

## Chapter 7

### Heating, Ventilation, and Air Conditioning

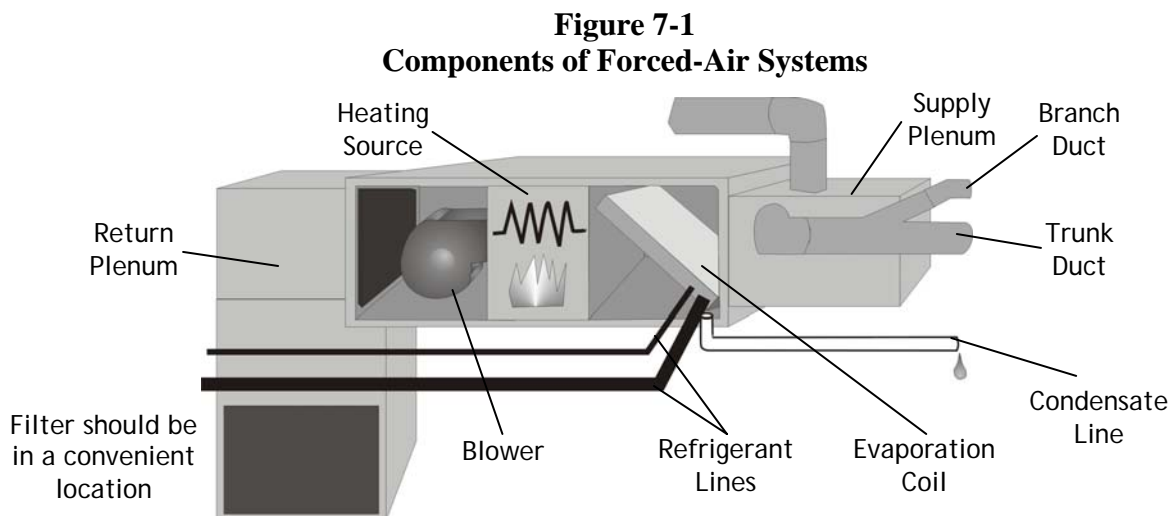
One of the most important decisions regarding a new home is the type of heating and cooling system to install. Equally critical is the heating and cooling contractor selected, as the operating efficiency of a system depends as much on proper installation as it does on the performance rating. Keys to obtaining the design efficiency of a system in the field include:

- Sizing and selecting the system for the heating, cooling, and dehumidification load of the home being built
- Correct design of the ductwork or piping
- Proper installation and charging of the HVAC unit
- Insulating and sealing all ductwork or piping

#### *Types of HVAC Systems*

There are two primary types of central heating systems - forced-air systems and radiant heating systems. Most new homes have forced-air heating and cooling systems - either using a central furnace and air conditioner or a heat pump. Figure 7-1 shows that in forced-air systems a series of ducts distribute the conditioned heated or cooled air throughout the home. The conditioned air is forced through the ducts by a blower, located in a unit called an air handler.

Most homes in Louisiana have three choices for central, forced-air systems: electric resistance heat or fuel-fired furnaces with electric air conditioning units or electric heat pumps, which can be either air-source or ground-source (geothermal). The best system for each home depends on many factors - - cost, comfort, efficiency, annual energy use, availability, and local prices for fuels and electricity.



When considering a HVAC system for a residence, remember that energy efficient homes have less demand for heating and cooling, so substantial cost savings may be obtained by installing smaller units that are properly sized to meet the load. Because energy bills in more efficient homes are

lower, higher efficiency systems will not provide as much annual savings on energy bills and may not be as cost effective as in less efficient houses.

### Sizing

It is important to size heating and air conditioning systems properly. Not only does oversized equipment cost more, but it can waste energy and may decrease comfort. Do not rely on rule-of-thumb methods to size HVAC equipment. Many contractors select air conditioning systems based on a rule such as 500 square feet of cooled area per ton of air conditioning (a ton provides 12,000 Btu per hour of cooling). Instead, use a sizing procedure such as:

- Calculations in Manual J published by the Air Conditioning Contractors Association
- Similar procedures developed by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
- Software procedures developed by electrical or gas utilities, the U.S. Department of Energy, HVAC equipment manufacturers, or private software companies

The heating and cooling load calculations rely on the size and type of construction for each component of the building envelope, as well as the heat given off by the lights, people, and equipment inside the house. If a zoned heating and cooling system is used, the loads in each zone should be calculated separately.

Simplified rules of thumb typically provide oversized heating and cooling systems for more efficient homes. Oversized units cost more to install, increase energy bills, suffer greater wear and tear, and often may not provide adequate dehumidification. It takes about 15 minutes for most air conditioners to reach peak efficiency. During extreme outside temperatures (under 32°F in winter and over 88°F in summer) the system should run about 80% of the time. Oversized systems cool the home quickly and often do not operate long enough to reach peak efficiency.

Proper sizing includes designing the cooling system to provide adequate dehumidification. In Louisiana's humid climate it is critical to calculate the latent load - the amount of dehumidification needed for the home. If the latent load is ignored, the home may become uncomfortable due to excess humidity.

The Sensible Heating Fraction (SHF) designates the portion of the cooling load for reducing indoor temperatures (sensible cooling). For example, in a HVAC unit with a 0.75 SHF, 75% of the energy expended by the unit goes to cool the indoor air. The remaining 25% goes for latent heat removal - taking moisture out of the air in the home. The Manual J system sizing procedure includes calculations to estimate latent load.

Many homes in Louisiana have design SHFs of approximately 0.7, that is, 70% of the cooling will be sensible and 30% latent. Systems that deliver less than 30% latent cooling may fail to provide adequate dehumidification in summer.

### Temperature Controls

The most basic type of control system is a heating and cooling thermostat. Programmable thermostats, also called setback thermostats, can be big energy savers for homes by automatically adjusting the temperature setting when people are sleeping or are not at home. Be certain that the programmable thermostat selected is designed for the particular heating and cooling equipment it will be controlling. This is especially important for heat pumps, as an improper programmable thermostat can actually increase energy bills.

A thermostat should be located centrally within the house or zone on an interior wall. It should not receive direct sunlight or be near a heat-producing appliance. A good location is often 4 to 5 feet above the floor in an interior hallway near a return air grille.

The interior wall, on which the thermostat is installed, like all walls, should be well sealed at the top and bottom to prevent circulation of cool air in winter or hot air in summer. Some homeowners have experienced excessive energy bills and discomfort for years because air from the attic leaked into the wall cavity behind the thermostat and caused the cooling or heating system to run much longer than needed.

### **Multiple HVAC Zones**

Larger homes often use two or more separate heating and air conditioning units for different floors or areas. Multiple systems can maintain greater comfort throughout the house while saving energy by allowing different zones of the house to be at different temperatures. The greatest savings come when a unit serving an unoccupied zone can be turned off.

Rather than install two separate systems, HVAC contractors can provide automatic zoning systems that operate with one system. The ductwork in these systems typically has a series of thermostatically controlled dampers that regulate the flow of air to each zone. Although somewhat new in residential construction, thermostats, dampers, and controls for zoning large central systems have been used for years in commercial buildings.

