CONNECT 2011

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GETTING THE MOST OUT OF HYDRONIC HEATING SYSTEMS

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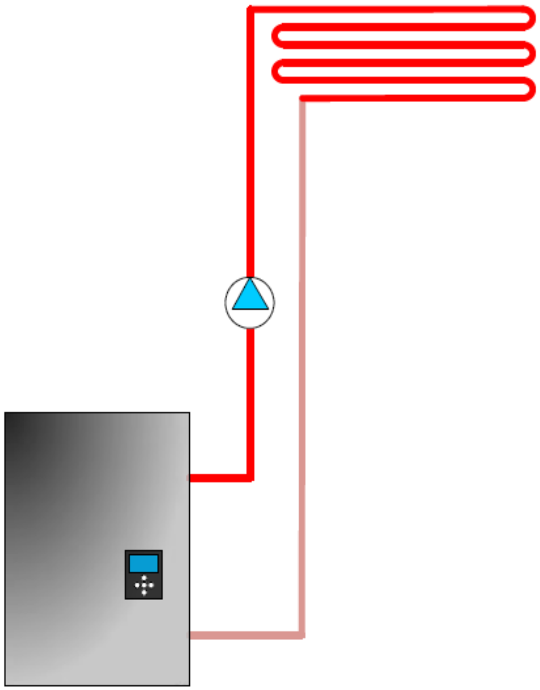
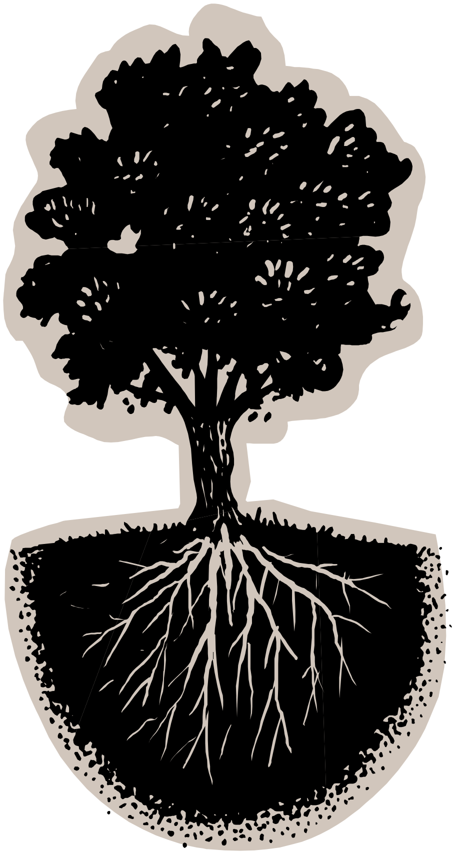
Topics

- 10,000 Foot View
- Why Hydronics?
- Systems Approach
  - Heating Source
  - Distribution System
  - Heating Emitter



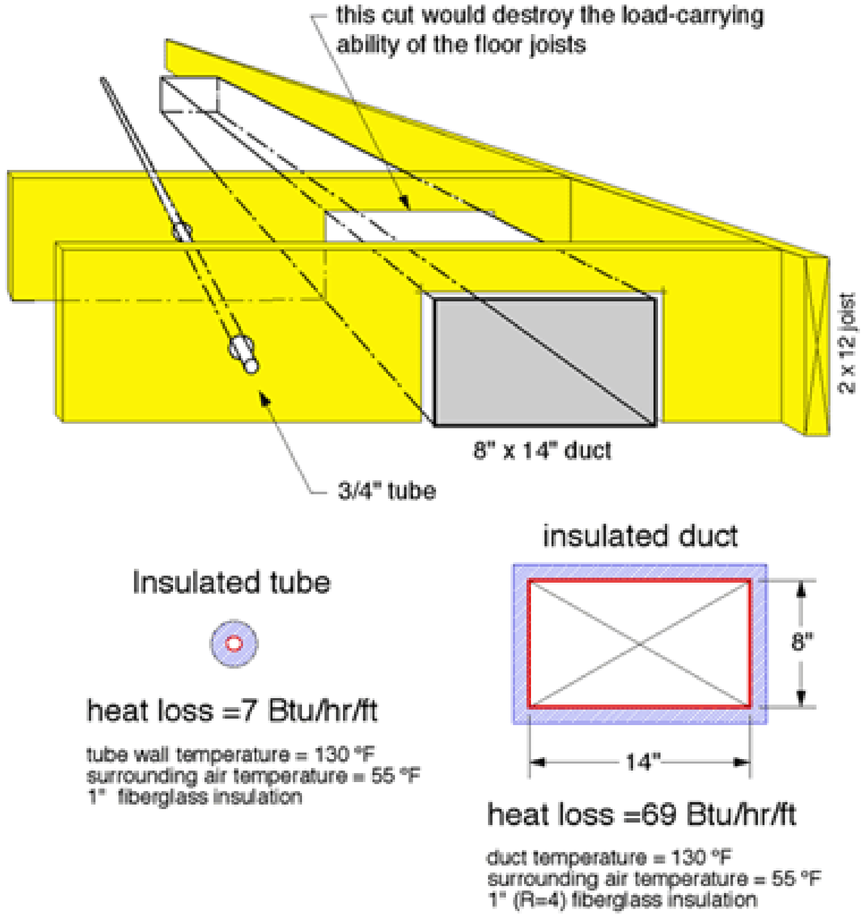


10,000 Foot View

- Why Are We Here?
  - Variability in Fuel Costs
  - Energy Independence
  - Savings $$
  - Reduce Emissions
  - Comfort
  - The Future

Why Hydronics?

- Comfortable
- Quiet
- No drafts
- Efficient
- Ease of zoning
- Physical characteristics



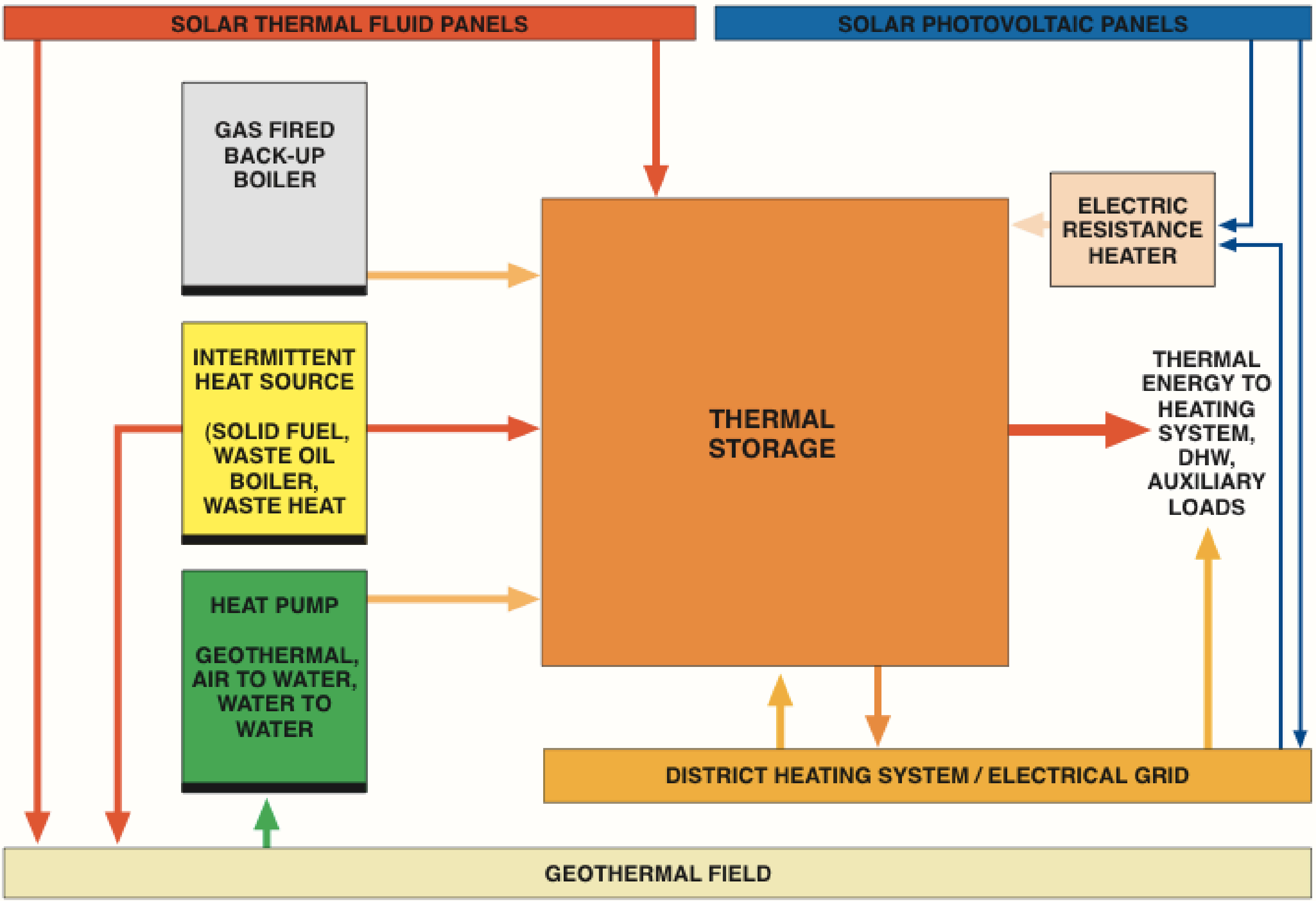
<u>Heat Capacity (Btu/ft^3/°F) at Room Temp</u>

Water = 62.4
Air = 0.018

Water can hold 3500 times as much heat as air!

