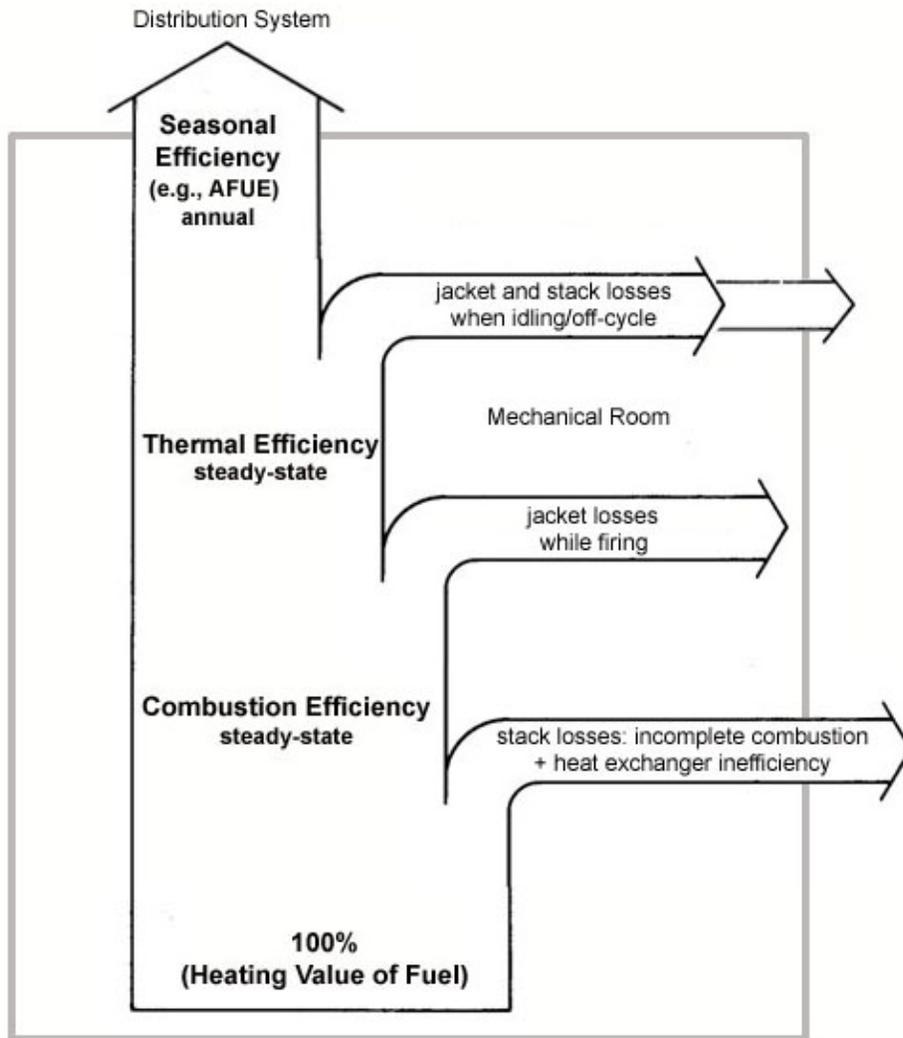


MULTIFAMILY PERFORMANCE PROGRAM

Tech Tip – Boiler Efficiency

Boiler Efficiency Definitions



There are many different terms to describe the efficiency of heating systems, and some of those terms have more than one definition. When you see “combustion efficiency,” “thermal efficiency,” or “boiler efficiency” it is important to understand what definition was intended.

For the purpose of NYSERDA’s Multifamily Performance Program, the critical distinction is between descriptions of steady state efficiency and descriptions of seasonal or annual efficiency.

Combustion efficiency and thermal efficiency describe steady state efficiency. Annual Fuel Utilization Efficiency (AFUE) and other measures of seasonal or annual efficiency are non-steady state measures that include a boiler's performance when it is operating at part load and idling between calls for heat.

