Reducing Hydronic System Temperature for Improved Biomass Boiler Performance

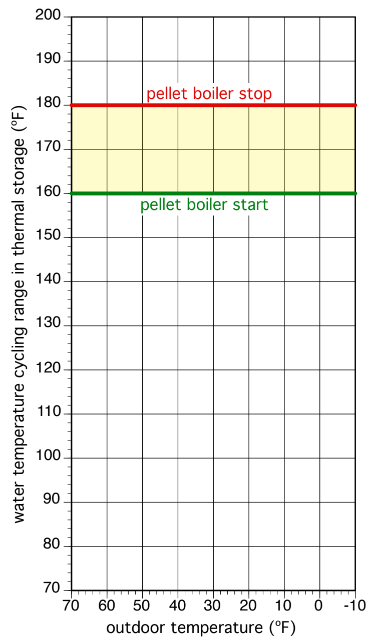
Webinar presented in support of
Renewable Heat NY

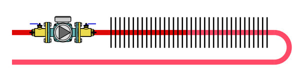
NEW YORK STATE OF OPPORTUNITY. | NYSERDA Sponsored

presented by:

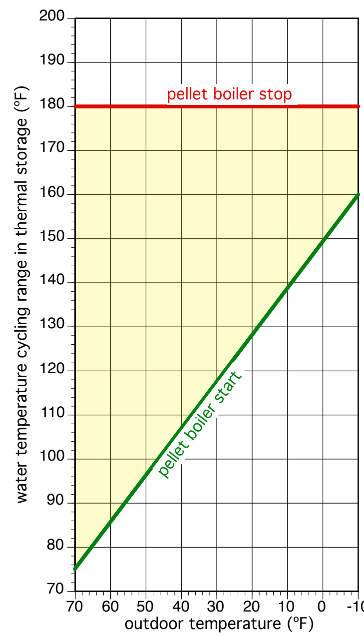
John Siegenthaler, P.E.
Appropriate Designs
Holland Patent, NY
www.hydronicpros.com

- High temperature heat emitters
- No outdoor reset control





- High temperature heat emitters
- With outdoor reset control of pellet boiler start temperature



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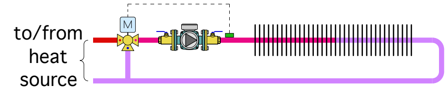
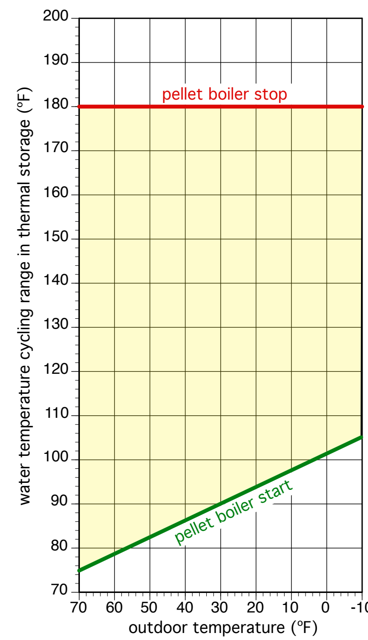
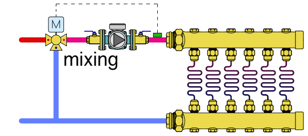


mixing with 3-way motorized valve

- Low temperature heat emitters
- With outdoor reset control of pellet boiler start temperature
- Mixing of supply water temperature required



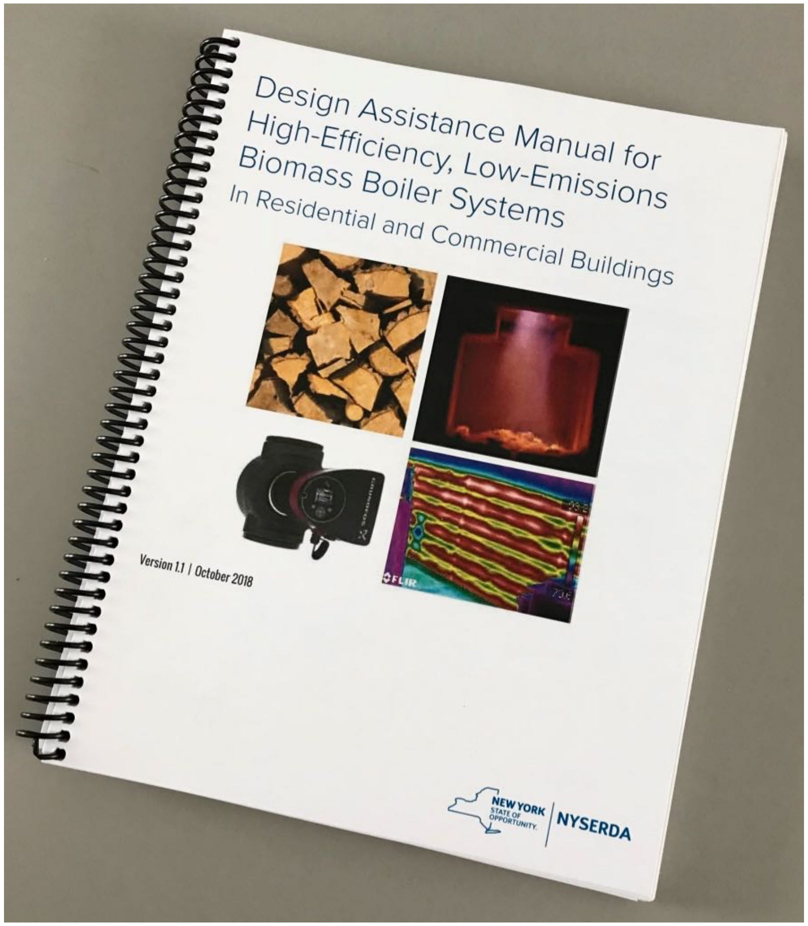


Reducing Hydronic System Temperature for Improved Biomass Boiler Performance

Topics:

- Why modern heat sources need lower water temperatures
- Why thermal storage benefits from lower water temperatures
- Hydronic heat emitter options
- *Reducing water temperature using building envelope improvements*
- *Reducing water temperature by adding heat emitters*
- Modifying existing piping systems
- Example system
- Design guidelines

Design Assistance Manual for High Efficiency Low Emissions Biomass Boiler Systems



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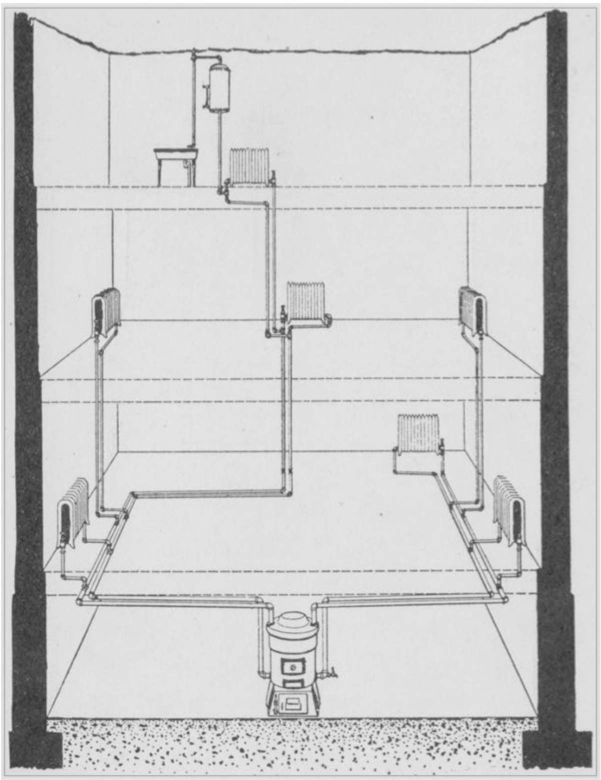
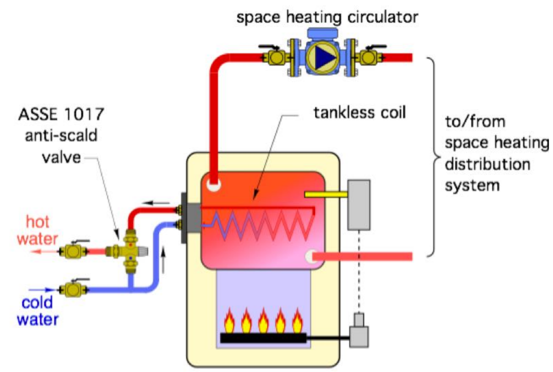
It's available as a FREE downloadable PDF at:

https://www.nyserda.ny.gov/-/media/Files/EERP/Renewables/Biomass/Design-Assistance-Biomass-Boiler.pdf

Most “legacy” hydronic heating systems were designed around high water temperatures



“gravity” hot water system
(pre-circulator)



- Fossil fuels were cheap and in seeming abundance…

- 2000 ºF combustion temperatures could easily create 200+ ºF water

- higher water temperatures means smaller heat emitters, and reduced installation cost.

Modern heat sources all yield higher efficiency at lower water temperatures

geothermal water-to-water heat pump

air-to-water heat pump

solar thermal collectors

biomass boilers w/ thermal storage

modulating / condensing boilers

Biomass boiler “Bliss”…

Long “ON” cycles

Long “OFF” cycles

Stretch out those cycles…

Cordwood gasification boilers

- 2-stage combustion
- Thermal efficiency 80-85% (@high load,steady state)
- Very little ash or “clinker” residue
- Available for inside or outside placement

image courtesy of Econoburn

For highest efficiency...

- **Burn Hot & Burn fast**

Heat output often exceeds heating load

Storage is needed

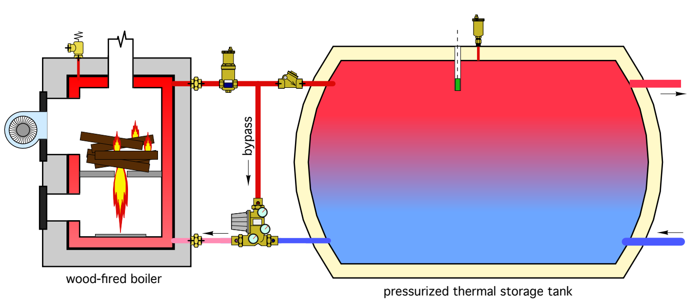


image courtesy of New Horizon Corp.

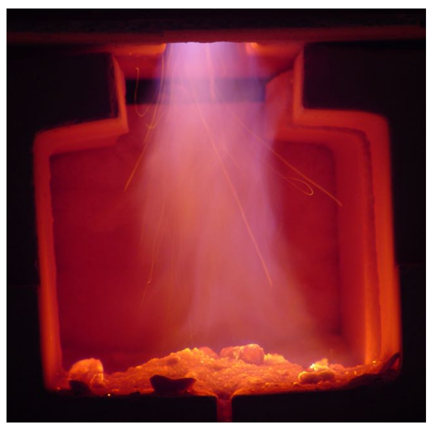
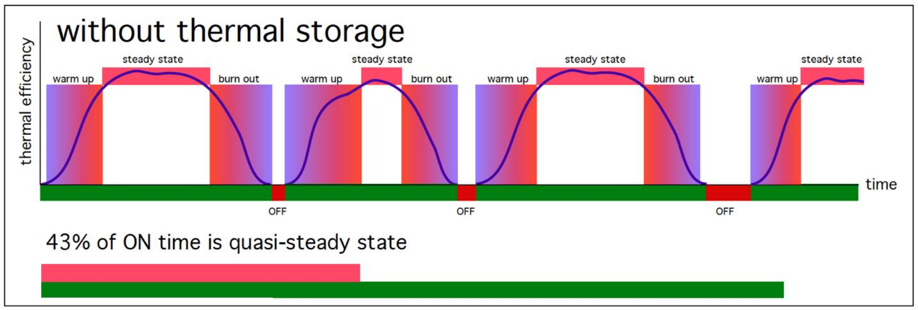
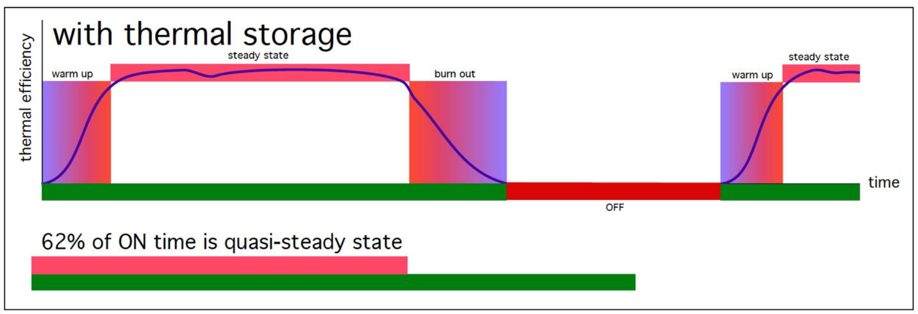
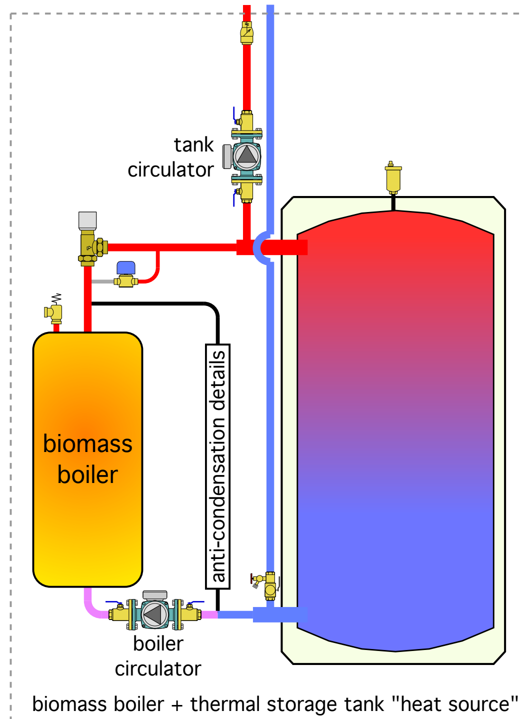


image courtesy of Tarm Biomass

To achieve **high thermal efficiency** and **low emissions**, pellet boilers should operate with long on-cycles, followed by long off-cycles.
(suggest 3 hr run time per start)







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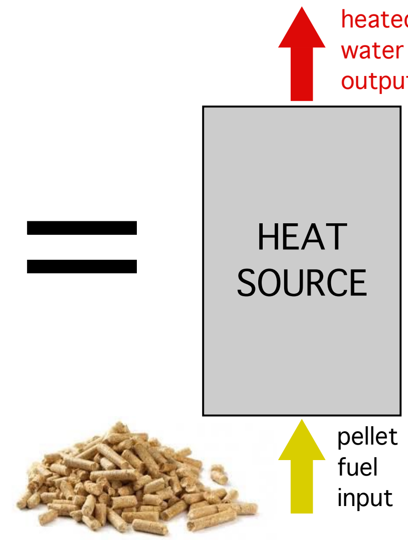
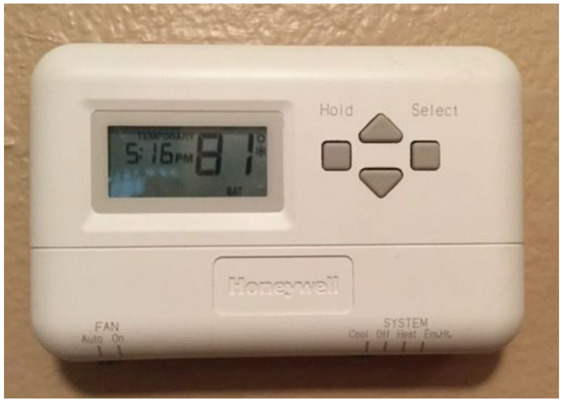


In most applications, pellet boilers require substantial thermal storage *(typically 2 gallons / 1000 Btu/hr boiler output)* to achieve these long operating cycles.

Pellet boiler operation based on storage tank temperature

A typical pellet boiler is turned on and off based on temperatures in thermal storage. **(It operates independently of "calls" for heat from zone thermostats)**



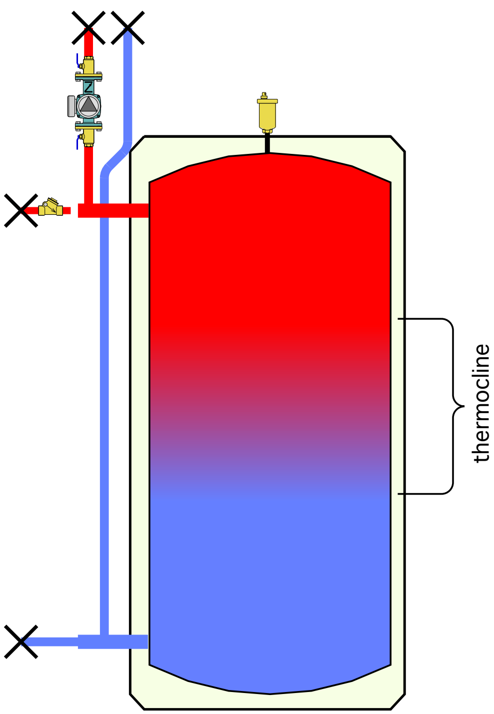
This does NOT turn the pellet boiler on and off.

