



Everyday Environmental Stewardship

Boilers and Furnaces

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Key issue:

Inefficient heat generation

Stewardship Opportunity

High-efficiency equipment

Timely maintenance and, when needed, replacement of heat generating equipment is important to achieving best-possible efficiency and preventing sudden breakdowns. A standard 15 year-old boiler or furnace can have an efficiency rating well below 70%.¹ New equipment can reach an efficiency of well over 95%. High efficiency boilers and furnaces are available for both oil and natural or propane gas. Replacing old equipment can increase heating efficiency by 20% or more. This means 20% less green house gases emitted into the atmosphere and 20% savings on heating fuel costs, which climb every year.

Heating systems can last 25 years, or more. Many houses-of-worship and homes have 30+ year-old heating systems. Though these systems may still “work”, they have long ago passed their useful life. In other words, there is more reliable, more efficient equipment available. Since the heating system is a very large energy consumer, it also provides the great opportunity for environmental stewardship.

When replacing a boiler or furnace, use the most efficient equipment on the market. Many “standard” new boilers and furnaces have AFUE² ratings in the mid 80% range. Contemporary equipment can reach up to 98%. Look for *condensing*-mode equipment which reaches over 95% efficiency.

Today’s equipment also has features not included on older equipment. These features include electric ignition eliminating the need for a pilot light (and consequently standby cost), new combustion technologies increasing efficiency, and sealed combustion using outside air, reducing draft and improving safety.

Hot-Air

Furnaces generate warmth by heating air and blowing it through air ducts. Furnaces have a central fan blowing the hot air through all of the air ducts. This fan can consume much electricity. Also hot-air systems make zoning extremely difficult. Consider replacing the fan with one that runs efficiently at low or variable speeds to significantly cut down on electricity consumption.

¹ **Boilers** heat water for hot water (“hydronic”) or steam systems. **Furnaces** heat air.

² AFUE is Annual Fuel Utilization Efficiency

Steam

Since steam systems boil water, they always run at 212° or higher. This is often too hot for much of the heating season, when the differential between inside and outside temperature is 35°± or less (68° inside vs. 38° outside, for example.) Steam boilers run at a much higher temperature than hydronic boilers, so they are by definition less efficient. Why heat water to 212° degrees when 160° or less works? So when building new and especially when undergoing major renovations, switch to a more efficient hydronic heating system. And remember, steam pipes don't last forever. Steam condenses in the system and over time causes rust throughout the pipes. (The photo of a pipe almost entirely filled with rust is from *Christ Church United*, Lowell, which learned the hard way!) If the steam system is 75+ years old, it's getting near time to change pipes and thus to hydronic radiation also.



Hydronic

Hydronic boilers heat water to a desired temperature. Assuming the boiler has an *outdoor reset control*, this enables higher efficiency.³ Compared to hot air and steam systems, hydronic systems run at much lower temperatures. Because these systems use heated water that runs through small pipes, it is easy to add zones by installing valves in the boiler room which controls flow to the hydronic supply pipes for each zone. **Zones** are identified based on timing and frequency of use. The biggest “zone” in a House Of Worship (the sanctuary) often has over 50% of space in the building that needs heat, but is used typically 4± hours/week, for Sabbath services. By comparison the smallest but most frequently used zone is the office. Zoning with *smart* programmable thermostats is an easy way to lower heating fuel consumption. Ask for heat only when a space is used! St Andrew's Wellesley went from 3 steam to 22 hydronic zones, and, in combination with highest efficiency hydronic boilers, reduced its fuel consumption by over 65%!

Modulating Boilers for Even Higher Efficiency

One new technology which helps boilers reach their highest efficiency is modulating. Modulating burners are designed to control the burner output (size of flame) to match the boilers variable load requirements. During the modulation process, the burner is designed to stay at the correct fuel-to-air ratios ensuring maximum combustion and boiler efficiencies. Contemporary modulating boilers can drop to as low as 10% use.

Oil vs. Gas

New high efficiency natural or propane gas boilers and furnaces can reach higher efficiency than oil-fired equipment. Oil-fired equipment can use bio-heat fuel as a way to further reduce environmental impact, but still are less efficient than gas.

