Scope

To assess and upgrade the ventilation system in an existing home, do the following:

- Preliminary Planning
  - Determine project goals with respect to ventilation.
  - Determine what code or program requirements must be met.
  - Assess existing ventilation systems (including local ventilation for kitchen and bathrooms).
  - Assess existing heating and cooling systems – especially if new ventilation may be integrated with existing HVAC systems.

- Determine the most appropriate type of ventilation.
- Install and commission ventilation system.

For an overview of whole-building ventilation systems, see the Building America Solution Center guide Whole-Building Delivered Ventilation. For information on assessing the performance of existing ventilation systems, see the Pre-Retrofit Assessment of Ventilation Systems.

The U.S. Department of Energy’s Standard Work Specifications have additional information on ventilation systems.

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
**Description**

For an overview of whole-building ventilation systems for new homes, see the Building America Solution Center guide [Whole-Building Delivered Ventilation](#). Information specifically relevant to existing homes is presented here.

**Ventilation Goals and Requirements**

The “appropriate” amount and type of ventilation varies from home to home and from occupant to occupant. Different households have different occupancy levels (people and pets), schedules, activities, health concerns, and other preferences that will influence appropriate ventilation systems and operation. While acknowledging these variations, ASHRAE Standard 62.2 provides guidance for calculating minimum ventilation rates. See the Compliance tab for more information on this standard (including different versions) and other codes and standards related to ventilation.

This guide largely focuses on whole-house mechanical ventilation. While local ventilation, such as kitchen and bathroom exhaust fans, is intended to intermittently remove contaminants near where they are generated, whole-house ventilation is intended to operate continuously (or at regular, frequent intervals) to provide ongoing fresh air and dilution of potential contaminants. Exhaust-only systems like kitchen and bath fans can combine both of these roles of ventilation (local and whole-house) by exhausting stale air locally and from the whole house but they bring in air through leaks in the building envelope. However there are other whole-house ventilation strategies that bring in air intentionally through ducted, filtered fresh air intakes. These methods are central fan-integrated supply ventilation, which provides fresh air through an intake that is ducted to the home’s central heating and cooling system air handler and heat recovery ventilators (HRVs) or energy recovery ventilators (ERVs), which simultaneously bring in fresh air and exhaust stale air with both ducts passing through a heat exchanger for heat recovery. All three ventilation strategies are described in greater detail below. (See Figure 1 for a depiction of these three strategies. A house might have one or more of these installed but it is not likely to have all three.)

**Ventilation Considerations and Strategies**

**Installation and Integration with Existing Systems**

In existing homes, installing whole-house ventilation systems is often more involved and costly than in new construction—especially with more complicated ventilation systems. The level of effort—and ultimately the cost—required to install a ventilation system in an existing home depends on many factors, including:

- existing ventilation systems
- existing ducted heating and/or cooling

![Figure 1. Examples of whole-house and local ventilation systems.](#)
accessibility to attics and/or basements

- scope of the renovation/rehabilitation project.

One of the most common types of whole-building ventilation is simple exhaust ventilation—where efficient exhaust fans run continuously (or intermittently with a dedicated controller) to remove indoor air. Bathroom exhaust fans are operable in many existing homes, but these older fans are usually not appropriate for whole-building ventilation (due to poor efficiency, poor air flow, or noise). The existing duct runs and electrical connections, however, may possibly be reused with the new system.

In homes with existing forced-air heating and/or cooling, it’s possible that a central fan-integrated supply (CFIS) ventilation system can make use of the ducts and the central air handler.

When there is no existing duct system—or at least no duct system appropriate for the desired ventilation system—installing new ducts and running electrical service to fans can be invasive and costly. These costs can be minimized when there is access from basements, crawlspaces, or attics. If ducts or electrical lines must be run between floors or in existing walls, sections of wall board must generally be removed and replaced. If other aspects of the renovation do not necessitate this level of intrusion, this invasive work can dramatically increase the cost of ventilation installation and integration.

Distribution and Mixing of Outdoor Air

Local exhaust ventilation for source control is properly targeted toward areas where contaminants, especially moisture, are frequently and intensely generated. Whole-building ventilation is intended to reduce contaminants throughout the entire home by diluting them with outdoor air. Certainly removing contaminants from and supplying outdoor air to every room in a home is ideal, but the installed costs of such systems can be quite high—especially in retrofit projects. Some ventilation strategies make use of point-source or local ventilation systems to meet whole-building ventilation requirements (e.g., a bath exhaust fan running continuously).

See the measure guideline report Selecting Ventilation Systems for Existing Homes for more discussion on the distribution of outdoor air.

Source of Outdoor Air

Outdoor air brought into a home as part of a ventilation system should be—as much as possible—free from contaminants. See the guide Ventilation Air Inlet Locations for more information on this topic.

By design or by default, most exhaust ventilation systems force infiltration through the building envelope. While this may not be ideal, there is not widespread consensus as to whether this is acceptable or unacceptable practice in particular circumstances. There are, however, several configurations that most agree are problematic:

- Depressurizing the home can interfere with any natural-draft combustion appliances located in the home.
- In a home with an attached garage, depressurization can pull in air from the garage. With the air can come traces of car exhaust, fuel, or solvents that may be stored in the garage.
- In a home with a moist, moldy crawlspace or basement, makeup air coming from such spaces may bring mold spores, humidity, or other undesirable elements.
- In some cases, depressurizing a home can exacerbate the introduction of radon or soil gas through the foundation.
- In attached or multifamily dwellings, makeup air can be drawn from neighboring units or other attached spaces.

These can be serious issues, and in some of these situations, exhaust ventilation—without makeup air provisions—should be avoided. In many cases, however, these issues can be addressed with common-sense solutions:

- Remove and replace natural-draft combustion appliances with direct-vent sealed-combustion appliances or noncombustion appliances.
- Meticulously air seal between the garage and the living space and/or install an exhaust fan in the garage that draws contaminants out of the garage and keeps the garage at negative pressure with respect to the living space.
- Create a well-sealed, dry, conditioned crawlspace or basement.
- Install a radon mitigation system if soil gas is a problem.

Most homes require exhaust ventilation, if only intermittently, to meet local ventilation requirements. The concerns above become somewhat more pressing when exhaust ventilation is used for whole-building ventilation and runs continuously.

Humidity

Bringing outdoor air into a home causes the heating or cooling systems to work more to condition this air. When humid air is brought into a home, however, air conditioners often cannot remove all of this additional moisture.
This problem is exacerbated in efficient homes: as sensible cooling loads (i.e., the energy needed to lower the air temperature) become smaller, air conditioners are sized smaller and/or run less frequently. When air conditioners run less frequently, less moisture is removed. In hot, humid climates, this can lead to real challenges. When ventilation systems bring more outdoor air into the home, an additional dehumidification system may be needed to keep indoor humidity at comfortable and healthy levels.