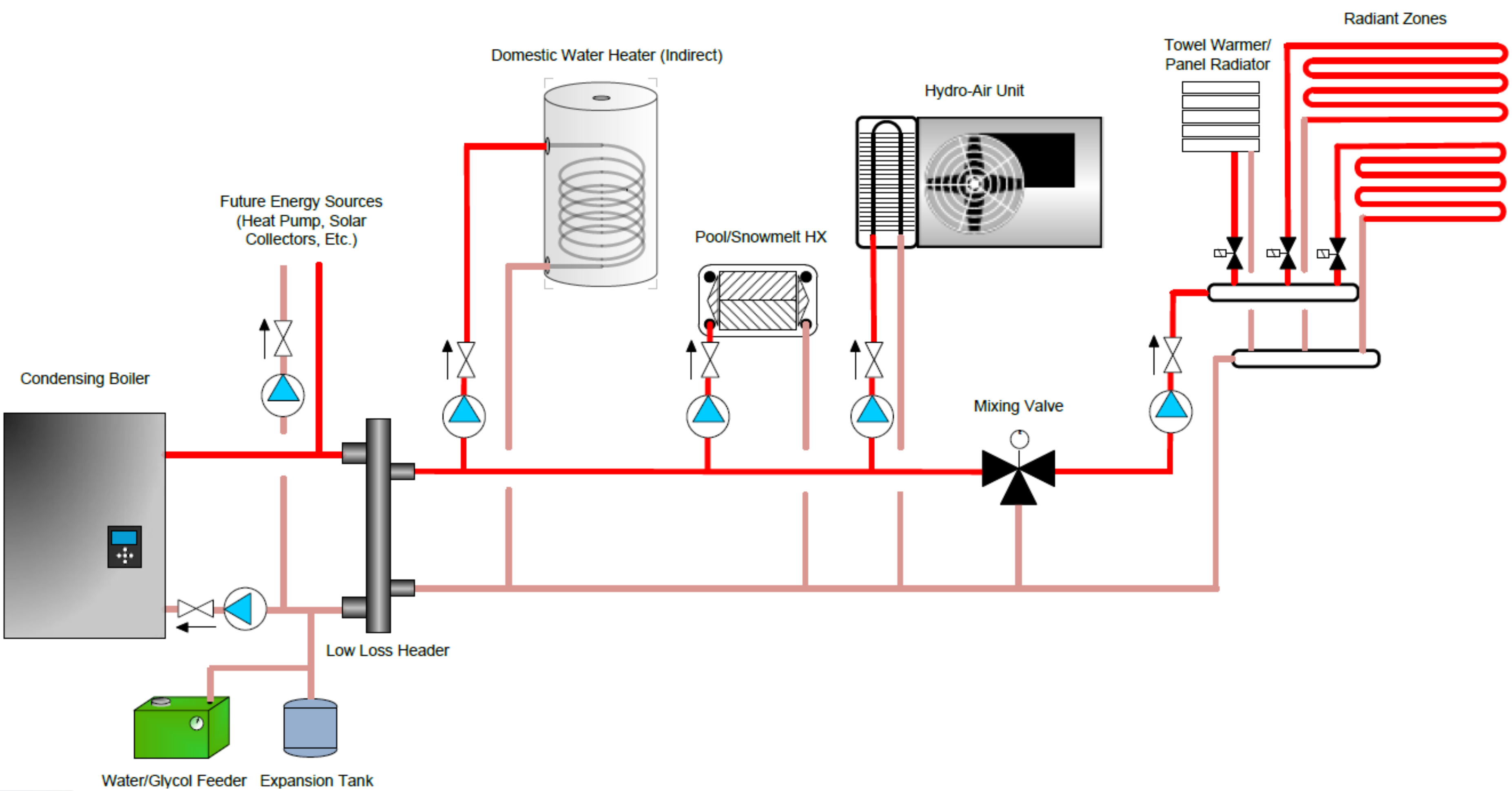
Source: Modern Hydronic Heating

Hydronics Tie It All Together



ALTERNATE HEAT SOURCE INTERACTIONS

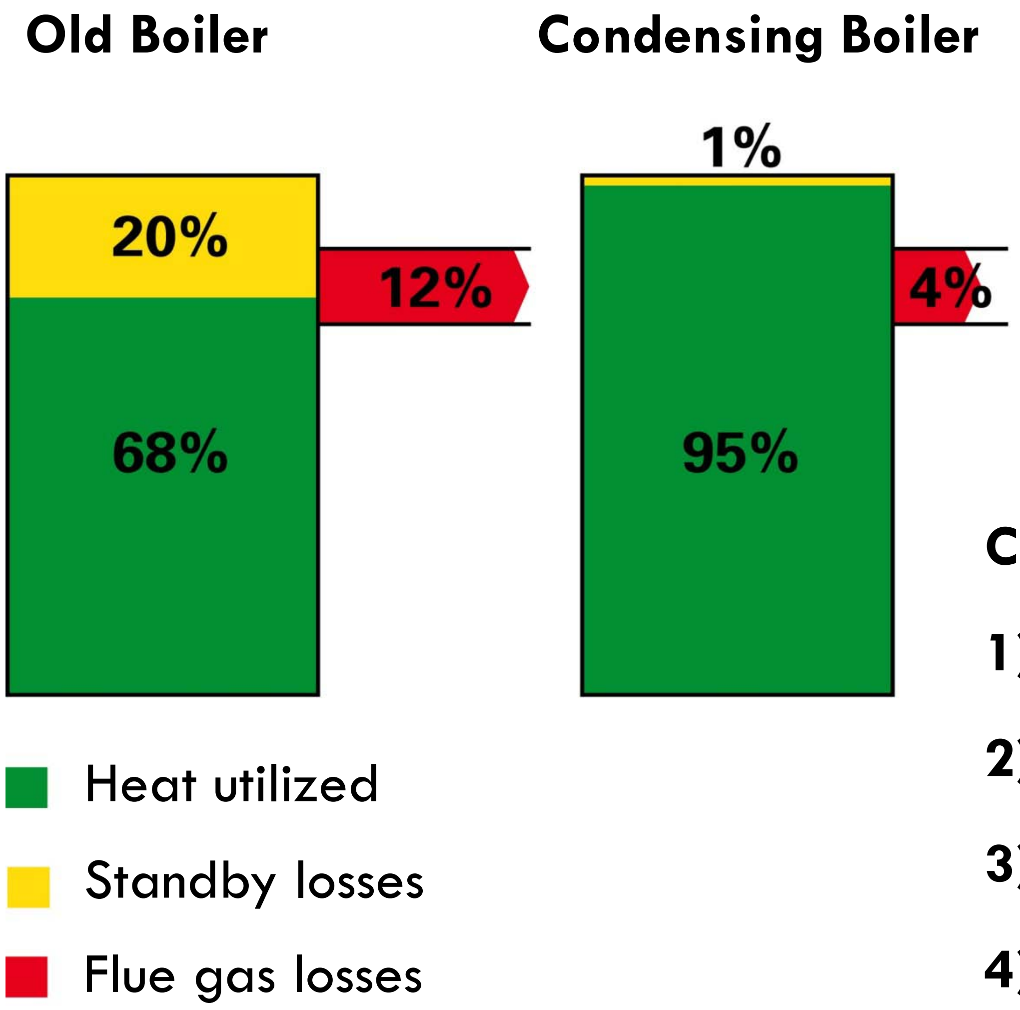
Hydronic Heating Concept



Heating Source

- Available Sources:
  - Boiler
  - Solar Thermal
  - Geothermal
  - Waste Heat
  - And others…

Heating Source



Condensing Boilers:

1) **Power Vented**
2) **Modulate Gas/Air Input**
3) **Extract Latent Heat**
4) **Experience Corrosion**

Climate

	HOURS OF TEMPERATURE OCCURANCE						
	TEMPERATURE RANGE						
Location	Unit	72 or More	72 – 57	57 - 37	37 - 22	22 - 7	7 or less
Boston	Hours	848	3080	3199	1359	260	14
	%	9	35	37	16	3	0.2
Burlington	Hours	601	2640	2611	1804	824	280
	%	9	30	30	21	9	3.2
Hartford	Hours	912	2875	2714	1747	463	49
	%	10	33	31	20	5	0.6
Portland	Hours	540	2622	3069	1827	592	110
	%	6	30	35	21	7	1.3
Average	Hours	724	2804	2899	1684	535	113
	%	8	32	33	19	6	1.3
						Heating = 8035 hours	
		Table 1				Cooling = 725 hours	

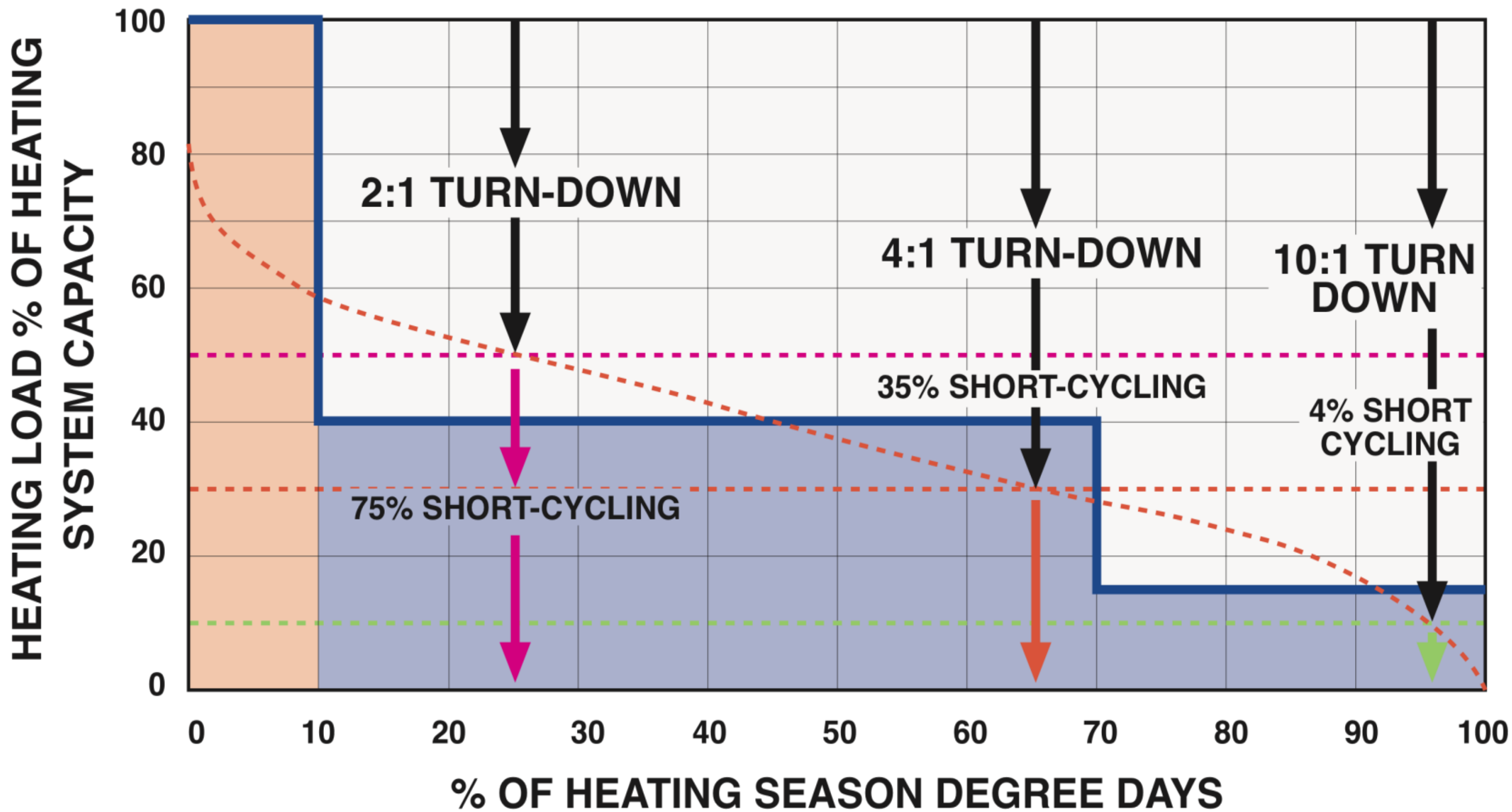
72% of year in Boston is between 37-72° F

Design Day

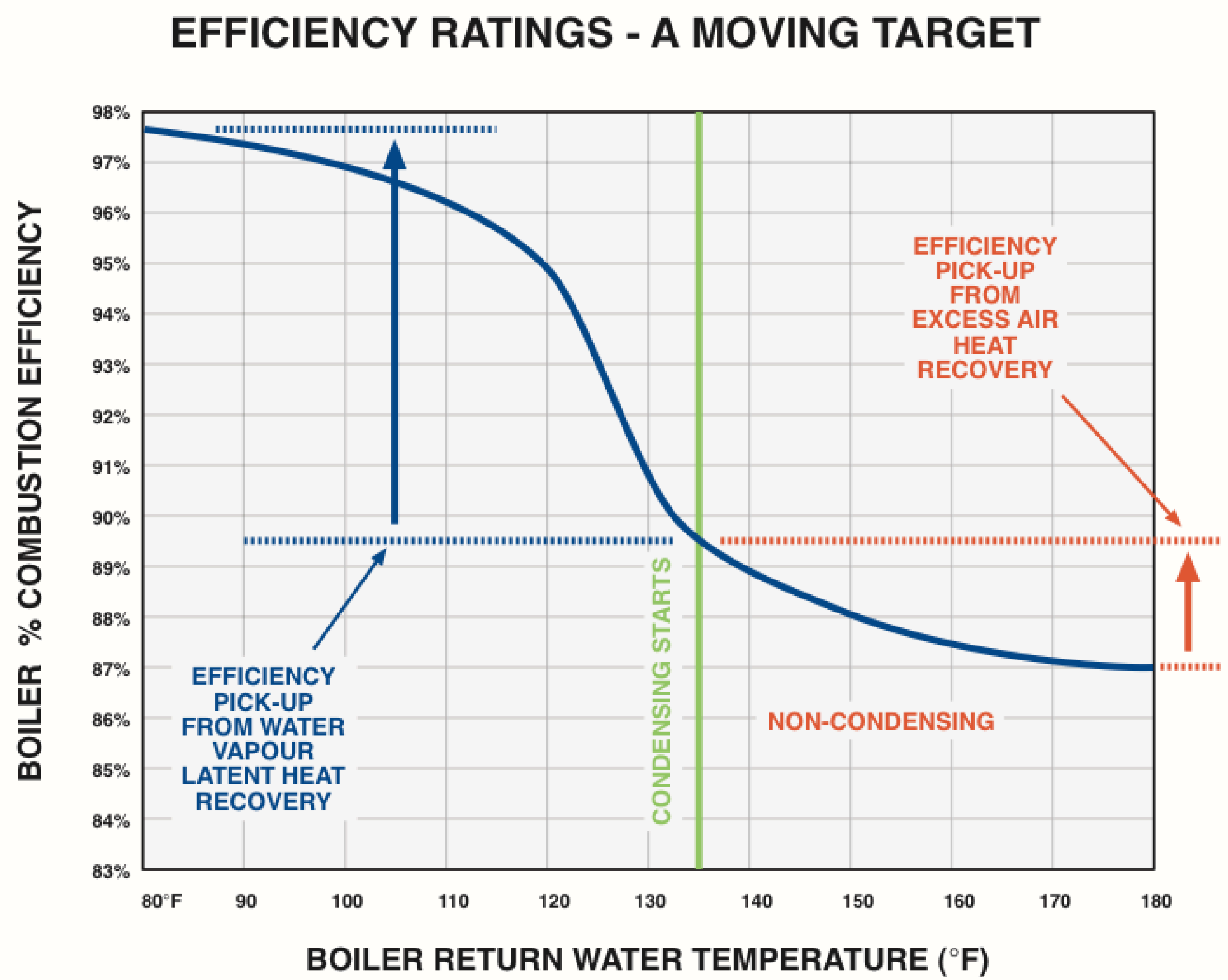
Source: ASHRAE

Boiler Modulation (Turn-Down)

