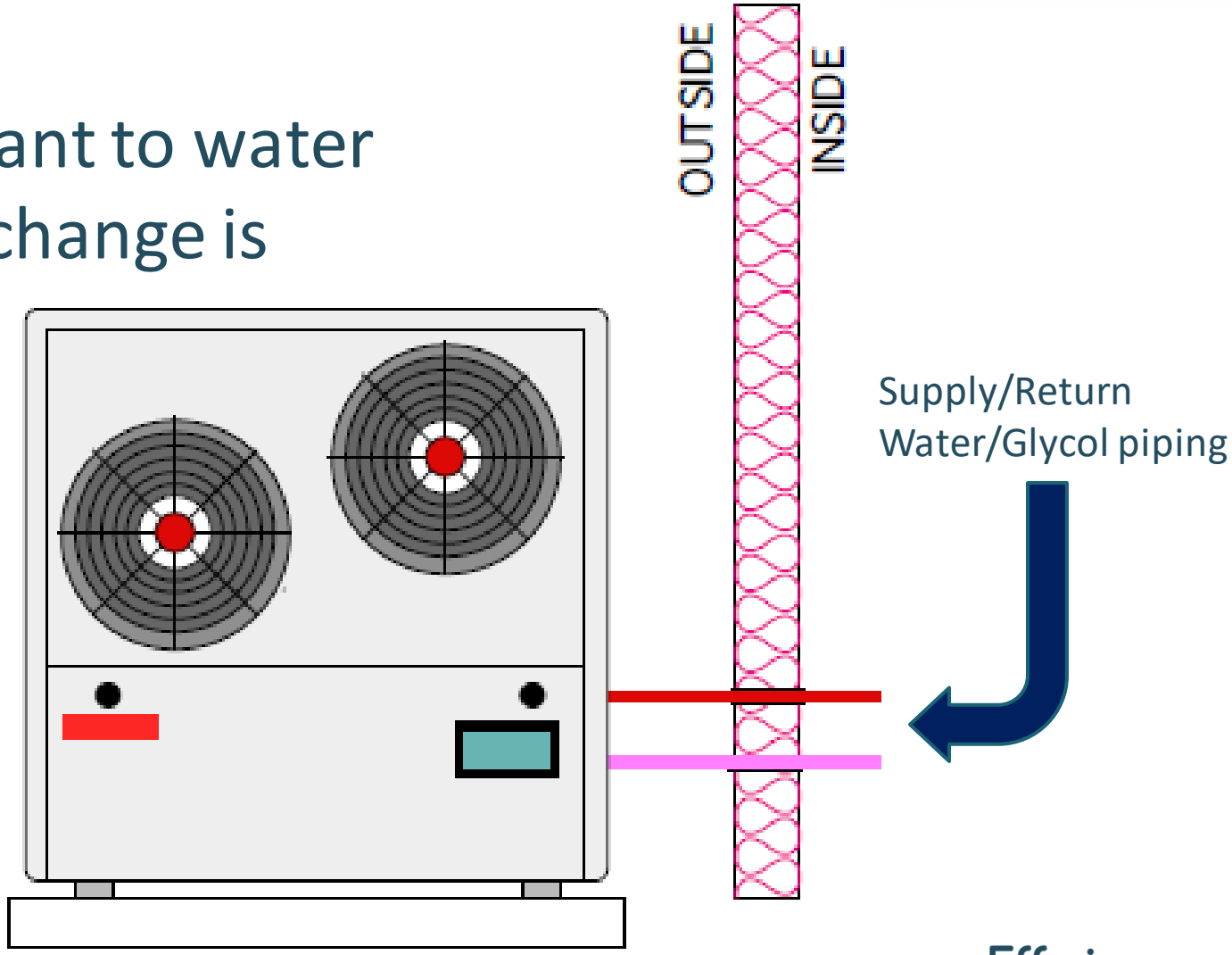
- Comfortable
  - Zonal
  - Fully Distributed
  - Reduced stratification
  - Quiet



