Principles of outdoor reset control.

Outdoor reset is boiler water temperature control scheme that uses outdoor temperature to establish the required temperature of the boiler loop needed to keep the building at the desired temperature. It takes advantage of the relationship that exists between outdoor temperature and building heat loss. Outdoor reset can reduce the operating cost of a boiler system by allowing lower boiler water temperatures during the milder months of the heating season.

All else remaining constant, heat loss of the building is described by the following formula:

Hourly Btu loss = U factor * square footage of building exterior * ΔT

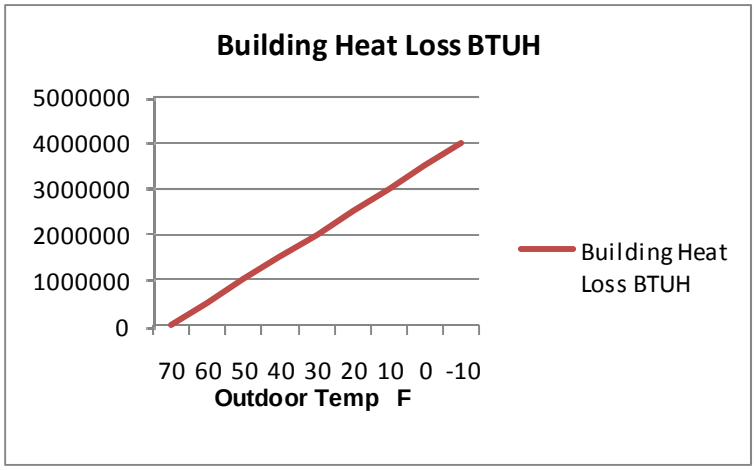
Where U factor is the averaged resistance to heat transfer of the all building components that comprise the exterior surfaces (walls, windows, doors, etc.) and ΔT is the difference in temperature between the outdoor air and the building space. If the U factor and square footage remain unchanged, it is the difference in outdoor air temperature that affects heat loss.

The relationship is obvious because boiler systems will operate longer and at higher output during the colder days of the heating season and fewer boilers will operate at lower firing rates when outdoor temperatures is milder.

How does a building stay warm when the boiler water temperature is reduced?

An example of the relationship between building heat loss and outdoor temperature is provided below as a table and corresponding graph. This example illustrates a building with a maximum heat loss of 4 million Btu on the coldest anticipated day of the heating season (also called "design day") Assume that on design day the boiler loop is to be heated to a 180 degree temperature supplying the building's air heating coils and that the coils are properly sized to emit the required 4 million Btu. How much colder can the loop temperature be when, for example, the outdoor temperature is 30 degrees instead of minus 10? Would a 140°F boiler loop be sufficient?

Outdoor Temp °F	Building Heat Loss BTUH	Percent or Total Heat Loss
70	0	0.0%
60	500,000	12.5%
50	1,000,000	25.0%
40	1,500,000	37.5%
30	2,000,000	50.0%
20	2,500,000	62.5%
10	3,000,000	75.0%
0	3,500,000	87.5%
-10	4,000,000	100.0%



We'll start with the makeup air ventilation coil. Let's assume that on design day the ventilation air coil must preheat 5000 cubic feet of air per minute from –10 to 65°F when supplied with 180°F boiler water. This would equal an output of roughly 430,000 Btu. What would the Btu output of this coil be if supplied with 140°F boiler water when the entering air temperature was 30°F as per the table.

The following formula provides the answer.

$$\frac{140°-30°}{180°-(-10°)} = 58\%$$

The ventilation air coil output is reduced to 58% of its design day capacity. This equates to roughly 250,000 Btu, which is more than adequate to heat the ventilation air to 65°F. This calculation can be confirmed by sizing software from air coil manufacturers.

According to our example, a 30°F outdoor air temperature resulted in building heat loss equal to 50% of the design day heat loss. As long as the air coils retain more than 50% of their heating capacity with the reduced boiler water temperature, the desired indoor temperature will be maintained.

