Heat Pumps - Their Theory, Function and Maintenance

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PREFACE

With most central heating systems, you pay for energy that never finds heat. Every oil- or gas-fired heating system loses some of the heat from the burning fuel straight up the chimney. Electric heat doesn't squander fuel that way. It's 100 percent efficient. But electricity is usually an expensive source of heat.

Because of the inefficiencies of oil and gas and the expense of electricity, some homeowners may be attracted by the advertised advantages of a fourth type of central heating system - the heat pump. It doesn't burn fuel to produce heat. Instead, it uses the same operating principle as a refrigerator or an air-conditioner to extract heat from the air or from the ground and deliver it to the house. Even when the air outside is cold, it contains some heat that can be collected and used to warm the house. Likewise, the earth contains a useful amount of heat, even in winter.

The heat pump's potential for reducing heating bills can sometimes justify the major capital expense required to replace a furnace. But the decision to install a heat pump isn't as cut-and-dried as the decision to replace an aged furnace with a new one. They can be cheaper to run than other heating systems. But you need the right climate or plenty of digging to accommodate one.

I. TYPES OF HEAT PUMPS

A. Air-Sourced Heat Pumps

Until recently, nearly all heat pumps were the air-sourced type, making use of the heat in outdoor air. This type is often nicknamed an air-conditioner in reverse.

In fact, many air-sourced models can provide heat in the winter and air-conditioning in the summer.

An air-sourced model can operate very economically in areas where the temperature rarely dips below freezing. As the outdoor air temperature drops, however, so does the heat pump's ability to deliver heat. The colder the air, the longer and harder the heat pump must work to extract a useful amount of heat for the house. You'd feel that particularly when the outdoor temperature dropped sharply or when you tried to warm up an unheated house. For that reason, an air-sourced heat pump is not the type to choose in colder parts of the country.

Designers usually try to compensate for a heat pump's cold-weather deficiencies by building electric heating strips into the system. When a thermostat senses that the unit's normal output isn't enough, the heaters automatically go on. That approach effectively converts the heat pump into an expensive electric resistance heater for part of the day.

The need for occasional backup heating also makes it uneconomical to turn down the thermostat at night, a common energy-saving strategy with other heating systems. Except in very mild weather, the additional cost of backup electric heating in the morning will almost always wipe out any saving gained overnight.

Ice is another cold-weather problem for an air-sourced heat pump. In near-freezing weather, moisture from the outdoor air condenses and freezes on the heat pump's exchanger, insulating it and worsening the pump's performance. Some heat pumps have electric heaters for deicing. Others run in reverse for a short time to let the warm refrigerant melt the ice. Either method entails an energy cost - electricity to run the heaters, or loss of heat from the house.

B. Water-Sourced Heat Pumps

These cost a good deal more to buy and install than air-sourced designs, but they can be used successfully in colder parts of the country.

Drawing heat from water instead of the air has definite advantages. For one, a given volume of water contains much more heat than the same volume of air at the same temperature. For another, the water is easier to use. All that's needed is a source of water that stays above freezing. (Below the frost line, which is two to four feet below the surface of the earth, most water stays at about 55°F year round.) In principle, water-sourcing works the same as air-sourcing.

An underground stream or a well does fine as a water supply if:

(a) There's enough water. A heat pump may require some 10 to 20 times the water of all other household demands combined. In the New York City area, for example, water consumption would be 10 to 20 gallons per minute.

(b) The water is noncorrosive. Acids in some water supplies can damage the heat pump's heat exchanger or other plumbing. Minerals can cause scaling.

(c) You can get rid of the waste water. Once the water goes through the heat pump, it must be disposed of. Some local codes may require a discharge well.