The is very different from a conventional boiler that is typically fired only when there is a call for heating from a thermostat, or other load sensing device.

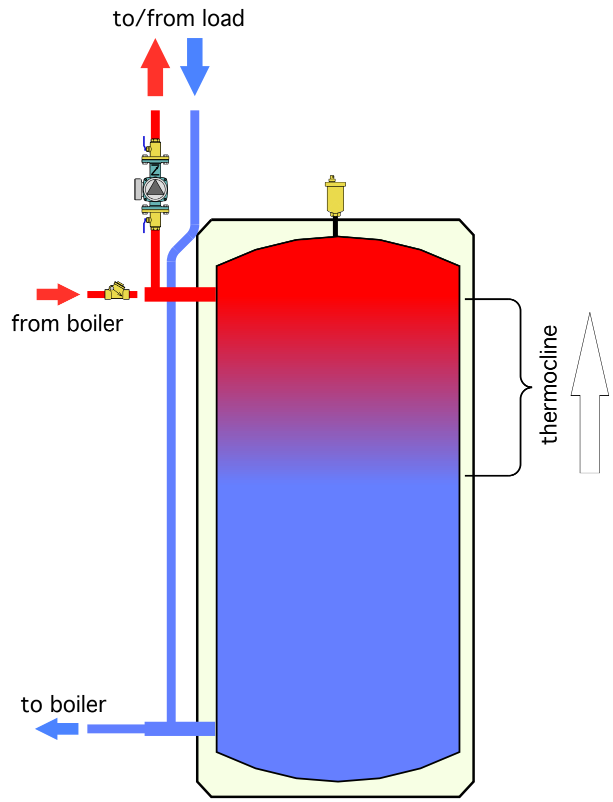
A different boiler on/off control concept is necessary to achieve long firing cycles.

Thermocline movement in tank

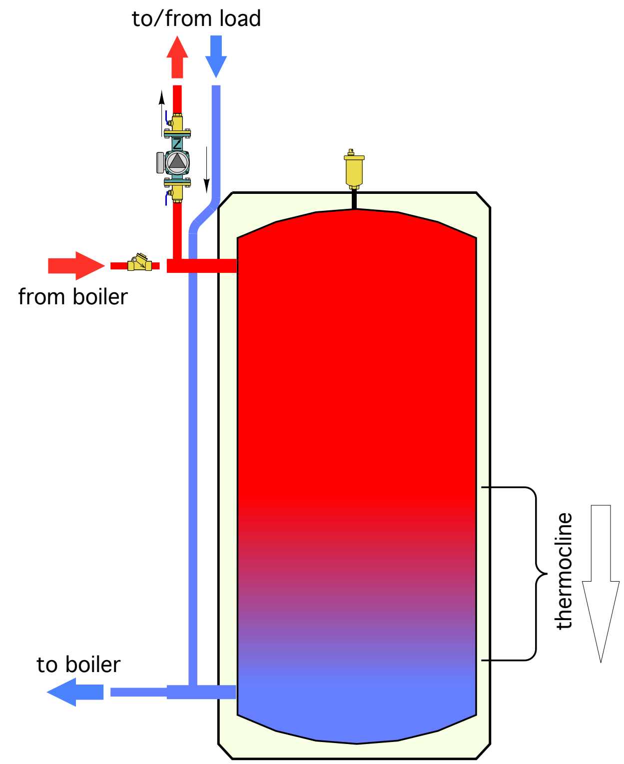
Indicates relative energy flow between boiler and load.



tank at rest. No flow from boiler or to load

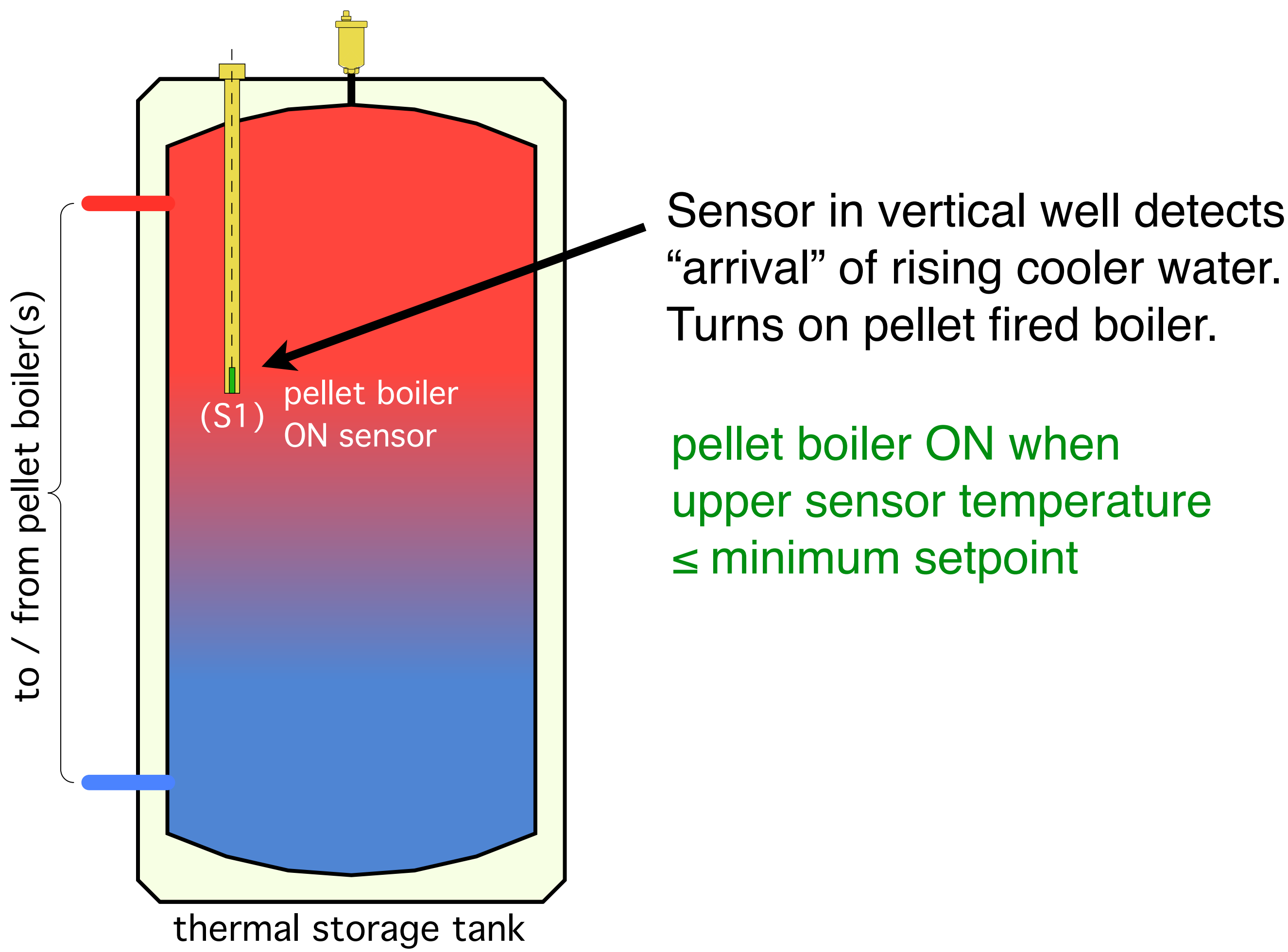


load extracting heat at rate > rate of heat output from boiler.
Thermocline moves up



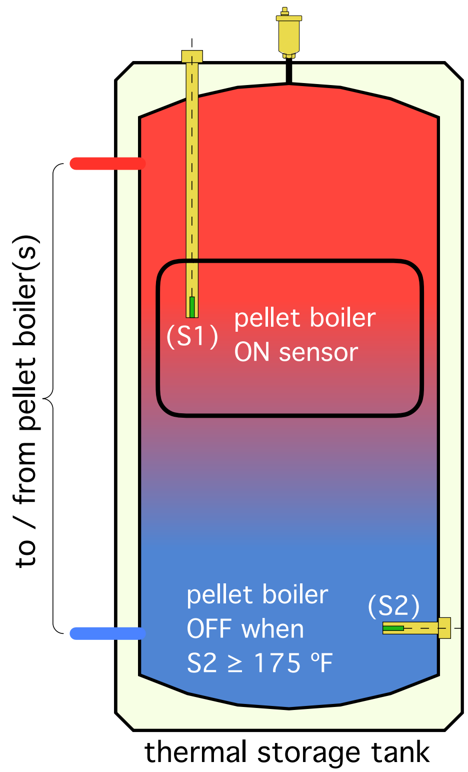
load extracting heat at rate < rate of heat output from boiler.
Thermocline moves down

The pellet fired boiler should be turned on ***before*** the hot water is depleted from top of tank.

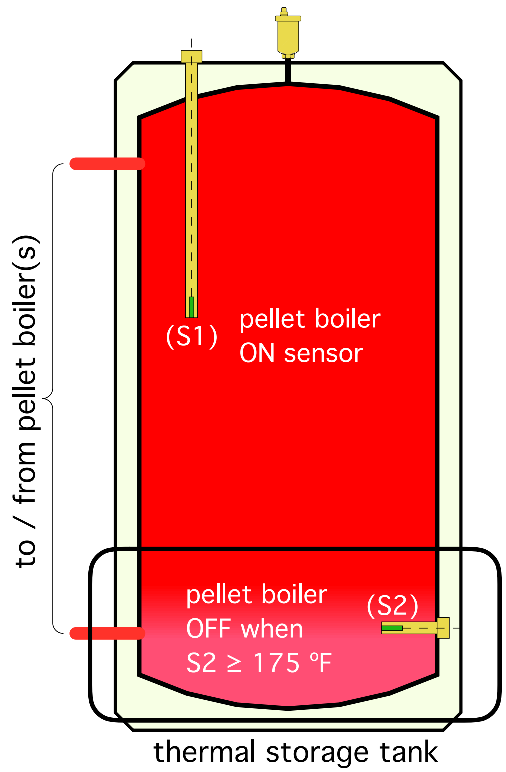


Temperature stacking

To lengthen pellet boiler on-cycle, keep it operating until a sensor in lower portion of tank reaches some higher preset temperature.

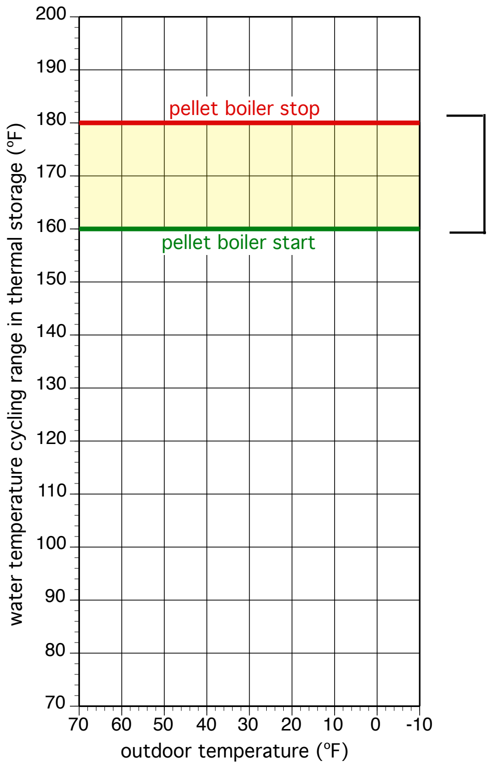


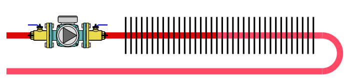
pellet boiler
"start"condition



pellet boiler
"stop"condition

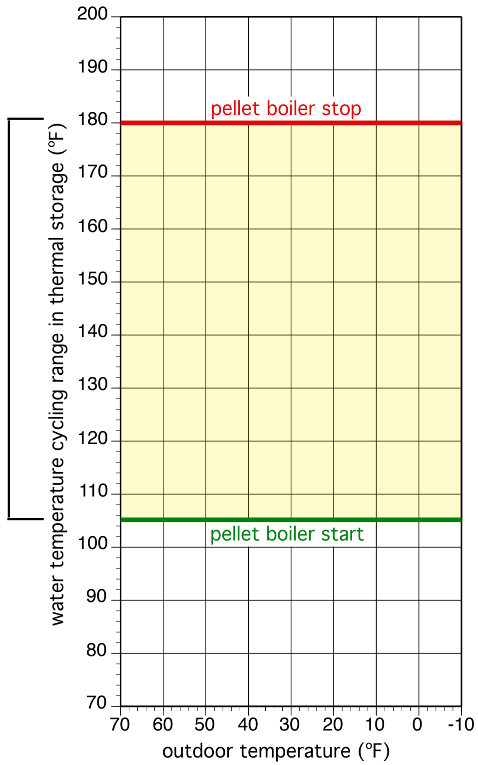
Temperature cycling range of storage is high dependent on the type of heat emitters used.

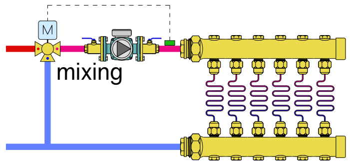




• HIGH temperature heat emitters
• No outdoor reset control of supply water temperature

Low temperature heat emitters allows for wider tank "draw down."



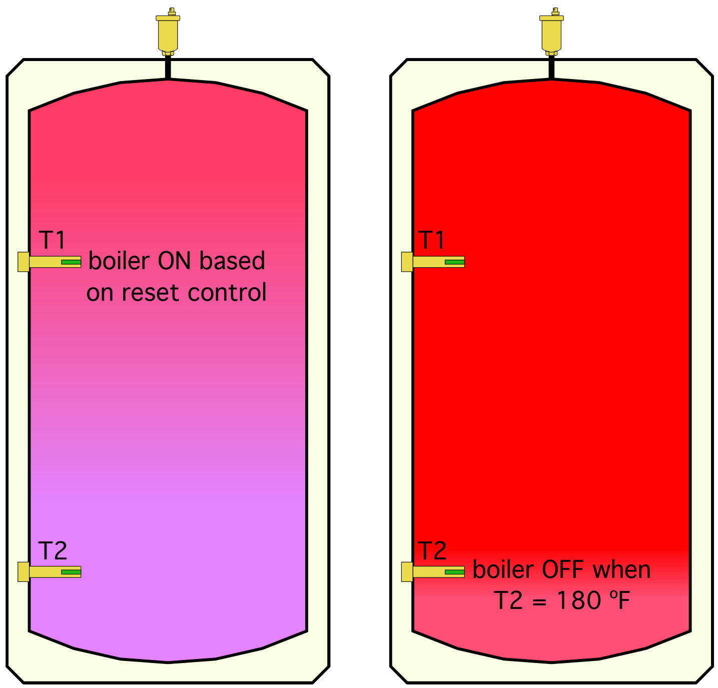


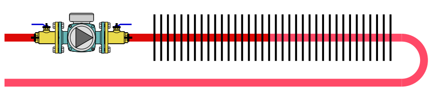
• LOW temperature heat emitters
• No outdoor reset control of supply water temperature

• **High temperature heat emitters**

• Temperature stacking (w/ upper & lower tank temp. sensors

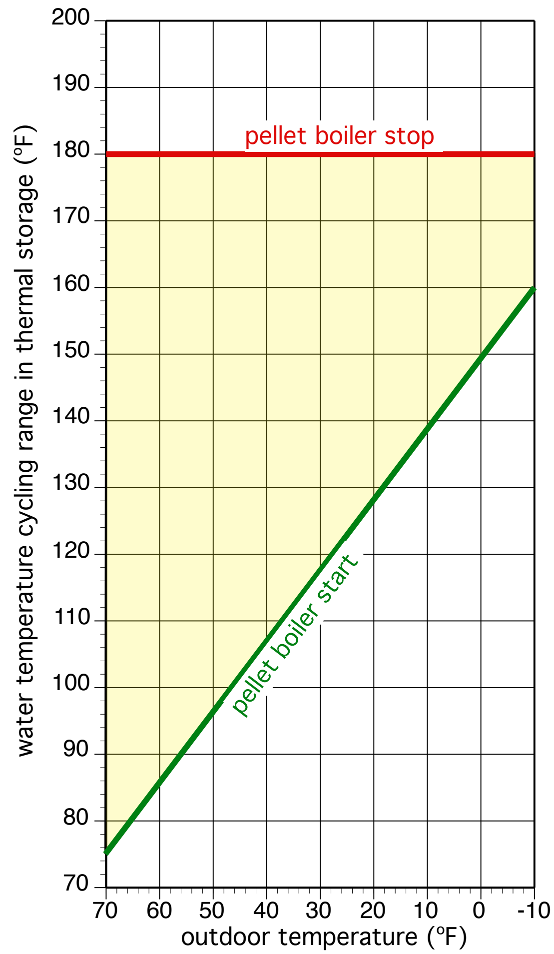
[***outdoor reset for boiler start***, *setpoint temperature for boiler off*]



