Chapter 9
Ventilation

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Key Points to Learn

- Every Alaska home should be built tight and have proper controlled ventilation.
- Ventilation is important to control both moisture and indoor pollutants.
- Good installation practices
- Commissioning (making sure it works)
- Operation and maintenance

Principles of Good Ventilation

The two main reasons to ventilate are to control moisture and to dilute pollutants. Good ventilation makes a home healthier and more comfortable, while poor ventilation can cause serious health risks to the occupants and structural damage to the house. Current research in Alaska homes reinforces the need for appropriate ventilation to reduce exposure to such harmful pollutants as carbon monoxide, benzene, and radon.

In the past, buildings were ventilated by the wind and other uncontrolled forms of air leakage. However, leaky buildings do not guarantee good indoor air quality. Particularly in a cold climate, comfort and health problems may result if the building is too leaky. A building leaking air during the coldest part of the winter will cause continuous drying of the indoor air and can lead to increased upper respiratory disease and discomfort. Leaky buildings enhance the transport of outdoor pollutants into the building through garages and damp crawlspaces. And as we learned in earlier chapters, leaking air carries moisture into the walls and attic of a house, leading to mold and rot.

Build It Tight

Most people no longer accept the cold, drafty houses of the past. Now, houses are expected to be cozy, draft free, and energy efficient. Even when builders don't intend to build a tight house, modern building materials tend to make newly constructed homes much tighter than old ones. Plywood, housewrap, better windows, caulk, and expanding foam are a few examples of common products that tighten a house.

In other chapters we discuss the many reasons to control the air flow in a home:

- comfort
- drafts
- health
- odors, particles, gases
- energy savings
- moisture control
- sound control
- required by codes

We also discuss many air-sealing techniques and systems. Every Alaska home should begin with a well–sealed and insulated envelope.

Ventilate It Right

Next, every Alaska home requires proper, controlled ventilation. When we control the amount and location of air moving into and out of the house, that air can then be:

- heated
- cooled
- humidified
- dehumidified
- cleaned, filtered
- distributed, mixed

As always when bringing in fresh air, energy is spent in the process, but it is under our control!

The Alaska Building Energy Efficiency Standard (BEES) requires all homes built to the BEES must comply with the ventilation requirements of ASHRAE 62.2-2004 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, and the Alaska –Specific Amendments. Refer to the ASHRAE 62.2 Standards and the AHFC amendments for detailed information. See standards on the next page.

ASHRAE 62.2-2004 including AHFC amendments

- Whole Building Ventilation rate is 10 cfm per person plus 1 cfm for every 100 sqft of floor area. Or see Table 9.1.
- Bathroom Exhaust Fan—50 cfm intermittent or 20 cfm continuous.
- Kitchen range hood—100 cfm intermittent required if continuous kitchen exhaust is less than 5 air changes per hour.
- Measures must be taken to assure ventilation air comes directly from outdoors and not from adjacent dwelling units, garages, and unconditioned crawlspaces.
- Quiet exhaust and whole house fans, including range hoods:
  Intermittent exhaust fans must have a maximum sound rating of 3 sones. (Exception for large range hoods which exceed 400 cfm.)
  Continuous ventilation fans must be rated at a maximum of 1 sone
- Clothes dryers shall be exhausted directly to the outdoors
- Maximum exhaust capacity where atmospherically vented combustion appliances or wood stoves is limited to 15 cfm/100ft^2 for the two largest exhaust fans. (Typically range hood and clothes dryer)
- Garages—must prevent migration of contaminants to adjoining occupiable spaces. A duct leakage test must be performed if a furnace or ductwork is located in the garage.
- Supply-only systems not allowed during the heating season. Balanced, heat recovery systems are strongly recommended.

Other Concerns

Recent research on indoor air quality in Alaska homes provides some sobering statistics.

Attached Garages

Most garages in Alaska are attached or "tuck-under." Many garages are heated and house the home's heating system as well. Recent research data suggests:

- Attached garages provide about 30% of the natural ventilation for homes.
- Attached garages significantly increase in-home exposure to benzene and carbon monoxide from in-garage car starts.
- Pollutant transfer is particularly high with furnaces in the garage. It is difficult to adequately seal duct and furnace leaks.
- Garages are the most common source for indoor carbon monoxide, which disperses rapidly once inside the home.
- Exhaust-only house ventilation appears to increase the flow of garage pollutants to the house, but it likely provides some reduction in total exposure.
- In tight garages, it might be necessary to provide garage exhaust ventilation to remove pollutants and prevent them from entering the house.

Crawlspaces

- Crawlspaces provide about 30% of natural ventilation air for homes.
- Increased testing indicates that radon may be more of a concern in Alaska than previously believed. Radon that enters crawlspaces can easily become part of the house air. Exhaust-only ventilation systems, because they depressurize the house, may increase the amount of radon that enters the living space.

Ventilation Codes

Most building ventilation codes are based on ASHRAE Standard 62. ANSI/ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings. It is the only nationally recognized indoor air quality standard developed solely for residential buildings. It requires mechanical spot ventilation for specific sources of indoor pollutants. It also requires general ventilation that operates whenever the house is occupied to maintain indoor air quality. The number of occupants determines the amount of general ventilation required. Even this standard acknowledges how difficult it may be to provide acceptable indoor air:

> While acceptable indoor air quality is the goal of this standard, it will not necessarily be achieved even if all requirements are met: (a) because of the diversity of sources and contaminants in indoor air and the range of susceptibility in the population; (b) because of the many other factors that may affect occupant perception and acceptance of indoor air quality, such as air temperature, humidity, noise, lighting, and psychological stress; (c) if the ambient air is unacceptable and this air is brought into the building without first being cleaned (cleaning of ambient outdoor air is not required by this standard); (d) if the system(s) are not operated and maintained as designed; or (e) when high-polluting events occur.

Sizing Your System: How Much Ventilation Air Do You Need?

It costs money to bring cold outdoor air into a home and then heat and distribute it, so we don't want to bring in any more than is needed to get the job done.

