HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

INDOOR VENTILATION

Minnesota Department of Commerce Energy Information Center

Build tight and ventilate right! For many years has been the guiding principle for advocates of high quality cold climate housing.

Indoor ventilation refers to the exchange of air inside the home, in the space inhabited by human occupants. It is separate from attic or roof ventilation and has a very different purpose. It has two essential functions: to exhaust pollutants, moisture, and odors from inside the house to the outside, and to bring in outdoor air to mix with the indoor air. This guide is designed to help homeowners understand the need for indoor ventilation, the options for achieving a satisfactory ventilation system, and how to operate the system effectively. It is intended for both buyers of newly constructed homes and for those thinking of installing a ventilation system in their present home.

Why ventilate?

Fresh air is needed inside the home to help eliminate odors and pollutants harmful to human health. Fresh air also helps eliminate excessive moisture that harms the building structure and furnishings and is the source of mold and mildew growth. It is also important to replace the air that is expelled out of the home by kitchen range fans, clothes dryers, and other exhaust equipment. Failure to replace exhaust air decreases air pressure inside the home, causing outside air to be pulled into the home through leaks and other openings. In Minnesota, where many homes are fairly air tight, this depressurization can result in backdrafting of the furnace and other combustion appliances: carbon monoxide and other dangerous gases are pulled back into the house rather than being expelled up the chimney.

Although open windows are often relied on to supply fresh air, in a climate like Minnesota's this is not practical year round. Here, homes are "built tight" to ensure comfort and keep monthly energy bills as low as possible, especially during the winter. Although tightening up a home to prevent air leaks and then bringing in outdoor air through ventilation may seem like a contradiction, it is not. Tightening is essential for comfort and energy efficiency; controlled ventilation is necessary to ensure that the proper amount of fresh air is brought indoors in all seasons.

How much fresh air is needed?

Ventilation for people and their activities: A home ventilation system designed to provide the fresh air needed by people must have the capacity to provide approximately a one-third (0.35) air change per hour (ACH). The full one-third air-change-per-hour is usually not needed round the clock, but only during periods of high occupancy or moisture producing activities such as cooking or cleaning. For this reason, the total one third ACH required capacity can be broken into two parts: the minimum round-the-clock ventilation amount and the supplemental amount needed for peak occupancy and special activities. The round-the-clock fresh air need is calculated on the basis of number of bedrooms and is measured in terms of the rate, or cubic feet per minute (cfm), at which air is brought in from outdoors. This basic ventilation rate is 15 cfm for each bedroom, plus 15 cfm, with a minimum of 45 cfm. A house with three bedrooms, therefore, needs air brought in continu-

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Related Guides:
Combustion & Makeup Air

An air-to-air heat exchanger is a balanced ventilation system, meaning that it exhausts out and brings in an equal amount of air. Its heat recovery feature makes it one of the more energy efficient ventilation systems available.

ously at a rate of 60 cfm; a one or two bedroom house requires 45 cfm on a continuous basis.

The supplemental ventilation amount is the difference between the round the clock amount and the total one third air-change-per-hour. A formula has been worked out for calculating the total one-third ACH: take the square footage of the house, including the basement, and divide by 20.

For example, to achieve a one-third air-change-per-hour, a 3,000 square foot home requires air to be brought in at a rate of 150 cfm (3,000 divided by 20 = 150). This same home - if it has three bedrooms - requires a basic ventilation rate of 60 cfm; the supplemental requirement, therefore, is 150 minus 60, or 90 cfm.

Makeup air needs. As important as fresh air is for people, it is even more critical that air be brought in to replace air exhausted out of the house. This makeup air requirement is in addition to the ventilation air needed for people and their activities, and it is needed to prevent depressurization of the house and the potential backdrafting of combustion furnaces and other appliances. (See sidebars on protection against depressurization and combustion air.)

