Introduction to Heat Pumps

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TABLE OF CONTENTS

	Page No.
Section 1. Systems	**1**
Section 2. Air-source	**2**
Section 3. Mini-split	**6**
Section 4. Geothermal	**7**
Section 5. Absorption heat pumps	**11**
Section 6. Operation and maintenance	**13**
Section 7. Thermostats	**14**
Appendix A. EnergyGuide and Energy Star labels	**16**
Appendix B. Minimizing energy losses in ducts	**18**

Section 1. Systems

Heat pumps offer an energy-efficient alternative to furnaces and air conditioners for all climates. Like your refrigerator, heat pumps use electricity to transfer heat from a cool space to a warm space, making the cool space cooler and the warm space warmer. During the heating season, heat pumps move heat from the cool outdoors into your warm house. During the cooling season, heat pumps move heat from your house into the outdoors. Because they transfer heat rather than generate heat, heat pumps can efficiently provide comfortable temperatures for your home.

1.1 Ducted Air-Source Heat Pumps

There are three main types of heat pumps connected by ducts: air-to-air, water source, and geothermal. They collect heat from the air, water, or ground outside your home and concentrate it for use inside.

The most common type of heat pump is the air-source heat pump, which transfers heat between your house and the outside air. Today's heat pump can reduce your electricity use for heating by approximately 50% compared to electric resistance heating such as furnaces and baseboard heaters. High-efficiency heat pumps also dehumidify better than standard central air conditioners, resulting in less energy usage and more cooling comfort in summer months. Air-source heat pumps have been used for many years in nearly all parts of the United States, but until recently they have not been used in areas that experienced extended periods of subfreezing temperatures. However, in recent years, air-source heat pump technology has advanced so that it now offers a legitimate space heating alternative in colder regions.

1.2 Ductless Air-Source Heat Pumps

For homes without ducts, air-source heat pumps are also available in a ductless version called a mini-split heat pump. In addition, a special type of air-source heat pump called a "reverse cycle chiller" generates hot and cold water rather than air, allowing it to be used with radiant floor heating systems in heating mode.

1.3 Geothermal Heat Pumps

Geothermal (ground-source or water-source) heat pumps achieve higher efficiencies by transferring heat between your house and the ground or a nearby water source. Although they cost more to install, geothermal heat pumps have low operating costs because they take advantage of relatively constant ground or water temperatures. Geothermal (or ground source) heat pumps have some major advantages. They can reduce energy use by 30%-60%, control humidity, are sturdy and reliable, and fit in a wide variety of homes. Whether a geothermal heat pump is appropriate for you will depend on the size of your lot, the subsoil, and the landscape. Ground-source or water-source heat pumps can be used in more extreme climates than air-source heat pumps, and customer satisfaction with the systems is very high.

1.4 Absorption Heat Pumps

A relatively new type of heat pump for residential systems is the absorption heat pump, also called a gas-fired heat pump. Absorption heat pumps use heat as their energy source, and can be driven with a wide variety of heat sources.

1.5 Advanced Features to Look for in a Heat Pump

A number of innovations are improving the performance of heat pumps.

Unlike standard compressors that can only operate at full capacity, *two-speed compressors* allow heat pumps to operate close to the heating or cooling capacity needed at any particular outdoor temperature, saving energy by reducing on/off operation and compressor wear. Two-speed heat pumps also work well with zone control systems. Zone control systems, often found in larger homes, use automatic dampers to allow the heat pump to keep different rooms at different temperatures.

Some models of heat pumps are equipped with *variable-speed or dual-speed motors* on their indoor fans (blowers), outdoor fans, or both. The variable-speed controls for these fans attempt to keep the air moving at a comfortable velocity, minimizing cool drafts and maximizing electrical savings. It also minimizes the noise from the blower running at full speed.

Some high-efficiency heat pumps are equipped with a *desuperheater*, which recovers waste heat from the heat pump's cooling mode and uses it to heat water. A desuperheater-equipped heat pump can heat water 2 to 3 times more efficiently than an ordinary electric water heater.

Another advance in heat pump technology is the *scroll compressor*, which consists of two spiral-shaped scrolls. One remains stationary, while the other orbits around it, compressing the refrigerant by forcing it into increasingly smaller areas. Compared to the typical piston compressors, scroll compressors have a longer operating life and are quieter. According to some reports, heat pumps with scroll compressors provide 10° to 15°F (5.6° to 8.3°C) warmer air when in the heating mode, compared to existing heat pumps with piston compressors.

Although most heat pumps use electric resistance heaters as a backup for cold weather, heat pumps can also be equipped in combination with a gas furnace, sometimes referred to as a dual-fuel or hybrid system, to supplement the heat pump. This helps solve the problem of the heat pump operating less efficiently at low temperatures and reduces its use of electricity. There are few heat pump manufacturers that incorporate both types of heat in one box, so these configurations are often two smaller, side-by-side, standard systems sharing the same ductwork.

