



COMBUSTION & MAKEUP AIR

Minnesota Department of Commerce Energy Information Center

All fuel burning equipment in your home needs a reliable supply of air to work properly. Furnaces, water heaters, fireplaces and wood stoves use large amounts of air in the combustion process. In addition, ventilation equipment, bathroom and kitchen fans, and clothes dryers all exhaust household air and can compete with the air needed for the safe operation of fuel burning appliances. Addressing your home's need for air is important for your safety.

To ensure that all fuel-burning appliances operate safely, air must be provided while they are operating. Without enough air, your house can quickly become polluted with unhealthy gases, including deadly carbon monoxide (CO). Carbon monoxide is odorless, colorless, and highly poisonous. The air needed for the safe operation of all fuel-burning or combustion appliances is called "combustion air."

Replacement air for all exhaust appliances is also critical. When a ventilation fan operates, it draws air from inside the house to the outside and creates or contributes to a slight vacuum in the house. The resulting negative pressure can be serious. If the negative pressure is strong enough, it can cause the furnace and other fuel-burning appliances to backdraft dangerous gases such as CO into the home. All exhaust fans, including clothes dryers, must have an adequate supply of air. The air needed for this purpose is called "makeup air."

Not just for new homes

No special means of supplying combustion or makeup air was installed in most older homes - the needed air was simply assumed to flow in through leaks in the structure. But factors such as temperature differences between indoors and outdoors and outdoor wind speeds affect the amount of air available for the safe operation of combustion

appliances. Research indicates that many older Minnesota homes are actually much tighter than once assumed. The result is that natural air leaks cannot be relied on to provide the fresh air needed for all combustion and makeup air needs.

The State Building Code has required combustion air for the installation of new fuel burning equipment for many years. For several years it also has strictly limited the conditions in new homes under which exhaust equipment can be used without supplying an equal amount of makeup air. Makeup air is now recognized as being equally important as combustion air and has been incorporated into the Mechanical Code provisions of the State Building Code.

The need for additional combustion and makeup air should be addressed when:

- Installing or adding any vented combustion appliance, including a solid fuel such as wood.
- Installing or replacing an exhaust system in a house constructed after 1999.
- Installing an exhaust system with a capacity greater than 300 cfm.
- Making any changes that will affect the air tightness of the building such as installing new windows, siding, and insulation.

Outside combustion air supplies for furnaces, water heaters, wood stoves and fireplaces

How to test for combustion air

The difference between makeup and combustion air

New Mechanical Code Requirements - see page 5



Related Guides:

- Wood Heat
- Indoor Ventilation
- Home Heating
- Home Cooling
- House Diagnostics

Types of combustion appliances

Natural draft. Sometimes referred to as atmospherically vented, this type relies on the hot gases to exhaust properly. Because air for combustion is taken from inside the building, this type of equipment has the greatest risk of backdrafting. Natural draft furnaces are also less energy efficient than power or direct vented appliances. If you have a natural draft appliance in you should have at least one carbon monoxide alarm (see page 3).

Fan assisted. This type of equipment uses a small capacity fan to push or pull air through the heat exchanger and can be vented in common with a water heater. These furnaces are difficult to distinguish from either a natural draft appliance or a power vent appliance and because combustion air is taken from inside the building, the danger of backdrafting is close to that of a natural draft appliance.

Power vented. Sometimes referred to as induced or forced draft, this type uses a fan or blower to push or pull the exhaust gasses out of the furnace rather than relying on natural draft. These units are distinguished from fan assisted, in that they cannot be vented in common with another combustion appliance (like a water heater). Similar to natural draft and fan assisted equipment combustion air is taken from inside the building.

Direct vent. Also referred to as sealed combustion, this type brings combustion air directly into the combustion chamber. Many new furnaces, boilers, and water heaters use this feature. In addition to improved safety, this equipment is the most energy efficient. Do not confuse sealed combustion with induced draft or forced draft equipment: these provide for mechanical exhaust, but not for bringing in outside combustion air. If you are in the market for a new furnace or water heater, we strongly recommend you buy a sealed combustion unit.