- 90%+ of the heating season the boiler is at part-load

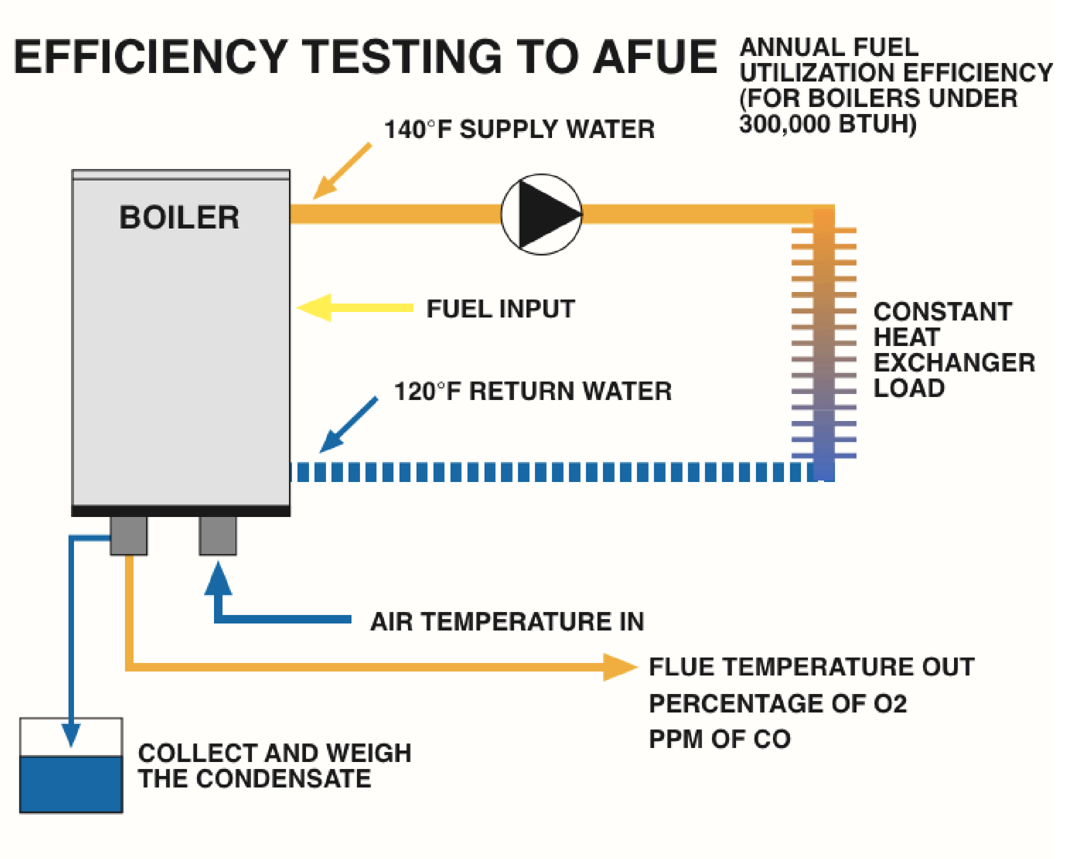


Condensing Boilers Only Condense When…

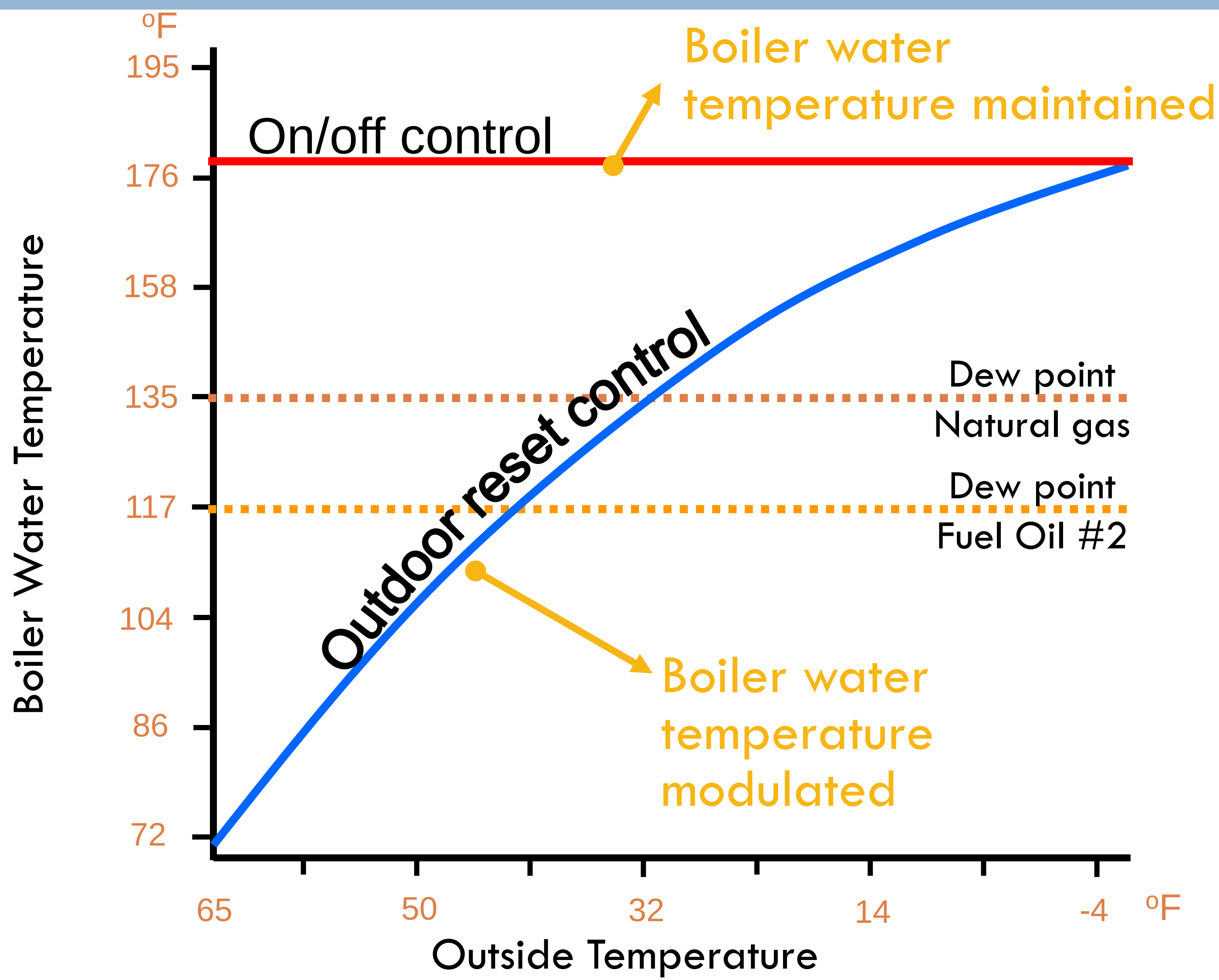


AFUE Testing

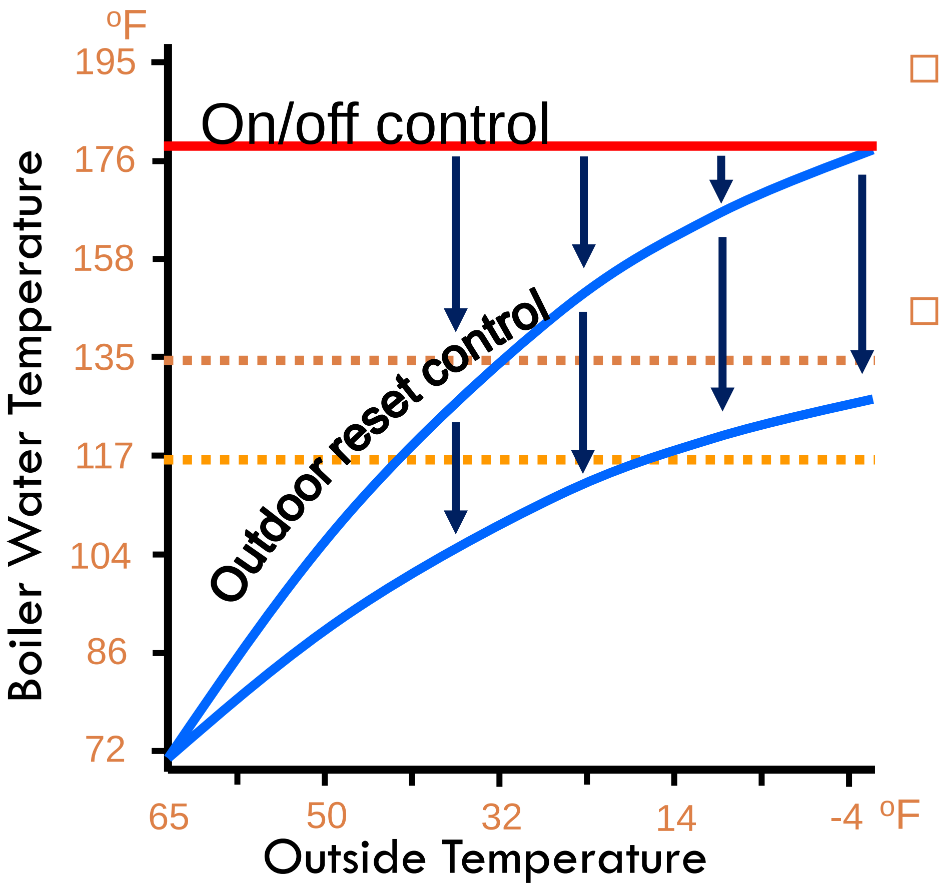
- Not Considered:
  - Short cycling
  - Jacket & standby losses
  - Part-load operation
  - Outdoor reset
  - Setback Schedule