In comparison with a combustion fuel-fired furnace or standard heat pump alone, this type of system can also be more economical. Actual energy savings depend on the relative costs of the combustion fuel relative to electricity.

Section 2. Air-source

An air-source heat pump can provide efficient heating and cooling for your home. When properly installed, an air-source heat pump can deliver up to three times more heat energy to a home than the electrical energy it consumes. This is possible because a heat pump transfers heat rather than converting it from a fuel like combustion heating systems.

Air-source heat pumps have been used for many years in nearly all parts of the United States, except in areas that experienced extended periods of subfreezing temperatures. However, in recent years, air-source heat pump technology has advanced so that it now offers a legitimate space heating alternative in colder regions.

For example, a study by the Northeast Energy Efficiency Partnerships found that when units designed specifically for colder regions were installed in the Northeast and Mid-Atlantic regions, the annual savings are around 3,000 kWh (or $459) when compared to electric resistance heaters, and 6,200 kWh (or $948) when compared to oil systems. When displacing oil (i.e., the oil system remains, but operates less frequently), the average annual savings are nearly 3,000 kWh (or about $300).

2.1 Types of Air-Source Heat Pumps

The different types of air source heat pumps are described below.

Ductless vs. Ducted vs. Short-Run Ducted

Ductless applications require minimal construction as only a three-inch hole through the wall is required to connect the outdoor condenser and the indoor heads. Ductless systems are often installed in additions.

Ducted systems simply use ductwork. If your home already has a ventilation system or the home will be a new construction, you might consider this system.

Short-run ducted is traditional large ductwork that only runs through a small section of the house. Short-run ducted is often complemented by other ductless units for the remainder of the house.

2.2 Split vs. Packaged

Most heat pumps are split-systems—that is, they have one coil inside and one outside. Supply and return ducts connect to the indoor central fan.

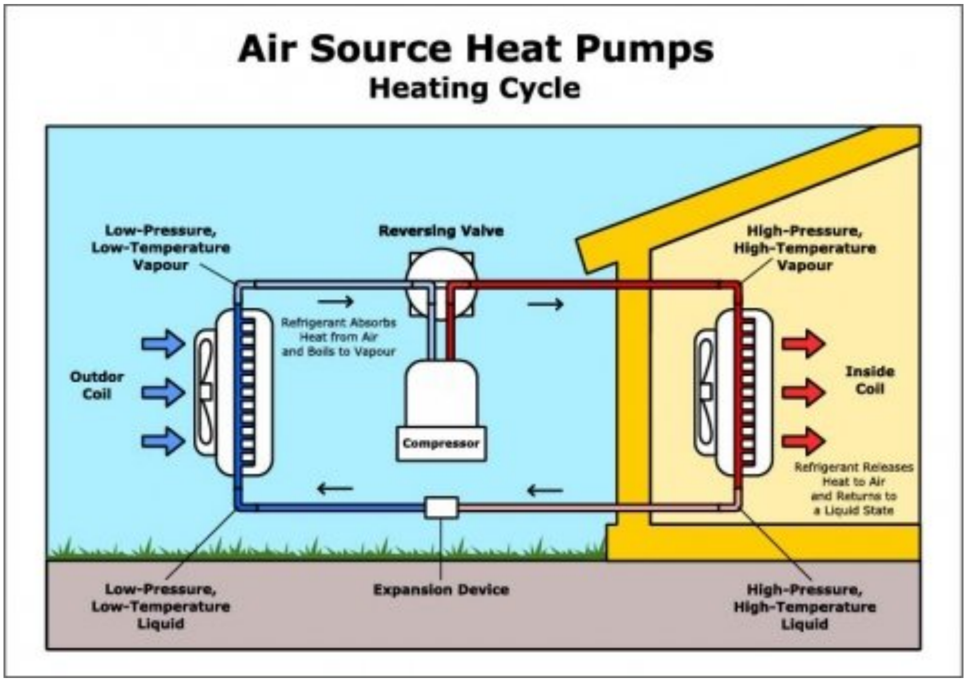
Packaged systems usually have both coils and the fan outdoors. Heated or cooled air is delivered to the interior from ductwork that passes through a wall or roof.

2.3 Multi-Zone vs. Single-Zone

Single-zone systems are designed for a single room with one outdoor condenser matched to one indoor head.

Multi-zone installations can have two or more indoor coils connected to one outdoor condenser. Multi-zone indoor coils vary by size and style and each creates its own "zone" of comfort, allowing you to heat or cool individual rooms, hallways, and open spaces. This distinction may also be referred to as "multi-head vs. single-head" and "multi-port vs. single-port."

2.4 How They Work



A heat pump's refrigeration system consists of a compressor and two copper or aluminum coils (one indoors and one outside), which have aluminum fins to aid heat transfer. In heating mode, liquid refrigerant in the outside coil removes heat from the air and evaporates into a gas. The indoor coil releases 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 mode as well as for defrosting the outdoor coil in winter.

The efficiency and performance of today's air-source heat pumps is a result of technical advances such as the following:

- 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.

