

TABLE 4. HEAT PUMP HEAT SOURCES AND SINKS

HEAT SOURCES	AIR	CITY WATER	WELL WATER	SURFACE WATER	WASTE WATER	EARTH	SOLAR
Source Classification Stability as Heat Sink Availability (Location) Availability (Time)	Primary Good Universal Continuous	Primary or auxiliary Good Cities Continuous—except local shortages	Primary Good Uncertain Continuous—unless well runs dry	Primary Good Rare Continuous	Primary or auxiliary Variable with source Limited Variable	Primary or auxiliary Usually poor Extensive Continuous, tempera- ture level drops from a maximum heat a minimum as heat is removed, slowly rises when pump is inoperative High, usually less than the cost of drilling a well Relatively moderate	Auxiliary None Universal Intermittent Unreliable, except over extended time Unexplored Unexplored, precipitating as auxiliary for reducing oper- ating cost Excellent Extreme Practically available Probably bulky Fair Air, earth, Probably will require heat storage equip- ment at either evaporator or condenser side.
Expense (Original)	Low, less than earth and water sources ex- cept city	Usually lowest	High, result of drilling well	Low	Variable		
Expense (Operating)	Relatively low	High, usually prohibi- tive	Low to moderate	Relatively low	Relatively low		
Temperature (Level)	Favorable 75-95% of time in most of U. S.	Usually satisfactory	Satisfactory	Satisfactory	Usually good	Initially good—drops with time and rate of heat withdrawal Large—less than for air, however Inadequate	Excellent
Temperature (Variation)	Extreme	Variable with loca- tion (9-25 F. Deg.)	Small	Moderate	Usually moderate		Extreme
Design Information	Inadequate	Usually adequate	Usually adequate	Usually ade- quate	Adequate if source is constant in supply and variable (usually moderate)		Practically available
Size of Equipment	Particularly bulky	Moderate	Moderate (except well)	Moderate	Variable (usually moderate)	Moderate (except ground coils)	Probably bulky Fair
Adaptability to Mass Production Sources it may Augment	Excellent, can be factory assembled and tested	Excellent	Excellent, (except well)	Excellent	Poor	Air, water	Air, earth, Probably will require heat storage equip- ment at either evaporator or condenser side.
Special Problems	Least heat available in summer and great- est in winter. Coils may become frozen, requiring extra capacity, alternate source, or standby heat. May require duct work. Variable air temperature makes control difficult.	Scale on coils. Local use restrictions dur- ing shortages. Dis- posal. Water tem- perature may be- come too low to per- mit further heat re- moval.	Corrosion, scale may form on heat trans- fer surface. Disposal. Water location, tem- perature, composi- tion, usually un- certain. Well may run dry.	Water may cause scale, corro- sion, and algae fouling.	Usually scale forming or corrosive. Often insufficient supply. Very difficult to locate. Very hence requires indi- vidual design.	Limited by local cool- ing and climate in- stallation costs dif- ficult to estimate. Re- quires considerable ground area, may damage lawns, gar- dens.	

installing a smaller refrigeration plant, augmented by a storage system, and by operating it for longer periods.

The Heat Pump

It has been almost 100 years since Prof. William Thomson (Lord Kelvin) first proposed the use of a compressor as a "warming engine" and as a means of heating buildings to replace equipment for direct burning of fuels. Several early working models were constructed, but the device has remained essentially of laboratory interest until the last 20 years.

Although frequently referred to incorrectly as the reverse cycle system, the heat pump cycle is identical with the ordinary refrigeration cycle, and differs only in the sense that the desired effect is rejection of the heat from the condenser rather than absorption of heat in the evaporator. A discussion of the coefficient of performance for the heat pump is found earlier in this chapter.

The first actual residential heat pump installation was probably made in Scotland in 1927 and since that time, a number of commercial and residential systems have been made in this country. Both progress and growth of interest have been particularly rapid in recent years and, consequently, at the present time there are several hundred residential installations and probably a greater number of commercial systems. However, much research is needed before the residential heat pump installation can successfully emerge to compete economically and with equal reliability with the more common forms of heating and fuels.

From an analysis of the equation for the coefficient of performance, it is evident that the economical adaption of the heat pump as a practical means of heating, requires that the temperature of the source from which the heat is extracted be as high as possible, and that the temperature of the sink to which the heat is rejected for heating purposes, be as low as possible. Thus, with a small temperature spread between the evaporator and the condenser, six or more times as much heat may be obtained theoretically (and three to five times practically) as the heat equivalent of the work necessary to operate the system. There are a number of limitations, however, the most serious of which is the lack of ready availability of a practical source of heat.

One of the major problems in the development of the heat pump involves research on, and the compilation of reliable design data for, the various heat sources and sinks available. The four principal potential sources of heat are air, water, earth, and solar energy. Of these, the first three are primary sources of heat which may be used alone. The fourth, solar energy, while of tremendous potentiality, will probably be developed in most localities as auxiliary to the other three. In addition, there are other minor sources such as process waste heat, sewage, etc., which may be used under special circumstance.

There are also a number of industrial applications of heat pumps, for purposes other than space heating, which are practical largely through economic considerations of the particular process involved. Table 4 presents a summary of the advantages and disadvantages of each of these major heat sources.

By reference to Table 4, it will be seen that, to date, the most satisfactory heat sources are air, water, and earth, and that air and water are the most satisfactory heat sinks. There are, therefore, six possible combinations of source and sink in application: air to air, air to water, water to air, water to water, earth to air, and earth to water. In addition, it should be recog-