by George Solli

Off-Peak Power for Home Heating

Sources of Heat

There are five principal sources of heat available to home owners. Of these five – wood, gas, coal, oil, and electricity – wood is almost never used other than in fireplaces or small cabins because of high cost either in dollars or in labor, and the need for constant attention to keep the fire going. Gas, in the interior of Alaska, is simply not available in quantity while the cost of propane makes it prohibitively expensive as a home heating fuel. Coal is used and, at present costs, is the cheapest source of heat for the home owner (see Figure 1). Coal is somewhat like wood in that it requires regular attention, removal and disposal of ashes and, in general, necessitates the control of dust and dirt. For these reasons people have been willing to pay the additional costs for the higher priced fuels. Oil is perhaps the most widely used fuel, more expensive than coal but easier to handle. Oil furnaces are automatic and one only has to set the thermostat and pay the bill. Electricity is another method of home heating. It provides, generally, more localized control of temperatures within the home. Although more expensive than coal or oil, the initial installation of an electrical heating system is lower. This, coupled with the convenience of setting individual room temperatures, has convinced some the added cost is worthwhile. Electrical power can be derived from a number of primary energy sources: *coal or oil fired boilers, diesel engines,* hydro stations or nuclear reactors.

Nuclear reactors are not generally available and can be considered still in the experimental/developmental stage. The few installations in operation are costly to run and to a large extent their principal purpose is the accumulation of engineering data needed in the development of nuclear power as a practical and economical source of power.

In the interior of Alaska, hydro-electric installations are non-existent. This source of power should be developed as it is one of the few sources of power that is renewable, non-polluting and reasonably efficient. Generation of electrical power is principally from coal or oil-fired boilers, with coal being far less costly than oil. Diesel engine-powered generators are only used when it is not feasible to use coal or oil or when additional power is needed for short periods of time.

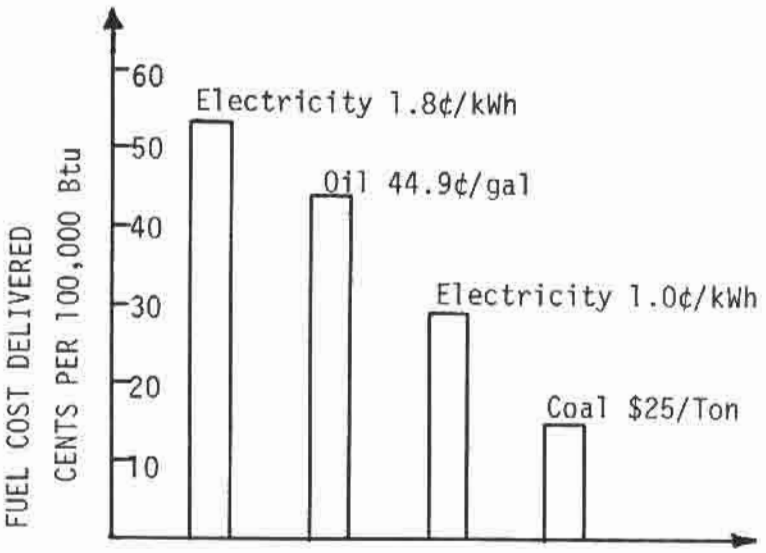

FIGURE 1. Fuel Costs

The practice of coal-generated power should be encouraged. Coal is available in large quantities compared with oil and can only be utilized as a fuel to supply heat. Oil, on the other hand, is in short supply and is used for lubricants, petro chemicals, automotive fuels and a host of products that cannot be made from coal.

Methods of Heating Homes

The principal goal of any heating system is to maintain a uniform air temperature within the space to be heated. Oil, coal, and electric heating systems have been developed which do this very well and, depending upon the system, do it with various degrees of effort on the part of the operator.

There are four principal methods of transporting heat from the heat source to the interior of the home. These are (1) hot water and interior convectors; (2) steam and interior convectors; (3) hot air distributed by ducts; and (4) electrically heated convectors.

Steam systems are rarely used in home heating any more due to the difficulty of maintaining small systems in proper operating condition; also the original installation costs are high.

The perimeter hot water convector systems are probably the most popular; they provide reasonably uniform temperature control and are reliable and relatively maintenance free. Forced hot air systems generally are improperly installed and, as a result, greater temperature variations are found along with drafts and increased noise. Properly installed systems have the *advantage of being able to humidify and* filter the air and can provide a dust-pollen free, uniform temperature environment for the resident.