2.5 Selecting a Heat Pump

Every residential heat pump sold in this country has an EnergyGuide label, which displays 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 a measure over an average heating season of the total heat provided to the conditioned space, expressed in Btu, divided by the total electrical energy consumed by the heat pump system, expressed in watt-hours.

Cooling efficiency is indicated by the seasonal energy efficiency ratio (SEER), which is a measure over an average cooling season of the total heat removed from the conditioned space, expressed in Btu, divided by the total electrical energy consumed by the heat pump, expressed in watt-hours.

In general, the higher the HSPF and SEER, the higher the cost of the unit. However, the energy savings can return the higher initial investment several times during the heat pump's life. A new central heat pump replacing a vintage unit will use much less energy, substantially reducing air-conditioning and heating costs.

To choose an air-source electric heat pump, look for the ENERGY STAR® label. ENERGY STAR certified heat pumps have higher ratings for SEER, HSPF, and energy efficiency ratio, and use about 5% percent less energy than conventional new models. In warmer climates, SEER is more important than HSPF. In colder climates, focus on getting the highest HSPF feasible.

The difference between the Energy Star label and the EnergyGuide label is discussed in Appendix A.

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.
- Fans and compressors make noise. Locate the outdoor unit away from windows and adjacent buildings, and select a heat pump with a lower outdoor sound rating (decibels). 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.

2.6 Performance Issues with Heat Pumps

Heat pumps can have problems with low airflow, leaky ducts, and incorrect refrigerant charge. There should be about 400 to 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 Appendix B. Minimizing energy losses in ducts.

Refrigeration systems should be leak-checked at installation and during each service call. Packaged heat pumps are charged with refrigerant at the factory, and 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

Section 3. Mini-split

Ductless, mini-split-system heat pumps (mini-splits) make good retrofit add-ons to houses with "non-ducted" heating systems, such as hydronic (hot water heat), radiant panels, and space heaters (wood, kerosene, propane). They can also be a good choice for room additions where extending or installing distribution ductwork is not feasible, and for very efficient new homes that require only a small space conditioning system. Be sure to choose an ENERGY STAR® compliant unit and hire an installer familiar with the product and its installation.

Like standard air-source heat pumps, mini-splits have two main components -- an outdoor compressor/condenser and an indoor air-handling unit. A conduit, which houses the power cable, refrigerant tubing, suction tubing, and a condensate drain, links the outdoor and indoor units.

3.1 Advantages

The main advantages of mini-splits are their small size and flexibility for zoning or heating and cooling individual rooms. Many models can have as many as four indoor air-handling units (for four zones or rooms) connected to one outdoor unit. The number depends on how much heating or cooling is required for the building or each zone. This can be affected by how well the building is insulated and air sealed. Each of the zones has its own thermostat, so you only need to condition occupied spaces, which can save energy and money.

Ductless mini-split systems are easier to install than some other types of space conditioning systems. For example, the hook-up between the outdoor and indoor units generally requires only a three-inch hole through a wall for the conduit. Most manufacturers of this type of system can provide a variety of lengths of connecting conduits, and, if necessary, you can locate the outdoor unit as far away as 50 feet from the indoor evaporator. This makes it possible to condition rooms on the front side of a house, but locate the compressor in a more advantageous or inconspicuous place on the outside of the building.

Mini-splits have no ducts, so they avoid the energy losses associated with the ductwork of central forced air systems. Duct losses can account for more than 30% of energy consumption for space conditioning, especially if the ducts are in an unconditioned space such as an attic.

In comparison to other add-on systems, mini-splits offer more interior design flexibility. The indoor air handlers can be suspended from a ceiling, mounted flush into a drop ceiling, or hung on a wall. Floor-standing models are also available. Most indoor units are about seven inches deep and have sleek, high tech-looking jackets. Many also offer a remote control to make it easier to turn the system on and off when it's positioned high on a wall or suspended from a ceiling.

3.2 Disadvantages

The cost of installing mini-splits can be higher than some systems, although lower operating costs and rebates or other financial incentives—offered in some areas—can help offset the initial expense.

The installer must correctly size each indoor unit and determine the best location for its installation. Oversized or incorrectly located air handlers can result in short cycling, which wastes energy and does not provide proper temperature or humidity control. Too large a system is more expensive to buy and operate.

Some people may not like the appearance of the indoor part of the system. While less obtrusive than a window room air conditioner, these units don't have the built-in look of a central system. There must also be a place to drain condensate water near the outdoor unit.

Section 4. Geothermal

Geothermal heat pumps (GHPs), sometimes referred to as GeoExchange, earth-coupled, ground-source, or water-source heat pumps, have been in use since the late 1940s. They use the relatively constant temperature of the earth as the exchange medium instead of the outside air temperature.

Although 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 these more favorable temperatures to become high efficient 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 may be returned in energy savings in 5 to 10 years, depending on the cost of energy and available incentives in your area. System life is estimated at up to 24 years for the inside components and 50+ years for the ground loop. There are approximately 50,000 geothermal heat pumps installed in the United States each year. For more information, visit the website for the International Ground Source Heat Pump Association.