The amount of makeup air required varies according to the number and power (cfm) of exhaust equipment and on the type of fuel-burning furnace or water heater, specifically on whether the combustion equipment relies on natural draft to exhaust its gases or whether it has sealed combustion or direct or power-venting. (For a description of the various kinds of equipment and a summary of requirements see the sidebar on page 4.)

Selecting a ventilation system

For new construction there are a number of choices for supplying ventilation and makeup air. The options include a combination of a balanced system (where powered exhaust air is equal to powered supply air) and exhaust only (air is exhausted by fan and supply air is not fan-powered). The most important factor in the choice of a ventilation system is the type of combustion appliances operating in the house (see Protection Against Depressurization sidebar).

Following is a description of the various types of ventilation systems and the conditions in which they should be used.

Balanced ventilation. Balanced systems use power both to expel indoor air and its pollutants and to bring in fresh air to supply basic, round-the-clock ventilation. A variety of balanced ventilation systems are available and are described below. The department recommends a balanced system such a heat recovery, or energy recovery ventilator. In most instances, these systems will be the most available, effective and easily understood equipment.

Heat recovery ventilator (HRV). These systems consist of a fan or fans to provide for the intake and exhaust of air, a duct system, and a heat exchanger. In the winter, the heat exchanger recovers the heat from the exiting air and transfers it to the incoming air. In the summer, this process can be reversed. Most models operate between 70 and 80 percent efficiency. HRVs can run continuously and also be controlled with timers or dehumidistat.

Energy recovery ventilator (ERV). The main difference between an HRV and an ERV is the way the heat exchanger works. In an ERV, a certain amount of water vapor is transferred along with heat energy, while in the HRV, only heat is transferred. Transferring water vapor across the heat exchanger core is desirable. In winter, household humidity stays more constant because some of the moisture from the exhaust air is transferred to the less humid incoming winter air. In the summer, the water vapor in the incoming air is transferred to the drier air leaving the house. If you use an air conditioner, an ERV generally offers better humidity control than an HRV and is usually a better choice. Talk to your contractor about whether the advantages of an ERV are right for your particular situation.

Central intake and exhaust fans with their own duct system are similar to the heat recovery ventilator without the heat recovery feature. The system also can be run continuously or by automatic controls. The initial cost is significantly less than that of a heat recovery ventilator or energy recovery ventilator.

Powered exhaust powered supply intake. This system has a number of variations, all of which call for some form of mechanical exhaust and

supply. In one case a centrally located exhaust fan is installed; in another case spot exhaust fans are used along with a whole house exhaust installed in the main living space. Still another variation uses a central exhaust duct system feeding one central fan, installed in the basement or a location away from the living space, that exhausts air from the kitchen range, bath, and other selected areas. In all of these cases air is brought in with fans or other mechanical equipment through inlet vents, mixed with household air to temper it, and then distributed through the home. All of these systems can be controlled automatically.