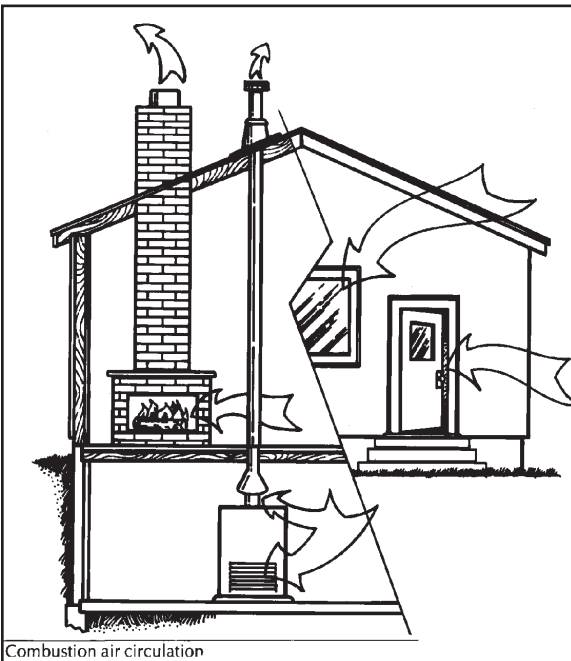


Figure 1.

The amount of combustion and makeup air required depends upon:

- The fuel-burning equipment in the house (furnace, water heater, or wood burning appliance).
- How the combustion equipment exhausts its gases: natural vent, direct vent (sometimes referred to as sealed combustion), power vent and fan assisted (see sidebar—types of combustion appliances).
- The airflow (in cubic feet per minute, or cfm) of the exhaust equipment.
- The relative air-tightness of the home.

This guide will discuss these variables and provide guidance as to the circumstances in which the addition of combustion or makeup air should be considered.

What causes dangerous combustion air problems?

Many furnaces and most wood stoves and fireplaces use a natural draft; the hot gases produced by the fire rise up the chimney without mechanical assistance. This natural draft up the chimney creates a slight vacuum, which draws in air through small holes and cracks in the house (see figure 1). Serious problems occur when this natural flow of combustion air and exhaust gases is disrupted.

In general, combustion air problems such as backdrafting of gases occur when fuel-burning appliances demand more air than the house can supply through normal air leakage. Here is an example:

A wood fire is burning in the fireplace, which uses room air for combustion. The strong natural draft of the fireplace sends the combustion products up the chimney; because air is going up the chimney a vacuum is created in the house. Because it is cold outside, windows and doors are shut. Eventually the furnace comes on. The natural tendency of the hot combustion gases is to rise, but the strong suction caused by the fireplace draft pulls air down the furnace flue and combustion gases spill out of the draft hood and remain in the house. This is called “backdrafting.” The backdraft hinders the furnace exhaust, and the

combustion gases can produce increasing amounts of carbon monoxide and other potentially dangerous gases.

Wood fires are not the only cause of backdrafting. Although combustion air problems are more likely to occur when there is an open wood fire, they are not limited to these situations. Clothes dryers, gas stoves, gas or oil water heaters, and bathroom and kitchen or range exhaust fans all make considerable demands on the air supply.

Combustion air problems can occur in any home, even older homes which were once assumed to have enough air leaks to provide outside air for combustion. *Any home improvement or weatherization measure (such as tightening up air leaks, adding insulation, or replacing windows) will increase the potential for backdrafting.* So, too, does the recent consumer trend of installing sophisticated cooking appliances with built-in high-volume exhaust fans. These fan/exhaust systems are powerful and remove more air from the home than what can be supplied through leaks or passive openings. Because dedicated makeup air is needed for these devices, kitchen exhaust fans with a design capacity greater than 300 cfm are strongly discouraged.

