NBSIR 87-3645

A Study of Three Measures for Energy Efficiency of Fossil Fueled Furnaces and Boilers

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U.S. DEPARTMENT OF COMMERCE
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U.S. DEPARTMENT OF COMMERCE, Clarence J. Brown, *Acting Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

ABSTRACT

The effectiveness of three measures of energy efficiency for furnaces has been demonstrated by comparison of the results for predicted energy savings against the cost savings predicted by the calculated total annual cost of operation using DOE test procedures. Two of the efficiency measures currently prescribed by DOE - the Annual Fuel Utilization Efficiency (AFUE) and the DOE Energy Factor (EF) are compared with an industry proposed energy factor - Seasonal Energy Utilization Factor (SEUF).

Various parameters which affect the SEUF factor have also been demonstrated. These include the effects of power rating (wattage), burner input rating, electric to fossil fuel cost ratio, and the effect of annual fuel utilization efficiency (AFUE).

Key Words: annual efficiency; boilers, combustion equipment, efficiency, furnaces; operating costs

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1.0 BACKGROUND

Currently, the Annual Fuel Utilization Efficiency (AFUE) rating for fossil fueled furnaces and boilers is a measure of fuel use and does not include the secondary electric energy used to operate fans, powered burner, etc. With conventional furnaces of moderate efficiency, the electric energy was a second order effect and was not considered necessary in the calculation of AFUE in order to have a consistent rating method. The electric energy cost is, of course, included in the calculation of annual operating cost. Since the efficiency measure is the dominant measure presented to the consumer (e.g., FTC labeling), a comprehensive study of the extent of misinformation caused by AFUE comparisons is needed. The National Bureau of Standards (NBS) and the Department of Energy (DOE) staff have been aware of possible inconsistency that can exist with the newer higher efficiency furnaces that now use less fossil fuel energy but more electrical energy. This would be particularly true for furnaces that modulate the fuel since the fan operates over a longer period.

Comments on this issue were received in 1983 by the DOE in response to proposed rule making published June 17, 1983 [1]. An analysis of those comments was prepared by NBS [2]. The DOE response was published in March 1984 [3] and is also included in Appendix E. The comments received on this subject related to a substitute for AFUE or a revised AFUE and was referred to as a Seasonal Energy Utilization Factor (SEUF). The equation for SEUF proposed by industry members and the Gas Appliance Manufacturers Association (GAMA) is as follows:

$$\text{SEUF} = \frac{(\text{EF})(\text{AFUE}) + \text{EAE}}{(\text{EF}) + (\text{RC})(\text{EAE})} (100)$$

where: $$\frac{(3.413)(\text{EE})(\text{EF})}{(\text{Q})} = \text{EAE}$$

EF = Annual Fuel Energy (Btu)

EE = Wattage Rating (Watts) as measured

Q = Burner Fuel Input (Btu/hr) measured

EAE = Heat Equivalent of Annual Electric Energy (Btu)

RC = Ratio of Electric to Fossil Fuel Cost Per Btu of Energy = \$ per Btu (electricity)/\$ per Btu (fossil fuel)

AFUE = Annual Fuel Utilization Efficiency (%)

3.413 = Conversion Factor Btu/hr per Watt

Industry also commented that the DOE Energy Factor does not adequately address this issue since the relative costs of electric to fossil fuel energy (RC) are not included. The equation used to calculate the DOE Energy Factor (DOE EF) is as follows:.

$$\text{DOE EF} = \frac{(\text{EF})(\text{AFUE})}{(\text{EF})+(\text{EAE})}$$

where: EF, EAE, and AFUE are as defined above.

2.0 SCOPE

This report addresses the following three questions:

- First, how well do the current DOE procedures for energy measures compare within themselves? That is, how well does AFUE and EF compare as a reference for comparison with the calculated total annual cost of operation (for electricity and fuel) as prescribed in the DOE procedures?
- Second, how well does the Industry's proposed SEUF method compare over a wide range of electric to fuel cost ratios with the DOE procedures for calculating total annual cost of operation?
- Thirdly, how does SEUF compare with AFUE over a wide range of the operating parameters which affect the SEUF? These parameters include electric to fossil fuel cost ratio (RC) power input rating (watts), and burner input rating (Btu/hr).

The SEUF is dependent on electric energy consumption (EAE) which is dependent on the power rating (EE) and the annual hours of operation. The term:

$$\frac{\text{EF}}{(\text{Q})}$$

gives the annual hours of burner operation needed to consume the annual energy (EF), where Q is the maximum burner input rate. Furnaces with modulated burner operation would use an average (Q) to estimate the hours of operation. The effects of burner input and modulated burner input control is an important aspect of this study and is discussed in Section 4.2.2 and Appendix A.

The product of power input EE and hours of operation is the kilowatt hours per year required. A multiplier of 3.413 converts electric energy to Btu equivalent which is the term EAE.

Since burner input rating (Btu/hr) and power rating (watts) are parameters in the calculation of SEUF, the calculations for this study included a range of wattage ratings which represent the lowest (400 watts) and highest (800 watts) that were determined by laboratory test to be typical of conventional and high efficiency furnaces, respectively. A range of fuel input rates of 50,000 Btu/hr to 150,000 Btu/hr covers the most typically used furnaces or boilers for single family residences. If an oversize factor of 70% were assumed, the range of design heating requirements that applies with steady state efficiency from 75% to 95% would be a minimum of 50,000 (0.75)/(1.7) = 22,058 Btu/hr to a maximum of 150,000 (0.95)/(1.7) = 83,823 Btu/hr.

The size range of homes that these reported results would apply to could be calculated given the home heat loss and the design temperature. Appendix B shows a calculation procedure used to show that with 50,000 to 150,000 Btu/hr input this ranges from 1384 sq ft to 5262 sq ft when the outdoor temperature is 0°F and the heat loss is taken as 10 Btu/sq ft/°day.

3.0 RESULTS

3.1 Comparison of Savings Predicted by Three Measures of Energy Efficiency (AFUE, SEUF, and DOE EF)

The most important aspect of an energy efficiency measure is how it compares in its determination of energy savings versus the savings determined by calculation for annual operating costs. Without having the numbers for total annual operating cost the consumer should be able to use the improvement in energy efficiency to predict what the dollar energy savings would be. This energy savings can be determined as a fraction from the relationship:

$$\text{Savings} = 1 - \frac{AFUE_{(1)}}{AFUE_{(2)}}$$

Where (1) and (2) refer to the low and high efficiency units being considered.

In order to evaluate the current DOE prescribed measures of energy efficiency (AFUE and DOE EF) as well as the Industry proposed SEUF factor, the energy savings predicted by these efficiency measures were compared to the dollar savings found by the DOE procedures. The later measure (total cost of fuel and electricity) was considered to be the most accurate measure and all other energy savings by an efficiency measure are compared to it.

In the DOE procedure, heat from the furnace blower is considered in reducing the heat which the furnace must provide. Energy savings determined using SEUF and the calculated savings based on annual cost should be identical by definition. In order to quantify the potential error in using the AFUE, a comparison was made between a conventional furnace efficiency of 70% AFUE (i.e. atmospheric burner design with electric ignition) with power rating of 400 watts and a high efficiency (condensing type) furnace having 95% AFUE and power rating of 650 watts. In order to maximize this potential difference between AFUE and SEUF the high efficiency furnace was also evaluated using the maximum known wattage rating of current condensing furnace design (i.e. 800 watts). A design heating requirement (building heating load) of 40,000 Btu/h was selected as a base case for the National average weather conditions of 5200 degree days, 5°F design temperature, and corresponding heating load hours of 2080. Specific design heating requirements for the same building located in three other cities were calculated by correcting the 40,000 Btu/h design heating load to the design temperature for each city. See Appendix C for example of calculations. In this way the same size house is compared for all cities. Burner input rate at each site is based on the calculated design heating requirement using a constant 70% oversize factor.

Table 1 shows the results of energy savings calculated by the three measures of energy efficiency investigated (AFUE, DOE EF, and SEUF) and the savings determined by annual cost of operation using the DOE test procedures to calculate fuel and electricity annual costs.

Table 2 shows the results used for calculating the savings shown in Table 1.

Table 3 shows the data used for calculating the results shown in Table 2 for each of these four sites. These cities vary from the minimum to the maximum known cost ratios (RC) applicable today. Table 4 shows cost ratios for major cities in the United States as of August 1986.