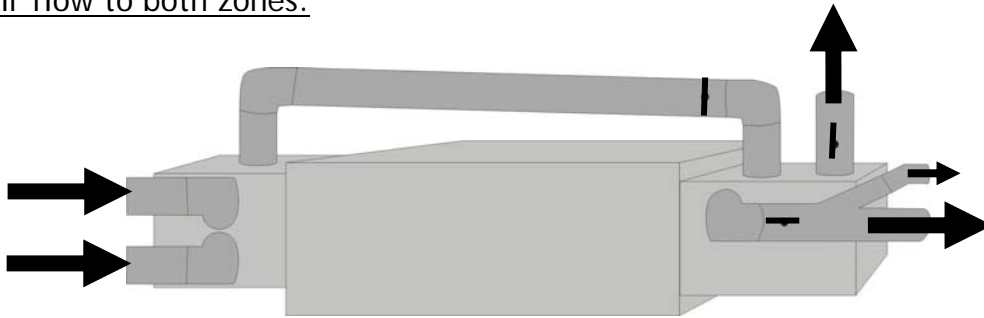
If your heating and air conditioning subcontractor feels that installing two or three separate HVAC units is needed, have them also estimate the cost of a single system with damper control over the ductwork. A single, larger system running longer is usually more efficient than separate systems.

Such a system must be carefully designed to ensure that the blower is not damaged if dampers are closed to several supply ducts. In this situation, the blower still tries to deliver the same air flow as before, but now through only a few ducts. The reduced air flow creates back pressure against the blades of the blower and may cause damage to the motor. There are three primary design options:

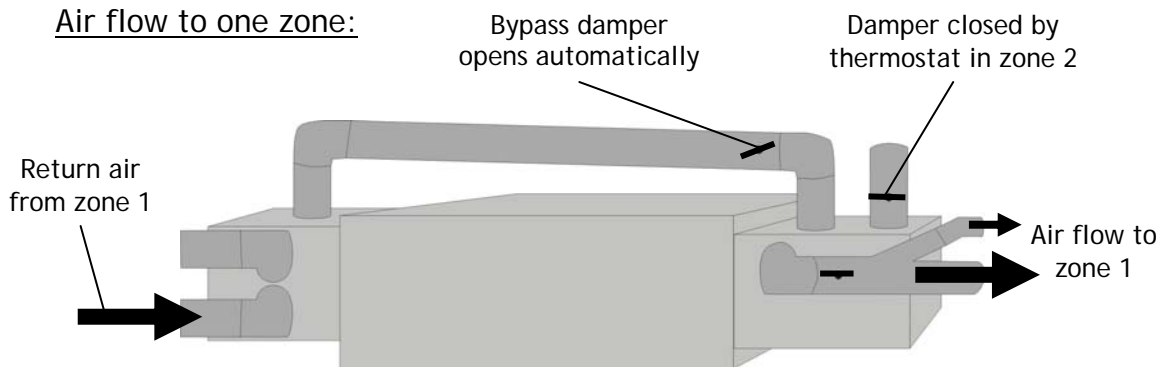
1. Create two zones and size the ductwork so that when the damper to one zone is closed, the blower will not suffer damage. The higher pressure can possibly damage the duct work as well, but that will not be noticed.
2. Install a manufactured system that uses a dampered bypass duct connecting the supply plenum to the return ductwork. The control system always allows the same approximate volume of air to circulate.
3. Use a variable speed HVAC system. Because variable speed systems are usually more efficient than single-speed systems, they will further increase savings.

**Figure 7-2**  
**Automatic Zoned System with Dampered Bypass Duct**

Air flow to both zones:



Air flow to one zone:



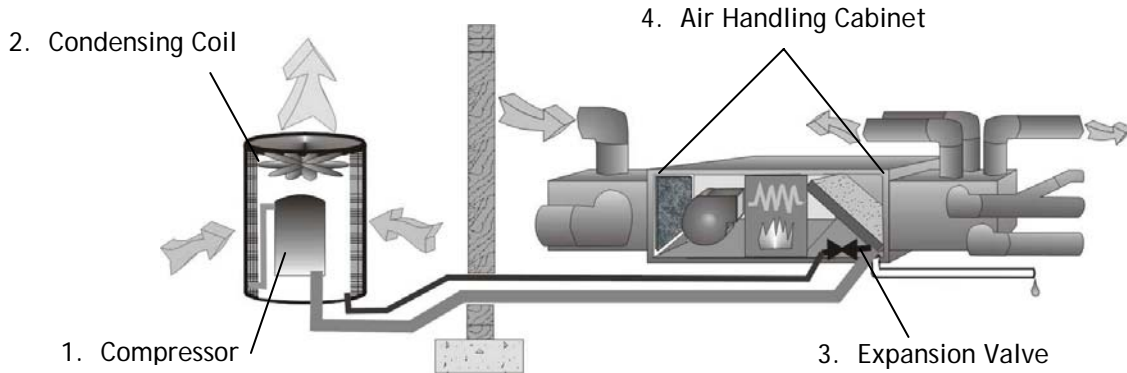
## ***Air Conditioning Equipment***

Air conditioners and heat pumps work similarly to provide cooling and dehumidification. In the summer, they extract heat from inside the home and transfer it outside. In winter, a heat pump reverses this process and extracts heat from outside and transfers it inside.

Both systems typically use a vapor compression cycle, which is described in Figures 7-3 and 7-4. This cycle circulates a refrigerant - a material that increases in temperature significantly when compressed and cools rapidly when expanded. The exterior portion of a typical air conditioner is called the condensing unit and houses the compressor, which uses most of the energy, and the condensing coil.

The inside mechanical equipment, called the air handling unit, houses the evaporator coil, the indoor blower, and the expansion or throttling valve. The controls and ductwork for circulating cooled air to the house complete the system.

**Figure 7-3**  
**Air Conditioning with the Vapor Compression Cycle**



1. Cold, liquid refrigerant circulates through evaporator coils. Inside air is blown across the coils and is cooled. This warms and evaporates the refrigerant. The cooled air is blown through the ductwork. The refrigerant, now a gas, flows to the outdoor unit.
2. The compressor (in the outside unit) pressurizes the gaseous refrigerant. The refrigerant temperature rises, but remains a gas.
3. Fans in the outdoor unit blow air across the hot, pressurized gas in the condensing coil. The refrigerant cools and condenses into a liquid.
4. The pressurized liquid flows inside to the air handling unit. It passes through an expansion valve, where its temperature drops as it vaporizes. The refrigerant flows to the evaporator coil and the process starts over.

The exterior, air-cooled condensing unit should be kept free from plants and debris that might block the flow of air through the coil or damage the thin fins of the coil. Ideally, locate the condensing unit in the shade. However, do not block air flow to or from this unit with dense vegetation, fencing or overhead decking.

### **The SEER Rating**

The cooling efficiency of a heat pump or an air conditioner is rated by the Seasonal Energy Efficiency Ratio (SEER), a ratio of the average amount of cooling provided during the cooling season to the amount of electricity used. Current national legislation mandates a minimum SEER 13 for most residential air conditioners. Pending federal policies may further increase minimum efficiencies. Some units can meet SEER 23 ratings. Packaged units have a minimum SEER of 13.

Builders should be aware that the SEER rating is a national average based on equipment performance in Virginia. Some equipment may not produce the listed SEER in actual operation in Louisiana's homes, particularly during the cooling season.