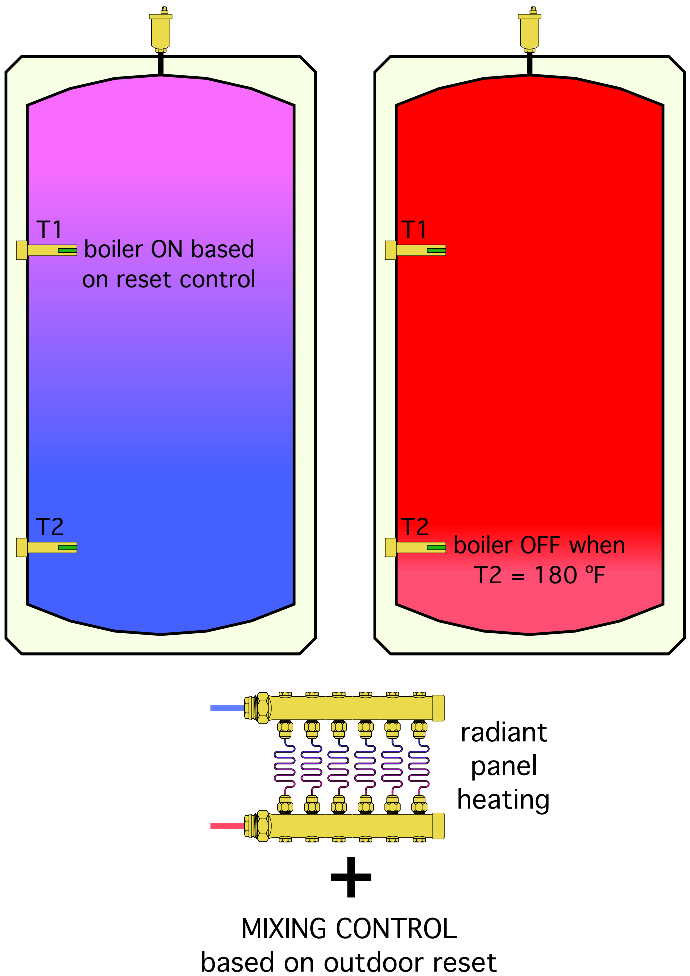


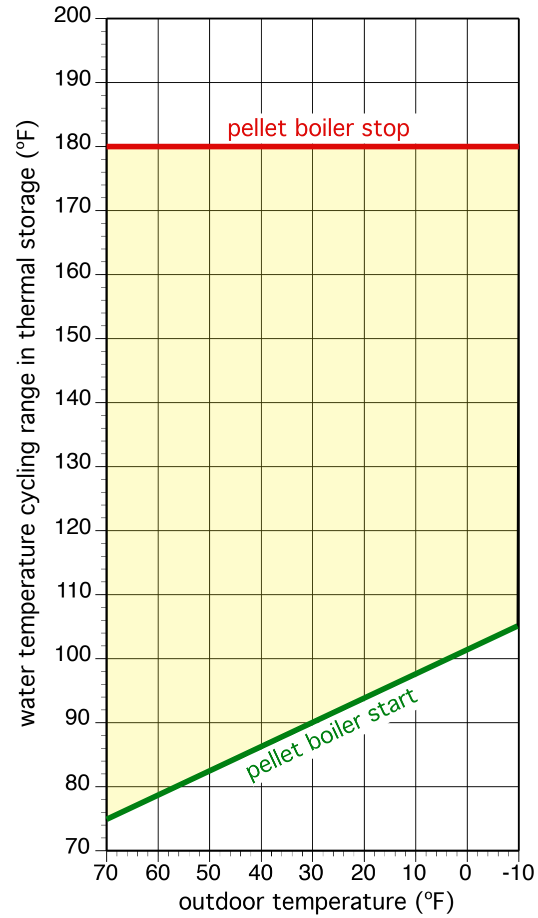
• HIGH temperature heat emitters

• Outdoor reset of pellet boiler start temperature

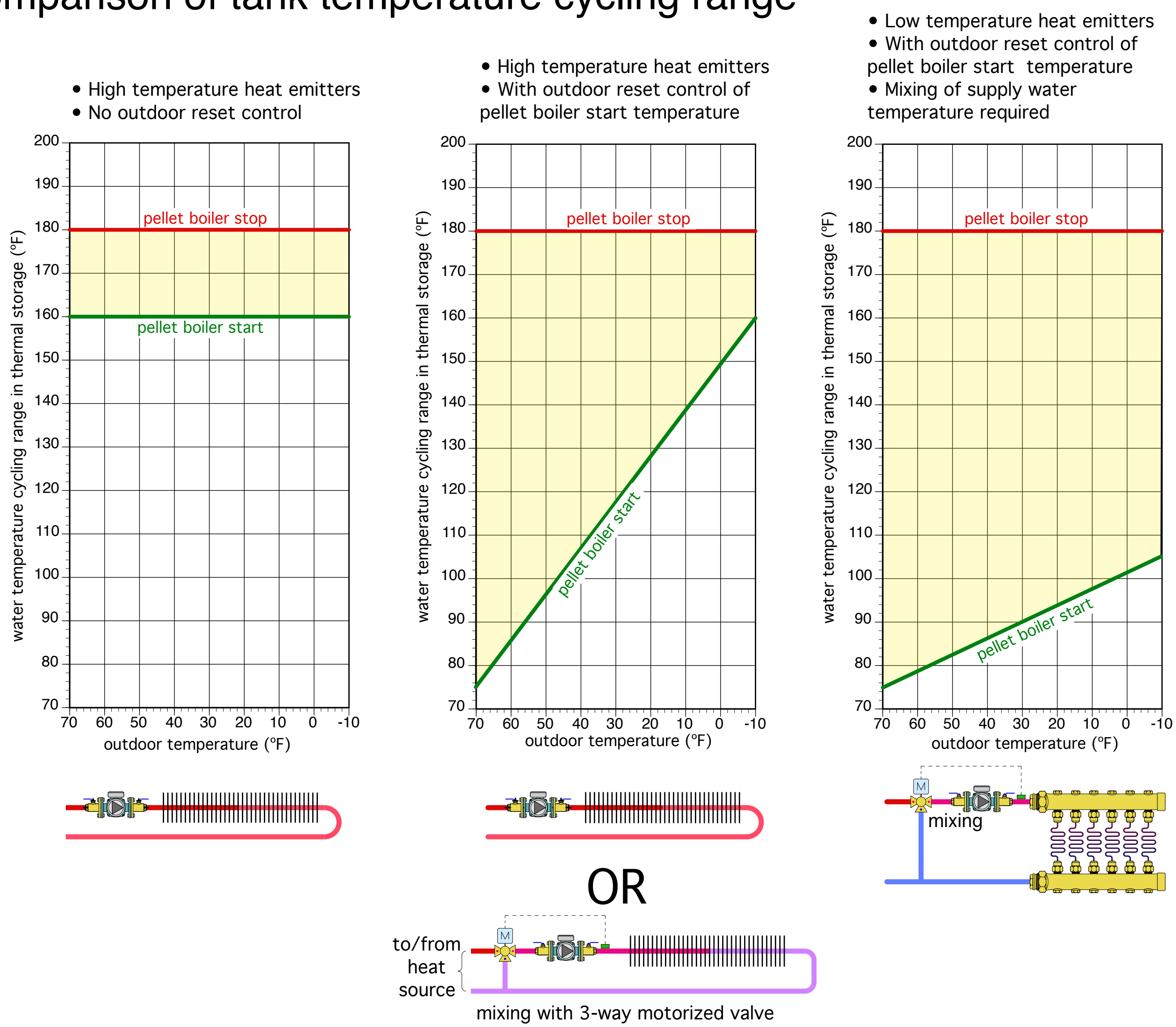


- **Low temperature heat emitters**
- Heat stacking (outdoor reset for boiler start, setpoint for boiler off)
- Mixing control of distribution water temperature





A comparison of tank temperature cycling range



Heat Emitter Options

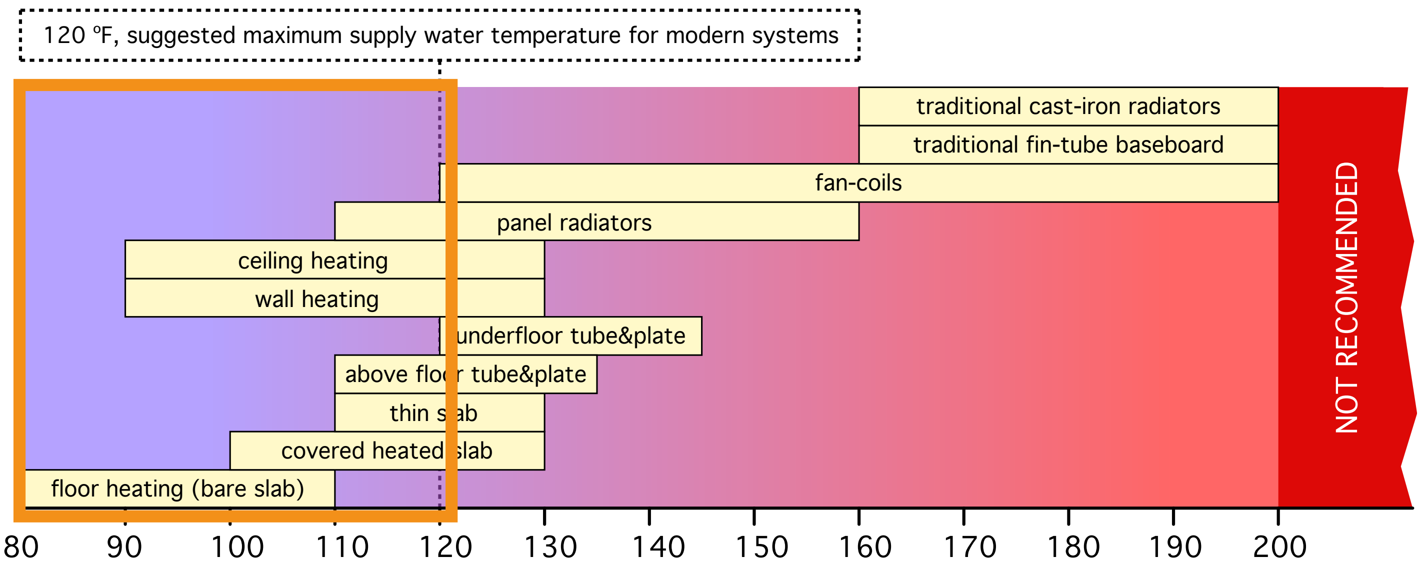
Heat Emitter Fundamentals

• The heat output of ***any*** heat emitter always drops with decreasing water temperature.

• There is always ***some*** output provided the supply water temperature is above the room air temperature.

• There is always a trade off between the *total surface area of the heat emitters* in the system, and the *supply water temperature* required to meet the heating load.

• ***More heat emitter area always lowers the required supply water temperature.***



• Don't feel constrained to select heat emitters based on traditional supply water temperatures…

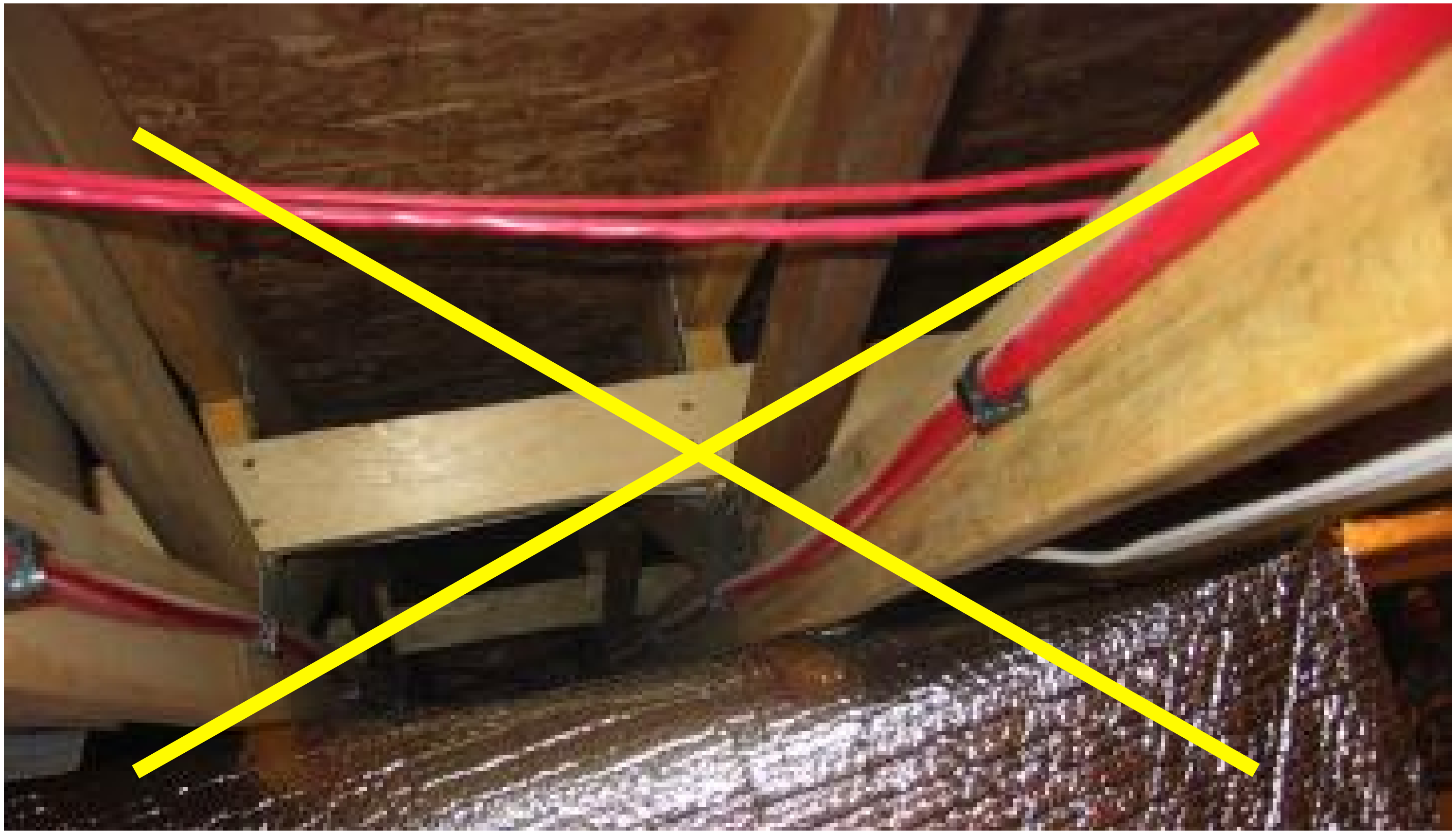
What kind of heat emitters should be used in combination with wood gasification or pellet boilers?

• They should operate at **<u>low supply water temperatures</u>** to allow maximum “draw down” on thermal storage.

Max suggested supply water temperature @ design load = 120 ºF

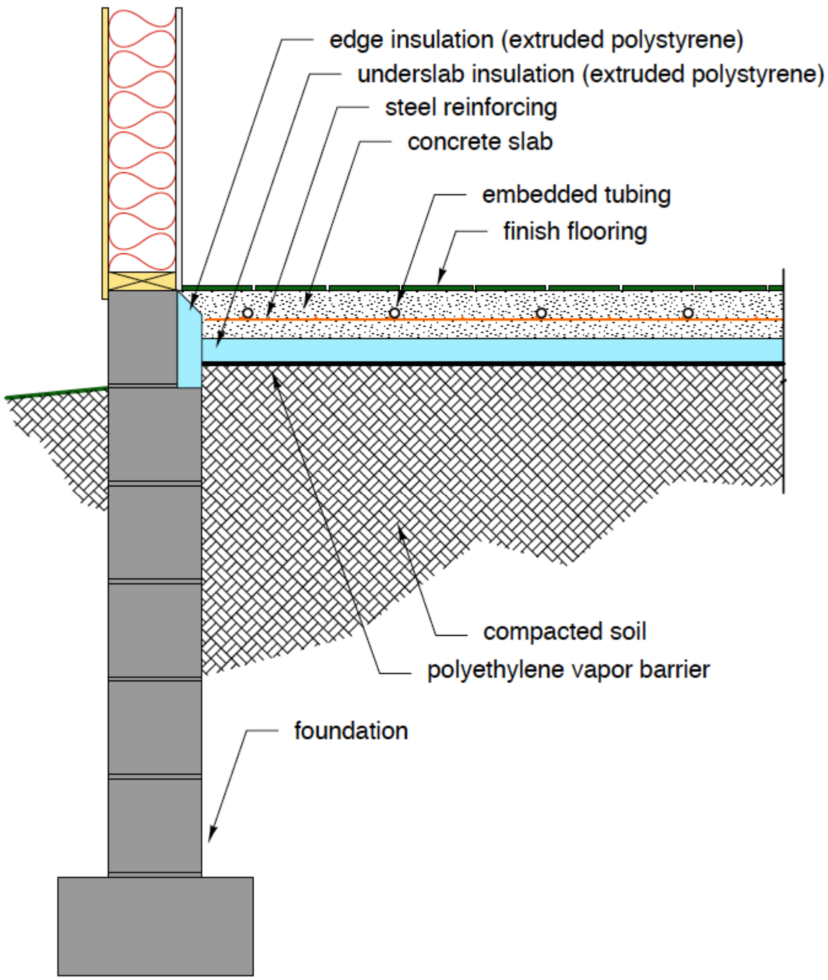
Low temperature hydronic distribution systems also help “future proof” the system for use with heat sources are likely to thrive on low water temperatures.

