upgrades 'cost effective' in terms of energy cost and repayment alone. But, if you look at the homeowner interviews, you see that there are substantial benefits that they perceive, besides low utility bills. Sound control, lack of drafts, and air quality are all important aspects of homeowner satisfaction. That is one main takeaway from this research."

Energy Design Update thanks Jordan Dentz, The Levy Partnership, Inc., and NYSERDA for opening their data and sharing their results with us. The Levy Partnership provides design, research, project management, technical support, and other mission-specific services to organizations involved in home building, commercial construction, property management, material and systems development, and market development, as well as federal and state agencies, energy suppliers, research groups, and non-profit agencies. They may be reached at *http://www.levypartnership.com* or (212) 496-0800. Jordan Dentz may be reached at *jdentz@levypartnership.com*.

NYSERDA may be visited online at *http://nyserda.ny.gov/ advanced-buildings*. Greg Pedrick, CEM, Buildings R&D Project Manager at NYSERDA, may be reached at 17 Columbia Circle, Albany, NY, 12203; via telephone at 1-518-862-1090, x3378; or via e-mail at *gap@nyserda.ny.gov*.

IN REFERENCE

What's in a Rating? (Part 2)

-Srikanth Puttagunta, PE
Vice President - Senior Building Systems Engineer, Steven Winter Associates, Inc

Furnaces

The Skinny

Furnaces are rated in terms of Annual Fuel Utilization Efficiency AFUE for heating under ANSI/ASHRAE Standard 103-2007. AFUE is expressed as a percentage – a ratio of the amount of heat delivered to the airstream divided by the amount of energy in the fuel supplied to the furnace. Because these units burn fuel to generate heat combustion, you get less heat delivered than energy consumed (unlike ACs and heat pumps that move heat). That's why these values are less than 1 (100%), and SEERs/EERs/HSPFs are greater than 1. Minimum rating requirements are provided in Table 3.

Some Gory Details

Though a fairly straight forward rating, AFUE doesn't directly translate to actual performance in a home. One example, AFUE is based on a national average outdoor temperature of 42°F for the combustion air intake. In addition, electrical energy is needed to operate the distribution fan and controls. This electrical energy is not accounted for in the AFUE rating, but rather in the Average Annual Auxiliary Electrical Consumption (Eae). This additional information is useful when calculating the operating cost of fossil-fuel furnaces to alternative heating options, such as heat pumps.

Boilers

The Skinny

Similar to furnaces, boilers are also rated in terms of AFUE for heating under ANSI/ASHRAE Standard 103-2007. Minimum rating requirements are provided in Table 4.

Some Gory Details

Traditional energy-efficient boilers have rated efficiencies between 85% and 87%. Condensing boilers can have rated efficiencies of 90–97% by recovering the latent heat in the combustion exhaust, rather than just exhausting it straight to the outdoors. However, these high-efficiency condensing boilers

Table 3

Heating Fuel Type	Federal Minimum AFUE	ENERGY STAR Minimum AFUE
Gas	78%	90%
Oil	78%	85%

Table 3. Minimum rating requirements for furnaces. Data courtesy Srikanth Puttagunta

Table 4

Heating Fuel Type	Federal Minimum AFUE	ENERGY STAR Minimum AFUE
Gas	80%	85%
Oil	80%	85%

Table 4. Minimum boiler rating requirements. Data courtesy Srikanth Puttagunta.

may not actually condense, resulting in lower actual performance. The issue here is common boiler distribution design results in higher return water temperatures than desired to achieve condensing. This is partly due to improper controls (i.e., lack of outdoor reset, high flows, high supply temperature), and partly due to the common requirement of a primary loop by manufacturers that can lead to a portion of the supplied hot water recirculating back to the boiler without going out to any heating zones.

Water Heaters

The Skinny

Most residential water heaters (less than or equal to 75,000 Btu/hr input) are rated in terms of Energy Factor (EF) per a Department of Energy (DOE) standard (USDOE *Code of Federal Regulations* 10 *CFR* Part 430). The Energy Factor is meant to represent fuel (or electricity) conversion efficiency, as well as standby losses (e.g., tank losses) under normal operating conditions. Some larger fossil-fuel units (greater than 75,000 Btu/hr input) are rated with thermal efficiency. The applicable standard for thermal efficiency is ANSI Z21.10.3. The thermal efficiency of water heaters is similar to the AFUE, as it only accounts for how efficiently fuel is converted to heat; it doesn't take into account any standby losses.

Table 5 provides the current minimum energy factor requirements for various water heater types. Current ENERGY STAR requirements for water heaters are presented in Table 6.

When selecting a water heater size, the first-hour rating (FHR, listed in gallons) is probably the most important factor. The FHR is the amount of hot water that a water heater can deliver in a single hour (when starting with a full tank of hot water). The FHR should be equal to (or greater than) the highest volume of water used during any hour of normal operation in the home.

Some Gory Details

The Energy Factor is calculated under a 24-hour test procedure. In this procedure, 64.3 gallons of water are drawn from the tank in six equal draws spaced one hour apart. The temperature of the drawn water is 1,355˚F and the ambient temperature is 67.5˚F. The Energy Factor is simply the ratio of delivered thermal energy (in the hot water) to energy consumed (fuel or electricity) over the 24-hour test procedure.

Although this is the industry-approved test method, the six, equal 10.7-gallon hot water draws exactly one hour apart are quite different than water use patterns in most homes. This difference in usage leads to actual installed efficiencies that are sometimes quite different from rated efficiencies. Many water heaters, for example, are less efficient when heating small, intermittent draws than when heating large, continuous draws, as in the test procedure. This is why it is important to know the recovery gallons per hour (which can be estimated based on the commonly provided first hour rating by subtracting out the storage tank capacity) of a water heater.

Energy Design Update thanks Srikanth for this excellent series. Srikanth Puttagunta is a Senior Building Systems Engineer with Steven Winter Associates, Inc., in Norwalk, CT. To contact via phone, call 203-857-0200 x275, or e-mail via *sputtagunta@swinter.com*.

Table 5

Type	Energy Factor	ENERGY STAR Minimum AFUE
Electric Storage	0.97 - (0.00132 * Rated Storage Volume in gals)	90%
Gas Storage	0.67 - (0.0019 * Rated Storage Volume in gals)	85%
Oil Storage	0.59 - (0.0019 * Rated Storage Volume in gals)	
Gas Tankless	0.62 - (0.0019 * Rated Storage Volume in gals)	

Table 5. Current minimum energy factor requirements for various water heater types. Data courtesy Srikanth Puttagunta.

Table 6

Type	Energy Factor	First-Hour Rating
Gas Storage	0.67	67 gal/hr
Gas Condensing	0.80	67 gal/hr
Heat Pump Water Heater	2.0	50 gal/hr
Type	Energy Factor	Gallons-Per-Minute
Gas Tankless	0.82	2.5 gal/min over a 77°F rise

Table 6. Current ENERGY STAR requirements for water heaters. Data courtesy Srikanth Puttagunta.