Outdoor Reset Curve



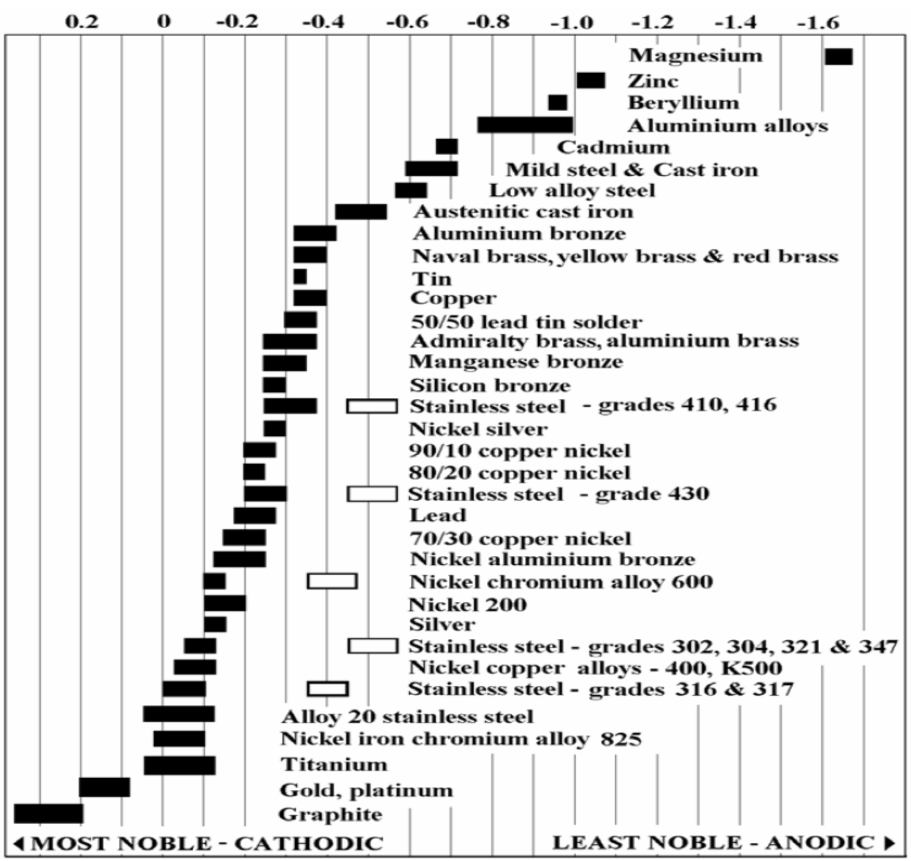
Outdoor Reset Curve



- The Goal:
  - Lower Supply Water Temp
  - ~For every 3 degrees, you gain 1% savings
- How?
  - Efficient Building Design/Construction
  - Better Heat Emitters (High Surface Area)

HX Material

- **High corrosion rate environment**
  - Electrochemical Corrosion= Oxygen+Water+Metal
  - Galvanic Corrosion= Two Dissimilar Metals + Water
  - Pit Corrosion= Localized breakdown by acids, oxygen, etc.
  - High Temp Corrosion= High temps in an oxidizing environment



Source: http://www.corrosionsource.com/handbook/galv_series.htm

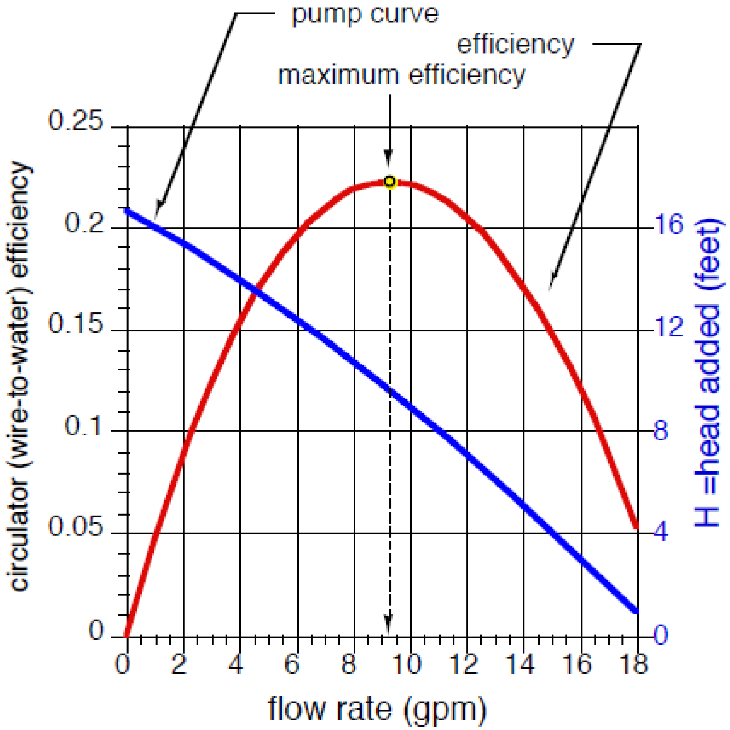
Boiler Design Summary

- **ModCon Boilers**
- **Pick the Right Size-** Manual J
- **High Modulation Range-** Reduce Short Cycling
- **AFUE isn't everything!**
- **HX Material-** High grade metal
- **High Surface Area HX-** Scrub all the heat out
- **Controls**- Outdoor Reset

Sweating is Good!

Distribution System

- Piping
  - Copper, Steel, PEX, PEX-AL-PEX
- Circulating Pumps
  - "It's just a pump" mentality
  - In general these are not that efficient



Source: John Siegenthaler

Distribution Efficiency

- Distribution Efficiency = $\dfrac{\text{Rate of Heat Delivered (Btu/hr)}}{\text{Distribution Equipment Energy Use (W)}}$

- Hydronic:
  - 100,000 Btu/hr design
  - 4x Circulators (85 W each)

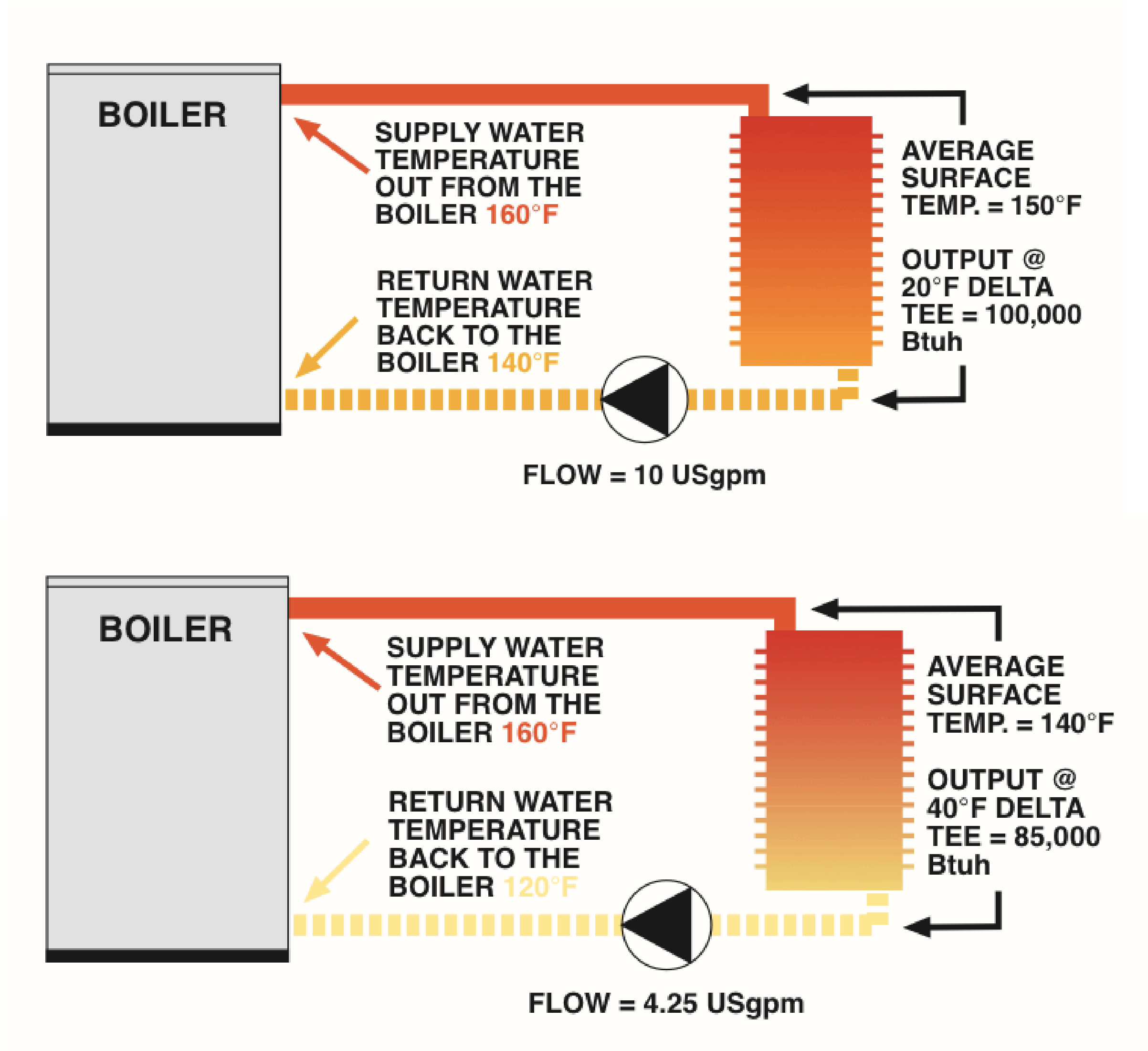
$$\frac{100{,}000\ \text{Btu/hr}}{340\ \text{W}} = 295\ \text{(Btu/hr)/W}$$

- Air (Furnace):
  - 100,000 Btu/hr design
  - 1300 W Blower

$$\frac{100{,}000\ \text{Btu/hr}}{1300\ \text{W}} = 77\ \text{(Btu/hr)/W}$$

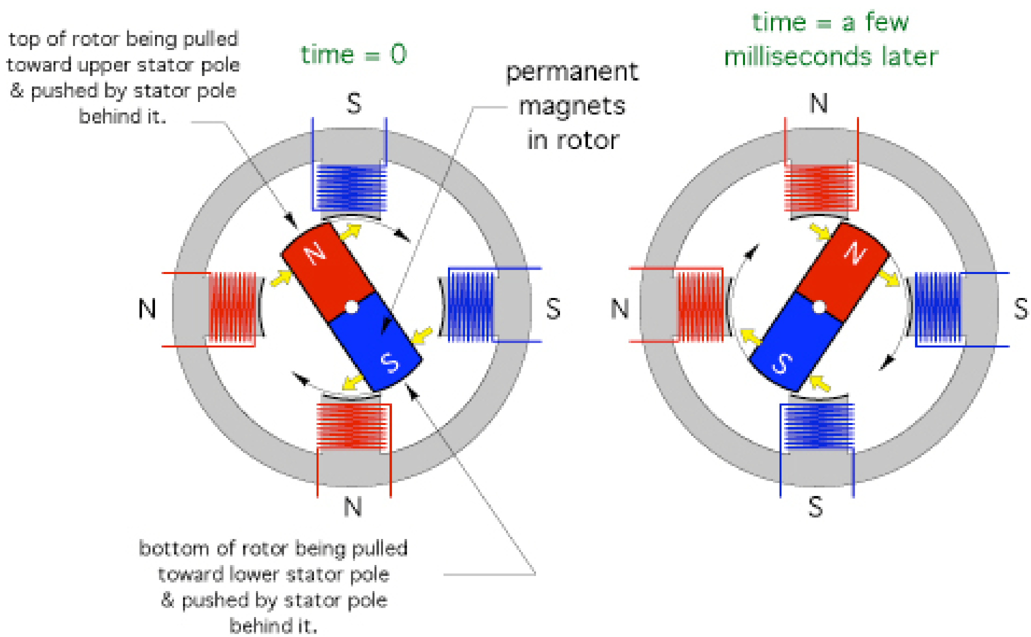
- Hydronic system moves the same amount of heat with almost 4 times less electricity!