Electric heat is introduced directly to the air in the space it is needed.

The total cost of heating a home is the cost of the Btu's used, the cost of the conversion unit and its distribution system amortized over the life of the system. A common misconception is that if insulation is better, electric heat is cheaper than oil heat. The amount of insulation used only affects the amount of heat used and not the cost of the heat. Better insulation

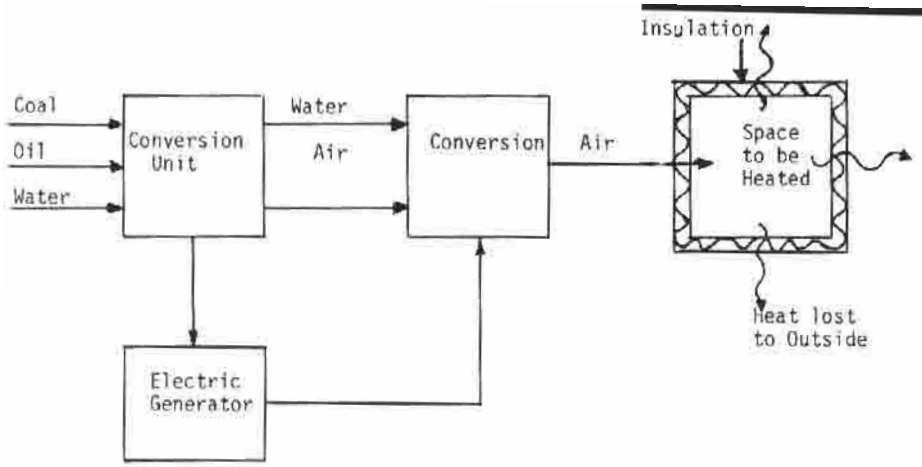

FIGURE 2. Conversion and Transportation of Energy

means less heat lost to the great outdoors and, therefore, a lower heating bill, regardless of the source of heat. (There are tradeoffs on the amount of insulation vs the amount of heat one can afford to lose, but that is another subject of lengthy proportions and has been treated previously in *The Northern Engineer:* Rice, Vol. 5, No. 2, Summer 1973).

Figure 2 shows, schematically, the principal methods used to heat homes.

Electric Heat

Large power stations are capable of generating large quantities of electrical power using coal or oil as the primary source of power. These power stations typically operate with efficiencies about 33 to 35 percent (see Figure 3).

Of the 285 Btu's derived from the combustion of the fuel, 35 Btu's are lost up the stack, 150 Btu's are lost in the cooling water and 100 Btu's are delivered to the electrical distribution system. The distribution systems usually are capable of about 95 percent efficiencies.

These large generation plants usually supply the base load demanded by the distribution system, but since their response time is slow compared to the demand variations, many generation systems rely upon diesel or gas turbine-generated power to meet peak power demands (see Figure 4).

The generation of power to meet the variations in demand is costly. Power companies are constantly striving to "level" the demand curve to reduce costs of operation and, hence, the cost of power to the consumer. Some power companies offer reduced rates to consumers who use off-peak power and almost all companies have rate structures for their large consumers, which provide for higher rates if the consumers' peak demands vary greatly from their base loads. This makes it attractive for large consumers of power to make a conscious effort to level their load requirements during each day, week or month. This has helped to level the demand load experienced by the generation plant.

Heat Sinks

In order to take advantage of off-peak power it is necessary to store the heat for use at a later time. In developing a storage system the cost must be low or the advantage is lost. There are a number of materials that can be used as a heat sink; however, it appears that water, concrete or cast iron/steel offer the lowest cost and best reliability. Figure 5 gives the heat capacity of various materials, the temperature range of operation and the amount of heat that can be stored.