3.2 Effects of Variables in Calculation for Seasonal Energy Utilization Factors (SEUF)

Two formats of results are presented in Figures 1 through 21 for comparisons of AFUE with SEUF and DOE EF. Figures 1 through 9 highlight the effect of energy cost ratio for specific furnace ratings, i.e. in terms of power rating and fuel input. These figures cover three selected power ratings (400, 650 and 800 watts) for the selected burner input ratings. Cost ratios (RC) in the range of 1.5 to 9.0 in increments of 0.5 were used with each of three burner fuel input ratings of 50,000 Btu/hr; 100,000 Btu/hr; and 150,000 Btu/hr. Figures 10 through 21 show more explicitly the effects of power ratings over the range of 300 to 800 watts in increments of 100 watts.

4.0 DISCUSSION OF RESULTS

4.1 Energy Savings-Efficiency Factors Versus Operating Cost Savings

In all cases as shown in Table 1, the AFUE somewhat over predicts energy savings (the amount depending on the RC value) compared to the savings calculated by annual cost. For a U.S. city average cost ratio of 3.8, and with the national average heating load hours, the AFUE over predicts savings only slightly (i.e. 26.3% versus 22.9% and 21.1%) as shown in Table 1. This amounts to only an error of $6.00 per year in cost savings. Table 1 shows the departure between AFUE savings versus annual cost savings is greatest when the electricity to fuel cost ratio (RC) is greatest. (i.e. greatest difference exists for Chicago where electric cost is greatest [13¢ per kwh] and over predicted savings by AFUE amounts to $44.00 per year.)

These differences between AFUE and cost savings detailed above apply only to the example chosen here for comparison. This example uses a conventional atmospheric furnace compared to either of two high efficiency condensing furnaces which use either 150 watt or 400 watt more electrical power. These are considered to be realistic examples for comparison purposes, and were chosen to show the improvement to be expected for SEUF versus AFUE. This power rating of 800 watts was found previously in tests of condensing furnaces at NBS (9). For the typical input of 80,000 Btu/hr a more typical high efficiency condensing furnace would have a wattage rating of 150 watts above that of the conventional furnace with atmospheric burner (8). Appendix A shows that AFUE for two stage or modulating burners will result in a more over predicted energy savings, and SEUF will allow for considerable improvement over AFUE for that type of furnace (see 4.2.2 for details).

4.2 Parametric Analysis of SEUF Calculations

4.2.1 Effect of Power Rating (Watts)

In Figure 1 we see that a furnace having a 60% AFUE rating, with a 400 watt power rating and with, for example, the U. S. city average cost ratio of 4.0, results in 3.4 percentage points difference between SEUF and AFUE (i.e. at 60% AFUE, SEUF = 56.6%). This difference increases to 7 percentage points at AFUE of 95%. At 800 watts rating (Figure 7), this difference increases from a 6.3 point difference at energy cost ratio of 4.0, and 60% AFUE, to a 12.5 point difference at 95% AFUE. The maximum difference between AFUE and the DOE energy factor is 2-3 points difference at 400 watts (Figure 1) and approximately 5 points difference at 800 watts (Figure 7). Cost ratio has no effect on the DOE EF (see Section 1.0).

Increased electric power would result in reduced fossil fuel energy needed since the fan energy used is transferred to the conditioned air as heat. Current DOE test procedures do recognize this effect in the calculation of burner operating hours and cost of operation.

An examination of the equation for SEUF in Section 1.0 reveals that annual fossil fuel energy (EF) is in each term of the numerator and denominator and therefore (EF) cancels out in the calculation for SEUF. This also applies in the calculation for the DOE energy factor.

4.2.2 Effect of Burner Input Rating and Modulated Burner Input

The burner input rate affects the hours of operation needed to provide a given amount of energy. Therefore, the lower input rate results in more operating hours and consequently more electric energy use and lower SEUF. The effect of modulated burner operation can be seen in Table 5. For the basis of calculations used to obtain these results see Appendix A. These results show the effect of a five percentage point increase in AFUE coupled with the increased electrical energy required for two stage operation (i.e., a doubling of the fan run time). These results show that the SEUF as a measure of efficiency savings is identical with annual cost of operation savings, (any small differences are due to rounding in calculations). These results show that for the two stage controlled furnace (or step-modulating furnace) the AFUE comparison with single stage furnace can be a misleading indicator-or energy savings especially in areas with high electric to fuel cost ratios (i.e., the AFUE predicts a +6.6% savings for Chicago where annual cost savings is calcualated as minus 3.3%).

This effect of burner input rate is also apparent in comparing Figure 1 with Figure 2 and Figure 3. These figures can also be used to see the effect of burner modulation. For example if a furnace rated at 100,000 Btu/h; AFUE 75%, and 400 watt power rating is equipped with modulating control such that burner input averages 50,000 Btu/h with same AFUE of 75%; the SEUF drops from 72.4% (i.e. Figure 2 with AFUE = 75%, RC = 4.0) to 70.1% (i.e. Figure 1 AFUE = 75%, RC = 4.0).

4.2.3 Effect of AFUE Rating

Lowering AFUE rating has a similar effect as reducing burner input rating since the burner operating hours is a function of the furnace heat output which is the product of burner input and operating (steady state) efficiency. In general AFUE is directly related to steady state efficiency.

4.2.4 Effect of Electric to Fossil Fuel Cost Ratio (RC)

Energy cost varies mainly with geographical location but also with usage and with time. Energy cost used is the analysis of Appendix A were obtained from 1984 data reported by the Bureau of Labor Statistics [4]. A more recent report of energy costs is included here in Appendix E. (See Appendix E for energy costs for 28 metropolitan areas of the U.S.) The U.S. city average cost ratio (RC) for August 1986 was 4.1 which is based on $60.078 per 100 therms of gas and $42.157 per 500 Kwh. (See Table 4.) Energy cost ratios (RC) for 23 cities (Table 4) shows a wide range of values (i.e. from 8.2 for Chicago to 1.8 for Seattle. These data for U.S. cities show that the range of costs for electricity is wider than for natural gas. Gas cost ranges from a low of 41% below the U.S. city average (i.e. for Houston), to a high of 52% above the average for New York City.. Electric cost ranges from 50% below the U.S. City average in Seattle to 73% above the average for Chicago.

5.0 CONCLUSIONS

Results of this study have shown that the efficiency measure, SEUF which includes the electric energy and its relative cost with respect to fuel cost (RC) would provide for an accurate reflection of the total energy cost savings, and is therefore a better measure of efficiency than the AFUE or DOE EF. The most significant improvement in the application of the SEUF factor over AFUE is expected for furnaces or boilers having modulating type burners.

6.0 REFERENCES

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Appendix A

Basis of Calculation for Comparing a Furnace Equipped with Single Stage Control Versus Furnace with Two Stage Control

Using oversize factor at design conditions as 0.7 (i.e., 70% oversize); design temperature and heating requirement at design conditions based on 40,000 Btu/h for the national average design temperature of 5 F; and design heating requirement for each city adjusted using design temperature for each city. (i.e., same house construction for each city.)

Burner operating hours and annual fuel and energy costs determined as shown in Appendix C. Burner input also determined as in Appendix C.

Specific conditions for single stage control:

Burner on time is based on furnace assigned values in DOE test procedures of 3.8 minutes on and 13.3 minutes off.

Power input is assigned a value of 400 watts.

Furnace Steady State efficiency = 75%; AFUE = 70%

Specific conditions for two stage control:

(1) Same furnace steady state efficiency at both maximum and reduced input as single stage control furnace.

(2) AFUE is increased by 5% due to the reduced cycling losses which apply for two stage control, with burner on and off times assigned as 10 minutes as per DOE test procedures for furnaces.*

(3) Output energy required to meet heating load is the same as for single stage furnace, consequently burner input rate at maximum input is the same as single stage furnace.

(4) Ratio of increased electrical use is the ratio of percent on time for each furnace (i.e., single stage = 3.8/(3.8+13.3) = 0.22

two stage = 10/10+10) = 0.50

Using these on time fractions the ratio of on time for the two stage vs the single stage furnace is 0.50/0.22 = 2.27

In other words the amount of electrical energy required for the two stage furnaces is 227% of the single stage furnace if the power rating of each is the same.