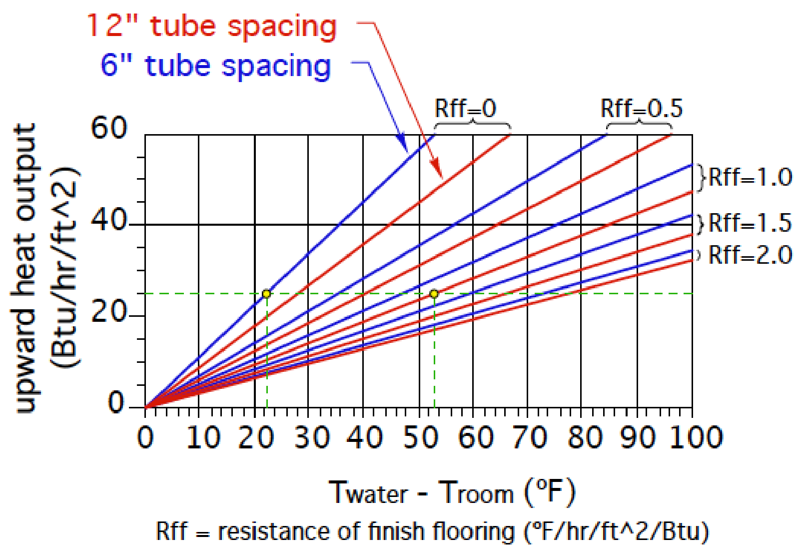
Don’t do this with ANY hydronic heat source!



Heat transfer between the water and the upper floor surface is severely restricted!

Slab-on-grade floor heating

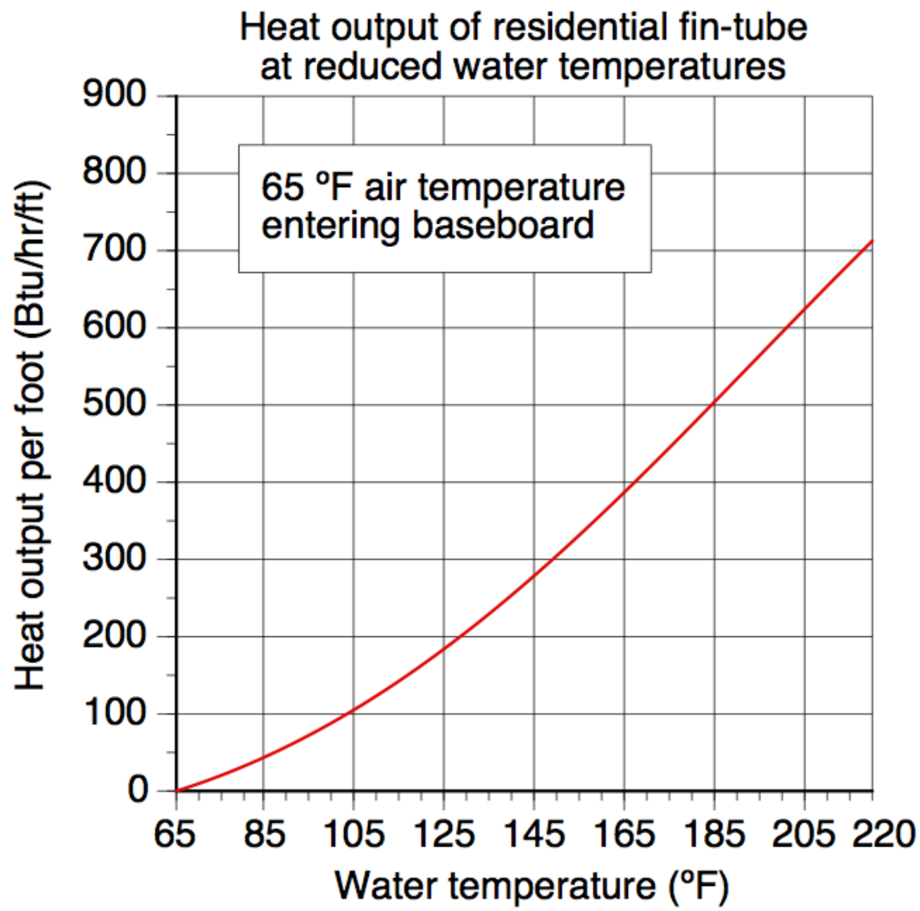




Most **CONVENTIONAL** fin-tube baseboard has been sized around boiler temperatures of 160 to 200 ºF. Much too high for good thermal performance of low temperature hydronic heat sources.

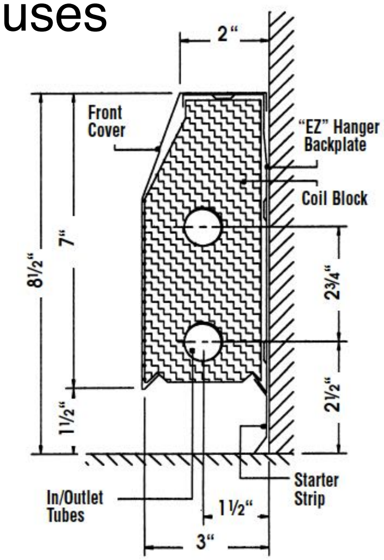
Could add fin-tube length based on lower water temperatures. BUT...

Fin-tube output at 120 ºF is only about 30% of its output at 200ºF



Hydronic heat emitters options for low energy use houses

Some low- temperature baseboard is now available



Images courtesy Emerson Swan

Heating Edge™
Hot Water Performance Ratings

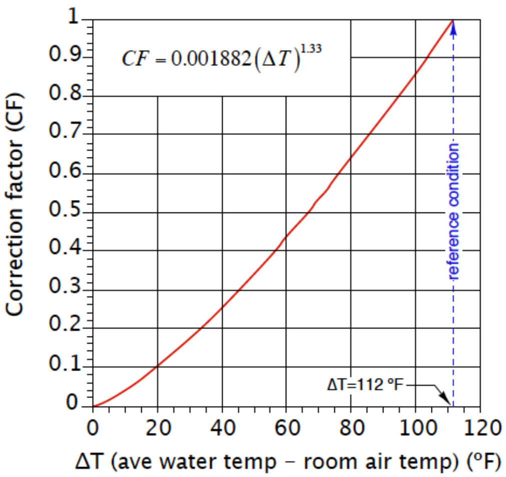
	Flow Rate GPM	PD in ft of H_20	Average Water Temperature (BTU/hr/ft @AWT in °F) 90°F	100°F	110°F	120°F	130°F	140°F	150°F	160°F	170°F	180°F	190°F	200°F	210°F
TWO SUPPLIES PARALLEL	1	0.0044	130	205	290	385	460	546	637	718	813	911	1009	1113	1215
	4	0.0481	155	248	345	448	550	651	755	850	950	1040	1143	1249	1352
TOP SUPPLY BOTTOM RETURN	1	0.0088	105	169	235	305	370	423	498	570	655	745	836	924	1016
	4	0.0962	147	206	295	386	470	552	640	736	810	883	957	1034	1110
BOTTOM SUPPLY TOP RETURN	1	0.0088	103	166	230	299	363	415	488	559	642	730	819	906	996
	4	0.0962	140	212	283	350	435	524	623	722	792	865	937	1013	1093
BOTTOM SUPPLY NO RETURN	1	0.0044	75	127	169	208	260	311	362	408	470	524	576	629	685
	4	0.0481	85	140	203	265	334	410	472	536	599	662	723	788	850

Performance Notes: • All ratings include a 15% heating effect factor • Materials of construction include all aluminum "patented" fins at 47.3 per LF, mechanically bonded to two 3/4' (075) type L copper tubes ("Coil Block") covered by a 20 gauge perforated, painted cover all mounted to a backplate. Please see dimensional drawing for fin shape and dimensions • EAT=65°F • Pressure drop in feet of H_2O per LF.

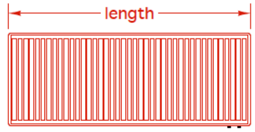
Heating Edge (HE2) has been performance tested in a BSRIA standards laboratory. The test chamber was set up according to IBR testing protocol. The above chart is shown in Average Water Temperatures (AWT) per market request.

Panel Radiators

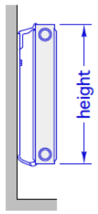
Adjust heat output for operation at lower water temperatures.



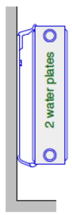
Reference condition:
Ave water temp. in panel = 180°F
Room air temperature = 68°F



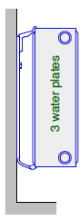
Heat output ratings (Btu/hr)
at reference conditions:
Average water temperature in panel = 180°F
Room temperature = 68°F
temperature drop across panel = 20°F



	1 water plate panel thickness					
	16" long	24" long	36" long	48" long	64" long	72" long
24" high	1870	2817	4222	5630	7509	8447
20" high	1607	2421	3632	4842	6455	7260
16" high	1352	2032	3046	4060	5415	6091



	2 water plate panel thickness					
	16" long	24" long	36" long	48" long	64" long	72" long
24" high	3153	4750	7127	9500	12668	14254
20" high	2733	4123	6186	8245	10994	12368
16" high	2301	3455	5180	6907	9212	10363
10" high	1491	2247	3373	4498	5995	6745

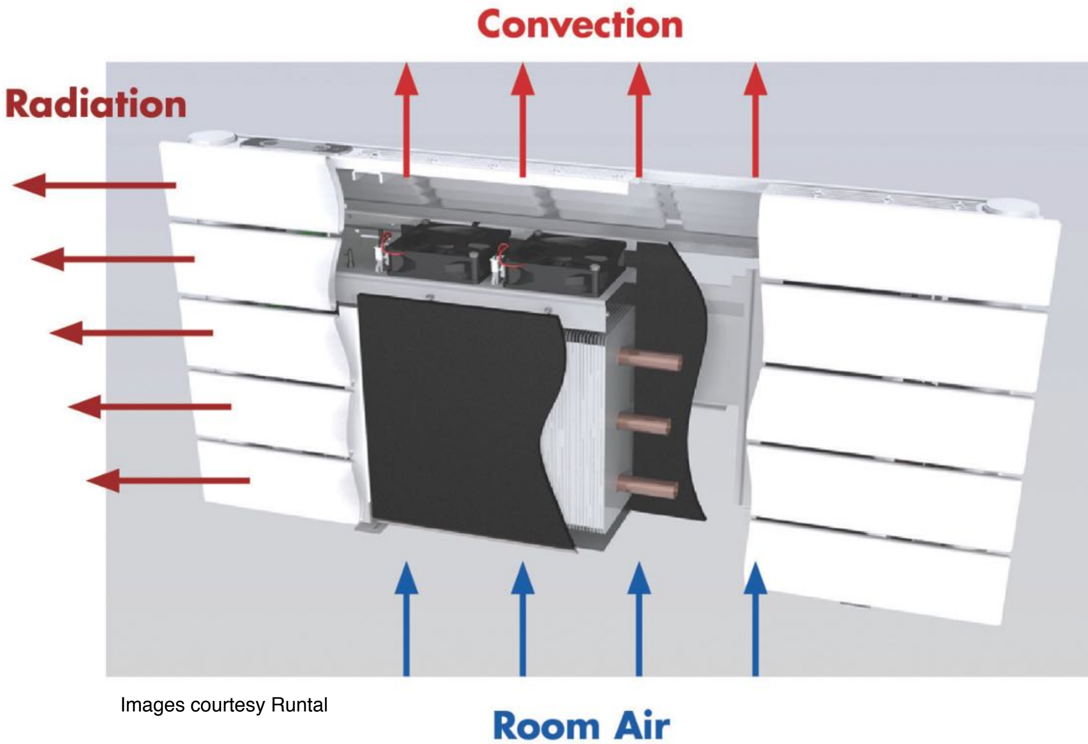


	3 water plate panel thickness					
	16" long	24" long	36" long	48" long	64" long	72" long
24" high	4531	6830	10247	13664	18216	20494
20" high	3934	5937	9586	11870	15829	17807
16" high	3320	4978	7469	9957	13277	14938
10" high	2191	3304	4958	6609	8811	9913

As an approximation, a panel radiator operating with an average water temperature of 110 °F in a room room maintained at 68 °F, provides approximately 27 percent of the heat output it yields at an average water temperature of 180 °F.

Fan-assisted Panel Radiators

The "NEO", from Runtal North America

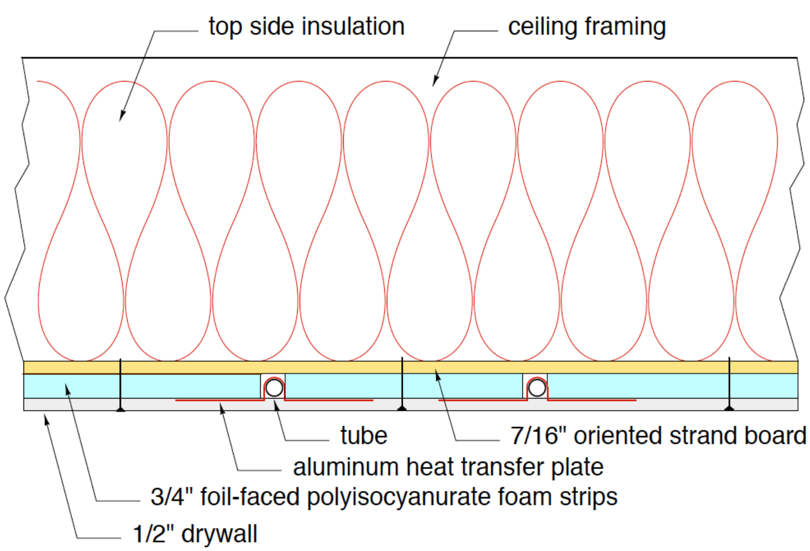


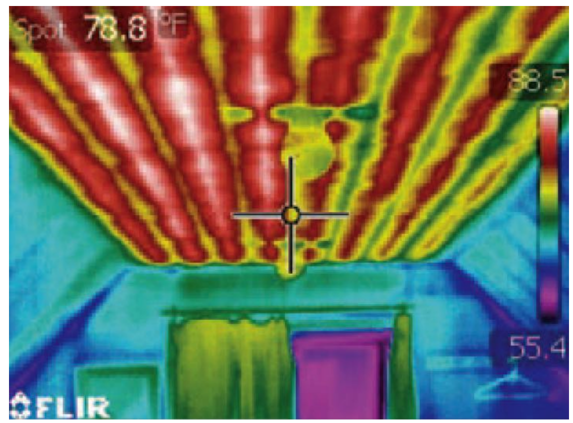
Images courtesy Runtal

8 tube high x 31.5" wide produces 2095 Btu/hr at average water temperature of 104 °F in 68°F room

8 tube high x 59" wide produces 5732 Btu/hr at average water temperature of 104 °F in 68°F room

Site built radiant CEILINGS...