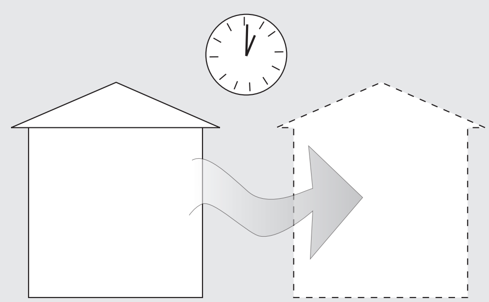
According to ASHRAE Standard 62.2-2004, single, detached residential buildings are required to meet a whole house ventilation rate based on the number of bedrooms in the house, or the number of occupants, plus an infiltration credit (1 CFM per 100 sq. ft plus 7.5 CFM per additional occupant, which includes a 2 CFM per 100 sq. ft. allowance for infiltration). There are a variety of ways to meet this standard.

Table 9.1: ASHRAE 62.2-2004 Ventilation Air Requirements, CFM

Local codes may require different continuous ventilation rates: always check with your building officials to determine your specific requirements.

Floor Area (ft²)	Bedrooms				
	0–1	**2–3**	**4–5**	**6–7**	**>7**
<1500	35	55	75	95	115
1501–3000	50	70	90	110	125
3001–4500	65	85	105	125	145
4501–6000	80	100	120	140	160
6001–7500	95	115	135	155	175
>7500	110	130	150	170	190

Air changes per hour is how many times all the air in a given volume of space (a house) is completely replaced in one hour's time.



Ventilation System Design Elements

A ventilation system that will be effective at maintaining reasonable indoor air quality and building durability must be designed that way. There is no "right" ventilation system that is appropriate for all homes. There are many factors that will influence particular design decisions. These may include:

- Code requirements
- Size and type of building
- Combustion appliance type
- Availability of equipment, parts, and service
- Knowledge and skill of the provider
- Owner and builder preferences
- Budget

At the same time, there are some qualities that should be part of any ventilation design:

- Effective indoor air quality control
  - Removes contaminants
  - Adequate air distribution to all rooms, especially bedrooms
- Comfort
  - Quiet
  - Tempered supply air
- Simplicity of operation
- Affordability
  - Energy efficient
  - Low maintenance
  - Equipment properly sized and installed
- Safety and durability
  - Balanced flows
  - System controls
  - No backdrafting concerns

Spending a little extra time on the ventilation system when designing a home can make installation easier and more affordable. It can also make operation more successful and more affordable.

Basic Decisions

- How will the house air pressures be controlled?
  - This is most often based on the type of combustion appliances: spillage susceptible or not?
  - If make-up air is required, how is it provided?
  - If make-up tempering is required, how is it provided?
- How will ventilation be distributed? This is often decided based on the type of heating system: forced air or not?
- How will comfort be maintained?
- How are contaminants removed?
- Will the outdoor air be acceptable year-round?

Effective Ventilation Systems

The best way to control indoor air quality is to keep pollutants from entering the house in the first place. However, not all indoor pollutants can be eliminated. Moisture and odors and other chemical pollutants are produced by many different activities, so ventilation is important.

There are two components of an effective mechanical ventilation system: local exhaust ventilation and central or whole-house ventilation for general indoor air quality.

Local Exhaust Ventilation

Local or spot ventilation captures pollutants at their source and exhausts them to the outside. This is not continuous ventilation, but is used on an as needed basis.

Kitchen Range Hoods

Cooking in the kitchen generates a lot of moisture and odors. While there are various ventilation strategies for a kitchen, the range hood is by far the most common.

Kitchen range hoods installed directly over the range capture heated air, moisture, smoke, and odors, while the fan exhausts them to the outside through ductwork. A filter trap makes it easy to remove and clean grease.

A kitchen range hood should be at least the same width as the cooking surface and mounted directly over it, 18 to 30 inches above the cooking surface. For normal cooking conditions, two-speed or variable speed controls provide a choice of a lower speed and quieter operation. Sone ratings vary. Choose a quiet or remote mounted fan so noise doesn't keep occupants from using the range hood when they cook.

Range hoods should be sized correctly. For a typical range, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the Home Ventilation Institute (HVI) recommend 100 cubic feet per minute (CFM). Larger fans may need to have make-up air provided, to prevent excessively depressurizing the home and potentially causing combustion equipment to backdraft.

Downdraft kitchen exhausters require a higher volume and velocity of air to capture contaminants. They are an alternative when canopy-style hoods are not desired due to location of the cooking surface and kitchen esthetics; however, their performance cannot equal that of hoods that capture the rising column of air above the cooking surface.

Nonducted, recirculating kitchen range hoods do not provide ventilation. For optimum kitchen air quality, always vent kitchen range hoods, kitchen fans, or downdraft kitchen exhausters directly outside the home.

Bathroom Fans: Moisture Control Where It is Needed Most

During a bath or shower, the humidity level in a bathroom provides a perfect breeding ground for mold, mildew, and microorganisms that can impact health and building durability. Exhaust fans ducted to the outside remove moisture and prevent these types of problems.

- For most effective bathroom ventilation, ASHRAE recommends 50 CFM of intermittent or 20 CFM of continuous ventilation.
- Fans should be installed as near to the shower as possible and, if marked as suitable for this location, directly over it to capture the moisture as directly as possible.

- Fans should have a control that will allow them to run at least 20 to 30 minutes after each shower. This could be a timer or dehumidistat controller.

Other Areas For Spot Ventilation

Many other rooms in the house can benefit from spot ventilation. Examples might include laundry and utility rooms; workshops and hobby areas; family rooms; and recreation rooms. Ventilation units for use in these areas are similar to those used for baths and kitchens.

Outdoor Vents for Clothes Dryers

You must vent dryers directly to the outside of the house. In many newer homes the laundry room is located away from the exterior walls, resulting in long ducts, which can restrict airflow. In these cases booster fans can be used to ensure proper airflow.

Local Exhaust Ventilation Considerations

- **Exhaust air close to the source.**
- **Provide quiet fans.** Noisy fans won't get used. Fan noise is measured in sones. The higher the sone level, the noisier the fan. Spot fans are typically rated at 3 to 4 sones, though some can be quite a bit louder. Fans rated at 1.5 sones are very quiet, and low-capacity fans rated as low as 0.5 to 1 sones are nearly inaudible.
- **Provide short, direct duct runs.** A low-sone fan attached to a duct that twists and turns, or is kinked or too small, will be just as noisy as the noisiest model. It will not provide as much ventilation as a short-ducted fan either.
- **Make sure fans provide the desired ventilation flow.** Measure fan flow after installation to verify that the system is operating properly.

