U.S. Department of Energy - Energy Efficiency and Renewable Energy

A Consumer's Guide to Energy Efficiency and Renewable Energy

Operating and Maintaining Your Heat Pump

Proper operation of your heat pump will save energy. Do not set back the heat pump's thermostat if it causes the backup heating to come on; backup heating systems are usually more expensive to operate. Continuous indoor fan operation can degrade heat pump performance unless a high-efficiency, variable-speed fan motor is used. Operate the system on the "auto" fan setting on the thermostat.

Like all heating and cooling systems, proper maintenance is key to efficient operation. The difference between the energy consumption of a well-maintained heat pump and a severely neglected one ranges from 10%–25%.

Clean or change filters once a month or as needed, and maintain the system according to manufacturer's instructions. Dirty filters, coils, and fans reduce airflow through the system. Reduced airflow decreases system performance and can damage your system's compressor. Clean outdoor coils whenever they appear dirty; occasionally, turn off power to the fan and clean it; remove vegetation and clutter from around the outdoor unit. Clean the supply and return registers within your home, and straighten their fins if bent.

You should also have a professional technician service your heat pump at least every year. The technician can do the following:

- Inspect ducts, filters, blower, and indoor coil for dirt and other obstructions
- Diagnose and seal duct leakage
- Verify adequate airflow by measurement
- Verify correct refrigerant charge by measurement
- Check for refrigerant leaks
- Inspect electric terminals, and if necessary, clean and tighten connections, and apply nonconductive coating
- Lubricate motors, and inspect belts for tightness and wear
- Verify correct electric control, making sure that heating is locked out when the thermostat calls for cooling and vice versa
- Verify correct thermostat operation.

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Geothermal Heat Pumps

Geothermal heat pumps (sometimes referred to as GeoExchange, earth-coupled, ground-source, or water-source heat pumps) have been in use since the late 1940s. Geothermal heat pumps (GHPs) use the constant temperature of the earth as the exchange medium instead of the outside air temperature. This allows the system to reach fairly high efficiencies (300%-600%) on the coldest of winter nights, compared to 175%-250% for air-source heat pumps on cool days.

While many parts of the country experience seasonal temperature extremes—from scorching heat in the summer to sub-zero cold in the winter—a few feet below the earth's surface the ground remains at a relatively constant temperature. Depending on latitude, ground temperatures range from 45°F (7°C) to 75°F (21°C). Like a cave, this ground temperature is warmer than the air above it during the winter and cooler than the air in the summer. The GHP takes advantage of this by exchanging heat with the earth through a ground heat exchanger.

As with any heat pump, geothermal and water-source heat pumps are able to heat, cool, and, if so equipped, supply the house with hot water. Some models of geothermal systems are available with two-speed compressors and variable fans for more comfort and energy savings. Relative to air-source heat pumps, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

A dual-source heat pump combines an air-source heat pump with a geothermal heat pump. These appliances combine the best of both systems. Dual-source heat pumps have higher efficiency ratings than air-source units, but are not as efficient as geothermal units. The main advantage of dual-source systems is that they cost much less to install than a single geothermal unit, and work almost as well.

Even though the installation price of a geothermal system can be several times that of an air-source system of the same heating and cooling capacity, the additional costs are returned to you in energy savings in 5–10 years. System life is estimated at 25 years for the inside components and 50+ years for the ground loop. There are approximately 40,000 geothermal heat pumps installed in the United States each year.

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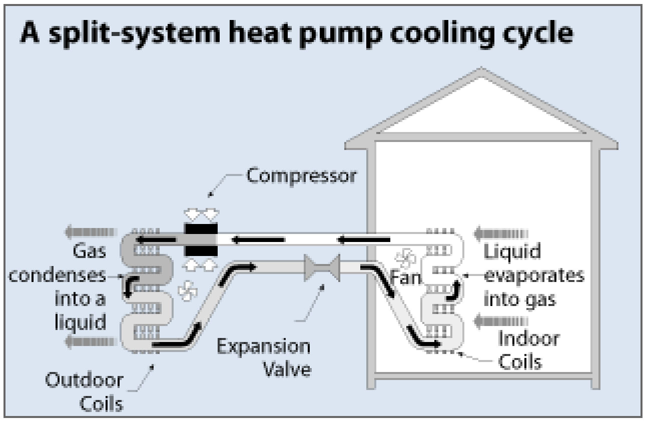
Air-Source Heat Pumps

An air-source heat pump can provide efficient heating and cooling for your home, especially if you live in a warm climate. When properly installed, an air-source heat pump can deliver one-and-a-half to three times more heat energy to a home than the electrical energy it consumes. This is possible because a heat pump moves heat rather than converting it from a fuel, like in combustion heating systems.

