# TECH TIP # 9

HEATING, AIRCONDITIONING & REFRIGERATION DISTRIBUTORS INTERNATIONAL

One of a series of dealer contractor technical advisories prepared by HARDI wholesalers as a customer service.

# ESTIMATING ENERGY USAGE

Recent articles on fuel shortages have rekindled interest in the detailed analysis of seasonal fuel consumption. Now there have been formulae to compute fuel consumption for many years --- with refinements added from time to time. It should be pointed out however, that estimating fuel consumption or heating costs is just that -- an estimate. In most cases proper records of past operating experiences can be a better guide than any *mathematical* approach. Errors by as much as 30 percent are quite possible because of the many variables and uncontrollable conditions involved -- one of which is the homeowner himself.

Despite the many complexities, efforts continue to improve the reliability of estimating procedures. Most formulae used to estimate fuel consumption are modifications of the degree day method:

$$F = \frac{h \times D \times 24}{E \times C}$$

where

**F** = the fuel consumption.
***h*** = the house design heat loss rate divided by the design indoor-outdoor temperature difference.
**D** = the seasonal accumulation of degree days.
**24** = the hours per day.
**E** = the seasonal utilization efficiency of heating equipment.
**C** = the heating value of the fuel.

Use of the degree day is a means to compensate for the fact that *all* the heat supplied to a home does not come from the heating system --- lights, appliances, people and solar heat gain all contribute energy, thereby easing the burden on the furnace.

(continued)

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The degree day is defined as the difference between the average daily temperature and 65º F (65º F is termed the base). So, if a home thermostat is set at 70 or 75º F, the degree day compensates for internal effects by a 5 to 10º F reduction in the indoor-outdoor temperature difference used to calculate the Btu's supplied by the heating system.

But since the adoption of the degree day in the 1930's, many changes have occurred in house construction. Interior lighting levels have increased as have the number and use of appliances, etc., so that, now, straight application of the degree day formula normally results in too high predictions of fuel consumption.

One revision -- made by the electric interests --- has been to reduce the value 24 in the formula by some amount (usually to 18.5) in an effort to make further compensation for modern day internal effects. (Also, since *h* is based on calculated heat loss -- meaning peak infiltration loads compensation is also necessary to allow for the fact that the wind does not blow at 15 mph all the time.)

A recent National Bureau of Standards report indicated that an estimating procedure developed by Professor (emeritus) W.S. Harris, University of Illinois, agree quite favorably with their own study of a full scale house in their test chamber. Here is that procedure.

The formula is identical to the degree day formula with the simple addition of a K correction factor which also includes the value of 24. Thus the revised formula is:

$$F = \frac{h \times D \times K}{E \times C}$$

in which K more realistically compensates for present day internal loads and changes necessary in the degree day base. Values of K for various heat loss rates (Btuh/F) and local degree days (65º F) are shown in Table 1 for an indoor control temperature of 73º F and Table 2 for and inside temperature of 75º F.

Here are the steps to follow to estimate the fuel requirements for a home. Consider a home that has a design heat loss of 60,000 Btuh for a 75º F inside temperature and a minus 5º F outside design temperature. The average seasonal degree days in the locality are 7,000.

The heat loss rate per degree (*h*) is 60,000/75 - (-5) or 750 Btuh/F. From Table 2, reading across from degree days of 7,000, the value of K is between columns headed *h* equal 700 and 800 and numerically is between 24.5 and 25.0 or 24.75. Thus, the Btu's to be supplied by the heating system total:

750 x 7000 x 24.75 or 129,937,500 Btu's/season

This represents the value of the *numerator* in the revised formula -- the product of *h* x D x K.

To determine the cubic foot of natural gas, Kw hour of electricity, or gallons of fuel oil necessary to produce this many Btu's, we must consider the terms in the *denominato*r of the formula.

The seasonal utilization efficiency (E) for oil or gas furnaces ranges between 70 and 80 percent. Electricity is usually considered to have a 95 to 100 percent utilization efficiency.

Table 3 indicates the heat content of each fuel (C) for typical sale units of the fuel in question --- cubic foot, gallons, Kw hr.

Assuming a utilization efficiency of 75 percent and a mean value of 1,000 Btu/cubic foot, the required cubic foot of natural gas to produce the estimated seasonal Btu's would be:

$$\frac{129{,}937{,}500}{(.75)\,(1{,}000)}$$

or 165,000 cubic foot/season

The required gallon of fuel oil --- assuming mean values of E and C would be:

$$\frac{129{,}937{,}500}{(.75)\,(139{,}400)}$$

or 1240 gallons per season

and the required Kw hour of electricity (E = 1) would be:

$$\frac{129{,}937{,}500}{(1.0)\,(3{,}413)}$$

or 38,100 Kw hour/season

The conversion of these fuel requirements into dollars and cents that the homeowner can appreciate more directly is not as easy as might first appear. Gas and electric rates are on a sliding scale. Actually, monthly costs depend upon the fuel consumption of non-heating related appliances as well -- dryer, water heater, oven and range, even lights and TV.

The dealer contractor in principle fulfills his responsibility by providing the customer with the estimated fuel requirements. But as a practical fact, the customer will probably ask for a dollar and cents figure, which means the dealer contractor must be familiar with local utility rate structures -- at least to the extent that some average figure such as 70 cents/therm for natural gas, 7.6 cents/Kwh for electricity or $1.10/gal for oil can be applied to get a reasonable comparative dollar analysis. For borderline cases, or for customers contemplating a single energy home, the homeowner can seek specific cost estimates directly from their local utilities -- armed with the fuel heating estimates.

