

MAXIMIZING BOILER EFFICIENCY With

HYBRID BOILERS

LEARN HOW THE STRATEGY PURSUES THE BEST OF BOTH WORLDS, AND WHERE IT MAY BE MOST USEFUL.

A hybrid boiler plant is defined as a hydronic heating plant combining condensing and non-condensing boilers. This system is designed to take advantage of the best properties of both types. Through the proper system design, control and boiler selection, we may be able to save the same amount of energy associated with a properly designed full condensing plant at a cost of one third to one half of an all-condensing plant.

WHERE TO USE HYBRID SYSTEMS

Hybrid plants can be utilized in existing plants or new designs. Depending on the condition of existing boilers, older, non-condensing boilers could be incorporated into the design and significantly reduce the overall project cost, provided their pressure vessel and burner are in acceptable shape.

One of the main stumbling blocks in using non-condensing boilers in higher efficiency designs has been the higher return water temperature requirements. In most applications, water has to be

returned to the boiler at or above 140F in order to prevent flue gas condensation from occurring. The dew point of exhaust gases is normally in the range of 135°F.

Creating an energy solution that combines the ideal number of condensing and non-condensing units can then lead to reduced fuel consumption in excess of 40% when compared to existing systems or all new non-condensing systems. The main benefit leading to this savings is the reduction of boiler cycling while satisfying all the design requirements for comfort, domestic water, snow melting, etc.

CUTTING TO THE CHASE

The heating profile of many buildings looks very similar to Figure 1. Within this profile, the maximum heating load occurs in the winter months. However, when you look at the fuel consumed normalized against a unit such as heating degree days, it becomes evident that we consume more heat per heating degree day in the off-peak months such as October and April. The leading contributor to this is the on-off cycling of boilers as the PID (Proportional-Integral-Derivative) loop can-

not be maintained within acceptable parameters, resulting in what is often referred to as short-cycling.

Two control concepts lead to the ultimate savings within a boiler system. See the green theoretical curve in Figure 2. The first area to consider is that of flow intelligence (patent pending). Current control schemes are based on PID temperature controls. This was a great improvement over older systems, but with the leap forward of software processing power, calculated BTU heating load consumption is lending itself to matching the exact heat profile needed instead of chasing the temperature change.

With the use of this applied control, needless cycling of the boilers is greatly reduced, if not eliminated. Under current control scenarios, on-off cycling of boilers at low load conditions, chasing PID loop temperatures, can reduce boiler efficiency by 20-30%. Even with a condensing boiler at low return temperatures, theoretical efficiencies of 95% can drop to as low as 65% under these high-cycling conditions. Through the use of system ΔT and flow rate, the actual consumed heating load can be calculated. Theoretical energy savings, therefore, is the difference between the curves in Figure 1 and Figure 2.

INTELLIGENT LOAD SHARING

The second concept to consider is that of intelligent load sharing. With a properly sized boiler, run cycles can be limited to two cycles an hour (or less) under no-load conditions. To accomplish this, a small boiler is sized to allow 30 min of run time under no load conditions. Given the system volume and the T of the boiler operating setpoint, the minimum firing rate can be calculated.

A boiler with appropriate turndown can be selected to achieve this outcome, picking up the minimum losses as they are occurring. During most evaluations, this turns out to be a smaller boiler than the rest of the units attached to the heating plant. This smaller boiler then becomes similar to the “sum-