Continuous, Whole-House Ventilation Strategies

While spot ventilation will certainly help control moisture problems, it may not provide adequate ventilation for the entire home. A whole house ventilation system is designed to operate continuously to provide fresh air whenever the occupants are home. One or more fans can be combined to supply fresh air and exhaust stale air to provide continuous general ventilation throughout the home. 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. Ductwork extends to rooms requiring ventilation.

It is important to choose a climate-appropriate system. Supply-only systems are best suited to hot and humid climates. In the heating season in cold climates, continuously operating supply ventilation may pressurize the home, driving warm humid indoor air into the wall cavities and attics, where condensation may occur.

Exhaust-Only Systems

A continuous whole-house exhaust system provides ventilation by using a single-point or multipoint central fan to remove air from the building. This system places the building under a slight negative pressure, drawing supply air into the building envelope through gaps or provided vents.

Unfortunately, fireplaces, wood stoves and gas-burning appliances were not designed to operate in a negative pressure environment. Under some conditions, even a slight negative pressure could cause flue gases, including carbon monoxide, to spill into the living space. **Exhaust-only ventilation systems should only be used in conjunction**

with sealed combustion appliances that draw air from outside, or when combustion appliances are located in a sealed room.

Exhaust-Only Ventilation Concerns

- If the building envelope is tight, negative pressure inside the building may lead to backdrafts from combustion appliances. Often these systems incorporate a pressure relief damper to alleviate pressure imbalances.
- Supply air enters the building in an uncontrolled manner and may be pulled in from undesirable areas such as garages, musty basements or crawlspaces, or dusty attics.
- Whole-house exhaust systems may not be appropriate in areas where levels of outside environmental contaminants are high. For example, researchers have found that exhaust systems may actually increase the indoor levels of radon.
- In severe climates, very cold supply air may create drafts. The largest cost of operating this system is for heating supply air rather than from operating the fan.
- Filtration cannot be added to an exhaust-only ventilation system.

Balanced Ventilation Systems

A balanced ventilation system uses two fans with separate ducting systems, one to supply fresh air and one to remove stale air from the building (Figure 9.4). The system should not affect the pressure balance of the interior space unless the return path between the supply and exhaust is blocked.

This ventilation strategy can be used effectively in any climate. It is possible to include a heat exchanger to recover heat from the exhaust air and use it to precondition the supply air. Extensive ducting is used to supply fresh air to living and sleeping rooms, while a separate exhaust system removes stale, often moist air from the kitchen and bathrooms.

Advantages include prefiltration of the supply air and energy savings from the heat recovery of the exhaust air.

Figure 9.1: Surface-mounted exhaust fan. The simplest controlled ventilation system uses a quiet, high-quality surface-mounted fan. Fresh air enters through passive vents located in window sashes or outside walls. Surface-mounted fans provide good ventilation for smaller areas. Large houses may need more than one.

- Noise Rating: 2.0 sones or less
- Locations: central bathroom
- Air Flow Capacity: 50–400 CFM
- Heat Recovery: none
- House Pressure: negative
- Makeup Air: passive inlets
- Multispeed Operation: no

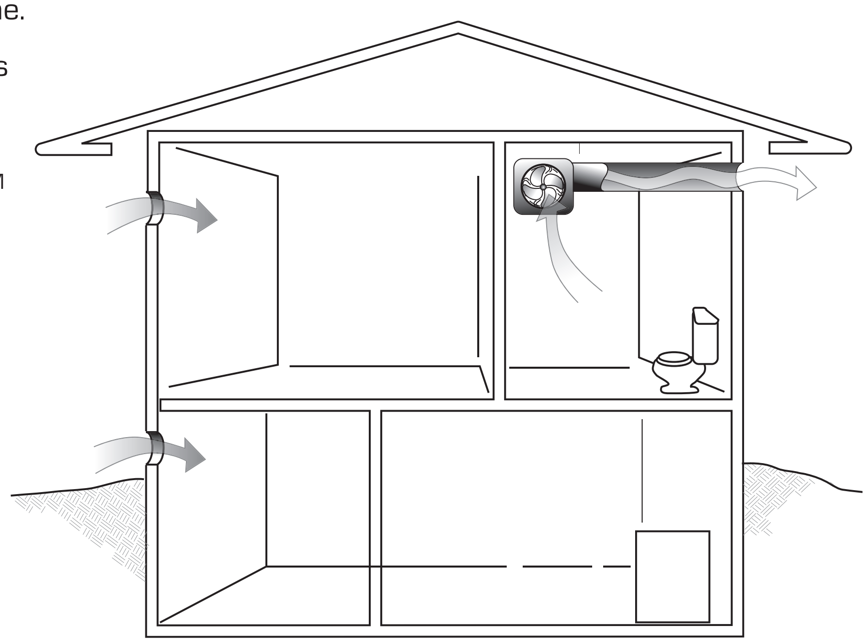


Figure 9.2: Remote-mounted in-line fans can pick up stale air from a single point or they can be attached to a branched duct system with pickups in two or three locations. This makes them a good choice for large houses. If properly rated, the fan could be attached to a range hood.

- Noise Rating: not applicable
- Locations: basement, attic, or crawlspace
- Air Flow Capacity: 80–400 CFM
- Heat Recovery: none
- House Pressure: negative
- Makeup Air: passive inlets
- Multispeed Operation: optional
- Equipment Cost: $150 to 250