One of the main problems with HVAC systems has been the inability of some higher efficiency equipment to dehumidify homes adequately. If units are not providing sufficient dehumidification, the typical homeowner response is to lower the thermostat setting. Since every degree the thermostat

is lowered increases cooling bills 3 to 7%, systems that have nominally high efficiencies, but inadequate dehumidification, may suffer from higher than expected cooling bills.

In fact, poorly functioning "high" efficiency systems may actually cost more to operate than a well designed, moderate efficiency unit. Make certain that the contractor has used Manual J techniques to size the system so that the air conditioning system meets both sensible and latent (humidity) loads at the manufacturer's claimed efficiency.

### Variable Speed Units

The minimum standard for air conditioners of SEER 13 provides for a reasonably efficient unit. However, higher efficiency air conditioners may be quite economical. In order to increase the overall operating efficiency of an air conditioner or heat pump, multi-speed and variable speed compressors have been developed. These units can operate at low or medium speeds when the outdoor temperatures are not extreme. They can achieve a SEER of 15 to 16.

The cost of variable speed units is generally about 30% higher than standard units. Advantages they offer over standard, single-speed blowers:

- They usually save energy.
- They are quieter, and because they operate fairly continuously, there is far less start-up noise (often the most noticeable sound in a standard unit).
- They dehumidify better; some units offer a special dehumidification cycle, which is triggered by a humidistat that senses when the humidity levels in the home are too high.

### Proper Installation

Too often, high efficiency cooling and heating equipment is improperly installed, which can cause it to operate at substantially reduced efficiencies. A SEER 15 unit that is installed poorly with leaky ductwork may only deliver SEER 10 performance. Typical installation problems are:

- Improper charging of the system – the refrigerant of the cooling system does the bulk of the work, flowing back and forth between the inside coil and the outside coil, changing states, and undergoing expansion and compression. The HVAC contractor should use the manufacturer's installation procedures to charge the system properly. The correct charge cannot be ensured by pressure gauge measurements alone. In new construction, the refrigerant should be weighed in based on the length and size of the refrigerant lines and the HVAC system. Then, use either the supercharge temperature method or, for systems with certain types of expansion valves, the supercooling method to confirm that the charge is correct.
- Reduced air flow – if the system has poorly designed ductwork, constrictions in the air distribution system, clogged or more restrictive filters, or other impediments, the blower may not be able to transport adequate air over the indoor coils of the cooling system.
- Inadequate air flow to the outdoor unit – if the outdoor unit is located under an overhang or a deck, or within an enclosure such as fencing or bushes, air may not circulate freely between the unit and outdoor air. In such cases, the temperature of the air around the unit rises, thereby making it more difficult for the unit to cool the refrigerant. The efficiency of a unit surrounded by outdoor air that is 10 degrees warmer than the ambient outside temperature can reduce the efficiency of the unit by about 10%.

For all types of HVAC systems, the best way to ensure proper installation is to include a set of specifications with the plans that dictate the following:

- The system shall be sized for the load using Manual J or other approved methods.
- The refrigerant charge shall be calculated, weighed in, and confirmed using manufacturer's suggested procedures.
- Ductwork shall be sized using Manual D, or other approved method, and fully sealed.
- Make certain supply air has a pathway back to the return. Many homes rely on undercut interior doors to let air flow from the room to a central return. However, as discussed in Chapter 8, many rooms, especially those with multiple supply ducts, become pressurized when the HVAC operates. As a consequence, when several interior doors are closed, the main section of the home where the central return is located becomes negatively pressurized. Rooms with more than one supply duct and no return should be connected to the central section of the home with a transfer grille, which permits air flow between the two spaces.
- The system's operation shall be checked, balanced, and confirmed.

## *Heating Systems*

Two types of heating systems are most common in new homes - furnaces, which burn natural gas, propane, fuel oil, or electricity, and electric heat pumps. Furnaces are generally installed along with central air conditioners. Heat pumps provide both heating and cooling, so separate units are not necessary. Some homes also use electric resistance heating. Resistance heating turns nearly all of the electricity used into heat. However, resistance heaters are only about 50% as efficient as heat pumps. Also, because of electrical losses in the power distribution grid, the resistance heater may use only about 30% of the energy of the original fuel source.

### Heat Pump Equipment

#### *Air-source heat pumps*

The most common type of heat pump is the air-source heat pump, which serves as an air conditioner during the cooling season. In winter, it reverses the cycle and obtains heat from cool outside air. Most heat pumps operate at least twice as efficiently as conventional electric resistance heating systems. They have rated lifetimes of 15 years, compared to 20 years for most furnaces; however, many homeowners have well maintained equipment over 20 years old that continues to work effectively.

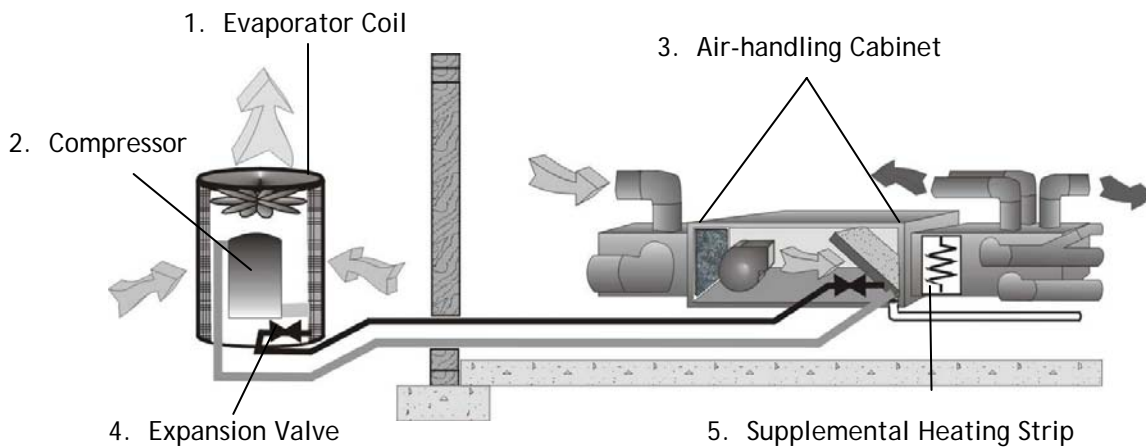
At outside temperatures of 30°F to 45°F, at a temperature known as the balance point, heat pumps can no longer meet the entire heating load of the home. Most systems use electric resistance coils called strip heaters to provide supplemental backup heat. Strip heaters, located in the air handling unit, are much more expensive to operate than the heat pump itself. They should not be oversized, as they can drive up the peak load requirements of the local electric utility.

A staged, heat pump thermostat used in concert with multistage strip heaters will minimize strip heat operation. Dual-fuel or piggyback systems heat the home with natural gas or propane when temperatures drop below the balance point.

Air-source heat pumps should have outdoor thermostats, which prevent operation of the strip heaters at temperatures above 38°F. The International Energy Conservation Code requires controls to prevent strip heater operation during weather when the heat pump alone can provide adequate

heating. In addition, tight ductwork is especially important in air-source heat pumps to prevent an uncomfortably low delivery temperature of supply air into the living areas.