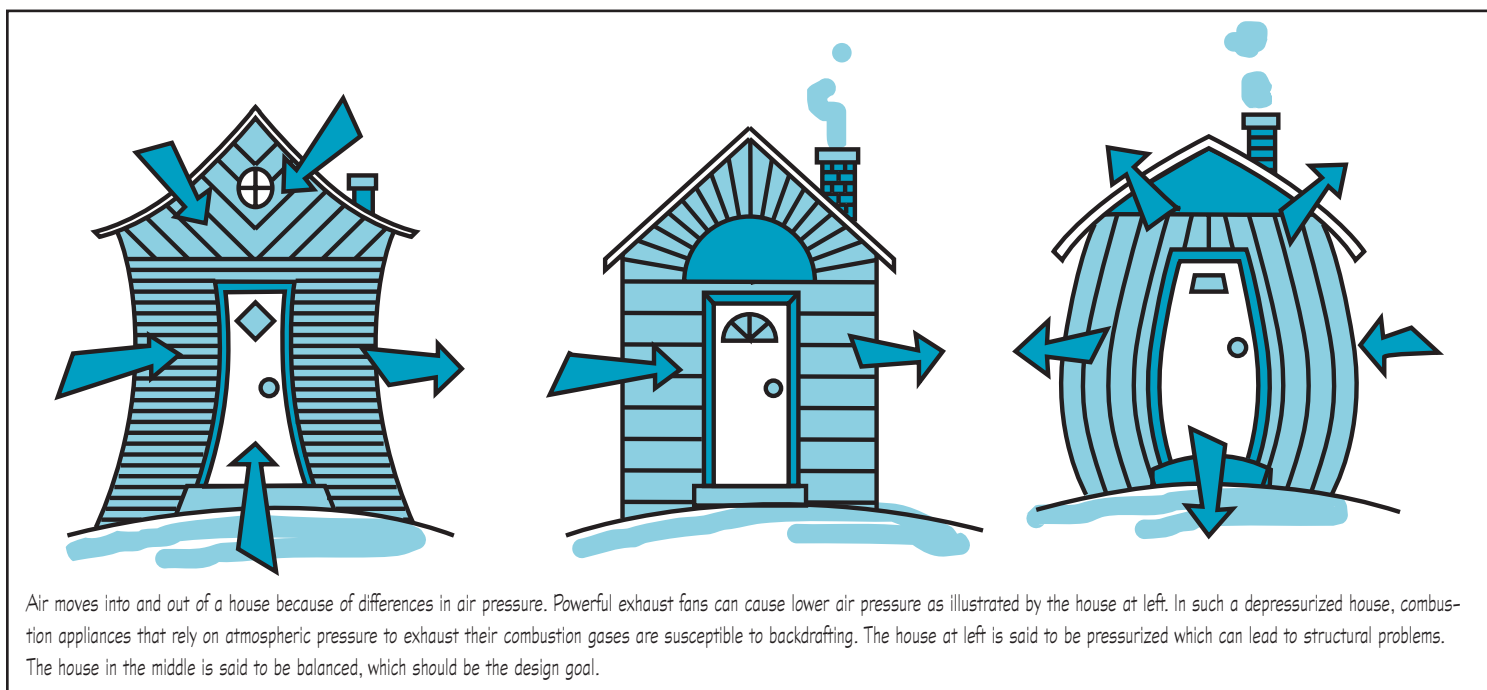
Bigger is not necessarily better when it comes to kitchen range exhaust systems. In order to be effective “downdraft” exhaust fans mounted near

the cooking surface must have a large exhaust capacity (600-cfm). A modest sized (250-cfm) hood exhaust will be just as effective at removing odors and pollutants

Protect your home with a carbon monoxide alarm

Every home should have at least one carbon monoxide alarm with a digital display. Look on the package for a product that meets the most recent Underwriters Laboratories (UL) 2034 standard, International Approval Services (IAS) 6-96 standard or the Canadian Standards Association 6.19-01 standard. CO alarms are available at discount stores, hardware stores, and building supply stores. Many utility companies also sell them to their customers. Expect to pay between \$35 and \$60 for a UL listed alarm.

The alarm should be capable of waking you up while you sleep and should be easy to test and reset. Battery operated devices should be tested weekly and the batteries replaced at least once a year. Hard-wired devices should also be tested regularly, usually on a monthly basis. The unit should be placed near the sleeping areas of the house. For more information about home carbon monoxide prevention, see the Minnesota Department of Health Web site (www.health.state.mn.us/divs/eh/indoorair/co/preventco.html).



