Energy Code Compliance

# Montana

Best Practices Newsletter

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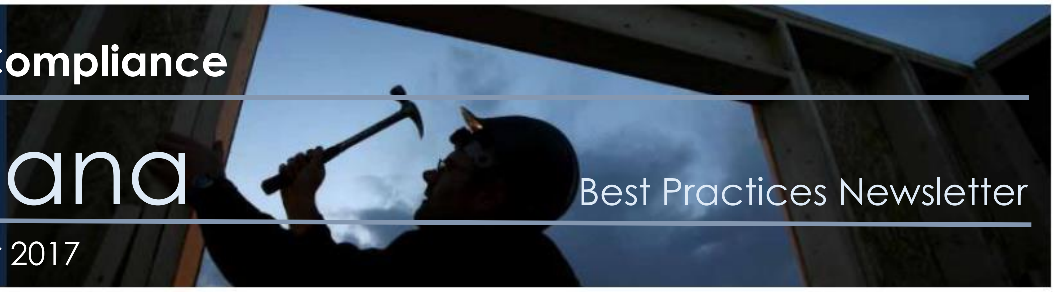

## Residential Mechanical Ventilation

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Natural ventilation using windows and other operable openings can provide adequate ventilation if they are used (which is more likely when the climate is more temperate than in Montana). However, there are many reasons why occupants may choose not to open the windows, including security, outdoor air quality, dust, or noise. Good ventilation in homes is important because it helps protect both occupant health and the house itself.

Building science has since taught us that we can't rely on natural forces to provide ventilation at all times of the year. In the meantime, we have introduced thousands of chemicals into our houses through building materials, finishes, packaging, furniture, carpets, clothing, and other products. This is in addition to the allergens and occupant-generated airborne chemicals that are present in our indoor environments.

## Why is Mechanical Ventilation Important?

Good ventilation protects home occupants from unpleasant odors, irritating pollutants, and potentially dangerous gases like carbon monoxide and radon. Well-planned ventilation also prevents the growth of mold and mildew, which can cause or aggravate allergic reactions and lung diseases such as asthma. As a result of building tighter homes with more insulation, the relative humidity in these homes has increased, and the potential for condensation on cool or cold surfaces has increased as well. The presence of moisture condensation is a leading cause of mold and mildew in both new and existing construction. Asthma has also increased as interior relative humidity has gotten higher. Therefore, it has become increasingly important to remove the moisture that results from bathing and cooking right at the source.

Good ventilation protects the home from damage by removing excess moisture-laden air from the house. Too much moisture rots window sills and attic eaves, peels paint, and invites insect infestation. Damp insulation in walls and ceilings means lost heat, higher fuel bills, and destructive and harmful mold growth. Carpeting, wallpaper, electronic equipment, and furniture all can be damaged by excess moisture. Condensation also occurs on the interior surface of a window based on the temperature of the glass and the relative humidity in the space.

The mantra of building science experts has become "Build Tight and Ventilate Right." Energy codes now require tight construction. All new houses in Montana must be tested to no more than 4 air changes per hour at 50 Pascals pressure. New homes also must comply with the *Air Barrier and Insulation Installation Table* in the Energy Code. Building and testing a tight envelope is fairly straightforward. In fact, if properly ventilated, a house building envelope can't be built too tight. Getting ventilation right is by far the more difficult challenge. While building science experts agree that mechanical whole-house ventilation is important, those same experts differ on exactly how much ventilation air is required and how to design an effective ventilation system.

**Common Terms**

**Air changes per hour at 50 Pascals (ACH50):** The number of times in an hour that the total air volume of a home is exchanged for outside air with the house depressurized or pressurized by a blower door to 50 Pascals with reference to the outside.

**cfm**: Cubic feet per minute; a standard measurement of fan airflow

**Efficacy:** Useful work divided by power. For ventilation fans, the efficacy is measured in cfm per watt (cfm/W).

**HVAC:** Heating, ventilating, and air conditioning

**Mechanical ventilation:** The active process of supplying air to or removing air from an indoor space by using powered equipment

**Pascals:** A measurement of air pressure. One inch of water column is equal to 249 Pascals of pressure.

**Sone:** A unit of how loud a sound is perceived. The sone scale is linear. Doubling the perceived loudness doubles the sone value.