**Figure 7-4**  
**Air Source Heat Pump**



1. The outdoor coil, which serves as the evaporator coil in heat pump mode, uses outside air to boil the cold, liquid refrigerant.
2. The compressor pressurizes the refrigerant.
3. The hot, gaseous refrigerant enters the inside coil, which is serving as the condensing coil. Inside air passes over the coil and is heated. The refrigerant is cooled and condenses into a liquid.
4. The pressurized, liquid refrigerant flows outside to the expansion valve. The expansion valve reduces the pressure and further lowers the temperature of the refrigerant. This completes the cycle.
5. If the outdoor air is too cold for the heat pump to adequately heat the home, supplemental heating must be provided. In Louisiana, a gas-fired heater or electric resistance strip heater is normally used for supplemental heating.

*Periodically in winter, the heat pump must switch to a defrost cycle, which melts any ice that may accumulate on the outside coil.*

### ***Geothermal heat pumps***

Unlike an air-source heat pump with its outside coil and fan, a geothermal heat pump relies on fluid-filled pipes buried beneath the earth as a source of heating in winter and cooling in summer. In each season, the temperature of the earth is closer to the desired temperature of the home than outdoor air, so less energy is needed to maintain comfort. Eliminating the outside equipment means higher efficiency, less maintenance, greater equipment life, less noise, and no inconvenience of having to mow around that outdoor unit.

Geothermal heat pumps have SEER ratings above 15 and can save up to 40% on the heating and cooling costs of a standard air-source heat pump. Some geothermal products have greater dehumidification ability as well. Many units can also provide hot water at much greater efficiency than standard electric water heaters.

Types of closed loop designs for piping include:

- In deep well systems, a piping loop extends several hundred feet under ground.



- Shallow loops placed in long trenches, typically about 6-feet deep and several hundred feet long; coiling the piping into a "slinky" reduces the length requirements but a relatively large ground area is required.
- For homes located on private lakes, loops can be installed on the bottom, which decreases the installation costs or a plate type heat exchanger can be suspended vertically below the surface.

The buried piping in geothermal systems usually has a 25-year warranty. Most experts believe the piping will last longer, because it is made of a durable plastic with heat-sealed connections, and the circulating fluid has an anticorrosive additive.

The actual costs of geothermal heat pumps vary according to the difficulty of installing the ground loops as well as the size and features of the equipment. Because of their high installation cost, geothermal heat pumps may not be economical for homes with low heating and cooling needs. However, their lower operating costs, reduced maintenance requirements, and greater comfort may make them attractive to many homeowners. Proper installation of the geothermal loops is essential for high performance and the longevity of the system, so choose only qualified, experienced geothermal heat pump contractors.

### *Measures of efficiency for heat pumps*

The heating efficiency of a heat pump is measured by its Heating Season Performance Factor (HSPF), which is the ratio of heat provided in Btu per hour to watts of electricity used. This factor considers the losses when the equipment starts up and stops, as well as the energy lost during the defrost cycle. The HSPF averages the performance of heating equipment for a typical winter in the United States, so the actual efficiency will vary in different climates.

Typical values for the HSPF are 7.7 for standard efficiency and 8.0 for high efficiency. Variable speed heat pumps have HSPF ratings as high as 9.0. Geothermal heat pumps are not rated by HSPF as yet; however, they are much more efficient than air-source heat pumps and work well at sub-zero temperatures. They are also quieter than conventional systems and include water heating capabilities. The ARI Directory of Air Conditioning Equipment lists the efficiencies of many different products.

### **Furnace Equipment**

Furnaces burn fuels such as natural gas, propane, and fuel oil to produce heat and provide warm, comfortable indoor air during cold weather in winter. They come in a variety of efficiencies. The comparative economics between heat pumps and furnaces depend on the type of fuel burned, its price, the home's design, and the outdoor climate. Recent increases in energy prices have improved the economics of more efficient heating and cooling systems. However, at this point in time it is difficult to compare furnaces and heat pumps of various types due to long-term fuel price uncertainty.

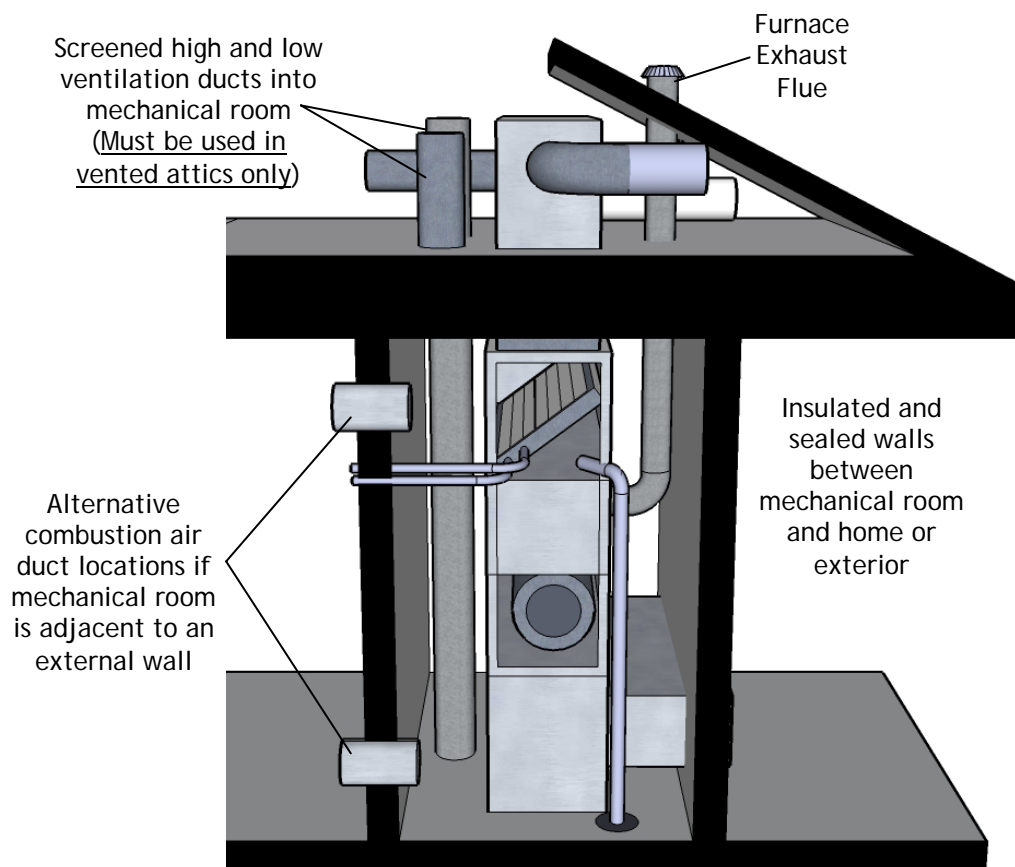
### *Furnace operation*

Fuel-fired furnaces require oxygen for combustion and extra air to vent exhaust gases. For many years, atmospheric or natural draft furnaces were the standard. These units draw in air from around them whether located in the house, crawlspace or attic. They have a single, unsealed exhaust stack to carry the hot exhaust gases out of the home. Older units used a continuously burning gas flame as a pilot light to ignite the fuel when the home's thermostat detected a need for heat.

Homes today are generally built much tighter, have central air conditioning, and a variety of exhaust fans including range hoods, bathroom exhaust fan, and clothes dryers. As discussed in Chapter 2 and in Chapter 8 on ductwork, operating exhaust fans and even closing interior doors can cause negative pressure in the area around the furnace, especially in tighter homes. If the negative pressure is sufficiently high, the furnace may backdraft, pulling the exhaust gases down the flue and into the home and creating potentially deadly levels of carbon monoxide.