Thermal image of radiant ceiling in operation

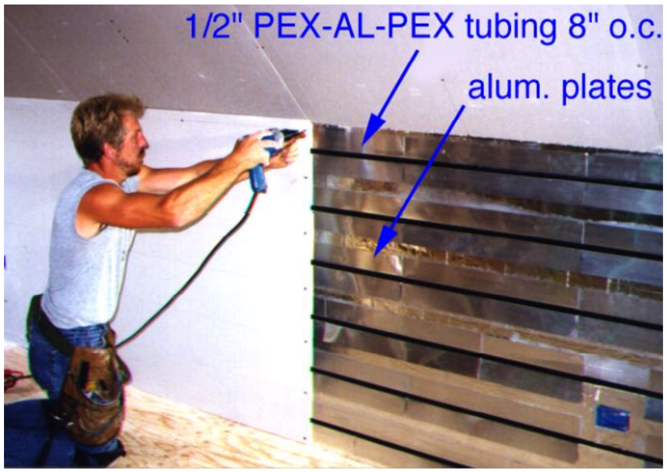
Heat output formula:

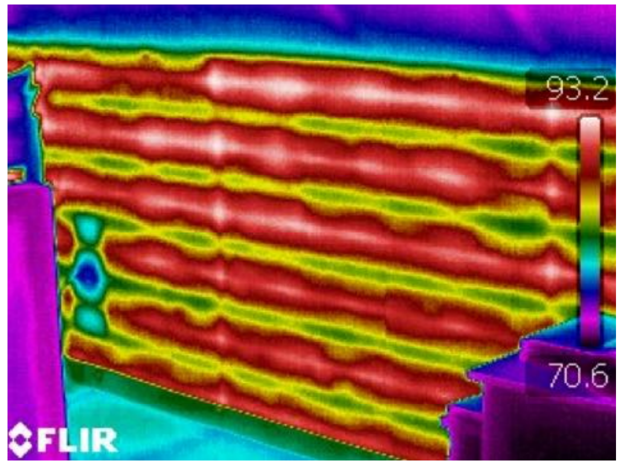
$$q = 0.71 \times (T_{water} - T_{room})$$

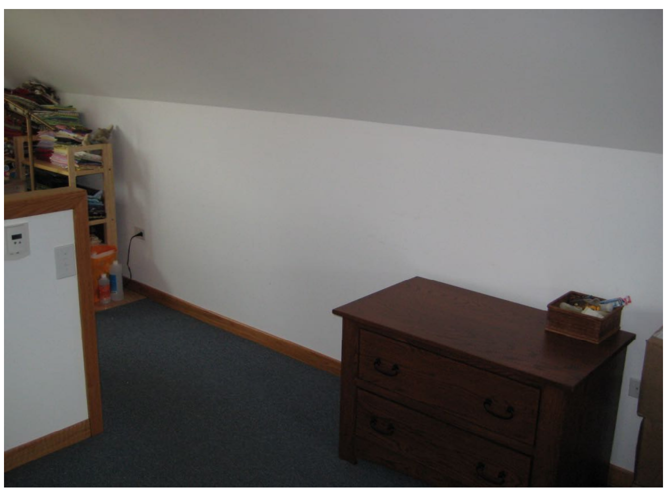
Where:

Q = heat output of ceiling (Btu/hr/ft²)
T_{water} = average water temperature in panel (°F)
T_{room} = room air temperature (°F)

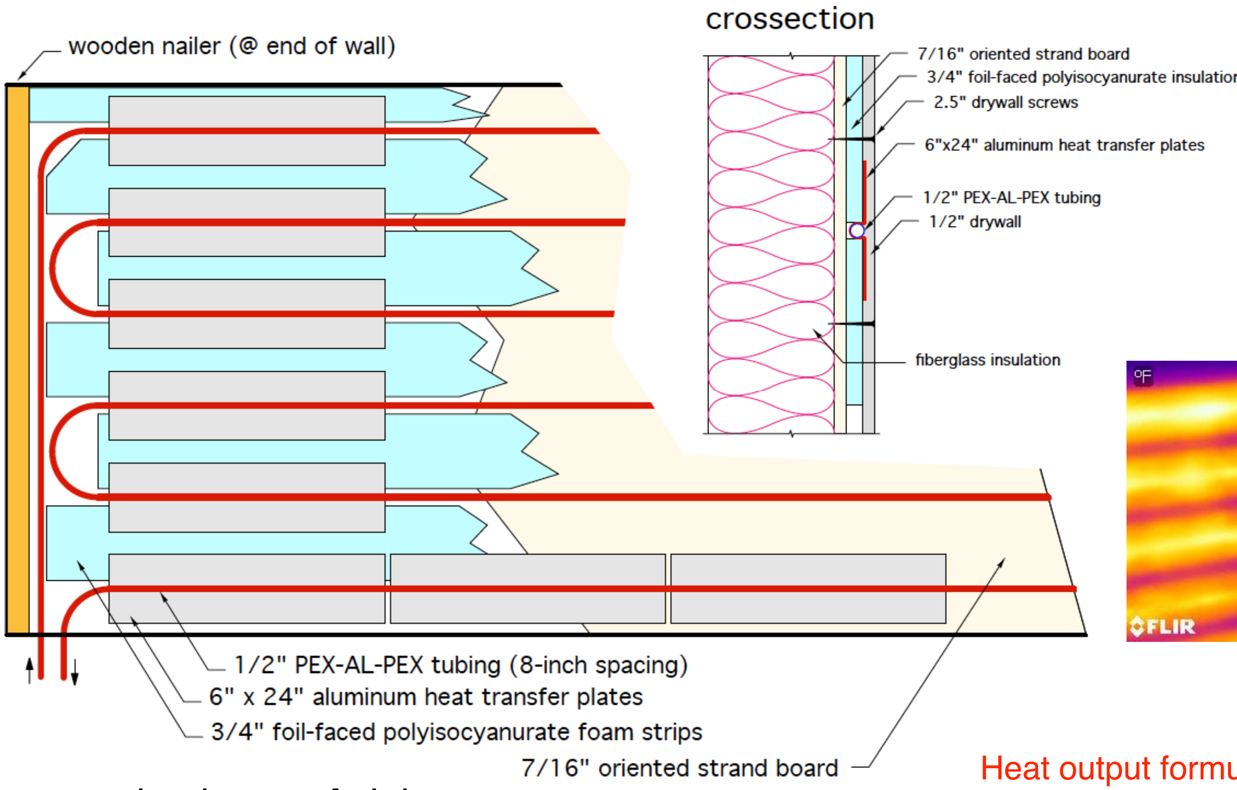
Site built radiant WALLS...

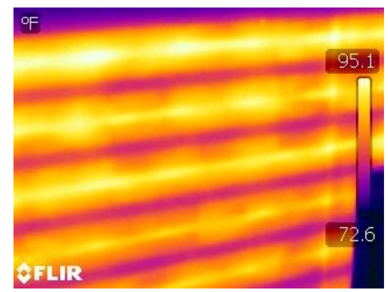






Site built radiant WALLS...





- completely out of sight
- low mass -fast response
- reasonable output at low water temperatures
- stronger than conventional drywall over studs
- don't block with furniture

Heat output formula:

$$q = 0.8 \times (T_{water} - T_{room})$$

Where:

Q = heat output of wall (Btu/hr/ft^2)
T_{water} = average water temperature in panel (ºF)
T_{room} = room air temperature (ºF)

Reducing water temperature in existing hydronic systems

Two ways to reduce the supply water temperature of any hydronic heating system:

1. Reduce the design load of the building envelope through improvements such as added insulation, better windows and reduced air leakage.

2. Add heat emitters to the existing system.

Combinations of these two approaches are also possible.

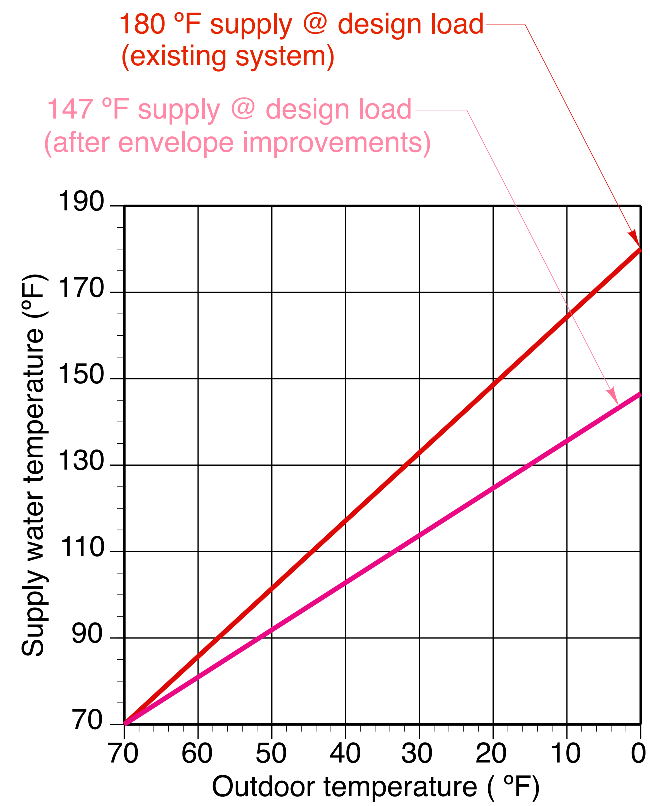
Change in supply water temperature by **building load reduction**:

$$T_{new} = T_{in} + \left(\frac{Q_{new}}{Q_{existing}}\right) \times (T_{De} - T_{in})$$

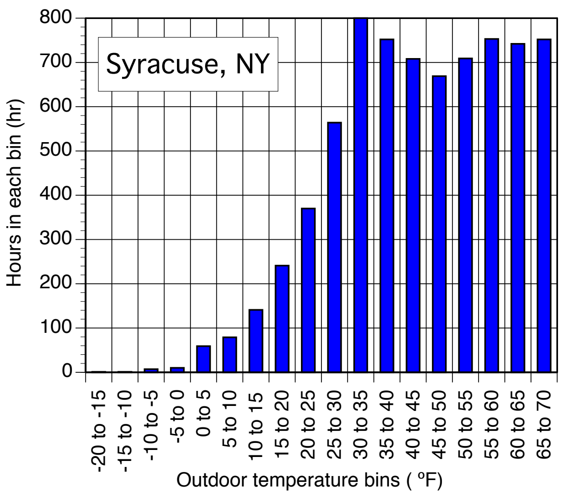
Where:
T_{new} = supply water temperature at design load after building envelope improvements (ºF)
T_{in} = desired indoor air temperature (ºF)
Q_{new} = design heating load after building envelope improvements (Btu/hr)
$Q_{existing}$ = existing design heating load (before improvements) (Btu/hr)
T_{De} = existing supply water temperature at design load (before improvements) (Btu/hr)

For example, assume an existing building has a design heating load of 100,000 Btu/hr, based on maintaining an interior temperature of 70 ºF. The existing hydronic distribution system uses standard fin-tube baseboard and requires a supply water temperature of 180 ºF at design load conditions. Also assume that improvements to the building envelope have reduced the design load from 100,000 Btu/hr to 70,000 Btu/hr. The new supply water temperature to the existing distribution system under design load conditions can be estimated

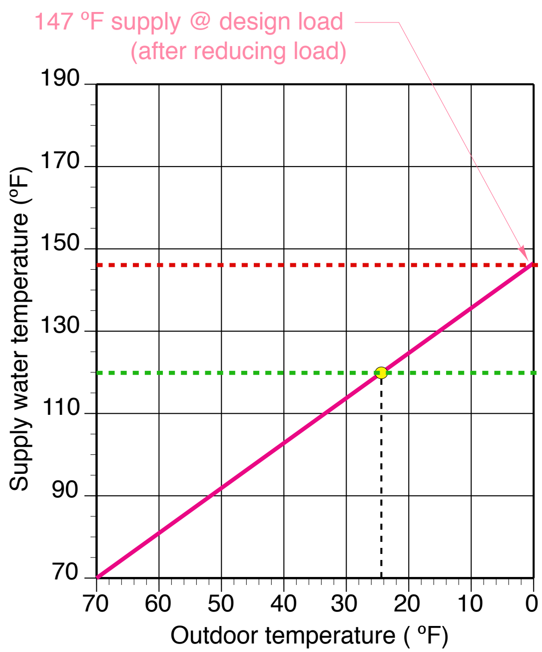
$$T_{new} = 70 + \left(\frac{70{,}000}{100{,}000}\right) \times (180 - 70) = 147^{o}\,F$$

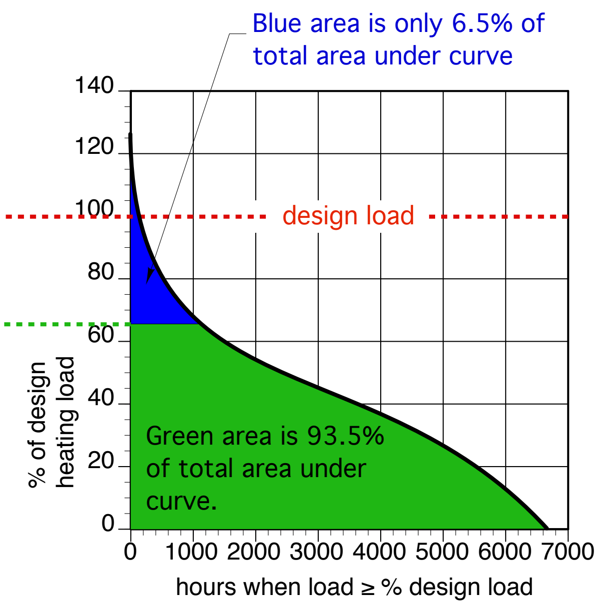


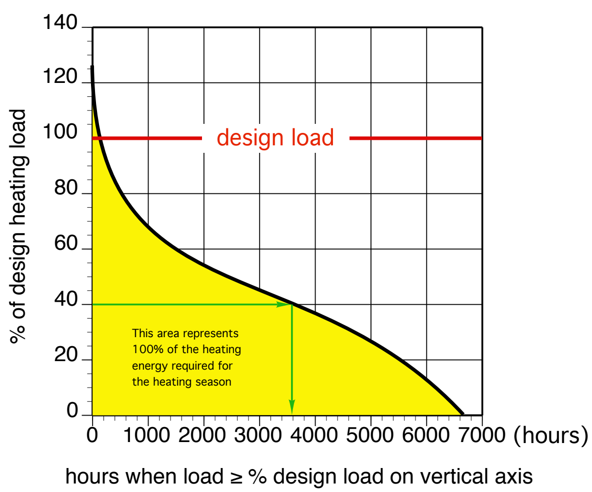
Assume a fin-tube baseboard system (after building envelope improvements) requires 147 °F supply water temperature at design load.



How much of the seasonal heating energy is required above 120 °F supply water temp?







In this case only 6.5% of heating energy use needs water over 120 °F

Change in supply water temperature by **adding heat emitters**:

This procedure can calculate the amount of finned-tube baseboard to be added to reduce the supply water temperature at design load to a pre-determined value.

It assumes that the baseboard being added is the same make and model as the existing baseboard. It also assumes that the existing baseboard is a standard residential-grade product with nominal 2.25" square aluminum fins with an I=B=R rated output of approximately 600 Btu/hr/ft at 200ºF water temperature.

Step 1: Accurately determine the building's design heat load.

Step 2: Determine the total length of *finned-tube* in the existing distribution system. Designate it as L_e.

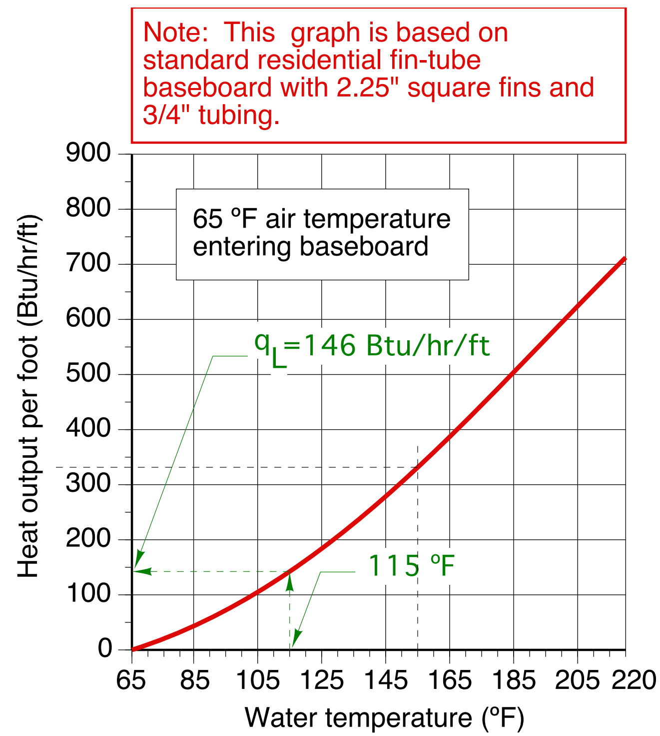
Step 3: Determine the desired (lower) supply water temperature for design load output.

Step 4: Estimate the lower *average* circuit water temperature by subtracting 5 to 10ºF from the supply water temperature determined in Step 3.

In circuits where flow rate through baseboard is more than 2 gpm assume the average water temperature is 5ºF *below* the supply water temperature.

In circuits where flow rate through baseboard is less than 2 gpm assume the average water temperature is 10ºF *below* the supply water temperature.

Step 5: Find the new average circuit temperature on the horizontal axis of the graph, and read the heat output of the finned-tube at the lower average circuit water temperature. This number is q_L.



Change in supply water temperature by **adding fin-tube heat emitters**:

$$L_{added} = \frac{\text{design load}}{q_L} - L_e$$

Where:
L_{added} = length of finned-tube of same make/model baseboard to be added (feet)
design load = design heating load of building (Btu/hr)
q_L = output of baseboard at the lower average circuit water temperature (Btu/hr/ft)
L_e = total existing length of baseboard in system (feet)

Example: Assume a building has a calculated design load of 40,000 Btu/hr, and its distribution system contains 120 feet of standard residential finned-tube baseboard. It is currently heated by a conventional cast iron boiler. The goal is to reduce the supply water temperature to 120 ºF at design conditions, using more of the same baseboard. Assume the temperature drop of the distribution system is 10 ºF. Determine the amount of baseboard that must be added:

Solution:

Step 1: The design load has been calculated as 40,000 Btu/hr.

Step 2: The total amount of finned-tube in the system is 120 feet.

Step 3: The lower supply water temperature at design load will be 120ºF.

Step 4: The lower *average* circuit water temperature will be 120 - (10/2) = 115ºF.

Step 5: The output of the finned-tube at an average circuit water temperature of 115 ºF is determined from Figure 4-2 as 146 Btu/hr/ft.

Step 6: The required additional length of baseboard is now calculated using Formula:

$$L_{added} = \frac{\text{design load}}{q_L} - L_e = \left[\frac{40{,}000 \frac{Btu}{hr}}{146 \frac{Btu}{hr \cdot ft}} - 120 \right] = 154\, ft$$

Although it might be possible to add 154 feet of baseboard to the system, it would require lots of available wall space. In most buildings, adding this much baseboard is not a practical solution, especially in kitchens or bathrooms.