**Watts:** Electrical power input to a fan or other equipment

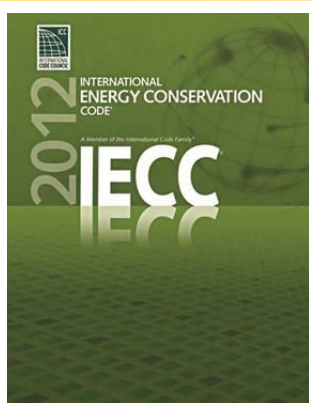
**Whole-house mechanical ventilation system:** The fans, controls, dampers, and ducts included in the system that supplies and exhausts or relieves ventilation air for the house. An important distinction is that a "whole-house fan" intended to flush air out of a house on summer nights is not typically part of the whole-house mechanical ventilation system; the airflow of a whole-house fan is much higher than that of continuous ventilation. A small whole-house fan may be used to provide the needed ventilation.

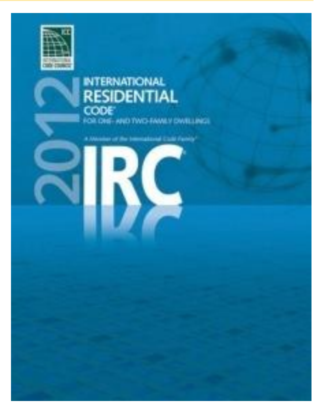
## Code Requirements: Whole-House Mechanical Ventilation

**Code Citation: IECC 2012, Section R403.5 Mechanical Ventilation (Mandatory)**
The building shall be provided with ventilation that meets the requirements of the International Residential Code or International Mechanical Code, as applicable, or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

**Code Citation: IRC 2012, Section M1507.3 Whole-House Mechanical Ventilation System**
Whole-house mechanical ventilation systems shall be designed in accordance with sections M1507.3.1 through M1507.3.3.

Both the 2012 International Energy Conservation Code (IECC) and the 2012 International Residential Code (IRC) require whole-house mechanical ventilation systems in the Montana climate zone. The IRC (R303.4) requires a whole-house mechanical ventilation system that complies with either Chapter 15 of the IRC, or the International Mechanical Code. The requirements of both are similar, but IRC Chapter 15 is much more user-friendly. In this discussion, only Chapter 15 of the IRC will be addressed.




**Code Citation: IECC 2012, Section R403.5.1 Whole-House Mechanical Ventilation System Fan Efficacy**
Mechanical ventilation system fans shall meet the efficacy requirements of Table R403.5.1.

As a result of the new ventilation requirements, fans designated for whole-house ventilation will have many more operating hours than bathroom or kitchen exhaust fans that are temporarily operated to remove local humidity or odors. Homes and dwelling units under the new ventilation requirements will expend significantly more energy on fan use; consequently, improved fan efficiency for those fans is cost-effective. The energy code requires the use of energy-efficient fans to provide whole-house mechanical ventilation. The table below specifies the efficiency of the fans that provide the required whole-house mechanical ventilation. Efficiency is given in cfm/watt.

**TABLE R403.5.1 MECHANICAL VENTILATION SYSTEM FAN EFFICACY**

| FAN LOCATION | AIR FLOW RATE MINIMUM (CFM) | MINIMUM EFFICACY (CFM/WATT) | AIR FLOW RATE MAXIMUM (CFM) |
|---|---|---|---|
| Range hoods | Any | 2.8 cfm/watt | Any |
| In-line fan | Any | 2.8 cfm/watt | Any |
| Bathroom, utility room | 10 | 1.4 cfm/watt | < 90 |
| Bathroom, utility room | 90 | 2.8 cfm/watt | Any |

IRC Table M1507.3.3 (1) shown to the right, specifies the minimum required whole-house ventilation air flow based on floor area and number of bedrooms. The code assumes that one bedroom will be occupied by two persons and each additional bedroom will be occupied by a single person. The code states that the ventilation may be either exhaust or supply, but a supply-only ventilation system is inappropriate for the Montana climate. The whole-house mechanical ventilation system must be provided with controls that allow manual override.

