



# Understanding Energy Efficiency Measures for Heating and Cooling Systems

R. Scott Frazier, PhD, PE, CEM  
Oklahoma State Energy Specialist

We see the terms “Btu,” “SEER,” “HSPF” and “AFUE” when describing the efficiency of heating and cooling systems. Contractors and vendors also describe the “tonnage” of the heating and cooling units. Is this describing the weight of the unit? If you are looking for a new heater, air conditioner or heat pump, be familiar with these acronyms. This Fact Sheet discusses the terms along with some other pertinent heating, ventilation and air conditioning (HVAC) topics.

## Btu: “British Thermal Unit”

The amount of heating and cooling an air conditioner or heater is capable of providing is listed in “Btu’s” (British Thermal Units). This old descriptive scientific unit dates back to the mid-1800s and is still used in North America. Essentially, a Btu is the amount of heat energy required to raise the temperature of one pound of water (about a pint) one degree Fahrenheit in one hour. This is also about the amount of energy given off by completely burning a wooden kitchen match. So, one Btu is not very much energy and *thousands* of Btu’s are used to describe heating and cooling equipment.

Why use a heating unit to describe an air conditioner? Because an air conditioner is really just moving heat – not producing “cold.” There actually is no such thing as a unit of cold – just units of heat moving out of a space (from the inside of your house on a hot day).

## Tons of Cooling/Heating

### Size or Capacity of Air Conditioning, Heating or Refrigeration Equipment

This is another old British scientific unit. It comes from the amount of heat required to melt one ton of ice in 24 hours, starting at 32 F. More importantly, one ton of cooling (or heating) is equivalent to moving 12,000 Btu’s per hour. Therefore, a “three ton” AC unit can move 36,000 Btu’s of heat per hour out of a space. Typical home air conditioning units are 3 tons to 7 tons in cooling capacity. This “ton” number is used to describe how much cooling or heating the unit can provide. Obviously the bigger the space, the more tons the unit has to be to move the heat. A window AC unit for a small bedroom might only be half a ton (6,000 Btu’s per hour) in size. The better insulated a building space is, the smaller (fewer tons) the AC or heater needs to be. The appliance “tonnage” is directly related to how much electrical power the unit consumes as well.

Oklahoma Cooperative Extension Fact Sheets  
are also available on our website at:  
<http://osufacts.okstate.edu>

## Correct Unit Sizing

The specifics of how a contractor should determine the correct size, or capacity, of a heater or AC unit will not be discussed here. However, it should be based on some type of calculation of the heat moved in a particular building. Usually this is done with very specialized software that needs details of the building, usage and local climate. Guessing is not an acceptable method of sizing HVAC equipment. Undersized equipment will not meet comfort standards and the problems are obvious. Therefore, when people estimate HVAC equipment size they tend to overestimate. This also has problems. Oversized equipment runs repeatedly for very short periods. This does not allow humidity to be removed from the home, is hard on equipment, is less efficient and the larger equipment has higher initial costs. Once the HVAC equipment is installed at the house, it is very expensive to fix a sizing mistake.

## ENERGY STAR®

This logo can be seen on all sorts of things from computers to entire homes to air conditioners (Figure 1). The mark is part of an energy efficiency rating program developed by the U.S. Environmental Protection Agency and the U.S. Department of Energy. While its main aim is the reduction of greenhouse gases by increased energy efficiency, it has become synonymous with energy efficiency standards for more than 70 product categories. Sometimes utilities or manufacturers offer rebates or other incentives for ENERGY STAR® certified products.



Figure 1. ENERGY STAR® Logo.

## SEER: Seasonal Energy Efficiency Ratio

This is the total cooling capacity of an air conditioner or heat pump in Btus during its normal annual usage, divided by the total electric input in watt-hours during the same time period. The higher the SEER number, the more efficiently the unit is at converting electricity into cooling for the home. This is very similar to miles per gallon in cars. In other words, a higher SEER air conditioner will cost less to operate than a similar size unit with a lower SEER. A 13 SEER AC unit is about 23 percent more efficient than a 10 SEER unit. Another way to think of this is that the 13 SEER unit will save about 23 percent of the cost to run the 10 SEER unit during a year (Figure 2). Some efficient equipment can have SEER ratings of more than 20.