Energy Savings

Combustion air and makeup air supplies are health and safety concerns and must be addressed. Bringing in combustion air from the outside will probably neither save nor cost energy. Energy savings occur when the vacuum pressure in the house is reduced, which reduces infiltration of cold air; when less warm room air is used for combustion; and when less warm air is pulled into the draft hood. Buying an energy efficient, sealed combustion furnace and water heater provides energy savings as well as increased safety.

How do you know if you have a combustion air problem?

Combustion air can be checked by performing a seemingly simple draft hood test. The draft hood is an opening in the vent pipe above the furnace or water heater that allows room air to enter the venting system. It is usually a hood-like device in the pipe just above the furnace (figure 2), or an opening near the top of the furnace (figure 3).

The test shows if air is being pulled into the draft hood, which means the furnace is venting properly. It is done by holding a smoking object (such as an incense stick) near the hood while the furnace burner is on and watching to see if the smoke is drawn into the hood (figure 4). If it is blown away from the hood, combustion gases are not going up the flue, as they should.

To be sure of the test results the draft hood test should be made twice. A third test should be done on homes with a wood stove or fireplace. The tests should all be performed on a mild day with very little or no wind. It is important to remember that the draft hood test is only a “snapshot” of what is happening in your home. A change in wind speed or direction, or an open window, might change the result. The test should be performed couple of times over the heating season. Also, if you make any of the changes to your home listed on page 1, it is advised that you

consult with a professional to test all of your combustion appliances.

It is important to have a carbon monoxide alarm in the area where the equipment is located while you do the test. Make sure that you can see the display. If your equipment does not pass the test you may be exposed to carbon monoxide. The Energy Information Center recommends you consult an ENERGY STAR qualified home performance specialist (see page 6) for this test.

Test 1. The first test is simply to see if the flue is clear of obstructions. Turn on the furnace and wait a minute for the draft to stabilize. Hold the smoke source two inches from the draft hood opening (figure 4). If the smoke is drawn in, your flue is clear. If it is blown away from the hood, it is essential that the flue is checked for obstructions before operating the furnace. *A qualified professional contractor should be consulted immediately.*

Test 2. To perform the second test, wait about an hour or so to let the flue cool. Close all doors, windows, and fireplace and wood stove dampers. All storm doors and storm windows should be in place and shut. Turn on all exhausting devices, such as kitchen and bathroom exhaust fans, clothes dryers (gas or electric), and all vented gas or oil appliances, such as water heaters. You may have to turn on a hot water tap to get the water