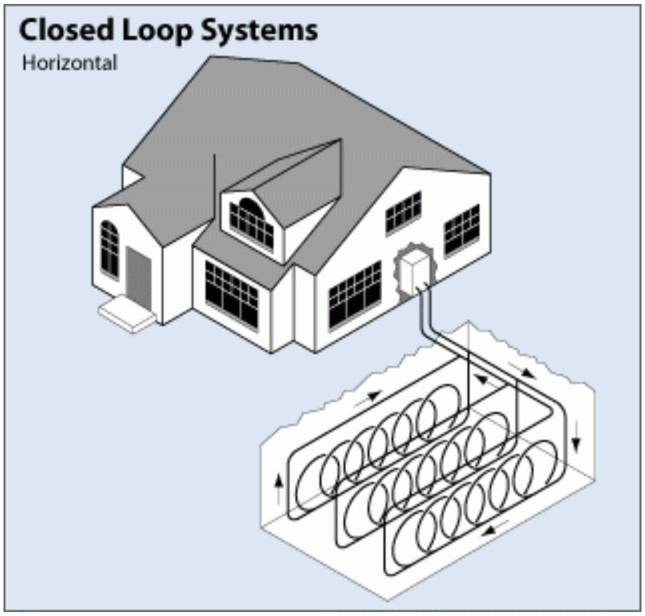
4.1 Types of Geothermal Heat Pump Systems

There are four basic types of ground loop systems. Three of these -- horizontal, vertical, and pond/lake -- are closed-loop systems. The fourth type of system is the open-loop option. Several factors such as climate, soil conditions, available land, and local installation costs determine which is best for the site. All of these approaches can be used for residential and commercial building applications.

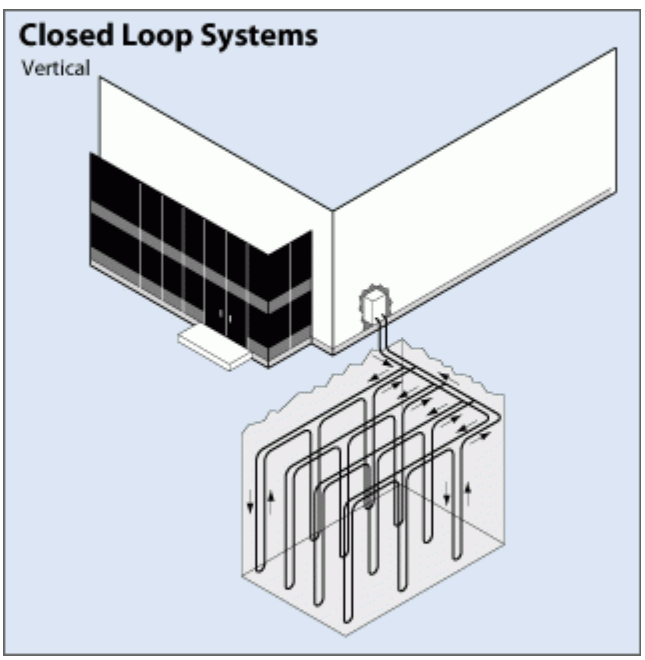
4.2 Closed-Loop Systems

Most closed-loop geothermal heat pumps circulate an antifreeze solution through a closed loop -- usually made of a high density plastic-type tubing -- that is buried in the ground or submerged in water. A heat exchanger transfers heat between the refrigerant in the heat pump and the antifreeze solution in the closed loop.

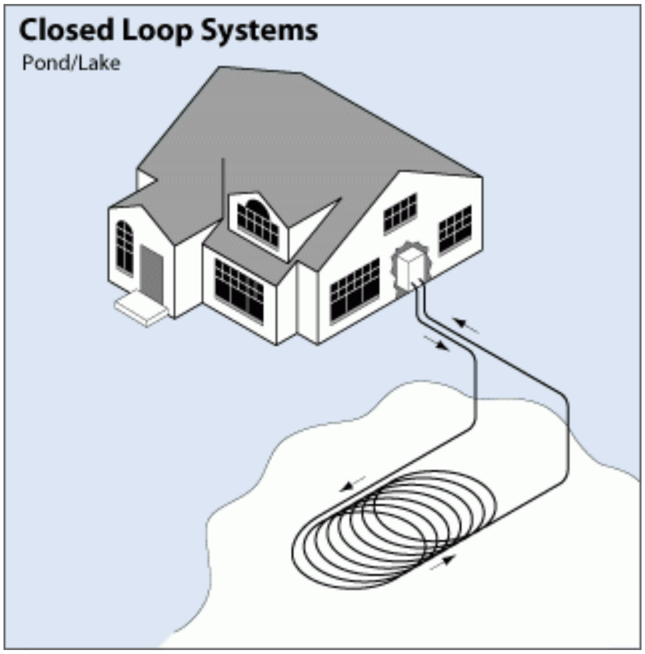
One type of closed-loop system, called direct exchange, does not use a heat exchanger and instead pumps the refrigerant through copper tubing that is buried in the ground in a horizontal or vertical configuration. Direct exchange systems require a larger compressor and work best in moist soils (sometimes requiring additional irrigation to keep the soil moist), but you should avoid installing in soils corrosive to the copper tubing. Because these systems circulate refrigerant through the ground, local environmental regulations may prohibit their use in some locations.