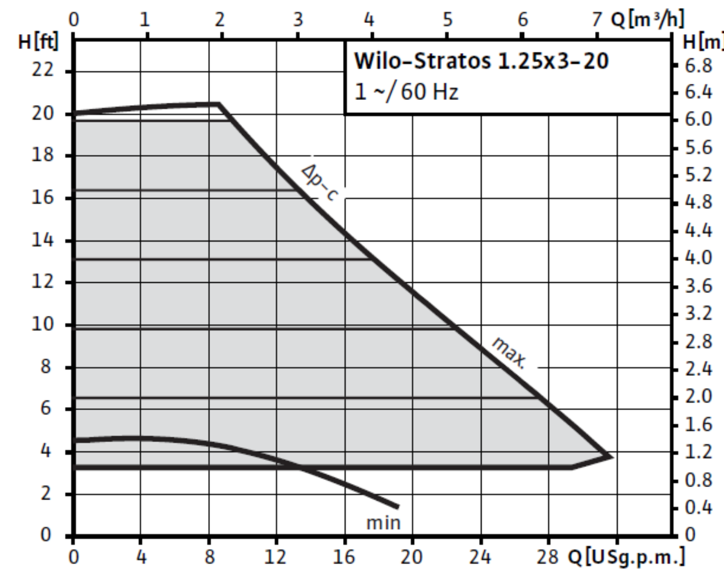
Slowing the Flow



How ECM Circs Work

- Standard Circulators = One Speed, throttle with brake
- ECM Circulators = Variable Speed (not a VFD)
  - Wire to Water Efficiency of double! = 50-90% energy savings

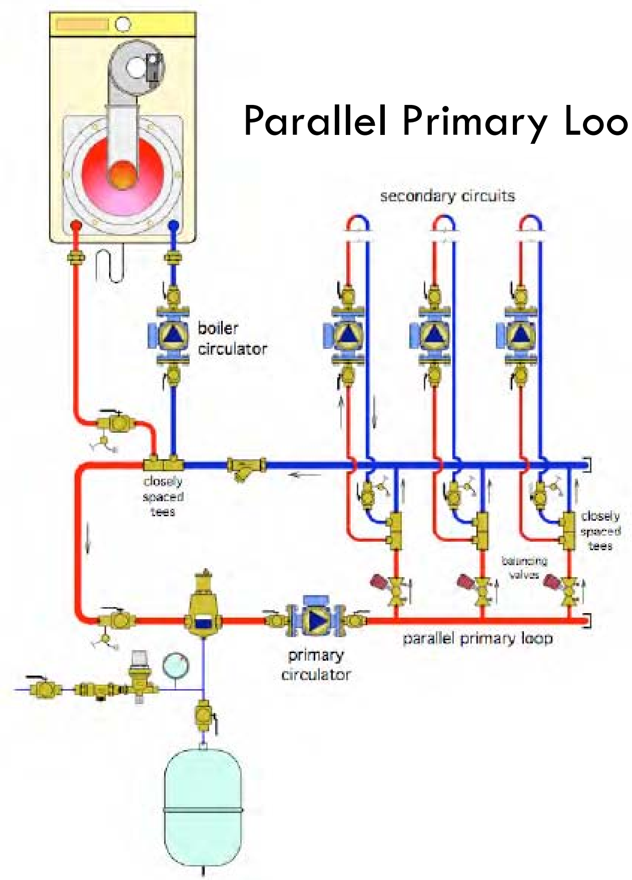




Re-Think Piping

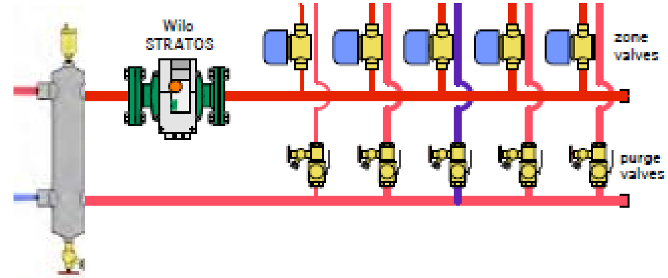
4 Single Speed Circulators vs. 1 ECM Circulator

Parallel Primary Loop



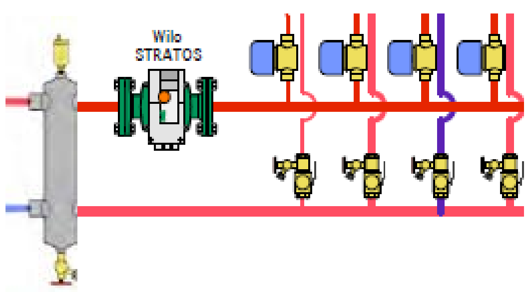
OR

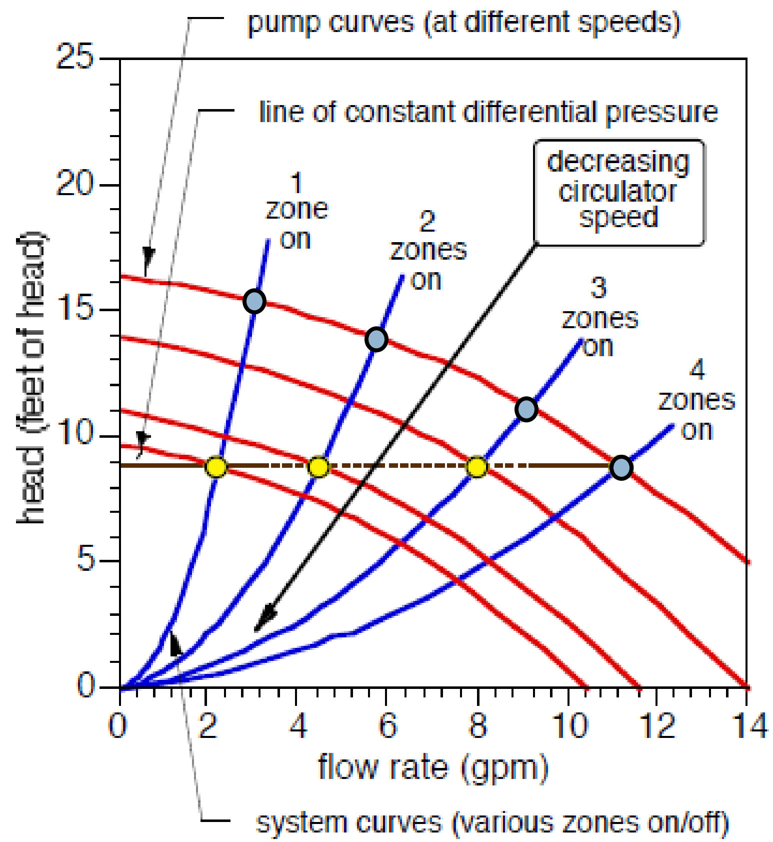
Low Loss Header with
ECM Circ and Zone Valves



Pump Curves

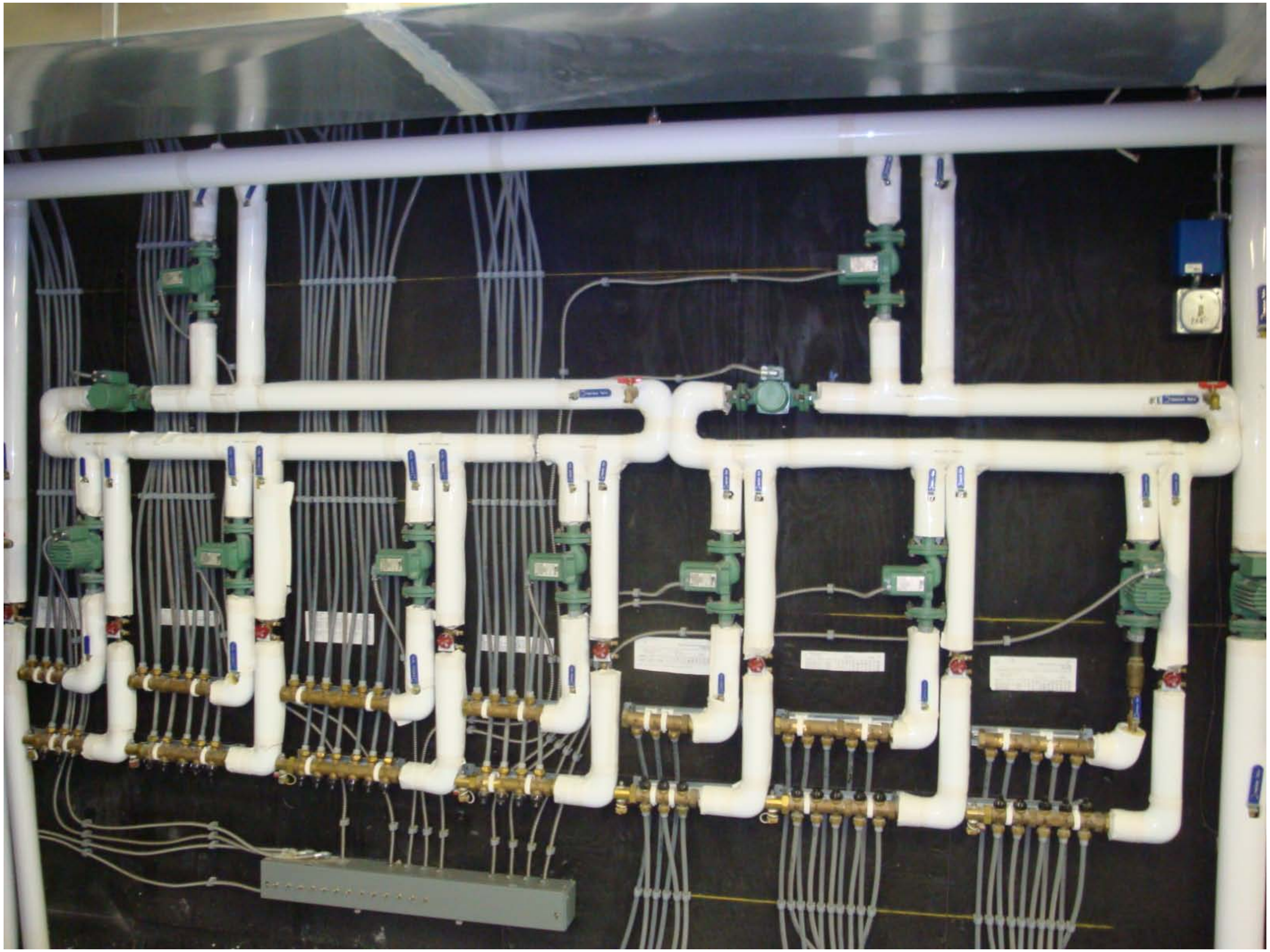
- ECM Circulator with Modulation
  - In Pressure Constant Mode
  - Impeller slows down or speeds up to maintain constant pressure in the system
  - This means $$$ savings!