*Data used to calculated part-load efficiency and AFUE in determining a nominal increase in AFUE for a forced air furnace was obtained from testing of a two stage forced air furnace at NBS. Results were reported in Reference 10.

(5) Burner operating hours and fuel energy required for the two stage are reduced due to increased electrical energy which is credited in reducing the house heating load.

The assignment of a power input for the two stage furnace consistent with power input of the single stage furnace in combination with the assignments of the ratio calculated in (4) above; and the assigned increase of 5% in AFUE for the two stage furnace allows for using the same calculation procedure for two stage control furnace as described in Appendix C instead of the detailed DOE procedures which require specific information on heat-up and cool down temperatures, etc. In this calculation the two stage furnace is treated as a single stage furnace with a power input rating of (2.27) (400) or 908 watts.

Appendix B

Calculation for Minimum and Maximum Heated Area of Homes

Example for minimum area:

Minimum Input Rate = 50,000 Btu/hr
Minimum Efficiency = 75% (Steady State Efficiency)

Minimum Heated area for heat loss of 10.0 Btu/sq ft/°day* and with outdoor temperature of 0°F

Degree days with 0°F = 65° - 0° = 65

Minimum Output Rate = 50,000 (0.75) = 37,500 Btu/hr

$$\text{Minimum Area} = \frac{(37{,}500 \text{ Btu/hr})(24 \text{ hr/day})}{(10 \text{ Btu/sq ft/°day})(65\text{°days})} = 1384 \text{ sq ft}$$

Maximum area with this same heating load is:

Maximum Output = 150,000 (0.95) = 142,500 Btu/hr

$$\text{Maximum Area} = \frac{142{,}500\ (24)}{(10)(65)} = 5{,}262 \text{ sq ft}$$

* The value of 10 Btu/sq ft/°day is considered to be consistent with energy consumption for gas fueled homes. The latest American Gas Association Household Heating Survey [5] reports annual fuel use for central heating as 75.6×10^6 Btu per year. If the national average for heating degree days is taken as 5,200 °days. The average area for a home is calculated from:

$$(A)\ (10 \text{ Btu/sq ft/°day})(5{,}200) = 75.6 \times 10^6 \text{ Btu}$$
$$A = 1{,}512 \text{ sq ft}$$

This area is considered representative of U.S. single family housing characteristics as reported for 1981 [6]. The mean number of sq ft of heated area ranges from 1,271 sq ft to 1,826 sq ft depending on the type of home.

Appendix C

(A) <u>Example Calculation for Annual Operating Cost, SEUF and DOE EF (Based on National Average Values for Weather and Energy Cost)</u>

Given: AFUE = 95%; ss = 95%; DHR = 40,000 Btu/hr or KDHR = 40

(FE+BE) = 800 watts - power rating; oversize (α) = 70%; HLH = 2080

(electric ignition) AFUE = N_u; Rc = 4.1 = U.S. city average

(1) Determine Burner input rate (Qin)

$$DHR = \frac{Qin\ (nss)}{(1 + \alpha)} \quad ; \quad Qin = \frac{(1.7)(40,000)}{0.95}$$

$$Qin = 71,578$$

(2) Determine Burner Operating Hours (BOH):

$$BOH = 2080\ (0.77)\ (A)(KDHR)$$

$$A = \frac{1000}{3413(EE) + Qin\ N_u}$$

$$\text{where } A = \frac{100,000}{3413(0.8) + 71578(0.95)} = 0.014$$

BOH = 911 Hrs

(3) Determine EF (Fuel Energy)

$$EF = BOH\ (Qin) = 65.2 \times 10^6 \text{ Btu} = 652 \text{ therms.}$$

(4) Determine Electric Annual Energy (EAE)

$$EAE = BOH\ (P) = 911(0.8) = 728 \text{ kwh}$$

(5) Determine SEUF (See equation in Appendix A)

$$SEUF = \frac{65.2 \times 10^6\ (0.95) + 728\ (3413)}{65.2 \times 10^6 + 4.1\ (728)(3413)} = 85.4\%$$

(6) Calculate Annual Operating Cost

Based on National Average Cost of 61.1¢ /therm and 8.0c /Kwh

Fuel Cost = 652 therms ($/ 0.611 therm) = $398.37

(7) Determine DOE Energy Factor (DOE EF) from equation in Appendix A.

$$\text{DOE EF} = 100 \frac{\text{EF x AFUE}}{\text{EF + EAE}} = 100 \frac{65.2 \text{ X } 10^6 (0.95)}{65.2 \text{ x } 10^6 + 728 \text{ } (34.3)} = 91.5\%$$

(B) Example of Recalculated Design Heating Requirement (DHR)

- Design temperature (TD) for Seattle is 26°F (See Table Below)
- Correct U.S. City Average value of 40,000 Btu/hr DHR (1) at TD of 5°F to Seattle, DHR (2) as follows:

$$\frac{\text{DHR (1)}}{\text{DHR (2)}} = \frac{\text{T(1)}}{\text{T(2)}} = \frac{65\text{-}5}{65\text{-}26}$$

$$\text{DHR (2)} = 40{,}000 \frac{(39)}{(60)} = 26{,}000 \text{ Btu/h}$$

Appendix D

Data Used to Calculate Operating Costs

City	Days	Design Temperature °F	Heating Load Hours	Cost (¢) Gas (Therm)	Cost (¢) Elect. (Kwh)
U.S. National Average	5200	5°	2080	61.1	8.0
Seattle	5145	26°	3166	64.8	4.0
Washington, D.C.	4224	17	2112	74.4	7.9
Chicago	6639	-4	2309	46.9	13.9

APPENDIX E

AVERAGE RESIDENTIAL PRICES FOR UTILITY (piped gas) ELECTRICITY AND FUEL OIL U.S. CITY AVERAGE

Data Used to Calculate Annual Cost of Operation (from Reference 4)

Average residential prices for utility (piped) gas, electricity, and fuel oil, U.S. city average and selected areas

Area, region and population size class	Utility (piped) gas per 40 therms July 1986	Utility (piped) gas per 40 therms Aug. 1986	Utility (piped) gas per 100 therms July 1986	Utility (piped) gas per 100 therms Aug. 1986	Electricity per 500 KWH July 1986	Electricity per 500 KWH Aug. 1986	Fuel oil #2 per gallon July 1986	Fuel oil #2 per gallon Aug. 1986
U.S. city average 1/................	$25.967	$26.260	$59.925	$60.078	$42.138	$42.157	$0.751	$0.726
Chicago, Ill.-Northwestern Ind.	20.412	20.346	47.235	47.111	65.900	66.239	.813	.857
Detroit, Mich.	25.543	29.254	57.465	58.258	46.640	46.197	.893	.892
L.A.-Long Beach, Anaheim, Calif. ...	26.923	26.923	77.225	77.225	43.503	43.512	NA	NA
N.Y., N.Y.-Northeastern N.J.	35.464	35.204	79.028	78.107	65.405	64.402	.820	.787
Philadelphia, Pa.-N.J.	30.251	30.251	71.999	71.999	52.951	52.951	.786	.750
Anchorage, Alaska 2/................	16.960	16.960	35.630	35.630	38.846	39.672	.931	.899
Baltimore, Md.	29.980	29.860	64.760	64.450	41.540	41.540	.807	.759
Boston, Mass.	30.990	31.360	69.010	69.940	46.519	44.272	.734	.712
Cincinnati, Ohio-Ky.-Ind. 2/........	23.758	23.707	53.044	52.930	37.440	37.440	.743	.698
Denver-Boulder, Colo. 2/............	23.738	23.738	51.342	51.342	40.267	41.157	NA	NA
Miami, Fla.	26.600	26.100	56.730	55.340	43.643	43.643	NA	NA
Milwaukee, Wis. 2/..................	28.391	28.391	65.464	65.464	38.480	38.480	.777	.743
Northeast Pennsylvania 2/...........	29.585	29.585	67.727	67.727	45.053	45.053	.704	.638
Portland, Oreg.-Wash. 2/............	26.800	26.338	62.008	60.858	24.469	24.469	.606	.570
St. Louis, Mo.-Ill.	28.953	28.093	57.330	54.470	50.392	50.598	.750	.731
San Diego, Calif. 2/................	23.294	23.294	68.128	68.128	59.652	59.652	NA	NA
Seattle-Everett, Wash. 2/...........	26.759	26.759	56.723	56.723	17.078	17.078	.719	.650
Washington, D.C.-Md.-Va.	31.560	31.732	65.677	64.849	39.332	39.286	.813	.788
Atlanta, Ga. 2/.....................	28.937	28.947	61.996	62.006	36.347	36.124	.650	.677
Buffalo, N.Y. 2/....................	29.360	26.819	65.163	57.973	42.494	41.543	.818	.760
Cleveland, Ohio.....................	23.620	22.880	52.620	50.780	55.440	55.440	.853	.773
Dallas-Fort Worth, Tex.	20.125	21.013	42.390	44.769	39.922	41.286	NA	NA
Honolulu, Hawaii 2/ 3/..............	49.760	50.160	115.400	116.400	39.590	39.460	NA	NA
Houston, Tex.	21.460	19.400	43.870	38.710	37.980	36.540	NA	NA
Kansas City, Mo.-Kans. 2/...........	18.836	18.913	39.129	39.243	46.712	46.845	NA	NA
Minneapolis-St.Paul, Minn.-Wis. 2/..	24.760	24.049	57.265	55.504	39.137	39.728	.765	.760
Pittsburgh, Pa.	32.911	33.096	60.991	60.530	41.763	42.780	.645	.622
San Francisco-Oakland, Calif.	19.055	19.055	65.095	65.095	39.785	39.785	NA	NA