This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-foot wide trench. The Slinky™ method of looping pipe allows more pipe in a shorter trench, which cuts down on installation costs and makes horizontal installation possible in areas it would not be with conventional horizontal applications.

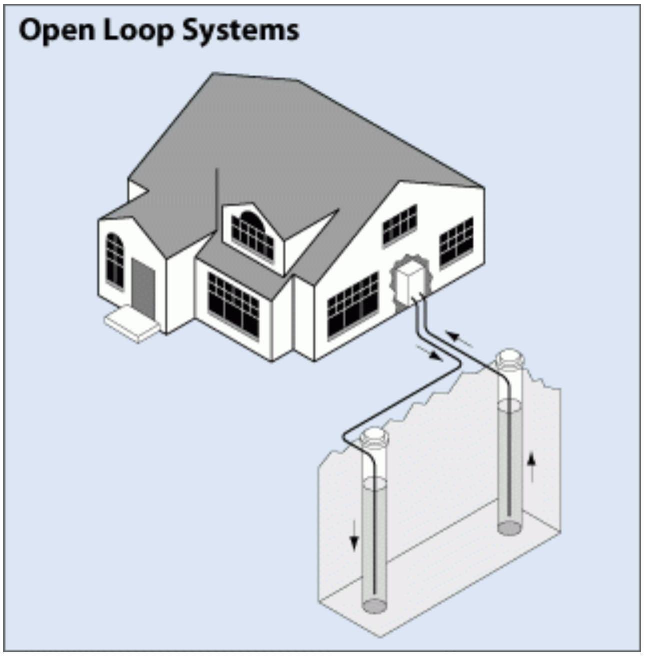


Large commercial buildings and schools often use vertical systems because the land area required for horizontal loops would be prohibitive. Vertical loops are also used where the soil is too shallow for trenching, and they minimize the disturbance to existing landscaping. For a vertical system, holes (approximately four inches in diameter) are drilled about 20 feet apart and 100 to 400 feet deep. Two pipes, connected at the bottom with a U-bend to form a loop, are inserted into the hole and grouted to improve performance. The vertical loops are connected with horizontal pipe (i.e., manifold), placed in trenches, and connected to the heat pump in the building.



Pond/Lake

If the site has an adequate body of water, this may be the lowest cost option. A supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality requirements.



4.3 Open-Loop System

This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the GHP system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.