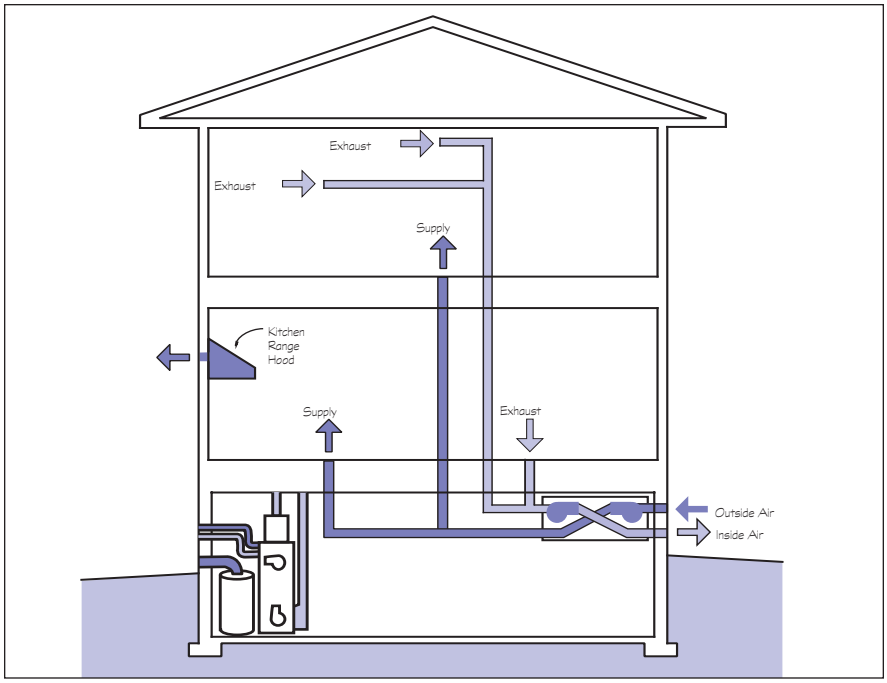
Exhaust only. Exhaust only systems use fans to remove moisture and pollutants from the house, but do not use fans or other mechanical means to bring in air from outdoors. They are, therefore, not balanced ventilation systems. Exhaust only systems include central exhaust systems (a central exhaust fan connects to individual exhaust ducts) and point source units that use fans at multiple sites such as bathrooms and kitchens to remove moisture and pollutants. These systems bring in replacement (makeup) air from outdoors either through vents (also called passive inlets) or by relying on infiltration leaks, around rim joists, windows, and doors, for example. In a newly constructed home built to high standards of air tightness, exhaust only systems–especially those that rely on air leakage–may create a significant imbalance in air pressure in the home. This imbalance can lead to dangerous backdrafting of the furnace, water heater, fireplace, and other combustion appliances. For this reason, exhaust only systems should be used only under certain conditions. (See sidebar, page 4.)

Features to look for.

In selecting a ventilation system, there are a number of features to look for and factors to consider:

Ventilation capacity. Can the system provide the total 0.35 air-change-per-hour needed for both basic and supplemental ventilation? Can it be set at a lower rate for round-the-clock ventilation needs? A system that can supply the .35 ACH is easier for the homeowner to understand, maintain, and operate effectively.

Controls. All controls should be accessible and easy to understand. They can be automatic or operated manually, but a system that allows a combination of automatic and manual control is probably preferable since there will be times when the homeowner will want to control the system.



A balanced ventilation system uses power both to exhaust moisture and pollutants to the outside and to bring in fresh air from the outdoors. The furnace and water heater shown in the diagram exhaust their combustion gases outside and bring in combustion air without mixing them with indoor air.

Supplemental ventilation for peak occupancy and other periods of high moisture can be controlled manually or it can be controlled automatically through the use of one or more devices. These include a timer that automatically increases or decreases ventilation rates during certain hours of the day when a higher or lower rate is needed; a dehumidistat that increases the ventilation rate whenever humidity exceeds a set amount

Air filters. The Department recommends that all ventilation systems filter incoming air, removing a good portion of incoming dust and pollutants. If a separate air filter is to be installed with the ventilator, select the two together so that the equipment is compatible.

Energy efficiency. The energy efficiency provided by a heat recovery ventilator (HRV's or air-to-air heat exchanger) or energy recovery ventilator (ERV) is a valuable feature. The heat recovered is

Protection Against Depressurization

Exhaust equipment, including kitchen range fans, clothes dryers, and other exhaust fans, profoundly influences the modern home environment. All homes in Minnesota are relatively "air tight." The air leaks around windows and doors, gaps in insulation, and other leaks in exterior walls and foundations that are common in older homes have largely been sealed. The result is a more energy efficient and comfortable home, but also one in which air leaks cannot be relied on to provide the fresh air needed for ventilation and makeup air. This is especially true in today's newly constructed home.