Figure 2

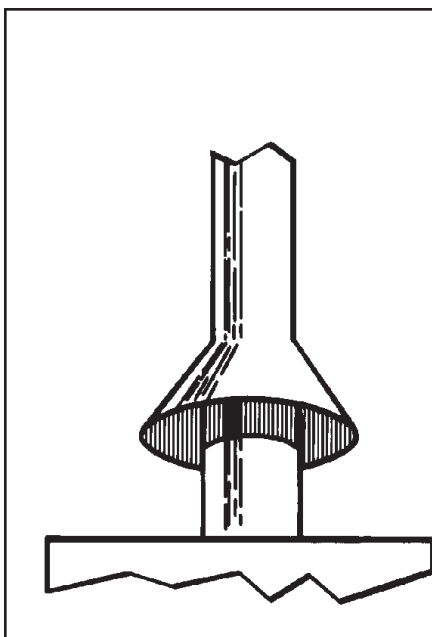


Figure 3

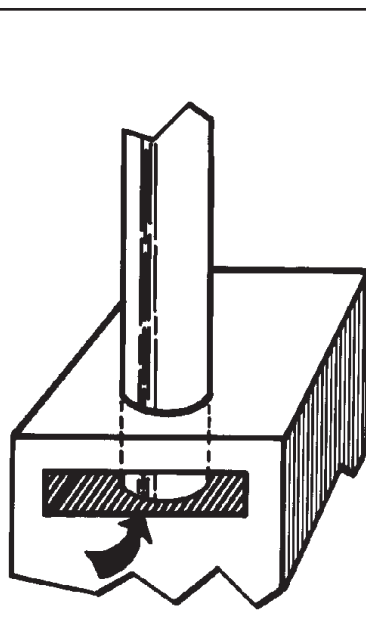
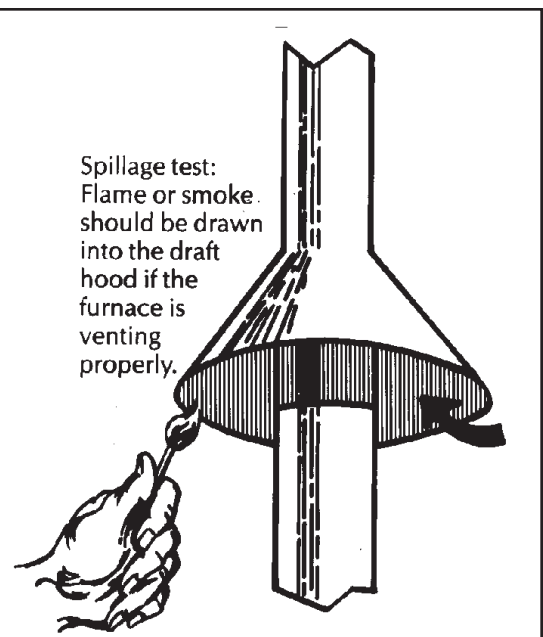


Figure 4



heater to come on. Open any doors between the furnace and any exhausting device. Then turn on the furnace, wait a minute for the draft to stabilize, and repeat Test 1.

If the smoke is not drawn up the draft hood, you need to bring additional air into the house immediately. Open doors and windows and air out the entire house. Then crack open a window in the furnace or fireplace room and leave it open until you can get professional advice and/or help to install an outside air duct to your furnace room, fireplace, or wood-burning stove.

Test 3. For wood stoves and fireplaces, perform the test once more. Leave the furnace off long enough for the flue to cool down. Then start a fire in the fireplace or wood stove and wait until the flames are burning well. Turn on the furnace and all the equipment as in the second draft test, wait a minute for the drafts to stabilize, and do the test as before.

If the smoke is not drawn up the draft hood, immediately open a window in the furnace room until you can install a combustion air supply. It would also be safest not to use the fireplace or wood stove until you can provide combustion air from a permanent duct.

Other warning signs. In addition to conducting the draft hood test, certain warning signs should be heeded. These include frequent headaches and a burning feeling in the nose and eyes of the human occupants, and the gas flame in the furnace or heater burning yellow instead of blue. Other indicators of a problem are:

- Oil furnace or heater. Black chimney smoke; fuel smell in the house; soot accumulation; outward leaking from doors or ports; popping, banging, rumbling, or delayed ignition.
- Natural gas. Excessive moisture collecting on windows and walls, although this could be a symptom of other moisture problems and not necessarily of combustion air problems.
- Wood. Smoking fire and improper drafting even when the flue has warmed up.

These problems could also be caused by clogged combustion air intakes on the furnace, problems

in the fuel-burning appliance, or an inadequate or damaged flue. If you notice any of these signs, you should have your system inspected by a professional heating contractor. Remember to have your furnace, water heater, and any other combustion appliance checked each year by a professional technician. The yearly tune-up should include testing for adequate combustion and makeup air.

Combustion & makeup air requirements of the State Mechanical Code

Whether or not you identify a problem, it is always wise to provide an outside combustion air supply for combustion appliances that are not direct or power vented. Always deal with a professional contractor and check with your local building inspector to find out what is required for your situation.

The mechanical code uses a calculation procedure to determine how much combustion and makeup air is needed based on a number of variables about the house. The amount of air needed for combustion and makeup air is calculated independently. The following variables influence the amount of air that is needed:

Volume and area space. The amount of combustion air required depends upon the volume of the space the mechanical equipment is located in and the amount of makeup air depends on the size (square footage and height of ceilings) of the living space.

Type and size of combustion appliance. All fuel-fired equipment exhausts gasses to the outside of the home. There are differences, however, in how that is accomplished. It is important to know what type of equipment you have in order to determine your need for an additional supply of air. In addition, you will need to know the input size (in Btu/hr) of the combustion equipment because the larger the equipment, the more combustion air is needed.