A house of 2,500 $ft^2$ conditioned floor area with three bedrooms would require 60 cfm of continuous ventilation.

**Intermittent Operation**. If the home uses intermittent ventilation instead of continuous ventilation, then the capacity of the ventilation system must be greater. Refer to IRC Table M1507.3.3 (2) shown on the following page. For example, if the whole-house mechanical ventilation system will operate only 50% of the time, the capacity of the system must be increased by a factor of 2 as specified by the table. If the system operates intermittently, then it must have controls that enable operation for not less than 25% of each four-hour period.

**IRC TABLE M1507.3.3(1)**
**CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS**

| DWELLING UNIT FLOOR AREA (square feet) | NUMBER OF BEDROOMS | | | | |
|---|---|---|---|---|---|
| | 0-1 | 2-3 | 4-5 | 6-7 | > 7 |
| | Airflow in CFM | | | | |
| < 1,500 | 30 | 45 | 60 | 75 | 90 |
| 1,501 - 3,000 | 45 | 60 | 75 | 90 | 105 |
| 3,001 - 4,500 | 60 | 75 | 90 | 105 | 120 |
| 4,501 - 6,000 | 75 | 90 | 105 | 120 | 135 |
| 6,001 - 7,500 | 90 | 105 | 120 | 135 | 150 |
| > 7,500 | 105 | 120 | 135 | 150 | 165 |

| DWELLING UNIT FLOOR AREA (square feet) | NUMBER OF BEDROOMS | | | | |
|---|---|---|---|---|---|
| | 0-1 | 2-3 | 4-5 | 6-7 | > 7 |
| | Airflow in CFM | | | | |
| < 1,500 | 30 | 45 | 60 | 75 | 90 |
| 1,501 - 3,000 | 45 | 60 | 75 | 90 | 105 |
| 3,001 - 4,500 | 60 | 75 | 90 | 105 | 120 |

| TABLE M1507.3.3(2) Intermittent Whole-House Mechancial Ventilation Rate Factors | | | | | | |
|---|---|---|---|---|---|---|
| Run-Time Percent in Each 4-Hour Segment | 25% | 33% | 50% | 66% | 75% | 100% |
| Factor | 4 | 3 | 2 | 1.5 | 1.3 | 1.0 |

**Code Citation: IRC 2012, Section M1507.4 Local Exhaust Rates**
Local exhaust shall be designed to have the capacity to exhaust the minimum air flow rate determined in accordance with Table M1507.4.

## Code Requirements: Local Exhaust

**Local Exhaust**. In addition to a whole-house ventilation system, the code also requires minimum local (also called "spot" or "point source") exhaust capability in kitchens and bathrooms. Kitchens must have a 100-cfm, intermittent exhaust, or a 25-cfm continuous exhaust. The fans must exhaust to the outside. Recirculation fans do not count toward ventilation requirements. Bathrooms must have either 50-cfm intermittent controlled exhaust or a 20-cfm continuous exhaust. If continuous exhaust is used to comply with the local exhaust requirement, it may also be counted toward whole-house mechanical ventilation.

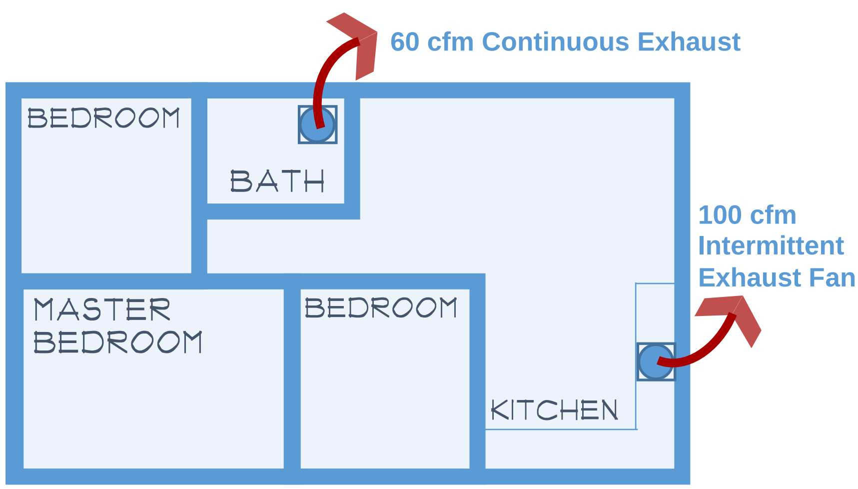
**Table M1507.4**
**Minimum Required Local Exhaust Rates for One- and Two-Family Dwellings**

| Area to Be Exhausted | Exhaust Rates |
|---|---|
| Kitchens | 100 cfm intermittent or 25 cfm continuous |
| Bathrooms-Toilet Rooms | Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous |