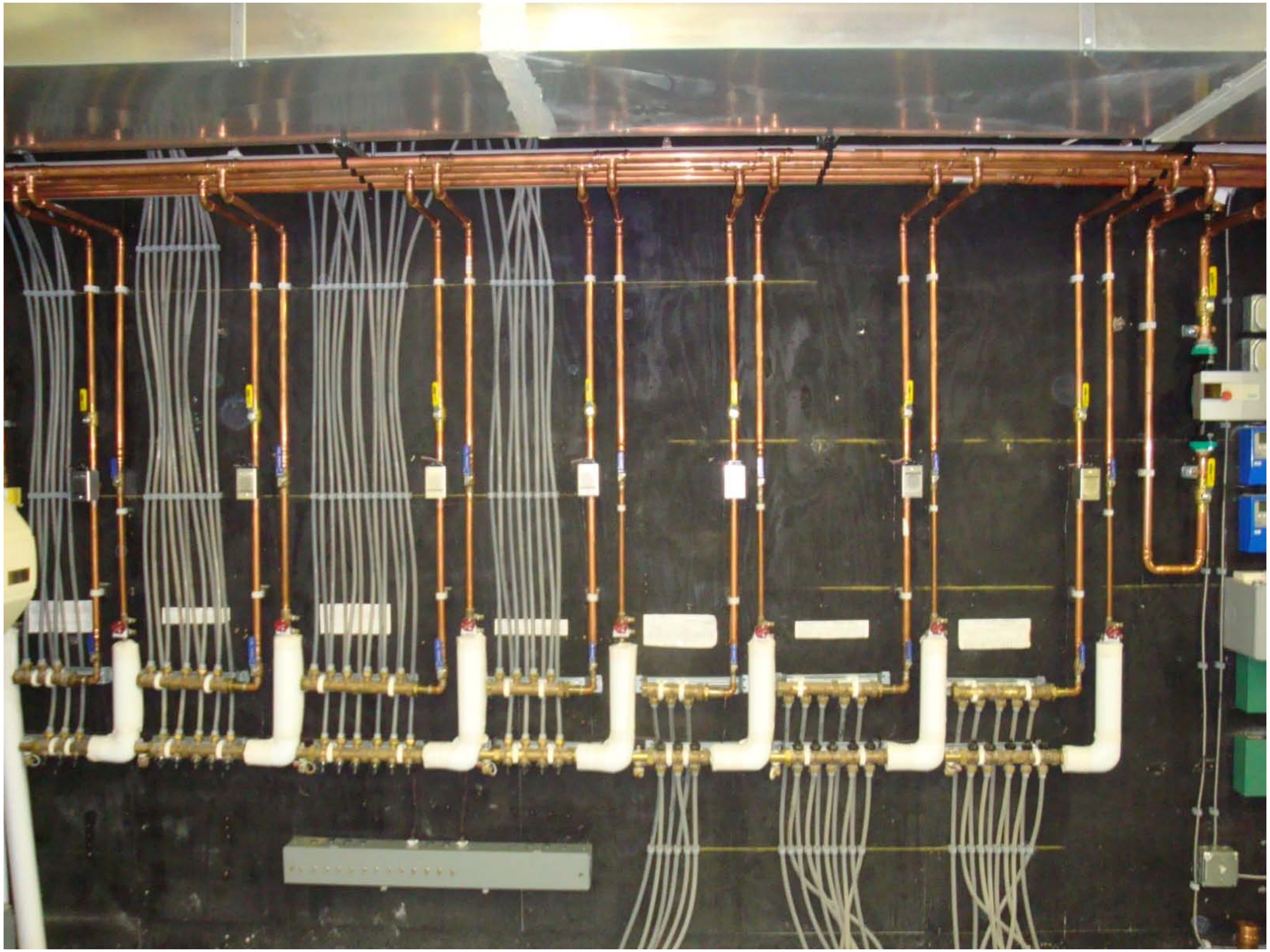


Source: John Siegenthaler

Case Study- Residential Pumping



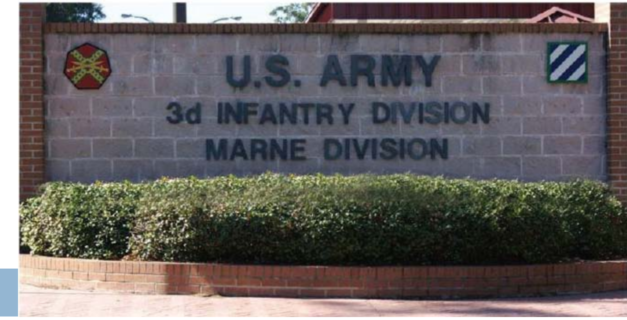
Example in ECM Pumping



Pumping Analysis

- Old version
  - 11 x Single Speed PSC Circs (~85 W) = 935 W
  - Plus all the controls and relays to run each pump…
- New version
  - 1x ECM Circulator (15-320 W) = 320 W
  - 7x Zone Valves (~15 W) = 105 W ⟶ 320+105 = 425 W
  - No External Communication or Wiring!
- On Design Day @ $0.16/kW-hr:
  - $3.59 vs. $1.63 (55% savings)

Case Study- Fort Stewart



Barracks 1511 – 3HP Constant Speed End Suction Pump

Barracks 1506 – Wilo Stratos 3x3-40

Case Study Analysis

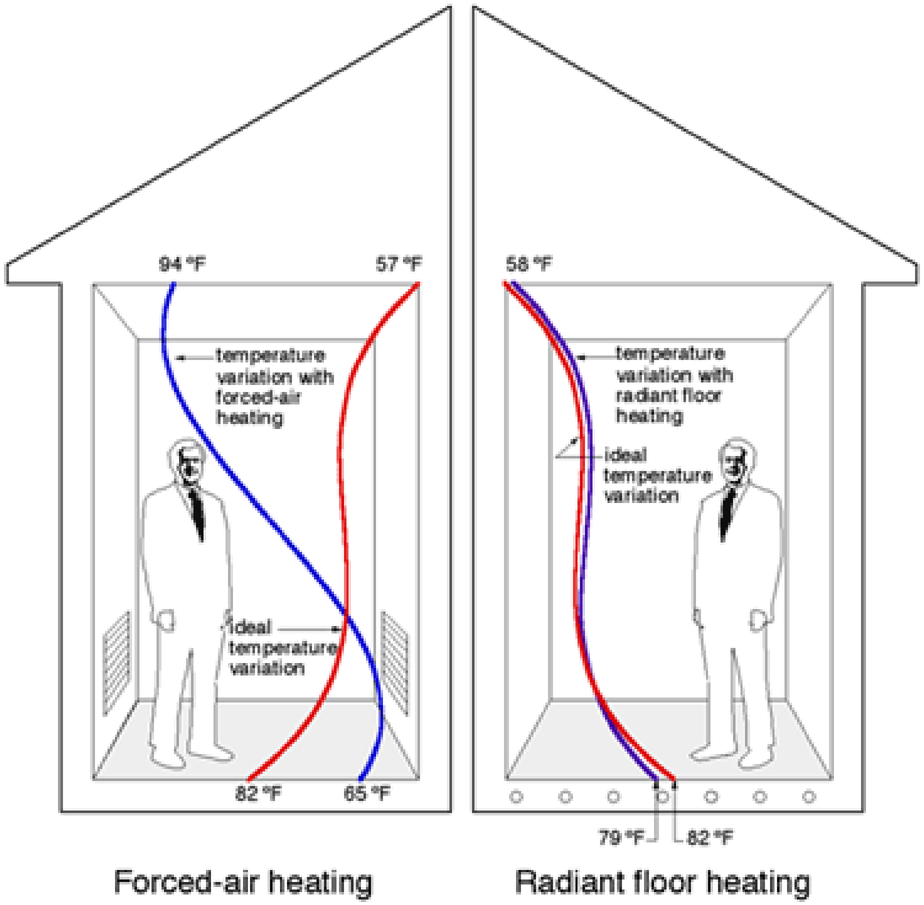
Building	Pump	Delta-T (Target 10°-12°)	kWh During Test Period
1511	Existing	4°	1144
1506	Wilo Stratos	10°	135
Energy Savings - Over 35-day test period			**88.2%**

Distribution System

- Distribution Efficiency
- Minimize the number of pumps
- Stop over pumping
  - Slower flow rates = Higher Delta T's
  - Condensing boilers enjoy 35°F Delta's T's
- ECM Circulators = Wire to Water Efficiency + Variable Flow
- Good hydraulic design
  - Low-Loss Headers, Correct Pipe Size, Mixing Valves, Etc.

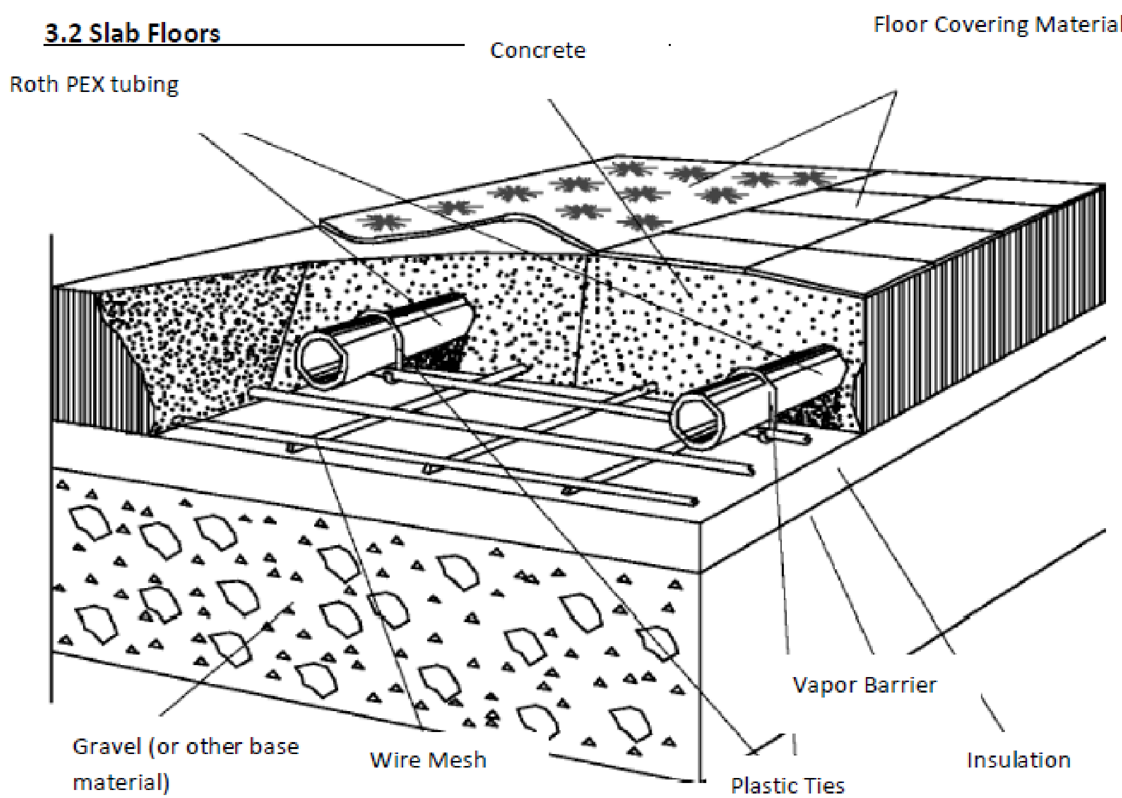
Hydronic Heat Emitters

- Heat where you need it!
  - Minimal Temp Variation
- Comfortable
- Flexible
- Variation of types…

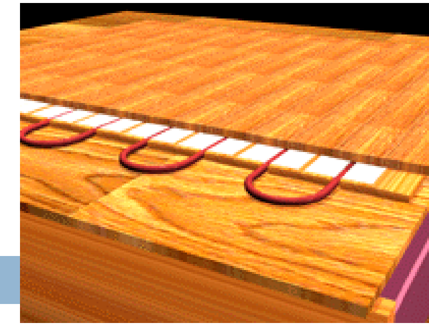


Radiant in Slab

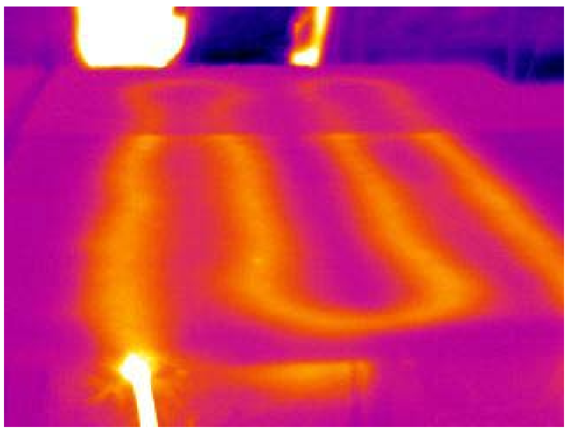
- High thermal mass
- Supply water ~100°F
- Slower response