Note: To calculate (RC) multiply electricity cost per 500 KWH by 5.8 and divide by gas cost per 100 therms of utility (piped) gas. For oil multiply electric cost per 500 KWH by 0.082 and divide by cost per gallon of oil.

APPENDIX F

DOE 1984 Response to Proposed Adoption of Seasonal Energy Utilization Factor

4. Energy Efficiency Descriptor

Although not directly related to any of the issues raised in the June 17 proposal, many commenters discussed the need for an energy efficiency descriptor (energy efficiency rating) to account for the electrical energy used by a fossil fueled furnace in addition to the fossil fuel used. The descriptor AFUE only accounts for the fossil fuel efficiency. *See* TRD, No. 7, at 1; Carrier, No. 10, at 1; and GAMA, No. 12, at 8. The proposed provisions for modulating controls drew these comments since in most modulating designs improved fuel efficiency (AFUE) is obtained at the expense of additional electrical energy consumption, (e.g. increased blower run time). The existing regulation for determining annual operating costs does reflect this concept, since electrical and fuel costs are separately determined and then summed. The commenters felt that in addition to the annual operating cost provisions, an energy efficiency descriptor needs to be added that will fairly disclose to the consumer the relative performance of different designs of furnaces that use both fossil fuel and electricity. Commenters felt the situation is exacerbated by FTC's labeling program, where for furnaces the dominant disclosure is AFUE and annual operating costs are relegated to the bottom of the Fact Sheet in grid format. The consumer may make a purchasing decision solely on the AFUE and not consider the electrical cost as well. Carrier delineated an example of the misleading nature of comparisons based on AFUE by showing where a higher AFUE furnace had an actual higher annual operating cost. *See* Carrier Corp., No. 10, at 2. Obviously, this outcome was dependent on assumed relative costs of the fuel and electricity. Other relative costs assumptions could lead to the opposite outcome, i.e., higher AFUE, lower operating costs. The commenters suggested the adoption of a new efficiency descriptor that includes an *average* electricity to fuel cost ratio. Any rankings developed from this descriptor would be identical to that developed on the basis of annual operating costs using the same average electricity to fuel costs ratio. DOE sees some merit to an efficiency descriptor based on the average electricity to fuel cost ratio but feels there exists, already in DOE procedures, a superior method of rating a furnace's performance in all costs scenarios, not just average costs scenarios. The DOE procedures currently provide the method of calculation needed to explicitly detail the electrical energy cost and the fuel energy cost for any furnace.

Therefore, for the reasons discussed above today's final rule does not include a new energy efficiency descriptor. However, DOE will continue to examine this subject and may consider revisions at a later date.

Table 1. Comparison of Savings by Three Measures of Energy Efficiency (AFUE, DOE EF, and SEUF) and by Annual Cost Savings for increase in AFUE from 70% with Power Rating of 400 Watts to AFUE of 95% and Power Ratings of 650 and 800 Watts.

Location (Cost Ratio)*	AFUE %	Power Rating	Savings (%) Determined by: AFUE	DOE EF	SEUF**	Annual** Cost
U.S. City	70	400	-	-	-	-
Average	95	650	26.3	25.1	22.9	22.9
(3.8)	95	800	26.3	24.6	21.6	21.1
Seattle	70	400	-	-	-	-
	95	650	26.3	24.6	24.4	24.5
(1.8)	95	800	26.3	23.7	23.9	24.0
Washington	70	400	-	-	-	-
	95	650	26.3	25.7	23.0	23.1
(3.1)	95	800	26.3	24.3	21.9	21.9
Chicago	70	400	-	-	-	-
	95	650	26.3	25.3	19.2	19.1
(8.7)	95	800	26.3	24.9	16.1	16.1

*Cost Ratios determined using Appendix E. - averages for all households.

**Any difference in percent savings between SEUF and Annual Operating Cost is due to rounding in the calculations.

Table 2. Annual Operating Cost and Efficiency Factors for Selected Cities from Minimum to Maximum Cost Ratios.

Location (Cost Ratio)	Power Rating Watts	AFUE %	EF %	SEUF %	Annual Cost $ (Total Fuel & Electric
U.S. City Average	400	70	69.0	67.6	$579.06
(3.8)	650	95	92.1	87.7	446.42
	800	95	91.5	86.2	456.61
Seattle	400	70	68.4	69.4	592.10
(1.8)	650	95	90.7	91.8	447.00
	800	95	89.7	91.2	450.10
Washington, D.C.	400	70	68.7	67.9	596.97
(3.1)	650	95	92.5	88.2	459.39
	800	95	90.7	86.9	466.49
Chicago	400	70	69.1	64.0	599.10
(8.7)	650	95	92.5	79.2	484.43
	800	95	92.0	76.3	502.66

Table 3. Data Used in Calculating SEUF, DOE EF and Total Annual Operating Cost*

Location and (Cost Ratio)	AFUE	HLH (hrs)	DHR Btu/h	Qin Btu/h	Power Rating (Watts)	Burner Operating Hours	Annual Therms	Fuel Cost $	Annual Electric Kwh	Energy Cost $	Total $
Seattle (1.8)	70	3166	26000	58933	400	1487	877	568.30	595	23.80	592.10
	95	3166	26000	46526	650	1366	635	411.48	888	35.52	447.00
	95	3166	26000	46526	800	1351	628	406.94	1081	43.24	450.18
Washington, D.C. (3.1)	70	2212	32000	72533	400	1045	758	563.95	418	33.02	596.97
	95	2212	32000	57263	650	963	551	409.94	626	49.45	459.39
	95	2212	32000	57263	800	954	546	406.22	763	60.27	466.49
Chicago (8.7)	70	2309	46000	104267	400	1100	1147	537.94	440	61.16	599.10
	95	2309	46000	82316	650	1017	837	392.55	661	91.88	484.43
	95	2309	46000	82316	800	1011	832	390.21	809	112.45	502.66
U.S. City Average (3.8)	70	2080	40000	90667	400	988	896	547.46	395	31.60	579.06
	95	2080	40000	71579	650	912	653	398.98	593	47.44	446.42
	95	2080	40000	71579	800	911	652	398.37	728	58.24	456.61

*See Appendix D for example calculation

Table 4 Electric to Fuel (Natural Gas) Cost Ratio Based on Cost Data for $/500 Kwh and $/100 Therm.* (See BLS Data Appendix E for August 1986.)

Cost Ratio Location		(RC)
1.	Chicago	8.2
2.	Kansas City	7.0
3.	Anchorage	6.5
4.	Cleveland	6.4
5.	Dallas/Ft. Worth	5.4
6.	St. Louis	5.4
7.	San Diego	5.1
8.	New York	4.8
9.	Denver	4.7
10.	Detroit	4.7
11.	Philadelphia	4.3
12.	Buffalo	4.2
13.	Cincinatti	4.2
14.	Minneapolis/St. Paul	4.2
15.	Pittsburgh	4.1
16.	N.E. Pennsylvania	3.9
17.	Baltimore	3.8
18.	Boston	3.7
19.	Washington, D.C.	3.6
20.	San Francisco	3.6
21.	Atlanta	3.4
22.	Milwaukee	3.4
23.	Los Angeles/Aneheim	3.3
24.	Portland, Oregon	2.4
25.	Seattle	1.8
U.S. City Average		4.1

* Cost for these larger amounts of energy is considered more representative for central heating customers than average data for all customers (i.e. Appendix E).