Although air-source heat pumps can be used in nearly all parts of the United States, they do not generally perform well over extended periods of sub-freezing temperatures. In regions with sub-freezing winter temperatures, it may not be cost effective to meet all your heating needs with a standard air-source heat pump.

However, new systems with gas heating as a backup are able to overcome this problem. There is also a "Cold Climate Heat Pump" which shows promise, but is currently facing manufacturing problems. In addition, a version called the "Reverse Cycle Chiller" claims to be able to operate efficiently at below-freezing temperatures.



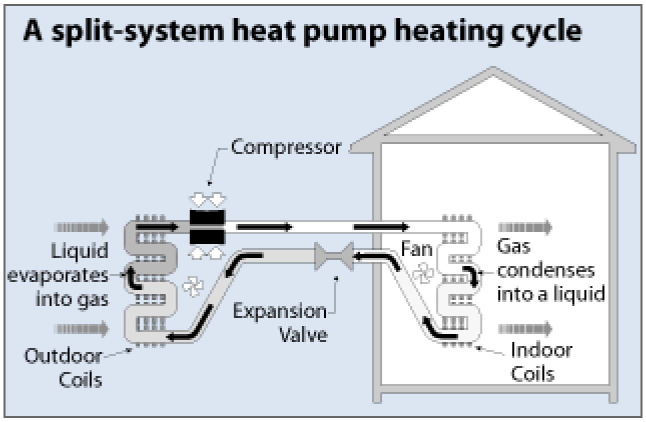
In cooling mode, an air-source heat pump evaporates a refrigerant in the indoor coil; as the liquid evaporates it pulls heat from the air in the house. After the gas is compressed, it passes into the outdoor coil and condenses, releasing heat to the outside air. The pressure changes caused by the compressor and the expansion valve allow the gas to condense at a high temperature outside and evaporate at a lower temperature indoors.

How They Work

A heat pump's refrigeration system consists of a compressor and two coils made of copper tubing (one indoors and one outside), which are surrounded by aluminum fins to aid heat transfer. In the heating mode, liquid refrigerant in the outside coils extracts heat from the air and evaporates into a gas. The indoor coils release heat from the refrigerant as it condenses back into a liquid. A reversing valve, near the compressor, can change the direction of the refrigerant flow for cooling as well as for defrosting the outdoor coils in winter.

When outdoor temperatures fall below 40°F, a less-efficient panel of electric resistance coils, similar to those in your toaster, kicks in to provide indoor heating. This is why air-source heat pumps aren't always very efficient for heating in areas with cold winters. Some units now have gas-fired backup furnaces instead of electric resistance coils, allowing them to operate more efficiently

The efficiency and performance of today's air-source heat pumps is one-and-a-half to two times greater than those available 30 years ago. This improvement in efficiency has resulted from technical advances and options such as these:



In heating mode, an air-source heat pump evaporates a refrigerant in the outdoor coil; as the liquid evaporates it pulls heat from the outside air. After the gas is compressed, it passes into the indoor coil and condenses, releasing heat to the inside of the house. The pressure changes caused by the compressor and the expansion valve allow the gas to evaporate at a low temperature outside and condense at a higher temperature indoors.

- Thermostatic expansion valves for more precise control of the refrigerant flow to the indoor coil
- Variable speed blowers, which are more efficient and can compensate for some of the adverse effects of restricted ducts, dirty filters, and dirty coils

- Improved coil design
- Improved electric motor and two-speed compressor designs
- Copper tubing, grooved inside to increase surface area.