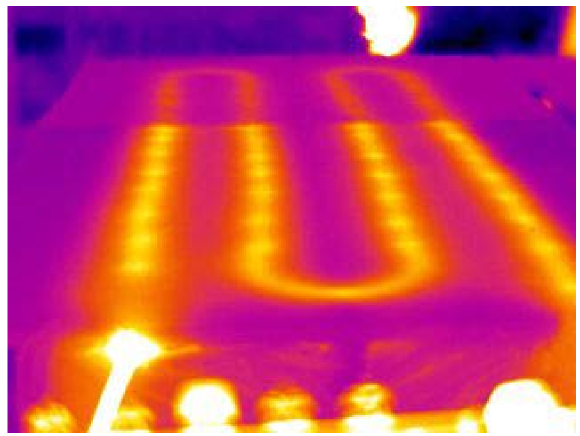
Radiant Above Subfloor



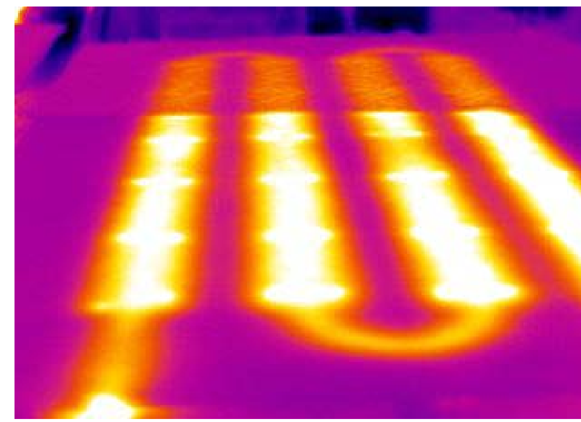
No Plates



Low Grade Materials



Aluminum Plates

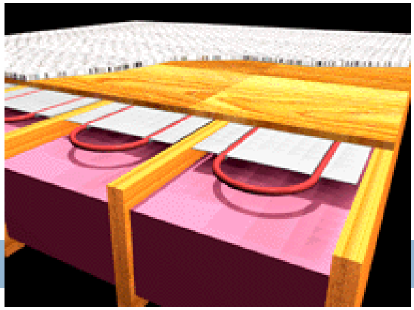


Lower Water Temperature

Better Heat Transfer

Faster Response

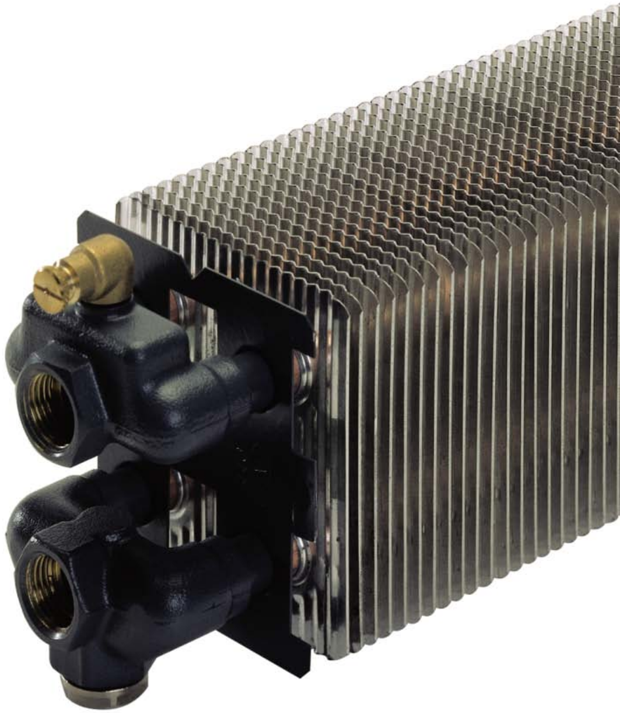
Radiant Beneath Subfloor

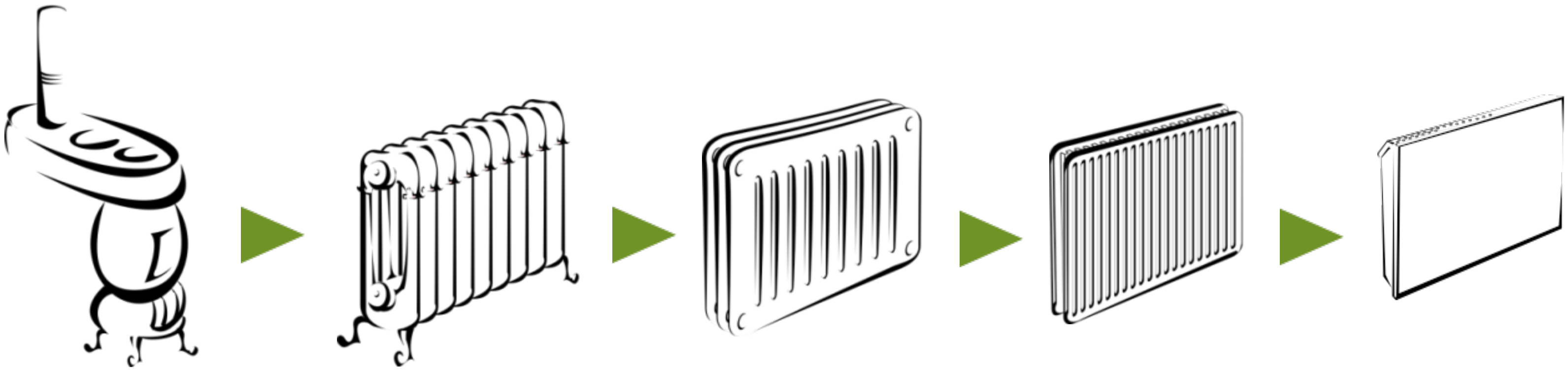


- Retrofit applications
- Minimize floor layers
  - Reduce R-value through floor
- Always insulate joist bays!
- Supply water temp ~ 140°F

Panel Radiators

- Low Water Temperature
- High Surface Area
- Low Water Content
- Fast responding





1930
7 Gallons
Very slow

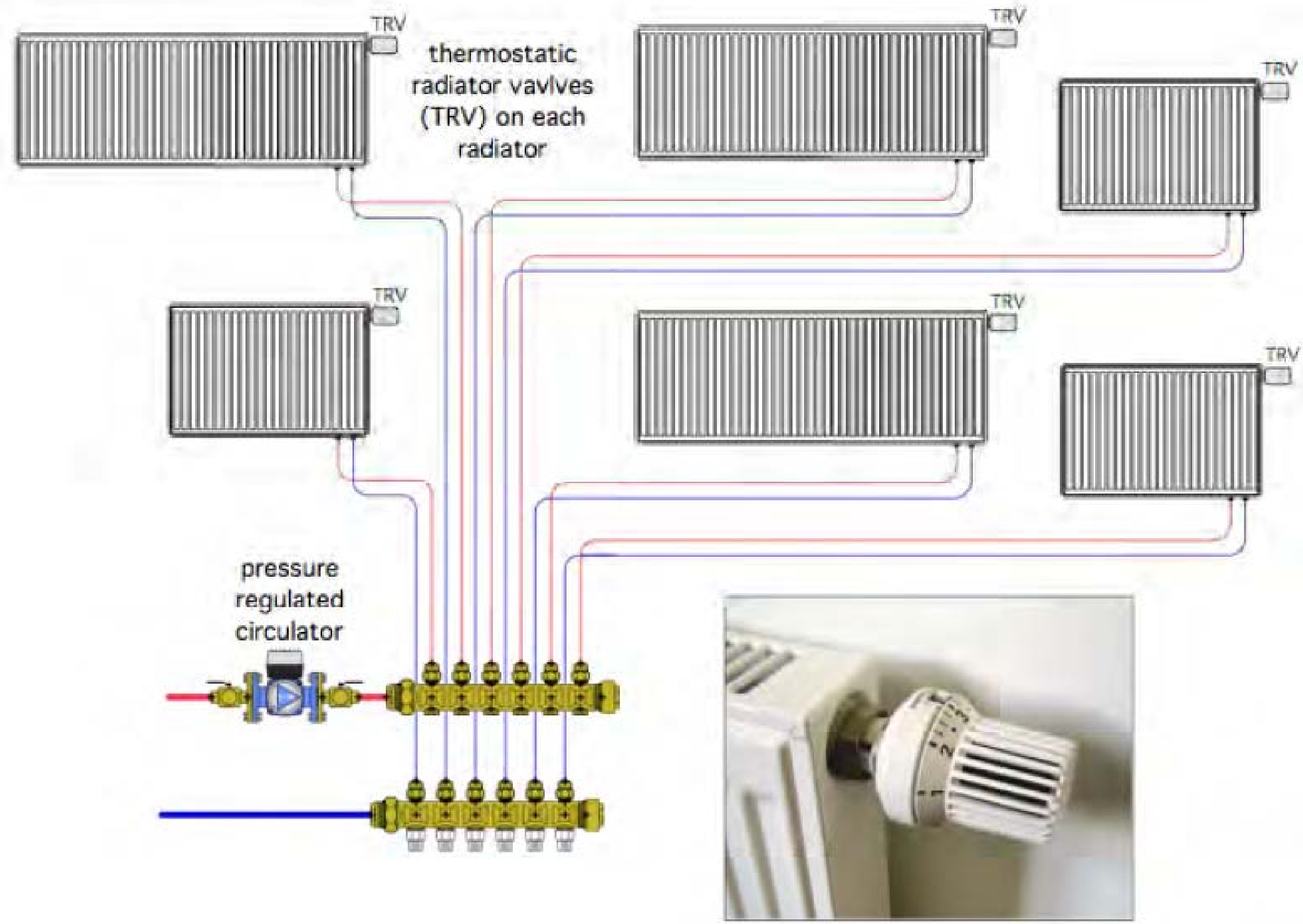
1960
3 Gallons
Slow

1980
2 Gallons
Slow

2009
0.25 Gallons
Fast

Panel Radiators

Zoning Without Thermostats



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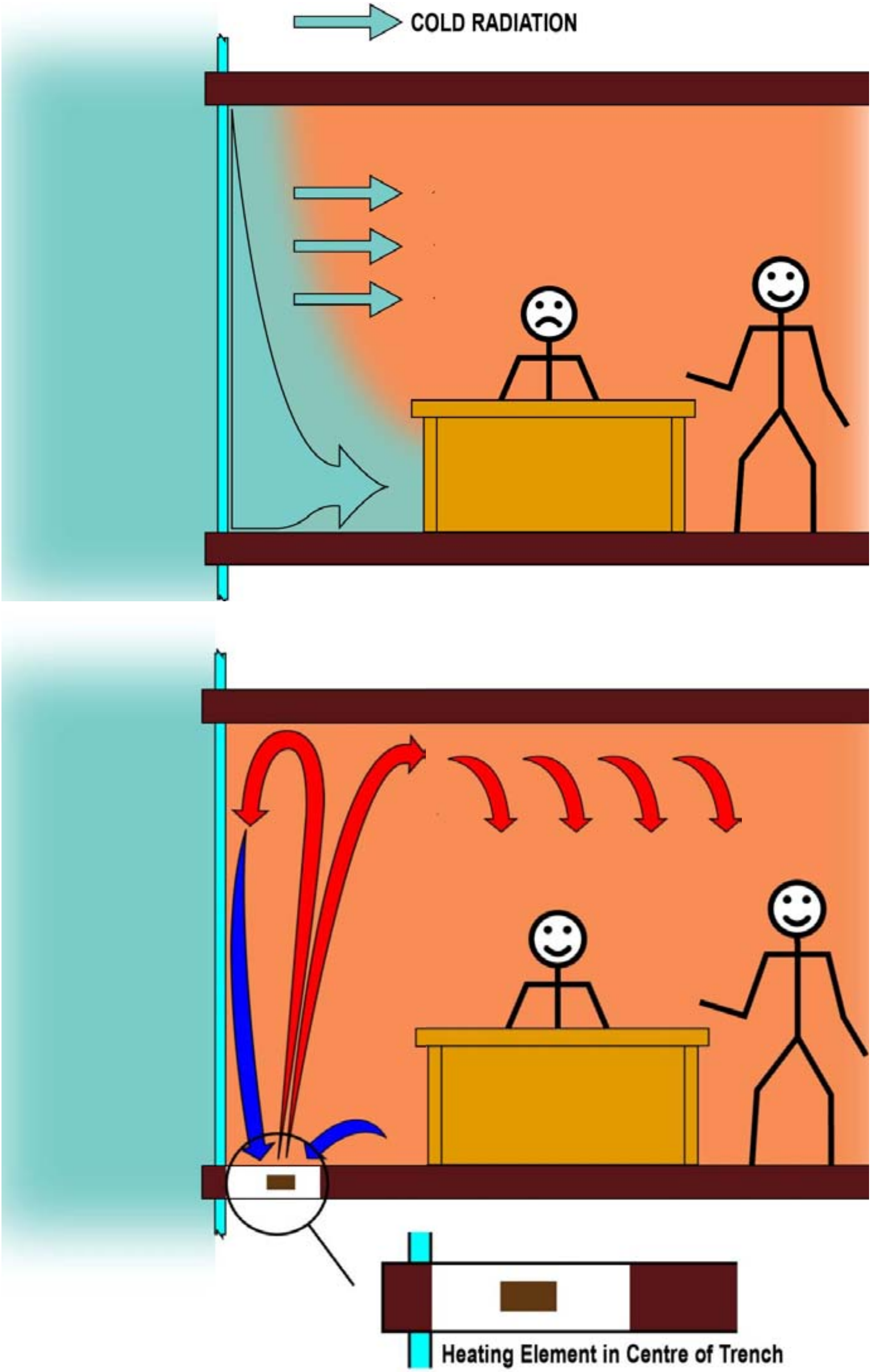
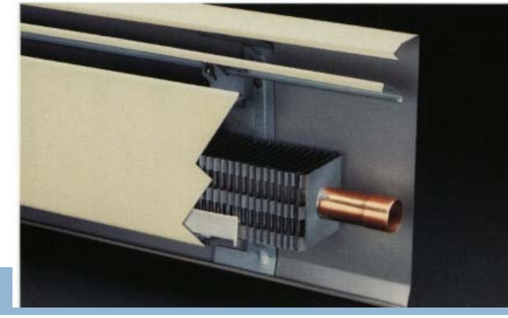