Using exhaust equipment to expel air from indoors but failing to bring in outside air to replace (or make up) this air can cause air pressure to drop in the home. In a depressurized home, standard combustion (fuel burning) equipment can backdraft dangerous gases (including carbon monoxide) into the house rather than being expelled up the chimney. For this reason, the State Building Code strictly limits conditions in newly constructed homes under which exhaust equipment can be used without bringing in an equal amount of fresh air either though passive inlets or by powered intake.

The Energy Information Center recommends that these guidelines be used in existing homes as well. The conditions for ensuring adequate amounts of makeup air are based on what type of combustion equipment– furnace, water heater, and fireplace are in the home. The safest type of combustion equipment is a sealed combustion system, which means that it brings in combustion air directly from the outdoors and exhausts gases directly outside without mixing with indoor air. Other types of combustion equipment include those that bring outdoor combustion air directly to the appliance, through a vent, and those that take combustion air from inside the building but use a fan to exhaust gases to the outdoors through a separate vent. The combustion equipment having the greatest risk of backdrafting is the atmospherically vented furnace or appliance, which takes combustion air from inside the home and exhausts gases up a chimney or vent without the aid of a fan or other powered device.

In all houses, new and old, the extent to which passive inlets or infiltration (air leaks) can be relied on to bring in fresh air for ventilation and makeup air is determined by what type of furnace, water heater, and fireplace is in the home and on the power of the exhaust equipment.

Following is a summary of conditions and restrictions based on the type of combustion equipment in the home. While designed for newly constructed homes, they should also serve as a guide when remodeling or making other improvements affecting indoor air pressure.

- If furnace, water heater, and fireplace are all sealed combustion or power vented, powered intake must be provided for only the most powerful exhaust equipment.
- If neither the furnace nor water heater is sealed combustion or power vented, powered intake must be provided for supplemental ventilation and all exhaust makeup air.
- A carbon monoxide detector should be installed in all homes.
- Using a performance option, any type of combustion, ventilation, and exhaust equipment could be installed as long as the home passes specified test procedures demonstrating that it is not subject to depressurization.

used to preheat incoming air. In an energy recovery ventilator, heat is recovered as well as the ability to control the import of high summer humidity. If you decide to invest in a heat or energy recovery ventilator, a reasonable efficiency to look for would be at least 70 percent. Some systems may achieve closer to 90 percent efficiency.

Noise level. It is important for the ventilation system to operate quietly. Not all ventilation systems are rated for sound; although surface mounted bath fans have such a rating. The general recommendation is a maximum sound rating of 1.0 sones. A noise level of 1.0 is equivalent to the sound of a newer refrigerator running. Some fans have a rating as low as 0.3.

Installation

The ventilation system can have its own separate supply and exhaust ducts, or either the supply or the exhaust duct may be connected to the forced air heating system. Both supply and exhaust ducts can be connected to the forced air heating system, provided controls are installed to ensure that the furnace blower fan runs whenever the ventilation system runs. Also, the exhaust air duct must be connected at least three feet upstream of the outdoor supply air duct. Because the furnace fan runs more often if the ventilation system uses the forced air system, selecting a furnace with a multispeed or variable speed fan is recommended, since it uses less electricity.

For all ventilation systems it is a good idea to locate exhaust grilles high on interior walls, run the ducts within the interior wall, and have the outlet from the fan exit out the rim joist. This avoids breaks in the ceiling air barrier, keeps air from rising through the duct when the system is not running, and prevents condensation from forming inside the duct in the attic and dripping back down through the grille. New ventilation system components should be installed to minimize noise and vibration transmission. It is also important to locate the ventilator or fans where they are easily accessible for operation and maintenance.

Ventilating an existing home

The question of whether and what kind of ventilation system to install in an existing home is open to consideration and depends on the type of appliances in the home and the possible interaction of appliances with each other and the ventilation system. We recommend that the ventilation principles and standards described above for new homes be used as a guide.

Shopping for a ventilating fan?