Efficiency Vermont

Mono-bloc

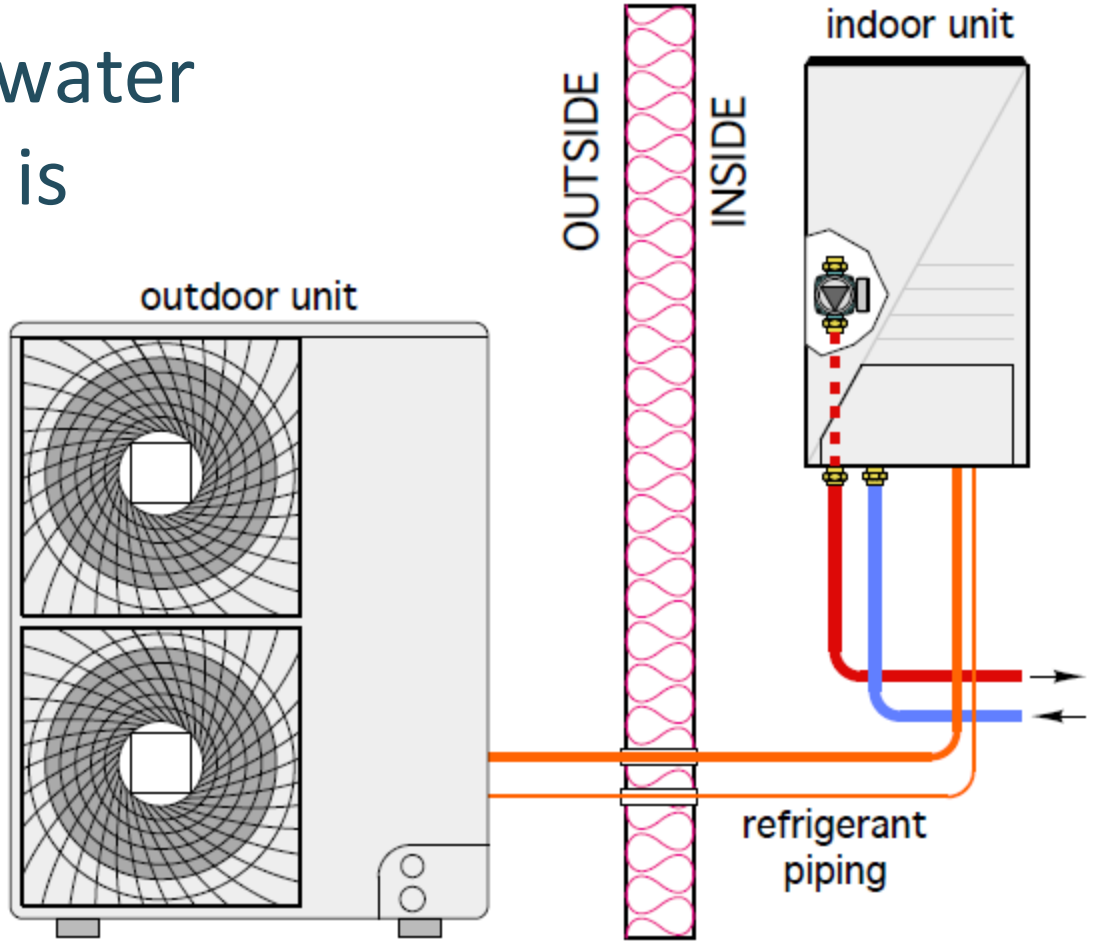
- Refrigerant to water Heat exchange is <u>outside</u>



Efficiency Vermont

Split Systems

- Refrigerant to water heat exchange is <u>inside</u>



Efficiency Vermont

Performance of ATW

- HSPF? SEER? NOPE!
- AHRI does not list/test
- No ENERGY STAR®
- IPLV – Integrated Part Load Value
- COP – Static points for varying outdoor and delivered water temperatures

Efficiency Vermont

COP Example

Supply Water Temp °F	Ambient Temp °F	Capacity BTU/hr	Watts	COP
110	-5	37,500	3880	2.30
	17	44,800	3970	2.70
	47	60,580	4263	3.75
120	-5	38,500	4513	2.00
	17	46,440	5790	2.35
	47	66,480	5963	3.26
130	-5	40,425	5249	1.86
	17	48,762	5371	2.18
	47	69,804	6768	3.04