The same calculation can be used to determine the revised output of the interior heating coils when boiler water to the coil is reduced from 180°F to 140°F. The calculation assumes 65°F air passing over the heating coil.

$$\frac{140°- 65°}{180°- 65°} = 65\%$$

Again, the interior heating coils retain more than 50% of their design day heat output, so the building heating system is providing more heat than the building is losing and the desired indoor air temperature will be maintained. These calculations can of course be performed at any point along the building's heat loss curve to determine the required boiler water temperature for any outdoor air temperature.

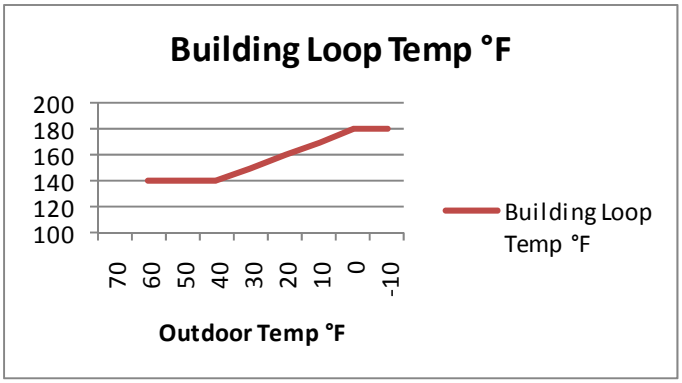
How does outdoor reset reduce boiler operating cost?

It's easier to transfer heat when the difference in temperature between the heating medium and the medium to be heated is larger. Compared to the average temperature of the products of combustion in a boiler (let's assume 750°F), a 20 degrees difference in entering water temperature may seem insignificant, but it can affect boiler efficiency by a full percentage point. The higher the efficiency of the boiler, the less fuel used to heat a given amount of water and the lower the fuel bills. So operating the boiler loop at lower temperatures, when possible, saves money.

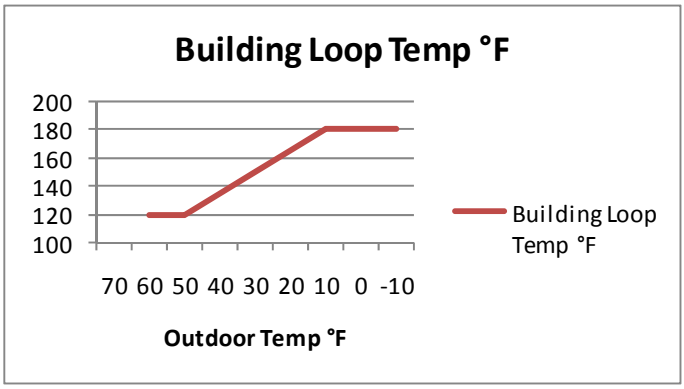
Condensing boilers take greater advantage of outdoor reset and low return water temperatures. When these boilers are fed return water at or below 130°F, they begin to capture the energy released when water vapor entrained in flue products condenses inside the boiler. By capturing this additional energy, which is lost out the stack in non-condensing boilers, the efficiency of the condensing boiler can increase into the 90 percentiles, further reducing the energy required to heat the boiler loop.

Examples of outdoor reset curves or schedules

An outdoor reset curve for the example building is shown below. This would be the appropriate curve for a boiler system consisting entirely of non-condensing boilers. This loop assumes a 20°F temperature drop in the heating loop on design day. Note: With air coils designed for a 20 degree delta on design day, the loop delta with 140 degree supply water is reduced to approximately 10 degrees as long as the gpm flow through the coil remains constant. This will not present a problem for non-condensing boilers. However, to be safe, water tube boilers should be equipped with thermostatic mixing valves to ensure that the minimum temperature of water entering the boilers is 130°F.



The curve below is appropriate for condensing boilers that can accept return water temperature below 130°F. Again, this curve assumes a 20°F temperature drop in the boiler loop, so on design day the temperature of water returning to the boiler would be 160°F.



This discussion assumes that the building heat emitters are air coils or fan coils. Different types of heat emitters have different output characteristics when entering water temperature changes. As a result, the outdoor reset curve will have to be adjusted for different heat emitters.

The outdoor reset curve is a programmable function of outdoor reset controls. Some controls allow the user to select among preset curves and other, more advanced controls, offer customizability.