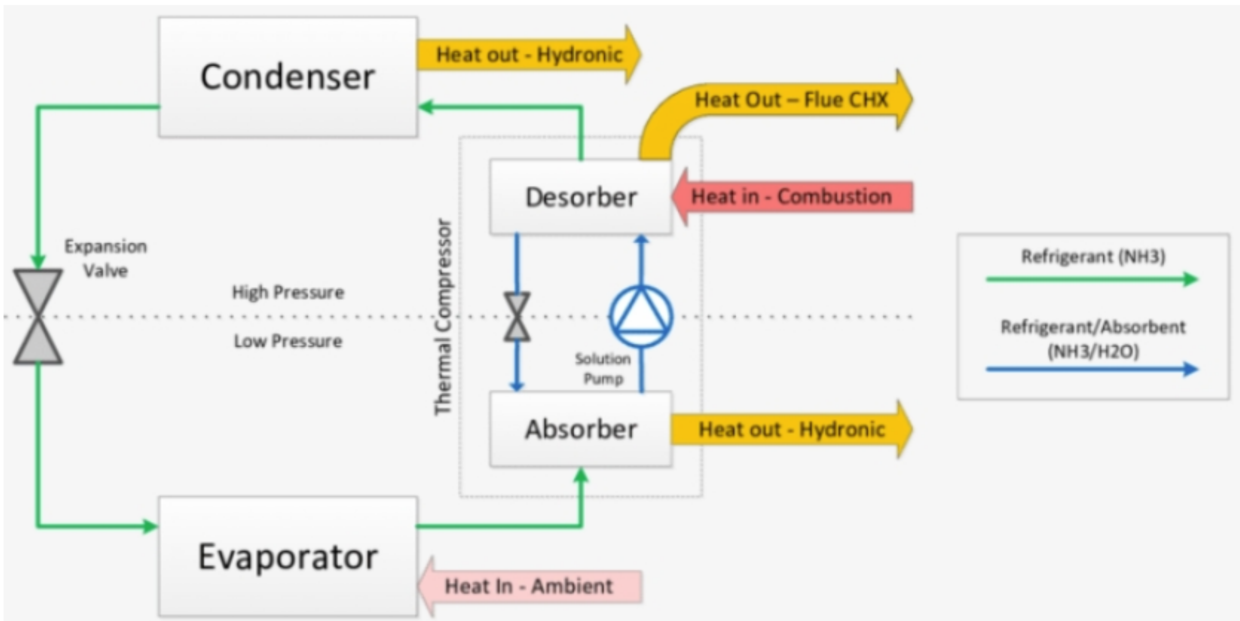
4.4 Hybrid Systems

Hybrid systems using several different geothermal resources, or a combination of a geothermal resource with outdoor air (i.e., a cooling tower), are another technology option. Hybrid approaches are particularly effective where cooling needs are significantly larger than heating needs. Where local geology permits, the "standing column well" is another option. In this variation of an open-loop system, one or more deep vertical wells is drilled. Water is drawn from the bottom of a standing column and returned to the top. During periods of peak heating and cooling, the system can bleed a portion of the return water rather than reinjecting it all, causing water inflow to the column from the surrounding aquifer. The bleed cycle cools the column during heat rejection, heats it during heat extraction, and reduces the required bore depth.

Section 5. Absorption heat pumps

Absorption heat pumps are essentially air-source heat pumps driven not by electricity, but by a heat source such as natural gas, propane, solar-heated water, or geothermal-heated water. Because natural gas is the most common heat source for absorption heat pumps, they are also referred to as gas-fired heat pumps. There are also absorption (or gas-fired) coolers available that work on the same principle.

Residential absorption heat pumps use an ammonia-water absorption cycle to provide heating and cooling. As in a standard heat pump, the refrigerant (in this case, ammonia) is condensed in one coil to release its heat; its pressure is then reduced and the refrigerant is evaporated to absorb heat. If the system absorbs heat from the interior of your home, it provides cooling; if it releases heat to the interior of your home, it provides heating.



Absorption heat pump operation

The difference in absorption heat pumps is that the evaporated ammonia pressure is not increased by a compressor. Instead, the ammonia is absorbed into water where a relatively low-power pump can then pump the solution to a higher pressure. The problem is then removing the ammonia from the water, and that's where the heat source comes in. The heat essentially boils the ammonia out of the water, starting the cycle again.

A key component in units presently on the market is generator absorber heat exchanger technology, or GAX, which boosts the efficiency of the unit by recovering the heat that is released when the ammonia is absorbed into the water. Other innovations include high-efficiency vapor separation, variable ammonia flow rates, and low-emissions, variable-capacity combustion of the natural gas.

Although mainly used in industrial or commercial settings, absorption coolers are now commercially available for large residential homes. The 5-ton residential cooler systems currently available are only appropriate for homes on the scale of 4,000 square feet or more.

Absorption coolers and heat pumps usually only make sense in homes without an electricity source, but they have an added advantage in that they can make use of any heat source, including solar energy, geothermal hot water, or other heat sources. They are also amenable to zoned systems, in which different parts of the house are kept at different temperatures.

The efficiency of air-source absorption coolers and heat pumps is indicated by their coefficient of performance (COP). COP is the ratio of either heat removed (for cooling) or heat provided (for heating) in Btu per Btu of energy input.

Section 6. Operation and maintenance

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 your system uses a high-efficiency, variable-speed fan motor. Operate the system on the "auto" fan setting on the thermostat. Consider installing (or have a professional install) a programmable thermostat with multistage functions suitable for a heat pump.

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% to 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 in 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.

Section 7. Thermostats

You can save money on your heating and cooling bills by simply resetting your thermostat when you are asleep or away from home. You can do this automatically without sacrificing comfort by installing an automatic setback or programmable thermostat.

Using a programmable thermostat, you can adjust the times you turn on the heating or air-conditioning according to a pre-set schedule. Programmable thermostats can store and repeat multiple daily settings (six or more temperature settings a day) that you can manually override without affecting the rest of the daily or weekly program.

Unfortunately, regular programmable thermostats are generally not recommended for heat pumps. In its cooling mode, a heat pump operates like an air conditioner, so turning up the thermostat (either manually or with a programmable thermostat) will save energy and money. But when a heat pump is in its heating mode, setting back its thermostat can cause the unit to operate inefficiently, thereby canceling out any savings achieved by lowering the temperature setting.

Recently, however, some companies have begun selling specially designed programmable thermostats for heat pumps, which make setting back the thermostat cost-effective. These thermostats typically use special algorithms to minimize the use of backup electric resistance heat systems.

7.1 Choosing and Programming a Programmable Thermostat

Most programmable thermostats are either digital, electromechanical, or some mixture of the two. Digital thermostats offer the most features in terms of multiple setback settings, overrides, and adjustments for daylight savings time, but may be difficult for some people to program. Electromechanical systems often involve pegs or sliding bars and are relatively simple to program.

When programming your thermostat, consider when you normally go to sleep and wake up. If you prefer to sleep at a cooler temperature during the winter, you might want to start the temperature setback a bit ahead of the time you actually go to bed. Also consider the schedules of everyone in the household. If there is a time during the day when the house is unoccupied for four hours or more, it makes sense to adjust the temperature during those periods.