³ *Outdoor reset controls* matches heat generated to need based on the differential between outside and inside temperature. An outside temperature of 40° might need the boiler to heat to 130°, while an outside temperature of 20° might need the boiler to heat to 160°.

Calculation Model

Though these efficient products can be somewhat more expensive to purchase up front, the cost difference will be paid back over time through lower energy bills. And they are eligible for rebates from the gas company! Here is a sample, showing the calculation of benefits of various approaches. This uses a typical household-scale effort.

New boiler

Replace the 17± year-old gas-fired boiler or furnace (80% efficient) with high-efficiency equipment rated at 135,000 btu. New 95% efficient condensing-mode equipment will result in a 19% improvement in efficiency as compared to the efficiency. The old boiler or furnace used 1,500 therms, costing \$2,310 at \$1.54/therm. The new equipment reduces use to 1,219 therms, costing \$1,877, saving \$433. To buy and install the new efficient equipment would cost approximately \$7,450. Regaining this money entirely through savings on gas bills would take about 17 years. Since fuel prices are virtually guaranteed to rise and there will be some gas company financial incentive, the actual payoff time will be considerably shorter.

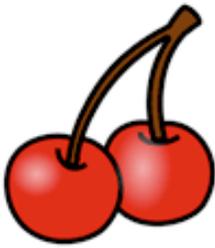
$$\begin{aligned} &(\text{New Efficiency} - \text{Old Efficiency})/\text{Old Efficiency} = \text{Savings} \\ &(95\% - 80\%)/80\% = 19\% \text{ savings!} \end{aligned}$$

$$\begin{aligned} &\text{Savings \%} \times \text{Annual Therms} = \text{Therms Saved} \\ &\text{Savings \%} \times \text{Annual \$s} = \text{\$s Saved} \end{aligned}$$

Remember to use *Heating* Therms and \$s only. Net-out the cost of generating domestic hot water (DHW). (See the MIP&L *EES* on DHW.) Using a boiler with an on-board “on-demand” DHW generation capacity is a double-benefit, reducing the cost of both heating and DHW equipment! And for natural gas, obtain *bulk-rate* pricing through *PowerOptions*, an energy buying consortium for non-profits. This will save about 10% on price alone. www.PowerOptions.org When all the savings are factored in (reduced use, rebates, lower cost/therm), the payback is likely to be about 10 years.

Of course, sooner or later the heat generation equipment must be replaced anyhow. **So**, a better way to understand the benefit is to figure the cost of a “typical” installation vs. “high-efficiency” equipment installation. For the example above, the typical equipment will cost about \$5,850 to install. It will have an efficiency about what the current equipment has: 80±%. The *Net* cost for the “high-efficiency” equipment is \$1,600 (the cost of the high efficiency minus the cost of the conventional equipment). Saving the same money means the “net” cost is paid-back is less than 4 years. If the installed equipment is gas and the utility company provides an \$800 rebate, the *Net* cost is only \$800, which means the pay-back happens in less than 2 years. With that kind of return replacing the heat generation equipment before the end of its “useful life” will make sense financially and in terms of good environment stewardship.

Before Buying New Equipment...



Find and pluck the low-hanging fruit! Improve the efficiency and insulation of the building concurrent with (or even before) installing a new heating system. A few simple actions will save on use and cost immediately. Two examples of *low-hanging fruit* are “smart” programmable thermostats, and interior “storm” windows. After improving the building’s heating efficiency as much as possible, you may actually need a smaller boiler or furnace, costing less to install and using even less fuel!

Boiler efficiency rating does not include the heat lost in the piping system which can account for as much as 35% loss. Insulating heating pipes and ducts will raise efficiency.

Make sure to check out the Thermostat, Utility Cost and Use, Domestic Hot Water, Interior “Storm” Windows, Home Energy Audit, Maintenance and other *EES Briefs* before buying and installing a new heating system. All of these have important information on how to lower heating fuel use and being more environmentally friendly.

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