Change in supply water temperature by **adding “high output” fin-tube heat emitters**:

Consider adding “high output” finned-tube baseboard rather than standard baseboard. This graph shows the heat available from high output baseboard (shown as the blue curve), and for comparison, standard residential baseboard (shown as the red curve).

Steps to determine the amount of high output finned-tube baseboard required to reduce the supply water temperature under design load.

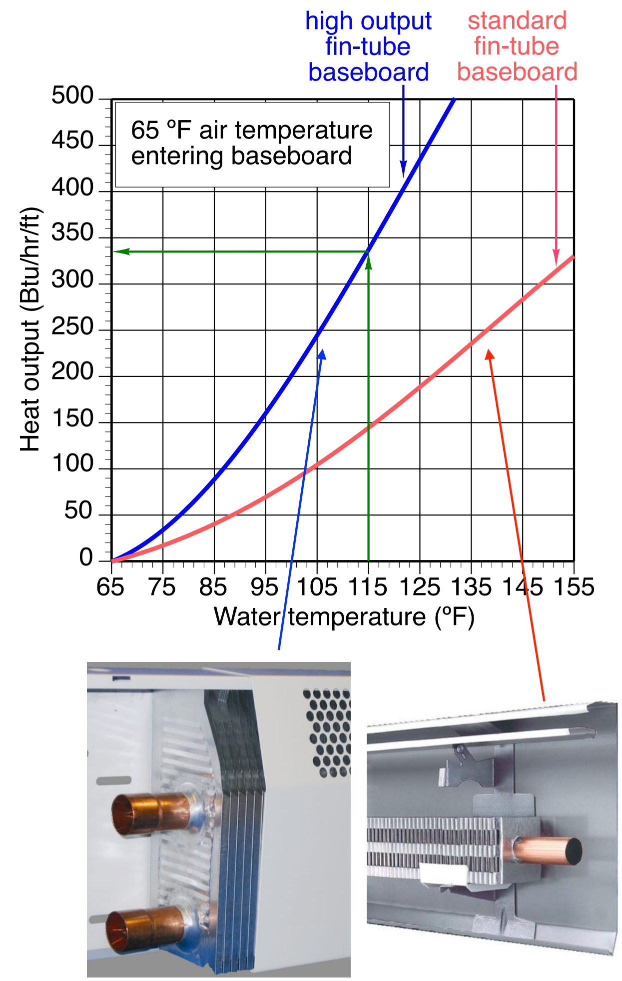
Steps 1-4 : Same

Step 5: Determine the output of high output baseboard at the average circuit water temperature using figure 4-7 (or manufacturer’s literature for a specific make and model).

Step 6: The required length of high output baseboard to add to the system is found using Formula below.

$$L_{ho} = \frac{\text{design load-}(q_L)(L_e)}{q_{ho}}$$

Where:
L_{ho} = length of high output finned-tube baseboard to be added (feet)
design load = design heating load of building (Btu/hr)
q_L = output of existing baseboard at the lower average water temperature (Btu/hr/ft)
L_e = total existing length of baseboard in system (feet)
q_{ho} = output of high output baseboard at the lower average water temperature (Btu/hr/ft)



Change in supply water temperature by **adding “high output” fin-tube heat emitters**:

Example: Assume a building has a calculated design load of 40,000 Btu/hr, and its distribution system contains 120 feet of standard residential finned-tube baseboard. The goal is to reduce the supply water temperature at design load to 120 °F. Additional high output baseboard will be added to allow this lower water temperature operation. Assume that the temperature drop of the distribution system at design load is 10 °F, and this existing baseboard has the same output as in the previous example (146 Btu/hr/ft at average circuit water temperature of 115 °F). Determine the amount of high output baseboard required based on the performance shown.

Step 1: The design load has been calculated as 40,000 Btu/hr

Step 2: The total amount of finned-tube in the system is 120 feet

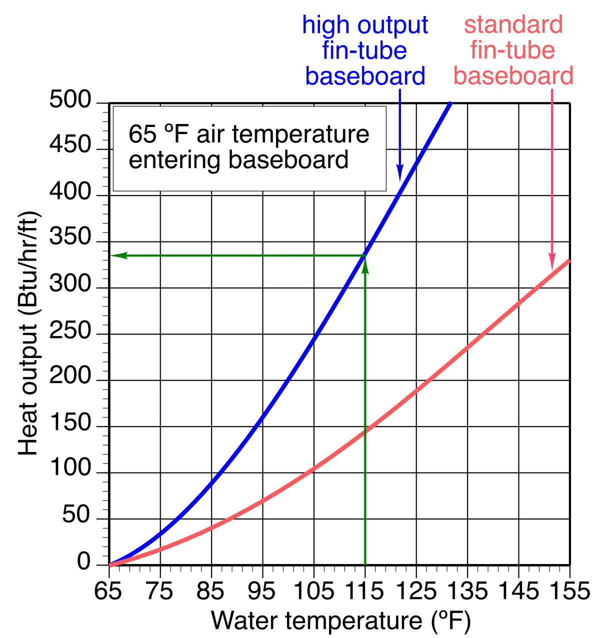
Step 3: The new lower supply water temperature at design load will be 120 °F

Step 4: The new lower average circuit water temperature will be 120 - 5 = 115 °F

Step 5: The output of high output finned-tube at an average water temperature of 115 °F is determined from figure 4-3 as 335 Btu/hr/ft.

Step 6: The required length of high output baseboard to add to the system is found using Formula.

$$L_{ho} = \frac{\text{design load-}(q_L)(L_e)}{q_{ho}} = \frac{40{,}000\text{-}(146)(120)}{335} = 67\,ft$$



Although this is a reduction compared to the 154 feet of added baseboard required in the previous example, it is still a substantial length. The building must be carefully evaluated to see if this additional length of baseboard can be accommodated.

Change in supply water temperature by **adding other types of heat emitters**:

If the amount of finned-tube that must be added is beyond what can be accommodated, consider other added heat emitter options. The selection of new heat emitters should be based on a selected supply water temperature at design load, along with a "credit" for the existing heat emitters in the system operating at the lower supply water temperature.

$$Q_n = \text{design load - } Q_e$$

Where:
Q_n = required heat output of the new heat emitters at lower supply water temperature (Btu/hr)
design load = the design heating load of the building (Btu/hr)
Q_e = heat output of existing heat emitters at the lower supply water temperature (Btu/hr)

Once the value of Q_n is determined, use tables or graphs from manufacturers to determine the heat output of specific heat emitters based on the *average* water temperature within them. Remember that the average water temperature will be 5 to 10 °F lower than the supply water temperature.

The goal is to select a grouping of new heat emitters with a total heat output that's approximately equal to the value of Q_n.

Assume a building has a calculated design load of 40,000 Btu/hr, and its distribution system contains 120 feet of standard residential finned-tube baseboard. The goal is to reduce the supply water temperature to 120 °F under design load conditions. Panel radiators are available in 24" x 72" size that can release 4,233 Btu/hr when operated at an average water temperature of 115 °F in rooms with 70 °F interior temperature. How many of these radiator are necessary to meet the design load?

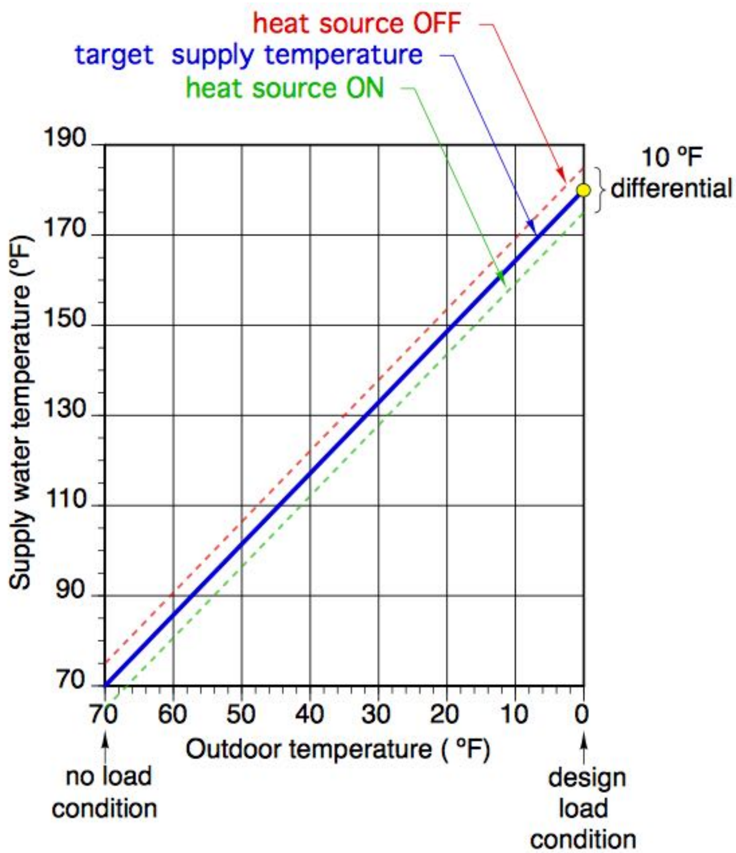
$$Q_n = \text{design load - } Q_e = \text{design load - } (q_L)(L_e) = 40{,}000 - (146)(120) = 22{,}480\,Btu/hr$$

$$\frac{22{,}480\,Btu/hr}{4233\dfrac{Btu/hr}{radiator}} = 5.3 \text{ radiators}$$

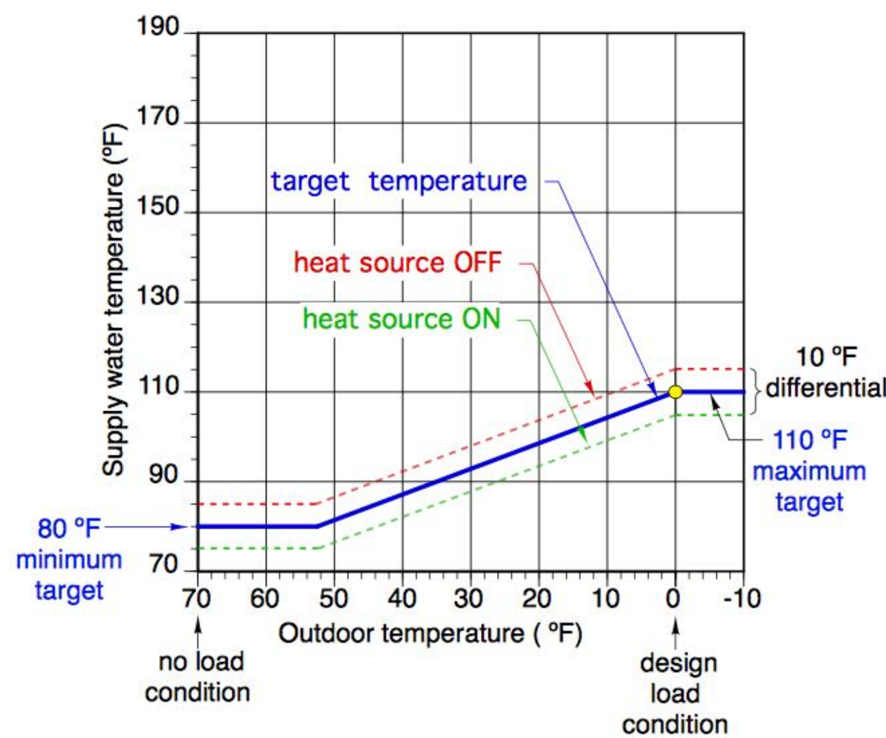
The designer could either add 6 of these panel radiators, or choose a slightly higher supply water temperature and use 5 radiators.