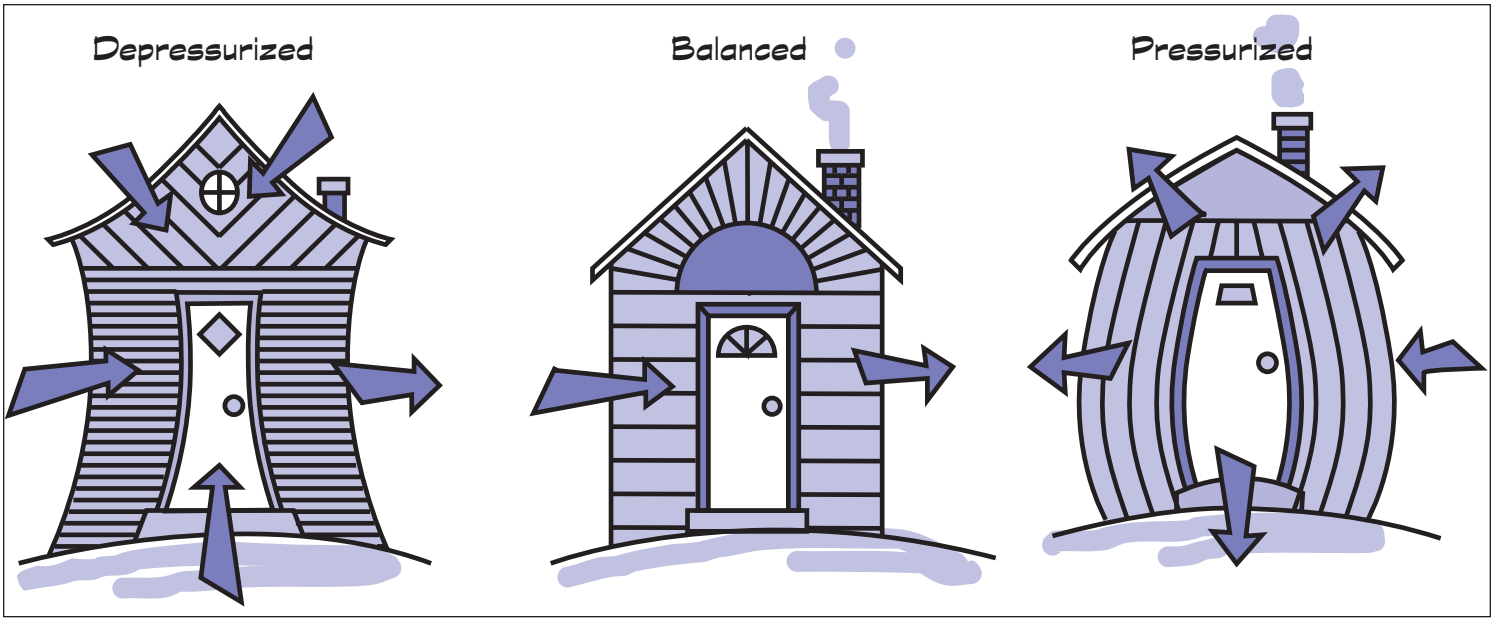
Look for the ENERGY STAR label.

The ENERGY STAR label ensures:

- Energy efficiency
- Quiet operation
- Long life

Go to www.energystar.gov for a list of products.

Air moves into and out of a house because of differences in air pressure. Wind, temperature, and fans all affect air pressure. Powerful exhaust fans can cause lower air pressure inside the house, as illustrated by the house at left. In such a depressurized house, combustion appliances that rely on atmospheric pressure to exhaust their combustion gases are susceptible to backdrafting. Indoor and outdoor air pressure are in balance in the center house. The house on the right is pressurized – indoor air pressure is higher than outdoor air pressure. If this situation persists, moisture could be driven into the walls, damaging insulation and the building structure.



COMBUSTION AIR

All fuel burning furnaces and appliances need a supply of outside air to operate properly. This air is in addition to the air brought in by ventilation system. No special means of supplying combustion air was provided in older homes – the needed air was simply assumed to flow in through leaks in the structure. We realize now, however, that factors such as temperature differences between indoors and outdoors and outdoor wind speeds affect air flow, and therefore it is not safe to rely on building leakage to provide combustion air.