Cfm capacity of larger exhaust equipment. Exhaust equipment such as clothes dryers, kitchen and bathroom fans, and central vacuums can create a negative pressure in the building and cause combustion equipment to backdraft. In any house, this can be a problem especially if there are large exhaust appliances with a capacity greater than

Updated State Mechanical Code

The updated Mechanical Code portion of the State Building Code came into effect September 2004. Major changes include the requirement for makeup air whenever mechanical changes are made to existing homes. In many instances additional makeup air will not be required.

Combustion Air has long been a requirement of the Building Code and is still a mandate whenever mechanical equipment is installed or changed. The latest Mechanical Code take into account the overall tightness of the building envelope and the type of combustion appliance; in some circumstances the size of the combustion air inlet can be reduced.

Software to help calculate the required amount of combustion and makeup air is available from Energy Information Center.

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 extremely important to provide makeup air for 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. 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.

300 cfm. In homes with large exhaust appliances, the Code may require a powered makeup air source.

Wood burning appliances. Referred to as "solid fuel" appliances, wood burning equipment requires large amounts of air for combustion. A small wood stove can create enough negative pressure to backdraft other appliances and create a serious safety problem in your home. If you install a solid fuel appliance you must consult a professional to carefully analyze the need for combustion and makeup air.

Air tightness of building envelope. As explained earlier, the air leakage through windows, doors and other openings is generally not enough to ensure safe combustion of appliances. The amount of air leakage (also called air infiltration) will determine how much additional makeup air is required.

The best way to determine the appropriate combustion air needed for your home is to hire a professional house performance specialist. These specialists provide a variety of diagnostic services, including a pressurization test to determine the level of tightness of the building. A list of ENERGY STAR qualified home performance specialists in Minnesota is available from the ENERGY STAR Web site (www.energystar.gov: click on "Home Improvement," scroll down to "Need Help," and select Minnesota).

A software program to help heating contractors, building officials and design professionals calculate what is needed is available from the Energy Information Center. The software is a useful tool to determine what is needed. If you are unsure of the requirements, verify that your contractor has used the software to calculate the right amount of air for your home.

The Bottom Line

Always remember - any time you make changes in your home that could affect the air supply, you must ensure that there is adequate combustion and makeup air. These changes include tightening up the home to eliminate drafts and cold walls, remodeling or adding an addition to the home, buying a new combustion appliance (unless it is a direct vent), or adding an exhaust fan or ventilation system. Consult with your local building inspector to make sure whatever is installed is done correctly.

Important Points to Remember

- Never block or close off your combustion air opening or duct. Make sure, by checking regularly, that the combustion air intake remains clear of snow, leaves, or other debris.
- Never supply combustion air from garages or other places where vehicles idle. This air may contain carbon monoxide and other contaminants.
- All fuel-burning equipment should be inspected regularly by a qualified service representative to keep it operating efficiently and venting properly. Inspect oil and gas equipment annually.
- Always test for combustion air during and after any remodeling project. Additions and remodeling change the air leakage characteristics of your home.
- Never use a gas range or oven for heating a room.
- Never use a charcoal grill inside or near an air supply into the home. Burning charcoal, whether it's glowing red or turning to gray ashes, gives off large amounts of carbon monoxide.
- Wood stoves (solid fuel appliances) require a separate chimney. Never vent them into the existing heating system chimney.
- Never use unvented equipment indoors. This includes kerosene, propane, gas and catalytic heaters, and gas lanterns. The State Building Code does not permit the use of any unvented heaters in any enclosed space. Exposure to emissions constitutes a health risk, even under relatively high ventilation conditions.

Minnesota Department of Commerce

Suite 500
85 7th Place East
St. Paul, MN 55101-2198
www.commerce.state.mn.us

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.

This publication was produced with funds from a U.S. Department of Energy State Energy Program grant. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author and do not necessarily reflect the views of the Department of Energy.



MINNESOTA
DEPARTMENT OF
COMMERCE

071505

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 containing 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 and 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.

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.

House Diagnostics explains what it entails and helps you decide if you need these services.

Ice Dams describes what causes ice dams and how to fix them.

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.

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

Water Heating 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.