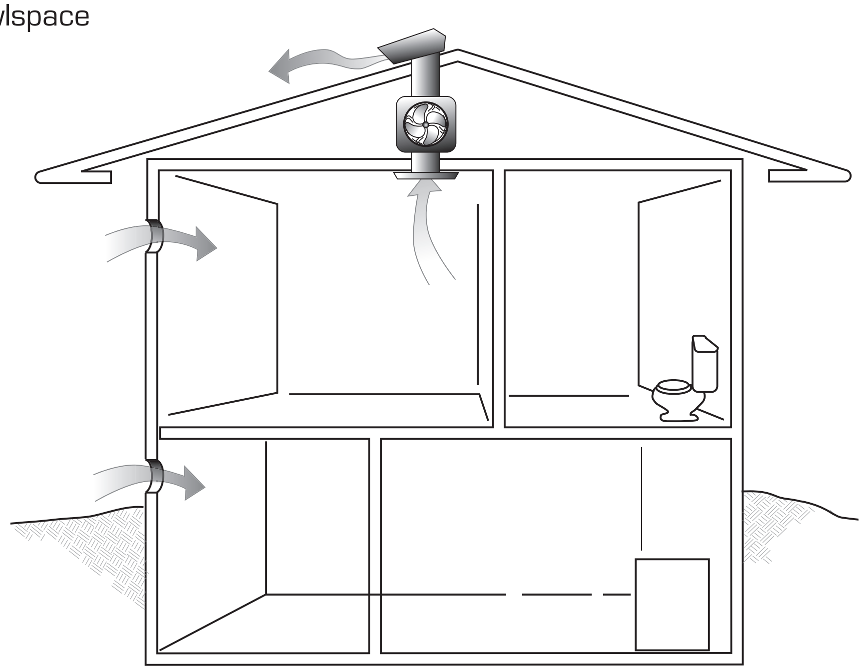
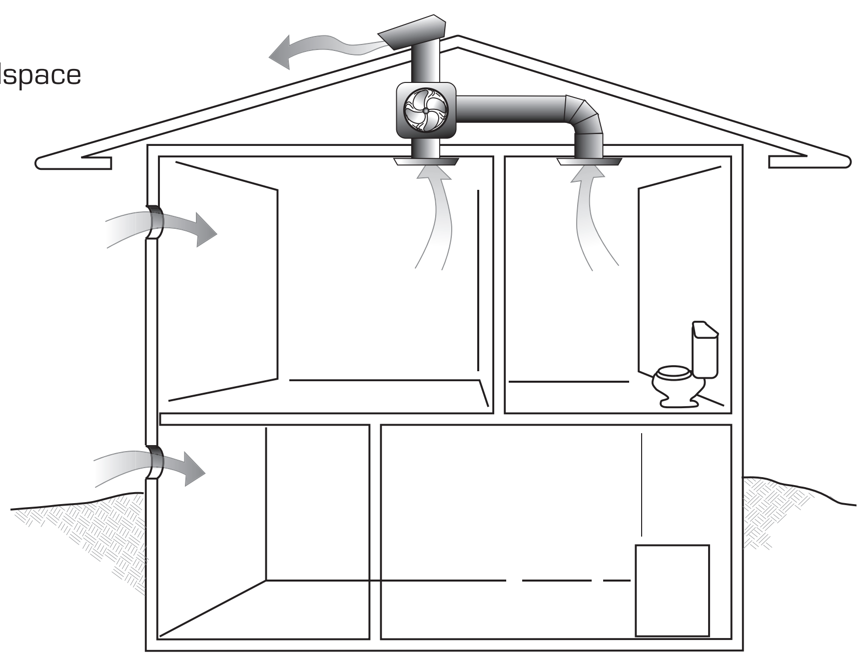


Figure 9.3: Remote-mounted multiport. Large houses and several multifamily units can be ventilated by a single multiport fan. Some units can accept a duct from the range hood. Most operate at two or more speeds. Several manufacturers sell complete kits with all the ducts and accessories. These may cost a bit more, but the kits simplify installation.

- Noise Rating: not as important
- Locations: basement, attic or crawlspace
- Air Flow Capacity: 100–400 CFM
- Heat Recovery: none
- House Pressure: negative
- Makeup Air: passive inlets
- Multispeed Operation: optional
- Equipment Cost: $200 to 700



Some disadvantages include installation costs, maintenance costs (because there are multiple fans), and fan noise when systems are not installed properly. Various strategies for soundproofing include insulating ducts and preventing fan vibrations. Reducing noise from ventilation systems has a positive impact on indoor air quality by reducing the likelihood that occupants will block vents or turn off the system.

Experience has also shown that balanced air flow can be difficult to achieve in a home with a balanced ventilation system connected to a forced-air heating system. Detailed duct design and careful installation and flow-balancing techniques are needed. Even then, air flow can be thrown off by someone closing a door between a supply and a pickup.

Heat and Energy Recovery Ventilation

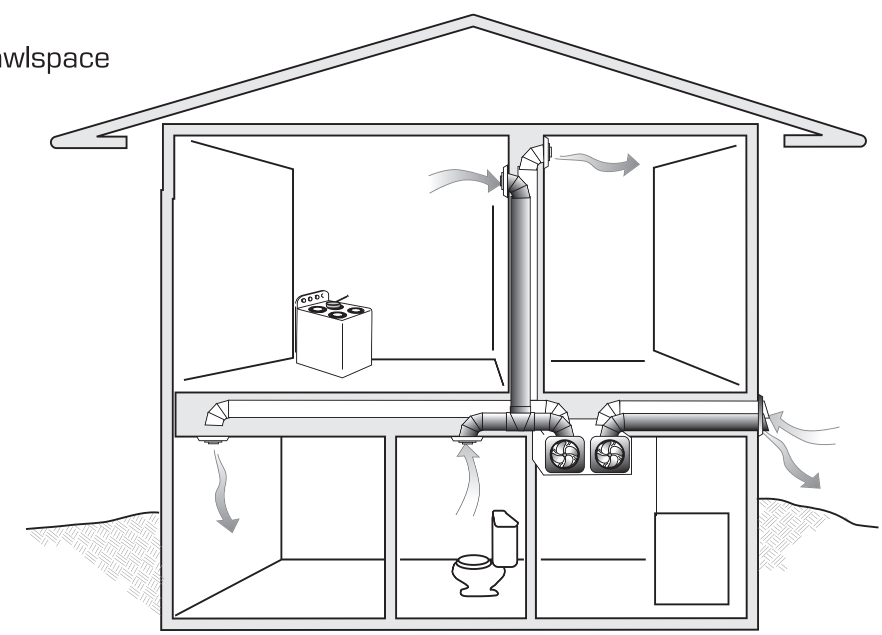
Controlled ventilation systems collect the outgoing air into a single duct, so it is possible to capture heat from that air with a heat-recovery ventilator (HRV). The most common type of HRV is an air-to-air heat exchanger. It transfers heat from the outgoing air stream to the incoming one. In these systems, air flow is balanced (Figure 9.5). An energy recovery ventilator (ERV) also modifies the humidity content of the fresh air through the transfer of water vapor from one air stream to the other. This may cause problems where moisture control is an issue. Since HRVs and ERVs combine both exhaust and fresh air intake, they are considered balanced pressure systems. One of the primary functions of an HRV is to temper the incoming supply air to minimize draft complaints and reduce the cost of heating the fresh air.