Because negative pressures can occur in virtually any home, atmospheric furnaces should not be installed in the conditioned space. If located inside the conditioned area of a home, they must be installed in a sealed and insulated closet, as shown in Figure 7-5, with two sources of incoming combustion air - one entering near the floor and the other near the ceiling. The unit must include an exhaust vent that extends through the roof.

**Figure 7-5**  
**Sealed Mechanical Room Design for Non-direct Vent Furnace**



More modern furnaces, known as direct vent or uncoupled furnaces, have a duct that supplies combustion air from the outside directly to the burner and a sealed exhaust vent to the outside. Because their combustion system is totally isolated from the living space, these units can operate safely inside a home, when in proper working order. They are recommended unless the furnace is completely outside the conditioned area of the home.

### *Measures of efficiency for furnaces*

The efficiency of a gas furnace is measured by the Annual Fuel Utilization Efficiency (AFUE), a rating which takes into consideration losses from pilot lights, start-up, and stopping. Unlike SEER and HSPF ratings, the AFUE does not consider the unit's electricity use for fans and blowers, which may exceed \$50 annually.

An AFUE rating of 78% means that for every \$1.00 worth of fuel used by the unit, \$0.78 worth of usable heat is produced. The remaining \$0.22 worth of energy is lost as waste heat exhausted up the flue.

Several years ago, the federal government mandated that furnaces have AFUE ratings of at least 78%. Old, atmospheric furnaces with pilot lights had AFUE ratings of only 50 to 60%. Manufacturers were able to meet the new standard by first replacing pilot lights with electronic ignition. Some of these units are able to operate at an AFUE of 78% and are being sold today in Louisiana.

Most manufacturers took the next steps of improving the heat exchanger inside the unit and installing a fan to force exhaust gases out of the flue. These furnaces are usually non-direct vent units because they do not have a sealed source of combustion air. They must be treated in the same manner as atmospheric furnaces, as described in the previous section. However, they are much less susceptible to backdrafting because of the fan for exhausting flue gases. Their AFUE ratings are typically 80% to 83%.

Models with efficiencies over 90% and up to 97%, commonly called condensing furnaces, contain secondary heat exchangers that actually cool flue gases until they partially condense. Heat losses up the flue are virtually eliminated. A drain line connected to the flue drains the condensate. One advantage of cooler exhaust gas is that you can use a plastic flue pipe that can be vented horizontally through a side wall. Metal flues, sometimes required by code, will quickly corrode when used with these high efficiency units. Make sure your local building official is aware of the need to install a plastic flue before ordering a condensing furnace.

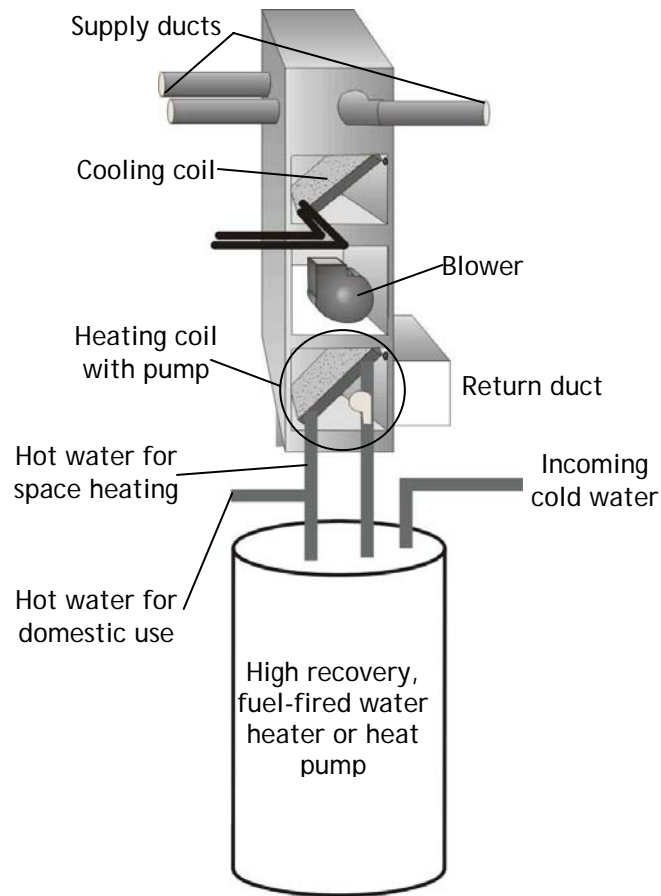
There are a variety of condensing furnaces available. Some rely primarily on the secondary heat exchanger to increase efficiency, while others, such as the pulse furnace, have revamped the entire combustion process.

Because of the wide variety of condensing furnaces on the market, compare prices, warranties, and service. Also, compare the economics carefully with those of moderate efficiency units. Condensing units may have longer paybacks than expected in energy efficient homes due to reduced heating loads.

### **Integrated Space and Water Heating**

An integrated space heating and domestic water heating unit provides a single, multipurpose system. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has developed standards by which to evaluate such systems, as well as methods of measuring the efficiency of integrated systems with either space heating or water heating as their primary purpose.

**Figure 7-6**  
**Integrated Space and Water Heating System**



### *Gas-fired integrated systems*

One type of integrated space and water heater system uses a quick recovery, high efficiency gas water heater to provide 140°F water that provides space heating and hot water. Heating needs are met by pumping hot water from the water heater to a heating duct coil in the air handling unit.

Household air passing through ductwork connected to this coil is heated to between 110°F and 120°F. The water, cooled to about 120°F by the air, returns from the heating coil to the integrated water heater for reheating. The air handler can also incorporate a cooling coil for air conditioning. The economics of these units can be quite favorable; however, it is often difficult to obtain an objective comparison between integrated systems and more conventional space and water heating equipment.

Some advantages of integrated systems are:

- They can save floor space, as some air handling units mount to the wall or within the wall cavity above the water heater tank.
- They may have lower installed costs - only one gas hookup and a single flue are required.
- They often have a more efficient water heater than standard homes.

Another integrated approach uses a central boiler to provide space and water heating. Typically, the boiler can provide hot water even in non-heating seasons more efficiently than standard water heaters. However, the greater initial cost of this type of system may limit its use to families with high hot water demands.

### *Electric integrated systems*

There are several products that use central heat pumps for water heating, space heating and air conditioning. These integrated units are available in both air-source and geothermal models.

Make sure the unit is not substantially more expensive than a separate energy efficient heat pump and electric water heater. Units within \$1,500 may provide favorable economic returns. The SEER of the unit should exceed 13.0. To be a viable choice, any type of integrated system should:

- Have a proven track record in the field.
- Cost about the same, if not less, than comparable heating and hot water systems of approximately the same efficiencies.
- Provide at least a five-year warranty.
- Be properly sized for both the heating and hot water load.

### Wood Heating

Wood can be a thrifty alternative to conventional heating sources. However, if the homeowner must purchase wood fuel, the savings will diminish. Wood heating also requires work, and a fire-safe installation is essential.

