Energy Innovators Initiative

Technical Fact Sheet

Installing **High-Efficiency Boilers** for Heating Plants

Description

With the recent emphasis on energy efficiency and reduced emissions, high-efficiency heating plants have become a practical option for both new and retrofit installations, because of the savings they can achieve over their life cycle. Typically, older boilers have seasonal efficiencies below 75 percent and new mid-efficiency boilers can achieve as much as 85 percent. Condensing high-efficiency boilers, like the ones shown in Figure 1, can achieve seasonal efficiencies as high as 96 percent, resulting in large annual reductions in gas consumption, although initial costs can be high.

The key difference between high- and mid-efficiency boilers is their ability to condense water from combustion products in order to extract as much heat as possible. However, under this type of corrosive operating condition, condensing boilers must be built with more expensive materials, which can almost double their cost.

Figure 1 – High-Efficiency Condensing Boilers

Technical Specifications

In existing buildings, heating plants are typically designed for high temperature loads. This means that the heating output for each zone depends on a high supply temperature and a small temperature drop between supply and return water – typically 10–12°C. In comparison, high-efficiency boilers operate at peak efficiency when the return water temperatures are between 32°C and 60°C (90°F and 140°F). If these conditions cannot be met, a mid-efficiency boiler may be more practical.

When selecting a high-efficiency boiler, many factors need to be considered in the design of the overall heating system:

1. Condensing boilers require a low return water temperature to operate at their highest efficiency.
2. Systems should be designed with lower flow rates. This means that piping, pumps and valves should be smaller than those used in mid-efficiency boilers.
3. Heating coils and radiators should be sized for a higher rate of heat transfer at lower supply water temperatures.
4. Condensing boilers can function with smaller venting pipes, although more expensive stainless steel is required for larger boilers. Smaller systems can use PVC pipe, which can be directly vented to sidewalls.

High-efficiency boilers are especially well suited to applications such as snow melting and in-floor radiant heating, because they typically have a large temperature drop and low return water temperatures. In general, heating systems must be able to perform adequately at return water temperatures below 57°C (135°F) in order to obtain operating efficiencies above 90 percent. If you are retrofitting a boiler, the system should be thoroughly evaluated. Most existing systems have been designed

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for a higher return water temperature (82°C, or 180°F), and may need to be modified to work at lower return water temperatures. Here are some features to look for in a condensing boiler:

- high-grade stainless steel construction to withstand the low pH of the continuously condensing flue gases;
- a power burner designed for minimal nitrous oxides (NO_x) emissions;
- a high turndown ratio for efficient operation at low loads; and
- a well-insulated jacket around the vessel to minimize heat losses to the room.

Energy Information

Mid-efficiency boilers are currently classified for energy efficiencies between 79 and 85 percent Annual Fuel Utilization Efficiency (AFUE). High-efficiency boilers achieve an AFUE rating above 85 percent, but because flue gases condense in boilers that are about 86-percent efficient, they must be made of above-standard materials that resist breaking down. High-efficiency boilers are not only more efficient, but can also save money over mid-efficiency systems – their pumps and fans use less energy, and costs are reduced for valves, fitting, venting and installing seismic restraints in existing vent systems.

Comparison

Condensing boilers are state-of-the-art systems with sophisticated controls and high-quality materials in the heat exchangers, which makes them costly to manufacture. Both Aerco and Viessmann, the manufacturers of the condensing boilers reviewed here, claim seasonal efficiencies as high as 95 percent. The cost for a 1000-MBtu/hr boiler ranges from $25,000 to $35,000, not including installation. Mid-efficiency boilers have a much lower initial cost (i.e., $10,000 to $20,000 for a 295-kW [1000-MBtu/hr] boiler). Table 1 gives an example of the savings from selecting high- over mid-efficiency in a 1175-kW (4000-MBtu/hr) installation.

Table 1 – Cost and Savings Comparison

	Base Case	**Installed Case** (Worst/Best)
Heating Plant	(2 boilers) 80%-efficient on/off boilers	(4 boilers) 88%-efficient condensing boilers
Approximate Boiler Costs (without installation)	$40,000	$100,000
Gas Usage (GJ)	4800	5550/5254
Savings/year at $9/GJ (2001 rates)		$4,390/$6,980
Simple Payback Period		13.7/8.6 years

Case Study

The city council of Richmond, British Columbia, south of Vancouver, wanted its newly constructed City Hall building (completed May 2000) to reflect its views on sustainable and energy-efficient design (Figure 2). Through an incentive program from Natural Resources Canada, the city was able to review its original design criteria and determine energy-saving strategies, including installing four Aerco KC-1000 condensing boilers to serve the low-rise building and office tower. These boilers will save between 475 and 775 GJ of energy annually compared with mid-efficiency boilers, which were part of the original design. This amounts to savings of as high as $6,980 per year in avoided gas costs at current prices. Without incentives or reductions in auxiliary equipment costs considered, the high-efficiency option will pay itself back in as little as 8.6 years.

Figure 2 – Richmond City Hall Building

For more information, contact

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