How They Work

Mechanically, the HRV or ERV is a combination of fans, controls, and heat recovery elements that exhaust stale air from the home, bring fresh air in from outdoors, and transfer heat en-

Figure 9.4: Balanced non-heat-recovery ventilation. (Only a few manufacturers provide balanced ventilators without heat recovery.)

- Noise Rating: not applicable
- Locations: basement, attic, or crawlspace
- Air Flow Capacity: 100–400 CFM
- Heat Recovery: none
- House Pressure: balanced
- Makeup Air: ducted
- Multispeed Operation: optional
- Equipment Cost: $400 to 800



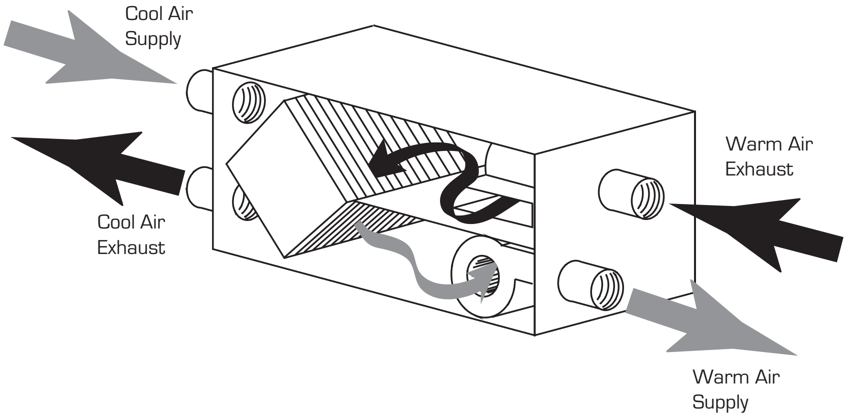


Figure 9.5: A typical heat-recovery ventilator schematic for air flow through the plate-type heat exchanger.

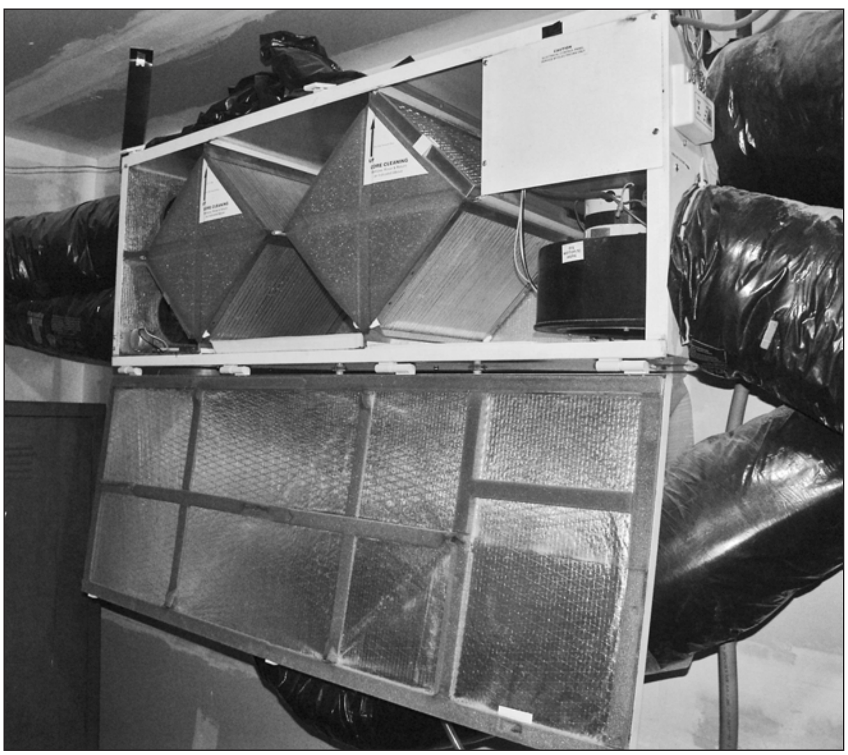


Figure 9.6: A heat-recovery ventilator opened for cleaning and maintenance. Two plate-type heat exchangers are used in this large-capacity model.

ergy from one airstream to the other. A continuously running HRV or ERV provides a steady supply of fresh air to the home, while recovering a portion (60% to 70%) of the energy normally lost through non-heat-recovery ventilation.

ERV's as opposed to HRV's are most useful when the average outdoor dewpoint temperature is well below the indoor dewpoint during winter and above the interior dewpoint temperature in summer. The closer the outdoor dewpoint is to the indoor dewpoint, the lower the ERV benefit. Where the outdoor dewpoint is well below the interior dewpoint, the ERV benefit is in recovering back some of the interior generated moisture to keep the house from being too dry. Where the outdoor dewpoint is above the interior dewpoint, the ERV benefit is to reduce the incoming moisture load in the outside air to reduce cooling/dehumidification energy consumption and to potentially keep the house dryer.

HRV's and ERV's have filters that minimize the entry of pollen, dust, and insects into the home with the fresh air. They are intended to operate year-round. Models suitable for use in extremely cold climates are equipped with automatic defrost mechanisms, allowing continuous operation throughout winter. HRV's and ERV's are available as stand-alone units with independent ductwork or they may be connected to existing forced air heating systems.

Balanced air flow can be difficult to achieve in a home with a balanced ventilation system connected to a forced-air heating system. Detailed duct design and careful installation and flow-balancing techniques are needed. Even then, air flow can be thrown off by someone closing a door between a supply and a pickup.

Furnace Integration

It is tempting to combine a controlled ventilation system with existing forced-air heating system ductwork. This can be accomplished by either supplying and exhausting ventilation air through the heating system's supply and exhaust ductwork, or by simply supplying fresh air.

However, before using heating ducts for fresh air distribution, several issues need to be recognized.