## Code Requirements: Examples

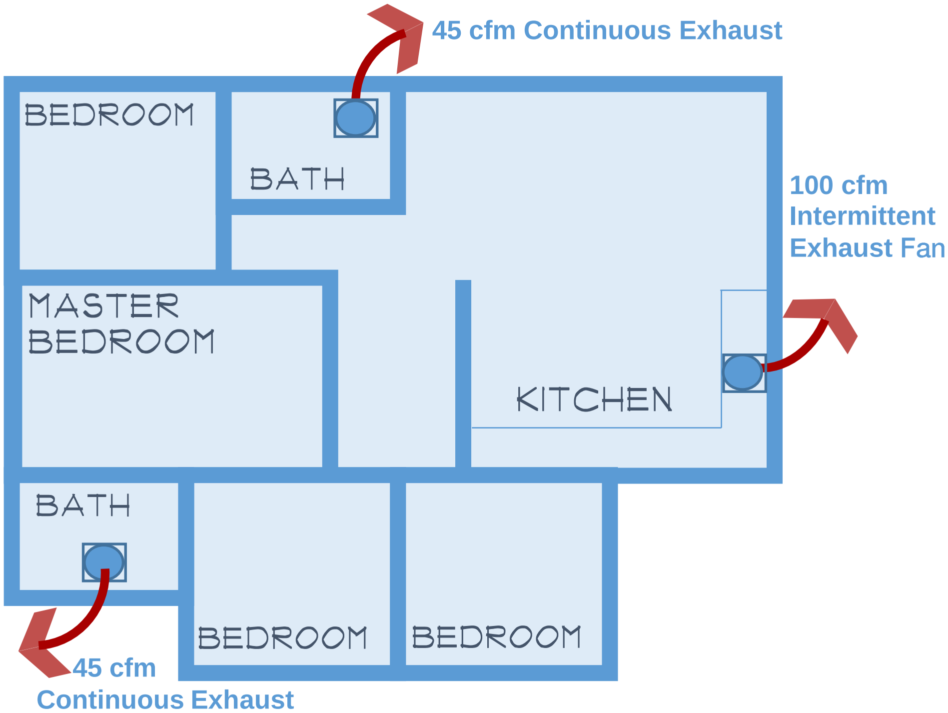
**Example #1: 2,000 ft$^2$, 3 bedroom, 1 bath**

**Example #1** is a 2,000 ft$^2$ single-story, three-bedroom house. This house requires 60 cfm of continuous ventilation. The house could comply with code with a continuous 60-cfm exhaust in the bathroom and a 100-cfm intermittent exhaust fan in the kitchen.