FIGURE 1

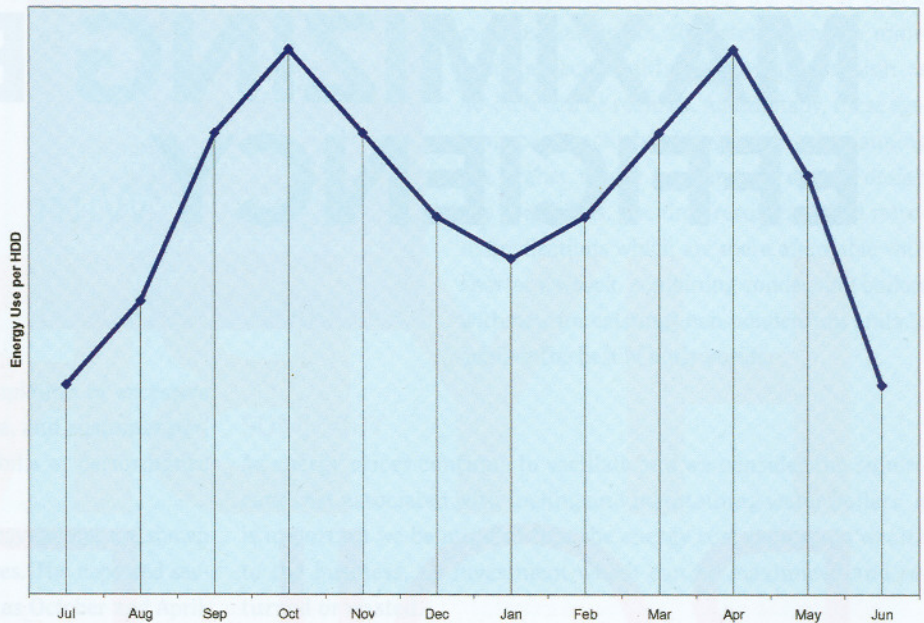
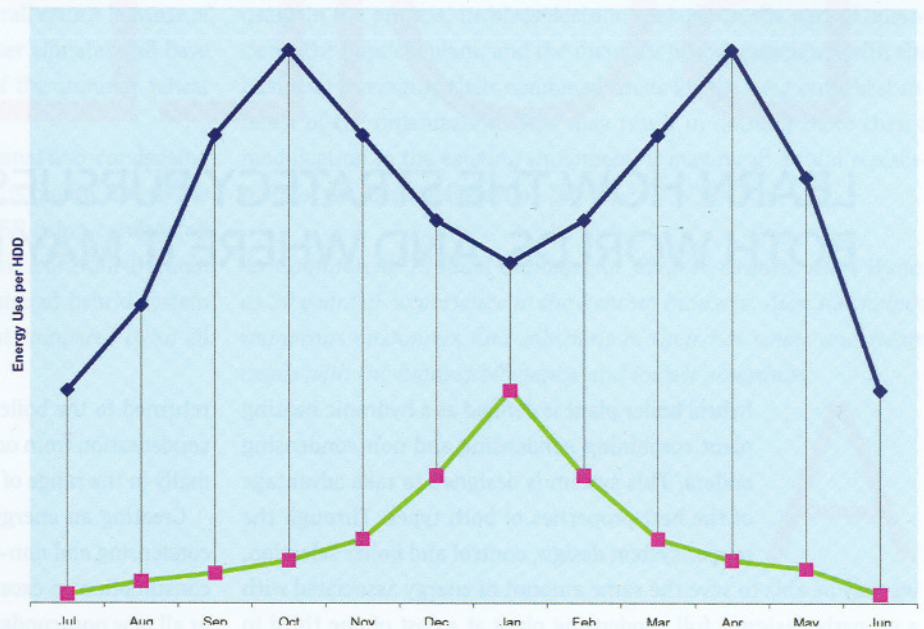