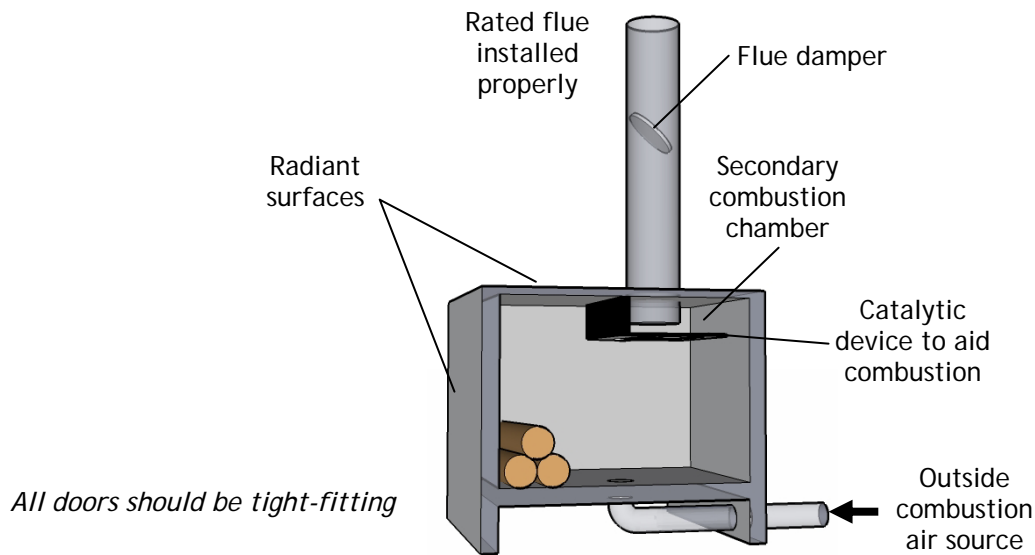
Although there are wood-burning furnaces designed for homes, most homeowners interested in wood heating use a fireplace or wood heater — either freestanding stove or fireplace insert. Fireplaces and wood heaters are primarily space heaters. They radiate heat to people and objects close by and, to a lesser degree, heat the surrounding air.

Like other fuel-burning equipment, fireplaces and wood heaters need air for combustion and must vent exhaust products to the outside. In standard construction, air infiltration provides the necessary combustion air. However, in energy efficient homes, the sources of air infiltration are greatly reduced so special measures to supply outside combustion air must be provided.

An energy efficient fireplace must have a direct vent that brings air from outside the home to the firebox. The vent should be designed so that it remains clear of ashes, wood, and other materials when a fire is burning. It should be located toward the front of the firebox and have a damper or lid that prevents infiltration when the fireplace is not in use.

In addition to an outside source of combustion air, a fireplace should have a tight-fitting flue damper and glass doors to reduce air leakage further. The flue damper should be opened before lighting a fire and closed after combustion is complete.

**Figure 7-7**  
**Efficient Wood Heater Design**

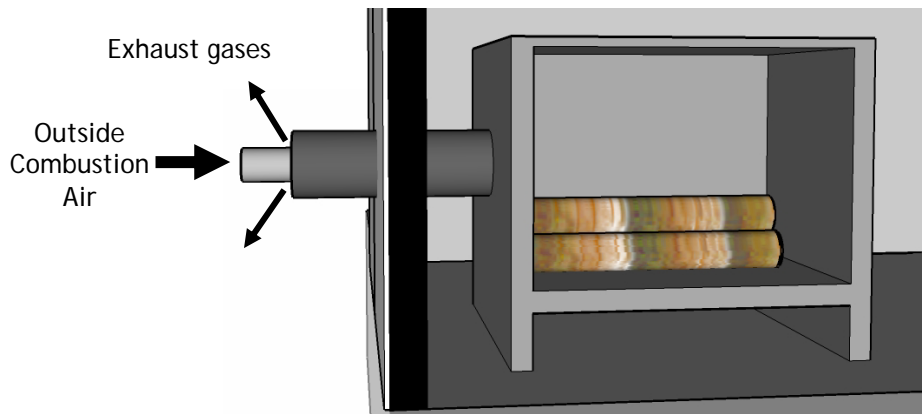


Some fireplace designs provide a means of heating room air by circulating it around the firebox where it is heated and then passed back into the house. These systems are more efficient than standard fireplaces.

Homeowners serious about using wood as a heat source should choose a high efficiency wood heater, such as an airtight wood stove. As with fireplaces, wood heaters in energy efficient homes should have an outside source of combustion air. In fact, even standard houses may not have adequate infiltration levels to maintain proper combustion and venting for a wood heater.

To ensure safety, select a wood heater designed to use outside combustion air. These units are required by code in manufactured housing and are usually sold by businesses supplying wood heaters and fireplaces. The wood heater should also be properly sized for the home. Many energy efficient homes have small heating loads, so large or even moderate-sized wood heaters may produce too much heat.

**Figure 7-8**  
**Direct Vent Heaters**



## Unvented Fuel-Fired Heaters

Unvented heaters that burn natural gas, propane, kerosene, or other fuels are strongly discouraged. While these devices usually operate without problems, the consequences of a malfunction are life-threatening; they can exhaust carbon monoxide, sulfur oxides, and nitrogen oxides directly into household air. They also can create serious moisture problems inside the home.

Most devices come equipped with alarms designed to detect air quality problems. However, many experts question putting a family at any risk of carbon monoxide poisoning - they see no rationale for bringing these units into a home. There are a wide variety of efficient, vented space heaters available. Examples of unvented units to avoid include:

- Flueless gas fireplaces - use sealed combustion, direct vent units instead
- Room space heaters - choose forced-draft, direct-vent models instead

## *Ventilation and Indoor Air Quality*

All houses need ventilation to remove stale interior air and excessive moisture. There has been considerable concern recently about how much ventilation is required to maintain the quality of air in homes. While there is substantial disagreement on the severity of indoor air quality problems, most experts agree that the solution is not to build an inefficient, “leaky” home. Because make-up air is brought in at outside temperatures, it often requires more energy to condition the home. However, the ventilation may reduce energy use by removing excess humidity. With Louisiana’s humid environment, though, the outside air will typically be more humid than the inside air.

Research studies show that standard houses are almost as likely to have indoor air quality problems as energy efficient ones. Most building researchers believe that no house is so leaky that the occupants can be relieved of concern about indoor air quality. They recommend mechanical ventilation systems for all houses.