Combustion air from outside is directly supplied to sealed combustion (sometimes called direct vented) furnaces and water heaters. The department strongly recommends buying this type of combustion equipment. In addition to having the safety feature of directly supplying combustion air, these appliances have a high level of energy efficiency.

If you do not have a sealed combustion furnace or water heater, you should install a combustion air supply for each fuel-burning appliance.

Instructions on how to do this are provided in the guide on Combustion & Makeup Air. Call the Energy Information Center for a free copy (see page 8).

Homeowners should consider installing a ventilation system if they are planning major remodeling or home improvements that are likely to alter the air tightness and air pressure characteristics of their home; these include:

- adding a room or in other ways expanding the home's square footage
- adding insulation
- installing exhaust fans
- replacing windows
- installing a new furnace or other combustion appliance
- sealing air leaks, caulking around windows and doors

If the home has heavy condensation on windows, mold on ceilings or walls, or other symptoms of moisture problems, installing ventilation may be considered, but only after evaluating the moisture source such as gutters, grading, or insulation faults.

The Department of Commerce strongly recommends that homeowners consult a building performance specialist and consider having a blower door test before deciding whether additional ventilation is needed. This test measures the house tightness and tests the performance of combustion appliances that rely on natural draft to exhaust their gases. Typical cost for this type of diagnostic testing can start at less than $200. When homeowners are faced with the possibility of investing hundreds or thousands of dollars on a ventilation system, the money spent for diagnostic testing to assure the value and need for the investment is very worthwhile.

In a home with a forced air heating system, the least expensive option may be to use the heating duct system to distribute the ventilation air. If you plan to connect the ventilation system to both supply and exhaust heating ducts, it is extremely important to pay careful attention to the installation of the system – see the section on installation above.

Operation and maintenance of ventilation system

The ventilation system providing basic fresh air needs should run continuously whenever the house is occupied, even on those days when windows are open. The ventilation system is needed in all seasons. Although it might be expected that running the ventilation system is more important in the winter, mechanical ventilation is needed during spring, summer, and fall to ensure that a proper amount of fresh air is brought in from outdoors.

In a new home, it is especially important to run the system continuously during the first year or two after construction to ventilate the extra moisture and gasses emitted from construction materials, carpets, and other new furnishings. If the ventilation system is not equipped with a timer or dehumidistat, the homeowner must manually increase the ventilation rate for those periods when supplemental ventilation is required. (See the above section on "How much fresh air is needed?")

Cleaning the fans, changing the filters, and cleaning the intake openings are important maintenance tasks. Filters should be changed at least twice a year. Having the ventilation system inspected annually by the heating contractor or other qualified service is also advised.

Resources

Energy Performance of Buildings group
(http://epb1.lbl.gov/EPB/)

The Energy Performance of Buildings group (EPB) is part of the Lawrence Berkeley National Laboratory. The EPB works on problems associated with whole-building integration involving modeling, measurement, design and operation. Most of its tasks have focused on the movement of air and associated penalties involving distribution of pollutants, energy and fresh air.

Health House
(http://www.healthhouse.org/)

The Health House® project is a national education program created by the American Lung Association of Minnesota to raise the standards for better indoor environments.

Healthy Indoor Air for America's Homes:
(http://www.montana.edu/wwwcxair/)

The Minnesota Indoor Air Quality Consortium
(http://www.dehs.umn.edu.homeiaq/)

A comprehensive collection of web resources about residential indoor air quality. Focus is on the identification of air pollutants, their health effects, and their sources as well as the prevention, investigation, and correction of indoor air quality concerns in houses. The site is maintained in cooperation with:

- Minnesota Department of Health (MDH)
- American Lung Association of Minnesota (ALAM) and its affiliates
- Indoor Air Quality Coordinators (EPA Cooperative Partners in Minnesota)
- University of Minnesota Extension Service
- U of M Department of Environmental Health and Safety (DEHS)

Building Science Corporation, Energy Efficient Building Association, and Shelter Source, *Builder's Guide: Cold Climate,* 1997. Copies available from Shelter Source, 17725 Juniper Path, Lakeville, MN 55044, phone 800-762-8399. www.buildingscience.com/

Stevens, Don, "Mechanical Ventilation for the Home," *Home Energy* magazine, March/April 1996. Available at www.homeenergy.org

Should I Ventilate My Existing Home?