FIGURE 2

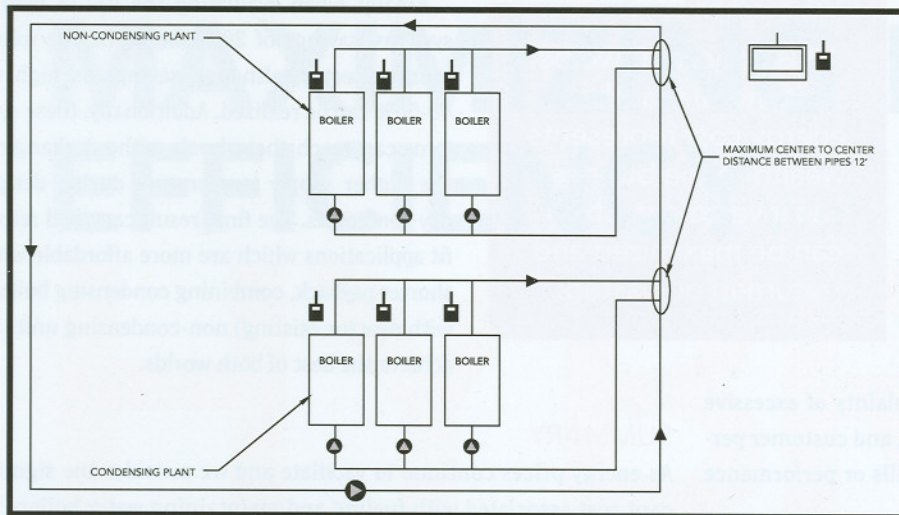


mer boiler” concept used in steam plants. In those cases, the small steam boiler is used to carry light loads such as the heating load being removed in the summer leaving a small process load. An example could be the steam used for sterilization, and/or humidification in a hospital.

To accomplish the intelligent load sharing, the heating plant control must be able to calculate the load consumed and recog-

nize the maximum and minimum capacity of each boiler attached to the heating plant. With this knowledge, the controller must also be able to stage modulating boilers to exactly match the load. In current designs, the sizing and control schemes using temperature variation only (without mass flow calculating/selection) usually employ multiple boilers of equal size resulting in considerable on-off cycling as the load drops

FIGURE 3



below the minimum turndown of these similarly sized units. This can be extremely inefficient due to the frequent pre- and post-purge losses, saying nothing about the stresses on the mechanical equipment leading to higher incidences of (costly) repair and downtime.

HOW IT WORKS

In hybrid systems, the use of condensing boilers occurs when heating loads drop to around 32-35° degrees outside air temperature. In the northern climates, this will account for approximately 75-80% of the heating season, and around one third of the heating load. Actual loads will need to be verified using load calculation software or existing load profiles.

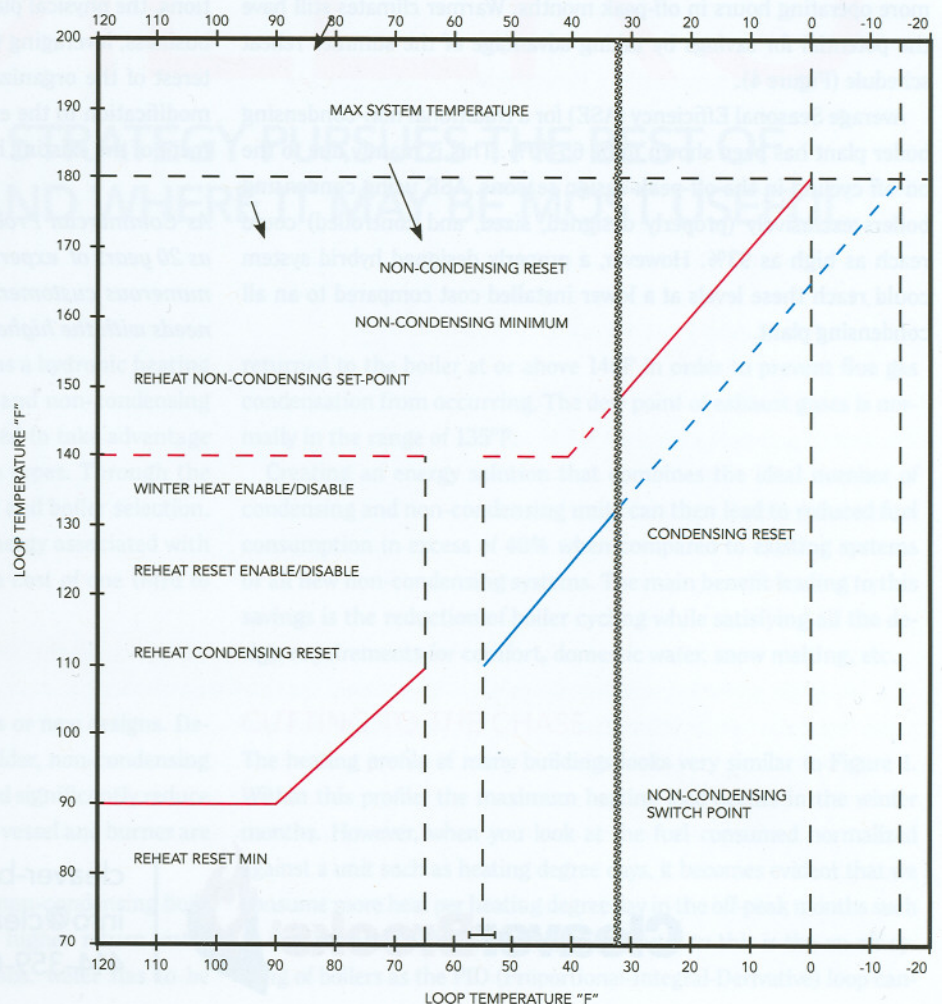
As the heating load increases with an outside air temperature drop, a change-over to the non-condensing boilers will provide heat for the incremental increase in demand. Built-in algorithms will enable the transition from condensing to non-condensing units. See Figure 3 for possible piping. Under this configuration, the outputs of the condensing boilers are driven up to above 140°. This will ensure that the inlet to the non-condensing boilers are adequate to prevent condensing from occurring in the unit. See Figure 4 (reset curves).