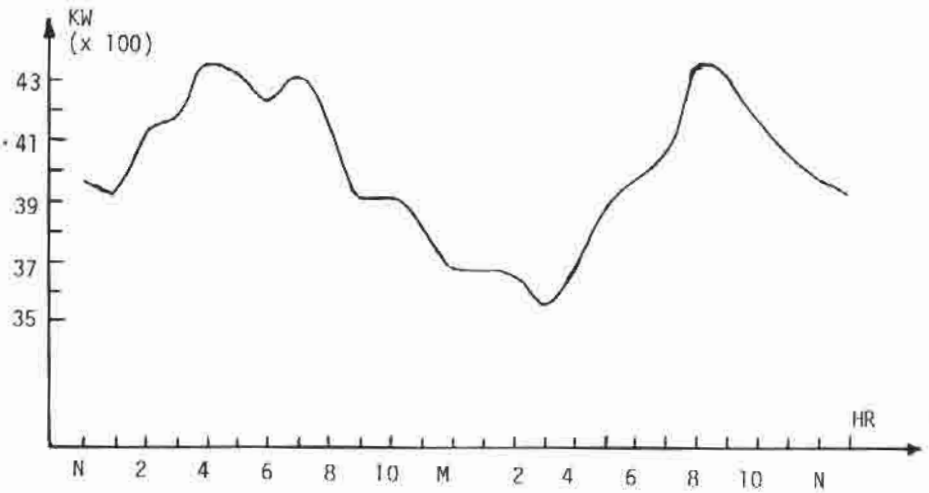

FIGURE 4. Power Demand Curve (Golden Valley Electric Association, Nov. 30, 1973)

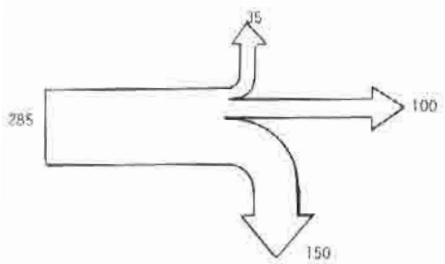

FIGURE 3. Efficiency of Large Electrical Power Generation Stations *(Building Systems Design,* **Dec/Jan '74, pp 15-18)**

The choice of material to be used as a heat sink is limited to water if a hot water baseboard heat transport system is to be used. All of the listed material can be used in a circulatory air system. In addition, the circulating air system makes it possible to install air filtering and humidity control, features which to many

MATERIAL	Btu ft^3/^{o}F	Δt ^{o}F	Btu/f^3
Water	62.4	100	6,240
Concrete	37.7	800	30,160
Iron-Steel	53.8	800	43,040
Brick	24.0	800	19,200
Ethylene Glycol	41.6	250	10,400

FIGURE 5. *Heat Pumps and Electric Heating,* **E. R. Ambrose, John Wiley & Sons, Inc. p. 21.**

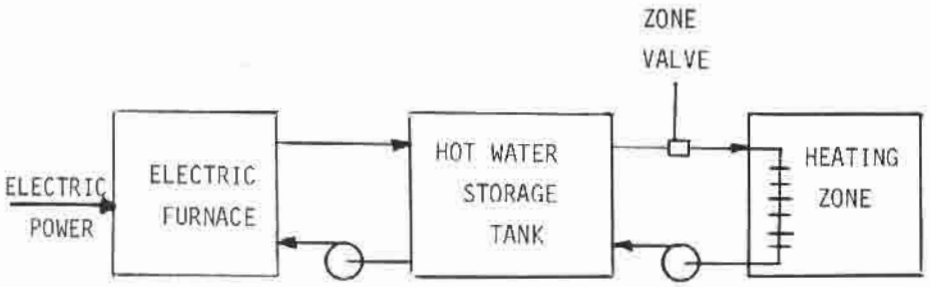

FIGURE 6. Electrical Heating System Utilizing a Heat Sink

people are highly desirable.

Hot Water System

A heating system utilizing water as the heat sink is shown in Figure 6. The size of the water tank needed for heat storage for a 24 hour period can be determined by the use of the chart shown in Figure 7. Since the house can be heated directly during the time the off-peak power is available, the volume of water required for heat storage is reduced (see Figure 8).

The chart, Figure 7, is used as follows: starting with the standard furnace size needed for normal 24 hour operation and moving clockwise, we can determine the size of the furnace needed for off-peak operation depending upon the time period off-peak power is available. The amount of Btu's supplied by the off-peak furnace is found by using the curve in the upper right quadrant. The volume of water, in cubic feet, if found in the lower right quadrant by relating the Btu requirement to the operating temperature range to be used. The lower left quadrant converts cubic feet of water to gallons.

In the example we have:

Standard furnace size	15 kW
Off-peak furnace size (12 hr)	30 kW
Btu's delivered	1,229,400 Btu
Volume of Water	245 cu. ft.
Volume of Water	1,920 gals.

This volume, 1920 gallons, will heat the house for a 24 hour period. Since, on a 12 hour off-peak cycle, it is only necessary to heat from the storage system for 12 hours, the volume required is one half or 960 gallons. (An 8 hour off-peak cycle would require 2/3 of the volume or 1278 gallons.)