Many researchers have examined—and continue to examine—this conundrum: how to provide adequate fresh air, keep indoor humidity at acceptable levels, and minimize the cost and energy needed for dehumidification systems. Using ERVs can help reduce moisture gains, but separate dehumidification is often needed. More information is in the guide Whole House Dehumidification and the report Impact of Residential Mechanical Ventilation on Energy Cost.

Energy Implications

Mechanical ventilation systems have two key energy impacts:

- electricity used to operate fans and ventilation equipment
- thermal energy required to condition outdoor air introduced into the space.

Electrical fan energy varies widely. The power range for most bathroom exhaust fans is 5 to 40 Watts. Power consumption for many HRVs and ERVs ranges from 30 to 200 Watts. The fan in a central air handler or furnace—used in some ventilation strategies—can use 200 to 1,000 Watts. These are very general ranges, and power consumption certainly varies with airflow and system configurations. Typically ventilation products with lower power consumption use variable-speed brushless permanent magnet (BPM) fan motors; these often carry a cost premium.

The second point—conditioning the introduced outdoor air—is climate-dependent. HRVs and ERVs can certainly mitigate this effect. The sensible effectiveness of ERV/HRV heat exchangers typically ranges from 55% to 95%. Again, the higher values typically come with a higher cost. More extreme outdoor temperatures mean greater benefits from heat recovery. In humid climates, the latent heat transfer capability of ERVs can help reduce moisture introduced by a ventilation system. See the Climate tab for example of the energy and cost implications of various ventilation strategies in different climate zones.

System Types

Exhaust Ventilation

Bathroom exhaust fans have been the standard ventilation practice for decades. Most often the fans are installed in bathroom ceilings with a small duct (typically 4-inch diameter) that carries air to an outdoor termination of some type. While many bathrooms already have exhaust fans, many older fans do not perform at the desired or rated ventilation rates. When local exhaust fans are used for whole-house ventilation, the fans operate continuously or on programmable timers. Fresh air is introduced through induced infiltration.

Exhaust Fan Assessment

If a bath exhaust fan already exists, evaluate how well it works. Measure the airflow using an appropriate flow hood or other device, as shown in Figure 2. Inspect the fan grille for dirt and dust. Remove the grille and inspect the fan blades and housing. Simply cleaning the fan housing and grille can sometimes dramatically improve performance. Of course disconnect power before working on any electrical equipment.

Figure 2. Measure the air flow of an exhaust fan with a flow hood (image source).

Locate the outdoor terminal of the duct run. Exhaust ducts should always terminate outdoors—never in an attic, basement, or...
crawlspace, like the exhaust duct shown in Figure 2, which ends near an attic vent grille but not outside. If possible, measure the flow rate here at the outdoor termination as well. A large disparity in measured flow rates implies leakage. If possible, trace the exhaust duct run and inspect for disconnects, crimps, leaks, etc.

Figure 3. This exhaust fan duct incorrectly ends near an attic vent rather than being routed through the wall to exhaust outdoors (image source).

Even if flow rates are acceptable, many older exhaust fans are not energy efficient nor are they rated for continuous operation. Fan replacement is recommended in most circumstances. Inspect the ceiling cavity for clearances, joist spacing, and mounting configurations. The electrical service to existing fans will often be adequate for newer fans, but as always refer to an electrician or qualified contractor to assess electrical issues.

If a bathroom does not have an existing exhaust fan, evaluate the effort required to install a fan and ducting. If a bathroom is located on the top floor beneath a vented attic, running electrical and ductwork may not be terribly difficult. On lower floors, installing a new duct run may be much more problematic. If the bathroom is on an exterior wall, a fan that exhausts directly through the wall is a possible solution.

**Exhaust-Only Cost**

Prices for exhaust fans themselves (efficient fans with BPM motors) range from $100 to $250 depending on flow rates, special features, etc. If installed as an upgrade (e.g., in a bathroom that already has an old exhaust fan, power, ducting, etc.), installation costs may be $100 to $200. If installed in a location that did not previously have a fan, costs can be much higher. If installed in a ceiling beneath an accessible attic, installation costs can be about $200 to $400. If drywall or finishes must be removed and repaired, costs can be substantially higher.

**Exhaust-Only Energy Implications**

A 10-Watt fan running year-round consumes 88 kWh. At $0.11/kWh, this costs $10/yr. As this system has no heat recovery, outdoor air brought into the building must be conditioned. Costs to do this vary with climate and HVAC equipment (see the Climate tab), but these costs are usually much larger than the cost of electricity to operate the fan.

The pros and cons of the exhaust-only ventilation approach are shown in Table 1.

Table 1. Exhaust-Only Pros & Cons
Selecting Exhaust Fans

Once the desired flow rates are known (based on a calculation to meet code-required ventilation rates, like ASHRAE 62.2), it’s usually best to select an exhaust fan that meets these flow rates at pressures of 0.25 in. w.c. Many fans list flow rates at 0.1 in. w.c., but most exhaust duct runs have much higher pressure drops.

ENERGY STAR-rated exhaust fans are recommended for most applications; the most obvious benefit of these fans is lower energy consumption. ENERGY STAR requirements for bathroom exhaust fans (with rated flow rates below 90 cfm) call for fans to deliver a minimum of 2.8 cfm/Watt. For fans with rated flows of 90 to 200 cfm, ENERGY STAR fans must deliver at least 3.5 cfm/Watt. See the Building America Solution Center guides Continuous Supply/Exhaust Fan Ratings and Intermittent Supply/Exhaust Fan Ratings for information on assessing fan ratings.

While these energy requirements represent great improvements over older fans, many manufacturers now have bathroom exhaust fans with efficacies of more than 10 cfm/Watt. These very efficient fans typically use brushless permanent-magnet motors (BPM motors). These motors are also referred to as DC (direct current) motors, ECMs (electronically commutated motors), or variable-speed motors. In addition to lower energy consumption, the variable-speed capabilities of these motors allow these fans to maintain design flow rates over a wide range of static pressures.

In existing buildings, exhaust duct runs are often concealed in walls or ceilings. It’s very difficult to determine the state of these runs, and many have twists and turns that result in higher pressure conditions. Fans with BPM motors and advanced controls are excellent choices for such retrofit applications because these fans can increase speed and flow to overcome most duct restrictions. Operating at higher fan speed increases power consumption somewhat, but this is usually a small price to pay for meeting airflow targets.

One additional benefit of efficient bath exhaust fans is lower noise. ENERGY STAR fans must meet maximum sound level requirements of 2 sones for most products. ASHRAE Standard 62.2-2016 requires a maximum of 1.0 sone when exhaust fans are operated continuously. Many bath exhaust fans are available with rated sound levels of 0.3 sone.