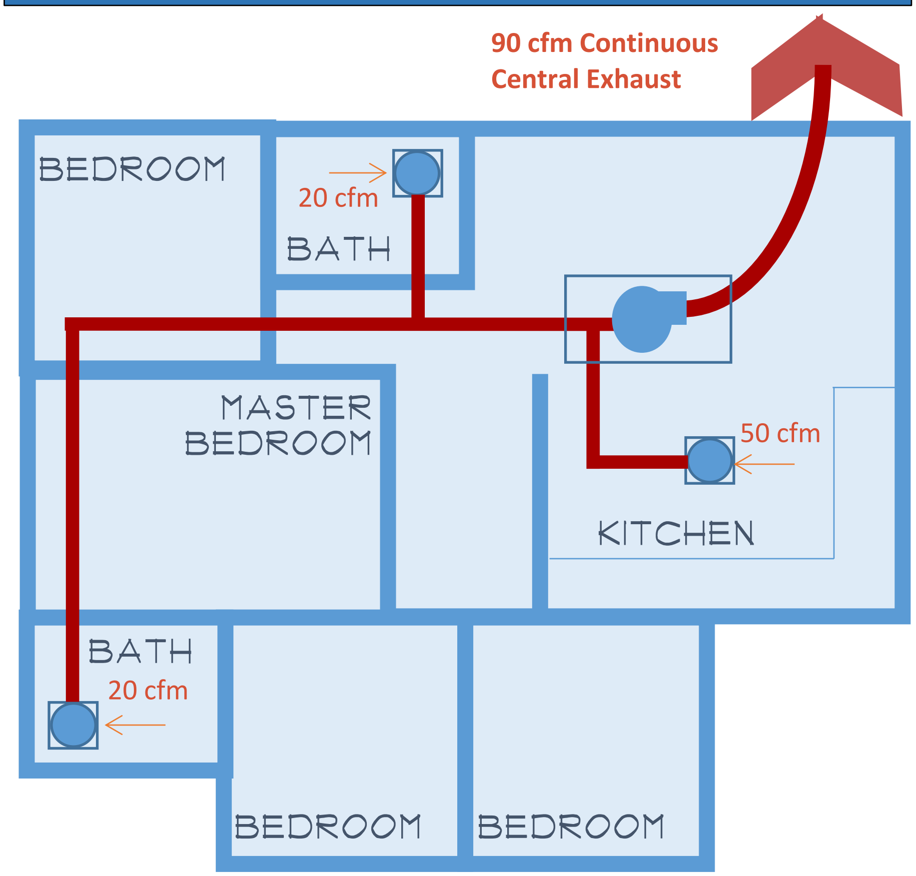
**Example #2: 3,600 ft$^2$, 4 bedroom, 2 bath**

In Example #2, a four-bedroom 3,600 ft$^2$, single-story home would require 90 cfm of continuous ventilation air flow, according to Chapter 15 of the IRC. One way to accomplish this is to have a continuous 45-cfm exhaust fan in each of the two bathrooms and a 100-cfm, manually controlled exhaust fan in the kitchen.




**Example #3: 3,600 ft$^2$, 4 bedroom, 2 bath**

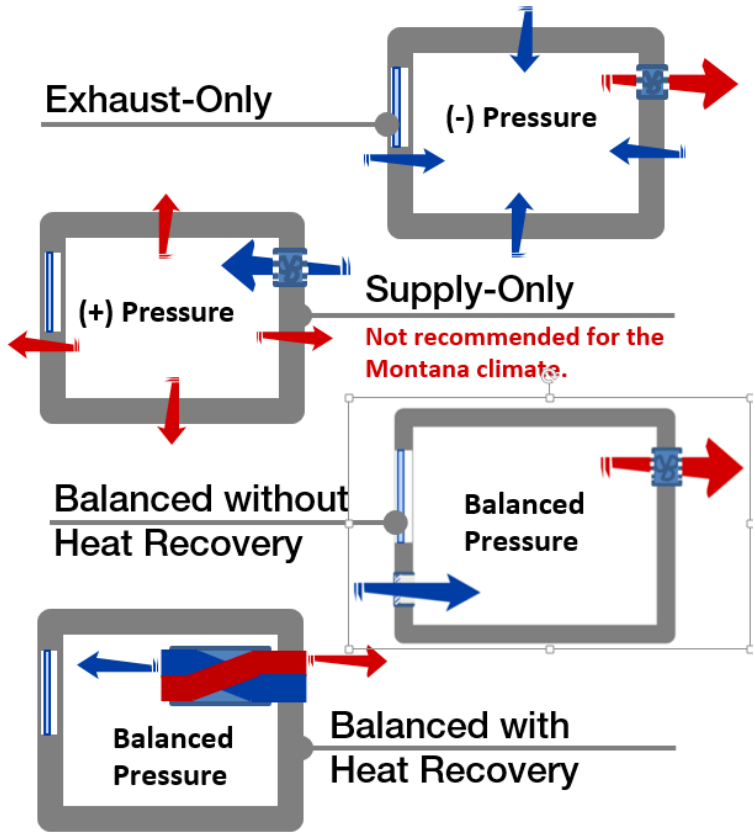
Example #3 illustrates another code-compliant ventilation solution for the same four-bedroom, 3,600 ft$^2$, single-story home. A central-exhaust system would continuously exhaust 20 cfm from each of the two bathrooms and 50 cfm from the kitchen. This satisfies both the whole-house air flow requirement and the local exhaust requirement. A central-exhaust system could feature heat recovery.