As the load increases (increasing heat loss), the non-condensing boiler will assume

the load. If the non-condensing units are sized for two thirds of the load, the condensing boilers can supplement when a smaller load is needed or during the most severe conditions. If more than one non-condensing unit is used, the control can also change or sequence the operating units in a lead/lag setting to equalize run time. The use of non-condensing boilers thereby allows higher temperature (more Btu) for colder design day temperatures of the legacy building.

Incorporating this concept into new designs allows higher supply temperatures to keep the heating coil surface in reheat boxes to a minimum, and it also accommodates the use of indirect domestic hot water heating, should that be part of the design scheme.

FIGURE 4



WHAT IS A GOOD CANDIDATE?

A ready source of determining a good candidate for a hybrid system is the burner management system (flame safeguard). Many units keep track of the cycles and run hours. If it can be determined that units are cycling excessively, the system is a good candidate for a hybrid design. Many boiler rooms can be shown to have cycles upwards of 10-40/hr. This is indicative of an oversized heating plant and may show up as customer complaints of excessive cycles. Other indicators can be complaints of excessive maintenance requirements, frequent downtime, and customer perceptions of general frustration, either in fuel bills or performance of the system.

Referencing Figures 1 and 2, the potential energy savings are shown as the difference between the blue and green lines. The captured savings will be greater in the off-peak months such as October and April. Systems in moderate or midrange climates will have a higher potential for savings and will generally lead to a higher overall return because of more operating hours in off-peak months. Warmer climates still have the potential for savings by taking advantage of the summer reheat schedule (Figure 4).

Average Seasonal Efficiency (ASE) for a traditional non-condensing boiler plant has been shown to be 65-70%. This is mainly due to the on-off cycling in the off-peak design seasons. ASE using condensing boilers exclusively (properly designed, sized, and controlled) could reach as high as 93%. However, a properly designed hybrid system could reach these levels at a lower installed cost compared to an all condensing plant.

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Finally, when evaluating the use of hybrid systems, savings of 20% should be the minimum expected, although savings as high as 40-50% can be realized. Additionally, these systems can reach these levels without changing the higher supply temperature during design day conditions. The final result can yield retrofit applications which are more affordable with shorter payback, combining condensing boilers with new (or existing) non-condensing units to achieve the best of both worlds.

SUMMARY

As energy prices continue to vacillate and we consider the significant cost associated with fueling and maintaining water boilers, it is important we be mindful that the energy cost represents wealth to the business, an investment which can be maximized and returned or wasted.

A decision on whether to retrofit or replace boilers, optimizing fuel usage in the process, involves decision making on the part of operations, the physical plant, and the financial people associated with the business, leveraging their combined needs for the long term best interest of the organization. This may result in nothing more than a modification to the existing equipment; it may mean a total replacement of the existing boiler(s). **TB**

As Commercial Product Manager at Cleaver-Brooks, Alan Wedal as 20 years of experience in the heating industry. Alan has helped numerous customers find solutions to their hot water and steam needs with the highest efficiency and lowest emissions.



cleaver-brooks.com
info@cleaver-brooks.com
414-359-0600