- Duct systems in new and existing homes have significant air leakage.
- Homes with forced air systems frequently have air pressure differences around the house that increase building air leakage.
- Typical furnace blowers are turned by large, inefficient motors. Running the typical single-speed blower an additional eight hours per day could easily burn more than 2,000 kilowatt hours per year. Some new air handlers reduce energy use with multispeed controls or more efficient motors. Consider an ECM blower with interlocking controller.

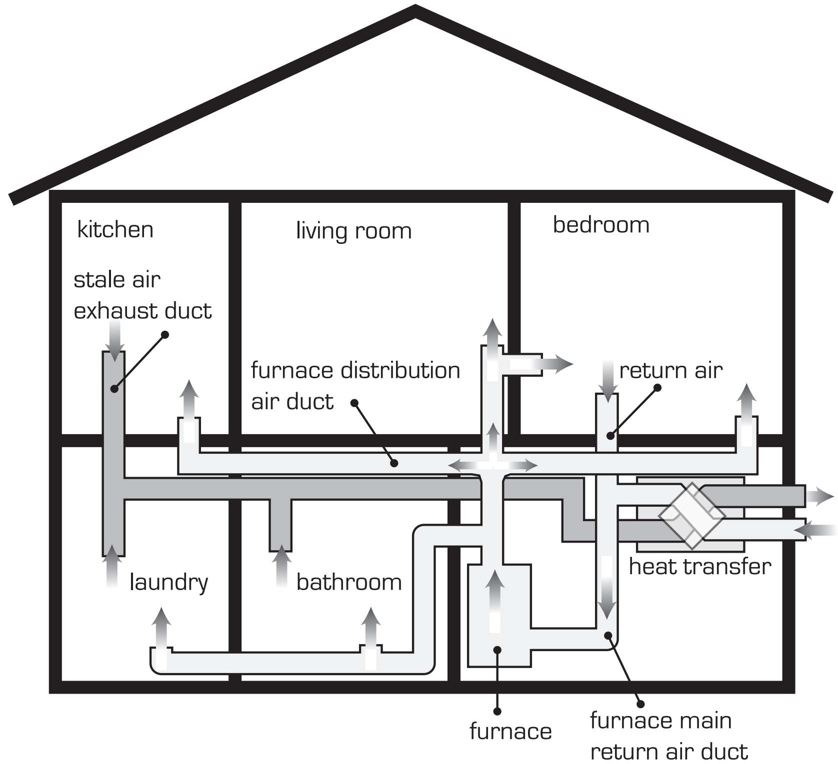
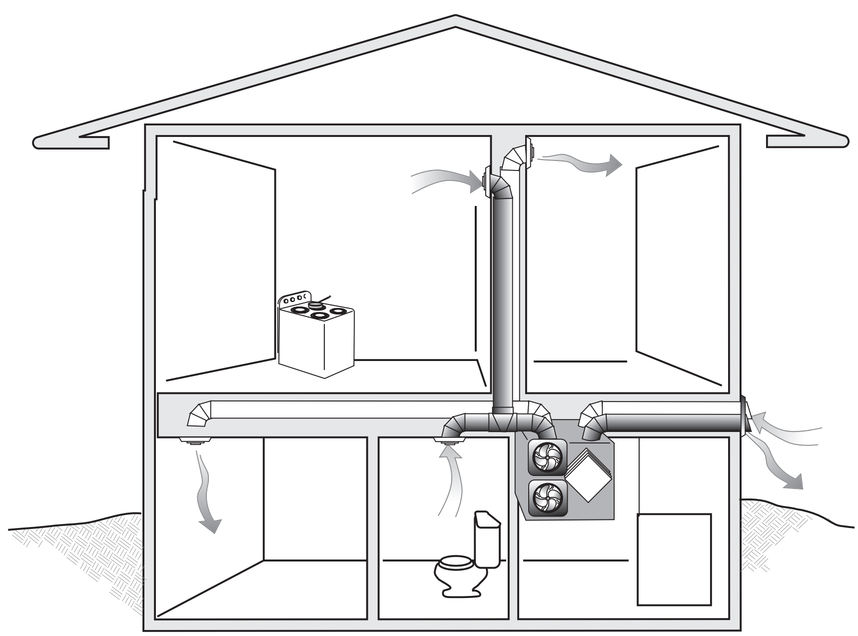


Figure 9.7: An HRV installed in conjunction with a forced-air furnace system

Figure 9.8: Heat recovery ventilation. This type of ventilation provides balanced air flow and recovers up to 85% of the heat from outgoing air. By warming the incoming air, HRVs provide greater comfort in cold climates than other types of ventilation systems. Units can be sized for any home and small commercial buildings.

- Noise Rating: not applicable
- Locations: basement, inside utility room, or any tempered space
- Air Flow Capacity: 150–1,200 CFM
- Heat Recovery: 60 to 85% recovery efficiency
- House Pressure: balanced
- Makeup Air: ducted
- Multispeed Operation: standard on most units
- Cost: $1.35 to $1.50 per square foot



- Balancing the HRV requires adjusting flows when the furnace is on low, high, and off.
- Proper furnace sizing and modulating the burn will maximize furnace runtime and maintain balance.
- Make sure that both furnace and HRV manufacturers approve of the connection.
- An alternative option is to provide an indirect connection of HRV supply. This will allow the HRV to operate in a more balanced mode whether the furnace is on or off.
- What happens to air quality, distribution when the furnace is off?
- Duty cycle issue: 60 CFM = 120 CFM at 50% run-time

An HRV can also be installed to work in conjunction with a forced-air furnace system, as illustrated in Figure 9.7. In this case, the HRV's fresh-air duct is connected to the furnace's main return air duct. The fresh air enters the furnace and is distributed throughout the house using the regular system of ductwork. In such a configuration, the furnace blower should run continuously at low speed when the HRV is operating to ensure a regular flow of fresh air throughout the house. (The furnace blower can also be wired to operate at the normal higher speed for heating and cooling. However, this higher speed can be noisy and may make the rooms feel cool if used to distribute ventilation air continuously.) Separate, additional ductwork may be needed to transfer stale air from wet rooms such as the bathroom and kitchen to the HRV.

How Much Does Ventilation Cost?