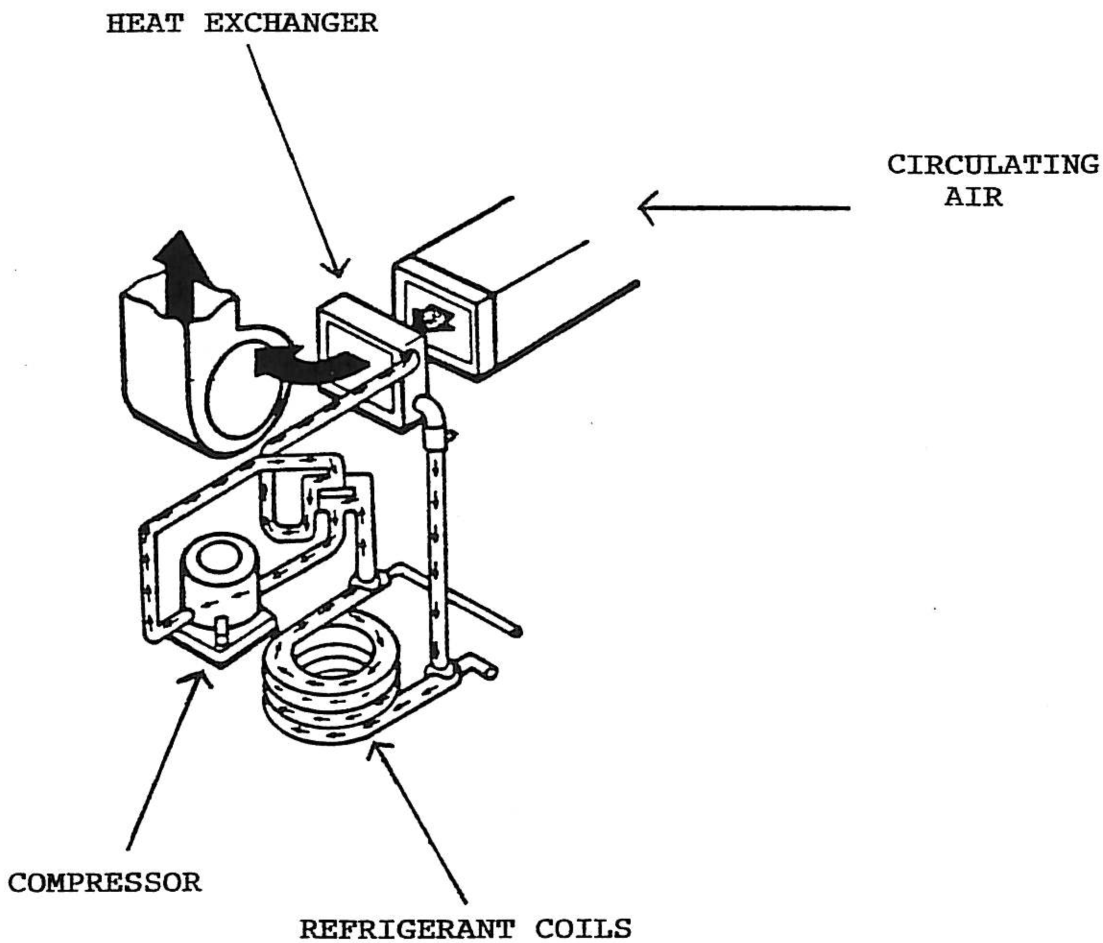
Some heat pumps recirculate water (sometimes laced with antifreeze), so they duck problems of capacity, corrosion, and disposal. On average, a house may need about 100 to 200 gallons. These systems require some means of rewarming the water once it has given up its heat to the house. Usually, heat from the earth itself is used. Below the frost line, the earth's temperature is surprisingly stable. Earth is a fairly good conductor of heat, so the water needs only to pass through a sufficient length of piping buried in a trench about four feet deep.

B. Water-Sourced Heat Pumps - Cont'd

"Sufficient length," however, can mean a lot of pipe and a lot of digging. Recirculating installations may involve runs of up to 2500 feet of 1-1/2-inch plastic pipe. A layout that long is feasible only on fairly uncrowded, uncluttered land.

Fitting a water-sourced heat pump into a rectangular plot smaller than 100 by 50 feet takes some ingenuity. Two parallel loops, stacked one above the other in a deep trench, can be used. Another alternative is the "geothermal well" - one or more deep holes containing vertical loops of pipe. Digging several shallow wells avoids the need for one excessively deep hole.

--- HOW HEAT PUMPS DO THEIR JOB ---



The refrigerant vapor draws heat from the air or water source. The refrigerant is then pumped to a compressor. Compressing of this gas causes it to heat itself to a temperature as much as 200°F. The hot gas then flows through a second heat exchanger where it gives up much of its heat and turns back into a liquid. Fans and ductwork direct the heat throughout the house.

II. EFFICIENCY VS. COST

A. Coefficient of Performance

To appreciate the possibilities of a heat pump, you need to know something about its competition. A typical oil or gas furnace loses at least 15 to 25 percent of its fuel's energy as it operates; that is, the furnace is only 75 to 85 percent efficient. Electric heating loses nothing; it's 100 percent efficient in use. But the heat pump can do better than that.

Consider an electric heat pump taking warmth from outdoor air at 47° (a standard temperature for rating heat pumps) and using it to heat a house to 70°. Suppose that pump, in continuous operations, delivered 2-3/4 times the heat of an electric heating system per kilowatt of electricity consumed. (That's a typical level of performance.) In effect, the heat pump would far surpass the electric heater's 100 percent use of its electricity. The heat pump is then said to have a coefficient of performance, or COP, of 2.75. (For all practical purposes, that's the same as saying that the heat pump's efficiency is 275 percent.) An electric heater has a COP of 1.00; a conventional gas or oil furnace's COP might be 0.75 or 0.85.

