

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

### 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.

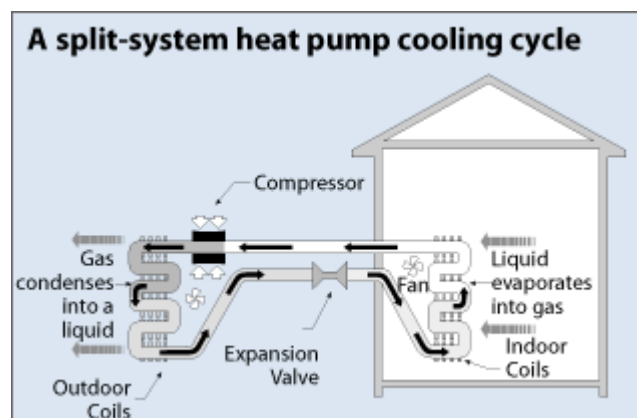
However, new systems with gas heating as a backup are able to overcome this problem. There is also a "Cold Climate Heat Pump" which shows promise, but is currently facing manufacturing problems. In addition, a version called the "Reverse Cycle Chiller" claims to be able to operate efficiently at below-freezing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

### 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 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.

- 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.

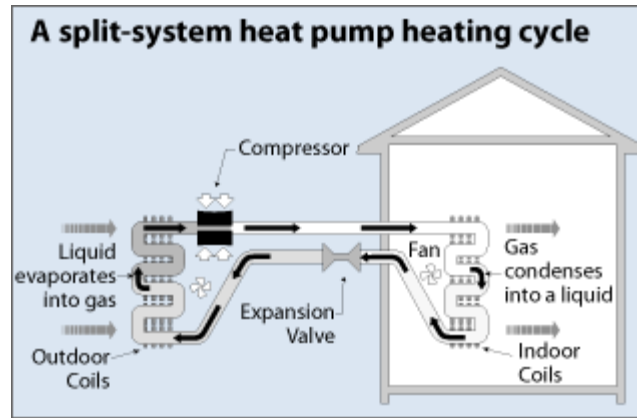
Heating efficiency for air-source electric heat pumps is indicated by the heating season performance factor (HSPF), which is the ratio of the seasonal heating output in Btu divided by the seasonal power consumption in watts. Cooling efficiency is indicated by the seasonal energy efficiency ratio (SEER),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



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.

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 dBA 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 on 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.

## **Learn More**

### **Codes & Standards**

- [Central Air Conditioner and Heat Pump Rulemaking](#)  
DOE Building Technologies Program

### Financing & Incentives

- [Rebate Locator](#)  
ENERGY STAR®
- [Find Federal Tax Credits for Energy Efficiency](#)  
ENERGY STAR®

### Product Information

- [Electric Air-Source Heat Pumps](#)  
ENERGY STAR®
- [Consortium for Energy Efficiency Directory of Verified Equipment](#)  
Air Conditioning Research Institute

### Professional Services

- [Air Conditioning Contractors of America \(ACCA\)](#)

### Department of Energy Resources

- [How to Buy an Energy-Efficient Air-Source Heat Pump](#)  
Federal Energy Management Program

### Related Links

- [International Energy Agency's Heat Pump Centre](#)
- [Reverse Cycle Chiller](#)  
PATH (Partnership for Advancing Technology in Housing) Technology Inventory

### Reading List

- Krigger, J.; Dorsi, C. (2004). *Residential Energy: Cost Savings and Comfort for Existing Buildings*. Helena, MT: Saturn Resource Management.
- "[Consumer Guide to Home Energy Savings](#)." (2003). American Council for an Energy Efficient Economy. 8th Edition.
- "Advanced Cold-Climate Heat Pump/Frostless Heat Pump." ([PDF 147 KB](#)). (2004). Emerging Technologies & Practices, American Council for an Energy Efficient Economy.
- "[Cold Climate Heat Pump Shows Promise, but Manufacturing Delayed](#)." (1 April 2005). News release. Chelan County PUD.
- "New Air Cooled Reverse Cycle Chiller Provides Cost Effective Heating at -15°F." (8 September 1997). *Air Conditioning, Heating & Refrigeration News*, pp. 22.
- "Nyle Corp. Unveils New Cold Climate Heat Pump." (October 2001). *Energy Design Update* (21:10); pp. 9-10.

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