## Ventilation Types


**A fundamental building science principle is that if one cfm of air leaves a building, then one cfm must enter the building.**

Before describing four basic types of mechanical ventilation, let's review an important building science principle related to ventilation. As shown in the adjacent diagram, the volume of air that is exhausted from a building is equal to the volume of air that enters the building. This basic principle of physics rings true for all types of ventilation systems.




The four most common types of ventilation system are exhaust-only, supply-only, balanced, and balanced with heat recovery. *Exhaust-only ventilation systems* are the most common and often least expensive. The make-up air for exhaust-only systems is supplied by various air leaks in the building envelope. Exhaust-only systems usually consist of simple exhaust fans in the bathrooms or kitchen. Exhaust-only systems depressurize the house without providing planned pathways for make-up air. This often results in very uneven distribution of fresh air throughout the home. Exhaust-only systems can contribute to depressurization in the combustion appliance zone, which can lead to backdrafting of atmospherically vented appliances.

*Supply-only ventilation systems* pressurize the house without providing planned pathways for exhaust air. Since pressurizing the house will force warm, moist, interior air into the building cavities, supply-only ventilation systems are **not** recommended for cool, dry climates such as Montana.

In *balanced ventilation systems*, a dedicated make-up air pathway is designed into the system. Providing this dedicated make-up air pathway has several benefits. It can minimize problems of over-pressurizing and under-pressurizing spaces within the home. A balanced ventilation system is more likely to provide design air quantities. Since make-up air is provided through planned pathways, air quality may be improved. Simple, balanced ventilation systems may use *trickle* or *passive* fresh air inlets installed as through-the-wall units or in window frames. Unfortunately, a recent study conducted by Washington State University Energy Extension found that *trickle* or *passive* fresh air inlets were no more effective than basic exhaust-only systems without air inlets.

Many balanced ventilation systems utilize local exhaust fans that are interconnected with a central air-handler. The exhaust fans, central air-handler fan, and a motorized damper on a fresh-air duct connected to the air-handler return duct are coordinated. The motorized damper in the make-up air duct establishes a fixed amount of outside air that enters the central system. This approach allows the central air handler to distribute and temper outside air. The outside-air duct should be insulated and sloped to the outside to deal with possible condensation. Use of flex duct should be avoided to reduce the chance of reservoirs collecting condensation. As noted by Joseph Lstiburek in Builder's *Guide to Cold Climates*, the mixed return air temperature should not be allowed to drop below 50° F in order to control condensation of combustion gases on the heat exchanger surfaces.

*Balanced ventilation systems with heat recovery* are designed to provide heat recovery. Typically, an HRV will transfer 60% to 90% of the heat in the stale air being exhausted from the home to the fresh air entering the home. Heat recovery ventilators (HRV) have the potential to provide energy savings and effective ventilation but only if designed and installed properly. For small energy-efficient homes, HRVs may not be cost-effective. If integrated with a central air handler, the chances of an HRV providing cost-effective savings is reduced. An HRV transfers heat from the exhaust air to the intake (outside) air. In this system, air is collected from spaces in the home that are most likely to produce moisture or pollutants and is then exhausted at a central point. Outside air is supplied by the central ventilation system to one or more spaces.

When an air handler is present, the fresh air supply from the HRV can be connected to the return side of the air handler and the low-speed air handler fan is interconnected with the operation of the HRV. While it is possible to integrate an HRV with a central air handler, it is difficult to balance the HRV in this configuration because of the ducting and operating conditions of the central air distribution system.