COLD RADIATION
Heating Element in Centre of Trench

Fin-Tube Radiation

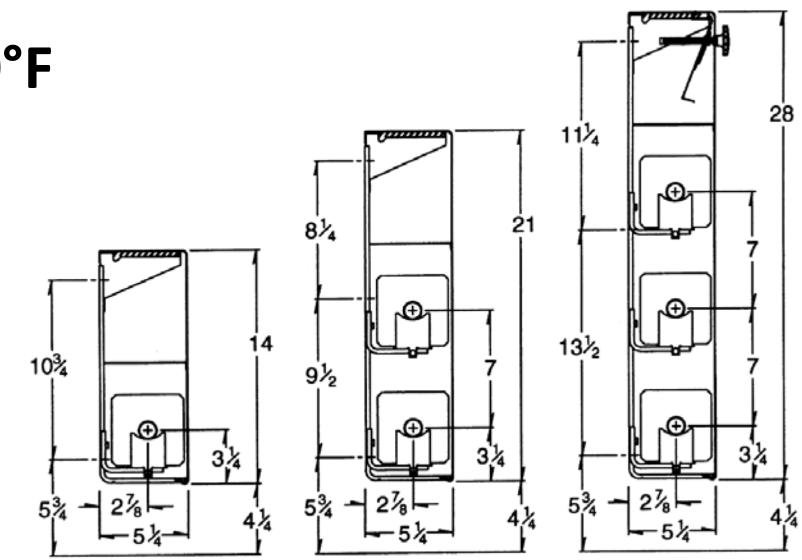


Tube Size and Material	Fin Size and Material	Fins per Foot	No. of Tiers 7" cl	Pressure Drop †	Steam 1 PSI* Btu/Hr. Per Foot	HOT WATER RATINGS* BTU/HR./FT. (Flow Rate 3 Ft./Sec.)											
						110°F	120°F	130°F	140°F	150°F	160°F	170°F	180°F	190°F	200°F	210°F	220°F
1¼"IPS steel	4¼" x 4¼" x .024"	32	1		1340	268	348	442	536	603	710	817	925	1045	1152	1273	1407
	electro-gal. steel		2	420	2410	482	627	795	964	1085	1277	1470	1663	1880	2073	2290	2531
			3		3170	634	824	1046	1268	1427	1680	1934	2187	2473	2726	3012	3329

*Based on 65°F Entering Air Temperature

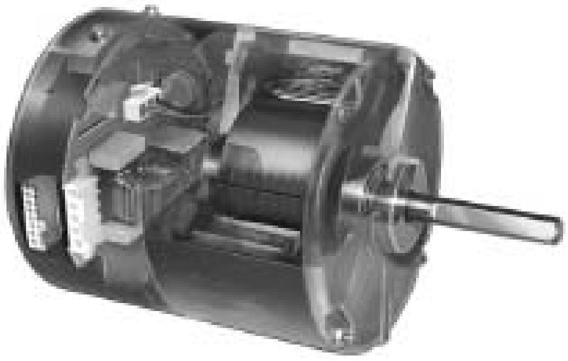
- Room Heat Load= 6300 Btuh (design day)
  - Option 1: 7 Feet of 1 Tier with 180°F
  - Option 2: 14 Feet of 1 Tier with 130°F
  - Option 3: **6 Feet** of 3 Tier with **130°F**

Boiler condenses with Options 2 and 3!

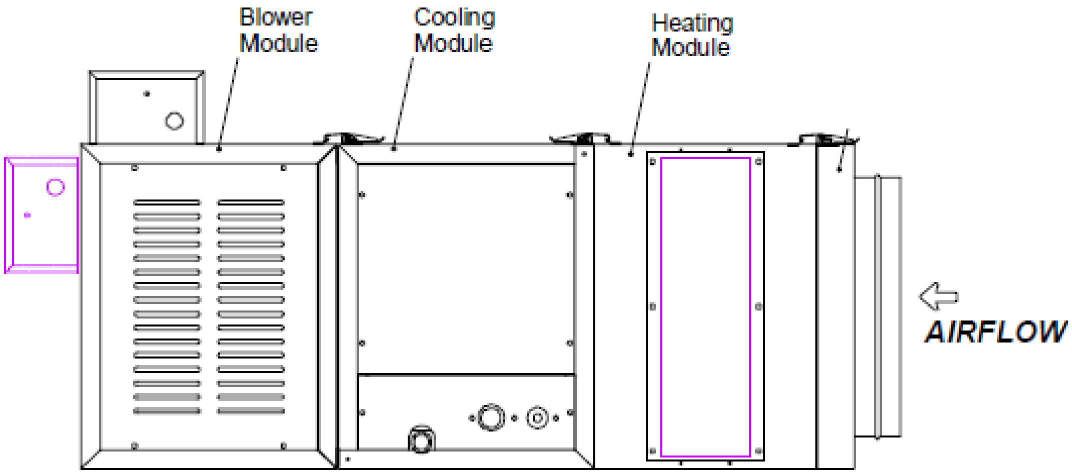


Hydro-Air

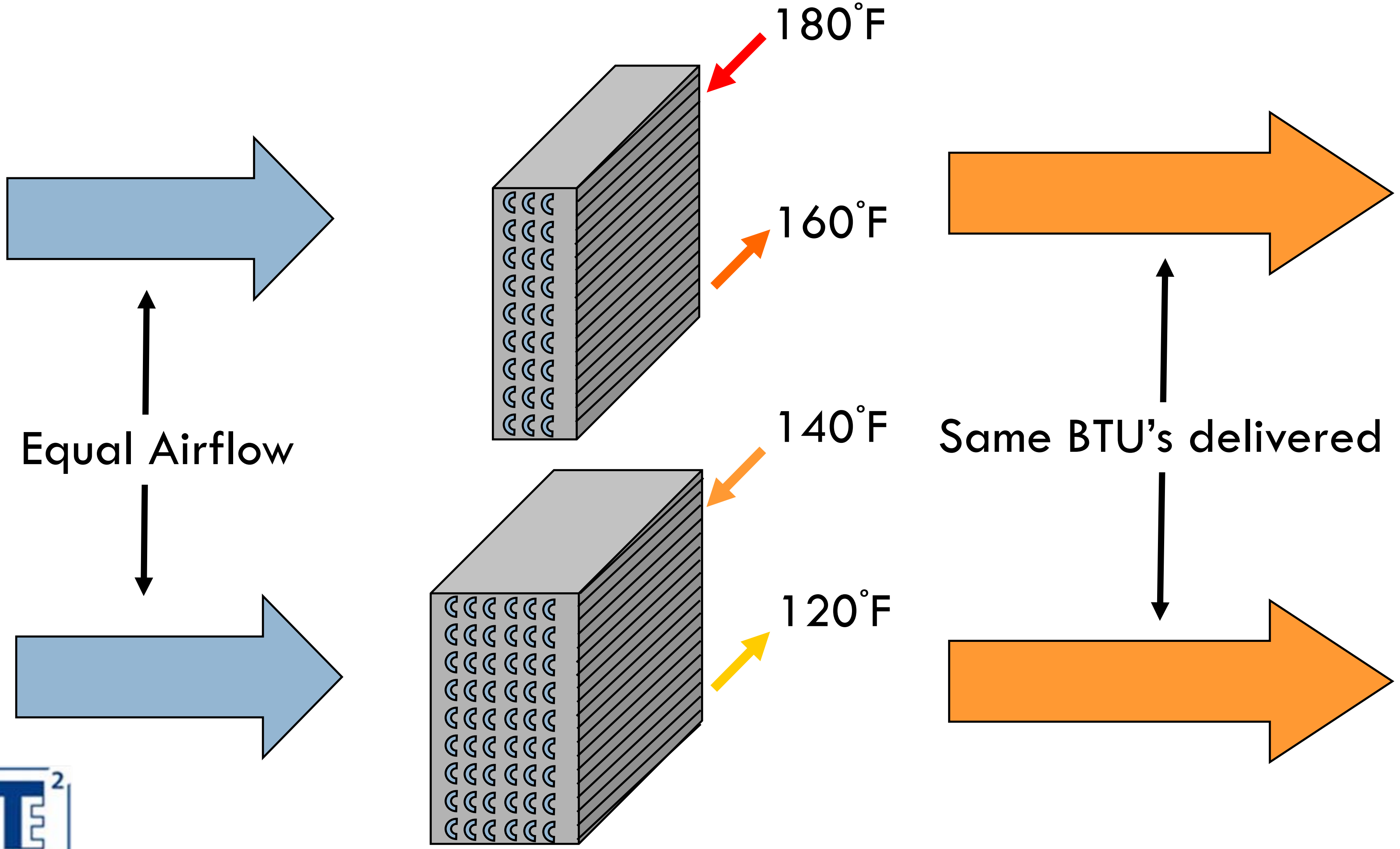
- High Surface Area Coil
- Low Water Temperature
- ECM Blower Air Handler
- Cooling and Heating



Variable Speed ECM Motor



Fan Coil Sizing



Hot Water Coil

- In many cases you can upsize the hot water coil to drop your water temps down…

64,000 BTU/HR:

SMALL HW COIL
Supply water=160 °F
Return water= 128 °F

LARGER HW COIL
Supply water=140 °F
Return Water =118°F

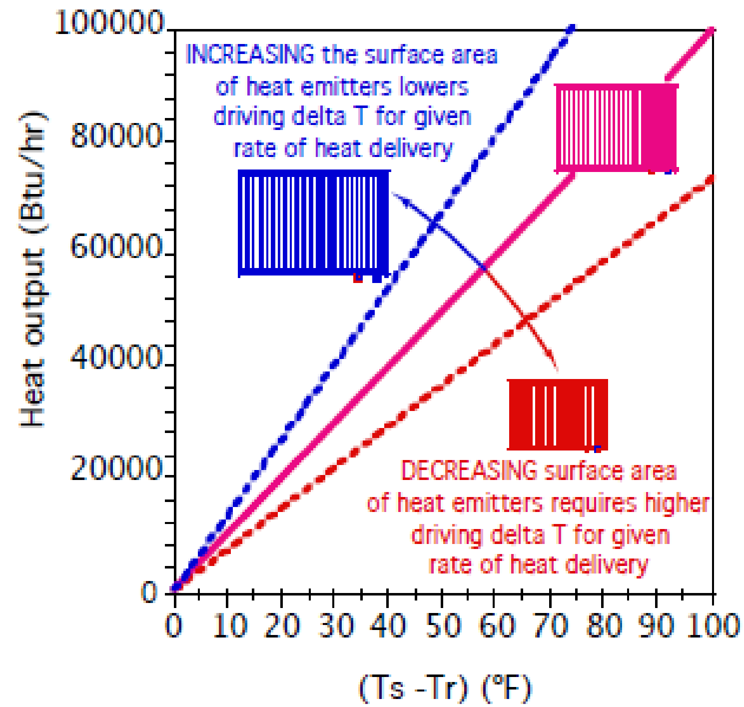
NOM. CFM	GPM (HTG)	P.D. (FT. WATER)	BTUH (1000) AT ENTERING WATER TEMPERATURE		
			140°F	160°F	180°F
1200	6 4 2	7.55 3.64 1.04	53.8 50.2 42.6	69.2 64.6 54.7	84.6 78.9 66.9
1200	8 6 4	4.83 2.90 1.40	66.6 63.6 59.0	85.7 81.8 75.8	104.7 100.0 92.7

*Based on 65°F Entering Air Temperature

Boiler operates at 95% vs. 90%

Heat Emitter Summary

- High Surface Area!
  - Upsize radiator size or hot water coil
- Low Water Temperature
- Various Types
  - Radiant In-Slab
  - Above/Below Subfloor
  - Panel Radiators
  - Fin-Tube Radiators
  - Hydro-Air



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Any Questions?

Contact: ross@te2engineering.com