According to recent studies, more than 30 percent of older homes in Minnesota likely need a ventilation system; many others could benefit from such a system. Also, almost any remodeling project – whether it be an addition, adding insulation, or installing exhaust fans – could alter the indoor air characteristics in your home. In such a case, you should definitely consider adding ventilation.

In deciding whether to add ventilation, homeowners are advised to consult a building performance specialist who can perform a series of tests to determine air leakage, combustion air safety, and other factors affecting indoor air quality and pressure. Call the Energy Information Center for a list of these building specialists.

Minnesota Department of Commerce

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Energy Information Center

Twin Cities:
651-296-5175

TTY: 651-297-3067

Statewide toll free:
1-800-657-3710

E-mail:
energy.info@state.mn.us

This information will be made available, upon request, in alternative formats such as large print, Braille, cassette tape, CD-ROM.

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MINNESOTA
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Minnesota Home Energy Guides

This guide is one in a series of publications designed to help Minnesotans save energy in their homes. Copies of the titles listed below are available by calling or contacting the Minnesota Department of Commerce.

CD-ROM contains all of the Home Energy Guides as well as several other publications of interest to homeowners, builders and contractors.

Appliances advises consumers on what to look for in energy efficient appliances and includes information on efficient operation and maintenance of refrigerators, freezers, washers, dryers, dishwashers, cooktops, ovens, and home office equipment.

Attic Bypasses explains how to find those "hidden air passageways" and fix them to prevent costly heat loss and damage to roofs, ceilings, walls, and insulation.

Basement Insulation discusses options to improving basement comfort, many not even involving insulation. It also provides details on exterior basement insulation, special foundation products and recommendations on interior insulation.

Caulking and Weatherstripping describes how to identify sources of air leaks, lists various types of caulk and weatherstripping, and provides illustrated how-to-apply instructions.

Combustion & Makeup Air describes the causes of dangerous combustion air problems and tells how to install an outside combustion air supply. It also tells how to test your home for combustion air problems.

Energy Saving Landscapes describes how to use trees and shrubs for long-term energy savings, and lists trees appropriate for energy-savings.

Home Cooling tells you how to cool without air conditioning, and provides information on buying and operating energy efficient air conditioners.

Home Heating describes proper maintenance techniques and helps you become an educated shopper if you are buying a new heating system.

Home Insulation helps the homeowner evaluate the benefit of added insulation, providing information on buying and installing insulation.

Home Lighting looks at new technologies for residential lighting, identifying four basic strategies and providing examples for putting them into practice.

Home Moisture describes symptoms of moisture problems, lists common indoor and outdoor causes, and discusses preventive and corrective measures.

Indoor Ventilation describes the types of home mechanical ventilation systems that are available, the amount of ventilation air needed, and how best to operate and maintain the system.

Low Cost/No Cost addresses the often overlooked energy saving tips for all areas of your home.

New Homes discusses a wide range of options for increasing energy efficiency beyond the normal building code requirements. Subjects covered include insulation, ventilation, air-vapor controls, heating and cooling, windows, doors, and appliances.

Water Heaters helps you determine whether to buy a new water heater or improve the old one. It explains the efficiency of different types of water heaters and provides installation tips.

Windows and Doors helps you decide whether to replace or repair windows or doors and gives a good summary of energy efficient replacement options.

Wood Heat offers advice on purchasing and installing a wood stove, with special emphasis on safety.