Table 5 Comparison of Savings Determined by Three Methods (AFUE, SEUF, & Cost of Operation) for Single Stage vs. Two Stage Furnace Control

Table 5A

National Average Weather and Fuel Cost of 64¢/Therm and Electric Cost of 8¢/Kwh

Control Type	Annual Cost of Fuel	Annual Cost of Electricity	AFUE	SEUF	Total Annual Cost
Single Stage	$547	$32	70.0	67.6	$579
Two Stage	$499	65	75.0	69.3	$564
% Savings	--	--	6.6%	2.5%	2.5%

Table 5B

Chicago, IL
(Fuel Cost 46.9¢/Therm; Electricity Cost 13.9¢/Kwh)

Control Type	Annual Cost of Fuel	Annual Cost of Electricity	AFUE	SEUF	Total Annual Cost
Single Stage	$538	$ 61	70.0	64.0	$599
Two Stage	$492	$127	75.0	62.0	$619
% Savings	--	__	6.6%	-3.2%	-3.3%

Table 5C

(Cleveland, OH)
(Fuel Cost 50.8¢/Therm; Electricity Cost 11.0¢/Kwh)

Control Type	Annual Cost of Fuel	Annual Cost of Electricity	AFUE	SEUF	Total Annual Cost
Single Stage	$526	$47	70.0	65.6	$573
Two Stage	$480	$97	75.0	65.0	$577
% Savings	--	--	6.6%	-0.9%	-0.7%

Seasonal Energy Utilization Factors (SEUF) and DOE Energy Factors vs. AFUE for Cost Ratios (RC) from 1.5 to 9.0

Figure 1. For Input Power Rating of 400 Watts and Burner Input Rating of 50,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

RC \ AFUE	60	65	70	75	80	85	90	95
1.5	60.3	65.1	69.9	74.7	79.5	84.3	89.1	93.9
2.0	59.5	64.2	69.0	73.7	78.4	83.2	87.9	92.7
2.5	58.7	63.4	68.1	72.8	77.4	82.1	86.8	91.5
3.0	58.0	62.6	67.2	71.8	76.5	81.1	85.7	90.3
3.5	57.3	61.8	66.4	71.0	75.5	80.1	84.6	89.2
4.0	56.6	61.1	65.6	70.1	74.6	79.1	83.6	88.1
4.5	55.9	60.3	64.8	69.2	73.7	78.1	82.6	87.0
5.0	55.2	59.6	64.0	68.4	72.8	77.2	81.6	86.0
5.5	54.5	58.9	63.2	67.6	71.9	76.3	80.6	85.0
6.0	53.9	58.2	62.5	66.8	71.1	75.4	79.7	84.0
6.5	53.3	57.5	61.8	66.0	70.3	74.5	78.8	83.0
7.0	52.7	56.9	61.1	65.3	69.5	73.7	77.9	82.0
7.5	52.1	56.2	60.4	64.5	68.7	72.8	77.0	81.1
8.0	51.5	55.6	59.7	63.8	67.9	72.0	76.1	80.2
8.5	50.9	55.0	59.0	63.1	67.1	71.2	75.3	79.3
9.0	50.4	54.4	58.4	62.4	66.4	70.4	74.4	78.5

DOE ENERGY FACTOR

RC \ AFUE	60	65	70	75	80	85	90	95
ALL*	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

Note. Input power rating and burner input ratings refer to metered rates during steady state operation.

* DOE energy factors do not change with RC ratios. Values shown apply to RC from 1.5 to 9.0 as well as all other RC values.

Figure 2. Input Power 400 **Watts**, **Burner** Input 100,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.1	65.0	69.9	74.8	79.7	84.6	89.5	94.4
2.0	59.7	64.6	69.5	74.3	79.2	84.1	88.9	93.8
2.5	59.3	64.2	69.0	73.8	78.7	83.5	88.3	93.2
3.0	59.0	63.8	68.6	73.4	78.2	83.0	87.8	92.6
3.5	58.6	63.3	68.1	72.9	77.7	82.4	87.2	92.0
4.0	58.2	62.9	67.7	72.4	77.2	81.9	86.6	91.4
4.5	57.8	62.5	67.2	71.9	76.7	81.4	86.1	90.8
5.0	57.4	62.1	66.8	71.5	76.2	80.8	85.5	90.2
5.5	57.1	61.7	66.4	71.0	75.7	80.3	85.0	89.6
6.0	56.7	61.3	66.0	70.6	75.2	79.8	84.4	89.1
6.5	56.4	61.0	65.5	70.1	74.7	79.3	83.9	88.5
7.0	56.0	60.6	65.1	69.7	74.3	78.8	83.4	88.0
7.5	55.7	60.2	64.7	69.3	73.8	78.3	82.9	87.4
8.0	55.3	59.8	64.3	68.8	73.4	77.9	82.4	86.9
8.5	55.0	59.5	63.9	68.4	72.9	77.4	81.9	86.3
9.0	54.7	59.1	63.6	68.0	72.5	76.9	81.4	85.8

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7

Figure 3. Input Power 400 **Watts**, **Burner** Input 150,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.1	65.0	70.0	74.9	79.8	84.8	89.7	94.6
2.0	59.8	64.7	69.6	74.6	79.5	84.4	89.3	94.2
2.5	59.6	64.4	69.3	74.2	79.1	84.0	88.9	93.8
3.0	59.3	64.2	69.0	73.9	78.8	83.6	88.5	93.4
3.5	59.0	63.9	68.7	73.6	78.4	83.3	88.1	92.9
4.0	58.8	63.6	68.4	73.2	78.1	82.9	87.7	92.5
4.5	58.5	63.3	68.1	72.9	77.7	82.5	87.3	92.1
5.0	58.3	63.0	67.8	72.6	77.4	82.2	87.0	91.7
5.5	58.0	62.8	67.5	72.3	77.1	81.8	86.6	91.3
6.0	57.8	62.5	67.2	72.0	76.7	81.5	86.2	90.9
6.5	57.5	62.2	66.9	71.7	76.4	81.1	85.8	90.6
7.0	57.3	62.0	66.7	71.4	76.1	80.8	85.5	90.2
7.5	57.0	61.7	66.4	71.1	75.7	80.4	85.1	89.8
8.0	56.8	61.4	66.1	70.8	75.4	80.1	84.7	89.4
8.5	56.5	61.2	65.8	70.5	75.1	79.7	84.4	89.0
9.0	56.3	60.9	65.5	70.2	74.8	79.4	84.0	88.6

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1

Figure 4. Input Power 650 Watts, **Burner Input** 50,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.4	65.1	69.8	74.5	79.2	83.9	88.5	93.2
2.0	59.2	63.8	68.4	73.0	77.6	82.1	86.7	91.3
2.5	58.0	62.5	67.0	71.5	76.0	80.5	85.0	89.5
3.0	56.9	61.3	65.7	70.1	74.5	78.9	83.3	87.8
3.5	55.8	60.1	64.4	68.8	73.1	77.4	81.7	86.1
4.0	54.7	59.0	63.2	67.5	71.7	76.0	80.2	84.4
4.5	53.7	57.9	62.0	66.2	70.4	74.6	78.7	82.9
5.0	52.7	56.8	60.9	65.0	69.1	73.2	77.3	81.4
5.5	51.8	55.8	59.8	63.9	67.9	71.9	75.9	79.9
6.0	50.9	54.8	58.8	62.7	66.7	70.6	74.6	78.5
6.5	50.0	53.9	57.8	61.7	65.5	69.4	73.3	77.2
7.0	49.2	53.0	56.8	60.6	64.4	68.2	72.1	75.9
7.5	48.3	52.1	55.9	59.6	63.4	67.1	70.9	74.6
8.0	47.6	51.2	54.9	58.6	62.3	66.0	69.7	73.4
8.5	46.8	50.4	54.1	57.7	61.3	64.9	68.6	72.2
9.0	46.0	49.6	53.2	56.8	60.3	63.9	67.5	71.1