Efficiency Vermont

Performance of ATW

- Overall – Very Good!
- Better with low supply water temperatures
- Similar to ductless, but does not account for distribution energy
- Good cold weather performance, but…
- We need a good metric and cold climate specification

Efficiency Vermont

Buffer Tanks

- Small, not thermal storage (25-40 gal common)
- Prevents short-cycling
- Optimizes operation
- Not always needed (modulating systems)
- Adds cost/complexity
- Some DR opportunity

Efficiency Vermont

Why they installed an Air to Water heat pump

Efficiency Vermont

Homeowner reflections

- Very happy with system, 1st heating season coming up
- Needed new $1000+ electric panel (bummer)
- The whole project took longer and cost more than original estimates
- Need a fair bit of utility room space for split system, buffer tank and HP water heater
- Really glad they went with HP water heater

Efficiency Vermont

Equipment Types

Mini split heat pumps
Ducted heat pumps
Air To Water heat pumps
Ground Source heat pumps
Advanced Pellet heating
Distribution systems
Ventilation
Domestic Hot Water systems

Efficiency Vermont

Ground Source Heat Pumps

Efficiency Vermont

Ground Source Heat Pumps

- **Benefits:**
  - Can be sized to meet load, no back up needed
  - Good COPs, efficient systems
  - Performance not dependent on outdoor temps
  - Can heat DHW
  - Hydronic or Air distribution
  - Tax Credits

Efficiency Vermont

Ground Source Heat Pumps

Three Part Systems

1. **Earth Connection Subsystem**
   - Heat source in winter, Heat sink in summer
2. **Heat Pump Subsystem**
   - Removes heat/cool from ground, concentrates it
3. **Heat Distribution System**
   - Distribute concentrated heat/cool throughout building

Efficiency Vermont

Ground Source Heat Pumps

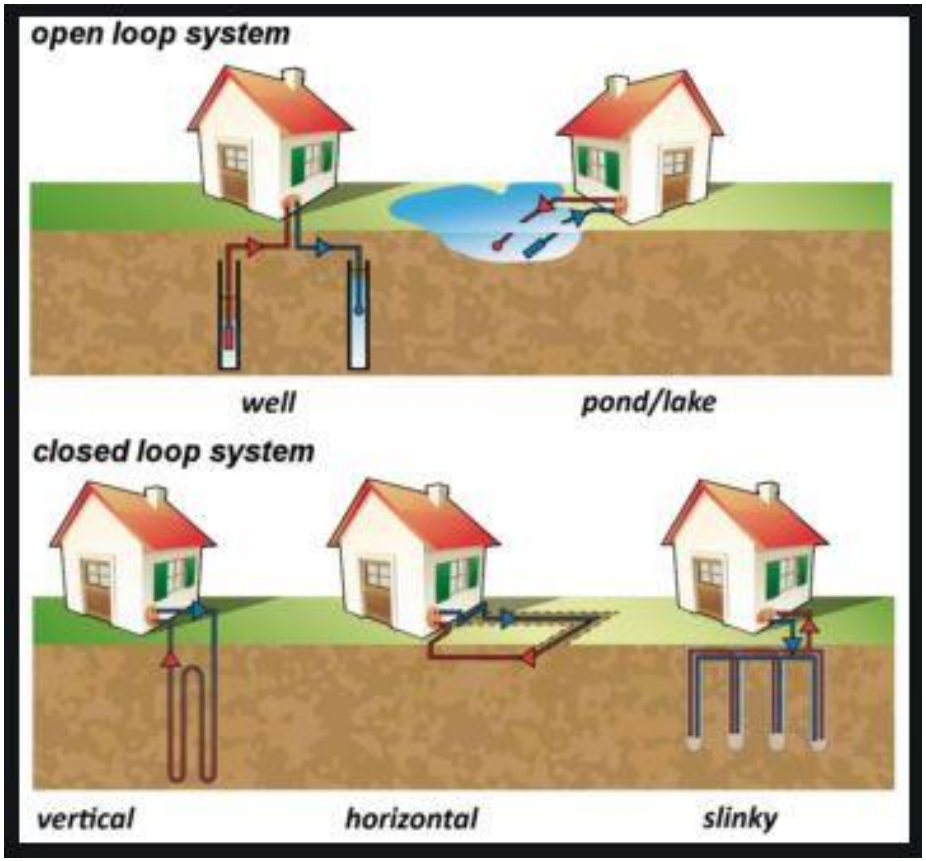


Image stolen from the internet

Efficiency Vermont

Geothermal System Overview

Tekmar 260 heating control w/ outdoor temp logic

Taco six zone controller w/ DHW priority

105 gal Marathon radiant storage tank

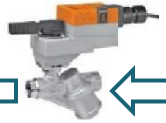
Grundfos Alpha 3-speed constant pressure circulator