Design load conditions only occur a small % of heating season

Take advantage of outdoor reset control

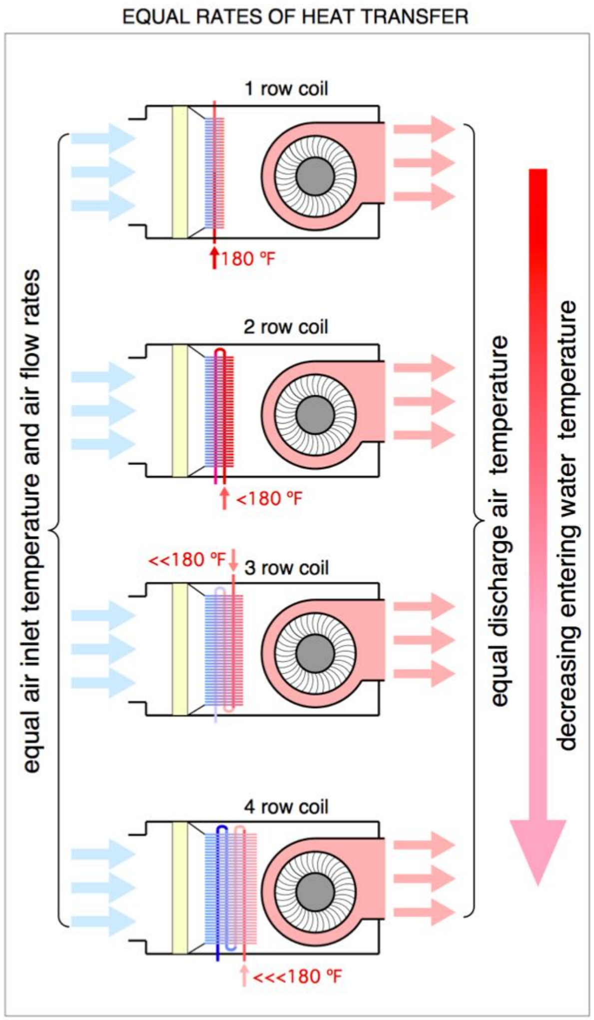


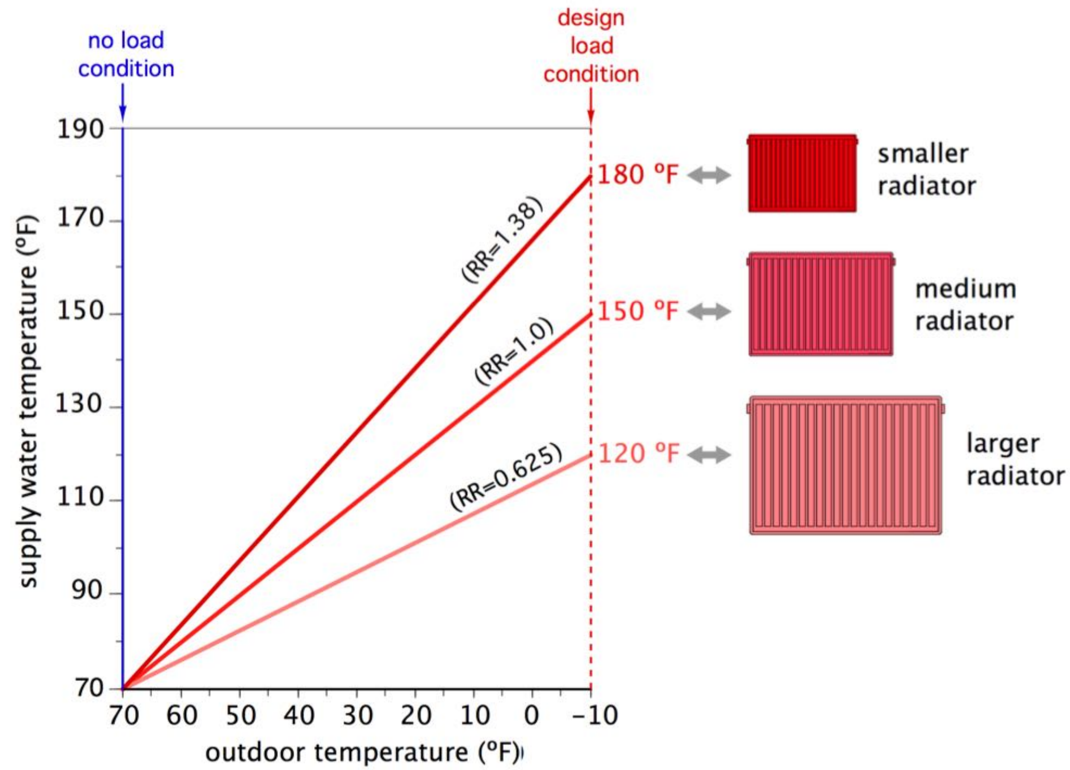
Typical for fin-tube BB



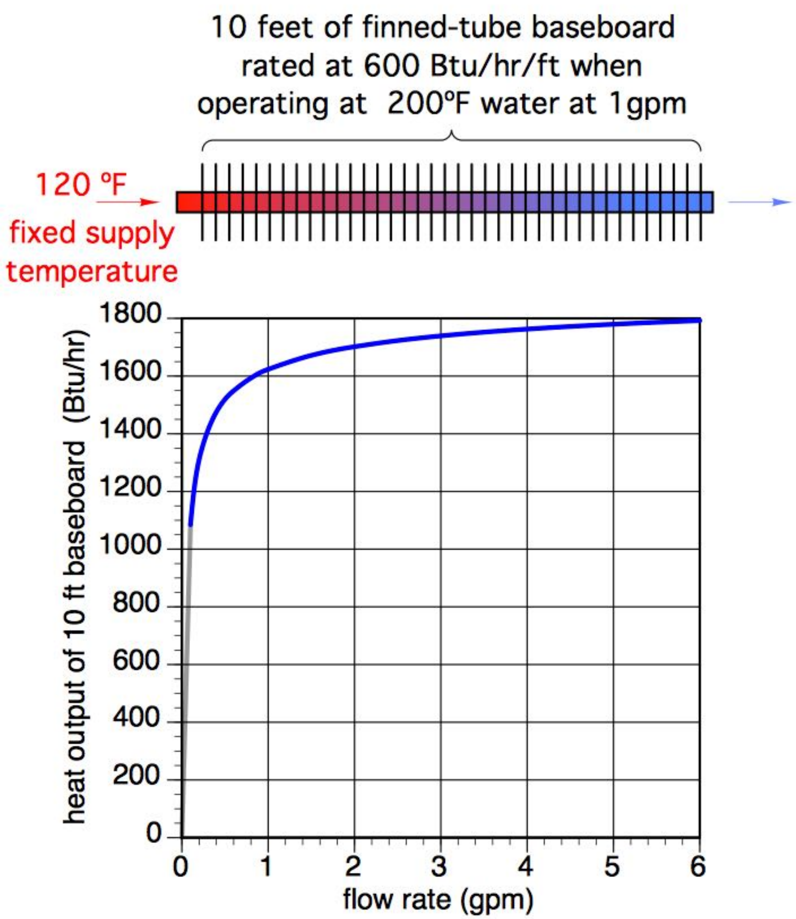
Typical for heated floor slab

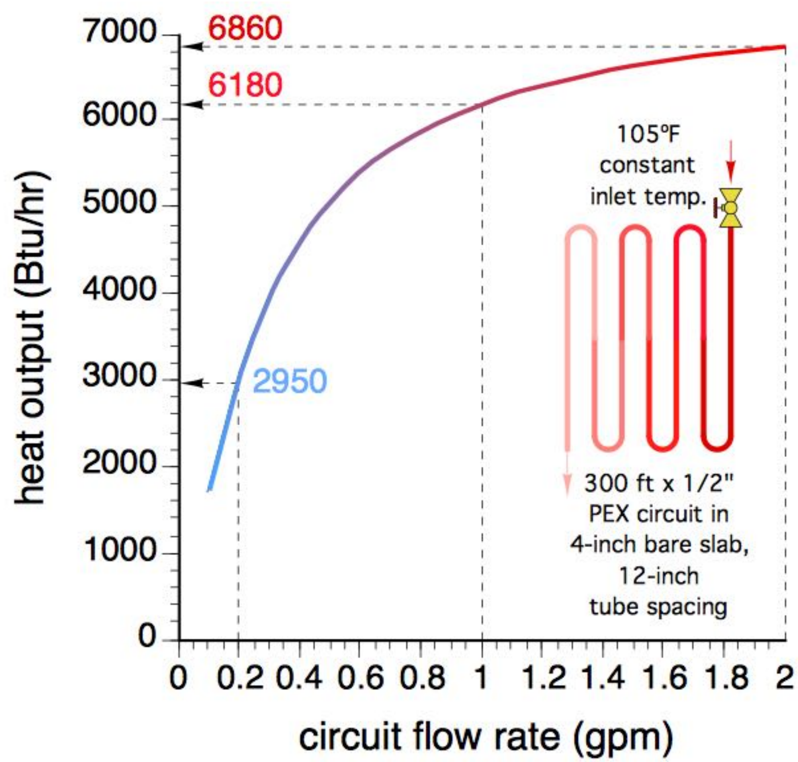
The greater the surface area of the heat emitters, the lower the supply water temperature to achieve thermal equilibrium.





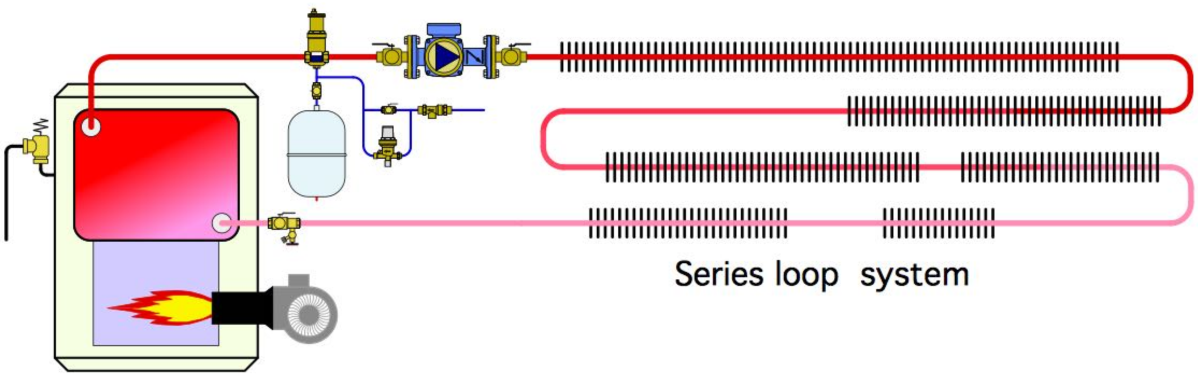
Changing the flow rate causes non-linear changes in heat output





Note diminishing gain in heat output at higher flow rates

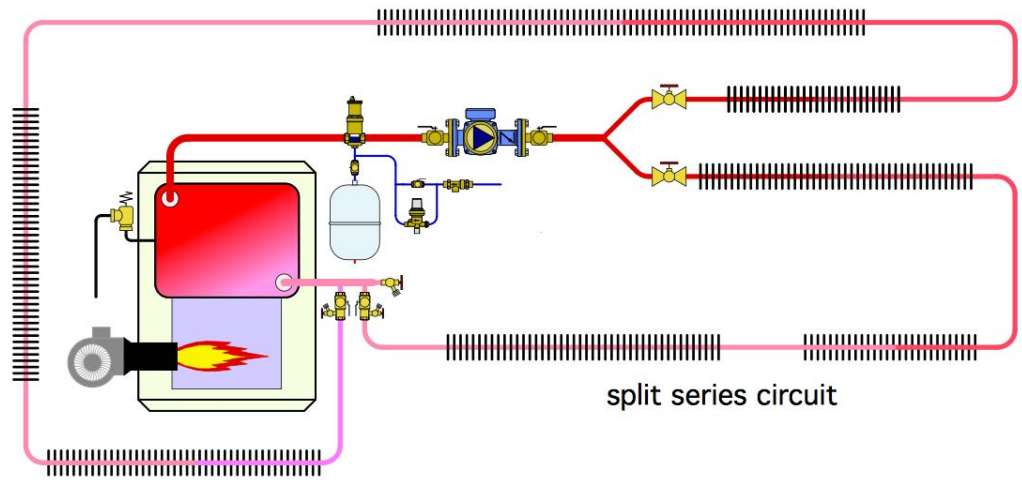
Retrofitting existing high temperature distribution systems



Series loop system

Common piping configurations for residential fin-tube baseboard systems.

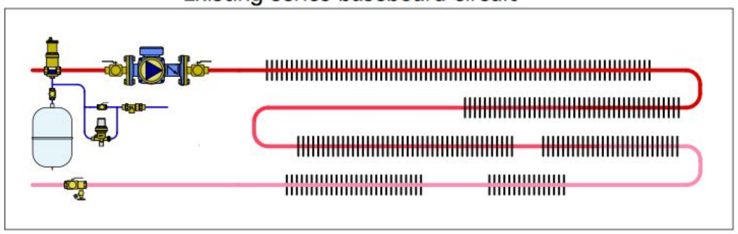
Fin-tube typically sized based on supply water temperatures (180-200 °F) at design load conditions.



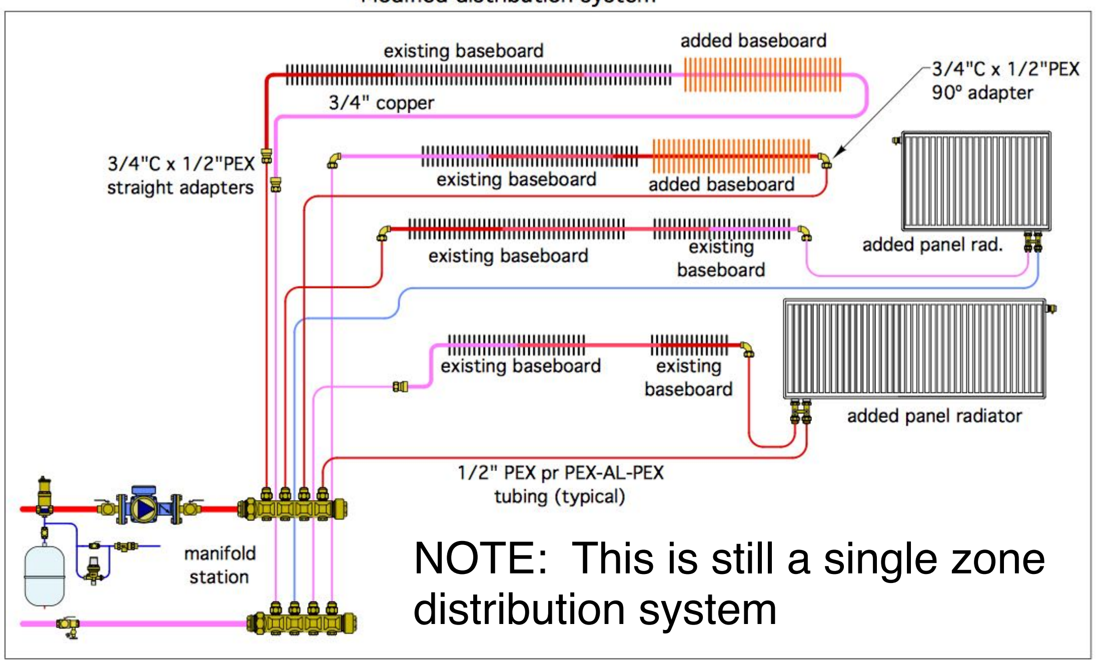
split series circuit

Convert the series system to a parallel system

Existing series baseboard circuit



Modified distribution system

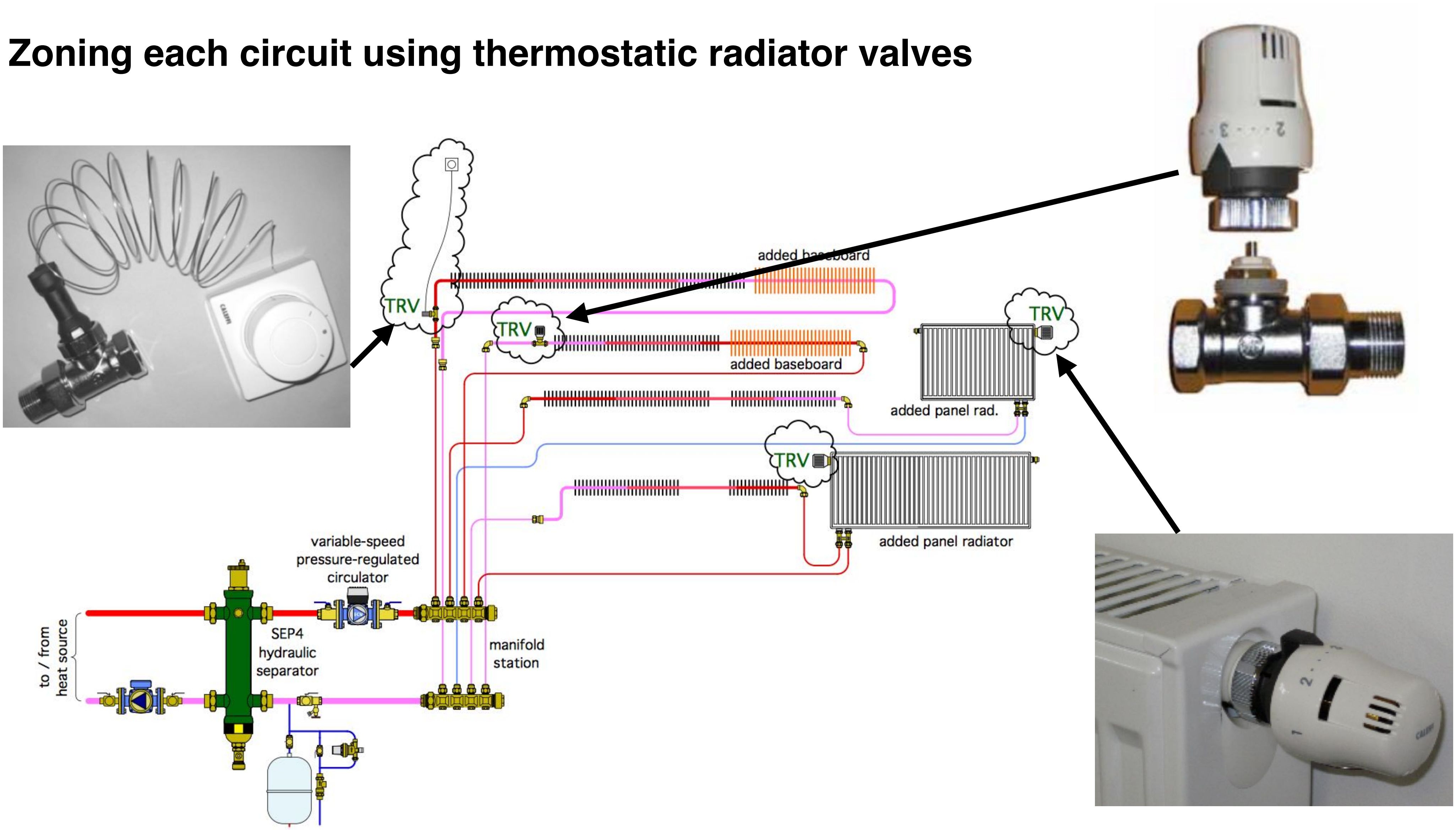


• Parallel piping of heat emitters is preferred over series piping because is ***eliminates sequential temperature drop*** from one heat emitter to another.

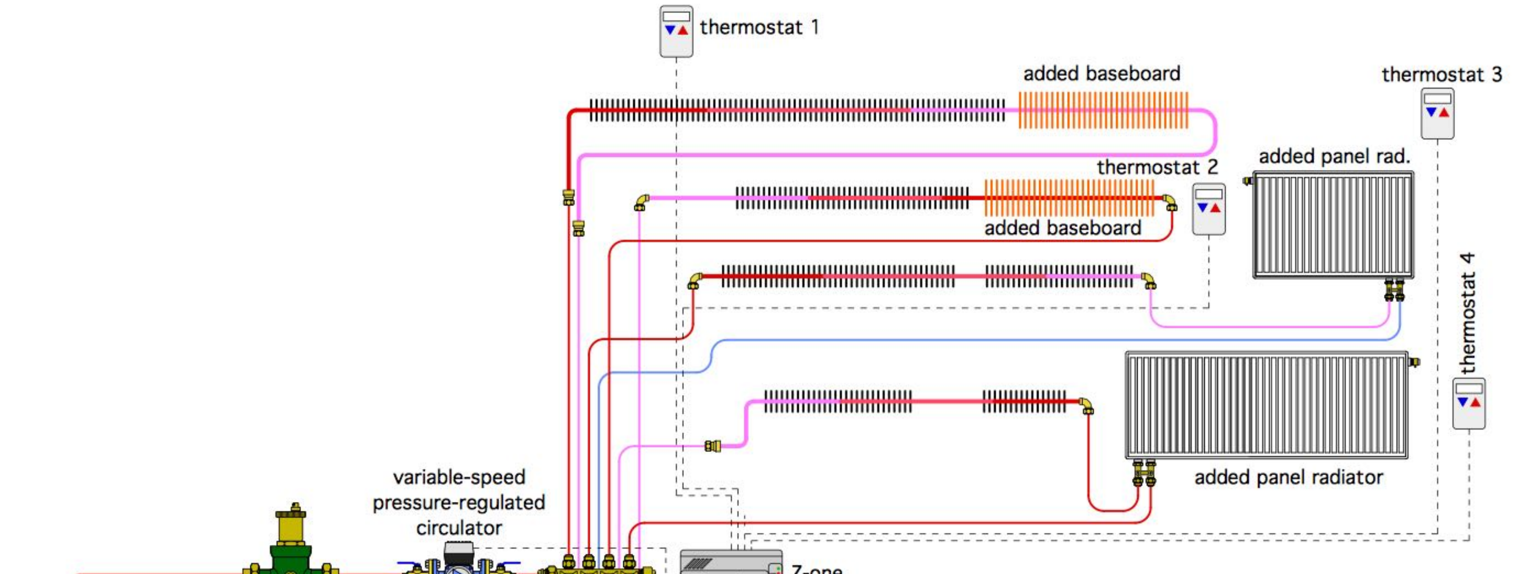
• Parallel piping also allows for ***easier zoning and flow balancing***.

•Likely easier to "morph" distribution system from series to parallel using homerun circuits of 1/2" PEX or PEX-AL-PEX.