**Table 1 --- CORRECTION K** as a function of heat loss rate (*h*) and degree days for an inside temperature of 73º F.

| **Value of K -- Inside Temperature 73º F** | | | | | | | |
|---|---|---|---|---|---|---|---|
| *h* = | 300 | 400 | 500 | 600 | 700 | 800 | 900 |
| Degree Day/Season | | | | | | | |
| 1,000 | 6.1 | 12.2 | 15.9 | 18.4 | 20.1 | 21.4 | 22.4 |
| 2,000 | 12.0 | 16.1 | 18.6 | 20.2 | 21.4 | 22.3 | 23.0 |
| 3,000 | 14.5 | 17.8 | 19.7 | 21.0 | 21.9 | 22.6 | 23.2 |
| 4,000 | 16.0 | 18.7 | 20.4 | 21.5 | 22.3 | 22.8 | 23.3 |
| 5,000 | 16.9 | 19.4 | 20.8 | 21.8 | 22.5 | 23.0 | 23.4 |
| 6,000 | 17.6 | 19.8 | 21.1 | 22.0 | 22.6 | 23.1 | 23.4 |
| 7,000 | 18.2 | 20.2 | 21.4 | 22.2 | 22.7 | 23.2 | 23.5 |
| 8,000 | 18.6 | 20.5 | 21.6 | 22.3 | 22.8 | 23.2 | 23.5 |
| 9,000 | 19.0 | 20.7 | 21.7 | 22.4 | 22.9 | 23.3 | 23.6 |
| 10,000 | 19.3 | 20.9 | 21.9 | 22.5 | 23.0 | 23.3 | 23.6 |
| 11,000 | 19.5 | 21.1 | 22.0 | 22.6 | 23.0 | 23.4 | 23.6 |
| 12,000 | 19.7 | 21.2 | 22.1 | 22.7 | 23.1 | 23.4 | 23.6 |

Seasonal fuel requirements can be estimated by using the formula F = *h*DK/EC --- where *F* is fuel needs in cubic foot, gallons, etc. per season; *h* is house heat loss divided by design temperature difference; *K* is revised correction for internal gains (values are in Table 1 and Table 2 below); *E* is utilization efficiency -- 70 to 80 percent for gas and oil; 95 to 100 percent for electricity; and *C* is heat content of fuel -- Table 3.

Example: assume house loss is 60,000 Btuh with 75º F inside and minus 5º F outside. Degree days total 7,000. Design difference is 75 - (-5) or 80º F; thus *h* is 60,000/80 or 750 Btuh/F. From Table 2 (below), *K* equals 24.75 (between 24.5 and 25.0 -- see bold figures).

For gas assume *E* is 75 percent and *C* is 1,000 Btuh/cubic foot. Hence: 750 x 7,000 x 24.75 divided by 0.75 x 1,000 yields that F equals 165,000 cubic feet per season.

**Table 2 -- VALUE OF K** for selected degree days and house heat loss (h) and an inside temperature of 75º F.

| Value of K -- Inside Temperature 75º F | | | | | | | |
|---|---|---|---|---|---|---|---|
| *h* = | 300 | 400 | 500 | 600 | 700 | 800 | 900 |
| Degree Day/Season | | | | | | | |
| 1,000 | 11.9 | 17.9 | 21.8 | 24.0 | 25.7 | 27.2 | 28.3 |
| 2,000 | 15.9 | 20.0 | 22.5 | 24.0 | 25.1 | 26.1 | 27.0 |
| 3,000 | 17.6 | 20.8 | 22.8 | 24.0 | 24.9 | 25.7 | 26.3 |
| 4,000 | 18.6 | 21.2 | 23.0 | 24.0 | 24.8 | 25.4 | 25.9 |
| 5,000 | 19.2 | 21.6 | 23.1 | 24.0 | 247 | 25.2 | 25.7 |
| 6,000 | 19.6 | 21.9 | 23.2 | 24.0 | 24.6 | 25.1 | 25.5 |
| 7,000 | 20.1 | 22.0 | 23.3 | 24.0 | 24.5 | 25.0 | 25.4 |
| 8,000 | 20.4 | 22.2 | 23.3 | 24.0 | 24.5 | 25.0 | 25.3 |
| 9,000 | 20.6 | 22.3 | 23.4 | 24.0 | 24.5 | 24.9 | 25.2 |
| 10,000 | 20.8 | 22.4 | 23.4 | 24.0 | 24.5 | 24.9 | 25.1 |
| 11,000 | 20.9 | 22.5 | 23.4 | 24.0 | 24.4 | 24.8 | 25.1 |
| 12,000 | 21.0 | 22.5 | 23.5 | 24.0 | 24.4 | 24.8 | 25.0 |

**Table 3 -- HEAT CONTENT (C) of fuels per sale unit**

| Value of C | |
|---|---|
| Fuel | Heat Content |
| Natural Gas | 950 to 1050 Btu/cubic foot |
| No. 2 Fuel Oil | 137,000 to 141,800 Btu/gallon |
| Electricity | 3413 Btu/kilowatt hour |