1.5 GPM per zone

Radiant floor & wall heat distribution

Flat plate heat exchanger

Belimo flow control valve 12 GPM



400’ well 6” bore

½ HP VFD pump

Return flow to top of well 40 F typical

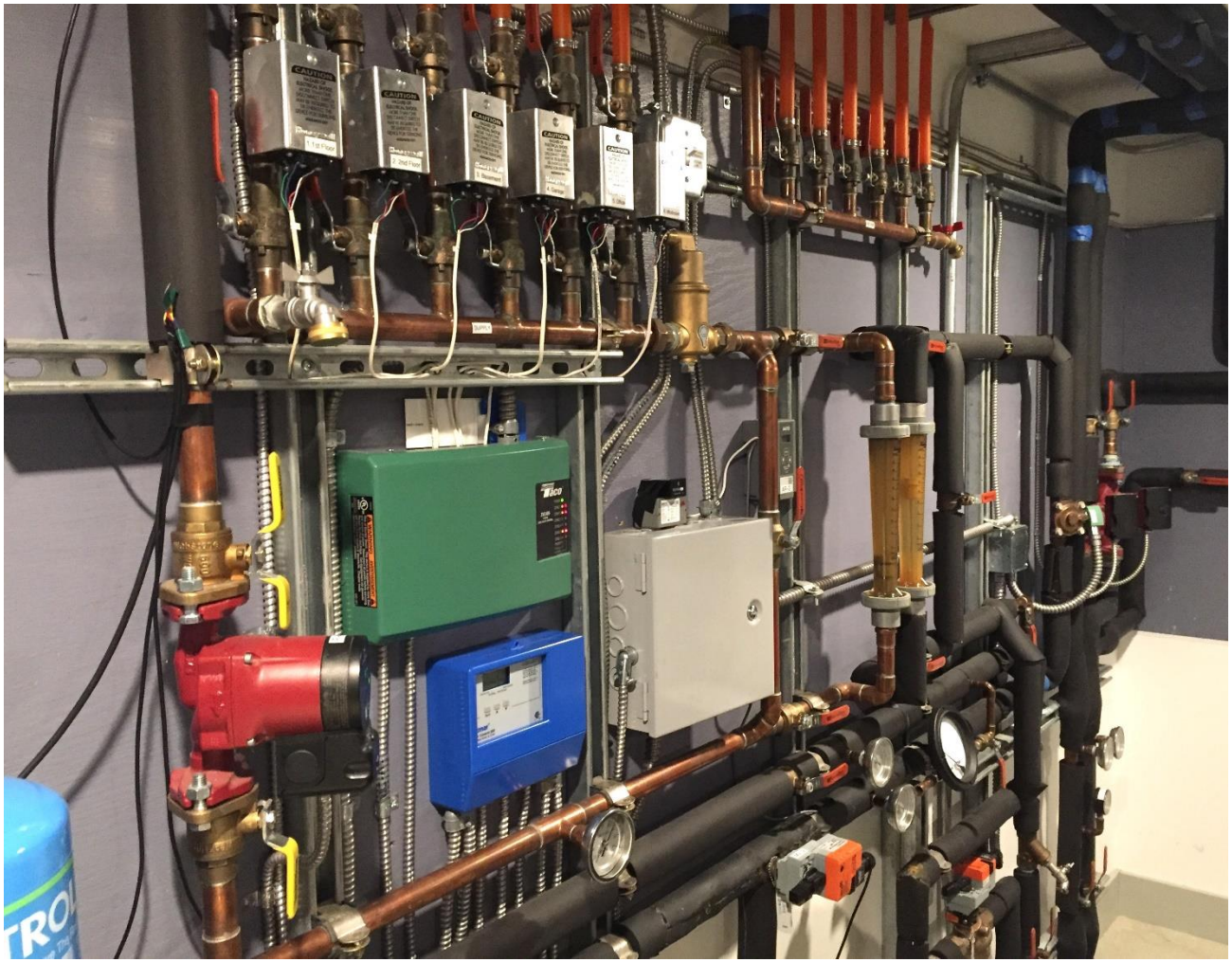
Supply temp 48 F typical

Trane 5-ton heat pump with ni-cu coil

105 gal Marathon DHW tank with electric backup

Efficiency Vermont

Simple Concept Meets Reality



Efficiency Vermont

Ground Source Heat Pumps and Domestic Hot Water

- **Desuperheater**
  - Transfer excess heat from compressor to DHW tank
  - Only works when GSHP is running, may not meet DHW loads at all times
- **Full Demand**
  - Manufacturer installs separate heat exchanger
  - Meets all household DWH needs
- **Separate DHW system**
  - HPWH

Efficiency Vermont

Equipment Types

Mini split heat pumps

Ducted heat pumps

Air To Water heat pumps

Ground Source heat pumps

Domestic Hot Water systems

Efficiency Vermont

Water Heating

Efficiency Vermont

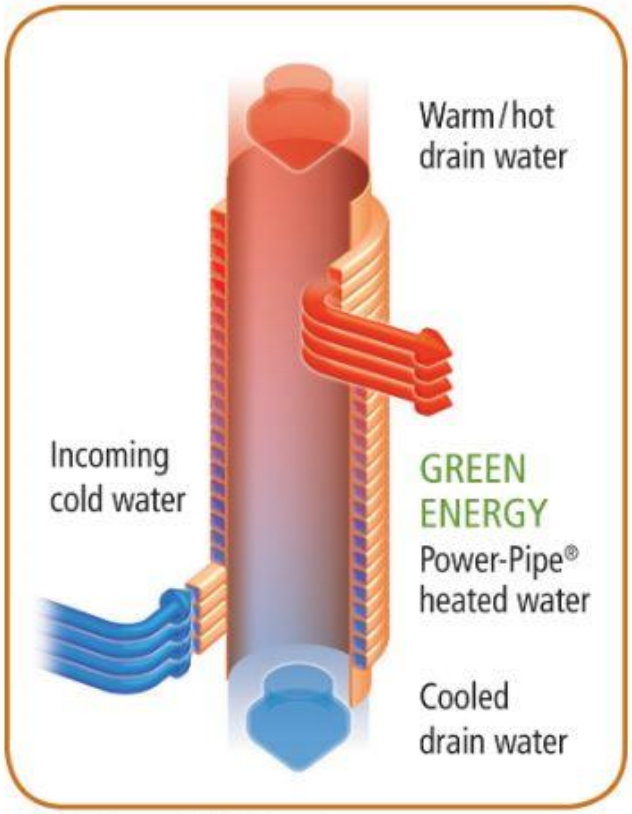
Sanden C02, split system water heater

- Indoor tank
  - 43 gal
  - 83 gal
  - 119 gal
- Outdoor refrigeration system
  - Run water outdoors
  - No refrigerant indoors
  - Natural refrigerant!