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	57.5	62.2	67.0	71.8	76.6	81.4	86.2	91.0

Figure 5. Input Power 650 Watts, Burner Input 100,000 But/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.2	65.1	69.9	74.7	79.6	84.4	89.2	94.1
2.0	59.6	64.4	69.2	73.9	78.7	83.5	88.3	93.1
2.5	58.9	63.7	68.4	73.2	77.9	82.6	87.4	92.1
3.0	58.3	63.0	67.7	72.4	77.1	81.8	86.5	91.2
3.5	57.7	62.4	67.0	71.7	76.3	80.9	85.6	90.2
4.0	57.1	61.7	66.3	70.9	75.5	80.1	84.7	89.3
4.5	56.6	61.1	65.7	70.2	74.8	79.3	83.8	88.4
5.0	56.0	60.5	65.0	69.5	74.0	78.5	83.0	87.5
5.5	55.5	59.9	64.4	68.8	73.3	77.7	82.2	86.6
6.0	54.9	59.3	63.7	68.1	72.6	77.0	81.4	85.8
6.5	54.4	58.7	63.1	67.5	71.9	76.2	80.6	85.0
7.0	53.9	58.2	62.5	66.8	71.2	75.5	79.8	84.2
7.5	53.3	57.6	61.9	66.2	70.5	74.8	79.1	83.4
8.0	52.8	57.1	61.3	65.6	69.8	74.1	78.3	82.6
8.5	52.3	56.6	60.8	65.0	69.2	73.4	77.6	81.8
9.0	51.9	56.0	60.2	64.4	68.5	72.7	76.9	81.0

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	58.7	63.6	68.5	73.4	78.3	83.2	88.0	92.9

Figure 6. Input Power 650 Watts, Burner Input 150,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.1	65.0	69.9	74.8	79.7	84.6	89.5	94.4
2.0	59.7	64.6	69.4	74.3	79.1	84.0	88.9	93.7
2.5	59.3	64.1	68.9	73.8	78.6	83.4	88.2	93.0
3.0	58.9	63.7	68.4	73.2	78.0	82.8	87.6	92.4
3.5	58.5	63.2	68.0	72.7	77.5	82.2	87.0	91.7
4.0	58.0	62.8	67.5	72.2	76.9	81.6	86.4	91.1
4.5	57.6	62.3	67.0	71.7	76.4	81.1	85.8	90.5
5.0	57.2	61.9	66.6	71.2	75.9	80.5	85.2	89.8
5.5	56.9	61.5	66.1	70.7	75.3	80.0	84.6	89.2
6.0	56.5	61.1	65.7	70.2	74.8	79.4	84.0	88.6
6.5	56.1	60.6	65.2	69.8	74.3	78.9	83.5	88.0
7.0	55.7	60.2	64.8	69.3	73.8	78.4	82.9	87.4
7.5	55.3	59.8	64.3	68.8	73.3	77.8	82.3	86.8
8.0	55.0	59.4	63.9	68.4	72.9	77.3	81.8	86.3
8.5	54.6	59.1	63.5	67.9	72.4	76.8	81.3	85.7
9.0	54.3	58.7	63.1	67.5	71.9	76.3	80.7	85.1

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	59.1	64.1	69.0	73.9	78.8	83.8	88.7	93.6

Figure 7. Input Power 800 Watts, Burner Input 50,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.5	65.1	69.7	74.4	79.0	83.6	88.2	92.9
2.0	59.0	63.5	68.0	72.5	77.0	81.6	86.1	90.6
2.5	57.6	62.0	66.4	70.8	75.2	79.6	84.0	88.4
3.0	56.2	60.5	64.8	69.1	73.4	77.7	82.0	86.3
3.5.	55.0	59.2	63.4	67.6	71.7	75.9	80.1	84.3
4.0	53.7	57.8	61.9	66.0	70.1	74.2	78.3	82.5
4.5	52.5	56.6	60.6	64.6	68.6	72.6	76.6	80.6
5.0	51.4	55.3	59.3	63.2	67.1	71.1	75.0	78.9
5.5	50.3	54.2	58.0	61.9	65.7	69.6	73.4	77.3
6.0	49.3	53.1	56.8	60.6	64.4	68.1	71.9	75.7
6.5	48.3	52.0	55.7	59.4	63.1	66.8	70.5	74.1
7.0	47.4	51.0	54.6	58.2	61.8	65.4	69.1	72.7
7.5	46.4	50.0	53.5	57.1	60.6	64.2	67.7	71.3
8.0	45.6	49.0	52.5	56.0	59.5	63.0	66.4	69.9
8.5	44.7	48.1	51.5	55.0	58.4	61.8	65.2	68.6
9.0	43.9	47.2	50.6	53.9	57.3	60.7	64.0	67.4

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

Figure 8. Input Power 800 Watts, Burner Input 100,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.3	65.1	69.9	74.7	79.5	84.3	89.1	93.9
2.0	59.5	64.2	69.0	73.7	78.4	83.2	87.9	92.7
2.5	58.7	63.4	68.1	72.8	77.4	82.1	86.8	91.5
3.0	58.0	62.6	67.2	71.8	76.5	81.1	85.7	90.3
3.5	57.3	61.8	66.4	71.0	75.5	80.1	84.6	89.2
4.0	56.6	61.1	65.6	70.1	74.6	79.1	83.6	88.1
4.5	55.9	60.3	64.8	69.2	73.7	78.1	82.6	87.0
5.0	55.2	59.6	64.0	68.4	72.8	77.2	81.6	86.0
5.5	54.5	58.9	63.2	67.6	71.9	76.3	80.6	85.0
6.0	53.9	58.2	62.5	66.8	71.1	75.4	79.7	84.0
6.5	53.3	57.5	61.8	66.0	70.3	74.5	78.8	83.0
7.0	52.7	56.9	61.1	65.3	69.5	73.7	77.9	82.0
7.5	52.1	56.2	60.4	64.5	68.7	72.8	77.0	81.1
8.0	51.5	55.6	59.7	63.8	67.9	72.0	76.1	80.2
8.5	50.9	55.0	59.0	63.1	67.1	71.2	75.3	79.3
9.0	50.4	54.4	58.4	62.4	66.4	70.4	74.4	78.5

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

Figure 9. Input Power 800 Watts, Burner Input 150,000 Btu/h

SEASONAL ENERGY UTILIZATION FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
1.5	60.2	65.0	69.9	74.8	79.6	84.5	89.4	94.2
2.0	59.6	64.5	69.3	74.1	78.9	83.8	88.6	93.4
2.5	59.1	63.9	68.7	73.5	78.3	83.0	87.8	92.6
3.0	58.6	63.4	68.1	72.8	77.6	82.3	87.1	91.8
3.5	58.1	62.8	67.5	72.2	76.9	81.6	86.3	91.0
4.0	57.6	62.3	66.9	71.6	76.3	80.9	85.6	90.2
4.5	57.1	61.8	66.4	71.0	75.6	80.2	84.9	89.5
5.0	56.7	61.2	65.8	70.4	75.0	79.6	84.2	88.7
5.5	56.2	60.7	65.3	69.8	74.4	78.9	83.5	88.0
6.0	55.7	60.2	64.7	69.3	73.8	78.3	82.8	87.3
6.5	55.3	59.8	64.2	68.7	73.2	77.6	82.1	86.6
7.0	54.8	59.3	63.7	68.1	72.6	77.0	81.4	85.9
7.5	54.4	58.8	63.2	67.6	72.0	76.4	80.8	85.2
8.0	54.0	58.3	62.7	67.1	71.4	75.8	80.1	84.5
8.5	53.5	57.9	62.2	66.5	70.9	75.2	79.5	83.8
9.0	53.1	57.4	61.7	66.0	70.3	74.6	78.9	83.2

DOE ENERGY FACTOR

\A R\F C\U \E	60	65	70	75	80	85	90	95
ALL	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

Seasonal Energy Utilization Factors (SEUF) and DOE Energy Factors vs. Furnace Power Rating (Watts -EE) for Annual Fuel Utilization Efficiencies (AFUE) from 60 to 95% and for Electric to Fuel Cost Ratios (RC) from 1.5 to 8.5