Exhaust Fan Installation

<table>
<thead>
<tr>
<th>Exhaust-Only Pros</th>
<th>Exhaust-only Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust-only, whole-building ventilation is one of the most common systems employed in homes, especially existing homes. The key reasons for this are its low cost and simplicity. Nearly all homes have exhaust fans, and upgrading one (or more) fans to an efficient model designed for continuous operation is usually straightforward.</td>
<td>Depressurizing the home draws in air from outside the home. The key question is: where does this makeup air come from? Are contaminants being introduced? Exhaust-only ventilation should not be used in homes with: atmospheric combustion appliances, makeup air coming from damp, moldy crawlspaces or basements, attached garages (that are not well air-sealed from the home), other situations where contaminants are likely to be introduced continuously.</td>
</tr>
<tr>
<td>Exhaust fans that use very little electricity are available (5–12 Watts for 50–80 cfm).</td>
<td>Exhaust-only ventilation is typically not distributed. A single exhaust fan removes air from one location, and makeup air enters where it will. With such a system, it is likely that different parts of the home will be ventilated to different degrees—especially when interior doors are closed. When doors are open or when a forced-air system is operating in the home, differences in air changes throughout the home are usually small.</td>
</tr>
<tr>
<td>Exhaust fans require very little maintenance. Typical maintenance instructions are to vacuum or wipe the fan grille from time to time. In this regard, exhaust-only ventilation can be very reliable.</td>
<td></td>
</tr>
</tbody>
</table>
Tight bends in exhaust fan ducts can reduce flow rates, increase noise, and increase power consumption (image source).

If an older exhaust fan is present, replacing the fan—but keeping the existing duct—can be a relatively low-cost project. If possible, the duct run should be inspected for leaks, insulation, obstructions, etc. and repaired as necessary. Duct size should also be verified; some older ducts may only be 3 inches in diameter; ducts that are too small can restrict flow dramatically. Use the duct size recommended by the fan manufacturer. At a very minimum, the outside terminus of the exhaust run should be located and inspected. Exhaust fans should vent directly outdoors—not to an attic, crawlspace, etc. If an existing fan is terminated inappropriately, a new outdoor termination must be installed. Outdoor terminations should be properly air sealed and flashed, and should include proper screens or backdraft dampers to prevent insects and other pests from entering the ducts.

If a new duct must be installed, duct runs should be as short and as straight as possible to an appropriate outdoor termination. If an elbow is required to redirect the ductwork, it is recommended that 2 to 3 feet of straight run is provided directly off of the fan housing prior to the elbow and tight bends, like the bend shown in Figure 4, should be avoided. Refer to fan literature to determine the proper duct diameter; larger ducts generally result in better flow rates and are more forgiving than long or winding duct runs. Joints in the duct system should be sealed with mastic, and any ducts located outside of conditioned space (e.g., the attic) should be insulated to prevent condensation of the humid exhaust air.

Ideally, replacing an existing exhaust fan will require minimal drywall and/or ceiling finishing work. However, the variability in size and configuration of these fans makes this hard to predict. Refer to retrofit installation instructions provided by the manufacturer and, if possible, select a new fan with a ceiling opening similar to—or slightly larger than—that of the existing fan. It’s also a good idea to inspect the ceiling cavity to make sure clearances are acceptable. Sealing the fan housing to the ceiling (with caulk or appropriate material) can help maintain envelope integrity.

**Exhaust-Only Controls**

While simple on/off switch controls may be acceptable in some situations, controls that ensure continuous operation of fans are usually desirable. A wide range of control options are available:

- Timers can operate fans at programmed intervals (usually a set number of minutes each hour). These typically include override switches to turn on exhaust fans when desired.
- Some fans include controls for continuous, low-speed settings along with a switch for a high-speed boost setting.
- Occupancy sensors and humidity sensors can be used to turn on fans or to boost fans into high speed when higher exhaust flow rates are desired.
- There are a wide array of after-market boost switches and timers that work with many exhaust fans.

See the guide [Continuously Operating Ventilation and Exhaust Fans](#) for more on fan controls.

**Exhaust Measurement, Verification, and Commissioning**

Commissioning of exhaust fan operation is usually very straightforward. First, verify that the fan actually turns on when manually switched on and/or when programmed to turn on (e.g., with a timer, occupancy sensor, etc.). The exhaust airflow rate is easily measured with a flow hood or flow meter. If delivered flow rates do not match design rates, inspect the duct system (when possible) to see if there are any obstructions, if backdraft dampers are operating properly, etc. It is common to see the exhaust fan backdraft damper restricted due to screws being used to connect ductwork to the fan housing collar. Screws should not be used to make this connection. Instead, use clamps plus mastic or approved foil-faced tape.

**Exhaust-Only Operation and Maintenance**

Exhaust fans require relatively little maintenance. To maintain proper flow rates, however, most manufacturers do recommend periodic vacuuming of the exhaust fan grille and cleaning of the fan housing with a damp cloth. Refer to operation instructions for details. On the outside of the home, the exhaust outlet should be checked periodically for obstructions or debris.
Central Fan Integrated Supply

Central fan-integrated supply (CFIS) systems use a fresh air intake ducted to the home’s central furnace or air handler unit to supply fresh air throughout the home. A duct is run between the return plenum and the outdoors. CFIS controllers are programmed to turn on the air handler fan and open the motorized damper. Outdoor air is drawn into the return plenum, mixed with return air, and distributed throughout the home.

CFIS Cost

If the central air handler is accessible in a basement or attic, and a duct can be fairly easily run from outdoors, the total CFIS installed cost may range from $500 to $900 (including the controls, motorized damper, sealed insulated duct run, and outdoor duct termination). If installing the outdoor air duct is involved or requires removal of drywall, refinishing, etc., costs can increase dramatically.

CFIS Energy Implications

CFIS systems can consume large amounts of electricity, because the large central fan is turning on just to circulate fresh air, and a central fan would typically be moving much more air at higher power consumption than is needed for this use. However, variable-speed fans with ECM motors can modulate down to a lower flow rate when in ventilation-only mode. If using a relatively efficient AHU fan motor (300 Watts) and run an average of 8 h/day for ventilation (i.e., in addition to operation needed for space conditioning), a CFIS would consume 876 kWh/yr. At 0.11/kWh, this costs $96/yr. Most central air handlers have motors that are not this efficient so it is not uncommon for power draws to be two or three times higher.

Basic CFIS systems have no heat recovery, so outdoor air brought into the building must be conditioned. See the Climate tab for examples of these cost implications. If CFIS is used in a system with considerable duct leakage, these thermal conditioning costs can be much, much higher. However, overall equipment expenses are low since this ventilation method would only be chosen if the home already has a ducted HVAC system with a central air handler or central furnace. The pros and cons of CFIS systems are outlined in Table 2.