Most central heat pumps are split-systems—that is, they each have one coil indoors and one outdoors. Supply and return ducts connect to a central fan, which is located indoors.

Some heat pumps are packaged systems. These usually have both coils and the fan outdoors. Heated or cooled air is delivered to the interior from ductwork that protrudes through a wall or roof.

Selecting a Heat Pump

Every residential heat pump sold in this country has an EnergyGuide Label, which features the heat pump's heating and cooling efficiency performance rating, comparing it to other available makes and models.

Heating efficiency for air-source electric heat pumps is indicated by the heating season performance factor (HSPF), which is the ratio of the seasonal heating output in Btu divided by the seasonal power consumption in watts. Cooling efficiency is indicated by the seasonal energy efficiency ratio (SEER), which is the ratio of the seasonal heat removed in Btu per hour to the seasonal power consumption in watts.

The Heating Seasonal Performance Factor (HSPF) rates both the efficiency of the compressor and the electric-resistance elements. The most efficient heat pumps have an HSPF of between 8 and 10.

The Seasonal Energy Efficiency Ratio (SEER) rates a heat pump's cooling efficiency. In general, the higher the SEER, the higher the cost. However, the energy savings can return the higher initial investment several times during the heat pump's life. Replacing a 1970s vintage, central heat pump (SEER = 6) with a new unit (SEER=12) will allow the use of half the energy to provide the same amount of cooling, cutting air-conditioning costs in half. The most efficient heat pumps have SEERs of between 14 and 18.

To choose an air-source electric heat pump, look for the ENERGY STAR® label, which is awarded to those units with SEERs of 12 or greater and HSPFs of 7 or greater. If you are purchasing an electric air-source heat pump and are uncertain whether it meets ENERGY STAR qualifications, look on the bright yellow EnergyGuide label for an efficiency of 12 SEER/7HSPF or greater. For units with comparable HSPF ratings, check their steady-state rating at -8.3 degrees C, the low temperature setting. The unit with the higher rating will be more efficient.

Consider buying a heat pump with an HSPF of at least 7.7. In September 2006, the U.S. Department of Energy will begin enforcing a new standard that will require central heat pumps to have a minimum rating of 7.7 HSPF. In warmer climates, SEER is more important than HSPF; in colder climates, focus on getting the highest HSPF feasible.

These are some other factors to consider when choosing and installing air-source heat pumps:

- Select a heat pump with a demand-defrost control. This will minimize the defrost cycles, thereby reducing supplementary and heat pump energy use.
- If you're adding a heat pump to an electric furnace, the heat pump coil should usually be placed on the cold (upstream) side of the furnace for greatest efficiency.
- Fans and compressors make noise. Locate the outdoor unit away from windows and adjacent buildings, and select a heat pump with an outdoor sound rating of 7.6 bels or lower. You can also reduce this noise by mounting the unit on a noise-absorbing base.
- The location of the outdoor unit may affect its efficiency. Outdoor units should be protected from high winds, which can cause defrosting problems. You can strategically place a bush or a fence upwind of the coils to block the unit from high winds.

See the section on Selecting and Replacing Heating and Cooling Systems for information about choosing a contractor, and see the section on Sizing Your Heating and Air Conditioning System for proper sizing techniques.

Performance Issues with Heat Pumps

According to a report on research funded by ENERGY STAR, more than 50% of all heat pumps have significant problems with low airflow, leaky ducts, and incorrect refrigerant charge.

There should be about 400–500 cubic feet per minute (cfm) airflow for each ton of the heat pump's air-conditioning capacity. Efficiency and performance deteriorate if airflow is much less than 350 cfm per ton. Technicians can increase the airflow by cleaning the evaporator coil or increasing the fan speed, but often some modification of the ductwork is needed. See the sections on Minimizing Energy Losses in Ducts and on Insulating Ducts.

Refrigeration systems should be leak-checked at installation and during each service call. Room heat pumps and packaged heat pumps are charged with refrigerant at the factory. They are seldom incorrectly charged. Split-system heat pumps, on the other hand, are charged in the field, which can sometimes result in either too much or too little refrigerant. Split-system heat pumps that have the correct refrigerant charge and airflow usually perform very close to manufacturer's listed SEER and HSPF. Too much or too little refrigerant, however, reduces heat-pump performance and efficiency.