7.2 Other Considerations

Electric resistance systems, which as was mentioned previously are the most commonly used heat-pump backup for cold weather, require thermostats capable of directly controlling 120-volt or 240-volt circuits. Only a few companies manufacture line-voltage programmable thermostats.

The location of your thermostat can affect its performance and efficiency. Read the manufacturer's installation instructions to prevent "ghost readings" or unnecessary furnace or air conditioner cycling. To operate properly, a thermostat must be on an interior wall away from direct sunlight, drafts, doorways, skylights, and windows. It should be located where natural room air currents–warm air rising, cool air sinking–occur. Furniture will block natural air movement, so do not place pieces in front of or below your thermostat. Also make sure your thermostat is conveniently located for programming.

Appendix A. EnergyGuide and Energy Star labels

Difference Between the EnergyGuide and ENERGY STAR LABELS

EnergyGuide Label

Who: Managed by the Federal Trade Commission (FTC)

Purpose: Estimates annual energy use and operating cost of the product

How to spot it: Yellow sticker or tag found on product

Manufacturers are required to display the EnergyGuide label on a long list of energy-using products, including appliances, heating and cooling equipment, and televisions. Its purpose is to provide potential purchasers an estimate of annual energy consumption and a sense of where the product ranks compared to others in terms of annual energy cost. The dollar amount at the bottom of the EnergyGuide is the estimated yearly operating cost based on the national average cost of electricity. Your exact costs will depend on local utility rates and the type and source of your energy. If you need another copy of the EnergyGuide label, check your retailer or manufacturer's website.

Benefit: The EnergyGuide is useful for directly comparing the energy use of similar models in the store.

ENERGY STAR Label

Who: U.S. Environmental Protection Agency (EPA)

Purpose: Designates highly efficient products

How to spot it: Blue, square label

The ENERGY STAR label saves you the effort needed to process all the information on the EnergyGuide sticker by simply designating the products that are highly efficient. When you see a product that has earned the ENERGY STAR, it means it meets strict guidelines for energy savings set by the EPA. Only manufacturers that independently certify their product's performance are allowed to use it. (And when they do, you'll find that manufacturers sometimes incorporate the ENERGY STAR label right into the EnergyGuide label, giving you the best of both worlds).

Benefit: The ENERGY STAR makes it easy to identify the most energy-efficient products that offer savings on energy bills without sacrificing performance, features, and comfort.

Both the EnergyGuide and the ENERGY STAR labels are intended to help you make smart energy choices. Used in conjunction, these labels can help you choose which product is right for you. The ENERGY STAR label will help you easily identify which products are the most efficient options, and then the EnergyGuide can be used to directly compare your top choices and give you an estimate of the energy use and operating cost.

Appendix B. Minimizing energy losses in ducts

Air ducts are one of the most important systems in your home, and if the ducts are poorly sealed or insulated, they are likely contributing to higher energy bills.

Your home's duct system is a branching network of tubes in the walls, floors, and ceilings; it carries the air from your home's furnace and central air conditioner to each room. Ducts are made of sheet metal, fiberglass, or other materials.

Ducts that leak heated air into unheated spaces can add hundreds of dollars a year to your heating and cooling bills, but you can reduce that loss by sealing and insulating your ducts. Insulating ducts in unconditioned spaces is usually very cost-effective. Existing ducts may also be blocked or may require simple upgrades.

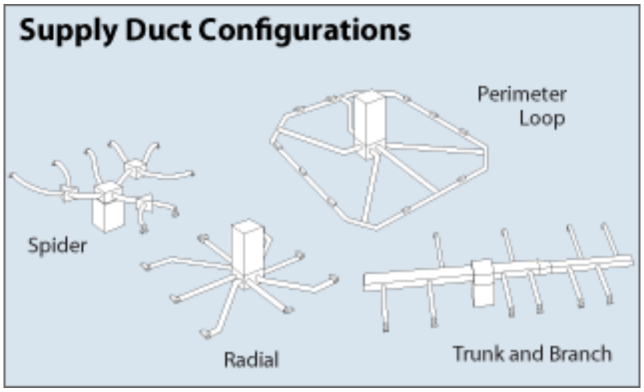
Designing and Installing New Duct Systems

In new home construction or in retrofits, proper duct system design is critical. In recent years, energy-saving designs have sought to include ducts and heating systems in the conditioned space.

Efficient and well-designed duct systems distribute air properly throughout your home without leaking to keep all rooms at a comfortable temperature. The system should provide balanced supply and return flow to maintain a neutral pressure within the house.

Even well sealed and insulated ducts will leak and lose some heat, so many new energy-efficient homes place the duct system within the conditioned space of the home. The simplest way to accomplish this is to hide the ducts in dropped ceilings and in corners of rooms. Ducts can also be located in a sealed and insulated chase extending into the attic or built into raised floors. In both of these latter cases, care must be taken during construction to prevent contractors from using the duct chases for wiring or other utilities.