Table 2. CFIS Pros and Cons

<table>
<thead>
<tr>
<th>CFIS Pros</th>
<th>CFIS Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Along with exhaust ventilation, CFIS is one of the most simple and affordable systems to install in existing homes.</td>
<td>The home must have a forced-air heating or cooling system.</td>
</tr>
<tr>
<td>CFIS systems distribute outdoor air to all parts of the home.</td>
<td>The largest drawback of CFIS is the high electricity consumption from using the air handler fan for modest ventilation needs. This strategy should be considered only when the air handler has an ECM blower.</td>
</tr>
<tr>
<td>Aside from keeping the air intake free from debris, a CFIS system requires little maintenance beyond maintenance of the central heating and cooling system.</td>
<td>If the central duct system is leaky, heating and cooling cost penalties may be extremely high. Indoor air quality can actually be diminished if the ductwork is located in an unconditioned attic or crawlspace.</td>
</tr>
<tr>
<td>Outdoor air is filtered (through the central air handler filter).</td>
<td>There is potential for comfort problems if cool mixed air blows on occupants during the winter (or warm, humid air blows on them during the summer). If the forced-air system is noisy, more frequent operation may also disturb occupants.</td>
</tr>
</tbody>
</table>

CFIS Assessment
A central fan-integrated supply system uses a fresh air intake ducted to the home’s central furnace or air handler unit to supply fresh air throughout the home (image source).

Clearly, CFIS systems are only appropriate in homes with forced-air heating or cooling systems. Examine the air handler and return plenum location. Make sure the area is accessible and that there is adequate room to install an outdoor air duct.

Determine a good air intake location. The air intake should draw in clean outdoor air without restrictions. Outdoor air should not be drawn from an attic, basement, garage, or crawlspace. Intake should be well above the ground and snow level, away from garages or parking areas, and away from any exhaust termination. See the guide Ventilation Air Inlet Locations for more information.

Map the duct run. Make sure a duct can be run from the return plenum to the outdoor air intake location within the project’s scope. Duct runs should be as short and as straight as practical to provide unrestricted airflow.

Measure airflow and return static pressure. With the air handler in “fan only” mode (i.e., heating and cooling turned off but the fan turned on), measure the system airflow and the static air pressure in the return plenum.

Inspect the AHU fan motor. Determine the type of air handler fan motor and/or measure the power consumption of the motor. Variable-speed motors (also called ECMs or BPM motors) typically use 25% to 50% less electricity than older permanent split-capacitor (PSC) motors when heating and cooling. (See the guide ECM Air Handler Fans for more information.) During fan-only operation, these motors can run at lower speeds and provide further savings. Using CFIS with PSC fan motors is not recommended (and is not permitted by the International Energy Conservation Code, Section R403.6.1).

Determine the outdoor air flow rate and operating schedule. The approximate outdoor air flow rate can be calculated from the measured return static pressure and the total equivalent length (TEL) of the duct run. Each linear foot of outdoor air intake duct counts as 1 foot of TEL, but bends and fittings also increase TEL. Many elbows, for example, add at least 15 ft to TEL; an air intake hood may add 30 ft. See ACCA Manual D for more details about calculating TEL. See the measure guideline report Selecting Ventilation Systems for Existing Homes for more details and calculation examples.

The more outdoor air introduced into the system, the less time the air handler must operate to deliver outdoor air. A key limitation, however, is the temperature of the mixed air (i.e., the mixture of return air and outdoor air) supplied to the home. Cool air can cause comfort problems during the winter and many furnace manufacturers require that air passing over the heat exchanger to be above a minimum temperature (55° to 60°F is common; see the manufacturer’s literature). Locating air intakes upstream from heat exchangers can provide better mixing and dilution of cold, outdoor air. The mixed air temperature can be calculated by the ratio of air temperatures and flow rates. See the measure guideline report Selecting Ventilation Systems for Existing Homes for more information.

Selecting CFIS Equipment

Controller. There are several CFIS controllers on the market. These controllers are available as discrete components, but many are also available as part of a kit that also includes a controller, a motorized damper, and a transformer. Make sure the device (or kit) used is compatible with the existing air handler and control system.

Ducts and Dampers. Duct runs should be as short and straight as is practical. Ducts bringing outdoor air through conditioned spaces should be insulated. Motorized dampers—which open to allow outdoor air in and close when the ventilation quotas have been met—are often available as part of a CFIS package or kit. If a different sized damper is needed, motorized dampers can certainly be acquired separately. Refer to the manufacturer’s literature to ensure that the dampers are compatible with the controller. In addition to the motorized damper, a manual balancing damper in the outdoor air duct may help adjust the volume of outdoor air introduced into the system.

Air Handler Fan Motors. As mentioned above, CFIS ventilation systems are not recommended with an inefficient AHU fan motor. For older furnaces or air handlers, there are efficient fan motor replacements available. (See the guide ECM Air Handler Fans.) While the electricity consumption of these motors depends a great deal on HVAC system characteristics, these motors may consume 25% to 50% less electricity to deliver the same flow rate. If central air handlers do not have an efficient motor, and replacing the motor is not possible or practical, a different type of ventilation system is recommended.

CFIS Installation

A qualified HVAC contractor should install the controller, ducts, dampers, and other components. The location of the duct run, connection to the return plenum, and location of the outdoor air intake should be planned beforehand.

Ducts should be sealed with approved foil-faced tape or mastic as appropriate. Ducts running through interior spaces should be insulated to prevent condensation. Outdoor air intakes should be equipped with screens to keep out insects and debris. Outdoor air must also be filtered before entering the air handler; sometimes the AHU filter can be used, but a separate filter is necessary if the outdoor air intake is downstream of this filter. As mentioned above, outdoor air intakes should be well above snow level, but it’s preferable that they be accessible from the ground for cleaning and maintenance. Outdoor intakes should be integrated with the siding and flashed properly to prevent air and water intrusion, and penetrations through exterior walls or ceilings should be appropriately sealed to limit infiltration. See the guide Ventilation Air Inlet Locations for more information.

CFIS Measurement, Verification, and Commissioning
After installation, commissioning of the system is critical. The first step is usually checking to ensure that when the controller calls for outdoor air, the air handler turns on and the motorized damper opens. The outdoor air flow rate should then be measured. This can be accomplished in several ways, but two common methods are as follows:

- A measurement in the outdoor air duct with a pitot tube or anemometer will provide air velocity. Velocity (feet per minute) multiplied by the cross-sectional area (square feet) of the duct will yield volume flow rate (cfm).
- At the outdoor air intake, a flow hood can measure airflow being drawn into the system. (This typically requires little or no wind for accurate measurements).

Finally, the balancing damper and the controller should be adjusted so that the desired amount of outdoor air is introduced into the system at the desired schedule.

**CFIS Operation and Maintenance**

As always, refer to manufacturer instructions for maintenance. One of the appealing features of CFIS systems is low maintenance, but this does not mean “no” maintenance. One very common cause of failure is clogging of the air intake. Regularly check the air intake to make sure it is free from debris (leaves, grass clippings, trash, bird nests, etc.).

**Heat Recovery Ventilators (HRVs) and Energy Recovery Ventilators (ERVs)**

HRVs and ERVs are balanced systems. This means they exhaust air and supply outdoor air simultaneously at very similar rates. The two airstreams cross in a heat exchanger, where heat from the warm duct is passed to the cooler duct, so during the winter, much of the heat in the exhaust stream is transferred to the supply stream (the reverse is true in the summer). HRVs transfer sensible heat only; ERVs also transfer moisture (latent heat).