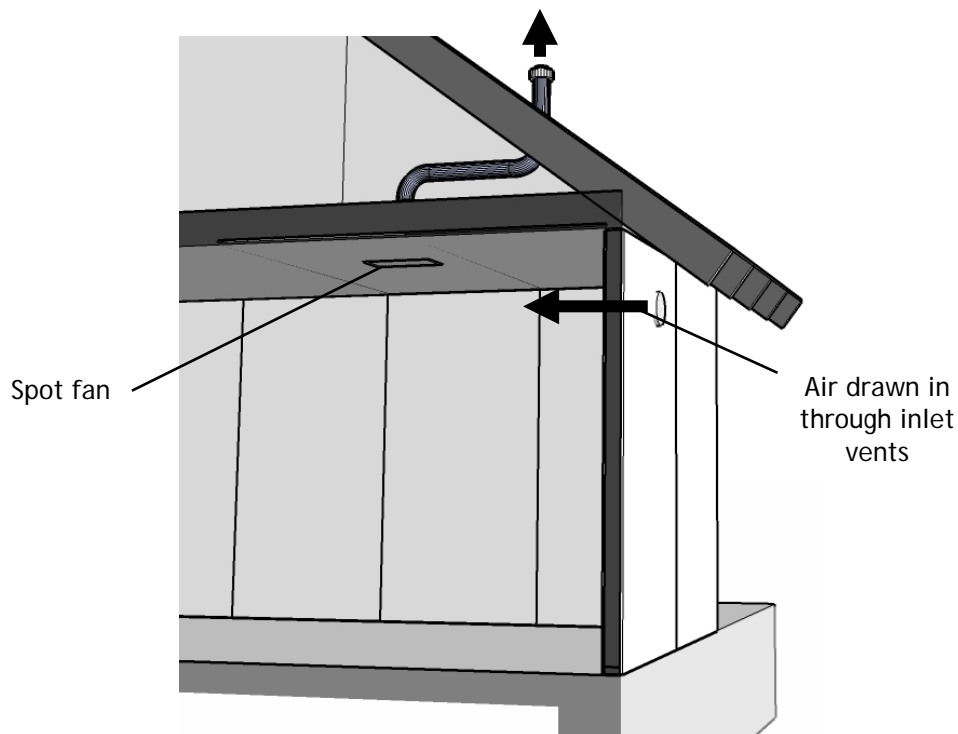
The amount of ventilation required depends on the number of occupants and their lifestyle, as well as the design of the home. The ASHRAE standard, “Ventilation for Acceptable Indoor Air Quality” (ASHRAE 62) recommends that houses have 0.35 natural air changes per hour (nach) or 15 cubic feet per minute of ventilation per occupant.

Older, drafty houses can have infiltration rates of 1.0 to 2.5 nach. Standard homes built today are tighter and usually have rates of from 0.5 to 1.0 nach. New, energy efficient homes often have less than 0.35 nach.

Infiltration is not a successful means of ventilation because it is not reliable and the quantity of incoming air is not controllable. Air leaks are unpredictable, and infiltration rates for all houses vary. For example, air leakage is greater during cold, windy periods than during muggy, hot weather. Thus, pollutants may accumulate during periods of calm weather even in drafty houses. These homes will also have many days when excessive infiltration provides too much ventilation, causing discomfort, high energy bills, and possible deterioration of the building envelope.

Concerns about indoor air quality are leading more and more homeowners to install controlled ventilation systems that provide a reliable source of fresh air. The simplest approach is to provide spot ventilation of bathrooms and kitchens to control moisture. Nearly all exhaust fans in standard construction are ineffective — a prime contributor to moisture problems in Louisiana homes. Builders should select quality fans with low noise ratings.

**Figure 7-9**  
**Ventilation with Spot Fans**



General guidelines call for providing a minimum of 50 cubic feet per minute (cfm) of air flow for baths and 100 cfm for kitchens. Manufacturers should supply the cfm rating for any exhaust fan.

The cfm rating typically assumes the fan is working against an air pressure resistance of 0.1 inch of water - the resistance provided by about 15 feet of straight, smooth metal duct. In practice, most fans are vented with flexible duct that provides much more resistance. Many ventilation experts suggest choosing a fan based on a resistance of 0.30 inches of water.

While larger fans cost more, they are usually better constructed and therefore last longer and run quieter. The level of noise for a fan is rated by sones. Choose a fan with a sone rating of 1.5 or less. Top quality models are often below 0.5 sones.

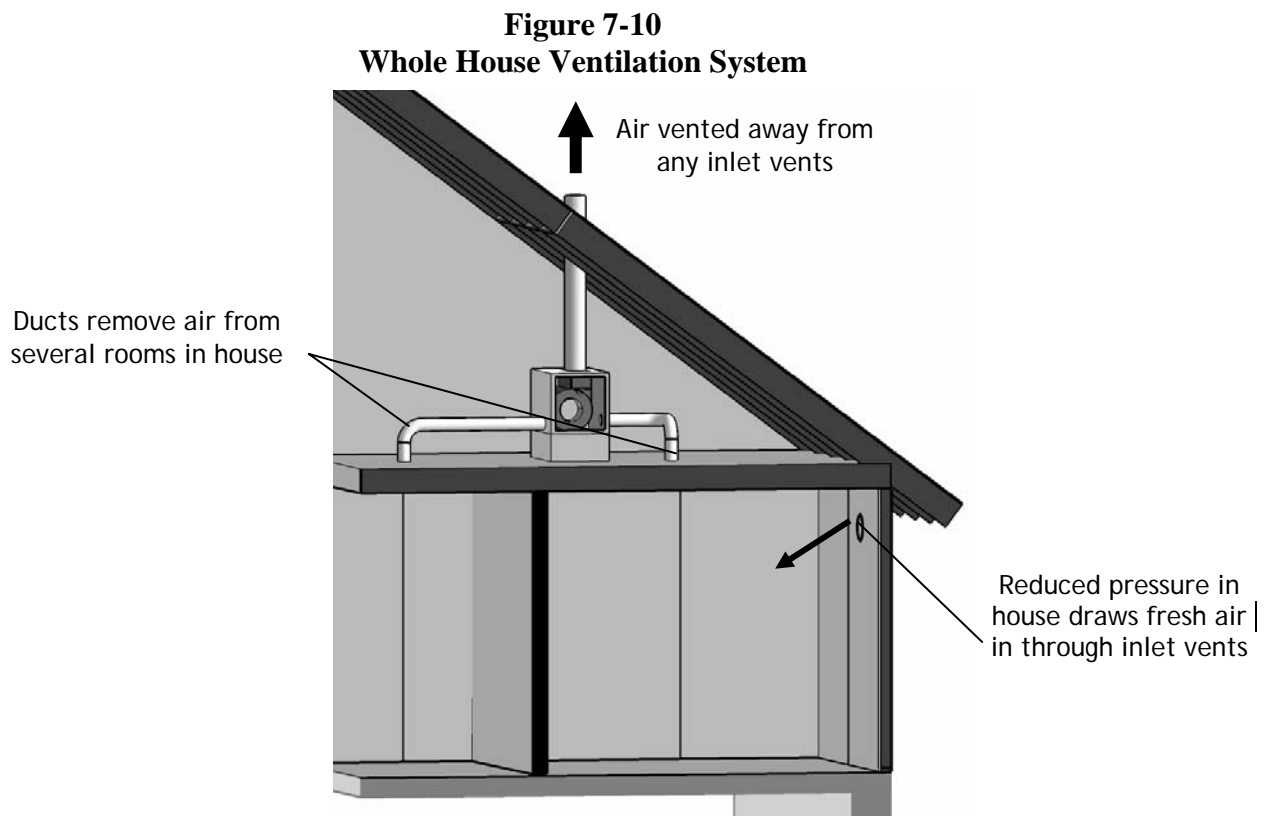
Many ceiling- or wall-mounted exhaust fans can be adapted as “in-line” blowers located outside of the living area, such as in an attic or basement. Manufacturers also offer in-line fans to vent a single bath or kitchen, or multiple rooms. Distancing the in-line fan from the living area lessens noise problems.



Bath and kitchen exhaust fans should vent to the outside - not just into an attic or crawlspace. Avoid side-vented stove units whose exhaust fans pull 400 to 700 cfm from the house. Unless some form of make-up air is supplied, these units can create high levels of negative pressure.

Always test a home for pressure imbalance problems when fans are operating. In tighter homes, a single bathroom exhaust fans may backdraft fireplaces or combustion appliances. If pressure problems exist, the home should have a source of make-up air, which is described in the next section.