HVAC units in the U.S. make up a significant amount of the national energy consumption. For this reason, the Department of Energy keeps raising the minimum SEER number allowable for new air conditioners and heat pumps sold in the U.S. At present, the minimum standard SEER for newly manufactured air conditioning and heat pump units (other than window units) is 13 SEER. As a buyer, however, even higher SEER units are available, but will initially cost more. High efficiency ENERGY STAR® units must have a SEER of at least 14. One has to weigh the increase in initial cost versus the yearly savings to determine if it is desirable to spend more for a higher SEER unit. Window AC units are exempt from these regulations and their efficiency tends to be around 10 SEER when new.

It should be mentioned that a unit's actual SEER rating will decline over time as coils get dirty, motors and compressors age, and the refrigerant degrades. The SEER rating also declines as the outside temperature rises. If the unit is installed incorrectly or the ductwork is leaky and not well made, the actual overall SEER rating can be much lower as well.

## HSPF: Heating Seasonal Performance Factor

This measure is for **heat pumps** in the heating mode. This is the total heating output of the heat pump during its

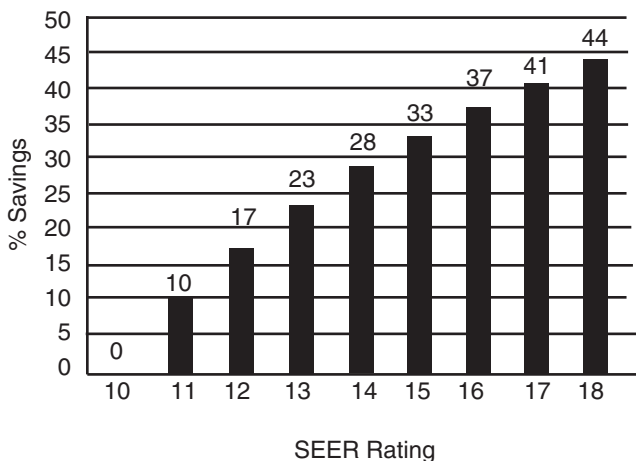


Figure 2. Energy cost savings due to higher SEER rating versus a SEER 10 unit.

normal annual usage divided by the total electric input in watt-hours during the same time period. This rating is similar to the SEER rating, but is for heating and is used only with heat pumps. Like the SEER rating, the higher the HSPF, the more efficient the unit is at heating. And similarly, the higher the HSPF, the less the unit costs to heat a space during one year (Figure 3).

As of January 23, 2006 the government established minimum standards for newly manufactured heat pumps at 7.7 HSPF. Split system heat pumps that are considered high-efficiency have at least an HSPF of 8.2 (some units currently go as high as 9.35). Ground source heat pumps ("geothermal") tend to have high HSPF's because the heat source (ground temperature) is very stable and predictable, therefore the equipment can be designed very specifically. The consumer pays more for equipment with higher HSPF ratings and, like the AC units, it becomes a decision of initial cost versus yearly savings for new equipment.

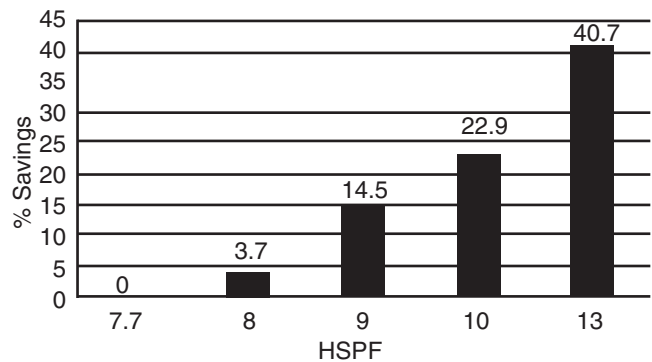


Figure 3. Energy cost savings due to higher HSPF rating versus an HSPF 7.7 unit.

## AFUE: Annual Fuel Efficiency Ratio

This measure is for oil or gas (not electric) fired heaters and boilers. Similar to SEER and HSPF, this compares the heater's annual heat (energy) output to its annual energy input in Btu's. The calculation is a bit complicated and includes expected pilot flame losses and heater use during a typical year at an "average" location in the U.S. The minimum allowed AFUE rating for a non-condensing (typical home heater) fossil-fueled, warm-air furnace is 78 percent; the minimum rating for a fossil-fueled boiler is 80 percent; and the minimum rating for a gas-fueled steam boiler is 75 percent. However, there are some systems capable of very high AFUE's of around 97 percent. Again, these systems will be more expensive and the consumer must weigh the lower fuel use against the higher initial cost (see Table 1).