Figure 10. Burner Fuel Input Rating 50,000 Btu/h

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 1.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	60.2	65.0	69.9	74.8	79.6	84.5	89.3	94.2
400.	60.3	65.1	69.9	74.7	79.5	84.3	89.1	93.9
500.	60.3	65.1	69.8	74.6	79.4	84.1	88.9	93.6
600.	60.4	65.1	69.8	74.5	79.2	83.9	88.6	93.4
700.	60.4	65.1	69.8	74.4	79.1	83.8	88.4	93.1
800.	60.5	65.1	69.7	74.4	79.0	83.6	88.2	92.9

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 2.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.0	63.8	68.5	73.3	78.1	82.8	87.6	92.3
400.	58.7	63.4	68.1	72.8	77.4	82.1	86.8	91.5
500.	58.4	63.0	67.6	72.2	76.9	81.5	86.1	90.7
600.	58.1	62.7	67.2	71.7	76.3	80.8	85.4	89.9
700.	57.9	62.3	66.8	71.3	75.7	80.2	84.7	89.1
800.	57.6	62.0	66.4	70.8	75.2	79.6	84.0	88.4

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

Figure 11. Burner Fuel Input Rate 50,000 Btu/h; RC = 3.5 - 4.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 3.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	57.9	62.6	67.2	71.9	76.6	81.2	85.9	90.6
400.	57.3	61.8	66.4	71.0	75.5	80.1	84.6	89.2
500.	56.6	61.1	65.6	70.0	74.5	79.0	83.4	87.9
600.	56.1	60.4	64.8	69.2	73.6	77.9	82.3	86.7
700.	55.5	59.8	64.1	68.3	72.6	76.9	81.2	85.5
800.	55.0	59.2	63.4	67.6	71.7	75.9	80.1	84.3

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 4.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	56.8	61.4	66.0	70.5	75.1	79.7	84.3	88.9
400.	55.9	60.3	64.8	69.2	73.7	78.1	82.6	87.0
500.	55.0	59.3	63.6	68.0	72.3	76.6	81.0	85.3
600.	54.1	58.3	62.6	66.8	71.0	75.2	79.5	83.7
700.	53.3	57.4	61.5	65.7	69.8	73.9	78.0	82.1
800.	52.5	56.6	60.6	64.6	68.6	72.6	76.6	80.6

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

Figure 12. Burner Fuel Input 50,000 Btu/h; RC = 5.5 and 6.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 5.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	55.8	60.3	64.8	69.2	73.7	78.2	82.7	87.2
400.	54.5	58.9	63.2	67.6	71.9	76.3	80.6	85.0
500.	53.4	57.6	61.8	66.0	70.2	74.4	78.6	82.9
600.	52.3	56.4	60.5	64.6	68.6	72.7	76.8	80.9
700.	51.3	55.3	59.2	63.2	67.1	71.1	75.1	79.0
800.	50.3	54.2	58.0	61.9	65.7	69.6	73.4	77.3

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 6.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	54.8	59.2	63.6	68.0	72.4	76.8	81.2	85.6
400.	53.3	57.5	61.8	66.0	70.3	74.5	78.8	83.0
500.	51.9	56.0	60.1	64.2	68.3	72.4	76.5	80.5
600.	50.6	54.6	58.5	62.5	66.4	70.4	74.3	78.3
700.	49.4	53.2	57.1	60.9	64.7	68.5	72.3	76.1
800.	48.3	52.0	55.7	59.4	63.1	66.8	70.5	74.1

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

Figure 13. Burner Fuel Input 50,000 Btu/h; RC = 7.5 and 8.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 7.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	53.8	58.1	62.5	66.8	71.1	75.5	79.8	84.1
400.	52.1	56.2	60.4	64.5	68.7	72.8	77.0	81.1
500.	50.5	54.5	58.5	62.4	66.4	70.4	74.4	78.4
600.	49.0	52.9	56.7	60.5	64.3	68.2	72.0	75.8
700.	47.7	51.4	55.1	58.7	62.4	66.1	69.8	73.5
800.	46.4	50.0	53.5	57.1	60.6	64.2	67.7	71.3

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 8.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	52.8	57.1	61.4	65.6	69.9	74.1	78.4	82.7
400.	50.9	55.0	59.0	63.1	67.1	71.2	75.3	79.3
500.	49.2	53.0	56.9	60.8	64.7	68.5	72.4	76.3
600.	47.5	51.3	55.0	58.7	62.4	66.1	69.8	73.5
700.	46.1	49.6	53.2	56.7	60.3	63.8	67.4	71.0
800.	44.7	48.1	51.5	55.0	58.4	61.8	65.2	68.6

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
400.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5
500.	58.0	62.9	67.7	72.5	77.4	82.2	87.0	91.9
600.	57.6	62.4	67.2	72.0	76.9	81.7	86.5	91.3
700.	57.3	62.0	66.8	71.6	76.4	81.1	85.9	90.7
800.	56.9	61.6	66.4	71.1	75.9	80.6	85.3	90.1

STOP

Figure 14. Burner Input 100,000 Btu/hr; RC = 1.5 and 2.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 1.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	60.1	65.0	69.9	74.9	79.8	84.7	89.6	94.6
400.	60.1	65.0	69.9	74.8	79.7	84.6	89.5	94.4
500.	60.2	65.0	69.9	74.8	79.7	84.5	89.4	94.3
600.	60.2	65.0	69.9	74.8	79.6	84.5	89.3	94.2
700.	60.2	65.1	69.9	74.7	79.5	84.4	89.2	94.0
800.	60.3	65.1	69.9	74.7	79.5	84.3	89.1	93.9

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 2.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.5	64.4	69.3	74.1	79.0	83.9	88.8	93.6
400.	59.3	64.2	69.0	73.8	78.7	83.5	88.3	93.2
500.	59.2	64.0	68.8	73.6	78.4	83.2	88.0	92.7
600.	59.0	63.8	68.5	73.3	78.1	82.8	87.6	92.3
700.	58.9	63.6	68.3	73.0	77.7	82.5	87.2	91.9
800.	58.7	63.4	68.1	72.8	77.4	82.1	86.8	91.5

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

Figure 15. Burner Input 100,000 Btu/hr; RC = 3.5 and 4.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 3.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.9	63.7	68.6	73.4	78.2	83.0	87.9	92.7
400.	58.6	63.3	68.1	72.9	77.7	82.4	87.2	92.0
500.	58.2	62.9	67.7	72.4	77.1	81.8	86.5	91.3
600.	57.9	62.6	67.2	71.9	76.6	81.2	85.9	90.6
700.	57.6	62.2	66.8	71.4	76.0	80.6	85.3	89.9
800.	57.3	61.8	66.4	71.0	75.5	80.1	84.6	89.2

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 4.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.3	63.1	67.9	72.7	77.5	82.2	87.0	91.8
400.	57.8	62.5	67.2	71.9	76.7	81.4	86.1	90.8
500.	57.3	61.9	66.6	71.2	75.9	80.5	85.2	89.8
600.	56.8	61.4	66.0	70.5	75.1	79.7	84.3	88.9
700.	56.3	60.8	65.4	69.9	74.4	78.9	83.4	87.9
800.	55.9	60.3	64.8	69.2	73.7	78.1	82.6	87.0

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

Figure 16. Burner Input 100,000 Btu/hr; RC = 5.5 and 6.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 5.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	57.8	62.5	67.2	72.0	76.7	81.4	86.2	90.9
400.	57.1	61.7	66.4	71.0	75.7	80.3	85.0	89.6
500.	56.4	61.0	65.6	70.1	74.7	79.3	83.8	88.4
600.	55.8	60.3	64.8	69.2	73.7	78.2	82.7	87.2
700.	55.1	59.6	64.0	68.4	72.8	77.2	81.7	86.1
800.	54.5	58.9	63.2	67.6	71.9	76.3	80.6	85.0

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 6.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	57.2	61.9	66.6	71.3	76.0	80.7	85.3	90.0
400.	56.4	61.0	65.5	70.1	74.7	79.3	83.9	88.5
500.	55.5	60.0	64.5	69.0	73.5	78.0	82.5	87.1
600.	54.8	59.2	63.6	68.0	72.4	76.8	81.2	85.6
700.	54.0	58.3	62.7	67.0	71.3	75.6	80.0	84.3
800.	53.3	57.5	61.8	66.0	70.3	74.5	78.8	83.0