In actual use, however, COP figures quoted for any heating system can be overly optimistic. The COP ratings used by heat-pump manufacturers assume continuous operation. But heat pumps generally don't run continuously. Every time the unit goes off, hot working fluid in its innards cools, losing some heat to the outdoors. When the heat pump goes on again, it will use some energy to repressurize the working fluid. It must also use energy to deice itself whenever moisture from the air freezes on its components. Finally, the COP ratings used by manufacturers relate to performance only at 47°. An air-sourced heat pump's COP drops with the outdoor temperature. The heat pump with a COP of 2.75 in 47° weather would have a COP of a bit more than 1.00 if the mercury hit 5°. At that point, the heat pump would be little more than an elaborate electric heater.

A reasonable estimate of a heat pump's performance over an entire heating season is the Seasonal Performance Factor. That factor is always less than the theoretical COP, although it can come close in regions where winters are mild.

II. EFFICIENCY VS. COST

B. Purchase Consideration

Even though a heat pump is a more efficient heater than its competitors, differences in energy prices tend to reduct that advantage.

A heat pump probably makes the most sense for two types of homeowners: Those who want to replace electric heating and those who use air-conditioning more than heating.

If you live in an area where winter temperatures seldom drop below about 45°, an air-sourced unit will serve; one that can handle a 2000-square-foot house might cost $3500 to install. Air-sourced models really aren't an option in areas with severe winter weather. You'd need a water-sourced unit with its buried piping, at a cost of about $5000. In both cases, ductwork would be extra.

A heat pump may take some getting used to if you're accustomed to the hot blast of air and the quick heating that a forced air furnace provides. Heat pumps deliver air that's only 90° to 100°, and they heat a cold house relatively slowly.

Be aware that heat pumps, especially water-sourced ones, are a relatively new technology. Should you decide to have one installed, you'd be wise to buy it as a package from a single contractor who will service the whole unit if anything goes wrong.

II. EFFICIENCY VS. COST

C. Dual Purpose Heat Pumps

Heat pumps deliver cool air, too. Many heat pumps are designed to lead two lives--heating the house in the winter, cooling it in the summer.

A heat pump devoted only to heating has its compressor indoors todeliver heat, and its evaporator outdoors. A dual-purpose unit contains valves that allow the compressor and evaporator to switch functions. The heat pump then works like a conventional air-conditioner, drawing heat out of the house.

The industry uses two numbers to characterize the efficiency of a dual-purpose heat pump. The wintertime number is the coefficient of performance (COP). The summertime number is the energy-efficiency rating (EER), the same number used for other air-conditioners. The higher the EER, the more efficient the unit. An often-used variation on the EER is the seasonal energy-efficiency rating, or SEER, which takes into account losses of efficiency over the course of a cooling season. Typically, an air-sourced heat pump has an EER that's comparable with the EER for a conventional central air-conditioning unit. But water-sourced units often have a higher EER.

A dual-purpose heat pump can be an excellent choice for homes--particularly new construction--in the South or along parts of the Pacific coast, where winters are mild but summers are brutal.

III. CLEANING, RESTORATION AND MAINTENANCE

A. General Cleaning

Regular cleaning should be accomplished in much the same way that you would maintain a household air-conditioning unit or refrigerator. An accumulation of dust or lint should be vacuumed away. Any further necessary cleaning can be accomplished by a typical wash method using a wet terrycloth towel and a typical high solvency household soap. When working with the wet cloth, care and caution should be exerted around any of the electrical or mechanical components. Common sense safety procedures should be followed at all times.

B. Restoration After a Fire or Smoke Loss

Cleaning after a light to moderate loss should be accomplished in the same fashion as the general cleaning procedure listed above.

Cleaning and restoration related to a heavy smoke loss should follow the above procedures, however, an additional measure needs to be followed. A spray solvent (i.e. WD-40, Tuner Cleaner, etc.) can be sprayed onto the affected areas, allowed to dissolve the film or residue and then wiped away with an absorbent cotton cloth. Repeating this process may be necessary for total results.

If the heat pump is so severely damaged that the above described cleaning methods have little or no results, then any further restoration procedure should be accomplished by a skilled service technician only. You should consult the homeowner for the name of the contractor that originally installed the unit, otherwise, consult the local advertising media (i.e. yellow pages) for a skilled technicial for the particular manufacturer of the unit that has been damaged.