Efficiency Vermont

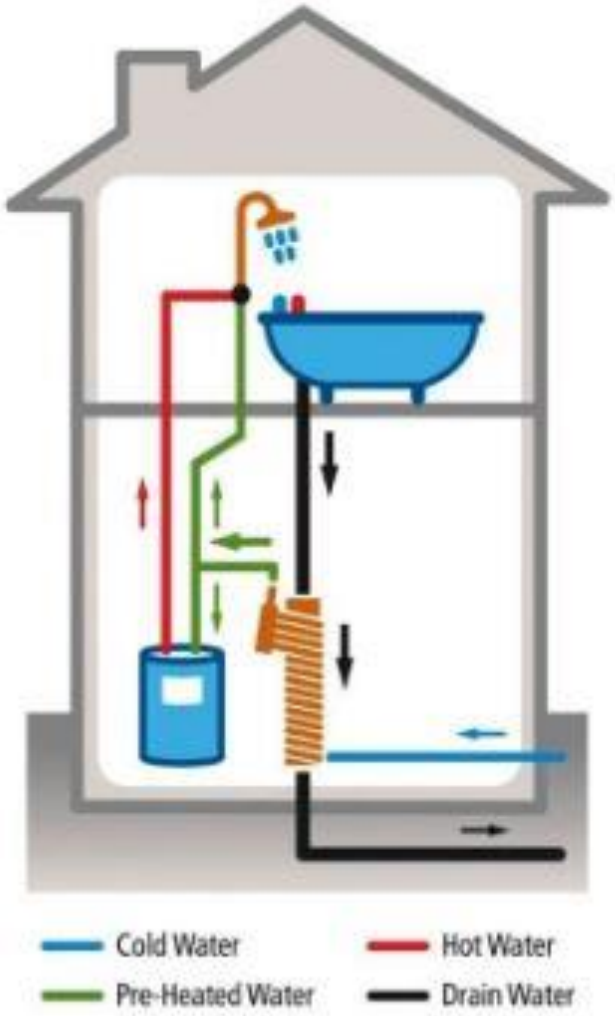
Drain Water Heat Recovery

- Preheat cold water supply to DHW
- 40-60% recovery efficiency
- Reduce energy for DHW
- Improve capacity of water heater