It is estimated that a 2,000 gallon tank and the related piping, pumps and controls could be installed and properly insulated at a cost of about $1,000 if installation took place during the initial house construction. If the cost of electrical power is reduced from 1.8 cents per kWh to 1.0 cents per kWh, the cost of installing the hot water storage tank will be paid for when 125,000 kWh of electrical power has been used.

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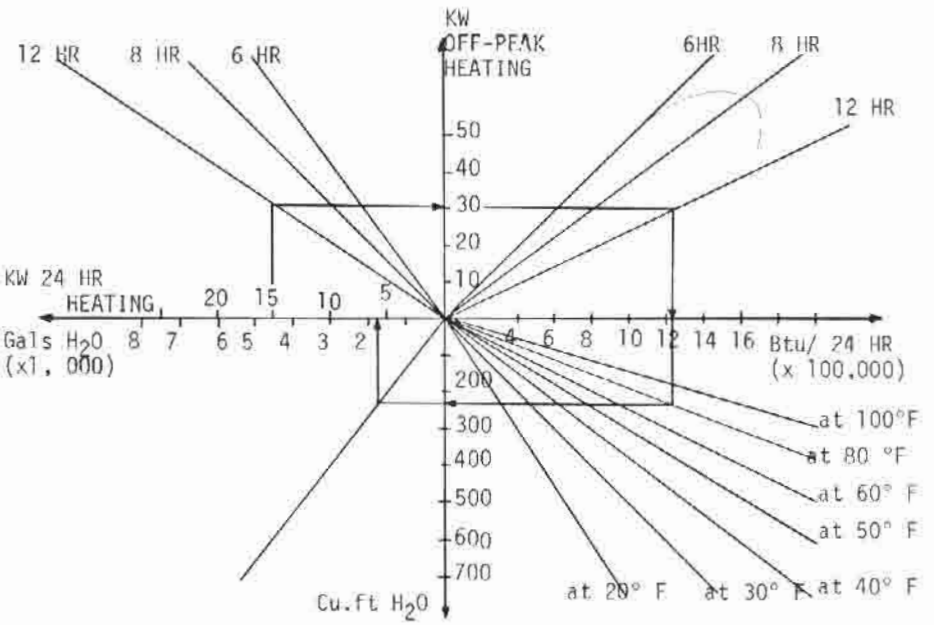

FIGURE 7.

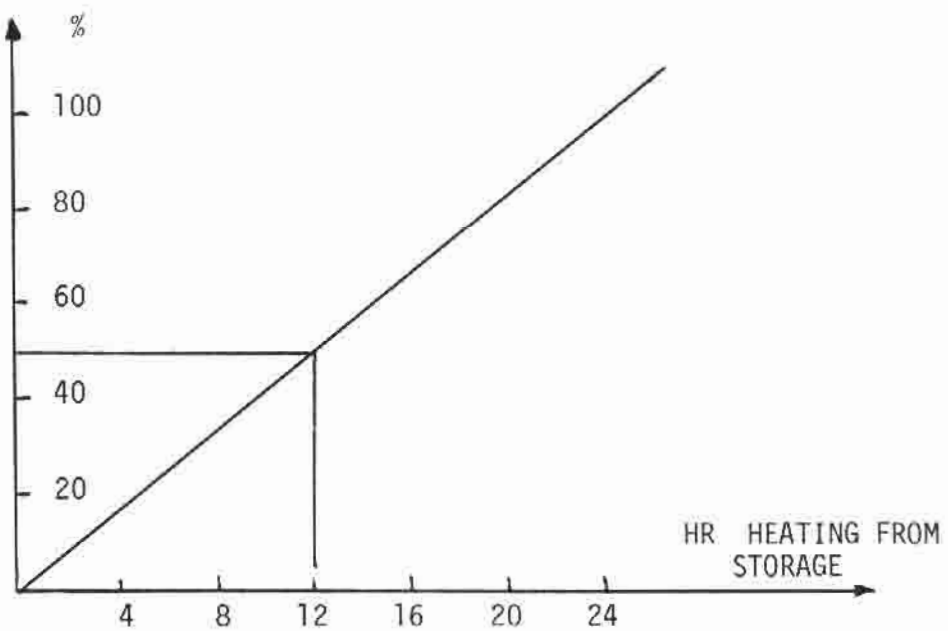

FIGURE 8. % of Volume of Water Needed vs the Time of Heating from the Storage System.