A house that is leaky enough to provide effective natural ventilation costs more to heat, it is likely to be drafty, and the air quality may still be poor. Controlled ventilation brings a specific amount of outside air and distributes it through the house. Nevertheless, pulling outside air into a space and then heating it up does consume energy and still costs money. While the home builder and buyer may be concerned about the up-front costs of fans, ductwork, grilles, and installation, in Alaska it is cost of heating fresh air that is most important.

An energy use modeling program, such as the State of Alaska's AKWarm software program, can be most helpful in comparing costs. You can see from Table 9.2 that both the type of ventilation system and the airtightness are important. For every area of the state, at 2005 energy costs, heat recovery ventilation in combination with a tight building shell is the most cost effective option. Note also that in a leaky house (7 air changes per hour at 50 Pascals), there is so much natural ventilation provided by the house leaks that the mechanical ventilation systems are useless.

Table 9.2: AKWarm-predicted annual energy costs for a home comparing ventilation system and airtightness levels

Location	Airtightness 1.5 ACH @50 Pa			Airtightness 4 ACH @50 Pa			Airtightness 7 ACH @50 Pa		
	HRV	Continuous Non-HRV Vent	No Controlled Vent*	HRV	Continuous Non-HRV Vent	No Controlled Vent*	HRV	Continuous Non-HRV Vent	No Controlled Vent*
Fairbanks	$2560	$2761	$2807	$2705	$2741	$2807	$2976	$2976	$2976
Juneau	$1798	$1932	$1961	$1885	$1917	$1961	$2055	$2055	$2055
Anchorage	$1552	$1600	$1593	$1569	$1580	$1593	$1632	$1632	$1632
Nome	$3741	$4065	$4152	$4055	$4068	$4152	$4702	$4702	$4702
Barrow	$1323	$1365	$1369	$1368	$1368	$1372	$1494	$1494	$1494

* No controlled ventilation assumes open windows to provide adequate ventilation.

Table 9.3: Equipment & installation costs for new mechanical ventilation systems (Rudd 2005) (Note: equipment costs do not include ducting or labor costs, which will vary depending on the installation design.)

Ventilation System Description	Central fan use*	Equipment Costs	Installation Costs	Total Costs
Single-point Exhaust	Off 10 min/hr	$70 $125	$0 $20	$70 $145
Multipoint Exhaust, 2 bath fans	Off 10 min/hr	$140 $195	$0 $20	$140 $215
Multipoint Exhaust, remote fan	Off	$450	3 points, $400 4 points, $500	$850 $950
Single-Point HRV	Off 10 min/hr	$800 $800	$550 $570	$1350 $1370
Multipoint HRV	Off	$800	3 points, $750 4 points, $770	$1550 $1570
Central-fan integrated supply with continuous single-point exhaust	Off 15 min/hr 15 min/hr w/damper	$125 $125 $180	$100 $100 $120	$225 $225 $300
Central-fan integrated supply with intermittent exhaust	Off 15 min/hr	$160 $160	$100 $100	$260 $260

*Central fan is used to mix and distribute air

Components of a Ventilation System

Figure 9.9: This sequence shows a defrost mechanism on an HRV. It operates as a flap valve automatically triggered by temperature to change the source of fresh air for a few minutes. This valve opens ductwork from an indoor source and warm air is run through the heat exchange core to melt accumulated frost from condensation.

A ventilation system generally consists of the following equipment:

- Insulated ducts for incoming (fresh) and outgoing (stale) air, along with exterior hoods
- Ductwork to distribute fresh air throughout the home and to collect stale air
- Fans to circulate air throughout the home and to exhaust stale air to the outdoors
- Operating controls to regulate the system according to ventilation needs
- If it is an HRV it will have:
    - a heat-exchange core, where heat is transferred from one air stream to the other;
    - filters to keep dirt out of the heat-exchange core;
    - a defrost mechanism to prevent freezing and blocking of the heat-exchange core when the temperature of the incoming air is cold;
    - a drain to remove any condensation from inside the HRV (may not be required with all models); and

Fans

Controlled ventilation systems operate many hours every day. Some never turn off. You want a durable, high-quality fan intended for continuous operation. Most high-quality fans use permanent split capacitor motors.

Three of the most important characteristics to look for in a fan are size, noise level, and energy efficiency. If a fan is the wrong size, too noisy or too costly to operate it will not be used as often as it should be, making it ineffective. Fans selected for whole-house ventilation systems should be manufactured for continuous operation and long life (greater than 10 years), and installed in a location that is easily accessible for regular maintenance.

Fans should be sized and selected to provide necessary airflows based on the type, length, and design of the duct system. Because fans have differing capacities for moving air, it is important to make sure the fan has enough capacity for the application. Fan exhaust capacity is rated in cubic feet per minute (CFM). The fan's certified CFM rating appears on the product or on the Home Ventilating Institute (HVI) label displayed on each unit, in the manufacturer's literature describing the fan, and in the HVI Certified Products Directory at www.hvi.org.

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.

Bathrooms, Kitchens, and Other Rooms

For adequate ventilation, HVI recommends the following guidelines for minimum recommended flow rates for exhaust fans when designed to operate in continuous mode and intermittent mode.

Location	**CFM/ Continuous Type Fan**	**CFM/ Intermittent Type Fan**
Kitchen	60	100
Bathroom	20	50

Sound

Noise prevents many people from operating fans. Low sone ratings are less important for remote-mounted fans. However, you should use sound absorbing fan mounting and duct connections to prevent sound transmission into living areas. Choose as quiet a fan as you can afford.

Table 9.4: ASHRAE 62.2-2004, Prescriptive Duct Sizing

Duct Type	**Flex Duct**				**Smooth Duct**			
Fan Rating CFM @ 0.25 inch wg (l/s @ 62.5 Pa)	50 (25)	80 (40)	100 (50)	125 (65)	50 (25)	80 (40)	100 (50)	125 (65)
Diameter in. (mm)	**Maximum Length ft. (m)**							
3 (75)	X	X	X	X	5(2)	X	X	X
4 (100)	70(27)	3(1)	X	X	105(35)	35(12)	5(2)	X
5 (125)	NL	70(27)	35(12)	20(7)	NL	135(45)	85(28)	55(18)
6 (150)	NL	NL	125(42)	95(32)	NL	NL	NL	145(48)
7 (175) and above	NL	NL	NL	NL	NL	NL	NL	NL

This table assumes no elbows. Deduct 15 feet (5 m) of allowable duct length for each elbow.
NL = No Limit on duct length of this size.
X = Not allowed. Any length of duct of this size with assumed turns and fitting will exceed the rated pressure drop.