Efficiency Vermont

Equal Flow Plumbing



CSA B55.1 performance testing

Best Practice when feasible

Not just for new construction projects

Efficiency Vermont

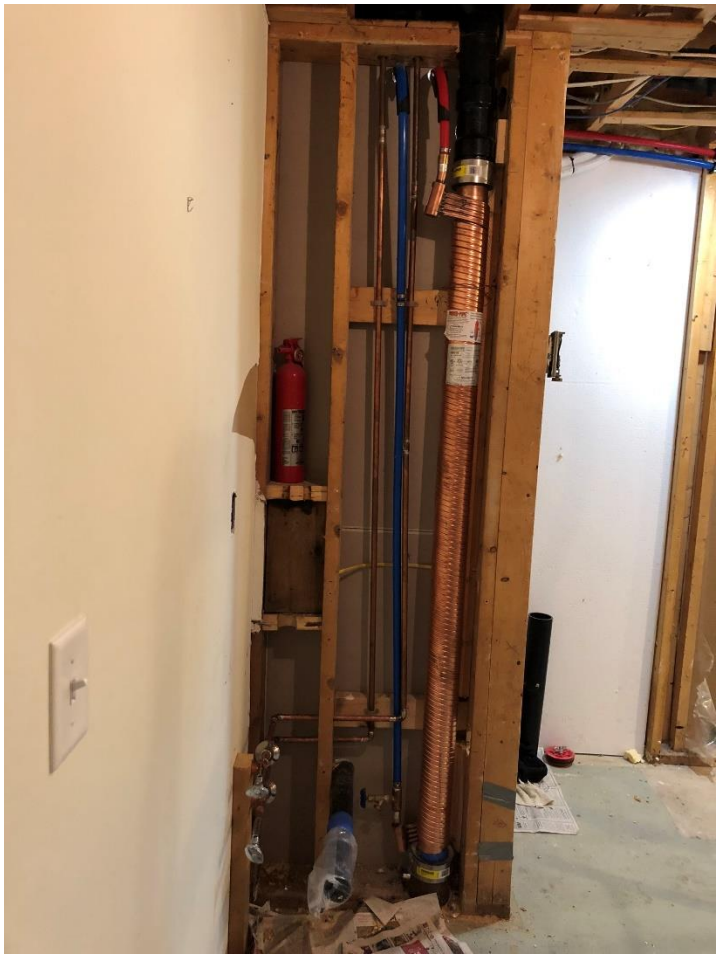
Water Heater Replacement

Efficiency Vermont

Water Heater Replacement

Efficiency Vermont

Drain Water Heat Recovery



Efficiency Vermont

Drain Water Heat Recovery

Efficiency Vermont

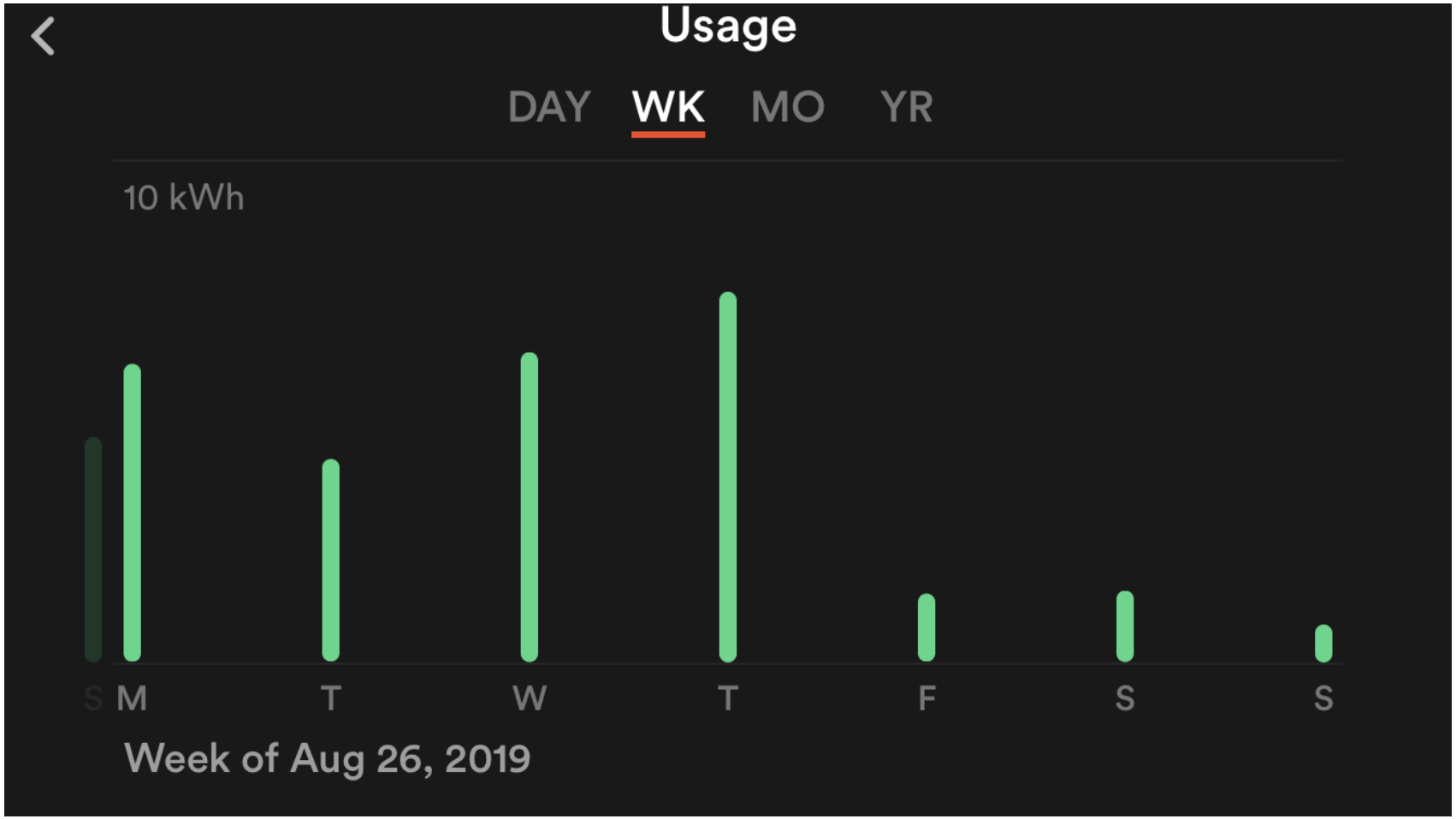
Getting that other drain

Efficiency Vermont

Equal Flow Plumbing

Efficiency Vermont

Combined DWHR and HPWH



Efficiency Vermont

Water Heating Bottom Line

- Be deliberate about the water heating strategy
  - It can be the biggest load in the house
- Heat pump water heaters may need cooling and noise mitigation strategies
- Water conservation and heat recovery are just as important as high efficiency water heating
- Reduce plumbing core in new construction

Efficiency Vermont

Thank You

Matt Sargent
Efficiency Vermont
802-540-7619
msargent@veic.org

Efficiency Vermont