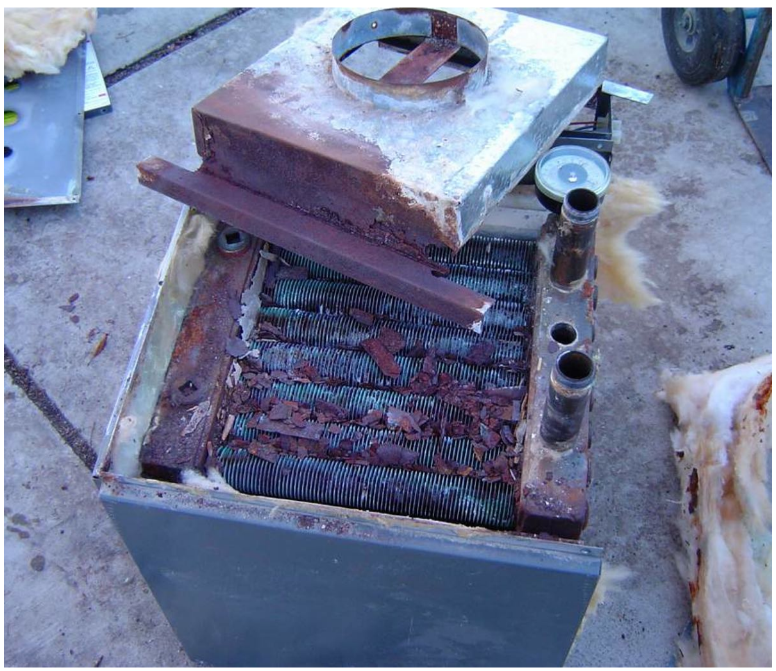
Zoning each circuit using thermostatic radiator valves



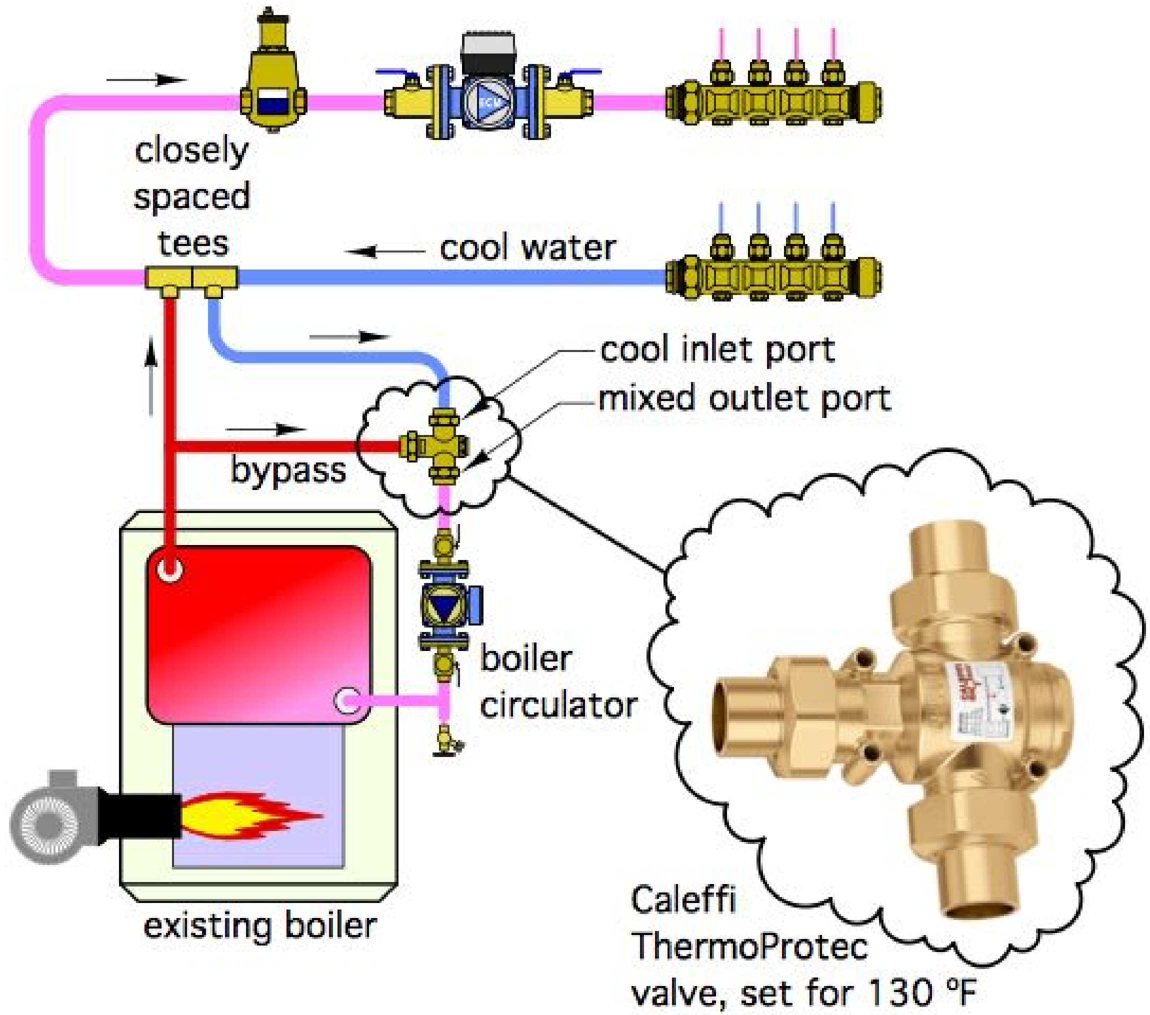
Zoning each circuit using manifold valve actuators



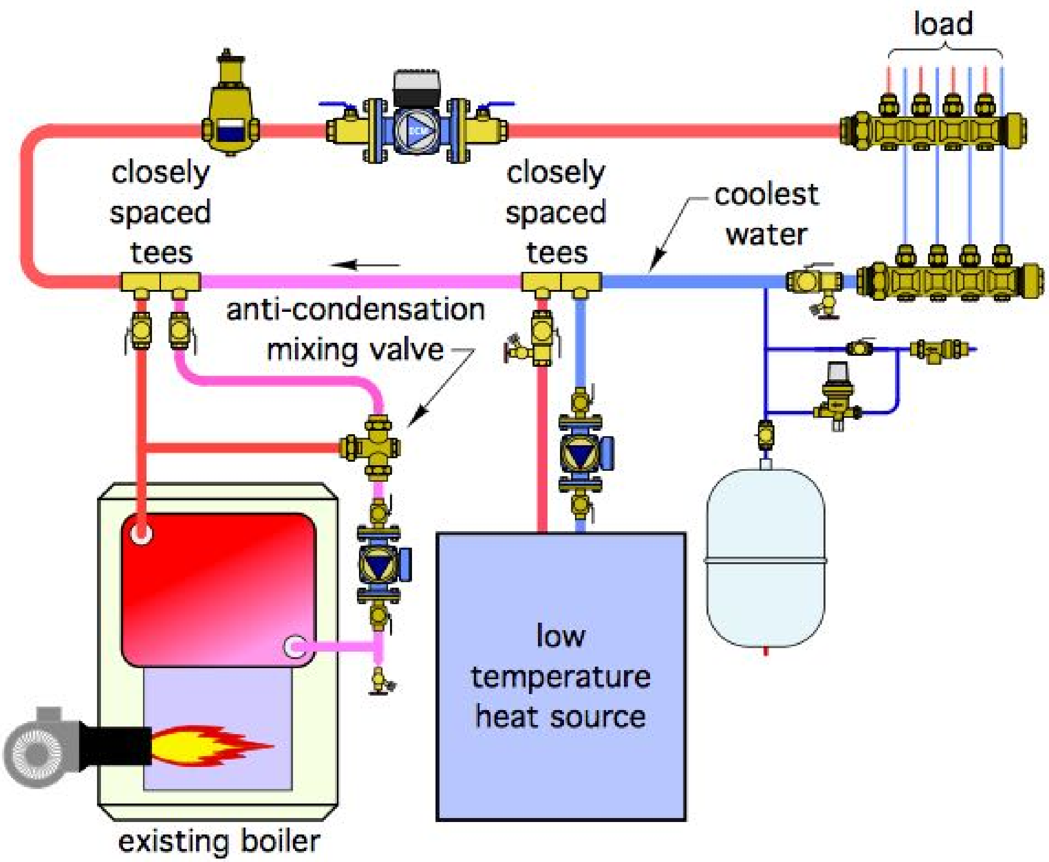
Protect "conventional" boilers from sustained flue gas condensation when they remain in a modified (now lower temperature) distribution system.



courtesy of Dave Stroman



Keep low temperature heat source "upstream" of existing higher temperature heat source.



Allow the coolest water returning from the load to be available to the low temperature heat source.

This also allows possibility of simultaneous operation of both heat sources (using proper controls)

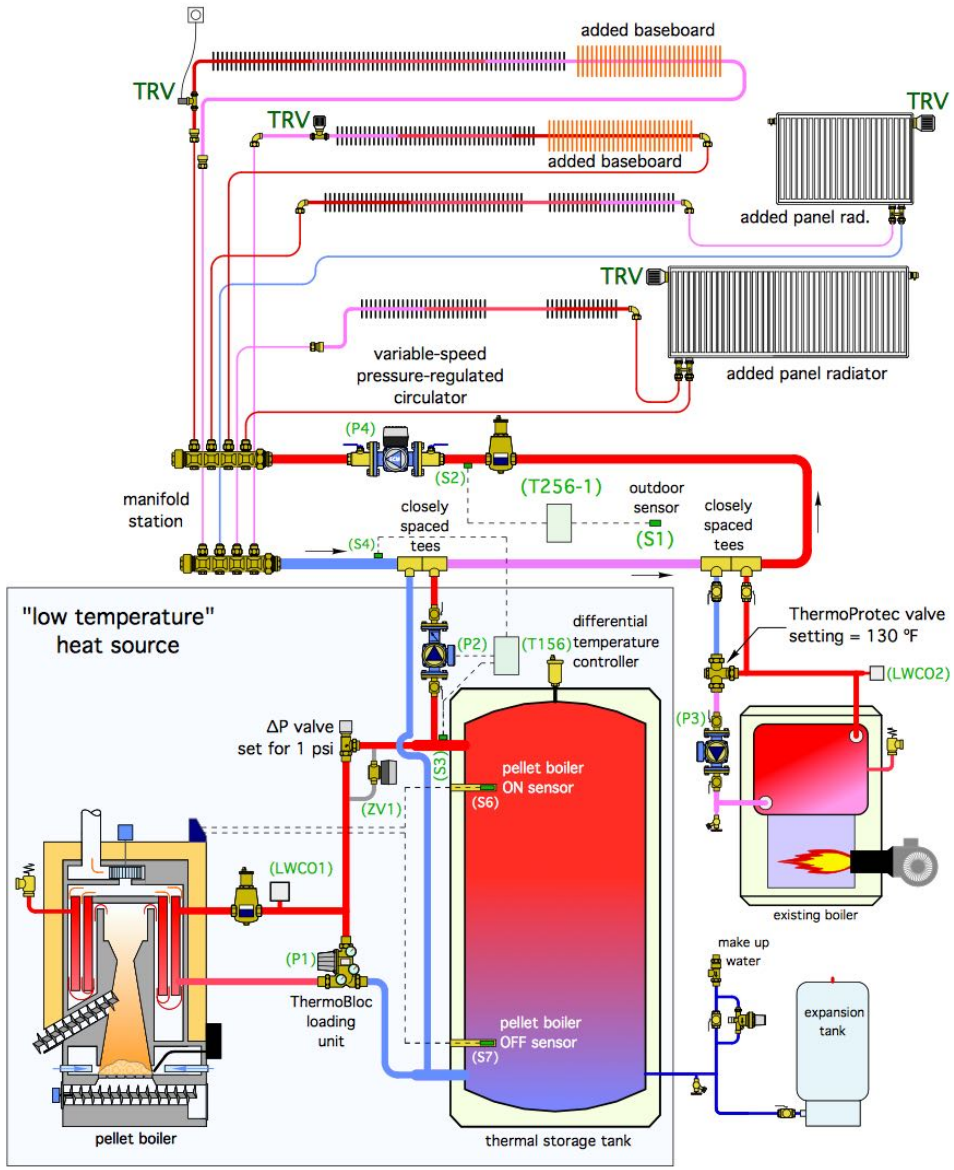
Keep low temperature heat source "upstream" of existing higher temperature heat source.

Example of a pellet boiler with thermal storage upstream of an existing conventional boiler.

Either heat source can supply load.

With proper controls, both heat sources can operate simultaneously.

(Don't allow heat generated by the supplemental boiler to be added to thermal storage).



Design Guidelines:

1. Determine the maximum water temperature that the new low-temperature heat source can produce at design load conditions. A suggested maximum supply water temperature at design load is 120ºF. Even lower temperatures are preferred if feasible.

2. Determine the type and size of the supplemental heat emitter(s) to be used in each room and where it (they) will be located before modifying the piping.

3. Panel radiators and fan-coils can provide a given rate of heat output while occupying far less wall space compared to fin-tube baseboard.

4. Radiant floor, wall and ceiling panels are excellent low-temperature emitters, provided that they can be reasonably retrofitted.

5. Use as much of the existing piping and heat emitters as possible.

6. Always consider the benefit versus cost of creating new zones when modifying the existing system.

7. Once all the supplemental heat emitters have been selected, and the proposed modifications to the distribution system have been sketched, always run a flow and head loss analysis for the modified system.

8. If the existing conventional boiler will be retained for use as a backup heat source for the low-temperature system, be sure the boiler is protected against sustained flue gas condensation.

Design Assistance Manual
for High Efficiency Low Emissions Biomass Boiler Systems

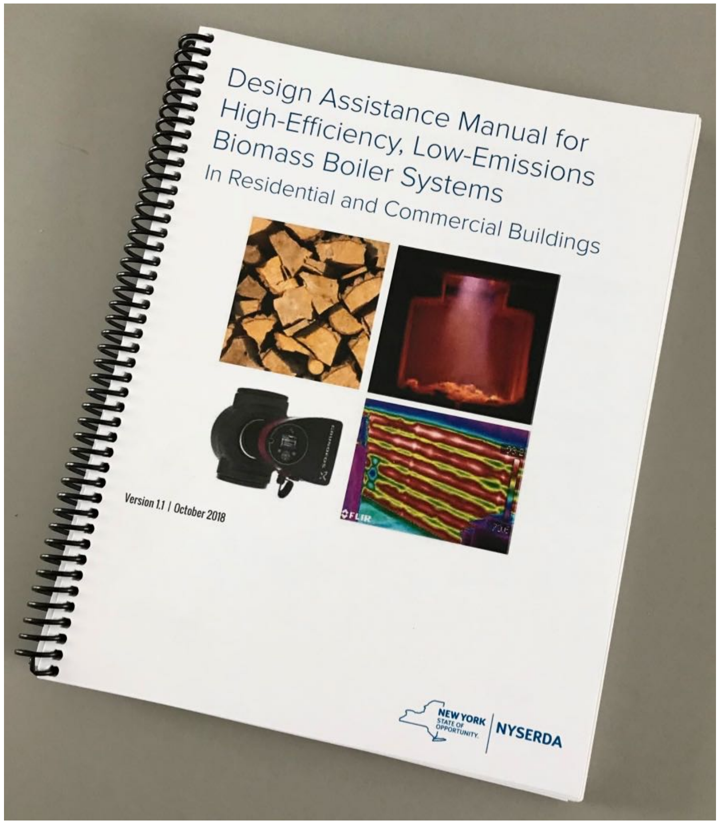


Table of Contents:

It's available as a FREE downloadable PDF at:

https://www.nyserda.ny.gov/-/media/Files/EERP/Renewables/Biomass/Design-Assistance-Biomass-Boiler.pdf

Summary of NYSERDA Renewable heat NY program

Renewable Heat NY (PON 3010)

Renewable Heat NY (RHNY) provides incentives toward the installed costs of high-efficiency, low-emission wood heating systems for homeowners and businesses not currently using natural gas.

Benefits of High-Efficiency, Low-Emission Wood Heating Systems

- New high-efficiency systems are automated and cleaner burning
- More efficient combustion means less fuel is required

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Residential / Small Commercial Boilers (≤300,000 Btu/h)

System Type / Technology	Incentive amount
Advanced Cordwood Boiler with Thermal Storage	25% of installed cost up to $7,000
Small Pellet Boiler with Thermal Storage	45% of installed costs up to $36,000

An additional $5,000 for the recycling of old outdoor/indoor wood boiler or $2,500 for recycling a whole house wood furnace

Large Commercial Boilers (>300,000 Btu/h)

System Type / Technology	Incentive amount
Large Pellet Boiler with Thermal Storage	65% of total installed cost up to $325,000
Tandem Pellet Boiler with Thermal Storage	75% of total installed cost up to $450,000

Sizing ≤ 60% design day load, thermal storage, careful system integration with existing heating system and heat distribution system and controls.

Receive a site assessment and support from NYSERDA technical consultant during system design and commissioning.

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www.nyserda.ny.gov/renewableheatny

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Postponed, not cancelled…

The full day training :

Hydronics for High Efficiency Biomass Boilers

Originally scheduled for April 10 at SUNY Morrisville, will be rescheduled for this fall (September or October)

Check the Renewable Heat NY website for scheduling

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Questions?