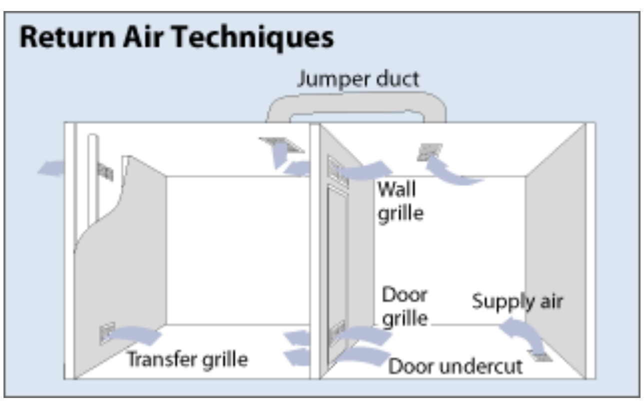
In either case, actual ducts must be used -- chases and floor cavities should not be used as ducts. Regardless of where they are installed, ducts should be well sealed. Although ducts can be configured in a number of ways, the "trunk and branch" and "radial" supply duct configurations are most suitable for ducts located in conditioned spaces.



Air return duct systems can be configured in two ways: each room can have a return duct that sends air back to the heating and cooling equipment, or return grills can be located in central locations on each floor. For the latter case, either grills must be installed to allow air to pass out of closed rooms, or short "jumper ducts" can be installed to connect the vent in one room with the next, allowing air to flow back to the central return grilles. Door undercuts help, but they are usually not sufficient for return airflow.

You can perform a simple check for adequate return air capacity by doing the following:

1. Close all exterior doors and windows
2. Close all interior room doors
3. Turn on the central air handler
4. "Crack" interior doors one by one and observe if the door closes or further opens "on its own." (Whether it closes or opens will depend on the direction of the air handler-driven air flow.) Rooms served by air-moved doors have restricted return air flow and need pressure relief as described above.



Maintaining and Upgrading Existing Duct Systems

Sealing your ducts to prevent leaks is even more important if the ducts are located in an unconditioned area such as an attic or vented crawlspace. If the supply ducts are leaking, heated or cooled air can be forced out of unsealed joints and lost. In addition, unconditioned air can be drawn into return ducts through unsealed joints.

Although minor duct repairs are easy to make, qualified professionals should seal and insulate ducts in unconditioned spaces to ensure the use of appropriate sealing materials.

Aside from sealing your ducts, the simplest and most effective means of maintaining your air distribution system is to ensure that furniture and other objects are not blocking the airflow through your registers, and to vacuum the registers to remove any dust buildup.

Existing duct systems often suffer from design deficiencies in the return air system, and modifications by the homeowner (or just a tendency to keep doors closed) may contribute to these problems. Any rooms with a lack of sufficient return airflow may benefit from relatively simple upgrades, such as the installation of new return-air grilles, undercutting doors for return air, or installing a jumper duct.

Some rooms may also be hard to heat and cool because of inadequate supply ducts or grilles. If this is the case, you should first examine whether the problem is the room itself: fix any problems with insulation, air leakage, or inefficient windows first. If the problem persists, you may be able to increase the size of the supply duct or add an additional duct to provide the needed airflow to the room.

Minor Duct Repair Tips

- Check your ducts for air leaks. First, look for sections that should be joined but have separated and then look for obvious holes.
- Duct mastic is the preferred material for sealing ductwork seams and joints. It is more durable than any available tape and generally easier for a do-it-yourself installation. Its only drawback is that it will not bridge gaps over ¼ inch. Such gaps must be first bridged with web-type drywall tape or a good quality heat approved tape.
- If you use tape to seal your ducts, avoid cloth-backed, rubber adhesive duct tape -- it tends to fail quickly. Instead, use mastic, butyl tape, foil tape, or other heat-approved tapes. Look for tape with the Underwriters Laboratories (UL) logo.
- Remember that insulating ducts in the basement will make the basement colder. If both the ducts and the basement walls are not insulated, consider insulating both. Water pipes and drains in unconditioned spaces could freeze and burst if the heat ducts are fully insulated because there would be no heat source to prevent the space from freezing in cold weather. However, using an electric heating tape wrap on the pipes can prevent this. Check with a professional contractor.
- Hire a professional to install both supply and return registers in the basement rooms after converting your basement to a living area.

- Be sure a well-sealed vapor barrier exists on the outside of the insulation on cooling ducts to prevent moisture condensation.
- If you have a fuel-burning furnace, stove, or other appliance or an attached garage, install a carbon monoxide (CO) monitor to alert you to harmful CO levels.
- Be sure to get professional help when doing ductwork. A qualified professional should always perform changes and repairs to a duct system.

Carbon Monoxide Detectors

Carbon monoxide (CO) detectors are required in new buildings in many states. They are highly recommended in homes with fuel-burning appliances such as natural gas furnaces, stoves, ovens, water heaters, and space heaters. An alarm signals if CO reaches potentially dangerous levels.

Acknowledgement. The material for this course has been compiled from the U.S. Department of Energy website, www.energy.gov/energysaver and other DOE websites in which energy efficiency is discussed.