**HRV/ERV Cost**

The range of ERV and HRV equipment costs is quite wide. Until recently, costs for core hardware ranged from approximately $400 to $2,000. Not surprisingly, the units with lower electricity consumption (> 1 cfm/Watt) and higher heat recovery effectiveness tend to be most expensive. Recently, some higher end European products have become available in the U.S. market. These systems boast even lower electrical consumption (near 3 cfm/Watt) and higher heat recovery effectiveness but with price tags of $3,000 to $5,000.

Installation costs vary tremendously; key factors include:

- Location of the core unit. If installed in an accessible space (such as a basement), core equipment installation and duct connections may be fairly simple.
- If ducts can be run in an open space (basement or attic), wall and ceiling finishes may be left mostly undisturbed.
- More and longer duct runs translate into higher installation costs.
- The need for a condensate drain and/or pump adds cost.

Some contractors have quoted installation costs of $1,000–$1,500 when the system is entirely installed in a basement, attic, or other accessible space (i.e., very little ceiling or wall removal or finish work needed). Rules-of-thumb fail with more complex installations requiring ceiling, wall, or floor removal, construction of chases, refinishing, etc.

To help justify the higher costs of ERVs and HRVs, manufacturers will suggest that one or two bathroom exhaust fans can be eliminated and instead the ERV/HRV can be used to continuously exhaust air from each bathroom. This arrangement often meets code or program requirements for local ventilation, but ERVs/HRVs usually do not deliver the same exhaust rates as dedicated exhaust fans. Also, while this can be a cost savings in new construction, in an existing home that already has exhaust fans installed, the savings are nullified.

**HRV/ERV Energy Implications**

One of the main benefits of ERVs/HRVs is heat recovery. In colder climates, the savings from heat recovery are more pronounced. The electrical power consumption of these systems can also vary significantly; in milder climates, the electricity costs can actually be greater than the thermal energy savings. See the Climate tab for energy and cost examples. The pros and cons of HRV and ERV ventilation systems are summarized in Table 3.

Table 3. HRV/ERV Pros and Cons
HRV/ERV Assessment

Most HRVs and ERVs are housed in rectangular cabinets that contain fans, filters, heat exchange media, etc. Four ducts usually connect to this cabinet: outdoor air intake, exhaust to the outdoors, outdoor air supply to the home, and exhaust from the home. Use the following steps to assess the viability of an HRV or ERV installation.

1. Determine the location for the equipment. The ERV/HRV should be located so that duct runs can be short and straight, power and control wiring can be connected easily, and the unit can be easily accessed for maintenance. Many ERVs/HRVs produce a fair amount of noise; keep this in mind if units will be located near sensitive areas (e.g., bedrooms). In retrofits, basements and attics are common locations for ERVs and HRVs as running ducts from these locations may be less intrusive.

2. Determine outdoor air intake and exhaust locations. The outdoor air intake should draw in clean outdoor air. Outdoor air should not be drawn from an attic, basement, garage, or crawlspace. The intake should be well above the ground and snow level, away from garages or parking areas, and far from any exhaust termination. See the guide Ventilation Air Inlet Locations for more information.

3. Determine fresh air supply locations. One of the potential advantages of an ERV or HRV system is the ability to distribute fresh air to several locations. While providing outdoor air to all spaces may seem ideal, it is rarely practical. Especially in an existing home, running ducts to all parts of a home is difficult and costly. If an ERV is installed in a basement, for example, delivering fresh air to first-floor spaces may be straightforward but reaching second-floor spaces may be quite challenging. Even a single fresh air supply register—located relatively far from exhaust registers—can provide better mixing of fresh air than local ventilation systems.

In their product literature, some manufacturers recommend integrating ERVs/HRVs with the central duct systems used for heating and cooling, as shown in the schematics in Figure 6. This requires much less work, especially in an existing home. Short duct runs can bring fresh air to the supply plenum and exhaust can be drawn from the return plenum. Research has found that this strategy does not work well. When the central air handler fan is not running, the outdoor air follows the path of least resistance. In the schematic on the left in Figure 6, the path of least resistance is for fresh air to move backwards through the air handler and be exhausted through the duct in the return plenum. In both arrangements; very little fresh air is introduced into the living space.

Turning on the air handler when the ERV/HRV operates can solve this short-circuiting problem, but this increases electricity consumption dramatically and is not recommended. In addition, if the duct system is leaky (like most ducts in older homes), this...
leakage can result in significant energy penalties. One solution is that at least one side of the ERV/HRV system (i.e., either the exhaust or return side) be ducted separately. In Figure 7, for example, air is exhausted through a dedicated exhaust duct and tempered outdoor air is supplied to the return plenum. This can solve the short-circuiting problem but not the duct leakage problem. A fully ducted system—where ventilation supply and exhaust ducts are separate from heating and cooling ducts—may offer the best distribution of outdoor air, but this is often impractical and costly in retrofit applications.

Size ducts and map duct runs. To determine duct sizes, refer to the manufacturer’s literature. For more detailed sizing calculations, refer to ACCA Manual D.

Selecting ERV/HRV Equipment

Energy Recovery Ventilator or Heat Recovery Ventilator?

ERVs transfer moisture (latent heat) as well as temperature (sensible heat). HRVs transfer sensible heat only; they do not transfer moisture. Which type to choose is not always a straightforward decision, but the key question to ask is: Is it usually too humid outdoors? If so, an ERV may be a better choice.

The ERV/HRV question is easiest to answer in hot, humid climates. In Florida, for example, air inside comfortable homes is generally cool and dry. Outdoor air is quite humid. When outdoor air passes through an ERV, both moisture and heat will pass from the incoming air to the outgoing air, so the incoming air will be somewhat cooled and dehumidified. This does not mean an ERV dehumidifies the home. On the contrary, running an ERV will increase the amount of humidity in the home, but the humidity increase will be less than if a different ventilation strategy was used.

Outside of hot, humid climates, selecting ERVs or HRVs is not as straightforward. Some manufacturers provide recommendations or even maps of the country showing which type of system is most appropriate, but the recommendations vary from manufacturer to manufacturer. A few example situations are below.

- In many older homes in colder climates, indoor air during the winter is often uncomfortably dry—so dry that many people use humidifiers. An ERV can help retain moisture within the home and potentially improve comfort.
- In very airtight homes in cold climates, especially smaller homes with lots of moisture generation, indoor air humidity can be uncomfortably high. In this case, an HRV can help reduce indoor humidity.
- In hot, dry climates there is a similar trend: larger or leakier homes with low moisture generation may benefit from ERVs (to retain indoor moisture), while smaller, tighter homes with higher occupancy may benefit from HRVs (to reduce indoor humidity levels).
There is not a hard-and-fast rule about which type of system is more appropriate. Especially in mixed climates, there are many situations where an ERV may be more beneficial during the cooling season and an HRV might be more appropriate during the heating season. Installers should use their judgment when selecting systems.