Energy Efficiency

The efficiency or efficacy of a residential fan is expressed as cubic feet per minute per watt (CFM/W). It is determined by dividing the volume of air that the fan moves by the amount of energy used. Efficient small-bathroom fans—less than 76 CFM—will have a minimum efficacy of 1.4 CFM/W. Better large bathroom fans—76 CFM and over—as well as range hoods will have a minimum efficacy of 2.8 CFM/W. Remember: the larger the efficacy number, the better!

Remote or "In-Line" Fans

In-line fans are duct-mounted, remote fans that can provide ventilation or boost airflow with little detectable noise. They provide a solution to noisy or ineffective bathroom fans, ineffective dryer exhaust, and recirculating range hoods.

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 simple single-port or versatile multiport in-line fans that can be used to supply ventilation for most single-family residential applications. A multiport design allows one fan to provide ventilation for multiple rooms, such as two bathrooms and a laundry (Figure 9.3).

Ducts

The most efficient ventilation ducts are smooth, short, straight, and properly sized. Smooth sheet-metal ducts offer low airflow resistance. Because corrugated (flex) ducts have greater flow resistance, it is important to keep them as short as possible—stretch the corrugated material to its full length and cut off the excess. Minimize the number of elbows. Provide adequate support. Use mechanical fasteners and sealants (preferably duct mastic) at all joints. Ducts located outside the conditioned space should be insulated.

Duct Terminations

Ducts that exhaust water vapor or other pollutants must exhaust directly to the exterior—never into attics or crawlspaces. Use wall caps with flap dampers, screens, or both to deter access and to reduce air infiltration. Unless they are already integrated into the system (e.g., wall cap with flapper), equip ventilation ducts with backdraft dampers at or near the insulated building boundary. Note: Roof jacks could cause problems because of condensation within the duct or icicles created by melting snow.

System Controls

Ventilation system controls range from simple to complex. People are not generally reliable ventilation controllers, so you shouldn't count on a manual switch as the primary ventilation control. An automatic control is essential. However, people should be able to activate or disable the system when necessary. So, most systems require at least two controls wired together.

Here are a few control options that would work with most types of ventilation systems:

- Timers
    - Twenty-four hour timers allow the occupants to set certain times for ventilation. Set the timer to run the fan at least eight hours per day.
    - Twist timers, also called interval timers, allow occupants to turn on the fan whenever it's needed. Twist timers can be set for up to 60 minutes and are generally located in bathrooms, utility rooms or kitchens.

- Sensors
    - Indoor air quality sensors activate a fan when they detect carbon monoxide, formaldehyde or other pollutants.
    - Dehumidistats engage the fan on rising humidity. They work well when relative humidity accurately indicates the need for ventilation. By setting the dial at 40, you are telling the dehumidistat to operate the fan whenever the humidity is 40 percent or higher. Unfortunately, relative humidity isn't always a reliable indicator. Climates with low humidity might never reach 40 percent, so the fan would never turn on. In wet climates the fan might never turn off during mild weather. Dehumidistats aren't used as much as they once were because of this problem.
- Speed controllers allow the fan to operate at low speed for background ventilation with a manual high-speed boost.
- Continuous operation simplifies the controls, but you should at least install an on/off switch. It's a good idea to locate the switch out of the way to reduce the chance that someone will accidentally flip it off.

Indoor Air Circulation

Indoor air must be free to flow between supply and return ports of whole-house ventilation systems. If a supply and return port is not installed in every room, then through-the-wall transfer grills should be installed above doors in rooms with doors that are often closed, or the doors should be undercut to facilitate air flow.

Commissioning a System

Once the installation is complete, the installer should visually inspect the components in the system, correct any deficiencies, and then start up the system and check its operation.

Test procedures will vary depending on the complexity of the system, but the goal is to be confident that the system will operate as designed, providing adequate airflow, proper operational control, and adequate distribution of ventilation air while avoiding pressurization or depressurization problems

- Measure airflows to rooms
- Balance supply and exhaust airflows
- Check controls
- Clean all filters and core
- Clean outside supply air intake
- Compatibility with combustion appliances

Occupant Information

Controlled ventilation systems are new to most home buyers. It's your job to educate the occupants.

- Label all components, including the fan, controls, and ducts.
- Provide building owner an operation and maintenance manual with a brief description of the system that explains the principles of operation, control strategy and maintenance. This manual should include the installer's name and phone number, product literature for all components, ventilation system model and serial number, ventilation airflows, and the operation and maintenance schedule.
- Show the occupants the location of each component and how to operate the system.

Good information is essential because even the best ventilation system needs to be operated and maintained properly.

Summary

Good ventilation must be effective at maintaining reasonable indoor air quality and building durability. When done right, mechanical ventilation can improve air quality and protect the building. When done wrong it can cause many problems including poor indoor air quality. You should understand basic design and installation principles that will help ensure adequate airflow, proper operational control, and adequate distribution of ventilation air while avoiding pressurization or depressurization problems.

A properly ventilated home is designed to provide:

- local or spot ventilation to remove moisture, odors, and other pollutants at the source;
- whole-house ventilation for supplying fresh air to remove contaminants by dilution; and
- control of airflow through building so air can't carry contaminants into and around the house.

A successful ventilation system, from the simplest to the most complex, must be acceptable to the occupants and they must be willing and able to maintain it. It must be unobtrusive, quiet, comfortable, simple and affordable to operate, and easy to maintain.

Below is a checklist of steps to follow in order to have success in each of your projects.

- ❑ **Be sure that the home is tightly constructed.** Conduct blower door testing, if possible, to determine natural air infiltration levels.
- ❑ **Be sure the duct system is also tightly sealed**, especially if the ventilation system will use the central air handler.
- ❑ **Work with a knowledgeable HVAC contractor** to design and select a ventilation system that is appropriate for the home and the climate.
- ❑ **Consider the loads induced by the ventilation system** when sizing heating and cooling equipment.
- ❑ **Consider wiring and controls** for the ventilation system.
- ❑ **Test and adjust** the ventilation system, as necessary.
- ❑ **Educate the homeowner** on the proper operation and maintenance of the system.