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

Figure 17. Burner Input 100,000 Btu/hr; RC = 7.5 and 8.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 7.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	56.7	61.3	66.0	70.6	75.2	79.9	84.5	89.2
400.	55.7	60.2	64.7	69.3	73.8	78.3	82.9	87.4
500.	54.7	59.1	63.6	68.0	72.4	76.9	81.3	85.7
600.	53.8	58.1	62.5	66.8	71.1	75.5	79.8	84.1
700.	52.9	57.1	61.4	65.6	69.9	74.1	78.4	82.6
800.	52.1	56.2	60.4	64.5	68.7	72.8	77.0	81.1

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 8.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	56.1	60.7	65.3	69.9	74.5	79.1	83.7	88.3
400.	55.0	59.5	63.9	68.4	72.9	77.4	81.9	86.3
500.	53.9	58.3	62.6	67.0	71.4	75.7	80.1	84.5
600.	52.8	57.1	61.4	65.6	69.9	74.1	78.4	82.7
700.	51.9	56.0	60.2	64.3	68.5	72.6	76.8	81.0
800.	50.9	55.0	59.0	63.1	67.1	71.2	75.3	79.3

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.4	64.3	69.3	74.2	79.2	84.1	89.1	94.0
400.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
500.	59.0	63.9	68.8	73.7	78.7	83.6	88.5	93.4
600.	58.8	63.7	68.6	73.5	78.4	83.3	88.2	93.1
700.	58.6	63.5	68.4	73.2	78.1	83.0	87.9	92.8
800.	58.4	63.3	68.1	73.0	77.9	82.7	87.6	92.5

STOP

Figure 18. Burner Input 150,000 But/hr; RC - 1.5 and 2.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 1.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	60.1	65.0	70.0	74.9	79.9	84.8	89.8	94.7
400.	60.1	65.0	70.0	74.9	79.8	84.8	89.7	94.6
500.	60.1	65.0	69.9	74.9	79.8	84.7	89.6	94.5
600.	60.1	65.0	69.9	74.8	79.7	84.6	89.5	94.4
700.	60.2	65.0	69.9	74.8	79.7	84.6	89.5	94.3
800.	60.2	65.0	69.9	74.8	79.6	84.5	89.4	94.2

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 2.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.7	64.6	69.5	74.4	79.3	84.2	89.2	94.1
400.	59.6	64.4	69.3	74.2	79.1	84.0	88.9	93.8
500.	59.4	64.3	69.2	74.0	78.9	83.8	88.6	93.5
600.	59.3	64.2	69.0	73.8	78.7	83.5	88.3	93.2
700.	59.2	64.0	68.9	73.7	78.5	83.3	88.1	92.9
800.	59.1	63.9	68.7	73.5	78.3	83.0	87.8	92.6

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

Figure 19. Burner Input 150,000 Btu/hr; RC = 3.5 and 4.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 3.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.3	64.1	69.0	73.9	78.8	83.7	88.6	93.4
400.	59.0	63.9	68.7	73.6	78.4	83.3	88.1	92.9
500.	58.8	63.6	68.4	73.2	78.0	82.8	87.6	92.5
600.	58.6	63.3	68.1	72.9	77.7	82.4	87.2	92.0
700.	58.3	63.1	67.8	72.5	77.3	82.0	86.8	91.5
800.	58.1	62.8	67.5	72.2	76.9	81.6	86.3	91.0

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 4.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.9	63.7	68.6	73.4	78.3	83.1	88.0	92.8
400.	58.5	63.3	68.1	72.9	77.7	82.5	87.3	92.1
500.	58.2	62.9	67.7	72.4	77.2	81.9	86.7	91.5
600.	57.8	62.5	67.2	71.9	76.7	81.4	86.1	90.8
700.	57.5	62.1	66.8	71.5	76.1	80.8	85.5	90.1
800.	57.1	61.8	66.4	71.0	75.6	80.2	84.9	89.5

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

Figure 20. Burner Input 150,000 Btu/hr; RC - 5.5 and 6.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 5.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.5	63.3	68.1	72.9	77.8	82.6	87.4	92.2
400.	58.0	62.8	67.5	72.3	77.1	81.8	86.6	91.3
500.	57.5	62.2	66.9	71.7	76.4	81.1	85.8	90.5
600.	57.1	61.7	66.4	71.0	75.7	80.3	85.0	89.6
700.	56.6	61.2	65.8	70.4	75.0	79.6	84.2	88.8
800.	56.2	60.7	65.3	69.8	74.4	78.9	83.5	88.0

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 6.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	58.1	62.9	67.7	72.5	77.3	82.0	86.8	91.6
400.	57.5	62.2	66.9	71.7	76.4	81.1	85.8	90.6
500.	56.9	61.6	66.2	70.9	75.6	80.2	84.9	89.5
600.	56.4	61.0	65.5	70.1	74.7	79.3	83.9	88.5
700.	55.8	60.3	64.9	69.4	73.9	78.5	83.0	87.5
800.	55.3	59.8	64.2	68.7	73.2	77.6	82.1	86.6

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

Figure 21. Burner Input 150,000 **Btu/hr; RC** - 7.5 and 8.5

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 7.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	57.7	62.5	67.2	72.0	76.8	81.5	86.3	91.0
400.	57.0	61.7	66.4	71.1	75.7	80.4	85.1	89.8
500.	56.3	60.9	65.5	70.2	74.8	79.4	84.0	88.6
600.	55.7	60.2	64.7	69.3	73.8	78.3	82.9	87.4
700.	55.0	59.5	64.0	68.4	72.9	77.4	81.8	86.3
800.	54.4	58.8	63.2	67.6	72.0	76.4	80.8	85.2

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

ELECTRIC TO FOSSIL FUEL BTU COST RATIO (RC)= 8.5

SEASONAL ENERGY UTILIZATION FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	57.4	62.1	66.8	71.5	76.3	81.0	85.7	90.4
400.	56.5	61.2	65.8	70.5	75.1	79.7	84.4	89.0
500.	55.7	60.3	64.9	69.4	74.0	78.5	83.1	87.7
600.	55.0	59.5	63.9	68.4	72.9	77.4	81.9	86.3
700.	54.2	58.7	63.1	67.5	71.9	76.3	80.7	85.1
800.	53.5	57.9	62.2	66.5	70.9	75.2	79.5	83.8

DOE ENERGY FACTOR

\A E\F E\U \E	60	65	70	75	80	85	90	95
300.	59.6	64.6	69.5	74.5	79.5	84.4	89.4	94.4
400.	59.5	64.4	69.4	74.3	79.3	84.2	89.2	94.1
500.	59.3	64.3	69.2	74.2	79.1	84.0	89.0	93.9
600.	59.2	64.1	69.1	74.0	78.9	83.9	88.8	93.7
700.	59.1	64.0	68.9	73.8	78.7	83.7	88.6	93.5
800.	58.9	63.8	68.7	73.7	78.6	83.5	88.4	93.3

STOP

NBS-114A (REV. 2-80)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 87-3645	2. Performing Organ. Report No.	3. Publication Date OCTOBER 1987

4. TITLE AND SUBTITLE

A Study of Three Measures for Energy Efficiency of Fossil Fueled Furnaces and Boilers

5. AUTHOR(S)

Esher Kweller

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
U.S. DEPARTMENT OF COMMERCE
GAITHERSBURG, MD 20899

7. Contract/Grant No.

8. Type of Report & Period Covered

NBSIR

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

U.S. Department of Energy
Office of Builidng Energy Research and Development
Washington, DC 20585

10. SUPPLEMENTARY NOTES

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The effectiveness of three measures of energy efficiency for furnaces has been demonstrated by comparison of the results for predicted energy savings against the cost savings predicted by the calculated total annual cost of operation using DOE test procedures. Two of the efficiency measures currently prescribed by DOE - the Annual Fuel Utilization Efficiency (AFUE) and the DOE Energy Factor (EF) are compared with an industry proposed energy factor - Seasonal Energy Utilization Factor (SEUF).

Various parameters which affect the SEUF factor have also been demonstrated. These include the effects of power rating (wattage), burner input rating, electric to fossil fuel cost ratio, and the effect of annual fuel utilization efficiency (AFUE).

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

annual efficiency, boilers, combustion equipment, efficiency, furnaces, operating costs

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☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

43

15. Price

$11.95

USCOMM-DC 6043-P80