HRV/ERV Thermal Efficiency

The Home Ventilating Institute (HVI) publishes standards for testing and rating the efficiencies of ERVs and HRVs. Apparent Sensible Effectiveness (ASEF) is the most commonly published rating for heat recovery during cold weather. Look for ASEF values above 80%; the most efficient systems have values above 90%. Total Recovery Efficiency (TRE) is listed for ERVs, and it accounts for sensible and latent heat recovery during the cooling season. For best performance, look for TRE values above 50%. A full listing of certified equipment is available on HVI’s website [https://www.hvi.org/](https://www.hvi.org/).

HRV/ERV Power Consumption. Power consumption can vary widely, from below 30 Watts to above 200 Watts. Systems with low power consumption often have variable-speed motors (ECMs) that allow for better control of ventilation rates. While systems with low power consumption (> 1 cfm/Watt) are often more expensive, they are strongly recommended. In addition to the lower electricity consumption and better controllability, they also usually generate less noise.

HRV/ERV Controls and Features. Most ERVs and HRVs are available with programmable timers of various types. These are usually quite versatile and can be set to various schedules. In many ERVs or HRVs, flow rates can be adjusted by changing the fan speeds. These can often be manually boosted to high speed when more air is desired. Some systems offer advanced features (often at a premium) such as:

- Controls with carbon dioxide and/or humidity sensors can boost speed at higher concentrations (which usually indicate higher occupancy).
- Some systems can boost speed and/or bypass the heat exchanger to take advantage of nighttime cooling.
- Higher levels of filtration are sometimes available (including HEPA) to remove airborne allergens and other pollutants.

HRV/ERV Installation

Installation should be done by a qualified professional. Follow manufacturer instructions for proper installation. Be sure to install the ERV/HRV unit where it can be easily accessed for maintenance, where power can be safely run to the unit, and where the system’s noise will not disturb occupants. Install condensate drains as required by the manufacturers.

All duct runs should be as short and straight as is practical. Be sure outdoor penetrations are properly air sealed and flashed and have the appropriate screens for pest protection. Ideally, these penetrations will be easily accessed from the ground so occupants can make sure they stay free of debris.

Ducts should be sealed (see the report [Measure Guideline: Sealing and Insulating Ducts in Existing Homes](https://www.hvi.org/)) and the ducts running to and from the outdoors should be insulated. If the ERV or HRV is installed in unconditioned space (e.g., in a vented attic), the ducts carrying exhaust air and tempered outdoor air should also be insulated.

Most of the HRVs and ERVs discussed here are ducted systems—i.e., two ducts run from the unit to the indoors and two ducts run from the unit to the outdoors. The cost for installing these duct systems is often a large part of total system cost. To help address this challenge, some manufacturers have introduced local ERVs. Figure 8 shows such a unit installed in a ceiling in a manner somewhat similar to a bathroom exhaust fan. The unit requires two outdoor air ducts (one intake and one exhaust), but the unit exhausts directly from and supplies directly to the room below. Compared to conventional ERVs, this system can dramatically simplify installation and reduce costs; however, outdoor air is not distributed throughout the home but only to the room or area in which the local ERV is located. Also, heat recovery is only moderately efficient and these systems change to exhaust-only operation in cold weather.

ERV/HRV Measurement, Verification, and Commissioning

![Figure 8. Lower-cost local ERVs are usually installed in a ceiling to supply outdoor air to and exhaust air from the room in which they are located.](https://www.hvi.org/)

<table>
<thead>
<tr>
<th>Ducts should be sealed (see the report <a href="https://www.hvi.org/">Measure Guideline: Sealing and Insulating Ducts in Existing Homes</a>) and the ducts running to and from the outdoors should be insulated. If the ERV or HRV is installed in unconditioned space (e.g., in a vented attic), the ducts carrying exhaust air and tempered outdoor air should also be insulated.</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>
As with all ventilation systems, it’s important to measure the delivered airflows and make sure they meet specifications or requirements. Measuring flow rates at each register is the only practical way to check system balancing.

If indoor supply or exhaust registers cannot all be accessed (e.g., if air is supplied to the return plenum of the central heating and cooling system), flow hoods can be used at the terminations outdoors. This is usually practical only if the terminations are accessible from the ground and if outdoor conditions are calm (i.e., no wind).

As described for CFIS systems, a duct traverse with a pitot tube or anemometer can provide velocity and flow rate. Some ERV and HRV units are, in fact, equipped with pressure taps so that flows can be measured by connecting a manometer directly to the ERV/HRV itself.

If flow measurements do not match specifications or design targets, adjust the controls if appropriate. If the desired flow rates are hard to achieve, inspect the duct system, registers, and exterior terminations for obstructions. If controls have advanced features (e.g., timers, flow boosts, etc.), ensure that these functions are working properly.

**HRV/ERV Operation and Maintenance**

As always, refer to manufacturer’s instructions for proper maintenance. Maintenance requirements of HRVs and ERVs are often more rigorous than for other ventilation systems. Many systems require periodic cleaning and/or replacement of heat exchange media, filters, and other parts prone to collect dust and dirt. In addition, outdoor air inlets should be checked periodically to make sure they are free from debris (leaves, grass clippings, trash, etc.). Some devices are equipped with indicator lights that alert occupants when it’s time for maintenance. If these are not present, residents should be meticulous in maintaining a schedule.
Ensuring Success
See the Solution Center guide [Whole-Building Delivered Ventilation](#) for descriptions of basic types of ventilation.

**Combustion Safety**

Ventilation systems have the potential to change pressures within the home, which can interfere with the operation of combustion appliances. This is especially a concern with exhaust ventilation in homes with atmospheric combustion or natural-draft appliances. Ensure that combustion appliances are operating properly before and after ventilation systems are installed. For more on combustion safety, see these Building America guides and reports:

- [Pre-Retrofit Assessment of Combustion Appliances](#)
- [Combustion Appliance Zone (CAZ) Testing](#)
- [Measure Guideline: Combustion Safety for Natural Draft Appliances Using Indoor Air](#)
- [Measure Guideline: Combustion Safety for Natural Draft Appliances through Appliance Zone Isolation](#)

**Testing and Commissioning**

After a ventilation system is installed, it's critical to ensure it is operating properly and delivering the desired air flow rates. Check controls to ensure that fans turn on and off and that dampers open and close when appropriate. Also measure flow rates delivered to (and/or exhausted from) the home. Proper flow measurement strategies and devices vary with system type, but refer to this ANSI standard for some best practices:

**Operation and Maintenance**

One important—though sometimes overlooked—aspect of a ventilation system is the level of maintenance required. All mechanical systems require some maintenance, but maintenance required on ventilation systems can vary greatly. On one end of this spectrum, local bathroom exhaust fans have very modest requirements. Typical maintenance instructions are—at least once per year—to clean/wipe the exhaust fan grille, vacuum dust and dirt from the fan body, and wipe the fan body clean.