Working with Efficiency Ratings

ASHRAE Standard 90.1-2004 describes the minimum acceptable ratings for new boilers:

<u>Boiler Btu/hour input</u>	<u>Standard Used for Minimum Rating</u>
<300,000	AFUE
300,000 - 2,500,000	Thermal Efficiency (E_t)
>2,500,000	Combustion Efficiency (E_c)

The Hydronics Institute Division of GAMA (HI) provides directories listing these ratings at [GAMA Product Directories](#).¹ Specifically, see the directories for [Residential](#)² and [Commercial](#)³ boilers.

$$\text{Combustion Efficiency \%} = ((\text{Fuel Input} - \text{Stack Losses}) \div \text{Fuel Input}) \times 100$$

Combustion efficiency is most commonly defined as shown above and usually describes the results of a combustion efficiency field test on an existing combustion appliance. Combustion efficiency does not account for jacket losses or off-cycle losses. The test estimates the heat lost up the stack when the combustion appliance has been firing long enough to reach equilibrium. Stack heat loss is assessed by measuring:

- Net stack temperature, the difference between the temperature in the flue and the temperature in the mechanical room
- Carbon dioxide concentration or oxygen concentration in the flue gas (%)

Carbon monoxide is also often measured, as an indication of unburned flue gases.

Combustion efficiency measurements for an installed combustion appliance account for any inefficiency of the heat exchanger due to soot, scale, or poor maintenance, because heat that fails to transfer through the heat exchanger goes up the stack.

The Hydronics Institute Testing Standard BTS-2000 provides a test procedure for rating the combustion efficiency of new boilers. The BTS-2000 combustion efficiency test is a more precise version of the combustion efficiency field test. Values for combustion efficiency measured using this standard are given in the Hydronics Institute commercial boiler directory referenced above.

$$\text{Thermal Efficiency \%} = (\text{Output} / \text{Input}) \times 100$$

The definition of thermal efficiency shown above is also from BTS-2000. When a boiler nameplate provides the input and output btus, the ratio of those numbers expresses the thermal efficiency. Thermal efficiency cannot be tested in the field; it requires metering the fuel input and measuring the

¹ <http://www.gamanet.org/gama/inforesources.nsf/vContentEntries/Product+Directories?OpenDocument>

² [http://www.gamanet.org/gama/inforesources.nsf/vAttachmentLaunch/C2E0C5B4405EB75385256FA1008396CC/\\$FILE/01-08_RBR.pdf](http://www.gamanet.org/gama/inforesources.nsf/vAttachmentLaunch/C2E0C5B4405EB75385256FA1008396CC/$FILE/01-08_RBR.pdf)

³ [http://www.gamanet.org/gama/inforesources.nsf/vAttachmentLaunch/E9E5FC7199EBB1BE85256FA100838435/\\$FILE/01-08_CBR.pdf](http://www.gamanet.org/gama/inforesources.nsf/vAttachmentLaunch/E9E5FC7199EBB1BE85256FA100838435/$FILE/01-08_CBR.pdf)

pounds of steam, rate of hot water production, and condensate produced (for steam boilers or condensing boilers). The biggest difference between combustion efficiency and thermal efficiency is that thermal efficiency accounts for the heat lost through the boiler jacket during boiler firing.

Annual or Seasonal Efficiency

Seasonal efficiency cannot be tested in the field, nor can it be described with a simple equation. In addition to stack losses and jacket losses, seasonal efficiency accounts for heat loss during periods that the boiler is “idling” to maintain its internal temperature while the building is not calling for heat.

The AFUE rating system applies to boilers up to 300,000 Btu per hour input. ASHRAE is working on Standard 155P, a similar rating system for larger boilers and boiler systems. Values for AFUE are given in the Hydronics Institute residential boiler directory referenced above.

ASHRAE/ANSI Standard 103-1993 describes the procedure used to calculate AFUE, which includes assumptions such as:

- Varying outdoor temperatures in order to simulate a “typical” winter. Although this is a typical winter for the entire United States, not a typical New York State winter, it does model boiler performance at part load.
- An oversizing factor, which means the boiler does not run at full capacity, even on the coldest day.

An accurate description of seasonal efficiency would be the closest approximation of the boiler’s actual performance in a particular building. The AFUE rating system makes simplifying assumptions that may not apply to a particular installation, but as a single number to represent seasonal efficiency, it comes closer than any other rating system currently available.