For satisfactory performance and efficiency, a split-system heat pump should be within a few ounces of the correct charge, specified by the manufacturer. The technician must measure airflow prior to checking refrigerant charge because the refrigerant measurements aren't accurate unless airflow is correct. When the charge is correct, specific refrigerant temperatures and pressures listed by the manufacturer will match temperatures and pressures measured by your service technician. Verify these measurements with the technician. If the manufacturer's temperatures and pressures don't match the measured ones, refrigerant should be added or withdrawn, according to standards specified by the EPA.

Advanced Technologies: Reverse Cycle Chillers

One of the more notable innovations in air-source heat pumps is called a Reverse Cycle Chiller (RCC). It offers the advantages of allowing the homeowner to choose from a wide variety of heating and cooling distribution systems, from radiant floor systems to forced air systems with multiple zones. It also offers the potential for lower winter electric bills and hotter air out of the supply vents for greater comfort.

An RCC is especially economical for all-electric homes or in areas where natural gas is not available. Depending on other fuel rates, it may even be the least expensive heating option over all of the remaining heating fuel choices.

The system consists of a standard 12 SEER, single speed, air-source heat pump, sized to the heating load rather than the usual smaller summer cooling load. The heat pump is connected to a large, heavily insulated tank of water that the heat pump heats or cools, depending on the season of the year. Most systems will use a fan coil with ducts, employing the stored water to heat or cool the air and distribute it to the house. During the heating season, the hot water can be distributed through a radiant floor system.

The RCC eliminates one of the biggest complaints about air source heat pumps, which is the periodic blowing of cool air during their defrost cycle and during the initial start of the heating cycle as the distribution ducts warm up. The RCC system solves these problems by using the stored heat in the water tank to defrost the cooling coils, rather than the room air.

The RCC system also allows the heat pump to operate at peak efficiency even at low temperatures. This provides greater comfort and economy without the need for electric resistance auxiliary heating coils. For example, in one Michigan installation, the RCC system supplied 115°F water to the air handler and a radiant floor system even though the outdoor temperature was negative 15°F.

Another significant energy saving benefit is that the RCC can be equipped with a refrigeration heat reclaimer (RHR). This is similar to the common desuperheater coil found on the high-end heat pumps and air conditioners (discussed below). The main difference is that the RHR not only makes hot water during the cooling season, but also does it during the heating season by using the excess capacity of the outdoor unit during the milder winter weather to make essentially free domestic hot water. In the summer it makes free hot water by reclaiming the waste heat from the house as long as the system is also cooling the building.

The combined RCC and RHR system costs about 25% more than a standard heat pump of similar size. The simple payback on the additional cost in areas where natural gas is not available is in about 2–3 years.

Advanced Technologies: Cold Climate Heat Pump

One company has developed the Cold Climate Heat Pump, which features a two-speed, two-cylinder compressor for efficient operation; a back-up Booster compressor that allows the system to operate efficiently down to 15°F; and a plate heat exchanger called an "economizer" that further extends the performance of the heat pump to well below 0°F, according to the company.

The system has been tested favorably by several utilities in the Northwest, which announced that the heat pump showed a 60% efficiency improvement over standard air-source heat pumps in preliminary testing.

The product has never been made available to consumers on a large scale, but it appears that manufacturing may resume and the heat pumps will soon be available to consumers.

Advanced Technologies: All-Climate Heat Pump

Another technology showing promise is an All Climate Heat Pump, which the manufacturer says can operate in the coldest days of winter without supplemental heat, maintaining comfortable indoor temperatures even when the temperature outdoors falls below zero. The heat pump could reduce heating and cooling costs 25%–60%. Wenatchee Valley College in Washington has installed the heat pump and campus and has been testing it since October 2006.

While the design of most heat pumps puts the focus on cooling, the All Climate Heat Pump was designed with heating as the primary focus. Initial costs for the All Climate Heat Pump are high, but if it continues to work as well as predicted, the energy savings over the life of the system would more than make up the up-front cost. The All Climate Heat Pump is currently available for consumer purchase.