## EER and COP

These two measures are typically used by engineers for large systems and may not be encountered very often by consumers, but are included here for information.

**Table 1. Comparison of change in heater operation costs for every \$100 of fuel cost at different AFUE's (based on DOE EERE Consumer's Guide: Furnaces and Boilers).**

Existing System AFUE	New/Upgraded System AFUE								
	55%	60%	65%	70%	75%	80%	85%	90%	95%
50%	\$9.09	\$16.76	\$23.07	\$28.57	\$33.33	\$37.50	\$41.24	\$44.24	\$47.36
55%	*	\$8.33	\$15.38	\$21.42	\$26.66	\$31.20	\$35.29	\$38.88	\$42.10
60%	*	*	\$7.69	\$14.28	\$20.00	\$25.00	\$29.41	\$33.33	\$37.80
65%	*	*	*	\$7.14	\$13.33	\$18.75	\$23.52	\$27.77	\$31.57
70%	*	*	*	*	\$6.66	\$12.50	\$17.64	\$22.22	\$26.32
75%	*	*	*	*	*	\$6.50	\$11.76	\$16.66	\$21.10
80%	*	*	*	*	*	*	\$5.88	\$11.11	\$15.80
85%	*	*	*	*	*	*	*	\$5.55	\$10.50
90%	*	*	*	*	*	*	*	*	\$5.30

### EER (Energy-Efficiency Ratio)

An air conditioner's EER, or Energy-Efficiency Ratio, is the ratio of the cooling output in Btu's divided by the unit's power consumption in Watts *at a specific temperature* (usually 95 degrees Fahrenheit). The higher the EER, the more efficient the model. ENERGY STAR's® minimum EER requirements for a room air conditioner vary, depending upon capacity, enclosure type and whether or not the model has louvered sides. The SEER rating is probably a better indicator of general efficiency for residential units than EER because it looks at the unit's operation through variety of conditions and time.

### Coefficient of Performance

COP, coefficient of performance, is the measurement of how efficiently a heating or cooling system does its job. As

with all the measures described here, a higher COP is more efficient and desirable than a lower one.

### A Final Note

Selecting a new heating or cooling unit is a tradeoff between several factors. Initial cost, energy savings, type of fuel, etc. A very important consideration is the quality of system installation including the duct work for air distribution. A 14 SEER system can be brought down to an actual 5 SEER if not installed correctly. Duct work should be insulated and sealed.

Finally, HVAC units are like any other complicated machinery, they need periodic maintenance. The filters need replacing, the coils need to be cleaned on occasion, duct work inspected and thermostat checked. Like a car, the owner must protect the investment through maintenance and periodic inspection.

# The Oklahoma Cooperative Extension Service

## *Bringing the University to You!*

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
  - It is administered by the land-grant university as designated by the state legislature through an Extension director.
  - Extension programs are nonpolitical, objective, and research-based information.
  - It provides practical, problem-oriented education
- for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
  - It utilizes research from university, government, and other sources to help people make their own decisions.
  - More than a million volunteers help multiply the impact of the Extension professional staff.
  - It dispenses no funds to the public.
  - It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
  - Local programs are developed and carried out in full recognition of national problems and goals.
  - The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
  - Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

Oklahoma State University, in compliance with Title VI and VII of the Civil Rights Act of 1964, Executive Order 11246 as amended, and Title IX of the Education Amendments of 1972 (Higher Education Act), the Americans with Disabilities Act of 1990, and other federal and state laws and regulations, does not discriminate on the basis of race, color, national origin, genetic information, sex, age, sexual orientation, gender identity, religion, disability, or status as a veteran, in any of its policies, practices or procedures. This provision includes, but is not limited to admissions, employment, financial aid, and educational services. The Director of Equal Opportunity, 408 Whitehurst, OSU, Stillwater, OK 74078-1035; Phone 405-744-5371; email: eeo@okstate.edu has been designated to handle inquiries regarding non-discrimination policies; Director of Equal Opportunity. Any person (student, faculty, or staff) who believes that discriminatory practices have been engaged in based on gender may discuss his or her concerns and file informal or formal complaints of possible violations of Title IX with OSU's Title IX Coordinator 405-744-9154.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 20 cents per copy. 0116 GH