While improving spot ventilation will certainly help control moisture problems, it may not provide adequate ventilation for the entire home. A whole house ventilation system can exhaust air from the kitchen, all baths, and perhaps the living area or bedrooms.



Whole house ventilation systems usually have large single fans located in the attic or basement. Ductwork extends to rooms requiring ventilation. These units typically have two-speed motors. The low speed setting gives continuous ventilation – usually 10 cfm per person or 0.35 ach. The high speed setting can quickly vent moisture or odors.

## Supplying Outside Make-up Air

### *From air leaks*

The air vented from the home by exhaust fans must be replaced by outside air. Air leaks can provide the make-up air, but this does not guarantee fresh air. It is far better to provide a controlled mechanism for make-up air as an integral part of the house design. Relying on air leaks requires no extra equipment; however, the occupant has little control over the air entry points. Plus, many of the air leaks come from undesirable locations, such as crawlspaces or attics. If the home is too airtight, the ventilation fans will not be able to pull in enough outside air to balance the air being exhausted. This may threaten air quality by pulling exhaust gases from flues and chimneys back into the home. The homeowner can alleviate the pressure problems by opening windows slightly though this may pose a home security risk.

### *From inlet vents*

Providing fresh outside air through inlet vents is another option. These vents can often be purchased from energy specialty outlets by mail order. They are usually located in exterior walls. The amount of air they allow into the home can be controlled manually or by humidity sensors.

Locate inlet vents where they will not create uncomfortable drafts. They are often installed in bedroom closets with louvered doors or high on exterior walls. Ideally, they should be filtered and located as far as possible from all exhaust vents.

### *Via ducted make-up air*

Outside air can also be drawn into and distributed through the home via the ducts for a forced-air heating and cooling system. This type of system usually has an automatically controlled outside air damper in the return duct system. The blower for the ventilation system is either the air handler for the heating and cooling system or a smaller unit that is strictly designed to provide ventilation air.

## Dehumidification Ventilation Systems

Louisiana homes are often more humid than desired. A combined ventilation-dehumidifier system can bring in fresh, outdoor air, remove its moisture, and supply it to the home. These systems can also filter incoming air. Because these systems require an additional mechanical device - a dehumidifier installed on the air supply duct - they should be designed for the specific needs of the home.

## Heat Recovery Ventilators

Air-to-air heat exchangers, or heat recovery ventilators (HRV — described in Figure 7-11), typically have separate duct systems that draw in outside air for ventilation and distribute fresh air throughout the house. In winter, heat from stale room air is “exchanged” to the cooler incoming air. In summer, the hot outdoor air is cooled and may be partially dehumidified by the cooler exhaust air. Some models, called enthalpy heat exchangers, can also recapture cooling energy in summer by exchanging moisture between exhaust and supply air.

While energy experts have questioned the value of the heat saved in Louisiana homes for the cost for an HRV, recent studies on enthalpy units indicate their dehumidification benefit in summer offers an advantage over ventilation-only systems. The value of any heat recovery ventilation system should not be determined solely on the cost of recovered energy. The improved quality of the indoor environment must be considered as well.

## Sample Ventilation Plans

### *Design 1: Upgraded Spot Ventilation*

This relatively simple and inexpensive whole house ventilation system integrates spot ventilation using bathroom and kitchen exhaust fans with an upgraded exhaust fan (usually 100 to 150 cfm) in a centrally located bathroom. When the fan operates, outside air is drawn through inlets in closets with louvered doors. The fan is controlled by a timer set to provide ventilation at regular intervals. Interior doors are undercut to allow air flow to the central exhaust fan. The fan should be a long life, high-quality unit that operates quietly. In addition to the automatic ventilation provided by this system, occupants can turn on all exhaust fans manually as needed.

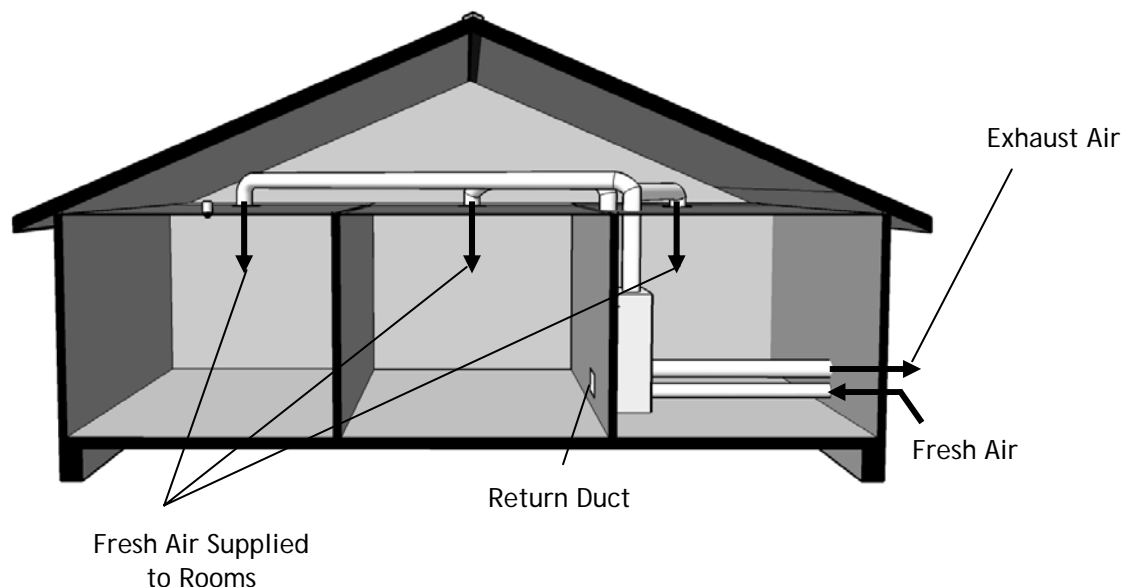
### *Design 2: Whole House Ventilation System*

Whole house ventilation systems use a centralized, two-speed exhaust fan to draw air from the kitchen, bath, laundry, and living area. The blower is controlled by a timer. The system should provide approximately 0.35 ach on low speed and 1.0 ach on high speed. Outside air is supplied by a separate dampered duct connected to the return air system. When the exhaust fan operates, the outside air damper opens and allows air to be drawn into the house through the forced-air ductwork.

### *Design 3: Heat Recovery Ventilation System*

HRV systems draw fresh outside air through ducts into the heat exchange equipment and recaptures heating or cooling energy from stale room air as it is being exhausted. Some systems, called enthalpy heat exchangers, also dry incoming humid air in summer - a particular benefit in the Southeast. Fresh air flows into the house via a separate duct system, which should be sealed as tightly as the HVAC ductwork. Exhaust room air can either be ducted to the exchanger from several rooms or a single central source.

**Figure 7-11**  
**Heat Recovery Ventilation (HRV) System**



## *Overall HVAC Recommendations*

Heating, ventilation, and air conditioning are very important components of a healthy, comfortable, and efficient house. Be sure to have the HVAC contractor size all HVAC equipment properly. Also, ensure that the house receives proper ventilation. Using leaks to provide fresh air can be a problem, because the air could be pulled from a polluted source. Ensure that all inlet vents are located in an area that will remain free from pollutants like car exhaust.

## *Notes:*