Some of the higher performing ERVs, by contrast, require checking or cleaning filters, heat exchange media, and exterior duct terminations quarterly. While exhaust fan maintenance instructions may consist of four or five short bullet points, instructions for checking and cleaning ERV components can be several pages. This increased level of maintenance is not a design flaw; it is simply necessary with more complex systems with greater functionality.
Climate

Ventilation brings outdoor air into a home. During cold weather, this air needs to be heated; during hot weather, this air needs to be cooled. The energy needed to condition outdoor air drives differences in ventilation operating costs in different climates (along with varying energy rates, of course). Tables 1 and 2 below show example ventilation-related energy consumption and costs for four ventilation systems in six different climates. Table 1 shows exhaust-only and CFIS systems and Table 2 shows HRV and ERV systems. Table 3 shows average energy costs in the six locations. The values were generated using BEopt modeling software, and each system delivers 50 cfm of outdoor air continuously (except for the CFIS system, which provides the equivalent but runs intermittently). The example was based on one heating and cooling system typical in an older home - a 78% AFUE gas furnace and a 13 SEER air conditioner. In this example, we are assuming that there is no duct leakage to the outdoors; this is especially relevant for the CFIS system. If a system has substantial duct leakage (as many older systems do), energy penalties can be several times the value listed. All costs are annual and relative to a home with no whole-building ventilation.

<table>
<thead>
<tr>
<th>Location</th>
<th>Exhaust-only, 10W</th>
<th>CFIS, 300W, 8 hr/day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kWh</td>
<td>Therms</td>
</tr>
<tr>
<td>Chicago</td>
<td>182</td>
<td>107</td>
</tr>
<tr>
<td>San Francisco</td>
<td>114</td>
<td>55</td>
</tr>
<tr>
<td>Atlanta</td>
<td>264</td>
<td>47</td>
</tr>
<tr>
<td>New York</td>
<td>187</td>
<td>81</td>
</tr>
<tr>
<td>Phoenix</td>
<td>469</td>
<td>11</td>
</tr>
<tr>
<td>Orlando</td>
<td>419</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1 - Sample Energy Usage and Costs for Exhaust-Only and CFIS Ventilation Systems in Six U.S. Cities (Source: BEopt Modeling Software)

<table>
<thead>
<tr>
<th>Location</th>
<th>HRV, 55W, 70% ASEF</th>
<th>ERV, 30W, 90% ASEF, 55% TRE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kWh</td>
<td>Therms</td>
</tr>
<tr>
<td>Chicago</td>
<td>534</td>
<td>42</td>
</tr>
<tr>
<td>San Francisco</td>
<td>498</td>
<td>33</td>
</tr>
<tr>
<td>Atlanta</td>
<td>648</td>
<td>22</td>
</tr>
<tr>
<td>New York</td>
<td>562</td>
<td>36</td>
</tr>
<tr>
<td>Phoenix</td>
<td>733</td>
<td>5</td>
</tr>
<tr>
<td>Orlando</td>
<td>850</td>
<td>3</td>
</tr>
</tbody>
</table>

ASEF=Apparent Sensible Effectiveness; rating for heat recovery during cold weather.
TRE= Total Recovery Efficiency of the ERV; rating for sensible and latent heat recovery during the cooling season.

Table 2 - Sample Energy Usage and Costs for HRV and ERV Ventilation Systems in Six U.S. Cities (Source: BEopt Modeling Software)

<table>
<thead>
<tr>
<th>Location</th>
<th>Energy Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>/kWh</td>
</tr>
<tr>
<td>Chicago</td>
<td>$0.13</td>
</tr>
<tr>
<td>San Francisco</td>
<td>$0.14</td>
</tr>
<tr>
<td>Atlanta</td>
<td>$0.11</td>
</tr>
<tr>
<td>New York</td>
<td>$0.17</td>
</tr>
<tr>
<td>Phoenix</td>
<td>$0.12</td>
</tr>
<tr>
<td>Orlando</td>
<td>$0.12</td>
</tr>
</tbody>
</table>

Table 3 - Typical Energy Costs in Six U.S. Locations

This is a simple, illustrative example only. True costs will depend on a wide range of variables. The example demonstrates, however, that the benefits of efficient heat recovery are more pronounced in colder climates. Operating costs for the CFIS ventilation option were the highest. Note that CFIS energy costs can increase dramatically if there is duct leakage from the heating/cooling system to the outdoors.
This comparison of operating costs for exhaust-only, CFIS, HRV, and ERV ventilation systems in six U.S. cities shows CFIS has the highest annual costs. (Source: BEopt Modeling Software).
Training

Right and Wrong Images

Display Image: description3.png

Display Image: description4.png
CAD
None Available
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ASHRAE Standard 62.2-2010

A growing number of codes and home performance programs are starting to address ventilation in a more meaningful way. While requirements can vary considerably, ANSI/ASHRAE Standard 62.2 is—or is becoming—the most common standard referenced for ventilation requirements in homes. Newer versions of the standard 62.2 have been published, but Standard 62.2-2010 is still referenced by many programs.

ASHRAE 62.2-2010 requires local ventilation in bathrooms (with capacity of at least 50 cfm intermittently or 20 cfm continuously) and kitchens (with capacity of at least 100 cfm intermittently or 5 ACH of kitchen volume continuously). These local exhaust systems are required to remove odors and pollutants—especially water vapor—from these key areas. While exhaust fans are common in many existing homes, older and low-cost fans often perform very poorly—exhausting a very small fraction of the design flow rates—and consume a large amount of electricity.

ASHRAE 62.2-2010 also requires whole-building ventilation. Whole-building ventilation “is intended to dilute the unavoidable contaminant emissions from people, from materials, and from background processes.” The required whole-building ventilation capacity (expressed in outdoor air flow rate) depends upon home size and number of bedrooms.

\[
Q_{\text{fan}} = 0.01A_{\text{floor}} + 7.5(N_{\text{br}} + 1)
\]

where

- \(Q_{\text{fan}}\) = Whole-building ventilation flow rate (continuous) [cfm]
- \(A_{\text{floor}}\) = Floor area [ft\(^2\)]
- \(N_{\text{br}}\) = Number of bedrooms

ASHRAE 62.2-2010 assumes a home will have a baseline level of infiltration—2 cfm/100 ft\(^2\) of floor area. If blower door tests of existing homes show infiltration rates above this level, then the amount of whole-building ventilation can be reduced.