## Ventilation Effectiveness

While the codes set important minimum whole-house mechanical ventilation requirements, the code provisions alone do not assure that the installed system will provide effective and energy-efficient ventilation to occupants of new homes. To the contrary, it takes thoughtful design, proper installation, and appropriate occupant behavior to provide healthy, comfortable, and energy-efficient ventilation. This newsletter is too brief to provide a comprehensive discussion of ventilation system design, but following are some design and operational considerations that improve the effectiveness and energy efficiency of whole-house ventilation systems.

- A whole mechanical ventilation system must be used in order to be effective. Factors that discourage use and cause occupants to disable the systems include noise, cool air blowing on occupants, complex controls, lack of understanding of system operation by occupants, and controls not being labeled.
- Simplify and label controls. Although not mandated by the code, the mechanical ventilation system manual control should be clearly and permanently labeled, especially the required override switch.
- Exhaust air from source locations. Air should be exhausted from the rooms where most pollutants, odors, and moisture are generated, such as bathrooms, laundry rooms, and kitchen.
- Supply air to occupied rooms. Supply and returns to each bedroom will assure that each is well ventilated, even when doors are closed.
- Distribute fresh air directly to occupied rooms. Good distribution means fresh air is supplied to the rooms where occupants spend most of their time, such as the living room and bedrooms.
- Exhaust kitchen range hoods to exterior. Kitchen range hoods should exhaust outside to remove moisture, odors, and pollutants. Recirculation hoods allow grease vapors and odors to remain in the house and should be avoided.
- Install quiet fans. Fan noise can be a major factor in whether occupants use the ventilation system provided. If fans are rated over one sone, there is a good chance the system will be deactivated by the occupants. Exhaust

fans are rated for noise. A sone is a measure of loudness. The higher the sone rating, the louder the sound. Exhaust fans with a sone rating of one or less will be quiet and much less likely to be disabled by the occupant.

- Beware of backdrafting. Backdrafting is the spillage of combustion gases, including carbon monoxide, from a combustion appliance such as fireplace, woodstove, atmospherically vented gas furnace, or atmospherically vented gas water heater. Installing sealed-combustion, power-vented, direct-vented, and induced-draft appliances will assure backdrafting is not a problem, but they are usually more expensive. Gas ovens and gas stovetops are also sources of combustion gases and should only be used with an exhaust hood directly vented to the exterior. Unvented gas fireplaces or gas heaters should never be installed.
- Test exhaust and supply flow. Flow hoods and other testing equipment are available to test the air flow at ventilation devices. The test is usually quick and easy. Actual fan flow depends not only on the fan capacity but also on the length and character of the duct. If the duct to the exterior is long, compressed, or has sharp bends, then then flow will be significantly reduced.
- Beware of radon. Radon enters a home through cracks in concrete, joints in construction below grade, and through poorly sealed crawlspace construction. You can't test for radon before construction. That is why the U.S. EPA recommends that all homes built in Zone 1, which includes most of Montana, have radon-mitigation systems installed at time of construction.

## Plan Review Pointers

1. Identify the fans that are part of the whole-house mechanical ventilation system and ensure that they provide the required airflow rate (cfm). (Note: Supply-only, exhaust-only, whole-house exhaust systems are not recommended for Montana's climate.)
2. Review specification information on the proposed fans and verify efficacy for each fan in terms of cfm/W.
3. Verify that all fans included in the whole-house mechanical ventilation system meet the efficacy requirements, and if integral with a central air handler, verify that the air-handler fan is powered by an electronically commutated motor.
4. Check that required local-exhaust fans in kitchens and bathrooms, either continuous or intermittent, have been identified and sized per the code.

## Field Inspection Pointers

1. Verify that all fans included in the whole-house mechanical ventilation system match the efficacy of specified units or the submittals provided and assessed during plan review. Verify that all exhaust is to the outside. Recirculation fans do not comply.
2. Verify that an occupant override has been installed as required for the whole-house mechanical ventilation system.
3. Verify that all local exhaust fans match the efficacy of specified units or the submittals provided and assessed during plan review. Verify that all exhaust is to the outside. Recirculation fans do not count toward required ventilation.

DEQ
Montana Department of Environmental Quality

For questions, suggestions, or to be removed from the newsletter distribution list, email daleh@ncat.org.

## Energize Montana Energy Code Website:

**http://deq.mt.gov/Energy/EnergizeMT/EnergyCode**