ASHRAE 62.2-2010 has a special provision for ventilation in existing homes (Appendix A). If adding or improving local ventilation (kitchen or bathroom) to meet ASHRAE 62.2-2010 requirements is impractical or beyond the project’s budget, the standard can be met by increasing the whole-building ventilation rate

ASHRAE 62.2-2013

The primary change in the 2013 version of Standard 62.2 is the elimination of the built-in “infiltration credit” discussed above. The newer formula for calculating whole-building flow rate is:

\[
Q_{\text{tot}} = 0.03A_{\text{floor}} + 7.5(N_{\text{br}} + 1)
\]

where:

- \(Q_{\text{tot}}\) = Total required whole-building ventilation rate [cfm]

If a blower door test is done on a single-family home, however, it’s likely this ventilation flow rate can be reduced.

\[
Q_{\text{fan}} = Q_{\text{tot}} - Q_{\text{inf}}
\]

where \(Q_{\text{inf}}\) is the “Effective Annual Average Infiltration Rate”.

Calculating \(Q_{\text{inf}}\) is described in the standard (ASHRAE 2013), but there are several online tools where these calculations can be done, such as:


Another critical difference in the 2013 version of ASHRAE 62.2 is in the treatment of multifamily buildings. ASHRAE 62.2-2013 does not allow infiltration credits for multifamily homes. Like the 2010 version, ASHRAE 62.2-2013 makes special provisions for existing buildings. If adding local ventilation is beyond the scope of the project, whole-building ventilation rates can be increased to compensate.

ASHRAE Standard 62.2-2016

Overall ventilation requirements in the 2016 version of the ASHRAE standard are similar to those in the 2013 version. Changes to whole-building ventilation include:

- The standard applies to all single-family and multi-family homes
Some attached, single-family homes (e.g. row-houses) can take an infiltration credit when calculating required ventilation rates. In existing homes, if the calculated whole-building ventilation rate is less than 15 cfm, no whole-building ventilation rate is required. More guidance for measuring ventilation flow rates.

Online tools are available to determine required flow rates per ASHRAE 62.2-2016; see for example:


**2009 IECC**

Section R403.5 requires automatic or gravity-fed dampers on ventilation system outdoor air intakes and exhausts. Table 405.5.2(1) specifies ventilation requirements for the Simulated Performance Alternative.

**2012 IECC**

Section R403.5 requires that the building have ventilation that meets the International Residential Code or International Mechanical Code. Fan efficiency is specified in Table R403.5.1. Table 405.5.2(1) specifies ventilation requirements for the Simulated Performance Alternative.

**2015 IECC**

The 2015 IECC specifies minimum performance of some ventilation systems (R403.6). This includes minimum efficacy of 2.8 cfm/Watt for range hoods, in-line fans, and bath/utility exhaust fans rated at 90 cfm or higher. Bath exhaust/utility exhaust fans less than 90 cfm must be at least 1.4 cfm/Watt. This section also requires that when other HVAC equipment is used for ventilation (e.g. CFIS), this equipment must have an electronically commutated fan motor.

**2018 IECC**

Same requirements as 2015 IECC but efficacy requirements for ERVs and HRVs were added to Table R403.6.1; they must meet a minimum efficacy of 1.2 cfm/watt.


Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

**2009 IRC**

Section M1507 specifies that exhaust air should not be recirculated in the house but should exhaust outdoors and that ventilation rates should be 100 cfm intermittent or 25 cfm continuous for kitchens and 50 cfm intermittent or 20 cfm continuous for bathrooms.

**2012, 2015, and 2018 IRC**

The 2012 and 2015 IRC require whole-house mechanical ventilation for relatively air-tight homes (R303.4, M1507.3 in 2012 and 2015 IRC; R303.4, M1505.4 in 2018 IRC). The ventilation flow rates are similar to those required in ASHRAE 62.2-2010. The codes do not have credits for infiltration as do the ASHRAE standards.


Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.

**Other Programs**

Ventilation requirement for new home programs including the DOE Zero Energy Ready Home Program, EPA Indoor airPLUS, and ENERGY STAR Certified Homes are discussed in some detail in the compliance tab of the Whole-Building Delivered Ventilation guide.
More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

Case Studies

1. **Technology Solutions Case Study: Selecting Ventilation Systems for Existing Homes**
   Author(s): CARB
   Organization(s): CARB
   Publication Date: December, 2014
   
   Case study aimed at helping contractors and building owners choose the best ventilation for existing homes.

References and Resources*

1. **Central Fan Integrated Ventilation Systems**
   Author(s): Building Science Corporation
   Organization(s): Building Science Corporation
   Publication Date: May, 2009
   
   Report about ventilation system design, including central fan integrated supply (CFIS) system, made up of a 6-inch outdoor air intake duct connected to the return side of the air handler with a fan cycling control to make sure the fan runs a programmed minimum amount of time.

2. **Evaluating Ventilation Systems for Existing Homes**
   Author(s): Aldrich, Arena
   Organization(s): CARB, Steven Winters Associates, SWA
   Publication Date: February, 2013
   
   Report describing the evaluation and selection of ventilation systems for homes retrofitted for energy aesthetic and health/safety improvements in Las Vegas.

3. **How Much Ventilation Do I Need?**
   Author(s): Home Ventilating Institute
   Organization(s): Home Ventilating Institute
   Publication Date: February, 2018
   
   Website with articles on home ventilation and indoor air quality.

4. **Impact of Residential Mechanical Ventilation on Energy Cost and Humidity Control**
   Author(s): Martin
   Organization(s): Building Science Corporation, Florida Solar Energy Center, FSEC, IBACOS
   Publication Date: March, 2014
   
   The study described in this white paper is based on building energy modeling with an important focus on the indoor humidity impacts of ventilation.

5. **Measure Guideline: Selecting Ventilation Systems for Existing Homes**
   Author(s): Aldrich
   Organization(s): CARB, Steven Winter Associates, SWA
   Publication Date: February, 2014
   
   This document addresses adding—or improving—mechanical ventilation systems to existing homes. The purpose of ventilation is to remove contaminants from homes either directly or by dilution. This report discusses where, when, and how much ventilation is appropriate in a home, including some discussion of relevant codes and...

6. **Multifamily Ventilation Retrofit Strategies**
   Author(s): Ueno, Lstiburek, Bergey
   Organization(s): Building Science Corporation, National Renewable Energy Laboratory
   Publication Date: December, 2012
   
   Research study examining the performance of existing multifamily ventilation central systems and explored alternative solutions in retrofit situations.

7.
**READ THIS: Before You Ventilate**
Author(s): Building Science Corporation
Organization(s): Building Science Corporation
Publication Date: December, 2006

Document reviewing ventilation strategies for different climate zones and includes schematic drawings and photographs of various ventilation installations.

8. **Review of Residential Ventilation Technologies**
Author(s): Russell, Sherman, Rudd
Organization(s): Lawrence Berkeley National Laboratory
Publication Date: August, 2005

Document reviewing current and potential ventilation technologies for residential buildings with particular emphasis on North American climates and construction.

9. **Ventilating Your Home**
Author(s): Puttagunta
Organization(s): CARB, Steven Winter Associates, SWA
Publication Date: August, 2009

Information sheet about proper ventilation and air sealing.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.*

**Contributors to this Guide**
The following authors and organizations contributed to the content in this Guide.